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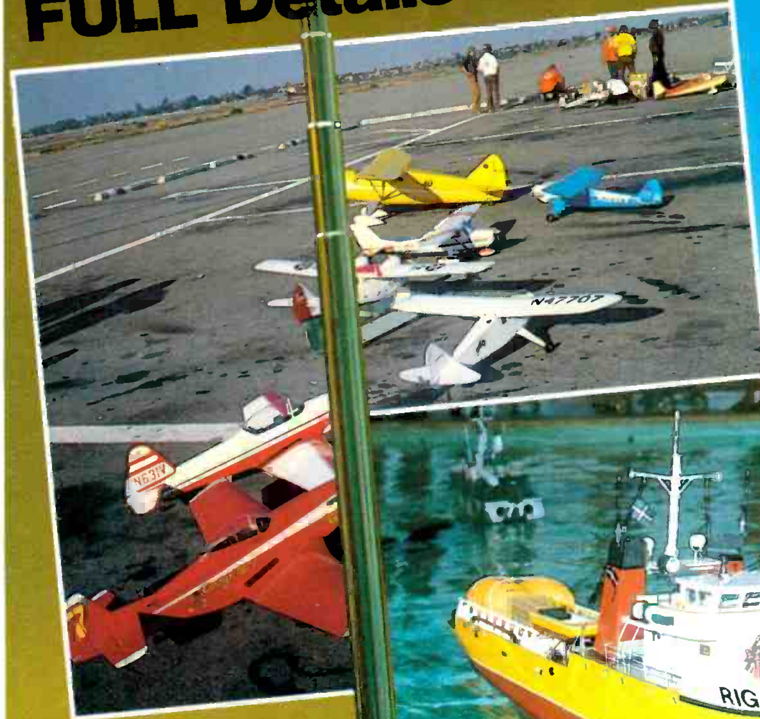
electronics today

INTERNATIONAL

OCTOBER 1980 60p

FM RADIO CONTROL
FULL Details Inside



SPECIAL COMPUTER INTERFACE

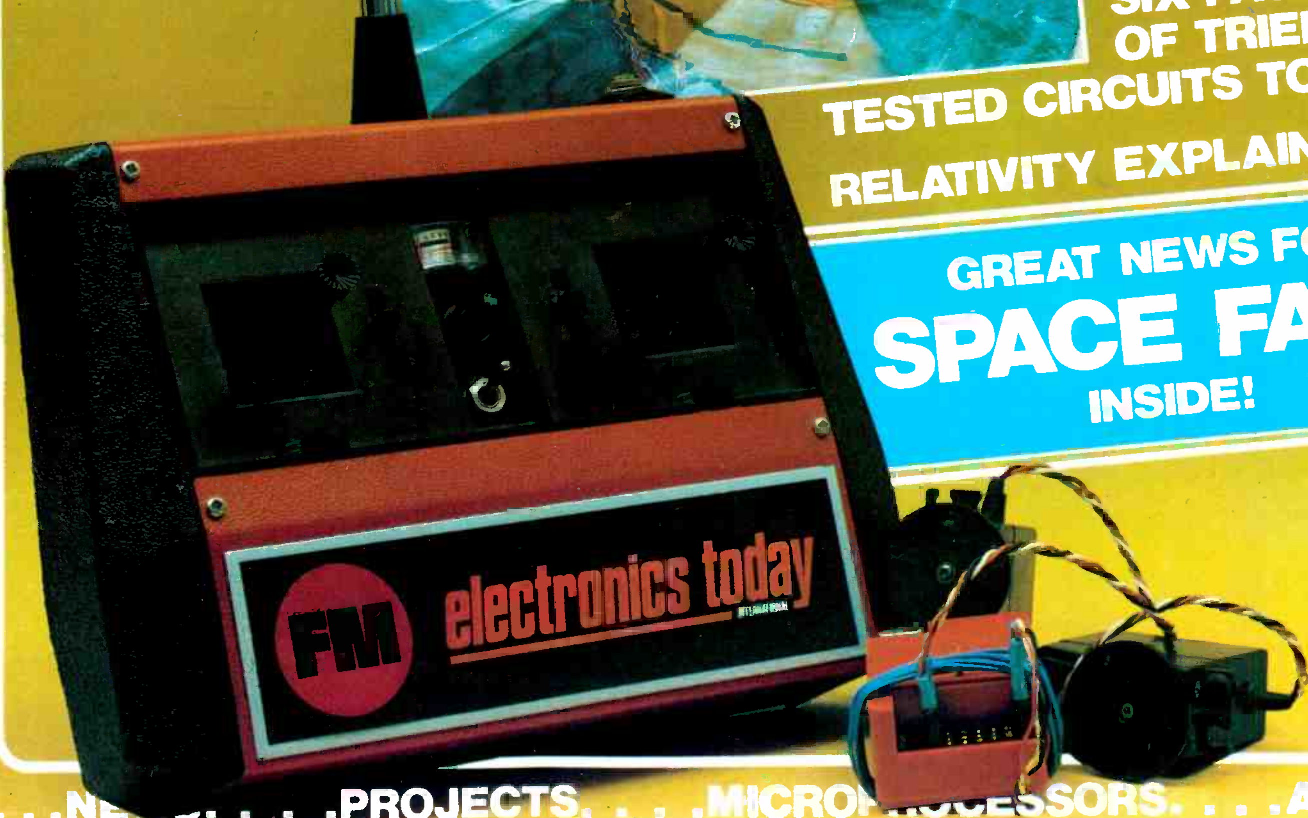
FLASH TRIGGER

SUSTAIN PEDAL

SIX PAGES OF TRIED AND TESTED CIRCUITS TO BUILD

RELATIVITY EXPLAINED!

GREAT NEWS FOR
SPACE FANS
INSIDE!



. . .NE . . . . .PROJECTS. . . .MICROP . . . SSORS. . . .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

COMPLETE KIT
NOW ONLY £225 + VAT

Cabinet size 19.0"x15.7"x3.3"
Television not included in price

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

BEING FEATURED IN THIS ISSUE
★ ETI VOCODER ★

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

14 CHANNELS!
NOISE GENERATOR!
LED PPM METERS!
SLEW RATE CONTROL!

2 OSCILLATORS!
VOICED/UNVOICED DETECTOR!

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!

POWERTRAN

OUR CATALOGUE IS **FREE!** WRITE OR PHONE **NOW!**

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PRICE STABILITY: Order with confidence. Irrespective of any price changes we will honour all prices in this advertisement until November 30, 1980, if this month's advertisement is mentioned with your order. Errors and VAT rate changes excluded.
EXPORT ORDERS: No VAT. Postage charged at actual cost plus £1 handling and documentation.
U.K. ORDERS. Subject to 15% surcharge for VAT. No charge is made for carriage, or at current rate if changed.

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.

MANY MORE KITS ON PAGE 8

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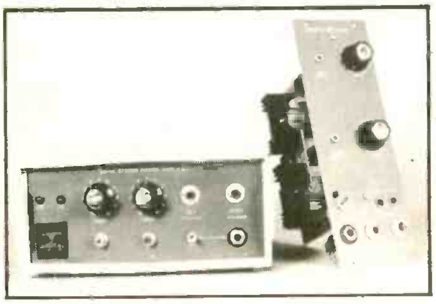
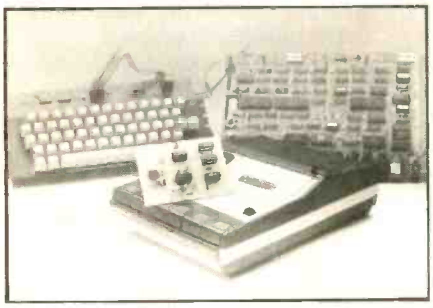
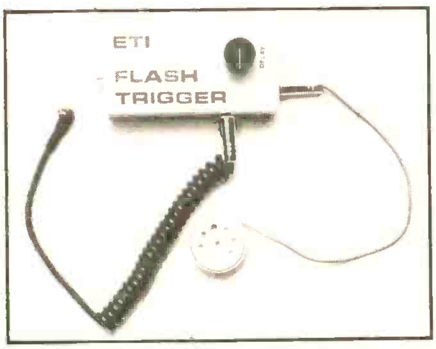
Single chip control system. p.15



Sounds for Project 80. p.79



From micro to tape in a flash. p.63



For photo special effects. p.30

FEATURES

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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, the world's most popular computer language for beginners and experts alike.

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

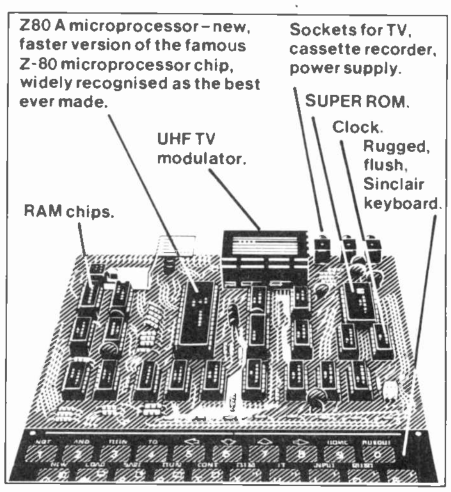
Fewer chips, compact design, volume production–more power per pound!

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



TTLs by TEXAS

7400	11p
74S00	60p
7401	12p
7402	12p
7403	14p
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7405	18p
7406	36p
7407	36p
7408	17p
7409	19p
7410	15p
7411	24p
7412	20p
7413	30p
7414	40p
74C14	90p
7416	27p
7417	27p
7420	17p
7421	40p
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7430	17p
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7438	35p
7440	17p
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7443	112p
7444	112p
7445	100p
7446A	93p
7447A	75p
7448	80p
7450	17p
7451	17p
7453	17p
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7470	36p
7472	30p
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7475	38p
7476	32p
7480	50p
7481	100p
7482	84p
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7485	110p
7486	34p
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74164	120p
74165	130p
74166	120p
74167	200p
74170	240p
74172	450p
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74174	90p
74175	85p
74176	90p
74177	90p
74178	160p
74180	93p
74181	160p
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74185	150p
74186	500p
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74190	120p
74191	120p
74192	100p
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74199	150p
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74LS SERIES

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74LS73	50p
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74LS139	75p
74LS145	120p
74LS147	220p
74LS148	175p
74LS151	80p
74LS153	60p
74LS154	200p
74LS155	80p
74LS156	90p
74LS157	60p
74LS158	60p
74LS160	90p
74LS161	75p
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4016	45p
4017	80p
4018	89p
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4075	25p
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40107	60p
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40114	250p
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4512	80p
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4569	250p
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40097	90p
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14412	1100p
14433	1100p
14500	700p
14599	290p

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75110	325p
75150	175p
75154	175p
75182	230p
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75365	250p
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75491/2	96p
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81LS98	140p
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9602	220p

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9321	225p
9322	150p
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9370	300p
9374	200p

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74S373	500p
74S374	500p

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AY1-1320	320p
AY1-5050	140p
AY3-1270	840p
AY5-1224A	240p
AY5-1315	600p
AY5-1317A	775p
AY5-4007D	520p
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CA3046	70p
CA3048	225p
CA3080E	72p
CA3086	48p
CA3089E	225p
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CA3189E	300p
CA3280	160p
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FX209	750p
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ICL8038	300p
ICM7555	80p
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LM3915	225p
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LM13600	125p
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MC1458	48p
MC1495L	350p
MC1496	100p
MC3340P	120p
MK50398	750p
ML920	775p
MM57160	620p
NE531	150p
NE555	22p
NE556	70p
NE562B	425p
NE564	420p
NE565	130p
NE566	155p
NE567	140p
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S566B	270p
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SL490	400p
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SN76013N	140p
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SN76023N	140p
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SN76477	175p
SP8515	750p
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TBA641B11	225p
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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	300p
TDA2002V	325p
TDA2020	320p
TL071/81	45p
TL072/82	75p
TL074	130p
TL084	110p
TL170	60p
UAA170	175p
UDN6118	320p
UDN6184	320p
ULN2003	100p
XR2206	300p
XR2207	400p
ZN414	90p
ZN419C	225p
ZN424E	135p
ZN425E	400p
ZN427E	750p

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
LM317T	200p
LM323K	550p
LM723	37p
78HGKC	600p
78H05KC	600p
78MGT2C	135p
79HGKC	700p
TL497	300p

OPTO-ELECTRONICS

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

OPTO-ISOLATORS

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

LEDS

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

DISPLAYS

3015F	200p
DL704	140p
DL707 Red	140p
707 Gr	140p
DL747 Red	225p
747 Gr	225p
FND357	120p
FND500	120p
FND507	120p
MAN3640	175p
MAN4640	200p
NSB5881	570p
TIL311	600p
TIL312/3	110p
TIL321/2	130p
TIL330	140p
7750/60	200p

DRIVERS

9368	250p
9370	300p
UDN6118	320p
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	40p
BC547B	16p
BC548C	9p
BC549C	18p
BC557B	16p
BC559C	18p
BCY70	18p
BCY71/2	22p
BD131/2	50p
BD135/6	54p
BD139	56p
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	40p
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	60p
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	25p
2N708	25p
2N918	45p
2N930	18p
2N1131/2	36p
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	55p
2N5401	50p
2N5457/8	40p
2N5459	40p
2N5460	60p
2N5485	44p
2N5875	250p
2N6027	48p
2N6052	300p
2N6059	325p
2N6107	65p
2N6247	190p
2N6254	130p
2N6290	65p
2N6292	65p
2SC1172	150p
3N128	120p
3N140	120p
3N141	110p
3N201	110p
3N204	120p
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	100p

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
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	70p
1A 400V	90p
3A 400V	100p
8A 600V	140p
12A 400V	160p
16A 100V	160p
16A 400V	180p
BT106	110p
C106D	45p
MCR101	36p
TIC44	27p
2N3525	130p
2N4444	140p
2N5060	34p
2N5064	40p

LOUDSPEAKERS

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

MEMORIES

2101-4L	400p
2102-2L	120p
2107B	500p
2111-4	300p
2112-4	300p
2114	300p
2114-2L	500p
4027-3	375p
4044	700p
4116	400p
5101	510p
6810	325p
74S201	350p
82S16	325p

ROM/PROMs

71301	700p
74S188	225p
74S387	350p
74S470	650p
74S471	650p
74S571	650p
82S137	750p

CPUs

1600	1200p
1802CE	750p
2650A	2000p
6502	750p
6800	650p
6802	1100p
6809	2500p
8080A	450p
8085A	1100p
INS8060	1000p
Z80	750p
Z80A	950p

EPROMS

1702A	500p
2708	450p
2716 (+5V)	£10
2732	£25

SUPPORT DEVICES

3242	800p
3245	450p
6522	800p
6532	900p
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6821	375p
6845	£20
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8205	320p
8212	225p
8216	225p
8224	275p
8226	400p
8228	525p
8251	475p
8253	1000p
8255	450p
8257	900p
8259	950p
Z80PIO	600p
Z80APIO	700p
Z80CTC	600p
Z80ACTC	700p
MC14411	1100p

UART

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

CHARACTER GENERATORS

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

KEYBOARD ENCODER

AY-5-2376	700p

CRYSTALS

32.768KHz	250p
100KHz	300p
200KHz	370p
1.0MHz	295p
1.008MHz	350p
1.8432MHz	350p
2.00MHz	350p
2.45760MHz	350p
3.276MHz	300p
3.579MHz	160p
4.00MHz	290p
4.194MHz	POA
4.43MHz	125p
5.0MHz	325p
6.0MHz	325p
6.144MHz	325p
7.0MHz	325p
7.168MHz	325p
8.00MHz	325p
8.867MHz	300p
10.00MHz	300p
10.7MHz	300p
12.0MHz	350p
16.00MHz	350p
18.00MHz	350p
18.432	450p
19.968MHz	450p
26.690MHz	300p
27.145MHz	300p
38.6667MHz	350p
48.0MHz	300p
55.5MHz	350p
116.0MHz	350p

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

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

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

TRANSFORMERS

(prim 220/240V)

6-0-6 100mA	95p
9-0-9 75mA	100p
12-0-12 500mA	280p
9-0-9 1Amp	330p
15-0-15 1A	330p
0-12-15, 20-24-30 1A	410p

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)	£4.25	7912	£6/10
2708 (650 ns)	£3.75	2114L (450 ns)	£28/8
2716 (plus 5V only)	£9.00	2732	£20
4116 (200 ns)	£24/8		

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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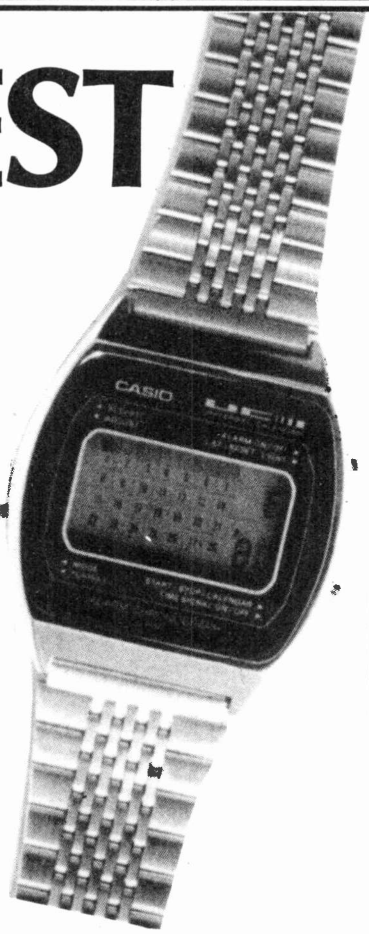
DIGEST

Watch Out

For under £44.95 you too can own a new Casio watch with continuous time readout, date display, full month, calendar information, professional grade stopwatch, plus alarm and time signal functions with a choice of tone pitch. What more can you ask for? And it's all in the 79CS51B Casio Stopwatch. A conventional LCD readout shows hour, minute, second, am/pm and date. Push a button to display year, month date and day. Press again for full calendar and cycle the display through earlier and later months if so desired. The automatic calendar is programmed from 1901 to 2099. As a stopwatch the 79CS51B has a running time of 12 hours and a measurement unit of one-tenth second. It handles normal start-stop timing, net timing, lap timing and first-second place timing. The watch will also sound an alarm at any preset time and/or signal every hour. One lithium battery will last about 15 months average use. For further information contact Casio Electronics Co Ltd, 28 Scrutton Street, London EC2A 4TY.



This Is A Recording

The Compur 385 is a new telephone answering machine from Agovox. It is a compact module which sits neatly under a conventional telephone. The facilities available include a remote control electronic decoder which enables the machine to be telephoned from anywhere in the world and instructed to play back over the telephone any messages received from previous callers. The machine is also capable of recording both sides of a conversation and can be linked to a standard recorder for retaining permanent records of calls. It is also fully compatible with existing dictating machines which utilise minicassettes and has a foot switch and head set available. Message lengths can be limited and a call counter enables easy location and logging of messages. The 385 is available for rent at between £3.72 and £6.46 depending on the type of rental contract or £750 for outright purchase. For further information contact The Sales Office, Agovox Limited, 4 Sydenham Road, London SE26 5QY.

EMP — The Answer

All our inquiries addressed to the Prime Minister, the Home Secretary and the Secretary of State for Defence on the Government's plans to cope with the Electromagnetic Pulse effect (EMP) in wartime eventually found their way to the same office somewhere in the depths of the Home Office. This is what HM Government has to say: 'Her Majesty's Government is aware of the phenomenon of EMP and its possible effects on communications systems. We take it into account in the design of civil and defence systems but cannot, of course, comment on the details of all the forms of EMP protection used.

The Home Office has given guidance to local authorities and other essential services concerned with the planning of communications systems for war, on the effects of EMP and about certain precautions that can be taken to reduce the risk of EMP damage to communications equipment.

The requirements for home defence communications are currently being reviewed and possible measures to protect them against the effects of EMP will be considered in the course of the review.'

So, it seems the Government and local authorities know all about EMP, but they aren't going to tell the likes of us.

In a statement to the Commons on August 7th, the Home Secretary (William Whitelaw) outlined developments in Britain's civil defence programme. The UK warning and monitoring organisation is to improve its communications. Improvements are also to be made to the wartime broadcasting service to ensure the continuation of public broadcasting even after a large-scale attack (but no mention of EMP).

After a lengthy pronouncement on Central/Local Government co-operation in wartime, increased expenditure on equipment and services, greater involvement in civil defence by Central Government departments and finishing up with news of the refurbishment of our stocks of emergency fire appliances (Green Godesses?), Mr. Eric Heffer's immediate reaction was, "The right hon. Gentleman must be joking".

We'll keep you posted on any further developments. Keep your letters coming. These given here are representative of those we have received so far. This article has stimulated a greater reader response than anything previously published in ETI. Most of our correspondents have understood the need for caution in our approach to publication.

The letter from Mr Keightley is particularly interesting and we are contacting Mr J. Pawsey MP to gather his views on the subject. In addition investigations are under way to find out exactly what that "guidance to local authorities" referred to in the Home Office reply consists of and of how much use it has proved to be. We hope to be able to report back next issue on the results of that investigation.

In the meanwhile keep your letters coming to us and why not follow Mr Keightley's example and write to your local MP? Maybe together we can overcome the vast governmental inertia and raise the heads above the sand just a little.

Dear Sir,

I think you should visit the inside of a NATO USA or British Radar Command Station.

We have in the UK high gain very large units operating on all bands ie:- VLF to UHF by a switching unit thus making jamming very hard because the unit sends out piano type signal and only receives back the same. All are sent out through banks of pure mechanical harmonic filters, that also process the received signal. The Front end is in liquid He and of the thermocouple type. Most of the units have a large valve content of the ECC82 size.

All cable passing through the 14g sheet steel building shield have 80 to 120 bd RFI filters even the power cable. The building is bonded every four feet against RFI.

You will find that you can get an electric shock from nylon rigging seven miles out from the radar station such is the power.

Thank you for bringing your statement to the public and that many items are covered up, it would seem that the designers took into account EMP in the design of the radar system and my part was commissioning the 3000 kW cooling system.

P.S. Do you think I have time to scrap my TI51 III which is very limited and purchase and use a TI59 before EMP!

M.G. Wadlow
Project Engineer

Dear Sir,

Congratulations on a most interesting article ("EMP"; ETI August 1980). The text was crisp and informative.

In view of the potential devastating effect of EMP, I feel that more people, both the public and industrialists should be made aware of this aspect of, perhaps, an inevitable nuclear war.

For my part, I have been largely unaware of EMP but feel that I may be able to at least inform engineers and managers in telecommunications.

Yours sincerely,
S.F. Gatley
Senior Electronics Engineer
Plessey Telecommunications

Dear Sir,

Thanks to ETI for an informative article on EMP.

I have drawn this article to the attention of Mr Jim Pawsey, the Member of Parliament for Rugby, who is also the secretary of the Civil Defence Committee in the House of Commons.

He informs me that he has tabled a question in the House on this matter after reading your feature.

As you may know, a major statement on Civil Defence by the Home Secretary has been promised before the House rises on August 8th.

Incidentally, a range of devices which offer protection from EMP are being marketed by Suhner. These incorporate a Cerberus gas discharge tube in a coaxial (50R) line.

Yours faithfully,
M.R. Keightley, B.Sc., G8BLK
Bilton, Rugby,
Warwickshire

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 116. MORE KITS AND ORDERING INFORMATION ON INSIDE FRONT COVER

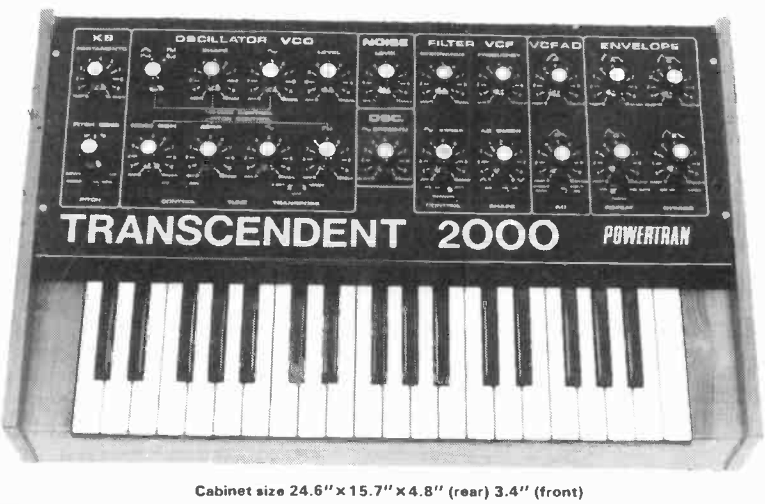
TRANSCENDENT 2000 SINGLE BOARD SYNTHESIZER

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

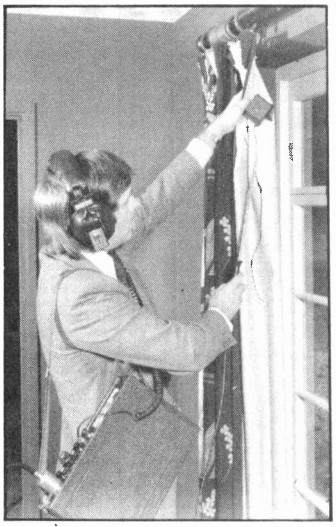
The TRANSCENDENT 2000 is a 3 octave instrument transposable 2 octaves up or down giving an effective 7 octave range. There is portamento, pitch bending, a VCO with shape and pitch modulation, a VCF with both low and high pass outputs and a separate dynamic sweep control, a noice generator and an ADSR 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.

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!



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



Something Bugging You?

With the increase in telephone tapping and boardroom bugging, Audiotel International have developed a simple to use, yet sophisticated successor to their Scanlock radio surveillance receiver. It is called the Scanlock Mark V8 and is a fast, easy means of detecting and locating an eavesdropping transmitter as well as being capable of routine 'sweep' searches of high level meetings rooms. Carried in a vehicle it can also locate any bleeper bug used for 'trailing'.

The Scanlock is not limited to the conventional radio receiver's range of 88-108 MHz. It covers the wider frequency spectrum of 10-1800 MHz and its automatic 'sweep' mode scans this range four times a minute. Finally all that is necessary is to press the 'Locate' button and use the hand-held wand to guide you to where the bug is located. The kit is the size of a small briefcase, weighing 6.3 Kg, complete with spare battery pack. There is also provision for mains usage. For further information contact Audiotel International Ltd at Saddlers Court, Yately, Surrey, GU17 7RX.

Show Time

Virtually every major electronic manufacturer I spoke to at this year's American Summer Consumer Electronics Show claims to be perfecting speech capable products, whilst only a handful are available.

The leader in voice technology manufacturing is Texas Instruments. Two years ago the firm unveiled the industry's first speech capable product, Speak 'n' Spell, and the consumer electronics world hasn't stopped talking about it since. This year, TI introduced two other talking 'electronic learning aids' and is also predicting a bright future for its talking translator. The $300 unit offers approximately 500 spoken and displayed words.

If you don't know what type of video tape system you should be using, brace yourself because more befuddlement is brewing. Early next year in the States two manufacturers, perhaps even three, mutually incompatible video disc players will be each shouting the virtues of their products whilst cleverly knocking the others.

Pictures that I have seen from the newest Pioneer, Magnavox, JVC and RCA players are all amazingly detailed and noisefree. The Magnavox and Pioneer machines play compatible twelve inch discs by bouncing a focused laser beam from a spiral track of microscopic pits etched onto the disc's reflective surface. A clear plastic coating makes the disc immune to dust and smudges from handling.

RCA's Selecta Vision video disc player has been completely overhauled since it was introduced and field tested several years ago. The basic playback principle is unchanged; a stylus electrode replaced every two or three years, senses a TV signal as electrical capacitance variations in disc grooves spinning at 450 rpm. Playing time was boosted to one hour per twelve inch disc side by doubling disc grooves to just under ten thousand per inch. Home tests show that dust and other groove contamination from handling messed up pictures. So RCA's improved Selecta Vision has a sealed disc caddy.

JVC have illustrated a system that combines the low cost aspects of selectavision with the operating options of free flowing slow motion etc. of optical machines. Not only that JVC included options for a super hi-fi audio disc. It calls the whole package its VHD/AHD System (Video/Audio High Density).

Signals are stored as capacitance variations from minute pits in the conductive plastic. The stylus rests over central spiral tracks distributing pressure and minimising wear. (Stylus life is 2,000 hours, roughly 10 times RCA's).

Sony's newest addition to its Beta family of accessories is the Beta stack model AG300. The unit automatically ejects and loads up to 4 Beta Max video cassettes with record, playback and re-wind capabilities; this accessory can be used with the current Beta Max models SL5400 and SL5600 or with the programmable SL5600. When used with the regular Beta Max models it offers a maximum of 20 hours recording time. With a programmable unit the change allows a user to record separate programmes on separate cassettes: up to 4 events on different channels and different days within a two week period.

A new company, Activision, has released four new cartridges to work with the Atari video computer system; they are dragster, chequers, boxing and fishing derby. The general opinion is that these cartridges have a far higher resolution and superior game content than any of the Atari manufactured units; is this why Atari is suing them for $20 million? Anyway these cartridges will certainly be available in the UK via at least one well-known mail order house.

Good news for all you home computer owners. At last you can connect with the real world. Yes, the BSR System X10 is going to be available in January 1981. In case you are unfamiliar with the system here is a brief run-down. Just plug in the command console and various modules into the household supply outlets and you're ready to take control. No special wiring is needed. From one convenient location you can control a bedroom light, hall light, television, radio, stereo, porch light, back door light as well as lights in the dining room. The command console comes in two versions, either with or without a cordless controller. The lamp module receives signals from a command console to turn on, off, dim or brighten any incandescent lamp up to 300 W. The wall switch receives signals from the command console to turn on or off or brighten any light or lamp normally operated by a wall switch up to 500 W and the appliance module receives signals from the command console to turn an appliance on or off.

Gerald Chevin

Fly The Flag

The familiar terminals in British Airways reservations offices are getting a bit long in the tooth. They're ten years old. A British company, Videcom, has won the £500,000 contract for terminal replacement, against competition from three other contenders — one British and two American. Videcom supplied a substantial number of the existing BA terminals.

The 280 new keyboard VDUs are to be installed at 69 sites throughout 15 European countries. Installation started in July in Berlin and should be completed by the end of 1981.

The type 101 VDUs to be supplied were designed specifically for airline operations. They use Hall-effect, contactless, solid state keys for maximum reliability and life expectancy. The VDU is part of an integrated terminal system including cluster control units and terminal drive units, which can support up to 128 terminals.

Eagle Sounds

Eagle International have just introduced their new consumer catalogue for 1980/81. Although it's only 20 pages long it covers a lot of ground — hi-fi separates and rack systems, portable radios, in-car entertainment systems, etc.

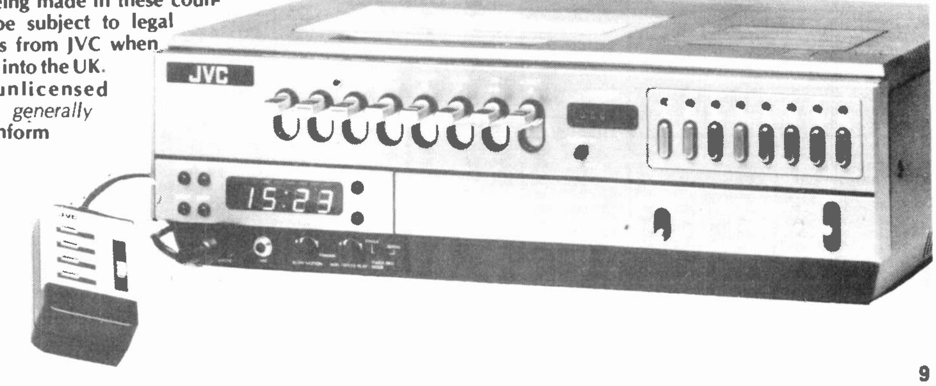
You can get hold of a free copy of this full colour guide to Eagle's wares by writing to Eagle International, Precision Centre, Heather Park Drive, Wembley HA0 1SU.

Video Pirates

Victor Company of Japan (JVC), who developed the popular VHS system, are concerned with the increasing number of unlicensed "pirate" VHS blank cassettes that are being imported into the UK. In response, they have issued the following statement to their dealers.

1. JVC hold an exclusive patent of the design, construction and appearance of VHS cassettes in the UK.
2. JVC will protect their rights.
3. JVC is concerned about the importation of unlicensed VHS cassettes into the UK because of their inferior quality as well as their illegality.
4. These illegal cassettes originate from Taiwan, Singapore and Hong Kong — there are no VHS cassette making licensees in these countries, thus VHS cassettes which are identified as being made in these countries will be subject to legal proceedings from JVC when imported into the UK.
5. These unlicensed products *generally* do not conform to VHS standard dimension, construction, mechanical operation and electrical performance. This *may* affect the overall performance and operation of VHS recorders for which JVC are otherwise responsible.

So, you've been warned. Beware of cheap tapes and what they might do to your machine.



Audiophile Amplifier

We've collected together all the corrections to the Audiophile Amplifier project in one place for easy reference.

If you've experienced any trouble with RF oscillation causing overheating in the power amplifiers, connect a 1000pF capacitor across the base-collector leads of Q12 and a second 1000pF capacitor across the base-collector leads of Q13 (power amplifier circuit diagram, p.56). As a safety measure, R10 can be increased to 47R to reduce drive current and prevent overheating without loss of performance.

R15, 115 (p.62, Fig.4) mount directly on SW6. In the Parts List on the same page, C10 should be 12nF polyester (or carbonate). The toggle switch shown on the rear of the power amplifier case (p.63) is a selector switch for the two pairs of speaker output sockets we used. It is a dual, three position, centre-off switch. P.64, Fig.6 — R1 (2k2) in series with LED 1 should be R3 (2k2). The unmarked lead in Fig.8, p.65 (third one down) goes to T1. There are three connections only to the 0 V tag — C3/C4 junction, C103/C104 junction, LED 1 cathode. All other 0 V connections are made to the 0 V junctions of the smoothing capacitors. In Fig.9 on the same page, the foil pattern of the component overlay has been printed upside down.

In the Parts List on p.65, the power amplifier supply transformer should be 25-0-25 V and the transformer for the preamp supply should be 15-0-15 V.

Shocking Truth

Static is a nuisance all of us experience at sometime or other. Often it only appears to be an irritating and uncomfortable surprise; not often enough is it realised that static can damage expensive equipment and lead to fire and other hazards in a working environment. 3M has produced a 14-page booklet outlining these hazards and it is available from Keith Nunn, Static Control Systems Group, 3M United Kingdom, PO Box 1, Bracknell, Berkshire, RG12 1JU.

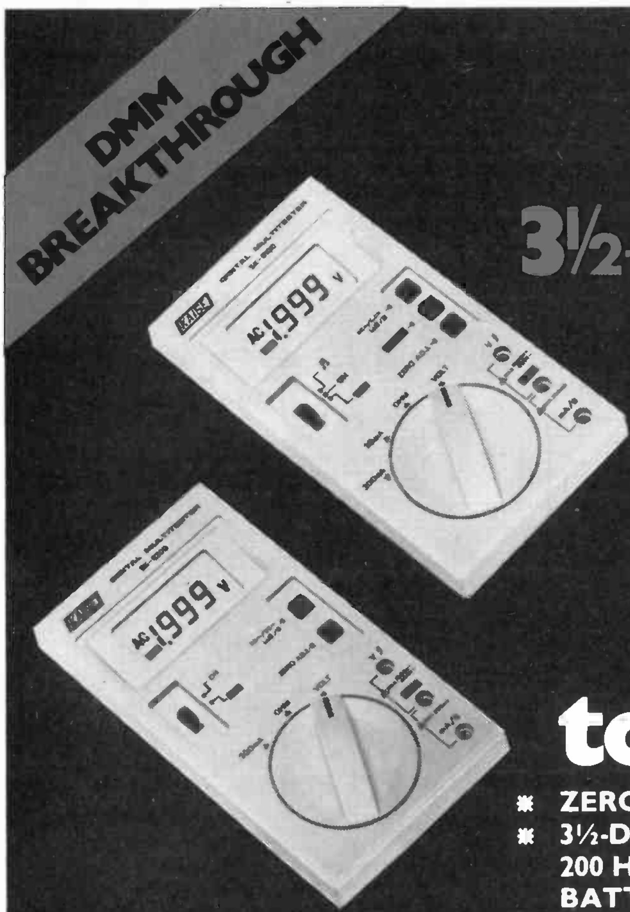
Kit Update

We're still receiving news of kits, in response to our kit survey, featured in the May issue. Partridge Electronics have introduced a 'Community Mixer Kit', which, they claim, is unique, in that it is the first complete mixer designed specifically for applications like hospital broadcasting. The design and straightforward construction take into account the limited budget available to buy equipment for voluntary broadcasting organisations.

The mixer has been designed in modular form, so that you can buy a basic mixer kit for £250 + VAT (8 input) or £300 + VAT (12 input) plus your choice of meter kit (VU, PRVU or PPM) plus your choice of preamp kit (microphone, disc, tape, cassette, etc). Each preamp kit comes in one of two forms (with or without equalisation). If you have some money to spare, you can also buy a number of extras, such as an autofade unit or a telephone interface studio terminal unit.

For further details contact Partridge Electronics, 56 Fleet Road, Benfleet, Essex SS7 5JN.

Hart Electronics can supply a range of cassette recorder and amplifier kits. Two high quality Linsey Hood cassette recorder kits are available at £81.50 + VAT and £94.90 + VAT respectively. The VFL 910 vertical front-loading deck hardware used in the top range model is available separately at £31.99 + VAT. Two 30 W amplifier kits complete the picture. For further information contact Hart Electronic Kits, Penylan Mill, Oswestry Shropshire.



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	6100	6110	6200	6220
RESOLUTION	1mV, 10μA, 0.1Ω on all models			
FULL AUTO RANGING	✓	✓	✓	✓
RANGE HOLD	✓	✓		
UNITS OF MEASUREMENT DISPLAYED	mV, V, mA	mV, V, mA, A	mV, V, mA	mV, V, mA, A
FUNCTIONS DISPLAYED	Ω, KΩ, AUTO, BATT, ADJ, LO, – and AC			
MEASURES DC VOLTAGE TO:	1000V	1000V	1000V	1000V
MEASURES AC VOLTAGE TO:	750V	750V	750V	750V
MEASURES AC/DC CURRENT TO:	200mA	10A	200mA	10A
ZERO ADJUSTMENT	Zeros out minute test-lead resistances for precise measurements			
ACCURACY	0.5%	0.5%	0.8%	0.8%
LOW POWER OHM RANGES	For in-circuit resistance measurements on all models			
BUZZER – Continuity Test	✓	✓		
BUZZER – Over Range Indicator	✓	✓		
COMPLETE WITH	Batteries, pair of Test Leads, Spare Fuse, One Year's Guarantee			
PRICE	ONLY £64.95	ONLY £74.95	ONLY £39.95	ONLY £49.95
p&p	£1.15	£1.15	£1.15	£1.15

Why such a low, low price? Because the A/D converter and display are custom built! This is a genuine top-spec DMM. Check these features for *unbeatable* value – you won't find a hand-held DMM with these features at these prices again!

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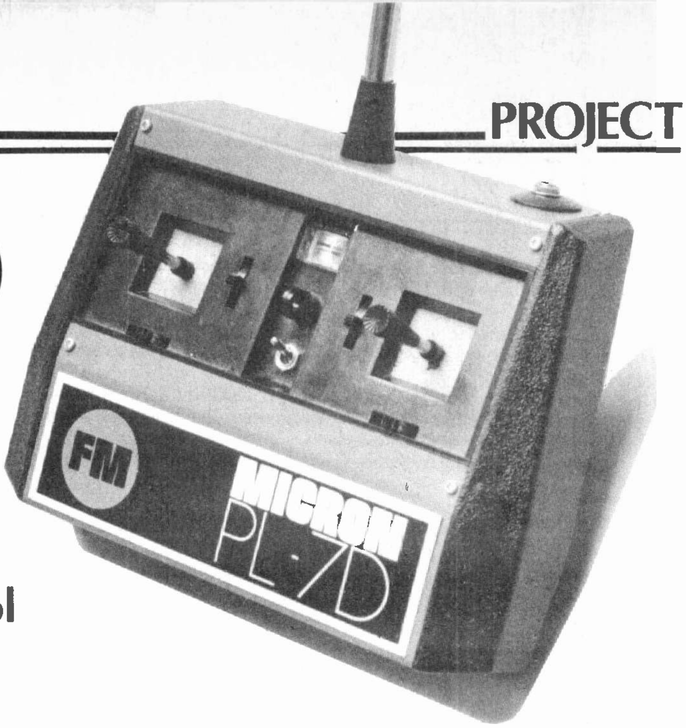
FM RADIO CONTROL



William Poel of Ambit International describes a complete FM radio control link using only two ICs.

Components for radio control systems have been developed very intensively during the past year or so. The evidence is found in in the plethora of radio controlled toys available from virtually any toyshop. Many of these systems employ control techniques that are, to say the least, crude. Most seem to rely on control that is virtually 'bistable' ie, all on or all off.

Digital Proportional Control

Despite the name, the 'digiprop' system isn't entirely digital in nature. The control medium is more correctly 'pulse width modulation' since the main information medium is the varying width of individual pulses in a data 'frame'. A remote receiver decodes the frame back into individual pulses and individual servos then compares this decoded pulse against a locally generated standard (1.5 mS nominally) and the error drives the output control medium. Feedback is provided from the control medium in the shape of a potentiometer that adjusts the locally generated reference pulse and varies it until the local pulse and the decoded pulse are exactly coincident (Fig.1). So some parts are digital, but the most inportant part, the pulse width, is not.

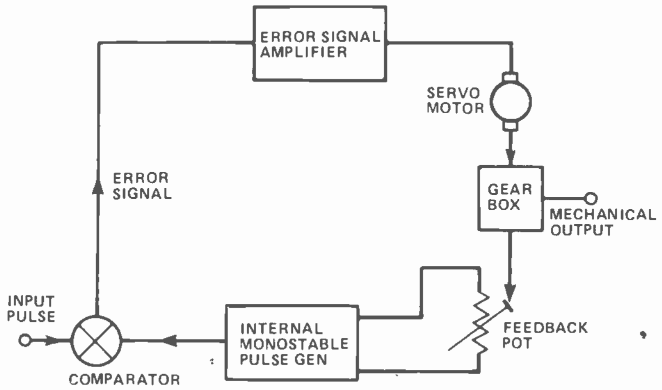


Fig.1 Block diagram of the 'digiprop' control system.

Until Now

This form of pulse width modulation can be transmitted on a variety of carrier systems. Amplitude modulation (AM) had been almost universal until about two years ago, when low power, low voltage ICs for FM were adapted from communication equipment for the purposes of FM RC. The advantages of FM were quickly appreciated and most serious enthusiast systems use this exclusively.

The major feature of FM is improved immunity to interference form the mainly AM forms of interference around 27 MHz. CB is either AM or SSB and the limiting action of the FM system removes a lot of trouble before it can distort the decoded waveform. FM also means that AGC systems are no longer necessary (except in extreme circumstances). The output waveform of the transmitter can be significantly cleaner (in terms of RF pollution), since the carrier in AM systems is virtually being switched 'on and off' by the data frame (Fig. 2).

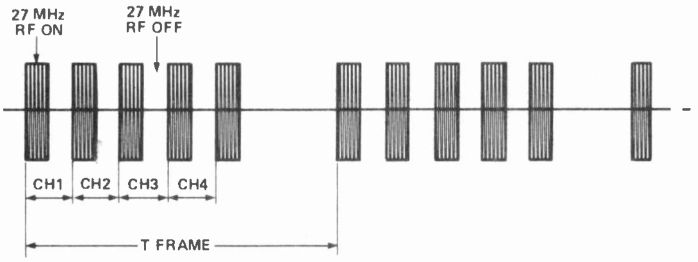


Fig.2 Waveforms associated with AM systems.

Good Ideas

It seems only to be a matter of time before good ideas with market potential get integrated into as few ICs as possible. It's happened with AM radio control (LM1872) and now it's happened to FM digital proportional radio control with a pair of ICs from TOKO that offer a nearly instantaneous solution to providing a fully proportional FM radio control link (Fig. 3).

The KB4445 is a four channel encoder/transmitter (Fig. 4). It would have been a five channel encoder, but for the need to use one of the pins of the package for a decoupling capacitor instead. All the necessary frame timing and control is achieved in this single IC, which also incorporates a crystal oscillator, FM modulator and RF driver.

The output stage of the transmitter is placed outside the KB4445, since requirements in this area will vary quite enormously from the 100 mW for ground based toys to a watt or so for serious airborne applications.

The KB4446 (Fig. 5). provides all receiver functions for a five channel digiprop system, together with an interference rejection comparator and decoder, so that the outputs can be fed directly to the servo decoders.

The KB4445 is an I²L bipolar IC, comprising a 4 channel multiplexer encoder, RF oscillator with FM modulator (switch type) with a 30 mW RF output.

It is also provided with an undervoltage warning system using a flashing LED when the supply voltage drops below 4V4 from a nominal supply of 6 V.

The encoder section consists of a string of cascaded RC monostable time constants, determining the pulse width according to the position of the external control potentiometers.

Channel and frame times are similarly externally programmable.

Specification

Item	Min	Typ	Max	Comments
Power supply (V DC)	4	6	12	LED flashes at 4V4
Consumption (mA)		20		Oscillator stopped
Output power (mW)		30		
Dissipation (mW)			450	4.5 mW/°C
Operation temp (°C)	−10		+60	
Storage temp (°C)	−55		+125	
Encoder pulse width (uS)		200		
Channel pulse width (mS)		1.5		
Frame pulse width (mS)		20		
Frequency deviation (kHz)	2	4		Fo + Fdev when modulated
Crystal frequency (MHz)	8	27	50	Crystal f = f out/2

The KB4445 adopts one of the most universal encoder formats and is thus widely compatible with existing FM systems. The 'on-board' RF section is intended to be used as a driver for an external output stage and where sufficient supply voltage is available, a single power MOSFET may be used to achieve power levels in excess of 2 W.

The external circuit shown on the applications diagram delivers approx 400 mW RF to the antenna, which is sufficient for reliable control over 200 m with the KB4446 at the receiver.

Pin 12 of the KB4445 is the switching point of the modulator and it should be noted that the modulation action is achieved by switching an external capacitor in series with the crystal. Thus the level of deviation (more accurately termed modulation 'on' offset) may be controlled by a trimmable value at this point in the circuit. The capacitors across pins 10 and 11 form the feedback of a Colpitts oscillator and thus also affect the order specification of the transmit crystal in conjunction with the capacitor selected at pin 12.

Adjustment of the capacitor at pin 12 is an essentially iterative adjustment, altering the output frequency at the same time as the deviation level, so care must be taken when setting up inital values in this part of the circuit.

Pin 13 of the KB4445 offers access to the modulator switch filter and may thus be tailored to provide optimum bandwidth by selection of an external value.

KB4446 Receiver IC

Specification

Item	Min	Typ	Max	Remarks
Supply voltage (V DC)	2.1	3.0	4.0	LED flashes at 2V2
Supply current (mA)	15	20	25	at 3V
Receiver sensitivity (dBu)		26		20db S/N
Limiting sensitivity (dBu)		40		
Detector output (8) (mV)		300		60dBu input
S/N at 60 dBu in (dB)		40		
LED drive current (mA)		5		At Vcc. 2V2
Std pulse width (uS)		200		
Channel (mS)		1.5		
Frame (mS)		20		
Output source current (uA)		100		Decoder outputs
Output sink current (mA)		2.0		Int. 20k

The KB4446 receiver IC uses a third overtone (30pF parallel load) crystal in the local oscillator circuit, selected to be either 455 kHz high or low of the incoming transmitter frequency. Oscillator low is usually preferred.

The mixer output will match either L/C IF filtering or ceramic filter systems in much the same way as the MC3357P. A tuned IFT is however recommended at this point in the circuit, since most ceramic filters will offer little or no attenuation to the local oscillator present at this pin.

The detector uses a standard form of quadrature at pin 2 of the IC — a Q of approx 80 will give results in the above table, although other values may be used if provision is left to include a damping resistor. The choice of the coil will determine the output for a given deviation — in this case 2 kHz is used as the reference (ie 4 kHz total displacement.)

The detector output is fed to a comparator at the decoder input, which provides immunity to noise effects present on the detected signal. The values selected for the inputs at pins 21 and 22 will reject most HF noise and are based on the frame and pulse timing stated here. Other values may be used with non-standard forms of timing sequence.

A good quality capacitor should be used at pin 20 since this is the reset timimg capacitor, setting the frame at approximately 20 mS total with the values shown.

Fig.3 (right) Block diagram of the FM Radio Control link.

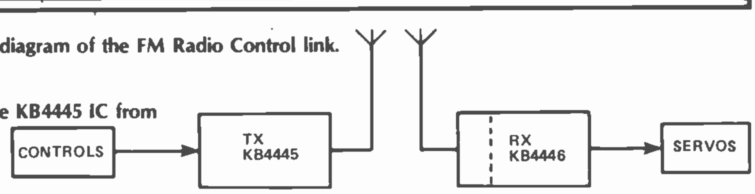
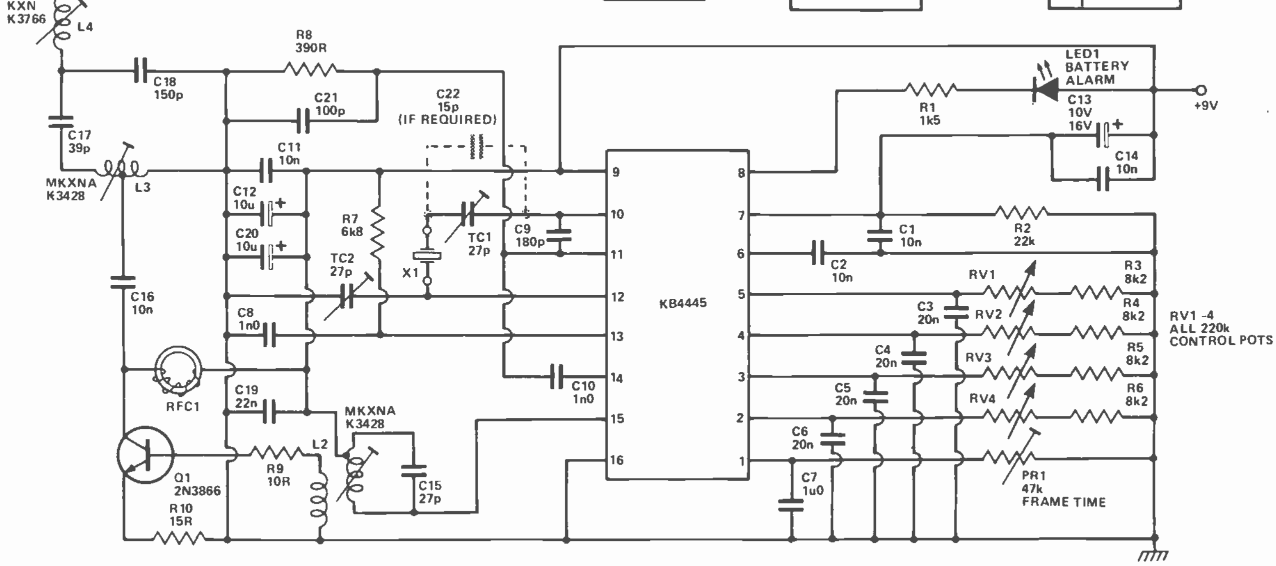


Fig.4 Circuit diagram of the transmitter, based on the KB4445 IC from TOKO.



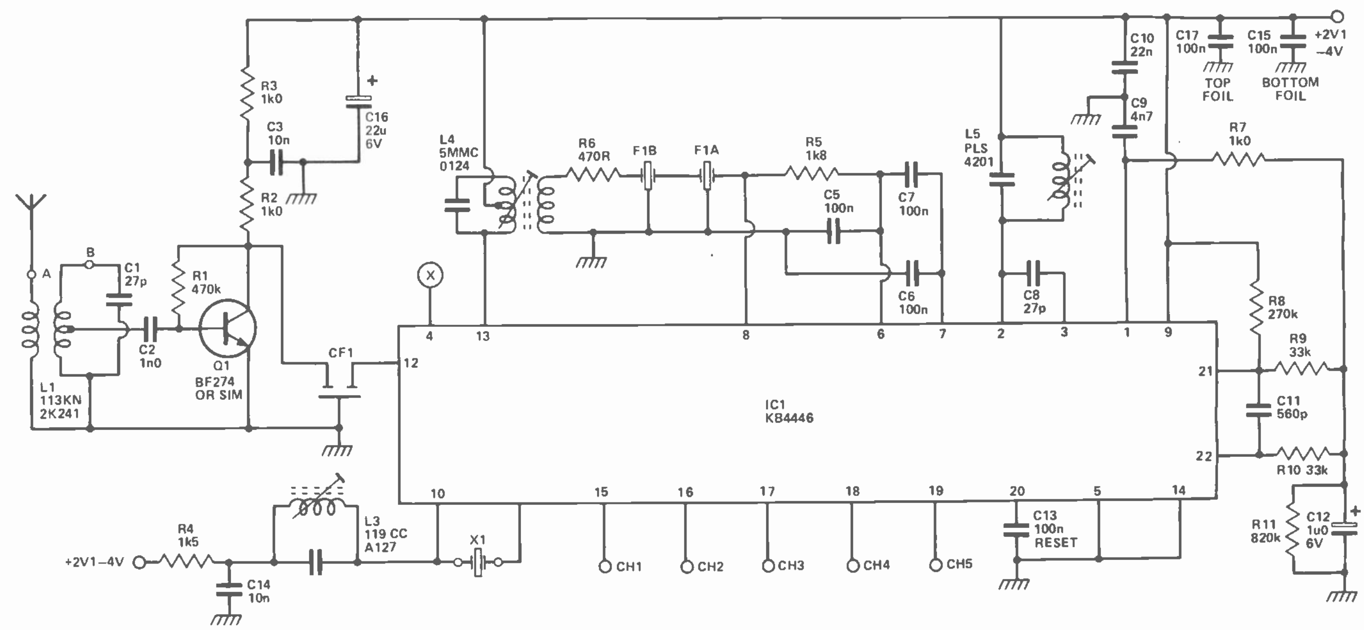


Fig.5 Circuit diagram of the receiver, built round the KB4446 IC, also from TOKO.

Supply And Demand

The KB4446 is designed to work on the exceptionally low voltage supplies (from 2V1 to 4 V) to be precise. This is because the standard servo supply rail of 4V8 is subject to a lot of fluctuation and noise from the effects of the DC motors continually stopping and starting. Despite NiCad batteries being a very low impedance power source, there is nearly always some effect on the supply voltage when the start and stall current of average servos are being drawn, but the difference between 4V8 and the nominal 3V0 of the KB4446 is quite enough to permit stabilisation via a pass transistor.

Both ICs contain an under voltage LED indicator to let you know when the power is approaching a dangerously low level. The indicator need not necessarily be a LED, as the output is available to drive a variety of alternative warning devices. A high efficiency peizo-ceramic resonator may be a more satisfactory system for outdoors applications where the light of a LED is easily flooded by sunlight. A suitable circuit is shown in Fig. 6.

Construction

The PCB and layout (Fig. 7) of the receiver reveals very little, apart from the fact that you will need a steady hand and a fine point on your soldering iron. The receiver was designed to fit into a standard plastic case with the facility to easily swap crystals and servo connections, so some aspects of the layout are not perhaps as ideal as the RF purist would have chosen. Nevertheless, it works.

The transmitter PCB is a straightforward device, since it is not necesssary to apply the same size constraints. The board is designed to slot into a standard case made by Micron radio control.

Testing And Setting Up

The first thing to do is to ascertain that the transmitter is working. Those with access to an oscilloscope can check the data frame shape and size. Reference back to the internal layout of the KB4445 (Fig.4) shows that the modulating waveform is available at pin 12 of the IC.

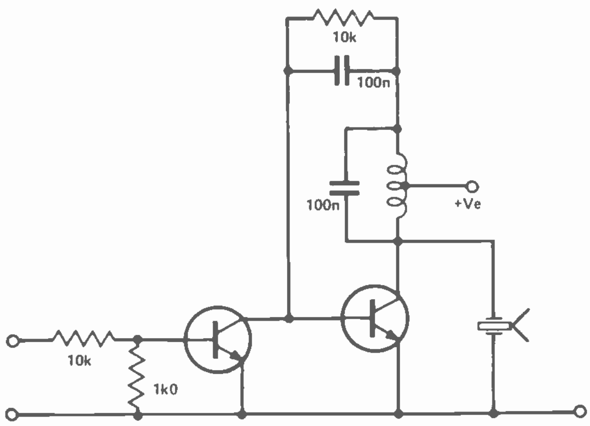


Fig.6 This piezo-electric resonator can be used as a low power alarm instead of a LED.

Carry out such tests with the crystal removed, since the close proximity of a strong RF field will tend to distort the readings of better (wide bandwidth) oscilloscopes. The frame signal should be set to 20 mS using the preset on pin 1 of the KB4445. If you do not have the necessary equipment to check this, set the 50k preset approximately halfway. The control sticks should similarly be set halfway.

The crystal may now be plugged in and attempts be made to set up the RF output. The best way to to do this is with a spectrum analyser (and who hasn't got one these days ??). The next best thing is an absorption wavemeter, which is easily made by using a standard frequency coil and a small meter (Fig. 9).

This is standard procedure in many RC transmitters, although you must be careful where to dangle the pickup section, since it is possible to get misleading results due to localized RF fields that have very little in common with what's actually being transmitted by the antenna. By placing the pickup close by the output of the KB4445 at pin 15, it should be possible to get a reading without too much trouble. If not, the best thing to do is find someone with a known working 27 MHz transmitter and adjust your wavemeter for peak reading with this.

PARTS LIST

TRANSMITTER	
Resistors ¼W, 5%	
R1	1k5
R2	22k
R3,4,5,6	8k2
R7	6k8
R8	390R
R9	10R
R10	15R
Potentiometers	
RV1-4	220k linear
PR1	47k preset
Capacitors	
C1,2,11,14,16	10n ceramic
C3-6	20n ceramic
C7	1u0 35V tantalum
C8,10	1n0 ceramic
C9	180p ceramic
C12,13,20	10u 16V electrolytic
C15	27p ceramic
C17	39p ceramic
C18	150p ceramic
C19	22n ceramic
C21	100p ceramic
TC1,2	27p trimmer
Inductors	
RFC1	10 turns 32/36 SWG enamelled copper wire on ferrite
L1	1uH
L2,3	MKXNA K3428
L4	KXN K3766
Semiconductors	
IC1	KB4445
Q1	2N3866 or 2N4427
LED1	any LED
Miscellaneous	
X1	13.5740 MHz
PCB, Q1 heatsink, joystick pots (x2), telescopic antenna, case to suit	
RECEIVER	
Resistors ¼W, 5%	
R1	470k
R2,3,7	1k0
R4	1k5
R5	1k8
R6	470R
R8	270k
R9,10	33k
R11	820k
Capacitors	
C1	27p ceramic
C2	1n0 ceramic
C3,4,14	10n ceramic
C5,6,7,13,15	100n miniature ceramic
C8	27p ceramic
C9	4n7 ceramic
C10	22n polyester
C11	560p ceramic
C12	1u0 6V tantalum
C16	22u 6V tantalum
Inductors	
L1	113KN 2K241
L3	199CC A127
L4	5MMC 0124
L5	PCS 4201
Semiconductors	
IC1	KB4446
Q1	BF274 or similar
Miscellaneous	
CF1	SFE27MA
F1A	CFM2 455D
F1B	NTK LFC6
X1	26.640 MHz 3rd order T type
7 way servo connector block, PCB, case to suit.	
WAVE METER	
Potentiometers	
PR1	47k preset
Capacitors	
C1	22p (if required)
C2	10n
C3	27p trimmer
Semiconductors	
D1	any Germanium diode
Miscellaneous	
M1	100-500 uA
L1	MKXNA K3428

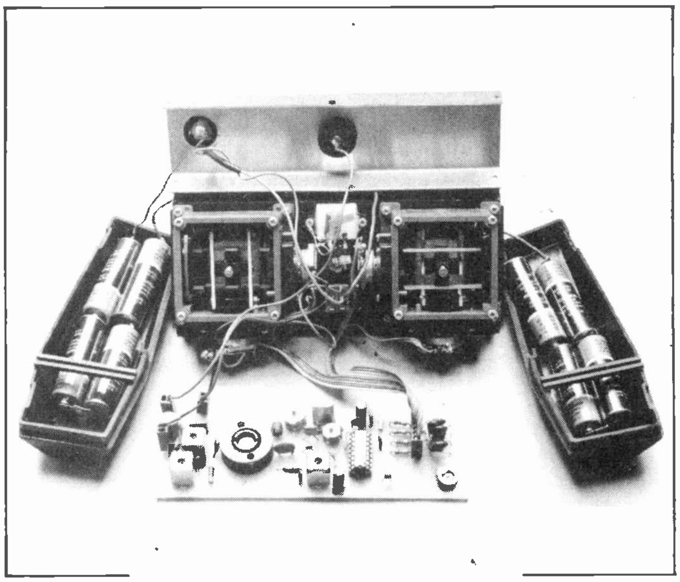
The antenna is a vital part of the output tuned circuit. It is an electrically 'short' transmission antenna, which creates a number of problems for the RF designer, the major one being that it is an integral consideration of the output tuning and so any adjustments really need to be made with the antenna in its finally intended form.'

As soon as the first coil peaks, the current drawn by the transmitter should go up fairly dramatically as the output stage begins to warm up. Keep dabbing a finger on the PA stage to check that it does not get too hot. Using the absorption wavemeter placed by the antenna about halfway up and as far away as possible whilst still getting a reading (about 1m should be feasible), peak the coils in the transmitter.

The Receiver

If you have access to a working FM transmitter, use it for setting up the receiver (remember to use the correct crystal pair).

An audio amplifier with high input impedance can be used to monitor the detector of the KB4446 on pin 1, so you can



BUYLINES

Ambit International can supply a kit of parts for the transmitter unit for £6.80 + VAT. The case hardware and crystal are extra. A complete kit of parts for the receiver is also available for £8.00 + VAT. The crystal is extra.

Ambit International, 200 North Service Road, Brentwood, Essex.

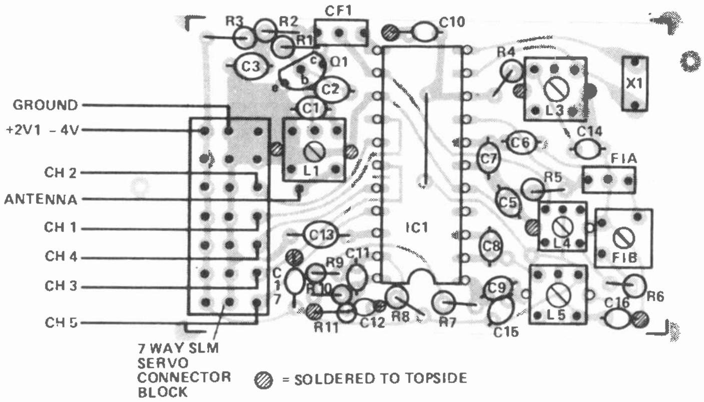
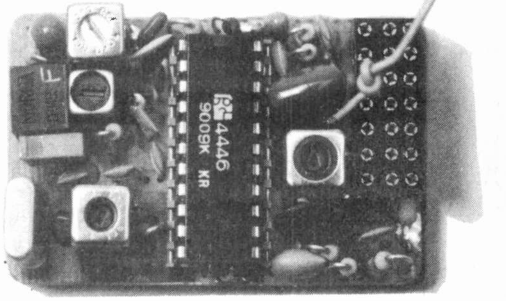


Fig.7 Component overlay of the receiver board (double sided).



(Right) The receiver circuit board (double sided). It's a bit of a squeeze, but it does all fit in.

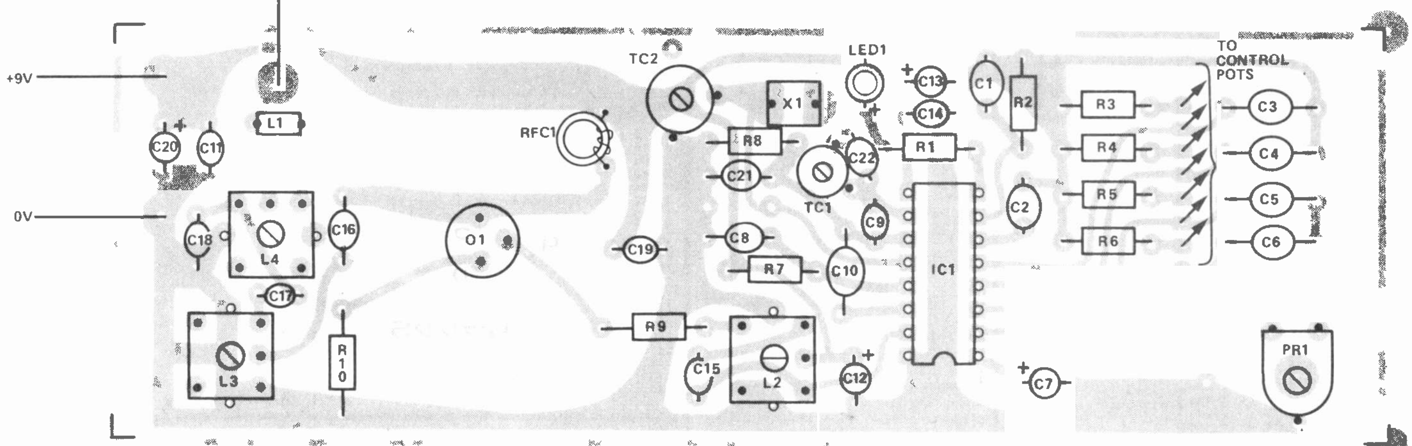


Fig.8 Component overlay of the transmitter board.

hear what is going on whilst tuning up. An oscilloscope at this point will display the detected control 'frame' It should be the same as that appearing at pin 12 of the KB4445 transmitter IC.

By starting with the transmitter and receiver in close proximity, you should have no trouble in getting a signal with which to commence the alignment process. By progressively reducing this input signal and peaking the coils, you will reach an optimum that corresponds to about 2 uV input for a correctly assembled unit. The setting of the crystal oscillator coil (at pin 10 of the KB4446) is critical and may need retrimming as the alignment proceeds to make certain the receiver and transmitter are correctly aligned co-channel. One of the few drawbacks of the FM system is the need for a more carefully matched Rx/Tx frequency than with AM. Stick to one particular make of crystals so that the loading requirements are the same.

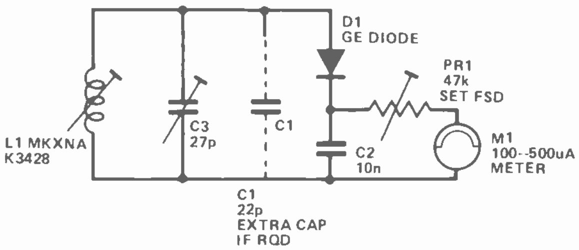


Fig.9 This absorption wavemeter can be used to set up the RF output.

Connect a servo to one of the output pins. It should work in response to adjusting the transmitter control. At least one commercial servo is a must, as this can then be used as a reference for the 1.5 mS channel pulse, ie with the controls at centre, the trimming should be adjusted so that the servo is at mid travel. If this is not possible, then a further preset may be needed in series with the control stick pots to bring them in range. If nothing at all happens with the servo connected, then it may be necessary to fit an external pull-up resistor on the output of the KB4446 (10k) to the supply rail of the servo amplifier IC.

Repeat the check on each channel and carry the transmitter down the garden whilst someone monitors the receiver and servos to ensure that adequate range can be achieved.

Finally

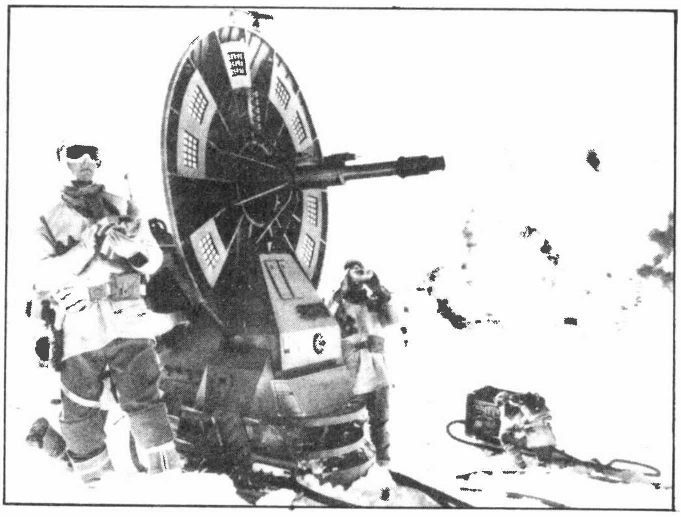
Under no circumstances should any home-made RC equipment be fixed into a model aircraft and flown. Apart from rules preventing flying in parks, the dangers of propelling a few pounds of balsa and metal about at 40-60 MPH demand that a much more cautious approach be adopted. The home made RC can be checked and verified in cars, boats and similar ground-based systems first, or you can have it professionally 'certified'. A licence is required and some experience and training in flying is essential.

ETI

NEXT MONTH

electronics today INTERNATIONAL

Look out for the November issue — on sale October 3rd.



SPACE INVADERS

In the past few months we've seen all manner of Space Invaders games — from enormous pub machines to programs on tape cassette for home computers. We've spent many a long hour researching the game in pubs and clubs from Land's End (Watford) to John O' Groats. Next month we present the ETI Space Invaders game for you to build. ☐ Plug the lead into the back of your telly and sit back with the box of tricks on your lap. Off you go — blasting aliens out of existence (with full sound effects, of course). ☐ World War III's OK, but there's nothing like the real thing — ETI Space Invaders — a computer game with a trick or two up its sleeve, as you'll find out next month.

Photos courtesy of Twentieth Century Fox.

FREE PCB

As we finish printing each issue of ETI with our John Bull set, we're sticking a free, gratis, no-more-to-pay printed circuit board on the cover. It has a million and one uses — you can prop up a wobbly coffee table, make a shower for the budgie . . . OR build the five projects we've designed for your free PCB. There's an RIAA equalised preamp, a 2 W amplifier, a touch doorbell, a light switch and a metronome. ☐ We give you the PCB; we give you the project designs . . . it couldn't be easier.

RADIOACTIVITY

Know your alpha, beta, gammas? If it's all just radiation to you, you could learn a thing or two from A.S. Lipson's excursion into that fantastic, frazzling, phenomenon of modern physics — Radioactivity. What makes something radioactive? What exactly is radioactivity? All will be revealed next month.

EVEN MORE PROJECTS

Not satisfied with bringing you our amazing Space Invaders game and FIVE projects for your free board, we've also got a doorbell with a difference (it plays tunes) and a straightforward, no frills Bench Amplifier for your test bench. It's all in ETI November.

AND THAT'S NOT ALL

Data Sheet puts in an appearance with all you need to know about a family of monolithic switched capacitor filter chips and a speech generator chip (a very clever little block of plastic). ☐ Talking of blocks of plastic, voltage regulators this time — we look at a very simple discrete component regulator design (for when you don't have the necessary chip to hand then and there). ☐ We know now that the Space Shuttle launch has definitely been postponed until at least next March. Astrologue explains why.

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

SPOT DESIGNS

Six pages of Spot Designs — a bumper bundle of tried and tested circuits with the ETI stamp of approval.

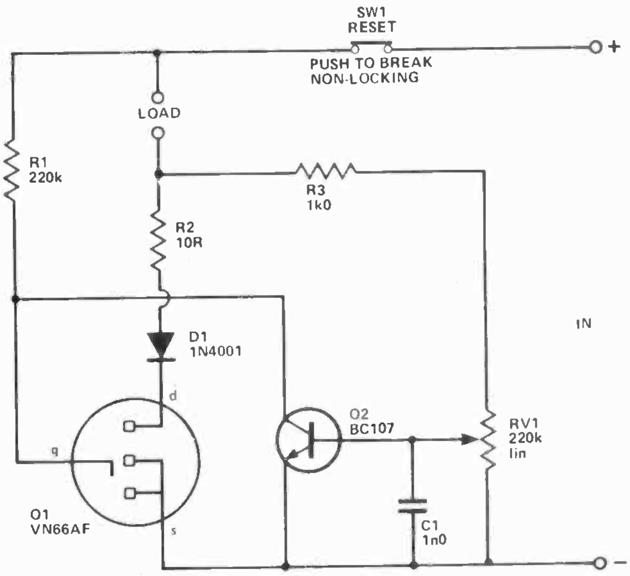
Overload Current Trip

Most power supplies incorporate some form of protection circuitry so that an excessive output current cannot flow in the event of an overload. However, these protection circuits are often designed merely to prevent the supply circuitry from sustaining damage, and in the event of an overload permit a level of current flow that is sufficient to damage the circuit being powered. This overload current trip can be used between the powered equipment and the power supply and will cut off the supply almost instantly if a preset threshold current is exceeded. The trip current can be varied from just a few to a few hundred milliamps. The unit will work with supply voltages of 5-40 V.

When power is first applied to the circuit, power FET Q1 will be biased hard into conduction by bias resistor R1. Power is, therefore, supplied to the load via Q1, D1 and R2. There will be a voltage drop across these components, and to some extent this varies with changes in the supply current. At low output currents there is likely to be a voltage drop of something in the region of 0V7, but this increases to a volt or so at high currents.

RV1 is adjusted so that at output currents below the required threshold level the proportion of the voltage dropped across Q1, D1 and R2 (and fed to Q2's base terminal) is not sufficient to switch on Q2. If the threshold current is exceeded, the voltage fed to Q2's base is then adequate to switch the device on and it diverts the bias current that formerly went to Q1's gate terminal. Q1 then switches off and cuts the supply to the load. Q2 remains switched on as it receives a strong base bias from the positive supply through the load, current limiting resistor R3 and RV1. Once tripped, the circuit thus latches in the "off" state. It can be returned to the "on" state by clearing the overload and then briefly operating SW1 so that the supply is momentarily disconnected from the unit. When the supply is restored it then starts at the "on" state once again. C1 ensures that the circuit does always initially assume the correct state and it also helps to prevent spurious triggering of the unit.

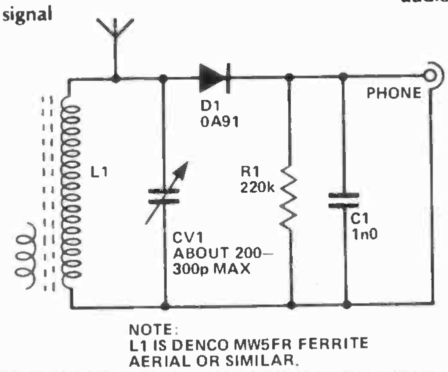
When using the unit it should be kept in mind that about 1 V is lost through the device and the output voltage from the supply must be adjusted to compensate for this. The current trip inevitably causes some loss of regulation efficiency, but this is only marginal. If the unit is to have a trip current of about 100 mA or more, R2 can be reduced to about 1R8 in order to maintain the low voltage drop and marginal degradation of regulation efficiency.



Crystal Set

The most simple form of radio for receiving broadcast stations is the crystal set, or more precisely, a modern equivalent using a semiconductor diode to provide detection. This simple set covers the normal medium wave broadcast band, has an output for a crystal earpiece and, in most areas, should give reception of Radios 1, 2 and 3 at reasonable volume (plus any local radio stations where these are in operation on the medium waveband). It requires no battery or other form of power source since energy derived from the received transmission is used to drive the earpiece. However, this does bring the disadvantage of needing an external longwire aerial to operate the set, as an ordinary ferrite aerial does not give sufficient pick up.

(a) received signal (b) action of D1 (c) recovered audio signal

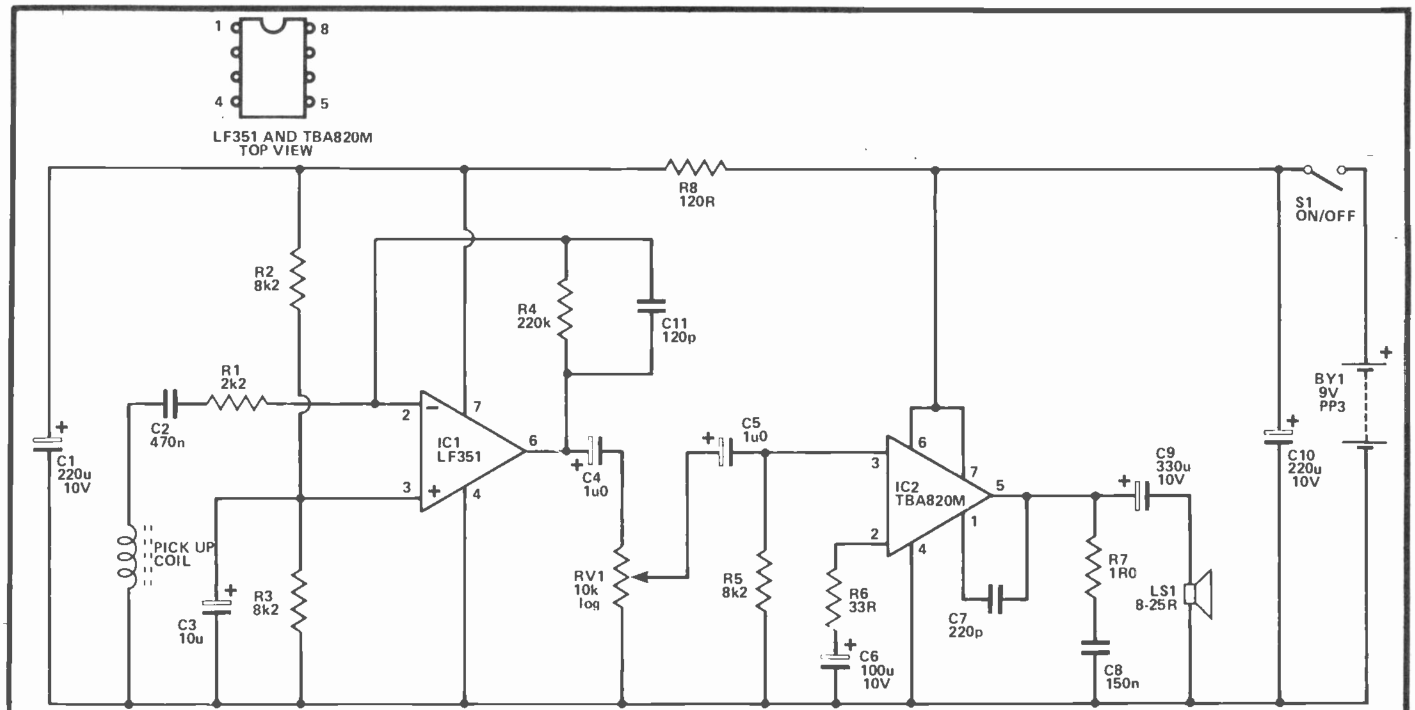


NOTE:
L1 IS DENCO MW5FR FERRITE AERIAL OR SIMILAR.

The tuned circuit is formed by L1 and CV1. This selects the desired transmission and rejects other stations. CV1 permits full coverage of the normal medium wave broadcast band to be achieved. In order to obtain good volume from the unit it is necessary to directly couple the aerial to the tuned circuit. For the same reason it is necessary to take the output to the detector direct from the tuned circuit. This inevitably gives the set rather poor selectivity, but it should still be adequate in this respect.

The form of modulation used on the medium wave band is AM (amplitude modulation). This consists of varying the strength of the RF signal in sympathy with the amplitude of the modulating audio signal. D1 half wave rectifies the RF signal to leave only the positive half cycles. R1 and C1 are used to smooth the RF half cycles, but their time constant is too short to produce a steady DC output. Instead the output rises and falls in sympathy with the mean RF signal level, so that the original audio signal is recovered at the output and fed to the earpiece.

The only adjustment the finished unit requires is to slide the aerial coil (L1) along the ferrite rod to find a position that permits full coverage of the medium wave band. The coil is then taped or glued in this position. The smaller winding of the ferrite aerial is not required and is either removed or just ignored. The aerial should preferably be an outdoor type about 10m or so long, but a few metres of hook-up wire fixed around the walls of a room or in a loft should give reasonable results.



Telephone Amplifier

A telephone amplifier enables more than one person to follow a telephone conversation. The unit described here, in common with all normal units of this type, requires no direct connection to the telephone. Instead, the special pick-up coil has a built-in rubber suction cup that enables it to be easily attached to the telephone base. This produces only a very weak signal from the magnetic field radiated by an inductive component inside the telephone, but satisfactory results can be obtained if it is fed to low noise, high gain amplifier. It would of course be possible to use a much simpler circuit if a direct connection to the telephone were to be made, but this would make installation more difficult and it is ILLEGAL to make a direct connection to a Post Office telephone anyway.

The preamplifier stage of the unit is based on IC1 which is a low noise op amp having a FET input stage. This is used in the conventional inverting audio amplifier mode and the negative feedback network, R1,4, sets the voltage gain at about 40 dB. (100 times). C11 reduces the gain slightly at high frequencies in order to obtain an improved signal to noise ratio.

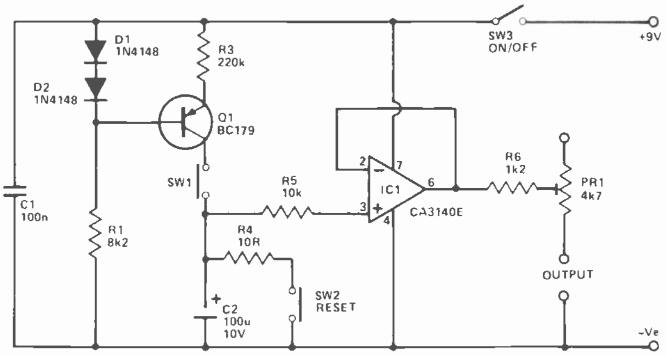
C4 couples the output from the preamplifier to volume control, RV1, and from here the signal is coupled to the power amplifier by C5. The output stage uses the TBA820M. This is a class B amplifier which will give an output power of a few hundred milliwatts RMS. The closed loop voltage gain of the device is determined by the value of R6, about 25 dB. (180 times) with the specified value. This gives the required very high overall gain in conjunction with the preamplifier's gain. C7, R7 and C8 are needed in order to maintain stability.

The quiescent current consumption of the unit is only about 5 mA, but this rises to as much as 50 mA or so at high volume levels. The best position for the pick-up coil on the telephone base (not the handset) can be located with a little experimentation. Be careful not to place the handset near the amplifier's loudspeaker or advance the volume control too far as this will cause a howling sound due to acoustic feedback.

D.M.M. To Stopclock Convertor

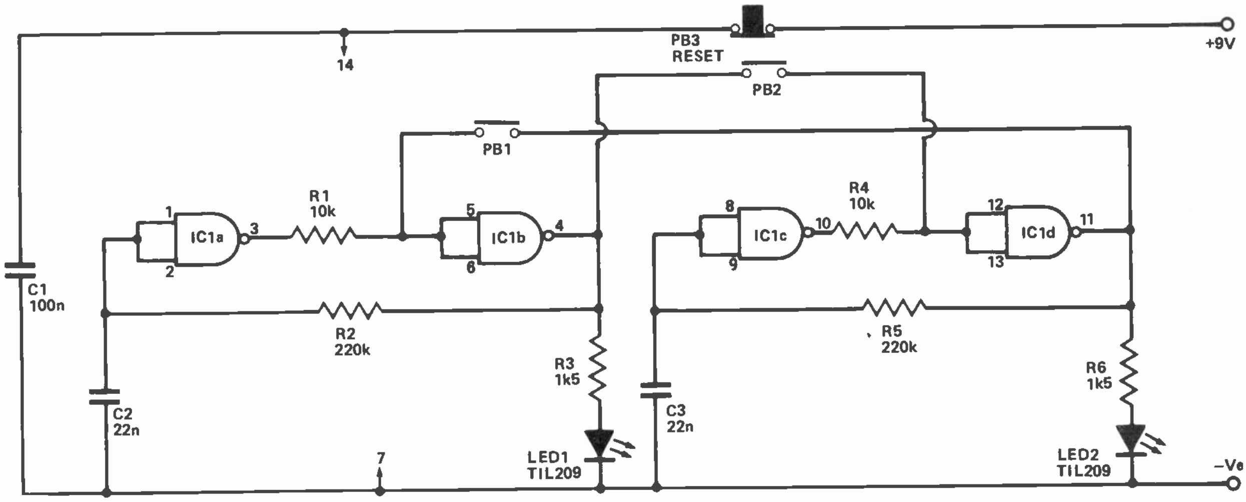
This simple add-on circuit can be used with a DMM switched to the 1 mA range to give a stopclock having a range of 0-99 S (or 0-199 S for a 3½ digit instrument). It can also be used with an ordinary analogue multimeter or panel meter, giving a range of 0-100 S, but the resolution will be lower than with a digital instrument.

The unit relies on the fact that a linear rise in voltage is produced across a capacitor if it is fed with a constant charge current. The capacitor (C2) must be a high quality type. The use of a tantalum bead component is, therefore, recommended. C2 cannot simply be charged from the supply lines via a resistor, since the voltage across the resistor would drop as the voltage across C2 increases. This would give a decreasing charge current as C2 charges exponentially and the required linear voltage slope would not be produced. C2 is, therefore, charged from a conventional constant current source which is based on Q1. D1, D2, and R1 form a simple shunt regulator circuit which bias the base of Q1 approximately 1V3 below the positive supply potential. There is a voltage drop of about 0V65 across the base emitter terminals of Q1, giving about 0V65 across emitter resistor R3. This gives an emitter current of roughly 3 uA and, as the collector and emitter currents of a high gain device (such as the BC179 used in the Q1 position) are virtually identical, a constant charge current of about 3 uA is fed to C2 when SW1 is operated. This low charge current together with the fairly high value of C2 produces a suitably long time constant.



It is essential that the voltmeter circuit takes no significant current from C2 as this would affect accuracy and would result in a decaying reading at the end of a timing run. Operational amplifier IC1 is, therefore, used as a unity gain buffer stage which gives an input impedance of about 1.5 million megohms and ensures that there is no significant loading on C2. PR1 enables the sensitivity of the voltmeter circuit to be adjusted to the correct level. In practice, SW1 is depressed for (say) 90 S and then PR1 is adjusted for the appropriate reading on the DMM.

SW2 is a reset switch and this discharges C2 (via current limiting resistor R4) if it is briefly operated. SW3 is an ordinary on/off switch. The current consumption of the circuit is only about 4.5 mA.



Quiz Monitor

This circuit is useful when playing "snap" or TV quizzes where the first person to have an opportunity of answering the question is the first to operate their push button switch. Operating it causes an indicator light to switch on and prevents the opponent's switch and indicator light from working. Thus, there is no doubt as to which push button switch was operated first.

The circuit is based on a CMOS 4001 quad two input NOR gate, but all of the gates have their two inputs connected together so that they, in fact, operate as simple inverters. The circuit has two identical sections, one for each player, each using two of the gates.

If we consider gates 1 and 2, at switch on C2 is in a discharged state and, therefore, takes the input of gate 1 low. This causes the output of gate 1 to go high, taking the input of gate 2 to the same state due to the coupling through R1. The output of gate 2 then goes low and feedback through R2 holds the input of gate 1 in its original low state, thus latching the circuit in this condition. LED 1 is driven from the output of gate 2 via current limiting resistor R3. At first it will obviously be switched off. So will LED 2 which is the indicator light for the other player. It is driven from an identical arrangement.

If PB1 is activated, the input of gate 2 is taken low, since it will be taken to the low output of gate 4. This sends the output of gate 2 high, the input of gate 1 high (due to the feedback through R2) and the output of gate 1 low. The circuit will hold itself in this state even if PB1 is released. Operating PB2 will have no effect now, since this will merely connect the high output of gate 2 to the high input of gate 4, producing no changes in logic state. Thus the required blocking is obtained. Of course, if PB2 was operated first, LED2 would switch on and PB1/LED1 would be disabled, with the basic circuit action being the same as described above. The operating speed of the circuit is extremely fast and even with a very small gap between the two switches being operated, the unit is capable of determining which was operated first and there is no danger of both LEDs switching on.

The circuit is reset by briefly operating PB3 so that power is removed from the circuit and it starts once again from the beginning when PB3 is released. No on/off switch is required as the unit has a negligible quiescent current consumption.

Simple Preamplifier

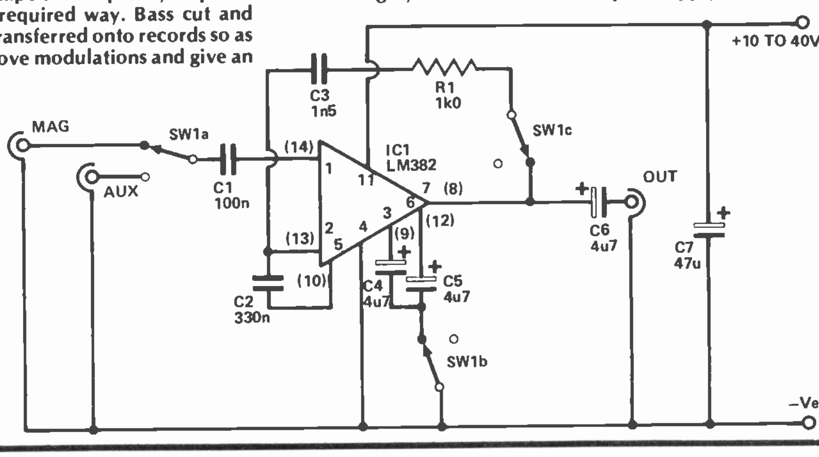
This preamplifier has two inputs; one for a magnetic cartridge and the other is an "Aux" input for a tuner, tape deck, etc. Although the circuit is very simple, it uses an IC which is specifically designed for this application and provides low levels of noise and distortion. The unit is suitable for stereo operation and both the required amplifiers are contained within a single LM382 IC.

The circuit diagram is for one channel only, but apart from the IC pin connections the other channel is identical. The numbers in brackets show the pin connections for the other channel. The supply connections of IC1 are common to both channels.

The LM382 has an internal biasing circuit which sets the quiescent output voltage at approximately 6 V and no discrete biasing components are required. C6 provides DC blocking at the output. When switched to the "Mag" mode, external feedback components are required in order to shape the frequency response characteristic of the amplifier in the required way. Bass cut and treble boost are applied to the signals transferred onto records so as to prevent excessive low frequency groove modulations and give an improved signal to noise ratio. The preamplilfier must give corresponding bass boost and treble cut in order to give a flat overall frequency response to the system. C2, C3 and R1 are the discrete feedback components and the LM382 itself contains some feedback resistors. C4 and C5 provide DC blocking for two shunt resistors in the feedback network.

When switched to the "Aux" mode, most of the feedback components are not required and are switched out of circuit by SW1a and SW1c. C2 is left in circuit, but is superfluous. In this mode the circuit has a voltage gain of only about four and is really just operating as a buffer stage. SW1a connects the input of the amplifier to the appropriate input socket and C1 provides DC blocking at the input. Of course the input wiring must all be screened to prevent stray pick-up of mains hum, etc.

The current consumption of the circuit is about 12.5 mA. Due to the high supply ripple rejection of the LM382, it is not necessary to have a highly smoothed and decoupled supply.



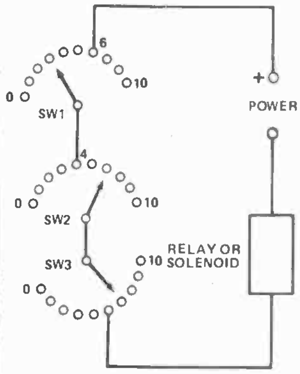
Combination Lock

Most combination locks are based on the simple arrangement shown in (a). This merely consists of three ten way rotary switches wired in such a way that they will connect power to the relay or solenoid if the correct combination is set on them (6-4-5 in this case). This basic circuit is not often used in practice since it does not take very long to quickly adjust the switches through all the 1,000 possible combinations (0-0-0 to 9-9-9 inclusive) if it is done in a logical manner.

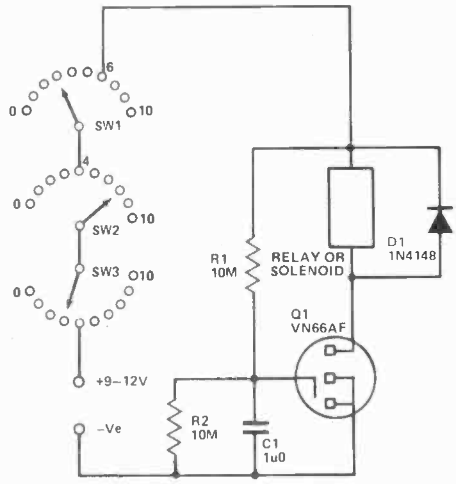
One of the simplest and best methods of overcoming this problem is simply to build a delay circuit into the unit so that power is not supplied to the solenoid or relay until the correct combination has been present for a few seconds. Quickly running through all the possible combinations is then ineffective at "cracking" the unit, as the delay circuit will prevent the unit from responding when the correct combination is briefly present. Anyone trying to "crack" the unit is very unlikely to succeed unless they know of the delay circuit and are prepared to devote a good deal of time to finding the correct combination.

Circuit (b) has an additional time delay circuit which is based on VMOS device Q1. When the correct combination is set on SW1 to SW3 and power is supplied to the circuit, C1 will be uncharged, giving zero gate bias to Q1. Q1 is, therefore, switched off and no significant current is supplied to the relay or solenoid which forms its drain load. C1 slowly charges via R1 and after about 4 S the charge voltage on C1 will be large enough to bias Q1 into conduction and switch on the relay or solenoid.

R2 discharges C1 when the unit is reset, so that it is quickly ready to operate properly once again. R2 limits the maximum gate voltage of Q1 to only about half the supply voltage, but this is more than adequate to bias the device hard into conduction and is of no practical consequence. D1 suppresses the high back EMF produced across the relay or solenoid when it switches off and prevents possible damage to Q1.



(a)



(b)

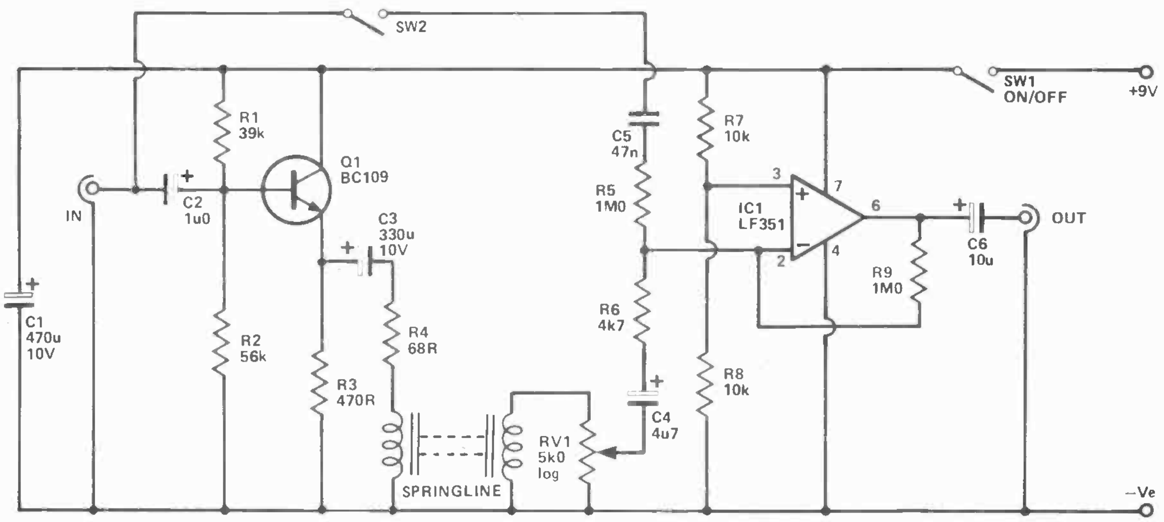
Reverberation Unit

This unit simulates the long reverberation time of a large hall (usually around 2 S or so) and can be employed as a musical effects unit or to improve certain types of home-recording. Reverberation is caused by sounds being reflected around the interior of a room and in the case of a large hall the sounds are usually reflected many times before losing sufficient energy to render them inaudible. This, coupled with the fairly long distances covered by the sound waves between reflections, gives the long reverberation time and reverberant sound of a large hall.

There are several ways of simulating reverberation, but the simplest and most commonly used is probably the springline based system. A springline consists of two transducers linked by one or two long springs. If a signal is fed into one transducer it produces a corresponding audio signal which is transmitted down the spring to the second transducer. Here it is reconverted into an electrical signal again. However, the sound signal travels down the spring relatively slowly, and the signal is reflected backwards and forwards along the spring many times before it decays to an insignificant level. Thus, the output from the second transducer is a good simulation of natural reverberation.

In this circuit the input signal is fed to the low impedance input transducer of a short springline via an emitter follower which gives a reasonably high input impedance of about 10k or so. This uses Q1 in a conventional configuration. The output of the springline unit is fed to one input of a mixer circuit. This is based on IC1 and again uses a conventional and well known arrangement. There are substantial losses through the springline and so the mixer is designed to boost the output of the springline by over 46 dB (200 times). The other input of the mixer is fed with the input signal, but the high value of R5 gives only about unity voltage gain at this input, so that the main signal does not overwhelm the reverberation signal.

RV1 enables the amount of reverberation signal mixed into the main signal to be controlled. It can be reduced right down to zero by fully backing off RV1. SW2 can be used to cut out the main signal so that only the reverberation signal appears at the output, if desired. The only other control is on/off switch SW1. The current consumption of the unit is approximately 10 mA.

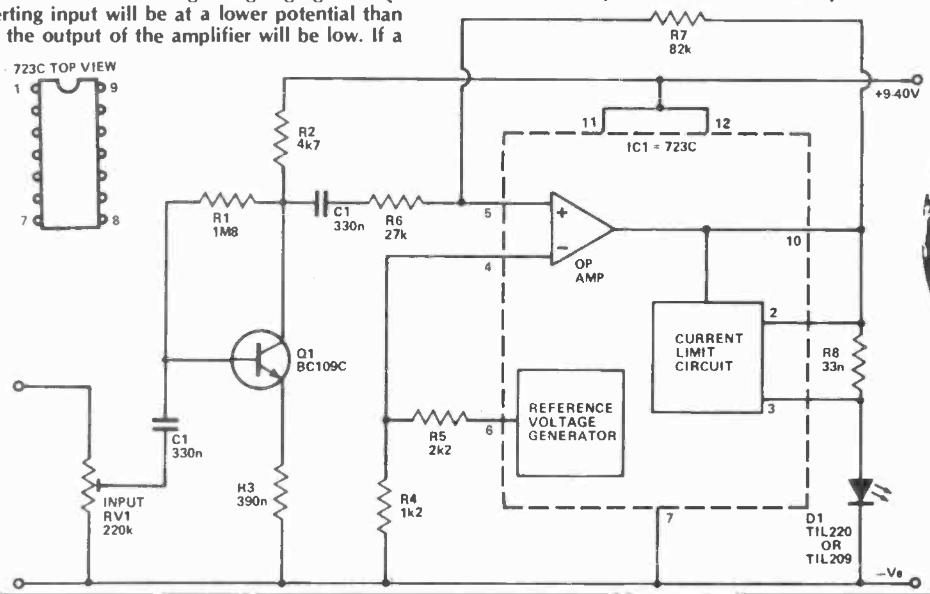


Peak Level Indicator

Peak audio level indicators can be used in tape recorders, amplifiers, mixers, and other radio equipment to provide a visual overload warning, and unlike slower responding VU meters, they produce a proper response to fast transients. This circuit is based on the inexpensive 723C device which, although primarily intended for use as a voltage regulator, can be adapted to work well in many other applications.

The 723C has a highly stable 7 V (nominal) reference voltage available at pin 6. This is coupled to the inverting input of an operational amplifier (which is also part of the 723C device) via an attenuator, R4,5. This gives a stable reference potential of a little over 2 V at the inverting input. The input signal is coupled by way of sensitivity control RV1 to a common emitter amplifier based on Q1 and fed to the non-inverting input of the operational amplifier by C2 and R6. Under quiescent conditions or with a negative going signal at Q1 collector, the non-inverting input will be at a lower potential than the inverting one, and the output of the amplifier will be low. If a positive going signal reaches a high enough amplitude, though, the non-inverting input will reach a higher potential than the inverting one causing the output to go high. D1 is then switched on with a current that is determined by the output of the amplifier and which is largely independent of the supply voltage. Discrete resistor R8 actually sets the output current. The specified value gives a nominal 20 mA LED current. R7 provides positive feedback which ensures that D1 is either fully on or off. It also tends to hold D1 in the on state for slightly longer than would otherwise be the case, thus giving a clearer indication of a brief overload.

The unit can be adjusted to respond to input levels down to about 100 mV RMS, which should be more than adequate for all normal requirements. RV1 is adjusted for the lowest sensitivity that causes D1 to come on with an input signal level equal to the lowest overload level. Quiescent current consumption is only about 4 mA.



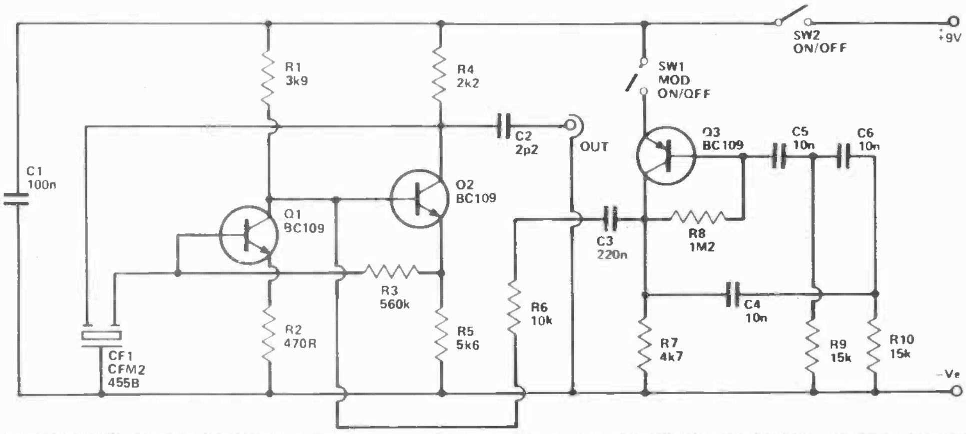
I.F. Alignment Oscillator

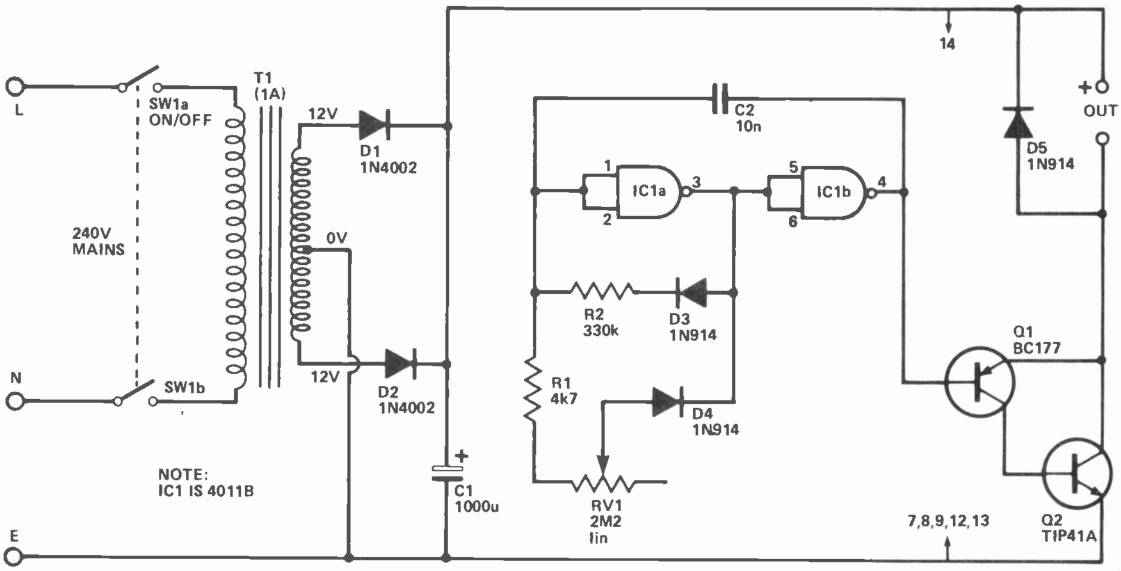
This simple piece of test equipment can be very helpful when aligning or realigning an AM superhet receiver. It provides an output at 455 kHz, which can be modulated by an audio tone if the set is being adjusted for maximum AF output. The modulation can be switched off if the IF transformers are to be adjusted for maximum AGC voltage.

The circuit consists of two oscillators, Q1 and Q2 being used in the one which generates the 455 kHz signal and Q3 in the one which provides the modulation signal. Q1,2 are connected in a straightforward two stage, direct coupled, common emitter configuration. However, neither of the emitter resistors are bypassed in this case as only a low voltage gain is required. The input and output are in phase and positive feedback between the two is provided by ceramic filter CF1 (available from Ambit International). A significant amount of feedback is only provided at the 455 kHz operating frequency of the filter and so the circuit oscillates at this frequency.

A ceramic filter gives good frequency stability, requires no adjustment in order to produce the correct output frequency and is cheaper than using a crystal. C2 provides DC blocking at the output, although it should normally only be necessary to connect the "hot" output to the receiver, no chassis connection being necessary.

A straightforward phase shift oscillator is used to provide the modulation signal and the specified C-R values give an operating frequency of about 500 Hz. C3 and R6 couple this signal to the base of Q2 where it amplitude modulates the 455 kHz signal. SW1 can be used to cut the supply to Q3 and thus remove the modulation. Current consumption is about 2.5 mA with the modulation switched on and approximately 1.7 mA switched off.





12V DC Motor Speed Controller

This motor speed controller is of the type where the motor is fed with a series of pulses of fixed duration and the power fed to the motor is varied by altering the frequency of the pulses. The higher the frequency, the greater the power fed to the motor, up to the point where there is virtually no gap between the pulses and the motor is operating at full speed. A useful characteristic of this type of controller is that it gives relatively good results at low speeds and wastes little power with consequent low dissipation in the circuit. This circuit is for 12 V DC motors having a maximum current consumption of up to 1 A (or 2 A if the secondary current rating of T1 is raised accordingly).

T1, D1, D2 and C1 form a simple DC supply which gives a loaded voltage of just over 12 V (just over 17 V unloaded). This is used to drive a CMOS astable multivibrator which is based on two of the gates in a 4011B device. The two gates that are used each have their two inputs connected together so that they act as inverters and are connected in what is basically just the standard CMOS astable circuit.

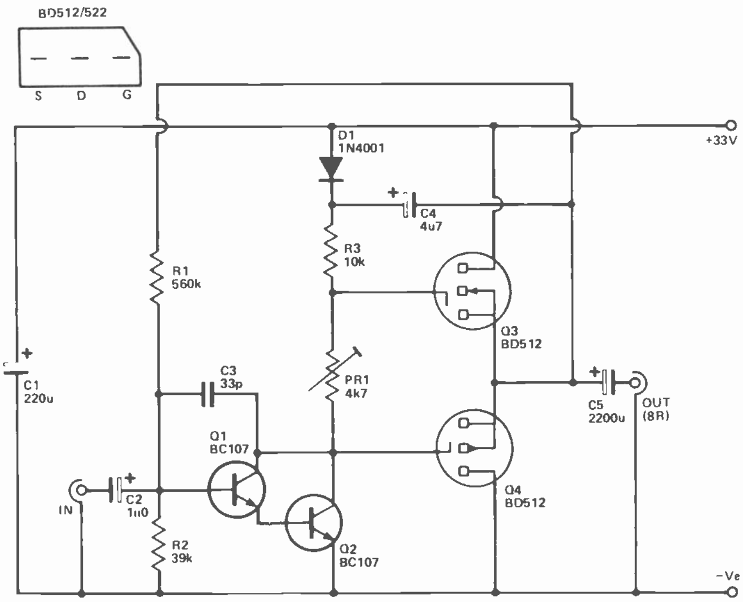
The circuit differs from the standard configuration in that there are two timing resistances; one formed by R2 and the other by the series reistance of R1 plus RV1. D3 and D4 are steering diodes. In effect, R2 forms the timing resistance when the output of the astable is high and gives an output pulse of fixed duration. RV1 and R1 act as the timing resistance when the astable's output is low and the duration between output pulses can, therefore, be varied using RV1.

With RV1 at minimum resistance there is a negligible gap between the output pulses, giving maximum speed from the motor. Increasing the resistance of RV1 increases the duration between the pulses, giving decreased average output power or no significant output power at all with RV1 at maximum resistance.

Since the astable has only a low output current capability, the motor must be driven via a buffer amplifier. This uses Q1 and Q2 in the common emitter mode, with 100% overall negative feedback so that unity voltage gain (but a high current gain) is obtained.

VMOS 10 Watt Amplifier.

At first sight this circuit may seem to be a straight foward Class B design having an emitter follower, complementary output pair and Darlington Pair common emitter driver stage. However, the output devices are, in fact, complementary VMOS transistors used in the source follower mode (the FET equivalent of the emitter follower). In most other respects the design is quite conventional.



R1 and R2 are used to bias the unit to give the optimum quiescent output potential and they provide overall negative feedback, which improves the quality of reproduction. D1 and C4 are bootstrapping components, enabling the gate drive voltage to Q3 to go above the positive supply potential, giving improved efficiency to the circuit. R3 is the main collector load for Q2 and PR1 is used to give a standing bias on the output transistors that gives a quiescent current consumption of about 25 mA. The thermal compensation circuitry normally used is totally unnecessary in this circuit, since VMOS devices do not suffer from thermal runaway. In fact the quiescent bias current will drop slightly as the output devices heat up, but not sufficiently to give rise to significant cross-over distortion.

C2 and C5 provide DC blocking at the input and output respectively, while C1 is a supply decoupling component. C3 gives a degree of high frequency attenuation and aids the stability of the circuit.

Athough the current in the driver stage, only about 1 mA, may seem to be totally inadequate, it is in fact more than sufficient since the VMOS devices have extremely high input impedances and consume no significant input current. This is one of their main advantages over bipolar devices. One disadvantage in this particular application is lower efficiency due to the higher threshold voltages and on resistance of VMOS transistors in comparison to bipolar devices. However, the circuit will give an output of 10 W RMS using a supply voltage of about 33 V or so (with a current drain of up to about 600 mA). An input of about 500 mV RMS is needed for maximun output.

Note: The output devices do not have internal zener protection diodes and the appropriate handling precautions should be taken. These devices are available from J.W. Rimmer, 367 Green Lanes, Harringay, London, N4 1DY.

FLASH TRIGGER

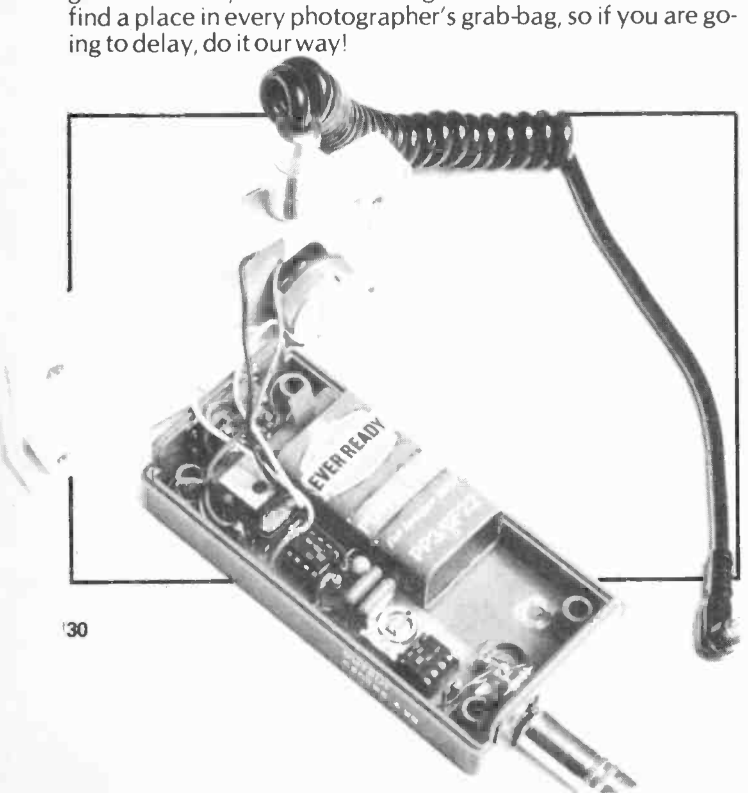
This versatile unit fits in your pocket — ready for use in a flash.

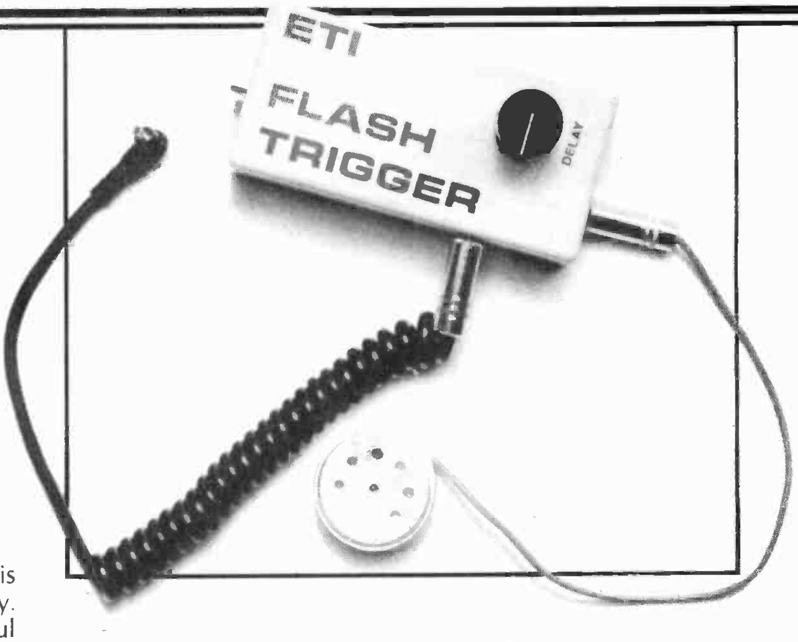
Flash triggers have been with us for a few years now. This design offers all the usual features plus pocketability. Only a couple of cheap chips are used with a caseful (check the photos) of other components. Using the specified component values, the unit may be employed either as a direct slave or may introduce a delay variable between 10 mS and 200 mS. Other delay times may be achieved by a single component change.

A number of devices may be used to trigger the unit. Operation as a sound operated flash requires only one extra component, a crystal insert or microphone.

Construction

Our PCB design will enable you to build the unit into a compact case. A preset component was used for PR1, though a standard potentiometer can be substituted if you have room and require adjustable sensitivity. If you do use our PCB then construction will be straightforward. Just follow our drawings and PCB overlay. As usual, insert the low-profile components first taking care to orient the semiconductors correctly. If you do not have a BC184L, almost any other small NPN silicon transistor can be substituted. However, note the TO92A pin configuration which differs from that of many popular transistor types. We included a power 'on' LED indicator in our design next to the input socket. A word of warning: remember that the trigger leads of many flash guns may have a potential of up to 200 V across them. This is usually low current but may give the clumsy constructor a tingle. This versatile unit should find a place in every photographer's grab-bag, so if you are going to delay, do it our way!





HOW IT WORKS

The flash gun is discharged by short circuiting its trigger contacts. This is usually achieved by a mechanical contact closure operating synchronously with the camera shutter release. In this design, the camera contacts are replaced by an electronic switch, thyristor Q2. This device is turned on, simulating a contact closure, by application of a positive-going pulse to the gate.

With SW1 in the 'direct' position, the thyristor will be triggered from the output of IC1, a 741 op-amp configured in the variable gain non-inverting mode. The use of C1 gives the amplifier a high available AC gain while minimising the effects of amplifier offsets. Gain is preset to the desired level by adjustment of PR1. For a straightforward sound operated flash, the input to IC1 may consist of a simple crystal insert connected between the junction of R1, 2 and ground. Any device capable of producing a small pulse may be employed at the input. Note that the unit will trigger from positive going edges in the 'direct' mode and from negative edges when switched to 'delay'.

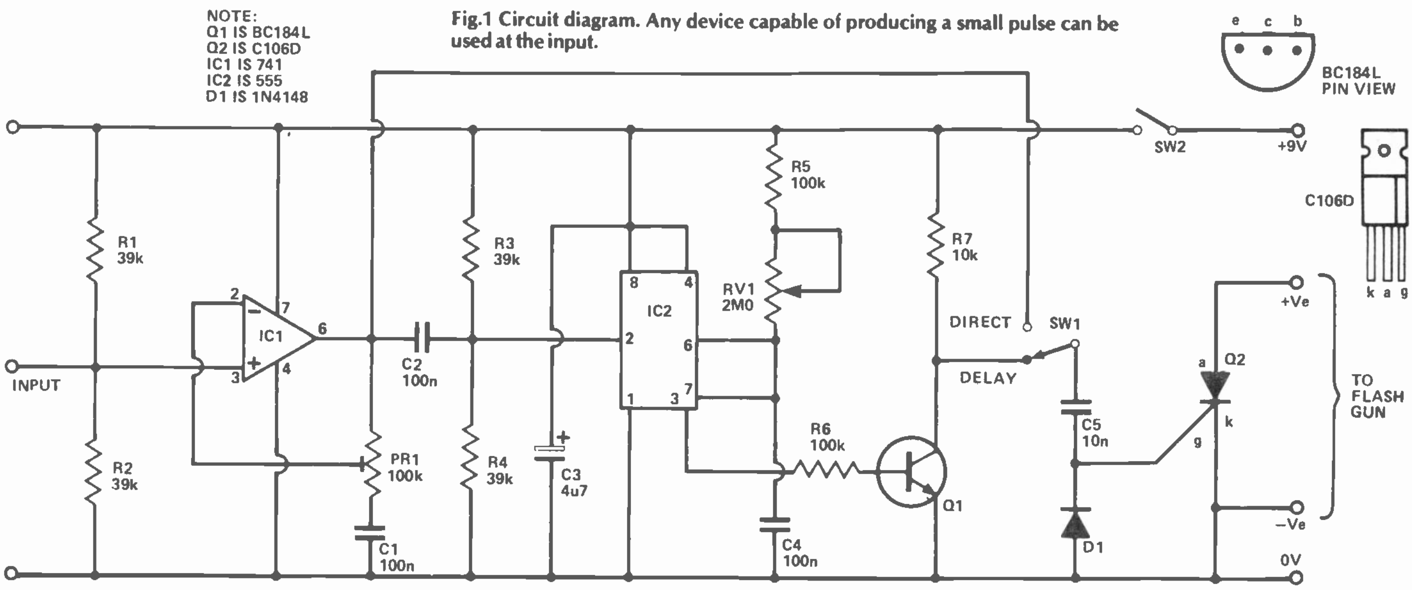
A negative going output from IC1 will trigger the 555 timer, IC2. The delay introduced by this chip is variable between about 10 mS and 200 mS by adjustment of RV1. Other delays may be achieved by changing the value of C4. As the delayed trailing edge output from IC2 is of the wrong sense, it is inverted by Q1 to provide a suitable trigger pulse for Q2. Capacitor C3 provides overall decoupling.

There isn't a lot of space to spare inside the case. Make sure you leave a corner free for the potentiometer body, or the case won't close properly.

PARTS LIST

Resistors all ¼ W 5%	
R1,2,3,4	39k
R5,6	100k
R7	10k
Potentiometers	
PR1	100k horizontal preset
RV1	2M0
Capacitors	
C1,2,4	100n polyester
C3	4u7 tantalum
C5	10n polyester
Semiconductors	
IC1	741
IC2	555
Q1	BC184L
Q2	C106D
D1	1N4148

Fig.1 Circuit diagram. Any device capable of producing a small pulse can be used at the input.



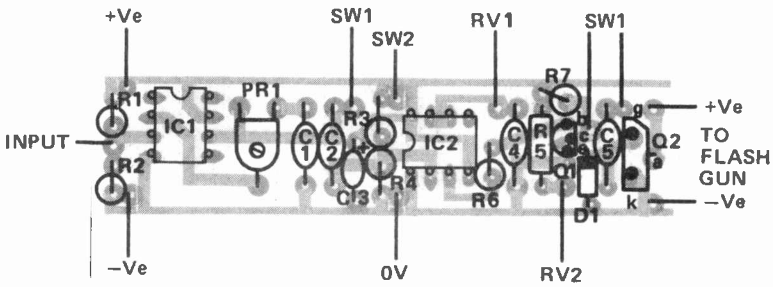


Fig.2 Component overlay.

BUYLINES

All the electronic components should be readily available from your usual supplier or see the adverts in this issue. The Vero plastic box we used is their stock number 202-21027E.

ETI

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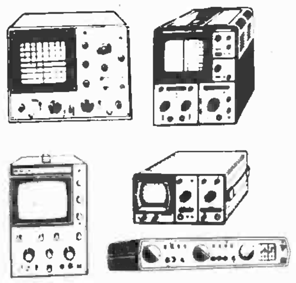

SINGLE TRACE (UK c/p etc £2.50)

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SC110 10mHZ Battery portable, 10mV 3.2 × 2.6cm display (Optional case £8.80, Nicads £7.95, Mains unit £4.00) **£152.50**
LBO512A 10mHZ, 10mV, 5'' display (plus FREE probe) **£195.50**
CS1559A 10mHZ, 10mV, 5'' display **£198.50**

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DUAL TRACE (UK c/p etc £3.50)

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CS1566A 20mHZ, 5mV, 5'' display **£323.15**
CS1352 15mHZ, 2mV, 7.5cm display, battery/mains portable (Nicads pack £29.90) **£346.15**
Hm412-4 20mHZ, 5mV, 8 × 10cm display plus Sweep Delay **£399.50**
CS1577A 30mHZ, 2mV, 5'' display **£455.40**
CS1572 30mHZ, 5mV, 5'' display plus Video Delay **£472.65**
CS1830 30mHZ, 2mV, 5'' display plus sweep delay **£507.15**
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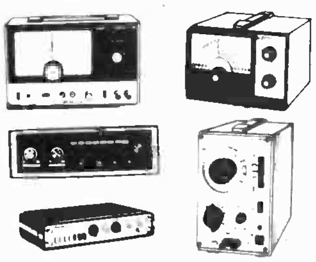

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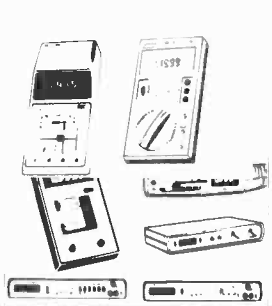

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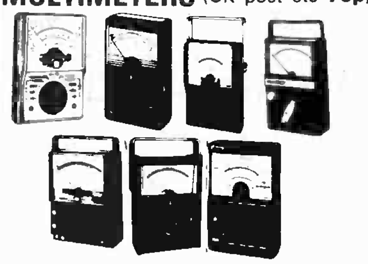

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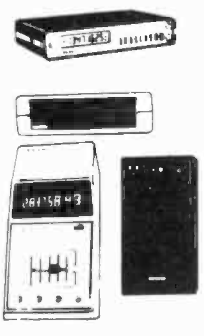

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Hobby Electronics

Next Month

ON SALE SEPTEMBER 12th

Kitchen Timer

This handy little gadget will soon take pride-of-place on the kitchen shelves. It'll accurately indicate periods of up to six and a half minutes in thirty second steps. All the components are easy to obtain and it shouldn't take more than a couple of hours to build.

Freezer Alarm

Still in the kitchen, we've cooked up another winner for you with this little freezer alarm circuit. Should the temperature rise above a pre-determined level then the alarm will sound. Anyone who has ever seen a freezer full of unfrozen food will know how valuable this little project could be!

Light Dimmer

Here's one for those afraid of bright lights. This all new dimmer circuit will fit into the standard light switch socket. It'll let you control your lighting from a harsh glare to a warm seductive glow, just right for those long winter evenings in front of the telly. It might even save a few bob on the electricity bill too!

Doorbell

Just in case you've fallen asleep, safe in the knowledge your freezer's OK, the lights are low (courtesy the HE Light Dimmer), the meal was perfect (thanks to the HE Kitchen Timer), you'll be glad to know that the HE Nobell Doorbell will wake you up. This novel little circuit faithfully re-creates the sound of a mechanical door-knocker. No prizes for guessing why we called it the Nobell.

Temperature Controlled Soldering Iron

If we've tempted you into building any of these projects then you should know about our Temperature Controlled Soldering Iron project next month. You'll be able to build all of the projects without worrying about burnt out bits anymore.

Home Electronics

To round it all off we will be taking a look at some of the benefits electronics has brought to the home. The homely Tina Boylan looks at some of the gadgets on sale today and some of the labour saving devices we can expect in the next few years.

The items mentioned here are those planned but unforeseen circumstances may affect the actual contents.

SPECIAL RELATIVITY

Einstein ranks as one of the giants of physics. A.S. Lipson looks behind the equations and tells the story of the special theory of relativity.

In 1905, Einstein published three papers. It was the third of these which was concerned with special relativity. In this paper — "On the Electrodynamics of Moving Bodies" — he set out by making two apparently innocent assumptions; that the velocity of light as measured by some inertial observer does not depend on the velocity with which this observer is moving, but will only be affected if the observer is accelerating or decelerating (an inertial observer is one who travels with constant velocity, without accelerations or decelerations) and that the laws of physics as measured by the observer are also independent of his velocity. From these assumptions, Einstein produced — using the most beautifully simple arguments — conclusions that rocked common sense and upset people's basic ideas about space and time.

If the laws of physics, *all* laws of physics, are the same, no matter what the velocity of the observer measuring those laws is, then there is no way in which that observer can tell with what velocity he is moving, or even if he is moving at all, just by performing an experiment in his own reference system, which is moving along with him.

Relative Motion

If, for instance, you are in a smoothly-running train, with all the windows covered over, and without noises from outside, such as the sounds of the wheels on the tracks, then you cannot tell by any means whether the train is in uniform motion, or standing still. However, should one of the windows be uncovered, so that you can see outside, you can then tell whether or not the train is moving by whether or not the buildings outside appear to be passing you at high speed.

Even so, information from the outside world can be very difficult to interpret sometimes. If your train is in a station, with another train on the line just next to it, then when your train pulls out, it can be very difficult to decide whether the motion you observe is due to the other train travelling slowly in one direction, or your own train travelling slowly the other way.

Ether It's There Or It Isn't

Since Newton, there had been a running debate among physicists as to whether light consisted of a wave or a beam of particles. These days, it is believed that it actually consists of a sort of cross between the two, which is virtually impossible to visualise, but is extremely useful for explaining various phenomena. However, by the second half of the nineteenth century, everyone was pretty certain that it was a wave. Maxwell had predicted the theoretical speed of electromagnetic waves and it had turned out to be pretty nearly the same as the experimentally measured speed of light and that was that — light was probably an electromagnetic wave. The one problem was that all other known waves travelled through a medium of some kind; sound waves through air, water waves

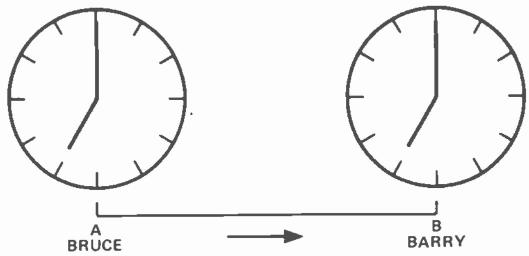

Fig.1 To Bruce it appears that Barry's timescale is 'running slow'. To Barry it appears that it is Bruce's timescale that is slow.

(obviously) through water, and so on. Light seemed to travel through a vacuum — for instance, from the Sun to the Earth. It didn't seem to need a medium. So they invented one; the ether

The ether supposedly filled all space, acting as a medium for light, but not interacting with matter. (So, for instance, it didn't slow down the Earth in its orbit around the Sun.) The fact that there was no experimental evidence for this ether did nothing to change physicists' minds.

Now we can see why Einstein's ideas were so radical and unpalatable to scientists of the time. He, a mere patent clerk at the time, was daring to challenge the scientific principles laid down by Isaac Newton, acknowledged as the greatest scientist of all time. What Einstein was saying was that there was no need for an 'absolute' reference system — or even for the concept of the 'ether'. In order to make these statements logically consistent, though, he had also to abolish the concept of absolute time.

Time

Time, according to the special theory of relativity, is dependent on velocity. This is best explained by giving an example. Consider two inertial observers, moving rapidly towards each other. For the sake of argument we can call them Bruce and Barry. Let us imagine that Bruce and Barry are approaching each other with a velocity v, and that each of them has a very accurate clock, which they carry along with them. Now according to relativity, if Bruce looks at Barry's clock and compares it with his own, it will appear to him that Barry's clock is running fractionally slower. Not only that; Barry himself will also be 'running slower' — his breathing, pulse rate, and so on will all have slowed down by just the same amount. In fact, it will appear to Bruce that Barry's time scale has slowed down! Well, if this is so, then it follows that it appears to Barry that Bruce's clock will be running fast. Or does it? Unfortunately not. If Barry looks at Bruce's clock, he will observe the same effect — that Bruce's clock is running slower; in fact, that Bruce himself will be running slower. Each of the two observers appears to the other to have a slower timescale.

And That's Not All

Time wasn't the only thing that took a bashing from Einstein, though; he had something to say about space, as well. If you are travelling at high speeds, the way you perceive objects will also change. Originally, it was thought that relativity theory stated that objects appeared shorter at high speeds. In fact, this is not quite accurate. If objects moving at high speeds are looked at, then they actually appear rotated, rather than contracted in length. If the objects are measured, however, allowing for the travel time of light, then they do appear to be contracted. This decrease in length at high speeds is known as the 'Lorentz Contraction', after a scientist who suggested it (although for different reasons than those of Einstein) shortly before Einstein's paper, in 1895.

We can calculate the apparent length of an object and draw out a table of it against velocity. If l_0 is the length of the object measured at rest, and l is the length measured at some velocity v, then $l = l_0\sqrt{1 - v^2/c^2}$, where c is the velocity of light. In the table below, v is expressed as a fraction of c, and l as a fraction of l_0

Velocity(v)	l/l_0	Velocity(v)	l/l_0
0	1.0	0.9c	0.4359
0.4c	0.9165	0.95c	0.3122
0.8c	0.6	0.99c	0.1411

You can see that, as v gets close to c, the apparent length of an object drops dramatically, although at low speeds, less than 0.4c, the effect is fairly small. In fact, this is why we don't notice relativistic effects in normal life and why it took a mind like Einstein's to point them out. Even the fastest speeds that we normally come across are such small fractions of the velocity of light that the relativistic effects are too small to be measured.

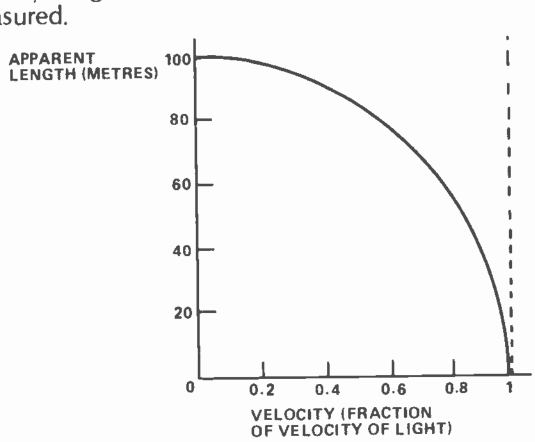

Fig.2 Objects appear to grow shorter at high speeds.

Time Dilation

The same arguments apply to the peculiar 'time dilation' effects we looked at earlier. At the sorts of velocities we are used to, the effects are too small to notice. Timescales, in fact, are related by exactly the same formulae as are lengths. Going back to Bruce and Barry, if t is the time Barry measures by his own clock, then $t' = t\sqrt{1 - v^2/c^2}$

At this stage, it might appear, looking at the equations, as though, if we could reach the velocity of light; that is, if v was equal to c, then time would appear to stop altogether and objects would appear to be so shortened as to be totally flat. In fact, this does not happen, and for a simple reason — the speed of light cannot be reached.

Weight A Minute

Physics is concerned mainly with the study of four quantities and the interactions between them. These four quantities are distance, time, electric charge and mass. So far, we've seen that distance and time are both affected by high velocities. What about the other two? Well, electric charge doesn't seem to be changed, however fast you move it, but mass, on the other hand, can be very significantly changed.

The change that occurs is very similar to those with distance and time. If we measure the mass of something when it is at rest with respect to us as m_0 — the 'rest mass', as it is called — then when it is travelling relative to us with a velocity v, we will find its mass to be given by $m = m_0/\sqrt{1 - v^2/c^2}$ and, hardly surprisingly, we see that this equation is strikingly similar to those giving time dilation and Lorentz contractions. The only difference being that m_0 is divided by $\sqrt{1 - v^2/c^2}$ whereas l_0 and t were multiplied by it.

The acceleration (that is, the rate of increase of velocity) of an object is given by the force applied to it, divided by its mass. Hence, as velocity increases, so does mass, and for a set applied force, acceleration becomes smaller. As v gets close to c, mass gets very close to infinity and the force needed to accelerate the body also gets higher and higher. To accelerate a body to the velocity of light would require an infinite force applied over a finite time, and hence would take infinite energy. Such an acceleration, then, is not possible. Although we can, in theory, get as close as we like to the velocity of light, we can never actually reach it.

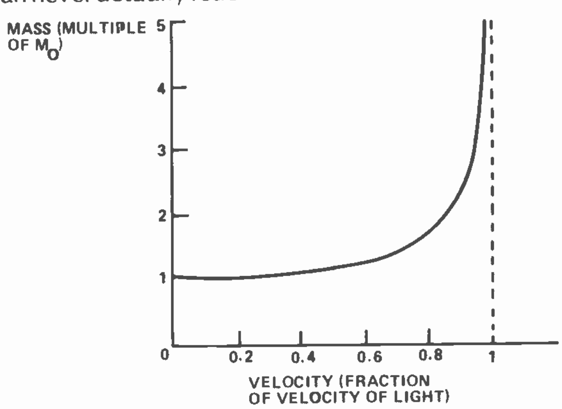

Fig.3 Mass increases at high velocities.

So Where Does It All Come From?

All right. So an object's mass increases at it travels faster (Fig.3). Where does all this mass come from, though? Well, it originates in the energy that we put into the object while accelerating it and this is where what is possibly the best known equation in physics comes in:

$$E = mc^2$$

Energy equals mass times the square of the velocity of light. The extra mass actually *is* all the energy that was put into the acceleration. Because of this, when we slow the object down again, it loses all the excess mass, because in decelerating it, we extract all the energy again.

Unfortunately, the equivalence of mass and energy has another application. It is the conversion of mass to energy that forms the basis of operation of the atom bomb. And because c is so large, it requires only a little mass to make an incredibly large quantity of energy. A match-head if totally converted into energy, could keep a 100 W bulb shining for about 500 years!

ETI

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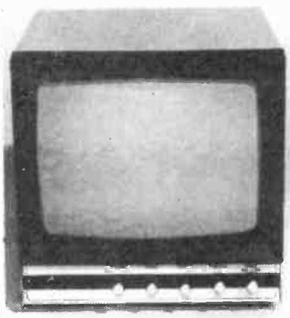

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PRESETS (.15W HORIZONTAL)
100 Ohms to 2 Mohms 7p
POTENTIOMETERS (¼W)
Linear & Log Scales
4K7 to 2M2 33p

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709-8	28p
710-14	35p
741-8	20p
747-14	50p
748-8	35p
CA3018	70p
CA3028A	85p
CA3046	50p
CA3054	40p
CA3080E	75p
CA3130E	90p
CA3140E	40p
CA3090AQ	★200p
LF351N	44p
LF356N	85p
LM301AN	30p
LM308N	55p
LM318N	120p
LM318H	120p
LM324N	57p
LM339N	52p
LM348N	90p
LM377N	175p
LM380N	90p
LM381N	★120p
LM382N	★90p
LM1310N	115p
LM1458N	★40p
LM3900N	★50p
LM3909N	75p
MC1496P	80p
NE531	110p
NE555	22p
NE556	★45p
NE566	140p
SN76115N	★80p
TBA641B	200p
TBA800	75p
TBA 810S	110p
ZN414	90p
ZN1034E	220p

DIODES

BY127	12p
OA47	8p
OA91	★6p
OA200	6p
OA202	9p
1N916	5p
1N4148	4p
1N4001/2	4p
1N4003	5p
1N4004/5	6p
1N4006/7	8p
1N5400	13p
1N5401	14p
1N5402	15p
1N5404	16p

BRIDGE RECTIFIERS

WO2M	20p
WO6M	30p
1A/50V	22p
1A/100V	27p
1A/200V	32p
1A/400V	34p
2A/50V	40p
2A/100V	42p
2A/200V	48p
2A/400V	55p

DIL SOCKETS

8 pin	★8p
14 pin	★9p
16 pin	★10p
18 pin	16p
22 pin	20p
24 pin	21p
28 pin	25p
40 pin	35p

OPTO/ELECTRONIC

2N5777	55p
OCP71	65p
ORP12	70p
DL704	110p
DL707	110p

0.125″ & 0.2″ **LEDs:**

Red	10p
Green	13p
Yellow	13p
0.125″ Clip	3p
0.2″ Clip	4p

VOLTAGE REGULATORS

79L05	30p
79L24	30p
7805	65p
7812/15	65p
7818/24	65p
7905	75p
7912/15	75p
7918/24	75p

THYRISTOR

C106D (4A/4000V)	40p

CMOS AE

4000	16p
4001B	18p
4002	16p
40068	75p
4007	★16p
4008	85p
4009	42p
4010	48p
4011B	18p
4012	25p
4013B	45p
4014/5B	80p
4016	44p
4017	70p
4018	85p
4019	50p
4020B	100p
4021/2	95p
4023	22p
4024B	55p
4025	20p
4027	50p
4028	70p
4029	90p
4030	55p
4035	110p
4041	85p
4042	80p
4043/4	99p
4047	105p
4048	60p
4049	50p
40508	50p
4066	60p
4068/9	22p
40708/1	22p
4072/3	22p
4081/2	26p
4086	80p
4510	100p
45118	90p
4516/8	105p
4520/8	105p

TTL

7400/1	16p
7402/3	16p
7404/5	16p
7406	18p
7407	25p
7408	22p
7409	13p
7410	13p
7411/2	17p
7413	21p
7414	45p
7416	20p
7417	25p
7420	★14p
7421	30p
7422	26p
7427	20p
7428	28p
7430	16p
7432	20p
7433	38p
7437	14p
7438	18p
7440	13p
7441	52p
7442	32p
7443	60p
7444	100p
7445	64p
7446	65p
7447A	50p
7448	52p
7450	10p
7451/3	13p
7454	10p
7460	13p
7470	20p
7472	19p
7473	★18p
7474	★25p
7475	★25p
7476	20p
7480	32p
7485	80p
7486	18p
7490	★25p
7491	57p
7492/3	30p
7494	50p
7495	40p
7496	37p
7497	200p
74100	60p
74105	43p
74107	22p
74109	34p
74110	40p
74118	84p
74121	25p
74122	30p
74123	50p
74125/6	42p
74132	65p
74141/5	46p
74150	85p
74151	65p
74153	43p
74154	66p
74155	46p
74156	42p
74157	38p
74160	57p
74161	55p
74162/3	60p
74164/5	56p
74166	95p
74173	110p
74174/5	55p
74176/7	70p
74180	35p
74181	80p
74182	45p
74190	50p
74191	90p
74192/3	50p
74194	70p
74195	68p
74196	78p
74197	45p
74198	120p
74199	90p

TRANSISTORS

AC126/7	22p
AC128	20p
AC151	17p
AC153	25p
AC176	22p
AC187/8	22p
AC187K	30p
AD149	★50p
AD161/2	40p
AF114	30p
AF124	35p
AF125/6	35p
AF127	35p
AF139	40p
AF239	44p
BC107/B	10p
BC109	10p
BC117	23p
BC140	20p
BC142/3	30p
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	★8p
BC183B	10p
BC184	10p
BC186	25p
BC187	15p
BC207/9	13p
BC212	10p
BC212L	★8p
BC213L	10p
BC214	10p
BC214L	★8p
BC238	18p
BC261B	23p
BC301/3	32p
BC328	17p
BC338	17p
BC461	40p
BC477	35p
BC478	20p
BC479	23p
BC547/8	12p
BC549	12p
BC557/B	14p
BC559	14p
BCY70	18p
BCY71/2	18p
BD115	58p
BD121/3	75p
BD124	81p
BD131/2	35p
BD135 to BD140	35p
BF178	30p
BF179	19p
BF180	34p
BF181	8p
BF183	34p
BF184/5	25p
BF194/5	12p
BF196/7	12p
BF198	10p
BF200	23p
BF224B	14p
BF244B	45p
BF258	28p
BF259	40p
BFR39	30p
BFR40	20p
BFR79	32p
BFR80	20p
BFX29	25p
BFX84	25p
BFX85/6	20p
BFX87/8	25p
BFX88	25p
BFY50/1	20p
BFY52	22p
BRY39	50p
BSX19	12p
BSX20	22p
BU205	150p
BU208	210p
MJ2955	110p
MJE340	52p
MJE2955	110p
MJE3055	80p
MPF102	45p
MPF104/5	40p
MPF106	45p
MPSA06	26p
MPSA56	26p
MPSU06	60p
OC28/35	92p
TIP29	40p
TIP29B	42p
TIP30	40p
TIP30B	42p
TIP31A	★30p
TIP32	40p
TIP33	65p
TIP33C	70p
TIP34A	75p
TIP35B	200p
TIP36A	200p
TIP36B	210p
TIP41A	60p
TIP42A	60p
TIP2955	70p
TIP3055	★30p
ZTX107/8	12p
ZTX109	12p
ZTX300/1	14p
ZTX302/3	18p
ZTX304	23p
ZTX311	18p
ZTX500/1	15p
ZTX502	20p
ZTX503	17p
ZTX504	24p
2N696/7	20p
2N698	20p
2N706	14p
2N914	20p
2N918	35p
2N1302/3	35p
2N1304	35p
2N1306	30p
2N1308	35p
2N1613	25p
2N1711	13p
2N1893	25p
2N2217	18p
2N2219	23p
2N2222A	23p
2N2369	17p
2N2484	25p
2N2646	46p
2N2904/5	21p
2N2906/7	21p
2N2926G	10p
2N3053	20p
2N3054	40p
2N3055	45p
2N3442	140p
2N3702 to 2N3711	11p
2N3772	★80p
2N3773	250p
2N3819	21p
2N3820	40p
2N3823	70p
2N3866	65p
2N3903/4	15p
2N3906	15p
2N4037	45p
2N5457/8	40p
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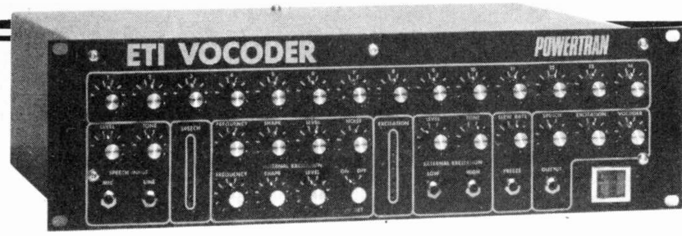


VOCODER

In the concluding part of the ETI Vocoder, Richard Becker deals with construction and setting up

Start construction with the power supply PCB and bolt this onto the rear panel with mica washers between the panel and transistors, which are on the underside of the board. Silicone grease will keep the washers in place during fitting. Wire up and check all is well when operating into 1k0 resistors as temporary loads.

Build up the rest of the boards. Use insulation on any links which touch the leads of components. On the LED PPM boards, fit the connector pins for the connector to the component side of the board for the excitation meter and the non-component side for the speech meter. Where there are jack sockets, solder short lengths of bare wire to the boards and fit both board and socket to the front panel before soldering the wires to the sockets, which then become firmly attached parts of the board assemblies. On the internal excitation board of the three controls with mounting frames fit to the underside of the board. The other four controls fit on the top side of the board. To get the correct spacing between the top and bottom controls the top ones are soldered to pins such that the tags just touch the top of the board.

Split Supply

The analysis/synthesis board is split in two halves to simplify manufacture. When the two halves are completed, fit the boards to the panel by means of the controls. Fit wire links between the boards and solder the two halves together by use of a bared length of wire along the joint. Fit the spacers to the back of the board and drop it into the chassis so that it can sit

PARTS LIST ● Slew Rate Control

Resistors all 2% metal oxide	
R1, 2	15k
R3, 6, 8	2k2
R4, 5, 7	10k
R9, 10	47R
R11	220R
R12	470R
R13	1k0
Potentiometer	
RV1	1M0 log with mounting frame
Capacitors	
C1, 5	10n ceramic
C2,	33n polyester
C3	100p ceramic
C4	560p ceramic
C6, 7	22u 25V
Semiconductors	
IC1	556
Q1	2N3904
Q2	2N3906
D1	1N4148
LED1	TIL220

Miscellaneous
Footswitch, Footswitch box, stereo jack plug and socket, 5 way connector, IC socket

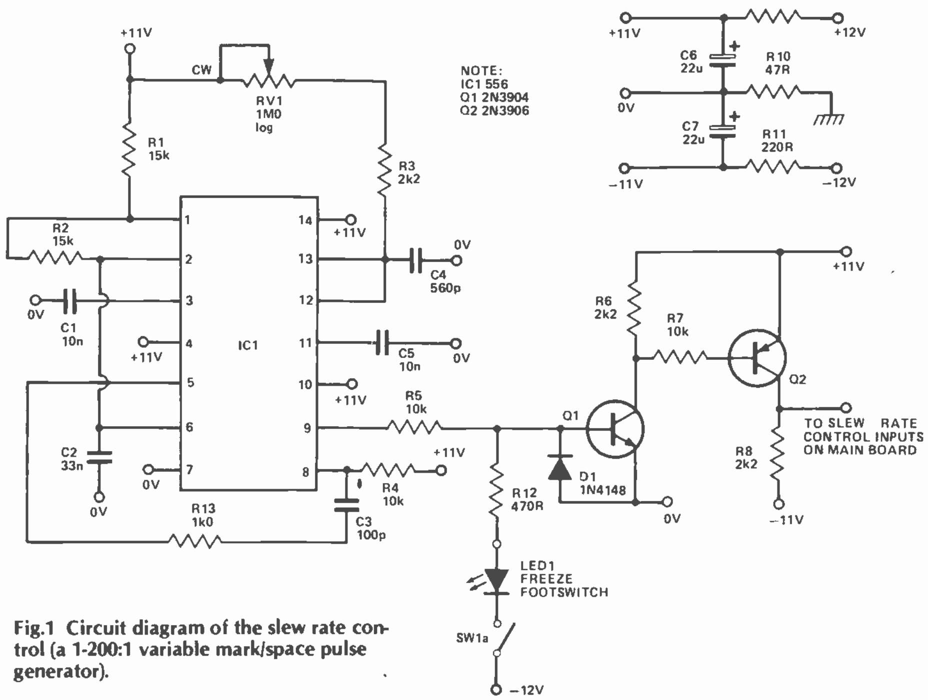
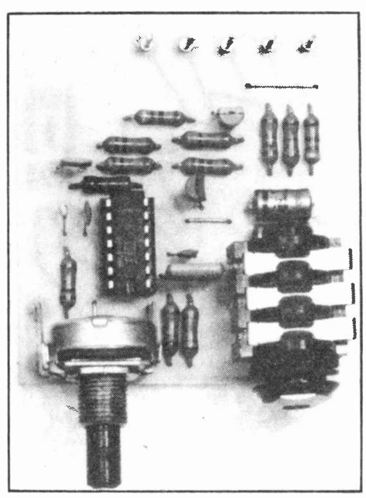


Fig.1 Circuit diagram of the slew rate control (a 1-200:1 variable mark/space pulse generator).



Slew rate control board.

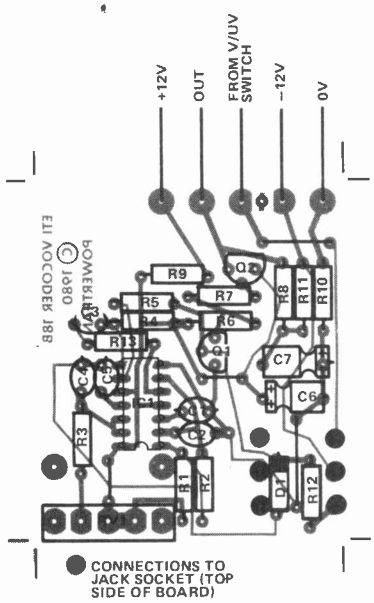


Fig.2 Component overlay of the slew rate control board.

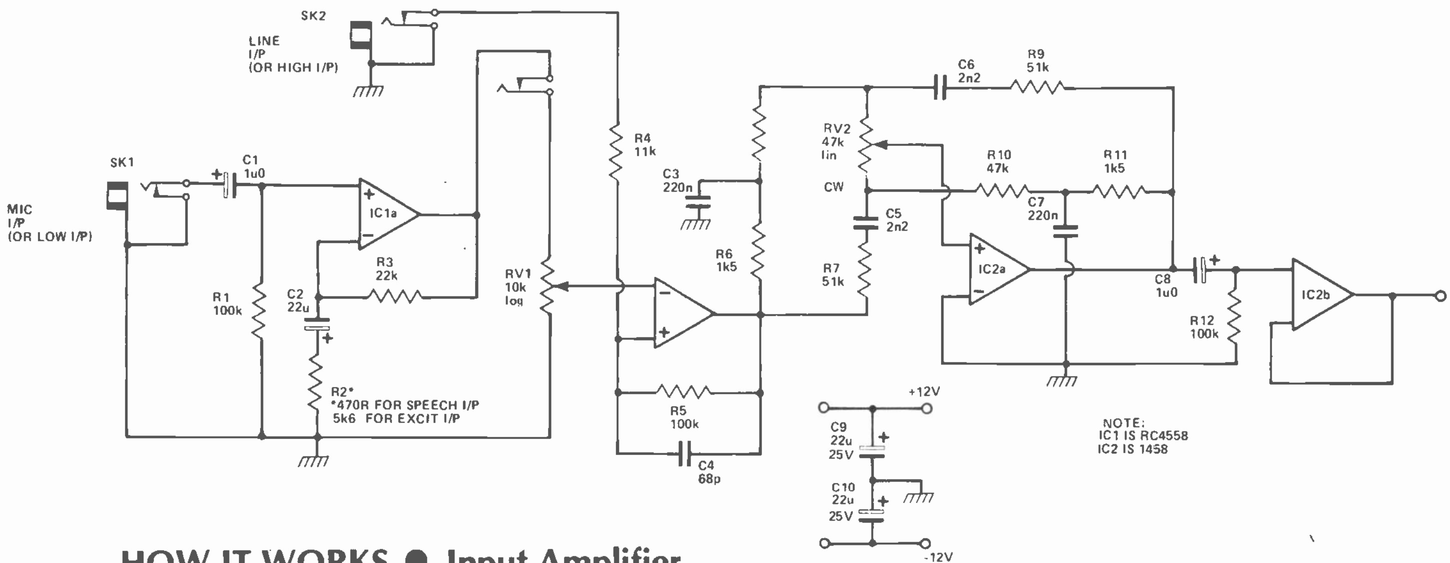
on its back edge whilst wiring up and setting up. Link together with a stretched length of wire on the back of the board all the excitation input pins and also the other inputs and outputs (a total of seven rails).

Make up the wiring loom and connect up all the boards.

HOW IT WORKS ● Slew Rate Control

This is a pulse generator of variable mark/space ratio. IC1 is a 556 which is a dual timer. Pins 1-6 form a 1 kHz 2:1 mark/space ratio pulse generator, its frequency being determined by R1, R2, C2. Its output is used to trigger via C3 and a monostable built round pins 8-13. The width of the output pulse is determined by C4, resistors R3, RV1. The output is buffered by Q1. Q2 is the output driver, switching from +11 V to −11 V. The freeze switch forces the output to −11 V thereby turning off all the FETs of the analysis/synthesis section. To isolate the heavy switching surges on the power rails from the rest of the machine the rails are decoupled by R9, 10, 11 and C6, 7.

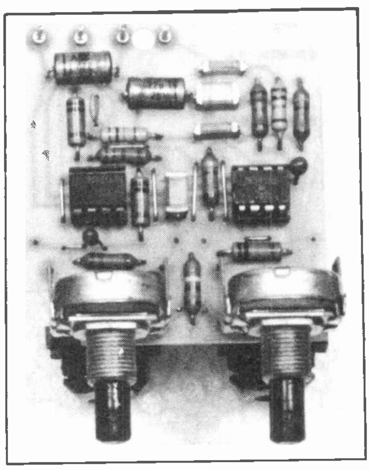
Fig.3 Circuit diagram of the input amplifier



HOW IT WORKS ● Input Amplifier

The preamplifier uses an RC4558, which is a low noise version of the 1458, for IC1. The overall gain of the stage is dependent on which input is used, being unity for SK2 and for SK1 it is 500 (speech) or 50 (excitation). The gain is distributed between IC1a and IC1b. If SK1 is used and SK2 is not, then amplified signal from IC1a is connected to RV1 via the switched contact SK2. Also R4 is connected to ground, through the other switched contact of SK2, giving IC1b a voltage gain of ten. If SK2 is used then IC1a is isolated and R4 is disconnected from ground making IC1b now have unity gain.

IC2 is a rather complex tone control stage giving, with a single control knob, treble boost with bass cut or bass boost with treble cut. R7, C5 and R9, C6 form high pass filters whilst R6, C3 and R11, C7 form low pass filters. When the wiper is clockwise the input of IC2 is connected to the input of the stage via C5, R7 whilst RV2 is in series with the feedback thereby boosting the gain at high frequencies. At the same time, bass from feedback path R11, C7, R10 is dominant over bass from the input, which has to pass through RV2. Therefore, the bass is cut. The opposite occurs when the wiper is anticlockwise.



Input amplifier board.

Setting Up

Check the power lines are still correct when all the boards are connected, set all presets to the centre of their travel and apply a sinusoidal signal to the speech line input. (If no oscillator is available use the cheap little circuit shown.) Set the level to where the sixth LED up just flickers, corresponding to 400 mV. Measure the AC voltage on pin 6 of IC1 channel 2. Adjust the frequency until the voltage reaches a peak, turn PR1 fully clockwise and turn it back slowly until 4 V RMS is measured at the resonant peak of the filter. Repeat this for the other analysis filters.

Connect a 56R resistor between the bias rail and +12 V, turn the slewing rate control fully clockwise, check the pulse generator is operating by listening for a whistle when the input jack of an amplifier is placed near the slew rate control board, switch off the unvoiced detector, plug the oscillator into the external excitation HIGH input and set up channel 2 excitation filter as for the analysis filters (except that now the point to measure is pin 1 of IC7 and the potentiometer to adjust is PR5). With RV1 fully clockwise adjust PR2 so that 4 V RMS is also at the output of the OTA buffer (IC6 pin 8). Repeat this for the other filters including channels 1, 14 where there is only PR2 to adjust.

Plug the vocoder into an amplifier, turn up all channel volume controls and the vocoder output control. Turn down the speech and the excitation inputs. Turn up one of the oscillators and adjust RV5 or RV6, as appropriate, so that the signal is heard to just disappear when the width control is anticlockwise. Repeat for the other oscillator.

PARTS LIST ● Input Amplifier

Resistors all ¼ W 5%	
R1, 5, 12	100k
R2 (speech)	470R
R2 (excitation)	5k6
R3	22k
R4	11k
R6, 11	1k5
R7, 9	1k
R8, 10	47k
Potentiometers	
RV1	10k log with mounting frame
RV2	47k lin with mounting frame
Capacitors	
C1, 8	1u0 16V tantalum
C2	22u 16V tantalum
C3, 7	220n polycarbonate
C4	68p ceramic
C5, 6	2n2 polycarbonate
C9, 10	22u 25V electrolytic
Semiconductors	
IC1	RC4558
IC2	1458
Miscellaneous	
5 way connector, connector pins, IC sockets, jack sockets.	

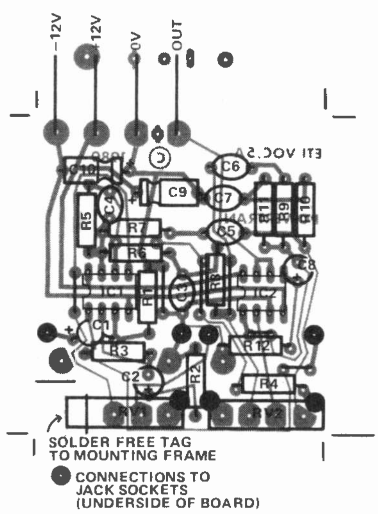


Fig.4 Component overlay of the input amplifier board.

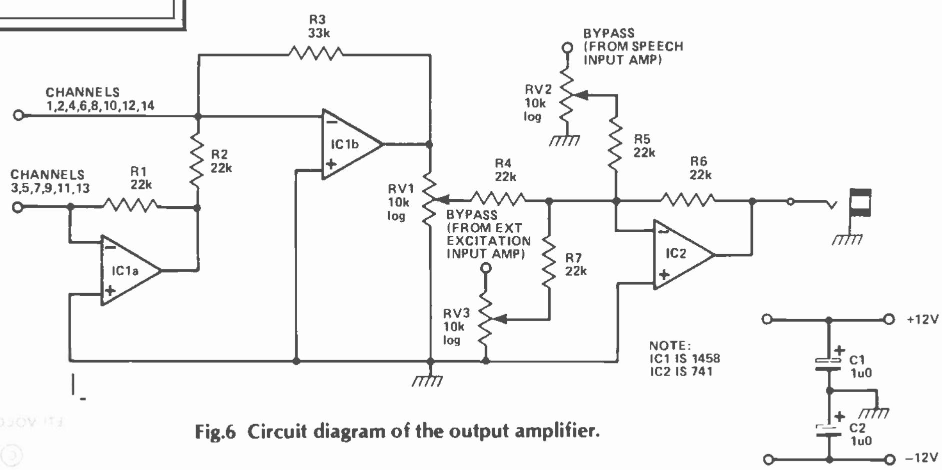
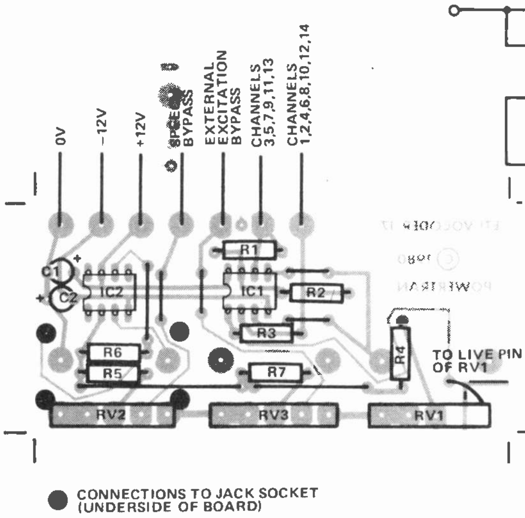


Fig.6 Circuit diagram of the output amplifier.

Fig.5 (below) Component overlay of the output amplifier board.

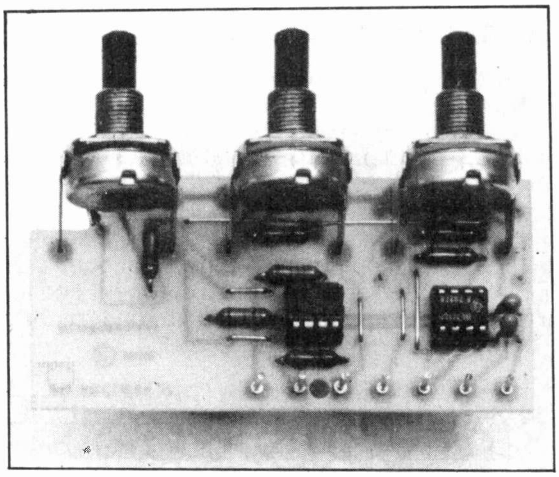


HOW IT WORKS ● Output Amplifier

Outputs from channels 3, 5, 7, 9, 11, 13 are mixed by IC1a and the inverted output mixed with the outputs of channels 1, 2, 4, 6, 8, 10, 12, 14, by IC1b. The output of this is then mixed with the speech and external excitation signals by IC2.

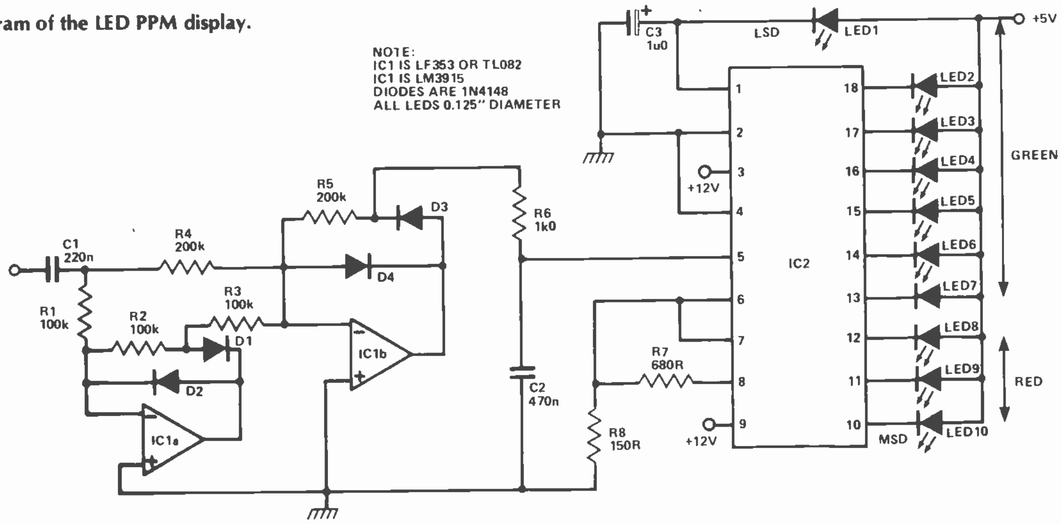
PARTS LIST ● Output Amplifier

Resistors ¼W 5%	
R1, 2, 4, 5, 6	22k
R3	33k
Potentiometers	
RV1, 2, 3	10k log with mounting frames
Capacitors	
C1, 2	1u0 16V tantalum
Semiconductors	
IC1	1458
IC2	741
Miscellaneous	
Jack socket, 7 way connector, connector pins, IC sockets.	



Output amplifier board.

Fig.7 Circuit diagram of the LED PPM display.



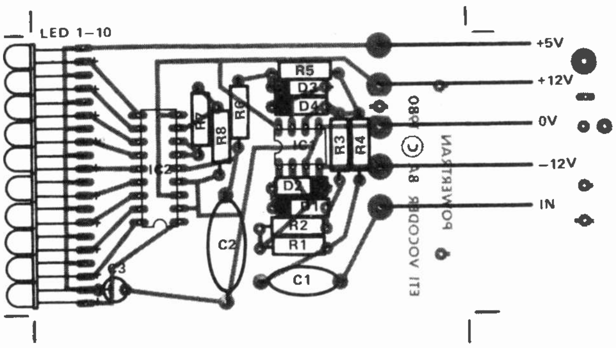


Fig.8 Component overlay of the LED PPM display board.

HOW IT WORKS ● LED PPM Display

IC1 is a full wave rectifier with peak detector charging C2 to the peak voltage of the input signal. IC1 is a logarithmic display driver, the sensitivity of which is determined by R7, 8. The LEDs are at 3 dB spacing. The red LEDs illuminate when the filters overload. The LEDs have their own power supply.

PARTS LIST ● LED PPM Display

Resistors ¼W 5%	
R1, 2, 3	100k
R4, 5	200k
R6	1k
R7	680R
R8	150R
Capacitors	
C1	220n polyester
C2	470n polyester
C3	1u0 16V tantalum
Semiconductors	
IC1	TL082 or LF353
IC2	LM3915
D1-4	IN4148
LED 1-7	TIL211 (green)
LED 8-10	TIL209 (red)
Miscellaneous	
5 way connector, connector pins, IC sockets.	

Noise Abatement

Remove the 56R resistor, turn down all the channel volume controls and the oscillators. Turn up the noise level to maximum, turn up channel 1 and adjust PR3 to the point just before the noise disappears. Repeat this for the other channels.

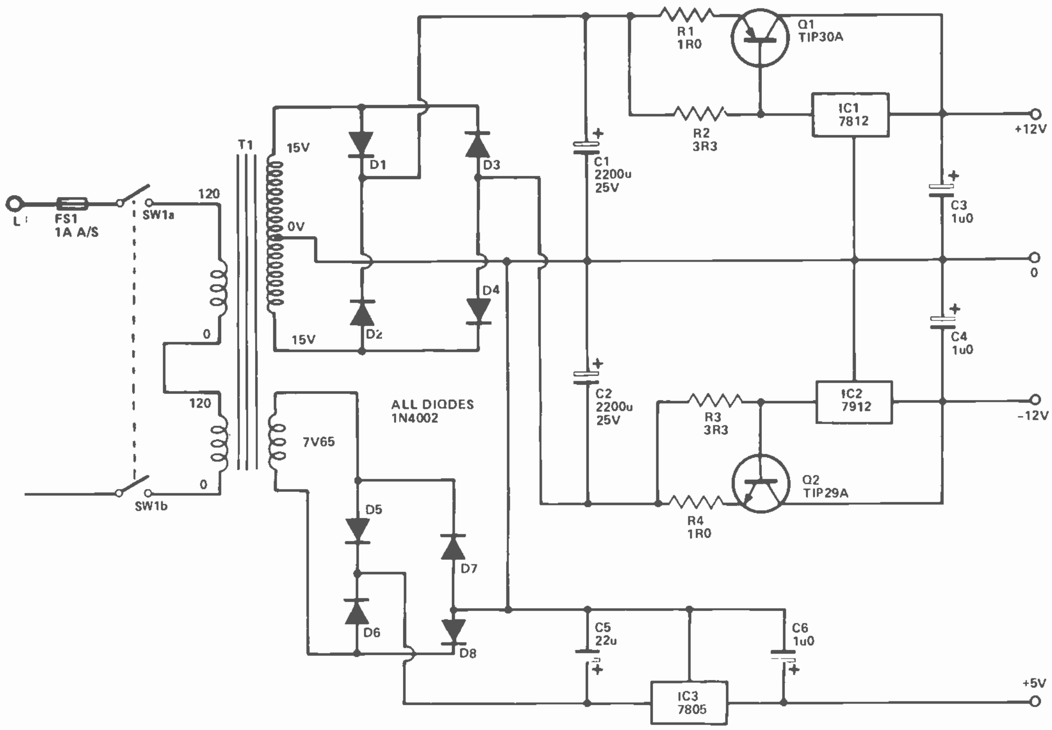
Disconnect the excitation and speech inputs from the analysis/synthesis board and temporarily connect the excitation to the speech input of the board so that noise can be applied to the analysis section. Turn up channel 1 and the noise control. Adjust PR4 for minimum breakthrough of the control signal which will be heard as a low rumble. Repeat this for the other channels and then re-connect the inputs.

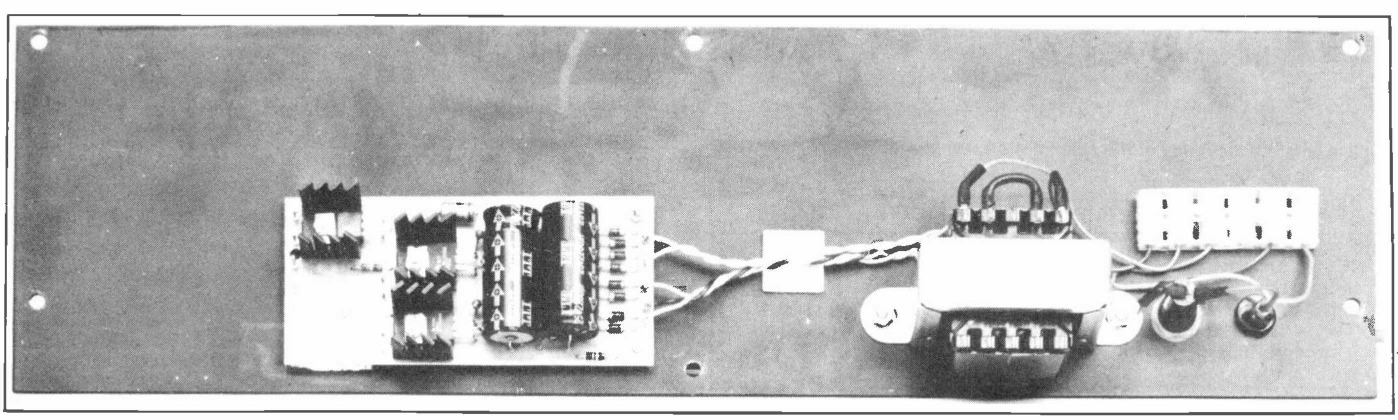
Turn on the voiced/unvoiced detector, apply a high frequency signal to the speech input and the V/UV LED will light up. Turn up all the channel volume controls and the noise control and noise will be heard. Adjust PR2 to halfway between the points where the noise is heard to start limiting. Turn down the noise control and adjust PR1 to the point where noise is just heard to disappear. Turn up the noise again and alter the frequency of the test oscillator. Adjust PR3 to where the noise level drops by about 6 dB, as indicated on the LED PPM, when the V/UV LED is illuminated.

HOW IT WORKS ● Power Supply

Raw positive DC is regulated by IC1. To reduce heat dissipation the current is shared with Q1 roughly in the proportion of R2 to R1. The negative supply is similar. The LEDs of the PPM meters have their own supply. This can be very raw indeed and smoothing capacitor C5 is very small. IC3 is used simply to limit the voltage and not regulate it.

Fig.9 Circuit diagram of the power supply unit.





The power supply unit mounted on the rear panel.

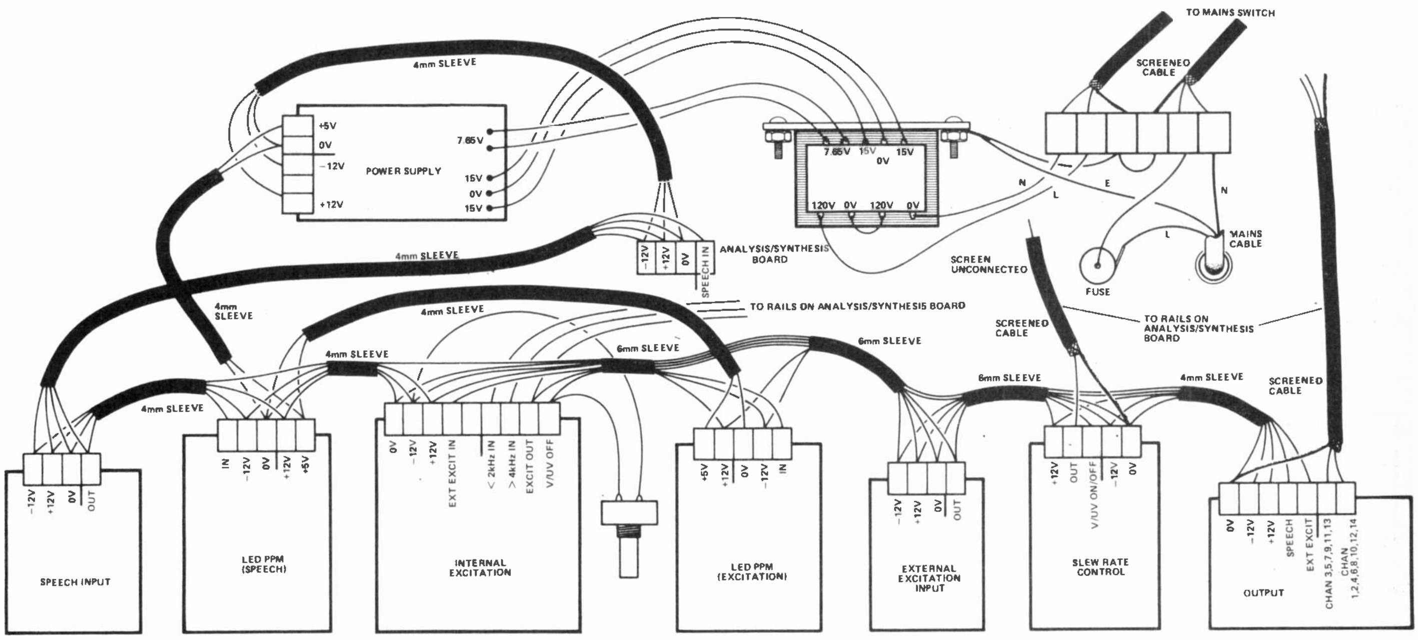


Fig.10 The job of wiring all the boards together is best tackled methodically and double checked by an impartial pair of eyeballs.

PARTS LIST ● Power Supply

Resistors ½W metal glaze	
R1, 4	1R0
R2, 3	3R3
Capacitors	
C1, 2	2200u 25V electrolytic
C3, 4, 6	1u0 tantalum
C5	22u 25V electrolytic
Semiconductors	
D1-8	1N4002
IC1	7812
IC2	7912
IC3	7805
Q1	TIP 30A
Q2	TIP 29A

Miscellaneous
Transformer 15-0-15 V at 1 A, 7V65 at 0.4 A, 5 way connector, connector pins, finned heat sinks, mica washers.

BUYLINES

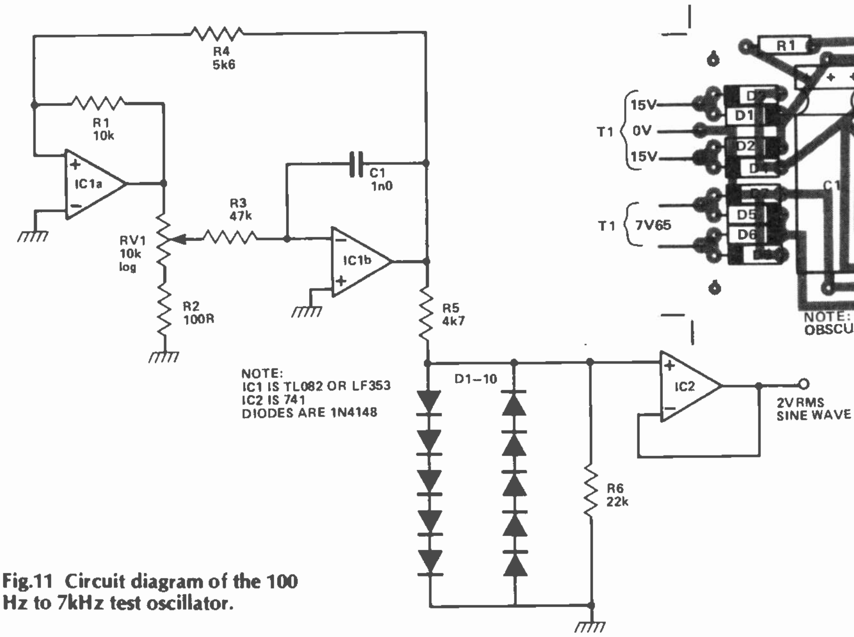


Fig.11 Circuit diagram of the 100 Hz to 7kHz test oscillator.

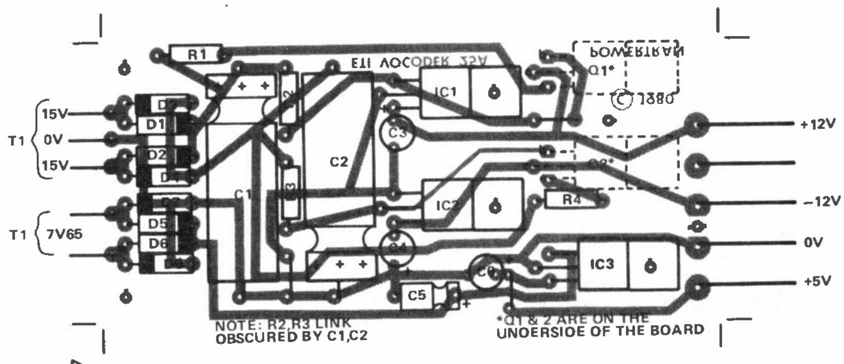


Fig.12 Component overlay of the power supply.

AUDIOPHILE

Ron Harris returns to his roots — well almost — for a look at a very promising new Thorens TD 160S turntable and has a severe shock in store for headphone owners!

Ashes to ashes. Dust to dust. Thorens to Thorens. Having launched off down the path to hi-fi many years ago in the august company of a TD 150 II turntable, it brought a whiff or two of nostalgia drifting back to lay hands on this new TD160S.

Thorens have received an indifferent press of late, mainly because some of their decks have failed to match the very high standards set in earlier days, by the 150 and 125 machines.

The standard 160 has been enthusiastically received, however, even by the usually isolationist 'cult' press. There was, though, a lot that could still be done to improve things and after some years of watching other people make money doing them, Thorens have decided enough is enough — and the TD160S is born.

Vive La Difference

Compared to a standard 160, the 'special' is more solidly constructed all around, has a massively heavy chipboard base, a better bearing system, thoroughly damped sub-chassis and improved suspension. The arm-board is also much heavier, but we'll come to *that* again later.

The standard Thorens mat has been dumped overboard and a much more sensible specimen is fitted in its place. The emphasis of the work has been upon suppression of resonance and isolation from feedback. I think the changes made show a clear enough improvement in the final sound to be immediately obvious in an A - B test, even in a crowded dealer's. Taking this into account, therefore, one is forced to consider the 160S in a higher league entirely — so it was with the greatest of expectations that I approached the packing case . . .

Set Up By The Setting Up

The deck employs the (by now) well known Thorens three point spring suspension. This method of 'floating' a sub chassis away from the base on springs has been employed by Thorens for many years, long before either the Linn or the Ariston arose to dazzle the eyes of belt-driven enthusiasts. The intent is to isolate the turntable and arm assembly from the rest of the known universe. And very effective it is too, I may say.

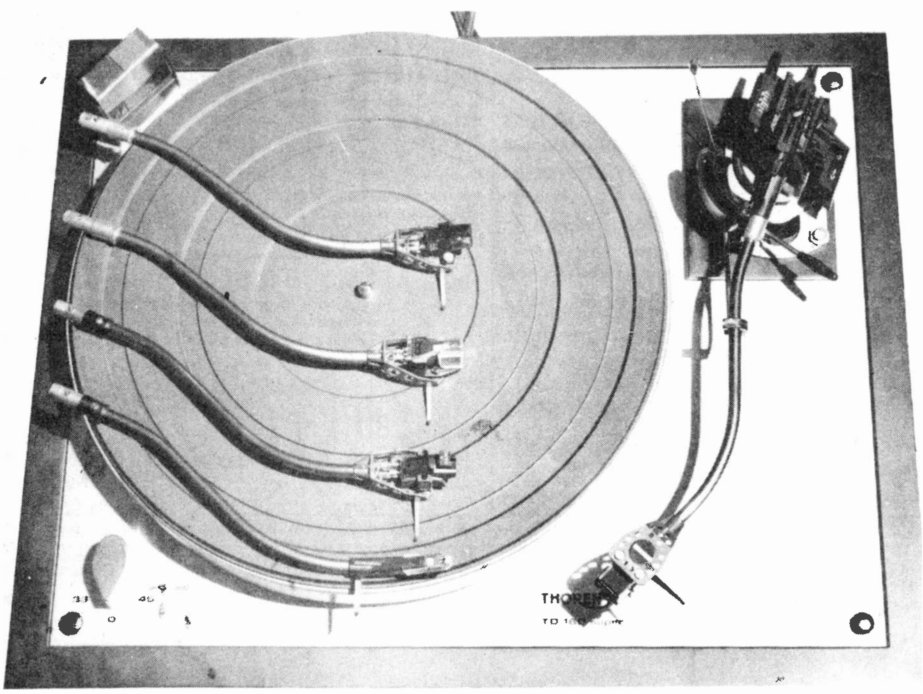
However, this apparently ultimate solution is not without some practical drawbacks. Once the chosen arm is fitted, the whole assembly must be levelled by adjustment of the three springs, which are situated beneath the deck. Which means at every step:- removing the outer turntable, upending the deck, removing the base, replacing the outer turntable and checking with a spirit level. If it is *still* not right, then it's remove the outer turntable, upend the deck . . . and so on and on ad frustratum maximum.

Once this has been achieved, the arm leads must be arranged within the plinth so that they do not re-couple the sub-chassis to the base, thus negating a large portion of the benefit gleaned from the spring suspension. This is fairly straightforward at least, but with an SME the leads are very stiff indeed, making the adjustment critical. Naturally though, SME can supply a flexible link if your patience falls short of the task.

Things That Go Bump In The Night

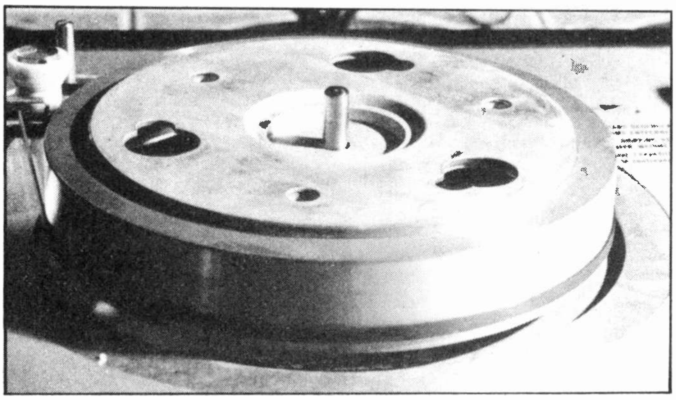
Mention of the magnificent SME brings me onto the subject of fitting said arm to this deck.

'Difficult' sums it up nicely.



Left: The 160S with SME/V15 IV installed. Note the improved turntable mat and relatively small arm-board. The base is much more massive than the standard version and the base-plate is of thick chip-board. A slot will need to be cut through this to clear an SME lead, however. The two small openings Thorens provide are simply not big enough!

Arranged across the deck are some of the pickups used in evaluating the 160S. Top to bottom these are: Goldring G900 IGC, Coral MC81, Empire 600LAC and the elegant Ortofon/SME 30H. The variation in type of sound between these units was most helpful in identifying which effects were caused solely by the 160S!



Above: The Thorens sub-chasis with outer turntable removed. Note the position of the drive belt.

The 'new improved' arm-board fitted here — and the sub-chassis — have barely enough room to accept the SME III. Barely in this case means slightly less than 1/10th of a gnat's whisker. I would strongly advise any prospective owners of this combination to shell out the required sum of £8.62 and let SME send you a fully cut board. I assure you it is a miserly sum indeed, when weighed against the blood, sweat and tears you will expend trying to be a DIY hero. You have been warned.

Come to think of it, how about supplying the SME board with the 160S, eh Thorens? All else is but dross anyway!

Failure to line up the arm *exactly* will result in the pillar not clearing the sub-chassis cut-out, which is every bit as generous as the pickup board, or just as musically, bumping away at the base every time someone breathes on the turntable.

All in all then, an enthusiast's — or a dealer's — task. Patience is the order of the day and if you fancy a TD 160S, but don't fancy setting it up, then your friendly neighbourhood dealer *should* do it for you. If he doesn't, simply find another (more) friendly neighbourhood dealer.

Down To Earth

Earthing the sub-chassis and arm means linking the earth of this to the base earth point beneath the turntable, from where a lead can be run to the amplifier — a point not well explained in the literature, I feel.

I earthed my Decca cleaning arm to the same point to keep down the number of wires trailing around. I have heard it said that use of these 'in-play' brush cleaners re-couples the turntable in the same manner as a badly arranged output lead beneath the base. Frankly, I don't go along with that at all. If the tracking brush is set up properly to a very small down force, then I cannot see that it will affect matters significantly. During listening tests I tried to identify any audible effect produced by employing the brush — and found only that it removed the dust! Really exciting that, huh?

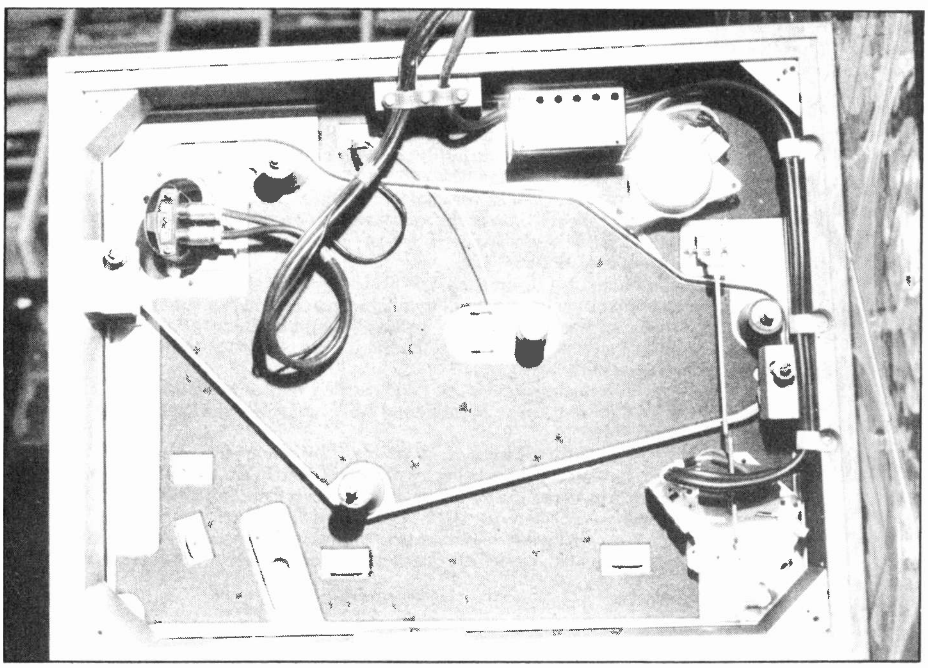
All Hands On Deck

Listening to the TD 160S was carried out with an SME III on the arm-board, and a variety of cartridges, including a Goldring G900IGC and a Coral MC81. Also a Shure V15 IV was used on most comparisons as was an Ortofon/SME 30H. Regular readers will have seen this little lot before!

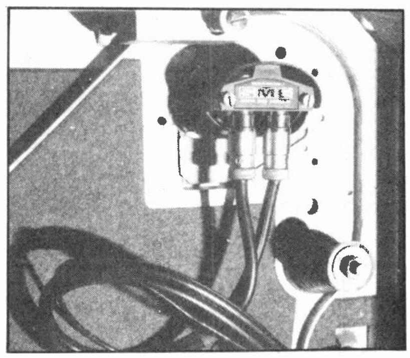
Incidently I have had some letters questioning my continued use of an SME III as a reference, when as one reader put it, "there are stacks of better arms around."

The answer to all these people lies in the fact that I personally don't think there are ANY better arms around.

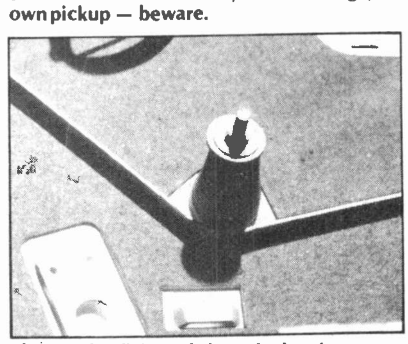
The SME is an excellently engineered, universal pick-up arm, which is as neutral as any on the market and a damn sight easier to use than most. Don't be fooled into equating tedious setting up with final quality. It does not automatically follow. The SME is a *dream* to use and offers facilities that allow for useful optimisation of the pickup cartridge in use.



Above: The TD160S revealed. The dark areas are damping compound, not applied to the standard 160. Top right is the drive motor and below that the speed change mechanism. Note the loop in the arm lead to keep the sub-chassis decoupled.



Close-up of the arm pillar. There is not a great deal of room here so if you are fitting your own pickup — beware.



Above: The fixing of the sub-chassis suspension springs. The foam plugs have been sensibly removed on this model.

A small number of top-end pick-ups have been specifically designed for arms other than the SME and will thus operate better in the designed-for carrier.

However, for universal application and sheer engineering excellence, I don't think anyone has gotten near SME yet!

So there.

Back to the plot. After the setting-up was finally concluded and the cartridges aligned I could gratefully sink into the armchair — brandy in hand — and, wiping the sweat from the editorial brow, settle down to some music.

The biggest surprise was the mid-range. With all the cartridges the 160S produced a cleaner and clearer sound than I had heard from them before. Bass was firm and well-controlled, albeit with a nagging doubt concerning the extension. Treble was unimpeachable.

Continued listening has largely removed that doubt over the bass extension and I realised on a direct A - B it was the reference deck that had a slight upper bass prominence compared to the Thorens, which set me onto the thought in the first place! Instructive things comparisons. Learn something new every time.

A Right Little Belter

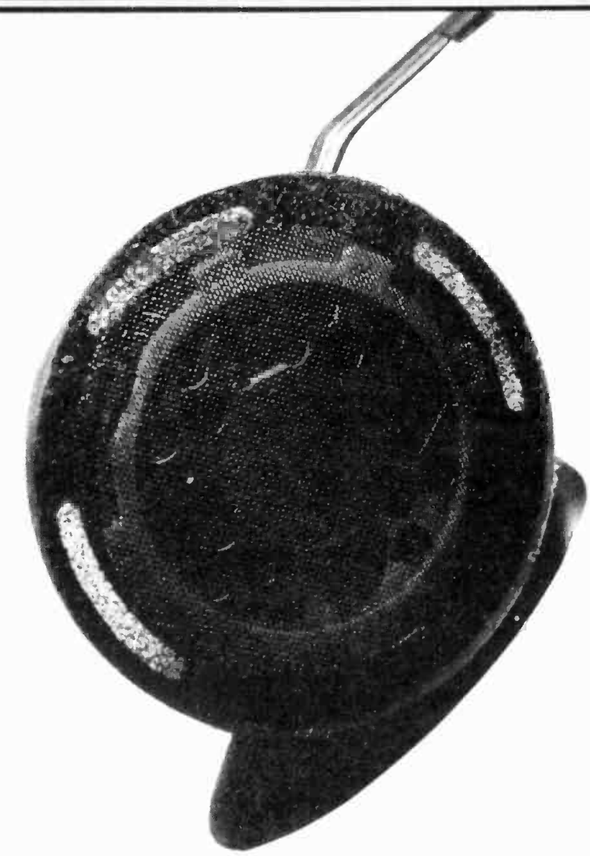
This comparison was set up with two SME III arms and two Shure V15 IV cartridges — and my warmest thanks to both firms for helping out at short notice so graciously — on the Thorens and the reference.

Even after several hours of this switching back and forth between decks I am left with nothing to be able to criticise in the TD 160S sound! It comes very, very close to being the best turntable I've ever heard and even changing the mat for a GA Audio Soundisc failed to make any improvement. If anything it muddled up the mid-range detail. Some may find it a little bland methinks — but look ye to your references gentlemen!

Taking price into account, the 160S is an excellent buy. It offers superb performance for its £140 price tag and should make prospective purchasers of decks twice the price stop and think very carefully indeed. To its price must be added, however, the need for precise setting up and a new arm-board! Still, with a good dealer neither should deter a single true audiophile.

An important addition to the ranks of hi-fi then, and I urge you to go and hear for yourself.

The reference cartridge for the comparisons was a Shure V15/IV.



Above: Close-up on the MDR-7 drive unit. The fine film driver is behind the mesh protection and can be clearly seen here. The foam earpads clip around the whole assembly and a spare set is provided.

Big Brother Is Here!

Perhaps the best-selling headphones so far in 1980 have been the Sony MDR-3s. And quite right too, many of you will say. Good value for money, they certainly are, and up to the 21st of last month I would have said the *best* value under £50. Alas this is true no longer. There is now a unit on the market whose performance far surpasses the MDR-3, adding to it a wealth of bass extension and clarity, sufficient by far to justify an asking price of around £30. These new phones are little larger than the MDR-3 and not noticeably heavier. The fit is comfortable and the sound dynamic. Their name? Why the MDR-7 of course! What else?

Since they fell into my hands I have been using them in preference to my own Koss ESP-10 electrostatics a lot of the time — and there is no better recommendation than that.

Comparing against the ESP-10s shows the MDR-7s to have a better bass extension than the Koss and to be able to accept higher levels without distress. Their mid-range is coloured with a slight warmth that can add a 'weight' to some music that is simply not there. The treble is smooth and goes a long way past your powers of hearing.

Overall, the sound is lively and detailed without being intrusive. It is easy to listen through them to the music and the comfortable fitting greatly assists matters here.

The MDR-7 will be widely available in this country from September 1st. At the same time an MDR-5 is being released which fills in the considerable gap in price between the three and the seven. I haven't heard them, but on the strength of those on both sides of them, the MDR-5s should not disappoint.

Sony apparently have no plans to bring out an MDR-9. At least not yet. At least that is what they tell me *now*. I can just see Audiophile in a year's time . . .

Conclusions

A nice production yet again. Well built and well presented. A spare set of earpads are included in the price — for when you forget to wash your ears — or just want a change of colour! Selling tag will lie around £30-35 and no doubt the MDR-7 will quickly repeat the sweeping success of its little brother. It deserves to do so, no doubt about it.

Above: The MDR-7 in use. Only one earpiece is adjustable, the other being fixed to a swivel joint to better aligh with the user's head. Cable entry is side-on and much more convenient than on the MDR-3 where it hangs awkwardly, stethescope-like, behind the ear pieces.

The MDR-7 is very comfortable in action, but must be precisely aligned with the ear for best performance.

Odds And . . . Pieces Of Turf

Next month I hope to be able to offer you a complete — cassette based — stereo system at a ludicrously low price. Negotiations continue to bring about an offer on the launch of a new range of budget hi-fi from regions east of Suez! The importers are Videotone and a pair of their excellent GB2 loudspeakers will provide the voice for the system. Everything else — amp, tuner and cassette deck bear a name you will not have heard before, Seoum, and offers 30 W RMS per channel, with good transient delivery, M/C input, FM/AM with good sensitivity, LED level metering on tape and input power and best of all a good sound quality.

Price will be under £300 complete, so if you're looking for equipment in this price area hold on a little — you could save yourself some money!

Also next month I'll be starting to run some of your letters to Audiophile as a regular feature, be they queries or just communications! So if you've anything to say on matters even vaguely hi-fi let's hear from you.

The Audiophile enquiry service will still operate for anyone with a hi-fi problem. Don't forget to give details of the full system you're using and to mark the envelope for 'Audiophile'. ETI

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Description	No.	Price
20mm x 5mm chassis mounting	506	£0.18
1¼in. x ¼in. chassis mounting	507	£0.14
1¼in. car inline type	508	£0.18
Panel mounting 20mm	509	£0.23
Panel mounting 1¼in.	510	£0.37

QUICK BLOW 20mm

Type	No.		Type	No.		Type	No.	
150mA	711	7p	1A	615	6p	3A	619	6p
250mA	612	6p	1.5A	616	7p	4A	620	10p
550mA	613	6p	2A	617	6p	5A	621	6p
800mA	614	8p	2.5A	618	7p			

ANTI-SURGE 20mm

Type	No.	Type	No.	Type	No.
100mA	622	1A	625	2.5A	628
250mA	623	2A	626	3.15A	629
500mA	624	1/6A	627	5A	630

All 8p each

QUICK-BLOW 1¼in.

Type	No.	Type	No.	Type	No.
250mA	631	500mA	632	800mA	634

All 8p each

Type	No.	Type	No.	Type	No.
1A	635	2/5A	638	4A	641
2A	637	3A	639	5A	642

All 60p each

NUTS AND BOLTS

BA BOLTS — packs of BA threaded cadmium plated screws slotted cheese head. Supplied in multiples of 50.

Type	No.	Price	Type	No.	Price
1in. OBA	839	£1.38	½in. 4BA	846	£0.37
½in. OBA	840	£0.86	¼in. 4BA	847	£0.29
1in. 2BA	842	£0.75	1in. 6BA	848	£0.46
¾in. 2BA	843	£0.52	½in. 6BA	849	£0.24
¼in. 2BA	844	£0.60	¼in. 6BA	850	£0.20
1in. 4BA	845	£0.51			

BA NUTS — packs of cadmium plated full nuts in multiples of 50.

Type	No.	Price	Type	No.	Price
OBA	855	£0.83	4BA	857	£0.35
2BA	856	£0.55	6BA	858	£0.28

BA WASHERS — flat cadmium plated plain stamped washers supplied in multiples of 50.

Type	No.	Price	Type	No.	Price
OBA	859	£0.16	4BA	861	£0.14
OBA	860	£0.14	6BA	862	£0.14

SOLDER TAGS — Hot tinned supplied in multiples of 50.

Type	No.	Price	Type	No.	Price
OBA	851	£0.46	4BA	853	£0.25
2BA	852	£0.32	6BA	854	£0.25

TRANSFORMERS

MINIATURE MAINS Primary 240V

No.	Secondary	Price
2021	6V-0-6V 100mA	£1.04
2022	9V-0-9V 100mA	£1.04
2023	12V-0-12V 100mA	£1.29

MINIATURE MAINS Primary 240V with two independent secondary windings

No.	Type	Price
2024	MT280-0-6V 0-6V RMS	£1.84
2025	MT150-0-12V 0-12V RMS	£1.84

1 AMP MAINS Primary 240V

No.	Secondary	Price
2026	6V-0-6V 1 amp	£2.88 P & P 45p
2027	9V-0-9V 1 amp	£2.30 P & P 45p
2028	12V-0-12V 1 amp	£2.00 P & P 55p
2029	15V-0-15V 1 amp	£3.16 P & P 66p
2030	30V-0-30V 1 amp	£3.97 P & P 86p

STANDARD MAINS Primary 240V
Multi-tapped secondary mains transformers available in ½ amp, 1 amp and 2 amp current rating. Secondary taps are 0-19-25-33-40-50V Voltages available by use of taps.
4, 7, 8, 10, 14, 15, 17, 19, 25, 31, 33, 40, 25-0-25V

No.	Rating	Price
2031	½ amp	£3.91 P & P 85p
2032	1 amp	£5.06 P & P 85p
2033	2 amp	£6.27 P & P £1
2035	240V Primary 0-55V @ 2A Secondary	£7.30 P & P £1

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2042 240V Primary 0-20V @ 2A Secondary. By removing 5 turns for each volt from the secondary winding any voltage up to 20V @ 2A is easily obtainable, ideal for the experimenter.
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TRANSFORMER 240v Primary 0-20v @ 2A Secondary. By removing 5 turns for each volt from the secondary winding, any voltage up to 20v @ 2A is obtainable. Ideal for the experimenter. No. 2042 **£1.50 + 86p P &P**

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3139	47MFD 35V	£0.13		3144	22MFD 16V	£0.25
3140	1.0MFD 35V	£0.13		3145	47MFD 6.3V	
3141	2.2MFD 35V	£0.14		3156	33MFD 35V	£0.13
3142	4.4MFD 35V	£0.21				

ELECTROLYTIC CAPACITORS

3185	1,000uF 25V	£0.32	3190	4700uF 25V	£0.92
3186	1,000uF 63V	£1.27	3191	4700uF 63V	£2.42
3187	2200uF 25V	£0.69	3192	2200uF 100V	£2.88
3188	2200uF 40V	£0.69	3196	100uF 100V	£0.09
3189	3300uF 100V	£3.61			

POTENTIOMETERS

CARBON POTS (Linear Track)
Single gang with wire and terminations, 6mm x 50mm plastic shaft 10mm bushes supplied with shake proof washer and nut. Tolerance 20% of resistance.

1831 1k ohms	1835 22k ohms	1839 470k ohms
1832 2k2 ohms	1836 47k ohms	1840 1 Mag
1833 4k7 ohms	1837 100k ohms	1841 2M2
1834 10k ohms	1838 220k ohms	**All at 30p each**

CARBON POTS (Log Track)

1842 4k7 ohms	1846 100k ohms	1850 wM2
1843 10k ohms	1847 220k ohms	**All at**
1844 22k ohms	1848 470k ohms	**30p each**
1845 47k ohms	1849 1 Meg	

Designed to fit 2.54mm pitch board. All tracks are linear law.
VC7

1816 100 ohms	1822 10k homs	1828 1 Meg ohms
1817 220 ohms	1823 22k ohms	1829 2M2 ohms
1818 470 ohms	1824 47k ohms	1830 4M7 ohms
1819 1k ohms	1825 100k ohms	**All at**
1820 2k2 ohms	1826 220k ohms	**10p each**
1821 4k7 ohms	1827 470k ohms	

DUAL CARBON POTS (Log Law)

1860 4k7 ohms	1864 100k ohms	1868 2M2
1861 10k ohms	1865 220k ohms	**All at**
1862 22k ohms	1866 470k ohms	**99p each**
1863 47k ohms	1867 1 Meg	

SINGLE GANG SWITCHED (Lin Law)
These potentiometers are fitted with double pole on-off switches. The switch is incorporated within the rotary action of the pot. Specification of pot is as VC1. Switch rating 1.5 amps at 250v AC.

1870 4k7 ohms	1874 100k ohms	1878 2M2
1871 10k ohms	1875 220k ohms	**All at**
1872 22k ohms	1876 470k ohms	**75p each**
1873 47k ohms	1877 1Meg	

DUAL GANG LOG-ANTI-LOG POT
1888 Track specification as dual gang pots VC3, but tracks mounted to log-anti-log action 100k ohms **£0.86.**

SPECIAL VOLUME CONTROLS
A miniature 16mm type replacement volume control, incorporating single pole on-off switch. Resistance value 5k ohms. Tolerance 20% ⅛ watt rating.
1889 **£0.31** VC8

MINIATURE ROTARY VOLUME CONTROL
5k ohms log law with on-off switch, 20mm grooved spindle. Tag connections 17mm dia. Supplied with fixing nut. Used mainly for replacement.
1890 **£0.62** VC9

WIRE WOUND POTS
A range of wire wound single gang pots with linear tracks of 1 watt rating, fitted with 10mm bush and supplied with shakeproof washer and nut.
VC6

1891 10 ohms	1895 220 ohms	1899 4k7 ohms
1892 22 ohms	1896 470 ohms	**All at**
1893 47 ohms	1897 1k ohms	**92p each**
1894 20 ohms	1898 2k2 ohms	

SWITCHED POT (Log Track)
Specification as VC2 but track having (log) law.

1879 4k7 ohms	1883 100k ohms	1887 2M2
1880 10k ohms	1884 220k ohms	**All at**
1881 22k ohms	1885 470k ohms	**75p each**
1882 47k ohms	1886 1 Meg	

PRE-SET POTS HORIZONTAL MOUNTING
Miniature type for transistor circuits. The wiper of the preset is provided with a slot for screwdriver adjustment. The tags of the preset will fit printed wiring boards with a pitch of 2.54mm. All tracks are linear law.
VC7

1801 100 ohms	1807 10k ohms	1813 1M ohms
1802 220 ohms	1808 22k ohms	1814 2M2 ohms
1803 470n ohms	1809 47k ohms	1815 4M7 ohms
1804 1k ohms	1810 100k ohms	**All at**
1805 2k2 ohms	1811 220k ohms	**10p each**
1806 4k7 ohms	1812 470k ohms	

PRE-SET POTS VERTICAL MOUNTING
Miniature type for transistor circuits. Wiper adjustment is made by a screwdriver slot.

ANTEX IRONS

1943	15 watt high quality soldering iron totally enclosed element in a ceramic shaft fitted with 3/32" bit	£4.83
1947	Replacement element for 1943 iron	£2.19
1944	Iron coated bit 3/32" for 1943 iron	£0.53
1945	Iron coated bit ⅛" for 1943 iron	£0.53
1946	Iron coated bit 3/16" for 1943 iron	£0.53
1948	General purpose 18 watt iron fitted with iron coated bit	£4.54
1952	Replacement element for 1948 iron	£2.19
1949	Iron coated bit 3/32" for 1948 iron	£0.53
1950	Iron coated bit ⅛" for 1948 iron	£0.53
1951	Iron coated bit 3/16" for 1948 iron	£0.53
1931	Highly popular x25 25 watt quality soldering iron ceramic shafts to provide near perfect insulation breakdown voltage of 1500 volts AC and a leakage current of only 3-5uA and another shaft of stainless steel to ensure strength	£4.83
1935	Replacement element for 1931 iron	£1.84
1932	Iron coated bit ⅛" for 1931 iron	£0.58
1933	Iron coated bit 3/16" for 1931 iron	£0.58
1934	Iron coated bit 3/32" for 1931 iron	£0.58
1953	SK1 soldering kit — This kit contains 15 watt soldering iron fitted with a 3/16" bit plus two spare bits, a reel of solder, heat-sink and a booklet 'How to solder'. In presentation display box	£6.38
1939	ST3 soldering iron stand. Stand made from high grade bakelite material chromium plated strong steel spring suitable for all models, includes accommodation for six spare bits and two sponges which serve to keep the soldering iron bits clean	£1.73

BIB HI-FI ACCESSORIES

O/No	Ref		Price
806	J	Compact tape head cleaning kit	£1.22
810	23	Tape Editing kit	£2.65
811	24	Cassette Tape editing and joining kit	£2.76
813	29A	Salvage cassette	£0.51
814	31	Cassette Head cleaning tape	£0.71
817	36A	Record & Stylus cleaning kit	£0.46
818	41	8-track Cartridge tape-head cleaner	£1.24
819	42	'Groove Kleen' automatic, metal record cleaner	£2.65
826	52A	Cassette storage tray (holds 10)	£0.92
827	53	Hi-Fi stereo test cassette	£3.17
829	60	Chrome finish 'Groove Kleen' (plastic)	£2.12
834	69	Anti-static Hi-Fi cleaning liquid	£0.35
838	78	Cassette fast hand tape winder	£1.50

VEROBOARD

2201 2.5"x5" .1 Copper **£0.71**	2211 2.5"x3.75" .15 Copper **£0.53**
2202 2.5"x3.75" .1 Copper **£0.61**	2212 3.75"x17" .15 Copper **£2.39**
2203 2.5"x17" .1 Copper **£2.14**	2213 3.75"x5" .15 Copper **£0.90**
2205 3.75"x3.75" .1 Copper **£0.71**	2217 3.75"x17.9" .1 Plain **£1.79**
2206 3.75"x17" .1 Copper **£2.76**	
2207 4.75"x17.9" .1 Copper **£3.61**	2218 3.75"x2.5" .1 Plain **£0.44**
2208 2.5"x1", 5 in pack **£0.85**	2219 5"x3.75" .1 Plain **£0.68**
2204 3.75"x5" .1 Copper **£0.79**	2223 2.5"x5" .15 Plain **£0.37**
2210 2.5"x5" .15 Copper **£0.64**	2225 5"x3.75" .15 Plain **£0.56**

CASES AND BOXES

INSTRUMENT CASES in two sections vinyl covered top and sides, aluminium bottom, front and back.

No.	Length	Width	Height	Price
155	8in.	5½in.	2in.	£1.72
156	11in.	6in.	3in.	£2.92
157	6in.	4¾in.	1¾in.	£1.79
158	9in.	5¼in.	2½in.	£2.43

ALUMINIUM BOXES made from bright alli, folded construction each box complete with half inch deep lid and screws.

No.	Length	Width	Height	Price
159	5¼in.	2¼in.	1½in.	£0.85
160	4in.	4in.	1½in.	£0.85
161	4in.	2¼in.	1½in.	£0.85
162	5¼in.	4in.	1½in.	£0.97
163	4in.	2½in.	2in.	£0.87
164	3in.	2in.	1in.	£0.60
165	7in.	5in.	2½in.	£1.43
166	8in.	6in.	3in.	£1.82
167	6in.	4in.	2in.	£1.18

SLOPE front aluminium boxes with black vinyl base and sides and aluminium back, top and front — strong construction easily accessible.

169	2½in.	5⅛in.	2¾in.	12in.	3½in.	8in.	£5.45
168	2⅝in.	7¼in.	4in.	16in.	4½in.	11in.	£8.21

VERO plastic case box. These boxes consist of top and bottom sections which include fixings points for horizontal mounting PC boards/chassis plates, the two sections are held together by four screws which enter through the base and are concealed by plastic feet.

No.	Length	Width	Height	Price
170	140mm	40mm	205mm	£4.14
171	140mm	75mm	205mm	£4.62
172	140mm	110mm	205mm	£6.00

AUDIO LEADS

No.	Type	Price
107	FM indoor Ribbon Aerial	£0.69
113	3.5mm Jack plug to 3.5mm Jack plug length 1.5mm	£0.86
114	5 pin DIN plug to 3.5mm Jack connected to pins 3 & 5 length 1.5m	£0.98
115	5 pin DIN plug to 3.5mm Jack connected to pins 1 & 4 length 1.5mm	£0.98
116	Car aerial extension screened insulated lead. Fitted plug and socket	£1.44
117	AC mains connecting lead for cassette recorders and radios 2 metres	£0.78
118	5 pin DIN phono plug to stereo headphone. Jack socket	£1.21
119	2 + 2 pin DIN plugs to stereo Jack socket with attenuation network for stereo headphones. Length 0.2m	£1.04
120	Car stereo connector. Variable geometry plug to fit most car cassettes, 8-track cartridge and combination units. Supplied with inlined fuse power lead and instructions	£0.69
123	6.6m Coiled Guitar Lead Mono Jack plug to Mono Jack plug Black	£1.72
124	3 pin DIN plug to 3 pin DIN plug. Lengt 1.5m	£0.85
125	5 pin DIN plug to 5 pin DIN plug. Length 1.5m	£0.85
126	5 pin DIN plug to Tinned open end. Length 1.5m	£0.85
127	5 pin DIN plug to 4 Phono Plugs. All colour coded. Length 1.5m	£1.49
128	5 pin DIN plug to 5 pin DIN socket. Length 1.5m	£0.92
129	5 pin DIN plug to 5 pin DIN plug mirror image. Length 1.5m	£1.21
130	2 pin DIN plug to 2 pin DIN inline socket. Length 5m	£0.78
131	5 pin DIN plug to 3 pin DIN plug 1 & 4 and 3 & 5. Length 1.5m	£0.95
132	2 pin DIN plug to 2 pin DIN socket. Length 10m	£1.13
133	5 pin DIN plug to 2 Phono plugs. Connected pins 3 & 5. Length 1.5m	£0.86
134	5 pin DIN plug to 2 Phono sockets. Connected pins 3 & 5. Length 23cm	£0.78
135	5 pin DIN socket to 2 Pyono plugs. Connected pins 3 & 5. Length 23cm	£0.78
136	Coiled stereo headphone extension lead. Black, length 6m	£2.01
178	AC mains lead for calculators, etc	£0.52

SWITCHES

Description	No.	Price
DPDT miniature slide	1973	£0.16
DPDT standard slide	1974	£0.17
Toggle switch SPST 12 amp 250V ac	1975	£0.38
Toggle switch DPDT 1 amp 250V ac	1976	£0.48
Rotary on-off mains switch	1977	£0.58
Push switch-Push to make	1978	£0.16
Push switch-Push to break	1979	£0.21

ROCKER SWITCH

	Colour	No.	Price
A range of rocker	RED	1980	£0.35
switches SPST-moulded	BLACK	1981	£0.35
in high insulation	WHITE	1982	£0.35
material available in a	BLUE	1983	£0.35
choice of colours ideal	YELLOW	1984	£0.35
for small apparatus	LUMINOUS	1985	£0.35

DESCRIPTION	No.	Price
Miniature SPST toggle 2 amp 250V ac	1958	£0.81
Miniature SPST toggle 2 amp 250V ac	1959	£0.86
Miniature DPDT toggle 2 amp 250V ac	1960	£0.91
Miniature DPDT toggle centre off 2 amp 250V ac	1961	£1.07
Push-button SPST 2 amp 250V ac	1962	£1.04
Push-button SPST 2 amp 250V ac	1963	£1.09
Push-button DPDY 2 amp 250V ac	1964	£1.34

MIDGET WAFER SWITCHES
Single bank wafer type — suitable for switching at 250V ac 100mA or 150V dc non-reactive loads make-before-break contacts. These switches have a spindle 0.25in. dia. and 30 indexing.

Description	No.	Price	Description	No.	Price
1 pole 12 way	1965	£0.55	3 pole 4 way	1967	£0.55
2 pole 6 way	1966	£0.55	4 pole 3 way	1968	£0.55

MICRO SWITCHES
Plastic button gives simple 1 pole change over action
Rating 10 amp 250V ac — 1970 — Price **£0.29**

All prices include VAT. Add 50p post per order — Just quote your Access or Barclaycard number
Terms: Cash with order, cheques, POs, payable to Bi-Pak at above address
Access and Barclaycard also accepted
GIRO A/C No. 3887006

SUSTAIN FUZZ BOX

For that raunchy sound beloved of electric guitarists the world over, this simple little project is just the thing.

Fuzz-tone is to guitar what salt is to meat — it adds flavour and body. The ETI Fuzz Unit has an added bonus in an in-built sustain circuit, adding a bit of extra spice to the idea. The device offers three distinctive sounds, in addition to the 'straight through' option: sustain, fuzz with sustain or fuzz without sustain.

How We Did It

To explain how these sounds are realised, we have to consider the circuit diagram.

The input amplifier, IC1, gives the system some overall gain to boost the treble response and present the correct load impedance to the instrument. The mid-range gain is set to five, allowing 1 V peak-to-peak input signals before distortion and producing the largest possible dynamic range. The frequency response is flat from 20 Hz to about 2 kHz, after which an 8 dB step provides a gentle treble boost up to 20 kHz, where the response is rolled off.

Following the input stage is IC2a, one half of an NE571 compander IC configured as a conventional compressor with a fixed compression ratio of 2:1. This compression effectively halves the dynamic range of the incoming signal by attenuating high level signals and boosting low level ones; thus the signal hangs on — "sustains" — for much longer than it otherwise would. The compression also provides a constant level drive to the clipping stage, making the fuzz sound independent of the instrument output level.

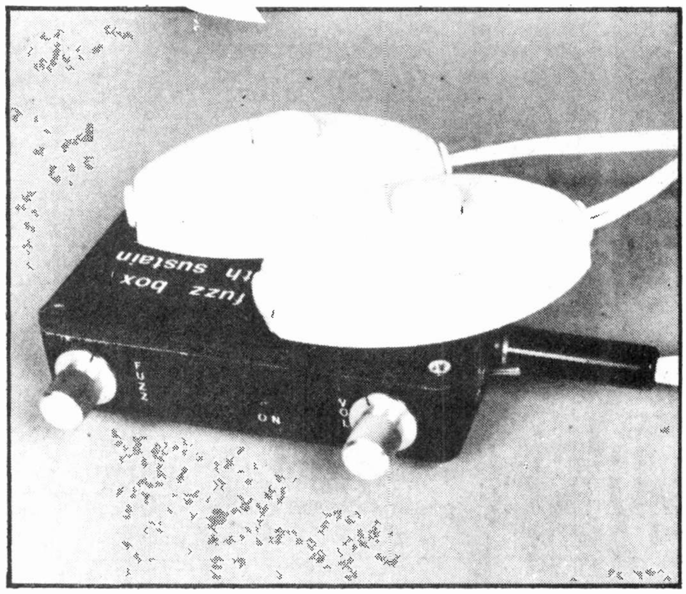
The fuzz stage, Q1, is a high gain amplifier stage. Because of the high, constant drive from the compressor it is always driven into hard clipping, resulting in an output which is substantially a squarewave. The output of the fuzz stage is fed through a tone control which varies the quality of the sound by rolling-off the high frequencies — one of the reasons for the treble boost at the input stage was to ensure that there would be some high frequencies to roll-off at this point!

Following Envelopes

The by now well-and-truly fuzzed signal is fed to the signal input of IC2b, the second half of the NE571 compander. This time the device is set-up as an envelope follower with a signal input and a control input; the output of IC2b is whatever frequencies are applied to the signal input but with the amplitude envelope of the signal fed to the control input. It is this envelope follower, plus some simple switching, which makes the Fuzz Unit so versatile — of which more shortly!

A deliberate modification to the envelope follower ensures that IC2b shuts-off completely when the signal on the control input falls below a certain level. This is a simple 'noise gate' function which prevents the amplification of low-level signals and noise, eliminating the hisses and buzzes of unwanted sounds and the squeals and howls of unexpected feedback! This function operates only when Fuzz function is selected.

The Fuzz Unit is capable of producing either sustain, fuzz with sustain, or fuzz without sustain. These variations are



achieved by selecting the appropriate output and the appropriate drive to the control input of the envelope follower.

The switching system is entirely electronic, so the guitar signal never leaves the box even if the footswitches themselves are a dozen yards away. The signal is not required to travel long lengths of cable and so is not attenuated or subject to interference. Also, single-pole non-audio type switches may be used, allowing a larger choice of switch types.

Two switch lines are used to control four electronic switches operating as two sets of change-over switches. One line controls A and B, (sustain on/off), the other controls C and D (fuzz on/off).

If neither fuzz nor sustain is selected, A and C are closed while B and D are open; the output of the unit is derived from the input pre-amplifier (so it will be a little louder and a little brighter than the guitar itself) via A and C.

If sustain is selected A and B change over and the output is from IC2a.

Selective Switching

Selecting fuzz closes D and opens C. Whether it is fuzz with sustain or fuzz without sustain now depends on the position of the sustain select switch. If sustain is selected the drive to the control input of the envelope follower is the compressed signal from IC2a; compression followed by expansion restores the amplitude envelope of the signal, so the output will have the dynamic characteristics of the original guitar sound, but will sustain for longer than usual. If sustain is not selected, the envelope follower control input is from the preamp. Therefore, the output of IC2b is the original signal expanded. Because of the value chosen for C7 and C16, the Fuzz Unit will produce a rather long 'delayed attack' effect when in

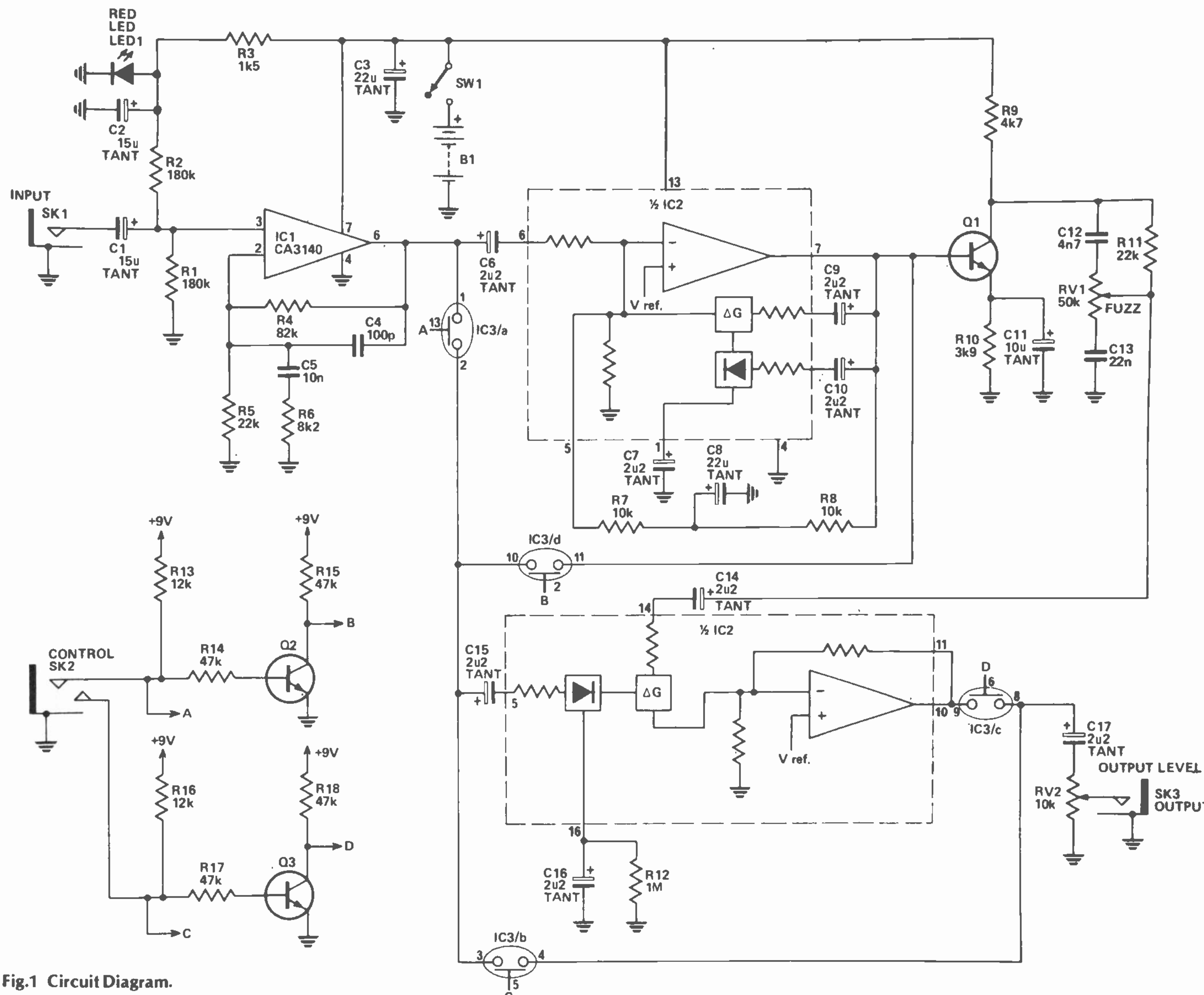


Fig.1 Circuit Diagram.

this mode. If a shorter attack is wanted, C7 and C16 should be reduced; this will give a faster attack in 'fuzz without sustain', and enhanced attack in 'fuzz with sustain'.

Once the box has been drilled, the PCB should be assembled according to the circuit and component overlay. Be sure that polarised components are correctly installed. The ICs should be put in last. Finally, make the control interconnections using the shortest possible lengths of wire.

Use insulated wire, and make sure that nothing is shorting to the box; the battery is best restrained by using a piece of double-sided tape.

After carefully checking that all connections are as they should be, apply power and you've got 'The Fuzz'.

Best results are obtained with the guitar output as high as it will go without causing distortion on loud notes when The Fuzz is switched to sustain only.

BUYLINES

Components for the ETI Fuzz/Sustain Box are readily obtainable from suppliers advertising in this issue.

HOW IT WORKS

The input amplifier (IC1) is a CA3140, chosen for its low noise. The input impedance of the device is quite high, so the effective value is determined by the parallel combination of R1, R2; the values used give end impedance of 90k. R1 and R2 can be as low as 10k or as high as 1M, as long as they are the same and within this range.

The bias for the CA3140 is filtered and regulated by R3, C2 and LED1; the LED also acts as a 'power on' indicator! The LED must be red as other colours have a different forward voltage. The stage gain of five is set by the ratio of R4 and R5, while C4, C5 and R6 tailor the frequency response.

IC2 is a dual gain control IC, NE571, which may be set-up to implement a number of signal processing functions. Each half of the IC consists of a full wave rectifier acting on the control input, a variable gain cell (signal input), an operational amplifier and a bias system. The blocks may be set-up as, for example, a compressor, an expander, a limiter or an envelope follower. The compression/expansion ratio is internally set at 2:1 while the attack and release times are determined by an external timing capacitor and an internal resistor, the attack-to-decay time ratio is internally set at 1:5.

It is possible to vary both the compression ratio and the attack/decay ratio by the use of complex external circuitry. However, the internally set values are adequate for the purpose of this gadget.

PARTS LIST

Resistors all ½W,5%

R1,R2	180k
R3	1k5
R4	82k
R5	22k
R6	8k2
R7,R8	10k
R9	4k7
R10	3k9
R11	22k
R12	1M0
R13	12k
R14,15	47k
R16	12k
R17,18	47k

Potentiometers

RV1	50k linear
RV2	10k logarithmic

Capacitors

C1,C2	15u tantalum
C3	22u tantalum
C4	100p disc ceramic
C5	10n ceramic
C6,C7	2u2 tantalum
C8	22u tantalum
C9,C10	2u2 tantalum
C11	10u tantalum
C12	4n7 ceramic
C13	22n ceramic
C14-17	2u2 tantalum

Semiconductors

Q1-3	BC548
LED1	TIL220 red or similar
IC1	CA3140
IC2	NE571
IC3	CD4016

Miscellaneous

Metal box, PCB, 9 V battery, DPST miniature switch, two jack sockets (mono), one jack socket (stereo).

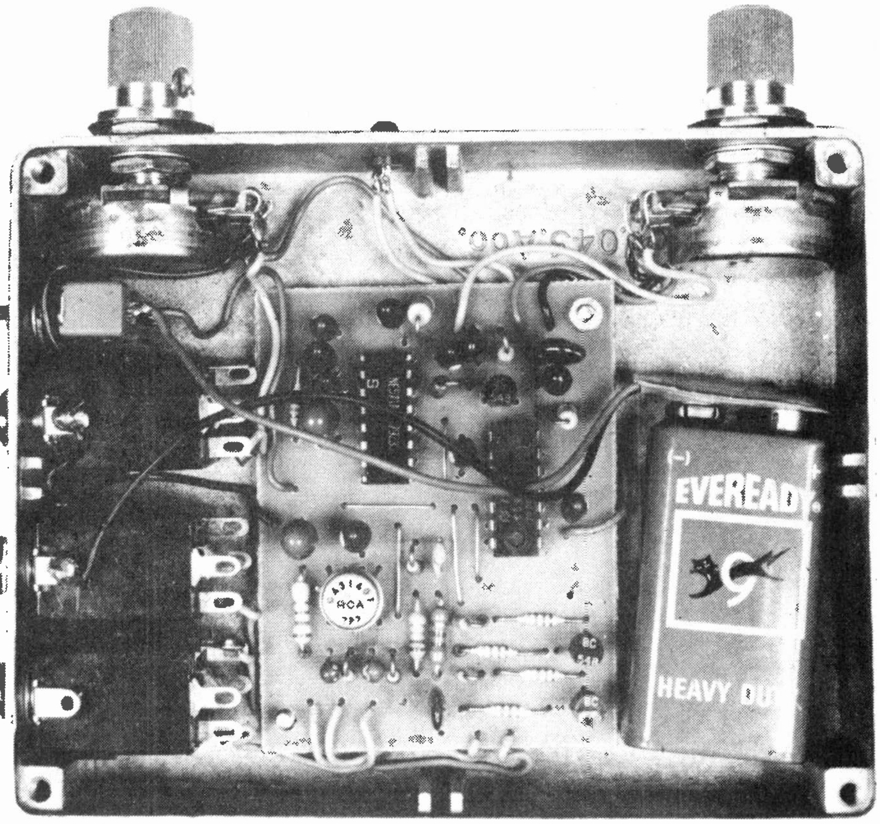
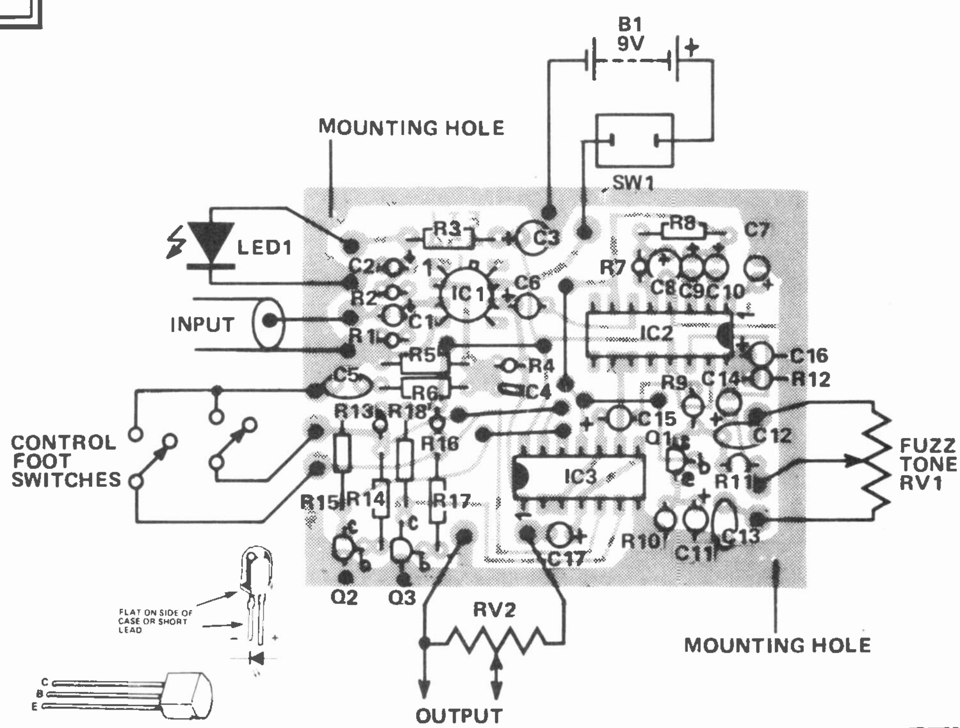


Fig.2 An internal view shows the relative positions of controls, PCB, sockets and battery. The battery can be held in place with a piece of double-sided tape. The unit can be installed in its own case as shown, or incorporated into an existing effects unit.

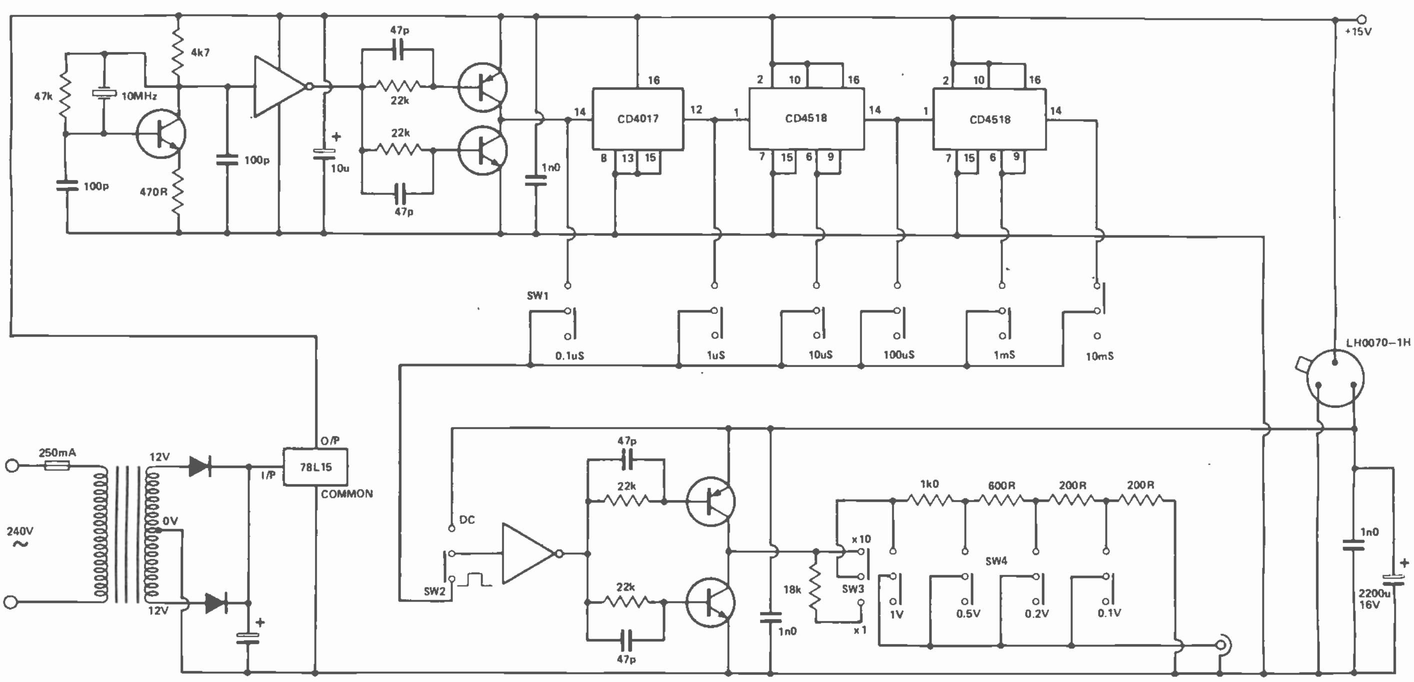
Fig.3 Component overlay. Note the orientation of IC1 and IC2; they are not mounted in the same direction. LED 1, in the bias network of IC1, is also used as a power on indicator. As the signal is switched electronically on the board, the control footswitches need not be expensive audio types.



BC547, BC548, BC549, BC557, BC558.

ETI

TECH TIPS



Scope Calibrator

M. Applebaum, London.

The oscilloscope calibrator shown has proved to be very useful for setting up the Y amps and TB ranges of most general purpose oscilloscopes. Needing no additional test equipment or adjustments the unit provides time markers from 0.1 uS to 10 mS in decade increments to an accuracy better than 0.01% and amplitude levels from 0V1 to 10 V with an accuracy better than 2%.

The calibrator is built around the DH0070-1H voltage reference having an output voltage of 10V00 ± 0.1% max. By using this as the supply to a transistor switch, the switched output level is within 1% of the reference voltage using transistor types 2N3904 and 2N3906 as the complementary switches.

The crystal controlled oscillator runs at a frequency of 10 MHz and uses a standard circuit and 10 MHz crystal. This is divided down by a CD4017 decade counter followed by two further CD451B ICs, each of which contains two BCD decade counters.

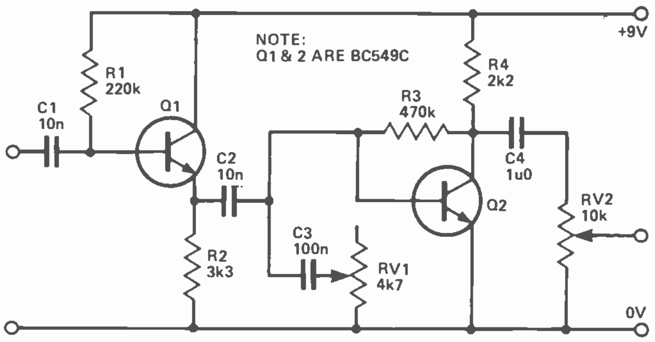
To maintain the voltage accuracy, the resistors in the potential divider chain should be 1% tolerance or better.

The output rise time is of the order of 50-70 nS, so that all leads should be kept as short as possible to avoid ringing appearing on the output voltage wave form. It is also advisable to fit 1n0 ceramic decoupling capacitors across the emitters of each pair of switching transistors.

In use, TB calibration would be effected by switching each decade of frequency and checking the oscilloscope horizontal scale at different positions of the TB range switch.

Y amp calibration and attenuator compensation should be adjusted by setting the calibrator to the 1 mS range and then adjusting the oscilloscope internal gain on the 0V1 range and attenuator compensation capacitors at each oscilloscope gain range suitably switching the calibrator output level accordingly. It should be noted that the output stage will not drive a capacitive load of more than 20 pf without distortion. Consequently a ÷10 oscilloscope probe should be utilised if a long length of screened lead is necessary between the calibrator and oscilloscope. The probe compensation should then be initially set up on the highest sensitivity Y amp range of the oscilloscope.

Tech-Tips is an ideas forum and is not aimed at the beginner. We regret we cannot answer queries on these items.
ETI is prepared to consider circuits or ideas submitted by readers for this page. All items used will be paid for. Drawings should be as clear as possible and the text should preferably be typed. Circuits must not be subject to copyright. Items for consideration should be sent to ETI TECH—TIPS, Electronics Today International, 145 Charing Cross Road, London WC2H OEE.



Guitar Treble Boost

J.R. Spink, Cleveland

Q1 is connected as an emitter follower in order to present a high input impedance to the guitar. C2, being relatively low capacitance, cuts out most of the bass and C3 with RV1 acts as a simple tone control to cut the treble and hence the amount of treble boost can be altered. Q2 is a simple preamp to recover signal losses in C2, C3 and RV1.

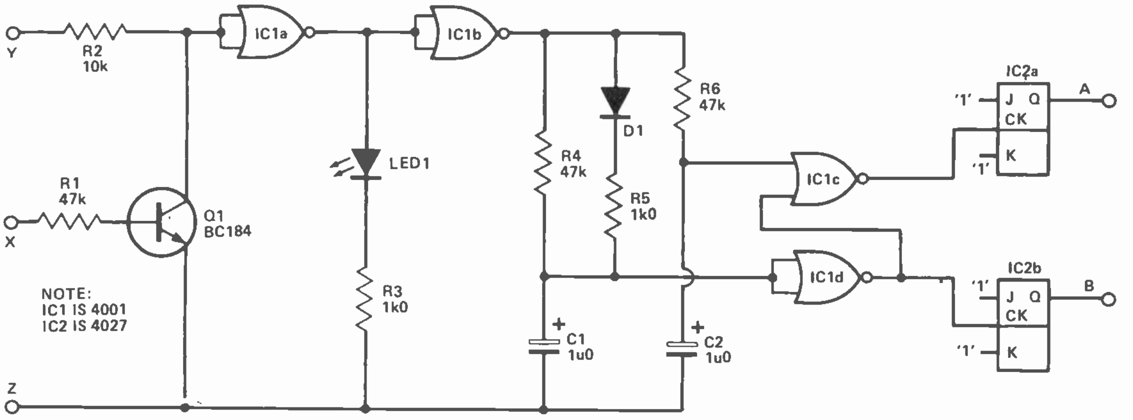
Dimmer Decoder

I. Henry, Kirkcowan

This circuit is an alternative decoder for the "ultrasonic remote control dimmer" project published in ETI June '79.

With this decoder, PB1,2 on the transmitter control two independent channels. PB1 gives a pulsed input at X and a high output is generated at IC1c; PB2 gives a high input at X and a high output is generated at IC1d. IC2 is a dual JK flip-flop, but in this case the inputs have been connected to logic 1 and the outputs of IC1c,d connected to the clock inputs of the flip-flops. In this configuration the outputs change state each time an input pulse is received, ie if A was at logic O and PB1 on the transmitter is pressed and released A will then be at logic 1.

The outputs A, B can be used via some buffering arrangement to switch relays for remote control of lights, etc.



Train Chuffer

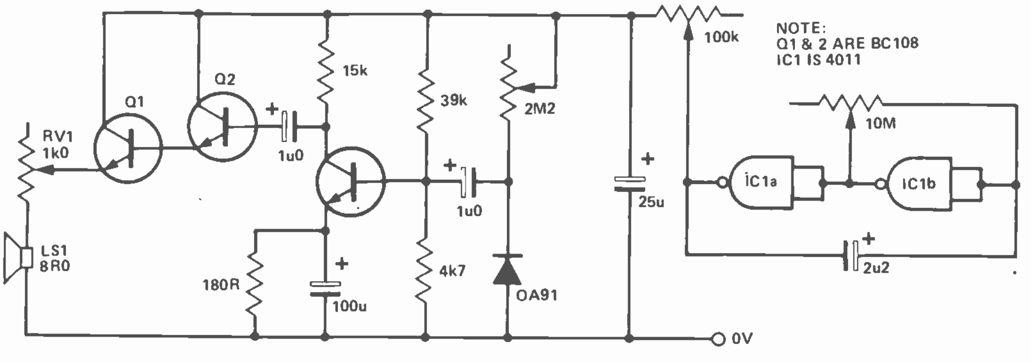
C.S. Histed, Chislehurst

This circuit will produce a 'train chuffing' noise and might prove interesting to anybody with their own train layout.

The circuit consists of a white noise generator, which only switches on with the 'high' part of the square wave output from the clock circuit. The frequency of the clock is adjusted with the 10M pot and the output voltage of the clock is adjusted by the 100k pot (these pots control the rate of chuff and the volume of the chuff).

The 2M2 pot controls the amount of noise produced and the 1k pot on the speaker controls the pitch of the average noise.

The circuit works by amplifying the amount of noise let through by the seemingly wrong way round diode and only letting the circuit be 'on' when the output of the clock is at logic 1.



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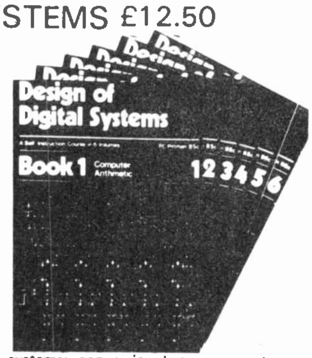

This course takes the reader to real proficiency. Written in a similar question and answer style to Digital Computer Logic and Electronics, this course moves at a much faster pace and goes into the subject in greater depth. Ideally suited for scientists or engineers wanting to know more about digital electronics, its six A4 volumes lead step by step through number systems and Boolean algebra to memories, counters and arithmetic circuits and finally to an understanding of calculator and computer design.

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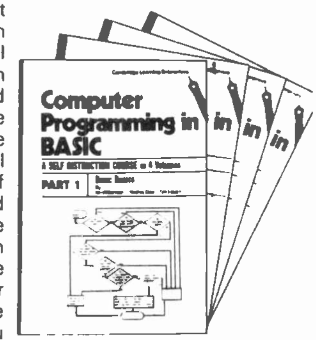

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CASSETTE INTERFACE

Use ETI's supersonic interface to store and retrieve digital data at an incredible 4800 bits per second. Design by Hugh Koanantakool.

Moderate-speed cassette systems running at speeds up to 1200 baud have been with us for some time, but unfortunately the standard setters seem to prefer a slower 300-baud Kansas City standard. 300-baud can be too slow if you have a lot of data to manipulate and is suitable only for software distribution. That is, once the original chunk of a software package has been implemented in a system, the user or owner could then make a copy of that piece of software for his (or her) normal use. This working copy should be running at the highest data-transfer rate that the owner can afford. In case of a failure in the fast working copy, the user can always fall back on the original master copy running at the slow rate. This design enables you to store and retrieve digital data using an unmodified cassette recorder at 4800 bits per second. The prototype proved to be as reliable as any 300-1200 baud systems.

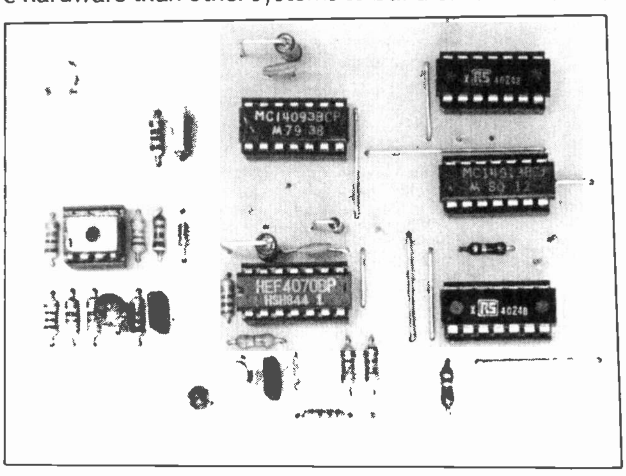
Dropout

One reason for cassette load/save failures is tape dropout — momentary loss of playback signal due to the absence of, or damage to, the ferromagnetic coating somewhere on an imperfect tape; or due to bad contact between the tape and the tape head. In audio cassettes, the tape runs at 1.875 inches a second. Thus, for a 300-baud KC (Kansas City) tape, a bit of data occupies approximately 0.00625 inches — how tiny! Any dropouts which are larger than that size will cause one or more bits of errors. The only practical solution is to use high quality cassettes which are certified or known to be originally free from dropouts. This applies to both 300-baud and the fast 4800-baud systems. From experience most tapes which are error-free at 300 baud can cope well at 4800 baud, but in the latter case, cassettes having good high-frequency specifications are preferred.

How Good?

This design aims to surpass all existing cassette interfaces in both speed and reliability, given that it should require no more hardware than other systems to build one. It should run well with an average tape recorder and cassette tapes which can cope with the KC standard or CUTS 1200-baud standard. There will be no timing adjustments. The system can be implemented on any existing serial, asynchronous communication channel and thus can be readily added to most home computers. If it becomes impossible to run the system at 4800 baud due to any reasons including those in my list of observations then you might have to slow down the data rate to, say, 2400 baud.

To do so you only have to slow down your UART (Universal Asynchronous Receiver and Transmitter) clock frequency. There is nothing else to adjust, thanks to the all-digital timing.



Phase Encoding

There is nothing new or magic about the phase encoding format for data storage on magnetic tapes. Figure 1 illustrates how it works. A logic one is represented by the 5 V level and the zero by 0 V (Fig.1b). Most tape recorders cannot record and playback slowly varying signals or DC. Therefore, a long series of ones or zeros will just come out the same if we attempt to connect the data signal (also called NRZ or Non-Return to Zero) directly to the recorder. This is because the data signal in NRZ format contains important information which is extended down to the very low-frequencies, beyond the frequency range of tape recorders.

Figure 1a shows a carrier wave oscillating at, in this case, 4800 Hz. The carrier is modulated by the data signal of Fig.1b by the following rules:

(a) The data signal is assumed to be synchronised to the carrier. This means their transitions (edges) are perfectly in alignment.

(b) The carrier wave is inverted if data is a one and normal ie non-inverted if data is a zero. The resulting modulated carrier is shown in Fig.1c.

The phase encoded signal in Fig.1c is known to contain very little energy at low frequencies and can be recorded and played back with little distortion.

Demodulation

Figure 1d shows the typical replay signal from the tape recording. Notice the rounding of all sharp edges — this is due to the high-frequency cut-off of the tape recorder. Also the high-frequency components of the signal will suffer from more attenuation than the low frequency components. By using some form of equalisation circuit, we can easily improve the signal into that shown in Fig.1e, which is now good enough for a slicer circuit to decide whether it is high or low. The sliced signal in Fig.1f is very similar to that of Fig.1c but it may or may not be inverted by the playback amplifier inside your recorder;

Construction of the board (left) should not pose any problems. The LED is on if there is no input or during normal data transfer and off if data transfer is about to take place or has just concluded.

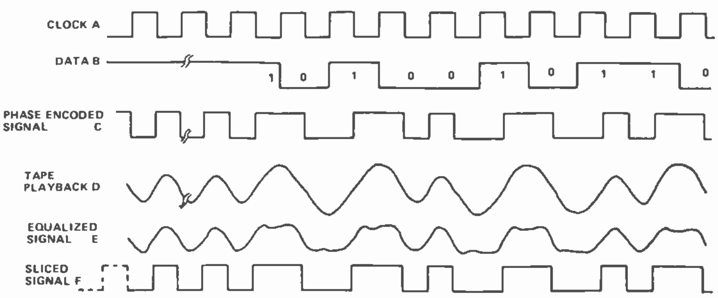


Fig.1 Timing diagram. The signal output is attentuated to about 100 mV (RMS), suitable for the mic input of most cassette recorders. A high pass filter is included to pre-compensate any loss in high frequency in the cassette. You may not need pre-emphasis capacitor C2 if you use a hi-fi deck.

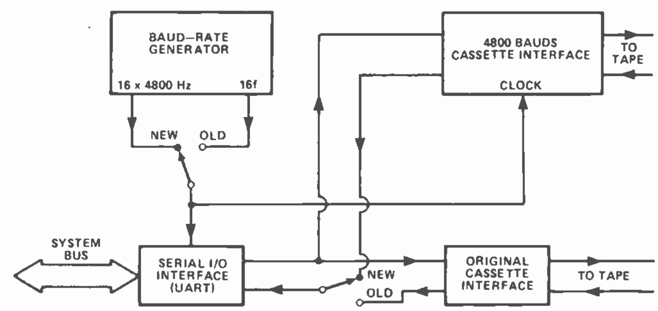


Fig.3 Adding the fast cassette interface to your system.

pulse transitions may not be so precisely timed as in Fig.1c due to tape-speed fluctuations and it is more or less independent of the playback volume control setting. We then feed the signal of Fig.1f to a digital circuit (a demodulator), which recovers the data signal (Fig.1b) from the sliced signal (Fig.1f) and presents it to the UART receiver section.

Implementation

You will probably need a "double standard" approach at least in the beginning so that tapes can be converted from the original slow rate to 4800 baud. The interface circuitry can be connected to your computer system using five wires:

- two power lines (common earth and the 5V supply),
- two serial data lines (one for transmit (dump), one for receive (load)),
- one clock line running at 16x the baud-rate, i.e. 76,800 Hz at 4800 baud.

The only assumption made is that your computer software could handle the UART at 4800 baud. Some systems may not cope with a fast transfer rate. The serial I/O by program control instead of using a dedicated UART could be too slow, or maybe the VDU or TTY is not fast enough to dump some characters, eg filenames, in real-time. However, if you are using a memory-mapped VDU (PET, Superboard II, UK101, NASCOM, etc) or your system monitor buffers the load time messages in RAM, there is no problem, since no major hardware modifications are to be made and no software or data format to be changed. The fast system has been in use since March 1979, accumulating the bit error rate to better than 1 in 10. The tape conversion process is fairly straightforward; switch your system to the original interface, load the original tape to computer, switch to 4800 baud and record the same software onto a new cassette.

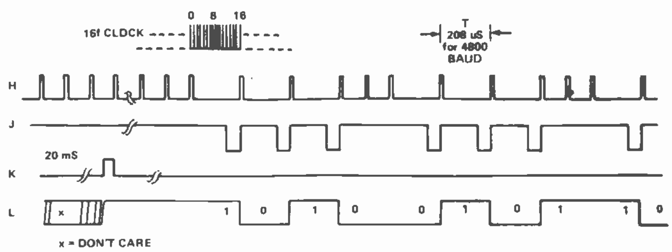


Fig.4 Timing diagram.

Postscript

After experimenting with various kinds of tape recorders it is sad to say that some cassette recorders just cannot cope with the 4800-baud system. These recorders don't work with 300-1200 baud systems anyway, (or work with persistent troubles) and they can't even play back a continuous tone steadily! That is, if you record a tone and playback, it sounds so wobbly that anyone can detect its poor speed regulation.

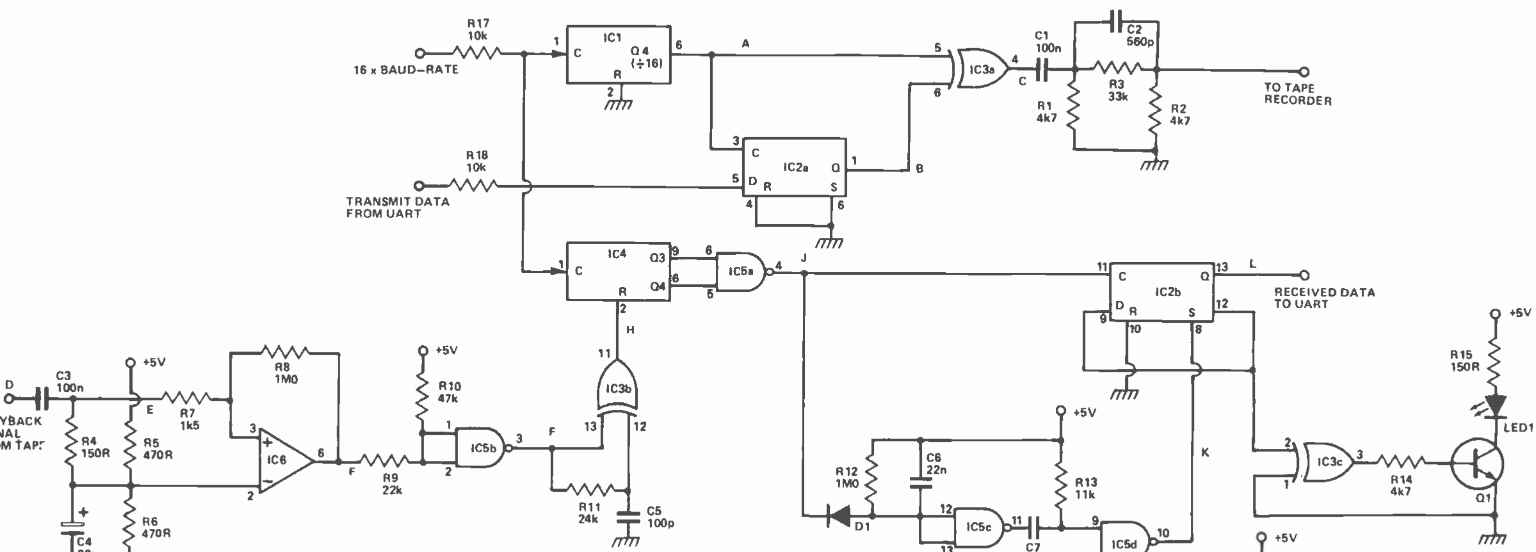


Fig.2 Circuit diagram. You may need a Request to Send (RTS) control. When the RTS output of the UART is active, the computer is ready to accept serial data from cassette interface or modem. When RTS is not used and there is no connection to IC3d pin 8, some series resistance is needed to prevent damage to the IC.

NOTE:
IC1 & 4 ARE 4024
IC2 IS 4013
IC3 IS 4030
IC5 IS 4093
IC6 IS 3140
Q1 IS BC109
D1 IS 1N4148

- ... blowing   found   - .. loading

HOW IT WORKS

The upper part of Fig.2 is the phase encoder. IC1 divides the UART clock signal by 16 to 1x baud-rate. The UART data signal is then brought to synchronism to our local clock (carrier) by means of a D-type flip-flop (IC2a). This synchronisation circuit makes sure that data transitions at IC2a always take place at the rising edge of the local clock (at A). However, if the computer data and the local clock happen to be in synchronism already, (a random choice of 1/16), this D-type flip-flop might be in trouble. In reality, this "perfect" chance of trouble never occurs, since the UART's internal ÷16 clock divider circuit works much faster than IC1, even though both are triggered by the same falling edges of the 16x clock. Thus it is sure to achieve perfect synchronisation.

The lower part of Fig.2 shows the receiver/demodulator section of the system. First the signal from the recorder's ear-phone plug is fed to IC6 via C3. The values of C3 and R4 are such that any drop in level of the high frequency signal from an average cassette recorder is equalised. IC6 then slices through the average level of the equalised signal (Fig.1e). IC6 is wired as a Schmitt trigger circuit in order to suppress the background noise during playback. The output of IC6 is further buffered by IC5b. R9 and R10 make sure that the op-amp signal is well within the input range of the CMOS gate, IC5b.

The sliced tape signal is then passed through IC3b, which is configured as a one-shot triggered by both positive and negative-going transients. Its function is to generate a short pulse at point H whenever there is a level of transition at pin 10 of IC5b. The timing diagram is continued in Fig.4 for the sake of explanation of the demodulation process. Pulses at H should be made as narrow as possible: anything shorter than 10 uS will be suitable. The pulse duration at H is proportional to the product of R11 and C5. The narrow H pulses reset the binary counter IC4, which is again clocked at 16x baud-rate. The counter outputs Q3 and Q4 are NANDed so as to enable us to detect whether its count reaches 12 or more (1100 to 1111 in binary notation). In other words, as long as the H pulses are no more than 0.75T apart, where T is the duration of one bit, the output of IC5a at J will always be a one. This is because the counter is always reset to zero before it counts to 12. At 4800 baud, T is 208 uS. Theoretically the H pulses are either 0.5T or 1T apart, corresponding to 8 and 16 counts respectively. Thus, discriminating the spacing interval by the threshold of 12 counts seems to be most logical, allowing some ±20% tape speed fluctuation. In the other case, if the H pulses are more than 0.75T apart, we will get a negative-going pulse at point J. If there are no pulses at H at all, as in the absence of the playback signal from the tape, the signal at J will be pulsed regularly at the baud-rate frequency with the mark-space ratio of 12:4.

From the timing diagrams (Figs.1 and 4), we may conclude that a "change" of the carrier phase corresponds to a change in the original data stream. This change in turn corresponds to the larger separation between successive H pulses, equal to 1T. Subsequently, long separation of H pulses is detected as a J pulse. We can, therefore, recover the original data signal from the J pulses by using IC2b, connected as a toggle flip-flop. It inverts its state upon receiving a J pulse. All seems to go well but we might still run into trouble if we happen to start IC2b wrongly and get all the data bits inverted, yet still obeying the change conditions discussed. Care must, therefore, be taken to ensure that the logic state of IC2b is always properly defined before data transfer can take place.

Fortunately, the asynchronous serial data transmission convention is such that on a UART getting ready to transmit, it always sends a series of marks (logic one). This means that we always have a steady tone recorded prior to the actual data signal. Therefore, we can preset IC2b to logic one before any transfer process commences. This function is carried out by means of IC5c and d. If the carrier is detected continuously for longer than 20 mS, the circuit will assume that this is a series of marks or logic one. It then resets IC2b accordingly. All subsequent data bits will then be demodulated with the correct polarity.

These properties are usually associated with cheap recorders. Users must avoid recorders with peak speed-fluctuations well over ±20%, our required tolerance. Poor speed-regulation of a new recorder is associated with the lack of motor-regulator circuit, but it can also happen to a more costly recorder if the pinch-roller has been deformed, eg by leaving the machine off in the play position for a long time.

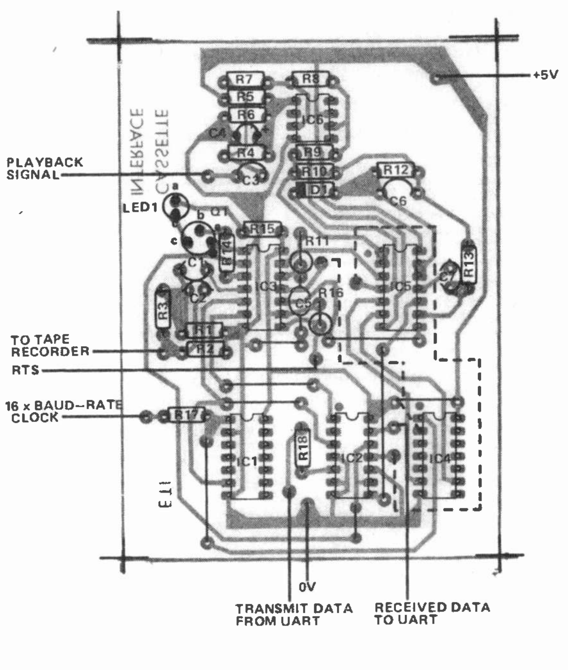
To sum up, the 4800-baud system may not work with all recorders due to the following reasons, in order of seriousness:

(a) recorder transport mechanics — you need a recorder that can at least reproduce clean steady tone,

(b) tape quality : use tapes which are better than just a "low-noise one, eg "Super Dynamic", "High Frequency", etc,

(c) recorder bandwidth — you tend to get more bandwidth from a radio-cassette than a hand-held recorder.

If your system has an RTS line and you are using it to control the cassette's motor, then you may also use it to control the received data line of this interface as well. When there is no input signal from the recorder, the idling sequence at point L (Fig.2) is 1010101, which is a series of the valid ASCII 'U' characters causing over-run error in the UART. This error is normally reset by the tape loader routine before the data transfer takes place. A normal way of tape loading is to type into the computer, specifying a tape load command, start playing the cassette recorder until you hear the header tone (continuous 4800 Hz) then type RETURN to start loading. The presence of the continuous tone is also indicated by the LED going off temporarily. However, if you happen to get a monitor which does not reset the UART (eg the UK101), then you need to get rid of the 1010101 . . . pattern by means of the RTS line. With RTS line low (no request for data transfer) the LED is also off and the data output line is kept high and no longer causes overrun errors.



- - - - - = INSULATED LINK ON UNDERSIDE OF PCB

Fig.5 Component overlay.

PARTS LIST

Resistors ¼W, 5%		C2	560p ceramic
R1,2,14	4k7	C4	22u 25V tantalum
R3	33k	C5,7	100p ceramic
R4,15	150R	C6	22n polycarbonate
R5,6	470R		
R7	1k5	**Semiconductors**	
R8,12	1M0	IC1,4	4024B
R9	22k	IC2	4013B
R10,16	47k	IC3	4030B
R11	24k	IC5	4093B
R13	11k	IC6	3140
R17,18	10k	Q1	BC109
		D1	1N4148
Capacitors		LED1	TIL209
C1,3	100n ceramic		

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2N3006	5p	MC4001	15p	MC4049	35p	TIS93	10p	4013	30p
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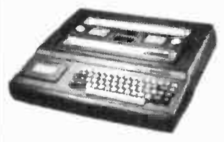

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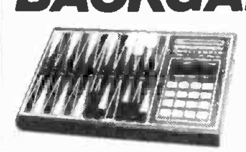

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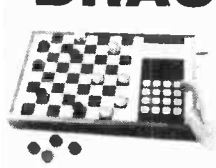

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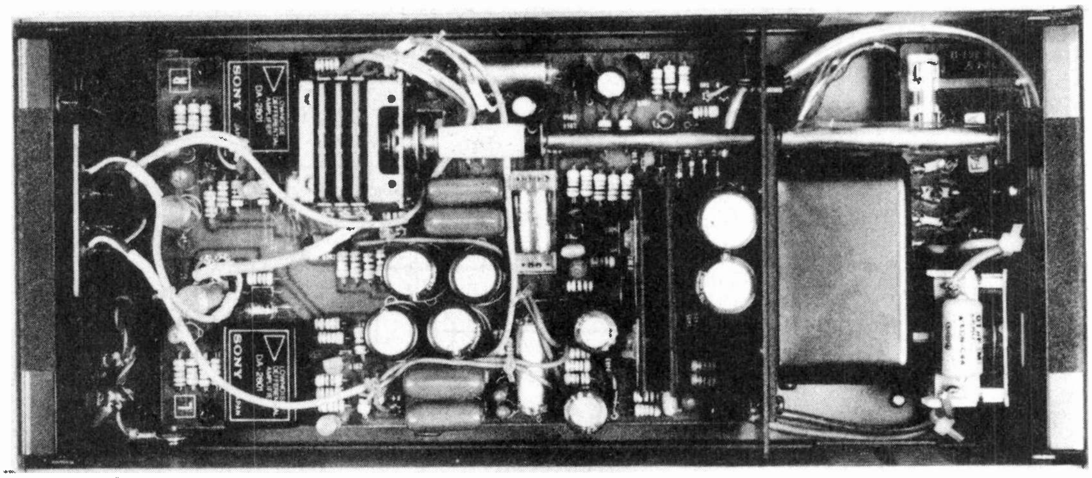
HEAD AMP DESIGN

Videotone's Andy Sykes rounds off his head amp design guide with a few words on the dreaded mains hum.



The head amplifier design published in ETI in January is a good example of a differential input stage (Fig.1), which also makes use of a symmetrical output stage. A different approach is shown in Fig.2, that of the Videotone H300 amplifier. This is a refined version of the circuit in Fig 6 (last month) and is based on a simple parallel transistor pair.

Eight transistors are used for Q1 and two for Q2 and a bootstrap capacitor is employed to increase the open loop gain and so keep the distortion well below the noise level.

Trickle Charge

The design also features switchable gain and input capacitance to allow many different cartridges to be catered for. The commercial unit is powered by a rechargeable battery which is put on trickle charge when the head amp is switched off. This neatly removes both the need for a sophisticated mains power supply and the tedium of changing batteries.

De-Thumper

Any output spikes produced on power up or down, so prevalent in other designs, are also eliminated by the use of a darlington pair to slowly raise and lower the supply rail when the power switch is operated. The time constant of this rise and fall is far greater than any others in the circuit and so the unit switches on and off without damaging your precious speaker cones if you inadvertently leave the volume turned up.

Another advantage of this particular configuration is that the feedback resistor provides the bias for the first stage so that potentially noisy input bias resistors are not required. The common emitter second stage gives a low output impedance, which enables relatively long signal leads to be used and renders variations in main amplifier input impedances unimportant. The frequency response extends well up into the MHz region to reduce susceptability to RF pickup and note also the use of an inductor in the supply line. It also sounds good, though perhaps I am a little biased.

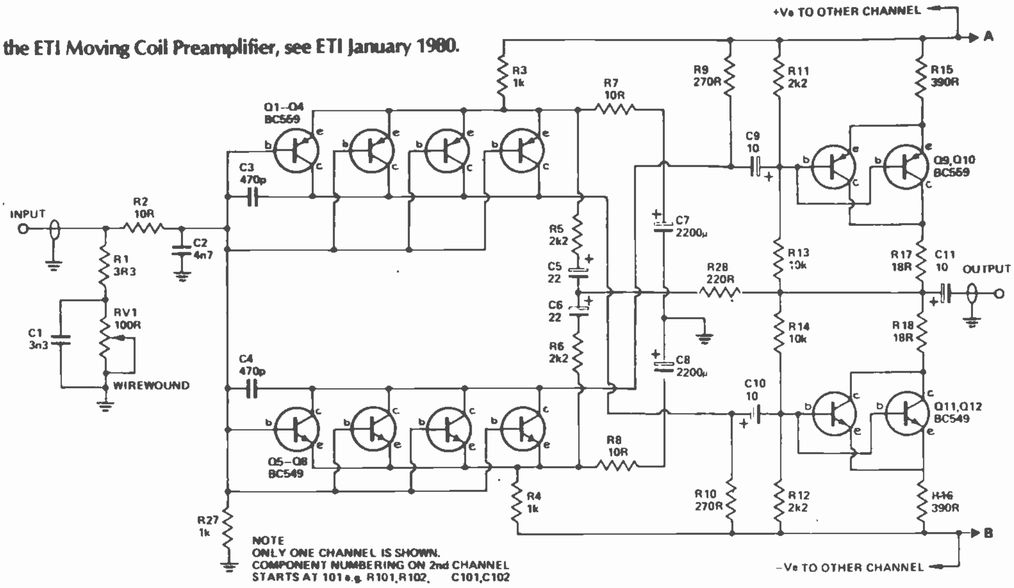
Mains Hum

The final point to be discussed is the bane of any audiophile's life, the dreaded mains hum. Oh for the DC supplies of yester-year. As with any other piece of sensitive electronics great care with screening and earthing arrangements must be taken to keep the hum gremlins at bay. The ideal case would be made of Mu metal, an alloy with particularly good screening properties, but this is not very cosmetic. If your head amp is to stand any chance of holding its own against the acres of brushed aluminium which enclose the average Hi-Fi, a smart but substantial aluminium or steel case is the next best thing.

Earth Loops

Connections to and from the head amp should be such that earth loops are avoided. Figure 3 illustrates one possible way of doing this, the turntable earth being separated from the signal earth to avoid hum pickup from the motor. It may also be necessary to tie the amplifier chassis down to a good earth

Fig.1. For full details of the ETI Moving Coil Preamplifier, see ETI January 1980.



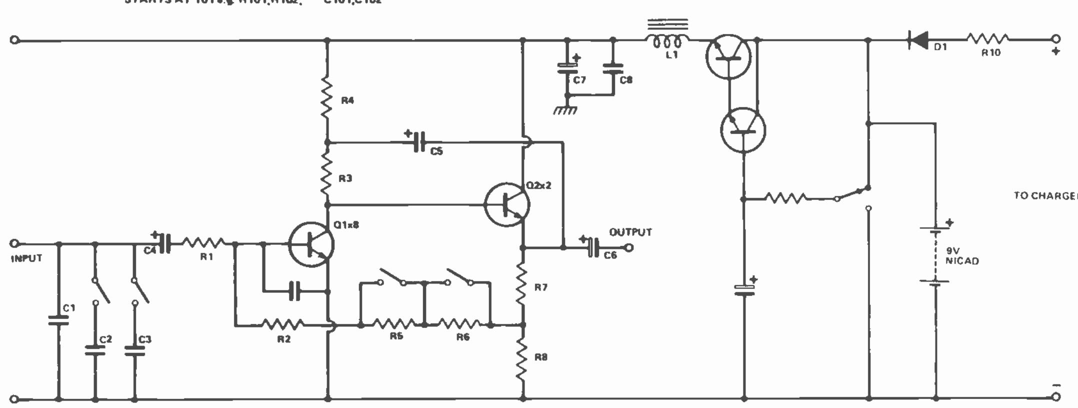


Fig.2. The Videotone H300 uses a different approach from the ETI design.

if it follows the modern trend of possessing a two-core mains cable. If your house wiring earth is not good enough, a passing water (not gas) pipe should be pressed into service, or even a length of copper pipe sunk into the back garden.

There is a case of a house with such bad earthing arrangements that the GPO telephone engineers not only resorted to sinking a rod in the garden, but instructed the occupants to water it before making a call in order to keep the telephone line from fading away.

Mains-Shy

A certain amount of experimentation may be necessary to obtain the best position to site the Head Amplifier. Keep it and all signal leads away from potential sources of electromagnetic radiation such as mains cables, amplifier transformers and electric motors. I know that all this is pretty boring stuff which all good Hi-Fi buffs have known since they were knee high to a volume control, but introducing a Head Amp to your Hi-Fi does increase the system gain by a further factor of 30 and so precautions against hum pickup must be correspondingly greater.

If you do plump for a mains powered design, a separate case away from the amplifier circuit will almost certainly be required. This supply should be as well regulated and decoupled as possible (the use of the various IC voltage regulators here is highly recommended). Long supply leads are a potential source of RF pickup so remember to decouple at high frequencies as well on the supply line as near to the amplifier circuit as possible. Again the use of an inductor in the supply lines is recommended.

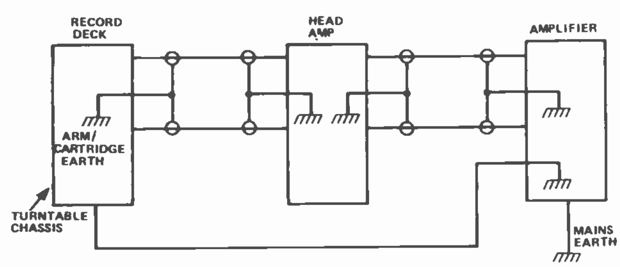
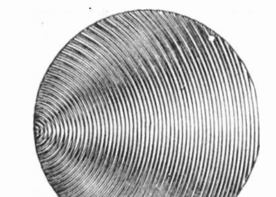


Fig.3. One possible way of avoiding earth loops.

Memories are Made of This

So there we have it, an albeit potted guide to Head Amplifier design, but it should point budding designers in the right direction, avoiding the more obvious pitfalls. It is well worth the time and effort expended on producing a head amp because, although the sound extracted from the record groove by a good moving coil cartridge is not startling when compared to a moving magnet of similar price, it is the subtleties of reproduction that are conspicuous by their absence; once heard, always hankered after. Even my wife can tell the difference and her normal assesment of any piece of Hi-Fi I bring home is based upon its ability to collect dust or support a plant pot. I am winning, though, slowly..... very slowly.

ETI



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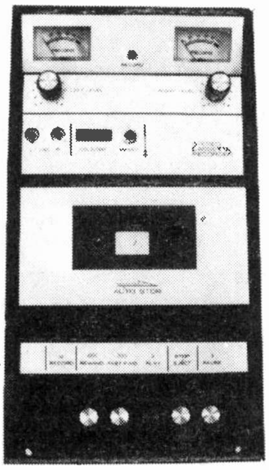

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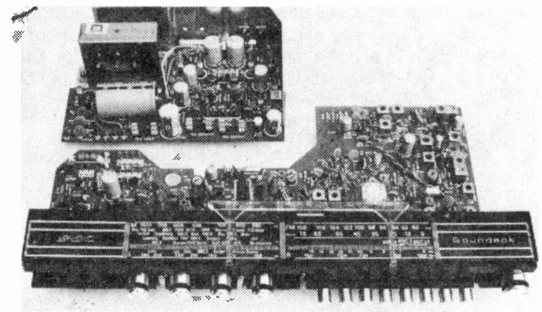

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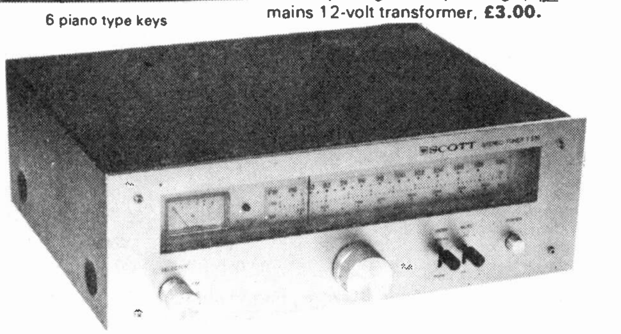

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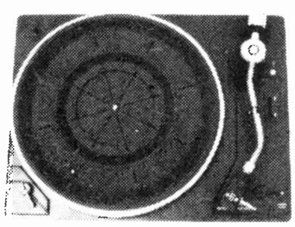

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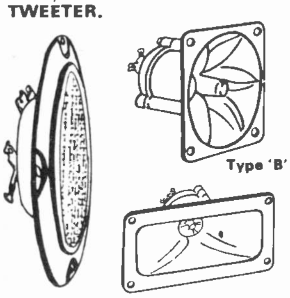

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DESIGNER'S NOTEBOOK

Ray Marston devotes this month's 'Notebook' to a discussion of practical temperature-sensing switches, alarms and metering circuits.

Temperature-sensitive circuits such as thermo-switches, alarms and electronic thermometers are amongst the most popular and common of all projects published in the technical Press. Such projects may use thermostats, thermistors or semiconductor devices as their basic temperature-sensing elements: each of these types of device has its own advantages and disadvantages and presents the electronics engineer with particular design problems. This month's 'Notebook' is devoted to a discussion of some of these problems.

Thermostats

The easiest way to implement a thermo-switch project is to use a commercially available thermostat of the type used in central heating systems, for instance, as the switching element. These devices usually take the form of a bimetal strip that closes a pair of contacts when the temperature falls below a preset 'trip' level, the level usually being variable over a limited range via a calibrated control.

The trip levels of these thermostats are usually accurate to within a degree or two and the devices give an adequate performance in most practical applications. They are simply wired in series with the switched load, as shown in Fig.1a, so that power is fed to the load when the temperature falls below the trip level.

You can reverse the action of a standard thermostat, so that power is fed to the load when the temperature rises above the trip level (contacts open) by using the simple circuit of Fig.1b. Here, when the contacts are closed the output of the inverting CMOS gate is driven low, so Q1 and the relay are off and zero power is fed to the load via the RLA/1 contacts. The circuit consumes a standby current (via R1) of only a microamp or so under this condition. When the thermostat contacts open, the input of the gate is pulled low via R1, so Q1 and RLA are driven on and power is connected to the load via the RLA/1 contacts.

Thermistor Circuits

Thermistors are simply resistive elements that are subject to fairly large changes in resistive value with small changes in temperature. They are ideally suited to use in sensitive or 'precision' thermal switching applications. The devices come in a variety of styles, but we'll concern ourselves here with inexpensive negative temperature coefficient (NTC) carbon-rod types only; a quick scan of component suppliers catalogues will show that these devices are readily available with a variety of resistance values at a variety of temperatures.

Figure 2 shows how you can use an NTC thermistor to make a precision under-temperature or 'frost' switch. Here, TH1 PR1 and R1-R2 are wired in the form of a bridge that is

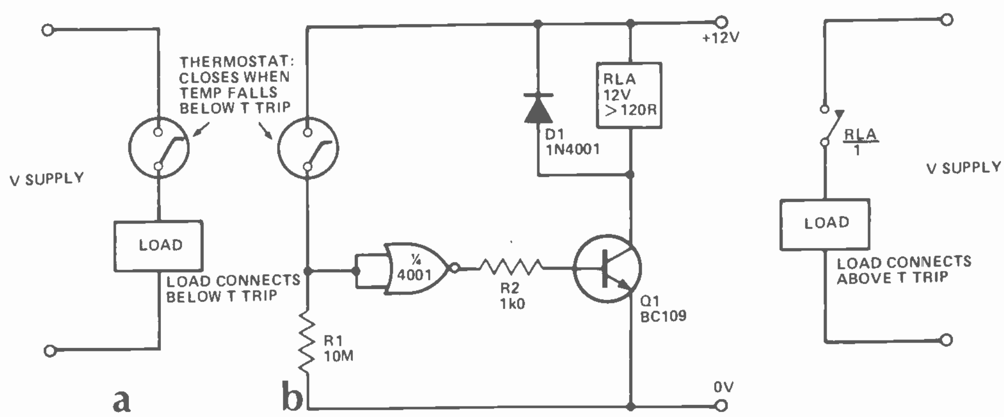

Fig.1 The effective switching action of a thermostat (a) can be reversed by using the circuit shown in (b).

almost balanced (via PR1) at the required trip temperature and the op-amp is wired as a voltage comparator with its output driving the relay via Q1. At temperatures below the trip level the pin 3 voltage of the op-amp output is driven to negative saturation and Q1 and the relay are driven on. At temperatures above the trip level the reverse action is obtained and the op-amp output is driven to positive saturation and Q1 and the relay are cut off.

The action of the Fig.2 circuit can be reversed, so that the circuit acts as an over-temperature switch, either by transposing the pin-2 and pin-3 connections of the op-amp or, as in the case shown in Fig.3, by transposing the TH1 and PR1 positions.

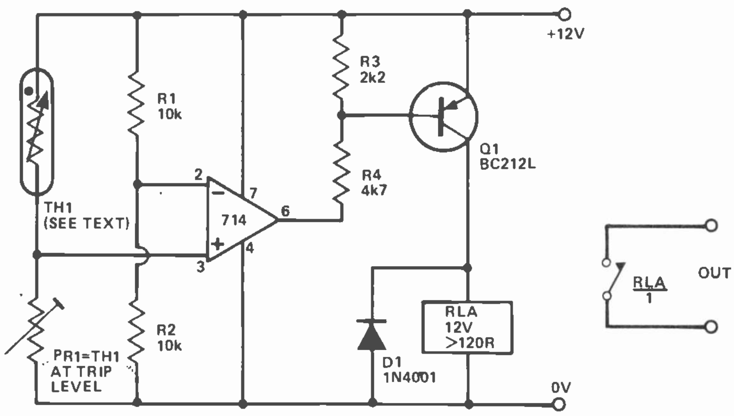

Fig.2 Precision under-temperature or 'frost' switch using thermistor sensor.

Two Into One

Figure 4 shows how the above two circuits can be used together to make a combined over/under-temperature switch in which the relay turns on if the temperature (of TH1) goes above a limit set by PR3 or below a limit set by PR2.

Note in the above three circuits that TH1 can be any NTC thermistor that exhibits a resistance in the approximate range 500R to 9k0 at the desired mean 'trip' temperature.

Finally, Fig.5 shows how an NTC thermistor can be used to make a direct-output alarm-call generator that produces a powerful fixed tone if the TH1 temperature falls below a level

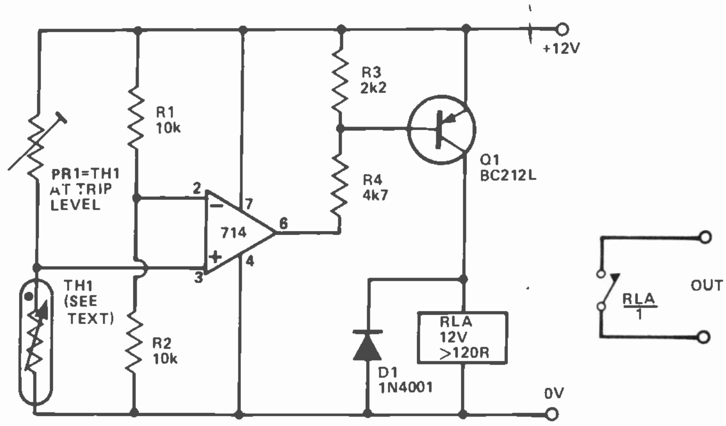

Fig.3 Precision over-temperature switch using thermistor sensor.

preset via PR1. The op-amp is wired as a conventional astable (with its output boosted by Q1-Q2), except that PR1-TH1 act as a potential divider between the output and pin-2 input of the op-amp and prevents the circuit from oscillating when the resistance of TH1 is below that of PR1. The action of the circuit can be reversed, so that it acts as an over-temperature alarm, by simply transposing TH1 and PR1. In either case, TH1 can be any NTC type that has a value in the range 2k0 to 2M0 at the required trigger temperature: the operating frequency of the astable can be changed by altering the C1 value.

Diode Sensors

Ordinary silicon diodes have junction temperature coefficients of about −2 mV/°C when forward biased and can thus usefully be employed as temperature sensing devices. Major advantages of such diodes are that they give readily repeatable and consistent results and, because of their small masses, have fairly rapid thermal response times. A major

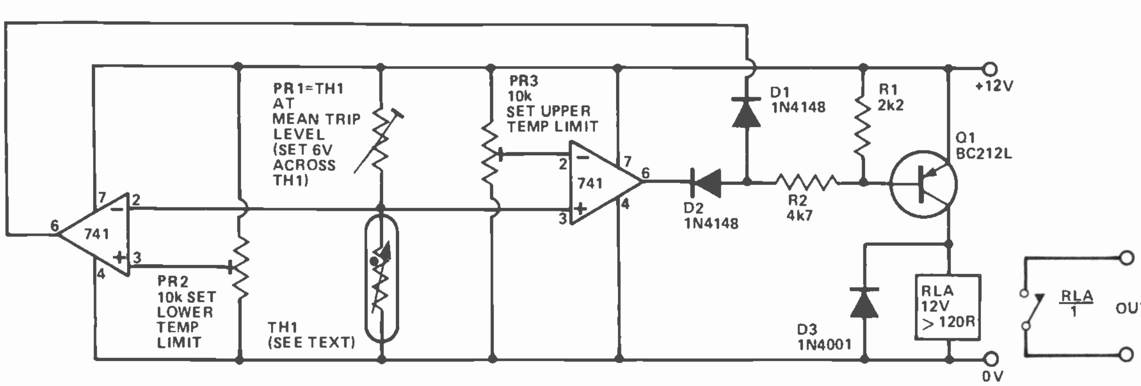

Fig.4 Method of combining the Fig.2 and 3 circuits to make a precision over/under temperature switch with independently adjustable upper and lower trip levels.

disadvantage is that their forward voltages are normally large compared to normal temperature-change values and are highly dependent on forward current: Typically, V_f values may be 630 mV at 1 mA and 660 mV at 2 mA, giving a nominal 3 mV V_f change (equal to to a 1.5°C error) with a 10% change of forward current.

Figure 6 shows how a pair of 1N4148 (or similar) diodes can be used to make a differential temperature switch in which the relay turns on when the D1 temperature rises above that of D2. The circuit is responsive to the relative, rather than the absolute, temperatures of the two diodes. PR1 enables the differential trip levels to be varied over a limited range.

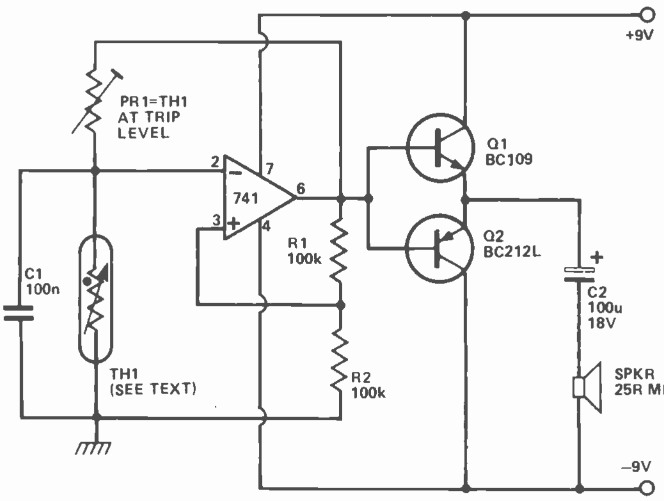

Fig.5 Direct output under-temperature alarm produces a powerful tone signal when temperature falls below a value preset by PR1. The circuit can be converted to an over-temperature alarm by transposing TH1 and PR1.

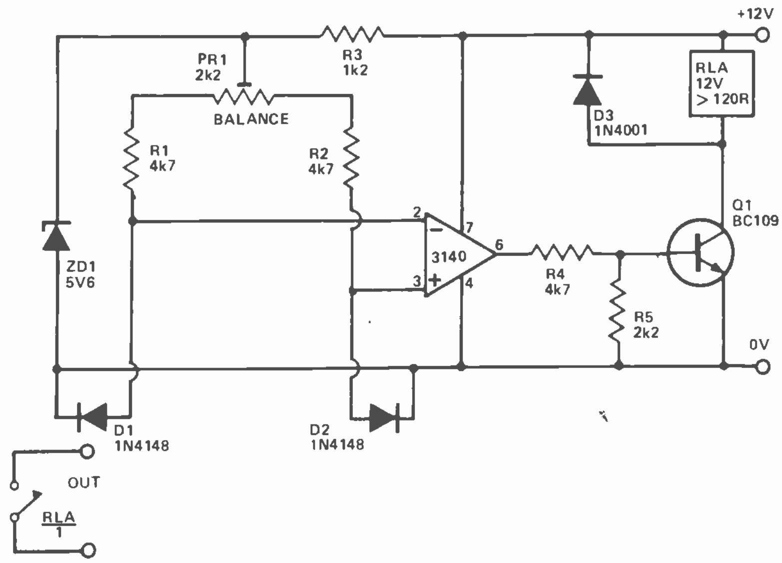

Fig.6 This differential temperature switch uses diode sensors and turns RLA on when the D1 temperature rises above that of D2.

ETI

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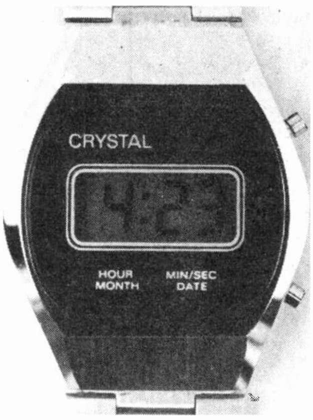

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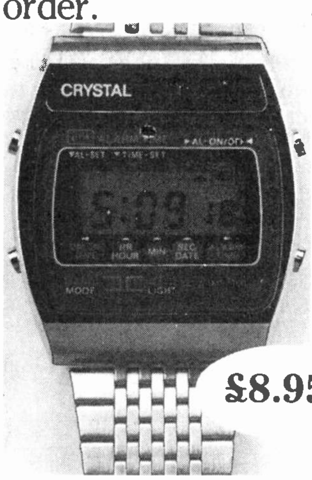

This model represents fantastic, incredible value for money. The 6 digit display continuously shows hours, minutes and seconds, or may be changed at will to hours, minutes and date. Its effective alarm is extremely useful and may be set to any time within a 24 hr. period. In addition, there is an alarm indicator, 4 year calendar and snooze repeater.

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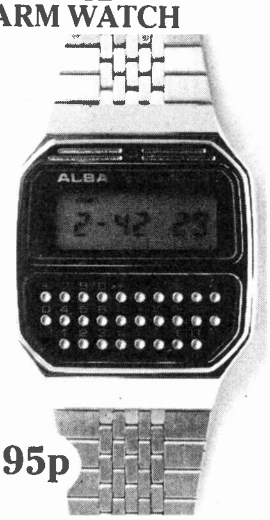

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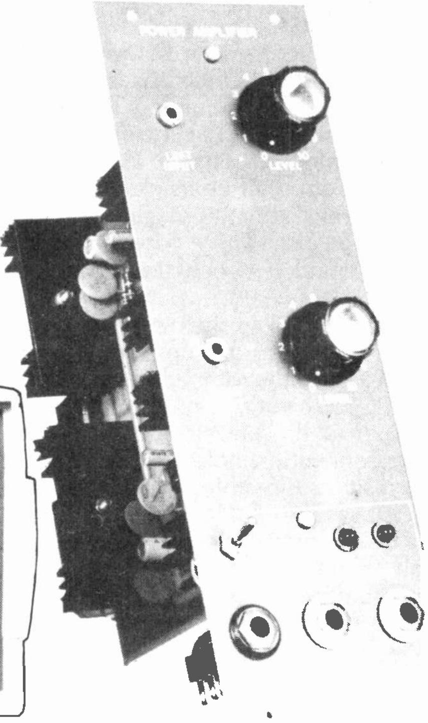
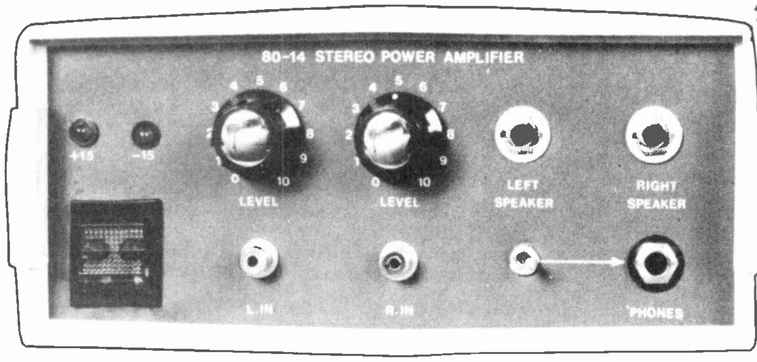




Sound out your collection of Project 80 synthesiser modules with this 10 W per channel stereo power amplifier. Design by Charles Blakey

The 80-14 Stereo Power Amplifier is designed to be used in conjunction with the Project 80 synthesiser but with a few component changes it may also be used as a compact general purpose amplifier. The amplifier has an input impedance of 100k and an output of 10 W per channel into 8R with a maximum distortion of 0.5% (typically 0.1%). For use with the synthesiser the input sensitivity is 1V2 RMS for the rated output and for the general purpose version the sensitivity is 250 mV RMS. A switched headphone output is incorporated, suitable for use with low impedance headphones.

The design is based on the TDA2030 which is a Class B amplifier with low harmonic and cross-over distortion. It incorporates power limiting circuitry, giving short-circuit protection, in addition to a conventional thermal shut down system. The choice is based on experience with the TDA2030, the fact that 10 W per channel is adequate for domestic or monitoring use, the need to keep heat generation to an acceptable level and, not least, to provide a compact module.

Power Regulations

To obtain the 10 W per channel output it is necessary to use a 30 V supply; the maximum rating of the device is 36V. Furthermore, synthesiser applications in particular can generate peak current demands and these factors dictated the use of a regulated +15 V supply and DC coupling of the speakers. The components for rectifying, smoothing and regulating the power supply have been incorporated on the same PCB as the amplifier. When used with the synthesiser this allows the same mains switch to be used as for the +15 V module supply (Project 80-1) and for the fuse and transformer for the amplifier to be housed in the keyboard case. A miniature three pole connector may then be used to couple the 15-0-15 V unregulated supply to the module housing allowing the module to be rapidly removed from the case when required. Also by having the capacitors on the PCB the ground returns from the speakers are kept short.

All Change

The component values shown in the circuit diagram are for the synthesiser version. For the general purpose amplifier the following component changes are required.

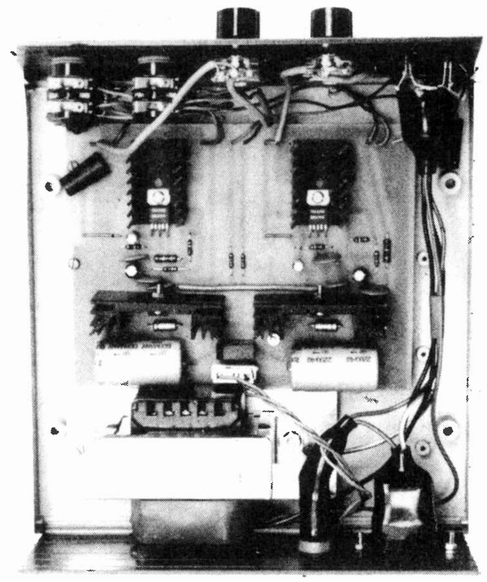
R3,8	wire links
R4,6,11,13	100k
R5,12	3k3
C6,11	4u7 PCB electrolytic

Construction

The module will fit onto the standard 9 x 3 inch panel and it can also be installed in a Teka Alba A23G case but as with the panel version the transformer will have to be external to the case. For the self-contained amplifier a case with minimum internal dimensions of width 220 mm, length 250 mm and height 90 mm is required.

Construction should be carried out in the following sequence. Make the one wire link with insulated wire then solder in the resistors, capacitors and the bridge rectifier. Next install the TDA2030s. Slide the heatsink under the TDA2030 and, after checking that the pins are still in place, bolt the IC and the heatsink to the PCB. Do not move the heatsink once the IC has been soldered since this will stress the pins. The voltage regulators are now bolted to their heatsinks (the pins should protrude from the side having the greatest distance from mounting hole to edge) and the combined heatsink and IC held firmly against the PCB while the regulator is soldered in place. There is no need to isolate any of the ICs from their heatsinks, but it should be noted that the heatsinks for the negative regulator and the TDA2030s will be at negative potential. A small amount of heatsink compound between the IC and their respective heatsinks is desirable.

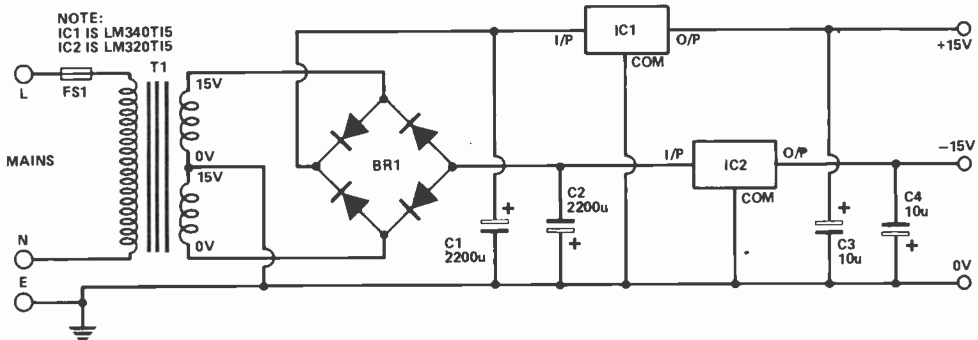
Next wire the PCB to the panel components. Screened wire should be used for the input leads which go from the input jack sockets to the rotary potentiometers and from the latter to the PCB. Do not common ground connections at the panel (except for the LEDs), but take them back to the appropriate connection hole on the PCB. Keep wiring as short and neat as possible. For the speaker leads it is preferable to use wire of at least equivalent to 16/0.2 mm. R8 and 15 can be soldered direct to the switch and a lead taken from the other end to the headphone socket while R9 and 16 should be soldered direct to the headphone socket. Remember to take a ground return from this socket to the PCB.

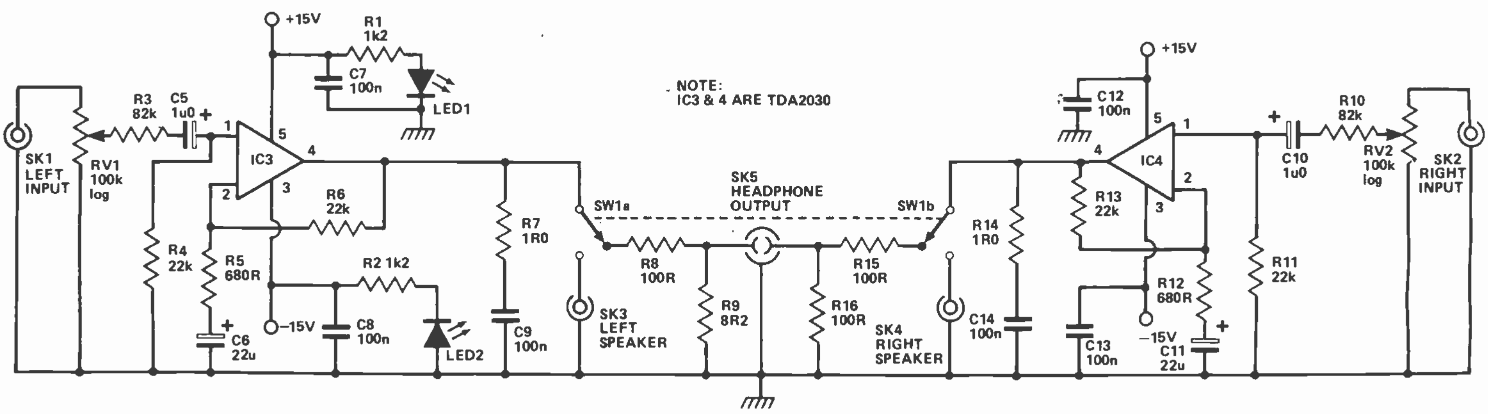


Inside the Project 80 Monitor Amplifier. Straightforward design and PCB layout makes for simple construction.

Fig.1 (right) Circuit diagram of the power supply. BR1 is a 2 A bridge rectifier.

Fig. 2 (below) Circuit diagram of the stereo Monitor Amplifier (synthesiser version). See text for alterations necessary to make a general purpose amplifier.





HOW IT WORKS

The TDA2030 power amplifiers (IC3 and IC4) require few external components and the function of the latter for the left input is described. C5 AC couples the amplifier while R3 and R4 form an attenuating network to reduce the sensitivity for use with the Project 80 synthesiser and, in the absence of RV1, determine the input impedance. RV1 provides manual adjustment of attenuation. R5 and R6 set the closed loop gain and for the general purpose version (R4 = 100k; R6 = 100k; R5 = 3k3) the voltage gain is approximately 30 dB. C6 is for DC decoupling of the inverting input and adjusts the low frequency cut-off. R7 and C9 increase frequency stability while C3, C4 (power supply) together with C7 and C8 are bypass capacitors which also reduce the risk of oscillation.

SW1 allows selection of speaker or headphone outputs and for the latter R8 and R9 attenuate the output to a level suitable for low impedance headphones.

The power supply is a conventional regulated supply with a nominal +15 V and 1A5 per rail which is sufficient for 8R speakers at peak output of the amplifiers (about 13 W with 10% distortion). The regulators will also cope with 4R speakers in combination with a suitable transformer. R1, R2 together with LED 1,2 give a visual indication of supply voltage to the amplifiers.

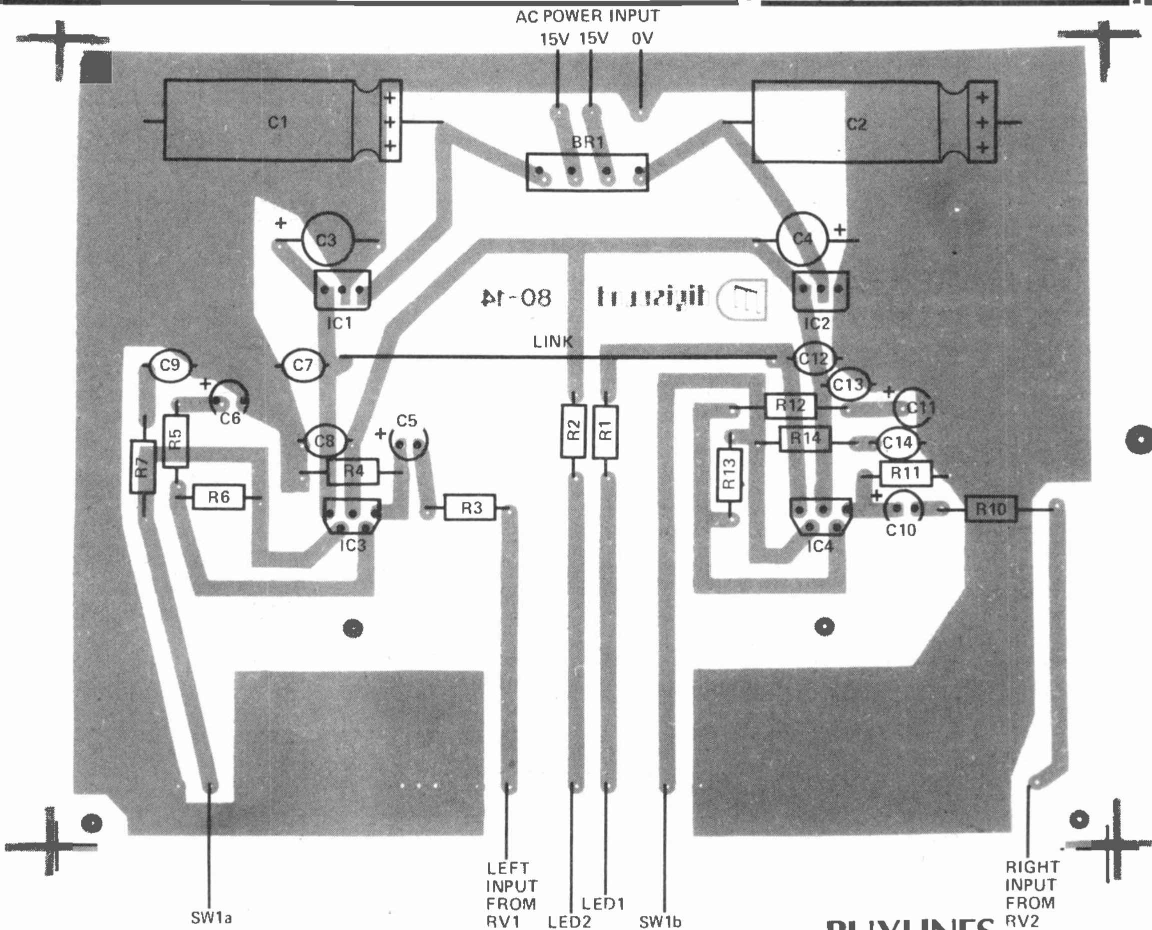


Fig.3 Component overlay.

BUYLINES

A kit for the stereo amplifier is available from Digisound Limited, 13 The Brooklands, Wrea Green, Preston, Lancs PR4 2NQ for £22.20 inclusive of postage and VAT. The kit includes the PCB and all listed components except transformer and case/panel. Please specify synthesiser or general purpose version.

PARTS LIST

(Synthesiser version, 8R speakers)
Resistors ¼ W carbon except where stated

R1,2	1k2
R3,10	82k
R4,6,11,13	22k
R5,12	68R
R7,14	1R0, ½ W
R8,15	100R, ½ W
R9,16	8R2, 2W5 wirewound
Potentiometers	
RV1,2	100k logarithmic
Capacitors	
C1,2	2200u 40 V electrolytic
C3,4	10u 25 V electrolytic
C5,10	1u0 100 V PCB electrolytic
C6,11	22u 25 V PCB electrolytic
C7,8,9,12,13,14	100n disc ceramic
Semiconductors	
IC1	LM340T-15
IC2	LM320T-15
IC3,4	TDA2030H
LED1,2	Red LED
B1	2 A bridge rectifier
Miscellaneous	
SW1	DPDT subminiature switch
SK1,2	3.5 mm jack sockets (phono sockets for GP version)
SK3,4	0.25 inch mono jack sockets
SK5	0.25 inch stereo jack socket
T1	50 VA transformer, dual 15 V secondaries in series or 15-0-15 V type.
FS1	Chassis fuse holder with 1 A fuse.

Heatsinks for IC1,2,3, and 4

Ironing

A final point to note is that comparatively heavy currents will flow through many of the connections and it is essential that they are properly soldered. The connections requiring most care are those to ground where the large foil area acts as a heatsink. This is eased by using a tinned PCB but even then it is necessary to place the soldering iron adjacent (not touching) to the lead to be soldered and allow the area to heat up sufficiently prior to heating the lead and applying solder to it.

After construction connect the transformer and switch on. Gently touch each IC in turn. These should remain cool, since the TDA2030 quiescent current to each is only of the order of 50 mA. The LEDs will indicate whether the power supply is functioning. If any of the ICs run hot at this stage check the component placement and condition of soldered joints. Next connect the speakers and if any hum is evident check the wiring from PCB to panel components. Finally connect the amplifier to an audio source to determine that the module is functioning correctly.

Conventional Hi-Fi speakers should not be used in conjunction with a synthesiser since single frequency tones of more than a few watts can damage treble speakers. For most purposes full range speakers with a nominal impedance of 8R and a rating of 15 W will prove adequate.

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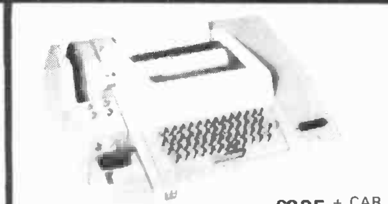

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ASTROLOGUE

Over the years ETI has covered almost every aspect of spaceflight. Now in the new regular series Ian Graham keeps you up to date with what's happening in the world of aerospace.

One aspect of the European space programme suffered a serious setback in May this year, when the Ariane launch vehicle ended up in the Atlantic Ocean two minutes after embarking on its second test flight.

Ariane is the key to Europe's future independence from America and Russia in placing satellites in Earth orbit. It will vie with the American Space Shuttle for business. Although the European Space Agency (ESA) is supporting the development and testing programme, once the hardware is proven Ariane will have to pay its own way by charging customers to carry their payloads into orbit.

The 200 tonne, three stage rocket first took to the air in December 1979 at the fourth attempt. The first hold-up was caused by excessive pressure readings in one of the four first stage Viking 2 engines. In fact the engines were OK. The fault was in the pressure sensor.

During the second attempted launch a fault appeared in the on-board batteries. Again, a sensor was found to be responsible. Unfortunately, this malfunction caused further delay by damaging one of the third stage subsystems (helium pressurisation). When Ariane finally got off the ground, its performance exceeded the designers' predictions, to the relief of all concerned. Ariane was a success.

Test Launch

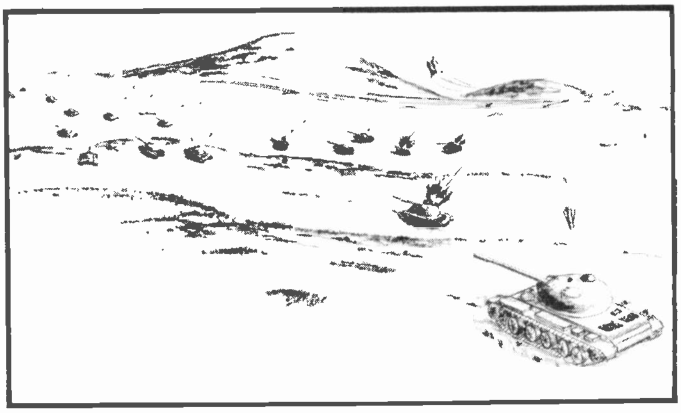
The second test rocket blasted off from the Guiana Space Centre in French Guiana on May 23rd. Within a few seconds of lift-off, pressure in one of the four first stage engines began to fluctuate. Two of the remaining engines suffered the same rapid pressure variations, which set up vibration in the structure itself. Eventually, the rocket broke up and blew itself to pieces.

The wreckage has now been recovered from the Atlantic mud and investigators have found a small metal identification tag in a fuel injector in one of the engines, although it isn't known if the tag was lodged in the injector at launch or during the break-up. The investigators are also looking at several other possible causes. The next test flight, originally scheduled for November, has been postponed until the beginning of next year.

Hughes' News

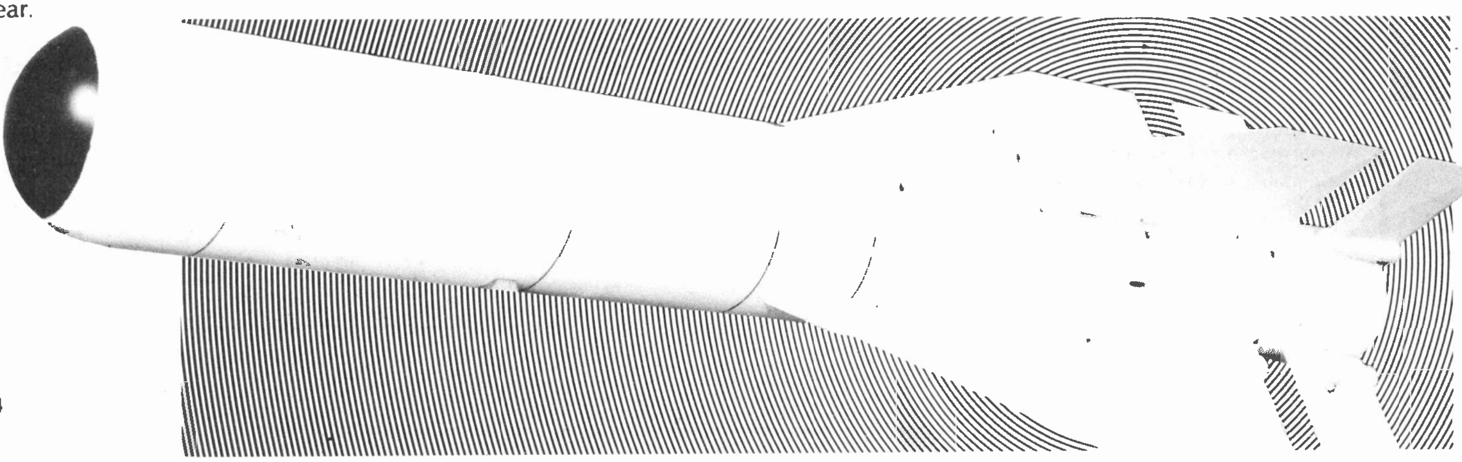
This is the first chance we've had to look at the new Hughes Aircraft Company Wasp anti-armour missile. It is one of a new generation of 'fire and forget' missiles; that is, once fired from an aircraft, the missile can carry on to its target without any guidance from the mother aircraft.

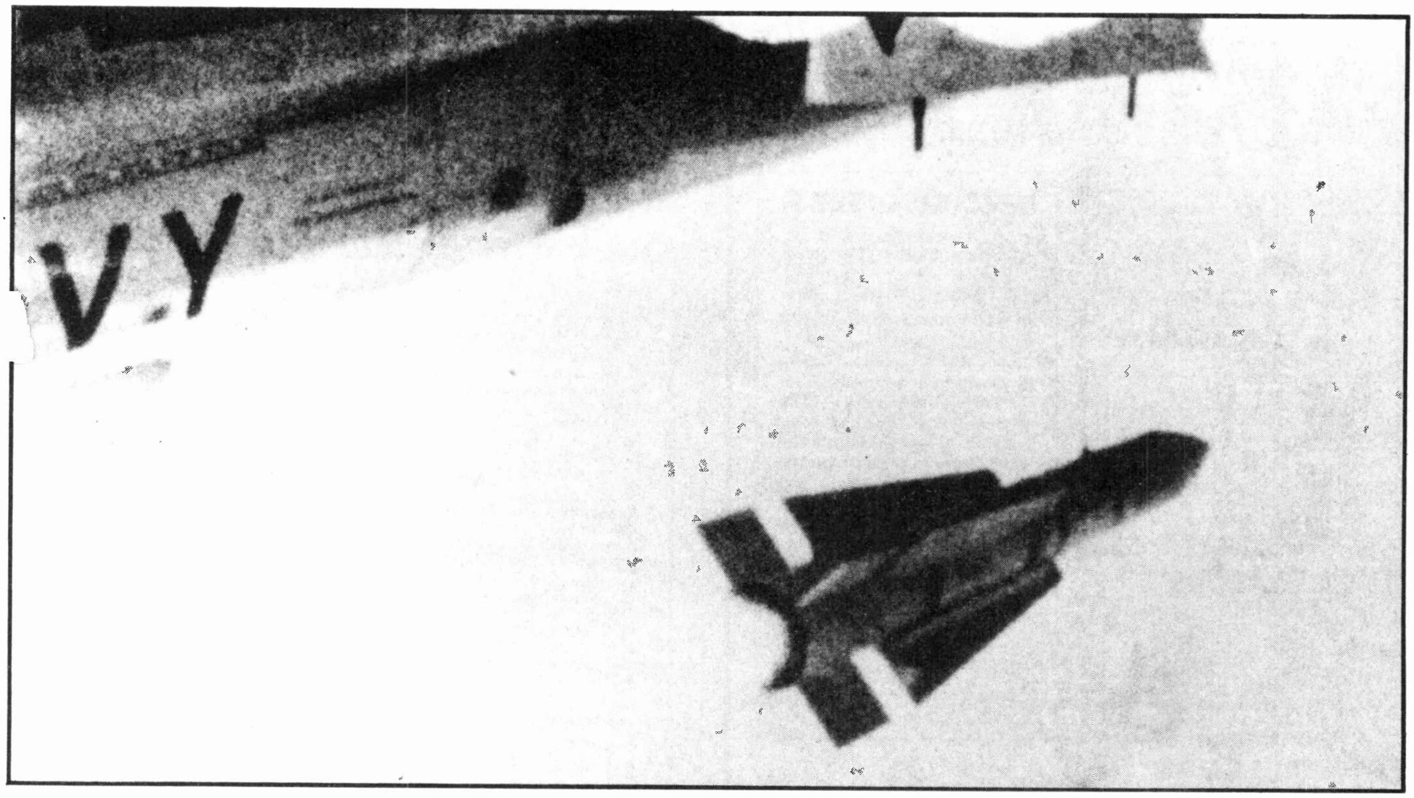
Of its predecessors, Maverick had to be targeted by the aircraft and could only be fired singly. Wasp can be fired either singly or in swarms of ten or more, but its over-riding advantage is that the aircrew do not have to identify a target before launch. The missile looks after all that itself. So, the aircrew can send a dozen Wasps on their way against a formation of enemy tanks and make for home without contacting the air defences. For that reason I'd guess Wasp will be a popular missile with the aircrew who will operate it.



In this artist's impression, a swarm of Wasps has been launched in the general direction of a formation of enemy tanks. The aircrew are already making for home. Each missile then seeks out a target and attacks.

The Hughes Aircraft Company's Wasp air-to-surface anti-armour missile. When the five feet long missile is launched, the wings flip out into the flying position.





An F-14 wing-tip camera catches a glimpse of the first airborne launch of the new upgraded version of the Phoenix air-to-air missile.

On Target

How does Wasp find its targets? Two sensors are under evaluation — infra-red and millimetre radar. Millimetre radar has three main advantages over infra-red. Its high resolution enables tanks to be distinguished from trees and buildings, it uses very small antennae and it is relatively unaffected by adverse weather conditions.

If a group of the missiles are fired at a number of targets, they will each attack a different target. If they can find only one target, it suffers a severe case of overkill. Wasp has a range of six miles when fired from an aircraft with a ground speed of 500 MPH. Two rival versions are under development by Boeing and Hughes.

AIM To Kill

Earlier this year the US Navy's new AIM-54C Phoenix air-to-air missile was successfully launched from an airborne F-14. It intercepted a drone aircraft target, passing well within the 'kill' range, if the missile had been armed. The Hughes AIM-54C, an improved version of the AIM-54A, carries a new digital electronics unit which is more flexible and reliable than the analogue unit it replaces. It also has a more effective target detector.

This first successful interception was achieved over a greater range than was possible with its predecessors. The F-14 launching aircraft travelled subsonically head-on towards the supersonic QF-4 fighter drone. In this launch, the Phoenix was guided on to the target by radar returns from the F-14's weapon control system. Closer to the target, it can switch to its own active radar system.

The upgraded Phoenix will become the US Navy's primary long-range air defence weapon in the 1990s.

SHORTS

A spacesuit was destroyed by fire at the Johnson Space Centre in April. Fortunately there was no-one in the suit at the time, although a technician was badly burned. To avoid a recurrence, a review board has recommended several modifications to the high pressure oxygen system and seals.

GEOS-D, the latest in a series of Geostationary Operational Environmental Satellites, is due to join its two companions in Earth orbit as we go to press. The 12 feet high by seven feet in diameter spacecraft will be launched from Cape Canaveral on September 9th by a three stage Delta 3914 booster. Next month I hope to bring you an in-depth report on this latest weather satellite and the GEOS system.

In July's Digest we brought you the sad news that the Viking Lander 2's batteries had run out of juice. The latest news on the Viking population of Mars is that Viking Orbiter 1 has now reached the end of its supply of attitude control gas. Viking Lander 1 is the only member of the foursome that is still functional.

We now know that the first Space Shuttle launch has been postponed from November this year until at least March next year. Next month Astrologue will look into the political, financial and technical problems that have beset the Space Shuttle from the start.

ETI

MICROBASICS

In the second part of our new series, Henry Budgett takes the mystique out of the inner workings of modern man's best friend and contemplates the bits and pieces necessary to make it all work.

Having introduced the various component parts of a computer system in last month's episode I shall now move onto the actual microprocessor itself. Just as we divided the computer up into a number of parts so we may dissect the microprocessor. It is important to understand at this early stage that the much-vaunted micro is merely a very complex piece of electronic logic and is totally useless on its own without the ranks of qualified engineers, programmers and other allied trades, the supposedly mighty micro is an incomprehensible lump of high technology!

Architectural Heritage

The average, general purpose computer can be divided into a number of discrete elements as we saw last month. One of these components is the Central Processing Unit or CPU and this can be sub-divided still further. The microprocessor is really a totally integrated central processing unit; it still needs all the other bits and pieces to make it perform as a computer. Some of the later designs do incorporate internal memory areas and one or two even have self-contained programs, the new SC/MP chip from National Semi with the NIBL BASIC built in being a prime example.

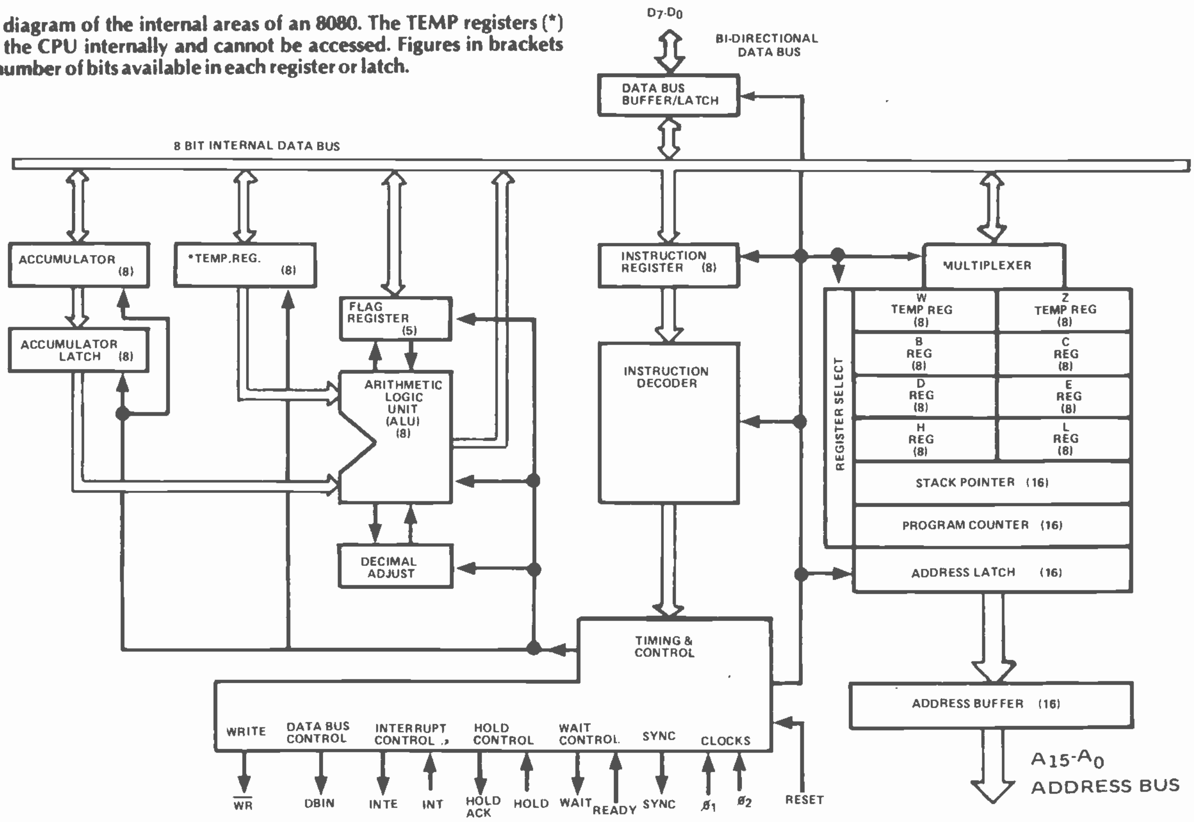
The three main sections of the CPU are the registers, the ALU and the control circuitry.

Taking them in order we find that the registers are a group of storage units within the CPU. Some of these are available to the programmer, others are used solely by the processor as counters or storage locations. The most important of these is the Accumulator. This register is used to store the data to be processed by the ALU, a typical instruction being to add the contents of some memory location to the Accumulator and to hold the result in the Accumulator for further processing. Many of the current families have other general purpose registers for data storage — the 8080 has six for example.

Flagging Already?

Closely associated with the Accumulator are a number of special registers called the flags. These are used to indicate the

Fig.1 Block diagram of the internal areas of an 8080. The TEMP registers (*) are used by the CPU internally and cannot be accessed. Figures in brackets refer to the number of bits available in each register or latch.



status of the ALU after an operation. Typical flags are 'carry' showing that an arithmetical carry has occurred, 'overflow' which simply shows that the number has exceeded the word length of the Accumulator and a number of bits which indicate the sign of the result in the Accumulator. There is also one other register connected with the Accumulator and ALU and that is the index register. This holds any offsets used in addressing or indexing and its inclusion is machine dependent.

The processor also requires a number of special registers, the instruction register and the program counter being two typical examples. These both have a 'double word' capacity, that is they can hold a full sixteen bit address. The contents of the program counter are always one in front of the address currently being used. This is in order to allow subroutines to rejoin the program at the right place. When multiple subroutines are used, these addresses are held in a LIFO memory area called the stack. Some processors have a built-in stack which allows only a certain number of subroutines, whereas others use a dedicated area of memory, which can be, in theory, as large as you like.

All the stored information in memory is, until decoded, garbage. The instruction register performs two tasks in that it not only holds the currently selected address contents but also decodes them to see if they are valid instructions or data. This is usually done by a mask programmed ROM (Read Only Memory) which has all the valid instructions stored in it. The reason for coding the instruction set into a 'microprogram' are twofold. Firstly, it makes the control circuitry much simpler and, secondly, one can, in theory at least, change the instruction set of one's processor. As an example of this there are some 20 extra codes built into the Z80 CPU that are not mentioned in the manuals. Apparently they are not all guaranteed to work on all Z80s. Anyone know what they are and what they do?

Cycling Around

All the processes of control are under the charge of a central clock which synchronises the various happenings within the CPU. Some processors require a two phase clock, others a single phase, but in almost all cases the clock must be crystal controlled. The reason for the accuracy needed is that, if one is to expand the system further than the basic CPU and its associated support circuitry, the clock must remain stable under variations of temperature and varying loads. Computer buses are fairly capacitive and can, over reasonable transmission distances, turn a nice square wave into a very unpleasant object indeed. The fundamental speed of the CPU is governed by the clock frequency. The original 8080 ran at 1 MHz and the 8080A, because of improved internal circuitry, runs at 2 MHz and will, therefore, process at twice the speed. However, and this is a common misconception, the actual CPU doesn't process at these speeds because of a number of reasons.

The most obvious reason is that the ALU is a serial device, that is it takes one bit at a time rather than processing the entire word. The second reason, which I will elaborate on in a minute, is that one has to perform a number of discrete operations within the chip just to get the information in a place where it can be processed and this takes time. All these operations are performed in cycles, the fundamental unit of time taken to fetch and execute a single instruction. On inspection of a data sheet on your chosen micro you will find this time quoted in terms of the number of clock cycles taken. All other instructions are then specified in the number of cycles that they take.

State Visit

To further explain this concept of instruction cycles let's take a look at the various types. The basic FETCH cycle, also known as the M1 cycle, is made up of four states. During the first three, the processor fetches the instruction from the memory location indicated by the program counter. The counter is at this point showing the current location and has not been incremented. The fourth cycle is taken up by decoding the instruction. An example of this is the instruction to add the contents of a register to the Accumulator. If we wish to access a memory location rather than a register, we will have to perform a memory read, which requires an extra machine cycle. Say we wish to add the contents of a given memory location to the contents of the Accumulator. The sequence of operations is as follows: the processor extracts the

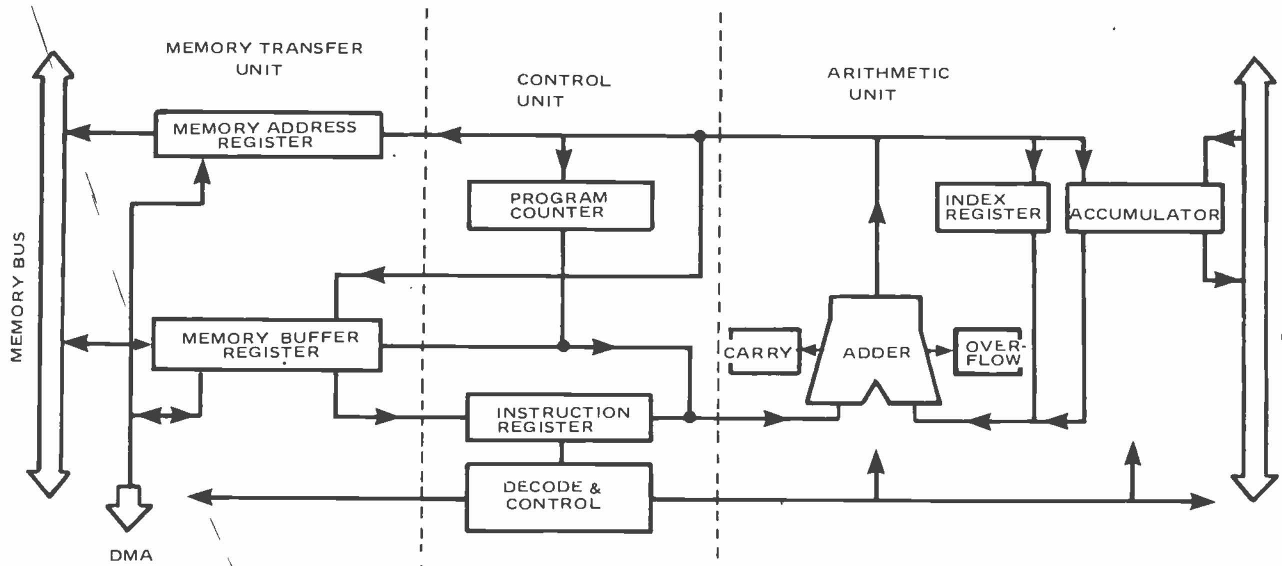


Fig.2 Functional block diagram of a CPU. This represents the minimal configuration you would expect to find. You could implement this (for fun) in discrete logic elements and see how it worked. It makes a good demonstration piece for schools and colleges.

single byte instruction from the memory location given in the program counter; this takes three states. This is decoded and the processor sends, as an address, the contents of its H and L registers. The data word returned during this cycle is held in a temporary register inside the CPU and we have now used six states. The final act of adding the temporary register contents to the Accumulator takes a further state making seven in all, or two cycles. The longest operation of all, in 8080 code, takes 16 states or five machine cycles.

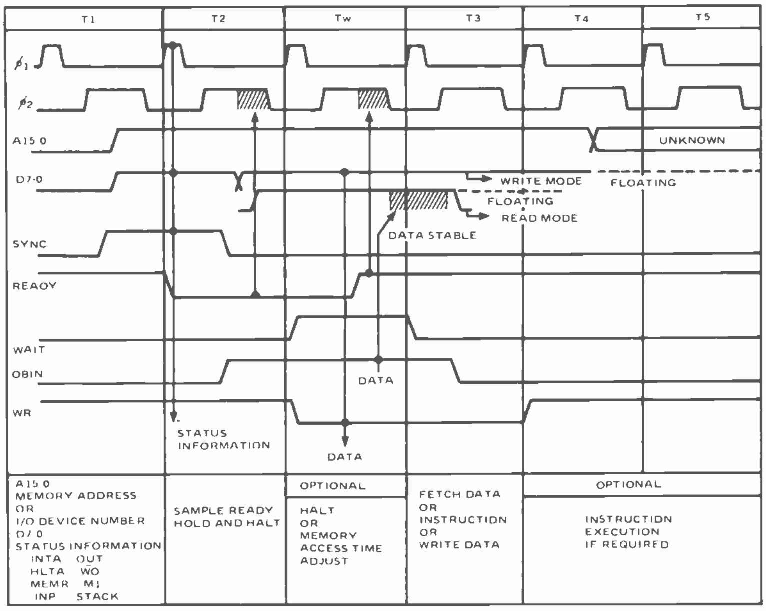


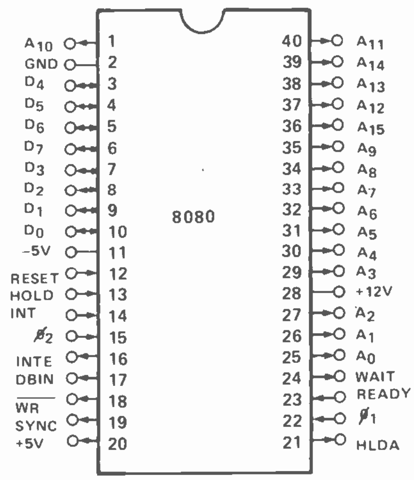
Fig.3 Timing diagram showing the various states that can make up a machine cycle: The vertical arrowed lines indicate information access states.

The Ins And Outs

The final section of our look at the internals of a CPU is the connections you can make with the outside world. Generally, the CPU is housed inside a DIL package with some 40 legs. Under normal circumstances, assuming the standard eight bit CPU, we will have 16 pins for the address bus, eight pins for the data bus and 16 pins left to play with. Just what you do with them depends on the kind of CPU you have, but let's take a close look at the pins on an 8080.

Having already mentioned the address and data bus, we only need to say that the data bus is a bi-directional system and is capable of tri-state operation. It can assume a high impedance state, which is neither a logic zero nor one and this is used under some special circumstances, which will be mentioned next month. Four further legs can be allocated to power; the device needs ± 5 V, $+12$ V and ground. Yet two more legs can be allocated to the required two phase clock, leaving us ten possible control signals to communicate the state of the device to the outside world. These are SYNC, DBIN, WAIT, HLDA, INTE, READY, HOLD, INT and RESET. Taking these in order, the SYNC indicates the first state of each machine cycle, thus acting as a synchronisation signal, hence the name. The DBIN signal tells the outside world that the CPU can accept data. It should be used to externally enable the transfer. WAIT is an indication that the CPU has entered a WAIT state, triggered by pulling the READY line low before the second state time. This causes extra states to be added to the cycle time for as long as the READY line is held low. The process is often used in situations where the memory or device currently being accessed is slower than the processor.

Our next signal, WR, is provided for the synchronisation of external transfers. These include memory and I/O operations and it is the converse of DBIN. There now follows a group of controls, which are concerned with things called interrupts. An interrupt is the computer equivalent of a tap on the shoulder and is used by peripheral devices to tell the processor that they are ready to be looked at. The INT line must be set high to tap the computer on its shoulder, but this will only work if the INTE line has been enabled previously. Inside the CPU, the interrupt is signalled by a status bit being set and the external device must put its instruction onto the bus in order for any action to be taken. The HOLD line is concerned with direct memory access and as such we shall not dwell on this until next month. The HLDA is merely an indication that the CPU is in a HOLD state. Finally we have the RESET line which, as its name implies, does. The signal will restore the CPU to the first state of a machine cycle and it also clears the program counter. It is essential to start all the power up sequences with this signal otherwise you never know what you may find yourself doing! It is also worth noting for all those sceptics among you that pressing RESET does *not* destroy all your registers, it merely sets you back to the beginning without destroying your program *unless* the person who programmed the monitor on your system clears the memory as the first operation. Whoever said that programmers were logical anyway.



Pin designations of the 8080. Developed by Intel, fathers of the micro, it is still regarded as the workhorse of eight bit processing. It also spawned the Z80, probably the most powerful eight bit chip using current technology.

Coming Soon

Next month's slice of bits will investigate the thorny topic of memory devices and show you the way in the ROM-RAM jungle as well as telling you how to ignore your CPU altogether and really make things work fast.

ETI

ELECTRONICS TOMORROW

A spanner's not much help when your computerised fuel injection system dies. Dave Raven of Metac Electronics reports on the quality control that keeps your chips up to scratch, with a footnote on hand-held games.

While we must welcome the arrival of new electronic circuitry in everyday products (cars, sewing machines, food mixers, etc), electronic failures always seem much worse and more difficult to put right. The difficulty now in making temporary repairs to an item, which has been transformed into a solid block of plastic containing a thick-film circuit, is underlined to the stranded motorist when he is out in the pouring rain.

My own recent experience of this occurred miles out in the countryside. I was directed with my faulty alternator to a small holding, miles from anywhere. The gentleman who attended to me was clearly an expert, despite outward appearances and disused cars littering his yard. A small workshop/caravan was crammed with used starter motors and dynamos. With the precision of a brain surgeon, he diagnosed my faulty alternator (a diode in yer alternator) and immediately commenced stripping it down and replacing the faulty component. With an elaborate piece of home made test equipment, which put Heath Robinson to shame, he tested the alternator on the bench under full load. While watching this rustic genius I felt assured that, even with the advent of microprocessors this man will survive. But what of all the other indispensable backyard mechanics who are willing to be called out on breakdowns at 9am on a Sunday morning? If you happen to be equipped with an elaborate computer-controlled fuel injection system, then just try and sort that out mate.

Quality Control

The whole elaborate procedure for the quality control of precision electronic equipment is now becoming of vital importance. If electronic products are to achieve the same reputation as earlier mechanical products, which appear to go on forever, it is necessary that they are produced to the same high standards. Electronic products properly tested can achieve very high levels of quality and reliability as any airline pilot or astronaut will testify. The term quality is used to express our level of satisfaction with either goods or a particular service which we use. The notion of quality becomes more ambiguous when we must express our satisfaction with a particular instrument after we have used it through several months. Even if the qualities noticed during the first few months have deteriorated, the product must remain within the specification during its useful life. The measurement of the deterioration of quality of a batch of instruments is when we start to examine the probability of failure or its reliability. A reliable instrument is one which maintains its performance throughout its useful life. A product's reliability can be defined within exact limits by the manufacturer and, naturally, the higher the product's reliability, the higher the price is. The reliability of an instrument is in the mathematical sense of the term — the probability of good functioning within clearly defined performances, in a given time period, under conditions of normal use. This reliability, in the form of probability, is expressed by the quotient of the number of instruments still working at the time of the test divided by the number of instruments initially put into service, when this latter tends towards infinity. The following formula can be used to calculate reliability:-

Reliability = No. of instruments working correctly at time of test/No. of intruments initially put into service.

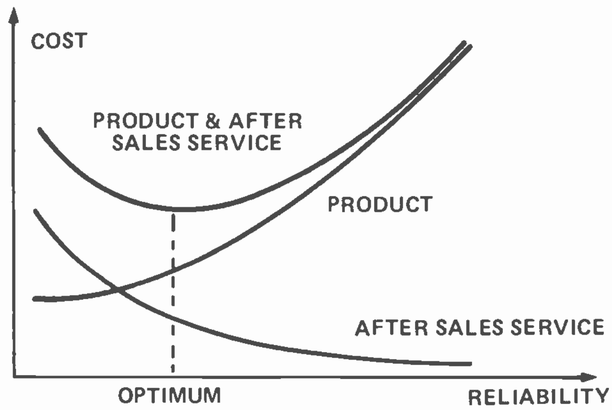


Fig.1. The optimum reliability, considering the cost of the product and the cost of repair during the after-sales service period.

Failure Rate

The other factor which is linked closely with reliability is the rate of failure. This parameter represents the speed with which the products cease to work correctly. The rate of failure in terms of time can be expressed graphically as a (bathtub) curve, which can be divided into three parts. The first part involves early failures which arise during the first few months. The second part involves random failures, with a constant rate of failure. No physical or chemical procedure can eliminate them and this is of prime importance to electronic products. The last part involves failures due to wear, signifying the end of a product's lifetime.

Image Projection

The failures which occur during the first few months are particularly unwelcome, since they do much to tarnish a supplier's image. They are also very expensive to deal with. The reliability tests which a watch would need to undergo if we are to meet the requirements of the Swiss Industry Standards are divided into two categories:-
1. Performance and quality tests.
2. Accelerated life tests simulating wear.

Testing Time

The example below is the type of performance that electronic watches must undergo if they are to reach an acceptable level of quality for the Swiss (and, indeed, Metac): Control for good functioning of all external controls accessible to the wearer, such as time setting, second stop, rapid corrector, etc; measurement of trimmer adjustment range in positive and negative areas; measurement of supply voltage at which the watch ceases to function correctly; measurement of current consumption and calculations of performance in terms of type of battery used; measurement of the performance deviation of the watch, expressed in seconds per day as a function of the supply voltage variation; determine the effects of temperature variation on the quartz crystal and the integrated circuit; measurement of the watch's resistance to thermal shocks and determination of the watch's resistance to magnetic fields.

Note: a watch can be termed anti-magnetic if it withstands without damage three passages in a magnetic field of 60 Oersted. A watch can be termed anti-shock if it withstands without damage two shocks corresponding to a fall from a height of one metre on a hard wood floor; the intensity of such a shock is around 5,000 g (1 g = unit of gravity acceleration).

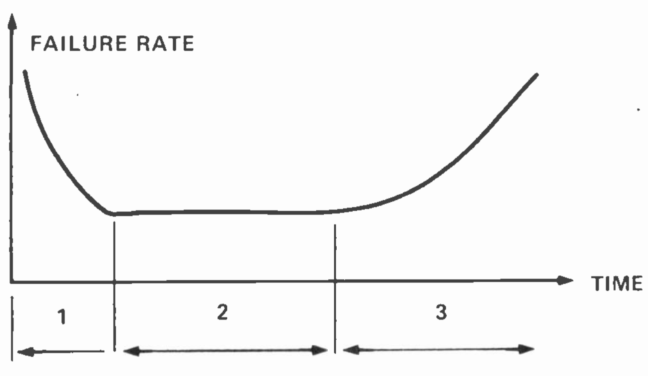


Fig.2. The bathtub curve shows the rate of failure of a product in terms of time. 1. Early rate of failure; 2. Random failures, with a constant rate of failure; 3. Failures due to wear.

Hand-held Games

Electronic games have been with us now for the last three years and are continually growing in their sophistication. The early TV game chip with its four simple games proved to quickly become a bore and probably ended up in the bottom of the toy cupboard the day after boxing day. Space Invaders and the other microprocessor based games, which until now were only to be seen at fun-fairs and in the local pub, are soon to emerge as portable hand-held games, which will easily fit into the Christmas stocking. The only viable way to produce really high technology microprocessor chips is in large volume. Once all the production problems are solved, the manufacturer starts to crank the handle and out spew millions of chips. Since rockets, machine tools, etc cannot consume very many chips in peace-time, the industry requires a volume product, which will soak up all this excess production.

Software In Hand

Now that chip shortages (which probably held back this product last year) have been overcome, the relatively simple task of assembling hand-held games will ensure their success this Christmas in a big way. Over 500 different hand-held games are being produced. However, reports from the Far East indicate that only a small number are up to standard and will be acceptable to the UK market. Finding a suitable game, which does not quickly become a bore, is a major headache for designers. The chip manufacturers are Texas Instruments, AMI and General Instruments in the main and these companies expend a considerable effort in writing software for hand-held game microprocessors. It still remains a very high risk business, however, and manufacturers and importers will try hard to ensure that they do not have large stocks remaining after Christmas.

Moving Pictures

Trends in hand-held games are in the direction of more LCD games than the LED type. These will last 20 to 30 hours compared to only three to five for LED ones. The use of fluorescent tube and larger memories are also expected developments. The drawback with LCD hand-held games is that they must have a combination of driver and LCD display. Companies in Hong Kong are working on this to produce the combination of chip and driver which makes players move on the display. The final touch will be a single chip direct drive microprocessor for LCD games. The standard type of LCD display has between 128 and 256 dots and the players and balls are mere blips on the screen. It is, however, hoped soon to produce a program of more than 600 dots and the LCD microprocessor will have drive capability with good resolution. Hand-held game trends are also moving towards devices that produce sounds. An example of this is sound producing microprocessors, which produce musical sounds in toys, or screeching wheels and engine sounds for toy cars. **ETI**

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10		8		10
15	8		9	11
22		8		13
33	8		9	
47		8	11	13
68	9			
100		9	13	
150	9	10		31
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.0022	6	7	.22	9	11
.0033	6	7	.33	11	
.0047	6	7	.47	14	
.0068	6	7	.68	17	
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10		7			8		9
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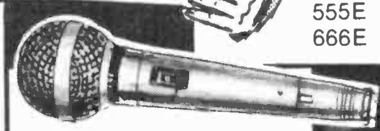

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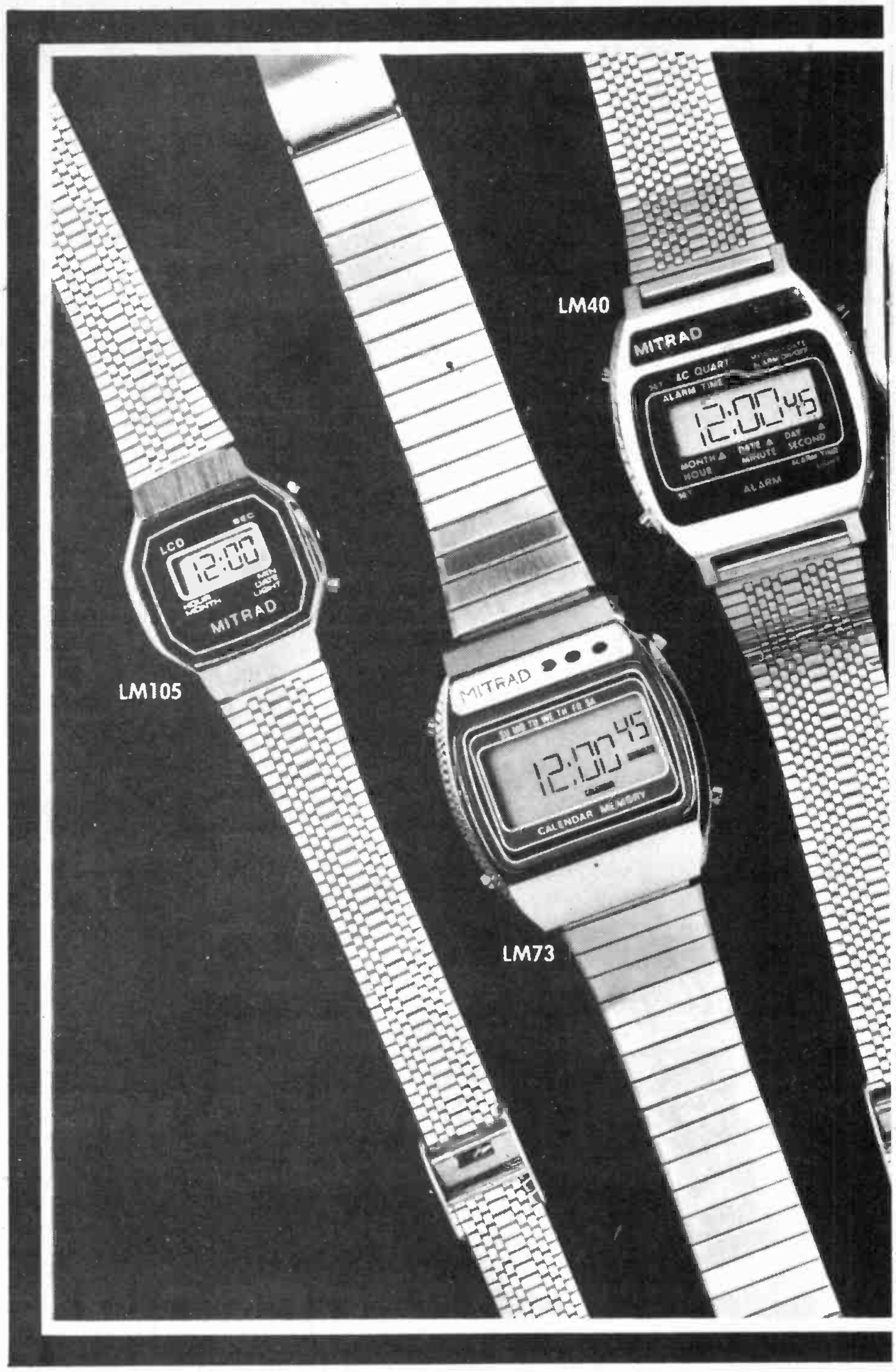

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2.2/25 R	.028	47/63 R	.045
2.2/63 A	.032	100/6 3 A	.020
4.7/10 R	.022	100/35 R PC	.035
4.7/25R	.028	220/16 A	.055
4.7/50 R	.034	220/25 R	.065
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10/25 R	.032	330/50 A	.075
10/25 R PC	.022	330/100 A	.085
10/25 A	.035	470/16 R	.080
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
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R=radial leads
A=axial leads
RC=tag ended can
R PC=short radial leads for PC mounting

POLYESTER CAPS

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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	.065
2 2	160V	Filmcap	.096
3.3	100V	Wima MKS	.15
4.7	100V	C281	.195
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TANT BEADS

1 5/35	.06
3 3/25	.08
10/25	.15

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Thompson/CSF miniature type in the following values
3 9pF, 4 7pF, 22pF, 33pF, 47pF, 47pF, 68pF, 82pF, 100pF, 560pF*, 2700pF† All 5% except *10%, †20%

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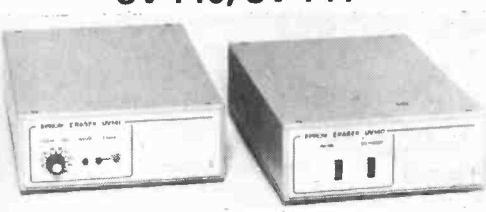
UV EPROM ERASERS

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.
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- Sliding tray carries proms on conductive foam.
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- 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".)

(Dimensions — 325×64×38mm)

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).
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The following computer boards have been added to the range for use with the Z80 (114×233mm fibreglass with gold plated edge connector).

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MXD2 16K dynamic ram board	£9.40

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(Subject to stocks)

No monthly accounts for these prices:

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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

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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
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4008	80p	4047	£1.71	40100	£1.92	4433	£12.30	4538	£1.20
4009	40p	4048	77p	40101	£1.69	4435V	£5.40	4539	97p
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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
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4029	99p	4073	25p	40194	£3.27	4516	£1.10	4581	£2.62
4030	74p	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		

MODULATORS

UM1111 E36 UHF Ch.36 Vision Modulator £2.50
UM1231 UHF Ch.36 Vision Modulator wide bandwidth (for computers etc.) £4.70
UM1263 FM Sound Subcarrier Modulator £2.50

SWITCH MODE PSUs

AC 5221S 5V/10A	£69.90
AC 9221S 5V/5A. 12V/1A. −12V/1A. −5V/0.1A	£86.80
AC 5421S 5V/20A	£99.20
AC 9421S 5V/10A. 12V/2A. −12V/2A. −5V/0.1A	£126.50

MICROPROCESSORS

COMPUTER BOARDS

114 x 203 mm fibreglass, gold plated edge connector.

Buffered SC/MP CPU	£9.40
SC/MP Protoboard	£9.40
Z80 CPU card	£9.40
VDU 'A' } set	£8.90
VDU 'B' } of	£8.90
VDU 'G' } three	£9.40
EPROM Programmer (2708s)	£9.40
4k PROM board (5204s)	£9.40
8k PROM board (2708s)	£9.40
2k RAM board (2102s) 1k-2k	£9.40
8k RAM board (2114s) 1k-8k	£9.40
Tape interface	£8.90
Keyboard interface	£8.90
PSU 5v. +12v. −12v board	£8.90
PSU 5v. −12v board	£5.50
ISBUS 1.1 13 slot back-board	£11.50

13"×14¾" approx. Epoxy Glass, tinned

Further details on request

Z80

Z80 CPU (2½MHz)	£9.90
Z80-CTC (2½MHz)	£5.95
Z80-P10 (2½MHz)	£6.60

(Add £1 for the 4MHz version of any of the above 3 chips.)

SC/MP II RAM I/O

SC/MP II (4MHz)	£10
INS 8154 RAM I/O	£9.40

6800

6800 MPU	£6.55
6802 MPU	£9.95
6810 (128 × 8 RAM)	£3.25
68A10 (128 × 8 RAM)	£3.75
6820, 6821 PIA	£3.96
6850 ACIA	£4.85
MC6880	£2.64

6502

6502	£7.95
6520 PIA	£6.22
6522	£7.95

CMOS

COSMAC CDP 1802CE	£6.50
COSMAC CDP 1802E	£10.85
CDP 1864	£7.25

STATICS (Mostly 450nS)

2101—256 x 4	£2.25
2102—1K x 1	£1.20
2111—256 x 4	£1.95
2112—256 x 4	£2.25
2114/4045—1K x 4	£4.39
8 x 2114	£28.00
2114L—1K x 4	£5.50
4118—1K x 8	£15.50

DYNAMICS

MK 4116 16K 250nS	£4.95
MK 4816 2K x 8	£30.52

UV ERASABLES

5204 (512 x 8)	£11.50
2708 1K x 8	£6.75
2716/2516 2K x 8 single 5v	£17.95
2532 4K x 8 (5v)	£47.00

PROMWASHING each Prom 50p (+30p + VAT)

UV PROM ERASER

UV140	£61.20
UV141	£77.70

INTERFACE

81LS95/6/7/8	£1.40
75491 LED driver	50p
75492	92p
ZN425	£3.95
8T26/8T28	£2.64
IL74	48p

CRT Controller: Uarts

Thompson CSF SF.F96364E	£11.50
AY-5-1013 UART TR 1602	£4.00
AY-5-1013A	£4.70
AY-3-1014A	£5.60
AY-3-1015	£5.60

CHAR. GEN. KEYBOARD ENCODER

MCM 66760	£9.75
MK 2302	£15.29
RO 3-2513 (5v Uppercase)	£6.00
DM 8678 CAB/BWF	£14.27
AY-5-2376	£9.75

FIRMWARE

ZMON for Z80 (1 x 2708)	£14.95
2K Tiny BASIC for Z80 (2 x 2708)	£19.95
4K NIBL for SC/MP (4 x 2708)	£49.95
4K NIBL-MM for SC/MP (4 x 2708)	£49.95
1K Various for SC/MP (1 x 2708)	£14.95

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

1K Elektor Junior 1x2708	£19.95
1½K ELBUG (3×5204)	£35.00
ETIBUG 1 (1×5204)	£14.95
ETIBUG 2 (1×5204)	£14.95
SCMP/KB (1×5204)	£14.95

74LS

		74LS27	28p	74LS76	40p	74LS125	60p	74LS163	£1.18	74LS240	£2.36	74LS283	£1.92	74LS375	£1.60
		74LS28	48p	74LS78	40p	74LS126	60p	74LS164	£1.14	74LS241	£2.32	74LS290	£1.28	74LS377	£2.12
74LS00	14p	74LS30	22p	74LS83	£1.15	74LS132	95p	74LS165	75p	74LS242	£2.32	74LS293	£1.28	74LS378	£1.84
74LS01	14p	74LS32	27p	74LS85	£1.18	74LS136	55p	74LS166	£2.26	74LS243	£2.32	74LS295	£1.85	74LS379	£2.15
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
74LS13	38p	74LS54	28p	74LS112	55p	74LS156	96p	74LS193	£1.30	74LS259	£1.60	74LS365	65p	74LS447	£1.44
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
74LS20	20p	74LS73	46p	74LS122	70p	74LS160	£1.28	74LS196	£1.00	74LS273	£2.44	74LS368	66p	74LS669	£1.82
74LS21	22p	74LS74	41p	74LS123	70p	74LS161	98p	74LS197	£1.40	74LS275	£2.50	74LS373	£1.80	74LS670	£2.48
74LS26	48p	74LS75	48p	74LS124	£1.80	74LS162	£1.38	74LS221	96p	74LS279	66p	74LS374	£1.95		

QUARTZ

32.768KHz (Watch)	£3.23
60 KHz	£9.95
100.0 KHz	£3.62
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204.8 KHz	£3.92
262.144 KHz	£3.92
307.2 KHz	£3.92
312.5 KHz	£3.92
455.0 KHz	£4.95
1.000 MHz	£3.62
1.008 MHz	£3.92
1.280 MHz	£3.92
1.8 MHz	£4.25
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
4.032 MHz	£3.23
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4.194304 MHz	£3.23
4.433619 MHz	£1.25
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4.800 MHz	£3.23
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
26.690 MHz	£2.10
27.0 MHz	£3.92
27.145 MHz	£2.10
27.648 MHz	£3.92
38.6666 MHz	£3.23
48.000 MHz	£3.23
100.000 MHz	£3.23
116.000 MHz	£3.23

VEROBOARD

0.1" Pitch with copper strips

2½"×1" (pack of 5)	74p
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2½"×5"	62p
2½"×17"	£1.86
3¾"×3¾"	62p
3¾"×5"	69p
3¾"×17"	£2.40
4.7"×17.9"	£3.14

0.1" Plainboard (no strips)

3¾"×2½"	38p
3¾"×5"	59p
3¾"×17.0"	£1.56
Terminal pins	£1.50/500
V-Q DIP board	£1.17
DIP breadboard	£2.91
Spot face cutter	93p
Pin insertion tool	£1.28

SOLDERCON PINS

100 50p 1000 £3.95

DIL SOCKETS

8/14/16 pin 10p/12p/13p
18/20/22 pin 18p/20p/25p
24/28/40 pin 30p/40p/50p
24 pin Textool lever type zero insertion force £8.50

EDGE CONNECTORS

43 way. 0.1" pitch. wire wrap, polarizing slot pin 37
Single sided (1×42) £3.11
Double sided (2×42) £4.10

TIMER ICs

NE555/556 29p/49p

OP-AMPS

(All Mini dips)

CA 3130E	84p
CA 3140E	35p
UA 741 (Texas)	22p

4 DIGIT LED DISPLAY

Multiplexed, common cathode, prime quality.
NSB 5881 (0.5) £5.75

LED DISPLAYS

DL-704E	99p
DL-727E/728E	£2.00
DL-747E/750E	£1.80
FND 500/560	£1.20

LIQUID CRYSTAL DISPLAY

4×0.5" Digits 40 pin DIL £9.95

CLOCK CHIPS

AY-5-1224A	£2.60
MK 50253	£5.50
MK 50366	£6.50

SIX DECADE COUNTERS

MK 50395/6/7	£9.90
MK 50398/9	£7.50

DATA

Note: in this section all data books are subject to 0% VAT. For postage see 'Terms' at top of page.

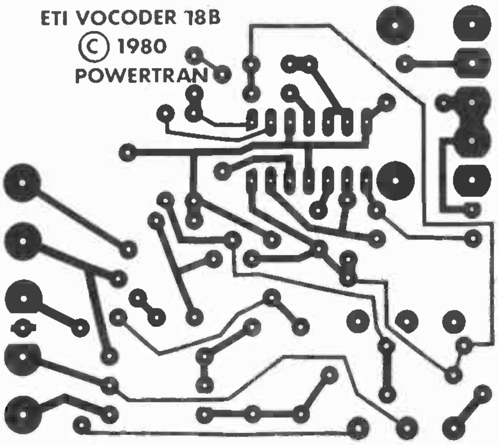
113 page Electronic Projects index 72-77 (North Tyneside Libraries)	£1.50
c650 page COSMOS Databook (RCA)	£4.95
c31 page 'A Guide to SC/MP Programming' by Dr. Drury (Kemitron)	£3.75
c20 page 'A Guide to Kitbug' (Kemitron)	75p
c24 page NIBL Reference Guide (National)	£3.45
Data for 4116 (Mostek)	50p
c6 page data for Mk 4118	25p
16-page data for IMS 8154 (ISP-8A/650) (National)	50p
20-page data for SC/MP II (National)	50p
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

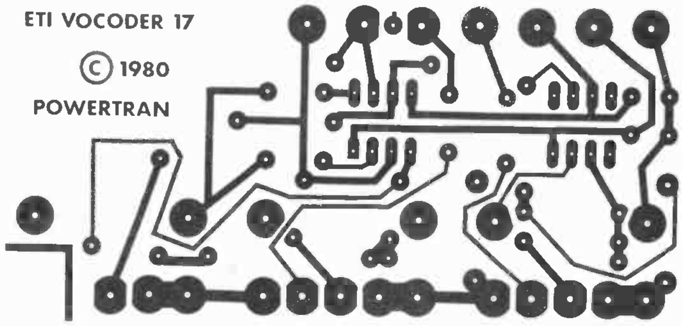
This contains all the data we can obtain on the Z80 CPU and related chips, and the Z80 Programming Manual. Depending on our own supplier, the data is either loose sheets, photocopies or bound volumes, or a combination of both. The weight of the set of data is about 1½ kilos, and some information on other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

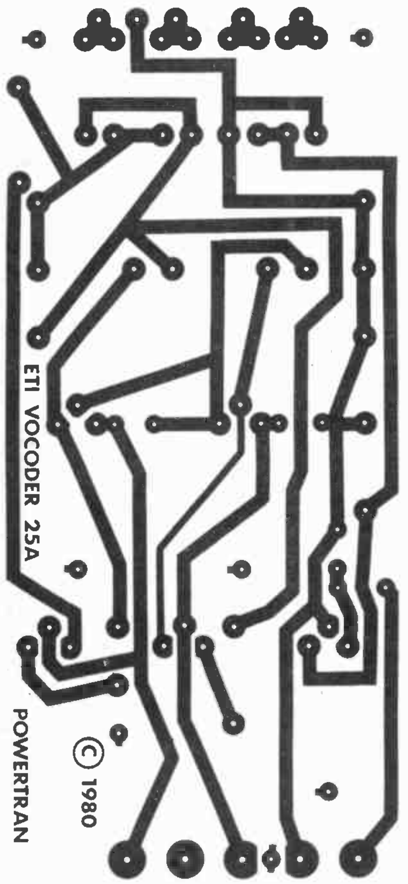
PCB FOIL PATTERNS



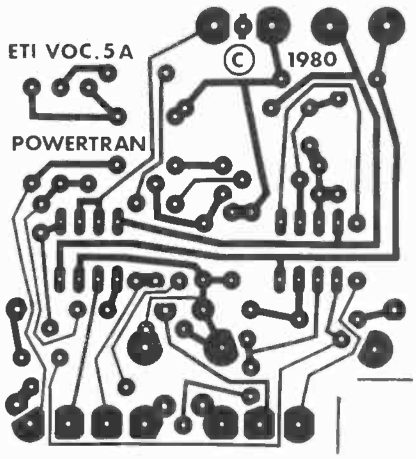
Vocoder Slew Rate Control Board



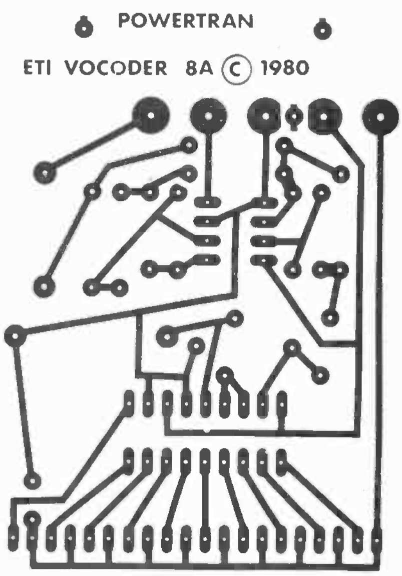
Vocoder Ouput Amplifer Board



Vocoder Power Supply Board

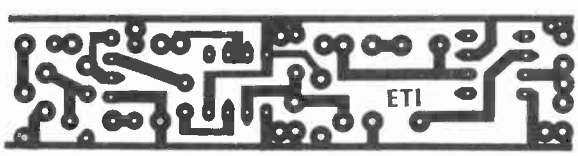


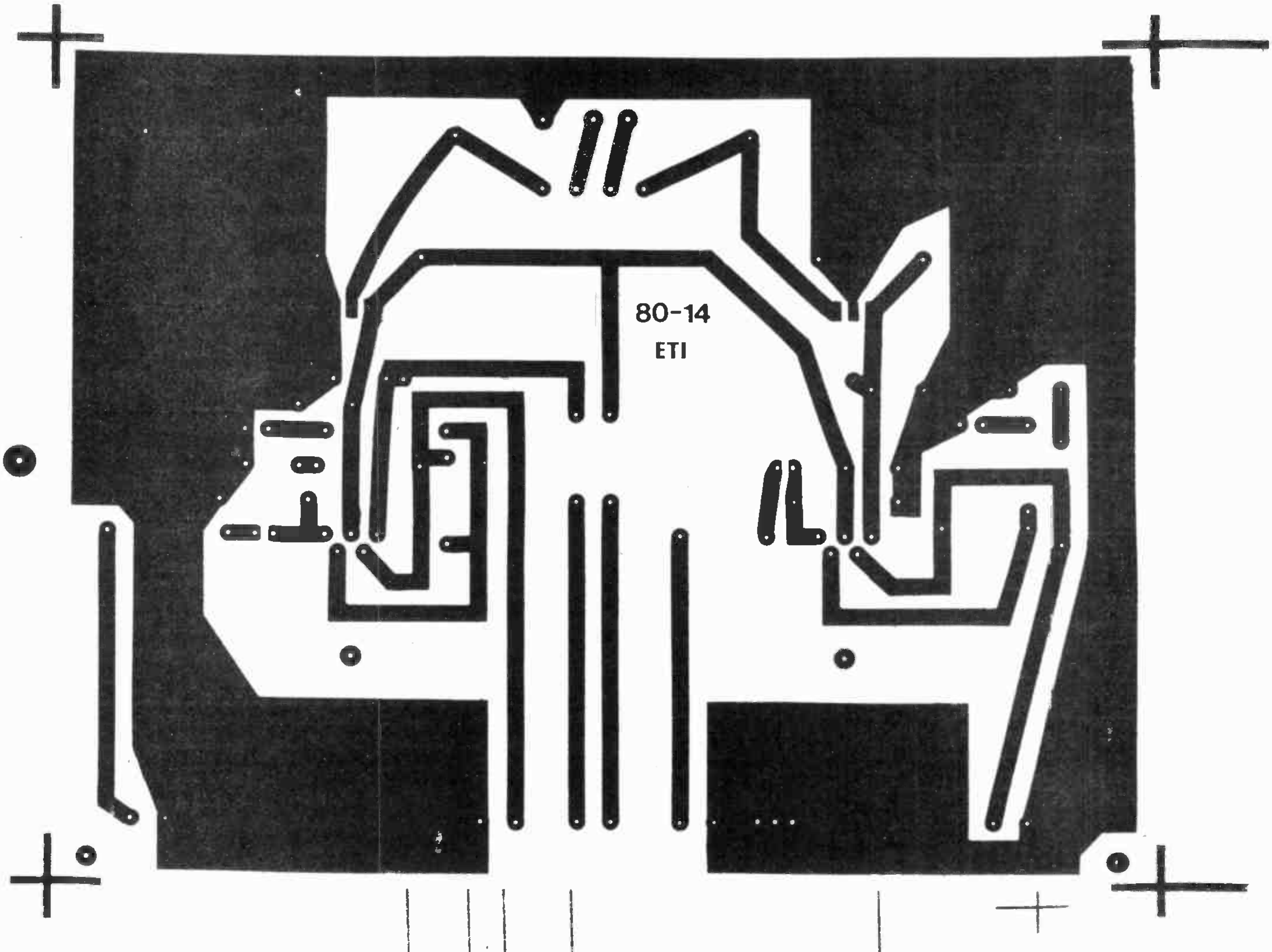
Vocoder Input Amplifier Board



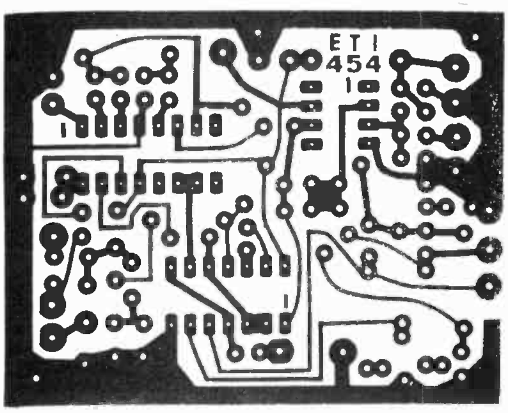
Vocoder LED PPM Display Board

(Below) Flash Trigger

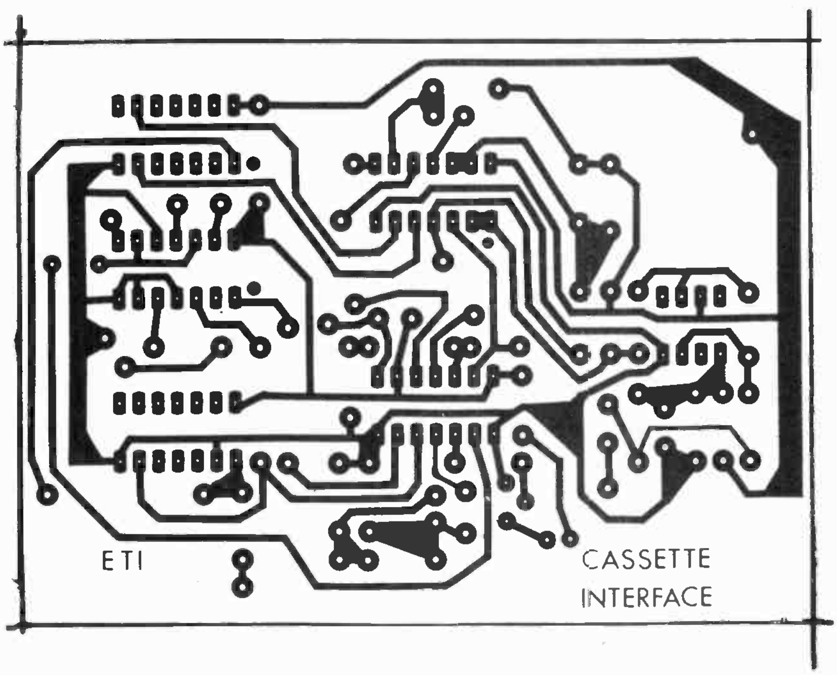


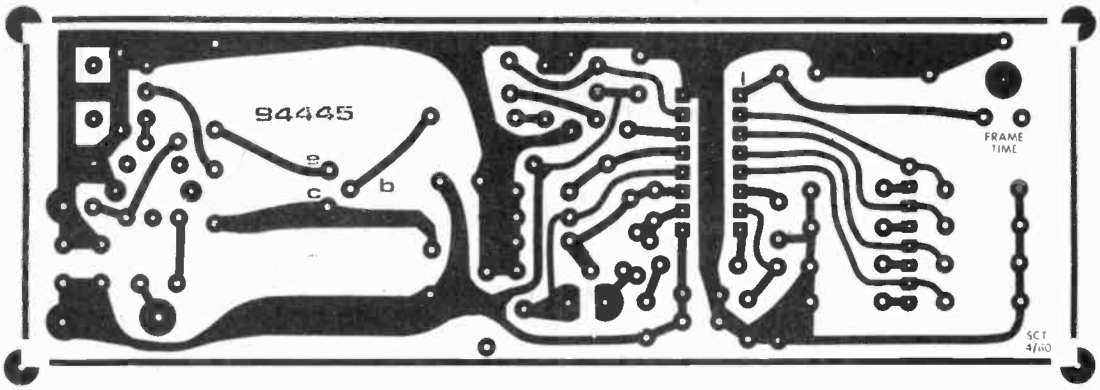


(Above) Monitor amplifier

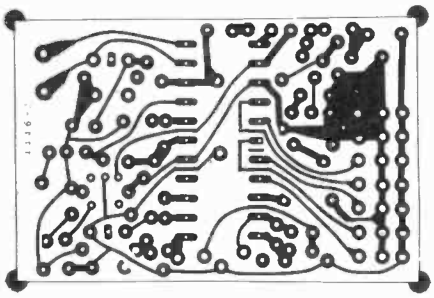


(Above) Sustain/Fuzz board

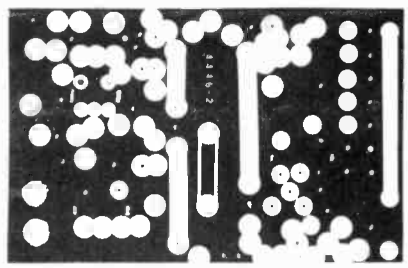




FM Radio Control transmitter board



FM Radio Control receiver board (topside)



FM Radio Control receiver board (bottom side)

STEVENSON

REGULATORS

78L05	33p	
78L12	33p	
78L15	33p	
7905 85p	7805	70p
7912 85p	7812	70p
7915 85p	7815	70p

TIC246 16A 400V Triac 115p
C106D 4A 400V 50SCR 45p

SPEAKERS

64mm 8Ω	110p
64mm 64Ω	110p
70mm 8Ω	140p
56mm 8Ω 100p · 70mm 80Ω	170p
Pair of ultrasonic transducers	380p
Magnetic earphone + 3.5mm plug	17p
Crystal earphone + 3.5mm plug	48p

POTENTIOMETERS

Preset ver. or hor.	8p
Rotary 5K-1M Log or Lin	33p
Rotary 5K-1M stereo	110p
Slide 60mm travel 5K-500K log or Lin, single	65p

Suitable knobs for above with coloured caps in red, blue, green, grey, yellow and black. Rotary 16p. Slide 12p each.

CONNECTORS

DIN	Plug	Chassis Socket	Line Socket
2 pin	9p	8p	12p
3 pin	12p	10p	12p
5 pin 180	13p	11p	16p
JACK	Plug	Scr. plug	Socket
2.5mm	10p	16p	9p
3.5mm	11p	18p	9p
std.	17p	30p	22p
Stereo	25p	39p	25p

MISC

8mm stranded conn. cable	30p
Min. mains cable per metre	25p
PP3 battery clips	6p
Crocodile clips	6p
AA rechargeable cells	145p
PP3 rechargeable cells	495p
Red or black terminals	30p
3 lead TO18 socket	15p
Red or amber neon indicator	42p
Subminiature SPST toggle	65p
Standard SPST toggle	40p
Miniature slide switches	16p
IP12W rotary switches	52p
Push to make switches	16p
TO5 heatsinks	12p
20mm panel fuseholders	22p
ORP12 LDR	70p
3.75 x 5 0.1 veroboard	99p
2.5 x 1 0.1 veroboard	21p
3 x 2 x 1 aluminium box	82p
6 x 4 x 2 aluminium box	99p
Miniature 606, 909 transformer	110p
TIL111 optoisolator	80p
4 self adhesive feet	20p
SRB Soldering iron	430p
Desoldering tool	550p

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TRANSISTORS

AC127	25p	BC547	8p	TIP30C	70p
AC128	25p	BCY71	18p	TIP2955	65p
AD161	40p	BD131	35p	TIP3055	60p
AD162	40p	BD132	35p	ZTX107	12p
BC107	10p	BD139	35p	ZTX108	12p
BC108	10p	BD140	35p	ZTX109	12p
BC109	10p	BFX29	25p	ZTX300	14p
BC147	9p	BFX84	26p	ZTX500	15p
BC178	16p	BFY50	23p	2N3053	25p
BC182	10p	BFY51	23p	2N3055	55p
BC182L	10p	MJ2955	98p	2N3702	9p
BC184	10p	TIP29C	60p	2N3703	9p
BC184L	10p			2N3704	9p
BC212	10p			2N3819	22p
BC212L	10p			2N3905	10p
BC214	10p			2N5777	50p
BC214L	10p				

DIODES

1N914	4p	1N4148	3p
1N4001	4p	1N4002	5p
1N4006	7p	1N5401	14p

BZY88 series 8p each.

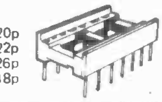
CMOS

4001	25p	4025	25p	4072	25p
4002	25p	4026	150p	4081	30p
4006	95p	4027	50p	4082	30p
4007	25p	4028	90p	4085	85p
4011	30p	4029	110p	4093	80p
4013	45p	4040	110p	4095	110p
4015	85p	4042	85p	4510	90p
4016	48p	4046	110p	4511	100p
4017	80p	4048	60p	4518	90p
4018	90p	4049	50p	4520	110p
4020	110p	4050	50p	4527	165p
4022	100p	4052	80p	4528	100p
4023	25p	4060	120p	4532	125p
4024	60p	4066	63p	4543	170p
		4068	25p	4583	80p
		4069	25p	4585	115p
		4070	25p		
		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		



LINEAR

741	18p	LM324	52p	MM57160	650p
747	70p	LM339	55p	NE531	140p
748	40p	LM348	100p	NE555	23p
7106	850p	LM377	170p	NE556	60p
CA3046	70p	LM378	230p	NE567	120p
CA3080	75p	LM380	80p	RC4136	100p
CA3130	100p	LM381	140p	SN76477	230p
CA3140	60p	LM382	120p	TBA800	80p
LF347	170p	LM386	90p	TBA810	110p
LF351	45p	LM387	120p	TDA1022	630p
LF353	90p	LM1458	40p	TL081	45p
LF356	95p	LM1830	180p	TL082	85p
LM301A	30p	LM3900	60p	TL084	125p
LM318	85p	LM3909	72p	XR2206	390p
		LM3911	120p	ZN414	80p
		LM3914	320p	ZN425E	475p
		LM3915	320p		

OPTO

	0.125in.	0.2in.	
Red	TIL209	TIL220	10p
Green	TIL211	TIL221	16p
Yellow	TIL213	TIL223	16p
Clips	3p	3p	
DL704	0.3in	CC	130p
DL707	0.3in	CA	130p
FND500	0.5in	CC	100p

PACKS

Specially designed packs intended for development work at a considerable saving.

¼w resistors. 10 of each value 4.7ohm to 1 Mohm. a total of 650 resistors. 530p each.
½w resistors. 10 of each value 4.7ohm to 1 Mohm. a total of 650 resistors. 875p each.
Presets. Pack of 5 of each value from 100ohms to 1 Megohm. a total of 65 presets. 390p each.
LED's. Pack containing 10 of each colour LED 0.2 size. Total of 30 Led's + clips. 450p each.
Zeners. Pack of 5 of each value from 2V7 to 33V A total of 130 zeners. 880p each.

CAPACITORS

TANTALUM BEAD

0.1, 0.15, 0.22, 0.33, 0.47, 0.68, 1 and 2.2uF @ 35V	12p
4.7, 6.8, 10uF @ 25V	20p
22 @ 16V, 47 @ 6V, 100 @ 3V	26p

POLYESTER (Mullard C280 series)

0.01, 0.015, 0.022, 0.033, 0.047, 0.1	6p
0.15, 0.22	8p
0.33, 0.47	12p

RADIAL LEAD ELECTROLYTICS

63V	0.47	1.0	2.2	4.7	10	7p
			22	33	47	9p
25V	10	22	33	47		7p
	100					9p
				470		20p
	1000					32p

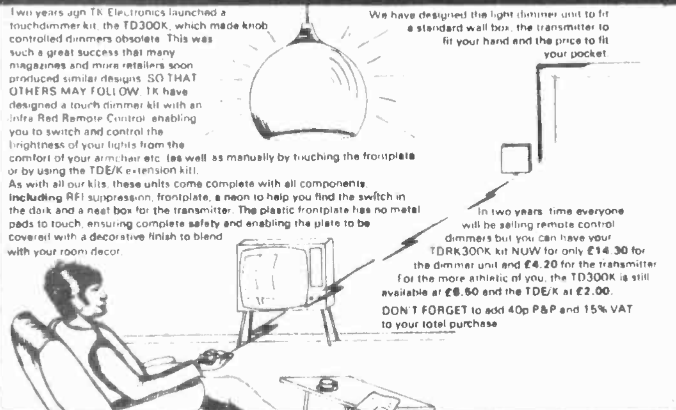
76 College Road, Bromley, Kent BR1 1DE.

AND NOW A DIMMER THAT MAKES TOUCH DIMMERS OBSOLETE

Two years ago TK Electronics launched a touchdimmer kit, the TD300K, which made knob controlled dimmers obsolete. This was such a great success that many magazines and more retailers soon produced similar designs. SO THAT OTHERS MAY FOLLOW, TK have designed a touch dimmer kit with an Infra Red Remote Control enabling you to switch and control the brightness of your lights from the comfort of your armchair etc. (as well as manually by touching the frontplate or by using the TDE/K extension kit).
As with all our kits, these units come complete with all components including RFI suppression, frontplate, a neon to help you find the switch in the dark and a neat box for the transmitter. The plastic frontplate has no metal pads to touch, ensuring complete safety and enabling the plate to be covered with a decorative finish to blend with your room decor.

We have designed the light dimmer unit to fit a standard wall box, the transmitter to fit your hand and the price to fit your pocket.

In two years time everyone will be selling remote control dimmers but you can have your TDRK300K kit NOW for only £14.30 for the dimmer unit and £4.20 for the transmitter. For the more athletic of you, the TD300K is still available at £6.60 and the TDE/K at £2.00.
DON'T FORGET to add 40p P&P and 15% VAT to your total purchase.



REMOTE CONTROL COMPONENTS

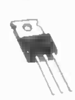
LD271 IR Emitting Diode	36p
SFH205 Photodiode Detector	95p
SL480 IC Pulse Amp	£1.70
SL490 32 command encoder/transmitter	£2.40
ML922 10 channel receiver + 3 analogue outputs	£4.20
ML926 16 channel receiver 4 momentary binary o/p	£1.40
ML928 16 channel receiver 4 latched binary o/p	£1.40
ML929 16 channel receiver 4 latched binary o/p	£1.40
Data Sheets per device	10p

These ICs can be used with infra red, ultrasonic or radio links, depending on range, cost and speed of operation.

RC500K KIT

If you do not require a sophisticated multi-channel remote control, we have developed a simple single-channel on/off infra red transmitter and receiver kit. The transmitter unit comes complete with a hand-held box and requires a PP3 (9V) battery. The receiver includes a triac capable of switching up to 500W at 240V a.c. and comprises a pre-amplifier bistable latch and a mains power supply, making the unit completely self contained. The small size of the receiver enables the unit to be "built into" all kinds of equipment from lamps to tape recorders. Range approximately 20ft.
£12.50

TRIACS



400V Plastic Case (Texas)

3A	49p	16A	95p
8A	58p		
12A	85p	25A	190p
6A with trigger			80p
8A isolated tab			65p
Diac			18p

TK's SPECIAL OFFERS OF THE MONTH

Orders must be received by 31.10.80

SPECIAL OFFERS

AY-5-1224 Clock IC	£2.20
LM3915 Bar/Dot Driver	£2.10
2 x DL304 0.3" cc Display	£1.35
2 x DL307 0.3" ca Display	£1.35
2 x 2N3442, 10 off each 0.2" LEDs Red, Green, Yellow	£1.80 / £2.90

MINI KITS

These kits form useful subsystems which may be incorporated into larger designs or used alone. Kits include PCB, short instructions and all components.

MK1 TEMPERATURE CONTROLLER/THERMOSTAT
Uses LM3911 IC to sense temperature (80°C max) and triac to switch heater. 1KW £4.00

MK2 SOLID STATE RELAY
Ideal for switching motors, lights, heaters, etc from logic. Opto-isolated with zero voltage switching. Supplied without triac. Select the required triac from our range. £2.60

MK3 BAR/DOT DISPLAY
Displays an analogue voltage on a linear 10-element LED display as a bar or single dot. Ideal for thermometers, level indicators etc. May be stacked to obtain 20 to 100 element displays. Requires 5-20V supply £4.75

MK4 PROPORTIONAL TEMPERATURE CONTROLLER
Based on the TDA1024 Zero voltage switch, this kit may be wired to form a "burst fire" power controller or a "proportional temperature" controller enabling the temperature of an enclosure to be maintained to within 0.5°C. 3KW £5.55

MK5 MAINS TIMER
Based on the ZN1034E Timer IC this kit will switch a mains load on (or off) for a preset time from 20 minutes to 35 hours. Longer or shorter periods may be realised by minor component changes. Maximum load 1KW £4.50

DISPLAY LIGHTING KITS

Each unit has 4 channels (rated at 1KW at 240V per channel) which switch lamps to provide sequencing effects, controlled manually or by an optional opto-isolated audio Inut.

DL1000K
This kit features a bi-directional sequence, speed of sequence and frequency of direction change being variable by means of potentiometers. Incorporates master dimming control. £14.60

DLZ1000L
A lower cost version of the above, featuring unidirectional channel sequence with speed variable by means of a preset pot. Outputs switched only at mains zero crossing points to reduce radio interference to minimum. £8.00
Optional Opto Input DLA1 60p

MINI TRANSFORMERS

Standard mains primaries 240V a.c 100mA secondaries

6-0-6V	80p
9-0-9V	85p
12-0-12V	90p

D.I.L. I.C. SOCKETS

8 pin	8p	18 pin	17p
14 pin	12p	28 pin	24p
16 pin	14p	40 pin	38p

INTEGRATED CIRCUITS

555 Timer	21p
741 Op. Amp.	19p
AY-5-1224 Clock	£2.60
AY-5-1230/2 Clock/Timer	£4.50
AY-3-1270 Thermometer	£8.20
ICL7106 DVM (LCD drive)	£7.00
LM377 Dual 2 W Amp	£1.45
LM379S Dual 6W Amp	£3.50
LM380 2W Audio Amp	80p
LM382 Dual/low noise Preamp	£1.00
LM386 250mW low voltage Amp	75p
LM1830 Fluid Level Detector	£1.50
LM2907 f-v Converter (8 pin)	£1.40
LM2917 f-v Converter (14 pin)	£1.60
LM3909 LED Flasher/Oscillator	60p
LM3911 Thermometer	£1.20
LM3914 Dot/Bar Driver	£2.10
MM74C911 4 digit display controller	£6.50
MM74C915 7 segment-BCD converter	96p
MM74C926 4 digit counter with 7 seg.o/p	£4.50
S566B Touchdimmer	£2.50
S9263 Touchswitch 16-way	£4.85
SN76477 Complex Sound Generator	£2.52
TBA800 5W Audio Amp.	68p
TBA810AS 7W Audio Amp.	£1.00
TDA1024 Zero Voltage Switch	£1.20
TDA2020 20W Audio Amp.	£2.85
ZN1034E Timer	£1.80

All ICs supplied with data sheets
Data Sheets only 10p each device.

ALL COMPONENTS ARE BRAND NEW AND TO SPECIFICATION. ADD VAT AT CURRENT RATE TO ABOVE PRICES. 40p P&P MAIL ORDER — CALLERS WELCOME BY APPOINTMENT

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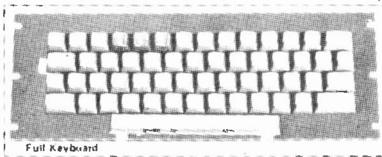
COMPUTER KEYBOARDS



STAR DEVICES MK III 71 keytouch sensitive keyboard. With numeric pad. All ASCII characters including control keys. Auto key repeat. Parallel output with strobe. Shift lock with indicator LED. Built in 'beeper' with level control. 5V DC at 300mA 15" x 7" x 1.25". Grey case with white keys on blue. 48.50 plus VAT

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In good condition at only £25 + VAT, P/P £2.50

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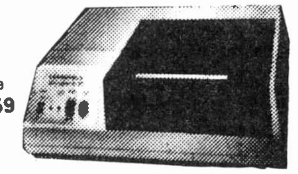

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16K RAM £127.50 ● 32K RAM £175.00
48K RAM £220.00
High Resolution Programmable Graphics £90
Colour Board Kit £140
High Resolution Colour add on £37.50

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The ASCII keyboard includes a numeric keypad and ribbon cable connector. Cabinet available at £20.00 plus VAT.
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Microtan 65 Assembled, £90.85

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Tanex Assembled Incl. VAT	£80.95
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Chunky Graphics Pack. Incl. VAT	£7.50
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Complete Tangerine range available

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6 for £6.50

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200 Micro
1½"x1½"x½"
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Contains a Foster type moving coil, mikes/earphones, V/C & switches as used on aircraft for passenger listening.
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1½" sq 2" deep

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12V	2 amps	3x2½x2½	£2.95
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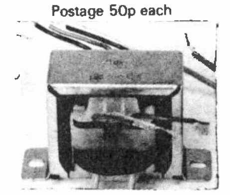
12£20V	1 amp		£2.50
14-0-14V	1.5 amp		£2.50
12V	1 amp		£2.50

Size 6x5x5mm
Postage 50p each



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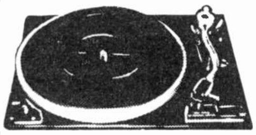

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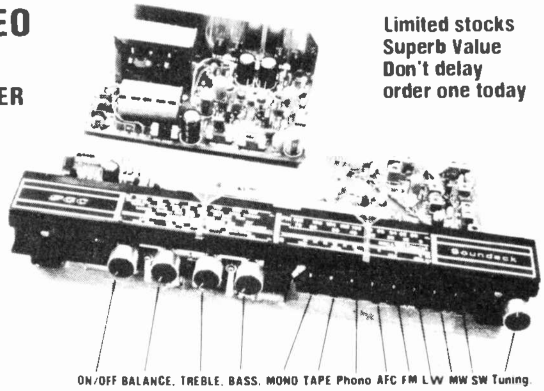

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Rotary Controls: Tuning on off volume balance treble, bass Stereo Beacon indicator
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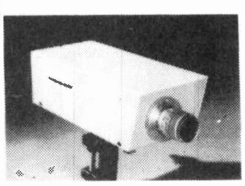

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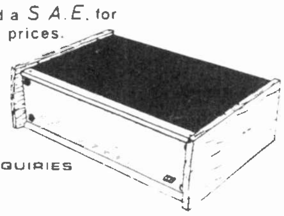

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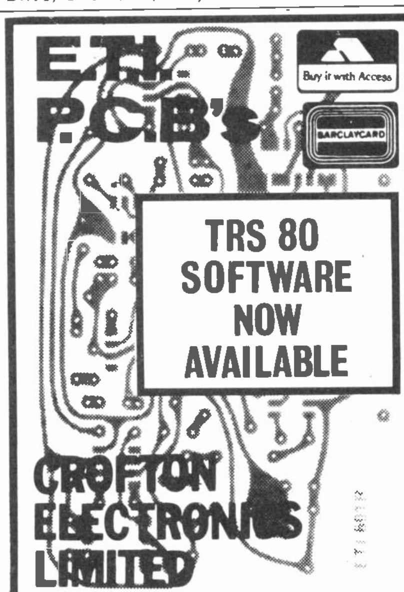

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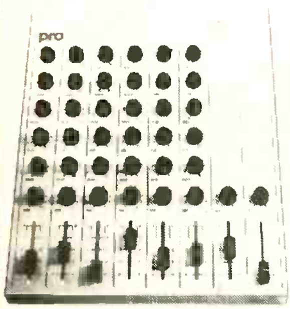

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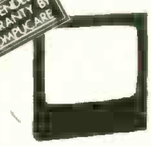

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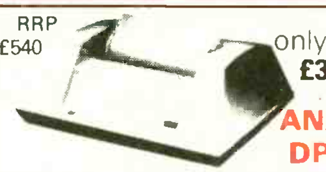

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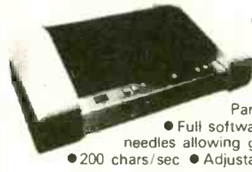

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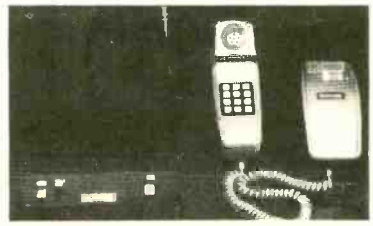

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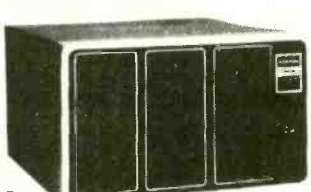

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