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PRACTICAL ELECTRONICS

NOVEMBER 1981

75p

Build our PE ROBOTS

FREE! ELECTROVALUE 64 PAGE CATALOGUE

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PRACTICAL
ELECTRONICS
VOLUME 17 No. 11 NOVEMBER 1981

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

OUR DECEMBER ISSUE WILL BE ON SALE FRIDAY, 13 NOVEMBER

(for details of contents see page 65)

SPEAKERS
8Ω, 0·3W, 2"; 2·25", 2·5", 3" **80p**
0·3W, 2·5" 40Ω; 64Ω or 80Ω **80p**

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OPTO SWITCH
TIL139 **170**

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Green/Yellow	**65**
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0·2" Red High Bright	**59**
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ORP12	**86**
LD271 Infra Red (emit)	**46**
TIL32 Infra Red (emit)	**52**
SFH205 (detector)	**91**
TIL78 (detector)	**54**

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AA119	**15**
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BY126	**12**
BY127	**12**
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OA47	**12**
OA70	**12**
OA79	**15**
OA85	**15**
OA90	**8**
OA91	**8**
OA95	**8**
OA200	**8**
OA202	**8**
1N914	**4**
1N916	**5**
1N4001/2	**5**
1N4003	**6**
1N4004/5	**6**
1N4006/7	**7**
1N4148	**4**
1N5401	**15**
1N5404	**16**
1N5406	**17**
1N5408	**19**
1S44	**9**
1S921	**9**
6A/100V	**40**
6A/400V	**50**
6A/800V	**65**

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(plastic case)

1A/50V	**20**
1A/100V	**22**
1A/400V	**29**
1A/600V	**34**
2A/50V	**35**
2A/200V	**40**
2A/400V	**46**
2A/600V	**65**
6A/100V	**83**
6A/400V	**95**
6A/600V	**125**
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10A/600V	**350**
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Noise Diode
Z5J **195**

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1A/400V	**70**
5A/300V	**38**
5A/400V	**40**
5A/600V	**48**
8A/300V	**60**
8A/600V	**95**
12A/100V	**78**
12A/400V	**95**
12A/800V	**188**
BT106	**150**
BT116	**180**
C106D	**38**
TIC44	**24**
TIC45	**29**
TIC47	**35**
2N5062	**32**
2N5064	**38**
2N4444	**130**

TRIACS

3A/100V	**48**
3A/400V	**56**
3A/800V	**85**
8A/100V	**60**
8A/400V	**69**
8A/800V	**115**
12A/100V	**78**
12A/400V	**82**
12A/800V	**135**
16A/100V	**103**
16A/400V	**105**
16A/800V	**220**
25A/400V	**185**
25A/800V	**295**
25A/1000V	**480**
30A/400V	**525**
T2800D	**120**

DIAC
ST2 **25**

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	Low profile	Wire wrap
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14 pin	**10p**	**35p**
16 pin	**10p**	**42p**
18 pin	**16p**	**52p**
20 pin	**22p**	**60p**
22 pin	**25p**	**70p**
24 pin	**25p**	**70p**
28 pin	**28p**	**80p**
36 pin	—	**105p**
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16 pin	**49**
24 pin	**88**
40 pin	**255**

Ribbon Cable ft.
10 way **22p**
20 way **40p**

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ZERO Insertion Force DIL Sockets
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	Plugs	Sockets	Covers plastic
9 way	**95p**	**125p**	**145p**
15 way	**135p**	**198p**	**150p**
25 way	**170p**	**250p**	**130p**
37 way	**290p**	**398p**	**185p**

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Jumper Lead Cable Assembly.

18" long, single end, Male	**520**
18" long, single end, Female	**525**
36" long, double ended M/M	**1020**
36" long, double ended F/F	**1010**
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14	**275**
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36	**£12**
40	**£13**

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	·1	·156
2×10 way	—	**135p**
2×15 way	—	**140p**
2×18 way	**180p**	**145p**
2×22 way	**199p**	**200p**
2×25 way	**225p**	**220p**
2×30 way	**245p**	—
2×36 way	**295p**	—
2×40 way	**315p**	—
2×43 way	**395p**	—

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6-0-6V 100mA; 9-0-9V 75mA; 12-0-12V 75mA **98p**
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50VA: 6V-4A 6V-4A; 9V-2·5A 9V-2·5A; 12V-2A 12V-2A; 15V-1·5A 15V-1·5A; 20V-1·2A 20V-1·2A; 25V-1A 25V-1A; 30V-·8A 30V-·8A **395p** (60p p&p)
100VA: 12V-4A 12V-4A; 15V-3A 15V-3A; 20V-2·5A 20V-2·5A; 30V-1·5A 30V-1·5A; 40V-1·25A 40V-1·25A; 50V-1A 50V-1A **920p** (60p p&p)
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JUMPER LEADS Ribbon Cable Assembly
Single ended DIP, 24" length Cable
14 pin **145p** 16 pin **165p;**
24 pin **240p;** 40 pin **380p.**
Double ended DIP

	14 pin	16 pin	24 pin	40 pin
6"	**185p**	**205p**	**300p**	**465p**
12"	**198p**	**215p**	**315p**	**490p**
24"	**210p**	**235p**	**345p**	**540p**
36"	**230p**	**250p**	**375p**	**595p**

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1A	T03	+ve		−ve	
5V	7805	**145p**	7905	**220p**
12V	7812	**145p**	7912	**220p**
15V	7815	**145p**	7915	**220p**
18V	7818	**150p**	—	
1A	T0220 Plastic Casing			
5V	7805	**50p**	7905	**55p**
12V	7812	**50p**	7912	**55p**
15V	7815	**50p**	7915	**55p**
18V	7818	**50p**	7918	**55p**
24V	7824	**50p**		
100mA	T092 Plastic Casing			
5V	78L05	**30p**	79L05	**60p**
6V	78L62	**30p**	—	
8V	78L82	**30p**	—	
12V	78L12	**30p**	79L12	**60p**
15V	78L15	**30p**	79L15	**60p**

		LM309K	**135**
LM300H	**170**	LM309KP	**99**
LM304H	**160**	LM317H	**280**
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78H05 5V/5A	**550p**	LM323K	**625**
78HG+5 to +24V 5A	**650p**	LM326N	**240**
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		TBA625B	**75**

SWITCHES

SLIDE 250V

1A DPDT	**14**
1A DPDT C/OFF	**15**
½A DP on/on/on	**40**

TOGGLE 2A 250V

SPST	**33**
DPDT	**44**
4 pole on off	**54**

PUSH BUTTON Spring loaded
Latching or Momentary 6A

SPDT c/over	**99**
DPDT c/over	**145**

MINIATURE Non Locking

Push to make	**15p**
Push break	**25p**

SUB-MIN TOGGLE

SP changeover	**60**
SPST on off	**54**
SPDT c/off	**85**
SPDT Biased	**105**
DPDT 6 tags	**75**
DPDT C/OFF	**88**
DPDT Biased	**145**
3 pole c/over	**205**

ROCKER: 5A, 250V, SPST **28p**
ROCKER: (white) 10A 250V SPDT changeover **38p**
ROCKER: With neon lights red when on. 10A 250V, DPST **85p**
ROCKER: (White) 10A/250V DPDT **72p**
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Accommodates up to 6 Wafers **90p**
Break before make Wafers. Silver contacts. 1 pole/12 way; 2 pole/6 way; 3 pole/4 way; 4 pole/3 way; 6 pole/2 way **65p**
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Screen & Spacers **6p**
ROTARY: (Adjustable Stop Type)
1 pole/2 to 12 way, 2p/2 to 6 way, 3 pole/2 to 4 way, 4 pole/2 to 3 way **45p**
ROTARY: Mains 250V AC, 4 Amp **56p**
DIL Switches: (SPST) 4 way **70p;** 6 way **85p;** 8 way **90p;** 10 way **145p;** (SPDT) 4 way **190p.**

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200KHz	**295**
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1MHz	**295**
1·28MHz	**392**
1·6MHz	**323**
1·8MHz	**323**
1·008M	**290**
1·8432M	**220**
2·0MHz	**240**
2·4576M	**220**
3·2768M	**220**
3·57954M	**150**
3·6864M	**300**
4·0MHz	**200**
4·032MHz	**290**
4·80MHz	**200**
4·194304M	**200**
4·433619M	**120**
5·0MHz	**200**
5·185MHz	**300**
5·24288M	**390**
6·0MHz	**220**
6·144MHz	**240**
6·5536MHz	**200**
7·0MHz	**200**
7·168MHz	**250**
7·68MHz	**200**
8·0MHz	**200**
8·867237M	**240**
9·00MHz	**200**
10·0MHz	**200**
10·7MHz	**220**
10·24MHz	**200**
12·0MHz	**290**
14·31818M	**320**
16·0MHz	**275**
18·0MHz	**240**
18·432M	**240**
19·968MHz	**325**
24·0MHz	**200**
26·69M	**290**
27·648M	**330**
27·145M	**240**
38·66667M	**290**
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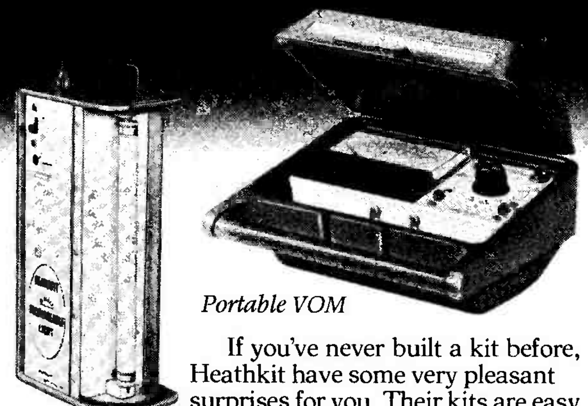

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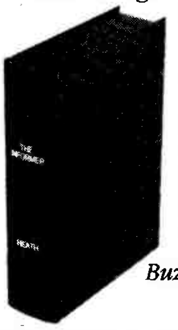

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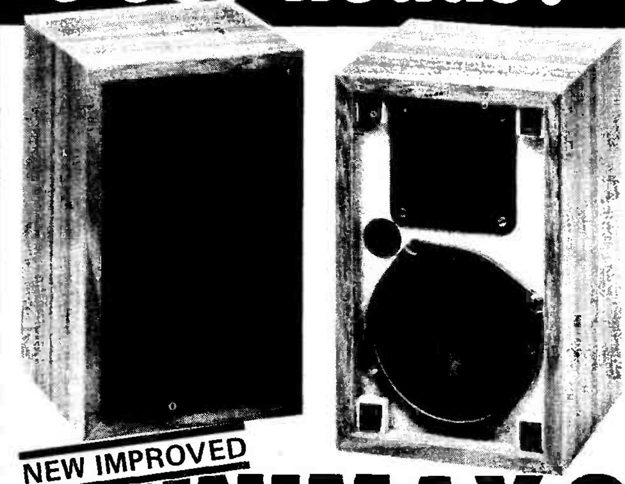

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Recommended amplifier power: 10 to 40 watts rms into 8 ohms.
Frequency Response: 80Hz – 20KHz ±5dB.
Finish: natural teak, veneer with black frets.
Size: 10 7/8" high, 6 3/4" wide, 7 1/2" deep.
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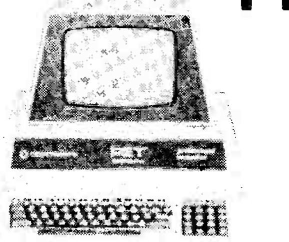

4016 16K RAM
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4022 80 column tracks feed.
3023 80 column friction feed.
C2N Cassette Unit.

For the business man we stock the 8000 range inc. 8032 and 8050 with daisy wheel printers coming soon.

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Utilises Z80, 12K level II Basic, Integral Cassette Deck, UHF O/P, 16K RAM, all TRS80 features. Simply plugs into monitor or UHF TV. With V.U. Meter.

NEW **VIDEO GENIE II** *NOW AVAILABLE*	£299.00
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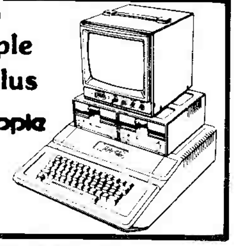
Accessory Cards, Software All Available – Phone for details.

Apple II plus



PRINTERS

Interfaces and Cables for APPLE II, PET, TRS80, RS 232, UK101, SHARP SUPERBOARD All Available

EPSON MX80 £359
Dot-matrix printer with Pet graphics interface. Centronics parallel and serial. Pet and Apple compatible. True bidirectional, 80 cps.

EPSON MX80 FT/1 £399
Dual single sheet friction and tractor, 9 wire head, true descenders.

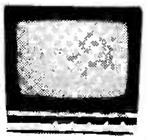
EPSON MX80 FT/2 £449
An FT/1 with high resolution graphics.

EPSON MX100 £575
Friction and tractor feed, high resolution graphics, wide carriage 15½".

SEIKOSHA GP80A £199
Dot matrix 5 × 7, 80 columns 30 cps. graphics, double width characters.

MONITORS

MON 10" (illust) B&W	£82.00
9" Green Monitor	£98.00
Hitachi professional monitors	
9" Black & White	£99.95
12" Black & White	£149.00



UK101 (DOWN IN PRICE)

UK 101 Kit **inc. 8K Memory**	£125
Ready Built **inc. 8K Memory**	£175
Complete in case	£199
4K Expansion 8×2114	£14
Memory Expansion Kit	
8K	£79.95
16K	£106.95
Printer Interface	£29.95
Sound generator plus PIO Kit	£29.95
Cases	£24.50

NEW

Chromasonics Sound Kit	£24.95
Colour Kit	£84.95

Inc. Demo Tape & Full Documentation. Send for details.

VIC 20

Colours
24 total. 8 for characters, 8 for border, 16 for screen mixed as you wish. Basic colours on program keys are black, white, red, blue, light blue, green, yellow, and purple.

Sound
3 Tone Generator for music
"White Noise" Generator for language and sound effects.
Each Generator gives 3 octaves.
Reproduction is through tv speaker.

Character/Line Display
22 Characters by 23 lines
64 ASCII characters, pet-type graphic character set.

Keyboard
DIN typewriter keyboard with 8 programmable function possibilities via 4 special function keys. Colours are directly addressable from the keyboard.

Peripherals/Accessories
VIC Datacassette with special interface to guarantee high reliability read/write quality (PET/CBM compatible).

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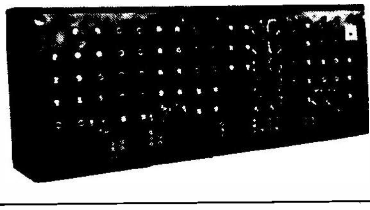
D.I.Y. KITS FOR SYNTHESISERS, SOUND EFFECTS



BASIC COMPONENTS SETS include all necessary resistors, capacitors, semiconductors, potentiometers and transformers. Hardware such as cases, sockets, knobs, keyboards, etc. are not included but most of these may be bought separately. Fuller details of kits PCBs and parts are shown in our lists.

LAYOUT DIAGRAMS are supplied free with all PCBs unless "as published".

PHONOSONICS

MAIL ORDER SUPPLIERS OF QUALITY PRINTED CIRCUIT BOARDS, KITS AND COMPONENTS TO A WORLD-WIDE MARKET

P.E. MINISONIC MK2 SYNTHESISER

A portable mains operated miniature sound synthesiser with keyboard circuits. Although having slightly fewer facilities than the large Formant synthesiser the functions offered by this design give it great scope and versatility. 3 Oct KBD & GJ contacts needed.

Set of basic component kits (excl.KBD R's & tuning pots – see list for options available) and PCBs (incl. layout charts) KIT 38-25 **£80.14**
"Sound Design" booklet **£1.00**
Knobs, skts, sw's See our list

P.E. 128-NOTE SEQUENCER

Enables a voltage controlled synthesiser to automatically play pre-programmed tunes of up to 32 pitches and 128 notes long. Programs are keyboard initiated and note length and rhythmic pattern are externally variable. 4 Oct KBD and GJ contacts needed.

Set of basic comps, PCBs and charts	KIT 76-7	**£35.56**
Set of text photocopies	TEXT 76	**£1.36**
Knobs, sets, sw's	HW 76	**£6.62**

P.E. 16-NOTE SEQUENCER

Sequences of up to 16 notes may be programmed by the panel controls and fed into most voltage controlled synthesisers.

Set of basic comps, PCBs and charts	KIT 86-5	**£32.10**
Set text photocopies	TEXT 86	**£1.84**
Knobs, sets, sw's	HW 86	**£11.15**

P.E. STRING ENSEMBLE

A multivoiced polyphonic string instrument synthesiser.

Set of basic comps, PCBs & charts	KIT 77-8	**£109.72**

ELEKTOR CHOROSYNTH

A 2½-octave Chorus synthesiser with an amazing variety of sounds ranging from violin to cello and flute to clarinet amongst many others. Experienced constructors can readily extend the octave coverage. 3 Oct KBD and GJ contacts needed.

Basic comps, PCBs and charts	KIT 100-8	**£44.39**
Text photocopy	TEXT 100	**70p**
Knobs, skts, sw's	HW 100	**£11.55**

ELEKTOR FORMANT SYNTHESISER

A very sophisticated synthesiser for the advanced constructor who puts performance before price.

Set of basic comps, PCBs (as publ.)	KIT 66-14	**£255.45**
Set of text photocopies	TEXT 66	**£7.83**
Knobs, skts, sw's		See our list

ELEKTOR DIGITAL REVERB UNIT

A very advanced unit using sophisticated i.c. techniques instead of mechanical spring lines. The basic delay range of 24 to 90mS can be extended up to 450mS using the extension unit. Further delays can be obtained using more extensions.

Main unit basic comps and PCB (as publ.)	KIT 78-3	**£49.95**
Extension unit comps and PCB	KIT 78-4	**£39.95**
Text photocopy	TEXT 78	**86p**
Knobs, skts, sw's	HW 78	**£2.94**

ELEKTOR ANALOGUE REVERB

Using i.c.s instead of spring-lines the main unit has a maximum delay of up to 100mS, and the additional set extends this up to 200mS. May be used in either mono or stereo mode.

Main unit basic component set	KIT 83-4	**£29.23**
Additional Delay basic components	KIT 83-2	**£20.07**
PCB (as publ.) to hold both kits included in Kit 83-4		
Text photocopy	TEXT 83	**67p**
Knobs, skts, switch	HW 83	**£2.84**

ELEKTOR SEWAR

For use with Elektor Analogue Reverb to give greater flexibility to the reverb effects.

Basic comps, PCB (as publ.)	KIT 101-1	**£18.19**
Text photocopy	TEXT 101	**60p**
Knobs, skts, switch	HW 101	**£2.44**

NEW KITS

EE 3-CHAN STEREO MIXER

Full level control on left and right of each channel, and with master output control and headphone monitor.

Basic comps, PCB & chart	KIT 107-1	**£8.61**
Text photocopy	TEXT 108	**65p**
Knobs, skts & sw's	HW 107	**£3.19**

3-MICROPHONE STEREO MIXER

Enables stereo live recordings to be made without the 'hole in the middle' effect. Independent control of each microphone.

Basic comps, PCB & chart	KIT 108-1	**£5.41**
Text photocopy	TEXT 108	**55p**
Knobs, skts, & sw's	HW-108	**£2.55**

E.E. HEADPHONE AMPLIFIER

For use with magnetic, ceramic or crystal pick-ups, tapedeck or tuner, and for most headphones. Designed with RIAA equalisation.

Basic comps, PCB & chart	KIT 104-1	**£9.79**
Text photocopy	TEXT 104	**85p**
Knobs, & sockets	HW 104	**£2.50**

E.E. AUDIO EFFECTS UNIT

A variable siren generator that can produce British & American police sirens, Star Trek, Red Alert, heart-beat monitor sounds, etc.

Basic comps, PCB & chart	KIT 105-1	**£4.87**
Text photocopy	TEXT 105	**65p**
Knobs, skts & switch	HW 105	**£1.91**

GUITAR PRACTISE AMPLIFIER

A 3 watt mains powered amplifier suitable for instrument practise or as a test gear monitor. Drives 8 or 15 ohm loudspeaker.

Basic comps, PCB & chart	KIT 106-1	**£9.81**
Text photocopy	TEXT 106	**65p**
Knobs, skts, switch	HW 106	**£2.02**

SIGNAL TRACER & GENERATOR

Allows audio signals to be injected into circuits under test, and for tracing their continuity. Includes frequency & level controls.

Basic comps, PCB & chart	KIT 109-1	**£5.80**
Text photocopy	TEXT 109	**55p**
Knobs, skts, sw's & probes	HW 109	**£3.17**

P.E. GUITAR SUSTAIN

Maintains the natural attack whilst extending note duration.

Basic comps, PCB & chart	KIT 75-1	**£6.99**
Text photocopy	TEXT 75	**38p**
Knobs & sets	HW75	**91p**

P.E. AUTO-WAH UNIT

Automatically give Wah or Swell sounds with each note played.

Basic comps, PCB & chart	KIT 58-1	**£10.11**
Text photocopy	TEXT 58	**58p**
Knobs & skts	HW58	**£1.26**

ELEKTOR WAVEFORM CONVERTER

Converts a saw-tooth waveform into sinewave, mark-space sawtooth, regular triangle, or square-wave with variable mark-space.

Basic comps, PCB & chart, but excl. sw's	KIT 67-1	**£9.24**
Knobs, skts, sw's	HW 67	**£4.23**

P.E. SWITCHED TONE TREBLE BOOST

Provides switched selection of 4 preset tonal responses.

Basic comps, PCB & chart	KIT 89-1	**£4.34**
Text photocopy	TEXT 89	**78p**
Knobs, skts, sw's	HW 89	**£1.89**

ELEKTOR RING MODULATOR

Compatible with the Formant & most other synthesisers.

Set of basic comps & PCB (as publ.)	KIT 87-2	**£6.84**
Text photocopy	TEXT 87	**38p**
Knob, skt	HW 87	**75p**

ELEKTOR FUNNY TALKER

Incorporates a ring modulator, chopper & frequency modulator to produce a fascinating sounds when used with speech & music.

Basic comps, PCB (as publ.)	KIT 99-1	**£9.60**
Text photocopy	TEXT 99	**40p**
Knobs & skts	HW 99	**£1.22**

ELEKTOR FREQUENCY DOUBLER

For use with guitars & other electronic instruments to produce an output one octave higher than the input. Inputs and outputs may be mixed to give greater depth.

Basic comps, PCB (as publ.)	KIT 98-1	**£5.48**
Text photocopy	TEXT 98	**20p**
Knobs & skts	HW 98	**£1.24**

P.E. SPLIT-PHASE TREMOLO

A simple but effective substitute for a rotary cabinet. The output of an internal generator is phase-split and modulated by an input signal from an electronic guitar or other instrument. Output amplitudes, depth & rate are variable. May be fed to one or two amplifiers.

Basic comps, PCB & chart	KIT 101-3	**£17.68**
Text photocopy	TEXT 102	**65p**
Knobs & skts	HW 102	**£2.53**

P.E. MINISONIC WAVEFORM CONVERTER

A simple converter that modifies the Minisonic sawtooth waveform to produce triangle and sine outputs. Ideally one should be used with each Minisonic VCO.

Basic comps, PCB & chart	KIT 96-1	**£3.98**
Knob, skts, switch	HW 96	**99p**

P.E. GUITAR MULTIPROCESSOR

An extremely versatile sound processing unit capable of producing, for example, flanging, vibrato, reverb, fuzz and tremolo as well as other fascinating sounds. May be used with most electronic instruments.

Basic comps, PCB & charts (excl. SWs)	KIT 85-5	**£49.23**
Set of text photocopies	TEXT 85	**£2.52**
Knobs, skts, sw's		See our list

P.E. PHASER

An automatically controlled 6-stage phasing unit with integral oscillator.

Basic comps, PCB & chart	KIT 88-1	**£10.91**
2-Notch extension, PCB & chart	KIT 88-2	**£6.36**
Text photocopy	TEXT 88	**68p**
Knobs, skts, switch	HW 88	**£1.63**

ELEKTOR PHASING & VIBRATO

Includes manual and automatic control over the rate of phasing & vibrato. Slightly modified to also include a 2-input mixer stage.

Set of basic comps, PCB & chart	KIT 70-2	**£21.67**
Text photocopy	TEXT 70	**67p**
Knobs, skts, sw's	HW 70	**£3.27**

P.E. GUITAR EFFECTS UNIT

Modulates the attack, decay and filter characteristics of a signal from most audio sources, produ ing 8 different switchable effects that can be further modified by manual controls.

Basic comps, PCB & chart	KIT 42-4	**£7.68**
Text photocopy	TEXT 42	**28p**
Knobs & skts	HW 42	**£1.85**

P.E. GUITAR OVERDRIVE

Sophisticated versatile fuzz unit incl. variable controls affecting the fuzz quality whilst retaining attack and decay, and also providing filtering. Usable with most electronic instruments.

Basic comps, PCB & chart	KIT 56-3	**£11.22**
Text photocopy	TEXT 56	**68p**
Knobs & skts	HW 56	**£2.29**

P.E. SMOOTH FUZZ

Basic comps, PCB & chart	KIT 91-1	**£6.52**
Text photocopy	TEXT 91	**55p**
Knobs & skts	HW 91	**£1.22**

WE ALSO SELL COMPONENTS ASK FOR OUR LIST

ADD: POST & HANDLING
U.K. orders: Keyboards add £2.70 each. Other goods: Under £5 add 50p, under £20 add 75p, over £20 add £1. Recommended insurance against postal mishaps: add 50p for cover up to £50, £1 for £100 cover, etc., pro-rata Insurance must be added for credit card orders.
N. B. Eire, C.I., B.F.P.O and other countries are subject to higher export postage rates.

ADD 15% VAT
(or current rate if changed). Must be added to full total of kits, discount post & handling on all U.K. orders. Does not apply to Exports, or photocopies.

EXPORT ORDERS ARE WELCOME but to avoid delay we advise you to see our list for postage rates. All payments must be cash-with-order, in Sterling by International Money Order or through an English Bank. To obtain list – Europe send 50p, other countries send £1.00.
Note that we do not offer a C.O.D. service and that our terms are payment in advance.

PHONOSONICS · DEPT PE16 · 22 HIGH STREET · SIDCUP · KENT DA14 6EH

TERMS: C.W.O., MAIL ORDER OR COLLECTION BY APPOINTMENT (TEL 01-302 6184)

AND OTHER PROJECTS

PHOTOGRAPHS in this advertisement show two of our units containing some of the P.E. projects built from our kits and PCBs. The cases were built by ourselves and are not for sale, though a small selection of other cases is available.

LIST—Send stamped addressed envelope with all U.K. requests for free list giving fuller details of PCBs, kits and other components.

OVERSEAS enquiries for list Europe—send 50p: other countries—send £1.00.

KIMBER-ALLEN KEYBOARDS AND CONTACTS

KIMBER-ALLEN KEYBOARDS as required for many published projects. The manufacturers claim that these are the finest moulded plastic keyboards available. All octaves are C to C, the keys are plastic, spring-loaded, fitted with actuators, and mounted on a robust aluminium frame.

3 Octave (37 notes) **£25.50** 4 Octave (49 notes) **£32.25** 5 Octave (61 notes) **£39.75**

CONTACT ASSEMBLIES (gold-clad wire) – 1 required for each KBD note:
Type GJ – SPCO **33p** ea. Type GB – 2 pr N/O **37½p** ea.

P.E. 6-CHANNEL MIXER

A high specification stereo mixer with variable input impedances

Basic comps & PCB's	KIT 90-8	**£56.43**
Extra 2-channel set with PCB	KIT 90-9	**£10.21**
Set of Text photocopies	TEXT 90	**£1.50**
Knob, skts, sw's		See our list

RHYTHM GENERATORS

Several available, including programmable 16 beat 64000 pattern, and pre-programmed 15 pattern using either M252 or M253 rhythm chips. A selection of effects instruments circuits is also available.

WIND & RAIN EFFECTS UNIT

A slightly modified version of the original P.E. unit.

Basic comps, PCB & chart	KIT 28-1	**£4.84**
Text photocopy	TEXT 28	**28p**
Knobs, skts, sw's	HW 28	**£1.65**

P.E. ENVELOPE SHAPER WITH VCA

Has an integral Voltage Controlled Amplifier, and has full manual control over the A.D.S.R. functions.

Basic comps, PCB & chart	KIT 50-1	**£8.03**
Text photocopy	TEXT 50	**58p**
Knobs, skts	HW50	**£1.32**

P.E. TRANSIENT GENERATOR

An ADSR envelope shaper without VCA, and additionally providing Repeat-triggering enabling a synthesiser to be programmed for mandolin of banjo effects.

Basic comps, PCB & chart	KIT 63-2	**£7.62**
Text photocopy	TEXT 63	**58p**
Knobs, skts	HW63	**£1.82**

P.E. EXTERNAL-INPUT SYNTHESISER-INTERFACE

Allows external inputs such as guitars, microphone etc., to be processed by synthesiser circuits.

Basic comps, PCB & chart	KIT 81-1	**£3.90**
Knobs, sets	HW 81	**£1.18**

P.E. TUNING FORK

Produces 84 switch-selected frequency-accurate tones with an LED monitor clearly displaying beat-note adjustments.

Set of basic comps, incl. power supply. PCBs & charts	KIT 46-3	**£23.32**
Text photocopy	TEXT 46	**97p**
Knobs, skts, sw's	HW 46	**£2.89**

P.E. TUNING INDICATOR

A simple octave frequency comparitor for use with synthesisers and other instruments where the full versatility of KIT 46 is not required.

Basic comps, PCB & chart	KIT 69-1	**£8.19**
Text photocopy	TEXT 69	**58p**
Knobs, skts, sw's	HW 69	**£1.56**

DIGITAL EXPOSURE UNIT

Controls up to 750 watts in ½ second steps up to 10 minutes, with built-in audio alarm.

Basic comps, PCBs	KIT 93-3	**£23.45**
Text photocopy	TEXT 93	**£1.20**
Knobs, skts	HW 93	**£2.48**

P.E. DISCOSTROBE

A 4-channel light show controller giving a choice of sequential, random, or full strobe mode of operation.

Basic comps, PCB & chart	KIT 57-3	**£19.37**
Text photocopy	TEXT 57	**78p**
Knobs, skts, sw's	HW 57	**£7.30**

P.E. CONSTANT DISPLAY FREQUENCY COUNTER

A 4-digit counter for 1Hz to 99kHz with 1Hz sampling rate. Readout does not count visibly or flicker due to blanking.

Basic comps, PCB & chart	KIT 79-4	**£31.61**
Text photocopy	TEXT 79	**78p**
Knobs, skts, sw's	HW 79	**£4.67**

P.E. VOICE OPERATED FADER

For automatically reducing music volume during talkover – particularly useful for discos.

Basic comps, PCB & chart	KIT 30-1	**£4.37**
Text photocopy	TEXT 30	**28p**
Skts	HW 30	**32p**

P.E. DYNAMIC NOISE LIMITER

Very effective stereo circuit for reducing the hiss found in most tape recordings.

Basic comps, PCB & chart	KIT 97-1	**£8.07**
Text photocopy	TEXT 97	**75p**

P.E. DYNAMIC RANGE LIMITER

Preset to automatically control sound output levels.

Basic comps, PCB & chart	KIT 62-1	**£5.31**
Skts	HW 62	**44p**

ALL KITS INCLUDE SPECIALLY DESIGNED PRINTED CIRCUIT BOARDS

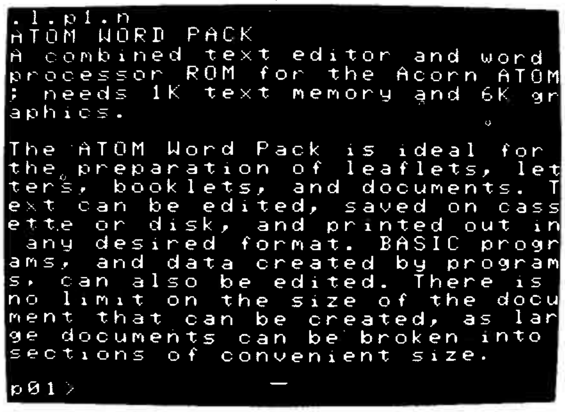
MORE KITS AND COMPONENTS ARE IN OUR LISTS

PRICES ARE CORRECT AT TIME OF PRESS. E. & O. E. DELIVERY SUBJECT TO AVAILABILITY.

PHONOSONICS

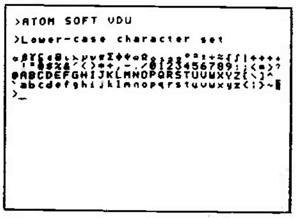
Attention Atom Owners become WORD PERFECT

WITH THE NEW ATOM WORD PACK

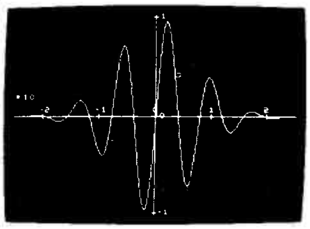


The ATOM word pack is ideal for the preparation of leaflets, letters, booklets and documents. Text can be edited, saved on cassette or disk and then printed out in any desired format. BASIC programs and data created by programs can also be edited. The Word Pack is a 4K ROM which simply plugs into the ATOM's utility ROM socket and adds EDIT and TEXT to the command set. Complete with a 16 page booklet giving full instructions and examples. Just £29.90 including post, packing and insurance.

Also Available:

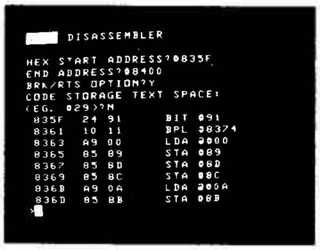


SOFT VDU
The soft VDU replaces the normal ATOM VDU, but provides 128 characters including upper and lower-case letters, and mathematical symbols. Program 1.5K, graphics 6K.



MATHS PACK 1
Plot A versatile graph-plotting package for research, accounting, schools and mathematics, or simply for amusement. Program 5K, graphics 6K.
Simultaneous Solves a set of simultaneous equations, with integer or real coefficients. Program 2K, graphics ½K.
Regression Calculates the best-fitting straight line to a specified set of data points, gives the equation and the correlation coefficient. Program 2K, graphics ½K.

UTILITY PACK 1
Disassembler Lists machine code in standard ATOM assembler form, or stores the assembler text into memory. Graphics 2K.
Fast Cos Modifies the ATOM's standard cassette-interface routines to operate at 1200 baud, or 4 times faster. Program 1K.
Renumber A fast renumber for BASIC or assembler programs, gives display of the numbers for labelled lines. Program 1K.



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Or ring 0223 316039 or 01-930 1614 quoting your Access or Barclaycard number. Allow 14 days for delivery.
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ACORNSOFT

All these advantages...

- Instant all-weather starting
- Smoother running
- Continual peak performance
- Longer battery & plug life
- Improved fuel consumption
- Improved acceleration/top speed
- Extended energy storage

..in kit form

SPARKRITE X5 is a high performance, top quality inductive discharge electronic ignition system designed for the electronics D I Y world. It has been tried, tested and proven to be utterly reliable. Assembly only takes 1-2 hours and installation even less due to the patented 'clip on' easy fitting.

The superb technical design of the Sparkrite circuit eliminates problems of the contact breaker. There is no misfire due to contact breaker bounce which is eliminated electronically by a pulse suppression circuit which prevents the unit firing if the points bounce open at high R P M. Contact breaker burn is eliminated by reducing the current by 95% of the norm.

There is also a unique extended dwell circuit which allows the coil a longer period of time to store its energy before discharging to the plugs. The unit includes built in static timing light, systems function light, and security changeover switch. Will work all rev counters.

Fits all 12 v negative-earth vehicles with coil/distributor ignition up to 8 cylinders.

THE KIT COMPRISES EVERYTHING NEEDED

Die pressed case. Ready drilled, aluminium extruded base and heat sink, coil mounting clips and accessories. All kit components are guaranteed for a period of 2 years from date of purchase. Fully illustrated assembly and installation instructions are included.

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Electronics Design Associates, Dept. PE/11/81
82 Bath Street, Walsall, SW1 3DE. Phone: (0922) 614791

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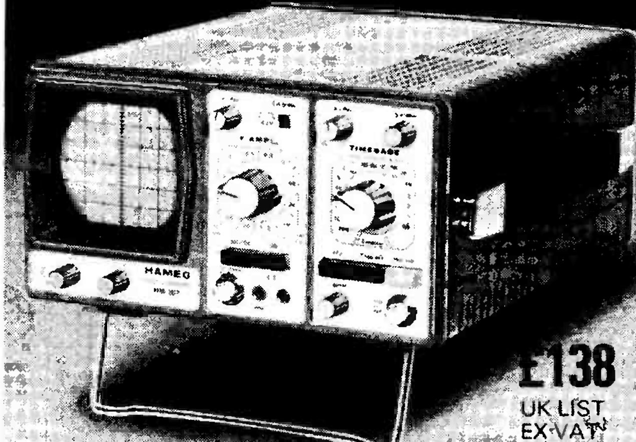
HM307



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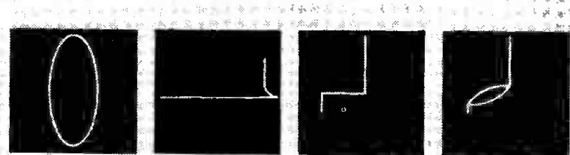
The first portable scope with a component tester.



Capacitor 33 uF | Transistor E-C | Transistor B-E | B-E 1 uF + 68 ohms

Oscilloscope Specifications:

Y Deflection

Bandwidth: DC - 10 MHz (-3dB)
Overshoot: Less than 1%
Sensitivity: 5 mV - 20 V/cm
Input Imp: 1 M ohm // 25pf

X Deflection

Timebase: 0.2s - 0.2 µs/cm
Triggering: 2 Hz - 30 MHz (3mm) Auto + level control
Bandwidth: 2Hz - 1MHz

General Information

Component Tester	For single components and in circuit
Calibrator	0.2V ± 1% for probe alignment
Power Supplies	Regulated including high voltage
A.C. Input	110, 127, 220, 237, V.A.C., 50 - 60 Hz
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Size	4-½"H x 8-3/8"W x 10-7/16"D

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Sinclair ZX81 Personal Comp
the heart of a system that grows with you.

1980 saw a genuine breakthrough – the Sinclair ZX80, world's first complete personal computer for under £100. Not surprisingly, over 50,000 were sold.

In March 1981, the Sinclair lead increased dramatically. For just £69.95 the Sinclair ZX81 offers even more advanced facilities at an even lower price. Initially, even we were surprised by the demand – over 50,000 in the first 3 months!

Today, the Sinclair ZX81 is the heart of a computer system. You can add 16-times more memory with the ZX RAM pack. The ZX Printer offers an unbeatable combination of performance and price. And the ZX Software library is growing every day.

Lower price: higher capability
With the ZX81, it's still very simple to teach yourself computing, but the ZX81 packs even greater working capability than the ZX80.

It uses the same micro-processor, but incorporates a new, more powerful 8K BASIC ROM – the 'trained intelligence' of the computer. This chip works in decimals, handles logs and trig, allows you to plot graphs, and builds up animated displays.

And the ZX81 incorporates other operation refinements – the facility to load and save named programs on cassette, for example, *and* to drive the new ZX Printer.

New BASIC manual

Every ZX81 comes with a comprehensive, specially-written manual – a complete course in BASIC programming, from first principles to complex programs.

Kit: £49.95

Higher specification, lower price – how's it done?
Quite simply, by design. The ZX80 reduced the chips in a working computer from 40 or so, to 21. The ZX81 reduces the 21 to 4!

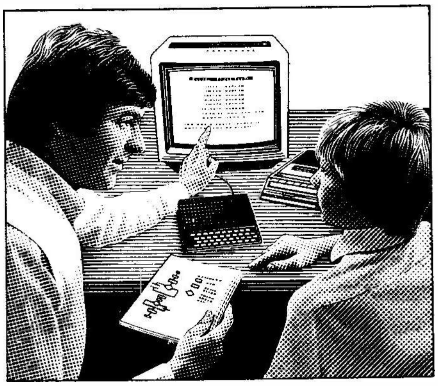
The secret lies in a totally new master chip. Designed by Sinclair and custom-built in Britain, this unique chip replaces 18 chips from the ZX80!

New, improved specification
- Z80A micro-processor – new faster version of the famous Z80 chip, widely recognised as the best ever made.
- Unique 'one-touch' key word entry: the ZX81 eliminates a great deal of tiresome typing. Key words (RUN, LIST, PRINT, etc.) have their own single-key entry.
- Unique syntax-check and report codes identify programming errors immediately.
- Full range of mathematical and scientific functions accurate to eight decimal places.
- Graph-drawing and animated-display facilities.
- Multi-dimensional string and numerical arrays.
- Up to 26 FOR/NEXT loops.
- Randomise function – useful for games as well as serious applications.
- Cassette LOAD and SAVE with named programs.
- 1K-byte RAM expandable to 16K bytes with Sinclair RAM pack.
- Able to drive the new Sinclair printer.
- Advanced 4-chip design: micro-processor, ROM, RAM, plus master chip – unique, custom-built chip replacing 18 ZX80 chips.

Built: £69.95

Kit or built – it's up to you!
You'll be surprised how easy the ZX81 kit is to build: just four chips to assemble (plus, of course the other discrete components) – a few hours' work with a fine-tipped soldering iron. And you may already have a suitable mains adaptor – 600 mA at 9 V DC nominal unregulated (supplied with built version).

Kit and built versions come complete with all leads to connect to your TV (colour or black and white) and cassette recorder.



uter-

Available now-the ZX Printer for only £49.95

Designed exclusively for use with the ZX81 (and ZX80 with 8K BASIC ROM), the printer offers full alpha-numerics *and* highly sophisticated graphics.

A special feature is COPY, which prints out exactly what is on the whole TV screen without the need for further intructions.

At last you can have a hard copy of your program listings – particularly useful when writing or editing programs.

And of course you can print out your results for permanent records or sending to a friend.

Printing speed is 50 characters per second, with 32 characters per line and 9 lines per vertical inch.

The ZX Printer connects to the rear of your computer – using a stackable connector so you *can* plug in a RAM pack as well. A roll of paper (65 ft long x 4 in wide) is supplied, along with full instructions.

16K-byte RAM pack for massive add-on memory.

Designed as a complete module to fit your Sinclair ZX80 or ZX81, the RAM pack simply plugs into the existing expansion port at the rear of the computer to multiply your data/program storage by 16!

Use it for long and complex programs or as a personal database. Yet it costs as little as half the price of competitive additional memory.

With the RAM pack, you can also run some of the more sophisticated ZX Software – the Business & Household management systems for example.

How to order your ZX81

BY PHONE – Access, Barclaycard or Trustcard holders can call 01-200 0200 for personal attention 24 hours a day, every day.

BY FREEPOST – use the no-stamp-needed coupon below. You can pay by cheque, postal order, Access, Barclaycard or Trustcard.

EITHER WAY – please allow up to 28 days for delivery. And there's a 14-day money-back option. We want you to be satisfied beyond doubt – and we have no doubt that you will be.

To: Sinclair Research Ltd, FREEPOST 7, Cambridge, CB2 1YY. **Order**

Qty	Item	Code	Item price £	Total £
	Sinclair ZX81 Personal Computer kit(s). Price includes ZX81 BASIC manual, excludes mains adaptor.	12	49.95	
	Ready-assembled Sinclair ZX81 Personal Computer(s). Price includes ZX81 BASIC manual and mains adaptor.	11	69.95	
	Mains Adaptor(s) (600 mA at 9 V DC nominal unregulated).	10	8.95	
	16K-BYTE RAM pack.	18	49.95	
	Sinclair ZX Printer.	27	49.95	
	8K BASIC ROM to fit ZX80.	17	19.95	
	Post and Packing.			2.95

☐ Please tick if you require a VAT receipt TOTAL £______

*I enclose a cheque/postal order payable to Sinclair Research Ltd, for £______

*Please charge to my Access/Barclaycard/Trustcard account no.

*Please delete/complete as applicable

Please print.

Name: Mr/Mrs/Miss

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FREEPOST – no stamp needed. Offer applies to UK only. PRE 11

sinclair
ZX81

6 Kings Parade, Cambridge, Cambs., CB2 1SN.
Tel: (0276) 66104 & 21282.

PE VOLUME 17 No. 11 NOVEMBER 1981

UNIQUE

Very often we on PE are in the fortunate position of being able to publish project designs for which similar ready made commercial equipment is either unobtainable or very expensive. This has occurred recently with the *PE Ranger 27FM*, where legal equipment is only now able to be manufactured and imported and is (at the time of writing) still not available to the general public, with the *Horologicum*, the *PE Robots* and next month with the *PE Car Computer*.

For different reasons all these are "exclusive" products introduced in PE. There are many others which we could list but most readers will be well aware of what they can make for themselves that is not otherwise available.

CAR COMPUTER

Having mentioned the car computer a look at the background of this project (publication starts next month) might be interesting.

Over two years ago PE started investigating the possibility of producing a car computer for readers to build. After initial enquiries it appeared that the electronics could be readily designed but we were faced with the problem of finding suitable, accurate speed and fuel flow transducers. Further investigation particularly regarding the flow transducer revealed that cheap flow meters were generally inaccurate and this did not tie up with our wish to produce a reasonably priced, accurate instrument. After all, what is the point of knowing your fuel usage to an accuracy of no better than 10 per cent when it is *that* very 10 per cent you are interested in saving?

TRANSDUCER

Where could we go from there — we could either scrap the whole thing or try to get a transducer organised! Luckily our investigations had led us to Mr. Lionel Taylor, who has had considerable experience in the design and manufacture of fuel transducers, for automotive, industrial and commercial use.

Lionel liked our ideas, added his own, and introduced us to Phil McFarlane, an electronics designer with a flair for the original. By incorporating his own sophisticated design techniques, Phil, through PIMAC (his company), has enabled us to present a highly accurate, professional instrument with many unique features we have yet to see on any commercial unit (and at a competitive price!).

We are highly delighted with the outcome of everyone's efforts. The unit makes exceptional use of the computing power available, and we believe it sets new standards for car instrumentation. It will prove very useful to all drivers and should be welcomed by everyone involved in tuning and testing small vehicles, and many forms of competitive motorsport.

More details on page 65. We hope you like it.

Mike Kenward

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Technical Queries
We are unable to offer any advice on the use or purchase of commercial equipment or the incorporation or modification of designs published in Practical Electronics.

All letters requiring a reply should be accompanied by a stamped, self addressed envelope and each letter should relate to **one published project only.**

Components and p.c.b.s are usually available from advertisers; where we anticipate difficulties a source will be suggested.

Back Numbers
Copies of some of our recent issues are available from: Post Sales Department (Practical Electronics), IPC Magazines Ltd., Lavington House, 25 Lavington Street, London SE1 0PF, at 95p each including Inland/Overseas p&p.

Binders
Binders for PE are available from the same address as back numbers at £4·30 each to UK or overseas addresses, including postage and packing, and VAT where appropriate. Orders should state the year and volume required.

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Copies of PE are available by post, inland or overseas, for £13·00 per 12 issues, from: Practical Electronics, Subscription Department, Oakfield House, Perrymount Road, Haywards Heath, West Sussex RH16 3DH. Cheques and postal orders should be made payable to IPC Magazines Limited.

...NEWS &

Edited by David Shortland & Jasper Scott

Citizens Band in chaos?

Far from becoming a clear legal situation, UK CB has stepped into a world of fiction, with lack of internal communication producing conflicting statements from the Home Office, and unbelievable claims being made by some manufacturers.

By delaying announcement of the start of the service the Home Office has encouraged a situation where few manufacturers are prepared to spend the necessary on sets just to have them sitting in warehouses, and this may result in a shortage of legal equipment on "day one".

We believe that "day one" will be during the last week of October but at the time of writing (September 16th) the Home Office would not confirm this. However, licence forms have been issued (coded CB01) and happily the licence, which covers three rigs per fee (cost not yet known, but about £8-£10) places very little restriction on CB operation, only banning use on aircraft and restricting aerials to straight single wire elements of less than 1·5 metres overall length. This restriction, which we understand does not apply to hand held portable equipment, appears to be an about face by the Home Office who had previously informed us that helical aerials would be legal. It has been quickly introduced to prevent the use of aerials which can radiate at harmonics and may be relaxed to include certain other types when time permits more investigation.

Our own *PE Ranger 27FM* (in kit form) was the only legal equipment available at the recent CB Exhibition in London and was shown on BBC1 and used for demonstrations to LBC and Capital Radio. One manufacturer at the show informed us that production was being held up pending announcement of a legalization date but a high street retail chain was claiming they had a warehouse full of sets from the same manufacturer!

Further confusion was added by a press release from the exhibition organisers stating that all the equipment on show would soon be legalised—since much of it was a.m. and many aerials were outside the spec., that is not true. Total chaos finally reigned when the London radio stations announced that the Home Office IEE Wednesday committee came out against 27MHz FM and the Home Office sent out restrictions on Evaluation and Demonstration Licences, due to complaints by the MOD that testing on legal rigs could cause interference with Met. Office radiosondes, presently operating on similar frequencies. Apparently, the Met. Office were not consulted on the CB frequencies and they are not able to move their sondes until early next year when they "plan to move up the frequency band slightly". They would not quote the new frequency but it is interesting to note that slightly further up is the 28MHz radio amateur band!

Information from radiosondes is monitored every day by a computer system at nine locations throughout the UK. Transmission times are at midday and midnight (G.M.T.) and between 6 and 9 G.M.T. in the evenings. Interference from Italian CB has already caused problems for the Met. Office.

CB has now become a political hot potato where one blunder has followed another, mainly due to the original Home Office reluctance to look into a system for the UK and the fact that the Government has now pushed through the 27MHz allocation against the advice of virtually all the technical bodies.

PRINTING... THE ZX WAY

Sinclair Research has introduced a new printer to complement its existing ZX range of personal computers and software. Designed for use with the ZX81 computer and the ZX80 with retrofit 8K ROM the new printer features full alphanumerics and high resolution graphics.

Special features include COPY which prints out exactly what is on the TV screen without further instructions with the operation complete in 14secs, L LIST which instructs the printer to produce an entire program, and L PRINT to print copy out on the printer and not the screen.

The ZX printer has 32 characters to the line, 9 lines to the vertical inch and a printing speed of 50 characters per second. For operation the printer is attached to the rear of the computer by a stackable connector which allows 16K of RAM pack to be used at the same time.

The printer, which is priced at £49·95 including VAT, is supplied with a 65ft roll of special aluminized paper—enough for over 250 full screens of text. Additional rolls are available in packs of 5 at £11·95.

Sinclair Research Ltd., 6 Kings Parade, Cambridge CB2 1SN.

Briefly...

Many schools who find that one computer per class tends to result in a state of chronic boredom as all the pupils await their turn will be interested in an ingenious solution by a Reading based company, Audio Systems Components Ltd. and their local comprehensive, Theale Green.

The company installed several micros in a classroom at the school free of charge and during the daytime the equipment is used to teach pupils at the school and in the evening the company takes over teaching programming to fee paying adults under the evening class scheme.

Breadboard '81

Breadboard 81, the annual electronics exhibition, will be held this year at the Royal Horticultural Society's New Hall, Greycoat Street, Westminster, London from Wednesday the 11th November to Sunday 15th November.

PE will once again be exhibiting at the show with many of our past, present and future projects on display including our PE Ranger CB rig.

Opening hours are as follows:
Wednesday 10 a.m.–6 p.m.
Thursday 10 a.m.–8 p.m.
Friday 10 a.m.–6 p.m.
Saturday 10 a.m.–6 p.m.
Sunday 10 a.m.–4 p.m.

MARKET PLACE

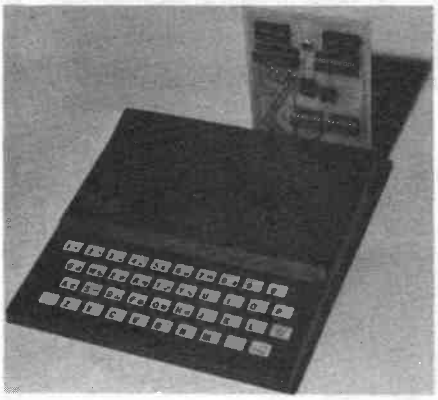
Items mentioned are available through normal retail outlets unless otherwise specified. Prices correct at time of going to press.

ADD-ON FOR ZX 80/81

Another accessory available for the Sinclair ZX80 and ZX81 is a low cost input/output port from Technomatic Ltd. This consists of a small board which plugs into the rear of the machine to provide an 8 bit input port and an 8 bit output port—thus allowing 8 independent input channels and 8 output channels, directly controlled from Basic or machine code.

A small loudspeaker may be connected to any one of the output channels to give programmable sound output in the range 200 Hz to 25 kHz; and examples of sound effects and other applications are provided in an accompanying booklet.

Each of the 8 output channels may be used to control a separate device—l.e.d. indicators may be directly driven from any channel, and relays may be controlled from each channel using a simple buffer—one uncommitted buffer is provided on the board for this purpose. Seven segment displays may also be controlled from the port.

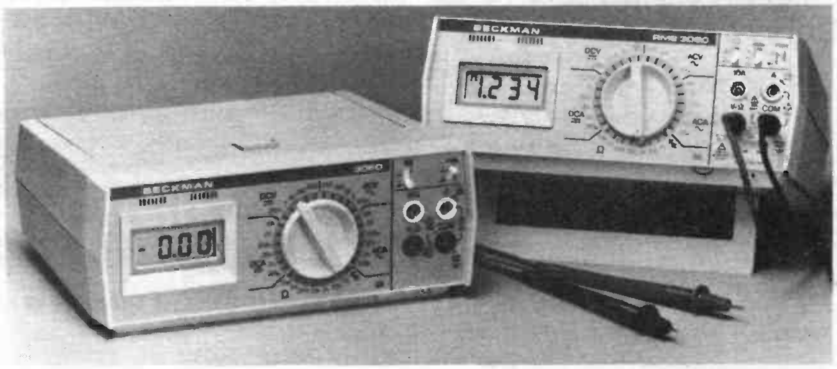


The 8 input channels may be used to connect games paddles, microswitch or reed switch detectors, a remote keypad, and light sensors for detecting the presence of objects etc.

Full details of the use of the port are given in an accompanying booklet, including applications.

The complete kit of parts including connector plugs and sockets for the i.c.s, a booklet of applications and a suitable loudspeaker is priced at £12·70 excluding VAT and p&p. Technomatic, 17 Burnley Road, NW10.

BECKMAN BENCH METERS



Following the success of their hand-held digital multimeter family, Beckman have introduced two portable bench-top models. The instruments require no external power supply and will operate continuously for 12,000 hours from standard alkaline batteries.

Model 3050 is an average sensing meter with a sine wave calibration, and model RMS 3060 is a true r.m.s. (a.c. and d.c.) or a.c. only meter. UK prices are £149 for the 3050 and £199 for the RMS 3060 (prices are exclusive of VAT).

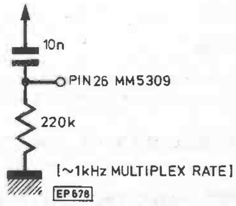
A single centre switch allows the user to select from the eight functions and 31 ranges. The instruments offer five d.c. and a.c. voltage ranges from 200mV to 1500V and 1000V respectively; six d.c. and a.c. current ranges from 200µA to 10A; seven resistance ranges from 20 ohm to 20 Mohm; and a diode test function as well as an audible and visual continuity test function. The RMS 3060 has an additional built-in temperature measuring facility. Both instruments have a highly stable band-gap reference element and thin-film voltage-divider networks which guarantee the specified 0·1 per cent accuracy for a one-year minimum, without calibration.

Beckman Instruments Ltd., Electronic Components UK Sales and Marketing Organisation, Mylen House, 11 Wagon Lane, Sheldon, Birmingham B26 3DU.

POINTS ARISING ...

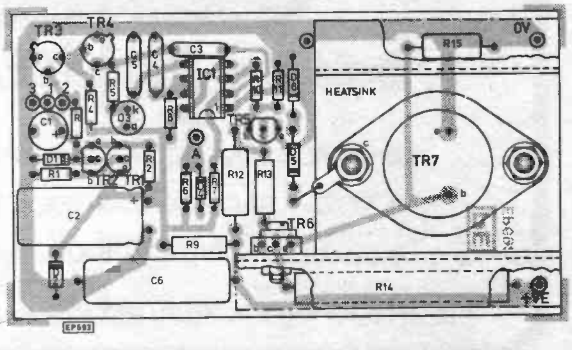
HOROLOGICUM (Oct. 81)

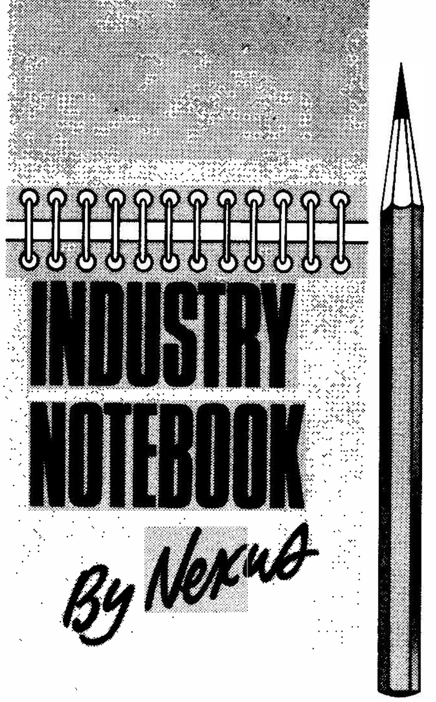
Fig. 4 was omitted from page 24, and is printed below.



INDUCTIVE IGNITION SYSTEM (Oct 1981)

The figure shown below should be substituted for Fig. 10 on page 44.





Bushido

The brand name Bush has been around in consumer electronics for 50 years, derived from Shepherds Bush, London, where a group of four youngsters, finding themselves redundant, decided to branch out on their own.

Rank acquired the name in 1941 and following the break-up of the joint deal with Toshiba last year decided to put the name on the market. Now it has been acquired by a new generation of entrepreneurs in the shape of Richard Schlagman and Mark Futter, both in their mid-twenties, who have renamed their company, Interstate Electronics, as Bush Radio.

So the good old British name is retained in British hands but the products are actually Japanese. I understand that the Bush label will be used only on high quality up-market goods, maintaining the brand image of the past half-century.

An example, perhaps, of Bushido, the code of honour and morals of the samurai of the Japanese warrior caste. The tradition may have been badly dented by the surrender to the Allies in 1945. But having lost the fighting war the same fanatical single-mindedness has been applied to winning the trade war. And how well they are doing!

The debate on import controls (and not only from Japan) re-opened in the seasonal round of TUC and Labour Party conferences as was the 'problem' of the multinationals and unfair subsidies. Much passion will have been generated, as in past years, but nothing will change. For the earnest delegates, during their moment of glory at the rostrum, temporarily forget that practically all our most successful companies are big exporters, many are multinationals in their own right and that our poor performers in our public sector are all heavily subsidised.

Silly Season

The long Parliamentary summer recess marked the opening of the silly season and on the industrial front the silliest debate of all was whether the economy had reached the end of the recession. There was a fascinating display of semantics with fine distinctions drawn on the meanings of 'bottoming-out' as distinct from 'recovery', or 'not getting worse', or 'bumping along the bottom'.

The field divided roughly equally between the economic optimists and the pessimists and a second, overtly political, group, generally the same types, who saw electoral prospects brighten or dim accordingly.

Taken overall I score a win for the optimists on the meagre facts available. An upturn in industrial production but over a shortish period, bolstered further by a substantial order for shipping plus some heartening investment announcements such as Hewlett-Packard's £12 million investment at Bristol and Motorola's £60 million expansion at East Kilbride. Construction work has also started on NEC's £40 million semiconductor plant at Livingston.

Such substantial investments will not shift many people from the unemployment register. After all the building work is completed permanent employment will be only another 1,000 at East Kilbride, 1,300 at Bristol, 800 at Livingston, and then not until 1985. A drop in the ocean. No wonder that Trades Union leaders greet these developments with less than whole-hearted enthusiasm. On top of this, all three investments are by great multinational corporations, and none can be said to be positively pro-union. All are dedicated to automated processes and efficiency, and to profit.

It may be an uncomfortable fact, but a fact which has to be faced, that all big business in the future will be in the same fashion of high investment and small, disciplined, highly-efficient labour forces.

This is why small business is so important and is being encouraged everywhere in the country. There are 1·2 million existing small businesses and it is conceivable, though unprovable as yet, that between them they could absorb, say, a million of those who are employable and at present on the register.

Misjudgement?

The electricity boards only a few years ago imagined that power consumption would forever increase, megawatt after megawatt. Some of the recent increases in unit charge are attributed to falls in industrial demand. This is true, of course, with some heavy users in industry, notably steel.

But I wonder if any of their statisticians took into account solid state electronics. Over 18 million TV licences are in force and many households remain unlicenced and many, legally or illegally, have more than one set.

The first generation of colour sets gobbled up in excess of 300 watts. Their solid-state successors have far less appetite, consuming less than 100 watts. The tubed radio receiver needed 60 watts or more, now reduced to 15 watts. The same with computers which today with equal computing power consume hundreds of watts rather than the kilowatts of older generations of machines.

Such dramatic improvements in efficiency when multiplied by, say, 10 million TV sets or more in operation on a typical evening are truly in the macroeconomic league.

But worse is to come for the electricity supply industry. Thorn has developed a new type of fluorescent lamp expected to be in the home and factory in five years time. It uses krypton rather than argon gas, has similar colour and light output of the 100 watt incandescent lamp but consumes only 21 watts and has five times the life.

Optics

Doing more with less, which is what technology is all about, is also apparent in the shift to optical fibre trunk links by British Telecom. By the end of the 1980s BT expects to have 100,000 km installed. New low-attenuation fibres reduce the need for repeaters. An example is the Luton–Milton Keynes link due for completion in 1984 which will have no repeaters at all over a distance of 27km. The conventional land lines of today will eventually disappear with the whole traffic load on the high-speed digital network comfortably handled by optical-fibre and microwave radio links.

The new monomode fibres can carry up to 8,000 telephone calls. But even with 'standard' fibre a pair will carry 2,000 calls on a cable ten times lighter and thinner than the conventional cable.

There is also movement at the exchanges. The first System X all-electronic local telephone exchange is now in service at Woodbridge, Suffolk, serving 1,000 lines expanding to 6,000 lines. The first ever System X to be commissioned is in London and switches a million calls a month between the 40 local exchanges in the London area.

Gas Control

Few people realise how important electronics is to the gas industry. EASAMS, the consultancy and management company in the GEC Group, is to design and supply a new computerised distribution, control and management strategy system for the British Gas Corporation under a £4 million contract.

Don't imagine that British Gas is backward in electronics. The present system of computer control uses fewer people, handles more gas and controls more functions than any system in the world of comparable size and complexity. The EASAMS system will increase handling capacity by a factor of four with equipment only half the size. But equally important is enhanced computing power for management of the whole complex with greater integration of the regional high-pressure grid system.


40 CHANNEL
LED PLL CIRCUIT
MICROPHONE
VOLUME
REALISTIC

Semiconductor UPDATE...

FEATURING ICL8073 AD7581 Z6132

R. W. Coles

THREE DEGREES . . .

Some time ago I covered the Analog Devices AD590 temperature sensor integrated circuit. If I remember correctly, I advised everyone to throw away their thermistors and thermocouples and use the AD590 instead for all applications which could use the simplicity of a combined sensor and amplifier giving a direct relationship between degrees and microamps at temperatures up to about 125 degrees C.

My advice still stands, but there is now an even better way for those jobs which require an output in degrees Centigrade or in degrees Fahrenheit, rather than in degrees Kelvin. The output of the three terminal AD590 was a current proportional to degrees K, so to turn this into a voltage proportional to degrees C or F ready to be measured and displayed using, say, a digital voltmeter, it was necessary to add an operational amplifier and a number of discrete components. This was a small price to pay compared with the horrors of thermistor linearisation and signal conditioning, but now you don't even have to bother with those simple additions, thanks to Intersil. Intersil knew a good idea when they saw one, and didn't waste any time in becoming a second-source for the original analog devices part, but they decided not to stop at the AD590 and have now introduced two new devices which will no doubt upstage their common ancestor in many new designs.

The canny engineers at Intersil soon realised that most users of the AD590 were adding bits and pieces to set a voltage output proportional to degrees C or F, which is hardly surprising since most applications outside of a scientific laboratory wouldn't know a degree Kelvin if they burned their fingers on it! What Intersil have done is to take all the stress and heartache out of designing an AD590 "fix" by building it into the sensor itself. So now if you want degrees Centigrade you buy an ICL 8073, and if you want degrees Fahrenheit you buy an ICL 8074—it's all done in the package.

Like the AD590 the two new parts are laser trimmed to give off-the-shelf accuracy without the need for external trim pots. The 8073 is available with accuracy ratings of 1·0, 1·5, and 3·0 degrees C with 0·5, 1·0, and 1·5 degrees C linearity ratings respectively, and the 8074 sports 1·0, 2·7, and 5·4 degrees F accuracy ratings with similar linearity specs. Add a simple digital voltmeter chip and a numeric readout and you can make a very simple, inexpensive, and accurate thermometer, ideal for your freezer or central heating controller perhaps.

The two devices come in six lead cans, and can run from single rail supplies, like the AD590.

EASY INPUT

We live in an analogue world, but for the moment at least, the most effective way to measure and calculate real world data is to treat it digitally using computers, logic circuits, or of course the ubiquitous microprocessor.

Since microprocessors must deal with the real world if they are going to be of any use to mankind, they have to be provided with the means to convert analogue data into a digital approximation at their inputs, and digital data into an analogue equivalent at their outputs. In many cases this can be arranged by using a human operator to do the necessary conversion before entering data via a keyboard, and to interpret results presented on a VDU for example. Another complete class of application, mysteriously called "Real Time Systems" do not have the benefit of a human "Slave" and must therefore be capable of doing their own conversions.

Real Time Systems come in all shapes and sizes, but typical examples are missile guidance computers, central heating controllers, and robots. These systems use Analogue-to-Digital and Digital-to-Analogue converters, usually in integrated circuit form to do the interfacing, but in the past these components have been notoriously difficult to control, and time consuming in operation. Take a simple process controller for example. Let us assume it has to read eight channels of analogue sensor data from thermocouples, pressure transducers, and position sensors, sampling at 500 times per second, calculate the best response and control, say, relays and valves to keep the process stable. As A/D converters are expensive, it is usual to use just one and precede this with an input multiplex switch controlled by the microprocessor. To keep up the sampling rate the micro must be interrupted every 250 microseconds so that it can switch to the next channel and initiate a conversion, a process which may take up to 100 microseconds depending on the type of converter and the speed of the micro, leaving very little time for processing the input data and making any sense of it. At this point, designers either specify a faster and more expensive processor, or they downgrade the system performance, but in future they can consider the very inexpensive alternative of using the AD 7581 from Analog Devices, and so can we!

The AD 7581 is even better than having a human slave as far as the micro is concerned, because there is no waiting around for keys to be pressed and no complicated channel switching or time consuming interrupt routine. The new device is just an eight channel analogue 'Port' which carries out all the channel switching and sampling automatically without the need for processor intervention. The secret of this simplicity lies with the AD 7581's on-chip eight byte RAM array which is continuously refreshed with new data from the input channels. Any time the microprocessor wants to know what's happening in the real world, it just has to look in those eight special RAM locations which are actually on the AD 7581 chip, an activity which need take no more than a few microseconds.

The AD 7581 is not just for professionals. It's simple to use, it uses CMOS technology, runs from a single 5 volt supply and does not cost an arm and a leg!

Just the thing for those multi-axis joysticks and that game of 3D space invaders!

BIG BYTE

While the bigger memory arrays will continue to be made with dynamic RAM chips organised as 16K or 64K by one bit, smaller systems will shun the need for eight separate devices by utilising the Bytewide concept championed originally by Mostek. Apart from the size advantage to be gained, the Bytewide system has the extra distinction of being completely compatible with sockets traditionally used for EPROMS such as the 2716 the 2732 and the new 2764. By populating a memory area with 28 pin sockets it is now possible to decide the mixture of ROM and RAM after the system has been built, a great advantage in many cases.

The first Bytewide RAM was the 4118 from Mostek organised as 1K by 8, but this was quickly followed by the 4802 organised as 2K by 8, both being static devices. The Bytewide concept is now taking off in a big way, however, with many other manufacturers announcing RAM devices which fit into 24 or 28 pin sockets, one of the latest offerings being the Z6132 from Zilog which offers a whopping 4K by 8 bits of dynamic memory running from single 5 volt supply. Don't let the "Dynamic" tag put you off, the Z6132 makes the periodic refreshing necessary with all dynamic parts very simple indeed, and does not require any special refresh logic.

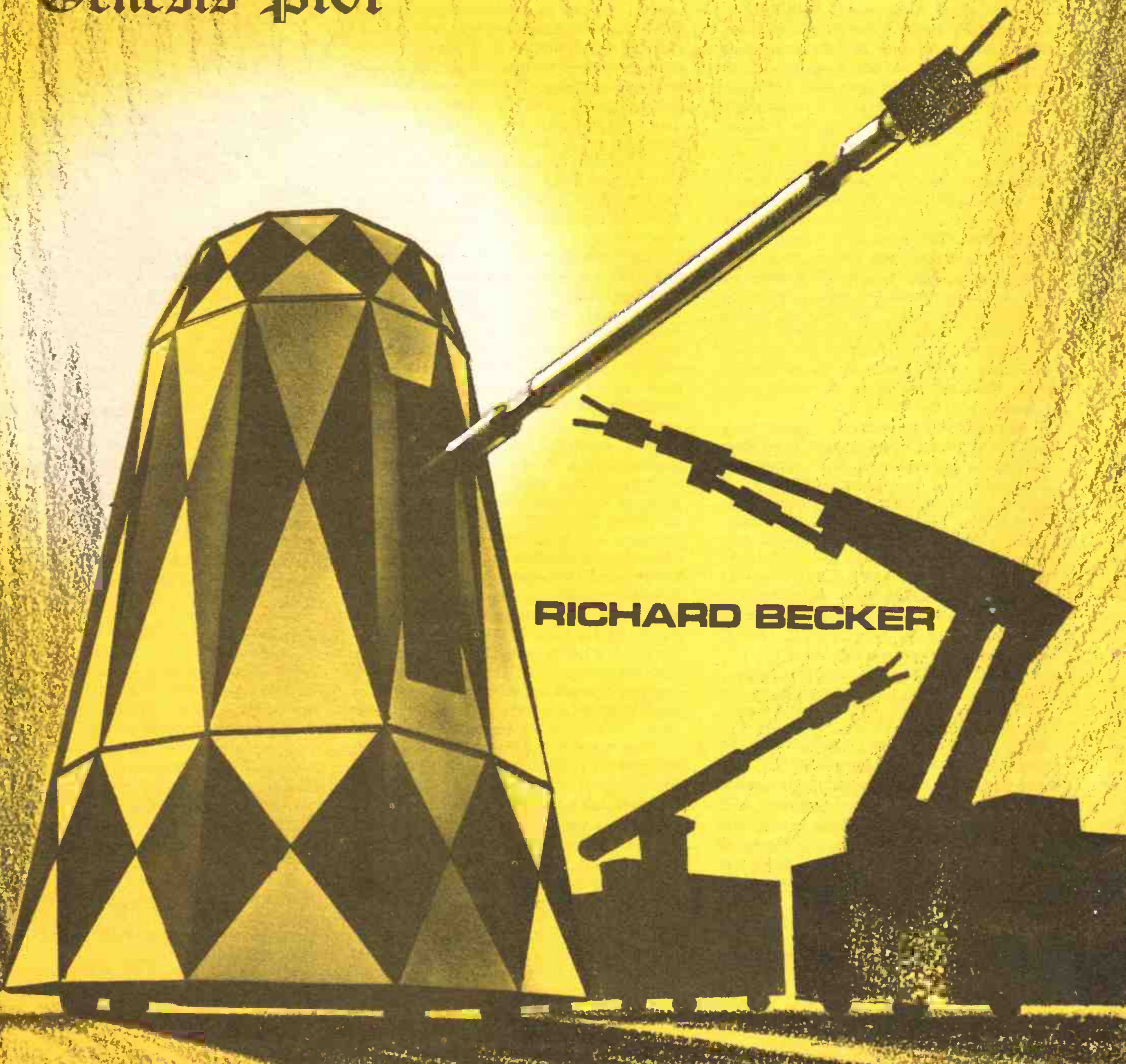
A 4K RAM array is a sizeable chunk of memory which may be sufficient for many hobby computers, and getting it all in one package will make system design easier than ever before!

PE ROBOTS PART 1

Mechanical design of robots

Genesis M101
Genesis S101
Genesis P101

A series of hydraulic computer controlled robots. Ideal for Education, Light Industry, and as powerful peripherals for personal computers.



RICHARD BECKER

Features

- Low cost
- Up to 6 controllable movements
- Positional sensing
- Servo control
- Continuous path motion
- Microprocessor controller
- Learning ability
- RS232C computer interface
- IR remote control for mobile unit

FOR THIS country to be competitive in world markets, increased automation is imperative. The third world countries have an excess of unskilled and semiskilled labour with remuneration substantially below that of their peers in the western world, consequently, wherever possible, assembly work of western designed products is carried out offshore. This means that much of the added value in a product sold in this country is going overseas. There are only two alternative courses of action possible. Either we reduce wages of the unskilled to be on a par with third world rates, which is politically impossible, or we manufacture our goods with extensive automation, thereby eliminating unskilled labour—a workforce which will then become available for the service industries expanding as a result of new wealth generated in modernised manufacturing. Unemployment is not an automatic consequence of automation but the result of successive governments spending beyond their means on consumption and on investment of a commercially non-viable nature. Political problems maybe? But problems to which electronics shall offer solutions.

AUTOMATION

The automation we require has in the past been in the form of expensive machines dedicated to particular tasks, hence suitable for high volume production only. With electronic control, machines with general purpose manipulators can be readily re-programmed for a variety of tasks rendering them suitable for small batch production too. A *re-programmable mechanical manipulator* is the Department Of Industry's definition of a robot.

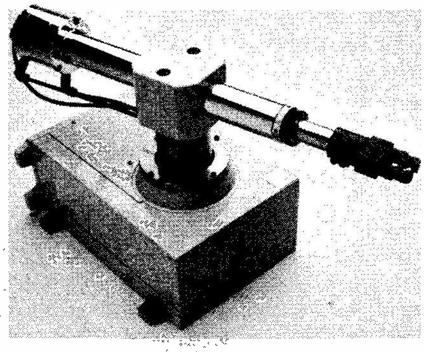
Although the number of robots in industry is still small their population is expanding rapidly, and it is going to be just as essential for those in industry, and those entering industry from full time education, to have hands-on experience with robots as it is to have experience with microprocessors and computers.

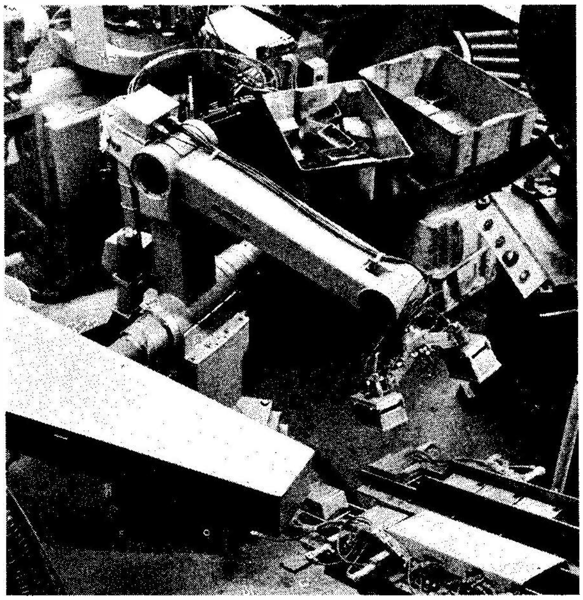
Unfortunately the mainstream industrial robots are still in a price region which has restricted their penetration into industry and educational establishments, and has ruled them out for experimental work by the home enthusiast.

INDUSTRIAL ROBOTS

The market leader is currently Unimation, with their electrically operated Puma range priced between £21,000 and £24,000, and their powerful hydraulically operated Unimate range priced between £30,000 and £45,000. Other machines prominent in the field are the hydraulically operated Cincinatti Milacron T^3 with a basic price of £40,000; the electrically operated ASEA IRb6 at £33,000 and, from British companies, the hydraulically operated Workmaster at £60,000 and a range of hydraulic machines from Hall Automation priced from £19,000 to £38,000. These machines offer servo controlled motion on between 4 and 6 axes and are capable of operation by computer. Lower cost machines, also described as robots, are in existence, such as the non servo-controlled Seiko 700 at £4,250, but this pneumatically operated machine is without continuous positional monitoring, working between mechanical stops, and is not suitable for computer control. In the US industrial market the average sales price is $72,000 for servo controlled machines and $10,000 for non-servo controlled machines.

The Seiko 700 industrial robot. The Seiko range of robots is based on modular design principles, offering the versatility of interchangeable attachments. Photo courtesy of Airstead Industrial Systems





Surrounded by work! The ASEA IRb6 industrial robot *awaits not* the factory hooter as it busily attends a number of machines. Photo courtesy of ASEA Ltd.

The machines to be described, costing a tiny fraction of these prices, make it possible for small businesses, educational establishments, even with their severely restricted budgets, and the home constructor to gain hands-on experience in this vital new technology.

Of the variety of ways of producing controlled mechanical movement those used in industrial robots are:

1) electric motors
2) pneumatics
3) hydraulics

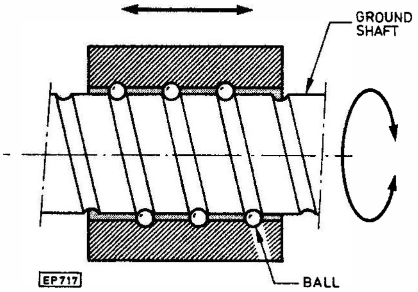
"*Failure* faces those who do not grasp the opportunities offered by robotics" . . . **The Prime Minister, AUTOMAN '81 May 1981**

ELECTRIC DRIVES

Electrically driven systems can use d.c. motors with a servo-controlled pulse-width modulated supply voltage, but more usually stepping motors are used. With the latter, the motor advances by a fixed increment for each pulse delivered to it. At first sight it would appear that a system could be controlled simply by delivering pre-determined numbers of pulses to the motors. This technique has been used on some designs offered to the amateur but repeatability cannot be relied upon, since acceleration and load conditions can result in the motor not responding to all of the pulses delivered to it, and in industrial machines, sensing of actual position is always carried out. Optical shaft encoders on the motor are usual.

Electric motors produce rotary motion. To convert to linear motion, a lead screw—usually of the "ball screw" variety—is used. See Fig. 1. These can be driven directly off a stepper motor, but for rotary motion, a gearbox is required. However, ratios in excess of 50:1 are frequently required and a conventional gearbox of this ratio gives substantial problems with friction and back-lash. Hence the almost universal adoption of the harmonic drive, where the reduction is determined by the ratio of the number of teeth of the larger of two toothed components *to* the *difference* in the number of teeth on the components, instead of it being the ratio of number of teeth on the larger to the number of teeth on the smaller, as in conventional drives. With these units reductions of up to 320:1 can be obtained in one stage. Unfortunately they are still very expensive and therefore not suitable for a low cost system (Fig. 2).

Fig. 1. Ball screw for converting rotary into linear motion



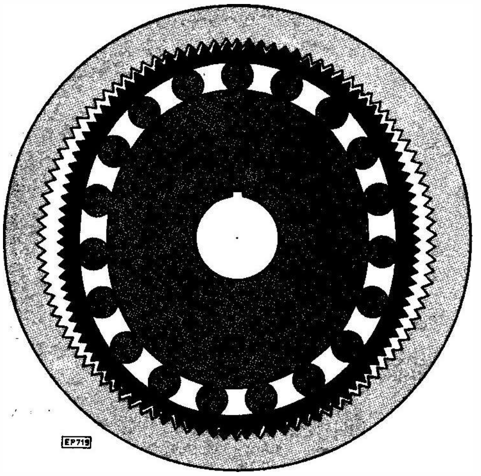
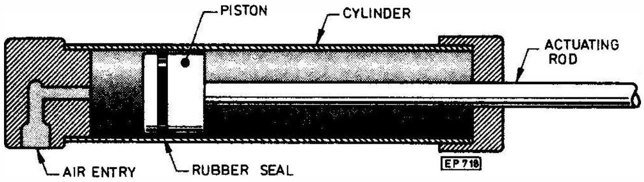


Fig. 2. Harmonic drive gears. The elliptical centre revolves, deforming the inner toothed component into contact with the outer toothed component

PNEUMATIC DRIVES

Pneumatic systems operate by passing compressed air into and out of a cylinder with a piston which provides linear motion (see Fig. 3). Air is a fluid with very low viscosity and will therefore move through the tubing and cylinder very fast and cycle times of under a second are realisable; however, gases are compressible, consequently with a given amount of air in the cylinder the position of the piston will be very dependent on the load being imposed on it. The only way of being sure of positional accuracy is the use of mechanical stops with the air providing substantially greater force against the stop than the load. Where rotary motion is required a lever system, or a rack and pinion, is used. The flow of the air is controlled by solenoid operated valves. Pneumatic systems require a compressor which typically is like an internal combustion engine with inlet and outlet valves and a reciprocating piston driven by electric motor. Being rather bulky, compressors are not usually integral with robots.

Fig. 3. Pneumatic cylinder



HYDRAULIC DRIVES

Hydraulic systems are widely used on account of their ability to transfer substantial power to a moving part where the weight of an electric motor and gearbox would be prohibitive. Cylinders with pistons similar to those designed for pneumatics are employed but a low viscosity oil is used instead of air. Being incompressible very firm positioning and smooth travel is obtained. Here too, the flow of the fluid is controlled by solenoid operated valves. Pumps for oil are very compact devices typically consisting of a pair of electric motor-driven gear wheels in a cavity where oil enters on one side, is trapped between the teeth of the gears and is expelled on the other side of the cavity. With a single pair of gears, pressures well over 100 bar are readily obtained (1 bar = approx. 14·5 p.s.i. = approx 1 atmosphere).

GENESIS ROBOTS

In each of the Genesis robots low pressure hydraulics were selected as the most suitable way to produce the powerful and controlled movements necessary for a machine that is to be useful.

Electric motors in general, and stepper motors in particular, are expensive. With these hydraulic robots a single motor of the low cost permanent magnet variety is sufficient

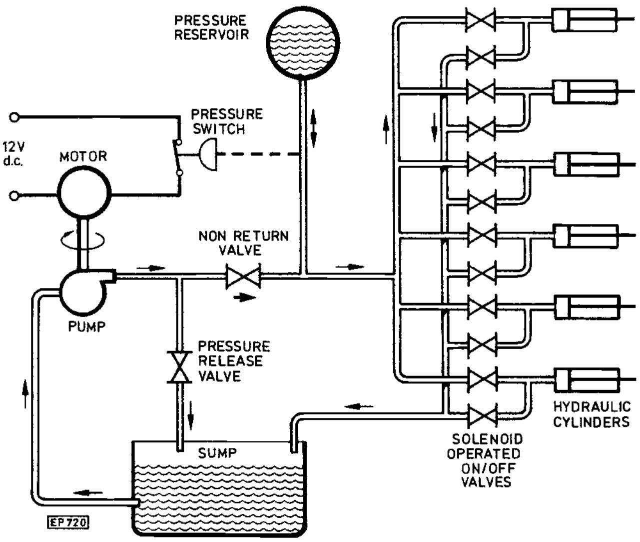
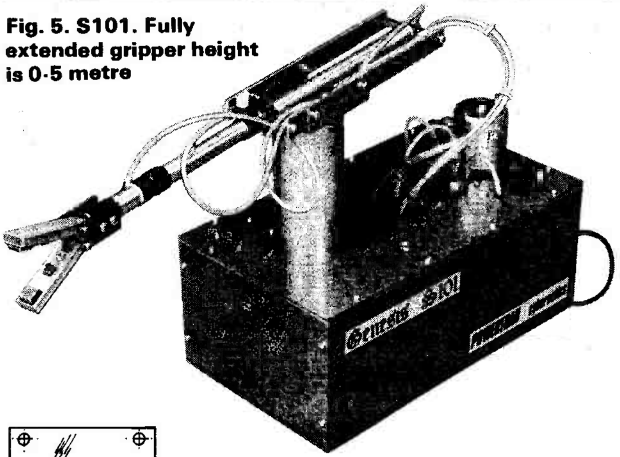


Fig. 4. Hydraulic system

Fig. 5. S101. Fully extended gripper height is 0·5 metre



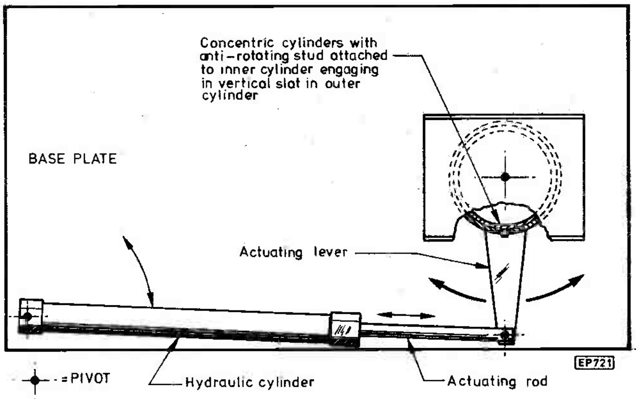


Fig. 6. S101 rotation

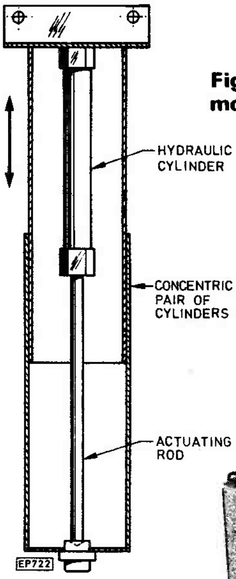


Fig. 7. S101 vertical movement

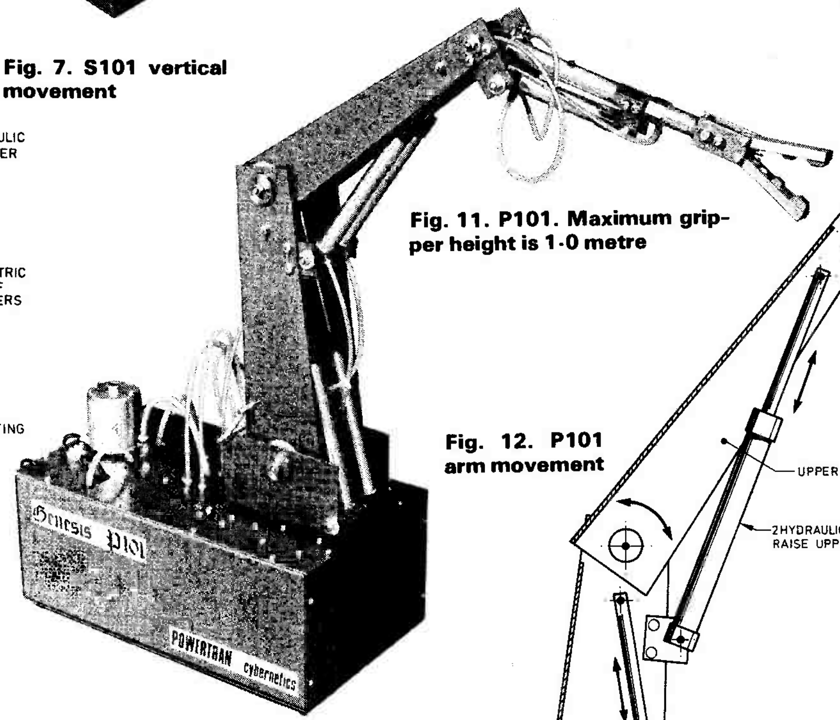


Fig. 11. P101. Maximum gripper height is 1·0 metre

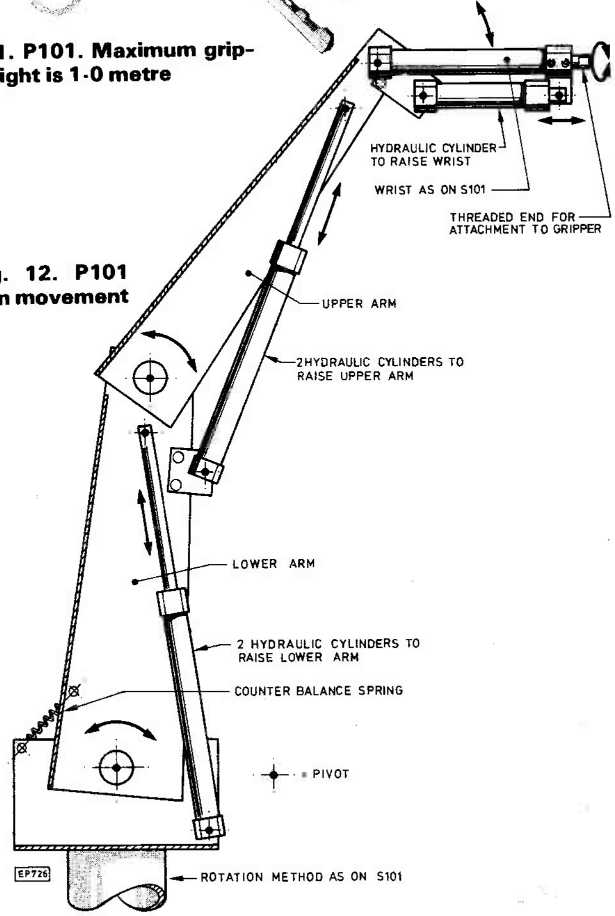


Fig. 12. P101 arm movement

Fig. 8. S101 horizontal movement

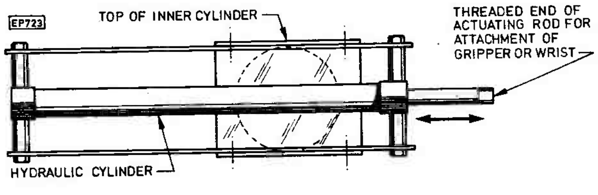
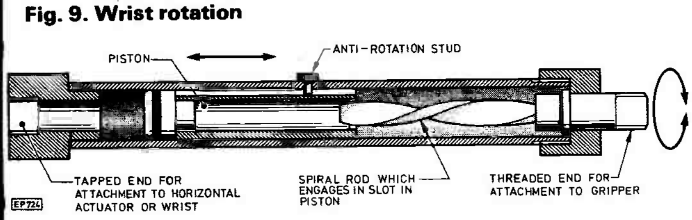


Fig. 9. Wrist rotation



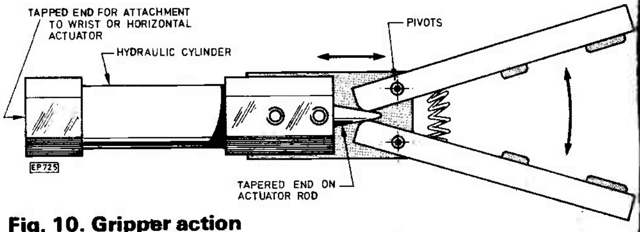


Fig. 10. Gripper action

MOBILE

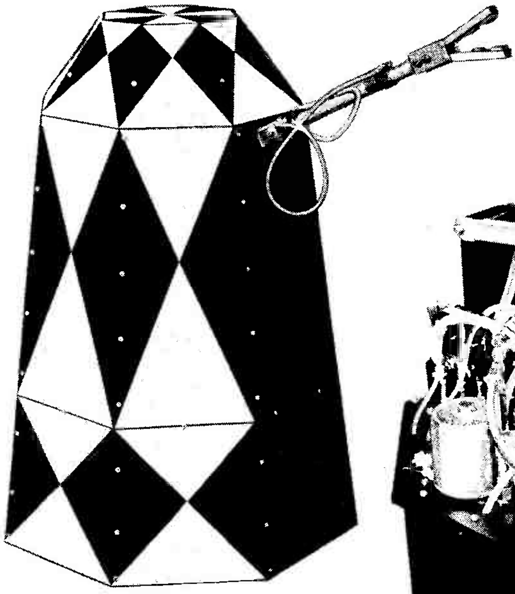
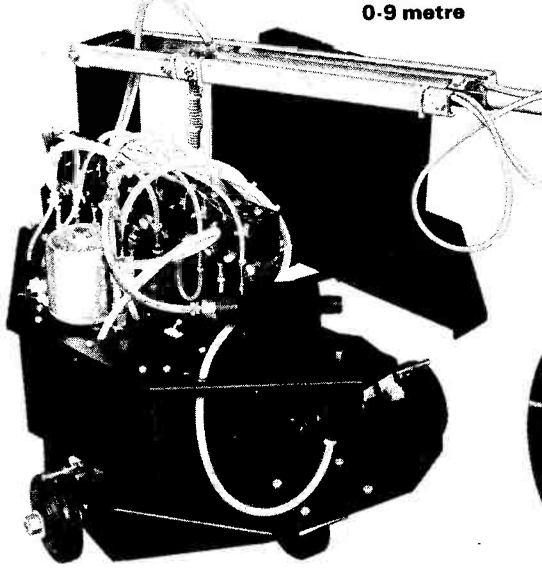
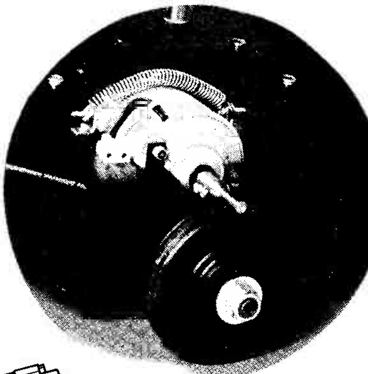


Fig. 13. M101. Maximum gripper height is 0·9 metre





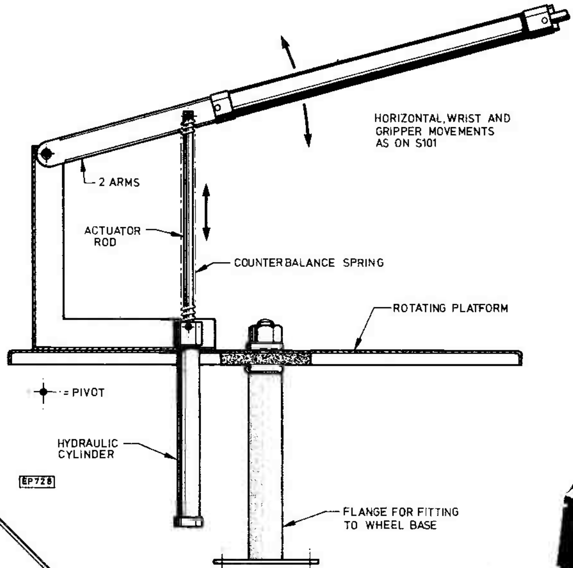
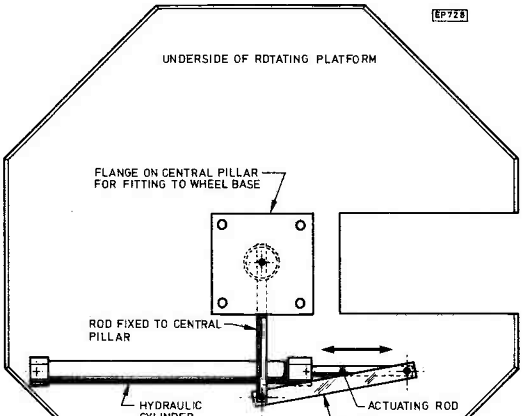
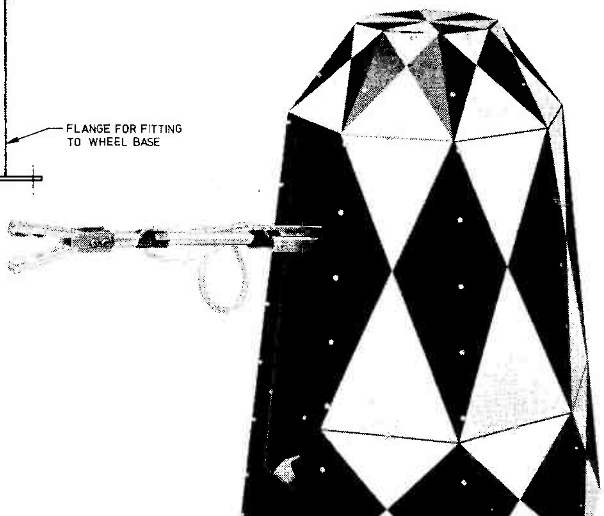


Fig. 15. M101 vertical movement

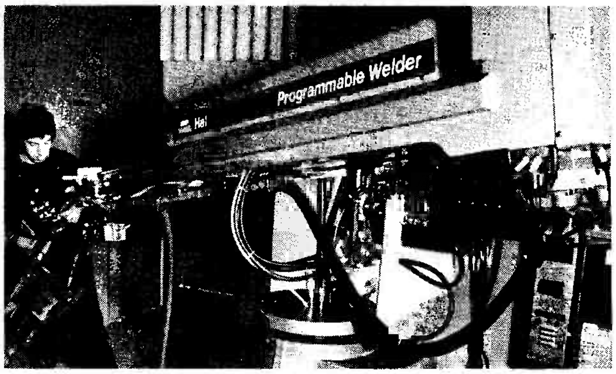
Fig. 14. M101 rotation





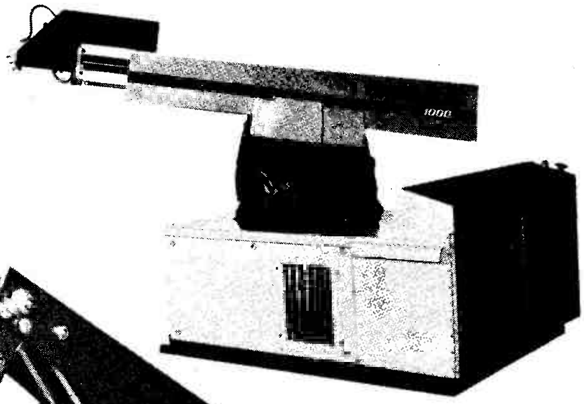
to power all of the arm and gripper movements. The motor drives a pump small enough to be incorporated in each of them. In hydraulic machines where the drive is taken directly from the pistons, gearboxes, with their expense or friction and back-lash problems, are not required—giving further advantage over electric systems.

Continuous positional control, which is extremely difficult with pneumatics but easy with electric and hydraulic machines, was made particularly easy to implement on these robots by suitable choice of materials making possible a low cost inductive coupling system monitoring the piston locations.



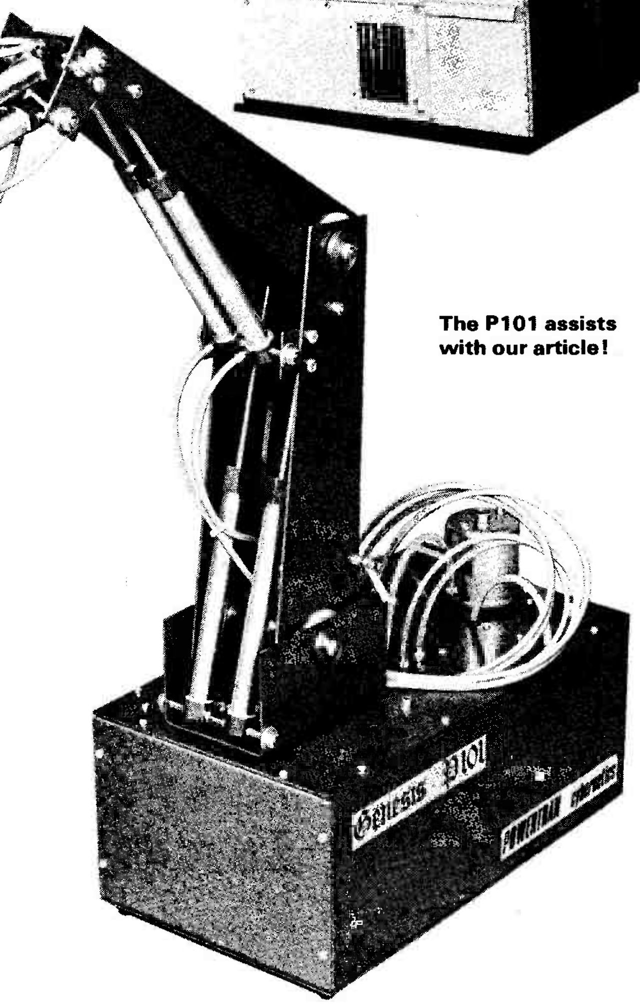
Welding robot in action. Courtesy of Hall Automation

Another big brother machine is the Unimate Puma 1000. Photo courtesy of Unimate Ltd.



THE HYDRAULIC SYSTEM

In each machine the hydraulic system is as in Fig. 4, with a pump drawing oil from the sump and pumping via a non-return valve into a pressure cylinder in the top of which air is being compressed, thereby acting as a reservoir of power when the pump is switched off which occurs by means of a pressure switch when the required working pressure of 8 bar (120 p.s.i.) is reached. For safety, a pressure release valve operating at 12 bar is included. The symbols representing the solenoid operated valves control the flow of the oil into the cylinders. The return of the pistons is by springs and/or gravity depending on the function of the cylinder. The interconnections are made with small bore flexible polythene and nylon pipes via screw-in fittings. With these fittings no problems with oil leaks have occurred and the machines are very clean in use. No special tools are required for assembling the robots.



The P101 assists with our article!

Constructor's Note

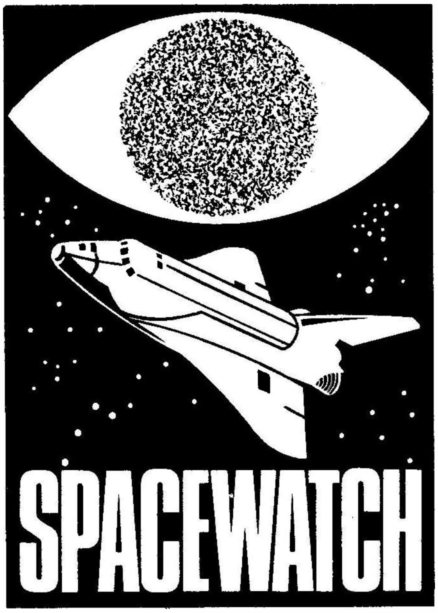
Complete kit of parts for this project can be obtained from Powertran Cybernetics, Portway Industrial Estate, Andover, Hants SP10 3WN. ✆ Andover (0264) 64455.

Each of the Genesis robots has its arm operating in a different manner. The S101 can be considered in terms of cylindrical co-ordinates with the arm rotating on a pillar which also moves up and down. The arm extends horizontally and there is a gripper which can be rotated by the wrist. See Figs. 5–10.

The P101, whose more complex movements are best considered in terms of cartesian co-ordinates, consists of an articulated arm, rotating on a pillar, corresponding to the human arm with the lower pivot the shoulder and the upper pivot the elbow. The wrist as well as rotating the gripper can also move up and down (Figs. 11 and 12).

The M101 mobile robot carries aboard its high manouverability wheel base an arm moving with spherical co-ordinates. The platform carrying the arm rotates relative to the wheel base. The arm is pivoted at one end so that a small movement of the hydraulic cylinder raising it results in a large movement of the gripper, and the M101 can lift from the floor to table top height. The arm extends and there is a wrist and a gripper, as shown in Figs. 13–15.

NEXT MONTH: Control electronics and wheel base.



FRANK W. HYDE

LONG DISTANCE COMMUNICATION

From a point far out in space Pioneer-10 continues to remain in contact with the monitoring stations on Earth. The vehicle has now been in space for 9 years, during which time it has returned very significant data. Some of this data has revealed conditions of the magnetic fields and particles in interplanetary space not previously known to exist or even considered. The vehicle is at the present time between the orbit of the planet Uranus and those of Neptune and Pluto (Pluto's orbit is within that of Neptune for the time being) and will be moving beyond the known planets by 1983.

The Solar Wind has been recorded at the present as still very strong. There were some astronomers who did not think that the effects of this outer fringe of the Sun's atmosphere would be in evidence much beyond Jupiter. Many of us however, are quite convinced that it extended far out beyond the known planets. The charged particle detectors and magnetometers continue to work satisfactorily. It is now suggested that the solar wind will extend out to five times further than originally thought, namely to 25 astronomical units. So far the region of the helipause, that is the area where the solar wind would reach the gas of interstellar space, shows no sign of appearing in the data.

There is still much Pioneer-10 can do. It is still picking up the disturbances caused by flares on the Sun and also the effects of the mysterious 'winds' which come from stars which are heavier than the Sun. These 'winds' contain a great deal of 'matter'—so much that some stars appear to give up some of their mass and as a result undergo a change of life cycle. The vehicle is travelling at such a speed that it can escape the control of the Solar System. Signals will be received at least until 1986 but there are considerations on which this depends. They are not technological but fiscal. The continuing operation of the earth stations for monitoring will depend on funds being available to staff those stations. It seems a signal failure that important scientific data should be at the mercy of political systems, almost an act of suicide. However, it may be that in the light of recent achievements and success of the Shuttle and other projects, the importance of the future will be obvious and paramount. At 25 astronomical units the spacecraft will be 25×94^6 miles from the Sun. At this distance the signals will take 3 hours 28 minutes and 20 seconds to reach the Earth. After leaving the Solar System it will take some 80,000 years to reach the nearest star.

SHUTTLE TO THE RESCUE

One of the benefits of the proposed shuttle operations is the provision of a space platform to operate servicing facilities for the maintenance of satellites. The first situation to arise which needs such a facility concerns the Solar Maximum Mission. This vehicle was launched last year to study the current cycle of Solar activity and the observation of flares. The satellite has lost its ability to point accurately to the Sun. This means that only two of the seven experiments aboard are working. The result is a severe reduction of the amount of data that can be retrieved. A plan is now being studied as to the best way of dealing with this situation.

When the project was mounted it was part of the plan to service in orbit but to bring the satellite back to Earth for refurbishing. To this end it was fitted with a grappling hook that would enable the shuttle to hoist it aboard. It will then be serviced and put back into orbit.

This does raise certain problems because of the high orbit. It is being discussed as a follow up to the performance of the first run of Columbia. The matter requires that the Shuttle shall be able to reach an orbit 570 kilometres above the earth. The need for this high orbit imposes certain restraints, the principal one being the need for extra propulsion. Not surprisingly the mood in this matter is one of excitement because the proven ability to rescue is a very important additional facility for the space age. Chris Rapley of the Mullard Space Science Laboratory of University College, London, says 'we shall have 1½ to 2 years to get ready for such an operation. We can study the data and will be ready to leap in and use the satellite again!'

The rescue could take place in 1983. Advantage will be taken of this time to improve the whole system and provide against failure due to substandard components.

THE SOVIET UNION

The proposed successor to Salyut-6 is not expected to go into orbit before 1982. The head of Soviet mission control Alexei Yeliseyev was speaking recently at a press conference in Moscow on the results of the last 5 missions of long duration. This project lasted over three years. He said that the Salyut-6 had all the necessary facilities for permanent space stations. The suggestions of the crews were being incorporated in the next version of the vehicle. The stations may alternate between man operated and automatic operation. The next station may be put into orbit rather further north than hitherto since the cosmonauts have been undergoing arctic training. So far Salyut-6 has not been put in orbit higher than 52° North. This does not even reach the latitude of Moscow. A higher orbit would mean a greater cover of Soviet territory. This is also in accordance with the past work of Salyut-6. Last June the satellite Cosmos 1267 docked with Salyut-6 and has remained in orbit. This satellite is larger than the Soyus units used to ferry cosmonauts. The present combination weighs about 40 tonnes, about half that of Skylab.

It would seem that continual additions of these craft combinations would enable large permanent stations to be operated for it must be remembered that a section, a substantial section in fact, of each Cosmos is a module which makes its way back to Earth. The limitations on the Soviet launchers at the moment restrict the size of the basic units which can be used to assemble a large station.

AMERICA PLANS A SPACE BASE

Basically a permanent station would cost America about £1,000million. The structure would consist of two Spacelab units. The manning would consist of three to six people who would live aboard for periods of the order of three months at a time. If approval is obtained then the work could begin soon and the station would be ready for launch in 1986. The assembly would start with a Spacelab module and a power pack module with solar cells and batteries. A second unit would follow in a few months. This particular proposal is said to be a 'modest low cost effort'. A more extensive plan would comprise two living units each about twice the size of Spacelab, each with living accommodation for 8 to 12 people. The station would include a rocket hangar containing an orbital transfer vehicle for servicing satellites from 300 to 36,000 kilometres to deal with low orbit craft and geostationary units.

WORLD DATA BANK

The World Data Centre 'A' for Solar-Terrestrial Physics is at Boulder, Colorado. Since the early 30's it has collected information about the solar events such as storms and their effects on the Earth's atmosphere and the magnetic field. Because of the cuts required by President Reagan this centre has been under threat of being closed.

Now, however, it has been reprieved. The protests from scientists all round the World have convinced the US National Oceanic and Atmospheric Administration that it should be kept alive.

TAIL PIECE

This is an addition at time of going to press and so will be a 'late news' spot. The problem of the stuck azimuth platform was overcome and the Voyager is on its way to a rendezvous with the Planet Uranus. When some of the data has been resolved there will be a full report of the findings of the Saturn pass. This and the French plans for an unmanned station in orbit will appear in the next issue of *Spacewatch*.

PE BAND-BOX

PART 1 A.J. BOOTHMAN

THE *PE* Band-Box is a new concept in musical instruments and is designed to provide, in one portable unit, a trio backing of drums, bass and a chord instrument for the solo musician. Utilising microprocessor technology the unit is user programmable up to a capacity of over 3,000 chord changes between approximately 120 different chords. This number of changes allows the creation of an electronically indexed music pad, stored on secondary battery back up, containing typically 60 separate scores (tunes) depending on the complexity of each score, and the trio can be quickly directed to play individual or groups of scores in any key and at a controlled tempo.

Facility exists for composition of introduction, repeat chorus, and coda sections, including linked multiple score sequences. Separate and mixed outputs are provided for drums, bass, and chord instrument and the addition of a volume pedal and footswitch allows simple control for use in a live performance environment.

BACKGROUND

The musical interests of the author over the past twenty years have borne greatest practical fruits in the playing of the tenor saxophone and whilst many enjoyable hours have been spent performing in the company of other musicians, from trios to big bands, frustrations have arisen in the playing of this instrument which have helped to create and foster the drive to develop electronic musical instruments which assist the task of the solo musician.

Much of this effort has been applied to progressive development of the electronic piano which, in addition to creating a more relaxed and happier pianist, enables the group to play in the region of concert pitch thus avoiding the disconcerting effect of collapsing mouthpieces and bad pitch blowing over the range. In 1980 the first respectable programmable drum machine was created, in the form of the *PE* Master Rhythm, to deputise for the drummer who is universally never available for practice sessions since he can always find a paying gig and usually claims not to need the practice anyway, but the frustrations continue for the instrumental or vocal soloist who cannot achieve satisfactory practice without the additional backing of a chord structure.

LIVE PERFORMANCE AND RECORDING

Whilst the initial concept of the Band-Box was as a practice instrument the last few years has seen a number of changes in musical presentation which make the unit ideal for live performance. The use of electronic drum machines by club and pub artists was noted at the time of publication of the *PE* Master Rhythm and the trend continues. The Band-Box can fill out the sound of this form of act to a new dimension without increasing the personnel. Despite some opinions to the contrary many Disco operators have musical ability and are only using the currently accepted medium for musical contact with the public. Singing disc jockies can add a new gimmick to their performance using the Band-Box and bring back some live musical creativity interspersed amongst the records.

The Band-Box, when used in this context, may appear to be aimed at replacing live musicians, but is more likely to encourage the emergence of a greater number of good solo musicians and singers who, given this concept of backing instrumentation, can provide creative entertainment at minimum cost.

The expression of musical creativity with "machines" is illustrated by the fact that rhythm machines and sequencers are currently being used on disc recording sessions, in addition to live drummers, thus producing new areas of sound. In the amateur world a fast growing generation of "electronic musicians" are actively applying creative musical arranging capabilities to multi-track recordings using a whole range of electronic musical instruments with or without playing technique. The Band-Box is ideally suited to this group of

SPECIFICATION

Music simulation capacity	Three backing instrumentalists Over 3,000 programmable stored chord changes Approximately 120 different chords.
Chord instrumentalist	Four note chords Four waveform options Four envelope options Sixteen permutations for piano, guitar, organ etc. Twenty four programmable rhythm patterns
Bass instrumentalist	Four voice/envelope combinations Four rhythmic figures
Drums	Twenty-four programmable patterns Eight tracks selecting from eleven Instrument sounds. Sticks, brushes & L.A. Sequence operation up to sixteen bar repetition
Playback facilities	Keypad selection of score (tune) Display of selected score Variable tempo Switched selection of any key In-play changes to key, tempo, and all instrument voices, rhythm patterns and levels Bar down beat indicator All-beat indicator Unlimited chorus repeats Coda key to cancel repeats Automatic stop Manual instant stop Automatic reset to beginning of selected score Measures/beat selectable to match four drumming styles
Composition facilities	Capacity for 40-100 backing scores (tunes) dependent on complexity Indexed start found on 35 pages each 100 lines long (3,500 lines total) No wasted memory Safety lock routines to deter erasure Automatic transposition from any key used during composition Chord table arranged in twelve groups Display of composition content Create intro. sections Create repeat sections Create coda sections Create multi-tune sequences Create bridges and modulation sequences
Composition instructions	One instruction per memory byte (a) Chord + duration (8 beats max) (b) Change chord group (c) Set start of repeat section (seg) (d) Set repeat from seg (dal segno) (e) Finish
Prerecorded scores	Demonstration chord sequence Major chord for tuning
Musical compass	Tuning range—one semitone Use alternative key for gross pitch change Bass compass—sixteen notes F1 to G2 # 44Hz to 104Hz Chord instruments—eighteen notes E3 to A4 165Hz to 440Hz Automatic chord inversion to fit compass
Percussion instruments	Bass drum, low & high tom-toms, snare drum, rim-shot, cymbal, long & short brushes, high bongo, claves, and accent for dynamics
Operator interfaces	Eight l.e.d. displays Two tempo indicators One power indicator Ten index entry keys Eight control keys Sixteen composition keys Musical key selector Tempo control Chord instrument waveform and envelope selectors Bass voice and rhythmic figure selectors Drum pattern, instrumentation, and sequence selectors Drum styles synchroniser Independant chord, bass, & drum level controls Master levels and cymbal tone controls
External sockets	Drum output—500mV nominal Bass output—500mV nominal Chord instrument—500mV nominal Instrument mix—500mV nominal Volume pedal—100 kilohms Footswitch—start and coda
Microcontroller	System monitor—2K bytes EPROM Score store—3·5K bytes CMOS RAM Working memory—0·5K bytes CMOS RAM Spare capacity—2/4K bytes EPROM System port—8 input port + 80 port capacity Clock frequency—1MHz Back-up power—90mAh Back-up drain—Approx 1µA
Overall system	Size—19in x 11in x 4½in. approximately Weight—11 lb Power requirements—240V 6W nominal Stand by drain on secondary battery 5µA Charging current during operation—Approx 1mA Total back-up capacity—90mAh Retains scores for over one year on full charge

people due to its wide range of voicing and complete programmability. Separate instrumentation can be individually processed to form the special effects normally associated with this technique.

The more musically advanced participants are looking to composition and a number of computer linked systems are becoming available. The Band-Box has a useful role in composition in the development of chord sequences and rhythm patterns along side melodic development by tape recorder or the newer computer-based systems.

TECHNOLOGY ADOPTED

Before proceeding to describe the Band-Box facilities in detail it is useful to take a look at the reasons for adopting microprocessor technology which at first sight may seem to have limited relevance to music systems.

In addition to the musical difficulties that are involved in disc or tape backing systems, the practical difficulties of speed of score selection and the inflexibility with regard to musical intros, repeat sections, codas, and multiple tune sequences, result in a cumbersome operating procedure which removes much of the pleasure, and limits public performance to very occasional use. A simple and quick method of score selection is therefore very important, with a clear indication of which score is about to burst forth from the Megawatt amplification system. This type of input keying/display activity is basic to microprocessor systems which can also readily cope with the increased complexity of recording input and display routines, and the translation of the resulting data into a format capable of maximising efficient use of the score memory which represents a significant proportion of the cost of the system.

It is at this point that the microprocessor controlled system has taken its first rapid departure from the considerably simpler concept of the widely used music sequencer.

CONVENTIONAL MUSIC GENERATORS

An instrument could easily be conceived, using the above, in the form of input keys, displays, and a microcontroller which contains the microprocessor, music score memory and monitor memory to dictate to the microprocessor the order in which all actions should be executed, and couple it to a conventional music generation system of either the voltage controlled synthesiser type or the electronic organ top octave/divider/tone forming system. Each of these has certain musical disadvantages which have usually had to be ignored ever since their widespread adoption. In the case of the synthesiser, based on a number of VCOs, the relative frequency stability and tracking accuracy of each oscillator is very important and difficult to achieve. Given good stability a four note system can be tuned with four oscillators in unison, but immediately controlled waveforms of even simple harmonic variety are required the number of oscillators and therefore cost increases rapidly and the time taken to set the intervals and relative levels leads to an instrument which is impracticable for serious use outside the recording studio.

Whilst the traditional electronic organ system presents an easier polyphonic tuning solution and can provide a high level of accurate harmonics, it is very difficult to use the harmonics in a controlled manner and it is very likely that this technique will disappear over the next few years in all but the cheapest instruments.

THE PROGRAMMABLE SOUND GENERATOR

Integrated circuits have appeared over the last three years under the general heading "Programmable Sound Generators" and have been specifically designed for computer controller interfacing. TV games, door bells, and many amateur computer enthusiasts have made use of the chips which at first sight appear to have potential in serious music applications. The PSG falls into the traditional electronic organ generator divider category giving high stability tuning of say three simultaneous notes which can be accurately placed independantly in any part of the fundamental frequency range of conventional musical instruments. Crude envelope controllers are also integrated into the same device plus the extra facility of noise generation. Multiple units could be used to provide the harmonic capability of a limited range organ generator system but the same problem of voicing exists.

THE MICRO AS A MUSIC GENERATOR

It is not the purpose of this series to present all the known complexities of microprocessor music generation, it will simply be treated as a means to provide the musical voices required in the bass and chord Instrument sections of the Band-Box. The two salient points are that the Microcontroller is arranged to act as a multi-channel programmable divider from 1MHz to produce five independent simultaneous notes at accurate musical fundamental frequencies, and that the harmonic content of the resulting wave forms is easily controlled within the microcontroller in terms of intervals and amplitude, even extending to the use of non-harmonically related overtones. This combines and makes more practical the good features of both synthesiser and organ generation techniques, and provides an additional facility which is impractical in either.

BAND-BOX FACILITIES

If a machine of this type is to have any real lasting value, as opposed to the many electronic "musical" gimmick items appearing daily on the market, it must have a wide capability. The operation of such a unit when described in words always appears more complicated than is actually found when hands-on experience is gained. A close perusal of the specification is recommended at this point to give some feel of the capability of the Band-Box, detailed operating procedures will be given later in a step by step format.

The layout of all controls is shown in the photograph and it can be seen that the *PE* Master Rhythm is an integral part of the Band-Box system, which, in addition to dictating operation of the drums and cymbals, provides control pulses to the Band-Box to determine the playback tempo and to produce twenty-four optional programmable rhythmic patterns to trigger the selected chord instrument. The latter facility is obtained using recording track six of the Master Rhythm, replacing the Long Cymbal originally in this position. The chord instrument will sustain during all measures on which a pulse is programmed and cease during periods of programmed rests. Thus for each drum pattern programmed into the Master Rhythm a separate chord rhythm is available to give guitar "licks" or keyboard stabbing techniques. Since different drum styles can be programmed into the Master Rhythm, based on $\frac{1}{6}$, $\frac{1}{3}$, $\frac{1}{4}$ or $\frac{1}{8}$ beats, a synchronisation control is provided below the beat indicator lamp to match the Band-Box to the style in use.

PLAYBACK

Operation of the Band-Box is organised in such a way that the natural keying procedure results in playback of a selected score. This helps to prevent unauthorised people accidentally or intentionally entering the composition, or recording mode, destroying the scores you will programme and wish to save, and also reduces the amount of thought required at the time of playback selection thus increasing operating speed.

The display panel guides the operator through the various procedures involved, whilst the numeric keypad provides facility to enter score page and line numbers working to an index in the same manner as a book wherein the length of the book is 3,500 lines split into 35 pages each 100 lines long. A line contains one instruction, usually a chord change and length in beats, and a complete score may consist of say 30-80 lines starting at, for example, page 4, line No. 35 which can be noted in a log book.

INSTRUMENTS

Prior to and during playback any instrument arrangement may be selected from four bass voices, which combine two waveforms and two envelopes, plus any of the sixteen permutations possible with the four waveforms and four envelope shapes available for the chord instrument. The bass

Layout of the control panel with the Master Rhythm top left

figure control offers the choice of four selected patterns for bass line movement. Balance of the trio is possible on three level controls and the mixed output has master and pedal volume controls.

PLAYBACK KEY

The key can be changed by rotating the twelve position control and will occur at the time of the next chord change. Playback key is completely independant of that used during composition, automatic transposition occuring within the Band-Box.

CODA KEY

A key is shown below the main key-pad which, when pressed, indicates to the Band-Box that the repeat chorus currently playing is no longer required. This causes playback to enter the coda section, and depending on the program may run to the next Score in a sequence of tunes. Automatic stop occurs as soon as a "Fine" instruction is seen in the programme. Adjacent to the Coda Key is a facility for calling up a blues or tuning sequence which are already permanently recorded in the machine.

COMPOSITION

The user's own chord sequences are entered into the score store of the Band-Box with the sixteen composition keys above the chord table which contain 120 different chords. The store retains the scores using an internal secondary battery which is automatically on charge whilst the machine is switched on.

In addition to the chord change and length instruction, the score can contain other instructions including automatic relative key changes, "repeat" and "repeat from" signs, and automatic stop.

SYSTEM DESCRIPTION

A schematic of the complete Band-Box system is given in Fig. 1, which shows a breakdown into three areas. The first area is the input/output system which consists of input keys and controls plus display and music generation output circuits. The system ports act as interfaces between the input/output area and the microcontroller which is shown on the right hand side of this diagram.

The internal operation of the Band-Box relies on the transfer back and forth of numbers which relate to some particular function. For example a switch with four positions is arranged to represent its current position by one of four numbers, 0, 1, 2 or 3 which can be put as signal levels into two wires in the binary format 00, 01, 10, 11 where 1=5 volts and 0=zero volts. As the number of linking wires between two areas increases the maximum number which can be represented increases rapidly to for example 256 (0-255) when 8 linking wires are used. To give a quick description for a group of wires the term "bus" is used, and to describe its size each wire represents a "bit" in the binary system so that an 8 bit bus is capable of transmitting any number which may be recognised between the limits of zero and 255.

THE MICROCONTROLLER

The Band-Box Microcontroller is constructed around an 8 bit microprocessor which at any moment is looking at (reading) or generating (writing) one number on an 8 bit data bus which is used as a common link between various memory positions in the microcontroller and the input/output ports.

When the "Reset" key is pressed any microprocessor is designed to first read the number in one fixed position within a memory described as the "monitor". This device in the case of the Band-Box is a 2K EPROM which means that it is a memory which can be prepared on suitable equipment to store 2,048 8-bit numbers which will not be lost during normal operation.

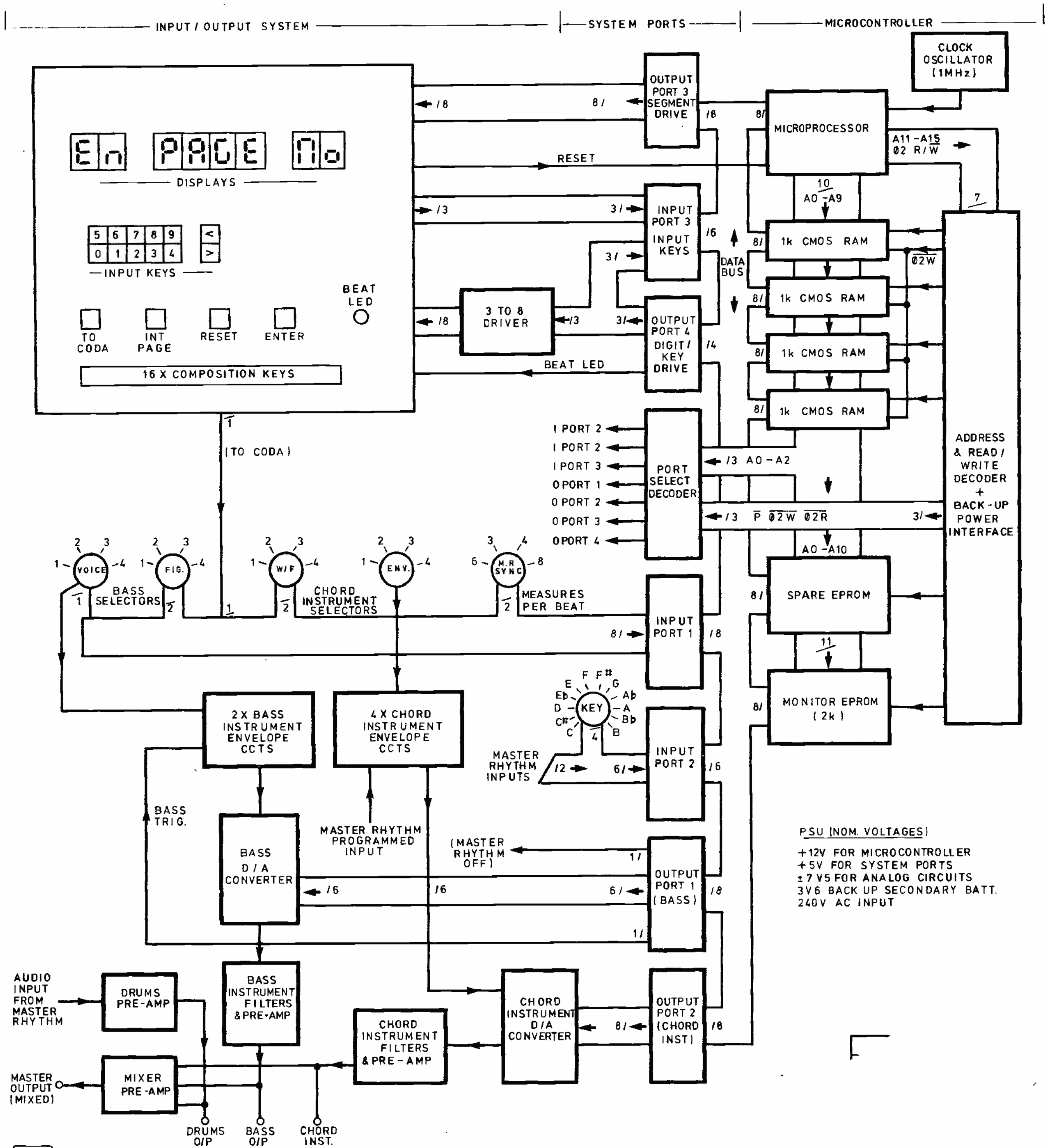
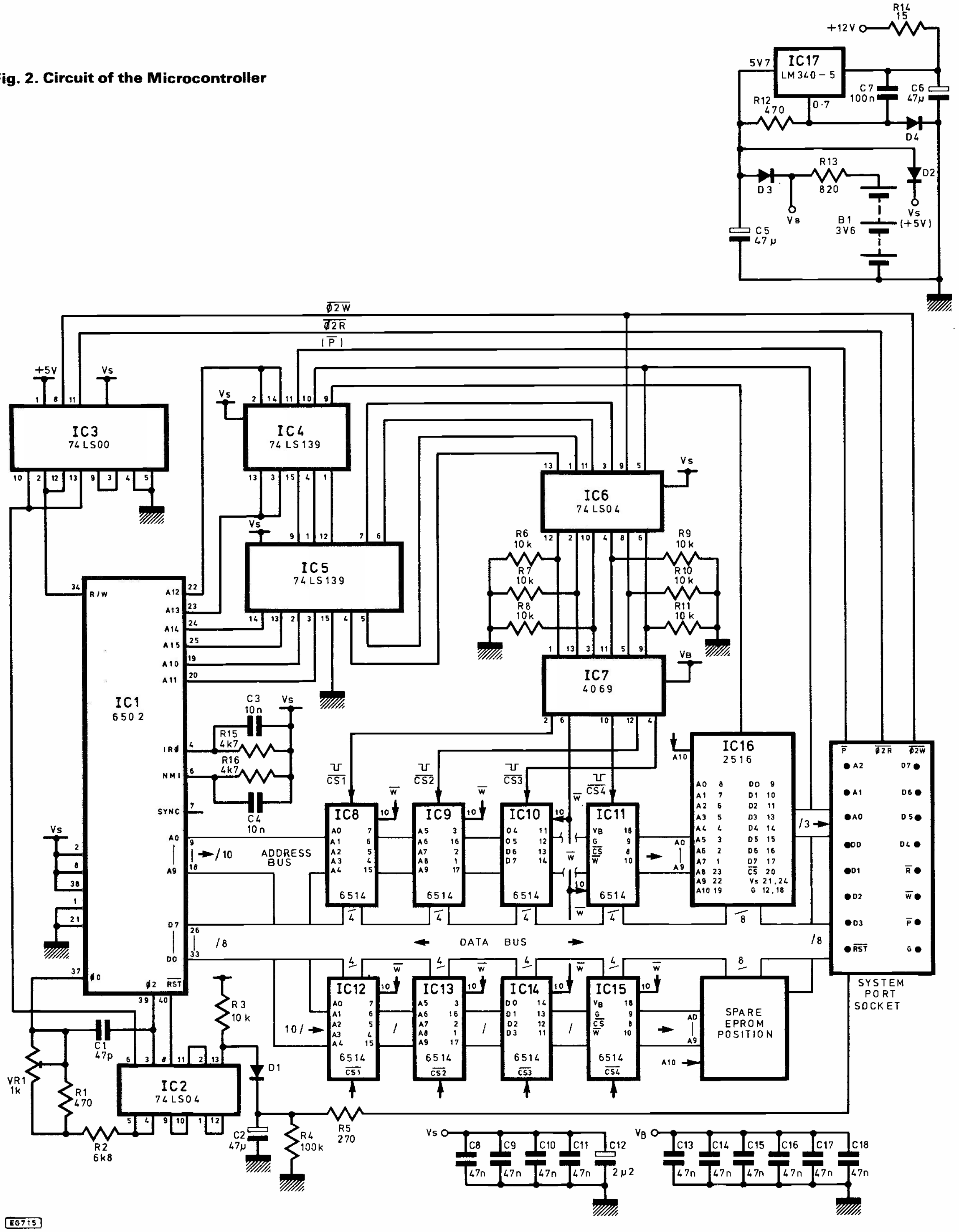


Fig. 1. Schematic of the Band-Box

Once the microprocessor has read the first number a continuous routine (program) automatically commences since the first number in the monitor tells the microprocessor what to do next. This will be a sequence of events which includes the placing of a number, corresponding to the position of a switch as described earlier, onto the data bus so that it may be read by the microprocessor. The numbers in the monitor, most of which are coded instructions for the microprocessor, will determine what should be done next dependent on the numeric value of the switch position.

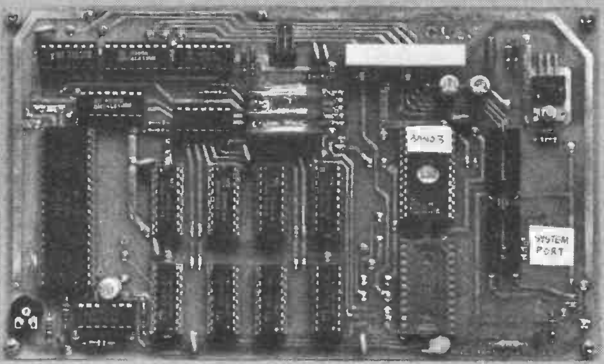
Of greatest importance to remember is that the microprocessor is only capable of one action at a time, such that a serial sequence of events has to be very carefully thought out with many branches to give all the functions required of a system. The great value of the micro-technique then arises from the speed at which the sequence of events can be carried out. Whilst the EPROM used to make the monitor is a standard microcomputer device, as are all other parts of the microcontroller and the system ports, it should be appreciated that the way in which the Band-Box functions is entirely controlled by the program which is put into the monitor EPROM and at this point it becomes the one

Fig. 2. Circuit of the Microcontroller



COMPONENTS

MICROCONTROLLER BOARD



Resistors

R1	470
R2	6k8
R3	10k
R4	100k
R5	270
R6-11	10k
R12	470
R13	820
R14	15 7W
R15-16	4k7

All resistors 0·25W 5% carbon film unless otherwise indicated

Potentiometers

VR1	1k horizontal preset 100mW

Integrated Circuits

IC1	6502
IC2	74LS04
IC3	74LS00
IC4-5	74LS139
IC6	74LS04
IC7	4069
IC8-15	6514
IC16	2516**
IC17	LM340-5

The EPROM requires to contain the special program and is available, as are all parts of the project, from **Clef Products (Electronics) Limited, 44A Bramhall Lane South, Bramhall, Stockport, Cheshire SK7 1AH.

Diodes

D1	1N4148
D2-4	1N4002

Capacitors

C1	47p silver mica
C2	47μ 16V elect.
C3-4	10n ceramic
C5-6	47μ 16V elect.
C7	0·1μ polyester
C8-11	47n ceramic
C12	2μ2 tantalum
C13-18	47n ceramic

Miscellaneous

Track pins	100
14 pin DIL sockets	4
16 pin DIL sockets	4
18 pin DIL sockets	8
24 pin DIL sockets	2
40 pin DIL sockets	1
3V6 secondary battery	1
Printed circuit board	1
3 pin molex connector	1 pair

special custom made device in the system.

Four blocks of CMOS RAM are shown in the Microcontroller, the major part of which forms the score store and holds the chord sequences, including the instructions mentioned earlier, in a coded format represented by numbers between 0 and 255. Random access memory (RAM) can store data sent to it by the microprocessor and any new data received replaces that previously held. The use of CMOS RAMs ensures that when the Band-Box is removed from the mains the chord sequences are retained using a very low (about 1μA) current drain from a secondary battery mounted on the Microcontroller p.c.b.

A 1 MHz oscillator drives the complete Microcontroller and has a small degree of frequency adjustment available to act as a tuning control. The remainder of the system consists of address decoding logic which will be described later, and is provided to determine which one element of the system is either reading or writing data at a particular moment.

SYSTEM PORTS

Three input and four output ports are used in the Band-Box. The input ports transmit switch information onto the data bus when requested by the Microcontroller whilst the output ports latch information, which is only available from the Microcontroller for less than 1μs, for use by other parts of the Band-Box. Decoding circuitry is provided to activate each port at the appropriate moment determined by the Microcontroller.

INPUT/OUTPUT SYSTEM

Signals for the multiplexed 8 digit display are also used to scan the complete keypad system. An 8-bit port drives the display segments, whilst 3 bits of output port 4 sequentially select each display and key column via a decoder. Keypad entry is detected on half a six-bit input port, the other half noting the display and key column selected. The fourth bit on output port 4 pulses an l.e.d. on all beats.

Input port 1 transmits information from three four position switches (3 x 2=6 bits) plus two states for the bass voice selector and two states (on/off) for the "Coda" key. This combines to make an 8-bit port.

Input port 2 combines the twelve position key selector with two Master Rhythm inputs, the first a continuous chain of pulses defining the tempo and the second signalling that the "Play" key has been pressed. Output port 1 provides six bits to define the bass instrument waveforms via the digital to analog converter plus a pulse to switch off the Master Rhythm on auto-stop, and a trigger pulse for the bass. Output port 2 provides eight bits to drive a DAC to produce the chord instrument waveform.

Reprints of the PE *Master Rhythm, published in the December 1980 and January 1981 issues of Practical Electronics, are available from Clef Products (Electronics) Limited, 44a Bramhall Lane South, Bramhall, Stockport, Cheshire SK7 1AH, Price £1·00 inc. VAT and p & p.*

MUSIC GENERATION

The music sounds are generated by converting the numbers presented at output ports 1 and 2 into analog voltages thus producing stepped waveforms which require filtering to remove the steps. More detail will be given on this technique later, but the schematic shows the two digital to analog converters followed by filters and preamplifiers.

Switched Envelope circuits drive the DACs giving a very simple system of music sound generation.

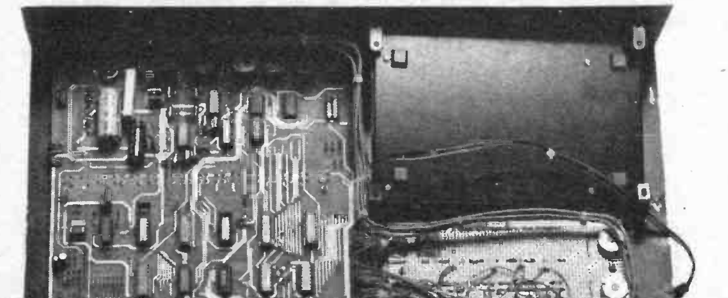
SYSTEM LAYOUT

The input/output system is contained on a single printed circuit board measuring 10in × 9in plus a display and keypad board 8in × 5in, whilst the Microcontroller is completely self contained on a $7\frac{1}{2}$in × $4\frac{1}{2}$in p.c.b. The Master Rhythm uses two p.c.b.s mounted in a metal case $8\frac{1}{4}$in × $5\frac{1}{4}$in × 3in and it is recommended that this unit is built and tested before proceeding with integration into the remainder of the Band-Box.

MICROCONTROLLER OPERATION

The complete circuit of the Microcontroller is shown in Fig. 3. Here an 8 bit data bus with lines DO and D7 links the microprocessor IC1 to CMOS RAMs IC8-13, the monitor EPROM, IC16, a spare extension EPROM position, and the system port which links to the system board by a flexible lead. IC1 controls what data is present on the data bus at any given moment either by instructing one of the memories or the system port to provide the data (read) or itself placing the data on the bus and instructing one of the other elements to receive it (write). To define which device is to be involved the microprocessor uses an address bus which since it has 16 bits (lines A0 to A15), can differentiate between 65,536 possible addresses. In the Band-Box application over 48,000 addresses are unused but could locate further memory if required giving another 750 tunes which is beyond most people's requirements.

In order to decode the required addresses some address lines go direct to memories and the system port whilst others go to the IC4 and IC5, containing dual decoders which reduce the large number of addresses to smaller blocks. For those interested in the addresses concerned (memory map) more detail will be given at the end of the series but it is not necessary to understand this in constructing the Band-Box. Address lines go positive for a '1', decoders give a −ve (0 volt) pulse when they are being addressed. $\overline{P}$ is a negative pulse from decoder IC4 which appears whenever devices on the system board are to be selected.



Rear view of control panel

CLOCK AND AUTO RESET

Both these functions are combined in IC2, two inverters acting in conjunction with VR1, R1, R2 and C1 to define the clock frequency which also determines musical pitch, and the remaining four inverters carry the reset signal. This is a negative pulse (from +5 volts) which must appear at pin 40 of IC1 to initiate operation of the complete cycle as discussed earlier. R3 and C2 provide a time constant to ensure that a reset pulse occurs when mains is applied to the Band-Box whilst D1 isolates this action on switch-off. The $\overline{RST}$ connection on the system port connector leads back to the reset button on the System Board and simply shorts to ground when pressed for subsequent reset actions.

OTHER CONTROL PULSES

The only remaining connection to the micro which is used in this application is R/$\overline{W}$. This is +ve when the micro wished to read or receive information and ground when sending or writing. In order to obtain clean transfer of data the first half of any clock period is reserved for establishing the address required and the second for actually transferring the data.

Consequently one of the clock signals Ø2 (out) is combined with R/$\overline{W}$ to give a pulse during the second part of the clock cycle when Ø2 (out) is high. Simple NAND gates in IC3 achieve this to give −ve write or read pulses which have been labelled $\overline{\emptyset 2W}$ and $\overline{\emptyset 2R}$ respectively. When combined later with a decoded address, these pulses make a clear statement "write to" or "read from" this "address".

ISOLATION CIRCUITRY

Since a fundamental requirement of the Band-Box is to store information without any loss when mains is removed, a secondary battery back-up is provided on the microcontroller board. The CMOS memories are controlled by −ve chip select pulses $\overline{CS}$, provided by the address decoding, and receive the $\overline{\emptyset 2W}$ pulse when new information is required to be written into the memories.

When the system is in the off-mains condition the battery provides the normal +ve supply and it is also necessary that $\overline{CS}$ and $\overline{W}$ are held at this level. The combination of IC6 and IC7 accomplish this without loss of data at the changeover points between mains and battery.

POWER SUPPLY

The complete Microcontroller, including memories, takes less than 200mA from an unregulated 12 volt supply. An on-board regulator IC17 in combination with D4 reduces this to 5V7, which after the drop through D2 further reduces to +5 volts nominal. R13 provides charging to the secondary battery when the unit is receiving power from the mains.

MICROCONTROLLER CONSTRUCTION

The photograph illustrates the single board assembly, which is mounted on a double sided printed circuit board, consisting of 6502 Microprocessor, eight 6514 1K X4 bit CMOS RAMS, a 2516 EPROM, six logic i.c.s, system port output socket and a secondary battery with power regulator and charging circuit.

Assembly of the board requires care due to the large number of tracks present and it is recommended that a 1mm soldering iron bit be used for most of the soldering operations with 22 s.w.g. solder.

Next month: Assembly of the Microcontroller single board will be described together with more circuit description.

Digital Design Techniques...

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Part 4 Sequential Logic

IN THE series so far we have mainly been looking at COMBINATIONAL logic; the various inputs are combined to produce one or more outputs, and these outputs are totally dependent on the logic states of the inputs at that time. (Time delaying circuits are a slightly different case than this, of course.) With the 'latch' circuit, because of its 'memory' type of capability, the output of the circuit is dependent not only on its inputs at that particular moment in time, but also the state of its inputs IN THE PAST. For example, looking at the NAND gate latch of Fig. 4.1a, the two inputs may currently be at logic 1; if A had at some time in the past been at logic 0, then Q would be 1; or if B had been at logic 0, then Q would be 0.

SEQUENTIAL CIRCUITS

This introduces a whole new world of logic circuitry, known as 'SEQUENTIAL' logic, which involves the use of basic 'memory' type circuits connected together in various combinations and arrangements. The basic latch circuit of Fig. 4.1a is also known as an R/S flip-flop; input A can be considered the 'set' input, causing Q to go to 1 when activated, and B the 'reset' input, causing Q to go to 0 when activated. It may be that we wish to first 'set up' the conditions of the two inputs, set and reset, and then activate the flip-flop into whatever states these inputs dictate. This can be done by 'enabling' the inputs with NAND gates, as shown in Fig. 4.1b. This arrangement is known as a 'clocked' R/S flip-flop; until the 'clock' input is taken to logic 1, any variations of the two inputs will have no effect on the Q and $\overline{Q}$ outputs. Note that set and reset actions occur when these inputs are at logic 1, not logic 0 as before, due to the inverting action of the extra NAND gates.

The problem with this circuit is that it can be in an indeterminate state. If both the set and reset inputs are at logic 1 at the same time, then the clock input is taken to logic 1 and back to logic 0, the Q and $\overline{Q}$ outputs initially both go to logic 1, then to an indeterminate condition which cannot be controlled; Q could be 0 and $\overline{Q}$ could be 1, or Q could be 1 and $\overline{Q}$ could be 0. To remove this uncertainty we can make sure that the set and reset inputs are never at the same logic state, by adding an inverter and using only one input to the system. This single input is now the 'Data' input, and hence the circuit is known as a 'D' type latch, or 'D' type flip-flop. See Fig. 4.1c. The clock pulse should be as short as possible normally, because any changes of the logic state of the D input which take place while the clock pulse is at logic 1 will be transferred directly to the $\overline{Q}$ output, and inversely to the Q output. In practice this problem is usually got round by adding extra internal gates to the i.c. which ensure that the output changes of state only occur when the clock input changes from 0 to 1 (or 1 to 0 in some i.c.s) and no change of output state can occur when the clock input is at a fixed logic level of either 0 or 1. The flip-flop is then known as an 'EDGE TRIGGERED' type. We can add extra inputs, set and

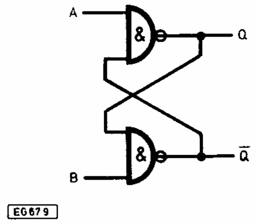


Fig. 4.1a. The 'latch' or 'R/S flip-flop'

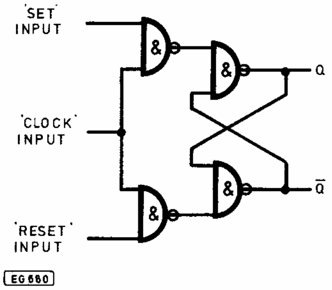


Fig. 4.1b. Clocked R/S flip-flop

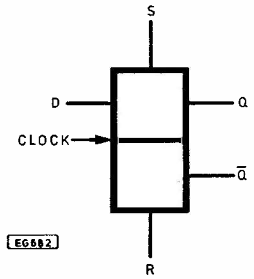


Fig. 4.1d. Edge triggered 'D' type flip-flop symbol

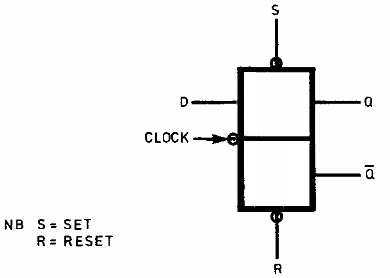


Fig. 4.1e. Inverting functions on some of the inputs

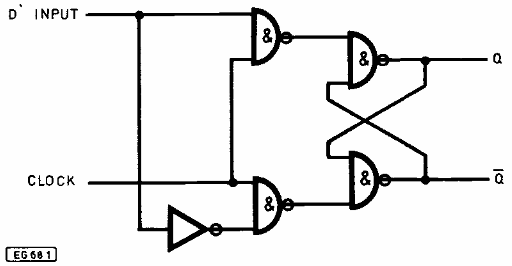


Fig. 4.1c. Clocked 'D' type flip-flop

reset, to over-ride the logic states produced by the D input and clock input. (The circuitry becomes very complex; that's why we're not showing it in detail here!) The result is the 'edge triggered' D-type flip-flop, with set and reset. Its circuit diagram symbol is shown in Fig. 4.1d.

Note that all the inputs to the device in Fig. 4.1d are shown connected directly to the flip-flop, meaning that all operations occur on the positive going edge of the clock, i.e. when logic 0 changes to logic 1; also set (or reset) is effected when the S (or R) input is at logic 1. (Set and reset functions are usually independent of the clock, as they over-ride any 'clocking' action.) If a circle is added on the diagram to an input connection, it indicates that the change occurs on the negative going edge of the clock pulse, or the device is set (or reset) when the relevant input is at logic 0. This arrangement is shown in Fig. 4.1e.

MASTER/SLAVE FLIP-FLOPS

Still more sophistication can be added to the basic, or "master" flip-flop circuit by adding a second "slave" flip-flop into the i.c., which is connected in different ways dependent on the device in question. Frequently, Master/Slave techniques are introduced to prevent any danger of the outputs being changed due to inputs changing together, or due to any other simultaneous logic changes. The best known Master/Slave device is the "Master/Slave J/K flip-flop", the symbol for which is shown in Fig. 4.2a.

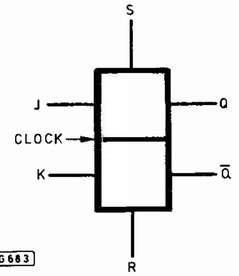


Fig. 4.2a. The Master/Slave J/K flip-flop symbol

Most TTL versions of this circuit use both edges of the clock input pulse to activate the device. On one edge the logic states on the J and K input pins are transferred into the first (Master) flip-flop, and on the other edge the outputs of the master flip-flop are transferred into the second (Slave) flip-flop, hence causing changes in the Q and $\overline{Q}$ outputs.

In most CMOS devices, the flip-flop uses only one edge of the clock input, but effectively in two stages. When the relevant edge of the clock input occurs the contents of the Master flip-flop are transferred to the Slave, and hence become available as Q and $\overline{Q}$ outputs. These outputs then

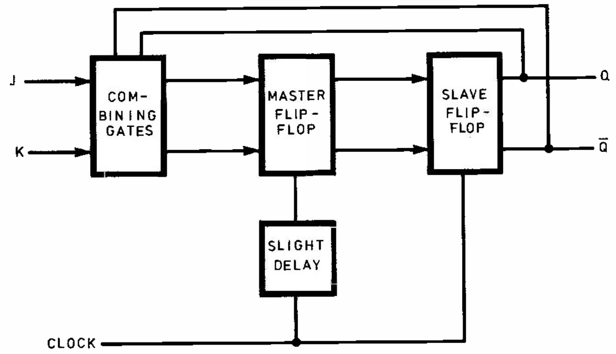


Fig. 4.2b. Block diagram of the J/K Master/Slave flip-flop

feed back to, and are combined with, the J and K inputs using logic gates, and the outputs of these combining circuits are then fed into the Master flip-flop. See Fig. 4.2b. The slight delay between these events is created by adding extra logic gates between the clock and the Master flip-flop, the propagation delay of these extra gates being long enough to give the Slave and combining gate circuitry time to change before the Master flip-flop does.

The combining feature is used to prevent any indeterminate states occurring, as in the case of the R/S flip-flop, due to both J and K inputs being at the same logic state simultaneously. It is arranged that if J and K are both at logic 1 when the clock pulse occurs, the two outputs will change state from whatever they were in prior to that clock pulse, and if J and K are both at logic 0 the output will not change state when a clock pulse occurs. Also, if J = 1 and K = 0 the flip-flop will set; i.e. if Q was 0 it will go to 1, and if it was 1 it will STAY AT 1. If J = 0 and K = 1, the flip-flop will reset, i.e. if Q was at 1 it will go to 0 and if it was at 0 it will STAY AT 0. This is quite different to the D-type flip-flop and is a very useful feature.

FLIP-FLOP TRUTH TABLES

We can conveniently draw out truth tables to show the operation of flip-flops; they are similar to the truth tables that we have already used to represent logic gates and combinational circuits, with additional columns to show the effects before and after clock input edge changes. See Figs. 4.3a and 4.3b. The action of the over-riding set and reset inputs has not been included in these diagrams for simplicity; in practice, they always over-ride any Q and $\overline{Q}$ output state, regardless of any changes of state of the clock. For example, if S = 1, then Q = 1 and $\overline{Q}$ = 0 no matter what. If R = 1; Q = 0 and $\overline{Q}$ = 1. If both R and S are 1, then usually Q = 1 and $\overline{Q}$

Fig. 4.3a. Truth table for 'D' type flip-flop (positive edge triggered)

BEFORE CLOCK GOES TO 1 (INPUTS) — AFTER CLOCK GOES TO 1 (OUTPUTS)

INPUTS		OUTPUTS	
CLOCK	D	Q	$\overline{Q}$
_|‾	0	0	1
_|‾	1	1	0
‾|_	0	NO CHANGE	
‾|_	1	NO CHANGE	

NO CHANGE: REMAIN Q & $\overline{Q}$

EG685

_|‾ = CLOCK CHANGES FROM 0 TO 1

‾|_ = CLOCK CHANGES FROM 1 TO 0

BEFORE CLOCK GOES FROM 0 TO 1 (CURRENT STATE OF OUTPUT, INPUTS) — AFTER CLOCK GOES FROM 0 TO 1 (NEXT STATE OF OUTPUT)

CURRENT STATE OF OUTPUT	INPUTS			NEXT STATE OF OUTPUT
Q	CLOCK	J	K	Q
0	_|‾	0	0	0
0	_|‾	0	1	0
0	_|‾	1	0	1
0	_|‾	1	1	1
1	_|‾	0	0	1
1	_|‾	0	1	0
1	_|‾	1	0	1
1	_|‾	1	1	0
X	‾|_	X	X	NO CHANGE

EG686

X = ANY STATE

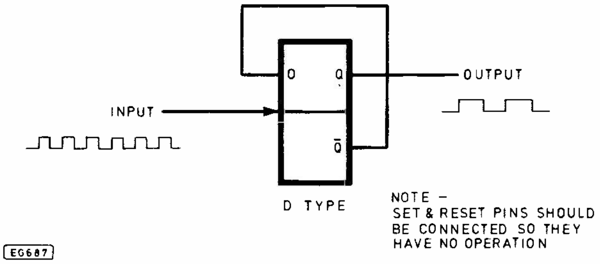
Fig. 4.3b. Truth table for the J/K flip-flop (positive edge triggered)

= 1; the exact way in which set and reset functions operate varies from i.c. to i.c., but most work along these basic lines.

There are other types of flip-flop, but the R/S, D-type and J/K are by far and away the most frequently used, and we shall stay with these for the rest of the series.

DIVIDING AND COUNTING

We can very easily connect flip-flops to give a "divide by two" function; in other words the output logic state changes once for every two changes of the input logic state. See Fig. 4.4; the circuits are shown with a stream of pulses coming into them.



The CMOS type 4013 is a 'dual device', two in each package

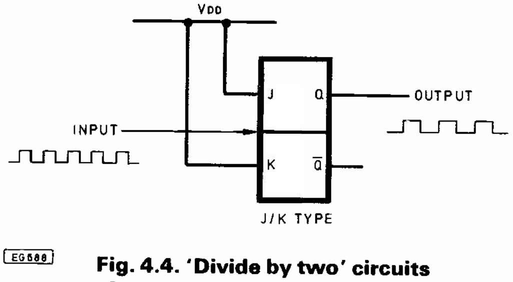


Fig. 4.4. 'Divide by two' circuits
The CMOS type 4027 is a 'dual device'

In the D-type circuit, if we assume that initially Q = 0, then Q̄ must be 1, so D = 1. When the clock input goes to logic 1, the 'D state' is transferred to the Q output, so Q becomes 1 and Q̄ becomes 0. When the clock input next changes to logic 1, the 0 now present on the D input is transferred to the Q output, so Q̄ goes back to 1 again; and so on.

The J/K circuit is even simpler; Fig. 4.3b showed that if both J and K are logic 1, then the output states simply reverse from the logic state that they were in before the clock input went to 0. So on every clock change from 0 to 1, the Q output reverses state, and, of course, the Q̄ output is the inverse of the Q output.

Since the circuit activity only takes place on one edge of the clock input, the output is not dependent on the input waveform as such; the input can be a square wave or pulses of any sort; the output will always be a 'square wave' of half the frequency.

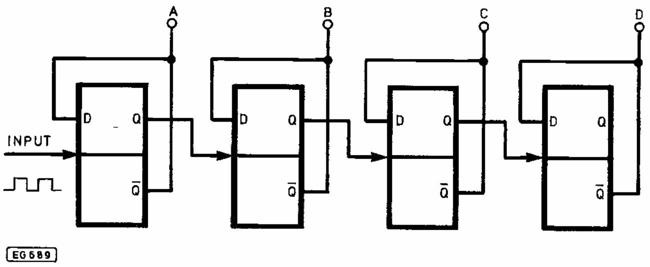


Fig. 4.5a. Cascaded divide by two circuits

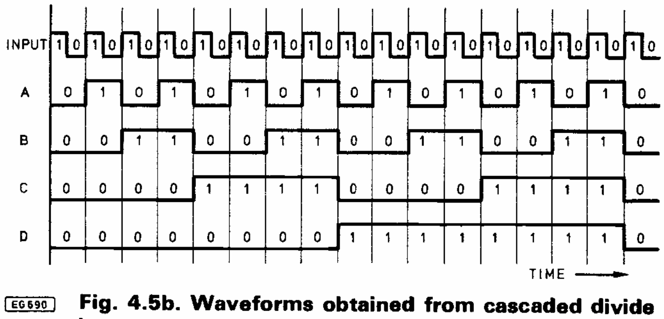


Fig. 4.5b. Waveforms obtained from cascaded divide by two's

These circuits can be connected together in series, or 'cascade', of course, to divide by 4, 8, 16, 32, 64 or any power of the number 2. An interesting effect happens if we connect some divide-by-two circuits up this way, and then look at the Q̄ outputs of all the flip-flops in the circuit simultaneously. Fig. 4.5a shows the circuit, and Fig. 4.5b shows the waveforms that we can obtain from it. A table can be made up to show all these changes together; each time the input is at logic 1 we can write down the states of the four outputs, A, B, C and D, by looking up the vertical columns drawn in Fig. 4.5b. For example, at the first input pulse, the output states are 0000; at the second 0001, at the third 0010, etc. Table 1 has been labelled with numerical

D	C	B	A	Numerical equivalent
0	0	0	0	0
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7
1	0	0	0	8
1	0	0	1	9
1	0	1	0	10
1	0	1	1	11
1	1	0	0	12
1	1	0	1	13
1	1	1	0	14
1	1	1	1	15

Table 1: Table of outputs obtained from cascaded divide-by-two circuits

equivalents for each set of logic states, with the 0000 state being zero. This table may well be instantly recognisable to you; it's a sequence of "Binary Numbers", i.e. numbers which use the base 2, instead of the base 10, which we use for our conventional number system. We'll be looking at numerical systems later in the series. Sufficient to say that at every input pulse the binary number increases by one, so the circuit of Fig. 4.5a is known as a "Binary up-Counter" or sometimes a "Binary Divider" since it is a series of divider circuits connected together.

An i.c. can contain many more than just four flip-flops, hence counters or dividers are available with many stages in them; typical and popular devices are the negative edge triggered 4020, a 14 stage device (although all these stages cannot be connected to some are connected internally only), and the negative edge triggered 4024, a 7 stage device. With all these counters, note that when the maximum count has been reached (all digits = 1), the next input pulse sets all outputs to 0, and the count continues again from zero.

SEQUENCING

It may be that we want to count in decimal, i.e. our conventional number system, rather than binary. Such a circuit would have, say, 10 outputs numbered 0 to 9. On the first input pulse, output number 0 would go to logic 1, and the rest would be at logic 0. On the second input pulse output 0 would go back to logic 0, output 1 would go to logic 1, and the other outputs would be at logic 0, and so on. This arrangement would ensure that only one output would ever be at logic 1 at a time, after the last one had been at logic 1, the first one would start again 'ad infinitum'. This circuit is sometimes known as a 'sequencer', because of the effect of 'moving' a logic 1 'along' its output at every input clock pulse.

A decimal counter can be made by adding logic gates to the outputs of a binary counter to decode the binary numbers into the decimal codes just described. In practice, however, decimal counter i.c.s are readily available, and have the decoding gates interconnected between the flip-flops, internal to the i.c. By far and away the most regularly used of these is the CMOS 4017; this is a decade counter, with a reset function which resets all the outputs of the counter to logic 0 when taken to logic 1, after which the count must start again from the beginning. The waveforms available from this device are shown in Fig. 4.6. As well as

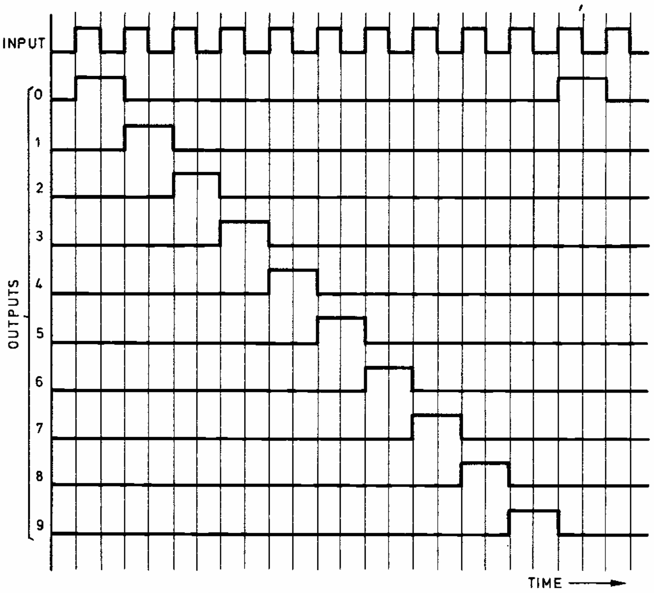


Fig. 4.6. Waveform diagram for the 4017 decimal counter

the normal outputs there is a 'carry out' facility. This is an output which goes to logic 1 when output 9 return to logic 0, then returns to logic 0 again later in the sequence; if connected to the clock input of another 4017 device it will cause this device to count up one for every ten input pulses; in other words, it will have cascaded the two counters to form a '2 decade' counter capable of giving an equivalent count of 99. This cascading arrangement, of course, can also be implemented very easily with binary counters by connecting the last output of one device to the clock input of the next one.

The 4017 also has a 'clock enable' input, which prevents any changes taking place (apart from reset) when held at logic 1; for normal operation this input should be held at logic 0. A final point to note about this i.c. is that it has built-in current limiting on the outputs, each output being able to directly drive an l.e.d. if supplies of 9V or less are being used; last month's article gave the details of this, of course.

TRIGGERING EDGES

So far we have mostly considered devices which are triggered by the positive going edge of an input or clock pulse. This, in the most case, is what is used, but BEWARE! Some devices are triggered on the negative edge, for example the 4020 and 4024 counters mentioned earlier. It is important to check which edge is used to trigger on; and, for that matter, other inputs too, before designing with i.c.s for the first time. Manufacturer's or Distributor's data sheets are good sources of information.

SELF-RESETTING

It may be that a counter, decimal or binary, is required to finish counting and start again at zero before it reaches its maximum count. For example, a sequence of six counts only may be wanted from a 4017, with the seventh input pulse causing it to 'start again', turning on output 0. This is very easily achieved by connecting the next output after the last one wanted, to the reset pin, either directly or via gates if a more complex facility is required. For example, if output number 6 of a 4017 is connected back to the reset pin, then the sequence will run: 0–1–2–3–4–5, and then as soon as output 6 goes to logic 1, the 4017 will be reset, and pin 6 will be forced to go back to logic 0 again, with the counter starting again at count 0. The pulse out of output 6, then, will be very short indeed; only as long as it takes for the device's reset circuitry to operate, which is less than one microsecond! In most applications this small pulse can be disregarded and the counter appears to be counting: 0–1–2–3–4–5–0–1–2–3–4–5–0–1–2 etc. Although this example is for a decimal counter, a binary counter can also be reset in similar ways, although frequently it has to have several of its outputs combined using gates, in order to reset the device when a certain combination of output states occurs.

Let's now look at a practical example of a 4017 counter in use: the 'DISCO HAT'. The '7-segment' l.e.d. displays that we shall use are very simple display devices, working on the principle that numbers, and, as we shall see, some letters, can be displayed as combinations of seven bars of lights, laid out in the familiar 'figure-of-eight' pattern, as shown in the component layout drawings. Each bar is lettered a, b, c, d, e, f, or g for convenience, with a common connection between all the anodes of the l.e.d.s making up the display. (We'll look more extensively at display types, and the driving of them, later in the series.)

THE DISCO HAT

If you've been out to a dance or disco recently, then you've probably seen a number of people wearing caps which have half a dozen flashing lights set into them. Well . . . here's a way of going one step better, with your own name being spelt in lights on the top of your head!

The disco hat in essence is a headband designed to fit any sort of cap or hat that you wish. One 7-segment display is used for every letter of your name, with a small battery and some circuitry to drive the displays. Simply switch on the hat, and it spells out your name; letter by letter at first, then in full, over and over again. In this case, because it was made for a friend, the hat spells "t – i – n – a – tina – t – i – n – a – tina – t – i" etc, etc, until the dancing gets the better of you or the battery gives up! On the other hand, if you're the DJ the project would make a great display on the front of your console, with two or more complete units giving the whole disco name.

The hat is based on the idea that you can use ordinary 7-segment displays, normally used for displaying numbers, to display letters too. Some letters are difficult to reproduce, and some impossible, so if you fall into the category of having a 'difficult' name in this respect you'll have to go for initials, or a nickname! Each 7-segment display can be 'programmed' to display the particular letter required by putting the correct combination of resistors on the board. Table 2 shows the letters available and the resistor positions you'll need to generate these letters. Name lengths of up to 9 letters can be catered for, although you head will have to be quite large to cope with it!

CIRCUIT DESCRIPTION

The complete circuit diagram of the Disco Hat is shown in Fig. 4.7.

IC1 is a low-power CMOS timer, connected to oscillate at approximately 2 hertz (2 cycles per second). This oscillation frequency is determined by R1, R2 and C3; varying any of these will vary the speed at which the spelling out of the name will take place. The positive supply for IC1, IC2, the timing resistor R1, and the reset pin of IC1, is derived from the main 9 volt supply rail via diode D1 and a smoothing capacitor C1; when the displays are switched on, sudden surges of current on the supply rails can cause malfunctions of IC1 and IC2 and this D1/C1 combination helps to combat this potential interference.

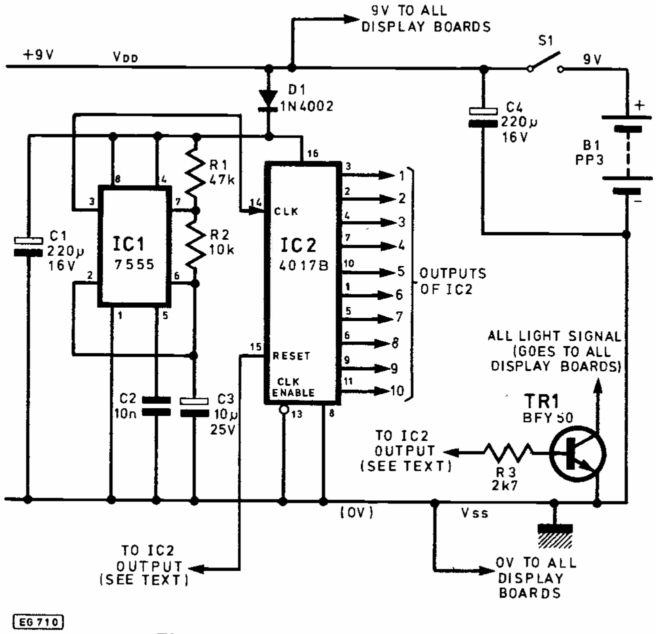


Fig. 4.7a. Control circuit diagram

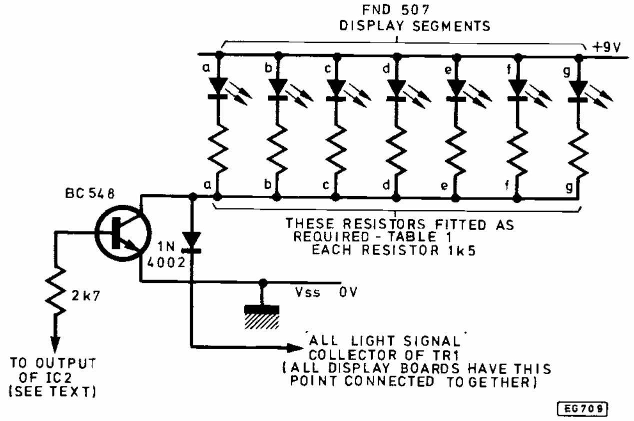


Fig. 4.7b. Display circuit diagram

Pin 3 of IC1, the output pin, drives into the clock input of IC2 the 4017 decode counter, the outputs of which are used to drive the displays via suitable circuits to boost the low current outputs of IC2 to a high enough level to drive the displays satisfactorily. (The 4017 cannot drive all the l.e.d.s in each 7-segment display, directly, at once.) After each of the letters has been lit individually by IC2, the next IC2 output is used to turn on TR1 via R3. This lights up all the displays at once, showing the name in full. The next IC2 output after that one is connected back to IC2 pin 15, the reset pin. So, after displaying the name in full, IC2 resets itself and starts spelling the name out again, 'ad infinitum'.

CONSTRUCTION

The circuits of Fig. 4.7 are constructed on Global's 'Matchboards' with the layout of components on the various cut up pieces of Matchboard shown in Fig. 4.8. The boards should be cut as shown, so that the control circuit fits on the first piece, and each letter then has its own small part of a board. One Matchboard will enable you to build the control circuit and two letters, with a small piece left over which you can use for the battery and switch board at the end. Each subsequent Matchboard that you buy will provide for a further four letters.

Build up the control circuit board and the required number of letter display boards as shown in Fig. 4.8, but for the time being do NOT put in the 'tie wires' on the boards. Build the battery and switch board using any suitable left over piece of board. Exactly how you wire this board will depend on the switch used; the layout shown is typical for a large slide switch. The only requirement is that this board switches +9 volts from the battery to the top rail, and connects 0 volts (the battery negative terminal) to the bottom rail. Finally, insert all display board resistors to make up the letters required; see Table 2 for details of what to put where.

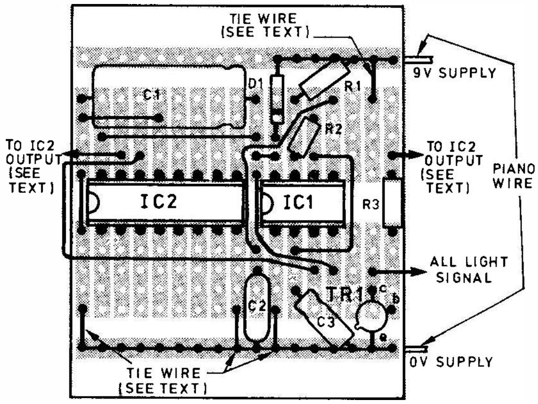


Fig. 4.8a. Control circuit board layout

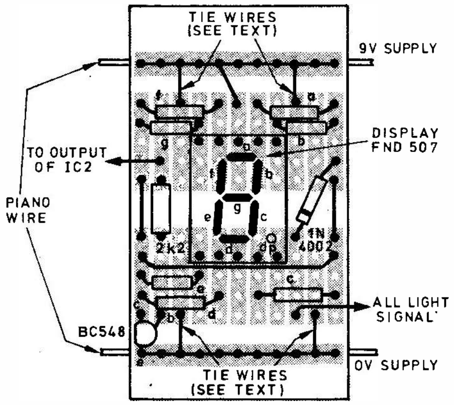


Fig. 4.8b. Display board layout

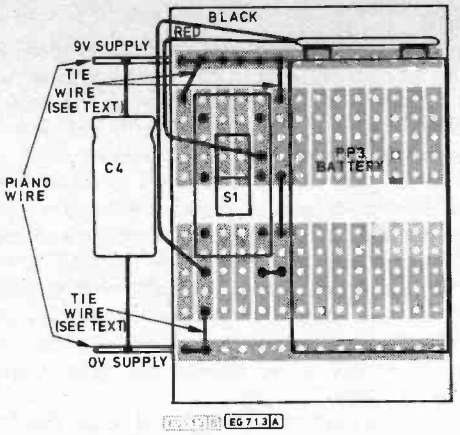
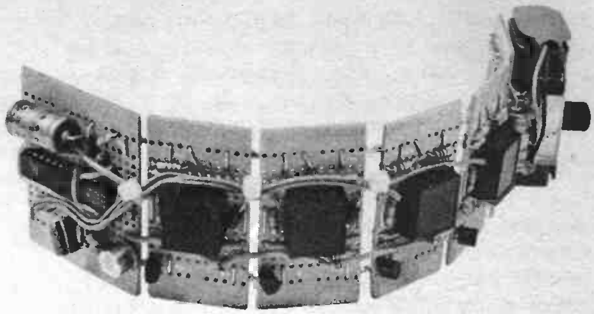


Fig. 4.8c. Battery and switch board layout

LETTER	RESISTORS NEEDED ON DISPLAY BOARD (See Fig. 4.8b)
A	a, b, c, e, f, g
b	c, d, e, f, g
C	a, d, e, f
or c	d, e, g
d	b, c, d, e, g
E	a, d, e, f, g
or e	a, b, d, e, f, g
F	a, e, f, g
G	a, c, d, e, f
H	b, c, e, f, g
or h	c, e, f, g
I	b, c
or i	c
J	b, c, d, e
L	d, e, f
N	a, b, c, e, f
or n	c, e, g
O	a, b, c, d, e, f
or o	c, d, e, g
P	a, b, e, f, g
q	a, b, c, f, g
r	a, b, e, f
S	a, c, d, f, g
t	e, f, g
U	b, c, d, e, f
or u	c, d, e
y	b, c, d, f, g

Table 2. Table of letters available and resistor positions needed.
Upper *and* lower case letters can sometimes be reproduced; choose whichever looks most in keeping with the letters on each side of it.
For 'Z', you could use a, b, d, e, g, but it's too much like a '2' really!
For 'M' and 'W', you could try a '3' (i.e. a, b, c, d, g) and turn the whole display board round on its side, but mounting it on the piano wire frame would be more difficult.

Take two lengths of 16 s.w.g. or 18 s.w.g. piano wire, clean them up with fine sandpaper, and then bend to suit the profile of the head, the hat used, and the number of boards, ensuring that along the length of each board the piano wire is straight, with the bends coming in between boards. Look carefully at the photograph to clarify this point. When the wires have been adjusted to fit correctly (it'll take a few tries to get it right!) cut off any excess, then 'tack' solder each



board to the piano wires in the centre of its top and bottom tracks only, to get the positioning correct. Now is the time to add the 'tie wires' to each board, as shown in Fig. 4.8. These are ordinary single core wire links, fed through the board as shown, then wrapped over the piano wires to secure them as firmly as possible. These tie wires should then be soldered to the Matchboard tracks, and to the piano wires, and the piano wires should be soldered to the Matchboard tracks along the whole of their lengths.

The whole assembly is made very strong indeed by this procedure, and the piano wires are used to distribute the power supply to all the boards. Capacitor C4 can now be added; this fits between the battery and switchboard, and the last display board, and has its positive end soldered directly to the top piano wire and the negative end soldered to the bottom piano wire.

The wires from the output of IC2 can now be added. The 2k7 resistor on the first display board connects to IC2 pin 3, (the first output of IC2). The 2k7 resistor from the second display board connects to IC2 (the second output of IC2).

COMPONENTS . . .

Resistors

R1	47k
R2	10k
R3	2k7
Plus	2k7 1 off per letter of the name
	1k5 up to 6 off per letter of the name

All resistors $\frac{1}{4}$W 5% carbon

Capacitors

C1, C4	220µ 16V elect. (2 off)
C2	10n polyester
C3	10µ 25V elect.

Semiconductors

D1	1N4002
TR1	BFY 50
IC1	ICM 7555
IC2	4017B
Plus	1N4002 1 off per letter of the name
	BC548 1 off per letter of the name
	FND 507 7-segment display (common anode)
	1 off per letter of the name

Miscellaneous

B1	PP3 9V high power (not alkaline see text)
S1	Any single or double pole switch
PP3 connector	
GSC Matchboard	(2 off for up to 6 letters, 3 off for up to 9 letters)
Piano wire	

The 2k7 resistor from the third display connects to IC2 pin 4 (the third output of IC2), etc., etc., Refer to Fig. 4.8 for all other IC2 output pin numbers. After the last display has been connected to IC2 connect R3 to the next IC2 output pin, and connect pin 15 of IC2 to the next output after that. To clarify this, let's look at the example of t – i – n – a:

"T" (first display) 2k7 resistor connects to IC2 pin 3
"I" (second display) 2k7 resistor connects to IC2 pin 2
"N" (third display) 2k7 resistor connects to IC2 pin 4
"A" (fourth display) 2k7 resistor connects to IC2 pin 7
R3 (on the control circuit board) connects to IC2 pin 10
IC2 pin 15 connects to IC2 pin 1.

If you are using the full capability of 9 letters, connect IC2 pin 15 to the 0 volts supply line (Vss); IC2 will cycle through from the last output to the first one again without needing to be reset each time. Finally, the 'All Light' points on the display boards (i.e. the cathodes of the IN4002 diodes) should be connected together in parallel, and then connected to the collector of TR1 on the control circuit board.

Check for short circuits, solder splashes, and wiring errors, then add a battery, switch on, and you should be away! If your name is very long, and the battery weak, the Disco Hat may 'jump' letters from time to time, or behave erratically, in which case increasing the values of C1 and C4 will help. Beware of alkaline batteries though; although they last a very long time, they have a relatively high output impedance, and in this particular circuit they can give poor results with some name lengths.

MILLINERY

The whole purpose of this 'mini-project' is to enable you to wear the gadget as described. Here's where, in many cases, it's time to hand the job over to the lady of the household! It really is up to you how to fit the unit into the hat, but to get you started, here's how I did it:

A piece of felt was cut large enough to cover the whole front of the electronic assembly and overlap 5mm over the back. Holes were then cut for all the displays and the on/off switch to poke through, and then the felt overlap at the back was glued to each board. (Use COPYDEX or EVO-STICK.) Be careful not to let any glue touch the tracks near IC1 or IC2 as this could affect operation of the high impedance CMOS inputs. Leave an area unglued around the battery, to enable you to change it easily.

The battery was held on to the board using double sided self-adhesive foam pads, e.g. 'Sticky fixers'. 'Velcro' was glued to the space in the middle of the back of each board, again being very careful not to get glue on the tracks of IC1 and IC2. A matching band of 'Velcro' was sewn to the cap; in this case an "Army and Navy" peaked cap, and the felt covered "electronic headband" assembly simply pushed on to the cap, to be retained by the 'Velcro'. It sounds crude, but it works a treat! Do feel free to come up with other ideas though.

NEXT MONTH: We'll look deeper into sequential circuits, more complex devices, and synchronous/asynchronous working. We'll look at problems that can arise when designing sequential circuits, and ways to get round them. And, of course, another mini-project!

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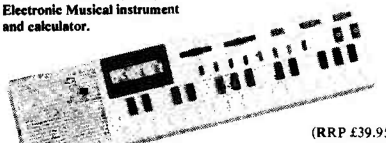

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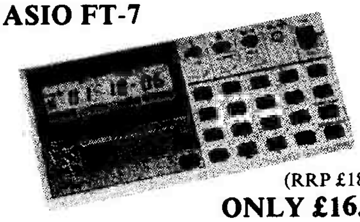

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PE RANGER 27FM CB
PART THREE

MICHAEL TOOLEY B.A.
DAVID WHITFIELD M.A. M.Sc

WHEN the component assembly is complete the p.c.b. should be carefully examined. Check that components have been fitted in the correct locations and that there are no unsoldered connections or solder bridges between tracks. The latter condition may be easily rectified with the aid of a sharp knife or scalpel. Time spent checking the p.c.b. at this stage is a good investment since it can save hours of agony at a later stage! Next mount the front panel controls and sockets (with the exception of the channel selector switch which is already fitted to the p.c.b.) on the rectangular metal front plate. The p.c.b. should then be fitted together with the front panel, loudspeaker, and sockets into the case. Wiring to the controls and sockets should follow closely the diagram shown in Fig. 3.1 and all connections should be kept as short as is reasonably possible. A short length of 50Ω coaxial cable should be used to link SK200 to the p.c.b. and attention should be given to making an effective earth connection through the braid of the cable to the front panel by means of the earthed body tag of SK200. A length of miniature screened audio cable is used to connect pins 1 and 4 of SK204 (1 being the inner conductor whilst 4 is the outer screen) to the microphone input on the p.c.b. This again should be kept as short and direct as possible. The external a.c. and d.c. sockets (SK201 and SK203 respectively) should then be mounted in the side of the case roughly adjacent to their respective connecting points on the p.c.b. Care should be taken to ensure that all of the external sockets are correctly wired to the p.c.b. Finally check the complete assembly before carrying out the "Initial Tests" detailed in the next section.

OUTPUT FILTER

The low pass filter network included in the transmitter output is to ensure that the radiation of unwanted harmonics is kept to a minimum. The three tuned circuits between the frequency tripler, TR2, and the output to the filter ensure that unwanted harmonics from the 9MHz oscillator are already more than 70dB below the output level. The Home Office specification calls for a maximum spurious output level of 50nW or 250nW, depending on frequency, which corresponds to 70dB or 63dB below the 500mW level, respectively. The most significant sources of harmonics of the 27MHz signal are the driver and r.f. power amplifier transistors, TR3 and TR4. The non-linearities and wide bandwidths of these devices can cause generation of unwanted harmonics, and appropriate steps must be taken to prevent their radiation.

The tuned coupling between all stages in the transmitter serves to suppress the level of unwanted signals, but it is still necessary to ensure that the level of spurious signals is kept well below the acceptable levels. A seven-stage Butterworth filter is used in the transmitter output to form a low pass

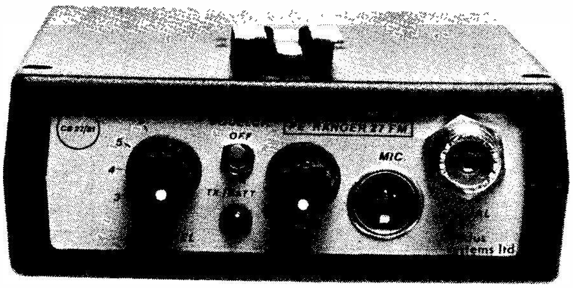
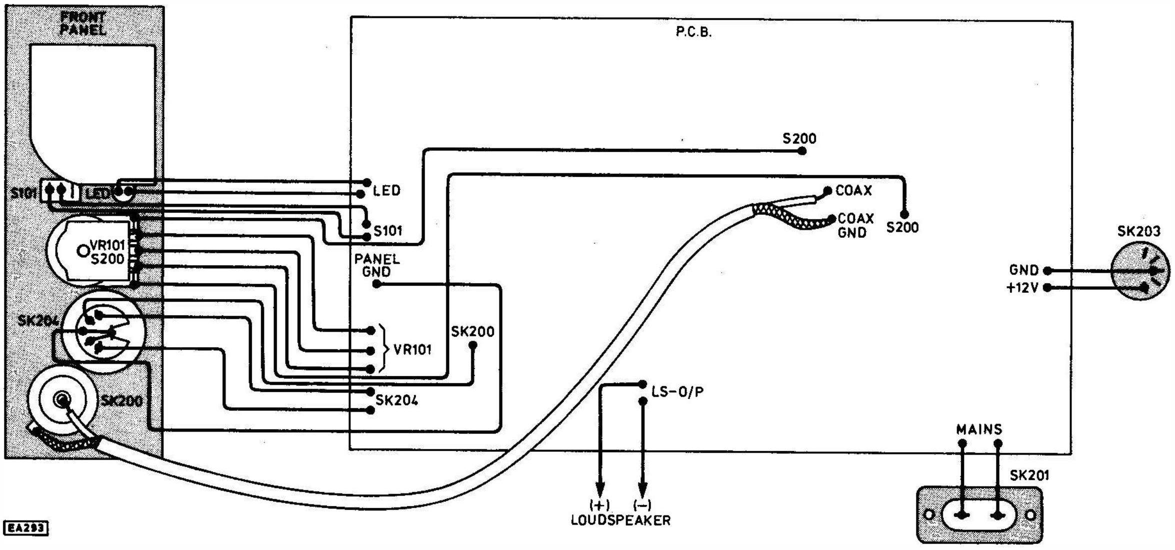


Fig. 3.1. Wiring diagram for the Ranger



filter. This allows signals of all frequencies up to the cut-off frequency to pass through substantially unaffected. Above the cut-off frequency, the attenuation is frequency dependent and increases very rapidly. The circuit for the filter used in the Ranger is shown in Fig 3.2; the cut-off frequency is around 40MHz, and the attenuation above the cut-off is around 42dB per octave. The inductors are self-supporting air-cored coils close-wound from 22 s.w.g. insulated copper wire (the shank of a twist drill is a good former when winding the coils).

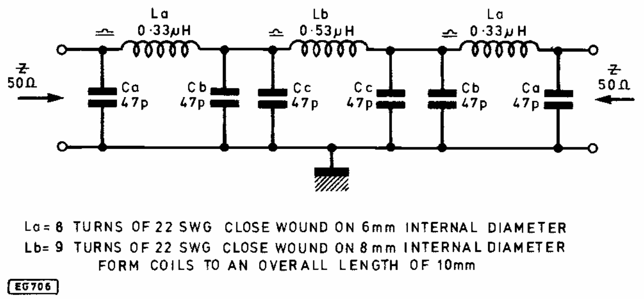


Fig. 3.2. Output filter circuit diagram

INITIAL TESTS AND ADJUSTMENTS

The purpose of these initial tests and adjustments is twofold; firstly to detect any obvious errors in assembly and secondly to ensure that the transceiver is in a fit state for alignment. Two additional items of equipment are required, a multi-range d.c. voltmeter having a sensitivity of at least 20kohm/volt and a current limited regulated d.c. power supply. The supply should be set to give 12V d.c. (±0·5V) and its current trip set to 500mA (±100mA). Where a current trip facility is not incorporated within the d.c. supply a quick-blow fuse rated at 500mA should be inserted in the positive supply rail to the transceiver. This protection is essential in order to prevent damage to both the external power supply and to the transceiver in the event of incorrect component connection or faulty assembly (e.g.: solder bridges between p.c.b. tracks).

Before connecting the external d.c. supply check that the internal battery pack and crystals have not been fitted. If they have been fitted they should be temporarily removed taking care not to short circuit the battery terminals or to overheat the crystal lead-out wires when soldering. Check also that the low-pass transmitter output filter has not been fitted and that a link is connected between its input and output pads on the p.c.b. It is important to note that, throughout the initial tests and in subsequent use, external a.c. and d.c. supplies should never be connected at the same time.

Make the following adjustments and connections in the order given before connecting the external d.c. supply:

(a) The transceiver should be switched 'off' (VR101 turned fully anti-clockwise until it clicks in the 'off' position).
(b) The r.f. output pre-set adjustment, VR2, should be turned to mid-position.
(c) The squelch pre-set adjustment, VR100, should be turned to fully open the squelch (VR100 fully clockwise).
(d) The modulation linearity pre-set adjustment, VR1, should be set to mid-position.
(e) The frequency deviation pre-set adjustment, VR3, should be set to mid-position.
(f) The squelch front panel switch, S101, should be switched to 'off' (S101 closed).
(g) Connect the microphone to SK204.
(h) Ensure that the external d.c. supply is switched 'off' and connect it to SK203 taking care to observe correct polarity. Note that inadvertent reverse polarity connection of the external d.c. supply may cause permanent damage to components in the transceiver.

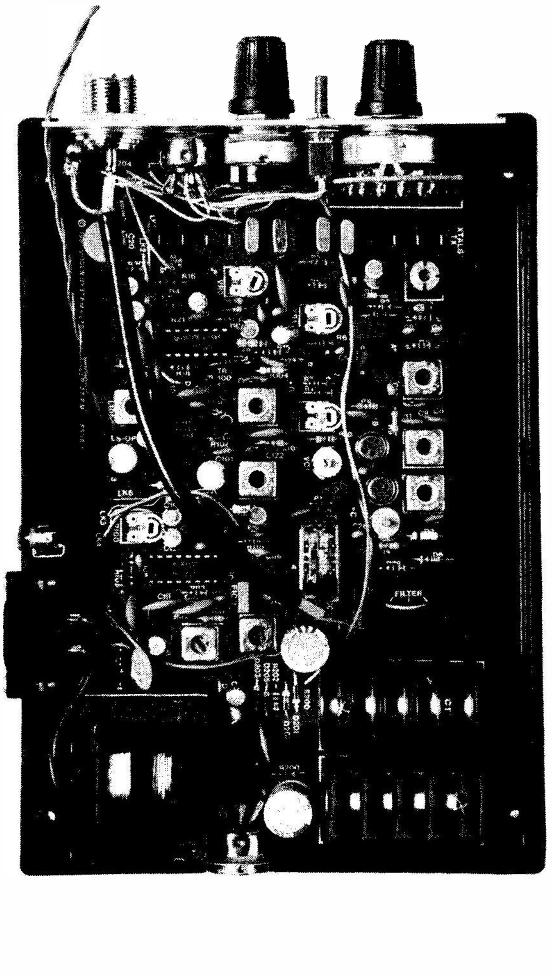
The following tests which are intended to confirm that various parts of the transceiver are working correctly should now be carried out in the order given. For each test a typical indication is given and, where this is not obtained, a course of action is suggested. In some cases it is possible to pinpoint a particular component or components that may be at fault but in others it is only possible to identify the general area of the fault. To save space the precise nature of the possible faults are not given and it is left to the constructor to check, within the area given, that:

(i) There are no shorted tracks or dry joints on the p.c.b.
(ii) The correct components have been fitted
(iii) The components have been fitted in the correct locations on the p.c.b.
(iv) Where appropriate, components have been fitted observing the correct polarity (this is important in the case of i.c.'s, transistors, diodes, and electrolytic capacitors)
(v) The components have not failed due either to excessive heat/mechanical strain in soldering or to faults in other parts of the circuit.

ALIGNMENT

In addition to the test equipment used in the previous section the following items will be required to carry out the alignment procedure:

(i) Suitable trimming tools for adjusting the r.f. and i.f. inductors and transformers. These should use



STEP NUMBER	TEST/CHECK PROCEDURE	TYPICAL INDICATION	WHAT TO DO IF NOT OBTAINED
1	Switch external d.c. supply 'on'. Measure the d.c. input voltage at SK203.	11·5 to 12·5V	Check external d.c. supply. If current limit is operating or fuse is blown check IC200 and associated components, D200, C200 and wiring to SK203.
2	Measure the d.c. voltage appearing at the internal battery connecting points on the p.c.b.	20 to 25V	Check IC200 and associated components, D201 to D207, R200, R201, C202, C204, R302.
3	Switch the transceiver 'on' and measure the voltage at TPg	10·8 to 11·8V	Check external d.c. supply. If current limit is operating or fuse is blown check C119, IC101 and associated components.
4	Measure the d.c. voltage appearing at the internal battery connecting points on the p.c.b.	10·5 to 11·5V	Check D207.
5	Measure the d.c. voltage at TPe.	5·7 to 6·2V	Check R110, D101, C104, C114, IC100 and associated components.
6	Advance the volume control, VR101, and listen for noise from the loudspeaker.	Noise should increase with the setting of VR101 and be quite loud with the control at its maximum setting.	Check IC101 and associated components, IC100 and associated components.
7	Switch 'off' the transceiver and external d.c. supply. Carefully wire a receive crystal to the p.c.b. Take great care not to overheat the crystal lead-out wires. Select the crystal position which you have just used by appropriate adjustment of the channel selector switch, S100. Switch the transceiver and external d.c. supply back 'on' and measure the d.c. voltage at TPf.	5·3 to 6·2V	Check R104, D100, C103, TR102 and associated components.
8	Advance the volume control, VR101, and again listen for noise from the loudspeaker.	Noise should increase with the setting of VR101 and should be greater than that obtained in test number 6.	Adjust the settings of L100/L101 and L102/L103 for maximum noise. If this makes no difference at all check TR102 and associated components.
9	Adjust the volume control for a reasonable level of noise output and switch the squelch 'on' (S101 open). Slowly back off the setting of VR100 moving it anti-clockwise.	Noise output should suddenly cease when VR100 is at about mid-position.	Check R106 to R109, S101 and components associated with the squelch function of IC100.
10	Leave VR100 set so that there is no noise output from the receiver. Switch the squelch 'off' (S101 closed).	Noise output should be restored regardless of the actual setting of VR100.	Check R106 to R109, S101 and components associated with the squelch function of IC100.
11	Momentarily 'key' the transmitter by operating the press-to-talk switch on the microphone	The following should be observed:—(a) The relay, RL200, should click; (b) the transmit indicator, D7, should be illuminated; (c) the noise output from the loudspeaker should cease.	If the current trip on the external d.c. supply is operating check C15, D206, IC1. If the current trip is not operating check PTT switch on the microphone, wiring to SK204, RL200, R28, D6, D7.
12	Remove the microphone plug and place a shorting link between pins 3 and 5 of SK204. Measure the d.c. voltage at TPh.	10·8 to 11·8V	Check C15, IC1, TR4 and associated components, R1.
13	With the shorting link still in place measure the d.c. voltage at TPk.	8·8 to 9·5V	Check D1, R1, C1, C2, VR1.
14	Again with the shorting link in place measure the d.c. voltage at TPj.	5·4 to 5·9V	Check R15, R16, R20, C17, C18, C19, IC1.

STEP NUMBER	TEST/CHECK PROCEDURE	TYPICAL INDICATION	WHAT TO DO IF NOT OBTAINED
15	Remove the shorting link and check that operation in receive mode is restored.	Noise output from receiver, transmit indicator D7 extinguished.	Check RL200.
16	Replace the shorting link and measure the d.c. voltage at TPa.	1·0 to 2·0V	Check TR1 and associated components including R3, R4, R5 and L9.
17	Switch the external d.c. supply 'off'. Carefully wire a transmit crystal to the p.c.b. Take great care not to overheat the lead-out wires. Select the crystal position you have just used by appropriate setting of S100. Switch the external d.c. supply back 'on' and, with the shorting link still in place, again measure the d.c. voltage at TPa	2·0 to 3·0V (An increase of around 1V from the previous reading)	If there is no change the oscillator is not functioning. Check S1, L1, D2, R2, and the crystal. It may also be necessary to adjust the core of L1.
18	Switch the transceiver 'off', disconnect the external d.c. supply, remove the shorting link from SK204 and connect the a.c. mains supply to SK201. Measure the d.c. voltage appearing at the external d.c. socket, SK203, with the transceiver still switched 'off'.	16 to 19V	Check mains plug and fuse, T200, D200, C200.
19	Switch the transceiver 'on' and, with the transceiver in the receive mode, measure the voltage at TPg.	14·5 to 16·5V	Check D201.
20	Connect the shorting link again to pins 3 and 5 of SK204. Now with the transceiver in the transmit mode measure the voltage at TPh.	12·0 to 14·5V	Check C15, R1, D1, RL200.
21	Switch 'off' the transceiver and disconnect the a.c. mains supply. Connect the internal battery taking care both to observe the correct polarity and to avoid short circuiting the battery terminals when soldering. Note that the battery voltage is normally supplied in a discharged state. Measure the voltage across the battery terminals.	6·5 to 12·5V	Check battery.
22	Re-connect the a.c. mains supply and ensure that the transceiver is switched 'off'. Measure the terminal voltage of the battery.	The battery voltage should start to rise slowly from the indication obtained in step 21. After a few minutes it should be between 9 and 13V.	Check IC200 and associated components, C204, C205, D203, D204, D205 and R202.
23	Disconnect the a.c. mains supply. Switch the transceiver 'on' and, with the transceiver in the receive mode, measure the terminal voltage of the battery.	The battery voltage should fall slightly. If the battery is in an uncharged state the fall in voltage will be rapid. If it is partially charged the fall in voltage will only be slight.	Check D202.
24	Switch the transceiver 'off' and reconnect the a.c. mains supply. With the transceiver in the receive mode measure the terminal voltage of the battery. After a minute or so switch the transceiver 'on'.	The battery voltage should start to rise again until the transceiver is switched 'on'. Then it should fall slightly and remain fairly constant.	Check D207.
25	Switch the transceiver 'off' but leave the a.c. mains supply connected for a period of between 10 and 14 hours. This should ensure that the battery is fully charged. At the end of the charging period measure the terminal voltage of the battery.	12·5 to 13·5V	Check mains plug and fuse, T200, D200, IC200 and associated components.

nylon or non ferrous metal blades. Note that the ferrite cores are extremely brittle they can be easily damaged by the use of incorrect trimming tools. In extreme cases the cores may split or crack and become locked in the former. It will then be necessary to replace the entire inductor or transformer assembly. It is therefore essential that the trimming tools have the correct dimensions to fit the cores. No attempt should ever be made to align the transceiver using a conventional screwdriver!

(ii) A receiver capable of tuning over the range 27·6 to 28·0MHz (or 28·0 to 29·5MHz in the case of an amateur 10m-band version). If a monitor receiver is not available (most domestic receivers do not have a short wave band which extends to 27MHz) the *27/28MHz Converter* described in *March 1981 PE* can be used with any existing medium wave receiver which has an external aerial socket. A further alternative is that of making use of another PE Ranger. This, of course, assumes that the second transceiver is working correctly, at least in the receive mode!

(iii) A 50Ω load/output indicator, the circuit diagram and constructional details for which are shown respectively in Figs. 3.3 and 3.4. The load should be coupled to the transceiver by means of a short length of 50Ω coaxial cable terminated in a PL259 plug to mate with SK200. With reasonable care this load will provide an accurate match and will exhibit a VSWR of less than 1·25:1. The meter indication provides a measure of the relative output power and, provided that the meter offers a sensitivity of 20kΩ/volt or greater and is used on its 10V d.c. range the approximate relationship between output power and meter indication is as shown in the table.

Before commencing the alignment procedure it is essential to ensure that the Initial Tests and Adjustments have been completed and at least one pair of crystals has been fitted according to the instructions given. The filter should not, however have been fitted but its input and output connections should be linked. Make the following initial adjustments:

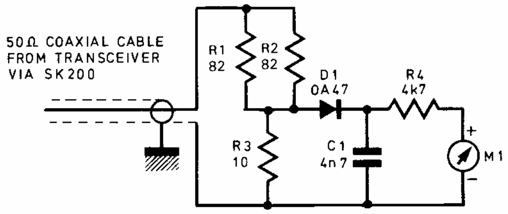


Fig. 3.3. Circuit diagram for the Dummy Load

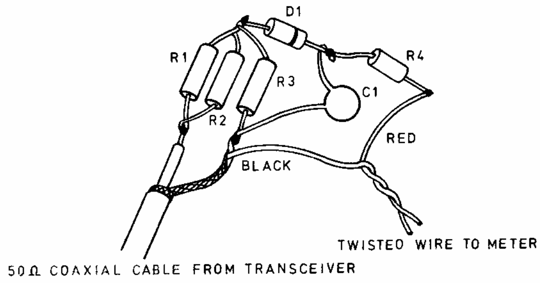


Fig. 3.4. Constructional details for the Dummy Load

(a) set VR1, VR2, and VR100 fully clockwise

(b) set the cores in the inductors, r.f. and i.f. transformers as shown below:

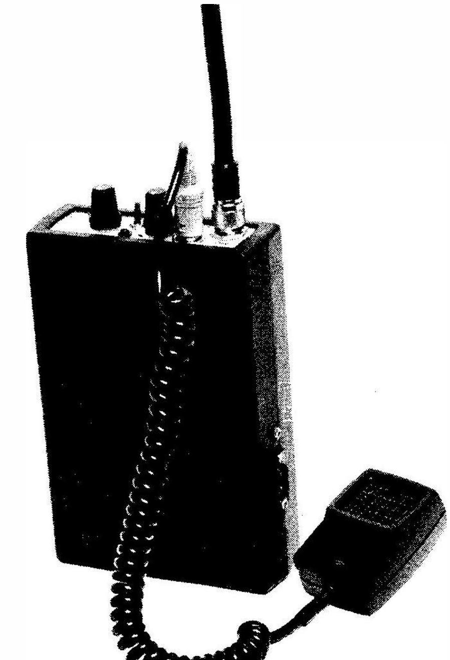
Inductor/transformer reference	Core position
L1	flush with top of former *
L2/3	mid-position
L4/5	mid-position
L7/8	mid-position
L100/1	$\frac{2}{3}$ way into the former *
L102/3	$\frac{2}{3}$ way into the former *
L104/5	flush with the top of the can
L106/7	$\frac{3}{4}$ turn from fully clockwise
L108	$\frac{1}{2}$ turn from fully clockwise

* or as otherwise determined during Initial Tests and Adjustments

(c) set VC1 and VC2 to mid-position

Terminate the aerial socket of the transceiver using the 50Ω load/output indicator and connect the external d.c. supply to the transceiver as before. It is unwise to make use of an external a.c. supply since the transceiver will be unprotected in the event of a fault condition arising. Follow the procedure described in the following steps in the order given:

POWER INPUT	INDICATED VOLTAGE
100mW	0·43V
200mW	0·68V
300mW	0·88V
400mW	1·05V
500mW	1·20V
600mW	1·33V
700mW	1·46V
800mW	1·57V
900mW	1·68V
1 W	1·78V



STEP NUMBER	PROCEDURE	NOTES
1	With the transceiver in the receive mode, squelch off, and volume control turned up to provide a suitable level of output adjust L108 for maximum noise.	Only a slight adjustment should be necessary and typically not more than ½ turn from the previous setting.
2	Adjust L106/7 for maximum noise.	As for step 1.
3	Repeat steps 1 and 2 peaking for maximum noise.	Only a slight change, if any at all, should be necessary.
4	Adjust L102/3 for maximum noise. If necessary reduce the volume control setting for a comfortable level of noise output.	This adjustment may be fairly sharp and should be typically not more than 2½ turns from the previous setting.
5	Adjust L100/1 for maximum noise.	This adjustment may be fairly broad and again should be typically not more than 2½ turns from the previous setting. If there is no discernible change leave the core set as previously instructed (ie: ⅔ of the way into the former).
6	Repeat steps 4 and 5 peaking for maximum noise.	Only a slight change, if any at all, should be necessary.
7	Connect a properly matched aerial system. This should preferably be an outdoor base station aerial and not the helical antenna designed for use with the Ranger. Listen for signals and peak L102/3 and L100/1 for maximum. Do not make any adjustments on strong signals since these will 'quiet' the receiver and adjustment can be misleading with little discernible change on a limiting signal.	Various signals together with background noise may be heard. Some of these signals will be from AM and SSB stations operating on adjacent frequencies and they will be distorted and almost certainly unreadable. The Ranger rejects all signals other than FM. Stations operating on the new UK FM system should, of course, be perfectly readable. If no signals are heard repeat steps 1 to 6.
8	If a local FM signal of moderate strength is available on the channel adjust L106/7 for maximum quieting (minimum background noise).	The signal should not be too strong or it will fully quiet the receiver and no background noise will be present. It should not be necessary to turn the core of L106/7 more than about ¼ turn.
9	As for 8 but adjust L108 for best audio quality.	This adjustment is quite critical but the correct setting should be fairly obvious. It should not be necessary to turn the core of L108 by more than about ¼ turn.
10	Disconnect the aerial and connect the 50Ω load/output indicator again. Place a link between pins 3 and 5 on SK204, so that the transceiver is operated in the transmit mode. Measure the voltage at TPb and vary the core of L2/3 for maximum meter indication.	A typical maximum indication of 0·75V should be obtained.
11	Adjust the core of L4/5 for a 'dip' in the meter indication.	This 'dip' will be very sharp and quite small (typically around 0·1V). If a clear 'dip' is not obtained reset the core of L4/5 to its original position and carry on to the next step.
12	Place the monitor receiver close to the transceiver and tune the receiver to the channel selected. Listen for the transmitted carrier.	A strong signal should be heard. This will appear as an unmodulated carrier.
13	Adjust L1 until the transmitted carrier is exactly in the centre of the receiver passband. This may not be readily possible on a tuneable receiver which does not have accurate calibration but should be quite easy when a channelised receiver/transceiver is used.	The carrier will appear to shift in frequency as L1 is adjusted. The typical range of adjustment is about 10kHz. A better method of setting the frequency is with the aid of a digital frequency meter and this is described in the next section.
14	Transfer the meter to TPc. Adjust VC1 for maximum indication.	A typical maximum indication of 1·2V should be obtained.
15	Adjust L7/8 for a 'dip' in the meter indication.	This 'dip' will be very sharp and rather small (typically 0·1V or less). If a clear 'dip' is not obtained reset the core of L7/8 to its original position and carry on to the next step.
16	Transfer the meter to TPd. Adjust VC2 for maximum indication.	A typical maximum indication of 10V should be obtained.
17	Transfer the meter to the 50 load/output indicator.	A typical reading of approximately 1·6V should be obtained.
18	Switch the transceiver 'off'. Remove the link between the input and output of the filter and install the filter p.c.b. checking that all three connections are correctly made. Switch the transceiver 'on'.	The meter reading should be somewhat less than that obtained in step 17.

STEP NUMBER	PROCEDURE	NOTES
19	Re-adjust VC1 and VC2 for maximum indication on the meter.	The meter reading should return to a value just slightly less than that obtained in step 17.
20	Back off the setting of VR2 to obtain a meter indication of 1·2V. This corresponds to an output power of approximately 500mW (see table).	If the output indication is less than 1V with VR2 fully clockwise repeat steps 10, 14, 16, 17, and 19 with the filter still in place.
21	Again listen to the transmitted signal using the monitor receiver. Check that it is 'clean' and free from any spurious signals.	The strong signal now produced by the transceiver may easily overload the receiver and, if this is the case, the separation between the two should be increased.
22	Remove the shorting link on SK204 and connect the microphone. Operate the press-to-talk switch on the microphone and listen to the audio from the monitor receiver. If this is only equipped for AM reception there may be some slight distortion apparent and it may be necessary to tune slightly to one side of the signal for best quality audio.	Vary VR3 for an adequate level of deviation whilst talking in an average voice level at a distance of some 6" to 8" from the microphone. Note that, with VR3 set fully anticlockwise, the maximum deviation produced will be approximately 3kHz peak.

This completes the Alignment procedure. Where more sophisticated test gear is available constructors may wish to carry out the more detailed tests outlined next month.

Constructors' Note

The PE Ranger 27FM will only meet the Home Office specification for UK CB if it is built from a complete kit of parts from Autumn Products Ltd which is the CB section of Modus Systems. No responsibility will be accepted by Autumn Products for sets which do not meet the specification due to incorrect assembly or alignment.

The PE Ranger 27FM kit including injection moulded case, mains and car input, rechargeable batteries, microphone, helical ⅝ wave aerial and crystals for two channels, £49·95 plus £1·40 p&p, plus VAT (£59·05 inclusive) or £97·00 for a matched pair of transceiver kits with crystals for two channels plus £2·80 p&p, plus VAT (£114·77 inclusive).

Extra sets of crystals are £2·25 for each channel plus 50p p&p (for any quantity), plus VAT.

Will constructors please note that they must obtain the necessary CB licence from the Post Office before operating the PE Ranger.

Autumn Products Ltd., Dept AP, PO Box 30, Letchworth, Herts. SG6 3DQ (✆ 046 26 74468/76392).

NEXT MONTH: FAULT FINDING

Readout...

A selection from our Postbag

Readers requiring a reply to any letter must include a stamped addressed envelope.
Opinions expressed in Readout are not necessarily endorsed by the publishers of Practical Electronics.

A true fraternity . . .

Sir—The original concept of the National Personal Computer Users Association, founded in 1979, was to circulate programs, ideas and information between personal computer users and to involve members in national projects proposed by individuals.

We have learned from members all over the world that they are primarily concerned with extracting information as there is no incentive to provide it for the use of others, and a cost effective method of communicating VIA the computer as well as WITH it was therefore proposed and is now applied to all standard computers that save programs on tape.

Each member is provided with a C-10 cassette and an SAE. Original material worthy of transmission is saved on tape while still in their computer and when the tape is full it is sent to us where it is copied and sent to other members. The member's original tape is loaded with other members' programs etc. and sent back to him with another SAE. No pens, paper, envelopes or stamps to restrict the continual flow of information. The more often a cassette is sent to us and refilled with fresh information the more value-for-money for the subscriber. Additionally component suppliers can advertise to members through the Association resulting in discounts for members.

Owing to the financial support of the advertisers, annual subscriptions (including cassette, envelopes, labels and postage) are only £12 in the U.K. and £15 overseas payable to the NPCUA with details of computer and monitor used. This scheme seems to have provided the key to a true fraternity of computer users.

Eric Keeley,
NPCUA,
11 Spratling Street,
Manston,
Ramsgate,
Kent.

Congratulations

Sir—May I congratulate you on your excellent booklet "Introduction to Legal CB", and I like the "puff" at the end for Amateur Radio.

However, I have a couple of quibbles, firstly on page 3 about halfway down: "... lies in its relative susceptibility to television interference etc. . . ." Writing as an EMC engineer, the susceptibility lies in the television, audio apparatus etc., and the emissions are generated by the transmitter. It is a pity (from the amateur point of view as well) that all apparatus of this type is not approved for susceptibility as is done in the Scandinavian countries.

My second quibble is regarding the aerial on 934MHz. Some ridiculous rubbish has been published on the subject and is best forgotten. As you mention, very effective aerials (antennae) can be made at this frequency, and I suggest that somewhere near 20dB is feasible.

Incidentally, some time in the early 1950s the Bell Telephone lab published a paper advocating 900MHz as probably a good frequency for internal city use on mobile radio. This was, of course, a theoretical study (I must try to dig it out of my files) and even valves then were a bit pushed.

John Haydn G3BLP
Dunstable.

The WERSI Concept

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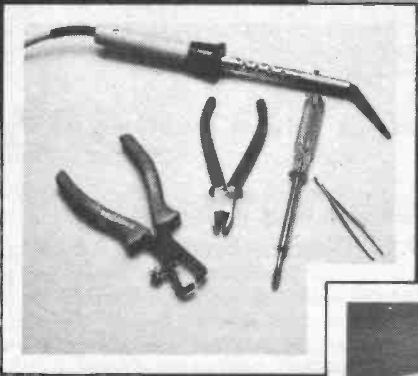

WERSI presents their new generation of electronic organs and accessories to you, the do-it-yourselfer. All the tools you need are illustrated left. The electronics involved is very revolutionary, making it very easy to understand. Every non-specialist who can read is able to do it. Building a WERSI organ from a kit can save you more than half the cost of a similarly equipped ready-made instrument and that means with WERSI and your own initiative and involvement you can afford a sophisticated electonic organ.

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PE11

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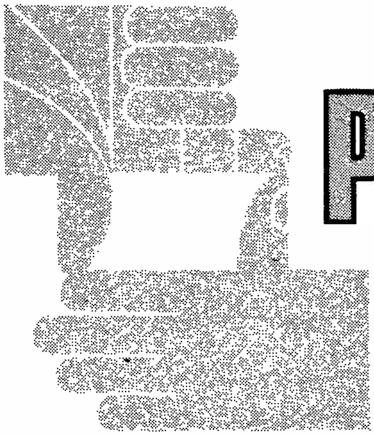


PATENTS REVIEW...

Copies of Patents can be obtained from:
the Patent Office Sales, St. Mary Cray, Orpington, Kent. Price £1·45 each.

DBX VERSUS TOSHIBA

There is an interesting story behind the patent coverage on DBX, the American tape and disc noise reduction system. The DBX system works by sensing the input signal level, and compressing it before recording; for reproduction the level is again sensed and the signal expanded in mirror image fashion. Noise introduced by the recording is lost in the process. Compression and expansion is by a ratio of 2:1, so a dynamic range of 100dB can be recorded on a disc or tape with a dynamic range capability of only 50dB. The heart of the DBX system is an RMS sensor which reads an average of the signal level. Clearly a high degree of accuracy is essential.

If level sensing at the compression or expansion stage is inaccurate, then severe distortion of the signal will result. For years it was thought impossible to build a simple circuit which would sense RMS values reliably, over a wide dynamic range and undisturbed by changes in ambient temperature. Circuits which worked on a sine wave signal would produce inaccurate results when confronted with pulse trains or transients. David Blackmer was the first engineer to produce a simple but reliable RMS sensor and this gave birth to the DBX system.

Blackmer's circuit is patented in the USA (US patent 3 681 618) but not in some other important countries. As a result there is no legal bar to other companies selling a noise reduction system based on Blackmer's RMS sensor in Japan, or Britain. But legal problems arise if equipment incorporating the RMS circuit is offered for sale in the USA. This explains why Toshiba has not yet been selling the ADRES noise reduction system, which is in many respects a cross between Dolby B and DBX, in the USA. But Toshiba engineers now feel they are free to sell ADRES in the USA, following a change in the level sensing circuits designed to avoid the DBX patent. The new Toshiba circuits are themselves patented, for instance in British patent 1 549 562. Blackmer's US patent 3 681 618 was filed in March 1971 and granted August 1972. It explains the problems of sensing true RMS value, and refers to the primitive methods in use before the DBX circuit was invented. These often relied on measuring the heating effect of a current through a resistive element.

Figure 1 of Blackmer's patent shows the basic DBX sensor circuit. High gain inverting amplifier 22 has a pair of oppositely conductive feedback paths. One path is collector-emitter circuit of PNP transistor Q1 and the other is the collector-emitter circuit of NPN transistor Q2. The emitters of transistors Q1 and Q2 are connected to op amps 28,30; one of these amps, 28 has a feedback resistor 29 connected to non-inverting input 34 and the other, 30, is back coupled to the inverting input. Transistors Q3, Q4 are connected to the outputs of the amplifiers 28, 30. Resistor 44 provides a constant current source which, in combination with capacitor 42, is said to be "very important". Figure 2 shows a modified circuit with NPN transistor Q5, supplied with constant current by resistor 50, to compensate for temperature offset in transistors Q1, Q2.

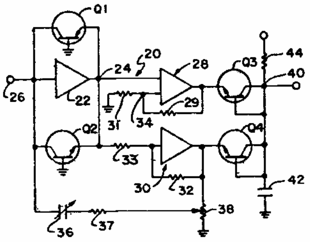


Fig. 1.

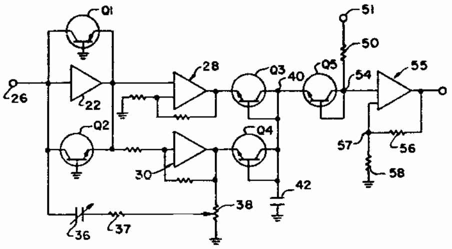


Fig. 2.

In either circuit, (Figure 1 or Figure 2) the input signal at terminal 26 is converted by amplifier 22 and transistors Q1, Q2 into a signal which has a value logarithmically related to the input. The value of capacitor 42 governs the recovery rate for falling signals and the circuit has a characteristic variable time response e.g. the initial rate of rise for a 20dB step increase in the input will be about 100 times greater than for a 0.1dB increase.

The Toshiba patent (BP 1 549 562) dates back to February 1977 and acknowledges existence of Blackmer's US patent. But Toshiba criticizes the DBX sensor for requiring careful selection of transistors and diodes of exactly the right characteristic. Toshiba also criticizes the DBX circuit for needing the additional components to compensate for ambient temperature changes. For ADRES, Toshiba has developed and patented an RMS circuit of which the logarithm amplifying stage does not rely on a PNP transistor. Also, Toshiba's full wave rectifier has an amplification factor of 1 instead of 2 and is thus supposedly less subject to any variation in the ratio of resistances uses in the amplifiers.

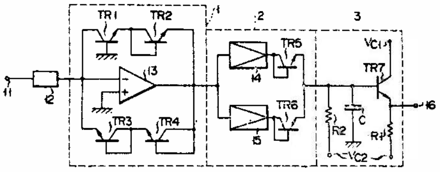
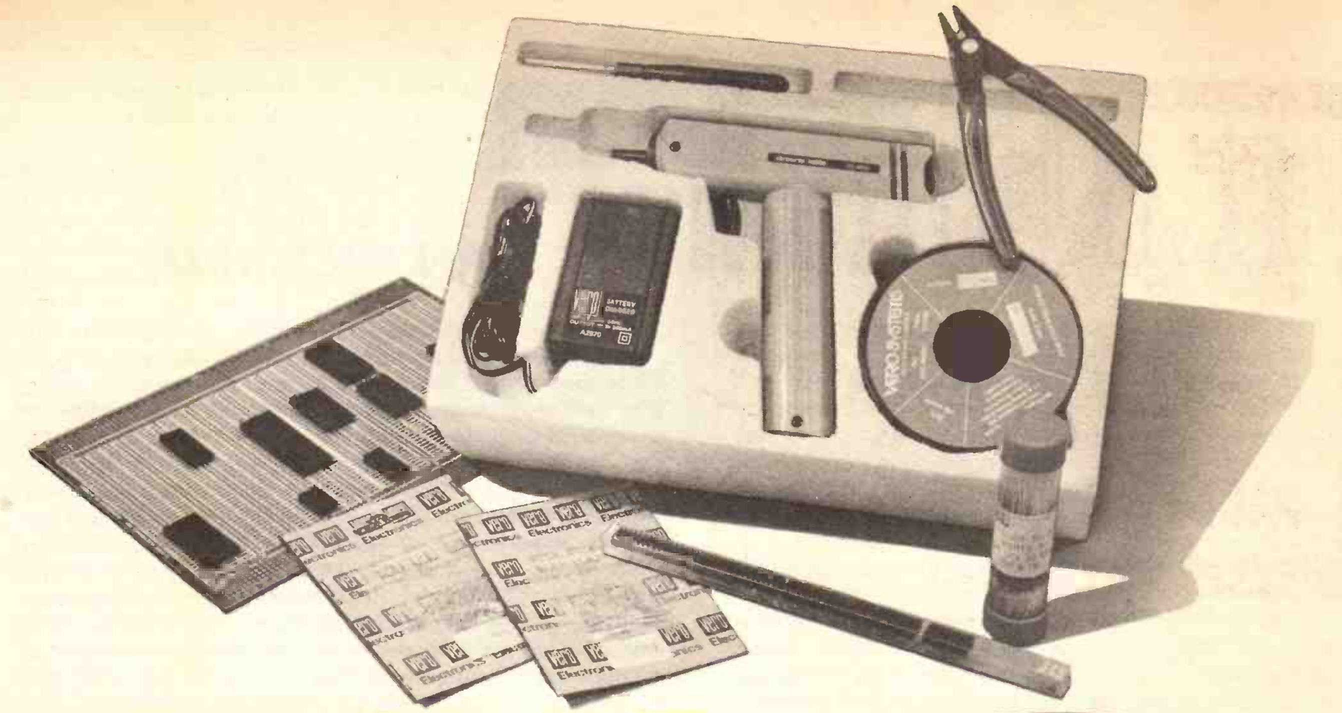


Fig. 3.

Figure 3 shows the basic Toshiba circuit. An input is applied to the inverting terminal of op amp 13,. A positive signal is processed by the op amp and NPN transistors TR1 and TR2, to produce an output voltage signal corresponding to twice the logarithmic value of the input. A negative input signal is processed by the op amp and NPN transistors TR3, TR4 to produce an output voltage signal corresponding to twice the logarithmic value of the negative input. The output of op amp 13 is divided into two components; one is supplied to in-phase amplifier 14 while the other is sent to inverting amplifier 15. The output from amplifiers 14 and 15 are added after full wave rectification at TR5, TR6 to produce a voltage signal corresponding to the logarithm of the square of the input signal. The output of the full wave rectifier is delivered to smoothing circuit 3 and output terminal 16 delivers a signal corresponding to the logarithm of the RMS value at the input.

It remains to be seen whether the new Toshiba circuit is, or is not, outside the scope of the Blackmer DBX patent claims. The grant of a patent on a new or modified idea is no guarantee that it does not still infringe an earlier patent on a broader concept. It will thus be interesting to observe whether Toshiba now sells ADRES noise reduction equipment in the USA and if so whether DBX makes any attempt to restrain such sale.



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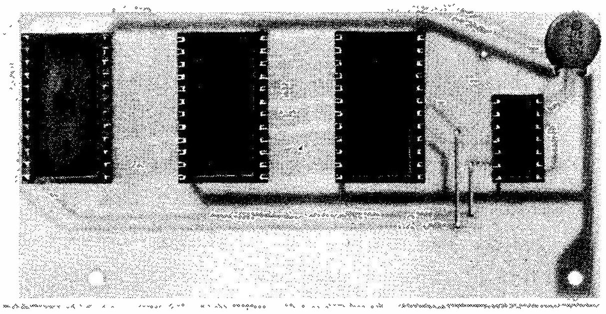
UK101 MONITOR CHANGE

IAN HICKMAN

THE UK02 monitor provides screen editing facilities, a very useful addition even though they are rather limited, a choice of steady or flashing cursor (with a different flash rate when in the edit mode) and a number of other useful facilities. Unfortunately, presumably to fit all this in, it was necessary to drop the disc bootstrap, which is inconvenient if one wishes to expand the facilities of this useful home computer to include a disc unit. Installing the UK02 in place of the original monitor is very easy, involving no more than swapping a couple of link positions on the board. (The UK02 is now supplied with the UK101 as standard.)

A 4K monitor from Watford Electronics called WEMON, is available in versions for several popular 6502 based microcomputers. This monitor incorporates a routine for interfacing with a printer via the Centronics parallel interface format. This interface is a virtual de facto standard for popular low and medium price printers. An RS232 serial interface adapter is typically likely to set one back another £45, so the WEMON (plus a 6821 Peripheral Interface Adapter) seems a good alternative.



Having installed WEMON, its many other virtues become apparent. The most immediate boon is the single keystroke BASIC command entry. WEMON also provides full editing facilities with cursor movement in all directions always available from the keyboard or from program, together with CLEAR SCREEN, HOME CURSOR (returns cursor to top left without clearing screen) etc. Tape handling is also much improved, with the ability to include a title (up to six characters) as a program label at the head of a BASIC program when recording and to search for and load only this program when reloading. As the BASIC programs are SAVEd in the tokenized version in which (for economy of RAM storage) they are stored within the computer, rather than in the full text version which is printed to the VDU screen by a LIST command, BASIC SAVE and LOAD is up to three times faster than the normal UK101 SAVE and LOAD speed, though of course the program is not listed to VDU as it is entered. However, WEMON can *also* LOAD BASIC programs stored in the slower full text format and, *yes,* it can even SAVE programs in that format too! Further, control of a cassette deck's motor is available both from keyboard and from program (with the aid of a few extra components) and of course on many cassette machines, a motor switching contact is conveniently available as part of the MIC input socket. WEMON also includes a DISC bootstrap, so that once again expansion to a disc system is possible.

Many more facilities are available in WEMON, too sophisticated to enumerate in the space available here, but a lot of them should prove ideal for anyone wanting to write their own word processor package. With all these facilities, it is not surprising the WEMON is a 4K ROM rather than 2K like UK02, and in consequence the circuit changes necessary to fit it are more extensive than when fitting UK02 in place of UK01, though well worth the effort—*there is one distinct disadvantage of WEMON.* It is incompatible with both the *extended monitor/disassembler* tape provided with the UK101 and the *machine code assembler* tape also available, as the vectors which control the machine code load routines are different. If you are just not interested in machine code programming this may be no drawback, but for the author it represents an unacceptable limitation. The ideal situation, then, would be to have both WEMON *and* UK02 monitors fitted simultaneously, with either selectable at will.

FITTING TWO MONITORS

Even without the echoing through 254 superfluous addresses, the mere location of the ACIA at $FØØØ and $FØØ1 creates a problem when wanting to fit the 4K WEMON, as this monitor's address range will need to start at $FØØØ. This is solved quite simply by relocating the ACIA. $EØØØ to $EØØ1 are both convenient and free. These are the addresses at which the cassette control routines within WEMON expect to find the ACIA.

The UK02 circuit changes from the original UK01 monitor are trivial, link switches W6 and W7 are simply set to the "up" positions. Fig. 1 shows the recommended changes to accommodate WEMON. As the latter is a 4K ROM, an extra address line (A11) is required by the monitor itself, whilst this same address line must be eliminated from the MCS (monitor chip select) decoding to enable WEMON over the whole of the last 4K of memory address space. The move of the ACIA from $FØØØ/1 to $EØØØ/1 means it needs $\overline{A12}$ instead of A12 in its decoding, so the partial decode of A12 to A15 inclusive at IC15a pin 1 can no longer be used. IC16a is used to provide $\overline{A12}$ which is routed to pin 10 of the ACIA in place of A10, which is no longer used. $\overline{ACS}$ (ACIA chip select) now includes only A13 to A15, but goes to pin 9 (an inverted chip select) as previously. The result of these changes is shown by the memory map in Fig. 2. This shows the new position of the ACIA at $EØØØ/1 and also how the omission of A10 causes the ACIA address to echo through a second block of 256 addresses starting at $E4ØØ—again of no significance to most users. The second block of 256 addresses can be shunted up to follow on directly from the first by connecting A10 to pin 14 of IC17 instead of A8, an improvement from the aesthetic point of view.

To be able to fit and use both monitors, further changes are necessary. The most obvious difficulty is that there is only one monitor socket, and the two monitors can't sleep in the same bed! So an add-on board is required to accommodate the two monitors, and to route the MCS (monitor chip select) signal only to whichever monitor is currently selected. Further, arrangements are needed to switch over.

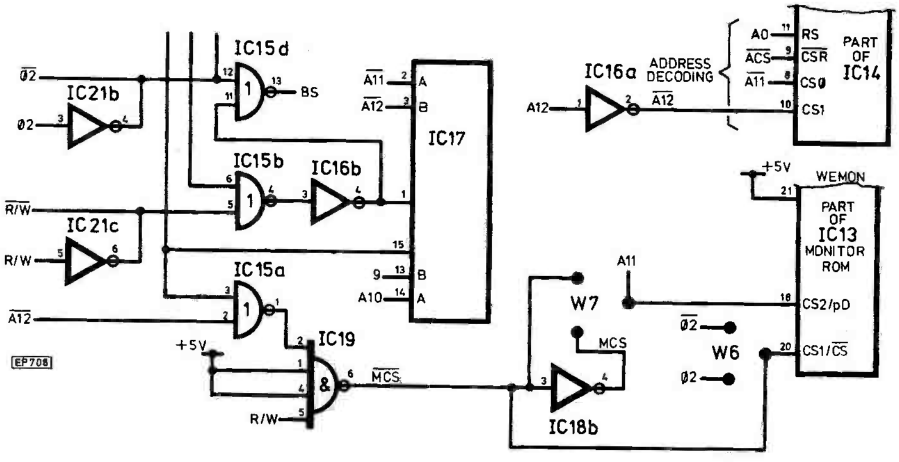


Fig. 1. Recommended changes to accommodate WEMON

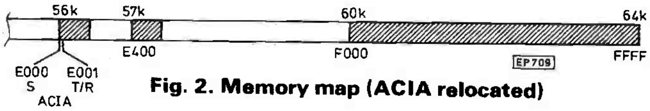


Fig. 2. Memory map (ACIA relocated)

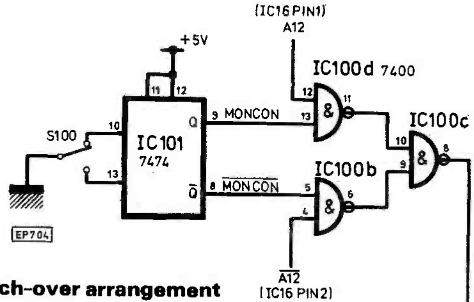
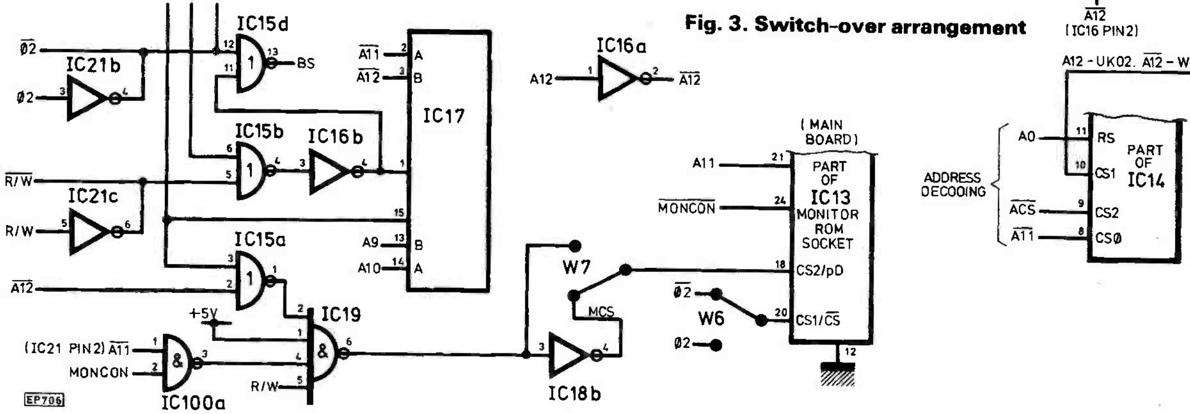


Fig. 3. Switch-over arrangement



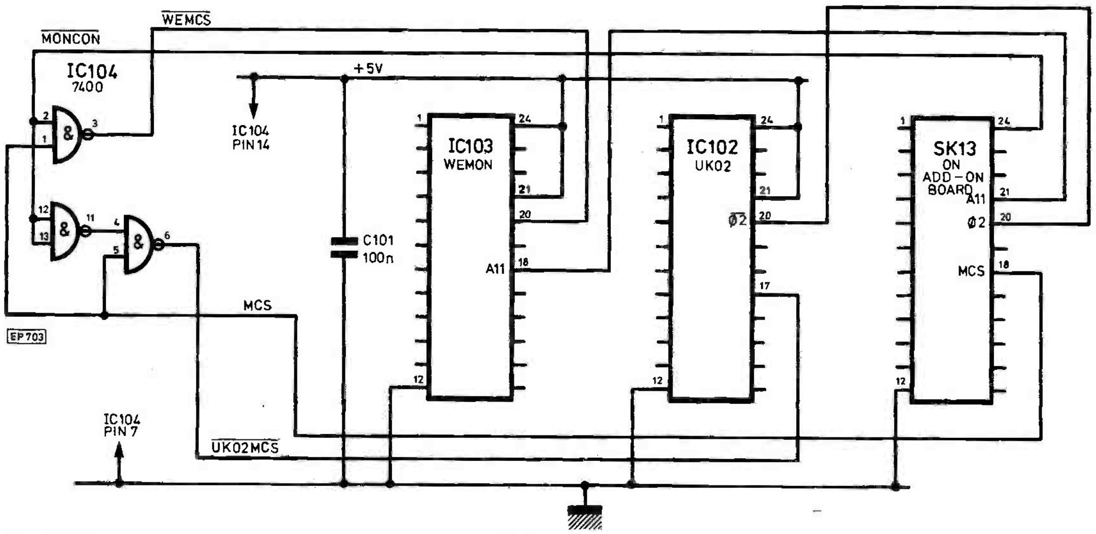


Fig. 4. Switch-over arrangement around monitor ROMs

The way this is organised is shown in Figs. 3 and 4. Half of a 7474 Dual D flip flop IC101 is used as a control memory to store the mode of monitor operation (UK02 or WEMON). Its Q and $\overline{Q}$ outputs are designated MONCON (monitor control) and $\overline{\mathrm{MONCON}}$ respectively, the state of the flip flop being controlled by S100. It might appear at first sight that IC101 is superfluous—why not just use S100 directly to ground either IC100 pins 2 and 13 or alternatively IC100 pin 5 and IC104 pins 2, 12, 13? Unfortunately this could be unreliable, since, for a period of some milliseconds during S100's changeover and bounce time, MONCON and $\overline{\mathrm{MONCON}}$ would be positive, enabling both monitors simultaneously.

CONSTRUCTION AND INSTALLATION

It has been mentioned that the two monitor i.c.s are mounted on an add-on board, and this avoids engaging the expansion socket. The author decided that the best place to accommodate the add-on "daughter board" was above IC22, 23 and the blank board area to their left. The daughter board is connected to the main board's monitor socket via a 6 inch 24-pin double-ended d.i.p. jumper lead. With this arrangement it will be found that the top section of the moulded plastic cabinet housing the computer still fits perfectly. ICs 100 and 101 are accommodated on the main board, between ICs 25 and 28, using i.c. sockets of course. The necessary holes in the main board are drilled in such a position as to straddle the tracks on the rear side of the board. Drilling these holes accurately is no problem. Just cut a small piece of 0·1 inch stripboard to size to accommodate two 14-pin d.i.l. sockets and mark the holes corresponding to the socket pins. Now temporarily stick this stripboard drilling jig to the main board, carefully lining it up in position so that the lines of holes will clear the tracks on the rear of the board, as mentioned above. The ideal adhesive for temporarily fixing the jig is a couple of tiny pellets of beeswax, warmed by rolling between finger and thumb. S100 is mounted wherever you find convenient; for example, just above the keyboard.

The connections to the daughter board required a little ingenuity, since basically the 24-way jumper does not provide sufficient leads. WEMON requires an extra address line (A11) whilst we also need $\overline{\mathrm{MONCON}}$ to control which monitor ROM receives the MCS enable signal. Fortunately pin 21 is available on all but the earliest models of the UK101. At present this pin duplicates the +5V connection to the monitor, although on the earlier boards it was connected to the Ø2 clock. The +5V track to pin 21 of the monitor socket is cut and A11 taken to this point instead. Similarly, pin 24 of the monitor socket is re-allocated to $\overline{\mathrm{MONCON}}$, and we now have all the necessary signals available at the

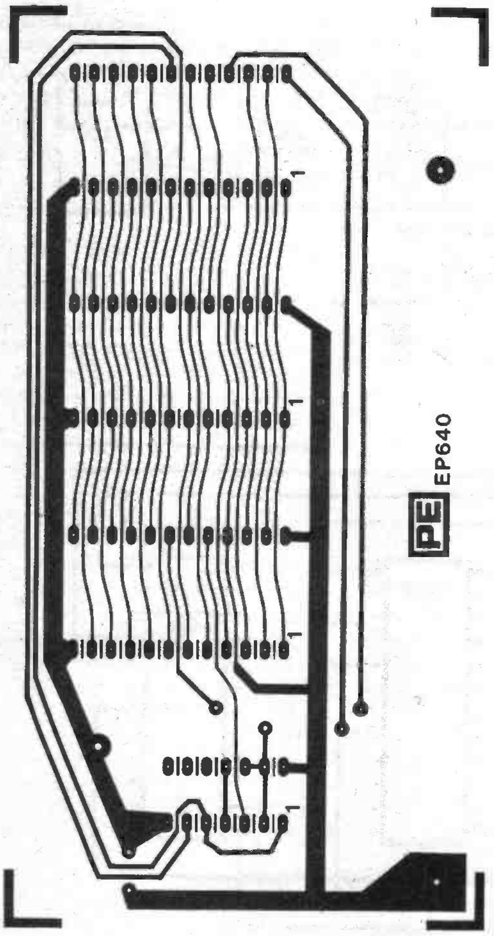


Fig. 5. Printed circuit layout (actual size)

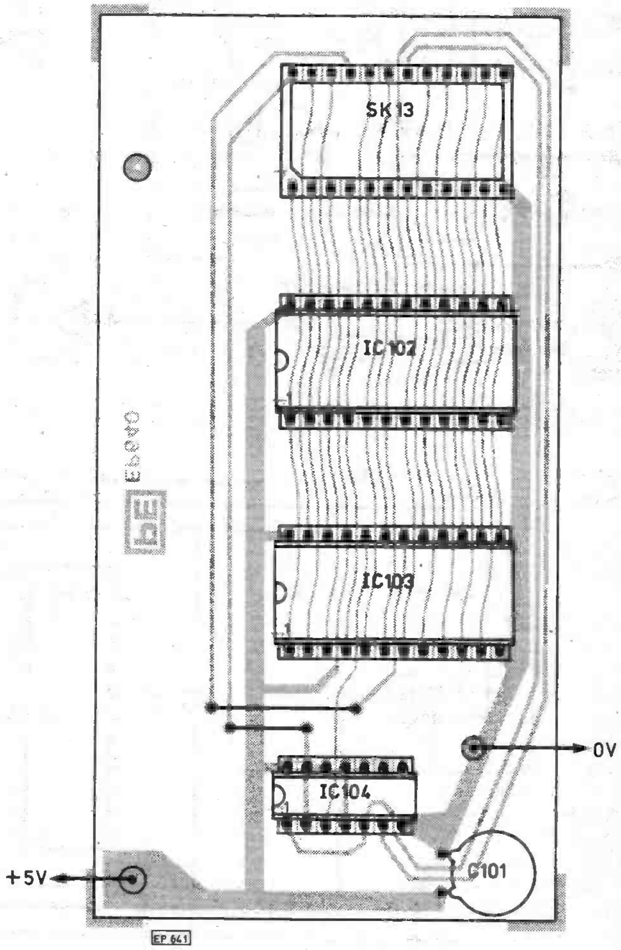


Fig. 6. Component overlay. SK13 accepts 24-way 160mm jumper lead from original monitor socket

COMPONENTS . . .

Capacitors

C101	100n disc ceramic

Integrated Circuits

IC101	7474
IC102	UK02 monitor
IC103	WEMON monitor
IC104	7400

Miscellaneous

SK13 24-way d.i.l. sockets (3 off)
Printed circuit board
14-way d.i.l. socket
24-way 160mm jumper lead
SPDT toggle switch

daughter board, but no +5V supply. This connection is made via one of the two 8BA screws which support the daughter board. These screws pass through the main board near IC5 (carries +5V to the daughter board) and IC15.

I.c. sockets should be used for ICs 102, 103 and 104 on the daughter board, and the local decoupling should on no account be omitted.

Having completed the constructional work, closely check all wiring: bus conflicts are embarrassing and potentially damaging. Check that S100 controls IC101 correctly and that either pin 3 or pin 6 of IC104 sits permanently at a "1" logic level accordingly. This shows that the $\overline{MCS}$ of only one of the two monitors is enabled at any one time.

USING THE UK101 WITH TWO MONITORS

With everything installed and working, pressing the RESET keys following switch-on should bring up the initiation message appropriate to whichever monitor is selected by S100. C for COLD START will be the appropriate reply for use in the BASIC mode, or M for machine code working. The facility for selecting either monitor was originally intended for use only in this way, i.e. at switch-on. It was found that once a BASIC program had been loaded and was in use, switching from one monitor to the other caused problems. On switching over, the keyboard locks out, so a RESET is necessary. Obviously a COLD START is no good as it clears the machine entirely, losing the program. On the other hand, a WARM START does not reset all the page two flags and vectors to the correct values for the monitor which has just been selected. What is needed is a "TEPID START", something which sorts out the mess in page two whilst not clearing program memory.

In fact, this is easily arranged by using the machine code monitor RESET routine, followed by a WARM START. In this way one can change monitors in mid-stream without any problems. The sequence is:

When selecting WEMON—

RESET M M RETURN FØØØ G W

and when selecting UK02—

RESET M FEØØ G RETURN W

The only other point to watch is fairly obvious—*don't change monitor whilst a program is running!* The time to change is when the monitor is sitting quietly scanning the keyboard; at this time, the program is not being accessed and no problems will arise.

In practice, the ability to change from one monitor to the other while operating in BASIC, whilst handy, would not be likely to be used all that much since WEMON is so much more convenient than UK02. The Assembler can only be used if 8K bytes of memory are available, rather than the meagre 4K supplied with the machine. ★

Readout...

A selection from our Postbag

Readers requiring a reply to any letter must include a stamped addressed envelope.
Opinions expressed in Readout are not necessarily endorsed by the publishers of Practical Electronics.

Decidedly "off"

Sir—I read your editorial entitled "The Protection Racket" in your September issue with interest and a wry smile. It is decidedly "off" that this kind of situation should arise. We had dealings with Metac shortly before "the end"—and would have advised anyone else "off the record" to steer well clear. The difficulty lies in the fact that you just do not dare say anything in public for fear of being sued for thousands. At least you can raise the matter in retrospect—as you have done regarding Metac in your latest issue. The trouble is that you have pulled your punches (as the "press" always does seem to do) in order not to destroy confidence in Mail Order Trading/Advertising—on which you depend for income. One way of avoiding the problem would have been to insist that firms so advertising open "Readers Accounts"—and trade through them . . or insist that the firms insure themselves against this type of liability. Really, however, a statutory scheme is the only answer. Also the whole law concerning bankrupt companies needs reviewing—as you imply.

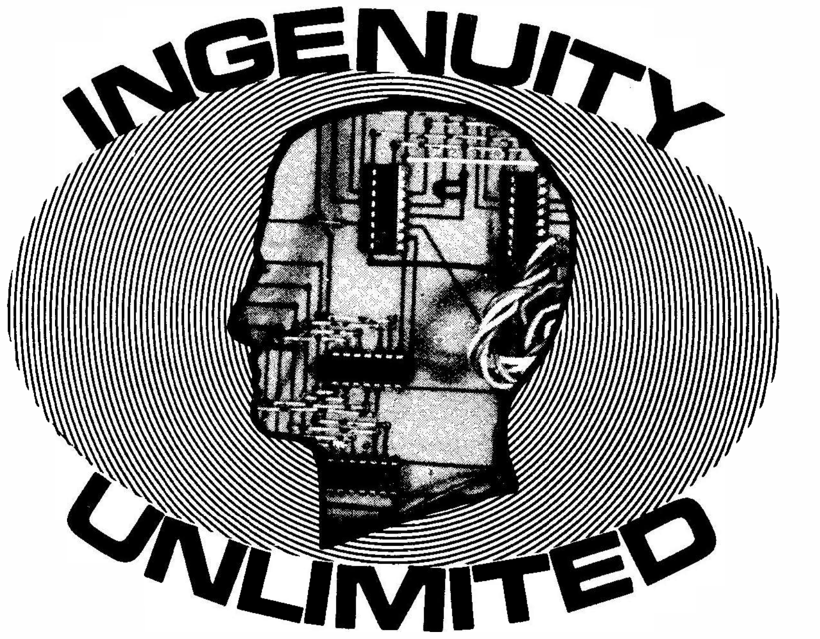
I appreciate especially *Semiconductor Update*—because it brings to our attention in a chatty sort of way, important developments we might have otherwise overlooked in the piles of technical literature that arrive by every post. I do note, however, that you never even get round to touching on the fields in which we work—namely telecopying and print scanning. This is a field where the imminent arrival of cheap fast memory is going to make an enormous impact in the next few years. To take an example—to store a newspaper page (of say 20" × 30") at high resolution (500 dots/inch) requires in the order of 10Mb of memory—which means about 320Mb for your daily paper. The days when your Sun or Guardian may be produced at the point of sale could be closer than many think.

The problem is to decide what intermediate processes are best suited to this technology. There is everything to be said for polling the memory anew for each copy, and then imaging the copy on a selenium/photoconductive drum in contact with ink toner—which then directly or indirectly transfers the image to paper. As you know, there are already many products on the market based on this technology. The alternative is to use an offset plate or sophisticated duplicating stencil as an intermediate. These can be sold at a few pence each—and can be used with much cheaper raw materials (paper + ink). This latter process, however, still demands a skilled/semi-skilled operator—and about 500 copies from each original to compete price-wise. Having said this—we have no doubt that it produces a far better result (well in excess of current newspaper standards). As you may have guessed, we are active in this last field.

At present, you are not giving your readers an "inkling" of what may be in store for them. Likewise you have ignored the various "typewriter substitutes" that are on the horizon replete with electrostatic ink guns and an ability to create graphics and reproduce half tones.

Hugh Bridge
Rectory Row Press
London.

We believe our Mail Order Protection Scheme gives our readers the protection they require, and they can thus buy from mail order advertisers in this magazine with confidence—Ed.



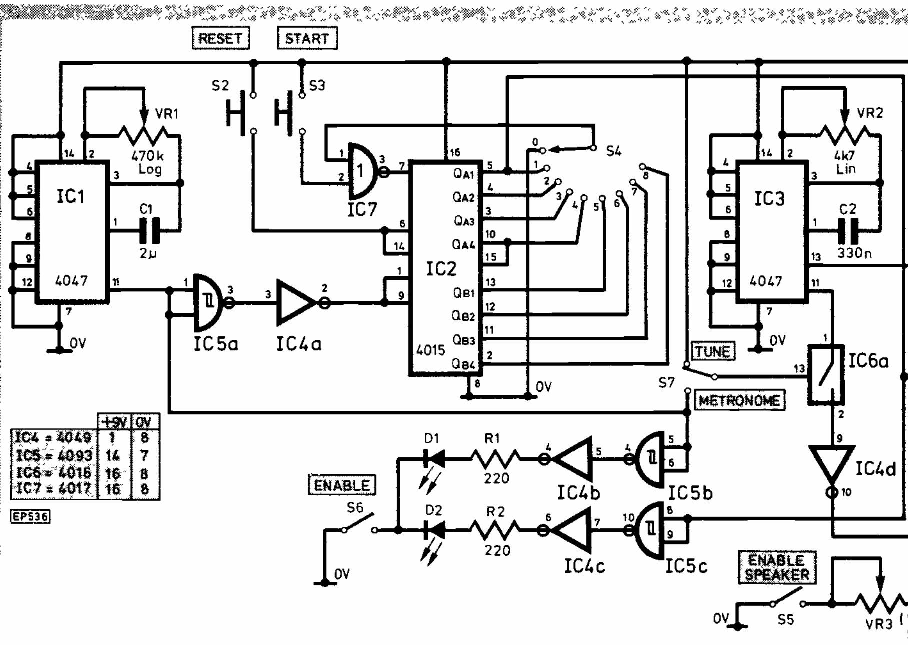
A selection of readers' original circuit ideas. It should be emphasised that these designs have not been proven by us. They will at any rate stimulate further thought.

Each idea submitted must be accompanied by a declaration to the effect that it has been tried and tested, is the original work of the undersigned, and that it has not been offered or accepted for publication elsewhere.

Why not submit *your* idea? Any idea published will be awarded payment according to its merits.

Articles submitted for publication should conform to the usual practices of this journal, e.g. with regard to abbreviations and circuit symbols. Diagrams should be on separate sheets, not inserted in the text.

ACCENTED-BEAT METRONOME



	+9V	0V
IC4 = 4049	1	8
IC5 = 4093	14	7
IC6 = 4016	16	8
IC7 = 4017	16	8

LIKE most mechanical metronomes, but unlike most electronic ones, this device is able to accent the downbeat at the beginning of a bar. The logic for this, which is based around a ring counter, can deal with any number from one to eight beats in a bar (including the odd ones, and even the ridiculous seven—which I suppose might just be useful for Benjamin Britten's music). The circuitry can be used either to drive two differently coloured l.e.d.s or feed two different tones to a loudspeaker.

Clock pulses are produced by IC1, a 4047 connected as a slow astable. With the quoted values for timing components C1 and VR1 the square-wave output is readily adjustable over the numerically useful range (0·5–3·5Hz). This drives l.e.d. D1 via NAND Schmitt trigger IC5b and inverting buffer IC4b, assuming that switch S6 (which enables the l.e.d. output) is closed. IC3 is a second 4047 running a good deal faster; with VR2 around the middle of its travel the output at pin 11 will be at about 400Hz.

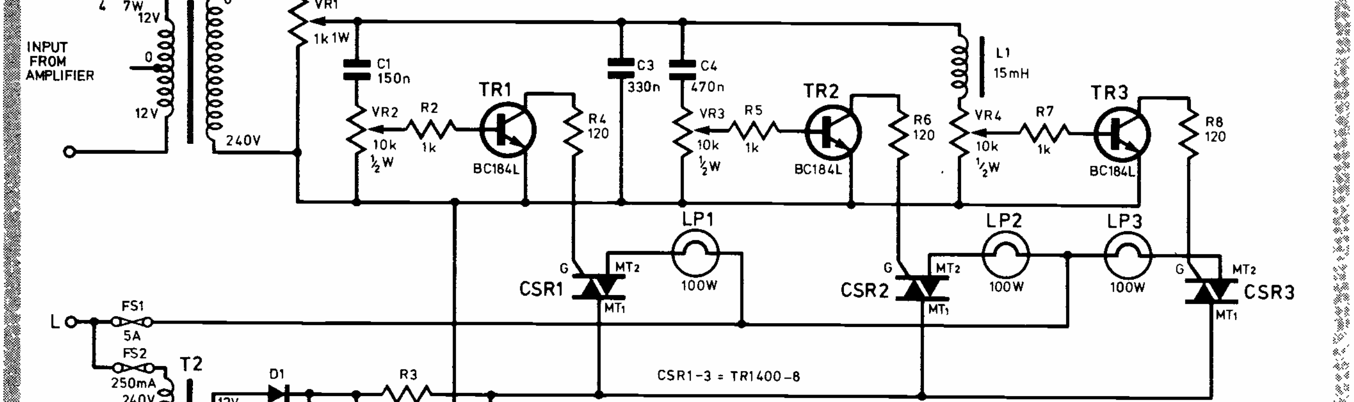
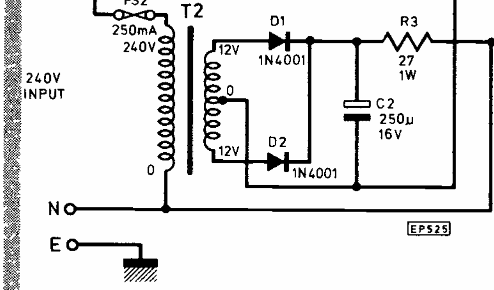
This is fed via inverting buffer IC4d to the loudspeaker LS1, the signal being gated with IC6a by the clock pulses. S5 enables the speaker output, VR3 functions as a volume control (or a suitable fixed resistor may be substituted), and S7 can be used to bypass the clock and keep IC6a always closed. This to allow the unit to be used as a tuning reference. VR2 may be adjusted to give a standard A (440Hz).

IC2 and S4 form a ring counter of variable length. The wiper of S4 is connected via OR gate IC7 to the serial input of the 8-bit shift register made by cascading the two 4-bit shift registers on the 4015 chip, whilst the poles of the switch are connected to the parallel outputs of the eight stages.

Pressing S2 clears the register to 'zero', whilst pressing S3 loads a 'one' into the serial input (pin 7). The ring counter is clocked by IC1 via IC5a, IC4a. If S4 selects way n, then the first stage output (pin 5), will be high once in every n clock pulses. The output at pin 5 is then used to drive D2 and to gate the octave time from pin 13 of IC3 to the loudspeaker, in exactly the same way as for the basic clock pulses. By selecting way 'zero' on S4 no beats will be accented.

P. C. French,
Humberstone, Leicester.

3-CHANNEL SOUND TO LIGHT

THE circuit is divided into three channels: bass, middle and treble, with controls for the adjustment of the sensitivity of these channels. An overall master control is provided, so it is only necessary to adjust one control instead of three if the input to the unit is changed.

Transistors are used to drive the triacs, to increase sensitivity, and the unit should work quite adequately with quite a low power input. In fact, the prototype could be adequately driven from an ordinary transistor radio.

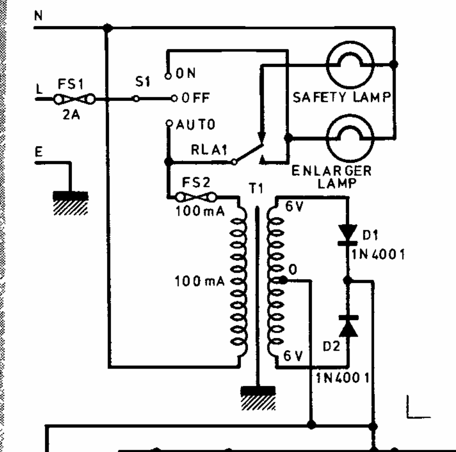
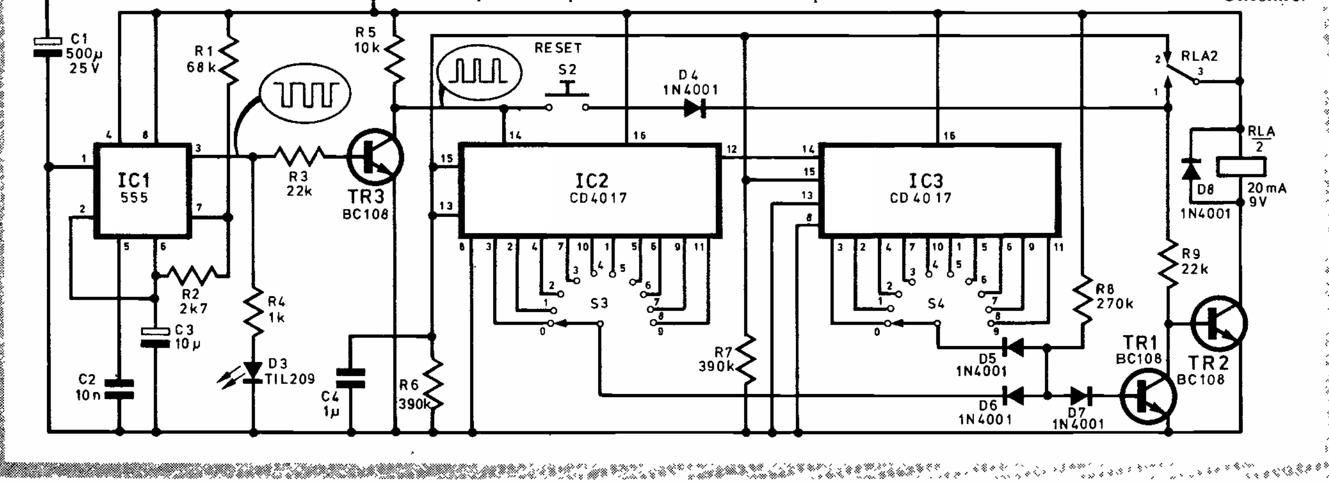
Although a transformer isolates the input source from the unit, the controls, VR1–VR4, are not similarly isolated and from a safety point of view, their spindles should be isolated from the user.

All resistors are ½ watt 5 per cent, except for R1 which should be at least a 7 watt wirewound type, and all potentiometers are ½ watt linear, except for VR1 which should be a 1 watt linear wirewound type.

The mains transformer used was a 250mA type. The triacs should be heatsinked, although in the prototype a load of 100 watts per channel was used and the triacs remained cool without heatsinks.

K. Badcock,
Kettering,
Northants.

0-99s PHOTOGRAPHIC TIMER

AS a keen amateur photographer I have found that one of the most tedious tasks in the dark room is trying to watch a wrist watch while printing or making test strips. With the circuit I have submitted all that has to be done is to set the appropriate time on the rotary switches and press the reset button which can be a foot switch if required, thus leaving the hands free for dodging etc. As with other timer designs I have seen, there is no need to calibrate the dials because the clicks on the rotary switches can easily be felt and counted which is a great advantage in the dark.

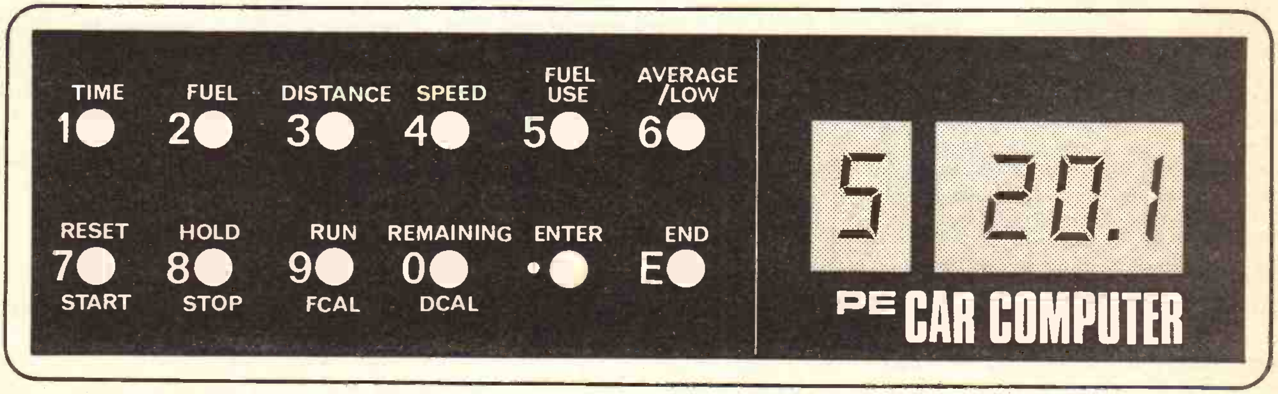
The timer is set to the appropriate exposure time, the reset button is pressed and the latching circuit is activated on the positive pulse from the clock pulse generator due to diode D4 in series with the press button. The circuit is then latched on via relay contacts 1 and 3 and the enlarger lamp turns on. When the required time is reached the AND gate receives a logic high voltage on the cathodes of D5 and D6 which biases on TR1 via the 270 kilohm resistor. TR1 is acting as a switch shorting out the bias voltage on TR2 when the set counting time is reached so turning off the enlarger. When the relay is de-energised the supply rail is taken to pins 15 on both counters via relay contacts 2 and 3 resetting them for the next counting cycle.

Gary Crawford,
Runcorn,
Cheshire.

NEXT MONTH...

FREE Tandy Catalogue WITH ALL U.K. ISSUES

PE CAR COMPUTER



Employing completely new, specially designed and manufactured, micro-computer circuitry and flow transducers, this car computer (shown actual size above) is able to provide the following digital information in either imperial or metric units!

Current or average speed and m.p.g., distance travelled, remaining distance possible on fuel left, average speed needed for remaining distance to meet an arrival time, acceleration and deceleration times between any two preset speeds, fuel used during acceleration, average m.p.g. during acceleration, distance covered including standing distance times and fuel used, etc. Can also provide indication of instant and average cost of fuel usage, e.g. miles per pound etc. There is also provision for a combination lock ignition cut out.

The unit can be easily and accurately calibrated in any car without special equipment and the calibration can be checked and altered at any time. Suitable for most negative earth 12V cars excluding those with fuel injection or diesel engines.

The unit's unique facility for providing accurate acceleration, time and fuel consumption figures, makes it possible to tune for a compromise between performance and economy, to check performance/economy at any time, and therefore check the engine has remained in tune.

A complete kit will be available including a custom injection moulded case, finished front panel and complete, ready to fit, sensors.

We believe the *PE Car Computer* is superior to any unit commercially available at the present time. Emphasis has been placed on versatility and accuracy.

Don't miss part 1 next month.

Also... SPACE EVADERS

Complete Index for Vol.17

PRACTICAL

ELECTRONICS

DECEMBER ISSUE ON SALE FRIDAY NOVEMBER 13th

MICRO-BUS

Compiled by DJD.

Appearing every two months, Micro-Bus presents ideas, applications, and programs for the most popular microprocessors; ones that you are unlikely to find in the manufacturers' data. The most original ideas often come from readers working on their own systems; payment will be made for any contribution featured.

THIS month's Micro-Bus focuses attention on the Sinclair ZX81 and ZX80 microcomputers, and includes two memory-expansion circuits, an encryption system, and a program renumber routine.

EXTRA RAM FOR ZX81

The programming space available on the ZX81 can be increased some 3 to 4 times by adding an extra 1K of memory, as shown in the simple circuit of Fig. 1. This was submitted by *D. Brownlee* of Hatfield who writes: "When I first took delivery of my ZX81 I attempted to enter a fairly long program published for the standard ZX80. However, I soon discovered that the program would not fit in, presumably because the ZX81 uses more of the RAM for its workspace. I overcame this problem with the RAM extension, and the circuit should be self-explanatory. The address decoding is performed by a 74LS10, and when the extra memory is addressed the internal memory is disabled by an extra gate and a diode."

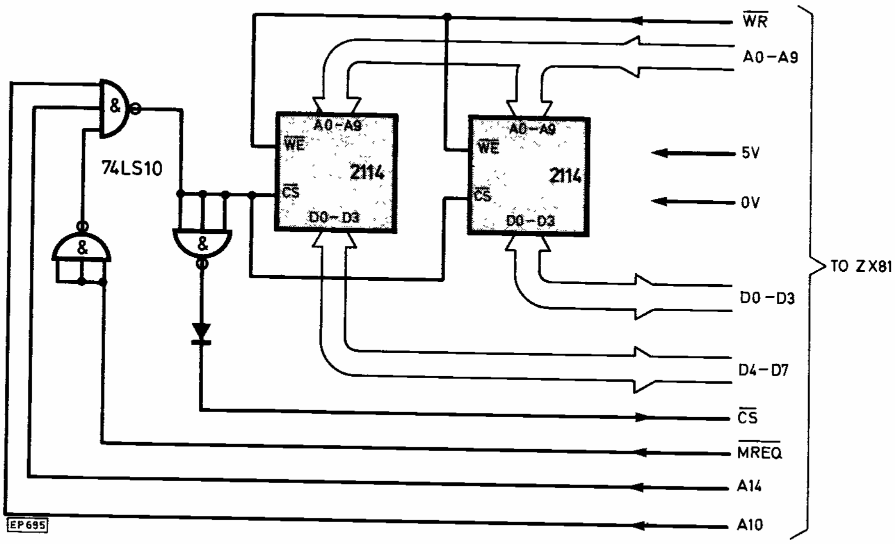


Fig. 1. 1K RAM Extension for a ZX81

7K EXPANSION

If more than 1K of expansion is envisaged the following design may be more suitable. It was sent in by *Howard Parry* of Manchester, and can accommodate up to 7K of RAM, or a mixture of RAM and I/O ports; what follows is based on his description.

"For the expansion I decided to use 2114 static RAM chips, the same as those used in the kit. One problem was the edge connector; I could not find a 23-way double-sided connector in any of the popular magazines, so I finally decided on a Vero double-sided 43-way connector which I cut down to size. It fits perfectly!

EXPANSION CIRCUIT

"The circuit, shown in Fig. 2, is based around a 74LS138 decoder i.c., and the memory chips. It works as follows: the 74LS138 decodes A14 and $\overline{MREQ}$ to enable the expansion to be positioned at the start of the 16K area. A10–A11 and A12–A13 decode one of eight 1K blocks from 16K to 23K. $\overline{MREQ}$ is required to make sure that the address lines are stable before memory is accessed for read and write operations. To disable the internal 1K RAM block Y0 is connected back to $\overline{CS}$ on the ZX81 bus.

"After building the RAM expansion I did the RAMTOP test: PRINT PEEK 16388+256*PEEK 16389 and, hey presto, the answer came up 18432!"

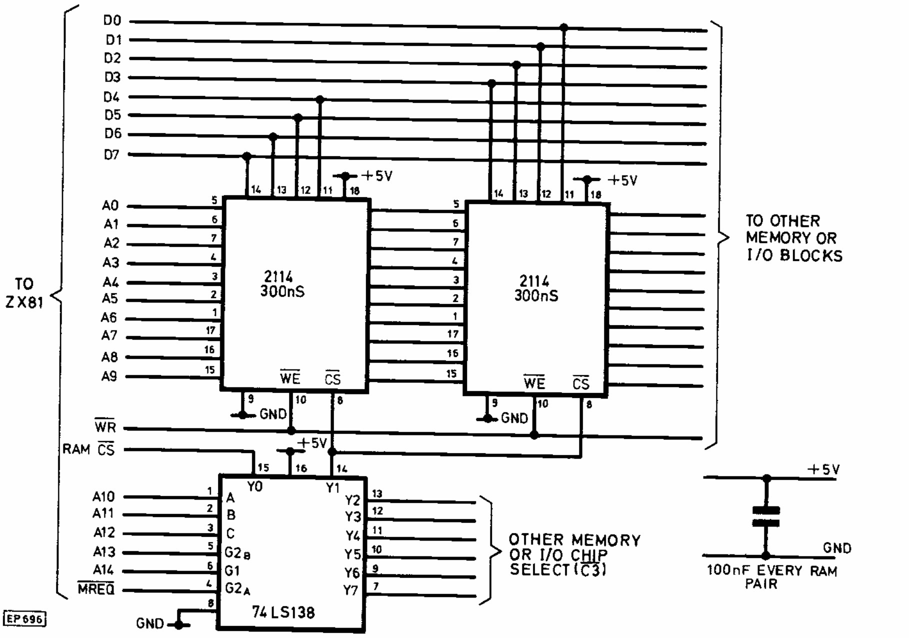


Fig. 2. Extension for the ZX81 can take up to 7K of RAM and/or I/O

ZX81 MASTERMIND

The following program for the standard ZX81, shown in Fig. 3, plays the plastic-peg game "Mastermind", and was submitted by *Leslie Green* of Norwich. A similar program for the ZX80 was featured in the August 1980 Micro-Bus. The computer generates a random 4-digit code which the human player must try to deduce within 13 attempts. Each digit in the code can be between 0 and 5, and each guess is entered as a string of four digits, followed by NEWLINE. The computer replies with the number of digits in the correct place (denoted by C), and the number of digits correct but misplaced (denoted by M).

```
100 DIM A(4)
110 DIM B(4)
120 DIM G(4)
130 RAND
140 FOR N=1 TO 4
150 LET A(N)=INT(6*RND)
160 NEXT N
170 LET X=0
180 LET Y=0
190 FOR N=1 TO 4
200 LET B(N)=A(N)
210 INPUT G(N)
220 PRINT " ";G(N);
230 IF G(N)<>B(N) THEN GO TO 270
240 LET X=X+1
250 LET B(N)=-1
260 LET G(N)=-2
270 NEXT N
280 FOR L=1 TO 4
290 FOR N=1 TO 4
300 IF G(L)<>B(N) THEN GO TO 340
310 LET Y=Y+1
320 LET B(N)=-1
330 LET G(L)=-2
340 NEXT N
350 NEXT L
360 PRINT "  ";X;"C,";Y;"M"
370 GO TO 170
```

Fig. 3. ZX81 Mastermind game; you have to guess the computer's code

PROGRAM OPERATION

In order to fit the program into the ZX81 all frills have been avoided, and space is saved by using N as the loop variable in three separate loops. Array A contains the computer's code, and initially arrays B and G contain this random selection and the player's guess respectively. As hits are scored the respective elements are set to illegal values, −1 and −2, to take them out of the proceedings. The number of digits in the correct position is calculated first (lines 190 to 270), followed by the number of misplaced digits (lines 280 to 350); finally, in line 360, the computer prints the result.

The range of numbers allowed is easily changed in line 150, and with more memory the program could be extended to work with more digits.

ALIEN INVADERS

The object of the following game for the standard ZX81, shown in Fig. 4, is to prevent invaders from taking over the Earth. It was devised by *I. Johnson* and *G. Boguszewski* of Doncaster, and demonstrates the use of the ZX81's PRINT AT statement, which allows strings and numbers to be printed at any specified co-ordinates on the screen.

The aliens are represented by random numbers which start at a random point on the screen, and move vertically downwards. As each alien moves its number changes; to stop it you must type its number at the keyboard. If you succeed you score 100 points; however, if you fail the alien will reach the Earth, represented by a row of asterisks. When five aliens have landed the Earth is overcome, and the game ends.

PROGRAM OPERATION

The aliens descend on the left-hand side of the screen, controlled by lines 60–100 of the program, at a speed determined by line 110. The score, and number of aliens that have landed, are continuously updated at the top right-hand side of the screen. Like most arcade games it is impossible to beat the aliens, and the aim of the game is just to achieve a personal best!

```
 10 LET S=-100
 20 LET A=0
 30 PRINT AT 14,0;"***********"
 40 LET S=S+100
 50 PRINT AT 0,20;"SCORE:";S
 60 LET M=INT(RND*10)
 70 FOR N=0 TO 15
 80 LET A$=CHR$ INT(RND*6+CODE"
0")
 90 PRINT AT N,M;A$
100 PRINT AT N-1,M;CHR$ 0
110 FOR I=0 TO 15
120 NEXT I
130 LET N=N+1
140 LET B$=INKEY$
150 IF A$=B$ THEN GO TO 40
160 IF N<15 THEN GO TO 80
170 IF N=15 THEN LET A=A+1
180 PRINT AT 1,20;"ALIENS:";A
190 IF A=5 THEN GO TO 210
200 IF A<5 THEN GO TO 50
210 PRINT AT 20,6;"ALIENS HAVE
LANDED"
220 PAUSE 600
230 CLS
240 GO TO 10
```

Fig. 4. Alien Invaders for the ZX81

ZX80 ENCRYPTION

The following encryption and decryption system works by combining a message with a key known only to the sender and receiver, and will enable two ZX80 owners to send each other messages that cannot be intercepted by anyone who does not know the key. An ingenious feature of the system is that the program is sent on tape along with the message. Thus, no retyping of the coded message is needed; the recipient has just to load the tape and run the program, and on entering the key the decoded message will appear on the screen.

The program, shown in Fig. 5, was devised by *Lars Silen* whose ZX80 string-manipulation routines have been featured in a previous Micro-Bus. Encription is performed by exclusive-ORing characters from the message and the key, a pair at a time. As the ZX80 does not have an XOR function this part is done by a machine-code subroutine which is set up by the program.

OPERATION

To use the system proceed as follows. First RUN the program, and enter the key, which may be any alphanumeric string, followed by NEWLINE. Then select mode 1 for encryption, and enter the message. The message may either be entered as a number of lines, separated by NEWLINE, or in a continuous block. The end of the message is signified by an empty line. Then the prompt "ENTER MODE" will appear again; typing 3 will stop the program, having destroyed the key for security.

Now save the program on tape; this will also save the encoded message which is in C$. The tape is totally secure, and can be sent to the receiver by mail, or any other channel.

To decode the message proceed as follows. Load the program and type "GO TO 1", followed by NEWLINE, as typing RUN at this point would destroy the string C$. Enter the key, followed by NEWLINE, and the message will be displayed in plain text on the screen.

```
   1 REM ENCRYPTION/DECRYPTION
  20 DIM M(10)
  30 LET E=PEEK(16392)+256*PEEK(
16393)+3
  50 POKE E+3,E-(E/256)*256
  60 POKE E+4,E/256
  70 POKE E+2,42
  80 POKE E+5,124
  90 POKE E+6,173
 100 POKE E+7,111
 110 POKE E+8,201
 200 PRINT "ENTER KEY"
 210 INPUT A$
 215 LET B$=A$
 220 CLS
 230 PRINT "ENCRYPT=1,DECRYPT=2"
 235 PRINT "-------------------"
 240 PRINT "ELSE STOP"
 245 PRINT "ENTER MODE"
 250 INPUT MODE
 255 CLS
 260 IF MODE=1 THEN GO TO 500
 265 IF MODE=2 THEN GO TO 270
 266 LET A$=""
 267 LET B$=""
 268 STOP
 270 PRINT "DECRYPT"
 275 PRINT "-------"
 280 IF C$="" THEN STOP
 285 LET K=CODE(C$)-2
 290 LET C$=TL$(C$)
 300 GO TO 800
 500 PRINT "ENCRYPT"
 510 PRINT "-------"
 515 PRINT "INPUT A LINE, END WI
TH NEWLINE"
 516 LET C$=""
 520 INPUT M$
 525 IF M$="" THEN GO TO 215
 540 LET A=CODE(M$)
 545 IF A=215 THEN LET A=25
 550 IF A=218 THEN LET A=16
 555 IF A=217 THEN LET A=17
 560 IF A=220 THEN LET A=18
 565 IF A=221 THEN LET A=19
 570 IF A=222 THEN LET A=20
 575 IF A=223 THEN LET A=21
 580 IF A=227 THEN LET A=22
 585 IF A=228 THEN LET A=23
 590 IF A=229 THEN LET A=24
 600 IF A=216 THEN LET A=26
 660 POKE E,A
 670 POKE E+1,CODE(B$)
 680 LET B$=TL$(B$)
 690 IF B$="" THEN LET B$=A$
 700 LET D$=CHR$(USR(E+2)+2)
 710 LET C$=C$
 720 LET D$=D$
 730 GO SUB 1000
 740 LET M$=TL$(M$)
 750 IF NOT M$="" THEN GO TO 540
 760 GO TO 520
 800 IF B$="" THEN LET B$=B$
 810 POKE E,CODE(B$)
 820 POKE E+1,K
 830 PRINT CHR$(USR(E+2));
 840 LET B$=TL$(B$)
 850 GO TO 280
1010 LET AD=PEEK(16394)+256*PEEK
(16395)-3
1020 LET AD=AD-1
1030 IF NOT PEEK(AD)=1 THEN GO T
O 1020
1035 LET TP=PEEK(AD+1)
1040 POKE AD,0
1050 POKE AD,PEEK(AD+2)
1060 LET AD=AD+1
1070 IF NOT PEEK(AD+2)=1 THEN GO
 TO 1050
1080 POKE AD+1,TP
1090 POKE AD,1
1100 RETURN
```

Fig. 5. Encryption program for sending messages between two ZX80's

PROGRAM DESCRIPTION

The program is based on an encryption algorithm first described by *Gilbert S. Vernam* in 1917, and works as follows: Lines

20 to 110 set up the machine-code XOR function, using the array M(10) to make space for the machine-code. Data for the routine is passed across in locations (E) and (E+1) using the POKEs in lines 660, 670, 810, and 820, and the routine is called with LET A=USR(E+2). The machine code is as follows:

```
DATA  .BYTE ;KEY CHARACTER
      .BYTE ;MESSAGE CHARACTER
ENTER LD HL,(DATA)
      LD A,H
      XOR L
      LD L,A
      RET
```

The key is entered in lines 200–220, and the mode is selected in lines 230–268. If mode 3 is selected the program stops, and the key is destroyed in lines 266 and 267.

Encryption is performed by lines 500 to 760. Lines 545 to 600 take care of a peculiarity of the ZX80 character set, and the coded character is put into the string D$. This string is then added to the end of the string C$ (lines 710–730 and 1010–1100) using the string-adder subroutine described in the April 1981 Micro-Bus. Lines 680 and 740 chop off the used characters from the message and the key.

Decryption is performed in lines 270–300 and 800–850 by encoding the message in C$ with the same key once more. As XOR is a symmetric operation this regenerates the original message.

The ZX80 uses a byte containing "1" to indicate the end of a string; to prevent this code from occurring within the encoded string, 2 is added to each encoded character (line 700), and is subtracted when decoding (line 285).

ZX80 LINE RENUMBER

The following program, submitted by *Alan Wagstaff* of North Yorkshire, will tidy up a ZX80 program by renumbering the lines in steps of ten. First list the program to be renumbered and note all lines referenced by GO TO, RUN, or GO SUB commands. Then add the lines shown in Fig. 6 to the end of the program. Execute the renumber routine by typing:

RUN 9000

and when the listing reappears delete lines 9000 to 9900. Finally, amend all the previously noted references to line numbers.

```
9000 LET X=10
9100 POKE 16424,X/256
9200 POKE 16425,X-(X/256)*256
9300 FOR M=16426 TO PEEK(16392)+
PEEK(16393)*256
9400 IF NOT PEEK(M)=118 THEN NEX
T M
9500 IF PEEK(M+2)+PEEK(M+1)*256=
9000 THEN LIST
9600 LET X=X+10
9700 POKE M+1,X/256
9800 POKE M+2,X-(X/256)*256
9900 NEXT M
```

Fig. 6. Renumber routine for the ZX80

The program works by directly POKEing the new line numbers into memory (lines 9700 and 9800), stopping when line 9000 is reached. As it stands the program renumbers starting with line 10, and with an increment of 10; this can be changed by altering lines 9000 and 9600.

CROSSHATCH GENERATOR

An essential item of equipment for aligning a colour TV is a crosshatch generator. The short program shown in Fig. 7 shows how a ZX80 can be used for this purpose, and was submitted by *Mr. C. Munton* of Kent, who writes:

"The most useful pattern was obtained with four spaces between the quotes in line 20, although other patterns are possible by altering this number. After RUN, entering the code for an inverse graphics character produces a useful test pattern. Code 147 for inverse "+" was found the most useful though others may also be of value. This program was successfully used to re-align the convergence circuits of an ITT CVC5 colour television."

```
10 INPUT X
15 FOR J=1 TO 4500
20 PRINT CHR$(X);"    "
40 NEXT J
```

Fig. 7. ZX80 crosshatch generator helps realign colour televisions

Countdown...

Please check dates before setting out, as we cannot *guarantee* the accuracy of the information presented below.

BEX Bristol Oct. 14–15. Exhibition Centre. **K**
Video Show Oct. 16–18. West Centre Hotel, London. **Z1**
Int. Business Show Oct. 20–29. NEC, Birmingham. **A2**
Com. Graphics Oct. 27–29. Bloomsbury Centre, London. **O**
Testmex Oct. 27–29. Wembley Conf. Centre, London. **T**
BEX Southampton Nov. 4–5. Polygon Hotel. **K**
Viewdata & TV Nov. 4–6. West Centre Hotel, London. **Z1**
Breadboard Nov. 11–15. Royal Hort. Halls, London. **B7**
IFSEC (Fire & Security) Nov. 17–19. RDS Dublin. **V**
Compec Nov. 17–20. Olympia, London. **Z1**
BEX Plymouth Nov. 18–19. Holiday Inn. **K**
Intron Nov. 24–26. RDS Dublin. **V**
Continuous events at Nat. Micro & Elect. Centre. **L1**

1982

IDEA (Domestic appliances) Jan. 12–14. B/ham. **B6**
OEM Assemblies Feb. 2–4. Royal Hort. Halls, London. **T**
Microsystems Feb. 24–26. West Centre Hotel, London. **Z1**
CAD Mar. 30–Apr. 1. Metropole, Brighton. **Z1**
Laboratory, Edinburgh Mar. 30–31. Ass. Rooms. **E**
Test & Measurement Mar. 30–Apr. 1. Forum, Wythenshawe. **T**

A2 Hart Browne & Curtis ✆01-439 8556
B6 Andry Montgomery Ltd. ✆01-486 1951
B7 Modmags ✆01-437 1002
E Evan Steadman, Saffron Walden ✆0799 22612
K Douglas Temple, Bournemouth ✆0202 20533
L1 World Trade Centre ✆01-488 2400
O Online, Northwood, Mddx. ✆09274 28211
T Trident, Tavistock ✆0822 4671
V SDL ✆ Dublin 763871
Z1 IPC Exhibitions, Sutton ✆01-643 8040

20 POWER AMPS 19 FUNCTIONAL MODULES DAWN

POWER UP TO 480 WATTS RMS SINGLE CHANNEL

Which amplifier?

I.L.P. Amplifiers now come in three basic types, each of which is available with or without heatsink. Having decided the system you want – home hi-fi (models HY30, 60 or 120 for example), super quality hi-fi with extra versatility (MOS120, MOS200) or Disco/PA/Guitar (HD120, HD200 or HD400) you will then decide whether amplifiers housed within their own heatsinks or plate amplifiers for bolting to a metal chassis will suit. With choice such as this and a brilliant new range of I.L.P. functional modules to choose from you now have the chance to build the finest audio system ever offered to the constructor.

AMPLIFIER WITH HEAT SINK

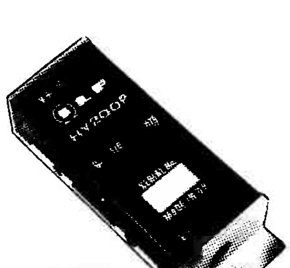


PLATE TYPE

BIPOLAR Standard, with heatsinks / Without heatsinks

MODEL NUMBER	OUTPUT POWER Watts rms	DISTORTION T.H.D. Typ at 1kHz	DISTORTION I.M.D. 60HZ/7kHz 4:1	SUPPLY VOLTAGE TYP/MAX	SIZE mm	WT gms	PRICE	VAT	MODEL NUMBER	SIZE in mm	WT gms	PRICE	VAT
HY30	15w/4-8Ω	0.015%	<0.006%	±18±20	76x68x40	240	£7.29	£1.09					
HY60	30w/4-8Ω	0.015%	<0.006%	±25±30	76x68x40	240	£8.33	£1.25					
HY120	60w/4-8Ω	0.01%	<0.006%	±35±40	120x78x40	410	£17.48	£2.62	HY120P	120x26x40	215	£15.50	£2.33
HY200	120w/4-8Ω	0.01%	<0.006%	±45±50	120x78x50	515	£21.21	£3.18	HY200P	120x26x40	215	£18.46	£2.77
HY400	240w/4Ω	0.01%	<0.006%	±45±50	120x78x100	1025	£31.83	£4.77	HY400P	120x26x70	375	£28.33	£4.25

Protection: Load line, momentary short circuit (typically 10 sec) *Slew rate:* 15V/μs *Rise time:* 5μs
S/N ratio: 100db *Frequency response (−3dB):* 15Hz – 50kHz
Input sensitivity: 500mV rms *Input impedance:* 100kΩ *Damping factor:* (8Ω/100Hz)>400

HEAVY DUTY with heatsinks / Without heatsinks

MODEL NUMBER	OUTPUT POWER Watts rms	T.H.D.	I.M.D.	SUPPLY VOLTAGE	SIZE mm	WT gms	PRICE	VAT	MODEL NUMBER	SIZE in mm	WT gms	PRICE	VAT
HD120	60w/4-8Ω	0.01%	<0.006%	±35±40	120x78x50	515	£22.48	£3.37	HD120P	120x26x50	265	£19.84	£2.98
HD200	120w/4-8Ω	0.01%	<0.006%	±45±50	120x78x60	620	£27.38	£4.11	HD200P	120x26x50	265	£23.63	£3.54
HD400	240w/4Ω	0.01%	<0.006%	±45±50	120x78x100	1025	£38.63	£5.79	HD400P	120x26x70	375	£34.28	£5.14

Protection: load line, PERMANENT SHORT CIRCUIT (ideal for disco/group use should evidence of short circuit not be immediately apparent).
The Heavy Duty range can claim additional output power devices and complementary protection circuitry with performance specs. as for standard types.

MOSFET Ultra-Fi, with heatsinks / Without heatsinks

MODEL NUMBER	OUTPUT POWER Watts rms	T.H.D.	I.M.D.	SUPPLY VOLTAGE	SIZE mm	WT gms	PRICE	VAT	MODEL NUMBER	SIZE in mm	WT gms	PRICE	VAT
MOS120	60w/4-8Ω	<0.005%	<0.006%	±45±50	120x78x40	420	£25.88	£3.88	MOS120P	120x26x40	215	£23.32	£3.50
MOS200	120w/4-8Ω	<0.005%	<0.006%	±55±60	120x78x80	850	£33.46	£5.02	MOS200P	120x26x80	420	£28.53	£4.28
MOS400	240w/4Ω	<0.005%	<0.006%	±55±60	120x78x100	1025	£45.39	£6.81	MOS400P	120x26x100	525	£38.91	£5.84

Protection: Able to cope with complex loads, without the need for very special protection circuitry (fuses will suffice).
Ultra-fi specifications:
Slew rate: 20V/μs *Rise time:* 3μs *S/N ratio:* 100db *Frequency response (−3dB):* 15Hz – 100kHz
Input sensitivity: 500mV rms *Input impedance:* 100kΩ *Damping factor:* (8Ω/100Hz)>400

PSU

POWER SUPPLY UNITS

MODEL NO.	FOR USE WITH	PRICE	VAT
PSU30	± 15V combinations of HY6/66 series to a maximum of 100mA or *one* HY67. The following will also drive the HY6/66 series except HY67 which requires the PSU30.	£4.50	£0.68
PSU36	1 or 2 HY30	£8.10	£1.22
PSU50	1 or 2 HY60	£10.94	£1.64
PSU60	1 x HY120/HY120P/HD120/HD120P	£13.04	£1.96
PSU65	1 x MOS120/1 x MOS120P	£13.32	£2.00
PSU70	1 or 2 HY120/HY120P/HD120/HD120P	£15.92	£2.39
PSU75	1 or 2 MOS120/MOS120P	£16.20	£2.43
PSU90	1 x HY200/HY200P/HD200/HD200P	£16.20	£2.43
PSU95	1 x MOS200/MOS200P	£16.32	£2.45
PSU180	2 x HY200/HY200P/HD200/HD200P or 1 x HY400/1 x HY400P/HD400/HD400P	£21.34	£3.20
PSU185	1 or 2 MOS200/MOS200P/1 x MOS400/ 1 x MOS400P	£21.46	£3.22

All models except PSU30 and PSU36 incorporate our own toroidal transformers.

FP480
BRIDGING UNIT FOR DOUBLING POWER

Designed specially by I.L.P. for use with any two power amplifiers of the same type to double the power output obtained and will function with any I.L.P. power supply. In totally sealed case, size 45 x 50 x 20mm, with edge connector. It thus becomes possible to obtain 480 watts rms (single channel) into 8Ω. Contributory distortion less than 0.005%.
Price: £4.79 + 72p. V.A.T.

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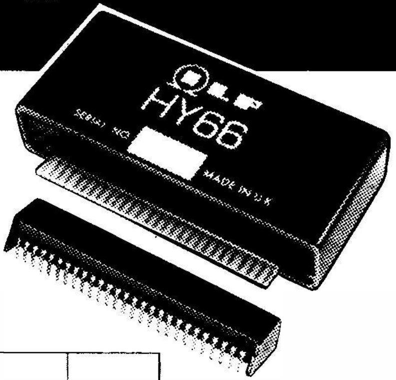

Which modules?

In launching eighteen different units all within amazingly compact cases to help make complete audio systems using I.L.P. power amplifiers, we bring the most exciting, the most versatile modular assembly scheme ever for constructors of all ages and experience. Study the list – see how these modules will combine to almost any audio project you fancy – and remember *all I.L.P. modules are compatible with each other*, they connect easily. Modules HY6 to HY13 measure 45 x 20 x 40mm. HY66 to HY77 measure 90 x 20 x 40mm. They are so reliable that all I.L.P. modules carry a 5 year no quibble guarantee.

MODEL NO.	MODULE	DESCRIPTION/FACILITIES	CURRENT REQUIRED	PRICE	VAT
HY6	MONO PRE AMP	Mic/Mag. Cartridge/Tuner/Tape/ Aux + Volume/Bass/Treble	10mA	**£6.44**	£0.97
HY7	MONO MIXER	To mix eight signals into one	10mA	**£5.15**	£0.77
HY8	STEREO MIXER	Two channels, each mixing five signals into one	10mA	**£6.25**	£0.94
HY9	STEREO PRE AMP	Two channels mag. Cartridge/ Mic + Volume	10mA	**£6.70**	£1.01
HY11	MONO MIXER	To mix five signals into one + Bass/Treble controls	10mA	**£7.05**	£1.06
HY12	MONO PRE AMP	To mix four signals into one + Bass/Mid-range/Treble	10mA	**£6.70**	£1.01
HY13	MONO VU METER	Programmable gain/LED overload driver	10mA	**£5.95**	£0.89
HY66	STEREO PRE AMP	Mic/Mag. Cartridge/Tape/Tuner/Aux + Volume/Bass/Treble/Balance	20mA	**£12.19**	£1.83
HY67	STEREO HEADPHONE	Will drive headphones in the range of 4Ω – 2KΩ	80mA	**£12.35**	£1.85
HY68	STEREO MIXER	Two channels, each mixing ten signals into one	20mA	**£7.95**	£1.19
HY69	MONO PRE AMP	Two input channels of mag. Cartridge/ Mic + Mixing/Volume/Treble/Bass	20mA	**£10.45**	£1.57
HY71	DUAL STEREO PRE AMP	Four channels of mag. Cartridge/Mic + Volume	20mA	**£10.75**	£1.61
HY72	VOICE OPERATED STEREO FADER	Depth/Delay	20mA	**£13.10**	£1.97
HY73	GUITAR PRE AMP	Two Guitar (Bass/Lead) and Mic + separate Volume/Bass/Treble + Mix	20mA	**£12.25**	£1.84
†HY74	STEREO MIXER	Two channels, each mixing five signals into one + Treble/Bass	20mA	**£11.45**	£1.72
†HY75	STEREO PRE AMP	Two channels, each mixing four signals into one + Bass/Mid-range/Treble	20mA	**£10.75**	£1.61
†HY76	STEREO SWITCH MATRIX	Two channels, each switching one of four signals into one	20mA	*To be announced*	
†HY77	STEREO VU METER DRIVER	Programmable gain/LED overload driver	20mA	**£9.25**	£1.39

†Ready September – may be ordered now

All the above modules operate from ±15V minimum to ±30V maximum higher voltages being accommodated by use of dropper resistors HY67 can only be used with the PSU 30 power supply unit

The modules are encapsulated and include latest design high quality clip-on edge connectors.

For easy mounting we recommend
B6 Mounting board for modules HY6 – HY13
78p + 12p. V.A.T.
B66 Mounting board for HY66 – HY77
99p + 13p. V.A.T.

All I.L.P. modules include full connection data.

I.L.P. Products are of British Design and Manufacture.

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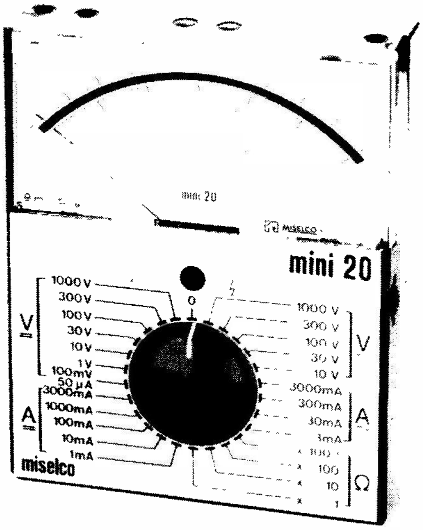

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a.c.I: 3mA, 30mA, 300mA, 3A.
Ohms: 0-1kΩ, 10kΩ, 100kΩ, 1MΩ.
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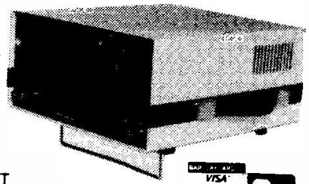

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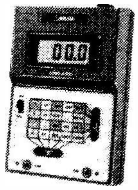

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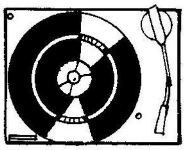

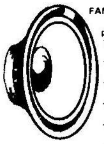

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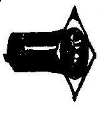

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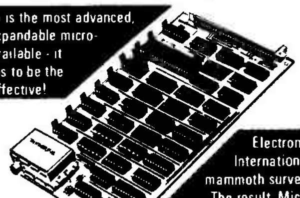

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High quality, plated thru hole printed circuit board, solder resist and silk screened component identification 6502 microprocessor 1K monitor TANBUG. Now with 'V' Bug. 1K RAM for user programme, stack and display memory. VDU alphanumeric display of 16 rows by 32 characters MICROTAN 65 system file binder 136 page, bound, users hardware/software manual with constructional details and sample programmes Logic and discrete components to fully expand MICROTAN 65

The MICROTAN 65 kit has won widespread acclaim for its superb presentation. We pay attention to detail!

KIT FORM £69.00 + £10 35 V.A.T., total £79.35

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Two integrated circuits which connect into locations on MICROTAN allowing 128 displayable characters
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Used to connect Microtan to Tanex
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Five integrated circuits which connect into locations on MICROTAN allowing the display of chunky graphics (64 x 64 pixels) What are chunky graphics? Well, imagine a piece of graph paper with 64 squares vertically and 64 squares horizontally, a total of 4096 Each square can be made black on white
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40K RAM CARD with 16K DYNAMIC RAM £76 +VAT
CONTENTS: High quality plated thru hole printed circuit board, solder resist and silk screened component identification Full complement of I C sockets for maximum expansion 64 way D I N edge connector. 1K RAM (2114). Data bus buffering TANRAM users manual.

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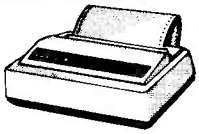

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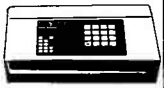

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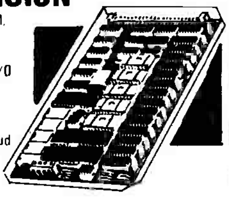

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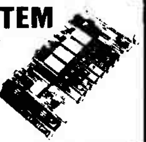

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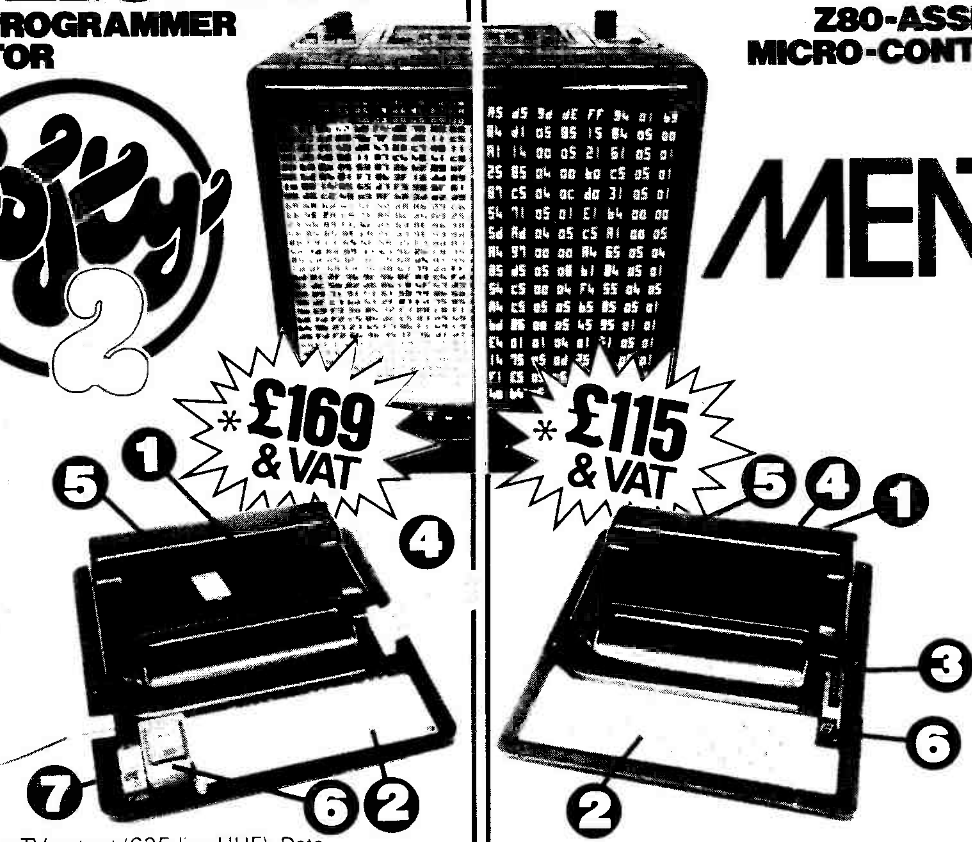

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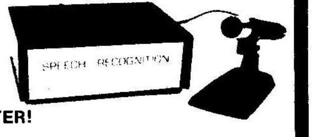

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PE RANGER

27FM CB PORTABLE

CB27/81

BRITISH MADE FOR U.K. MARKET

(Project described in Practical Electronics, Sept issue onwards)

THE RANGER CB rig has been designed to fit the new legal Home Office specification, and starts off as a hand held unit complete with aerial, mic., and rechargeable batteries.

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(+2.50 PP+VAT)

£97/matched pair
(+£5.00 PP+VAT)

This offer price includes rechargeable batteries, mic., aerial, mains lead and 2 channels.
Extra channels £2.25 each + 50p P.P. + VAT
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(Postage free with kit)
Tuneable Whip aerial magnetic or permanent car mount (state which)
£13.95 each + £1.00 P.P + VAT.

SPEC.
R.F. Power Output ½-1 Watt
AF (internal speaker) ½ Watt
Modulation: FM: freq. 27.6MHz-28MHz (CB Band) (excellent speech quality)
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Fully protected against bad aerial connection.

Coming soon...
BASE/MOBILE ADD-ON UNIT TO GIVE 4 WATTS AND 40 CHANNELS

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