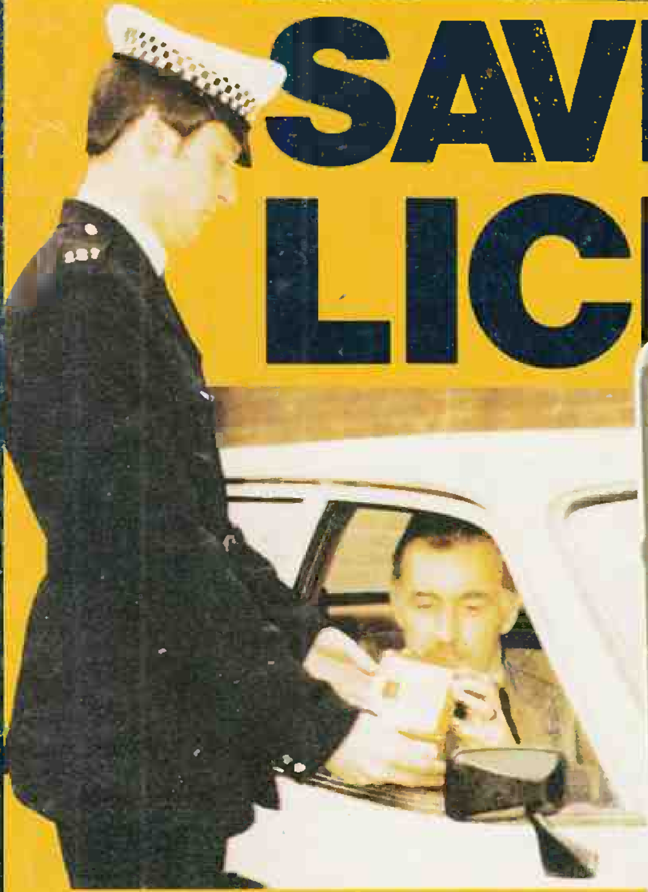
ISSN. 0142-7229

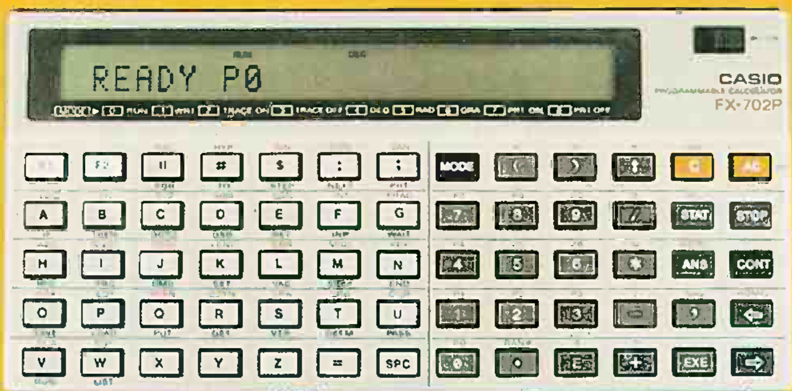
electronics today INTERNATIONAL

DECEMBER 1981 ONLY 65p

SAVE YOUR LICENCE!



Drive safely with our DIY Alcohometer



EXCLUSIVE REVIEW- CASIO'S HAND-HELD COMPUTER

INSIDE
NEW • ROBOTICS TODAY
news, views and projects for home roboticists

Bodywork Checker–find the filler for under a fiver

Expand Your Computer Cheaply–See Inside

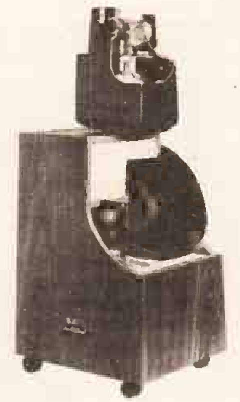
..AUDIO... ...TING....MUSIC...RADIO....ROBOTICS..

electronics today INTERNATIONAL

DECEMBER 1981 VOL 10 NO 12

Check your reactions p.79

FEATURES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PROJECTS


TV hi-fi p.37

INFORMATION

EDITORIAL AND ADVERTISEMENT OFFICE
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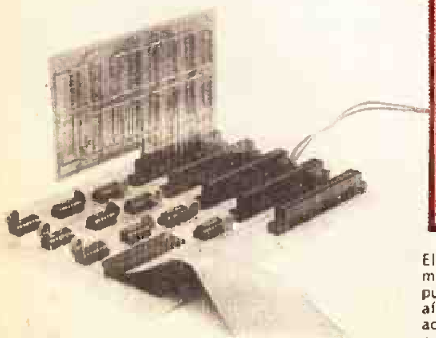
Expand your computer p.22

SWITCHES

TOGGLE: 2A, 250V.

SPST	33p
DPDT	44p

SUB-MIN TOGGLE

SPST on/off	54p
SPDT c/over	60p
SPDT centre off	85p
SPDT biased both ways	105p
DPDT 6 tags	75p
DPDT centre off	88p
DPDT biased both ways	145p
DPDT 3 positions on/on/on	185p
3-pole 2 way	205p

SLIDE 250V:

DPDT 1A	14p
DPDT 1A c/off	15p
DPDT 1/2A	13p

PUSHBUTTON 6A
with 10mm Button

SPDT latching	99p
DPDT latching	145p
SPDT moment	99p
DPDT moment	145p

Mini Non Locking

Push to Make	15p
Push to Break	25p

DIL SWITCHES
(SPST) 4 way 70p; 6 way 85p; 8 way 90p; 10 way 145p.
(SPDT) 4 way 190p.

ROTARY SWITCHES:
(Adjustable Stop type)
1 pole/2 to 12 way: 2p/2 to 6 way: 3 pole/2 to 4 way: 4p/2 to 3 way 45p

ROTARY: Mains DP 250V 4 Amp on/off 56p

ROTARY: (Mak-a-switch)
Make a multiway switch. Shafting assembly has adjustable stop. Accommodates up to 6 wafers (max. 6 pole/12 way + DP switch).
Mechanism only 90p

WAFERS: (make before break) to fit the above switch mechanism.
1 pole/12 way; 2 pole/6 way; 3 pole/4 way; 4 pole/3 way; 6p/2 way 56p
Mains DP 4A Switch to fit 45p
Spacers 4p. Screen 6p

ROCKER: 5A/250V SPST	28p
ROCKER: 10A/250V SPDT	38p
ROCKER: 10A/250V DPDT c/off	95p
ROCKER: 10A/250V DPST with neon	85p

DIL PLUGS

4pin	44p
16pin	49p
24pin	88p
40pin	250p

JUMPER LEADS (Ribbon Cable Assembly)
Single ended DIP Jumpers 24 inches 14 pin 145p; 16 pin 165p; 24 pin 240p; 40 pin 386p.

Double ended DIP Jumpers

Length	14 pin	16 pin	24 pin	40 pin
6in	185p	205p	300p	465p
12in	195p	215p	315p	490p
24in	215p	235p	350p	540p
36in	230p	250p	375p	595p

Ribbon Cable ft

10 way	20p
20 way	40p

AMPHENOL PLUGS IEEE 575p Centronics llel 657p

VEROBOARD 0.1in

	clad	plain
2½ × 3¼"	73p	52p
2½ × 5"	83p	
3¾ × 3¾"	83p	–
3¾ × 5"	95p	79p
3¾ × 17"	326p	211p
4¾ × 17"	426p	
Pkt. of 100 pins	50p	
Spot face cutter	118p	
Pin insertion tool	162p	

VQ Board	150p
DIP Board	330p
Vero Strip	144p

PROTO DECs

Veroblock	375p
S-Dec	350p
Eurobreadboard	520p
Bimboard 1	785p
Superstrip SS2	998p

VERO WIRING PEN + Spool 310p
Spare Spool 75p
Combs 6p

DALO ETCH RESIST PEN + Spare tip 90p

FERRIC CHLORIDE 1 lb bag Anhydrous 195p + 50p P&P

ULTRASONIC TRANSDUCER 40KHz 395p pr

COPPER CLAD BOARDS

Fibre glass	Single-sided	Double-sided
6" × 6"	90p	110p
6" × 12"	150p	195p

S.R.B.P. 9.5" × 8.5" 95p

DIL SOCKETS (TEXAS)

	Low Prof.	Wire Wrap
8pin	8p	25p
14pin	10p	35p
16pin	10p	42p
18pin	16p	52p
20pin	22p	60p
22pin	25p	70p
24pin	25p	70p
28pin	22p	90p
36pin		109p
40pin	30p	99p

EDGE CONNECTORS: (Double type)

	.1	.156
2x10 way	–	120p
2x15 way	–	135p
2x18 way	140p	145p
2x22 way	160p	165p
2x25 way	180p	175p
2x30 way	199p	–
2x36 way	235p	–
2x40 way	265p	–
2x43 way	280p	–

D CONNECTORS (Cannon type)

Pins	Plugs	Sockets	Covers
9way	95p	125p	145p
15way	135p	198p	150p
25way	170p	260p	130p
37way	290p	398p	185p

Soldercon Pins
100 pins 70p
500 pins 325p

PLUGS & SOCKETS

JACK	Plug	Socket	In-line
2.5mm (plastic)	8p	–	10p
Metal	15p	8p	18p
3.5mm (plastic)	10p	15p	12p
Metal	16p	10p	18p
¼in Mono			
Plastic	15p	20p	15p
Metal	36p	14p	30p
¼in Stereo			
Plastic	22p	24p	22p
Metal	36p	20p	39p
DIN			
2 pin	8p	6p	14p
3 pin	13p	10p	15p
4 pin	16p	12p	15p
5 pin	13p	12p	15p
BANANA			
1mm	9p	9p	–
2mm	13p	13p	–
3mm (wander)	11p	11p	–
4mm	13p	14p	–
CO-AXIAL (TV)			
Plastic	10p	16p	8p
Metal	19p	20p	40p

UHF Connectors (50Ω-CB)
plug PL259 40p; Reducer 14p;
Socket SO239 Round Chassis 40p
Socket SO239 Square Panel 38p

BULGIN OCTAL 250V-6A/pin
Plug P551 199p; Socket 68p

IEC 3 pin 250V/6A
Plug, chassis mounting 40p
Socket, free hanging 70p
Socket, with 2 metre lead 150p

ZERO INSERTION FORCE DIL SOCKETS 24 way 650p
28 way 820p; 40 way 975p

25way 'D' CONNECTOR
Jumper Lead Cable Assembly

18" long, Single End, Male	520p
18" long, Single End, Female	525p
36" long, Double Ended, M/M	1020p
36" long, Double Ended, F/F	1010p
36" long, Double Ended, M/F	1000p

ANTEX SOLDERING IRON
C-15W 420p; CX17W 430p.
CCN-15W 440p; CX25W 445p.
Spare tips, assorted sizes 50p
Spare Elements 210p
Iron stand with sponge 160p

SOLDER (Multicore)
18SWG
Size 5 Dispenser 75p
Size 12 Reel 360p
22SWG
PC115 Dispenser 100p
Size 10 Reel 360p

PANEL METERS

FSD
60x46x35mm
0-50μA
0-100μA
0-500μA
0-1mA
0-5mA
0-10mA
0-50mA
0-100mA
0-500mA
0-1A
0-2A
0-25V
0-50V AC
0-300V AC
"S"
"VU"
445p each

CRYSTALS

100KHz	290
200KHz	370
455KHz	383
1MHz	300
1.008M	395
1.28MHz	392
1.6MHz	323
1.8MHz	323
1.8432MHz	300
2MHz	305
2.4576MHz	300
3.2768M	240
3.57954M	150
3.6864MHz	300
4.000MHz	200
4.032	290
4.19430M	200
4.433619	120
5.0MHz	240
5.185M	300
5.24288M	390
6.0MHz	240
6.144MHz	240
6.5536MHz	200
MHz	200
7.168MHz	290
7.680M	200
8.0MHz	200
8.08333M	362
8.867237M	240
9.375M	323
10.0MHz	240
10.7MHz	270
12MHz	290
14.31818M	320
16.0MHz	275
18MHz	240
18.432M	240
19.968MHz	300
20.0 MHz	323
26.0 MHz	383
26.69 MHz	290
27.145MHz	240
27.648M	323
38.6667M	290
48.0MHz	270
100.00MHz	323
116.0MHz	300

RELAYS

REED. Encapsulated, Single Pole, 5W Normally Open, 200mA, 50V DC.

RL12	700Ω 6V to 9V	120p
RL13	1KΩ 9V to 12V	120p
RL14	1K7Ω 12V to 18V	120p
RL15	3KΩ 18V to 30V	135p

Single Pole, Change Over

RL16	1KΩ 4V to 10V	295p
RL17	1KΩ 9V to 12V	295p

Double Pole, Normally Open

RL18	350Ω 9V to 12V	200p

Miniature, enclosed, PCB mount. Our RL6 series.
S.P.C.D.
RL6-91 170Ω coil, 7V5 to 12V DC; 380V/6A AC; 1300VA/50W 210p
D.P.C.O.
43Ω coil, 4V2-7V DC; 250V AC; 5A; 1100VA/150W 218p
RL6-111 170Ω coil, 8V-14V; 250V AC 5A. 220p
RL6-114 740Ω coil, 17V5-29V 250V; 5A AC. 222p

CONTINENTAL Cradle Type Relays. Miniature Plug-in relays. 110V DC; 12V AC. 2A/DC: 2.5A AC 30W/100VA.
2 pole c/over 185Ω; 6V-18V. RL201 180p
2 pole c/over 13V to 35V: 700Ω; RL202 180p
4 pole c/over 9V to 18V; 185Ω. RL211 220p
High Power "Heavy Duty" PCB Mounting, Cradle type.
S.P.C.D. Power Gain 1:8000 380V AC/16A; 3.5K VA. 8 to 19V; 190Ω 295p

PIEZO TRANSDUCERS
Type PB-2720 75p

BUZZERS, miniature, solid-state 6V; 9V & 12V 70p

LOUDSPEAKERS
Miniature, 0.3W; 8Ω. 2in, 2¼in, 2½in, 3in 80p
2½in 40Ω, 64Ω or 80Ω 80p

WANDER MIKE
The new Radio microphone that transforms your FM radio into a cordless PA System. Just tune-in your radio on to 90MHz, turn on the Wander Mike and you have instant high quality sound reproduction. PA System. Has a range of 100 feet +. Also supplied is a 5-metre cable with jack plug, should you wish to use it as a standard microphone. Ideal for singers, musicians, conferences, lectures, discos, clubs etc.
DNLY £39.50

SPEAKING CLOCK
Complete Kit of parts available for this clock Only £37.50

TRANSFORMERS: Prim. 240V

6-0-6V; 9-0-9V; 12-0-12V 100mA 98p
pcb mounting, Miniature, Split Bobbin
3VA: 2x6V-0.25A; 2x9V-0.15A; 2x12V-0.12A; 2x15V-0.1A 200p
6VA: 2x6V-0.5A; 2x9V-0.3A; 2x12V-0.25A; 2x15V-0.2A 270p
Standard Split Bobbin type:
6VA: 2x6V-0.5A; 2x9V-0.4A; 2x12V-0.3A; 2x15V-0.25A 220p
12VA: 2x4.5V-1.3A; 2x6V-1A; 2x9V-0.6A; 2x12V-0.5A; 2x15V-0.4A; 2x20V-0.3A 275p (35p p&p)
24VA: 2x6V-1.5A; 2x9V-1.2A; 2x12V-1A; 2x15V-0.8A; 2x20V-0.6A 320p (60p p&p).
50VA: 2x6V-4A; 2x9V-2.5A; 2x12V-2A; 2x15V-1.5A; 2x20V-1.2A; 2x25V-1A; 2x30V-0.8A 400p (60p p&p).
100VA: 2x12V-4A; 2x15V-3A; 2x20V-2.5A; 2x25V-2A; 2x30V-1.5A; 2x50V-1A 920p (75p p&p charge to be added over and above our normal postal charge).

VOLTAGE REGULATORS

	+ve		-ve	
1A	TO3 metal case			
5V	7805	145p	7905	220p
12V	7812	145p	7912	220p
15V	7815	145p		–
18V	7818	145p		–
1A	TO220 Plastic Casing			
5V	7805	45p	7905	55p
12V	7812	50p	7912	55p
15V	7815	50p	7915	55p
18V	7818	50p	7918	55p
24V	7824	50p		
100mA	TO92 Plastic Casing			
5V	78L05	30p	79L05	60p
6V	78L62	30p		–
8V	78L82	30p		–
12V	78L12	30p	79L12	60p
15V	78L15	30p	79L15	80p

CA3085	95p
LM304H	170p
LM309KP	99p
LM300H	170p
LM305H	140p
LM309K	135p
LM317K	350p
LM317H	280p
LM323K	550p
LM325N	240p
LM326N	240p
LM327	270p
LM723	35p
TAA550	50p
TBA625B	75p
TDA1412	150p
78HO5 – 5V/5A	550p
78HG +5V to +25V 5A	650p
79HG-2.25V to 24V 5A	800p

CMOS

4000	14	4073	20	4536	295
4001	14	4075	20	4538	116
4002	14	4076	60	4539	115
4006	66	4077	26	4541	140
4007	18	4078	26	4543	135
4008	62	4081	26	4544	150
4009	35	4082	21	4549	395
4010	40	4085	65	4553	299
4011	15	4086	70	4554	190
4012	18	4089	140	4555	50
4013	34	4093	43	4556	55
4014	75	4094	168	4557	320
4015	66	4095	90	4558	120
4016	32	4096	90	4559	395
4017	48	4097	320	4560	180
4018	68	4098	88	4561	104
4019	42	4099	95	4562	495
4020	61	4160	95	4566	175
4021	70	4161	99	4568	250
4022	66	4162	99	4569	175
4023	20	4163	99	4572	36
4024	45	4174	99	4580	460
4025	19	4175	105	4581	250
4026	130	4194	105	4582	99
4027	38	4408	790	4583	99
4028	58	4409	790	4584	48
4029	77	4410	725	4585	99
4030	50	4411	695	4597	330
4031	170	4412	800	4598	290
4032	125	4415	480	4599	595
4033	165	4419	280	40097	88
4034	195	4422	770	40100	215
4035	95	4433	770	40101	130
4036	275	4435	850	40102	180
4037	115	4440	999	40103	175
4038	110	4450	350	40104	95
4039	290	4451	350	40105	115
4040	59	4490	350	40106	75
4041	78	4500	675	40107	80
4042	60	4501	28	40108	450
4043	70	4502	90	40109	100
4044	65	4503	50	40110	300
4045	120	4504	105	40114	240
4046	75	4506	65		
4047	75	4507	40		
4048	55	4508	265		
4049	30	4510	68		
4050	30	4511	68		
4051	78	4512	76		
4052	78	4513	199		
4053	78	4514	195		
4054	125	4515	198		
4055	125	4516	75		
4056	120	4517	415		
4057	1915	4518	42		
4059	480	4519	29		
4060	90	4520	78		
4061	1225	4521	200		
4062	995	4522	125		
4063	99	4526	95		
4066	36	4527	115		
4067	399	4528	80		
4068	22	4529	150		
4069	20	4530	90		
4070	26	4531	130		
4071	20	4532	110		
4072	20	4534	500		

OPTO ELECTRONICS

LEDs with Clips

TIL209 Red	13
TIL211 Grn.	17
TIL212 Yel.	18
TIL220 .2" Red	14
.2" Green, Yellow or Amber	18
0.2" Bi colour Red/Green	65p
Green/Yellow	65p
0.2" Tri colour Red/Green/Yellow	85p
Square LEDs, Red, Green, Yellow	30
LD271 Infra Red	46
SFH205 Detector	91
TIL32 Infra Red	58
TIL78 Detector	60
BARGRAPH. Red 10 segments	225
LS40C	255
OCP71	120
ORP12	86
ORP61	85
2N5777	45

ISOLATORS

IL74	55
TIL111/2/4	90

7 Segment Displays

TIL307	675
TIL312 .3" CA	105
TIL313 .3" CC	105
TIL321 .5" CA	115
TIL322 .5" CC	115
OL704 .3" CC	99
DL707 .3" CA	99
DL747 .6" CA	180
.8" Orange CA	250
FND357 Red	120
FND500	115
.3" Green CA	150
.6" Green CA	215
.3" ±1 Red CA	150
.3" ±1 Green CA	150
DVM176	1885
LCD 3½ Digits	675
LCD 4 Digits	750
LCD 6 Digits	850

NEON with resistor, push fit. 250V mains. Round.
Red or Amber 30p
Rectangular, nut gixing Red, Amber, Green 30p
Reflective Optical Switch 295p
Slotted Optical Switch 186p

COMPUTER CORNER

- VIC 20 MICRO COMPUTER connects directly to any colour TV set. Sound reproduced through TV Speaker. PET Graphics etc. . . £165
- Cassette Dec for VIC plus 6 prog. free cassette £34
- VIDEO GENIE A complete system including Cassette recorder. Ideal for School/Colleges & Home. 16K users RAM. 12K Microsoft Basic in ROM. 64 × 16 line display £279
- SEIKOSHA GP80A Unihammer Printer, gives normal & double width Characters as well as dot resolution graphics. 8" tractor feed. Parallel interface standard £195
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- EPSON MX80FT Has Friction feed & Tractor feed plus all the MX89's facilities £395
- EPSON MX80FT2 Has high resolution Graphics option plus all the MX80FT's facilities £435
- EPSON MX100 132 Column Printer plus has all the facilities of MX80FT2. Value for money £570
- SOFTY-2 As reviewed in PE Sept. '81 by Dr A. A. Berk. The complete microprocessor development system for Engineers and beginners alike. New powerful instructions. Accepts any 24 pin 5V single rail EPROM. Supplied fully built, tested. Enclosed in a black ABS case. Plug-in power supply included £169
- VIDEO MONITOR 9", fully cased & guaranteed. B & W. Excellent value for money £69
- TEX EPROM ERASER Erases up to 32 ICs in 15-30 minutes . . . £33
- SPARE 'UV' Lamp bulb £9
- 5V/5A Power Supply Ready-built & tested £25
- ABS CASE Attractive, Beige/Brown for Superboard, UK101 NASCOM, or HOme brew £26
- Extra 4K RAM (8 × 2114L-300n) 795p
- C12 CASSETTES in library cases 40p
- STAK-PAK 10 × C12 Cassettes in stackable drawers 550p
- WEMON Watford's own 4K Ultimate Monitor IC specially designed to produce the best from your Superboard, UK101 & Enhanced Superboard. As reviewed by Dr A. A. Berk in Practical Electronics 1981 . . . . 1995p

(p&p on most of the above items is extra)

Call in at our shop for demonstration on any of the above items. Be satisfied before you buy.

ETI/WATFORD'S MICRO EXPANSION SYSTEM

This versatile economical Expansion System, as published in ETI, provides a cheap but reliable expansion possibility for most of the popular Micro-computers.
Send SAE for details.

WATFORD'S BOOKSHOP CORNER

Texas TTL Data Book (Revised Edition)	680p
TTL Cook-Book	750p
European CMOS DataBook (Comprehensive)	750p
CMOS Cook-Book	750p
Personal Computer Book	695p
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BASIC with Style	540p
A Bit of BASIC	640p
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BASIC Computer Games	550p
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PASCAL with Style	600p
Programming in PASCAL (revised)	800p
CRT Controller Handbook	600p
CP/M Handbook	995p
Microprocessor Interfacing Technique	1120p
S-100 Bus Handbook	1100p
Writing Interactive Compiler & Interpreters	1340p

Please add 55p P&P charge on books

No VAT on books

DIGEST

Game, Set And Match

Extending the series of features on their C80 watch, Casio have decided to include alarm with tone control, day and date indication with time display, and a combat style electronic game. The two new models incorporating these features are called the CA90 and CA901. The first has a black resin case and bracelet; the second, a stainless steel coated case and solid stainless steel bracelet. Recommended retail prices are £22.95 (CA90) and £34.95 (CA901). They should be available from your friendly neighbourhood Casio stockist or in case of difficulty contact Casio themselves at 28 Scrutton Street, London EC2A 4TY.

In-Car Care

The high price of installing in-car sound systems is often due to the large proportion of cash earmarked for so-called expert installation. But Greens at Debenhams have come up with a less expensive alternative. They have introduced Track One — a range of in-car entertainment systems with full installation instructions, backed by a 24-hour helpline system. The equipment includes Citizens' Band radio, stereo and normal radio, and offers a wider range of choice than most high street shops. Each unit is accompanied by detailed fitting instructions, but should you get into difficulties just ring the number shown on the leaflet and an expert will talk you through to find out where you went wrong. You can find Greens at any of your local Debenhams stores.

Telecom Turnround

It seems that there has been some confusion about the use of the word 'illegal' in the article entitled Telecom Turnround published last month. 'Illegal supplier' and 'illegal equipment' were not clearly defined. In fact, there is nothing illegal about supplying or selling telephone equipment, and likewise the units themselves are not illegal. The law is only broken when an independent supplier *publicly states* that the equipment he sells can be connected to the UK network when it hasn't been approved by British Telecom. And again, the equipment is only illegal *once it has been connected* and in this case it is the *buyer* of the equipment who breaks the law, not the supplier.

We apologise to any readers (especially suppliers!) who may have been inconvenienced by this misinterpretation.

FM Main Man!

Here is a letter we received from the Electricity Council referring to our article on FM Mains Remote Control. Please note:

Dear Sir

FM Mains Remote Control

The feature in the October 1981 edition of Electronics Today describing a control device which utilises the electrical installation as the medium for communication between separate rooms of a house also mentioned the possibility of utilising the power distribution system between separate premises.

Would you please point out to your readers that under section 27 of the Electric Lighting (clauses) Act 1899 there is provision which states that if the owner or occupier of premises uses the energy supplied so as to interfere 'unduly or improperly' with the efficient supply of energy to any other person the Board may discontinue the supply.

We would also point out that if the power distribution system were to be used in the manner you describe the injected signals would not be restricted to the circuit between the 'helpful neighbours' but would be broadcast throughout the surrounding low voltage network and would therefore be 'received' by all the other electricity consumers connected to that network. Any detrimental effects the signals may have on any item of equipment being used by those other consumers must clearly be the responsibility of those involved in generating the signals regardless of whether they have 'spilled over' from the installation or whether they have been deliberately injected into the network directly.

Yours faithfully,

D.V. Ford
Head of Distribution Engineering

New Connections

Following up on our article last month about the new Telecommunications bill, we have found British Telecom are now pulling their proverbial receivers out. For example, a scheme designed to enable telephone sockets to become as commonplace as power outlets has recently been announced by BT. The scheme will be launched nationwide this autumn and follows a successful trial programme in Taunton and Carlisle which has been running since May this year. Instead of having telephones fixed permanently, customers now will be able to unplug them and move them from room to room wherever sockets have been installed. This idea will radically change the installation of the telephone service in and around the home, also simplifying the sale of some Telecom equipment, when phones will be available from some 40 shops by next April, mostly within department stores. These will be available for sale to customers to take home and plug in. As supplies of the new plugs and sockets become available, customers asking for extension phones will have sockets fitted, and will be supplied with a telephone of their choice, with a plug already connected to it. Engineers will also adapt existing phones on the same line to plug and socket connections. This will replace existing extension arrangements. Customers requiring an extension telephone will pay a connection charge of £25 with additional extensions provided at the same time for only £10. The rental will be £2.65 for a residential extension, complete with standard telephone and additional sockets on their own will be charged at 15p a quarter. All new installation work on residential and single business lines will incorporate the new system. Extra note: This means that all telephones approved after the new liberalisation comes into effect will be candidates for this kind of plug and socket connection.

Further update: Ferranti have just won a contract to supply British Telecom with the new ZN470AE Microphone Amplifier Integrated Circuit. This will be incorporated in the new linear electret microphone manufactured by AP Besson Ltd, which will replace the familiar carbon type, thus offering improved speech quality and long-term reliability.

THREE FOR FREE FROM GSC

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Electronics by Numbers Projects No 10, No 11, No 12

Available from selected stockists

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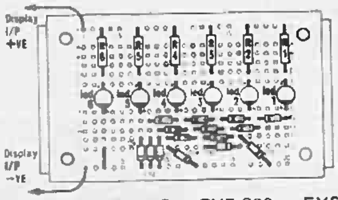
The suspense and excitement of the casino in your own home. Just press the button, the circle of lights go round and there is the sound of the roulette wheel as well, both gradually slowing down to reveal the winning number.

No. 12 EGG TIMER

How do you like your eggs done, hard or soft, just set the timer and it will sound when the egg is done to your liking. Long battery life because it switches itself off automatically. So get cracking now!

Want to get started on building exciting projects, but don't know how? Now using EXPERIMENTOR BREADBOARDS and following the instructions in our FREE 'Electronics By Numbers' leaflets, ANYBODY can build electronic projects. For example, take one of our earlier projects, a L.E.D. Bar Graph:



You will need: One EXP 300 or EXP 350 breadboard 15 silicon diodes 6 resistors 6 Light Emitting Diodes

Just look at the diagram, Select R1, plug it into the lettered and numbered holes on the EXPERIMENTOR BREADBOARD, do the same with all the other components, connect to the battery, and your project's finished. All you have to do is follow the large, clear layouts on the 'Electronics by Numbers' leaflets, and ANYBODY can build a perfect working project.

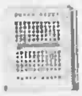
For full detailed instructions and layouts of Projects 10, 11 and 12, simply take the coupon to your nearest GSC stockist, or send direct to us, and you will receive the latest 'ELECTRONICS BY NUMBERS' leaflet.

If you have missed projects, 1, 2 and 3, or 4, 5 and 6, or 7, 8 and 9, please tick the appropriate box in the coupon.

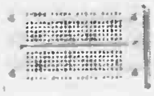
EXPERIMENTOR BREADBOARDS

No soldering modular breadboards, simply plug components in and out of letter number identified nickel-silver contact holes. Start small and simply snap-lock boards together to build a breadboard of any size.

All EXP Breadboards have two bus-bars as an integral part of the board, if you need more than 2 buses simply snap on 4 more bus-bars with the aid of an EXP 4B.



EXP 325 £1.60 The ideal breadboard for 1 chip circuits. Accepts 8, 14, 16 and up to 22 pin ICs. Has 130 contact points including two 10 point bus-bars.

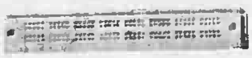


EXP 350 £3.15 Specially designed for working with up to 40 pin ICs perfect for 3 & 14 pin ICs. Has 270 contact points including two 20 point bus-bars.

EXP 300 £5.75 The most widely bought bread-board in the UK With 550 contact points, two 40 point bus-bars, the EXP 300 will accept any size IC and up to 6 x 14 pin DIPS. Use this breadboard with Adventures in Microelectronics.

EXP 600 £6.30 Most MICROPROCESSOR projects in magazines and educational books are built on the EXP 600.

EXP 650 £3.60 Has ·6" centre spacing so is perfect for MICROPROCESSOR applications

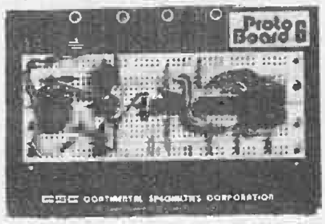


EXP 4B £2.30 Four more bus-bars in "snap-on" unit.

The above prices are exclusive of P&P and 15% VAT.

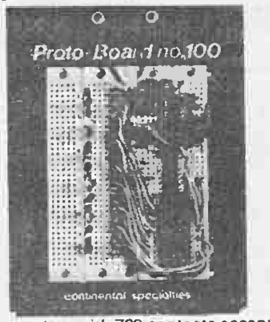
PROTO-BOARDS

The ultimate in breadboards for the minimum of cost. Two easily assembled kits.



PB6 Kit. 630 contacts, four 5-way binding posts accepts up to six 14-pin Dips.

PROTO-BOARD 6 KIT £9.20



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EXP 650	270	use with 0.6 pitch Dip's Strip Bus-Bar	**£ 5.00**	
EXP 4B	Four 40 Point Bus-Bars		**£ 3.50**	
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PB6	630	6	**£11.73**	
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Books, Books, Books...

Once again it's time to get to grips with the ever-increasing pile of review books that threaten to take over ETI's corner of the ASP offices.

The first one comes from Hodder and Stoughton, and is the latest Teach Yourself book in their Computer Science Studies range. Entitled 'Microelectronics and Microcomputers', the book is intended to provide a general background and introduction to microcomputers for people who want to come to terms with the increasing impact of computers both at home and at work. All aspects of the subject are covered, although briefly; the book starts with such basic topics as types of electronic components, the use of various number systems (decimal, binary, hex and so on), and simple logic of a microcomputer, peripheral devices and how to use them, programming, system development, data transmission and instrumentation techniques. The final five chapters describe numerous applications in the fields of industry, transport, consumer goods, education and business. No prior knowledge is assumed, although some experience of electronic theory would make the first half of the book easier to grasp. The authors have packed a great deal into the book's 225 pages, and it can be recommended as an introductory text for bewildered businessmen and for people interested in the forceful effects that computers are having on our society. 'Microelectronics and Microcomputers' is written by L.R. Carter and E. Huzan, and costs £1.95.

The rest of the books come from Bernard Babani. 'Audio Projects' (£1.95), by F.G. Rayer, gets down to the nitty-gritty very quickly — a brief introduction and then it's straight into the projects, over 30 of them, ranging from preamps, mixers and power amps to tone control networks, test gear and a simple tuner. Although constructional details are rudimentary and in some cases non-existent, none of the circuits should be at all difficult to build. '50 Simple LED Circuits Book 2', by R.N. Soar (£1.35), speaks for itself — the circuits are simple, they use LEDs, and there are 50 of them. A good buy for the absolute beginner; no constructional details are given but anyone should be able to build these circuits on Veroboard without any trouble. If you think BASIC is beyond you, 'An Introduction to BASIC Programming Techniques', by S. Daly, provides a simple guide to this popular high level computer language. The author covers all the statements you're ever likely to meet, keeping the examples simple and pointing out possible machine-dependent variation. In fact the book recommends that you try programming an actual computer as soon as possible — and so do we. This way you quickly find all the quirks of a particular BASIC, and the hands-on approach is definitely the fastest way to learn. 'An Introduction to BASIC Programming Techniques' will cost you £1.95. That's it for the time being; more reviews will follow, word blindness permitting!

Pack Up Your Troubles

Imhof-Bedco, the electronics packaging specialists, have just launched a range of 'camera craft' security cases. Of course, they needn't just be used for carrying cameras, as they are just as useful for carrying any sort of delicate equipment — test gear perhaps? They feature an aluminium frame and facing on rigid wooden panels, combining strength and smart appearance with light weight. Lockable toggle catches, robust hinges and riveted corner reinforcements add to the protection they can offer. The cases can be supplied in three different sizes complete with carrying straps and shock-absorbent foam inserts. The foam is easily cut to shape with the knife provided, so it can accommodate various shapes and sizes. There is also a briefcase version fitted with PVC lining and document wallet in the lid, just in case you have any briefs in need of protection! The cases are available ex-stock and prices start at £22. Further details are available from Mike Young, Imhof-Bedco Standard Products Ltd, Ashley Road, Uxbridge, Middlesex UB8 2SQ (telephone Uxbridge (0895) 37123).

Mail Order

Toolmail are offering two new helpful aids to the hobby enthusiast. The first of these is a hobby service case, available for the first time in this country. It has a robust metal frame containing 16 clear styrene drawers (each 5½ x 2¾ x 1½") for storage of components and small parts, and one strong base drawer (11 x 5½ x 3¼") for the storage of tools and other large or heavy items. The front of the tough vinyl outer case folds down to provide a useful working surface. The case is 12" high with a comfortable carrying handle. It is available for a limited period at the introductory price of £29.95 which includes VAT and free delivery (RRP is £34.95). The second offer is an electronics service wallet designed for work with computers, video and audio units. It includes a selected range of 25 precision miniature tools and is contained in a fitted zipper wallet. The tools include miniature soldering iron, desolder braid, solder, soldering tools, range of screwdrivers pliers and cutters, wire strippers, IC extractor, tweezers, scissors and contact cleaners. The kit costs £39.95 including VAT and free postage anywhere in the UK. Both of these items are available mail order from Toolmail Ltd, Parkwood Industrial Estate, Sutton Road, Maidstone, Kent ME15 9LZ.

Heavy Levy

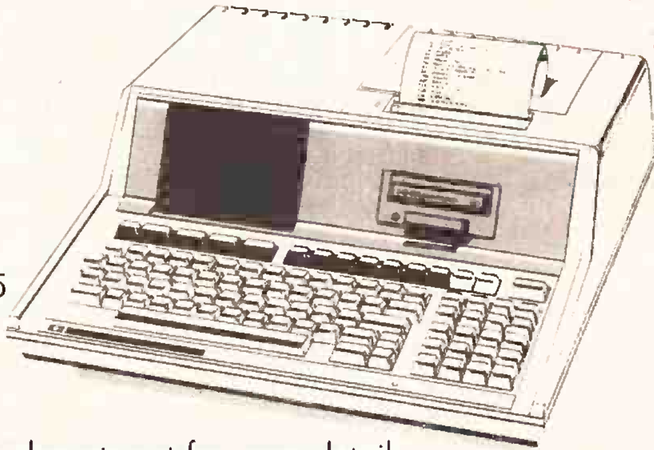
The Government is likely to face strong opposition from Britain's 25 million blank tape users if it goes ahead with its plan to put a levy on the sale of blank tapes. The levy is meant to compensate performers for their loss of sales and royalty payments due to home taping. The six main UK blank tape manufacturers will also be adding their weight to the argument through the auspices of the Tape Manufacturers' Group. The Group has been formed to fight the proposal reported to be contained in a Green Paper reviewing the whole area of copyright law, which is expected to be published shortly. The TMG includes representatives from BASF, 3M Maxell, Memorex, Sony and TDK, and Mr Bill Fulton, the Group's Chairman, maintains that the levy plan is unworkable and impractical and that the problem of home taping has been overstated. He also believes that any levy would penalise all tape users, whether or not they were breaking the copyright law, and that the levy would be like imposing a tax on blank tapes therefore effectively subsidising the record companies. The basis on which the levy has been proposed is that the British Phonographic industry claims that it is losing £1 million a day through breaches of copyright. But the TMG say they haven't produced any hard evidence to back up this fact.

V3 Loudspeakers

It looks as if our readers are not as handy with the woodsaw as they are with the soldering iron. Volt Loudspeakers, designers of the V3 (October '81 ETI), tell us they'd had almost as many enquiries for a woodwork kit as they have for the electronics. Consequently they have arranged for a complete set of precut chipboard panels to be made available by Wilmslow Audio, 35/39 Church Street, Wilmslow, Cheshire (telephone 0625-529599) — contact them for details. All you have to do is screw the panels together as described in the original article — now there's no excuse for not building a pair!

HEWLETT PACKARD

HP 85



Scientific and technical professionals favour the HP 85, they are being joined by increasing numbers of business professionals. Find out why the HP 85 is the professional microcomputer at your nearest Laskys store or write to our Mail Order department for more details.

LASKYS is the largest specialist Hi-Fi chain in Europe, in July 1980 they acquired Microdigital – an independent, specialist microcomputer store based in Liverpool. Since then specialist microcomputer departments have been set up within selected Laskys stores under the Microdigital name, these have now been renamed Microcomputers at **LASKYS**

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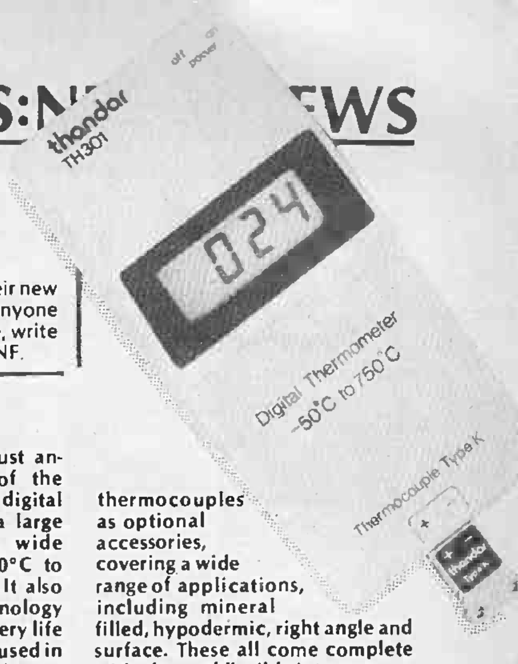
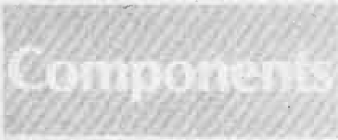
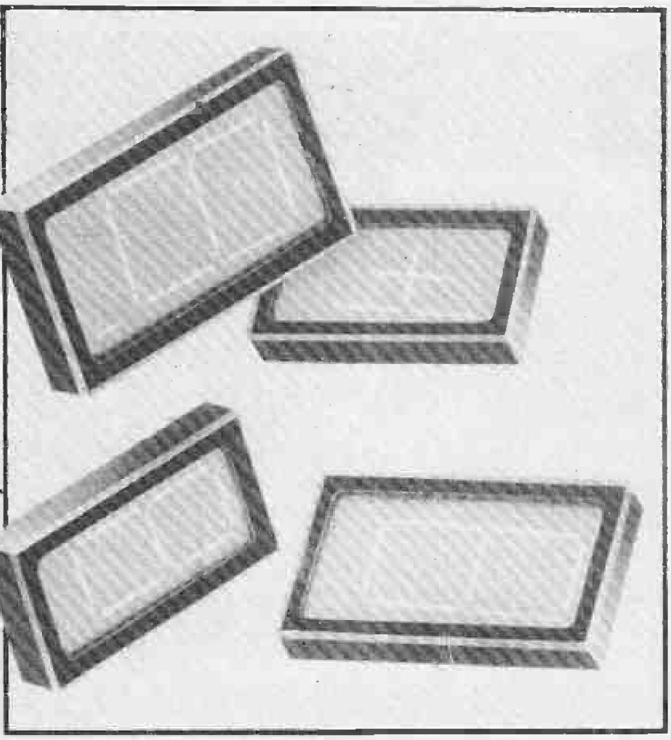
MICROCOMPUTERS AT LASKYS





B-B-Books from B-B-Babani

Bernard Babani Publishing Ltd will be happy to send copies of their new 1982 catalogue of Radio, Electronic and Computer books to anyone who cares to send them their name and address. So if you want one, write to them at: The Grampians, Shepherds Bush Road, London W6 7NF.



Hot Stuff!

Sinclair Electronics has just announced the launch of the Thandar TH301 hand-held digital thermometer. It features a large readout LCD display, a wide temperature range of −50°C to 750°C and 1°C resolution. It also incorporates the latest technology and over 1,000 hours of battery life is obtainable. The unit is housed in a strong Thandar case and is supplied complete with battery and fast response bead thermocouple. The price is £59.50 including VAT and Sinclair offer a range of thermocouples as optional accessories, covering a wide range of applications, including mineral filled, hypodermic, right angle and surface. These all come complete with plug and flexible interconnecting cable. For further details contact Sinclair Electronics Ltd, London Road, St Ives, Huntingdon, Cambridgeshire PE17 4HJ.

ELCB

B & R Relays have broadened their range of combined 13 A Earth Leakage Circuit Breaker (ELCB) socket outlets with the introduction of a new wall mounting version. Based on the successful HO4 portable ELCB with integral 13 A socket, the new model is designed for mounting directly on a convenient single of double outlet box. The new ELCB is simple to install — anyone capable of wiring up a standard socket can do it, be it at home, in the office, workshop or factory. The unit is available in sensitivities ranging from 10 mA to 30 mA, and a test button allows operation to be checked at any time as well as every time the device is switched off. Special socket styles can be supplied to ensure that particular equipment is always plugged into the ELCB and not a non-protected socket outlet. Further information can be obtained from B & R Relays Ltd, Edinburgh Place, Harlow, Essex CM20 2DJ.

Bright Flatpacks

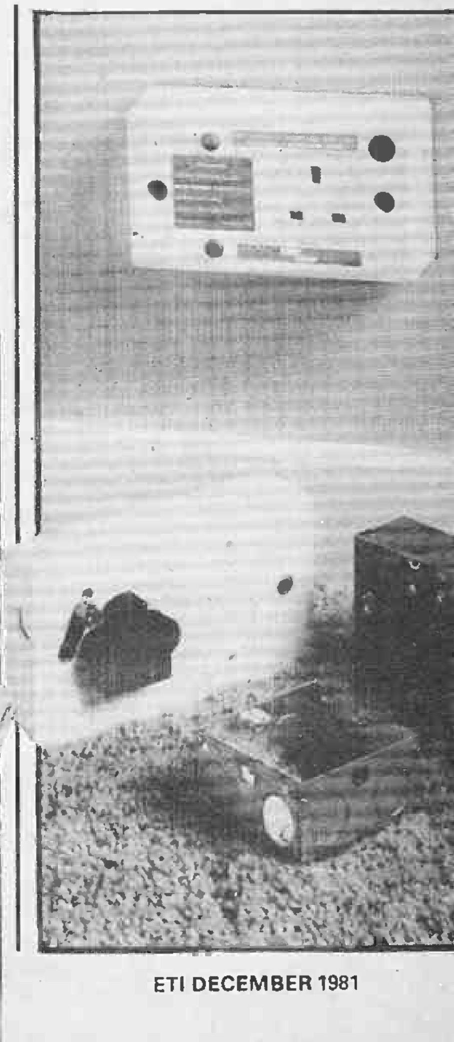
Perdix Components Ltd have just announced the release of two new incandescent digital displays for their Aurora line. The new FFD-71 (0.472" character) and FFD-81 (0.614" character) displays operate from 3.5 V DC with a low current drain of 7 mA while maintaining extremely high brightness levels. The units also feature TTL compatibility, are multiplexible, can operate from AC or DC power and can be filtered to almost any colour. For further information contact Perdix Components Ltd, 98 Crofton Park Road, London SE4.

Drilling Holes

OK Machine & Tool (UK) Ltd have launched a lightweight electric drill for drilling, grinding and polishing which is particularly useful on printed circuit boards. The PCB-258 drill is powered by a high-speed 220-240 V motor and measures 175 mm long x 44 mm diameter. Four different collet sizes are supplied to handle 0.4-3.2 drills. Optional extras include tungsten carbide cutter sets, grinding points, cutters, sanding discs and various drills. A drill stand is also available with a spring-mounted arm which provides good stability and can be used with circuit boards up to 280 mm. Further information and prices can be obtained from OK Machine & Tool (UK) Ltd, Dutton Lane, Eastleigh, Hants SO5 4AA.

New Improved DMMs

Fluke are now manufacturing a new series of digital multimeters. They are intended to replace the existing 8020A series by providing more features at even more competitive prices. The new features include four models instead of the previous three, three of which include a high-speed continuity bleeper as standard, improved calibration specification with two-year calibration guarantee, two-year parts and labour warranty, heavy duty 600 V fuse system to provide greater protection against high energy inputs and improved mechanical design with non-slip feet, tilt bail and easier-to-use layout. This new 'B' series will be available direct from Fluke at Watford or through their nationwide network of distributors. Further information from Fluke (GB) Ltd, Colonial Way, Watford, Herts WD2 4TT.



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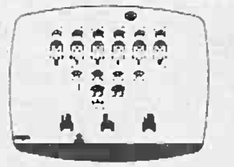

Hand-held Invaders Games available £19.95
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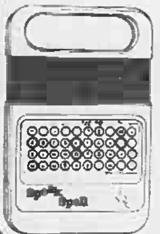

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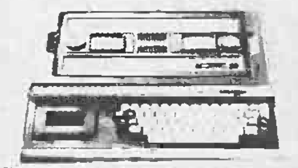

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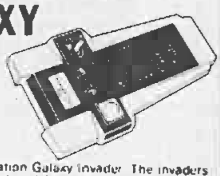

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THE OLYMPIA — POST OFFICE APPROVED TELEPHONE ANSWERING MACHINE

WITH REMOTE CALL-IN BLEEPER

This telephone answering machine is manufactured by Olympia Business Machines, one of the largest Office Equipment manufacturers in the U.K. It is fully POST OFFICE APPROVED and will answer and record messages for 24 hours a day. With your remote call-in bleeper you can receive these messages by telephone wherever you are in the world. The remote call-in bleeper activates the Answer/Record Unit, which will at your command repeat messages, keep or erase them, and is activated from anywhere in the world, or on your return to your home or office. The machine can also be used for message referral, if you have an urgent appointment, but are expecting an important call simply record the 'phone number' and location where you can be reached. With optional extra bleepers (£13 each) this facility can be extended to colleagues and members of the family. Using a C90 standard cassette you can record as many as 45 messages. The announcement can be up to 16 seconds long and the incoming message up to 30 seconds long.

The machine is easy to install and comes with full instructions. It is easily wired to your junction box with the spade connectors provided or alternatively a jack plug can be provided to plug into a jack socket. Most important, of course, is the fact that it is fully POST OFFICE APPROVED.

The price of £135 (inc. VAT) includes the machine, an extra light remote call-in Bleeper, the microphone message tape, A.C. mains adaptor. The unit is 9¼"x6"x2½" and is fully guaranteed for 12 months. The telephone can be placed directly on the unit — no additional desk space is required.

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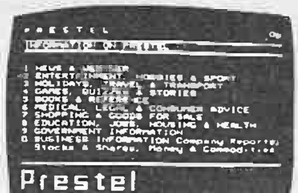

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Defence Digest

This new regular feature is devoted to defence electronics, its equipment techniques and application. Defence remains one of the largest growth areas in UK industry, with much of the real innovation and investment taking place there.

Defence Digest will thus act as a news (and views) section, containing up-to-date information and explanation of some of the happenings in the different sectors of the defence industry.

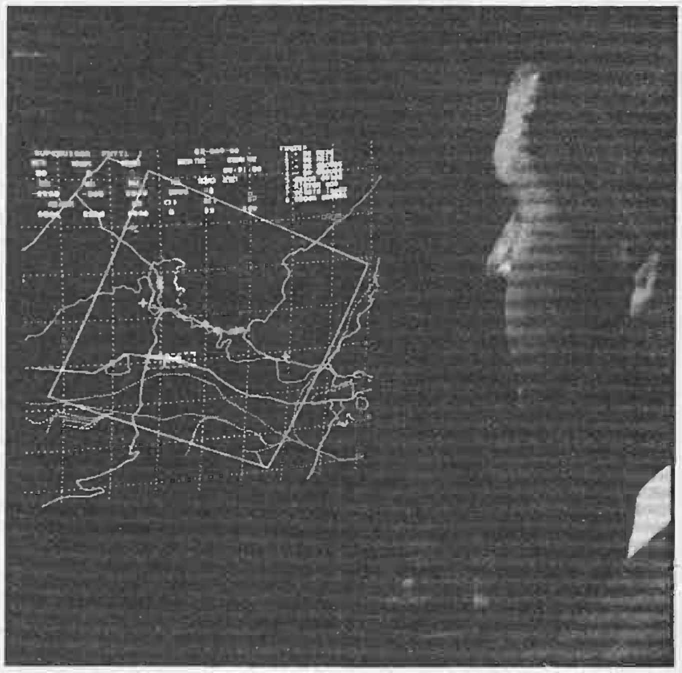
Companies with information and articles for these columns are invited to submit them direct to Defence Digest at our editorial address. Indeed, anyone with anything to say on the subject, be it information or opinion, is a potential contributor and should not refrain from putting pen to paper.

Acceleration

The picture shows Mr C.H. Davies (left), Director of Aircraft Production, Ministry of Defence (Procurement Executive), receiving from Mr Lester George, Managing Director of Ferranti Instrumentation Ltd, a presentation model of the Ferranti FA2 accelerometer to commemorate the production of the 9,000th instrument. Ferranti inertial grade accelerometers have been in full series production since 1968 and currently exist in five variants. Since that time they have been fitted in the inertial guidance platforms of all British military aircraft including the Nimrod, Jaguar, Buccaneer, Phantom and Tornado. Other applications have included use in airborne and shipborne radar antennas and sonar arrays. Satellite and rocket applications include Exosat, Skylark, Black Knight and Ariane.

Direct Hit

The first guided launch of the Hughes Aircraft Company's Advanced Medium-Range Air-to-Air Missile (AMRAAM) was a success with a direct hit on a drone aircraft target. It was tested in Holloman Air Force Base, New Mexico, and fired from a US Air Force F16 aircraft against an F-102 drone target. It closed in on its target using its radar guidance system, thus proving the missile's capability with this particular aircraft. The next generation AMRAAM missile will pack higher performance into an airframe which is only about half the weight of the missile it will replace — the AIM-7 Sparrow. The missile provides 'launch-and leave' capabilities enabling the pilot to break away immediately after launch to engage other targets. Hughes is one of two contractors selected for a 33-month prototype validation programme; selection of a winner is expected in October and the winning contractor will then start full-scale development. The AMRAAM program is a joint US Air Force and Navy effort to develop an advanced all-environment missile for operational use between 1985 and 2005.



Hughes Hues

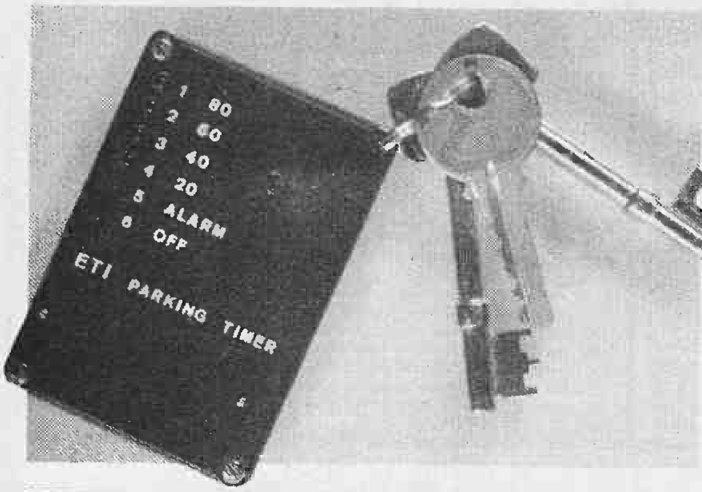
Here a Hughes Aircraft Company engineer uses a full-colour display to test a stand-off airborne system for detecting and tracking massed armour and other forces. The system is called Pave Mover and displays targets and their movements in full colour on a cartographic base, showing roads, railway lines, airfields and rivers. As many as 4,096 colour hues can be displayed. The Pave Mover uses airborne radar to relay target information via data link to a mobile ground-based Data Processing Control Station. Computers in the DPCS process the information and display the target data. Pave Mover's radar can also guide missiles or tactical aircraft to designated targets. Guidance commands and targeting information are supplied by the DPCS. The Pave Mover system is part of a broader Assault Breaker programme for neutralising enemy armour before it reaches the forward edge of the battle area. The system is being developed by Hughes under contract from the US Air Force and the Defense Advanced Research Projects Agency. It is being evaluated at White Sands Missile Range, New Mexico.

Tracking Helmets

Ferranti is to supply its advanced Helmet Pointing System (HPS) as part of the British Aerospace Dynamics Group Tracked Rapier Missile System for the British Army. The HPS, which was first seen at last year's Farnborough Air Show, is a revolutionary target sighting system which can direct weapon aiming sensors towards any target at which the wearer is looking. The HPS was originally conceived as a pilot's aid but it has received its first major contract as a land-based system. The Ferranti Helmet Pointing System is a very lightweight, simple system which improves normal weapon aiming. Basically, the entire system consists of the helmet-mounted sight and sensor, a radiator (mounted on a convenient nearby fixed object), a signal processing box, a control unit and an appropriate source of electrical power. The observer's sight is light and compatible with the latest protective masks. In the Tracked Rapier situation, the commander (observer) with his head out of the cupola, searches for possible targets. The sight on his helmet has an illuminated aiming mark, focused at infinity representing line-of-sight. A tiny sensor, also on the helmet, continuously monitors the angle and position of the Commander's head (and hence his precise sight-line) relative to the radiator fixed to the vehicle, with high accuracy. Once the observer has spotted a target, he overlays it with the aiming mark, as a means of designating his target. At the press of a button, the line-of-sight, as measured by the HPS, is transferred to the optical tracker, directing it to the target, which then appears in the tracker operator's sight. The operator then follows normal procedure through weapon release to target impact. In general use the Ferranti HPS can be used where an observer's sightline needs to be transferred to equipment that must be directed to the same 'target' — whether it be in low-flying aircraft, a ground target or in a commercial application.

NEXT MONTH

electronics today INTERNATIONAL



Meter Beater

If the bane of your life is the not-so-lovely Rita the Meter Maid then you need our all-singing, all-dancing project. The unit is the same size as a Barclaycard (though you can't get credit with it) and fits neatly onto your keyring. It has an LED display which indicates whether you're setting it for 20, 40, 60 or 80 minutes with the touch switch operation, and when you are nearing the time to beat Rita back to the limo, it beeps. We've set it so that for a 20 minute wait, it will go off three minutes before at 40, it goes off six minutes before, and so on. We reckoned that the longer you were leaving the car the further away you might be, cunning eh?

Dummy Load

We're making audio testing easy! Apart from your multimeter and your oscilloscope what you really need is a dummy load. Our version allows parallel and series connection as well as testing of both channels of a stereo amplifier at the same time. The advantages of using the unit are manifold — not only because the source is presented with an ideal resistive load of the correct value, but also because you can't damage expensive speakers during experimentation. Not only that — you don't annoy the neighbours when you're testing at full power and your eardrums are saved so you can still enjoy the music once you're finished.

Guitar Tuner

Our simple, low cost, easy to use (and all that jazz) Guitar Tuner is just the thing you need if you're a budding musician. Tuning up can be really irritating, but we've made it simple. You just plug the guitar into the unit and the oscillator with six reference frequencies does all the hard work for you. Just play the note and adjust the tuning until the built-in meter zeros, repeat the procedure for all the strings — et violà — it's tuned. The tuner can also be shifted one or two octaves down to make it suitable for bass or rhythm guitars. Play it again Sam!

Infant Guard

How do you like your children — fried or boiled? Or perhaps poisoned? Well, we prefer to see healthy specimens of the next generation, so we've designed a special guard for you to fit onto your medicine cabinet. When small inquisitive hands open the cabinet an alarm goes off, which not only puts the child off investigating further, but also warns you about what's happening. When the cabinet is shut, the unit switches itself off. For the adult who doesn't want to be shattered by the sound of the alarm as he/she is reaching for the hangover remedy, there's also a disable button on the outside of the cabinet which prevents the alarm going off when the cabinet is opened by someone who is meant to use it. It's a really useful gadget to have whatever age your children may be, and it's cheap and simple to build.

Robotics Today

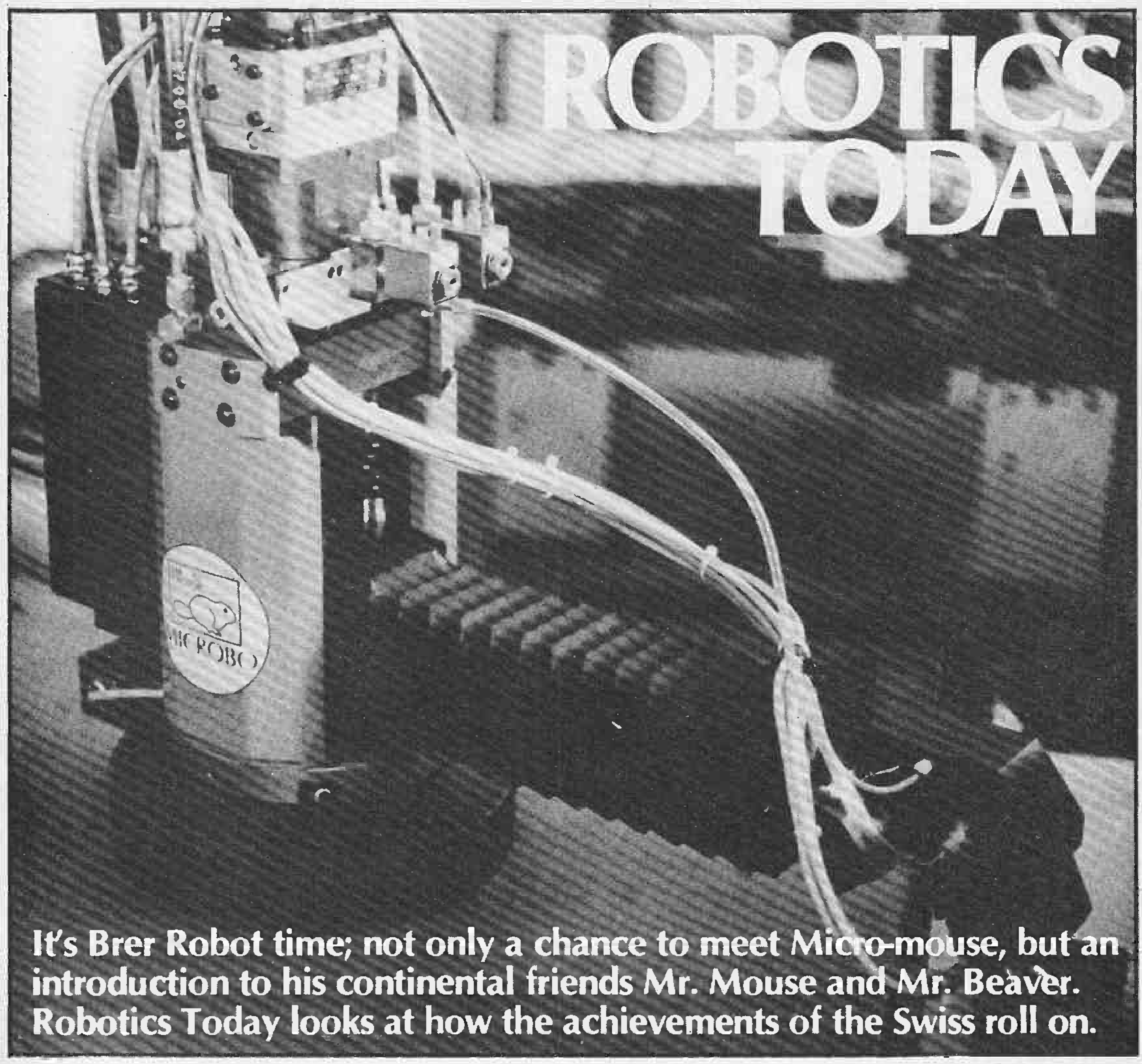
This month we have an in-depth study on the hobbyist approach to robotics written by one of our readers. It covers just about everything from thoughts on mechanical construction, through data processing and programming to experimental ideas for sensors. For a really down-to-earth approach to the exciting subject of Robotics read on......

DC Control of Audio

Taking still further our favourite theme of remote controlling everything in sight, Keith Brindley follows up his article on Voltage-Controlled Audio with this little offering. Using another of Mullard's chips to demonstrate, he delves into the murky depths of voltage-controlled volume and tone for use in preamps and to help put the theory into practice there are loads of good circuits to play with.

LOOK OUT FOR THE JANUARY ISSUE ON SALE DECEMBER 4th

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



ROBOTICS TODAY

It's Brer Robot time; not only a chance to meet Micro-mouse, but an introduction to his continental friends Mr. Mouse and Mr. Beaver. Robotics Today looks at how the achievements of the Swiss roll on.

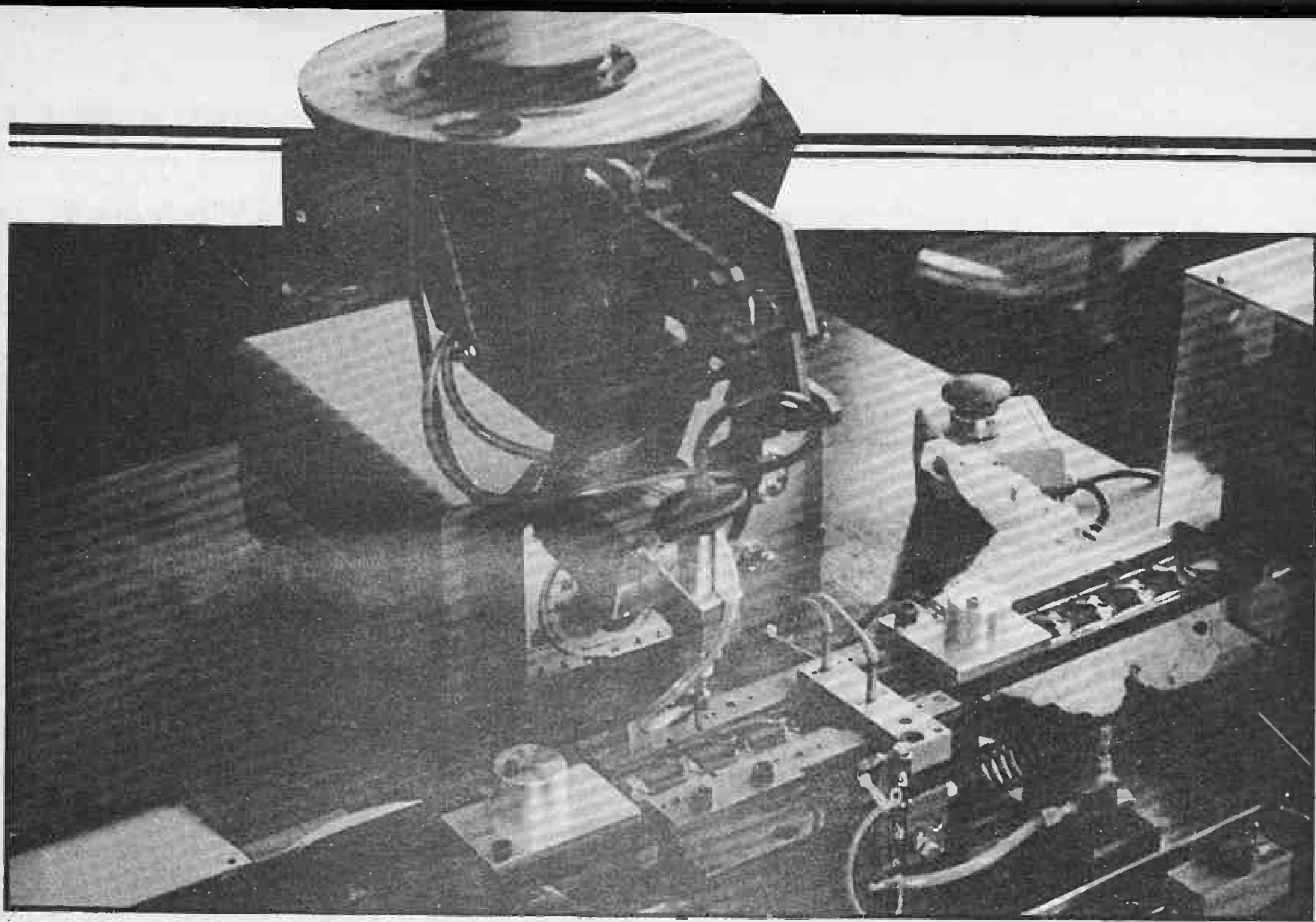
For centuries the Swiss have had a virtual monopoly on the world's timekeeping. A combination of geography, climate and national spirit have by some inexplicable coincidence led to a thriving cottage industry dedicated to high precision mechanics. Up until only 10 years ago it was a virtual certainty that most watches sold throughout the world, particularly those in the middle to upper price bracket, would be Swiss-made.

However, there can be little doubt that the Far Eastern countries, particularly Japan, Hong Kong and Taiwan, now dominate the electronic watch industry, a logical development of their undoubted expertise in miniature electronics. The Swiss, like any country with a international reputation for a particular product, had two choices: they could either resign gracefully, like the British motorcycle industry, or they could re-invest and at least try to regain that which was once theirs. The Swiss have for obvious reasons, chosen the latter path, but along that path have made some very shrewd and hopefully correct predictions about the future of personal timekeeping.

Time Zones

The most obvious decision was not to take on the Far East with purely digital watches. The LCD watch is now made almost exclusively in Hong Kong. No other country could even attempt to compete in the lower price bracket multi-function watch market. The Swiss have an enviable history of being able to work with micromechanics so the logical step was for them to marry the two technologies — mechanics and electronics — to produce watches with analogue displays, hands and faces but with the timekeeping controlled by integrated circuits and quartz crystals.

Fortunately for the Swiss the cottage industry that has developed around watch manufacture lends itself to a kind of co-operative operation where, for instance, a small area might have several factories producing different parts for different watches. Such an arrangement has existed, in fact, since 1939 when a number of companies got together to form ASUAG, which by the time it is translated into English stands for the General Corporation Of Swiss Horological Industries Ltd.



'Mr Mouse' assembling electronic watch chassis. The picture on the previous page is of the 'Mr Beaver' robot.

Within ASUAG are familiar names like Longines and Eterna, plus a dozen or so other companies which most of us will never have heard of but are nonetheless well known within the watch industry. ASUAG was primarily designed to rationalise the production of watch movements, thus making it easier for the industry as a whole to respond to changes in demand and fashion. As the age of the electronic watch dawned it became necessary for ASUAG to respond by producing electronic watches, so within the group certain companies changed their production from purely mechanical parts to wholly electronic parts. Within these companies diversification into the development of automated watch assembly has led to some exciting developments in robotics.

Swiss Success

The micromechanic expertise of one company, SSIH, has been channelled into the development of high precision robots. The term 'high precision' refers to the robots' ability to place miniature parts into assemblies with an accuracy that is measured in microns. So far SSIH have 20 working development machines with a further 200 planned for next year. The two types of robots (known as Mr Beaver and Mr Mouse!) use a combination of electronic and pneumatic power to articulate the arms. The mechanics are controlled by built-in microprocessor systems running on Swiss-developed software.

Although these robots were designed primarily for watch assembly, SSIH see a promising future of Mouse and Beaver in any situation that calls for high-precision, repetitive work. Such work might include the assembly of cameras, another area that would benefit from SSIH development.

At the moment SSIH have the field virtually to themselves. Robotics has, so far, concentrated more upon heavy industrial usage, car assembly and the like, where ultra-high-precision is not required. Doubtless the ability of the Swiss to produce mechanical systems to such high precision will keep other robot manufacturers out of the market for some time. It is tempting to speculate that SSIH have an eye on the Japanese and Hong Kong markets where much of the assembly for digital watches and similar items is still highly labour intensive. It would indeed be ironic to see the Swiss succeed in this area; Swiss robots assembling Far Eastern watches.

Time In Hand

If you're sweating over a hot keyboard, trying to finish your program for our Armdroid competition before the October 31st deadline, then panic not. There has been a hold-up in the supply of the driver boards to customers, so on the fairly reasonable basis that you can't test the software without the hardware, the closing date for entries has been extended to December 31st. This will allow those of you who want to see what's involved to visit our stand at the Breadboard Exhibition (see page 12) and watch our demonstration. We hope to have two Armdroids running, one under program control and the other with a manual control box so you can play with the system and get the feel of things. There may even be a competition to find the most dextrous manipulator amongst our readers.

Meet The Mouse

On the other hand, if you can't make it to Breadboard (in which case we'll never speak to you again!), cast your eyes across the page and you'll see details of the ACC's conference on robotics. One of the attractions will be this year's winner of the Micro-mouse competition (together with his designers, of course). We'll be providing some of the speakers at this meeting together with demonstrations of projects old and new. See you there!

This new series will provide a stage upon which our readers may display their robotics achievements. It is intended to cover the practical application of robots in Britain today, be it at hobbyist level or in industry.

Readers in either category are invited to write to the editor of ETI, detailing their experiments, projects, application or usage of robotics. Any articles published will be paid for at commercial rates. It is also hoped to run an 'Ideas Forum' wherein readers can exchange views and ideas but that depends upon the response of our readers — you!

Write to: THE EDITOR, ETI MAGAZINE, 145 CHARING CROSS ROAD, LONDON WC2H 0EE and mark your envelope "Robotics Today".

AMATEUR COMPUTER CLUB

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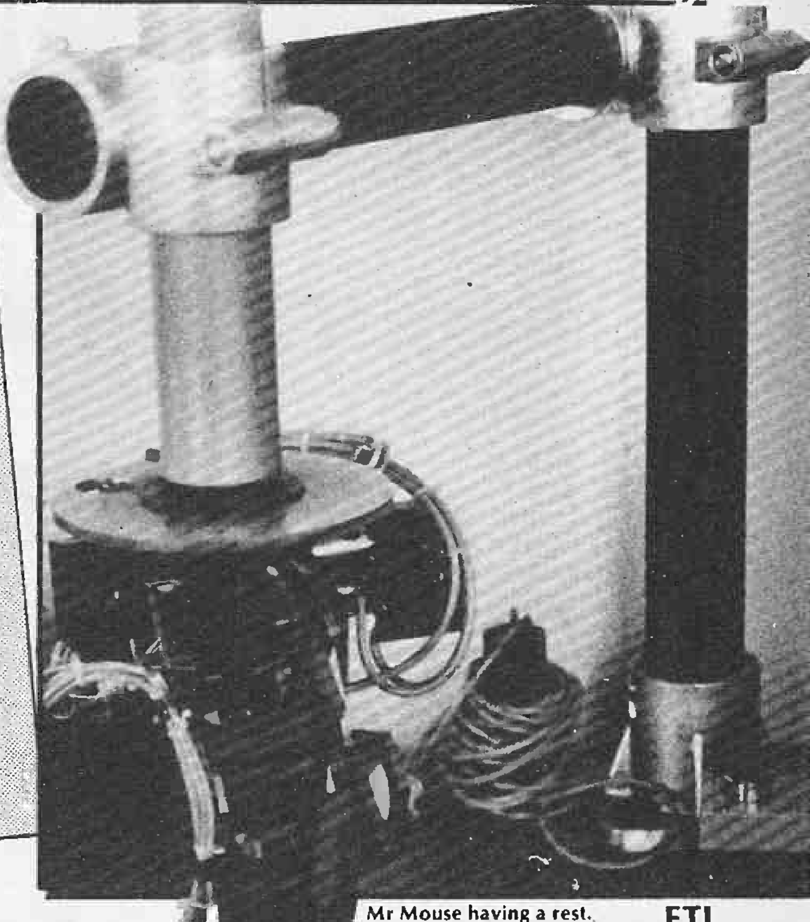
In addition to the formal programme, there will be an Open Forum during the afternoon for short presentations by individual robot enthusiasts and teams.

Space will also be available for demonstrations.

Please apply early to make this novel feature a success.



Mr Mouse having a rest. **ETI**

MICROCOMPUTER EXPANSION SYSTEM

Treat your home computer to extra memory and more peripherals with this versatile and simple expansion project. With the modules to be published you'll be able to custom-design your system to meet your requirements — and change it all around at a later date should you so desire. Design by Steve Wilding.

Home computers, like hi-fi, generally have a habit of starting out modestly (assuming your finances are anything like ours), and then growing steadily as you discover a burning need for more memory, more I/O, a printer, and finally the sound generator that turns the system into an all-singing, all-dancing electronic marvel. (Actually, computers almost never dance). To help out those of you in the upgrade market, we present this low-cost, flexible expansion system designed for a number of popular microcomputers on sale in the UK — ones based on the 6502 and Z80 microprocessors.

The system is made up of a motherboard and a range of expansion cards that plug into the motherboard as and when your needs dictate. For example, if your need is purely for RAM memory expansion then a motherboard and four RAM cards will give you an extra 32K of RAM. The constructional and application details are given for the motherboard and the 8K RAM card in this article — in subsequent articles details of the remaining expansion cards in the range will be provided. These will include an EPROM programmer and an EPROM card for use with 2516 and 2532 single rail EPROMs; a sound board utilising up to three of the popular AY-3-8910 programmable sound generator chips; a parallel I/O card providing two 6520s for uses such as a parallel printer driver (Centronics) and a low cost disc interface.

Two 40-pin input sockets are provided (SK6 and SK7) — these are wired in parallel so that two or more motherboards may be linked together. This allows you to use a larger number of those modular which use less than 8K of memory.

Vive La Difference

Obviously there are differences between computers and the expansion system must be capable of adapting to meet varying demands. The important difference for this application is the first free memory location available for expansion in your computer's memory. For RAM expansion to be effective it must run consecutively with the existing RAM. Table 1 gives the first free location for some popular computers.

For the more technically minded an explanation of how compatibility is achieved is given in the How It Works section. Suffice to say here that the system is capable of being moved around in memory to fit the particular computer's requirements. This is achieved by means of selective soldering of wire links as described later in the article.

Construction

Construction is best achieved using a 15 W soldering iron with a fine bit and 22 swg solder. First solder in the four wire links to select the correct location in the memory map for your computer (see Table 2). Solder the DIL sockets into the board taking care not to make any shorts between pins. Next fit the five edge connectors and lastly the ceramic capacitors — these can be held in place whilst soldering by slightly spreading their legs under the board. The PCB has plated-through holes and so it isn't necessary to solder a connection on both sides of the board; but allow enough time when soldering for solder to run through the hole as this ensures a good connection. Construction of the motherboard is now complete.

Follow the same instructions when constructing the RAM card — solder the IC sockets in first, then the eight ceramic capacitors and construction of the RAM card will be complete.

Finally insert all ICs according to the overlay, taking care not to bend any IC legs.

SPECIFICATION

Motherboard: This is the main board of the system. It allows up to five expansion cards to be used at once — socket 5 being a duplicate of socket 4, allowing smaller expansion cards to be used without tying up a whole 8K block each. Both the control bus and address bus are buffered by the motherboard but the data isn't, as this is already done by many micros. Power requirements are 5 V at 100 mA.

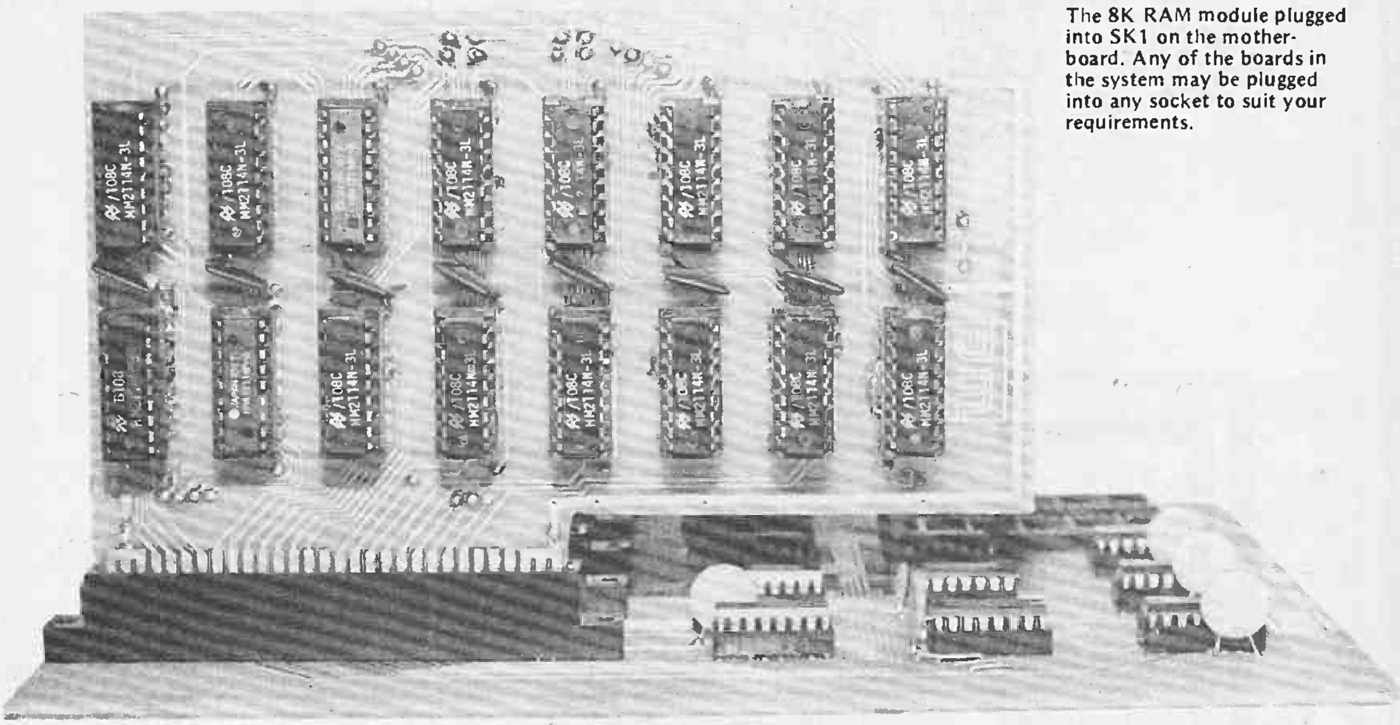
RAM Card: A static RAM expansion card using 16 2114L 300 ns RAM chips. Power requirements are 5 V at 650 mA.

EPROM Card: Available for either 2516 (2K x 8) 5 V single rail EPROMs or 2532 (4K x 8) 5 V single rail EPROMs.

EPROM Programmer: For programming 2516 or 2532 single rail EPROMs for use with the above card.

Sound Card: Allocation for up to three AY-3-8910 three-channel sound chips, allowing the generation of complex waveforms.

PIO Card: This board contains two PIO chips for 32 individual inputs or outputs. 12 of these are used for a Centronics-compatible parallel printer driver, for use with Superboard/UK101 and Watford's WEMON chip. Three connections are for use with a light pen and a further six are for power output applications.



The 8K RAM module plugged into SK1 on the mother-board. Any of the boards in the system may be plugged into any socket to suit your requirements.

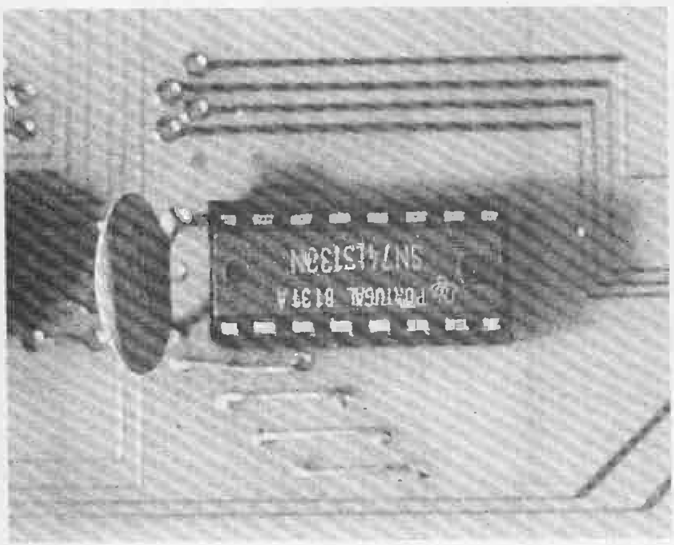
NEXT MONTH: Connection details for more machines, details of the modifications for use with Z80 micros, and the second of the plug-in modules.

TABLE 1

GROUP	FIRST FREE MEMORY LOCATION	COMPUTERS
1	2000	UK101 Ohio Superboard 8K PET Microtan 65
2	4000	16K PET
3	6000	16K TRS-80 16K Video Genie
4	8000	32K PET

TABLE 2

	GROUP 1	GROUP 2	GROUP 3	GROUP 4
Link W to:	A	B	C	D
Link X to:	B	C	D	E
Link Y to:	C	D	E	F
Link Z to:	D	E	F	G



The photograph above shows a close-up of the wire links around IC4. This board was in use with the 8K PET, a group 1 computer. (Check the links against Table 2 and Fig. 1).

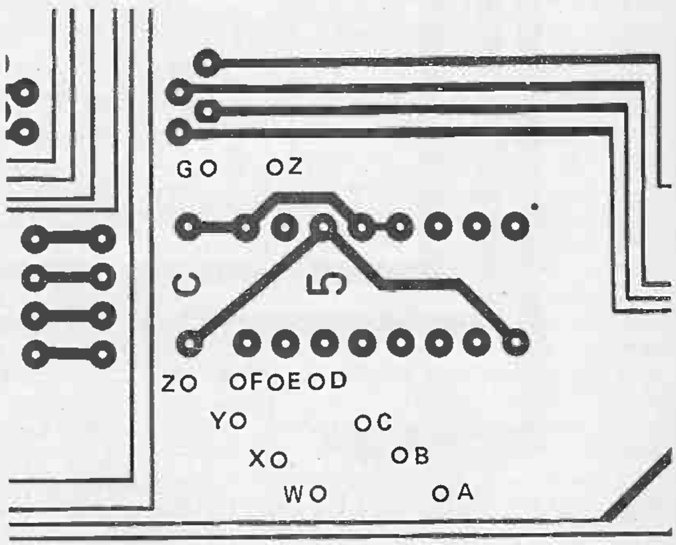


Fig. 1 Table 2 shows which of the lettered holes around IC4 to link in order to locate the expansion system at the correct point in your computer's memory. The 'thin' holes are not through-plated; the rest are.

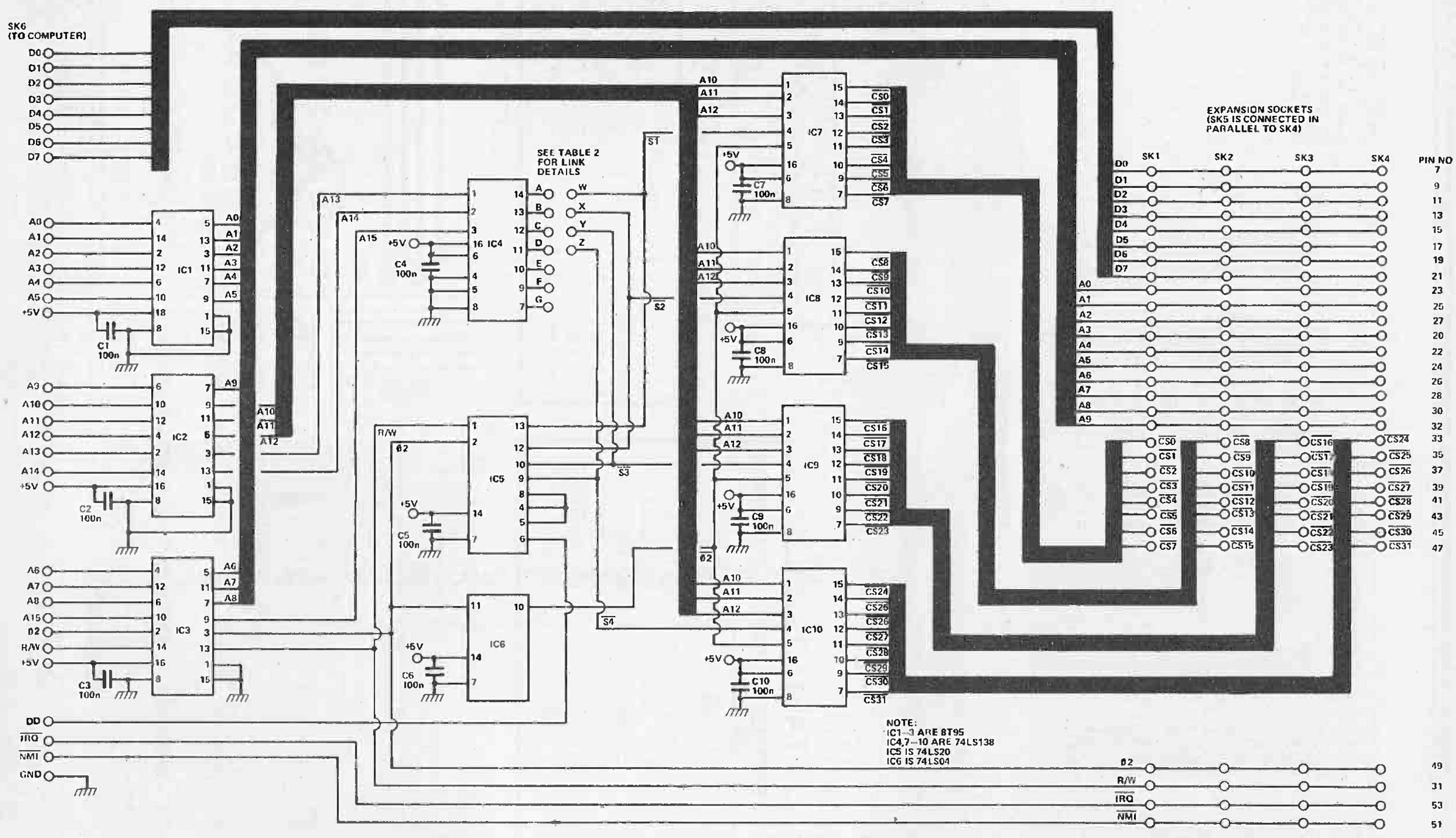


Fig. 2 Circuit diagram of the motherboard. To avoid large numbers of confusing lines, the buses are shown as thick black lines instead of eight or 16 thinner ones. SK7 is not shown – it is simply connected in parallel to SK6 to allow further expansion.

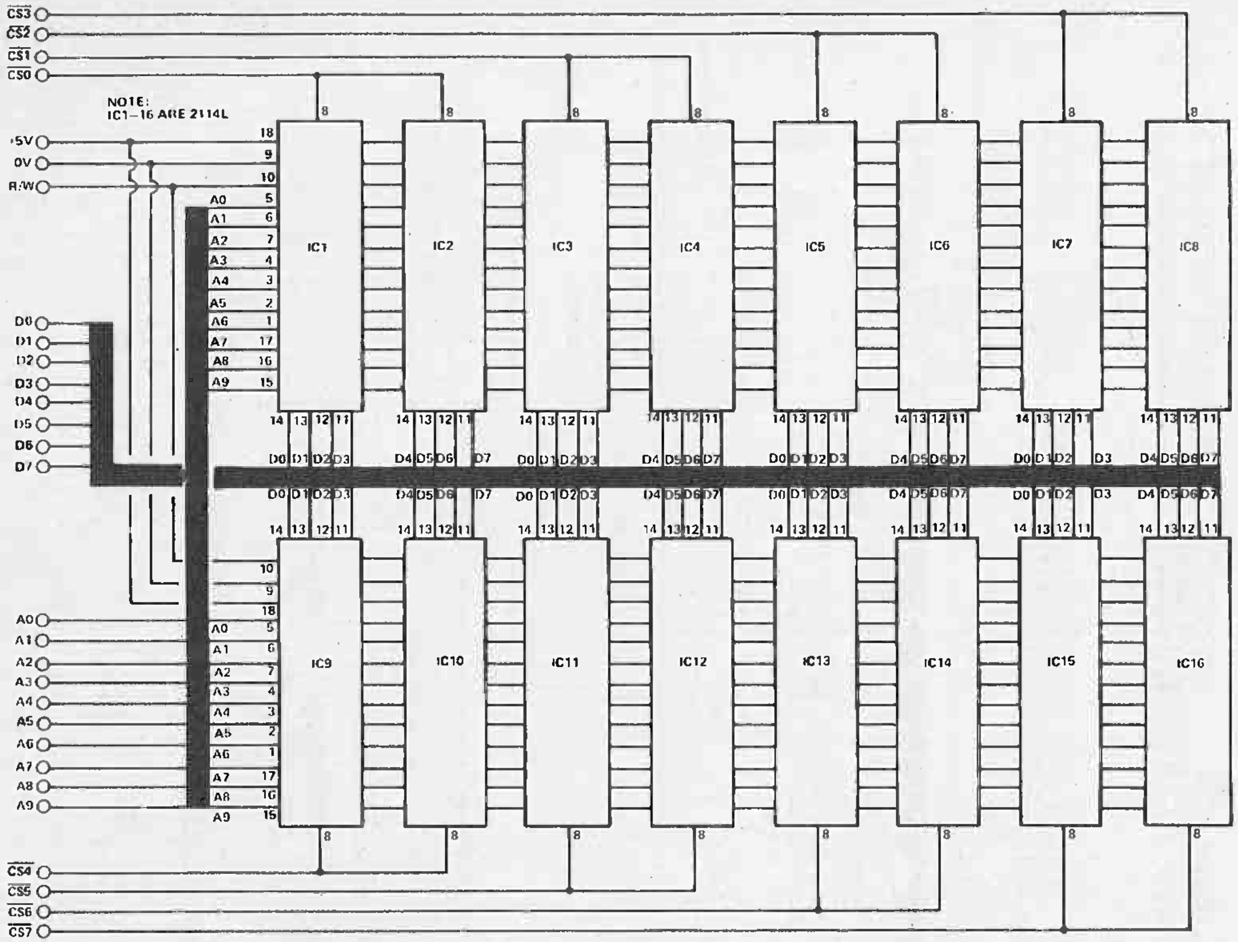
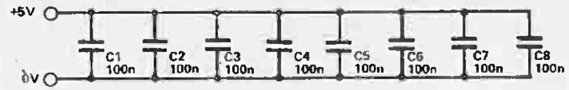


Fig. 3 Circuit diagram of the 8K RAM card.



BUYLINES

A complete kit of parts for this project is available from Watford Electronics, 33/35 Cardiff Road, Watford, Herts. The motherboard costs £39.95 and the 8K RAM card is £29.95 (p&p 75p if both are ordered together). A suitable power supply for the expansion system (5 V at 3 A) is available for £20 ready-built. The 40-way jumper lead for use with Superboard/UK101s costs £5.40 (for a 24" length). Prices for other connectors are available on application. All prices exclude VAT.

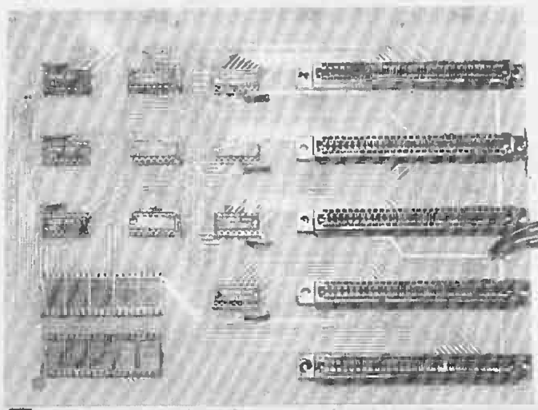
HOW IT WORKS

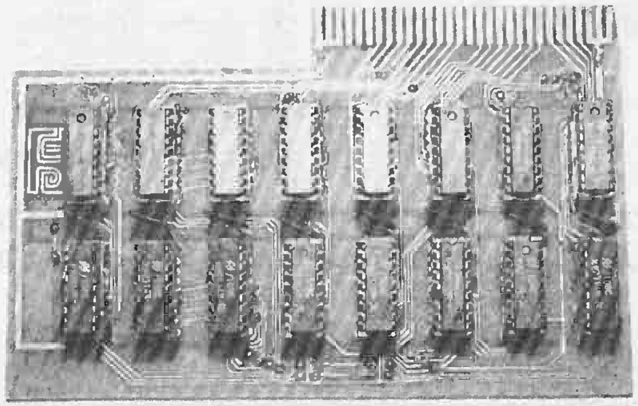
The address and part of the control bus from the host computer are buffered using three 8T95s (ICs 1-3), which are bidirectional hex buffers. A 74LS138 three-to-eight decoder (IC4) is used to decode the top three address lines (A13-A15) into 8K blocks. Of these, four are to be selected — one for each expansion card connector socket. The fifth socket is a duplicate of socket four so as to enable the use of two expansion cards in one 8K block: for example, the sound card and parallel input/output card use a small fraction of the 8K allocated to a socket, so by duplicating socket four we allow more expansion cards to be used at once.

The 8K blocks are located at 0000-1FFF, 2000-3FFF . . . E000-FFFF (Hex), so if the system is to be conficured to start at 2000 (group 1), then blocks 2 to 5 must be used. If your computer is in group 2 then its first free location is 4000 and blocks 3 to 6 must be selected. Similarily for group 3 blocks 4 to 7 are used, and for group 4 blocks 5 to 8.

Once selected, the four 8K blocks are then further decoded into 1K blocks by four more 74LS138s (ICs 7-10). The bus signals and these 1K decodes are then brought to the expansion socket connectors. The DD (data direction) signal is generated for system use with Ohio Superboards and UK 101s.

The RAM card is very straightforward, making use of 16 2114L 1Kx4 static RAMs. Each pair of RAMs is selected by its respective 1K decode generated by the motherboard. As the RAMs are only four bits wide, they are enabled in pairs to provide eight-bit bytes.





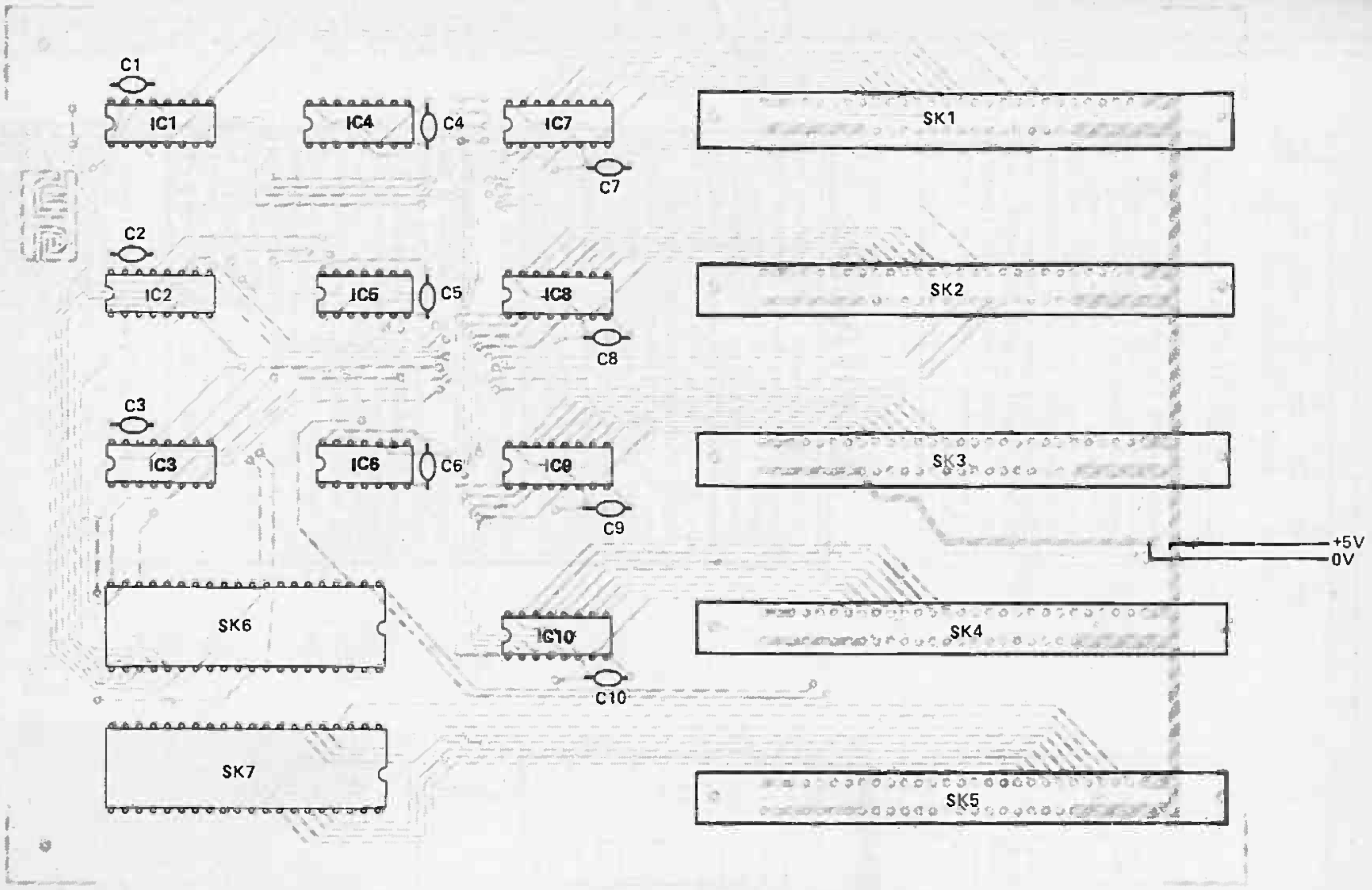
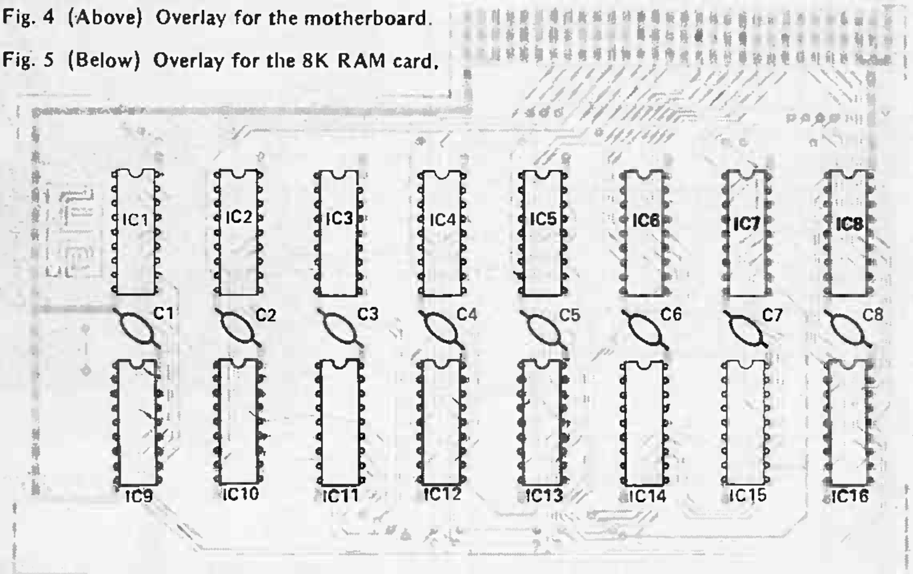


Fig. 4 (Above) Overlay for the motherboard.

Fig. 5 (Below) Overlay for the 8K RAM card.



PARTS LIST

MOTHERBOARD

Capacitors
C1-10 100n disc ceramic

Semiconductors
IC1-3 8T95
IC4,7-10 74LS138
IC5 74LS20
IC6 74LS04

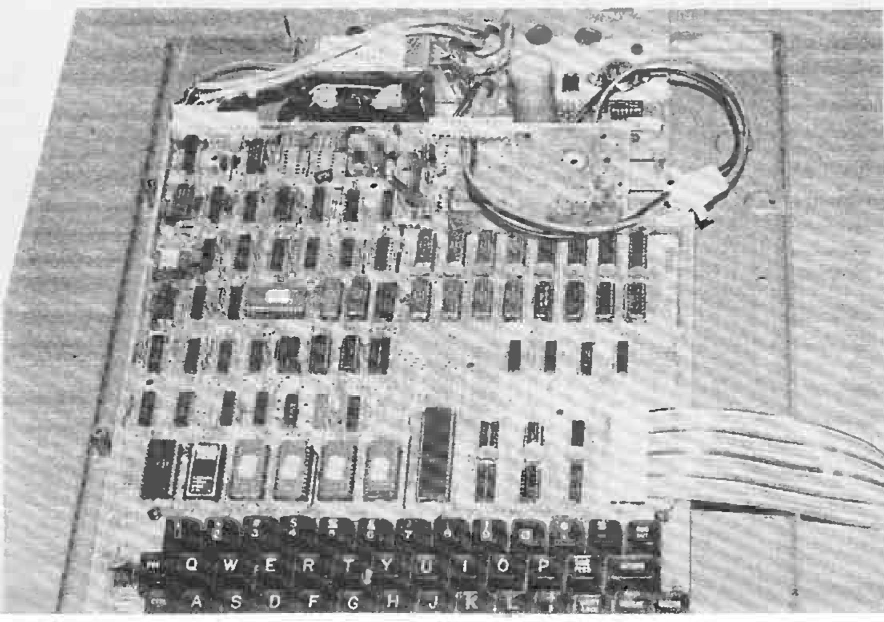
Miscellaneous
SK1,2 40 pin DIL socket
SK3-7 2 x 30 0.1" edge connectors
Double-sided PCB; DIL sockets for ICs; board support system etc.

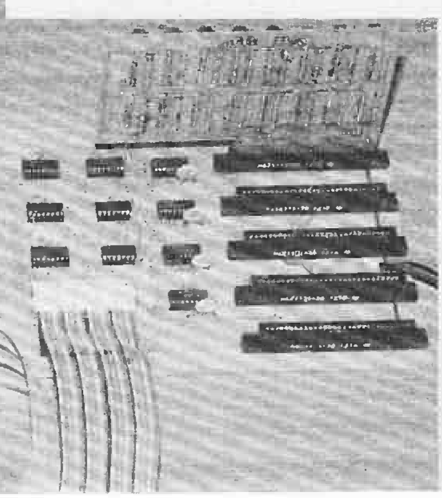
RAM CARD

Capacitors
C1-8 100n disc ceramic

Semiconductors
IC1-16 2114L

Miscellaneous
Double-sided PCB; DIL sockets for ICs.



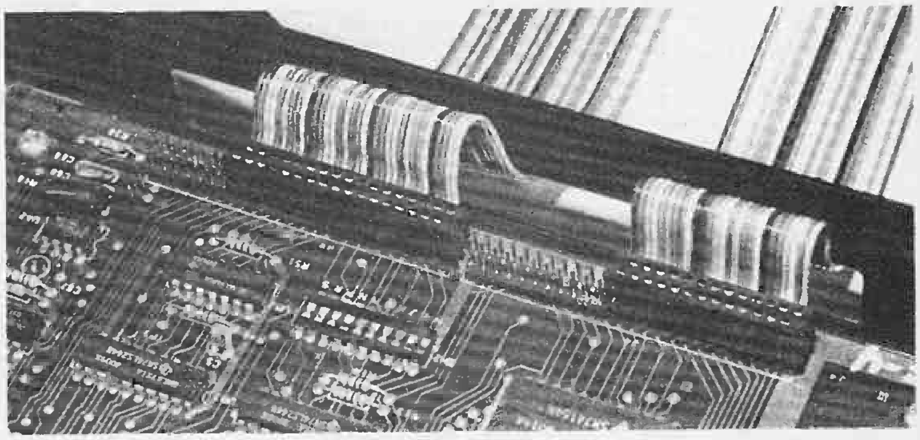


EXPANSION SOCKET PINOUTS

+VE	1	2	+VE
+VE	3	4	+VE
+VE	5	6	+VE
BD0	7	8	+VE
BD1	9	10	+VE
BD2	11	12	+VE
BD3	13	14	+VE
BD4	15	16	+VE
BD5	17	18	
BD6	19	20	BA3
BD7	21	22	BA4
BA0	23	24	BA5
BAI	25	26	BA6
BA2	27	28	BA7
	29	30	BA8
R/W	31	32	BA9
$\overline{CS0}$	33	34	
$\overline{CS1}$	35	36	
$\overline{CS2}$	37	38	
$\overline{CS3}$	39	40	
$\overline{CS4}$	41	42	
$\overline{CS5}$	43	44	
$\overline{CS6}$	45	46	Earth
$\overline{CS7}$	47	48	Earth
Ø2	49	50	Earth
$\overline{NMI}$	51	52	Earth
$\overline{IRQ}$	53	54	Earth
Earth	55	56	Earth
Earth	57	58	Earth
Earth	59	60	Earth

BD0-7	Buffered data lines
BA0-9	Buffered address lines
$\overline{NMI}$	Non-maskable interrupt
$\overline{CS0-7}$	Chip select lines
R/W	Buffered Read/Write
Ø2	Buffered clock
$\overline{IRQ}$	Interrupt request

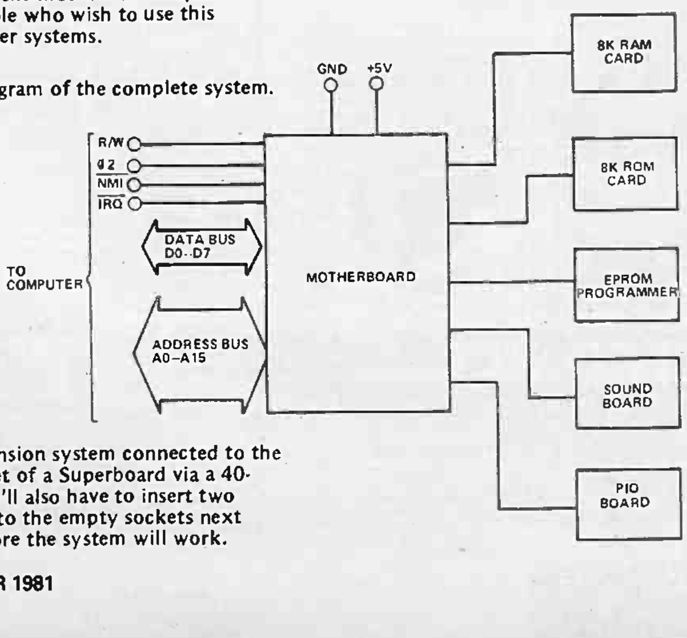
Each chip select line enables a 1K block in the memory. $\overline{CS0}$ is the lowest and $\overline{CS7}$ the highest within the 8K area assigned to that particular socket.



Top: You probably can't see it in the photo, but the screen of this 8K PET reads '15359 BYTES FREE' – courtesy of the expansion system. This is plugged into the PET using sockets J4 and J9, on the right of the PET at the back (above).

Table 3 (opposite) gives the connection details for SK6 (the motherboard input socket) for people who wish to use this project with other systems.

Fig. 6 Block diagram of the complete system.



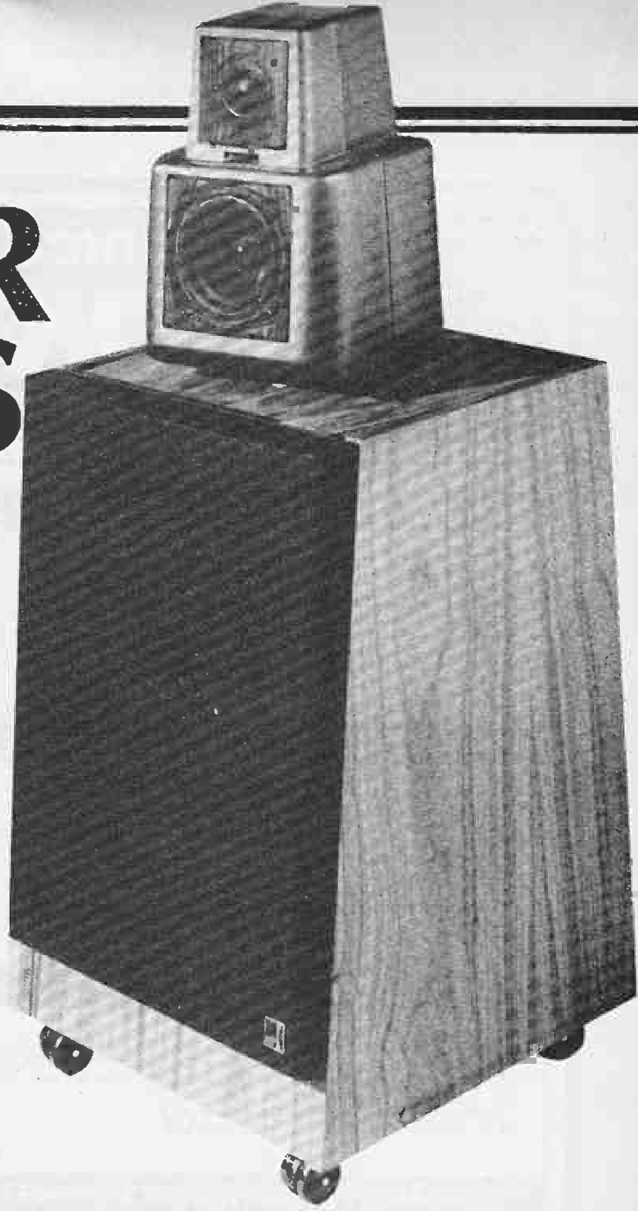
Left: The expansion system connected to the expansion socket of a Superboard via a 40-way cable. You'll also have to insert two 8T28 buffers into the empty sockets next to the CPU before the system will work.

TABLE 3

PIN	FUNCTION	PIN	FUNCTION
1	$\overline{IRQ}$	40	
2	$\overline{NMI}$	39	
3	DD	38	
4	D0	37	
5	D1	36	D4
6	D2	35	D5
7	D3	34	D6
8		33	D7
9		32	R/W
10		31	Ø2
11		30	
12	A2	29	
13	A1	28	
14	A0	27	A15
15	A3	26	A14
16	A4	25	A13
17	A5	24	A12
18	A6	23	A11
19	A7	22	A10
20	A8	21	A9

ETI

CROSSOVER NETWORKS



Put down that inductor you're winding on an old cotton reel and read this article on crossovers and loudspeaker design from KEF Electronics. It'll tell you why you've been wasting your time.

The basic requirements for a high-quality loudspeaker include on the one hand a smooth and uncoloured response maintained over an angle of radiation wide enough to cover the listening area, and on the other, freedom from audible non-linear distortion, together with a combination of efficiency and power handling capacity adequate for the conditions of use. For each drive unit in a multi-way system, there is only one frequency band over which all these requirements are simultaneously satisfied; outside this band there will be regions in which some of them cannot be met. A low-frequency drive unit, for example, if allowed to operate in the high-frequency range, would introduce colouration through diaphragm resonance. Again a high-frequency unit, if allowed to operate at low frequencies at which the necessary diaphragm excursion exceeds the linear limit, would introduce distortion products. To avoid degradation of the overall sound quality by such unwanted contributions, it is therefore essential that the output from each drive unit outside its working frequency range should be reduced to a sufficiently low level by adequate attenuation in the crossover filter.

Filtering Through

Filters in practice cannot have an infinitely sharp cut-off, so that there is an overlap region around the nominal crossover frequency in which the total sound output is made up of contributions from two different drive units. Ideally, the combined characteristic of each unit working in conjunction with its associated filter network should be such that the sum of the two contributions gives a flat response over the entire transition region; in addition, if the frequency characteristic of a unit within its working band is not quite flat, the network should be designed to rectify this . Each filter has therefore to be tailored to suit the response of its associated drive unit both in the working band and in the nominal cut-off region; moreover, it must be designed to operate into the input impedance of the unit, which will in general be complex and will contain additional components associated with the fundamental resonance of the diaphragm. Finally, the impedance presented by the filters to the power amplifier must be kept within prescribed limits which apply not only to the magnitude or modulus, but also to the relationship between the resistive and reactive components.

To measure the phase shift in a loudspeaker has been until recent times a very difficult operation, largely because of the additional — and much greater — phase shift associated with the time taken for the sound to reach the measuring microphone; this phase shift depends on the distance of the microphone from the acoustic centre of the drive unit, ie that point within the unit at which the sound appears to originate. The exact location of the acoustic centre is initially unknown but can be readily determined by the pulse test method developed by KEF; a short electrical impulse is applied to the unit, and the complete frequency response, in both amplitude and phase, is derived by computer analysis of the resulting transient sound output. This technique allows the phase shift introduced by the drive unit to be separated from the multiple phase rotations associated with the distance of the microphone from the acoustic centre, so that the position of the latter can be accurately calculated.

On Target

In designing crossover filters to suit individual drive units, the method adopted by KEF is to consider the overall electro-acoustic response of the network and unit together, and to make this conform as closely as possible to some known filter function that gives adequate attenuation in the cut-off region together with a smooth transition at crossover; the response/frequency relation to be aimed at is referred to as the Target Function and is represented by the symbol $T(f)$. The response/frequency function of the drive unit alone, already measured under working conditions, is represented by $S(f)$. The next step in design is to compute the frequency characteristic $H(f)$ of a filter that will convert the existing response $S(f)$ into the wanted reponse $T(f)$; the functions $T(f)$, $S(f)$ and $H(f)$ are in linear units, not dB, so that the conversion is a multiplication process, ie

$$T(f) = H(f).S(f) \text{ and } H(f) = \frac{T(f)}{S(f)}$$

In specifying the function $T(f)$ we can use any of the known forms of filter response, ignoring however the circuit configurations conventionally associated with these. The form commonly adopted is that of the classical Buttterworth filter. Figure 1

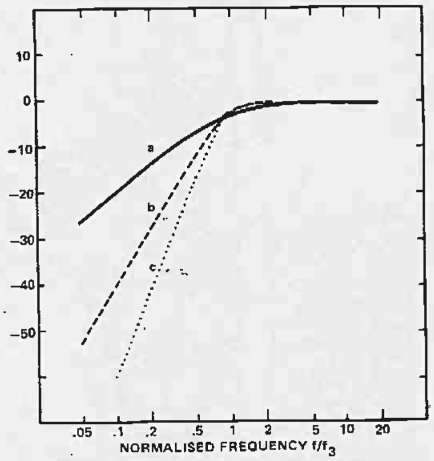


Fig. 1 Butterworth high-pass filter characteristics. (a) 1st order, maximum slope cut-off 6dB/octave; (b) 2nd order, 12 dB/octave; (c) 3rd order, 18 dB/octave.

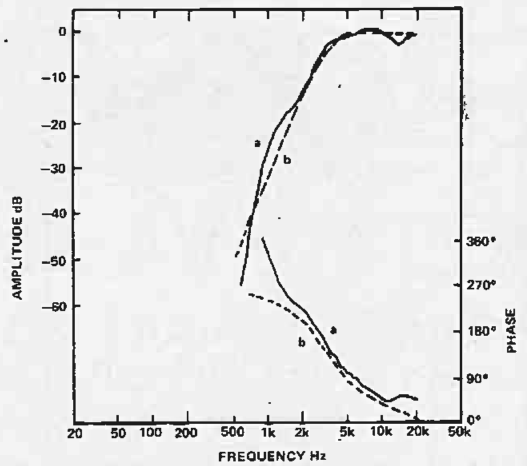


Fig. 3 (a) Measured amplitude and phase response of the Fig. 2 circuit; (b) Theoretical amplitude and phase response of the filter alone, terminated with the correct resistive load.

shows three high-pass filters of this type; the corresponding low-pass characteristics are the same but reversed left to right. All these curves are of the type described in filter theory as 'maximally flat'; this means that the attenuation within the pass band is kept as small as possible down to the nominal cut-off frequency f_3 — at which the loss is 3 dB — without introducing peaks or ripples in the characteristic. The curves in Fig. 1 represent Butterworth characteristics of the first, second and third order; the higher the order, the greater the cut-off slope — which in the three cases illustrated rises to a maximum of 6 dB and 18 dB per octave respectively — but also the greater number of circuit components required.

Cross Over Choice?

Although a first-order crossover network exhibits such desirable characteristics as unity amplitude and zero phase shift at all frequencies, the relatively slow cut-off rate of 6 dB/octave gives rise to a number of practical difficulties and such designs are not used. Crossover networks of the second order were at one time favoured but now have little application in high-quality systems. The overall frequency reponse obtained is not flat in the crossover region, but exhibits either a crevasse or a hump, depending on whether the drive units are connected in the same or opposite polarity; moreover, the cut-off slope of 12 dB/octave is still insufficient for many purposes.

Third-order crossovers, on the other hand, satisfy many of the requirements and are widely used. Figure 2 shows a commercial high-frequency drive unit fed through a conventional

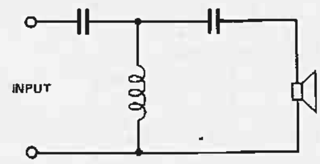


Fig. 2 High-frequency drive unit with conventional 3rd order Butterworth high-pass filter.

third-order Butterworth high-pass filter having a nominal cut-off frequency of 3 kHz, and Fig. 3a the measured amplitude and phase response of the filter unit together; Fig. 3b represents the theoretical response of the filter alone when loaded with a resistor numerically equal in value to the nominal impedance of the unit. Comparing curves (a) and (b) it will be seen that the response of the filter/unit combination deviates substantially from that which the filter was intended to produce. At high frequencies the characteristic is modified by the voice coil inductance, which resonates at 5 kHz with the second capacitor of the filter. From 3 kHz downwards, the cut-off slope, which for a third-order filter should be 18 dB/octave, starts off at 12 dB/octave and below 1.2 kHz — the fundamental resonance frequency of the diaphragm — increases suddenly to nearly 30 dB/octave. This large change in slope is reflected in the phase shift in the cut-off region, which far exceeds the proper value; the disparity extends up as far as the crossover frequency and would have a significant effect on the overall loudspeaker response in the transition region.

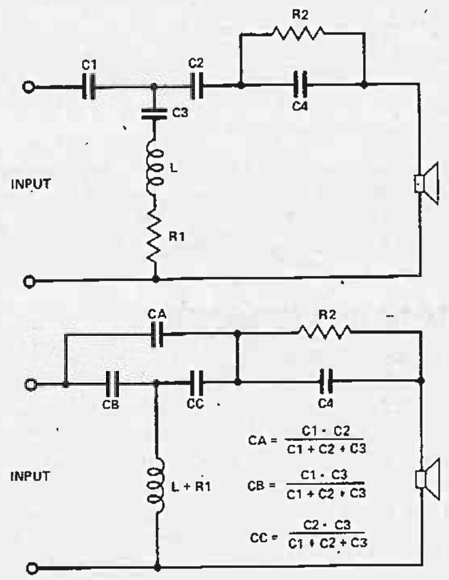


Fig. 4 (a) Computed Acoustic Butterworth filter designed to compensate for the non-flat response and complex input impedance of the high-frequency drive unit; (b) Practical realisation of Acoustic Butterworth filter.

Figure 4a shows the same high-frequency unit with a new network computed by taking the theoretical filter response of Fig. 3b as the target function; Fig. 4b illustrates a different but equivalent circuit configuration adopted for greater convenience in manufacture. The new network compensates for the electro-acoustic characteristics of the drive unit, including the effects of the voice coil inductance and the fundamental resonance. The voltage at the terminals of the unit varies with frequency in such a way as to produce the acoustic response shown in Fig. 5a; over most of the range from 500 Hz to 20 kHz this response conforms closely to the theoretical Butterworth characteristics, reproduced in Fig. 5b, the residual deviations being within ±1 dB in amplitude and within a few degrees in phase.

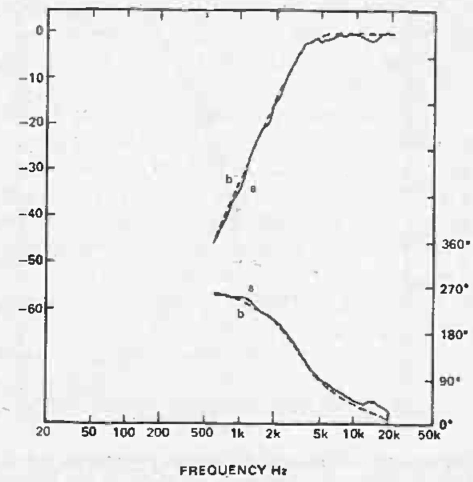
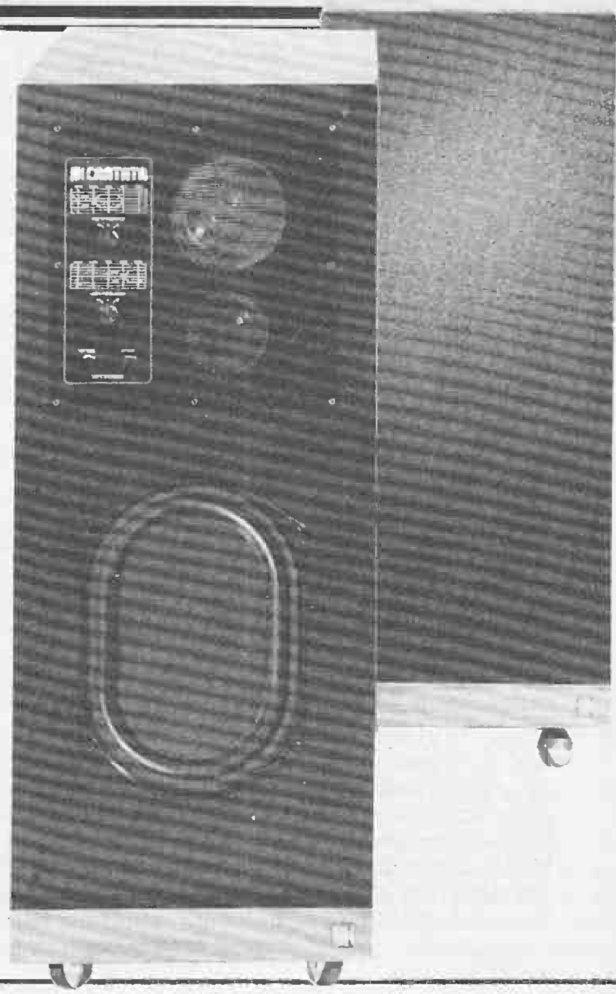


Fig. 5 (a) Measured amplitude and phase response of the high-frequency drive unit with the filter shown in Fig. 4; (b) Theoretical 3rd order Butterworth filter characteristic (as in Fig. 3b).



Avoiding Interference

For maximum horizontal distribution of sound without interference, the drive units in a multi-way loudspeaker should be mounted one above the other. Because of the unavoidable separation between the units, some interference effects must-then occur when the listener is located above or below the design axis and thus no longer equidistant from the different sound sources; the amount of this interference sets a limit to the angle above and below the axis within which the response can be maintained substantially constant.

This situation is further complicated by the phase shift necessarily associated with the high- and low-pass characteristics of the individual filter/unit combinations. The high-frequency drive unit, which at crossover normally has a phase lead over the low-frequency unit, is commonly mounted above the latter; what happens then is illustrated by the polar diagram in Fig. 6, which shows how the loudspeaker response at crossover varies with angle in the vertical plane. It will be seen that the main lobe of the polar characteristic, instead of coinciding with the axis of zero inter-unit time delay, is tilted downwards and has a maximum amplitude 3 dB above the on-axis response; a great deal of sound energy is thus directed away from the listening area and towards the floor, producing unwanted frequency-dependent reflections which modify the relationship between the direct and reflected sound in the room. Worse still, there is a region, just above the axis, where the outputs from the two units are beginning to get out of phase and at one angle almost cancel each other; as a result, a small vertical displacement produces a large change in the response of the system around crossover, and hence in the spectrum of the reproduced sound.

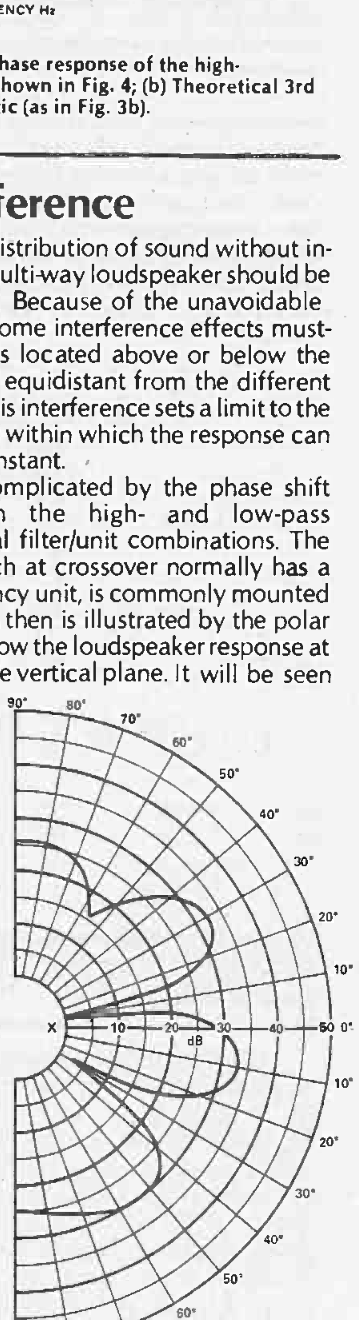


Fig. 6 Vertical plane polar diagram of two-way speaker system. X-Y indicates axis of zero inter-unit time delay.

One way of dealing with this situation is to mount the low-frequency drive unit (or mid-range unit in case of a three-way system) above the high-frequency unit, this turning the polar diagram upside down; the main lobe is then directed away from the floor and the cancellation region placed where it can do little harm. This arrangement is adopted in the KEF Calinda and Cantata loudspeakers. A more radical solution, applied in the KEF Model 105 loudspeaker, is to choose for the target functions a form of filter characteristic that keeps the acoustic outputs from the high- and low-frequency drive units in phase over the whole frequency range, so that the main lobe of the polar curve remains symmetrical about the axis of zero inter-unit time delay. The crossover networks used to achieve this end are of a special type of fourth-order filter which is equivalent to two second-order Butterworth filters in cascade and thus gives a cut-off slope of 24 dB/octave.

Time Travel

Before leaving the subject of interference, it may be noted that the acoustic centre of a high-frequency drive unit usually lies approximately in the plane of the panel on which the unit is mounted, while that of a low-frequency or mid-range unit is located further back, a short distance in front of the voice coil. The resulting difference in time delay can be allowed for in the physical positioning of the units in the loudspeaker assembly. It is however possible in some cases to achieve the equivalent result electrically by modifying the amplitude response, and hence the phase shift, in the crossover filters in such a way as to introduce a compensating time delay, while still satisfying the basic requirements of flat overall response and adequate cut-off slope. The target functions adopted then differ from the classical forms illustrated above — for example, the high-and low-pass characteristics at crossover may not be of the same order; given the necessary computational facilities, a number of useful variants of this kind can be evolved to meet particular design requirements.

The KEF Calinda (left) and Cantata (far left) loudspeakers avoid interference effects by putting the mid-range drive unit above the high-frequency unit. The KEF 105 II (lead picture) employs a more radical solution.

Network Synthesis

The design of the KEF Model 105.2 loudspeaker provides a good example of modern methods of network synthesis. The mid-range filter only is considered here: a similar procedure is adopted for the high- and low-frequency networks.

The first step is to examine the frequency response curves of a large number of mid-range drive units, measured under standard production test conditions, and to select one specimen, the characteristic of which coincides with the mean of the production spread. This unit is then mounted in the enclosure designed for the complete loudspeaker system, and its response under these conditions measured without a filter, ie with constant voltage applied to the input terminals.

Since the filter has to be designed to operate into the complex impedance presented by the input of the drive unit, this impedance must now be measured. For the purpose of network synthesis however it is convenient to represent the result by an equivalent electrical circuit with specified component values rather than by a series of resistance and reactance figures at a number of frequencies; this approach makes it easier to calculate the effect of certain parameters of the unit.

The next step is to decide what circuit configuration will produce the best fit to the desired network response curve while using the minimum number of components — taking into account the complex load imposed by the drive unit and the need to present an acceptable impedance to the power amplifier. The order of network required can usually be deduced by comparing the slope of the frequency characteristic for the drive unit alone with that of the target function representing the desired overall response curve. In principle, a number of alternative circuit configurations could be considered at this stage, but in the light of the designer's experience the choice will usually be narrowed down to one or two.

Details of each network to be investigated, the response characteristic required and the equivalent circuit for the drive unit input impedance are now fed into a computer; this is programmed to carry out an optimisation routine, which determines the network component values giving the best fit to the desired response curve and also the degree of accuracy achieved. The optimisation process is initiated by assigning approximate values to the various circuit elements; the computer then calculates the effect of making small changes in each element, and retains any of the new values that bring the response nearer to the ideal. This operation is repeated — possibly a thousand or more times — until the residual error in the curve fitting cannot be reduced any further. With the component values thus arrived at, the input impedance of the network is then checked to ensure that it remains within acceptable limits throughout the working frequency range.

The above procedure is repeated, if necessary, for alternative types of network so that a final choice of the optimum circuit configuration can be made.

Choose Your Components

At this stage the designer has to consider ways of utilising readily available circuit components, avoiding the need for non-standard values and close tolerance limits, both of which add considerably to the cost. The computer program is accordingly re-run with the calculated values of capacitors and resistors replaced by the nearest preferred values. Provided that a sufficiently accurate fit to the target response was achieved in the original calculation, the effect of these changes can be offset without appreciable detriment to the performance of the filter by altering the inductance values in the circuit — a simple matter since the coils are in any case wound to suit the individual design.

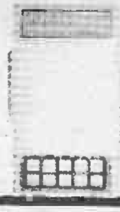
The process is now extended to allow for the production spread in component values. By arranging that the deviations of different circuit elements from their nominal values have opposing effects on the overall performance of the filter, it is possible to utilise stock components, having normal commercial tolerances, with very little wastage. The known manufacturing variation in component values, expressed in statistical form is fed into the computer, which calculates the maximum percentage of stock items that can be utilised in this way while keeping the filter characteristics within tolerance. Finally, permissible combinations of component values are worked out and incorporated in the instructions for assembling the networks on the production line.

Experts Rule OK?

It will now be clear why the standard of reproduction potentially attainable with a modern high-quality system cannot be realised by the home constructor with an assemblage of ready-made networks and drive units selected simply on the basis of their nominal frequency range, impedance and sensitivity ratings. Attempts have been made to ameliorate this situation by publishing descriptions of complete loudspeakers incorporating commerically available drive units, and giving circuit details of the filters to be used. The success of such designs however depends on the extent to which the author has taken into account all the factors referred to and has been able to measure the electro-acoustic characteristics of each type of unit specified allowing for manufacturing tolerances — before attempting to determine the appropriate network parameters.

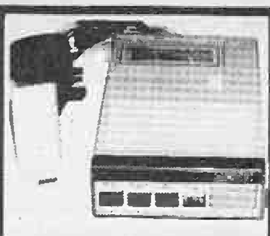
On the other hand, those manufacturers who have good facilities for acoustic measurement are usually well aware of the various pitfalls in filter design, and by means of computerised data-handling methods are able to produce the components of a multi-way loudspeaker in matched sets. These techniques ensure that the end product — whether in the form of a kit for assembly in an enclosure of prescribed construction such as the V3 speakers in the October ETI, or a complete system — represents the best combination of performance and cost-effectiveness that modern technology can provide. ETI

32 TUNES DOORCHIME/BURGLAR ALARM



This doorchime is powered from 9V d.c. source, and has battery back-up facility. It has an automatic tune advance facility and single or dual play options at 3 selectable speeds. A built-in burglar alarm circuit allows construction of a NORMALLY CLOSED alarm system, two bell pushes can be connected, each playing different tunes.

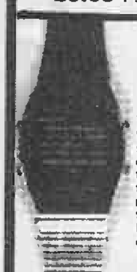
£9.95 + 95p P&P



POST OFFICE APPROVED TELEPHONE ANSWERING SYSTEM WITH REMOTE CONTROL

You will never miss that important phone call with this machine. You can call your number from any telephone and with the remote control bleeper check to see if any calls have been recorded. You can then erase or retain the messages. It comes complete with microphone, cassette, remote control bleeper and adaptor. We are offering this system at a very low introductory price. Elsewhere it is being sold for £149.

£119.95 + £2.90 P&P



DUAL TIME COUNTDOWN ALARM CHRONO

This superb watch has all the features one would ever need. It has selectable 12/24-hr. display count-down timer/alarm dual-time zone, chronograph with lap time facility, 24-hr. alarm with 5 min. snooze facility, back light fully adjustable stainless steel bracelet and we are offering it at our incredibly low price.

£8.95 + 50p P&P

ANALOGUE/DIGITAL LCD WATCH

with dual time, musical alarm, count down timer, chronograph and 12/24 hr selectable display mode.

This Analogue/Digital watch has no mechanical hands. Integral Liquid Crystal display shows time in analogue and digital form. The other features include:

* 2nd time zone
* Analogue display showing normal time
* 24 hour musical alarm
* Selectable 12/24 hr display mode
* Count down timer
* 1/100th sec Chronograph with lcd time
* Digital display shows hours, mins, secs, or hours, mins, date and day of the week
* Back light
* Alarm test function

We are offering all this at a very low price:

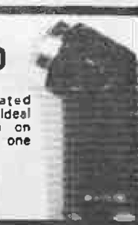
Model 1 with simulated leather strap

£17.95 + 75p p&p

Model 2 with stainless steel bracelet

£19.95 + 75p p&p

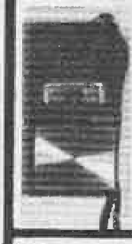
SANYO



Battery operated mini shaver. Ideal for use while on holiday. Uses one HP7 battery.

£4.95 + 75p P&P

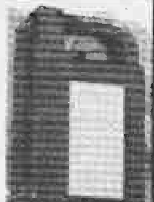
2-SPEED MICRO CASSETTE RECORDER



This is a very compact pocket size cassette recorder. It can be used for dictating or any other speech recording purpose. The high speed gives 15 mins of recording on each side and low speed gives 30 mins each side. It runs on 1 PP3 battery or an external 9V DC supply.

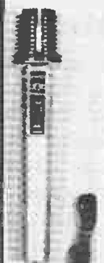
£19.95 + £1.95 P&P

FLUORESCENT PORTABLE LIGHT



A very useful battery-operated high-power fluorescent light for use in the car or for camping. Uses 8 'D' size cells and it has a socket for 12V DC input for use in the car. Power consumption is 6 watts. New circuit makes batteries last longer.

£4.95 + 95p P&P



FM WIRELESS MICROPHONE

This high quality Electret microphone can be tuned to transmit in the range 85-95MHz FM. It can be received on any FM receiver, the range depends on the sensitivity of the receiver. Uses one penlight battery which fits inside the microphone. Ideal for parties, discos and clubs.

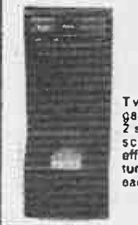
£8.95 + 50p P&P

TALKING WATCH

Speaks the time plus digital display. Speaking and musical alarm function. Lightweight and easy to set and use. Stainless steel strap.

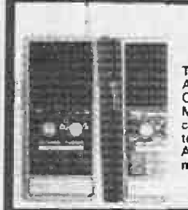
£49.95 + £1.95 P&P

SPACE INVADER BLOCK BUSTER



Two electronic games in one, with 2 skid levels, 2 digit score and sound effects. It plays a tune at the end of each game.

£15.95 + 95p P&P



WALKIE TALKIES WITH AM RADIO

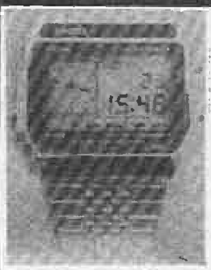
These walkie talkies have AM radio built into them. Other features include Morse Code key, volume control and telescopic antenna. Frequency 49MHz AM. Range approx. 1/8th mile.

£19.95 per pair + £1.95 P&P

LADY'S SUGAR COATED WATCH

Beautifully styled lady's LCD watch with matching bracelet, functions include: hours, mins, secs, month, date and back light. Super value for money. Its available in chrome or gold colour.

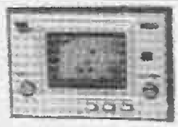
£5.95 + 50p P&P



CASIO AX-210 LCD ANALOGUE + DIGITAL WATCH

LCD and Digital Display shown side by side. Functions include: daily, hourly & countdown alarms, dual time and stopwatch mode, three selectable melodies, chrome finished case with dark blue surround, and adjustable stainless steel bracelet.

£25.95 + 50p P&P

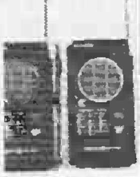


GAME & WATCH

Watch/game combination. 4 games available, each with two options. Fireman (pictured above) rescuers catch the LCD figures in a net as they jump from a burning building and bounce them into the ambulance. Also available – Exterminator, Juggler and Flagman.

£13.95 + 75p P&P (EACH)

SEARCH 2 WALKIE TALKIES



These are good quality walkie talkies made by GENERAL ELECTRIC CO. Features include Morse Code key and colour code telescopic antenna. Frequency 49MHz AM. Range approx. 1/8th mile. Price elsewhere £19.95. Our price

£12.95 per pair + £1.95 P&P

SLIM PENDANT WATCH

This watch is beautifully designed as a slim pendant and comes complete with a 26in. long neck chain. The functions include: hours, minutes, seconds, day, month and 4-year auto calendar. Comes in gold colour and is ideal for day and night wear.

£6.95 + 50p P&P

PUSHBUTTON TELEPHONE

This is a superbly styled, one piece, very compact push button telephone with last number redial facility (on pressing one button it will redial the last number you dialled). A special MUTE Button enables you to talk at your end without the other party hearing you. The electronic buzzer can be switched on or off.

£23.95 + £1.95 P&P

LEGAL FM CB TRANSMITTER AND RECEIVER

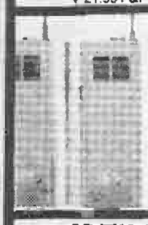
£79.95 + £2.90 P&P

SAE for details

QUARTZ TRAVEL ALARM CLOCK

This is a very versatile alarm clock, you can use it in the car, in the kitchen or as a desk top clock. Large (1cm character size) display makes it easy to read from a distance. It has 4-year auto calendar, backlight, AM/PM indicator and alarm on indicator.

£7.95 + 75p P&P

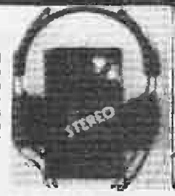


MINI COM WALKIE TALKIES

These are very neat and very small walkie talkies, they will fit in your pocket. Ideal gift for all ages. Frequency 49MHz AM. Range approx. 1/8th mile. Our price per pair is

£10.95 + 95p P&P

AM/FM STEREO RADIO



This is a lightweight 2-band receiver with hot line facility to let you know what is going on around you. It comes complete with stereo headphones and a carrying case. You can wear it on your belt or carry it on your shoulder.

£19.95 + £1.95 P&P

2-BAND HEADPHONE RADIO

You can buy this AM/FM Headphone radio for the price of just headphones. Runs off a single PP3 battery, has a volume control and a telescopic aerial for FM waveband. The ideal gift for youngsters.

£9.95 + £1.95 P&P

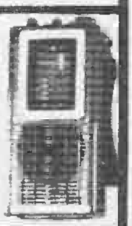
CAR STEREO PLAYER WITH AM/FM-MPX RADIO

This compact, quality product is designed to provide you with exceptional listening pleasure. The features include: AM/FM dial-in-door, local, distance attenuator switch for better stereo reception, AM/FM indicator, FM stereo indicator. Fast forward and eject button for cassette, balance, volume and tone controls.

£29.95 + £1.90 P&P

Suitable speakers £5.00 per pair + 95p P&P

CB/TV1-FM/AIR-PB-WB PORTABLE RADIO



This is a specialist receiver and it covers frequency bands which are not available on ordinary receivers. It covers 54-176MHz and also receives 40 channel CB. It has volume and squelch controls.

£14.95 + £1.25 P&P

SILENT ALARM/POCKET PAGER

This is an individually coded 4 watt radio transmitter and pocket pager receiver. It has a range of 2 miles. It can be used to protect your vehicle or a property and can also be used for paging. Power requirement for transmitter is 12V D.C.

£89.95 + £2.95 P&P

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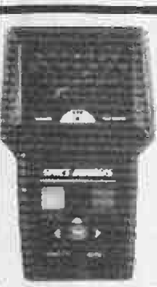
Clapper Sonic Control Car	£5.95 + 95p P&P
Lady's Snooze Alarm Watch	£6.50 + 50p P&P
Radio Controlled Porche 928	£21.95 + £1.95 P&P
Smoke Detector Fire Alarm	£7.95 + 75p P&P
Electric Car Aerial	£7.95 + £1.20 P&P
Mini Socket Set, 17 Pcs	£3.50 + £1.10 P&P
Car Coffee Maker	£3.50 + 75p P&P
Lady's 5F LCD Watch	£3.50 + 50p P&P
Gents 5F LCD Watch	£3.50 + 50p P&P
Slim Pen Watch	£6.95 + 50p P&P
Jewellers Screwdriver Set (5)	75p + 25p P&P
2 Station Intercom/Baby Alarm	£5.95 + 75p P&P
Electronic Lighter (Battery)	£3.95 + 50 P&P
Electronic Lighters (Piezo Electric)	£4.25 + 50p P&P
Car Stereo Casst Player, 16W Output	£14.95 + £1.50 P&P

HANDHELD SPACE INVADERS



A superb game, provides endless fun for children and adults alike. (WARNING – THIS GAME CAN SERIOUSLY EFFECT YOUR PASTTIME.) It gives you 90 seconds to hit enemy craft. The elapsing time and 4 digit score is constantly displayed. Score is decremented if you hit a friendly ship or if enemy missile penetrates your defence.

£10.95 + 75p P&P

MINI LCD DESK CLOCK

This is a very versatile desk clock with large (15mm high) digit LCD. Functions include hours, mins, secs, month and date

£7.95 + 75p P&P

TALKING ALARM CLOCK/STOPWATCH

This 'Sharp' Talking Clock is a 'state-of-the-art' product. On pressing the button it announces the time. At the preset alarm time a musical alarm is played and again the time is announced. It has 5 mins. snooze facility. Also has a useful timer and speaks time elapsed every 1 min., 5 mins. or 30 mins., whichever is selected in the stopwatch mode it announces the elapsed time at preset intervals or on pressing of a button at any time. It is an ideal gift, especially useful for blind people. Overall size is 11.4 x 6 x 2.2cms.

£39.95 + £1.95 P&P

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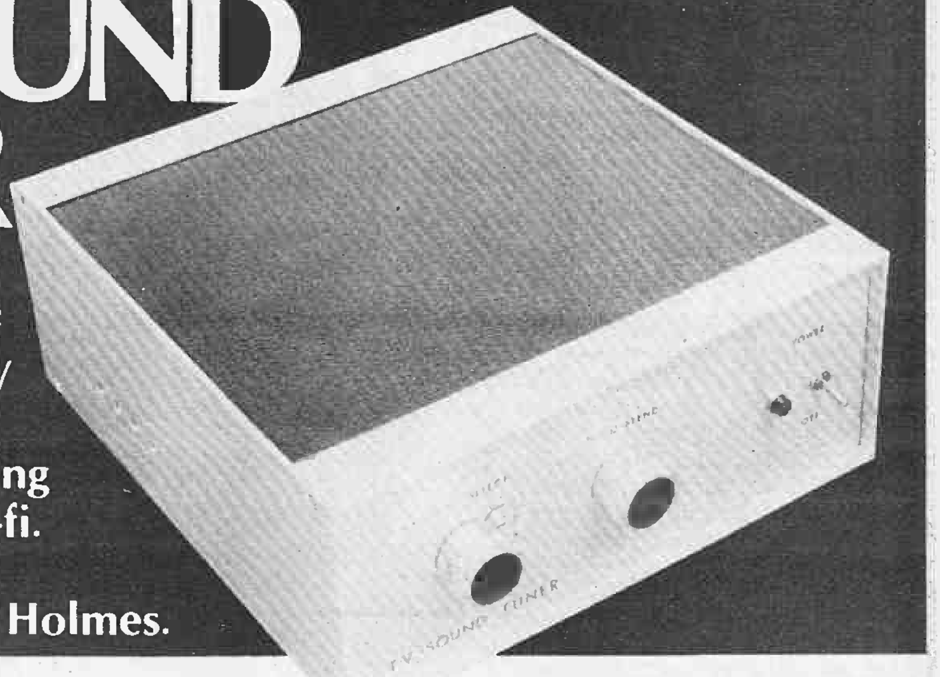
TV SOUND TUNER

We can't do much to improve the quality of the programmes on TV but at least we can do something about making the sound a bit higher-fi. Design by Bill Nemes. Development by Rory Holmes.



In the cut-throat world of consumer electronics, one of the questions designers apparently ponder over is 'Will anyone notice if we save money by chopping this out?' In the field of domestic TV sets, one of the first casualties always seems to be the sound quality; small speakers are used for cheapness and to reduce the size of the set, tone controls are rare, and as for separate bass and treble drivers — overdrafts at the ready if you want them.

This is a pity really, as the TV companies do their best to transmit the highest quality sound possible, using a FM modulated sound carrier. Perhaps the TV manufacturers think that viewers are going to be so engrossd by what's on the screen that they won't notice the inferior sound reproduction. Obviously they haven't watched television lately...

Get In Tune

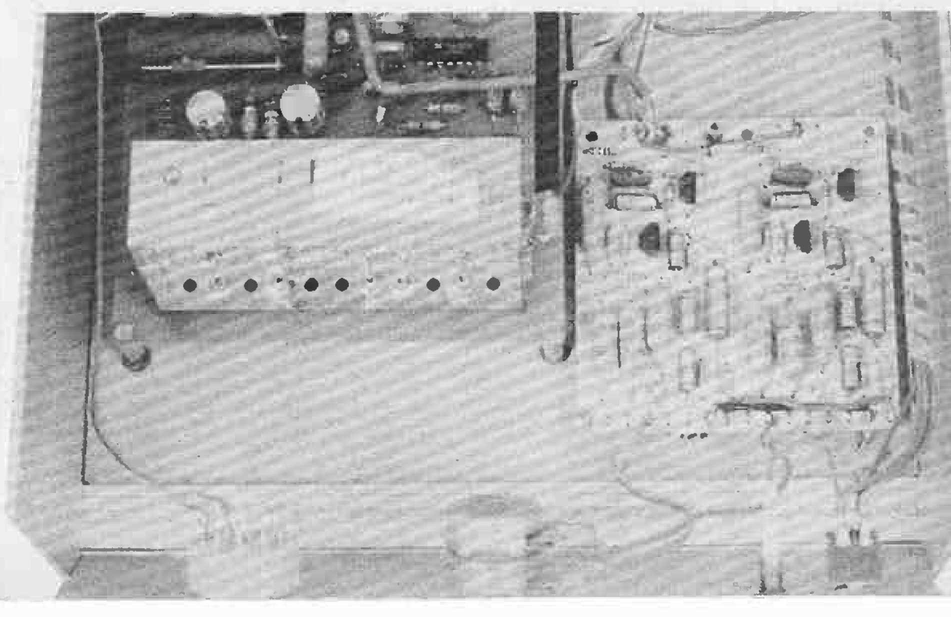
Naturally the more discerning members of the public (ETI readers,for example) will be dissatisfied with this state of affairs, and the easiest remedy is to build this TV Sound Tuner. The unit is designed round a ready-built and aligned UHF tuner module which is soldered directly onto the PCB containing the IF detector circuitry. The IF board filters out the sound carrier from the video, which is ignored (unless you want to try building a colour television, with Teletext, Prestel, remote control... oh alright, forget it), and the demodulated audio signal can be fed directly into your hi-fi, free from the abuse it normally receives at the hands of your telly.

Since TV sound is broadcast in mono (at present, anyway), an optional 'stereo simulator' based on a Mullard preamp module has been included in the design. With an eye on the future, four tuning pots are provided so that the fourth TV channel can be catered for when it arrives. The required tuning voltage is fed to the varicaps by a four-way selector switch.

The signal from the aerial has to be split so as to feed both the TV and the Sound Tuner, and first we toyed with the idea of fitting the tuner with 'aerial in' and 'aerial out' sockets, like a video recorder. But splitting a UHF signal involves, among other bits and pieces, the use of a balun coil and winding one of these just isn't worth the effort. Do what we did and buy an aerial splitter from your local accessory shop — it's cheaper, neater, easier and quicker. Ours cost £1.53.

A Classic Case

The kit supplied by RTVC (see Buylines) includes the PCB (which you will have to drill yourself), all the components for this board including the pre-aligned UHF tuner, a rotary switch for channel selection and the mains transformer. If required, the stereo simulator preamplifier module (which is supplied ready-built) can be obtained for an additional charge. Items which are *not* supplied include aerial and audio sockets, wire, the potentiometer for the stereo blend, mains switch, power-on neon and case. The case we used was from West Hyde Developments' Classic II range — everything fits in quite neatly.



Assembly of the main board is straightforward. Take the usual precautions with the orientation of the ICs, diodes and electolytic capacitors. To make life easier the PCB is overprinted with the component positions. The tuner module and the coils will only fit the board one way round, with the exception of L6. This coil should be soldered so that the printing on the can faces away from the tuner module.

L2 is to be wound by the constructor using the 18 swg wire supplied in the kit; it consists of 3¼ turns around a 10 mm former (which is removed before soldering the coil to the PCB).

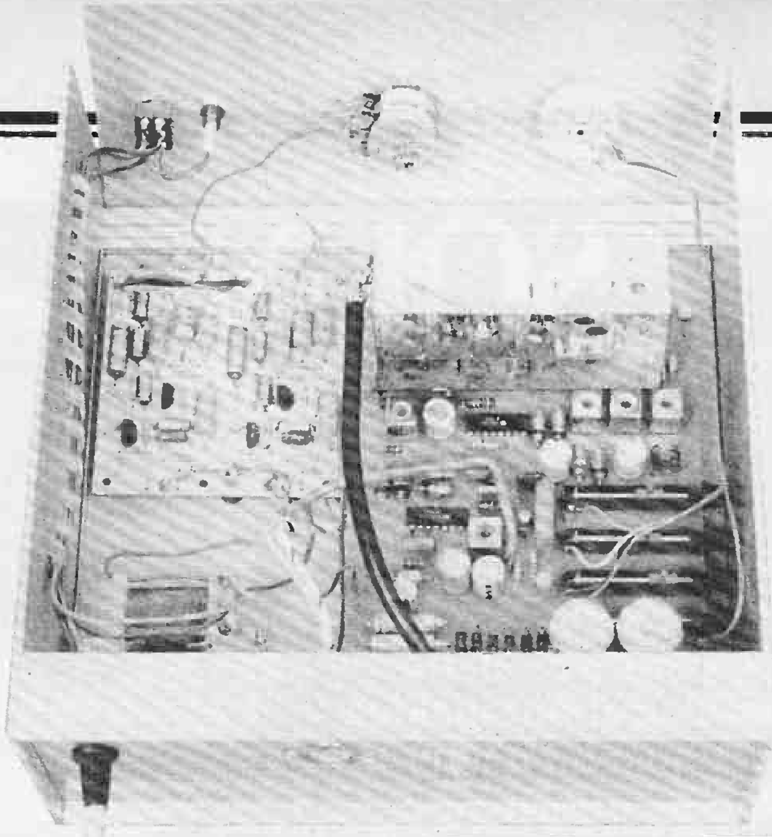
The values of C9 and C16 are not critical and the components supplied with the kit will depend on availability.

We mounted our PCB on stand-off spacers so that the varicap multiturn control pots are positioned level with holes drilled in the side of the case — these pots should only need to be set up once, using a small screwdriver. The position of the transformer, preamp board and the other hardware can be seen from the photographs, and the wiring diagram shows how to connect up all the various bits.

Alignment

As only the sound is to be extracted, the only equipment required is a non-metallic tuning tool. While monitoring the audio output tune L6 to receive maximum noise (or station if you were lucky enough to receive it the first time). Tune the selected multiturn pot to receive a station and adjust L5,L4,L3 and L1 for maximum output. Note that tuning of L1,L3 and L4 will appear 'flat', particularly in high signal strength areas. (R1 may be reduced should overloading occur).

This is the aerial splitter that we bought — much easier than making one. The aerial plugs into the socket on the right, while those on the left connect to the TV set and the tuner.



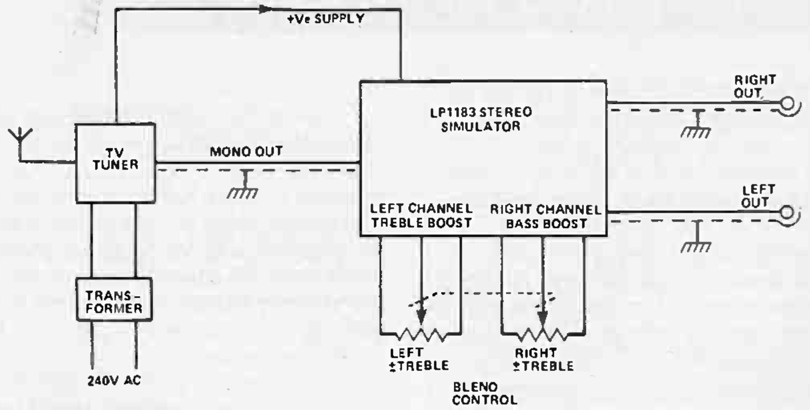


Fig. 1 Block diagram of the TV tuner.

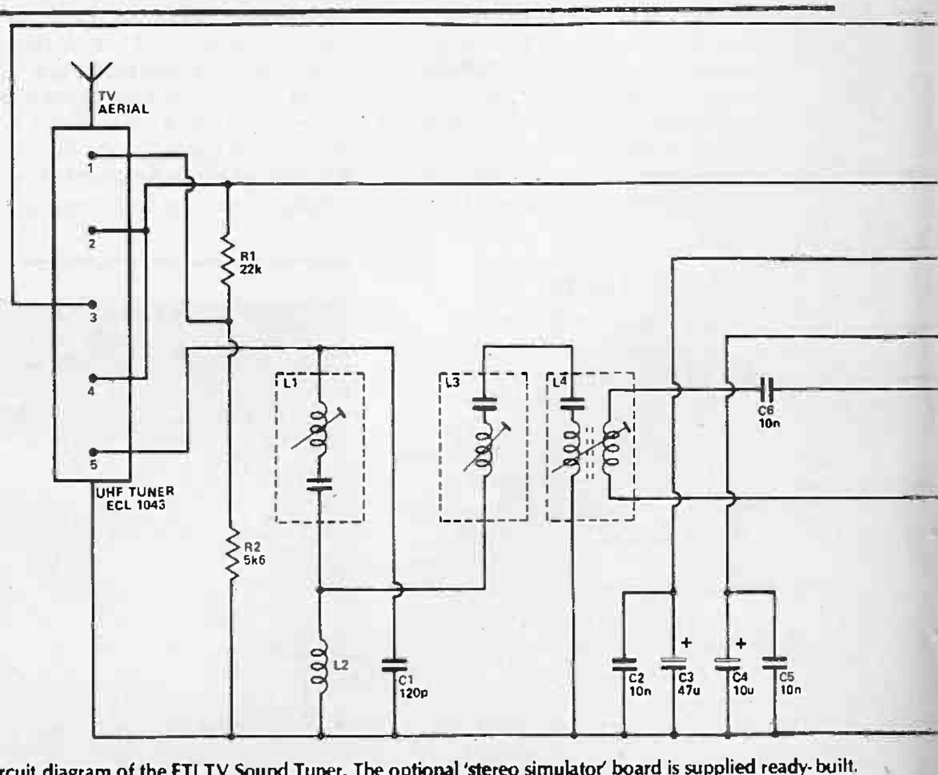


Fig. 2 Circuit diagram of the ETI TV Sound Tuner. The optional 'stereo simulator' board is supplied ready-built.

HOW IT WORKS

The ECL 1043 is a ready built and aligned varicap-tuned UHF tuner. Its 38 MHz IF output contains AM modulated video and FM modulated sound carrier frequencies. Pin 1 is the AGC input which is not used; R1 and R2 form a potential divider to preset the gain. The 38 MHz output is connected to IC1 via input-trapping circuitry. IC1 is an IF amplifier/video detector chip tuned by a single coil L5. As the sound carrier is spaced 6 MHz from the vision carrier frequency, the output on pin 12 contains the demodulated video (positive) and the 6 MHz FM modulated sound carrier frequency. The video is removed by using a 6 MHz ceramic filter. The filter also sets the operational frequency of IC2, which is an FM IF amplifier/ quadrature detector chip. Detection alignment is obtained by adjustment of a single coil L6, which provides the quadrature signal to the coincidence gate detector. Audio output is recovered at pin 14.

In preference to a multi-secondary transformer a readily available 7V5 single secondary transformer is used, at the expense of a few extra components. The supply voltage to the ICs and tuner is derived from a full wave voltage doubler. The tuning voltage is further quadrupled, filtered and regulated by IC3.

The stereo simulator is simply a stereo preamplifier with a bass control in one channel and a treble control in the other. A dual pot is used to control the cut and lift of these tone controls, so as the pot is rotated the high and low audio frequencies are directed to opposite speakers and a 'stereo' effect is obtained.

BUYLINES

A kit of parts containing those items listed in the text will be available from RTVC Ltd, 21E High Street, Acton, London W3 6NG (mail order only). The TV tuner costs £11.45 plus £1.50 p&p; the transformer is £1.50 plus £1.50 p&p (p&p free on transformer if ordered with kit); and the LP1183 preamp costs £1.95 plus 75p p&p. The case is available from West Hyde Developments — order as CL2 AEL.

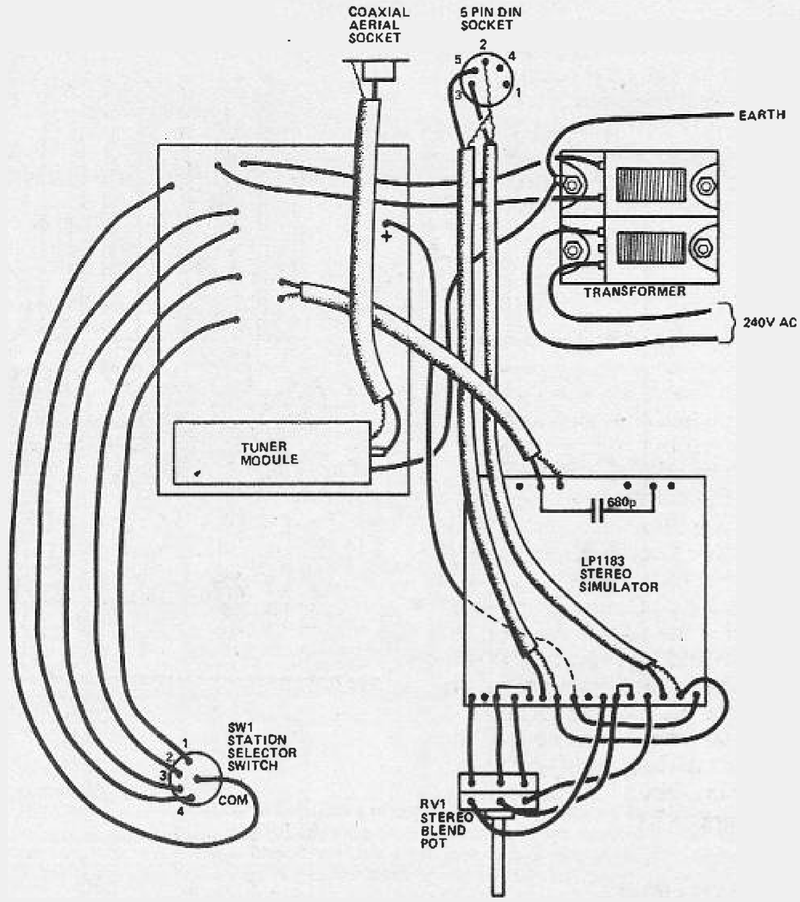
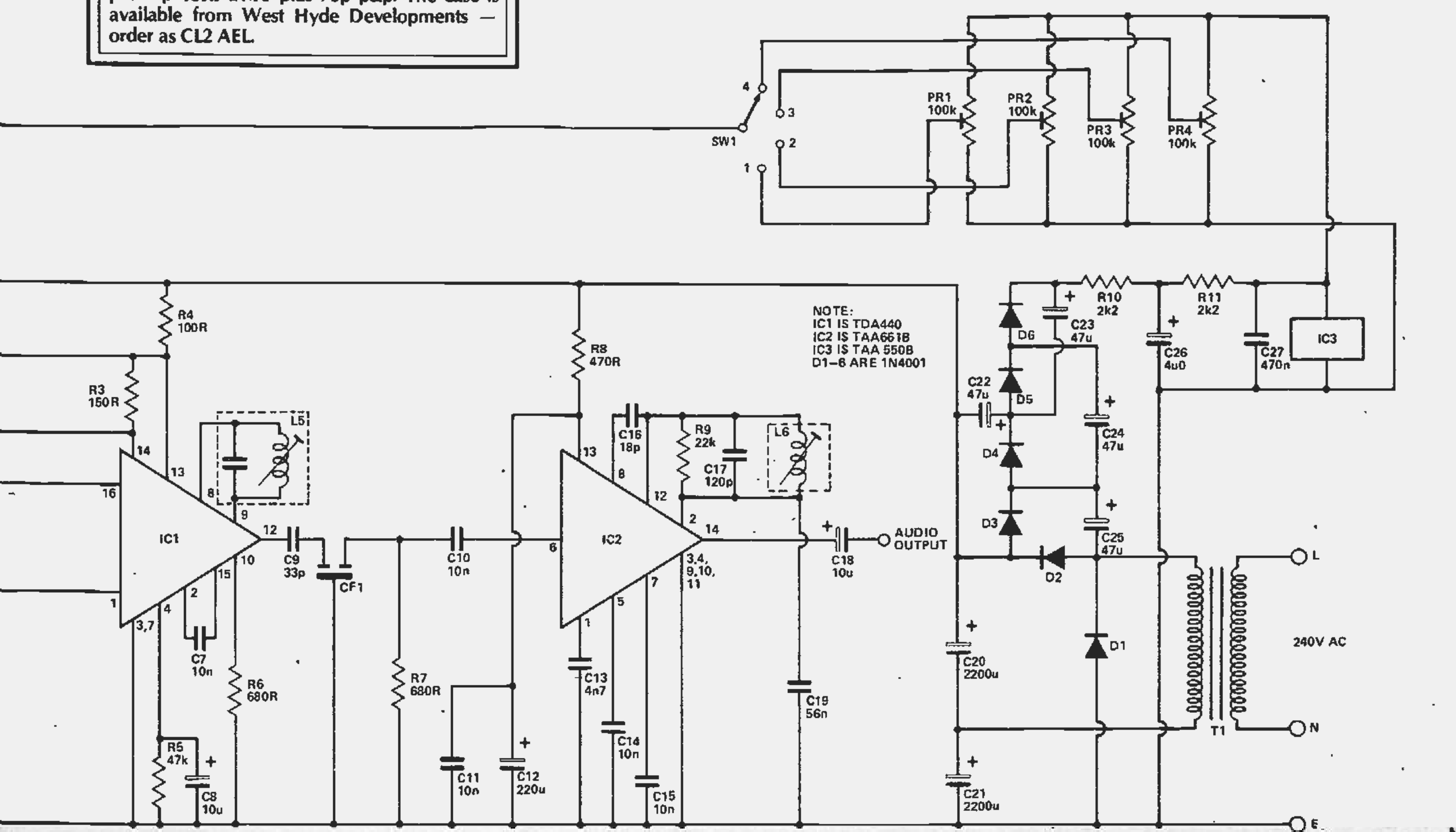


Fig. 3 Wiring diagram for the tuner project. Make sure you use shielded cable for the audio connections and UHF coax for the aerial connection, as shown, and don't forget to make the earth connection to the case of the tuner module.



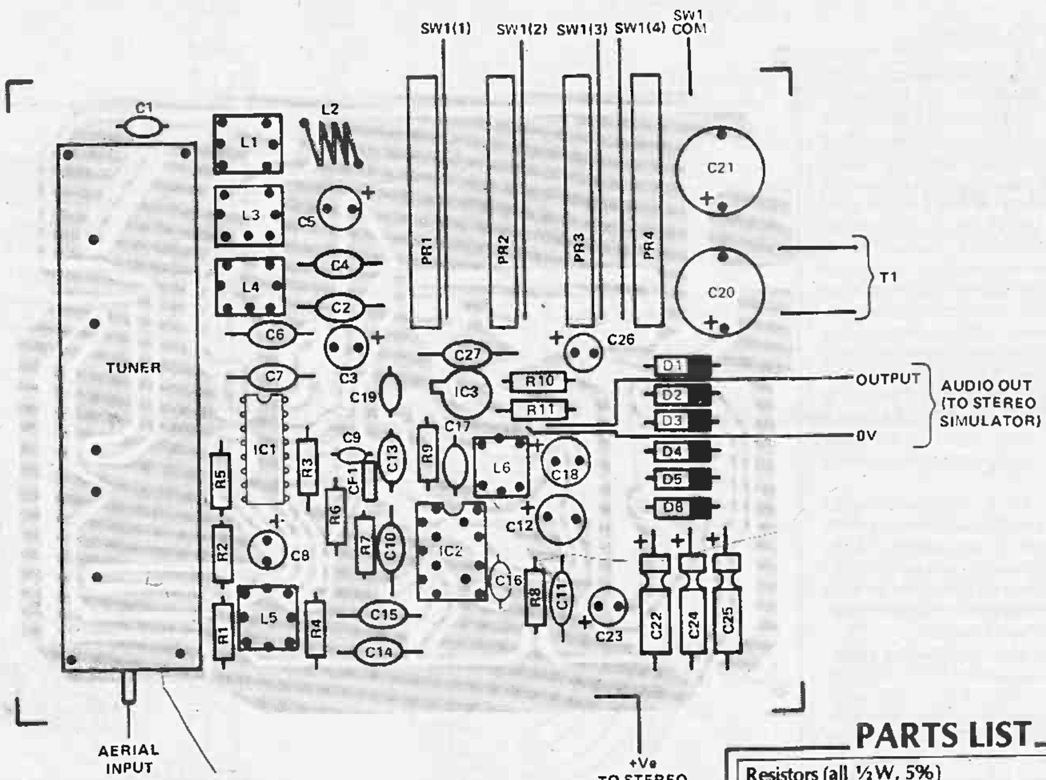


Fig. 4 Component overlay of the tuner board. IC2 comes in a quad-in-line package, so you'll have to solder it directly rather than use a socket. Do this quickly and carefully! Also make sure that L6 goes in the right way round — with the printing away from the tuner module. CF1 can be fitted either way round.

PARTS LIST

Resistors (all ½W, 5%)	
R1,9	22k
R2	5k6
R3	150R
R4	100R
R5	47k
R6,7	680R
R8	470R
R10,11	2k2
Potentiometers	
PR1-4	100k varicap multiturn controls
RV1	220k dual linear pot
Capacitors	
C1,17	120p polystyrene
C2,4,6,7 10,11,14,15	10n polystyrene
C3,23	47u 16 V PCB electrolytic
C5,8,18	10u 25 V PCB electrolytic
C9	33-39p polystyrene (see text)
C12	220u 16 V PCB electrolytic
C13	4n7 polystyrene
C16	18-22p ceramic (see text)
C19	56n mylar
C20,21	2200u 16 V PCB electrolytic
C22,24,25	47u 25 V axial electrolytic
C26	4u0 40 V PCB electrolytic
C27	470n polyester
Semiconductors	
IC1	TDA440
IC2	TAA661B
IC3	TAA550B
D1-6	1N4001
Coils	
L1	D1 (Toko)
L2	see text
L3	D3 (Toko)
L4	D8/9 (Toko)
L5	D10 (Toko)
L6	34721 (Toko)
Miscellaneous	
SW1	1-pole 4-way rotary switch
SW2	miniature DPDT mains switch
CF1	6 MHz ceramic filter

UHF tuner ECL 1043 (Mullard); transformer (7V5 secondary @ 100 mA minimum); LP1183 preamp (if required); mains neon; UHF aerial socket; 5 pin DIN socket; PCB; case.

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Combibox FW61 Charger for HP7, HP11, HP2			£16.50

CAPACITORS

SIEMENS LAYER B32560 7mm

.001	to	.015/400v	£0.08
.0082	to	.027/250v	£0.09
.033	to	.1/250v	£0.10
0.15/250	£0.12		
0.22/250	£0.14		
0.1/100	£0.12	0.15/100	£0.13
0.22/100	£0.45	.33/100	£0.20
0.47/100	£0.26	0.68/100	£0.34

SIEMENS LAYER B32561 10mm

.01 .022/400v			£0.08
.033/400v	£0.09	.047/400v	£0.10
.022/250v	£0.08	.047/250v	£0.09
.068/250v	£0.10	.1/250v	£0.13
.22/250v	£0.16	.47/250v	£0.26
.22/100v	£0.16	.47/100v	£0.25
.68/100v	£0.30	1.0/100v	£0.40

Other values stocked prices as reduced

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4.7/100	.13	22/40	.16
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10/100	.16	22/100	.20
47/25	.16	47/40	.19
47/63	.20	47/100	.24
100/25	.20	100/40	.19
100/63	.21	100/100	.44
220/16	.19	220/25	.22
220/40	.24	220/63	.45
220/100	.67	470/16	.23
470/40	.42	470/63	.77
470/100	1.16	1000/16	.45
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470/100v	75p	4700/40v	£2.10
1000/25c	45p	4700/63v	£3.50
2200/25v	75p	10,000/25v	£3.15
2200/40v	95p	10.000/40v	£3.75
4700/	£1.10		

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W01 1A/100V	.32	T1C106D 4A/200V	.43	T1C225D 6A/400V	.64
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CASIO FX-702P

Don't they ever sleep at Casio? No sooner do we review the FX 602P than its big brother the FX 702P drop through our letterbox. Peter Freebrey has been probing at the push-buttons to make this report.

First the Casio FX 502P, more recently the FX 602P and now we have the FX 702P. If my memory (unfortunately somewhat intermittently volatile!) serves me correctly the FX 502P was hailed as 'better than sliced bread'; sounds a bit crusty now but it helped persuade me to buy one of those little beauties back in 1980! The FX 602P was also rated highly and 'recommended to anyone seeking a powerful portable machine, which has comprehensive control over memory and data space'.

The FX 702P (RRP £134.95) follows in this fine Casio tradition, offering a lot more than its predecessors in that it has moved away from being an uprated programmable calculator (such as the FX 602P) to what is Casio's answer to the Sharp PC1211 — a fully fledged pocket computer. The FX 702P offers full alphanumeric capabilities and according to the instruction manual 'uses BASIC program lanugage'. Although this may appear to be true at first sight, Casio's BASIC does vary more heavily from the norm on this score. It is generally perfectly understandable to anyone with a knowledge of another dialect of BASIC and would be mastered just a quickly as any other form of BASIC by the newcomer. A number of instruction words are used in a shortened form, for example: PRINT becomes PRT, INPUT is INP, GOSUB is GSB, RETURN becomes RET, and so on. This minor variation was presumably brought about by a desire on Casio's part to save on display space (not to mention keeping the small keyboard clutter down to a minimum), and to follow the successful pattern of their previous programmable calculators. Reasonably logical on such a machine (machine?!) but is it still BASIC? I suppose one must concede that it is but do we look to a future generation of pocket computers sporting such commands as PT, GB, RT, IN? There are also one or two small anomalies; on the FX 702P RND(is an instruction to round off a number whereas in some other BASICs RND(is a call for a random number. Also, GET on the FX 702P is a tape handling command only ... not an instruction to 'get' a character from the keyboard, a function which is performed on the FX 702P by Casio's KEY command (not unlike other dialects' INKEY).

All in all slightly different from other BASICs, but perfectly workable once you have handled it for a relatively short time. Having struggled for a long time to familiarise myself with the standard (ugh!) QWERTY keyboard layout, I now have to relearn the positions of the letters of the alphabet!

From the above the FX 702P clearly shows its programmable calculator anticedents; it also has some fairly heavy guns on the statistical analysis front. The obvious question must be how it will compare with the Sharp PC1211. It offers more facilities than the Sharp and is in some ways more versatile. The comprehensive program library supplied with the FX 702P contains mainly scientific applications, many of them rewritten for use on the FX 702P from the previous FX 502 and FX 602 libraries. It will undoubtedly find many supporters from existing Casio programmable owners and I think its popularity will grow as its full capabilities are realised. The review model performed perfectly without a hitch and appears to do all that is claimed of it.

The instruction manual supplied, like many other manuals, is not all that one might expect. In this instance it suffers on two counts; the slightly stilted and occasionally unnecessarily involved English is probably due to inadequate translation facilities, and although all functions are explained somewhere there is no comprehensive index of list of them — so, if I have got it right, treasure the table of functions/commands that I've provided.!

The FX 702P, like the FX 602P, offers the user the option of defining the available memories at the expense of program steps. You can choose from 26 memories and 1680 program steps to 226 memories and 80 program steps. As an indication of steps required for a program:

```
10 PRT,10 GSB and 1000 PRT ............ use four steps
10 PRT"" .............................. uses six steps
10 PRT"HOW MANY STEPS" ............... uses 22 steps
```

So it would seem to be something like two steps for line number, two steps for BASIC command words and one step for each character.

The LCD display is very clear and a control for the contrast of the display is provided. 62 characters may be written on one line, 20 of them being displayed at any one time. The display scrolls to the left to enable long strings of text to be read. The characters are made up of a 7 x 5 dot matrix and no confusion arises between any two characters.

Also following previous practise, the FX 702P has a MODE key which defines the current status or mode that the machine is executing, thus:

MODE 0 ... RUN, manual and program calculation mode
MODE 1 ... WRT, program writing, checking and editing mode
MODE 2 ... TRACE, program RUN line by line in debugging mode
MODE 3 ... TRACE off
MODE 4 ... DEG, unit of angular measure will be degrees
MODE 5 ... RAD, unit of angular measure will be radians
MODE 6 ... GRA, unit of angular measure will be grads
MODE 7 ... PRT, print output mode if printer connected
MODE 8 PRT off

In MODE 0 the FX702P can be used either in the direct mode as a calculator or will RUN any currently stored programs from any one of the 10 'program areas' designated P0-P9. In direct mode and using the minimum number of memories each memory is assigned a label A-Z. You may therefore assign these memories by keying A = 2, B = 5, C = 1.234 etc. Should you use these characters as variables in a program they will either have the value already entered (A = 2, B = 5 etc), or if reassigned within the program the original value stored will be lost. Quite straightforward but you must make a note of what variable names and memory locations you have used. Which is normal practise, is it not ......!

All the normal operators (+ − / * ↑ = ≤ ≥ ≠ < >) and punctuation (. , ; : ? !) that you would expect to find on a BASIC language computer are available, together with a large number of predefined functions/command words. These are selected either by keying one of the two function select keys F1 and F2 followed by one other key, or by keying in the appropriate keyword using the alpha keys. So the PRINT command may be obtained either by pressing F1 and ; or by pressing PRT. Both result in PRT displayed.

Not only but also — there are some commands available only by keying in the appropriate keyword, for example CLR, CLR ALL, CNT, MX, MY and so on — wow!

Find The Function

With all computers there are usually a few functions/commands that are either missing or behave in a manner that is not what the user wants or expects. With computers above a certain complexity it is normally possible to persuade them to do what you want even though the specifications would have you believe that a particular facility is not available. The FX702P has a few such grey areas so perhaps the following hints will help.

To utilise MID(the string to be operated upon can only be assigned one name/label — $. This may be up to 30 characters long but *must* be called $. String variables A$, B$ C$ etc may only be up to seven characters long so you cannot directly extract a string of over seven characters from the possible input of 30. Should you wish to do so try this: check for the length of the string using LEN(, if it is over seven characters long use MID(to extract a portion of this string and assign this to A$. Take the next portion of this string and assign to B$, the next C$ and so on. When you need to display or use the overlength string for further string handling call up A$+B$+C$ either as PRT A$+B$+C$ or $ = A$+B$+C$. This is called string concatenation.

Missing from your BASIC vocabulary is VAL, the BASIC command that returns the numeric representation of a string; if the string is not numeric a zero is returned. This means that if you use the command KEY to enter a character from the keyboard that character can only be string variable and although it may be a numeral 0-9 you may not perform arithmetic on it directly. One way to overcome this is to use a series of IF commands so:

```
10 A$ = KEY:IF A$ = "" THEN 10
20 IF A$ = "1";X = 1
30 IF A$ = "2";X = 2
```

and so on. You now have X assigned to the numerical value obtained by using the KEY command.

Other common functions missing from Casio's BASIC are REM, READ, DATA and ON...GOTO. At first sight the missing REM is a nuisance and it means you cannot include any non-operative program information within the program. Fear not, where there is a will there is a way (sometimes!). How about a program line like this:

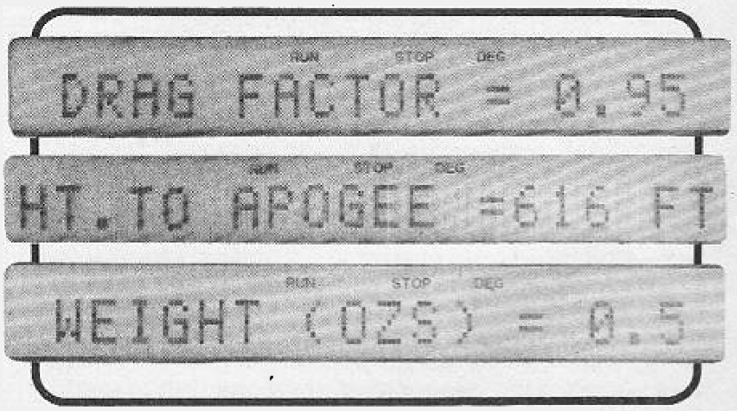
```
20 GOTO 30:THIS IS A HIDDEN REM
```

On executing the GOTO the computer ignores the text after the colon — so who needs a REM command! I'll let you think of ways around any other missing statements!

Tape Measures

A cassette tape recorder in conjunction with an FA-2 adaptor may be used to store programs or data on tape. The paragraph concerning this in the manual is a wonderful example of a (presumably) Japanese/English translation inferring that a magnetic tape recorder may be used to store important programs and data but that another type of recorder can also be used for recording (alto, bass, tenor?)

One could go on for some time praising and explaining the functions and capabilities of the FX 702P, which like all computers has characteristics unique to itself. The proof of the pudding is in the eating; I certainly enjoyed my feast with this latest offering from Casio. Look at the table of Functions/Commands and judge for yourself...



COMMAND	KEYING SEQUENCE	RESULT
EXE	EXE	EXEcute, instructs computer to action current instruction, enters program line.
MODE	MODE	Selects operating MODE — RUN, WRT, debug TRACE, unit of angular measure and printer operation
F1	F1	1st Function key (coded red)
F2	F2	2nd Function key (coded blue)
C	C	Deletes character to left of cursor
CLR		Deletes current program area
CLR ALL		Deletes all program areas
AC	AC	Clears display, terminates RUNing of program, will switch computer back on after auto shutdown
STOP	STOP	STOPs execution of program
CONT	CONT	CONTinues execution of STOPped program
ANS	ANS	Displays result of previous calculation
STAT	STAT	Input mode for performing statistical calculations
ASTAT	F1 ANS	Displays results of statistical calculations
SAC	F1 ,	Clears statistical summation memory
INS	F1 C(clear)	Inserts space at cursor position
DEL	F1 STAT.	Deletes incorrect statistical data
HOME	F1←	Positions cursor to left of display area
←	←	Cursor movement left
→	→	Cursor movement right

COMMAND	KEYING SEQUENCE	EXAMPLE	RESULT
FOR	F2 "	FOR K = n TO m	Increments from K = n TO K = m during which time program lines up to NEXT K are repeated
TO	F2 #		See FOR
STEP	F2 $	FOR K = n TO m STEP p	Optional increment in FOR...NEXT loop
NEXT	F2 :	NEXT K	Used in conjunction with FOR...
PRT	F2 ;	PRT A	Displays value of A
		PRT A$	Displays string A$
		PRT "TEXT"	Displays string enclosed within ""
IF	F2 A	IF X = Y THEN	Decision/comparative instruction
THEN	F2 B	IF .... THEN 200	In conjunction with IF, in example if comparison true jump to line 200
GOTO	F2 C	GOTO #5	Jump to execute program area P5
		GOTO 200	Jump to line 200
GSB	F2 D	GSB 500	Jump to subroutine at line 500
RET	F2 E	RET	End of subroutine RETURNs to program line following associated GSB
INP	F2 F	INP X	Assigns value of keyboard INPUT to
		INP X $	variable, numeric or string
WAIT	F2 G	WAIT 100	Determines display time when using PRT command, WAIT 100 = approx. 5 seconds
SET	F2 K	SET E,n	Defines number (n) of digits displayed
		SET E,n	Defines number (n) decimal places displayed
		SET N	Cancels SET command
VAC	F2 L	VAC	Clears data use memory.
STOP	F2 M	STOP	Suspends execution of program
END	F2 N	END	Terminates execution of program
SAVE	F2 0	SAVE [#n"filename"]	Command to SAVE program area n on tape under specified filename
LOAD	F2 P	LOAD [#n"filename"]	Command to LOAD from tape sepcified program to program area n
PUT	F2 Q	PUT ["filename"]A,Z	Command to save data variables to tape
GET	F2 R	GET ["filename"]A,Z	Command to read data variables from tape
VER	F2 S	GET ["filename"]	Verifies program or data written to tape

DEFM	F2 T	DEFM n	Increase number of memories available by 10 times n
PASS	F2 U	PASS "password"	Designation of password to protect program
RUN	F2 V	RUN [F1 n]	Executes program in specified program area
LIST	F2 W	LIST n	In WRT MODE displays specified program line and subsequent lines on keying EXE
KEY	F1 N	A$ = KEY	Reads one character from keyboard and assigns it to A$

FUNCTION	KEYING SEQUENCE	EXAMPLE	RESULT
RPC	F2 H	A = RPC x,y	Converts rectangular to polar coordinates
PRC	F2 I	A = PRC x,y	Converts polar to rectangular coordinates
DMS	F2 J	A = DMS A	Converts decimal to sexagesimal
RAN #	F1 .	A = RAN #	Generates random number where 1 > A > 0
SIN	F1 $	A = SIN x	A = Sine of angle x
COS	F1 :	A = COS x	A = Cosine of angle x
TAN	F1 ;	A = TAN x	A = Tangent of angle x
LOG	F1 A	A = LOG x	A = Common logarithm of x
LN	F1 B	A = LN x	A = Natural logarithm of x
EXP	F1 C	A = EXP x	Exponential function, A = e raised to the power of x
SQR	F1 D	A = SQR x	A = Square root of x
SGN	F1 E	A = SGN x	A = Sign of x (1, −1 or 0)
INT	F1 F	A = INT x	A = Integer part of x
FRAC	F1 G	A = FRAC x	A = Fractional part of x
ABS	F1 H	A = ABS x	A = Absolute value of x
RND (	F1 I	A = RND(x,y)	Rounding to significent number of digits (x displayed to yth significant place)
DEG (	F1 J	A = DEG(n,m,o)	Sexagesimal to decimal conversion
LEN (	F1 K	A = LEN(B$)	A = Number of characters in string B$
CSR	F1 L	PRT CSR n; X	Designates location of display, PRINTs X, n spaces from left of display
MID (	F1 M	A$ = MID(n,m)	Extracts n characters from string $ starting with mth character

Functions used in performing statistical analysis

FUNCTION	KEYING SEQUENCE	RESULT
SDX	F1 0	Standard deviation of x ($x\sigma_n - 1$)
SDY	F1 P	Standard deviation of y ($y\sigma_n - 1$)
SDXN	F1 Q	Standard deviation of x ($x\sigma_n$)
SDYN	F1 R	Standard deviation of y ($y\sigma_n$)
LRA	F1 S	Constant term (A)
LRB	F1 T	Regression coefficient (B)
COR	F1 U	Correlation coefficient (r)
EOX	F1 V	Estimated value of x ($\hat{x}$)
EOY	F1 W	Estimated value of y ($\hat{y}$)

Statistical functions not having shortened keying sequence (ie have to be entered in full).

FUNCTION	RESULT
CNT	Number of data (n)
SX	Sum of x (Σx)
SY	Sum of y (Σy)
SX2	Sum of squares of x (Σx^2)
SY2	Sum of squares of y (Σy^2)
SXY	Sum of products of data (Σxy)
MX	Mean of x ($\bar{x}$)
MY	Mean of y ($\bar{y}$)

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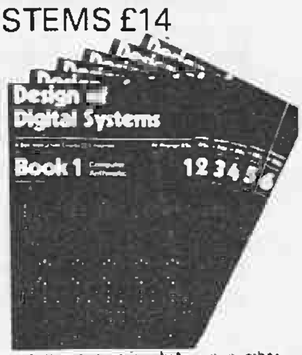

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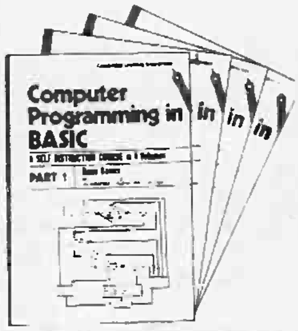

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SPECIFICATION

Input impedance:	magnetic pickup 47 k ceramic pickup 2M0 radio 100 k auxiliary 470 k
Input sensitivities:	adjustable
Treble control:	+ 15 – 15 at 15 kHz
Bass control:	+ 16 – 17 at 50 Hz
Power output (1 kHz 8 R):	Clipping level 1 channel 78 W RMS Clipping level 2 channels 74 W RMS
Harmonic distortion at all levels below clipping:	0.01% maximum
Stability:	unconditional and unaffected by load
Power amp input impedance:	220 k
Output impedance:	0.22 R
Bandwidth (3 dB):	3 Hz – 40 kHz
Rise time:	10 microseconds
Voltage gain:	33 (31 dB)

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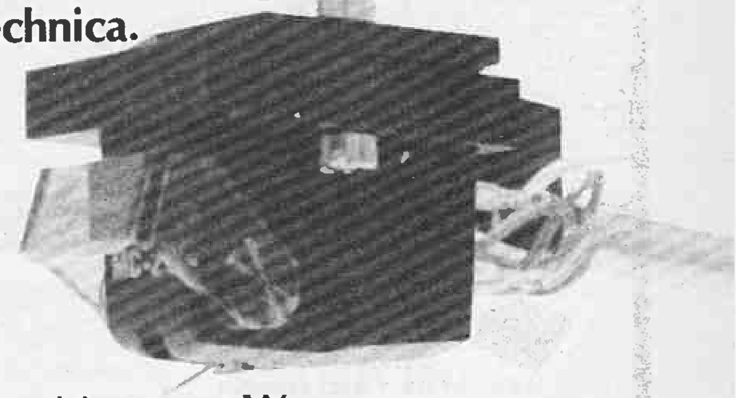
AUDIOPHILE

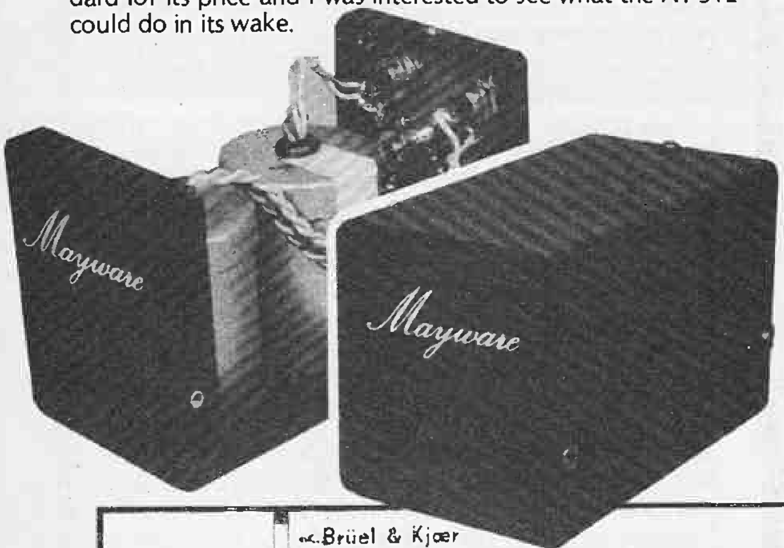
Source time again. Audiophile this month goes back to disc playing machinery, giving Ron Harris a chance to assess the complete Mayware pickup system and a new cartridge range from Audio Technica.



Mayware are best known for the pickup arm, the Mark III (née Formula 4, but re-named under an international agreement). However, they also market a small range of cartridges and a step-up transformer, the T-24.

I took a look at Mayware's low-cost high-output moving coil some months ago (ETI May '81), and found it a worthy product. Shortly afterwards I was tempted by an offer from Mayware to see what I could glean from a complete pickup of theirs — the Mark III arm, MC-2V cartridge and T-24 II transformer. (Overcoming temptation has never been a strong point of mine — I'm a pushover, in fact. One little exercise of the feminine wiles and logic flees the empty plains of my mind, taking any remaining vestige of willpower with it.)

Thus the Mayware pickup is duly considered herein. As an appropriate complement we have two units from a new range of cartridges from Audio Technica, the AT-3100XE and the more upmarket AT-31E. The now superseded AT-30 set a high standard for its price and I was interested to see what the AT-31E could do in its wake.



Mayware Wares

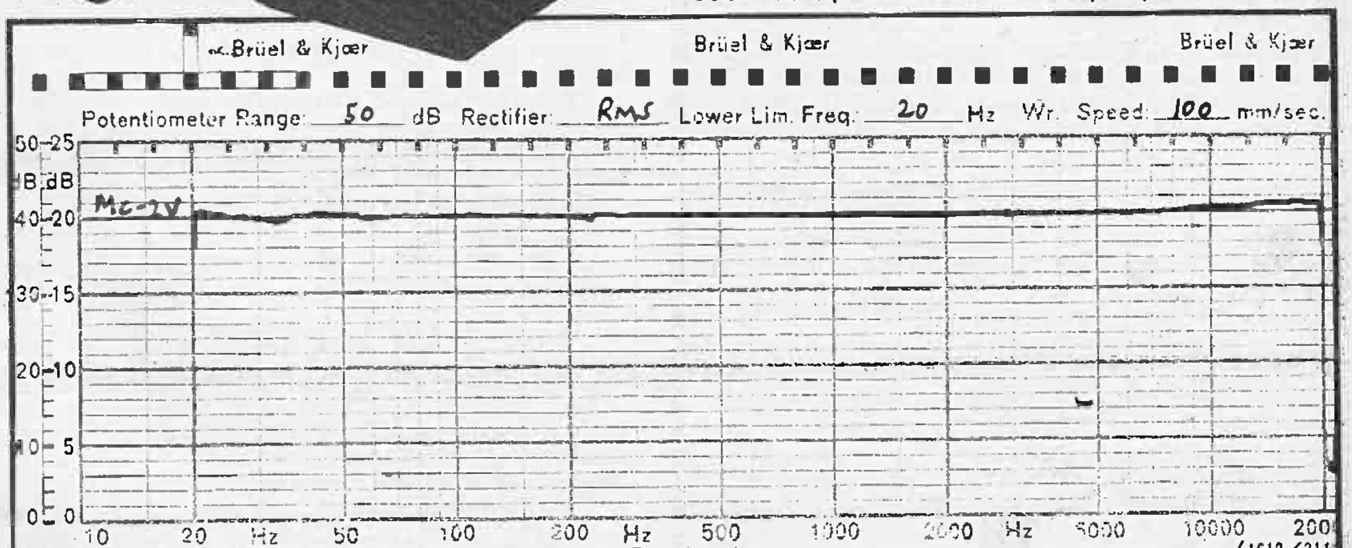
The MC-2V is a low output (around 0.25 mV) moving coil cartridge with a conical stylus tip — unusual even for these days of the ever-changing shape. Record wear is lower, for a given tracking force, with a conical stylus than with an elliptical tip, so the recommended 2 g downforce of the MC-2V should cause no tremors of uncertainty even in the fainthearted.

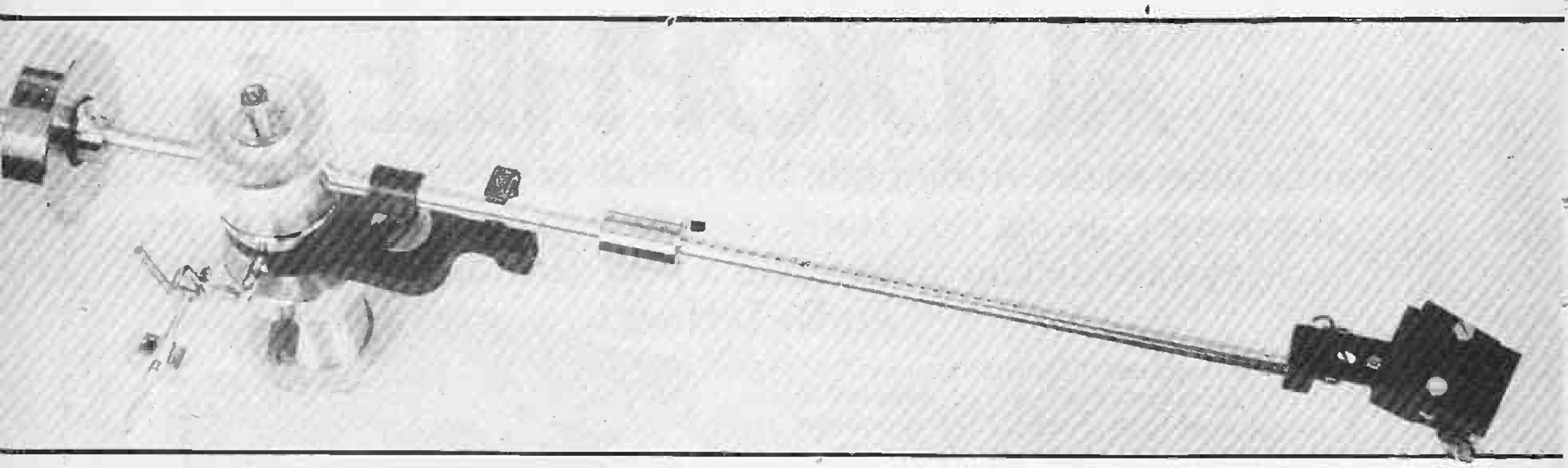
The T-24 is matched to the MC-2V, or vice versa if you prefer it, such that the two constitute one working unit. The T-24 has briefly raised its head before in Audiophile, competing manfully with the incomparable Ortofon T-30 transformer, and gave a good account of itself. Matched up to the MC-2V it did nothing but add to an already favourable impression.

In various forms the Mark III has been around hi-fi emporiums for a while now, but it continues to offer excellent engineering at a good price and deserves more publicity than it receives. Maybe now that Thorens and Mayware share a distributor it will rise into the sight of more enthusiasts, receiving due defence in the process.

Left: The Mayware T-24 II transformer; at £69 it is good value for money.

Below: The response curve for the MC-2V pickup.





Above: The Mayware Mk III pickup arm. Note the graduations down the arm, used in conjunction with the rider weight to apply tracking force. Why not dispense with the lot and graduate the *counterweight* side of the pivot, thereby reducing the effective mass? The arm gave a good account of itself with *most* cartridges, and whilst not as universal as, say, the SME III, in my opinion it's excellent value for money and well-engineered.

Arms And The Man

The Mark III is a unipivot design, with provision of a damping well around the bearing. Silicone fluid is employed to give a variable facility, primarily to control subsonic resonances.

An earlier headshell, which had been rightly criticised for its lack of rigidity, has been replaced here with a strong casting of greater substance. Downforce is applied, curiously, by sliding a rider-weight along the arm tube toward the pickup. Bias compensation is provided by a falling weight and thread arrangement, retained from earlier models.

The counterweight is eccentrically mounted on the arm tube, to provide some lateral balance — a necessity for unipivots, as they lack the stability of designs with 'twin' bearings in this plane. If incorrectly set-up they are liable to a strange rocking mode of oscillation.

The Mark III is well presented to the new purchaser and adequate setting-up instructions are provided by the sheet accompanying the arm. Alignment and mounting protractors are also thoughtfully present and installation is very straightforward. Instructions are clear and concise, if not up to SME standards. As the arm has no sliding base, adjustments for tracking error are made by the positioning of the cartridge in the headshell itself.

Sound Sense

Before fitting the MC-2V, I put the Mark III through its paces individually, to assess its strengths and weaknesses. Arm tube resonance is relatively minor, set at about 650 Hz, and there is a counterweight resonance at around 60 Hz. Pivot friction is commendably low, at <20 mg in both planes.

Using a reference cartridge of known quality, the Mayware III arm was shown to give a good basic performance with good, well-controlled bass and a clean, well-imaged, sound stage. It had a tendency towards a forward or bright presentation but not unduly so. For the price, an excellent result.

I would comment, though, that even with the low effective mass of 7.5 g, that rider weight is a strange way of adding downforce. Much better to keep it as far back towards the pivot as it will go, thus minimising its addition to effective mass, and applying tracking force by moving the counterweight forward.

Also, with low compliance moving coils, some addition to *headshell* mass would be beneficial, as it was to prove with the MC-2V (compliance = 8 cu). High compliance units give very good performances, and I tried both the Shure V15 IV and Empire 600 LAC cartridges in the Mark III with textbook results.

Transforming Levels

The T-24 II is a well-made little unit with no frills at all, save the gold-plated phono sockets provided for I/O purposes. Finished in matt black, it is small enough to sit unobtrusively in all but the most miniscule hi-fi set-up.

On the test bench it gave an exemplary performance, proving to be flat across 20-20 kHz ± 2 dB and with few phase problems. It will match cartridges of between 3-40 R impedance, although it appeared to operate best with those of low impedance characteristics, such as the MC-2V. Hum pick-up is particularly low and will give no trouble in use, I feel.

All Together Now. . .

And so, at last, to consideration of the pickup system as a whole. Setting up was simple and the MC-2V reached its best tracking levels at around 2.1 g. It is by no means an excellent tracker, but is more than a match for most MC units in this price class. Listening tests were conducted with the system set up on a Thorens TD 160S, feeding KEF 105 II loudspeakers via a Lecson/Monogram amplifier combination.

The overall impression was one of a well-balanced sound, but one which was not controlled tightly enough, and was a little bright overall, with a slight mid-range hardness. Adding a back-plate between the MC-2V and headshell to increase the mass damping effect greatly 'tightened-up' the presentation and gave improved detail all around. The brightness persisted, however, as the only blot on an otherwise impressive performance.

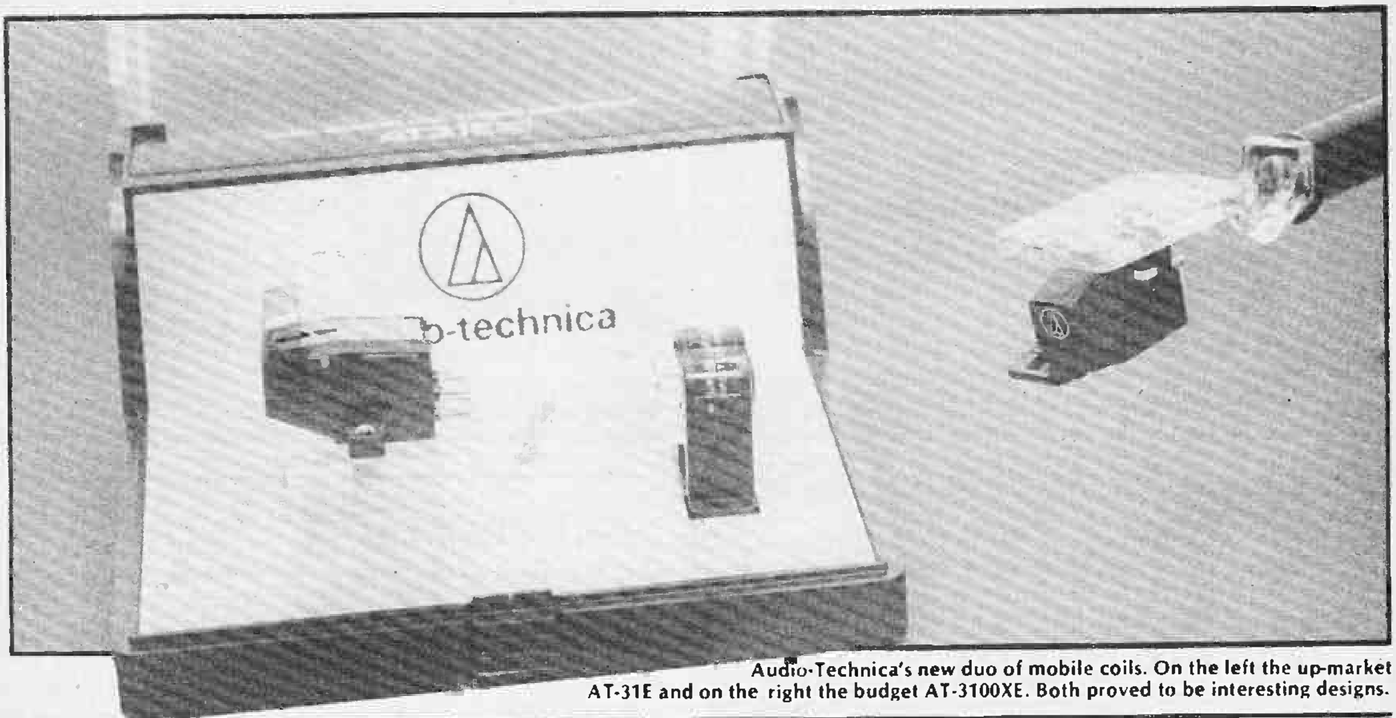
Going through the components, one by one, and fitting them into other systems (as with the arm) showed that, when mounted in an SME series III the MC-2V is a fine cartridge with excellent bass and mid-range, good treble register — but a slightly forward presentation.

Put simply then, both the arm and cartridge are excellent value for money and will perform better than their respective price tags would promise.

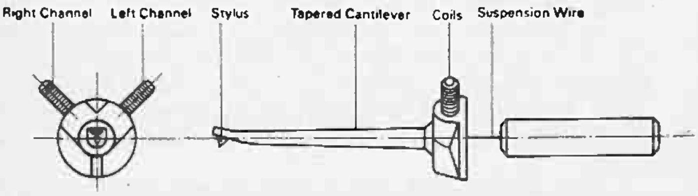
Match Of The Day

As a general recommendation, the MC-2V will match any of the higher mass rigid arms perfectly, and is usable in the more versatile low-mass designs, epitomised by the SME III, with the addition of headshell weight. Take care with loudspeaker matching to obtain the best from this high-quality unit, however.

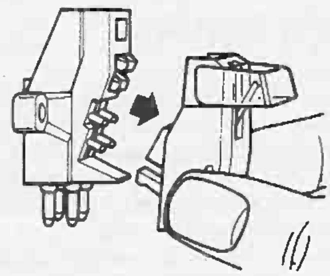
The Mark III arm is ideal for all high-compliance cartridges as it stands, and has the flexibility to support the lower compliance moving-coil designs perfectly adequately. It does have



Audio-Technica's new duo of mobile coils. On the left the up-market AT-31E and on the right the budget AT-3100XE. Both proved to be interesting designs.



Above: The alignment of the motor system of the new AT cartridges. The whole system is replaced with the stylus.



Changing the stylus on the AT-31E means pulling half the body off!

Below: A 'potted-down' version of the test results for this month's three cartridges. As you can see, there is little to choose, on paper, between the MC-2V and the AT-31E. Personally I preferred the AT-31E for its better midrange. An opinion only, and you should listen to both for yourself, if in that field you search for perfection's touch.

this slight tendency towards brightness, though this is not serious and should not deter an intending purchaser, merely engender the requisite care over matching.

The T-24 II transformer can be unreservedly endorsed as providing value for money and a good all-round performance, distinguished by faultless bass response and outstanding transient performance. At £69 including RRP it can be said to be value for money, too.

•

Technical Audio

Audio Technica have produced a new line in moving coils recently, and the AT-3100XE is a fine example of a budget unit (at under £30) with user replaceable stylus. (Surely one day all cartridges will be made this way?)

The AT-31E is an up-market elliptical unit, designed for the more demanding — and pecunious — enthusiast. Both are low output types, and will need step-up devices. Since the Mayware T-24 II was to hand, I used this to assess the Audio Technica units. Seemed sensible; besides which, AT hadn't sent me one of their AT 650 transformers, so serve 'em right if I don't use it!

AT make great play of their ingenious operating system, employed in this new range, in which the channel coils are wound onto separate formers and mounted in a V configuration, similar to that found in record cutting equipment.

TEST RESULTS

	Mayware MC-2V	Audio Technica AT-31E	Audio Technica AT-3100XE
Frequency response (see graphs):	20-20 kHz ± 2 dB	20-20 kHz ± 2 dB	20-20 kHz ± 3.5 dB
Output voltage (at 5 cms $^{-1}$):	0.2 mV	0.4 mV	0.4 mV
Channel separation (at 1 kHz):	23 dB	32 dB	29 dB
Channel balance:	within 1 dB	within 1 dB	within 1.5 dB
Tracking force (optimum):	2.1 g	1.6 g	1.8 g
Vertical tracking angle:	20°	20°	20°
Weight:	6.9 g	5 g	4.3 g
Typical price:		£56 (or less)	£29 (or less)

Claimed benefits are improved separation, better imaging and improved tracking due to reduced weight. Compliance is fairly high for moving coils and this allows a wider choice of arms than is usual. High energy (per weight) samarium-cobalt magnets are used and a spring-terminal set-up allows for user-replaceable styli.

This in itself is achieved in a novel and advantageous manner, where the generator elements are left undistributed — they are simply exchanged wholesale. Normally the stylus is changed, leaving one half of the motor, either coils or magnets, intact. Not so here, and the difference should make for more repeatable results and higher quality control standards.

Book Covers And Judges

If appearances dictated height of fidelity, these units would be well up on the scale. The AT-31E is a striking blue and silver and the 3100 a very prominent black/white/silver. Both arrive neatly packaged on a perspex headshell, with good instruction manuals and the usual hardware (nuts, bolts, cleaning brush and so on).

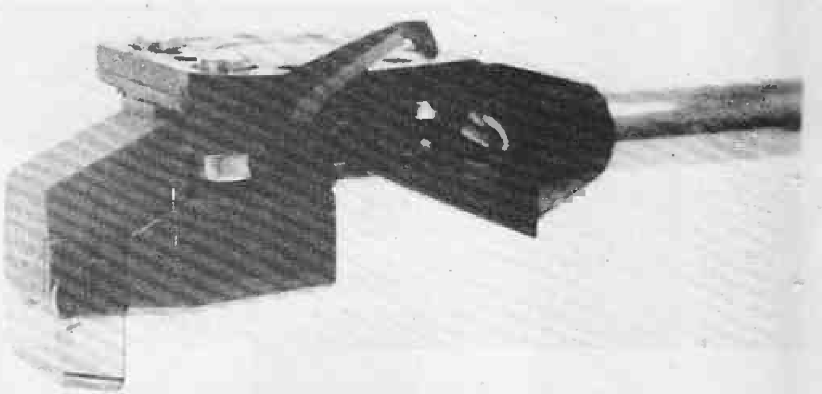
The AT-30, predecessor to the AT-31E, had some problems with response in the early days which were ironed out in later samples. The AT-31E has no such troubles! As the graph shows the trace is ruler-straight except for a very slight bass rise.

Removing the cartridge from the superb packaging proved entertaining, to put it mildly. To get the unit off that nice shining headshell, you've got to pull the stylus assembly off first, else the mounting screw won't come out. Damn sneaky if you ask me, and should be explained clearly ON THE BOX somewhere. Better yet, be sensible, AT, and set it up so you don't need to be able to solve Rubik's Cube in six seconds flat to play records. Silly people . . .

Once enthroned in a real headshell, however, the AT-31E made me inclined to forgive AT for the packaging. The imaging is excellent and the channel separation the best I've heard from a moving coil. For once, the publicity blurb is true! Tracking was above average, but not yet in the V15 IV class.

The sound quality was such that it reminded me of the Coral MC81 — only more refined! I set up a Coral for comparison and the analogy proved a good one. The AT-31E has all the Coral's strengths, in terms of mid-range detail and clarity, but none of the vices, ie slight roughness and bass extension worries.

As I was extremely fond of the MC81 (and still am, come to that) I couldn't be less than enamoured with the AT-31E. It is a fine unit and will be serious competition for the myriad other cartridges in the price bracket. Give it a listen.



Above: Safely mated with an SME headshell, the AT-31E prepares to make light of tracking and imaging problems. It matched the arm well and did itself proud in both test and living room.

AT-3100XE

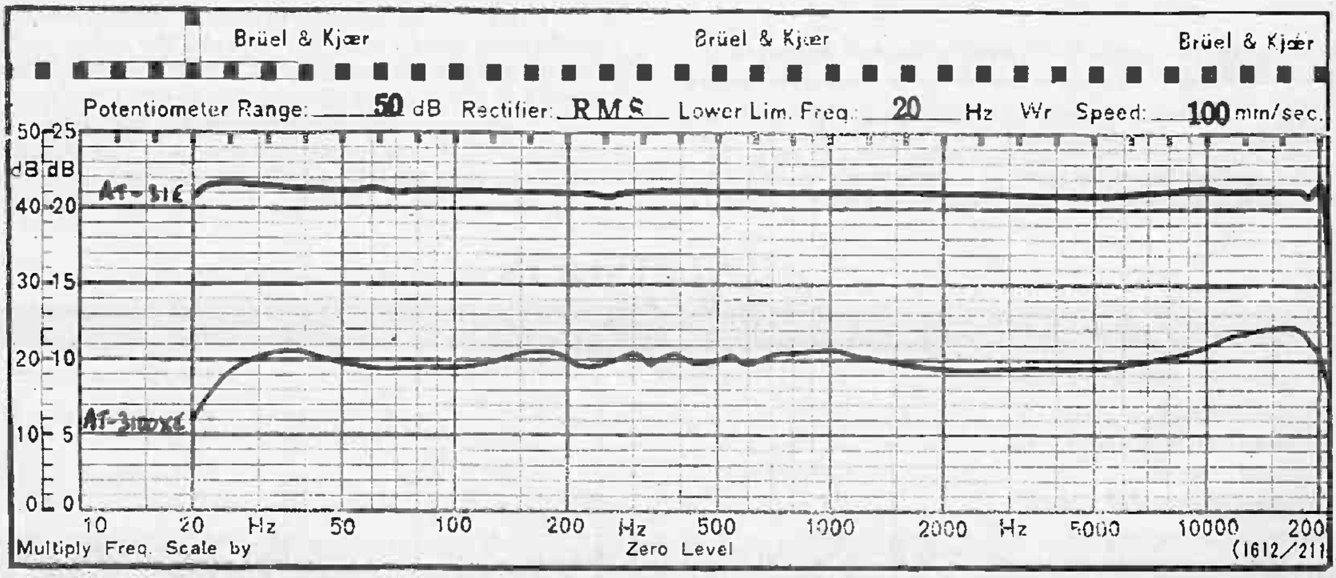
This too is a low-output design, although a higher output version — the AT-3200XE — is available. A step-up is thus required which will, to some extent, negate the advantage of low cost. We managed to try out the 3100 in a few decks costing between £70 and £150 and in the inevitable SME Series III later on. Time had gotten very short by now, but sufficient listening hours were clocked to facilitate sensible comment.

This unit too is characterised by attention to detail, especially in the mid-range. It handles complex material well, although with some roughness, be it said, in the lower registers. There is a slight rise in the hf end which is not serious, but could accentuate surface noise if the cartridge is not set up PRECISELY.

One should judge against price and competitors, and on that score the AT-3100XE comes out very well. For £30 you would be hard pressed to buy a better sound anywhere.

Man Of Letters

Dear Mr. Harris,
Thank you for producing such a great magazine which I read regularly and with pleasure. Your recent review of the Monogram Amplifier prompts me to tilt at windmills and ask some questions. I refer to the current obsession of manufacturers for more and more watts of output! 400 watts is



Above: Response traces for the AT-31E and the AT-3100XE. The h.f. rise on the later is almost certainly due to an impedance matching problem with my test rig. It was one of those days when the gremlins ruled OK and there was nought to be done! Still, it was a *repeatable* result so . . .

powerful stuff, useful perhaps for discos and Hyde Park corner, but hardly conducive to neighbourliness in domestic hi-fi.

It is recognised that Class A amps are superior in range and tonal qualities to the AB, but all that heat and metalwork, as well as PSUs needing gun-carriages to move the lot around. Is it worth it all when we consider the notorious inefficiency of the standard design loudspeaker. You rarely get out of a speaker what you put into it.

My own set-up is very modest; a pair of mongrel speakers which satisfy me if no-one else. They have a power rating of 15 watts apiece. The amplifier is also a hybrid — Capricorn preamp construted from your friendly rival, HE (sorry about that), and two ILP power amps, rated output 15 watts each. I did not build the HE power amps as I did not have £125 and could not think of a reason for needing 300 watts. I doubt I am using more than 20% of my output power in domestic use. The signal source is either radio or stereo tape deck. Which brings me to my questions.

Is the advantage of these larger output amps to be found in their class A quality rather than lots and lots of watts?

With my present speakers would it even be feasible to use power amps with such large outputs?

Thank you for reading this and please could you enlighten me. If the improvement in tonal quality were to be considerable, then I will go for Class A, hot though it may be, but at a more modest price.

Fr. K. Callaghan, Clapham, London.

Oh ye of little faith! Watts the point of me extolling the virtues of good PSUs, high powers and increased dynamic range if you're gonna ignore me totally? I give up. I despair. I resign from the human race (assuming I was ever in it).

High power amps are not a luxury, they are a necessity if you are to employ anything like the same range in your music as you would experience in the concert hall. Most domestic users probably run their systems under 1 W most of the time, but once a crescendo trots down the wires, or someone hits a bass drum, something like 100 W is needed to maintain the same fidelity levels on the signal.

If your amp is underpowered, the attempt to reach such heights simply boots the output into clipping — which sounds rough and harsh compared to that which has gone before. Even with your modest speakers, higher power would make itself audibly apparent, with a sense of ease and clarity. Start saving the pennies!

Dear Sir,
Having read your column on and off for some time now I have come to the conclusion, reluctantly, that you are biased against Linn products for some reason of your own. Answer me straight, is this true? If not, why don't you review one of their new arms, for example?

D. G. Chesterton, Tovil, Kent.

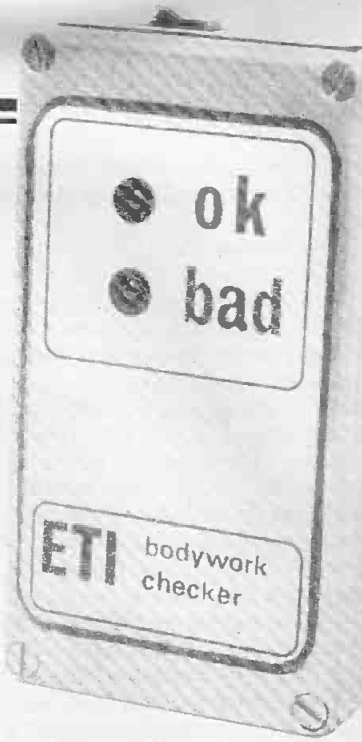
No it is *not* true. I consider the LP12 greatly overpriced for the performance it offers and refuse to concede that a Linn source is the *only* viable one. The Linn has its own sound, which is pleasant enough, but hardly totally uncoloured. Straight enough?
(P.S. I'd be only too happy to review the Basik (or any other product of theirs...) should Linn feel able to loan me one!)

Stop Press

If you like the idea of owning a pair of Volt V3 speakers (see October '81 ETI), but don't like the idea of chopping up the chipboard, then take heart. Wilmslow Audio are now offering a complete precut woodwork kit for this project. This news arrived so late we don't know the price yet, so for more information get in touch with Wilmslow, Cheshire (telephone 0625 529599).

ETI

BODYWORK CHECKER



Don't go out and buy a second-hand car without building this handy little gadget. It'll point out any problems under the paintwork. Design by Rory Holmes. Development by Tony Alston.

The purpose of this project is to help the selective second-hand car buyer detect the amount of body-filler used under well-disguised repair jobs. The unit gives a two-state indication of metal or plastic, ('OK' or 'BAD' respectively).

Our metal detector uses a capacitive sensing principle, which will detect the presence of *any* conductive object. Because of this the circuitry is much simpler and more reliable than metal detectors working on an inductive principle. It is also more suitable in this type of application where large areas of metal must be checked.

In use the device is switched on and lightly run over the car panels; if it runs over an area of body-filler the 'BAD' light will come on, otherwise it should read 'OK'.

Construction

The case is the most important part of this project as it is also part of the electronic sensing circuit. Take a careful look at the photographs of the finished project and you can clearly see the sensor area at the bottom rear of the case. First cut a rectangular hole (30 x 35 mm) about 8 mm from the bottom edge of the case and 14 mm from either side — make sure to clean off any burrs from the hole. A piece of single sided copper clad board (24 x 30 mm) is used for the sensor plate — this is centrally glued (copper side out) to a piece of plain paxolin or similar material (35 x 45 mm). This assembly is then glued to the case from the inside, so that the copper clad board will then be flush with case surface.

A small hole is drilled through to the copper side of the sensor plate and a short length of insulated wire, long enough to reach the main PCB, is soldered to the copper surface of the sensor plate.

The components can now be assembled and soldered to the main PCB as shown on the overlay diagram, making sure to correctly orientate D1,D2, IC1 and IC2 and the LEDs. Make sure to fit the link adjacent to IC1.

A short length of insulated wire is connected from the PCB to a solder tag fixed to the case — make sure this is a good connection as it forms part of the detecting circuit. The connecting lead from the sensor plate is soldered to the main PCB as indicated. A further insulated lead is taken from this same point on the PCB and held against the side of the case by a piece of insulating tape to form a capacitive trimming circuit (see photograph and refer to the setting up procedure). The LEDs are

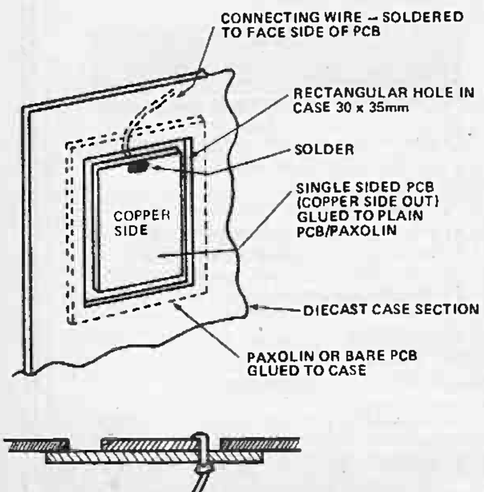
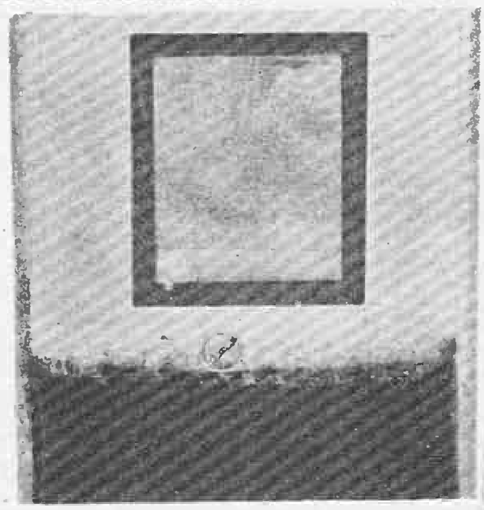


Fig. 1 This cutaway diagram shows the constructional details for the sensor plate.



With the protective felt peeled back to reveal the sensor, you can see how the fixing screws should be countersunk so they lie flush. In the internal shot (right), note how the trimming wire is taped to one side of the case.

directly mounted on the PCB and appropriate holes are drilled in the front case panel to allow these to pass through.

Finally, a piece of felt cut to size is then glued to the rear of the case, covering the sensor plate; this prevents the case from scratching the car bodywork and upsetting your friendly second-hand car dealer!

Setting Up

Setting up the circuit is straightforward; PR1 controls the detecting sensitivity and PR2 the metal/plastic switching threshold. When altering the presets bear in mind that replacing the case lid will slightly offset the adjustments, so replace the lid after each adjustment to check the effect.

Start with maximum sensitivity, ie set PR1 to its full resistance (anti-clockwise). Then place the case, sensor side down, onto a non-conductive object. With the lid off, PR2 can now be adjusted until the switching threshold is found. When the 'OK' LED is on, back off preset PR2 until it just extinguishes and the 'BAD' LED comes on (indicating no metal). The unit can now be placed against a metal surface and the 'OK' LED should re-light.

The trimming-wire capacitively couples a small degree of HF voltage into the detector, effectively altering the switching threshold. Its effect can be varied by trimming the length. By experimenting with this if necessary, together with PR1 and PR2, a suitable switching action can easily be found.

Note that the human body is a fairly good conductor — you can prove this by holding your hand against the sensor, when the 'OK' LED should come on. This resulted in one member of staff wandering round the office, checking out the female employees and reassuring them that all was well!

HOW IT WORKS

CMOS inverter gates IC2a and IC2b form a high frequency oscillator of about 150 kHz. This signal is connected directly to the case, which in turn is capacitively coupled via the sensor to the high-impedance detector circuitry based around IC1. This unusual way of screening the circuit prevents the user's hand from affecting the capacitance between the detector input and the 0 V ground rail.

D1, D2, C1, and PR1 rectify the signal from the sensor and pass this voltage to the positive input of the op-amp, which is configured as a simple comparator. PR1 is used to set the input impedance and hence the sensitivity of the sensor. PR2 sets the switching threshold voltage on the non-inverting input to the comparator. When the coupling capacitance is increased, due to a conductive object lying across the case and sensor, the high frequency signal strength arriving at the detector will increase, raising the voltage on pin 3 of the comparator above the threshold, and switching the output from pin 6 fully positive.

IC2c,d are connected as a Schmitt trigger with R4 supplying positive feedback. This sharpens up the switching action coming from the comparator and further provides suitable drive signals for the two LEDs. These drive signals are buffered and current-limited by IC2e,f which power the LEDs. When metal is detected LED2 is lit and LED1 is off; the converse is true if metal is absent.

BUYLINES

All ICs and other components for this project are readily available. Most mail-order who advertise within these pages, eg Bi-Pak, will be able to supply all that is necessary. The PCB is available from our PCB Service as advertised on page 94.

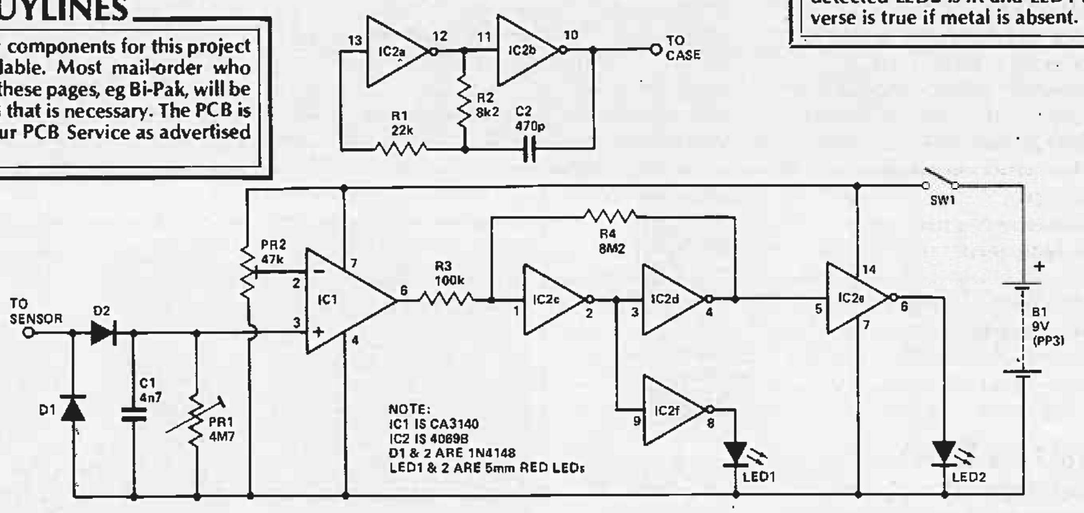


Fig. 2 Circuit diagram.

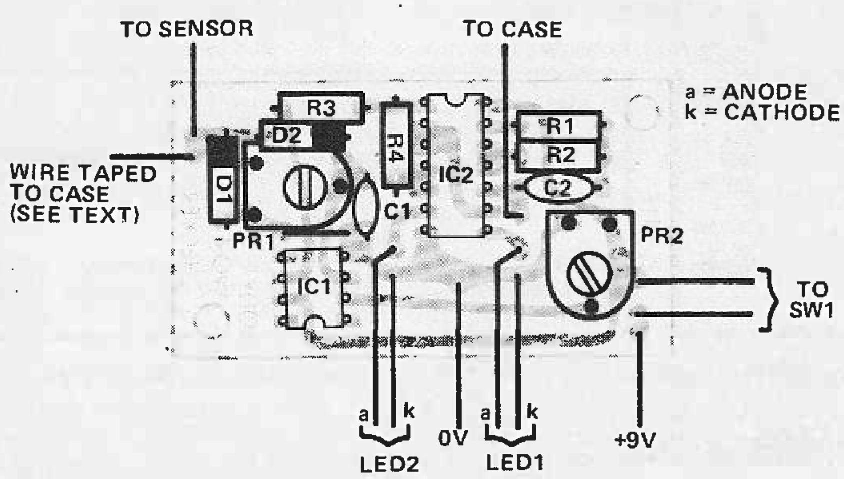


Fig. 3 Component overlay of the ETI Bodywork Checker.

PARTS LIST

Resistors (all ¼W, 5%)	
R1	22k
R2	8k2
R3	100k
R4	8M2
Potentiometers	
PR1	4M7 miniature horizontal preset
PR2	47k miniature horizontal preset
Capacitors	
C1	4n7 disc ceramic
C2	470p polystyrene
Semiconductors	
IC1	CA3140
IC2	4069B
D1,2	1N4148
LED1,2	5 mm red LEDs
Miscellaneous	
SW1	miniature rocker switch

Battery and clip (PP3); diecast case, approximate size 114 x 64 x 30 mm (RS 509-939 or similar — see Buylines).

WHY CLASS A?

The System A has aroused a lot of interest among our readers — and a few questions too. In this article Stan Curtis explains 'Why Class A?'.

Class A is a mode of operation in which all the output devices operate on the linear portions of their transfer characteristics all the time, the mean current drawn from the supply being constant irrespective of the signal. Class B is a mode in which the output devices split the positive and negative portions of the waveform between them, each device operating from an initially cut-off condition (or a low standing current in the case of Class AB). No matter how well engineered, this transition from positive to negative (and vice versa) will cause an irregularity or non-linearity in the transfer characteristic which in the worst case, causes a crossover distortion made up of high order harmonics at high peak amplitudes — harmonics which are very offensive to the ear.

The use of a small standing (quiescent) current through the output stage together with the application of large amounts of overall negative feedback minimises these effects but it must be remembered that at the actual transition point the amplifier becomes effectively open loop (ie no overall negative feedback because the output is zero) and has a very low overall gain (which is dependent upon the current through the output devices); hence the intermodulation distortion of a good Class A amplifier is virtually nil at low powers and then rises gradually with increased level (see Fig. 1).

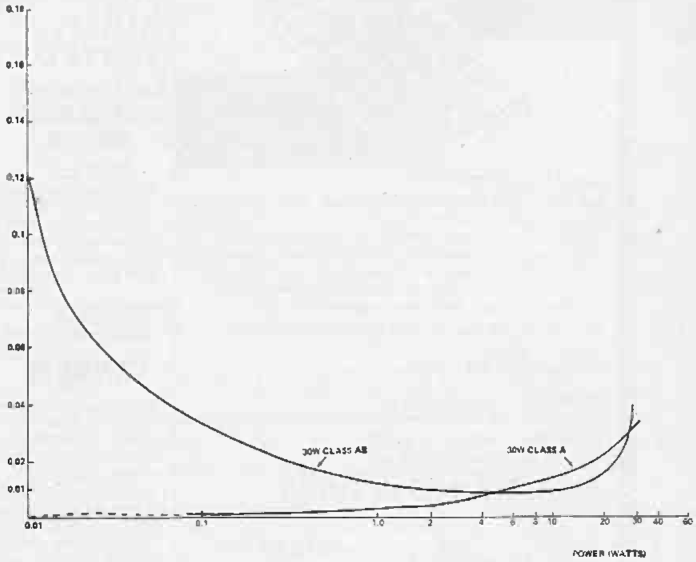
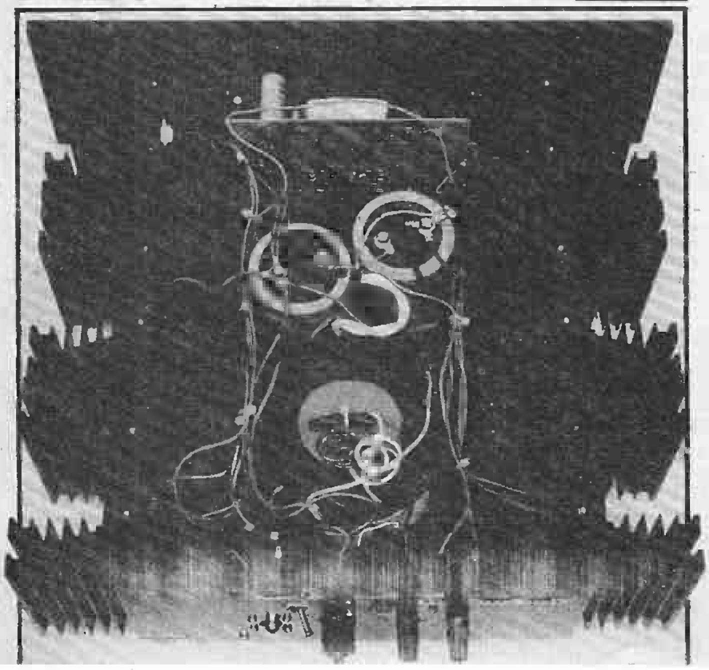


Fig. 1 Comparitive distortion versus power curves for two typical amplifiers. The vertical scale shows THD in %.

Improper Conduct

The second major problem of Class B amplifiers is their operation at high signal frequencies. Figure 2 shows a typical Class B transistor output stage. As the voltage across the base-emitter junction of Q1 changes from a negative (forward) bias to a positive (reverse) bias, the base current of Q2 will decrease. Because of emitter-base junction capacitance the base current of Q2 will lag the base-emitter voltage of Q1. Thus when the base-emitter voltage of Q1 is zero, there will still be some charge remaining on the base-emitter capacitance of Q2. This charge only leaks away slowly since Q1 is cut off. Thus Q2 remains conducting after Q1 has been cut off and so the conduction angle of each output transistor can be much greater than 180°. This results in the familiar 'notch' distortion, higher current drain from the power supply, lower efficiency and hence increased dissipation by the output transistors.



These problems do not occur in the Class A amplifier because the transistors are always on and so never have to be switched. Thus a Class A amplifier can be designed to have an extended bandwidth with a consequent reduction of high frequency distortion and increased slew-rate.

With all the output transistors conducting in the linear collector region, the distribution of the distortion harmonics is more desirable than the equivalent Class B (or Class AB) amplifier because the non-linearities in the transfer curve are smoother and less abrupt. These low order harmonics (primarily second and third) are far less audibly offensive than those of higher orders. The push-pull output stage of the System A power amp results in a cancellation of the even order harmonics leaving a small amount of the third harmonic which can be reduced to insignificance by the application of a moderate amount of negative feedback.

Heat Treatment

Another advantage of the Class A design is that of thermal equilibrium. The standing dissipation of the amplifier is between two and four times the rated output power. The output stage dissipation is lowest at full output; thus, in the case of a music signal, the amplifier will be operating near its normal running temperature (which is also its maximum temperature). This thermal stability will tend to minimise the temperature dependent variations of gain, V_{BE}, and reverse leakage current, as well as avoiding the danger of thermal shock when the signal level changes suddenly. Conventional Class AB amplifiers have their output stage biasing set by a transistor which is thermally coupled to the heatsinks; but there is a thermal lag between increase in the temperature of the output transistor junction and a proportional increase in the temperature of the heatsink. Thus following a large amplitude signal (and the consequent heating up of the junctions) the bias voltage will be tracking the wrong temperature and so, for a short time, the crossover non-linearity may be far worse than the designer intended.

Driving It Home

Loudspeakers are not the simple resistive loads that engineers desire them to be. This is not the time or the place to go into much detail but suffice it to say, that some amplifiers are completely incapable of driving a real loudspeaker with anything like the fidelity they demonstrate on the test bench. For one thing loudspeakers store energy particularly in their resonant conditions, and this same energy can be dissipated in the form of electrical current pushed back *into* the amplifier. Thus the perfect amplifier needs the ability to sink a lot of current as well as source it; and it should also have a very low output impedance (the theoretical ideal would be zero).

Most amplifiers achieve a low output impedance (ie high damping factor) by applying a large amount of negative feedback. For example the open loop output impedance could be 5R but apply 40 dB of negative feedback and it drops to a respectable 0.05R. But the mathematics show that the important thing is the open loop impedance so efforts must be made to keep this very low. Typical figures that I have measured on commercial amplifiers range mostly from 1R to 5R with a few much higher still and one or two lower at nearly 0.5R. The System A design has the advantage of effectively having three output stages in parallel and so the output impedance of one stage is effectively divided by a factor of three. In fact (skipping the mathematics again) the open loop output impedance of this amplifier is less than 0.1R. As a result the measured 'Interface Intermodulation Distortion' is very low indeed.

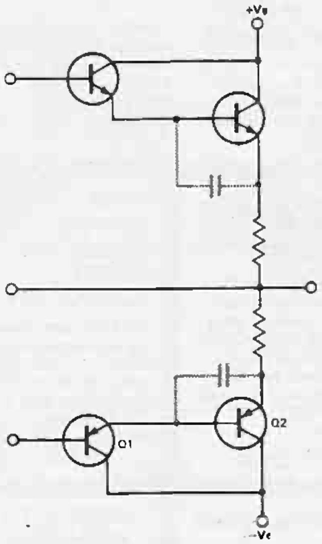


Fig. 2 Typical Class B output stage.

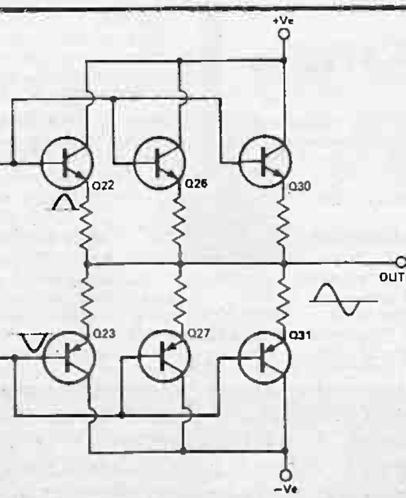


Fig. 3 Simplified diagram of the System A output stage; effectively it is three stages in parallel.

ETI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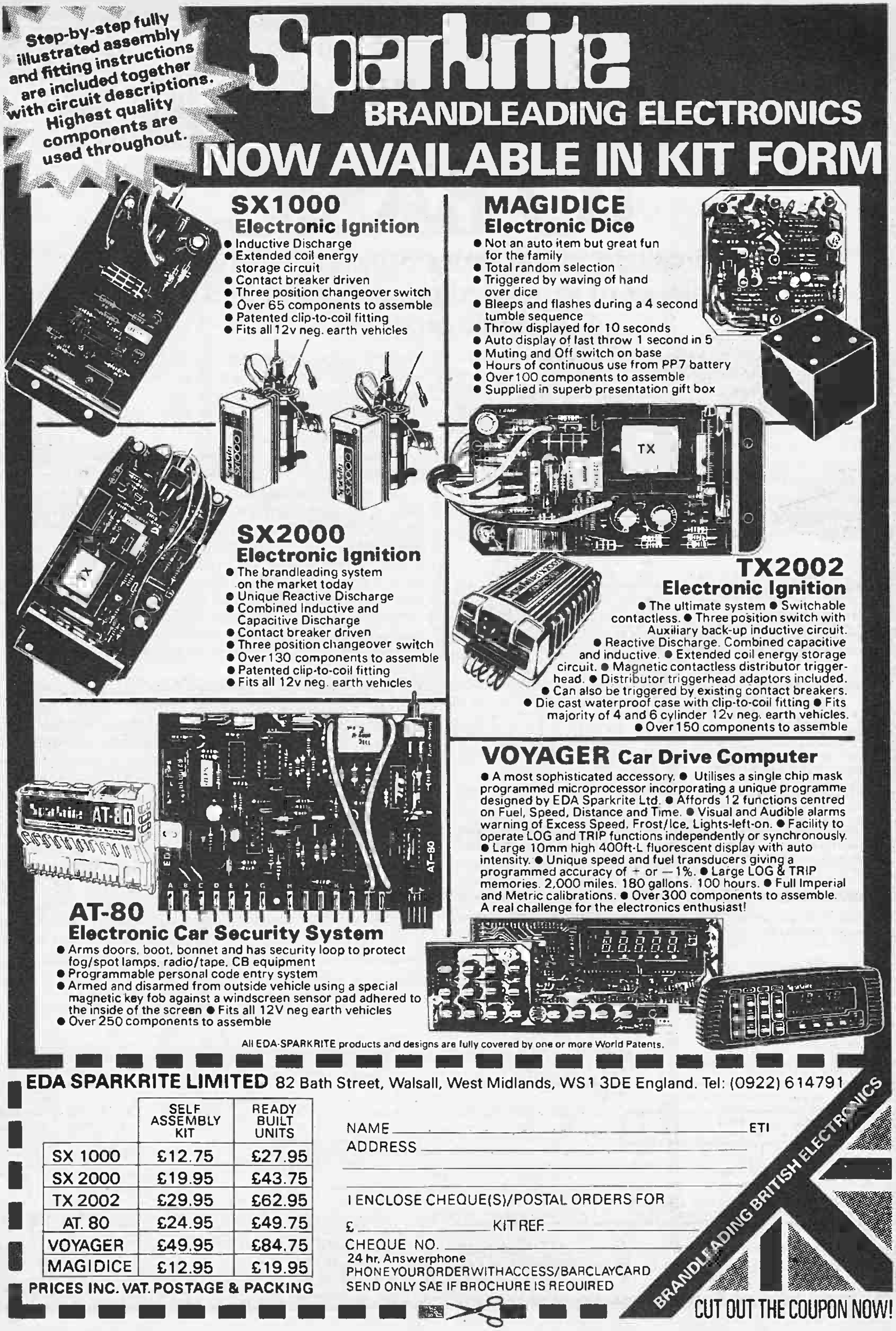
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ENGINEER'S GUIDE TO BASIC

In the final part of this series, Stewart Fleming looks at arrays, techniques of structured programming, and some simple example programs.

In this article a fourth type of variable item, the array, is introduced together with the DIM statement which is a preliminary statement usually required by BASIC before an array can be used. This is followed by a review of the naming conventions employed by different BASICs for all four types of variable. This section is concluded by a description of some problems that can occur with BASICs offering strings and floating-point numbers and how they can be easily and neatly overcome.(This will complement last month's issue where we looked at a limitation of BASICs which offer only strings and integers). Finally we introduce the concept of structured programming.

Hip Hip Array

In last month's issue, the variable was introduced as a box containing a value — string, integer or real. An array simply extends this idea to several boxes, side by side, but all having the same name.

A

2.6	7.8	4.0	−3.1	0.	0.	0.
A(0)	A(1)	A(2)	etc.			

Fig. 1 Real array containing seven elements.

Fig. 1 shows an array, A, seven elements long, with each element containing a single real number. This is known as a real array. It is also possible to have integer arrays, with each element containing an integer, and string arrays, where each element contains a string; the types of array available to the BASIC user will depend on his version of the language. Figures 2 and 3 show two more arrays, B$ and C.

B$

FRED	JOE	BOB	null
B$(0)	B$(1)	etc.	

Fig. 2 String array containing four elements.

C

−3	26	7	0	1
C(0)	C(1)	etc.		

Fig. 3 Integer array containing five elements.

Each element in an array behaves like a single variable, and is identified by its position relative to the leftmost box using an integer value known as the subscript. The subscript appears in brackets after the variable name. Thus in the first example, the value of A(2) is 4.0. Arrays are used to store data items which are similar in some way or when we wish to carry out a particular operation on several items of data. An example is given in the section on structured programming.

Sizing It Up

The size or length of an array is the number of elements it contains. Before an array is used in BASIC it should be dimensioned using the dimension statement DIM. Thus to create an array A of seven elements we would put the statement DIM A(6) (remember the numbering starts at zero) — preceded by a line number — in the program. If the DIM statement is omitted, an error is produced when an attempt is made to reference the array. A possible exception may occur as most BASICs (of which Research Machines' extended BASIC, PET and APPLE BASICs are examples) will create an 11 element array automatically on encountering a reference to an undimensioned array name. A dimension error is then only produced if the subscript is too big or too small.

Long, thin arrays as above are know as one-dimensional arrays or vectors. Most integer BASICs allow only one-dimensional arrays but, as we shall see later, arrays may also be two, three or multi-dimensional (a two-dimensional array is called a matrix). There is a theoretical maximum number of allowed dimensions (eg 88 for Applesoft BASIC) but if you think your program needs that many you can be sure your array is awry!

A final point on arrays also concerns Integer BASICs. As a general rule, BASICs which offer floating-point numbers tend also to offer string arrays — each element of the array being capable of holding a complete string of up to 255 characters. By contrast, integer BASICs (eg the ZX80 4K BASIC and Apple II BASIC) do not allow string arrays, and in addition some (such as Apple II BASIC) require ordinary string variables to be previously DIMensioned for the number of characters the variable is

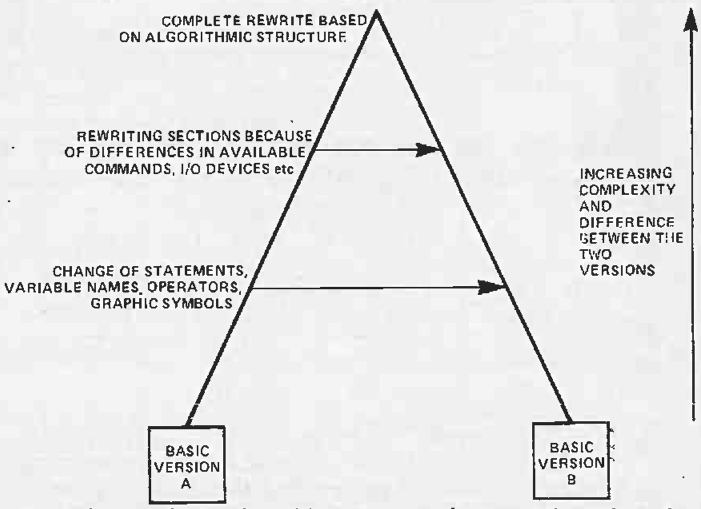

Fig. 4 The complexity of rewriting a structured program depends on the differences between the BASICs.

likely to contain. Acorn Atom BASIC is an interesting exception since it not only allows individual strings to be stored one character at a time in previously DIMensioned variables, but also allows lots of strings to be stored — one per element — in an array, each element of the array requiring to be separately DIMensioned for the number of characters it is likely to contain!

The Name Game

The naming conventions for all four types of variables, integers, reals, strings and arrays, varies considerably between BASICs.

Numeric (floating-point) variable names in Research Machines' Extended BASIC (Version 5) and Nascom II 8K BASIC begin with a letter and may be optionally followed by an alphanumeric (A to Z, 0 to 9). To improve readability, longer variable names such as SUM and AVERAGE may be used, but only the first two characters are significant — hence COMET and COEFF are equivalent. String variables are subject to the above restrictions but in addition the name has a dollar sign, $, appended. Real arrays have the same naming conventions as real variables; string arrays have the same naming conventions as string variables. Thus A$, X7 and XY are all valid but 7X is not. Note that A and A$ are separate variables and both may be used within the same program.

Applesoft BASIC and Commodore PET BASIC (Version 4.0) are similar to the above except that in addition, integer variable names have a percent, %, appended. Hence C% specifies an integer variable (or array).

Naming conventions for TRS-80/Video Genie BASICs are similar to those for the PET except, in addition, ordinary (single-precision) floating-point variable names may be optionally followed by an exclamation mark (eg D4!) and double-precision variable names must be followed by a hash symbol, # (eg A#).

With Apple II integer BASIC and Sinclair ZX80 4K integer BASIC, integer variable names start with a letter and may be followed by a number of alphanumerics (up to about 100 in Apple II) all of which are significant. The same applies to string variable names and array names in Apple II BASIC (string variables must also have a $ appended); with the ZX80, however, string variable names are restricted to a single letter followed by a $ and integer array names to a single letter. Thus FRED, JOE$ and ATILLA(1) could all occur in Apple II program but only FRED in a ZX80 4K BASIC program.

Acorn Atom BASIC allows 26 variables which may be used to store integers or strings. These are the letters A to Z. If a variable is to represent a string, it will be preceded by a $. Thus A is an integer variable; $B is a string variable. (There is also a variable denoted by @ and called the 'print field size'). Unlike most BASICs, the same letter cannot be used to simultaneously represent both types. Thus A and $A cannot both be used at the same time to represent a number and string respectively. Atom BASIC has 27 integer arrays AA...ZZ and @@. The floating-point extension additionally allows the user 27 real variables, %A, %B.....%Z and %@, and 27 real arrays %AA, %BB.....%ZZ and %@@.

A final note concerning variable names: no variable name must be the same as, or contain, a BASIC reserved word. Thus, FOR and ON will be illegal variable names as also will PONY (since it contains ON).

BASIC numeric values are initially set to zero, and string variables to the null string. Note that BASIC numeric arrays may not always be initially set to zero and so it is a good practice to set them to zero prior to use.

A Real Dilemma

Last month, we considered the limitations that can arise in a BASIC which only offers integers and strings. We shall complete this section by considering two situations that can arise when using a BASIC which offers real (floating-point) numbers. It is not to be supposed from this that a BASIC which only offers floating-point numbers is necessarily inferior to a BASIC offering integers as well; some BASICs offering both still convert integers to reals before performing any calculations (though ones which can also perform integer arithmetic offer advantages of speed and accuracy in some instances), and the two situations described here can arise with any floating-point BASIC.

Surprise Number 1 Consider the following program;

```
10 LET T = 1/10
20 LET S = 0
30 FOR I = 1 TO 1000
40 LET S = S + T
50 NEXT I
60 PRINT S
70 END
```

Those with some knowledge of BASIC will recognise this as a program to add up 0.1 a thousand times. What is surprising is that the computer may print 99.9991 or similar, rather than 100, at line 60. The reason is that the value of T, 0.1, can only be represented approximately in floating-point form. However, the small error is accumulated 1000 times as line 40 is repeatedly executed, hence the final error. If you suspect that something like this is happening in a program, and you know that the answer should be an integer, add 0.5 to the value and take the integral part:

```
55 LET S = INT(S+0.5)
```

will do the job.

This formula can always be used to force rounding to the nearest whole number. A general formula for rounding off a value X to D decimal places is:

```
X = INT(X* 10↑D + 0.5)/INT(10↑D +0.5)
```

where $X \geq 1$ and $X < 999999999$.

Actually, the PRINT instruction carries out slight rounding on your behalf, so the problem described here would not have occurred if the 1000 of line 30 had been replaced by, say, 30.

Surprise Number 2 In the following program,

```
10 LET T = 1/10
20 LET S = 0
30 FOR I = 1 TO 30
40 LET S = S+T
50 NEXT I
60 PRINT S
70 DIM A(3)
80 LET A(2) = 2
90 LET A(3) = 3
100 PRINT A(S)
110 END
```

the number 3 will be printed out at line 60, but 2 at line 100! The reason that this occurs is that real numbers are always truncated to the highest whole number in the evaluation of array subscripts. The value of S was very slightly less than 3, so it was truncated to 2 in line 100 and the value of A(2) was printed. This problem can always be remedied by adding a small number such as 0.1 to the array subscript; ie changing line 100 to

```
100 PRINT A(S+0.1)
```

prints 3 as required.

Structured Programs

As promised, we now briefly consider structured programming. This is a language-independent approach to program-writing in which all the tasks to be performed by the program are broken down into three types of item. Once the complete task has been specified as combinations of these three types of item in an algorithm, it may be readily programmed in a suitable language, in our case BASIC.

The three types of item are:

- Processing statements — these are straightforward actions, eg add 1 to X.
- Decision structures — these are of two types. The first has the following form:

if logical expression **then** processing statement A

The logical expression is a statement that may be evaluated as either true or false. For example, a decision structure might be

if X = 3 **then** add Y to X

The logical expression here is X = 3. If the current value of the variable X is actually 3 the expression is true; otherwise it is false.

If a logical expression is true, we carry out processing statement A and then go to the next part of the algorithm; if it is false, we go directly to the next part of the algorithm.

The second type of decision structure is

if logical expression **then** processing statement A
else processing statement B

In this case either processing statement A or processing statement B is executed (but not both), depending on the truth or otherwise of the logical expression, eg

if the river is >6ft wide **then** [walk to nearest bridge]
else [jump across]

The deviousness of structured programming begins to become apparent when we realise that the processing statements A and B may themselves be lists of processing statements or even another decision or looping structure. Note the use of positioning and brackets to make the algorithm clearer.

- Looping structures — these are also of two types. When we want to perform a processing statement a predetermined number of times, say 50, we use

loop for i = 1 to 50 **do** processing statement C, eg
loop for i = 1 to 50 **do** [add ith element of array A to T]

When the number of times the statement is to be performed depends on some factor which changes as processing statement C is repeatedly obeyed, we can use the second type;

loop while logical expression **do** processing statement C, eg
loop while there is still food on the plate **do** continue eating

Sorting It Out

An algorithm, then, is a list consisting of these three types of item. As each item in the list is obeyed, control passes to the next item in the list until it is exhausted.

Here is an algorithm to read 10 values into an array A, sort them into ascending order and print out the sorted array. The algorithm works by repeatedly comparing adjacent elements in the array and swapping them if they are out of sequence.

dimension the array A to size 10
put the 10 values into array A
loop for i = 1 to 9 **do** [pass through the array]
print out array A
where [pass through the array] equals
loop for j = 1 to 9 **do** [if jth element > j + 1th element
then [swap jth and j + 1th elements]]

Note that the processing statement corresponding to **loop for** i = 1 to 9 .... is itself a 'loop for' structure whose processing statement is actually a decision structure!

Attention To Detail

Another feature of structured programming is that, at the lowest level, the instructions will be able to be carried out on the computer in the language chosen (it is no good asking the computer to choose its favourite colour, but quite reasonable to get the computer to pick a random number between 1 and 10). The algorithm will hopefully be 'language-independent', however — that is, understandable without reference to any particular programming language or version of a language. The

```
100 HGR
110 HCOLOR = 3
120 E = 140:F = 60:N = 16:X = 0:Y = 10
129 REM **DRAWHEADANDBODY*****************************
130 FOR I = 1 TO N
140 X1 = 10*COS((6.283*I)/N)
150 Y1 = 10*SIN((6.283*I)/N)
160 HPLOT X + E, Y + F TO X1 + E, Y1 + F
170 X = X1:Y = Y1
180 NEXT I
190 X = 0:Y = 10
200 HPLOT E, F + Y TO E, F + Y + 40
210 G = F + Y + 10:H = F + Y + 40
219 REM **DRAWARMSANDLEGS*****************************
220 Y = 0
230 FOR K = 1 TO 2
240 W = 2*(K - 1.5)
250 HPLOT E, G TO E + 20*W, G
260 HPLOT E, H TO E + 20*W, H + 20
270 HPLOT E + 20*W, H + 20 TO E + 20*W + 7, H + 20 - 7*W
280 NEXT K
290 Y = 3 - Y
300 HCOLOR = Y
310 FOR K = 1 TO 2
320 W = 2*(K - 1.5)
330 HPLOT E, G TO E + 20*W, G + 20
340 HPLOT E, H TO E + 10*W, H + 25
350 HPLOT E + 10*W, H + 25 TO E + 10*W + 10, H + 25
360 NEXT K
370 FOR M = 1 TO 100:NEXT M
380 GOTO 230
390 END
```

Program 1. An Applesoft cartoon.

```
100 CLS
110 DIM A(59), B(59)
120 FOR I = 1 TO 59
130 READ A(I)
140 NEXT I
150 FOR I = 1 TO 59
160 READ B(I)
170 NEXT I
180 FOR I = 1 TO 19
190 SET (A(I), B(I))
200 NEXT I
210 FOR I = 20 TO 39
220 SET (A(I), B(I))
230 RESET (A(I + 20), B(I + 20))
240 NEXT I
250 FOR M = 1 TO 50:NEXT M
260 FOR I = 20 TO 39
270 RESET (A(I), B(I))
280 SET (A(I + 20), B(I + 20))
290 NEXT I
300 FOR M = 1 TO 50:NEXT M
310 GOTO 180
320 DATA 64,68,70,72,70,68,64,60,57
330 DATA 56,57,60,64,64,64,64,64,64
340 DATA 64,66,69,75,81,62,59,53,47
350 DATA 67,71,75,80,81,82,61,57,53
360 DATA 48,49,50,66,68,70,72,62,60
370 DATA 58,56,66,68,70,72,74,76,62
380 DATA 60,58,56,58,60
390 DATA 19,18,17,15,13,12,11,12,13
400 DATA 15,17,18,21,25,25,27,29,31
410 DATA 33,22,22,22,22,22,22,22,22
420 DATA 33,34,35,37,36,35,33,34,35
430 DATA 37,38,39,24,26,28,30,24,26
440 DATA 28,30,34,36,38,40,40,40,34
450 DATA 36,38,40,40,40
460 END
```

Program 2. A similar program to Program 1, but written for the TRS-80/Video Genie.

algorithmic structure of a program may be its 'lowest common denominator', and hence may be the only basis for the conversion of BASIC programs from one version to another. If the program has been well-structured, this task can be carried out one module or section at a time, and the new module tested before the new modules are reassembled to give a program which should work first time.

A Graphic Illustration

A particular case to consider is graphics programs or graphics modules within a program. Graphics facilities vary tremendously from one BASIC to another, as illustrated by Programs 1 and 2 which produce cartoons of a man walking. One is written for the Apple II (using Applesoft BASIC) and the other for the TRS-80/Video Genie. Were it not for the underlying algorithm — draw man in position 1, pause, erase man in position 1, draw man in position 2 and so on — one would be hard put to know it was the same language, let alone the same task being carried out!

Float On

We conclude this month's article with an algorithm for one of the subroutines used in last month's program to perform floating-point addition. (The subroutines make 10 floating-point variables available to the user. In the main program last month we read in two numbers and stored them in the fifth and eighth of the 10 available locations (lines 110 to 140), added them up, and stored the result in the fourth available location (line 150). Then we printed out the contents of the fourth location (line 160). However, we could have performed any number of additions on any of the 10 locations, or we could have incorporated the subroutines for use in any other program.)

Algorithm for converting strings to floating-point numbers (subroutine i in last month's program).

[Read in the string]
[Work out the sign for the floating-point number]
[Put ASCII code for sign in second location of floating-point number]
[Work out exponent for floating-point number]
[Put exponent in first location of floating-point number]
[Put mantissa in locations 3-10 of floating-point number]
where:
[Work out sign for floating-point number] equals
[if leftmost character of string is "+" or "−"
        then [sign = ASCII equivalent of leftmost character of sting. Drop leftmost character **else** [sign = 43 (positive)]]
[Work out exponent of floating-point number] equals
[[**if** string contains a "."
        then [exponent = (character position of "." within the string) — 1.
        Remove "." from string]
        else [exponent = length of string]]
        loopwhile leftmost character of string = 0
        do [subtract 1 from exponent. Drop leftmost character of string]]
[Put mantissa in locations 3-10 of floating-point number] equals
[**loop for** i = 3 to 10
do [put (ASCII equivalent of leftmost character of string) — 48 in location i of floating-point number. Drop leftmost character*]]

* Note that dropping the leftmost character of an empty string is considered to still leave an empty string. **ETI**

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MN22. 8 2" Led's with clips, 4 red, 2 yellow, 2 green
MN23. 300 asstd screws, nuts, washers, self-tappers etc.
MN24. 100 asstd. small springs
MN25. 50 asstd pop rivets
MN26. 50 asstd insulated crimps
MN27. 200 items, grommets, spacers, cable markers, plastic screws, sleeving, tie wraps etc
MN28. 20 asstd fuses, 1¼" 20mm etc
MN29. 75mts equipment, wire, asstd colours and sizes
MN30. 3 × 2m length, 3 core, mains cable
MN31. 12 asstd. trimmer capacitors, compression film. Air-spaced etc
MN32. 15 30pF Beehive trimmers
MN33. 20 coil formers, ceramic, plastic, reed relay etc.
MN34. 25 min. glass reed switch
MN35. 10 asstd switches, toggle, slide, micro etc.
MN36. 10 sub-min SP. C/O slide switch
MN37. 10 asstd audio connectors. Din phono etc.
MN38. 1 PCB with triac control IC data inc.
MN39. 1 oscillator PCB loads of components. (no data)
MN40. 50 Polystyrene capacitors
MN41. 12 BC549C (plastic BC109C) transistors
MN42. 10 BC107 Transistors
MN43. 10 BC108 Transistors
MN44. 10 Screwfix S.P.C.O. min. slide switches
MN45. 35 asstd diodes Zener, rect, signal, switching
MN46. 15 asstd Zener diodes
MN47. 3 × 68 mfd 16v tantalum bead capacitors.
MN48. 200 items 4BA asstd length screws, nuts & washers
MN49. 200 items 6BA asstd length screws nuts & washers
MN50. 3 pieces of veroboard useful sizes, min total 35 sq inch
MN51. 10 × 0.2" red LED
MN52. 10 × 0.125" red LED
MN53. 20 × 0.1 mfd 25v ceramic disc caps
MN54. 20 × 0.01 mfd 25v ceramic disc caps
MN55. 10 watt audio amp board with circuit
MN56. 10 14 pin low profile IC skt
MN57. 10 16 pin low profile IC skt
MN58. 2 × CA723 Voltage Regulator
MN59. 1 × LM380 2 watt audio amp IC + 555 timer IC
MN60. 10 asstd TTL IC's
MN61. 3 × TIP 32 Transistor
MN62. 3 × tip 31 Transistor
MN63. 30 mixed polyester caps C280, Seimens etc.
MN64. 5 Press to make min. switches
MN65. 3 BF245 FETS.
MN66. Bank of 11 push switches 4 interlocked, 4 latch
MN67. 11 3 momentary chrome plastic knobs to suit MN66
MN68. 200 asstd veropins, turret tags, PCB pins etc.
MN69. 4 min push to break switch
MN70. PCB with 3 × 250v AC 4 amp push SW with attractive chrome plastic knobs 1 × BD241, 1 × BC300, 2 × BC237, 1 × BC204, 4 × 1N4002, 2 × CMOS 4025, 200mm fuse holder + 22 resistors, capacitors, diodes etc.

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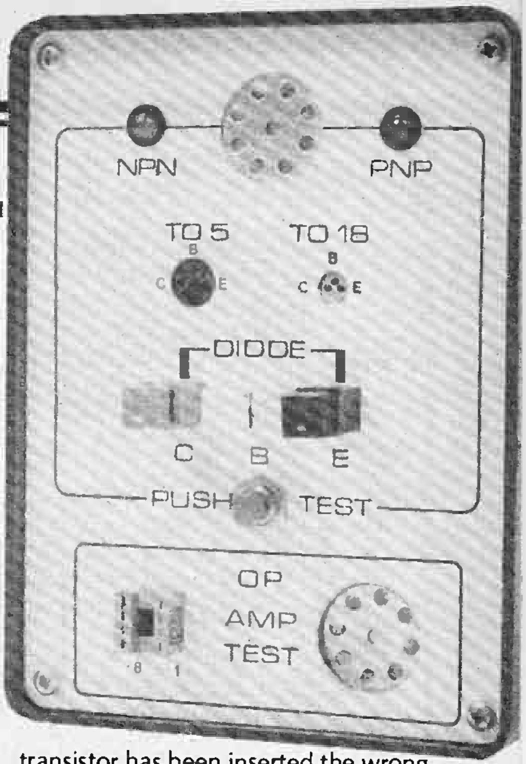
COMPONENT TESTER



Check out your semiconductors with this cunning but simple project. It's brilliant, even if we do say so ourselves (and we do). Design by Rory Holmes. Development by Tony Alston.

When you've completed your latest design, a brilliant project which not only solves the world energy crisis but proves that Einstein made a small mathematical error as well, it can be very frustrating if you rush to your junk box and discover that you can't breadboard the circuit because the markings have rubbed off your transistors. To help with this problem we've come up with *our* latest design, a brilliant project which tells you which lead is which, whether the transistor is OK, what polarity it is and its approximate gain. Diodes and LEDs may also be tested, and for good measure we've thrown in an op-amp checker. The world energy crisis you'll have to figure out for yourself.

Construction

Assembly is straightforward if the recommended PCB is used. Make sure to orientate IC1, IC2, D1 and D2 correctly, and use sockets for the ICs to avoid damage by soldering them. Remember to put the three wire links on the PCB!

Although there are quite a few off-board connecting wires, these should not be a problem if the circuit diagram, overlay and internal photos are studied carefully. Only one transistor test socket is shown on the circuit diagram but several types can be wired in parallel (as we did) to accommodate various types of transistor. The TO-5 and TO-18 types were epoxied to the front panel, as was the eight-pin DIL socket for the op-amp tester. Three insulated test terminals were also included for testing other types of transistors, diodes and LEDs.

TX1 and TX2 are crystal mike inserts, Eagle type MC25 or similar. Warning! — most inserts have one terminal connected to their case and as we've used a metal front panel for this project, TX2 should be insulated from this panel. Otherwise, TX1 and TX2 will be common linked and as the circuit diagram shows that TX1 is connected to 0 V, TX2's connection to IC1, IC2 and C2 will be incorrectly taken to 0 V. We got round the problem when we glued a circular fibre washer to one insert before fixing it to the front panel.

Testing Times

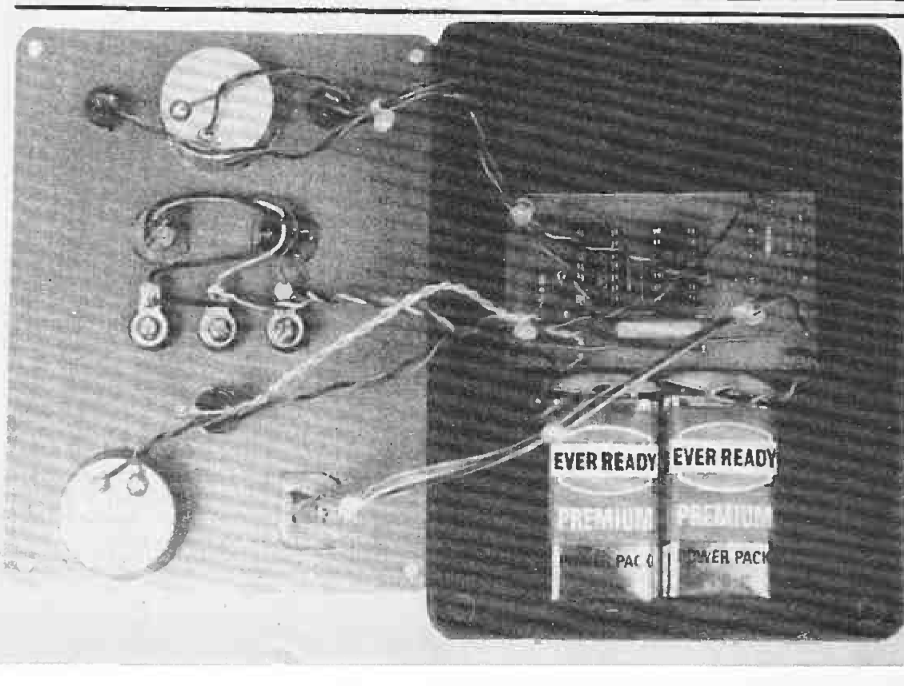
Transistors are plugged into the appropriate socket, and any type may be tested; NPN, PNP, small signal or power. No selection of NPN or PNP is necessary as this is done automatically by the tester. When the push-to-test button is pressed, an intermittent tone is produced. The frequency of the tone is proportional to the gain of the transistor, giving a rough guide. The LEDs also flash alternately in time with the pulsing tone; the LED that is on at the same time as the tone indicates the polarity of the transistor. If the transistor has no gain or is open circuit there will be no tone, although the LEDs will still flash. If the transistor has a large leakage current or is shorted, there will be a 'two-tone' sound. If the transistor has been inserted the wrong way there will be either no tone or a very high-pitched tone.

Diodes and LEDs may be tested across the 'C' and 'E' terminals. If it is OK, the LED under test will flash, accompanied by an intermittent high-pitched tone and flashing indicators. Ordinary diodes require a series resistor (any old value) and should then produce an intermittent tone and flashing LEDs as before; the coincidence of flashing LED and tone indicates the anode.

Op-amps are plugged into the IC socket and no push-switch is required; power is only applied when the IC is inserted, and a good IC produces a continuous tone from the second insert.

BUYLINES

No problems with anything used in this project; all components are standard items and are obtainable from the major mail order suppliers advertising in this issue. If you don't want to make your own PCB, you can obtain one from our PCB Service (see page 94).



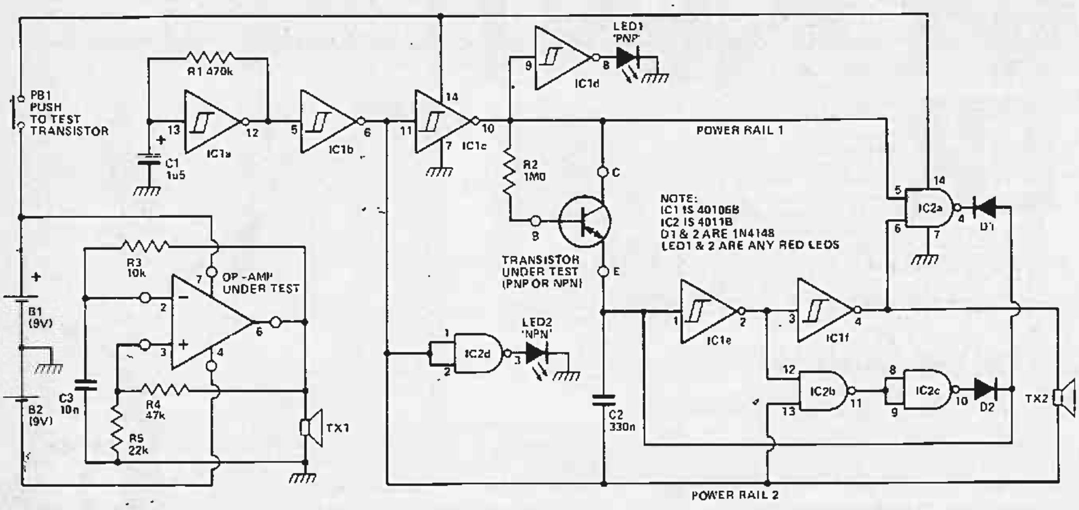


Fig. 1 Circuit diagram of the Component Tester.

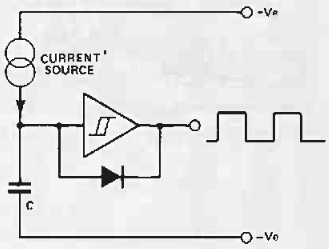


Fig. 2 Principle of the CCO.

HOW IT WORKS

The op-amp tester and transistor tester are completely separate circuits; we shall deal with the transistor tester first. IC1a, a Schmitt trigger inverter, forms a low frequency square wave oscillator with a period (determined by R1 and C1) of about 1 second. This square wave is used to switch the polarity of the 'power rails' (labelled 1 and 2 in the diagram) of the test transistor and its associated oscillator circuitry.

IC1b is used to buffer the square wave, and its output (on pin 6) is used to drive 'power rail 2'. This switching signal from IC1b is also fed to the input of IC1c, which inverts it and drives 'power rail 1'. Thus for half a second in each cycle rail 1 will be positive (high) and rail 2 (low); for the other half second rail 1 goes negative and rail 2 positive. Each power rail drives an LED (LEDs 1 and 2) via inverter gates IC1d and IC2d, such that an LED will be illuminated if its associated power rail is at 0 V. These LEDs will therefore flash alternately when the circuit is operating, providing an indication of the state of the power rails.

The oscillator circuit that is connected across these power rails is essentially the simple current-controlled oscillator shown in Fig. 2, but with some adaptations to enable it to work with either supply polarity. The oscillator of Fig. 2 works as follows. Assume C is initially discharged, so that the input to the Schmitt inverter is low; the output is thus high and the diode, being reverse biased, is effectively out of circuit. Capacitor C will now begin charging up from the current source and the input voltage to the Schmitt will be increasing. When the input passes the Schmitt threshold the inverter output will switch low; the diode is now forward biased and will rapidly discharge the capacitor. The process then repeats, producing a square wave output from the inverter with a frequency that is proportional to C and the current from the source. The bigger the current from the source, the faster C will charge and the higher the frequency will be.

The current source in our actual circuit is provided by the transistor under test. R2 supplies a small base current to the transistor, and the current flowing from the emitter will be proportional to the gain of the transistor. If the transistor is PNP it will only supply current to the CCO (current-controlled oscillator) when power rail 1 is negative with respect to power rail 2. Similarly, power rail 1 must be positive for the oscillator to function if the transistor is NPN. Thus the CCO will produce an intermittent frequency for either transistor polarity (assuming the transistor is a good one) with a frequency roughly proportional to the gain. If the frequency is audible when LED1 is on, the transistor is PNP, and if LED2 and the tone coincide then it is NPN.

Going back to the oscillator of Fig. 2, we see that if the oscillator is to work when the supply connections are reversed, then the diode polarity must also be reversed. In our circuit this is achieved by using two diodes, D1 and D2. When power rail 1 is at 0 V, the NAND gate IC2b will be disabled and its output (pin 11) will be high. This output is inverted by IC2c, thus reverse biasing D2 which is now effectively out of circuit. At the same time power rail 2 will be high, enabling NAND gate IC2a whose output (pin 4) will follow the logic level on the output of the Schmitt trigger IC1e via IC1f. Thus when IC1e goes low during an oscillation cycle, the cathode of D1 will also go low, forward biasing the diode and discharging C2 for the next cycle.

When the voltage on the two power rails is reversed a similar action occurs, but with D1 switched out of circuit and D2 providing the discharge path. The intermittent square wave produced at the output of IC1f is fed to crystal transducer TX2 which gives an audible note.

If an LED or diode is connected between the C and E terminals of the test socket, it appears to be a large-value current source in one direction only. Hence the circuit reacts as if a high-gain transistor were in circuit, and polarity is indicated as before.

The op-amp under test is configured as a simple RC relaxation oscillator. When the op-amp is plugged in, assume that its output (pin 6) is high (positive saturation). Then C3 will begin charging up to +9 V through R3 with a time constant C3.R3. When the voltage on C3 reaches one-third of the positive supply (this fraction is set by R4 and R5), the op-amp output will switch low, with R4 and R5 providing positive feedback for Schmitt trigger action. C3 will then discharge towards −9 V, until the op-amp switches back to positive saturation. This cycle repeats indefinitely, producing a square wave at the op-amp output which is fed to transducer TX1. This produces an audible note if the op-amp is good.

PARTS LIST

Resistors (all ¼ W, 5%)	
R1	470k
R2	1M0
R3	10k
R4	47k
R5	22k
Capacitors	
C1	1u5 25 V tantalum
C2	10n disc ceramic
C3	330n polyester
Semiconductors	
IC1	40106B
IC2	4011B
D1,2	1N4148
LED1	0.2" red LED
LED2	0.2" green LED
Miscellaneous	
PB1	momentary push-button
TX1,2	crystal mike inserts

2 off PP3 batteries and clips; transistor sockets; IC sockets; case to suit

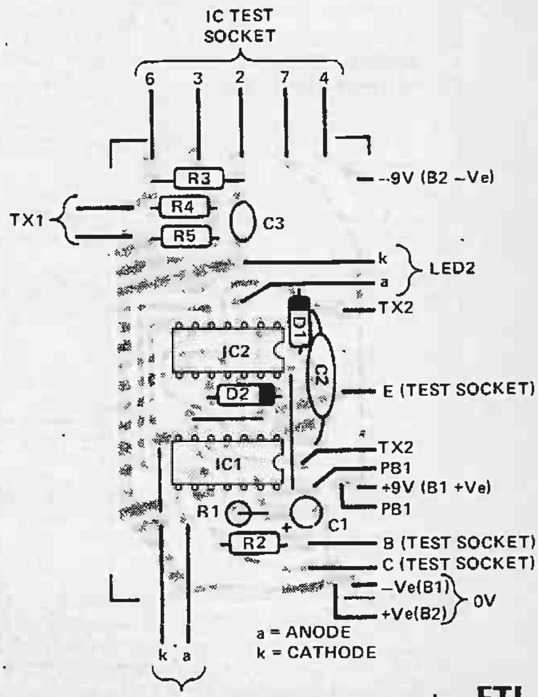
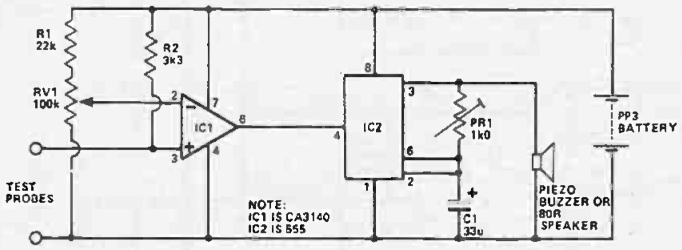


Fig. 3 Component overlay.

TECH TIPS

Adjustable Sensitivity Continuity Tester

David Wolfe, Cambridge



Continuity testers operate by comparing the resistance between the test probes with a fixed reference resistance (if the probe resistance is less than the reference then the tester indicates this somehow). This is fine if the tester is to be used in only one type of application, but means that the tester is limited to this application. For example, when testing continuity on a circuit board one is generally testing for very low 'hookup' resistances; when testing long cable runs, however, such as in house wiring, one tests for resistances often up to several kilohms.

This design overcomes this problem by having an adjustable reference. The tested resistance is configured as half of the potentiometer which is adjusted to give the required sensitivity. Obviously by changing the component values, especially that of R2, the range over which the tester can operate can be altered, but it should be remembered that for the tester to discriminate very low resistances the potentiomenter must be able to output voltages very close to 0 V.

Continuity can be indicated in several ways depending largely on user preference, but also on parameters such as current consumption and parts availability eg a mechanical 'buzzer', an astable driving a loudspeaker or an LED. These would all need a suitable driving circuit as the op-amp could not do this directly. In the prototype a piezo buzzer was used for low current consumption. A CA3140 IC was chosen in this circuit for its ability to operate with inputs near to the negative supply rail.

Micro-power VOX

David Ian, Hampton Court

Previously published voice operated switches seem limited in application due to their disproportionately high current requirements relative to the subsequently switched circuitry, eg battery operated baby alarms, portable transmitters and so on.

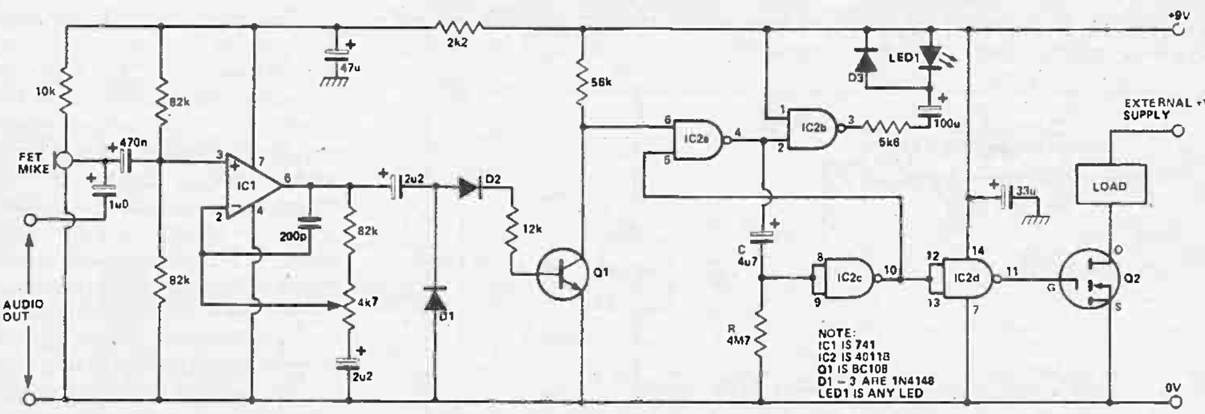
Including a visible indicator this design has, at 9 V, a quiescent consumption of a meagre 800 uA, rising to a maximum of 1.6 mA when triggered, but is capable of cleanly switching at least 250 mA at up to 30 V.

The 741 is wired as a decoupled, high-gain preamp, with RV1 controlling the switching point over a wide range of audio levels — anything from a whisper to a shout. The resulting voltage level triggers (via Q1) the monostable formed by three gates of a 4011. When the output of the third, inverting, gate goes high the N-channel VMOS FET, Q2, is enabled, thus completing the power supply of an external device.

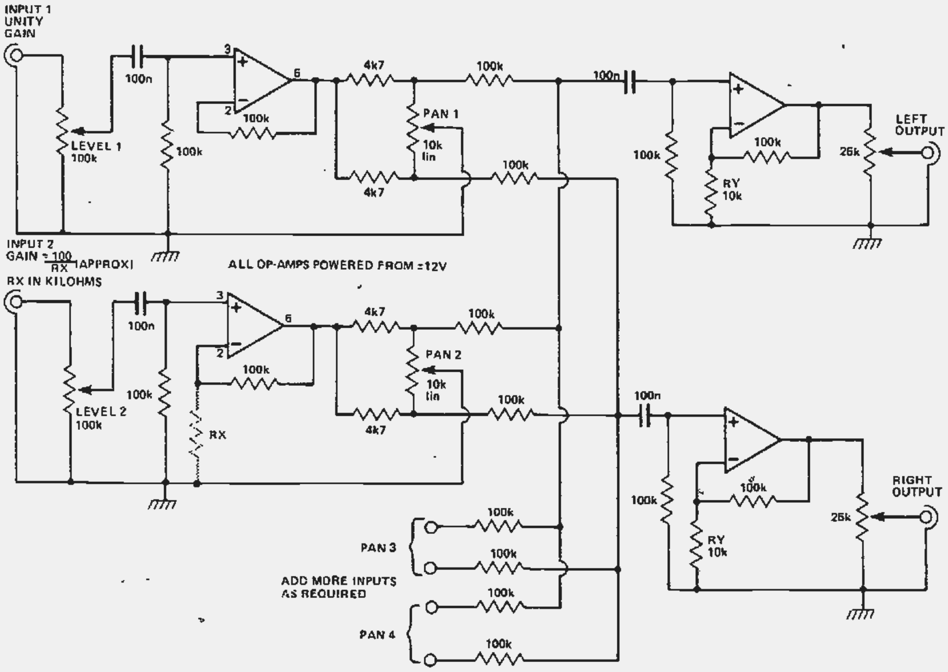
The 'on' resistance of a VMOS FET is less than 2R ("off" is tens of megohms) and quite large currents may be safely handled before a heatsink becomes necessary.

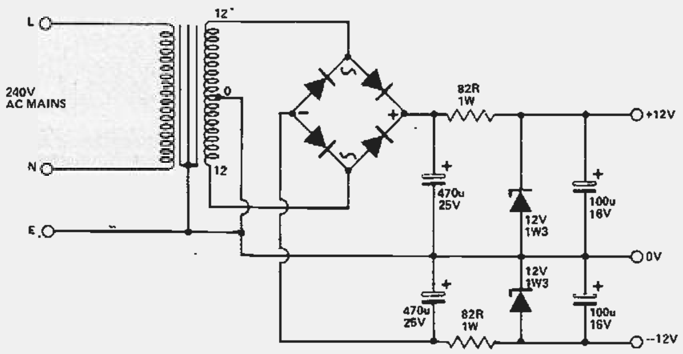
To aid setting to a given sound level the unusual, but current-saving, arrangement at the output of the remaining 4001 gate provides a single flash from LED1 whenever the monostable is triggered.

C and R were selected for the particular requirement of an 'on' time of 14 seconds; 1u0 and 1M0 gives approximately one second delay, depending on the individual gate's transition point. Any medium to high impedance microphone could be used; the electret type shown was to hand.



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 0EE.





Four Input Stereo Mixer

R.D. Pearson, Sheffield

The mixer circuit shown was designed to allow four or more inputs to be mixed down, producing a stereo output. Each input has stereo panning and a level control. The gain of the input stages can be boosted according to specific needs by adding RX, making it possible to use a direct input from guitars, microphones and so on. Note that to avoid poor frequency response, the gain of this stage should be kept below 50 (keep RX above 2k2). The input impedance is 100k and should be high enough for most applications.

The two output stages have sufficient gain to compensate for the attenuation of the panning controls. If more than four inputs are used it will be necessary to increase the gain of the output stages by decreasing the value of RY to 6k8 for six inputs or 4k7 for eight inputs.

741 op-amps should prove suitable for most purposes, but if lower noise is desired then a low noise op-amp such as the TL071 may be substituted. The simple zener regulated power supply shown should be suitable for general purpose applications.

Anti-Theft Device

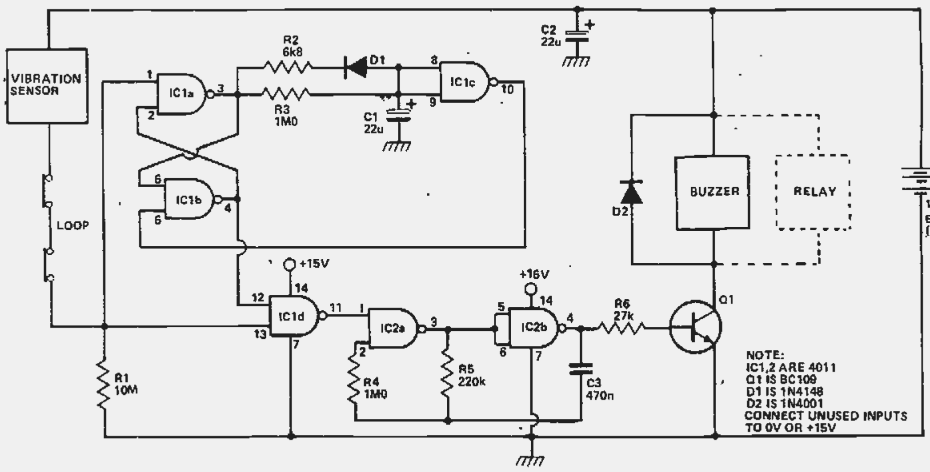
G.J. Phillips B.Sc, Durham

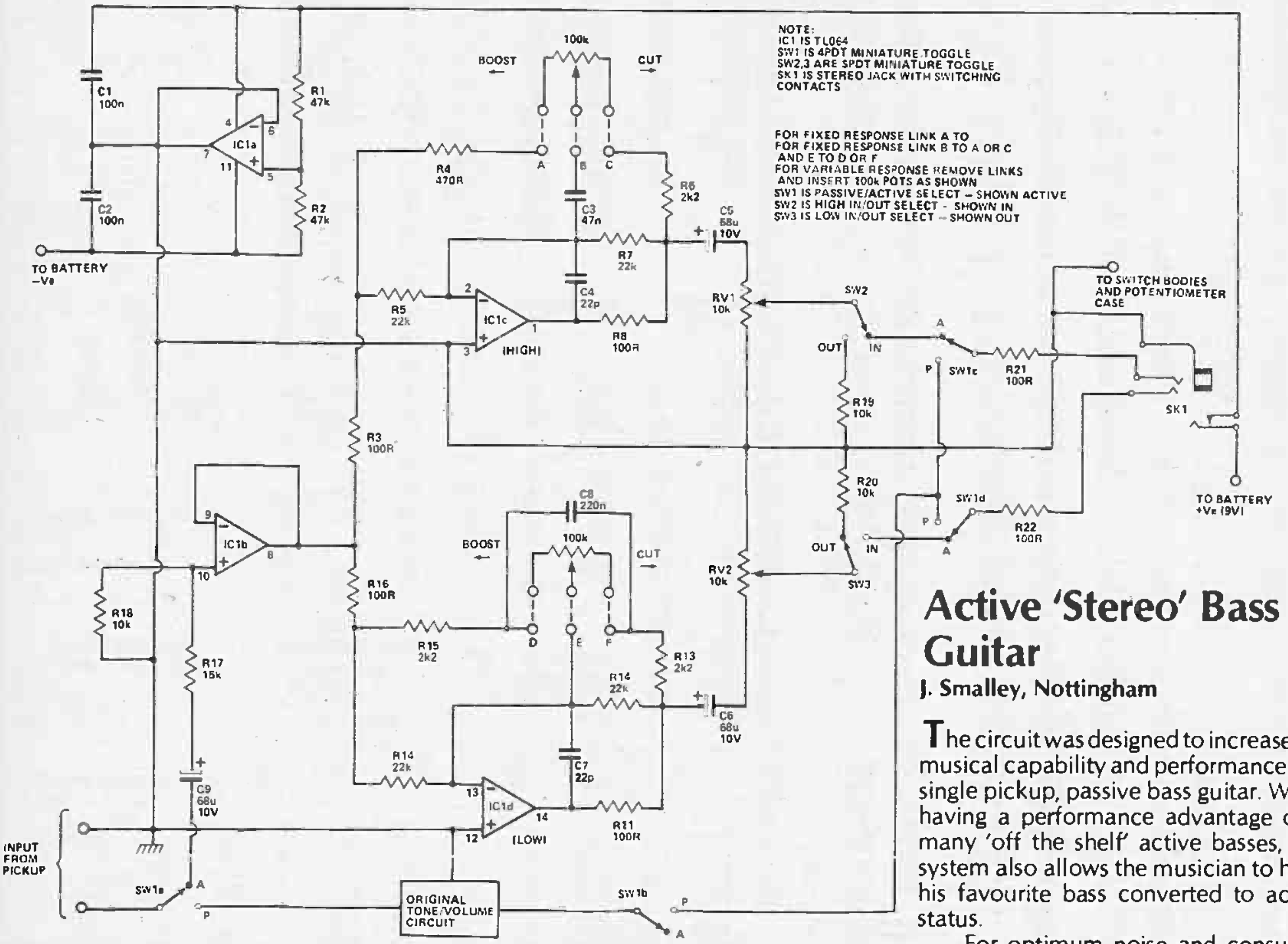
Many audio retailers employ anti-theft devices whereby a loop, made up of lengths of cable joined with plugs and sockets, is passed through the handles of radios and cassette players. If the loop is broken an alarm sounds.

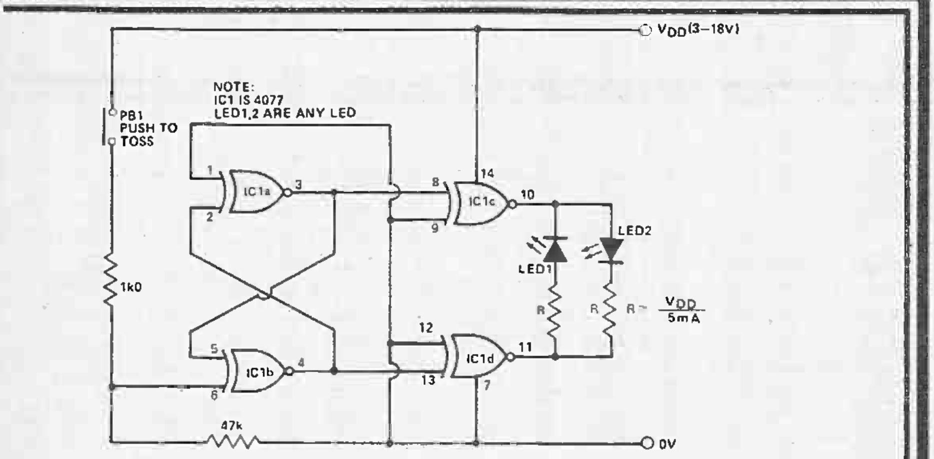
The circuit diagram shows a design which has been built in the lab and functions very well. R1 sets the quiescent current in the loop. The loops could include vibration sensors or any other suitable normally closed contacts. When the loop is broken, the logic 0 at R1 causes the astable multivibrator formed by IC2a,b to be enabled via gate IC1d, which acts as an OR gate for 0s at its inputs. The astable frequency is set at approximately ¼ Hz causing the buzzer to sound intermittently.

The logic 0 at R1 also triggers the monostable formed by IC1a,b,c and the output of this monostable also enables the astable via pin 12 of IC1d. Thus, if a quick-witted thief quickly remakes the broken loop or the vibration sensor quickly breaks the loop, the monostable ensures that the alarm continues to sound for approximately 20 seconds. If the loop is left open then the alarm will sound all the time. Unused inputs of the CMOS chips should be tied to V_{CC} or 0 V whereupon the quiescent battery drain will be less than a microamp.

R1 can be replaced with an LDR (ORP12) and a 10M resistor used to replace the loop. The alarm is then triggered by light. Place the device in your components drawer and you'll be able to nab the guy who's been pinching your ICs when no-one's looking.







Active 'Stereo' Bass Guitar

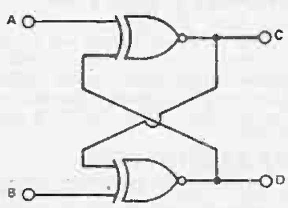
J. Smalley, Nottingham

The circuit was designed to increase the musical capability and performance of a single pickup, passive bass guitar. While having a performance advantage over many 'off the shelf' active basses, this system also allows the musician to have his favourite bass converted to active status.

For optimum noise and consumption of battery current (650 uA quiescent), the TL064 BIFET quad op-amp was chosen. As a result, the circuit may be broken down as follows: IC1a is a voltage follower and provides a low impedance 0 V rail to bias the remaining amplifiers. IC1b is also a voltage follower and serves to isolate the two filters from the pickup. IC1c,d are the high and low filters respectively. The response of each filter exhibits a shelving curve which rolls at 6 dB/octave. In rough musical terms, the slope break points are arranged so that bass notes are handled by the low filter and the higher notes by the high filter.

C3 or C8 may be adjusted for a different slope position, and the ratio R4:R5 (high) and R13:R14 (low) for an alternative differential gain ratio. R17 and R18 may also be adjusted for pickups with different output levels. SW2 and SW3 allow the filters to be 'in' or 'out', and SW1a-d allows the original tone circuits to be connected to the output jack, and totally disconnects the electronics. Battery on/off is via a pair of insulated switching contacts on the stereo jack socket. In the instrument modification, the original jack socket is removed and a stereo version fitted in its place.

Musical use is very much a matter of experiment, but best results were obtained when using a stereo lead with a twin channel amplifier. **ETI**



A	B	C	D	MODE
0	0	$\overline{D}$	$\overline{C}$	BISTABLE
0	1	$\overline{D}$	$\overline{C}$	ASTABLE
1	0	$\overline{D}$	$\overline{C}$	ASTABLE
1	1	D	C	BISTABLE

Heads Or Tails

D. Indyk, London

An ultra-simple heads or tails indicator can be built using a single 4077 EXNOR IC. The circuit is normally in a latched bistable mode; when the switch is closed the circuit will oscillate, ie toss the coin. The astable frequency is approximately 5-10 MHz. If desired a small push-to-make switch can be connected in series with the battery as an on/off switch, such that the battery will be disconnected from the circuit unless the device is being held. The LEDs can be any colour.

ALCOHOMETER

This remarkable reaction timer contains a crystal-controlled counter to determine drunkenness in alliterative alcoholics. Design and development by Rory Holmes.

Alcohol may be wonderful stuff (well, we think so), but it tends to have unfortunate side effects; too much of it will cloud your judgement, slow your reactions, affect your balance and, worst of all, make you certain that the exact opposite is true. Such a state of mind is dangerous if you intend using that modern offensive weapon, the motor car. The ETI Alcohometer is a crystal-locked reaction timer that is simplicity itself to use (always an advantage when you've had a few), and will prove to over-confident imbibers exactly how much effect the odd lunchtime pint or five has really had. Lots of fun at parties, too — although once you have trouble holding the button down, it's probably time to leave. In a taxi.

Button Up

When the Alcohometer is switched on the display is blank, except for the decimal point. To play, you hold down the push-button and wait. After a random time period lasting about one and a half to eight seconds, the display lights and starts counting up from zero. Releasing the push-button stops the count and displays your reaction time in seconds. To conserve power the display blanks automatically after a further eight seconds; if you're in a hurry to play again, pressing the push-button blanks the display and starts a new cycle. If you don't react within one second, the display latches at 000 so you can't claim a reaction time of 3 milliseconds just because the counter clocked round once before you noticed.

Brave ETI volunteers found that even one small drink could have a noticeable effect on reaction time, but don't take our word for it — start building one now and be ready for Christmas!

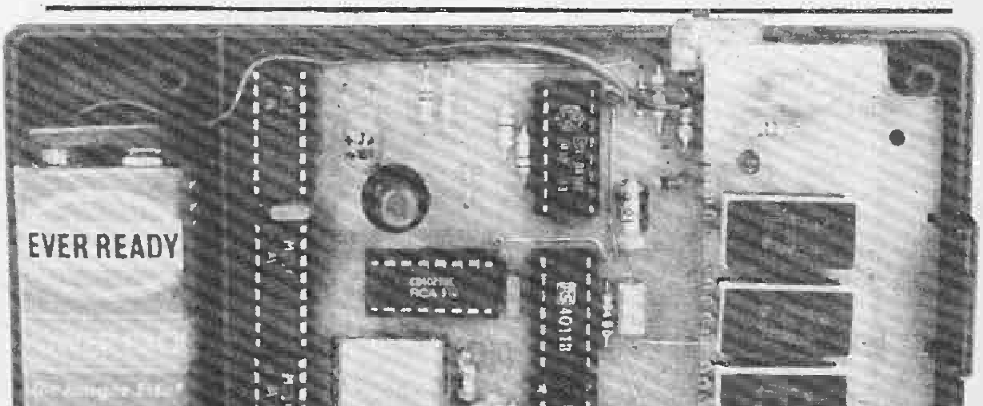
Construction

The construction is elegantly simple since all the parts are mounted on two PCBs; nevertheless it's quite intricate, due to the high component packing density. Solder the components into the main board first, not forgetting the orientation of the ICs, capacitors and diodes (see overlay). Use IC sockets, it's always a good precaution. Veropins should be soldered into the holes for the push-button switch, and the switch soldered in turn to these, so that the height from the top of the button to the board is 27 mm. Remember to put in all the board links, including the two underneath the board, but do not solder in the vertical links to the display at this stage.

After building up the prototype we discovered an unusual problem. It appears that some manufacturers produce longer plastic DIL packs than others, and if your 4017s are too long they won't fit the board. The Motorola chips we used (MC14017BCP) are OK, but if yours are too long you can always grind off the ends (carefully!)

If the crystal is a plug mounting type, don't worry; its pins can be cut shorter, and wire links soldered from the pins through the PCB holes. This same procedure will be necessary for the on/off switch (SW1) which is mounted sideways on the board (see photos). A small piece of plain PCB acts as a spacer between the switch and board, to align the switch with the moulded case cutout. It's a good idea to place the board in position on the case to check the exact switch placing, before securing it with superglue.

The display board is mounted above the main board and is held in



With the top off, you can see how everything fits into the case — just!

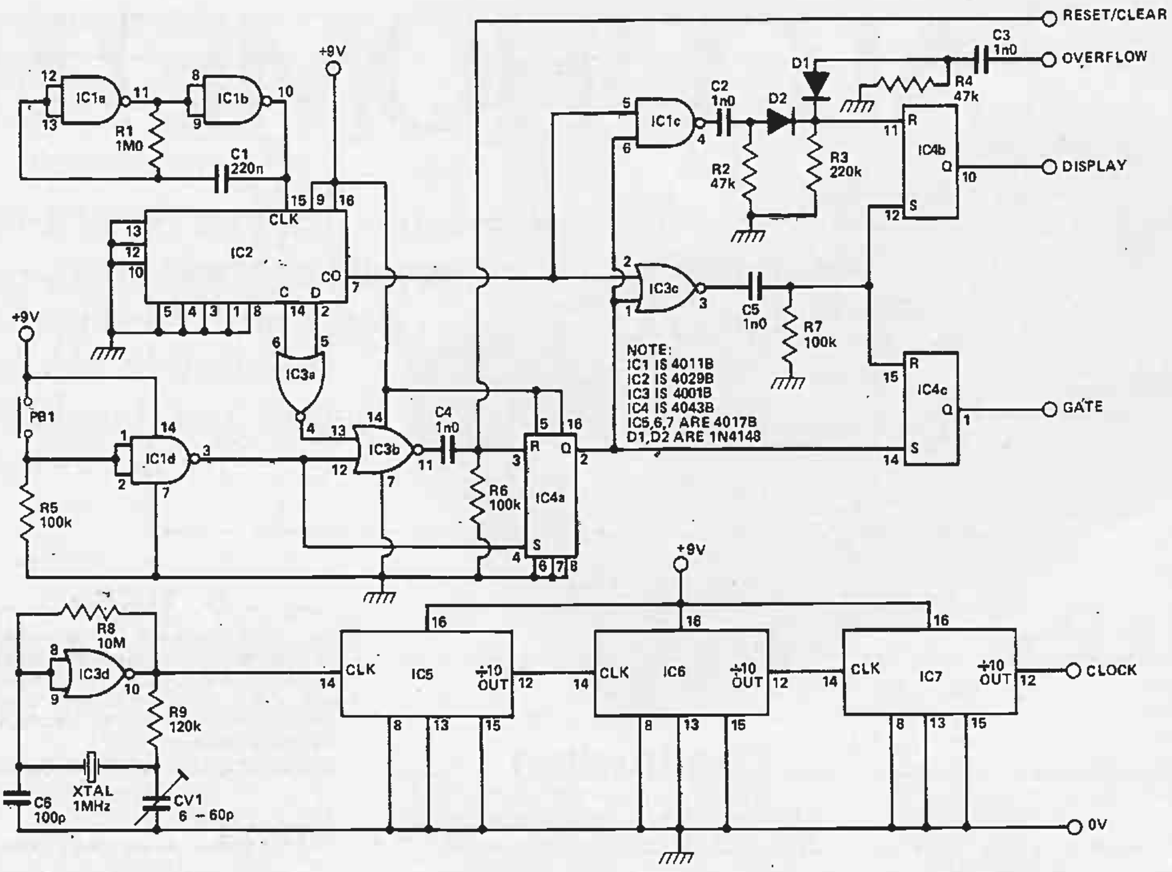


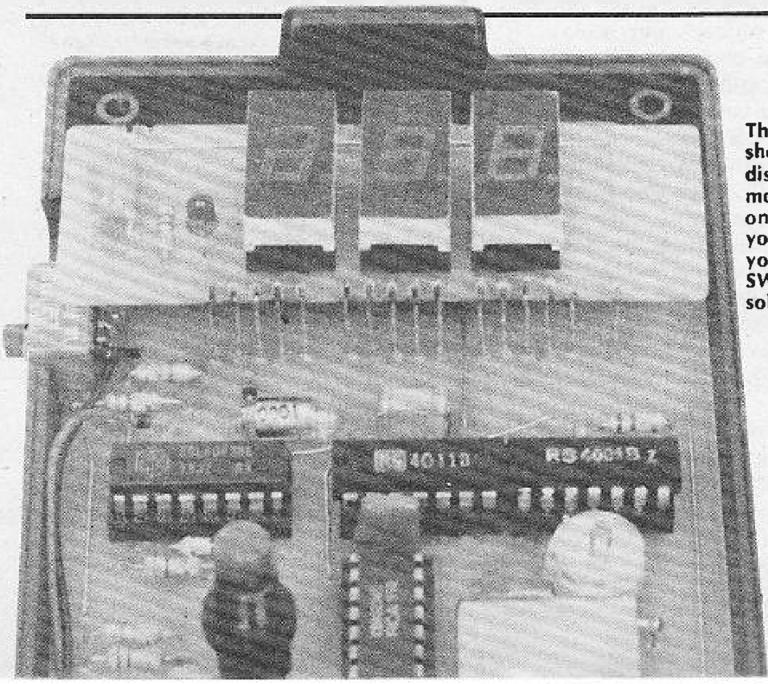
Fig. 1 Circuit diagram of the main control and oscillator section.

place by the vertical wire links (see photograph). Solder in all the components as per the overlay diagram, including the positive rail link, and noting the polarity of C9 and LED1. Sockets should be used for the seven-segment displays, both for protection and to give the required height. Lengths of tinned copper wire (about 2") should now be soldered at all the vertical lead out holes — 23 in total. After completing this carefully check the track side of the board for bad joints, solder bridges and other faults. It will be very difficult to correct mistakes after the boards are soldered together. Also check that all the ICs are plugged into the main board.

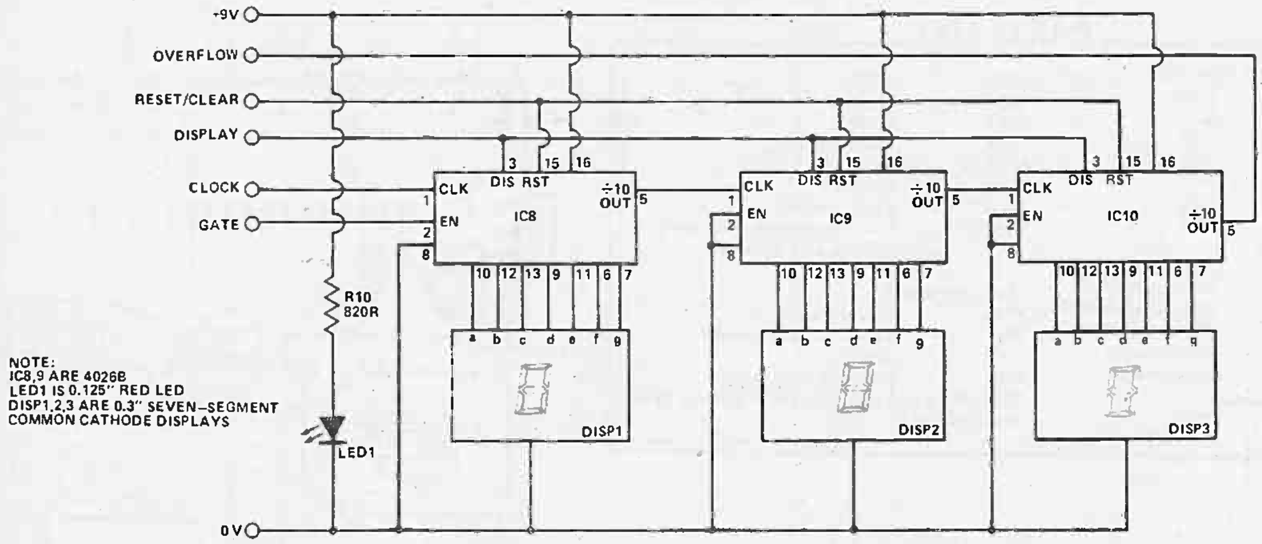
Now comes the tricky bit; all the 23 wires coming down from the display board must be inserted into the corresponding hole, vertically beneath, on the main board. It helps to trim the wires to different lengths, starting at about 1" at one end, and increasing to 2" at the other. They can then be inserted one at a time, as the boards are lowered together. When the boards are together the separation (between both parallel component surfaces) should be adjusted to about 13 mm. The wires can be bent under the board to hold this position, and then soldered and cropped.

Vero Intelesting

The case used is a two part moulded Verocase. This case has a built in battery compartment, and ready-made cutouts for the display and on/off switch. There is a small moulded stand-off in the centre of the bottom case half — this should be filed or cut down in size, until it's shallower than the three PCB stand-offs. The board assembly can now be fitted into the bottom case half. The PCB edges may need filing for the good fit against the bottom of the case (be careful not to file away the copper tracks at either edge). An appropriate hole must be drilled in the case front for the push-button; a good method is to put a small blob of ink on the button head and then bring the case halves together in the correct position. The ink will leave a drilling mark. The board can be secured in the bottom of the case using



This photograph shows how the display board is mounted piggyback on the main PCB. If you look carefully you can see how SW1 and PB1 are soldered in place.



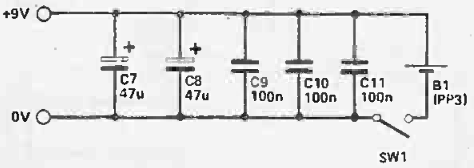


Fig. 2 Circuit diagram of the counter/display section (above) and the supply decoupling capacitors.

BUYLINES

The case used is one of the Vero range, order code 202-22275G. The two PCBs available from our PCB Service on page 94, and none of the other components should cause any problems (although you should note the point made in the text about the 4017s).

ordinary adhesive pads, if they are used double thickness. The displays should just come in line under the window when the two case halves are together. A suitably sized piece of red filter plastic or polarising sheet should be cut and glued underneath the display cutout. The battery can be held more securely by sticking a piece of plastic foam into the battery compartment for a compress fit.

Time To Test

You are now ready to test the finished article. With a PP3 (9 V) battery connected to the clip lead, and the power switch in the 'on' position, only the discrete decimal point LED should be illuminated. If you have access to a frequency meter you can use the trimmer capacitor to set the frequency of the crystal oscillator to exactly 1 MHz. Otherwise, leave it at about mid position. Now press down the push-button and keep it pressed; nothing should happen. . . Suddenly, the display will illuminate, and start counting at 1,000 counts per second. Having reached this stage, the idea is to let go of the button pretty smartly. The figure will freeze instantly, and continue to display your reaction time in seconds. After about eight seconds the display will disappear, and you may try again; alternatively, pressing the push-button will reset the display immediately for another attempt.

Note that it is impossible to cheat, except by precognition. . .

HOW IT WORKS

At some random time after push-button PB1 is pressed, the display comes on and commences counting. Releasing PB1 stops the count, freezing the display, which then shows the time elapsed between the end of the random period and the release of SW1. After a short time the display automatically turns off and resets, ready for the next reaction test. The random time period, which will be between 1½ to 8 seconds, is set up by IC2, a four bit binary counter wired to count down repetitively from 15 to 0. It is clocked at around 2 Hz by the slow oscillator built around IC1a and b, so that a complete count cycle takes about 8 seconds. With PB1 open, the output of IC1d will be high; this holds the output of IC3b in a low state and sets the Q output of IC4a, a NOR latch, to high. Meanwhile IC2 is continuously counting down from 15 to 0. One or other of C and D, the two most significant digit outputs, will be high when the count is above 3, ie for about 6½ seconds of the 8 second period. Thus the output of NOR gate IC3a is taken low, enabling IC3b, whenever the count is within that range.

Now, operating PB1 takes IC1d output low, putting a low on the second input (pin 12) of IC3b and the set input of IC4a. With both inputs low, IC3b output will go high; a positive pulse is applied through C4 to the reset input of the latch, allowing the Q output to go low and sending a CLEAR pulse to reset the counter section. If the IC2 count is less than 4 however, IC3a's output will be high, holding IC3b low so that the latch, with its reset input pulled low by R6, cannot change state. Thus the random time period, which ends when IC2 clocks down to zero some time after PB1 is pushed, cannot be less than a 3 count, ie around 1½ seconds.

When IC2 reaches 0, the carry out line (pin 7) goes momentarily low, taking one IC3c input low; the other input (on pin 1) is already held low by the Q output of IC4a. Thus IC3c output goes high and the positive edge through C5 will reset latch IC4c, so switching the GATE line from the Q output to its active low state. The positive pulse through C5 also triggers the set input of latch IC4b, taking the Q output high which turns on the display. This is the end of the random period and the start of the reaction timing.

The GATE signal starts the counter-timing section simultaneously with the display illumination. The user must now release PB1. As described above the set input of latch IC4a will then go high, taking the Q output high. This holds the set input of latch IC4c high and so takes the GATE line high again, stopping the count and ending the reaction timing. The pin 6 input of IC1c is now held high by the Q output of IC4a. Thus, when the IC2 CO line goes low again after a further 8 seconds, IC1c will go high and the positive pulse through C2 and D2 will reset the latch IC4b, taking a Q output low and turning off the display to conserve power. The latch IC4b can also be reset via D1, which steers a positive pulse derived from C3 and R4 to the reset input. C3 is connected to OVERFLOW, the final divide-by-10 output of the counter section, thereby blanking the display when the count reaches 1 second.

The display has three decimal digits following the decimal point, which are driven by IC8,9, and 10. These are integral decade counters and seven segment decoder drivers (4026) which drive common cathode LED displays. Since the readout is in seconds it follows that the clock frequency for the least significant digit must be 1 kHz. IC3d forms a CMOS oscillator, with the frequency set at exactly 1 MHz by the crystal. This output frequency is then divided down to 1 kHz by IC5,6 and 7 (4017 decade counters) and supplies the CLOCK for IC8 (pin 2).

All the pin 15s on ICs 8,9 and 10 are wired together and form the RESET/CLEAR line (active high). Likewise all pin 3s form the DISPLAY line, a low on these turns off the display. The GATE line goes to pin 2 (the enable) of IC8; when this is taken low the clock is enabled and will start counting. Pin 2 of IC8 and 9 are both wired to ground to permanently enable their clocks. The circuit is powered by one 9 V PP3 battery with an on/off switch SW1 in the negative rail. LED1 indicates when power is on and also marks the decimal point. Capacitors C8 through C12 provide supply decoupling for the ICs.

PARTS LIST

Resistors (all ¼W, 5%)	
R1	1M0
R2,4	47k
R3	220k
R5,6,7	100k
R8	10M
R9	120k
R10	820R
Capacitors	
C1	220n polycarbonate
C2,3,4,5	1n0 ceramic
C6	100p polystyrene
C7,8	47u 16 V tantalum
C9,10,11	100n ceramic
CV1	6-60p trimmer
Semiconductors	
IC1	4011B
IC2	4029B
IC3	4001B
IC4	4043B
IC5,6,7	4017B (see text)
IC8,9,10	4026B
D1,2	1N4148
LED1	0.125" red LED
DISP1,2,3	0.3" seven-segment common cathode LED displays
Miscellaneous	
XTAL	1 MHz crystal
PB1	miniature push-to-make switch
SW1	miniature slide switch
PP3 battery and clip; case (see Buylines); PCBs (see Buylines).	

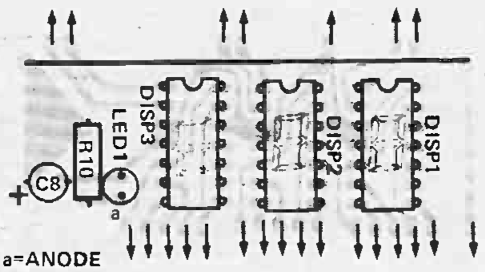


Fig. 3 Overlay for the display board. Arrows indicate vertical wire links to the other PCB.

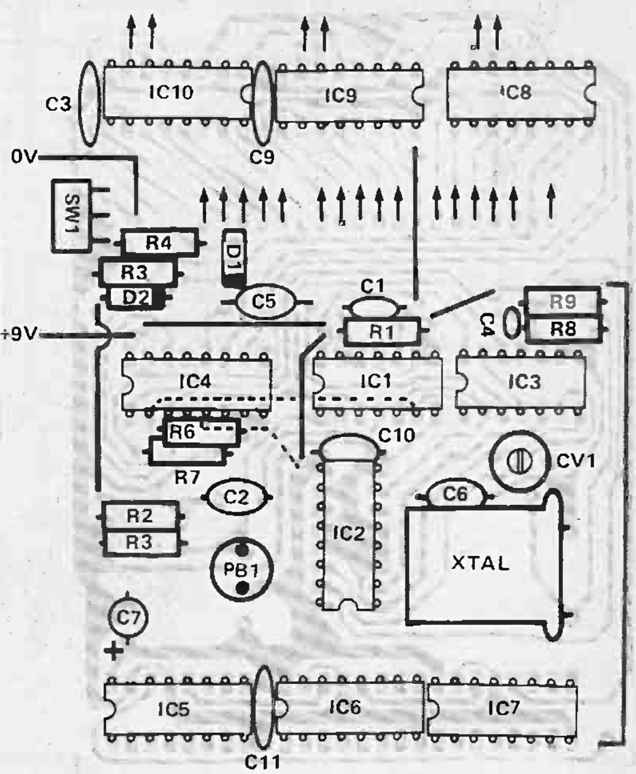


Fig. 4 Overlay for the main PCB. Note the insulated wire links under the board — IC4 pin 5 to IC2 pin 9, and IC4 pin 2 to IC1 pin 6.

ETI

DESIGNER'S NOTEBOOK

The XR2206 is a high-quality function generator chip, capable of producing sine, square, triangle, ramp and pulse waveforms. Ray Marston shows how to use the device in this month's edition of Notebook.

The XR2206 integrated circuit is undoubtedly the most useful function generator or waveform generator chip available. It can generate sine, square, triangle, ramp and pulse waveforms at frequencies ranging from a fraction of a hertz to several hundred kilohertz, using a minimum of external circuitry. The frequency can be swept over a 2000:1 range using a single control voltage or resistance, and sine wave distortion can typically be as low as 0.5%. The chip incorporates special built-in modulation facilities that enable the generated waveforms to be subjected to AM or FM control, or to phase-shift or frequency-shift keying.

The XR2206 chip is housed in a standard 16-pin DIL package and can be powered from either single or split supplies in the range 10 to 26 V. The sine wave output of the device has maximum amplitude of about $2V_{RMS}$ and output impedance of 600R. The frequency stability of the IC is excellent, being about 20 ppm/°C for thermal changes and .01%/V for supply voltage changes.

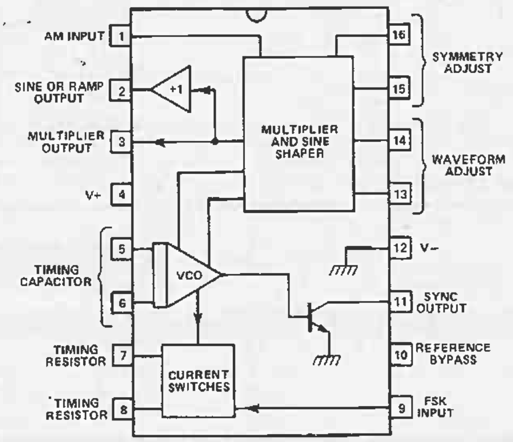


Fig. 1 Block diagram and pin notations of the XR2206 function generator IC.

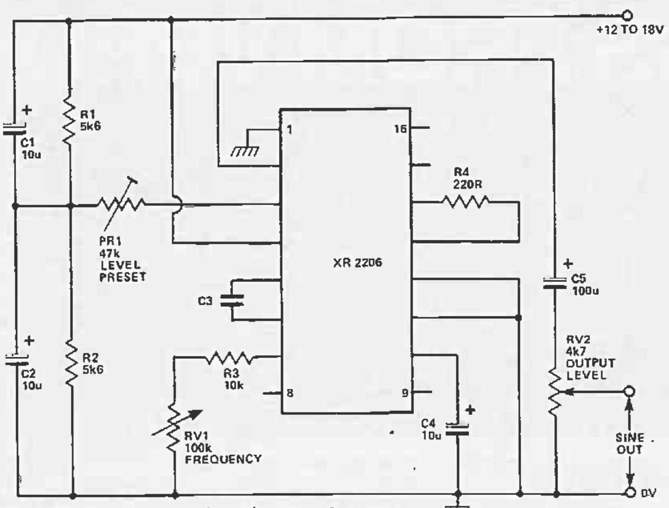


Fig. 2 Simple single-supply wide-range sine wave generator (10 Hz to 100 kHz). See Table 1 for values of C3.

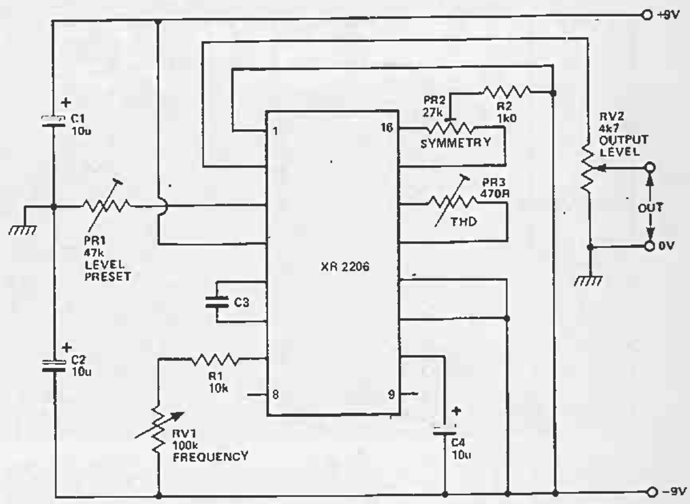


Fig. 3 High-performance split-supply sine wave generator. See Table 1 for values of C3.

C3	FREQUENCY RANGE
1u0	10 Hz TO 100 Hz
100n	100 Hz TO 1 kHz
10n	1 kHz TO 10 kHz
1n0	10 kHz TO 100 kHz

Table 1. Values of C3 for different frequency ranges.

Basic Waveform Generators

The XR2206 is a reasonably easy IC to use in basic waveform-generator applications. Figure 2 shows how to connect it for use as a simple wide-range sine wave generator that is powered from a single supply source in the range 12 to 18 V. The main timing resistance comprises R3-RV1; it is connected between pins 7 and 12 (ground) and is automatically selected by leaving pin 9 (FSK input) open circuit. The operating frequency can be varied over a decade range (using RV1) with any given value of C3, as indicated in the diagram. The circuit generates a sine wave output at pin 2, since a 220R resistor is wired between pins 13 and 14 of the IC; typically, the sine wave distortion is less than 2.5% with this simple connection.

In Fig. 2, the voltage to pin 3 is biased at half-supply volts by decoupled divider R1-R2, so the pin 2 sine wave is also biased near half-supply volts. PR1 enables the pin 2 sine wave magnitude to be preset to a value at which distortion (due to clipping) is minimal. To set PR1, first disconnect R4 (so that a triangle output is obtained), then adjust PR1 so that no triangle clipping is visible. Now re-connect R4 and check that a decent sine wave is available. Sine wave distortion can be reduced below the typical 2.5% value, if desired, by replacing R4 with a 470R preset and adjusting it for minimum distortion. The final sine wave output of the Fig. 2 circuit can be fully varied by RV2.

The Fig. 2 sine wave generator can be modified for split-supply operation by replacing all ground connections with negative-rail ones and by taking level control PR1 to the common supply (ground) line as shown in Fig. 3. This circuit also shows how the total harmonic distortion (THD) of the sine wave can be reduced to a typical value of 0.5% with the use of presets PR2 and PR3; these controls must be adjusted alternately to give the best possible sine wave output, after first setting

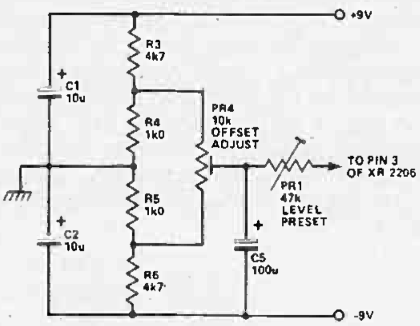


Fig. 4 Add-on modification for applying limited DC offset or nulling to the output of the Fig. 3 circuit.

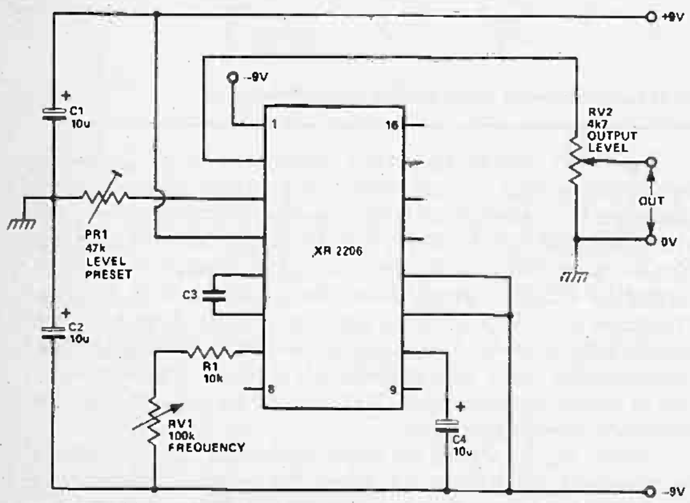


Fig. 5 Variable-frequency split-supply triangle wave generator. See Table 1 for values of C3.

PR1 to give a non-clipped triangle waveform as already described.

When using the low-distortion sine wave facility illustrated in Fig. 3, note that the signal appearing on pin 3 of the IC is similar to that of pin 2 but has lower distortion and higher output impedance; also, the pin 3 signal is closely centred on the common or ground line, but the pin 2 signal is offset by a few hundred millivolts. If desired, slight DC offset can be applied to pin 3, to bring output pin 2 to precisely zero offset value, by using the add-on modification shown in Fig. 4.

The XR2206 can be made to generate linear triangle waveforms by using the basic circuits of Figs. 2 and 3 without the sine-shaping resistors. Figure 5 shows the circuit of a variable-frequency split-supply triangle waveform generator. When used with a ± 9 V supply, the circuit can typically produce ramp signals with maximum peak-to-peak amplitudes of 12 V before clipping occurs.

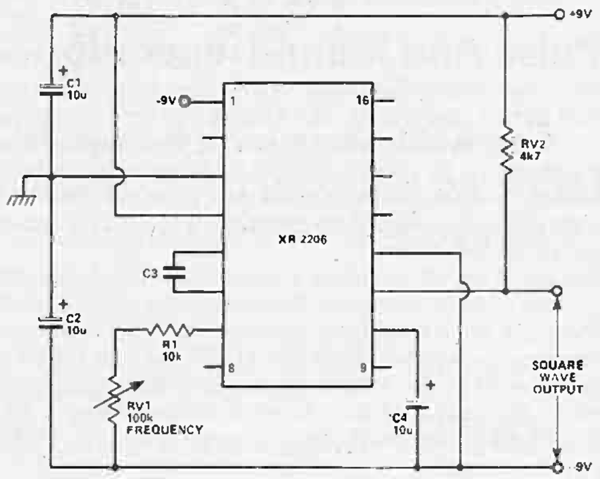


Fig. 6 Simple fixed-amplitude variable-frequency square wave generator. See Table 1 for values of C3.

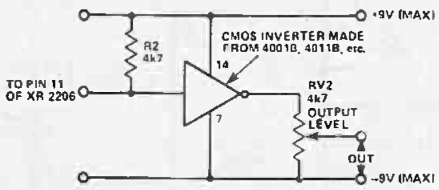


Fig. 7 Add-on variable-amplitude circuit for use with the square wave generator of Fig. 6.

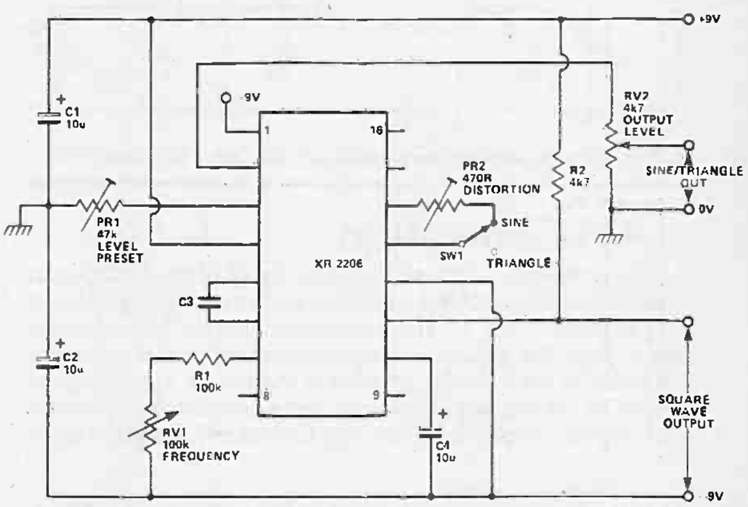


Fig. 8 Simple split-supply sine/triangle/square wave generator. See Table 1 for values of C3.

The XR2206 can be made to produce fixed-amplitude square wave signals at pin 11, either independently or simultaneously with sine or triangle waveforms, by wiring 4k7 load resistor between pins 11 and 4, as shown in the split-supply circuit of Fig. 6. The rise and fall times of the square wave output signals are typically 250 ns and 50 ns respectively when pin 11 is loaded by 10pF. Figure 7 shows how a simple CMOS inverter stage can be used as a buffer between pin 11 and the final square wave output, to give a variable amplitude with improved rise and fall times.

Naturally, the basic sine, triangle and square wave generator circuits of Figs. 2 to 6 can be combined in a variety of ways to make multi-function waveform generators. Figure 8 for example, shows how various circuits can be combined to make a simple split-supply sine/triangle/square generator. Here, the fixed-amplitude square wave is taken directly from pin 11 of the IC and is produced simultaneously with the variable-amplitude sine or triangle waveforms, which are selected by SW1.

Pulse And Ramp Generation

All of the circuits that we've looked at so far produce symmetrical output waveforms. The XR2206 can be made to produce non-symmetrical waveforms, such as ramp, sawtooth and pulse waveforms, by shorting the pin 9 FSK terminal to the pin 11 terminal, as shown in Fig. 9. Thus the circuit uses R1-RV1 to time one half of the waveform, and R2-RV2 to time the remaining half of the waveform.

The Fig. 9 circuit produces a variable-amplitude variable-slope ramp output waveform from the slider of RV3, and a simultaneous fixed-amplitude pulse or variable mark/space ratio rectangle waveform from pin 11. The rise and fall (or on and off) periods of the waveforms can be independently controlled by RV1 and RV2 and can each be varied over a 100:1 range, giving a total mark/space ratio range of 100:1 to 1:100.

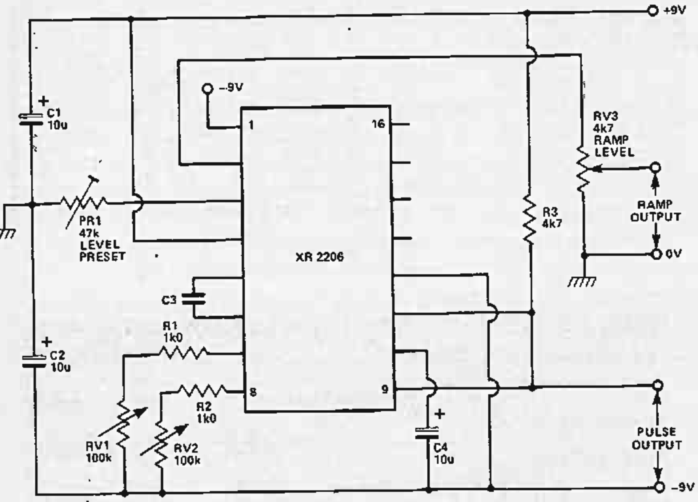


Fig. 9 Variable pulse and ramp generator circuit. See Table 1 for values of C3.

AM Generation

The amplitude of the pin 2 output signal of the XR2206 can be modulated by applying a DC bias and a modulating signal to pin 1 as shown in Fig. 10. The amplitude of the pin 2 signal varies linearly with the applied voltage on pin 1 when this voltage is within 4 V of the half-supply value of the circuit; in split-supply circuits, of course, the half-supply value equals 0 V. When the pin 1 voltage is reduced below the half-supply value the pin 2 signal again rises in direct proportion, but the phase of the output signal is reversed. This last-mentioned phenomenon can be used for phase-shift keyed (PSK) and suppressed carrier AM generation.

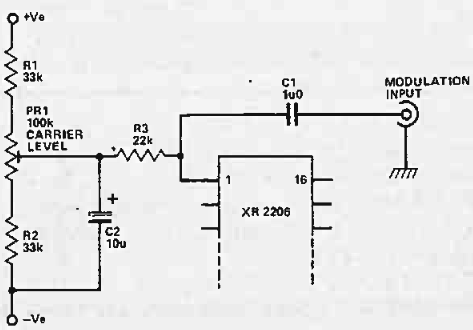


Fig. 10 Add-on AM facility for a split-supply circuit.

The pin 1 terminal of the IC can also be used to facilitate gate-keying or pulsing of the pin 2 output signal. This can be achieved by biasing pin 1 to near half-supply volts to give zero output at pin 2, and then imposing the gate or pulse signal on pin 1 to raise the pin 2 signal to the desired turn-on amplitude. The total dynamic range of amplitude modulation is 55 dB.

FM And Frequency-Sweeping

The frequency of oscillation of the XR2206 is proportional to the total timing current (I_T) drawn from pin 7 or 8 and is given by

$$f = \frac{320 \times I_T}{C} \text{ Hz}$$

where I_T is in milliamps and C is in microfarads.

The timing terminals (pin 7 and 8) are low-impedance points and are internally biased at 3 V with respect to pin 12. The frequency varies linearly with I_T over the current range 1 uA to 3 mA. Consequently, the frequency can be voltage-controlled by applying a voltage in the range 0 to +3 V between pin 12 and the timing terminal via a suitable resistor, so that the timing current is determined by the resistor value and the *difference* between the internal (+3 V) and external (0 to 3 V) voltages. This simple technique can be used to either frequency-sweep the generated signals using an externally applied sawtooth waveform, or to frequency-modulate the waveforms with an external signal.

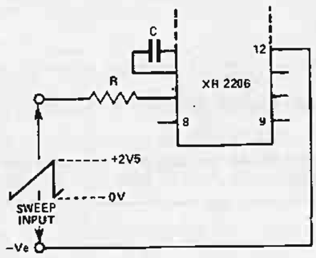


Fig. 11 Frequency-sweep circuit giving a 6:1 frequency range.

Figure 11 shows the basic connections of a simple frequency-sweep circuit with a 6:1 range of frequency coverage. The external sawtooth has a peak amplitude of 2V5: when the amplitude is zero, 3 V is developed across R and the frequency is 1/RC, as in the case of a normal resistance-controlled XR2206 circuit. When the sawtooth is at its peak amplitude of 2V5, only 0V5 is developed across R and the frequency falls to 1/6RC. The frequency is thus determined by the instantaneous value of the sawtooth voltage. The frequency can, in theory, be varied over 2000:1 range by using this simple frequency-sweep technique.

Finally, Fig. 12 shows the basic method of applying FM to the standard XR2206 circuit. Here, the external modulation signal is applied to the junction of R1-RV1 via blocking capacitor C1.

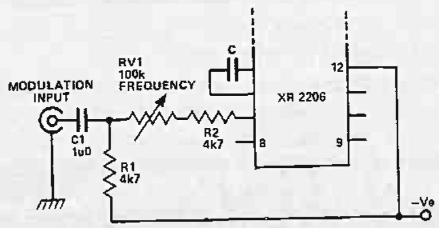


Fig. 12 Simple FM facility for the XR2206.

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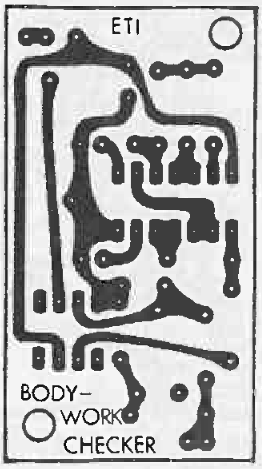
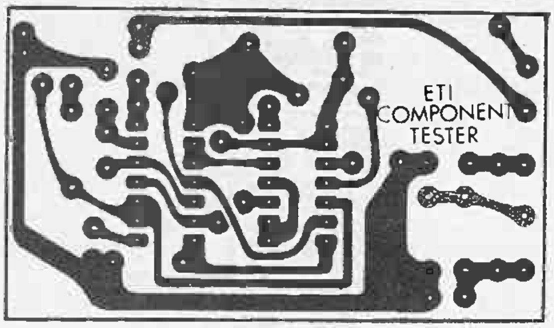
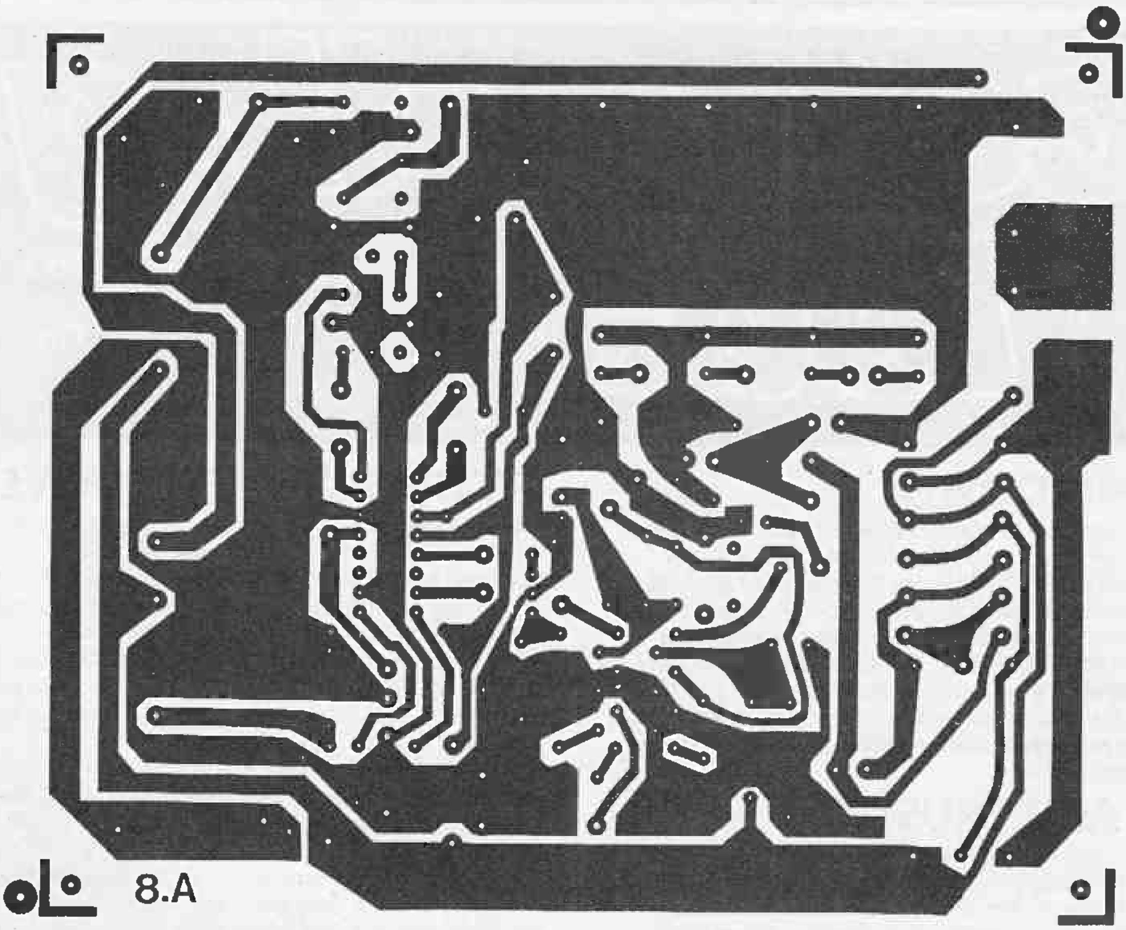


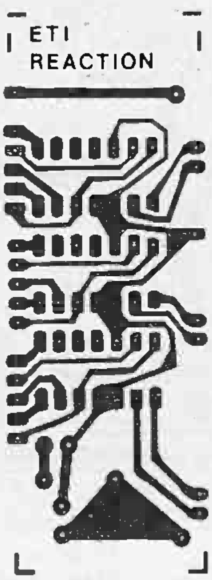
Above: Foil pattern for the Bodywork Checker.
Below: The board for the TV Sound Tuner.

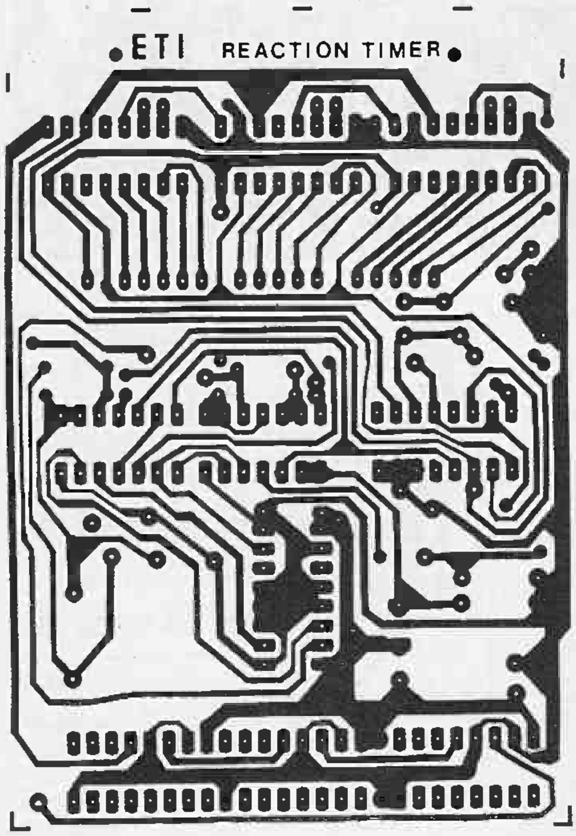


Above: Component Tester PCB.



The two foil patterns for the Alcohometer.





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Hobby Electronics

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We've got lots of projects to interest musicians next month:

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Car Electronics

There's no doubt that, although car manufacturers, overall, tend to be slow to change their ideas about the equipment that goes into their cars, they are at last waking up to the fact that electronics has a large part to play.

Guest writer Bill Mitchell tells you about the possibilities and probabilities of in-car electronics.

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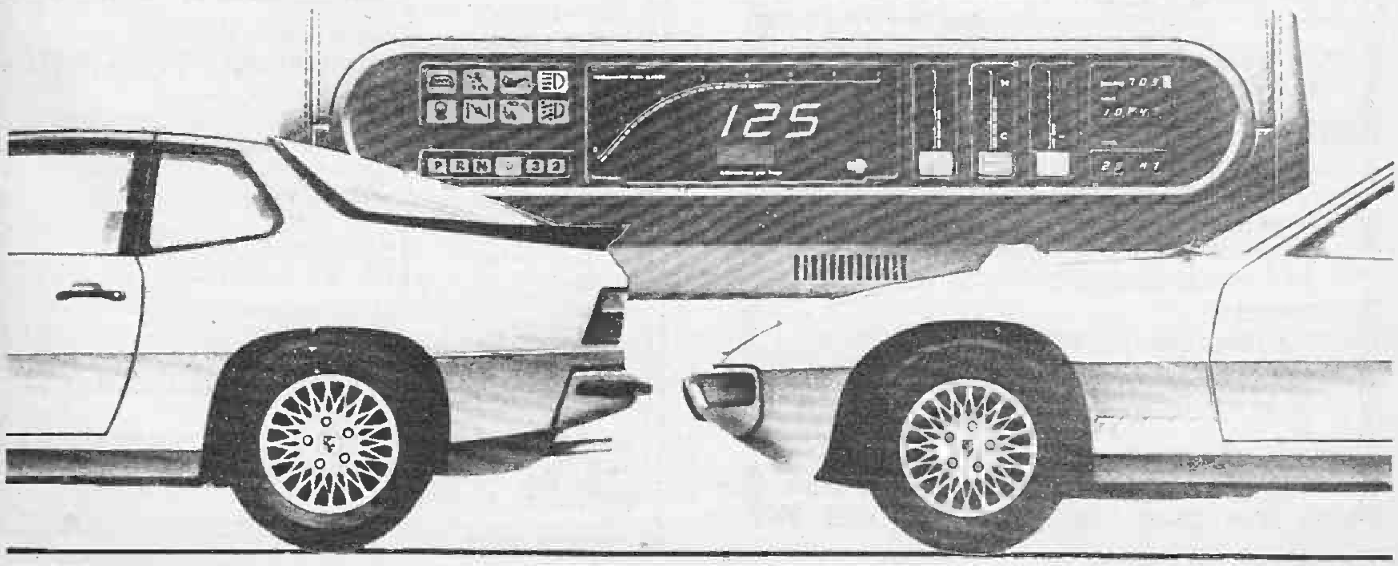

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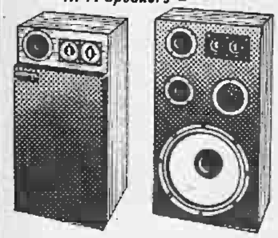

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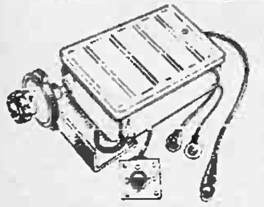

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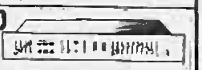

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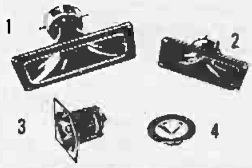

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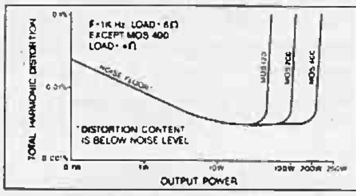

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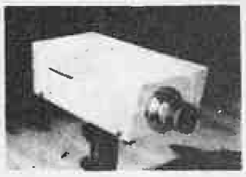

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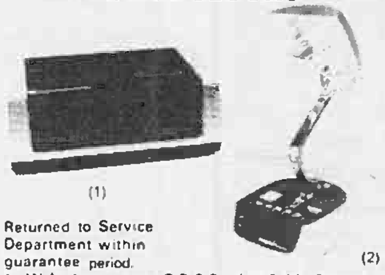

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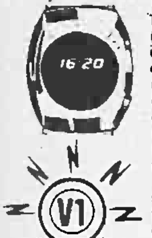

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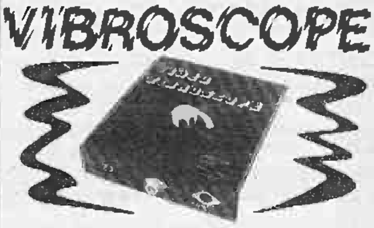

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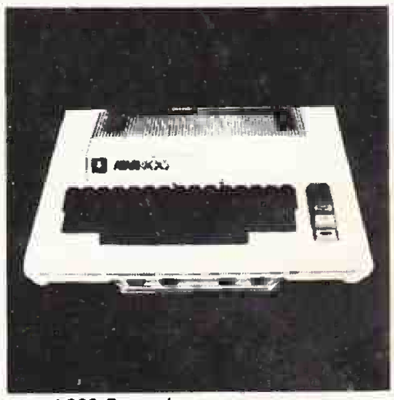

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