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VOLUME 18 No. 2 FEBRUARY 1982

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(for details of contents see page 31)

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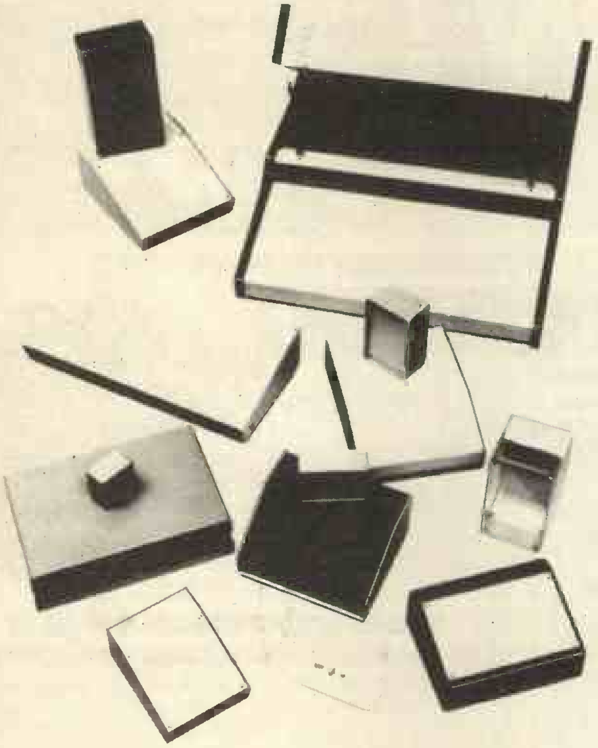

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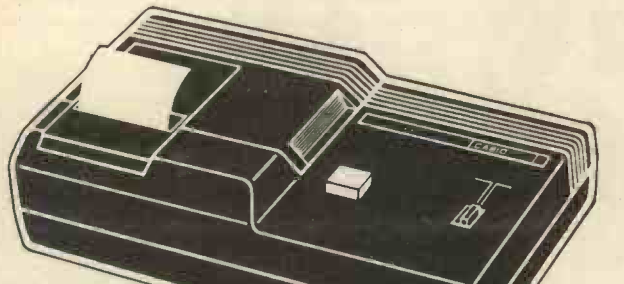
NEW CASIO FP-10 MINI PRINTER



AN INCREDIBLE

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Compatible with the FX-501P, FX-502P, FX-601P, FX-602P and FX-702P. This 5×7 dot matrix electric discharge mini printer stores up to 30 characters and prints up to 20 per line, at the fast speed of 2 lines per second. Four AA size batteries will print from 6,000-9,600 lines approximately, depending on type. The rechargeable pack, NP-4M (price £6.90) will print approximately 13,000 lines. The AC adaptor, AD-4150 (price £5.00) will also recharge the NP-4M in situ. Dimensions: 43.5H × 157.5W × 82.5D (1¾" × 6¼" × 3¼") Weight 372g (13.1 oz).

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To the busy professional, time spent writing computer programs is time wasted. Ordinary programmable calculators are hard to program and suffer from limited memories. Desk-top computers are expensive, seldom feature accurate math functions, and are still hard to program.

Now there is a revolutionary solution, the product of more than 2,000 hours development by **MiCROL**, one of Britain's most progressive Computer Companies. Its name is **PROCOS.**

Used with Casio's advanced FX-702P computer/calculator, PROCOS will enable you to create powerful, reliable programs in just minutes – even if you have never programmed a computer before.

PROCOS uses the FX-702P to create the electronic equivalent of pen and paper, giving you simple, one-touch commands to write information wherever you wish, and to move from one electronic page to another.

Using PROCOS, computer programs that meet your exact needs can be created in as little as 10%-20% of the time taken by conventional programming, saving you many hours of valuable time.

And PROCOS is powerful. With full 10-digit accuracy and 55 math and advanced statistics functions, your programs can use as many as 80 variables (data memories).

PROCOS is versatile too. Supplied in two versions, PROCOS A is ideal for complex, multi-variable calculations, while PROCOS B provides many of the features of 'Visicalc-type' modelling systems, helping you answer 'what if' questions and analyse trends.

PROCOS A & B are supplied together on a ready-to-run cassette, with a comprehensive User Manual. **Available exclusively from TEMPUS, price £24.95** (but see below for special system prices).

World's Most Powerful BASIC Pocket Computer

FX-702P

RRP £134.95

ONLY £119.95

Plus **FREE** MiCROL Professional Programming Pack* (RRP £9.95).

Flattens the Sharp PC1211

Alpha/numeric dot matrix scrolling LCD. Variable input from 1680 steps, 26 memories, to 80 steps, 226 memories, all retained when switched off. Up to 10 programs. Subroutines; 10 levels. FOR:NEXT looping; 8 levels. Debugging and Editing. 55 built-in functions, including Regression and Correlation, all usable in programs. Program/Data storage on cassette via optional FA-2 adaptor (£19.95). Auto Power Off. 17×165×82mm. 176g.

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CASIO FX-602P 512 step Programmable with **FREE MiCROL PPP*** (£9.95) **£74.95**

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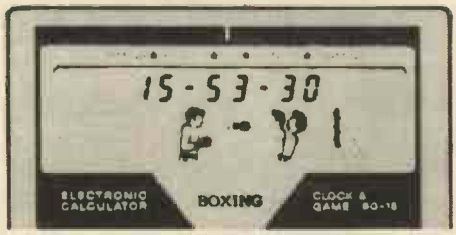
BG-15 Calculating Alarm Clock **ONLY £16.95**

Display.



Fight up to 100 challengers of 10 different weights and increasing speed and technique. All the realism of the ring with eight 30-second rounds per bout, with points scoring. You must win every bout on points or by KO to continue the game – scores are incremental. Raise or lower your guard in defence and attack, sway back to avoid a blow, or forward for maximum power. Throw stamina sapping combination punches (with digital display of stamina rating), high scoring counterpunches, knock-down and knock-out blows and lucky punches. You can even be saved by the bell! Digital display of hours, minutes and seconds. 24 hour alarm function. 8 digit calculator with full memory, % and sign change. Two silver oxide batteries last approximately 18 months. 7.3 × 68.5 × 113.7mm (5/16 × 2¾ ×4½"). 66g (2.3 oz). With wallet.

NEW SPACE INTERCEPTOR WATCH

GM-10 Alarm Chronograph **(RRP £22.95) £19.95**

LCD readout of hours, minutes and seconds, with continuous display of Space Interceptor graphics. Automatic day, date and month calendar function. Daily alarm mode, with hourly time signal option. 1/100 second stopwatch measuring net, lap and 1st and 2nd place times to 1 hour.

Interceptor Game

The UFO beams, travelling from left to right, have to be intercepted by changing the altitude of your defences and firing along the beam. A number will light up in the zone of the hit and when 4 zones are lit up a high bonus game starts. Shoot down 16 UFOs without losing 3 missiles and the next, speeded up, round starts. Sound effects are incorporated.

One lithium battery lasts approx 15 months. Black resin case/strap. Metal bezel. Mineral glass face.

World's Most Versatile Alarm Chronograph Watch

AX-210

10 alternative displays; over 60 functions. LCD ANALOG display of time, plus: DIGITAL display of: Time (12 or 24 hour); Calendar; Full month calendar (this month and next month); Dual time (12 or 24 hour); Alarm time; Countdown alarm timer with memory function; Professional 1/100 second stopwatch with laps, etc. Hourly time signal. Alarm – electronic buzzer or 3 selectable melodies. Rapid forward/backward setting. 9.4×35.4×36mm.

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Sets the pace for 1982

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Input data: Length of stride. Pacer signals, from 394 pips per minute to 63 pips per minute.

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Sinclair ZX81 Personal Comp[uter] 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 alphanumerics *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, Camberley, Surrey, GU15 3BR. **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	
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*Quantities approximate, count by weight.

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SX21	60	Mixed C280 type capacitors metal foil	£1
SX22	100	Electrolytics, all sorts	£1
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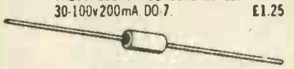

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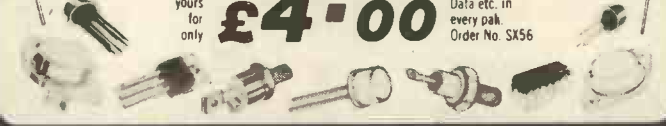

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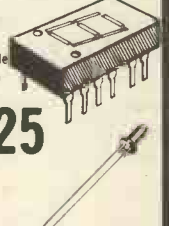

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Other types: LM340K — 5 volt — 18 volt — 24 volt. T03 — 40p. UA723 — 14 pin DIL — 40p.

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All at 50p per pack.

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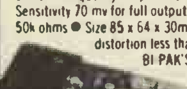

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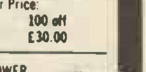

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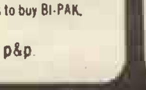

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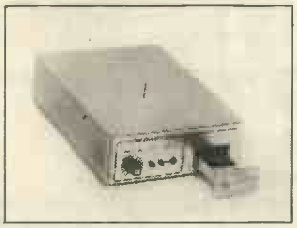

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HEATSINK Heatsink for T03 Regulators which mounts inside rear of enclose.
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£99.95 excluding carriage (£15.00) & V.A.T. (15%)

Device	Price
MEMORIES	
2114L-200ns	1+0.93
	25+0.89
2114L-300ns	1.55
(FOR ACORN ATOM)	
2708 450ns	1+1.75
	25+1.68
2716 450ns	1+2.49
(single +5V)	25+2.25
2716 350ns	6.95
2532 450ns	1+4.50
	25+4.25
2732 450ns	1+3.99
	25+3.80
2732 350ns	7.50
4116 200ns	1+0.74
	25+0.70
	100+0.67
4116 150ns	1+0.93
	25+0.89
4118 200ns	1+3.90
	25+3.45
4118 150ns	6.00
5516 200ns	12.50
6116 200ns	7.95
6116LP 200ns	9.50
6116LP 150ns	9.95
CRT CONTROLLERS	
EF6845P	9.50
EF9364P	5.94
EF9365P	62.90
EF9366P	62.90
EF9365/6 DATA AND APPLICATIONS	2.00
BUFFERS	
81LS95	0.90
81LS96	0.90
81LS97	0.90
81LS98	0.90
8T26A	1.20
8T28A	1.40
8T95	1.35
8T97A	1.35
8T98	1.45
DATA CONVERTERS	
ZN425E-8	3.45
ZN426E-8	3.00
ZN427E-8	5.99
ZN428E-8	4.75
ZN429E-8	2.10
ZN432CJ-10	28.09
ZN433CJ-10	2.59
ZN440	56.63
ZN432E-10	14.75
ZN447	9.14
ZN448	6.85
ZN449	3.20
NEW FLOPPY DISC CONTROLLERS	
FD1771	17.12
FD1791	32.61
FD1793	32.61
FD1795	35.33
W01391	45.50
WD1393	45.50
WD1395	45.50
WD1397	45.50
WD2143-01	5.45
WD1691	10.87
MISCELLANEOUS SUPPORT CHIPS	
AY-3-1015	3.25
AY-3-1270	7.95
AY-3-8910	6.95
AY-5-1013	3.45
AY-5-3600	7.95
AY-5-2376	6.95
DP8304	4.50
MC1488	0.59
MC1489	0.59
MC3446	2.95
MC3448A	4.25
MC3480	7.95
MC3487	2.95
MC14411	8.94
MC14412	7.99
RO-3-2513L	7.25
RO-3-2513U	5.99
ULN2803A(L203)	0.84
DVM CHIPS	
ZN450e	7.61
ZN450E DVM KIT	25.00
NEW LINEARS	
LM301AN	0.25
LM308N	0.89
LM311N	0.69
LM319N	2.20
LM324N	0.30
LM348N	0.59

Device	Price
LM555CN	0.16
LM556CN	0.49
LM725CN	3.20
LM741CN	0.14
LM747CN	0.70
LM748CN	0.34
REGULATORS	
7805	0.39
7812	0.39
7815	0.39
78L05	0.29
78L12	0.29
78L15	0.29
7905	0.55
7912	0.55
7915	0.55
79L05	0.59
79L12	0.59
79L15	0.59
LM309K	1.30
LM317K	3.20
LM323K	4.95
LM338K	4.75
Z80 FAMILY	
Z80 CPU	3.49
Z80A CPU	3.99
Z80 CTC	2.99
Z80A CTC	3.49
Z80 DART	10.00
Z80A DART	12.00
Z80 DMA	9.95
Z80A DMA	11.95
Z80 PIO	3.49
Z80A PIO	3.75
Z80 SIO-0	10.99
Z80A SIO-0	11.99
Z80 SIO-1	10.99
Z80A SIO-1	11.99
Z80 SIO-2	10.99
Z80A SIO-2	11.99
MK 3886	11.00
MK 3886-4	14.47
6800 FAMILY	
6800	2.99
6802	3.99
6803C	11.80
6809	9.99
6810	1.25
6821	1.25
6840	4.20
6850	1.50
6862	6.91
6871AIT	18.70
6880	1.07
6887	0.80
68488	9.11
6875	4.18
6843	13.99
68B00	4.70
68B02	19.11
68B21	2.29
68B10	2.00
68B40	4.70
68B50	2.15
68000C4	110.00
6500 FAMILY	
6502	4.25
6520	2.99
6522	4.75
6532	6.95
8080 FAMILY	
8085A	5.50
8212	1.70
8216	0.99
8224	1.95
8228	3.95
8251	3.80
8253	7.95
8255	3.80

Device	Price
CMOS 4000 'B' SERIES	
4000	0.11
4001	0.11
4002	0.13
4006	0.60
4007	0.15
4008	0.55
4009	0.28
4010	0.35
4011	0.12
4012	0.15
4013	0.29
4014	0.58
4015	0.58
4016	0.25
4017	0.45
4018	0.58
4019	0.29
4020	0.58
4021	0.60
4022	0.62
4023	0.17
4024	0.35
4025	0.16
4026	0.99
4027	0.30
4028	0.55
4031	1.65
4033	1.60
4034	1.55
4035	0.72
4040	0.54
4041	0.69
4042	0.54
4043	0.59
4044	0.64
4045	1.65
4046	0.68
4047	0.68
4048	0.54
4049	0.26
4050	0.26
4051	0.59
4052	0.68
4053	0.59
4054	1.20
4055	1.20
4060	0.79
4063	0.95
4066	0.34
4068	0.17
4069	0.17
4070	0.17
4071	0.17
4072	0.17
4073	0.19
4075	0.17
4076	0.62
4077	0.22
4078	0.24
4081	0.14
4082	0.19
4085	0.63
4086	0.69
4093	0.39
4502	0.69
4507	0.39
4508	1.90
4510	0.60
4511	0.49
4512	0.60
4514	1.49
4515	1.49
4516	0.69
4518	0.40
4519	0.28
4520	0.69
4521	1.49
4522	1.20
4526	0.70
4527	0.89
4528	0.70
4532	0.85
4541	0.99

Device	Price
4543	0.99
4553	2.90
4555	0.39
4556	0.44
4585	0.62
74LS SERIES	
74LS00	0.10
74LS01	0.11
74LS02	0.12
74LS03	0.12
74LS04	0.12
74LS05	0.13
74LS08	0.12
74LS09	0.12
74LS10	0.12
74LS11	0.12
74LS12	0.12
74LS13	0.22
74LS14	0.39
74LS15	0.12
74LS20	0.12
74LS21	0.12
74LS22	0.12
74LS26	0.15
74LS27	0.12
74LS28	0.15
74LS30	0.12
74LS32	0.12
74LS33	0.16
74LS37	0.15
74LS38	0.15
74LS40	0.12
74LS42	0.34
74LS47	0.39
74LS48	0.60
74LS49	0.59
74LS51	0.14
74LS54	0.15
74LS55	0.15
74LS73	0.19
74LS74	0.16
74LS75	0.24
74LS76	0.20
74LS78	0.19
74LS83	0.44
74LS85	0.85
74LS86	0.15
74LS90	0.30
74LS91	0.75
74LS92	0.34
74LS93	0.34
74LS95	0.43
74LS109	0.21
74LS112	0.21
74LS113	0.23
74LS114	0.19
74LS122	0.39
74LS123	0.99
74LS124	0.99
74LS125	0.25
74LS126	0.25
74LS132	0.34
74LS136	0.28
74LS138	0.34
74LS139	0.35
74LS145	0.75
74LS148	0.90
74LS151	0.39
74LS153	0.29
74LS155	0.39
74LS156	0.38
74LS157	0.31
74LS158	0.31
74LS160	0.39
74LS161	0.39
74LS162	0.39
74LS163	0.39
74LS164	0.47
74LS165	0.99
74LS166	0.84
74LS173	0.70
74LS174	0.47
74LS175	0.49
74LS181	1.28

Device	Price
74LS190	0.49
74LS191	0.49
74LS192	0.49
74LS193	0.46
74LS194	0.39
74LS195	0.39
74LS196	0.59
74LS197	0.65
74LS221	0.54
74LS240	0.89
74LS241	0.89
74LS242	0.79
74LS243	0.79
74LS244	0.65
74LS245	0.89
74LS247	0.63
74LS248	0.63
74LS249	0.63
74LS251	0.40
74LS253	0.39
74LS257	0.44
74LS258	0.39
74LS259	0.79
74LS261	1.95
74LS266	0.23
74LS273	0.75
74LS279	0.39
74LS283	0.44
74LS290	0.54
74LS293	0.45
74LS365	0.34
74LS366	0.36
74LS367	0.34
74LS368	0.49
74LS373	0.74
74LS374	0.74
74LS375	0.47
74LS377	0.89
74LS378	0.69
74LS379	0.64
74LS386	0.28
74LS390	0.54
74LS393	0.59
DIL SOCKETS LOW PROFILE - TIN	
8 pin	0.07
14 pin	0.09
16 pin	0.09
18 pin	0.13
20 pin	0.14
22 pin	0.17
24 pin	0.19
28 pin	0.25
40 pin	0.29
NEW LOW PROFILE - GOLD	
8 pin	0.22
14 pin	0.29
16 pin	0.31
18 pin	0.33
20 pin	0.35
22 pin	0.40
24 pin	0.42
28 pin	0.54
40 pin	0.81
NEW ZERO - INSERTION FORCE DIL	
24 pin	6.30
28 pin	7.40
40 pin	8.80
CRYSTALS	
1 MHz	3.00
1.008 MHz	3.45
1.8432 MHz	2.50
3.6864 MHz	2.95
4 MHz	1.65
6 MHz	1.80
8 MHz	1.95
14 MHz	3.45
NEW UHF MODULATORS	
6 MHz	3.70
8 MHz	4.40
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PE VOLUME 18 No. 2 FEBRUARY 1982

SAVE IT

One of the areas where application of electronics by hobbyists can be particularly rewarding is that of energy conservation. At one time—not so long ago—the popular press took up the solar heating theme and many homes were fitted with panels, pumps and control electronics. This fad seems to have died to some extent pending improved efficiency in the systems and a shorter payback time.

The more recent theme tends to be towards making the most efficient use of energy. With this in mind, and also with the knowledge that constructing your own electronic devices to assist efficient use is very rewarding and often financially advantageous, PE has developed and published many projects. Just recently our Car Computer is an exceptional illustration of how electronics can help save fuel and we believe our design is unique in so far as it can check the vehicle's performance as well as the fuel used. This month we publish an update of the renowned *PE Scorpio* ignition system which also makes for more efficient use of fuel in a vehicle.

ELECTRICITY

Having covered the motoring area fairly well, next month we turn our attention to the use of electricity. With ever increasing prices it is worth knowing just how much each of your appliances costs to run. The *Telectric* unit will give a direct readout of the cost of intermittent or long term electricity supplied to individual appliances.

Telectric has a digital readout that shows cost per unit (programmable up to 9·999p), elapsed time and cost of electricity used up to £99.9. It can thus show instantly the cost of heating water, tumble drying clothes, etc. This makes cost comparisons a simple matter e.g. is it cheaper to leave an immersion heater on all day or switch it on and off as required?, how much can be saved by boiling only the required amount of water in a kettle?, is a toaster more efficient than a grill for large quantities?, what is the cost of intermittent electric heating, of running a freezer and what is the increased cost when the fridge or freezer frosts up? etc.

FIRST

Just seeing the pounds and pence tot up as you use an appliance can lead to more efficient use as one is made instantly aware of the cost. The *Telectric* is a new application for the microprocessor and we believe a first in the UK. Once again we are pleased to be able to bring you another new development of technology, regular readers will be getting used to this by now, newcomers might too if they keep reading PE, we don't intend to let up!

The only problem we have at the moment is getting everything in each issue, this has meant that *Ingenuity Unlimited* has had to be dropped from some issues to make room for other things, but don't worry we are planning bigger issues and there should be room for everything again soon. So if one of your ideas has been accepted for I.U. don't give up on it.

Mike Kenward

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

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...NEWS &

Edited by David Shortland & Jasper Scott

Japan-in the lead once again...

Once again, the Japanese appear to be ahead of Western Industry, this time in the field of Microelectronics.

Two Japanese companies, NEC and Oki, are producing 256K memory chips, And in about 6 months time, another two Japanese companies are expected to have joined them.

Both RAMs and ROMs are being produced, and while few details of price and availability have been released, NEC have hinted that the chips should sell at between £30 and £40.

The other two companies who expect to be delivering 256K chips by mid-1982 are Hitachi and Toshiba. A fifth Japanese company, Fujitsu, is believed to be producing a 256K chip, but so far, they have released no details. How long it will take the electronics 'giants' in the West to catch up remains to be seen.

STRONG SPARKS

Pictured above is the latest addition to Sparkrite's well known range of electronic ignitions, the TX2002. The TX2002 is a contactless reactive discharge system which, according to Sparkrite, combines the advantages of both Inductive and Capacitive Discharge circuitry, resulting in the most thorough combustion of even weak mixtures.

Sparkrite's range of car accessories also includes a Drive Computer, and a Programmable Car Security System, the AT-80. As well as arming doors, boot and bonnet, the AT-80 protects against theft of in-car entertainment equipment and auxiliary lamps.

The TX2002 is available in kit form at £29.95 or ready built at £62.95. The AT-80 is priced at £24.95 in kit form, or £49.75 ready built. All prices include VAT, postage and packing. EDA Sparkrite Ltd., 82 Bath Street, Walsall, West Midlands WS1 3DE (0922 614791).

STEREO... IN MODULES

Four new stereo modules have recently been added to ILP Electronics' range of audio modules, bringing the total number available to almost fifty.

The four new modules introduced are the HY74 stereo mixer, the HY75 stereo pre-amp (with built-in two-into-one mixer), the HY76 stereo switch matrix, and the HY77 stereo VU meter drive—a programmable gain/l.e.d. overload driver.

ILP say that by using their range of audio modules, it is possible to assemble a complete hi-fi amplifier system rivalling commercial units costing up to £300 for as little as £60 (excluding cabinet). Nearly all the units in the range are cross-compatible.

Further details of all ILP modules are available from ILP Electronics Ltd., Freepost 2, Graham Bell House, Roper Close, Canterbury, Kent CT2 7EP (0227 54778).

Briefly...

Readers who own Ferrograph equipment will be pleased to hear that a spares and service company has been set up following the closure of NEAL Ferrograph. "Ferrograph Spares and Service" has been formed to manufacture and supply spare parts for all Ferrograph products including Series 6, Series 7, SP7, Logic 7 and Studio 8 tape recorders, Ferrograph Hifi equipment, Ferrograph Test Sets and Ferrograph Echo Sounders. In addition a fully staffed Service Department can service or refurbish all Ferrograph products.

For further information contact Tom Batey, Ferrograph Spares and Service, Unit 21, Royal Industrial Estate, Jarrow, Tyne & Wear (0632 893092).

• • •

D.S.N. Marketing Ltd., a subsidiary company of Vitavox (Holdings) Ltd., was formed recently with the aim of promoting, selling and servicing all Vitavox products. It will also be offering other products, both of U.K. and foreign origin.

The first new product lines to be handled are the "Bullet" range of loudspeaker components, and D&R mixing consoles and ancillary multitrack equipment. For further details contact D.S.N. Marketing Ltd, Westmorland Road, London NW9 9RJ. (01-204 7246).

TUNER MODULE

A recent addition to the BI-PAK range of audio modules is the S.453 FM stereo tuner. The unit features push button vari-cap tuning and a phase locked loop decoder for stereo or mono reception. It is fitted with a four-position switch for the selection of four pre-tuned frequencies. The selected frequencies are tuned by multi turn potentiometers.

The specified operating supply voltage is 18-25V. and the module has a tuning range from 88-108 MHz. Provision exists for the addition of an l.e.d. stereo indicator, a centre zero tuning meter and a mono/stereo switch.

The S.453 is priced at £19·00 + £2·85 VAT and 50p p&p. It is available from BI-PAK Semiconductors, P.O. Box 6, Ware, Herts. SG12 9AG.

MARKET PLACE

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

HOLD TIGHT

Two new Circuit Board Holders have recently been introduced by Carlton Nichol. Both are constructed in aluminium and plated steel and allow easy rotation of printed circuit boards through 360 degrees with positive locking at any angle.

The CNC 6 will take boards up to 10" × 7" and these are easily inserted in the spring loaded clips. The CNC 9 will take boards up to 8" × 8" and they are held in position by sliding vee clamps. These clamps eliminate the risk of damage to the face surfaces of the board and allow a high degree of accessibility.

An anti-static foam pad is also available as an optional extra to allow the insertion of a number of components before rotating the p.c.b. for soldering. The pad, which is on a backing plate, clips onto the rotating arms of the p.c.b. holder.

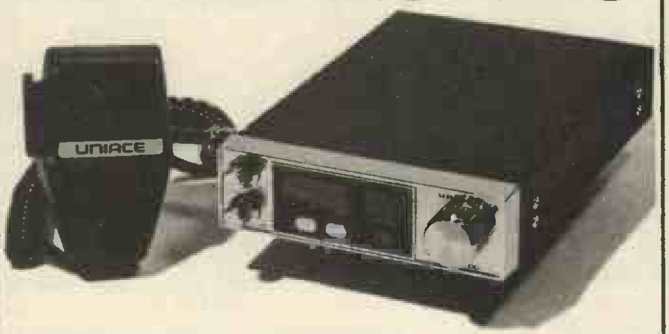
The list prices, including VAT, of these products are CNC 6—£13·80; CNC 9—£15·95; Anti-static Foam Pad—£9·20; and they are available direct from Carlton Nichol & Co. Ltd., Goldkey Industrial Estate, Kelvedon, Essex.

WHATEVER NEXT?

If you're fed up with hearing about the latest developments in hi-fi, and can't afford a £600 system anyway, read on. Perhaps the Record Runner (the latest in portable audio), is the thing for you.

As you can see from the photo, the Record Runner is a model VW van which drives round a record and plays it. It has a stylus mounted underneath, and a speaker mounted in the roof. While its sound reproduction is rumoured not to be the best in hi-fi, the Record Runner is certainly an ingenious idea, and stands a good chance of winning the prize for the biggest gimmick since CB radio. If you want to buy one, the paltry sum of £14·50 + £1 p&p will secure your order. Please send a self addressed label with your order to The Video Palace, 62/64 Kensington High Street, London W8.

ANOTHER LEGAL RIG



Details of the Uniden Uniace 100 FM mobile CB rig arrived in our offices too late to be included in our rig guide last month. The Uniace 100 features the basic channel, volume and squelch controls, plus PA/CB and 4W/0·4W power switches. Being only 40mm high, it is not as cumbersome as rigs with more features (including its big brother, the Uniace 200), which is worth bearing in mind if you own a small car.

Complete with mic., fixing brackets and connecting leads, the Uniace 100 is available at an inclusive price of £88·95 from RT-VC, 21b High Street, Acton, London W3 6NG.

Countdown...

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

IDEA (Domestic Appliances) Jan. 12–14. Birmingham. **B6**
OEM Assemblies Feb. 2–4. Roy. Hort. Halls, London. **T**
BEX Bristol Feb. 3–4. **K**
BEX Bournemouth Feb. 17–18. **K**
Microsystems Feb. 24–26. West Centre Hotel, London. **Z1**
Seminex Mar. 29–Apr. 2. Imperial College, London. **H1**
Laboratory Edinburgh Mar. 30–31. Ass. Rooms, Edinburgh. **E**
CAD Mar. 30–Apr. 1. Metropole, Brighton. **Z1**
Sensors & Systems Mar. 30–Apr. 1. The Forum, Wythenshawe, Manchester. **T**
ETM Mar. 30–Apr. 1. The Forum, Wythenshawe. **T**
Peripherals Mar. 31–Apr. 2. West Centre Hotel, London. **Z1**
Laboratory Manchester Apr. 7–8. New Century Hall, Manchester. **E**

B6 Andry Montgomery Ltd. ✆ 01-486 1951
E Evan Steadman, Saffron Walden ✆ 0799 22612
H1 Seminex Ltd., Tunbridge Wells ✆ 0892 39664
K Douglas Temple, Bournemouth ✆ 0202 20533
L1 World Trade Centre ✆ 01-488 2400
T Trident, Tavistock ✆ 0822 4671
Z1 IPC Exhibitions, Sutton ✆ 01-643 8040

INDUSTRY NOTEBOOK

By Nexus

Cable Capture

Cable and Wireless captured the imagination of the investing public with their recent share flotation. As I have often pointed out in this column, C & W is one nationalised company that has performed consistently well over many years. The company anticipated that nothing but good would come from so-called 'privatisation' in which the government share would drop to 50 percent together with a promise not to intervene in commercial decisions. In other words C & W now has the extra capital it needed and the freedom to exploit it in the best possible way.

The 50p shares offered at 168p were oversubscribed five times by eager buyers and when share dealings opened the price soon shot up to 197p. The employees had a preferential call on 13·5 million shares at the offer price and those who invested will have done well.

Inevitably there was some criticism that in view of the response the government 'gave away' their share of the company too cheaply. But think of the outcry if the price was too high and the issue had flopped in the market place. Apart from a lot of red faces the credibility of the company would have been damaged.

It is interesting to note that while most companies update their image periodically, often by a change of name, C & W, despite a leading world position in the application of high technology in communications, still clings to 'wireless' rather than the modern term radio. This did not deter investors who apparently knew a good thing when they saw it. Anyway, Cable and Radio sounds less classy to me than Cable and Wireless.

Electronic Journals

The electronic journal is a prospect which worries conventional publishers, newsagents and paper manufacturers. But printed matter is still very much with us and is likely to remain so until the great bulk of homes and offices have video terminals. The half-way house is the data base and we can see how much of a hold conventional journals still have by looking at the Inspec data base service run by the IEE. In providing a comprehensive scientific and technical information service, Inspec information scientists are constantly scanning 2,500 journal titles plus hundreds of conference proceedings to supply subscribers with what they need to know.

The snag here is that all publishing involves a lead time for editing, printing and distribution. With technical and other learned journals the lead time is weeks, sometimes months before the ultimate reader gets his information.

The newest Inspec data base is EMIS (Electronic Materials Information Service) dealing with semiconductor technology. EMIS will not only file all published information but will include data awaiting publication. So EMIS subscribers will have very fast access to 'hot' information. When the use of video terminals (plus printers when hard copy is required) is universal, there will be no need for printing and publishing as we know it today and true electronic publishing will have arrived.

Coups

Marconi Avionics has brought off something of a coup by winning a contract for the design and development of air data computers for re-equipping 27 variants of 10 types of aircraft flying operationally with the United States Air Force and Navy. A total of 6,000 aircraft is involved and the contract was won in the face of fierce competition from leading U.S. suppliers.

The Marconi design proposed has 80 percent commonality of sub-assemblies across all types and variants of aircraft from transports to fighters, thus simplifying servicing, cutting spares holdings and altogether saving on life-cycle costs.

Perhaps less of a coup because they have been there before is Rediffusion's contract worth £7 million for a flight simulator ordered by All Nippon Airways. It will be used to train crews on the new Boeing 767 airliner. This latest order is the eighth secured from Japanese air carriers by Crawley-based Rediffusion Simulators who have a world-wide reputation in a still-growing field which has been hugely stimulated by successive hikes in fuel cost which make it completely uneconomical to train pilots flying in real aircraft, not to mention the cost of a real crash in comparison with a simulated one.

Newcomer to the Japanese market is Micro Focus, claimed to be the first British computer software house to break through in Japan. Their order book for that country is reported to have already topped £1 million. Too little of such go-getters reaches the national news media. There are plenty of success stories around which are overlooked.

IT 82

Information Technology Year got itself launched with plenty of jazz. We are promised that IT 82 will be hard to ignore. Even the Post Office will be issuing special postage stamps.

Kenneth Baker, Minister for IT, has emerged as one of the big spenders. The promotional campaign is said to be budgeted at £600,000 and current government spending on supporting IT projects will run to more than £1 million a week, not only in IT 82 alone but beyond.

One of the longer term projects announced in a one-third share in the European Space Agency's L-Sat large satellite which will have cost £230 million by the time it is launched in 1986. British prime contractor is British Aerospace with back-up from Marconi as a major sub-contractor. There will also be a spin-off for other British companies. Government commitment on L-Sat will be £77 million.

X-Stream

X-Stream is the new in-word in IT. British Telecom explains it with X being the international symbol in the telecommunications world for data transmission. Stream is the stream of digits containing the information.

Within X-Stream are the sub-systems of Megastream, Kilostream, Switchstream and Satstream, the latter eventually linking in to the ground network ESA's L-Sat mentioned above. Marconi Communications has already won orders for Kilostream equipment from British Telecom worth £5 million and a further £3 million contract is under negotiation.

For its part British Telecom has achieved advance orders worth £750,000 for rental of lines from the first companies to use the system when the first phase comes into operation in 1982.

The beauty of X-Stream is its universal application. Transmission can be over wire or optical fibre cable, terrestrial microwave link or via space satellites. Depending on bandwidth of the links they will take speech, music, vision, facsimile and graphics as well as high speed data.

Classic

Newest in the long list of electronic system acronyms is CLASSIC (Covert Local Area Sensor System for Intruder Classification). The genius who thought this one up is a Racal person and the equipment it describes is a cunning innovation to detect enemy intrusion over a wide area and as far distant as 7km from an observer who has a monitor unit with LED display.

The sensor units are fitted with a tiny radio which gives a short burst transmission on VHF when an intruder is detected by seismic, infra-red, pressure pad or trip-wire methods. Up to eight sensors can be used with each monitor and the observer is able to deduce the nature and extent of the threat. Apart from battlefield use it clearly has application against terrorist infiltration across borders (e.g. Ireland). The sensors can easily and quickly be redeployed as necessary.

Racal-SES Ltd funded the project as a private venture. The British Army has ordered it with an initial £750,000 contract and a number of negotiations are under way with overseas customers.

Miniature SCORPIO Car Ignition

MIKE REES

AN update of the original Scorpio appeared in March 1974 as a *PE* blueprint feature, at a time when energy savings were beginning to take on increased importance.

The author having installed a Mk2 Scorpio on his own car, enthusiastic relatives requested units for theirs. All went well until one of them asked for a unit to fit a BLMC Mini; the rather cumbersome 7¼in × 4½in × 2in diecast box could not be squeezed in under the bonnet.

The requirement for a more compact unit started a substantial redesign exercise, which began with the following objectives.

The unit had to be completely contained in a 4½in × 2½in × 1¼in diecast box. Inflation had left its mark; the soaring cost of components had to be off-set with cheaper (though not necessarily inferior) alternatives.

It was anticipated that to achieve the size reduction, some loss of performance was inevitable. However, the end product had to be a very acceptable compromise and noticeably better than conventional ignition.

CONSTRUCTION

To make final assembly as easy as possible, it was decided to build the entire unit into the lid of the box, with connecting wires leaving the bottom of the box via a tight-fitting grommet. Use of plastic power devices gave both compactness and a neat appearance, with the secondary base-plate not only hiding the counter-sunk screws by which p.c.b. and all other components are mounted, but also providing a cheap and effective way of installing the unit in the vehicle. Choice of unit polarity is semi-permanent with this design, as the earth return is made via the case to simplify external wiring. (This will be dealt with in greater detail later in the article.) Mounting the unit to the vehicle with pan-head No. 10 self-tapping screws provides excellent security and electrical connection.

The two greatest areas of compromise lie in the choice of transformer and discharge capacitor, both of which are large and costly items. The first stage in development was to reduce the size of the pot core successively, and see how the output spark was affected. After much experimentation, it was found that very good results could be obtained with a 30mm pot core.

Having selected the transformer, the discharge capacitor posed almost insuperable problems. All those with a 400V a.c. rating were far too large, and very expensive. By reducing the secondary turns on the transformer to 330 (12V), the rectified inverted output across R12 is reduced to about 350V. A 400V d.c. capacitor was thus felt to be adequate, and the Siemens B32231 1·0μ 400V was chosen as the most compact available. Having thus derated the original design, a prototype was soak-tested for over a week without switching off, driven by a small square wave generator at a constant 10,000r.p.m. At the end of this time it was rather warm, but still operating, and deemed sufficiently proven to fit to the Mini. A second unit was subsequently built for a colleague at work. This has functioned well, on his BLMC Princess, for over 100,000 miles.

Accessories mounted under the bonnet of a motor car encounter one of the most adverse environments possible, with extremes of temperature, humidity and vibration. This design is considered to be vastly superior to the Mk2 in all three respects. Throughout this article there is much stress on guarding against the effects of vibration, and the constructor is urged to take careful note.

As can be seen from the circuit the only additional components to the March 1974 design are the in-line fuse FS1, R13 (added in series with C5 to protect against transients), and D7 (which gives reverse polarity protection to the complete unit). The remaining differences are either in value or choice of component type.

In searching *PE*'s pages for prices, the original Ferranti and Siemens semiconductors were found to be expensive, and sometimes difficult to obtain. The use of Texas transistors and thyristor solved both these problems. The author built about twenty Mk2 units in all, for various friends and relatives. These were bought in kit form from suppliers advertising in the pages of *PE*. Whilst the components supplied were new and correct according to the design, trial produced some repetitive failures in TR1 and TR3, thus for the new design Texas "Silect" devices were chosen, with higher ratings than the ZTX500s.

Another valuable piece of experience gained from building and fitting more than just the odd one or two Mk2 redesigns was the observation of minimum operating voltage. Whilst the inverter would happily continue down to about 5V, sparks stopped at about 7V. For cars with new batteries, this presented no difficulty, but for those with less-than-perfect cells it meant that the car would only start after the ignition key was released from the position which activated the starter solenoid. To cure this problem — which may simply have been an unfortunate mix of production tolerances — three actions were taken. High gain transistors were selected, so that saturation could be guaranteed over a wider voltage range. The values of R1, R2, R3, R11 and C2 were adjusted, the latter two to help CSR1 fire at a lower voltage. C1 was correspondingly adjusted to maintain a similar time-constant as previously. These changes also facilitated use of the smaller glass diodes for D1 and D2, and allowed C3 to be reduced without adverse effect. Another size problem was

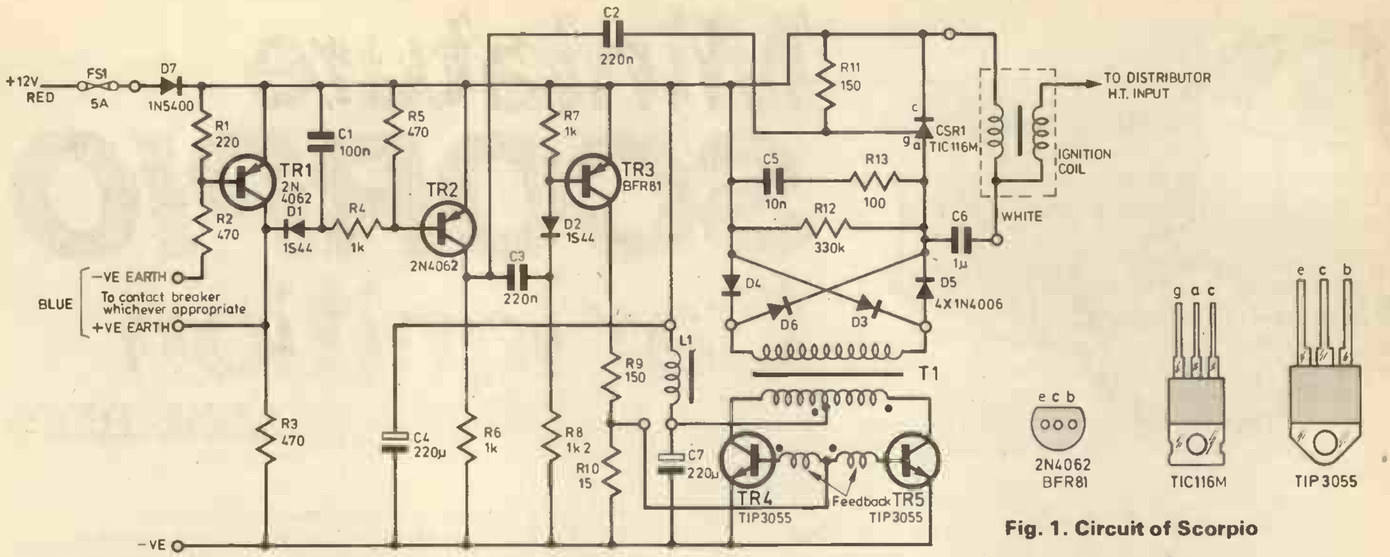


Fig. 1. Circuit of Scorpio

found in accommodating the specified 40V capacitors C4 and C7. Having noted that rarely in commercial car radios and cassette players do the supply smoothing electrolytics exceed 16V in rating, the Mullard 016/15221 was adopted. The final departure from the original Mk2 concerned the choke L1 used for interference suppression. To achieve compactness and more rigid mounting, a small pot core was chosen in place of the ferrite rod, with fewer turns now being required due to increased efficiency of the magnetic circuit.

PRINTED CIRCUIT

Fig. 2 shows the p.c.b. A word of caution first. Extreme care must be taken when mounting and soldering components, due to the small clearances involved in achieving the overall size. A miniature iron (25W maximum) with small bit is essential for quick effective joints without an excess of solder. It is recommended that only the listed components are used, as their heights and general dimensions have been specifically chosen to maintain adequate clearance both on the board itself and within the confines of the small diecast box. It should not be necessary to sleeve the leads of any components on the p.c.b. For ease of construction, mount the smallest items first, taking particular care with the diodes not to strain the leads.

Whilst the p.c.b. pins are a firm fit, it is essential that they are soldered on the copper side. When fitting C4 and C7, clearance has specifically been allowed on each positive lead; before soldering these leads, move the capacitors, as a pair, to give optimum clearances with the 6BA mounting-hole, choke pin, and fly lead from R13. The excellent Siemens B32560 100V capacitors save considerable space with but 7·5mm between pins (C1, C2, C3). The board has been designed so that a 10mm component may optionally be used for C3; should a constructor wish to retain a 0·47μ value here, Siemens make one in both spacings, the 10mm (being easier to manufacture) is a few pence cheaper. Note that the fly lead from R10 is used to connect the feedback winding centre-tap. To save space, R12 is mounted directly beneath C5, thus the resistor has to be fitted first.

Extreme care should be taken in fitting the inverter bridge diodes (D3, D4, D5, D6). Insert on the p.c.b. with alternating polarity, cathode uppermost for the one nearest the edge of the board. Gently twist the top leads of each pair, using long-nose pliers to prevent the body ends being strained. Trim the vertical tails flush with the top of C5; do not solder the twisted ends yet, but wait until the transformer secondary winding is wired later. These diodes seem particularly susceptible to damage by excess heat; with such short leads, joints should be made once only, and as quickly as possible.

Once C6 has been fitted to the board, a small amount of Evostik should be run between C5 and C6 to ensure rigidity.

TRANSFORMER

The general winding details do not differ from the original 1974 design, but to facilitate the use of a 30mm pot core,

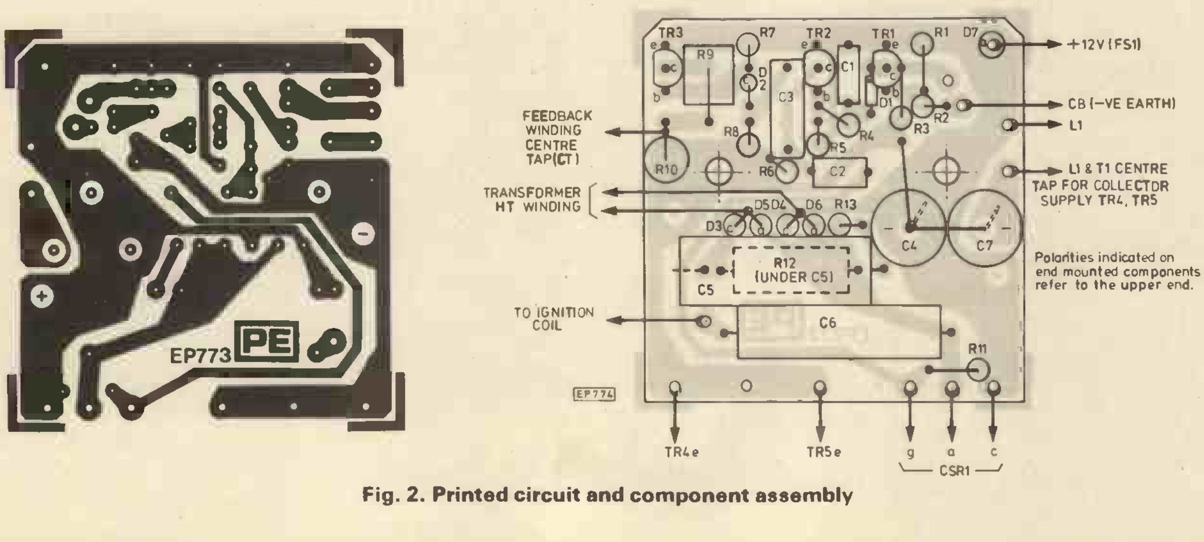


Fig. 2. Printed circuit and component assembly

smaller gauge wire is used. Copper losses rise, as does operating temperature, but the soak test and 100,000 mile field test indicate that adequate reliability remains. The high-voltage winding should be wound onto the bobbin first, followed by the collector and feedback windings in that order. As originally, the latter windings should each be made with two wires together, to give identical characteristics in each half of the tapped windings. Turns for each winding are:

High voltage 330T 34s.w.g.
Collectors 12T + 12T 24s.w.g.
Feedback 3T + 3T 30s.w.g.

Neatness in winding is essential to fit all windings onto the bobbin, each should be carefully insulated from the next. It is possible to obtain a very thin, high voltage rating, adhesive plastic tape specially designed for transformers. Care should be taken to ensure that the wire insulation (lacquer) is not damaged during winding or fitting of the ferrite cores. P.v.c. sleeving should be used on all transformer leads. Do not glue the core until ready for assembly onto the base-plate.

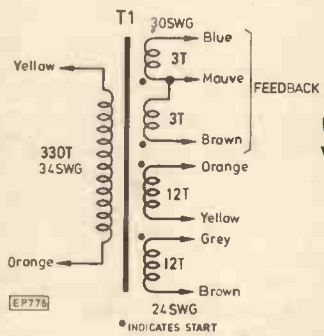


Fig. 3. Transformer winding details

CHOKE

Use of a small pot-core makes winding and fitting of the choke much quicker and easier than on the 1974 design. It was found that the bobbin could be held firmly by pushing over the tapered handle of a small paint brush. Using about $\frac{1}{2}$-metre (18-19 inches) of 16/0·2mm stranded p.v.c. single flex, wind just four turns on the bobbin, leaving the spare length as tails for wiring to the p.c.b.

ASSEMBLY SEQUENCE

Build up the p.c.b. first, and check the underside to ensure that there are no tracks shorted by excess solder, the mounting holes are free and chamfered on the copper side. The latter is to ensure that the mounting screw for the unearthed polarity does not short. Mount the p.c.b. onto the base-plate with two 6BA countersunk screws, taking care to place a 4BA nut (plated, not plain steel) over the chosen polarity for earth, the 4BA nylon nut insulating the other. (Looking at the soldered side of the p.c.b., each mounting-hole is part of one of the polarity rails, and marked positive and negative accordingly.) The chamfered corners of the p.c.b. should align with the corners of the diecast box; fit a shake-proof washer and apply a small quantity of nut-lock to the threads, then tighten down a 6BA nut on each screw to clamp the p.c.b. making sure that it is square (in plan view) inside the box. The screw with the 4BA plated nut gives direct earth connection via the case of the unit. It must be very tight, just the right side of stripping the thread. As this connection is so important, fit a second 6BA nut as a locknut, taking care that full nuts are used, and not $\frac{1}{2}$-nuts, as the latter can easily strip.

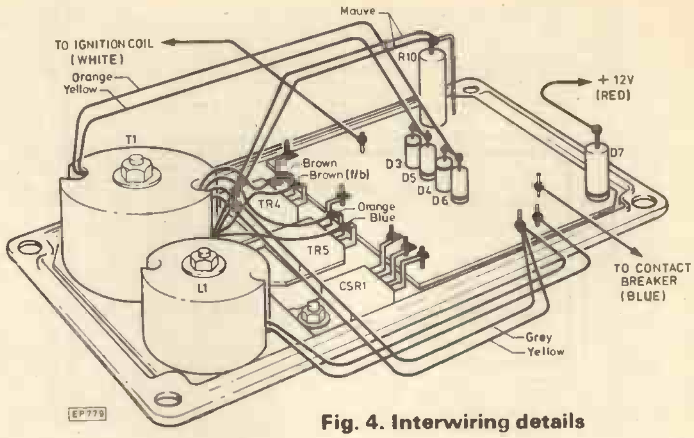


Fig. 4. Interwiring details

Next, fit the plastic power devices to the base-plate, taking care that the mica washers and plastic mounting screw insulators are properly fitted; mount each device after bending and trimming the leads.

Solder the five device leads to their pins after final tightening. The assembly order is — screw, mica, device, plastic bush, plain washer, shakeproof washer, nut-lock to thread, then tighten 6BA nut.

POT CORE ASSEMBLY

The ferrite pot cores can now be glued, assembled and mounted onto the base-plate. These components can be very easily cracked by over-tightening of the 4BA mounting screws, so be warned. It is recommended that a thin piece of rubber is placed between the base-plate and pot cores, to dampen vibration and cushion the clamping down. The assembly order is glue pot core faces and bobbin faces, assemble core, fit screw and rubber to base-plate, mount core, plain washer, shakeproof washer, nut-lock, then gently tighten the 4BA nut just enough to firmly pull the core faces together and pinch the ferrite into the rubber padding. Whilst Araldite is an excellent adhesive, it is rather permanent, and unless the constructor has supreme confidence, the author recommends the use of Evostik, which can be removed after a long soaking in petrol.

GENERAL WIRING

Wire up the choke leads first, trim to length, bare about 5mm ($\frac{1}{4}$"), twist the strands together, and lightly solder. Now shape a hook, with small long-nose pliers, and push over each p.c.b. pin marked for the choke. Solder only the pin that is furthest from C7 for now. At this stage, it is essential to identify the "starts" and "finishes" of the tapped transformer windings. If these were marked, fine; if not, use continuity testing to sort out for each tapped winding a start/finish pair that do not form a single winding, i.e. the centre-taps. Wire the 24s.w.g. collector winding next. Trim the centre-tap leads, taking them to the unsoldered tap/choke pin on the p.c.b. Tin the copper ends well, shape into hooks as before, and solder all three pin connections at the same time. Next wire the remaining two 24s.w.g. leads, each to a TIP 3055 collector (any lead to any TIP 3055); bend a hook on device lead and copper wire, link and pinch together before soldering.

Wire the feedback centre-tap next. Trim to length, tin the ends well, twist together, and tuck neatly under the top wire of R10. If the constructor can identify which of the remaining 30s.w.g. leads is a start, and which a finish, wire the

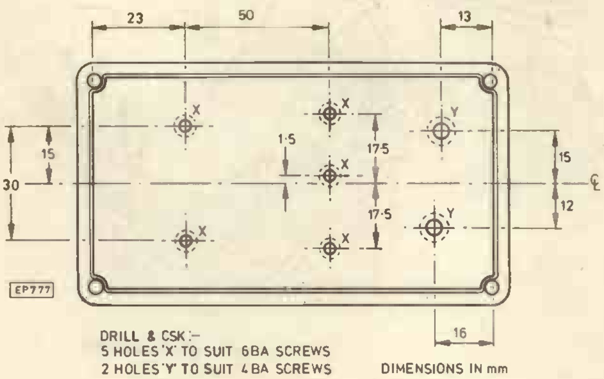


Fig. 5. Drilling detail of box lid

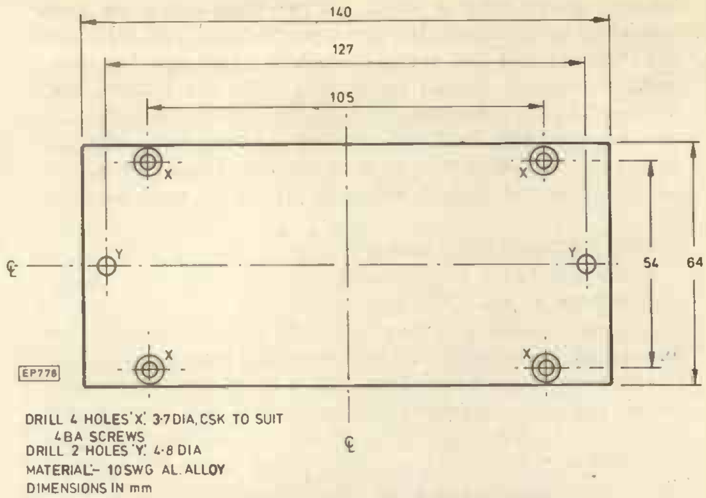


Fig. 6. Drilling detail of mounting plate

COMPONENTS . . .

Resistors

R1	220
R2, R3, R5	470 (3 off)
R4, R6, R7	1k (3 off)
R8	1k2
R9 (RS 155-447)	150 4W
R10	15 1W
R11	150
R12	330k 1W
R13	100

All $\frac{1}{4}$W unless otherwise stated 5% HS

Capacitors

C1	0·1µ 100V
C2	0·22µ 100V
C3	0·22µ 100V
C4, C7	220µ 16V (2 off)
C5	0·01µ 600V or 1000V
C6	1µ 400V

Ferrites

Choke (Siemens)	22mm pot core B65661 L0000 R026
Bobbin (Siemens)	B65662 A0000 T001
Choke (Mullard)	FX2239 (2 off)
Bobbin (Mullard)	DT2204
Transformer (Siemens)	30mm pot core B65701 L0000 R026
Bobbin (Siemens)	B65702 A0000 M001
Transformer (Mullard)	FX2241 (2 off)
Bobbin (Mullard)	DT2205

Semiconductors

TR1, TR2	2N4062 (2 off)
TR3	BFR81
TR4, TR5	TIP3055 (2 off)
D1, D2	1S44 (2 off)
D3, D4, D5, D6	1N4006 (4 off)
D7	1N5400
CSR1	TIC116m

Hardware

Fuseholder, auto in-line 5-amp anti-surge fuse

Diecast box	RS 509-939 $4\frac{1}{4}$in x $2\frac{1}{2}$in x $1\frac{1}{4}$in
Mounting plate	$5\frac{1}{2}$in x $2\frac{1}{2}$in x $\frac{1}{8}$in aluminium

3 metres auto cable

3 auto connectors and sleeves to suit vehicle

5 off	6BA countersunk $\frac{1}{4}$in screws
5 off	6BA shakeproof washers
2 off	4BA plain washers
2 off	4BA shakeproof washers
3 off	6BA plain washers
6 off	6BA full nuts
1 off	4BA nylon nut or $\frac{1}{8}$in nylon p.c.b. 6BA stand-off pillar
2 off	4BA countersunk 1in screws
3 off	4BA full nuts
4 off	4BA countersunk $\frac{3}{8}$in screws (RS box) or M3 x 15mm countersunk screws (BIM box)
2 off	No. 10 pan-head $\frac{1}{2}$in self-tapping screws
1 off	$\frac{1}{4}$in rubber grommet

Miscellaneous

Sleeving, rubber mounting sheet for ferrites, nut lock compound, Evostik, Araldite.

A full kit of parts, including suitable p.c.b., fully-drilled diecast box and mounting-plate, auto cable, all nuts and screws etc, ferrites, bobbins, and all electronic components, but excluding copper wire, available from **Microstate Limited, 5 Northfield Close, Fernhill Heath, Worcester WR3 7XB,** for £14.85 including VAT and postage. (The first 50 orders received will be given at no extra cost, transformer bobbins with high voltage windings already on, and copper wire for other windings.)

This special offer applies to orders for full kits only. Please note that the kit does not include solder, nut lock, Evostik or Araldite adhesives.

bases of the TIP 3055s so that on each device is a collector start/base finish and vice-versa. If not, just tack the base leads on to either device temporaily. Leaving the high voltage winding as yet unconnected, and free of anything else, connect a 12V supply, between case and D7 top end for a second or two and the inverter should oscillate. If not, reverse the base wires and try again. With the inverter working, connect a meter (400V a.c. range) to the high-voltage winding, and connect the supply again a reading of 350-370V a.c. unloaded should be indicated. Switch off the supply, and wire up the 34s.w.g. leads to the inverter bridge diode pairs (formed by twisting the vertical leads of adjacent diodes together) standing proud next to C5 on the p.c.b. With the meter switched to 400V d.c., and connected across C5, switch the supply on again; and a reading of 350-370V d.c. should be given. Should the inverter no longer oscillate, there is either a fault on the bridge wiring, the thyristor wiring, or perhaps in the transformer. Assuming all is well, the unit is virtually completed.

Wire about a metre of automobile cable to the three connection points for external wiring, these being the contact breaker for chosen earth polarity (blue), free end of C6 (to ignition coil), and top end of D7 (black for positive earth, red for negative earth). Take great care when wiring this thick cable to the p.c.b. pins, to keep absolutely clear of other components and connections. Trim and bare just enough length to hook around each pin, leaving no unsoldered strands or excess length. An ideal cable for this job is Delta 2491x which comprises 32/0·25mm conductors in a tough p.v.c. outer of 2·5mm overall diameter.

FINAL ASSEMBLY

The three auto cables need to be passed through the grommet in the diecast box end. Prior to attempting this, a simple knot should be tied in each cable so that when completely threaded through, enough slack remains to prevent tension on leads from reaching the p.c.b. pins. The grommet hole is deliberately small, to give leads a tight fit and prevent the ingress of dirt. The four screws retain both the box lid (base-plate) and the secondary base-plate. Once fully proved, the box and lid should be sealed around the lip; Araldite is recommended for this. Having assembled the unit into its box, fit the in-line fuse holder (FS1) in series with the supply lead (red or black), and insert a 5A anti-surge fuse. Finally solder on the appropriate terminals for the car (most use $\frac{1}{4}$in spade connectors), with p.v.c. sleeves where necessary.

INSTALLATION

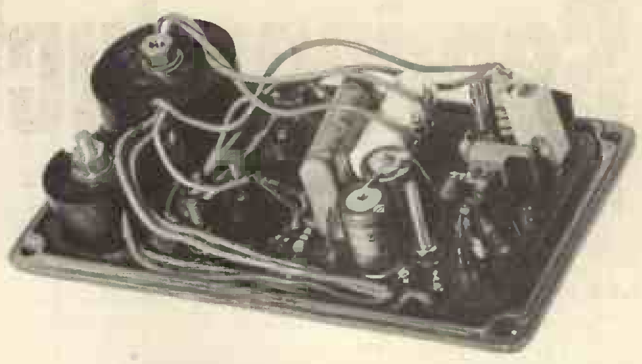
Bearing in mind the very important points made in the 1974 article about ballast resistors and tachometers, installation and wiring on the vehicle is far easier than before. Choose a flat metal surface close to the ignition coil, but ideally away from radiator or exhaust heat. Fit the unit to the car body with No. 10 pan-head self-tapping screws, giving secure fixing and direct earth return connection.

WIRING

For cars without ballast-resistor coils, and no tachometer, this is extremely quick and simple.

Negative Earth

Take the red lead to the side of the coil that is already wired to ignition-switched power. Remove the lead from the other side of the coil (contact breaker) and fit instead the white lead from the unit. Join the blue lead from the unit to the contact breaker lead previously removed from the coil.



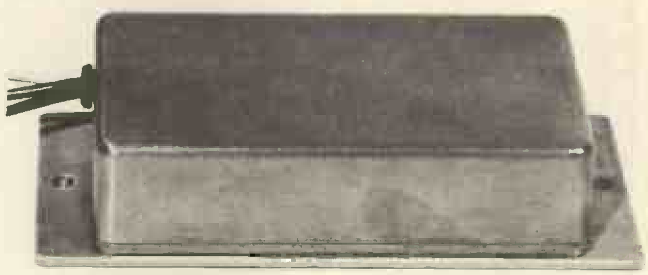
Showing component assembly to lid

Positive Earth

Remove the ignition switched power from the coil, and take it instead to the black lead from the unit. (For negative earth, the ignition switched power remained connected to both coil and unit). The bare coil connection should not be wired to earth. Remove the other (CB) lead from the coil, and join it to the blue unit lead. Connect the white unit lead to the coil CB side.

Ballast-resistor Coils

The author knows of none being used on positive earth systems so this is for negative earth cars. Remove the ignition switched power lead from the coil, and insulate securely with plastic tape. Find a source of power (e.g. ignition switched auxiliaries), and wire this to the coil in place of the ballasted supply, and connect also the red unit lead. Other wiring as above. Note that some cars have the ballast resistance built into the wiring loom as resistive cable; others have a high-wattage resistor under the bonnet or dashboard wiring.



Diecast box and mounting plate assembly

Tachometers

Most modern cars have more sensitive instruments than early ones; even current-driven types can usually be driven by the base-current for TR1. Voltage-operated types detect the change in potential across the contact breaker, thus usually little change to wiring is required. It is felt beyond the scope of this article to attempt to cover every type of tachometer, but the points made here may update those given in the original 1974 article to some extent. If a current-driven instrument is fitted, and the base current of TR1 is not sufficient, using the pulse from either the white or red leads should succeed. However, two points must be borne in mind. If the red lead is used, D7 may halve the pulse counting rate derived and may have to be removed. Also the direction of pulse flow through the instrument's current-sensing circuit is usually critical. ★

Unfortunately we are unable to supply reprints of the original article—Ed.

Semiconductor UPDATE...

FEATURING WD2123 OP-27

R.W. Coles

ACE DEUCE

The most commonly required interfacing function in any microprocessor system is the serial port. Communication with printers, Visual Display Units (VDUs), modems and a host of special peripheral devices is possible using one of the popular serial protocols such as RS232 or current loop, and this makes the provision of at least one such port mandatory on most systems.

You can implement a serial port in software if you are prepared to let the processor devote all its attention to the serialising and timing tasks, but except for simple systems it is generally better to use one of the special peripheral chips designed to remove this burden from the processor by controlling a complete serial transmit/receive scheme independently of software. Of course, the processor still has to load words into the interface device for transmission, and retrieve them after reception, but this can easily be arranged under interrupt control to cause the minimum of disturbance to the busy micro as it goes about its other, more important, business!

The serial peripheral chips come in all shapes and sizes, and have almost as many different names as there are microprocessor manufacturers, but most of these names resemble "UART", which stands for Universal Asynchronous Receiver Transmitter, a fair description of the chip's role I think. The Universal part means that there are loads of options concerning the length of the transmitted and received word, the format in which it is sent, and whether error detecting parity bits are to be used. The Asynchronous part means that each word is sent as a separate entity with its own start and stop bits added to form a frame, other words may or may not follow closely. (You can also get Synchronous versions, but these are generally for more specialised applications where large bursts of data are to be transmitted). The Receiver and Transmitter parts mean just that. Unfortunately, a UART is not enough by itself, because there is the knotty problem of what speed you want the link to run at. The speed is described as the "baud rate" and there are many standard possibilities between 110 and 19,200 which need to be catered for by the microprocessor system if it is going to have any chance of being general purpose. The answer here is to use a Baud Rate Generator chip which is really a programmable divider circuit used to turn a crystal oscillator frequency into any one of the desired baud clock rates to feed the UART. The desired clock rate can be switch selected, usually by those microscopic switches designed probably by, and certainly for, Lilliputians, or in more civilised systems, it is programmed under software control via the system keyboard. Serial ports are so important that it is nice to have more than one, like the expensive systems, but the cost of all those UART and Baud Rate Generator chips could put a body off where hobby projects are concerned, or at least it could until Western Digital played their new ace, the WD2123.

The WD2123 is a DEUCE or Dual Enhanced Universal Communications Element, and lurking within its natty 40 pin plastic package there are no less than two UARTs, each with its own baud rate generator, and a crystal oscillator. With one of these babies in your pet microcomputer you can grind out your listings at 300 baud on a printer whilst exchanging chess moves with your neighbour at 19,200 baud, assuming your software is up to these kinds of gymnastics of course! As far as I can see, there are no awkward compromises with this device, it seems capable of doing everything that ordinary, old fashioned UARTs and Baud rate Generators can do. It happily hooks onto a microprocessor bus which can address internal registers to program the two channels into any desired format and with any of 16 possible baud rates between 50 and 19,200. It has all the usual programmable features including stop bit length, word length and parity, and it provides a host of control outputs to let the microprocessor know what is happening. All you have to add is a single crystal, some RS232 buffers, and of course the micro itself.

ULTIMATE OP-AMP?

As a tone deaf electronics writer, I suffer from the terrible disadvantage of being totally unable to appreciate the finer points of a high fidelity sound production system, regardless of how much the equipment has cost its owner. (I suffer from a similar but inverted affliction of the taste buds which cause me to appreciate the finer points of all wines, even Dreadnought plonk at 50p a litre.) Imagine the difficulty I have, then, in commiserating with friends who lose sleep at nights over the few decibels of additional Total Harmonic Distortion which has apparently crept into their gleaming teak and chrome Hi-Fi shrines since the holidays!

Noise, on the other hand, I can understand:

a) Because I can see it on an oscilloscope,

b) Because the non-electronic variety generated by my offspring often drives me to despair.

On this topic I am therefore in complete sympathy with those who strive towards acoustic perfection and can announce with interest and understanding a new operational amplifier which has come closer than any other to the fabled zero noise point.

The new amplifier has been introduced by Precision Monolithics Incorporated, a Company justly famed for their high precision "up-market" analogue circuits, and for their advertisements which feature Alice in Wonderland themes. Apparently P.M.I. are as nutty as the Hi Fi freaks, and no less a person than their Engineering Vice President has spent a whole year and innumerable dollars in search of the Holy Grail of the analogue fraternity, the ultimate Op-Amp design. The ultimate Op-Amp would have zero noise, an infinite gain, and an infinite bandwidth, and that is a combination unlikely to be realised even by P.M.I. in the near future, but the actual results of their crusade, the OP-27 and the OP-37 devices, have certainly pushed the frontiers of precision Op-Amp technology further out than ever before.

The new designs are ideal for use in the front-end circuitry of audio amplifiers, especially tape head and magnetic microphone pre-amplifiers where impedances and signal levels are low and noise is a critical factor, although they will also be sought after by instrumentation engineers who need the ultimate in performance for their transducer amplifiers. The specifications of the two devices underline the success of the P.M.I. design approach. Gain bandwidth product of the OP-27 is 8MHz compared with 0·8MHz for the 741, common mode rejection ratio is 126dB compared with 90dB for the 741, and voltage noise is an incredibly low 3 nanovolts per root Hz at 1KHz. That noise figure can be compared with the standard rule of thumb for noise in a resistor which is generally taken to be 40 nanovolts per root Hz per 100K ohms, which means that for the same bandwidth the OP-27 generates less noise than a 10K resistor! (Remember though that amplifier noise specs are related to the *input*, and therefore the noise at the output of the circuit will be multiplied by the voltage gain.)

The OP-37 is an even faster version of the OP-27 with a gain-bandwidth product of 63MHz but must be used in circuits with a voltage gain of more than five to ensure stability. The OP-27 is unconditionally stable. Both amplifiers are compatible with 741 sockets if the offset null circuitry of that device is not used, and can be obtained in 8 pin mini-dip or TO99 packages.

They won't replace the wind-up gramophone of course, but they may allow the Hi Fi brigade to sleep more soundly!

BENCH P.S.U.

EVERYONE developing and building electronic circuits whether it be in industry or at home requires a power source. Ideally, this should be variable, highly stabilised, metered and well protected against accidental misuse.

The required voltage and current rating obviously depends on what is being developed but a 0–30V, 0–2A supply will cover 90 per cent of circuit developments.

Such power units are widely available in industry but the asking price is £80 upwards which generally puts such a unit outside the scope of home experimenters and they often have to make do with a temporary lash-up which suits one development but often not the next.

The unit to be described attempts to fulfil the above requirements at the lowest possible price without too many compromises.

DESCRIPTION

Conventional linear techniques are employed in the unit, series power transistors regulating the output voltage. They are driven by a linear i.c. which compares a portion of the output voltage with a reference voltage.

The unregulated d.c. is derived via a 50Hz power transformer, rectifier and capacitive reservoir. The range switch changes both the a.c. secondary voltage fed to the rectifier and the resistors in the voltage feedback circuit.

Series resistors in the power transistor emitters generate voltage drops which are used to operate the electronic overload circuitry and to drive the current metering.

The chosen i.c. is the well known 723 type which is a good compromise between cost and performance. It was not originally intended for use in laboratory power units where the output voltage is widely variable and usually down to zero.

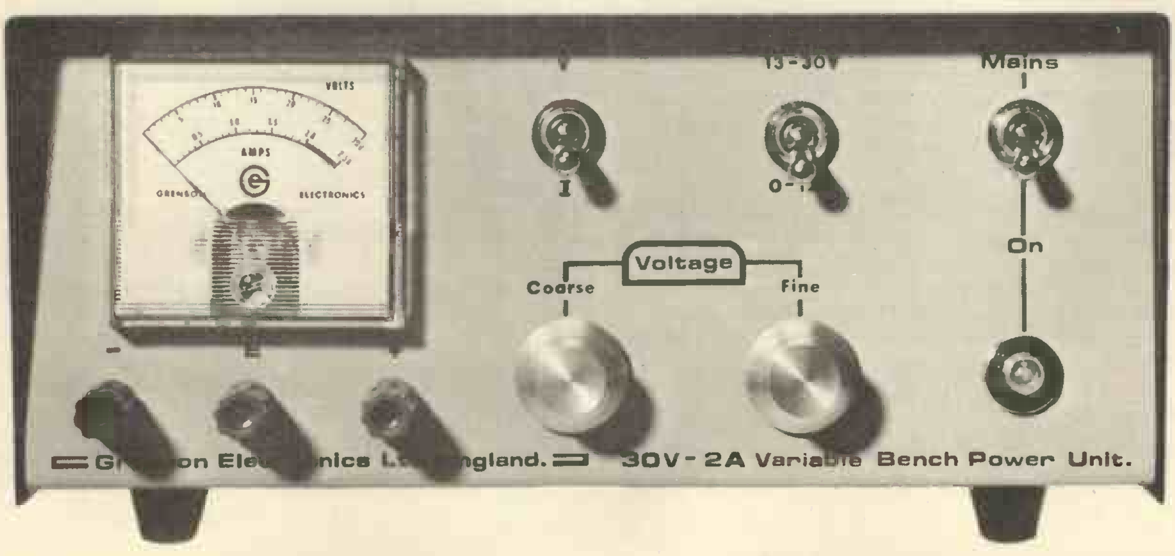
OPERATION

The mains input, 230 or 240V, is fed to the transformer primary via mains switch and 1A anti-surge fuse. The range selection switch S2, connects either half or all the secondary voltage to a full wave bridge rectifier via a 5A secondary fuse. This rectifier is made up of four BY299 2 amp diodes and supplies unidirectional current to the reservoir capacitor, C1. A lower ripple auxilliary supply is produced by D7, C2.

The load current then passes through the series power transistors TR3, TR4 and the current equalising and measuring resistors in their emitters and thence through the load and back to the return.

SPECIFICATION

Input	230V–240V a.c.
Output	2·5–30V d.c. stabilised in two overlapping ranges of 2·5–13V and 12V–30V
Maximum Current	2A throughout the range
Stability	Output change for 10% input change 0·5%
	Output change for zero-full load 0·10%
	Temperature coefficient 0·01%°C
	Ripple 0·05% peak-peak
	Transient load 3% excursion recovery in 1ms for half full load
Protection	Re-entrant foldback overload protection, operating at 20% overload
	Output protected against forward or reverse voltages being injected into output terminals
Metering	Output voltage and current metered by switchable moving coil panel meter
Size	$4\frac{3}{4}$in x 10in x $9\frac{1}{2}$in (H x W x D)— Weight 5kg



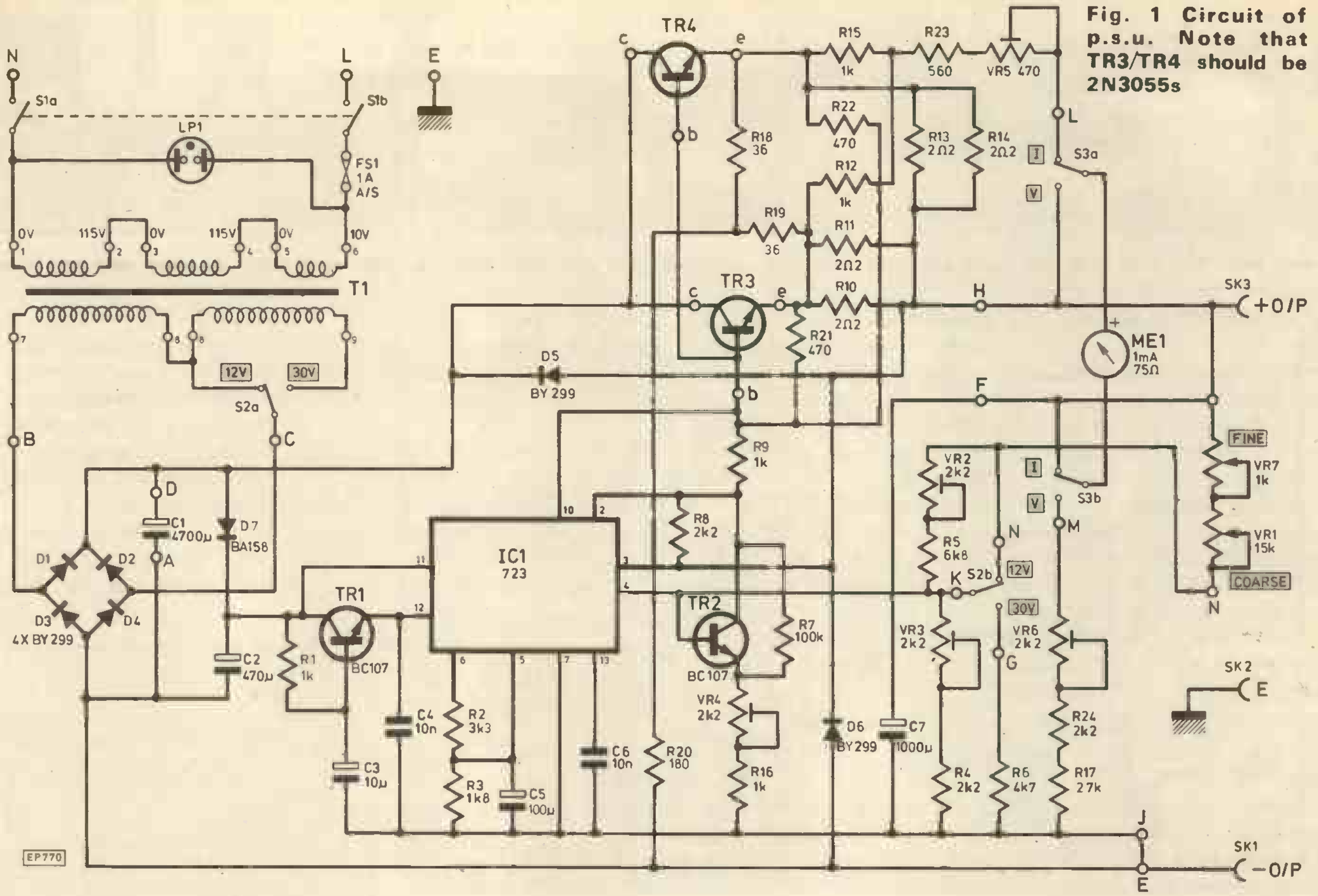


Fig. 1 Circuit of p.s.u. Note that TR3/TR4 should be 2N3055s

These transistors operate as emitter followers driven by the output current of the 723 i.c. which can be divided into five sections; a constant current device, feeding a Zener diode reference, an error amplifier, a power output transistor capable of passing 50mA and a current limiting transistor.

The Zener reference is compensated for temperature changes having a typical coefficient of 0·003%/°C. Feeding this via a constant current supply largely removes reference of about 7V. The error amplifier is a differential input amplifier whose output drives the base of the power output transistor.

A single transistor on the chip has its collector connected to the base of the output transistor, base and emitter being brought out to pins so that this current limit device can be used in several different ways.

In this power unit the 7V reference on pin 6 is divided by R2/R3 to give approximately 2·5V which is then fed back into the error amplifiers non-inverting input. A portion of the output voltage determined by VR1, VR3 and R4 (on the lower range) is fed to the inverting input (pin 4) and compared with the reference voltage. Until this portion reaches 2·5V the amplifier feeds current to the output transistor which in turn feeds the two series power transistors increasing the output voltage. This increase is fed back to the amplifier until stability is achieved. Thus a closed loop d.c. system is formed, the stability of the output depending only on the reference voltage and d.c. gain within the system.

Usually a.c. stability considerations limit the maximum d.c. gain but this design problem is simplified by using an i.c. such as the 723.

Overload protection is essential on stabilised p.s.u.s as their output resistance is, by design, only a milliohm or so. This is achieved by using the voltage drop across the 2·2 ohm wirewound resistors in the emitters of the power transistors. This is used to drive the on-chip transistor which then bleeds drive current away from the amplifier output and down through the load. This transistor could be driven directly by the resistor volt drop but this would give a constant current overload characteristics with resultant high dissipation in the series transistors requiring a much larger heatsink. At short circuit on the upper range the power would be 96W, when all the unstabilised input voltage would be across the power transistors and the current would be 20 per cent over full load current.

In the circuit used, a portion of the output voltage (2·5V) is applied to TR2 base, this transistor operating in a constant current mode at about 1mA (set by VR4), which produces a volt drop in R9 of 1 volt which is compared by the on-chip overload transistor with the voltage across R10, R11, R13, R14 effectively in parallel.

As the load current rises to 2·4A the voltage amplifier loses control and the overload transistor bleeds away drive current. This causes a fall in output voltage which reduces the 2·5V on TR2 base. In turn a reduction in the 1mA current and therefore, voltage across R9 occurs which reduces the overload current. Thus a 'foldback' characteristic is achieved so that increasing load produces less output current so that at short circuit the value is 0·5A. This greatly reduces power dissipation and means that the heat sinking is only dictated by normal operating conditions.

The volt drop across the R10, R11, R13 and R14 also drives the current meter, VR5 setting the range whilst the output voltage may be metered by switching S3, the voltage range being set by VR6.

D6 protects the unit against the injection of reverse voltage to the output while D5 protects against a forward

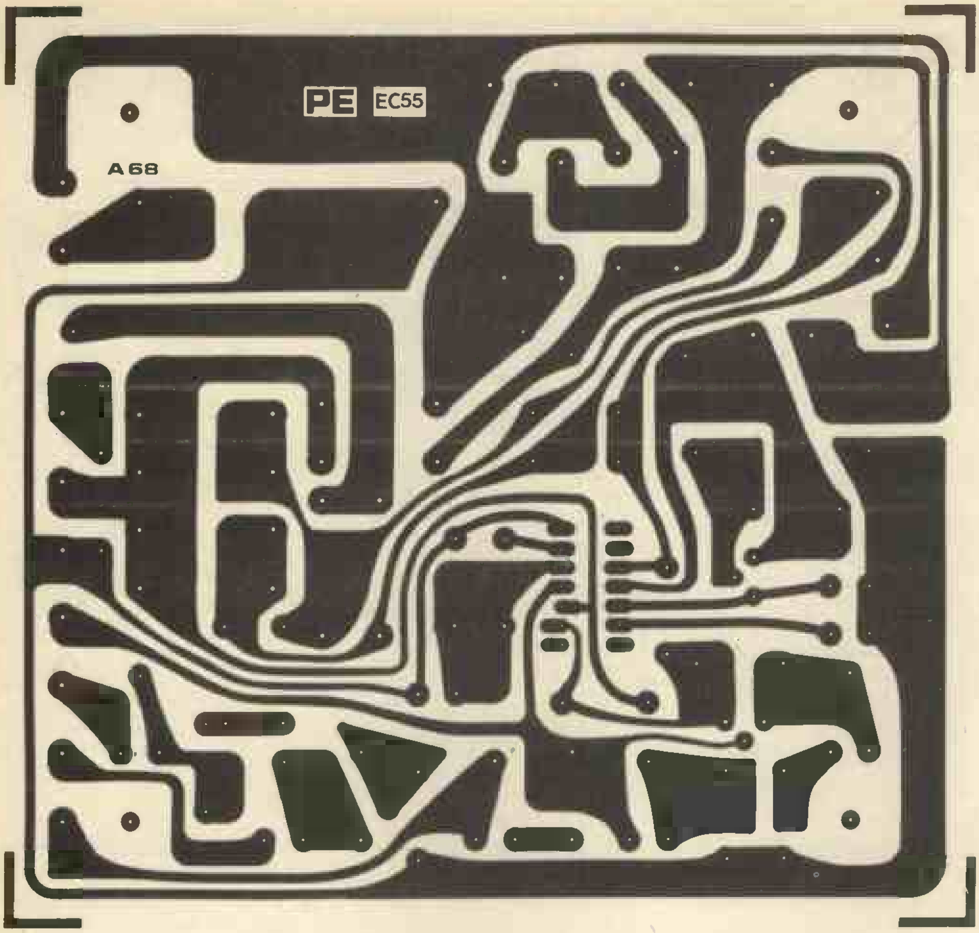


Fig. 2 Printed circuit board

voltage being applied to the output with C1 discharged i.e. unit switched off.

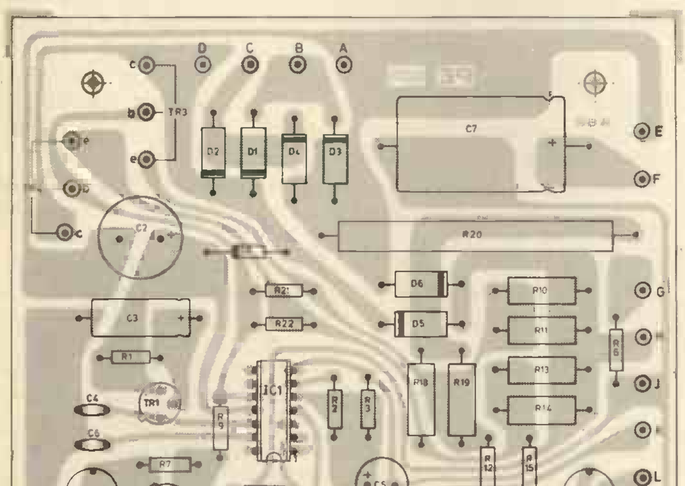


Fig. 3 Component overlay for the p.c.b.

CONSTRUCTION

The p.c.b. may be assembled first, inserting solder pins then small components such as resistors and semiconductors before capacitors. Note that diode cathodes are marked + on the p.c.b. Take great care with the polarity of these and capacitors as the low impedance paths in the p.s.u. spell death to incorrectly connected components.

Wirewound resistors should be mounted with the body about $\frac{1}{8}$in clear of the board to prevent heating of the SRBP material. This applies particularly to R20. Mount all front panel components except the meter which is fragile and better fitted last of all.

Wire, VR1, VR7, S2b and S3 forming a loom to pass horizontally behind the front panel at mid-height. All these wires except the two meter leads are connected to the pins on the front edge of the p.c.b. VR1 and VR7 must be wired as rheostats so that clockwise rotation gives increased resistance.

Mount the p.c.b. and terminate this loom adding in the double wires to the output terminals. Note the two wires to each terminal are power and sense and must be commoned at the terminal if maximum performance is to be maintained.

Make up the two heat sink assemblies ensuring that each power transistor (TR3 and TR4) is properly insulated using the mica and bushes supplied. A smear of silicone grease under transistor and mica helps heat transfer from the transistor case to the heat sink. Take the three leads from each power transistor through their respective rear panel grommetts to the p.c.b. pins, the collector to case connection being via a solder tag on the transistor mounting screw.

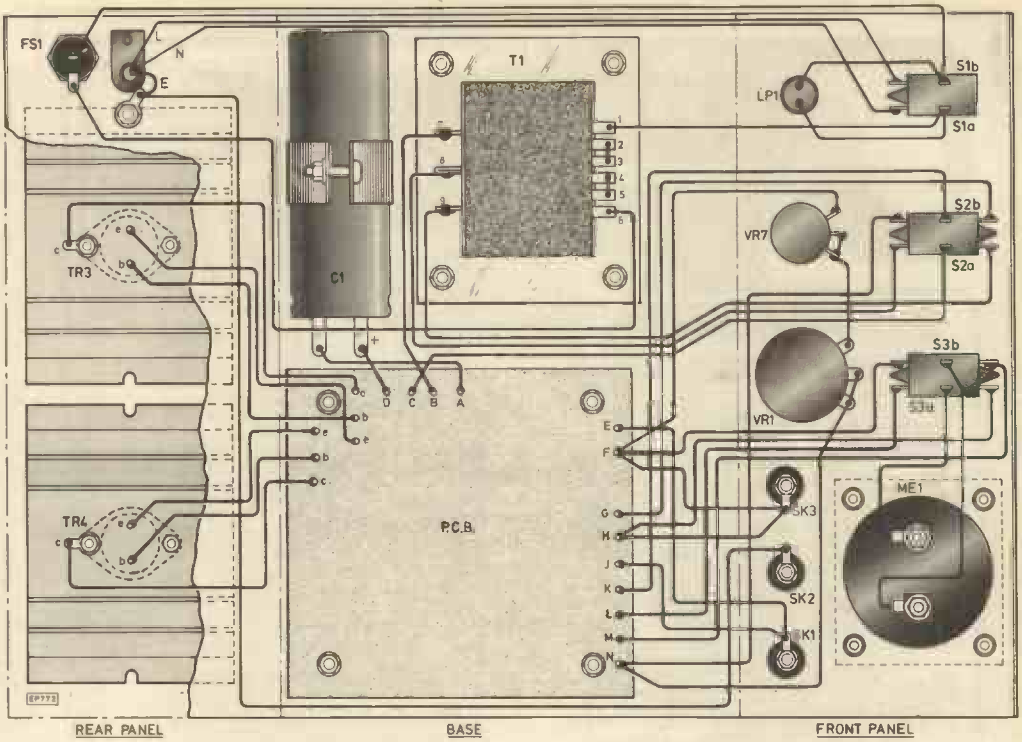


Fig. 4 Complete assembly detail

Use the large capacitor clip to mount C1 horizontally near the rear panel and fit the fuseholder and cable clamp on the rear panel. Wire C1 to the p.c.b. noting that the red tag is positive and must be connected to pin D, negative to pin A. The transformer should now be mounted using the $1\frac{1}{2}$in x 4BA screws and tapped spacers, the mains tags numbered 1–6 nearest the front panel.

Wire the mains fuse, switch and neon and the transformer primary taking care to ensure that a good earth is established by cleaning paint off under the heat sink mounting screw and using a solder tag. The primary consists of two 115V windings and one 10V so that all three should be in series for 240V. Connect the transformer secondary to the appropriate pins on the p.c.b. (B and C) via S2a.

Only the meter now needs mounting and wiring to S3a and S3b centre contacts, positive being to S3a.

SETTING UP

Before setting up the unit it must be working correctly and stabilising at some voltage.

On completion it is always worth spending a few minutes checking for correct polarity of components and wrong connections. In the case of a p.s.u. this is doubly important as many electrical paths are low impedance and wrong connections will destroy semiconductors at best and produce smoke and scorched p.c. boards and looms at worst. As a general rule do not work on p.s.u.s with the unit switched on — it may be tempting to save time but even a momentary short will usually destroy some semiconductor because of the low impedances.

If you have a Variac available use it for initial switch on and only feed in a few volts. Check that the polarity of the d.c. unstabilised voltage (across C1) is correct and increases when the unit is switched to upper range. Switch back to low and increase the Variac slowly checking that the output voltage rises about 3 volts behind the unstabilised. With the voltage pot (VR1) set midway the output should stabilise at 6–9 volts. Assuming all is well increase mains input to 240V and proceed with setting up in the order given; voltage low range, voltage high range, current overload, voltage metering and current metering.

Instead of a Variac some people just use strong nerves. In this case double check power connections i.e. transformer primary; is the fuse in circuit and the phasing correct? Check secondary wiring around S2 and ensure the diodes are correctly polarised in the bridge (D1–D4). Also check C1 is correct polarity. Check C2 polarity also. It is wise to disconnect the meter if you have no Variac as incorrect wiring could damage it virtually instantly.

Set pot VR1 to mid-range and voltage range switch to lower range. If all is well 6–9 volts should appear at output, you can then proceed to set up the voltage ranging.

V/I RANGING

All d.c. voltages are quoted with respect to -ve output.

Low range voltage

With 240V in check reference voltage on pin 5 of 723 is about 2·5V. Turn VR1 and VR7 fully anticlockwise and check output is 2·5V. Increase VR1 and VR7 to maximum and then adjust VR3 to give 13V out.

High range voltage

Reduce VR1 and VR7 to minimum and switch to high range. Adjust VR2 to give 12·5V output. Increase VR1 and VR7 to maximum and check output is about 31V or at least 30V.

The unit is now set to have two overlapping ranges of 2·5–13V and 12·5–31V.

Current

To set this a variable resistor of about 30Ω/2A is required although use may be made of the unit's variable output, which, with a little thought and ingenuity will enable anyone with only odd wirewound resistors to set up the current overload.

COMPONENTS . . .

Resistors

R1	1k
R2	3k3
R3	1k8
R4	2k2
R5	6k8
R6	4k7
R7	100k
R8	2k2
R9	1k
R10–11	2R2 4W w. wound (2 off) 5%
R12	1k
R13–R14	2R2 4W w. wound (2 off) 5%
R15-16	1k (2 off)
R17	27k
R18–19	36R 1W (2 off)
R20	180R 10W w. wound 5%
R21–22	47R (2 off)
R23	560R
R24	2k2

All $\frac{1}{8}$W 5% carbon

Capacitors

C1	4700μ	63V
C2	470μ	50V
C3	10μ	63V
C4	0·01μ	50V
C5	100μ	50V
C6	0·01μ	50V
C7	1000μ	40V

Semiconductors

TR1–TR2	BC107 (2 off)
TR3–TR4	2N3055 (2 off)
D1–D5	BY299 (5 off)
D7	BA158 or 1N4000
IC1	LM723CN

Potentiometers

VR1	15k w. wound
VR2–VR4	2k2 cermet
VR5	470R cermet
VR6	2k2 cermet
VR7	1kw wound

Switches

S1	Main/off double pole (250V/2A)
S2	Voltage range switch (250V/2A) d.p.d.t.
S3	Meter function switch (250V/2A) d.p.d.t.

Transformer

Mains primary; 15-0-15V at 4·6A

Miscellaneous

FS1–1A anti-surge, LP1—mains neons

A complete kit of parts is available from **Grenson Electronics Ltd., High March Rd., Long March Industrial Estate, Daventry, Northants NN11 4HQ** at £28.50 + £2.50 p.&p. + £4.65 VAT.

Assuming a variable load resistor is available connect it to the unit via an accurate meter (preferably 3A or 5A f.s.d.) and with minimum load, switch on with 12V output. Turn VR4 fully clockwise and adjust load to give 2·4A load current. Turn VR4 anticlockwise until the current just starts to fall. Carefully increase load and the voltage and current should fall until at any output, below 3V, the current is about 0·5A. Check the current limit is the same at the bottom of the low range and at both ends of the upper range.

Should you only have fixed wirewound resistors choose one or more in series that will give a suitable value (say 4 × 1Ω/5W in series) and connect across the output. The current can now be increased by increasing the output voltage until 2·4A is reached (9·6V).

Turn VR4 anticlockwise until current just starts to fall. Short out the resistors successively and check that the current falls to about 0·5A.

Voltage metering

Check with unit switched off that meter indicates zero — if not reset mechanical zero with centre screw.

Set the output to 30V using an accurate voltmeter and adjust VR6 with meter switched to voltage to give correct front panel meter reading.

Current metering

Connect a load in series with an accurate ammeter and adjust load (or output voltage) to give exactly 2A. With meter switch set to current adjust VR5 to give correct front panel meter reading.

TROUBLE SHOOTING

If the unit does not stabilise when switched on faults can be divided into two categories, power circuit and control circuit faults

Power circuit faults usually blow fuses or give no output at all. Check that C1 has about 20V d.c. across it on lower voltage range of correct polarity (mains at 240V). If this is the case but the unit gives no output or high output measure the voltage across the power transistors collector to emitter. Almost 20V here suggests the power devices are turned off whilst on 1–2 volts suggests they are turned on; In either case, probably a control fault.

If the output is high disconnect the power transistor base connection — the output will fall to zero if it is a control circuit fault. Reconnect the base drive and go logically through the circuit. Check reference voltage (IC1 pin 6) is 7V, check voltage on pin 5 is 2·5V, check voltage on pin 4 which should be 2·5V. If pin 4 voltage is higher than pin 5 voltage the output should be low and vice versa, provided the unit is basically correct. In this case the output voltage can be high because the resistive network dividing output voltage is wrong. A persistently low output when pin 4 and pin 5 voltages suggest it should be high is likely to be due to a fault in the overload circuitry — check R8, R9, TR2, R6, R7 and around pins 2 and 3.

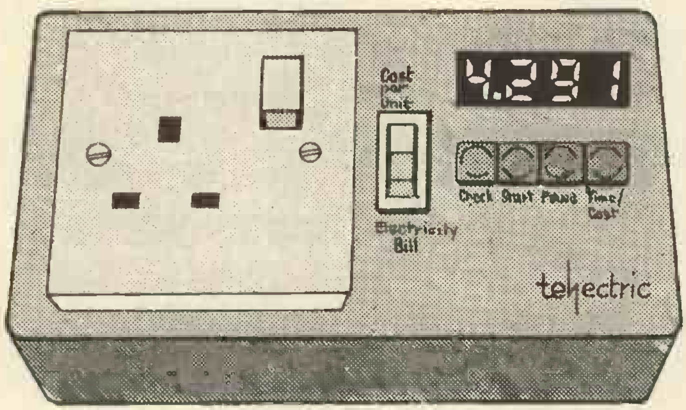
When the unit is operating correctly a load change of zero to full load will not give a visible meter deflection change on the voltage range. An apparent increase in voltage when a load is connected suggests that the unit is oscillating — check C4, C6 and C7. An oscilloscope, if available, will confirm this by connecting it across the output terminals.

NEXT MONTH...

2 FREE TRANSISTORS

Plus...6 Projects to Build

telectric... Electricity Cost Monitor



This unit can provide instant and long-term cost monitoring of almost any electrical appliance. It is programmable up to a maximum cost per unit of 9·999 pence and can monitor a total cost up to £99.9 over a maximum period of 99·9 days at better than one per cent accuracy on a 13A load.

Now you can readily find out if it pays to switch your water heater on and off, how much the freezer costs to run or what the cost of tumble drying the clothes is, etc. **Another breakthrough for microprocessor technology and another 1st for PE.**

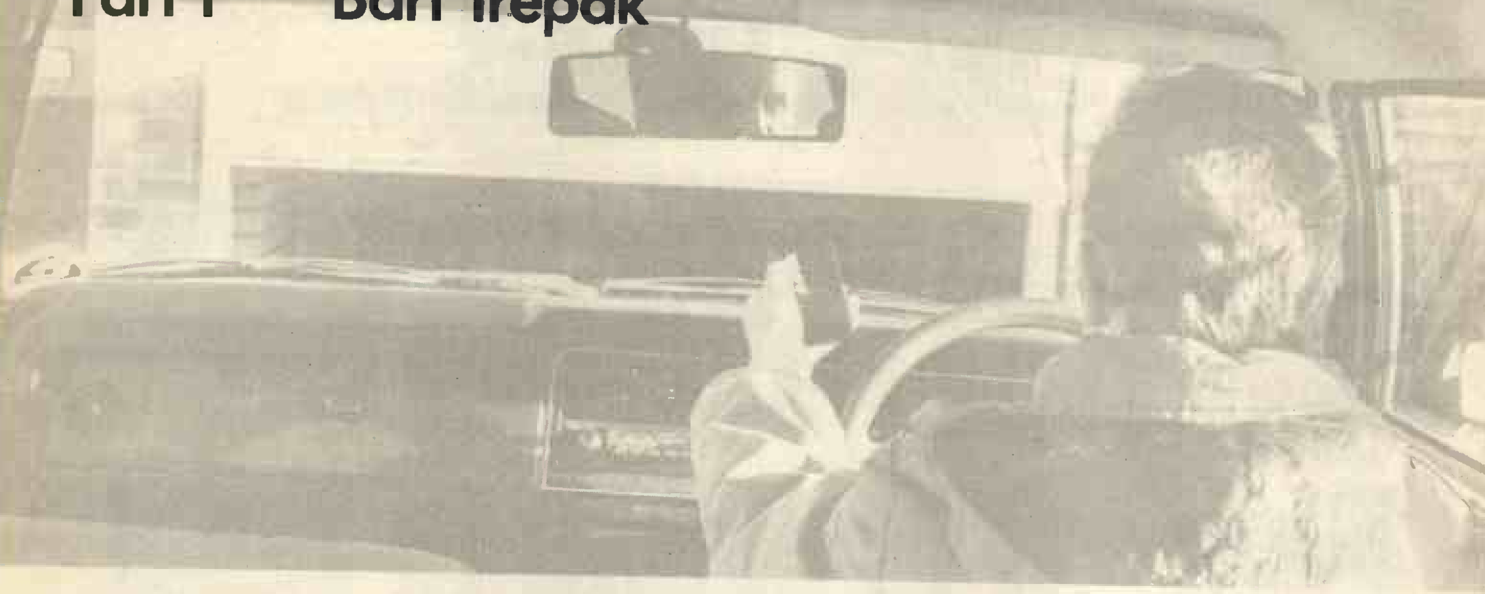
PRACTICAL

ELECTRONICS

MARCH ISSUE ON SALE FRIDAY FEBRUARY 12th

IR REMOTE CONTROL

Part 1 Bart Trepak



WITH English weather being what it is, it is strange that the remote control of garage doors is only now becoming popular. Until recently, the only alternative to getting out of your car to push a button to open an electrically operated garage door was to use a radio transmitter. This, although it has a good range, tends to be expensive and requires a licence. The obvious solution nowadays is to use infra red which uses inexpensive robust transducers which may be readily weatherproofed and penetrate glass easily, enabling a compact hand held transmitter to be built and then operated from within a car.

Since infra red transmitters are now being used to control televisions and other domestic equipment, it is essential from a security point of view to encode the infra red transmission to prevent anyone gaining entry to the garage by using his television transmitter. This also gives the system a high degree of noise immunity and prevents operation by natural sources of infra red, such as the sun.

The system to be described incorporates all the above features, together with a few novel ideas. The receiver is mains powered and has three outputs; a momentary action relay and two independent latched outputs with a common reset. The transmitter is a small hand held unit with four pushbutton switches and is powered by a PP3 9V battery.

The circuit is by no means limited to garage door control and may be used with slight modification to switch anything from televisions and radios to slide projectors. Further uses will be described later in the article.

THE TRANSMITTER

The circuit diagram of the transmitter is shown in Fig. 1. The transmitter circuit is based on the SL490 encoder i.c. which is capable of transmitting up to 32 different serial codes. Normally, the i.c. is used with a keypad matrix, the i.c. decoding the key that has been pressed and generating a 5-bit serial word corresponding to that particular key. This word consists of six pulses and it is the time interval between the pulses which is important (Fig. 2). A long period (t_s) is decoded in the receiver as the start of the word while a short period is a logic 1. A period between these is identified as a logic 0. The three periods, t_s, t_o and t_i are maintained in the ratio 6:3:2 by the i.c. Thus, by setting the t_o time, t_s and t_i are automatically set. This is done by adjusting the frequency of an internal oscillator by means of R1 and C1. The logic '0' period is given by $t_o = 1{\cdot}4C1R1$ sec., where R1 and C1 are in ohms and farads respectively. A code word, say 00001, is obtained by connecting pins 5 and 15 on the i.c.

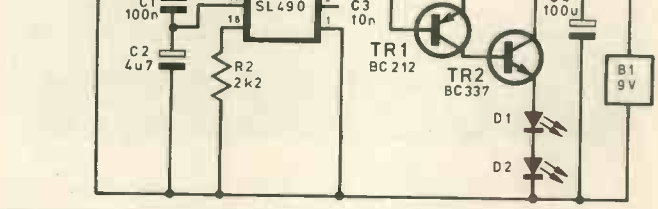


Fig. 1. Transmitter circuit diagram

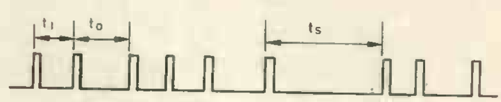


Fig. 2. Typical PPM waveform

When a key is pressed, say open/close, the i.c. detects this and generates the appropriate code, in this case 00001. The code continues to be generated while the key is depressed and when the key is released, the code transmission is completed before the i.c. powers down. This avoids the need for a separate on/off switch in the transmitter.

The negative going edges of the pulses appearing at pin 3 of the i.c. are amplified by the pnp transistor (TR1) and the npn driver (TR2) which pulses the two IR diodes. The pulse width is set at about 15μs by the capacitor/resistor combination, allowing the diodes to be driven at high currents to enable a reasonable range to be obtained while keeping the battery drain low. By fitting plastic clip-on-reflectors to the l.e.d.s, the range of the prototype was in excess of 40 feet, which should be sufficient for most applications. Without the reflectors a range of approximately 20 feet was obtained.

Since the receiver will only respond to the correct code at the correct data rate, each receiver/transmitter may be "tuned" to one frequency. This is best done by selecting a suitable value for R1 and C1 in the transmitter and adjusting the oscillator frequency in the receiver to suit. In this way, all receivers, although programmed to respond to the same code will not respond to a transmission unless the frequency (data rate) is also correct. The receiver oscillators may be tuned between 15Hz and 150kHz and with the allowed frequency tolerance up to three different frequencies per decade are available.

The transmission of other codes requires only the addition of a pushbutton (one per code) and three further codes (00010, 00100 and 01000) may be used without adding to the receiver complexity. These codes are used to control two independent on/off functions in addition to the open/close function.

THE RECEIVER

The receiver circuit shown in Fig. 3 uses a photodiode D1 to detect the IR radiation. This is basically a large area silicon diode specially fabricated to have a low junction capacitance, enabling it to respond to fast light pulses. The diode is reversed biased by transistor TR1 and associated components. This circuit presents a high impedance to the fast pulses of infra red from the transmitter but has a low impedance to d.c. or slowly varying IR from extraneous sources such as tungsten lamps, the sun, etc. The diode specifed is, in fact, encapsulated in a material which is opaque to visible light so that the diode responds only to the IR part of the spectrum, peaking at around 950nm, which is the wavelength transmitted by the diodes in the transmitter.

Any incident IR light increases the leakage current of the diode and the resulting voltage across the load is fed to IC1, which is a high gain 3-stage differential amplifier. The frequency response and gain of each stage may be set by external resistors and capacitors. For maximum gain, the resistors are dispensed with except the one at pin 8, which controls the gain of the second stage and prevents instability. The output of the amplifier which consists of positive going pulses is coupled directly to the decoder IC2. This i.c. contains a counter which is reset whenever a pulse is received and allowed to count at half the oscillator frequency set by the capacitor and resistor connected to pin 2. If the oscillator has been set to 1·5kHz, for example, resetting is blocked for the first 14ms after a pulse has been received and windows from 22ms to 40ms determine whether a logic 0 or 1 is transmitted. Periods between pulses 40 and 80ms are recognised as word intervals. After checking that 6 pulses of 5 bits have been received, and the word is valid one, it is stored. Two consecutive and identical words must be received, before the outputs of the decoder will respond to the incoming code.

This pulse position modulation (PPM) system ensures that neither the transmitter or receiver oscillator frequencies need to be particularly stable and a variation of up to 10 per cent can be tolerated by the system. High noise immunity is also obtained by this circuit, and noise of a sufficient amplitude and rate will only prevent the decoder from responding. The four outputs of IC2 respond to the transmit-

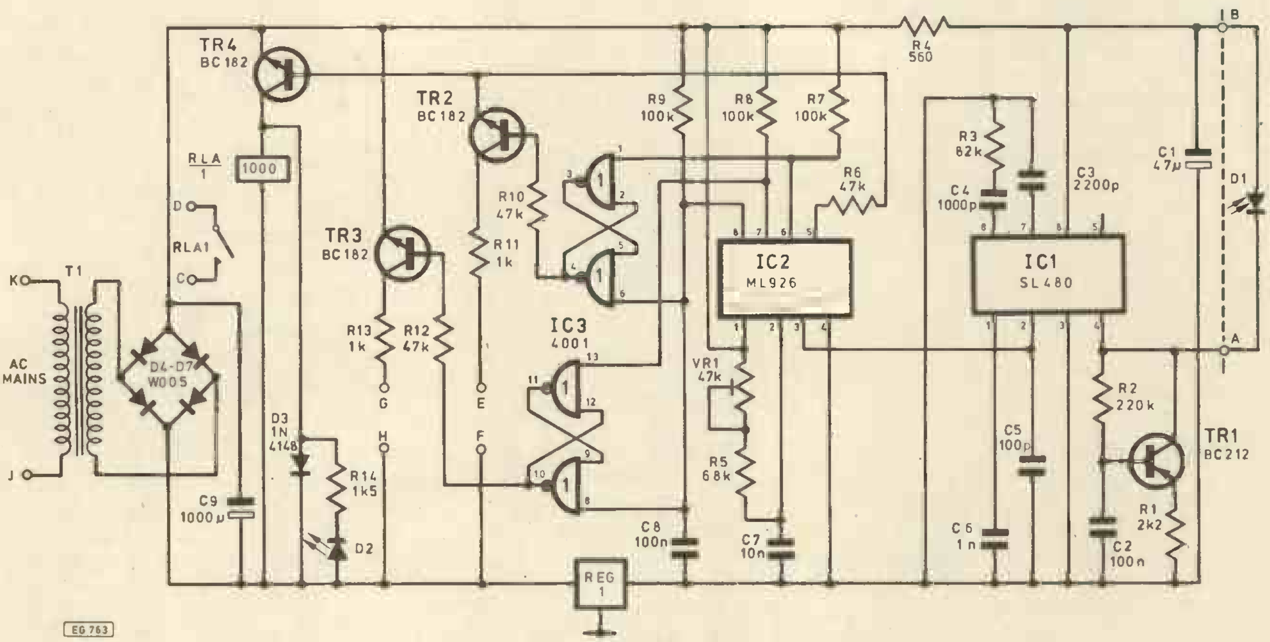


Fig. 3. Receiver circuit diagram

ter codes 00001, 00010, 00100 and 01000. Thus each output may be switched by transmitting the appropriate code, no further decoding being required. The outputs are normally logic 0 (if pull down resistors are used) going to a logic 1 (+15V) for the duration of the transmission. Most motor driven garage door controllers require a single contact closure (i.e. pushbutton switch) to initiate the opening or closing action; various other interlocks being present in the controller to switch the motor off when the fully open or closed position is reached, together with the logic necessary for controlling the direction of the motor drive. This will not be described as this circuitry is normally supplied with the motor.

The pushbutton may thus be replaced by a reed relay driven via a transistor from one of the i.c. outputs, i.e. TR4, RLA/1 and associated components. The other three outputs on the receiver may be used to control other functions or equipment if required, such as drive lights, etc. Two of the decoder outputs are used to control the set inputs of two RS bistables wired from the four NOR gates available in a CMOS 4001 package. By transmitting codes 00010 or 00100 the outputs of the respective bistables may be switched to logic 1. This will turn on TR3 or TR4.

The transistors TR3 and TR4 can be used to control mains loads such as lamps by using the circuit of Fig. 4. When the transistor switches on, the l.e.d. in the opto isolator switches on. The opto isolator specified differs from normal isolators in that it has a triac output instead of the more common transistor types. This triac is used to switch the main triac CSR1, which can be rated to carry the full load current. The advantage of this arrangement, apart from isolating the remote control receiver circuit from the mains, is that no separate supply is required to trigger the triac. Also, if the lamp or other device to be switched is a long way from the receiver, the circuit of Fig. 4 may be located conveniently close to the load and connections made using cable with a low voltage rating, e.g. bell wire, without the precautions necessary with wiring carrying mains voltages, thus making the system easier and cheaper to install.

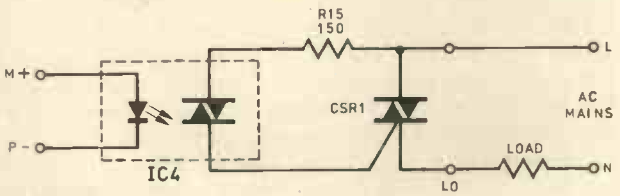


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Fig. 4. Mains control board

NEXT MONTH: Construction and applications.

COMPONENTS . . .

TRANSMITTER

Resistors

R1	33k
R2	2k2
R3	10k
R4	82

All resistors ¼W 5% carbon

Capacitors

C1	100n
C2	4μ7 100V elect.
C3	10n 50V ceramic
C4	100μ 10V elect.

Semiconductors

D1, D2	LD271 (2 off)
TR1	BC212
TR2	BC337
IC1	SL490

Miscellaneous

Hand held control box
Keyswitches (4 off)
l.e.d. clips

RECEIVER

Resistors

R1	2k2
R2	220k
R3	82k
R4	560
R5	68k
R6, R10, R12	47k (3 off)
R7, R8, R9	100k (3off)
R11, R13	1k (2 off)
R14	1k5
R15	150

All resistors ¼W 5% carbon

Potentiometers

VR1	47k vertical preset

Capacitors

C1	47μ 16V elect.
C2, C8	100n polyester (2 off)
C3	2200p ceramic
C4, C6	1000p ceramic
C5	100p ceramic
C7	10n polyester
C9	1000μ 25V elect.

Semiconductors

D1	SFH 205
D2	CQY 40
D3	1N4148
D4–D7	W005
TR1	BC212
TR2, TR3, TR4	BC182 (3 off)
IC1	SL480
IC2	ML926
IC3	4001
IC4	MOC3020 opto isolator
REG1	78L15
CSR1	TIC 226D

Miscellaneous

T1	Mains transformer 18V 100mA Sec.
RLA	Reed relay 1000Ω coil

7 2-way p.c.b. terminal blocks
Suitable case

Constructors' Note

A complete kit of parts for the infra red remote control is available from **TK Electronics, 11 Boston Road, London (01-579 9794)**

Digital Design Techniques...

Tom Gaskell B.A.(HONS) ELEC. ENG.

Part 7 When Analogue meets Digital...

IN the series so far we have concentrated on the design and operation of "all-digital" circuitry; the only interface with the analogue world has been the driving of l.e.d. displays and simple loads, and the control of logic inputs by sensors and switches. This month we carry these principles further, into the driving of more complex displays, and into the areas where analogue and digital circuitry meet and interact directly.

MULTIPLEXING

The term "multiplexing" is used to describe the process of scanning, sampling or feeding signals to various points in a circuit on a repetitive continuous basis. A single pole 12-way rotary switch can be used to feed a signal to one of 12 destinations, one at a time, or to collect a signal from each of those 12 destinations, one at a time; if this switch is rotated continuously it becomes a multiplexer. (Often, the term "multiplex" is reserved for the collection of data into one signal, and the term "de-multiplex" is used for the distribution of a signal to many destinations.) The technique of multiplexing is essentially used to cut down on the amount of circuitry or interconnections within a system: if the multiplexer is operated at a fast enough rate, a common wire or circuit can be used by many different signals which all "time share" the common circuit. The circuit design, of course, must allow for the fact that signals become non-continuous or "sampled". In most cases this is a very simple problem to overcome.

Our immediate interest in the technique of multiplexing is in the design of multi-digit displays. Such a display might consist of, for example, four 7-segment l.e.d. displays mounted adjacently. Each of these four displays would require seven wires carrying the drive current to its segments, and one common connection. Hence, there would have to be a total of 28 l.e.d. driver stages to feed the whole 4 digit display, and 28 interconnections between that driver circuitry and the display (plus common connections, of course). This would prove to be very complex and costly, so we choose to multiplex the l.e.d. drive to each display. All the appropriate segments of each digit are illuminated for a small fraction of a second. The first digit has its segments illuminated, then the second, then the third, and finally the fourth. After the required segments of the fourth display have been illuminated, the first starts again, and so on.

The human eye has a "persistance", which means that any flashes of light which occur at a frequency of above 20 to 30Hz "run together" to give the effect of a continuous glow. This is the same principle on which individual still picture frames on the television or on cine film can be made to appear to give continuous motion. Hence, if we ensure that each display is illuminated more frequently than 20 or 30 times per second, there will be no obvious flickering due to the multiplex action, and the segments will appear to be continuously lit. This technique is normally limited to 8 digits or less; more than this can again cause flicker or extreme dimness, because the eye begins to detect the "off" periods. For more than 8 digits, several separate multiplex systems should be used.

The drive circuitry must be specially configured to ensure that the correct segments for any particular digit are illuminated at exactly the right point in time; see Fig. 7.1. The switches are shown diagrammatically as "mechanical" switches; in fact, these are all logic gates (with current driving stages interfacing with the common anode display), gated on and off by the control logic.

Although the diagram may appear to be complex, the techniques used lend themselves very readily to building in i.c. form, usually with other circuitry to actually generate the signals which require to be displayed (counters, decoders, etc.). The whole circuit can be made complete by these means, and connections to the i.c. can be kept to a minimum. The most common example of this is in a counter i.c.; a four (or more) digit BCD counter with many different functions is incorporated with a complete multiplexed driving circuit, all in the same i.c. Hence, only eleven connections are needed between the i.c. and the entire display!

If all the displays are turned off for a fraction of a second prior to each change of the "digit selector" multiplex switch, then the display will appear dimmer than when no "all-off" states were used. By varying this off period, the display brightness can be continuously varied; this is usually done by varying the mark/space ratio of the clock, and using the clock waveform to disable the display driving logic. Because each l.e.d. segment is only illuminated for a short period of time, fairly high peak currents can be passed through the segments, resulting in high brightness illumination yet maintaining a safe average current flow. By this means, the whole circuit can draw less current than a non-multiplexed one (i.e. "direct drive") yet can appear to be brighter!

OTHER DISPLAY TYPES

Phosphorescent displays are often seen in calculators and digital clocks, giving out a pleasant blue-green colour. Their operation is similar to that of a cathode ray tube, with a heater cathode, a grid, and an anode coated with a fluorescent phosphorous material. They can be driven by standard

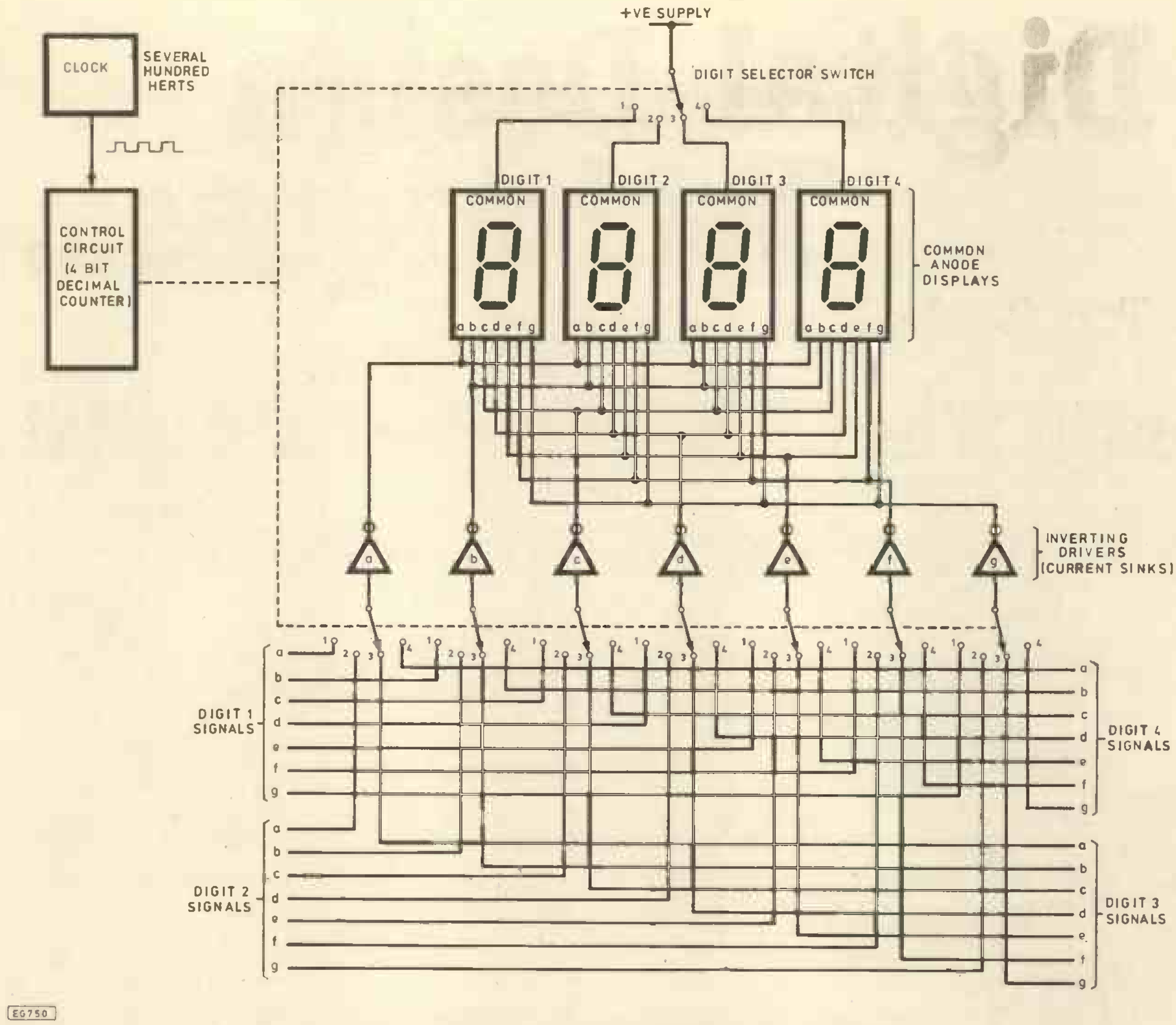

Fig. 7.1. Block diagram of a multiplexed display system

15 volt CMOS 7-segment drivers, but external voltages must be applied to correctly bias the grid and to supply current to the heater filament. Multiplexing of these displays is quite straightforward.

Gas discharge displays produce a very bright orange glow which is sometimes filtered to appear orange/green in colour. A high drive voltage is needed, typically 180V d.c., so special display driving i.c.s must be used. Multiplexing is more difficult than in the case of other displays, and normally requires the use of a number of different driver i.c.s for the whole display.

One of the newer display types is the liquid crystal, as seen in digital clocks, watches and calculators. Its main advantage over the other technologies is its low power consumption. Each display segment merely allows light to pass through it or blocks the light, it is not self illuminating, so virtually no power is consumed. To maintain contrast and give good life expectancy, there must be NO d.c. signal whatsoever across the display. A special form of a.c. drive is used, as shown in Fig. 7.2.

The divide-by-two circuit is added to ensure that the drive to the EX-OR gates and the backplane is exactly a square wave; if this were not so, there would be an overall d.c. component across the liquid crystal. When the segment input is at logic 1, the segment drive voltage and the backplane voltage are exactly 180° out of phase (i.e. the inverse of

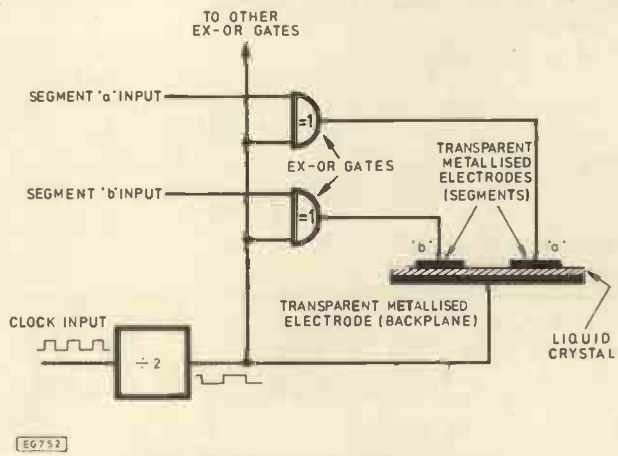

Fig. 7.2. Liquid crystal driving circuit

each other) so there is an overall a.c. voltage across the liquid crystal, resulting in the segment appearing dark. When the segment input is at logic 0, the segment drive and the backplane are exactly in phase; there is no voltage across the liquid crystal and the segment remains transparent. This circuit arrangement is fairly straightforward, but again is ideally suited to incorporation within a larger i.c. For this reason, many complex i.c.s have their own built-in liquid crystal drive circuits. Multiplexing of liquid crystals is possible, but due to their very slow response time the frequency of operation of the mulitplex system must be kept low. As a result, the number of digits which can be multiplexed tends to be lower than with other display technologies.

There are yet more display types, for example the large displays seen in airports and stations, and the small incandescent 7-segment displays often found in petrol pumps, but their use is more limited, and we won't go into it here. Formats other than 7-segment are possible, of course; for example, the 16-segment display, which permits the full alphabet to be displayed with good intelligibility. This is often seen in sophisticated test instruments, small computer terminals, supermarket checkouts, etc. This display is shown in Fig. 7.3. The 16-segment format, and others giving various dot matrices, shapes, characters, etc., can all be controlled and multiplexed in similar ways to the 7-segment types. The use of them, however, is very specialised, so we won't be giving further consideration to it. We shall move on, instead, to the control of analogue signals by digital gates.

THE ANALOGUE TRANSMISSION GATE

The CMOS family is unique in having the ability to switch analogue signals on and off using digital controls. This is essentially due to the characteristics of the MOSFETS used to make up CMOS i.c.s which can be made to act as voltage controlled resistors over part of their operating range. When an N-channel and a P-channel device are connected "back-to-back" in a circuit, any analogue voltage within the supply rails can be turned on and off; the gate can pass the analogue signal, or block it in the same way as a conventional mechanical switch. The diagrammatic representation of this gate is shown in Fig. 7.4. It's known as an "analogue switch", or "analogue transmission gate".

Note that the device is bi-directional; there is no statutory input or output terminal, and so signals can pass in both directions, again like a conventional switch. The "control" terminal is simply fed from a normal CMOS level, since it is an ordinary CMOS gate input.

DEGENERACY EFFECTS

To a circuit designer the analogue transmission gate can seem too good to be true! In reality it is a useful and versatile circuit element, so long as some basic facts and limitations of its use are observed. The voltage handling capability of the device is limited; analogue voltages must not exceed the supply rails. The current that may be passed through the device is limited to only a few milliamps. Ron, the effective series resistance of the switch, varies with the supply voltage and signal voltage. From an initial value of between 80 and 200 ohms, this variation of Ron with signal amplitude can cause distortion of the signal waveform; typically 0·4% at 1kHz. The effective parallel capacitance, Cf, causes breakthrough of signals when the switch is in the "off" state; —50dB at 1MHz is typical.

Finally, there is the problem of "click breakthrough". Due to capacitive coupling between the control and the input/output terminals, a transient spike is fed into the analogue circuitry whenever the logic state of the control input is changed. This spike causes audible clicks in audio cir-

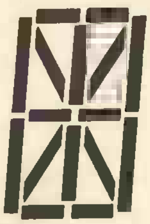

Fig. 7.3. The 16-segment display format

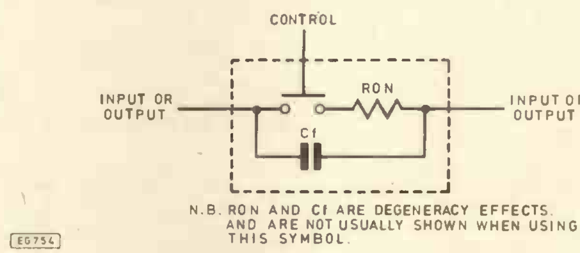

Fig. 7.4. The Analogue transmission gate

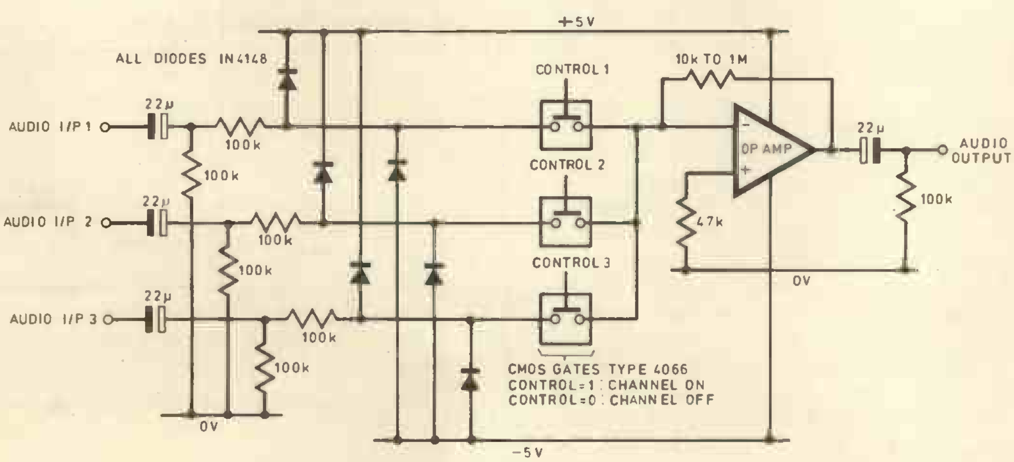

Fig. 7.5. Audio input selector circuit

cuitry, and can give rise to errors and other problems in non-audio systems.

Various design techniques can be used to get round these problems. For example, using the switch in series with fairly large values of resistance (10k and 100k) helps to prevent the value and the variation of Ron from affecting the signal amplitude significantly. Fig. 7.5 shows a typical audio input selector circuit, for controlling the inputs to an audio mixer or pre-amplifier. Note that the supplies to the entire logic system should be: Vss = −5V, Vdd = +5V. This ensures that symmetrical analogue signals about zero volts can be correctly handled by the circuitry.

Because the transmission gates are fed directly into the virtual earth input of the op-amp, which is a very low impedance point, the click breakthrough is minimised; for most audio systems it will be reduced to an unobtrusive level. If minimisation of signal breakthrough in the "off" condition is the most important parameter, then using two switches with their controls inverted is the norm, as shown in Fig. 7.6. This ensures very effective muting of signals in the off state, i.e. when the control is at logic 0.

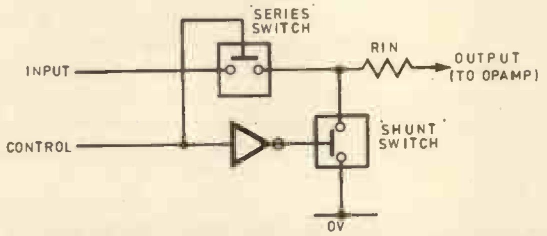

Fig. 7.6. Circuit to minimise signal breakthrough

The most widely used CMOS analogue switches are the 4016 and the 4066, the latter having better performance but at a slightly higher cost. These are both "Quad" switches i.e. they have four independent switches in the one package. The 4416 is another device, which has its four switches internally arranged to provide the format of a double pole, double throw switch. Other CMOS analogue switches are available, specifically designed to achieve extremely low Ron values and much improved overall performance. They are, however, very expensive; several pounds per i.c. as opposed to 40 to 60 pence per i.c. for the simpler CMOS devices, so they tend only to be used in more specialised and demanding applications. A variety of analogue multiplexers are also available working in a very similar way to the digital multiplex systems described earlier. The 4051, 4052 and 4053 are all popular, and have built in level shifters to allow the logic control levels to be different to the analogue supply voltages, for example, 0 to +5 volt logic could be used, while the analogue signal supplies could be +5V and −5V. The 4067 has a more conventional supply arrangement, but is a very large (24 pin) device, with a total of 16 analogue channels; again, a fairly popular device for larger applications.

DIGITAL TO ANALOGUE CONVERSION

By using analogue switches and a combination of resistors a binary number can be used to control the amplitude of an analogue voltage. If the circuitry is arranged such that the analogue voltage is exactly proportional to the value of that binary number, then we have an accurate "Digital to Analogue" or "D to A" converter. This can be of considerable use to us, as it enables purely digital signals and codes to be converted into analogue levels which can then feed into other circuitry and systems. For example, digital circuitry could be used to generate a series of numbers which increase and decrease in size continuously in an accurate and controlled way. By using a D to A converter, this could be turned into a digitally controlled sine-wave, which could then be fed into an audio system for test purposes.

There are many different types of D to A converter, each with its own particular advantages and disadvantages, but to illustrate the principles involved Fig. 7.7 shows one of the most common arrangements, the "Binary Ladder" (a 3-bit device is shown for simplicity). The reference voltage generator is a very stable, temperature compensated voltage source, producing a precise output voltage level; for the purposes of this example, let us say that it produces 8 volts. The voltages given out by the circuit are shown in Table 1. Only two resistor values are used, R and 2R; these are usually high stability close tolerance resistors, since their accuracy largely determines the accuracy of the whole conversion. The op-amp on the output prevents the other circuitry, which is fed by the converter, from having any loading effect on the ladder.

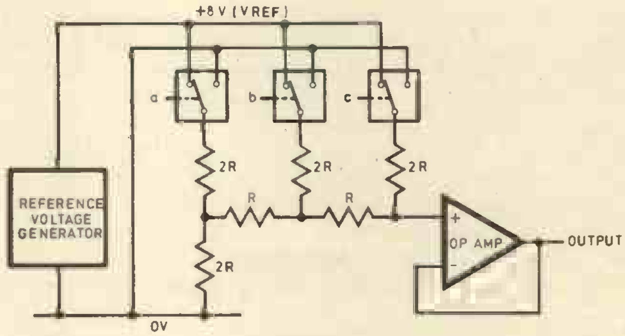

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Fig. 7.7. The binary ladder D to A converter

TABLE 1

INPUT			OUTPUT VOLTAGE
c	b	a	
0	0	0	0
0	0	1	1V
0	1	0	2V
0	1	1	3V
1	0	0	4V
1	0	1	5V
1	1	0	6V
1	1	1	7V

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Not all D to A converters use CMOS switches. To achieve fast operating speed and high accuracy, other switch circuitry is used, often PMOS, or even conventional bipolar transistor switching. Most D to A converters come as a complete i.c., with or without a precision voltage reference, so their design and operation is a very straightforward process in most applications.

ANALOGUE TO DIGITAL CONVERSION

This is a more complex business than D to A conversion, and is a more widely used technique. A to Ds are found in all digital multimeters and voltmeters, as well as in instrumentation; test equipment, computer interfaces, etc. Some techniques use voltage controlled square wave oscillators, with the analogue voltage controlling the oscillator frequency, and the digital circuitry measuring that frequency. This design, however, is fairly crude, and is usually slow and inaccurate.

The most basic system is the "comparison" A to D converter shown in Fig. 7.8. Initially, the counter is at zero and the output of the D to A converter is 0 volts. When a positive analogue input is applied, the comparator output goes high, i.e. logic 1. This enables the NAND gate, which then feeds clock pulses to the counter, causing it to count upwards. This count is fed to a D to A converter, which re-converts it back to an analogue voltage and feeds it to the other comparator input. When the D to A converter output becomes

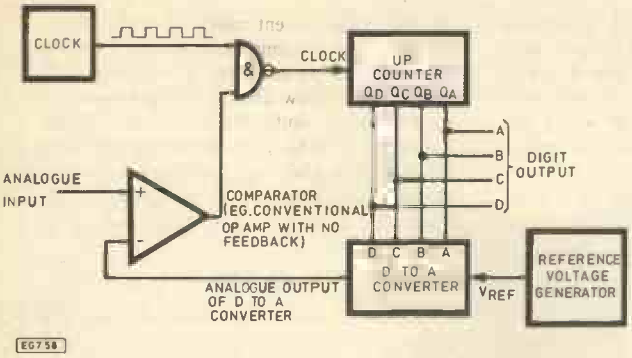


Fig. 7.8. The "Comparison" A to D converter

marginally higher in voltage then the analogue input, the output of the comparator goes low, i.e. logic 0, so the clock pulses are inhibited from feeding the counter. The counter output is now the final converted digital output; it can be latched into the following circuitry; the counter re-set, and the process can start again. Unfortunately, this is a very slow way to convert from Analogue to Digital. The number of clock pulses needed for a large signal levels is considerable, so it can take a relatively long time to perform the conversion. Surprisingly, one of the fastest generally used techniques for conversion is an adaptation of the same principle:

THE SUCCESSIVE APPROXIMATION CONVERTER

The counter in a "comparison" A to D converter is replaced by a complex set of circuitry which effectively makes a series of "guesses" as to the final value of the converted digital number. After each guess had been made, the output of the comparator is examined, and the logic state of the comparator output determines the next guess to be made. For example, to convert an input of 5 volts to the binary number 101:

1) Guess that the most significant bit (MSB) is 1, so set input to the D to A to be 100.
2) Output of comparator is still logic 1, so our final number must be higher than 100.
3) Guess that the next most significant bit (NMSB) is 1, so set input to the D to A to be 110.
4) Output of comparator goes to logic 0, so our final number must be lower than this.
5) The final number must be larger than 100, yet smaller than 110, so the answer is 101.

This may appear rather lengthy and complex, but for large numbers of bits it is a very effective and fast system.

SLOPE INTEGRATION

This is the final type of A to D conversion that we shall consider, and is the most widely used technique. See Fig. 7.9. A "start" signal causes a voltage ramp to be generated by the ramp generator circuitry, which starts at a negative voltage and passes through zero volts. As zero is passed through, comparator 2 feeds a pulse to the latch, causing the following NAND gate to be enabled, which then feeds the clock pulses to the up counter. When the analogue input level is reached by the ramp, comparator 1 passes a pulse to the other latch input, causing the NAND gate to be disabled and preventing any further counting from taking place. The digital output is now proportional to the time "t" taken for the ramp voltage to pass from 0 volts to the analogue input voltage. For a "straight line" voltage ramp slope, the digital output is proportional to the analogue input voltage.

The technique is not very fast, but can be made quite accurate by careful circuit design. A further refinement uses "dual slope integration"; a second ramp is generated after the first, travelling in the opposite direction back towards zero. The counting is done during this second ramp period, which helps to remove effects caused by noise and interference on the analogue input.

As in the case of D to A converters, the majority of A to D's are available in i.c. form, with only a small number of external components needed to complete the circuit. The use of all these different types of converter is rather complex, and further reading is essential prior to the design of any system in which such a circuit is to be used; there are many hidden requirements and conditions which must be met. For example, the input voltage must be held constant during the conversion from analogue to digital, necessitating the use of a "sample and hold" circuit. These details are beyond the scope of this series, however, since we are mainly concerned with the digital side of the process!

NEXT MONTH:

Next month, in the final article of the series, we look further into LS1, and into the realm of the microprocessor and microcomputer. We cover the forefront of digital circuit technology, and the changes that we can expect to see in the next few years.

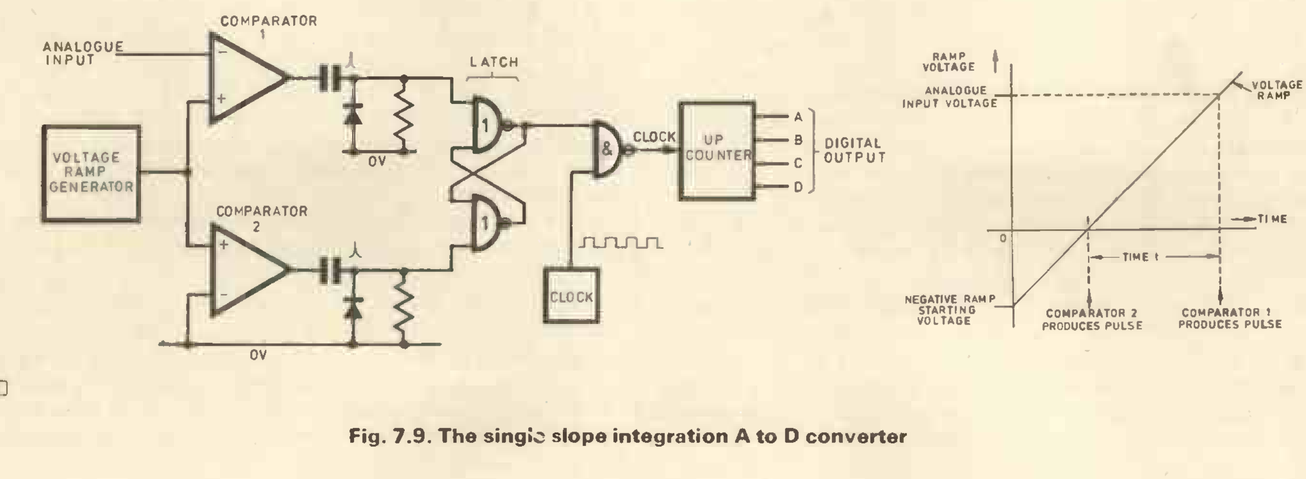


Fig. 7.9. The single slope integration A to D converter

FRANK W. HYDE

SAD NEWS

President Ronald Reagan's budget has severely curtailed some of the most important activities of the American Space Programme. Now, in addition to withdrawing from the Halley Comet original programme, there comes the news that three of the Deep Space Tracking aerials, the 85ft diameter dishes, will be shut down. Three of the 210ft dishes will continue to monitor data from Voyagers 1 and 2, Helios 2, the Viking 1 lander on Mars and Pioneers 6 to 12. There will also be included the Venus orbiter, which is still returning data from above the atmopshere of the planet. This is at least something, but still there will be a 30% reduction in data acquisition capability.

That this preserved the Shuttle from being set back is to be regarded as good, for there is more need than ever now to move forward in space. Fortunately, the next Shuttle 099 is 80% complete. The experience gained from the two missions of the model 102, now known as Columbia, has contributed much to bringing the 099 along. This vehicle was originally a test-bed facility and only recently, in order to reduce the time scale, the vehicle was judged fit to take to operational level. This means that the target dates for 1982 can be met.

Orbiter 099 will be the first of the vehicles to be fitted with a head-up display. These instruments developed by Kaiser Electronics will enable the flight crews to have information as to approach, that is the altitude, airspeed and heading displayed in front of the commander and pilot. Each will have his own independent equipment. These are mounted in the shuttle avionics bay. A small screen about 6 inches square gives the information. The first instruments will reach the Orbiter 099 assembly in January 1982. Each of the succeeding Orbiters, as well as Columbia, will also be equipped in the same way.

Orbiter 103 will have a new type of thermal protection. This results from the development of a new material FRCI-12. This is a mixture of 75% silica fibre and 22% aluminium borosilicate with a density of 12lb per cubic foot. The strength of these new tiles is said to equal those previously used with a great saving in weight. The new tiles will weigh just over half that of the present ones. The performance is judged to be as good. When considered overall, the weight benefit could be as great as 1200 lb.

THE THIRD MISSION OF COLUMBIA

The next date for Columbia to go aloft is expected to be in early March 1982. This mission is planned for up to seven days. In addition to extending the length of the mission, Columbia will have a greatly increased workload. A number of new services are to be monitored in operation.

The launch will, as in the previous flights, be from the Kennedy Space Centre in Florida, and the return landing will again be at the Dryden Flight Research Facility, the dry lake bed in California. The major object of the third flight will be to check out the vehicle's capabilities and flight characteristics. In addition, this flight will carry more scientific and technical experiments than last flight.

On this flight there will be an innovation which will give a very wide range of use to independent business. It will rent space on the shuttle to small businesses, individual and small laboratories. These customers will have to enclose their packages in such a way that can withstand exposure to weightlessness and to the environment. The smallest space likely to be offered is about 0·135 cu. metre, and will cost about 3,000 dollars. Up to 80 kilograms could be accommodated in that volume. Already more than 250 applications have been received from various individuals and organisations. This includes some countries outside the United States. NASA has a name for this new venture and is calling it the Get-Away Special.

One of these will, in fact, be a container which holds the required instrumentation to measure temperature, acceleration, vibration and noise. Its purpose is to discover what kind of conditions the Get-Away Specials may have to endure, orbital flight and re-entry into the atmosphere and subsequent landing, in order that the customers can prepare their packages suitably. This mission is the third phase of the planned life of the Shuttle, and after this third mission it will 'go operational'. This first operational flight is expected to be scheduled for late 1982. From this time, frequent flights will be offered for the placing of satellites, for communications, weather observation, navigation and earth resources, into earth orbit.

The Mission Staff Engineer Horace E. Whitacre said that they were adopting a 'building block approach' which means that at each successive launch the demands made on the vehicle are increased. For example, the launch trajectories already used have indicated that higher payloads could be used. Of course, this will increase the dynamic pressures.

On the third flight the manipulator arm will be used to move a load with its grasping device. While the vehicle is in orbit at about 240 kilometres above the Earth the arm will lift out an instrument called the Induced Environmental Contamination Monitor from the shuttle cargo bay and move it to various positions above, below and at different places on the body of the shuttle and then return it to the parking bay. This exercise, which will take about an hour and a half, will test the ability of the arm which weighs, or would weigh, on Earth 360 kilogrammes, to manipulate loads with precision. The exercise will enable the ICEM to detect pollution such as that from engine exhaust.

Among other experiments will be that which requires the nose of the shuttle to be turned to face the Sun. For 80 hours this will be continued, so that extremely high temperatures will be met. For 26 hours the cargo bay will be exposed to the Sun and then for 30 hours the tail also. Thus the extreme heat at the side facing the Sun will experience stresses throughout the frame for in each case the opposite side will become intensely cold.

It is necessary to know these things since the cargo doors must operate in spite of the uneven heat and must be able to be closed properly before coming back through the atmosphere to land. It might be necessary to do this in a hurry. The vehicle would not be expected to survive a re-entry with the doors open. These are but the preliminaries. A very extensive programme is scheduled for this 7-day trip. The experiments will include:

> A plant lignification test. This will use seedlings of oats, peas, pine and cucumbers to discover how the woody components and plant tissues react to weightlessness.
>
> Experiments to check the electrical and magnetic field effects and the radiation from solar flares.
>
> Some biological experiments to determine whether it is feasible to separate biological substances in weightless conditions.
>
> A special experiment of value to pharmacy where latex spheres can be made to much closer tolerances than on Earth. When these are added to medicines they can greatly improve their efficacy. The spheres can be made larger and more accurately in weightless conditions.

Another point of interest about the launch is that it has been decided to change the colour of some of the paint instead of the usual white protection paint over the brown insulation of the external fuel tank. Eliminating most of the white paint will not harm the insulation but will save 270 kilogrammes of weight. The flight engineers on the project are anxious to have a cross wind and so the next flight after Columbia in March may be scheduled to land at the Kennedy Space Centre in Florida. If the conditions are favourable on the return of the next shuttle a cross wind landing might be attempted in California.

The future is bright for this new era of space activities and already plans are so advanced in tentative form that these have been considered even as far forward as the 40th mission. The fifth flight is expected to carry a double crew, two as pilots and two as mission Specialists. Some of those who have waited long in the queue, must be seeing their dreams coming closer to realisation. Perhaps America will have 'First Woman in Space'.

TV CAMERA

PHILLIP GAFFNEY

Part 2

THE SOURCE of signal to be amplified by the video board is taken from a vidicon tube. This vacuum device produces an electrical signal, the amplitude of which is proportional to light focussed onto it by the camera lens. In order to explain the design parameters of the video board, it is first necessary to describe the vidicon tube in some detail as this component is the heart of the camera. See Fig. 2.1.

In essence, the vidicon comprises a light sensitive element and an electron gun housed in an evacuated glass tube. The camera lens is used to focus light from the scene being televised onto the light sensitive target of the vidicon tube. The vidicon's function is to convert this image into an electrical signal, suitable for processing by the rest of the camera.

The light sensitive element comprises a transparent conductive coating deposited on the inner surface of the tube faceplate. This layer is coated with a thin film of photoconductive material. A target ring is fitted to the outer edge of the faceplate and is connected to one side of the photoconductive layer via the transparent coating. The other side of the layer is scanned by a low velocity electron beam. The layer may be regarded as being composed of many discrete capacitors each one insulated from its neighbour, but each having one of its plates connected to the target ring via the transparent coating. The other side of each capacitor is left floating.

The target is biased to a positive potential and the electron beam is made to scan the floating side of all the capacitors. There is thus an electron flow which charges up all the individual capacitors. The individual discharge times of each capacitor will depend on the light falling on it, due to the photo-conductive nature of the target material. The greater the illumination, the lower the internal resistance, and the faster the discharge rate.

Therefore, each subsequent scanning will have to supply charge directly proportional in magnitude to the level of light falling on the faceplate between scans. This varying signal, as the electron beam scans all the capacitors, is sampled across a load and used as the video signal.

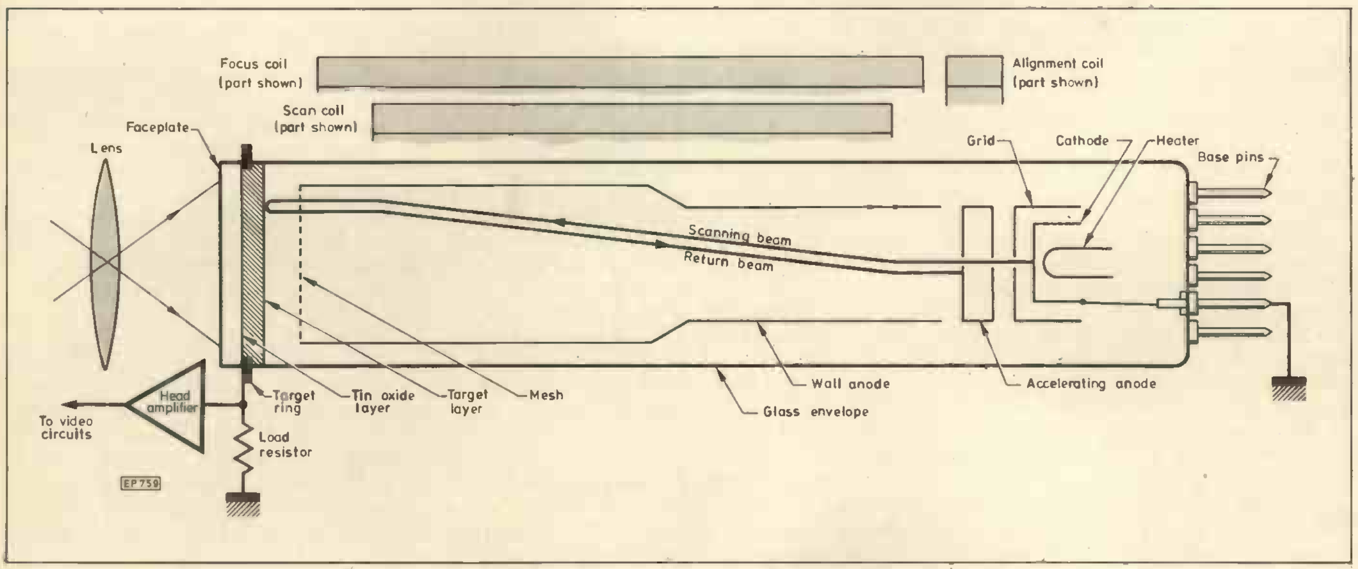
The electron beam is produced by an electron gun (comprising cathode, control grid and anode). The mesh anode is a fine wire mesh placed closely to, and parallel with the photo-sensitive layer to slow the electron beam down, reducing secondary emission and improving resolution.

The output of the vidicon may be considered as a current source (i.e. having infinite shunt resistance). Conversion of signal current to voltage is then achieved by passing I_t (target current) through R_i (input resistance of the video amplifier). Ohm's law $V_t = I_t \times R_i$, therefore, the magnitude of the voltage available to the video amplifier will be proportional to the value of R_i. However, there is also a shunt capacitance C_i which comprises the output capacitance of the vidicon and the input capacitance of the video amplifier. C_i will in conjunction with R_i set the maximum frequency response of the input network. See Fig. 2.2.

Essentially C_i is of fixed value, and therefore R has to be limited to a value giving 5-6mHz required for 625 line operation.

VIDEO AMPLIFIER CIRCUIT DESCRIPTION

The signal from the target of the vidicon is fed, via C2 which isolates the d.c. potential applied to the target from



the following stages, to the gate of a high frequency field effect transistor TR1. This transistor is used in the common source mode to provide a low impedance output to the next stage. The f.e.t. has a high input impedance, which prevents any undue loading of the vidicon's output, as with the high impedance associated with the vidicon, this would lead to degradation of the signal quality. See Fig. 2.4.

The drain to TR1 is a.c. coupled to the emitter of TR2 a common base stage by C4. This stage has a low input impedance together with a high output impedance giving a voltage gain of about 100. The common base configuration, because of its low capacitance between collector and emitter is very stable at high frequencies relative to the common emitter mode. The output of this stage is directly coupled to an emitter follower buffer stage—(high input impedance, low output impedance) to drive the next stage TR4 and the automatic light control circuitry, see Fig. 2.3. TR4 has a frequency peaking network as its emitter load, peaking its response for high frequencies. R11, C6 and R12 modify the phase response of the circuit. This stage provides an overall attenuation of the signal by a factor of four. TR5 and TR6 are d.c. coupled and are used to provide current gain and set the output impedance to a value suitable for the black-level clamp built around TR7. This field effect transistor ensures that at the end of a line the video signal is returned to blanking level. This N-channel f.e.t. can be likened to a switch which is normally on, but which may be biased off by applying a slightly negative voltage to the gate relative to the source. In our camera, the gate is supplied with line blanking pulses 12µs wide. Therefore, TR7 is turned on for 12µs at the end of each line. This forces the base of TR8 to the dc level preset by the pedestal control, hence at the end of each line, the video signal is held at blanking level to allow the later insertion of synchronisation pulses. The video signal buffered by TR8 is then mixed with line and field (mixed) sync. pulses. Diode D1 acts as a d.c. restorer and level shifter, resistors R, R26 and R28 are responsible for inserting the mixed sync. pulses from the logic board. These pulses are connected via the three way ribbon cable which runs between the video and logic printed circuit boards.

The d.c. coupled output pair TR9 and TR10 provide the necessary amplification and impedance matching to give either standard CCIR video at 75Ohm impedance, or direct drive to the UHF modulator unit which generates a modulated UHF carrier at around channel 36.

Throughout the video board, each stage has been separately decoupled with resistor/capacitor networks to improve stability and reduce interference on the video output.

The video board also carries the low voltage regulator and smoothing capacitor and the automatic light control circuit. The regulator is extremely simple as a monolithic integrated circuit is used, requiring only two small capacitors to form a highly efficient low voltage stabiliser. A 7815 IC is used, giving a 15V supply rail which is used to run the video board and logic circuits. This regulator is bolted to one of the aluminium support bars, which conducts heat away from it.

CONSTRUCTION

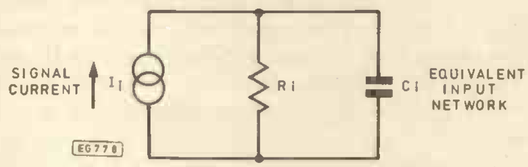
Once the p.c.b. is assembled (see Figs. 2.5 and 2.6) and the two aluminium bars attached, remove the cover from the UHF modulator and mount the modulator as shown, inserting the two wires into the correct holes.

Turn the board over, and whilst holding the modulator in position solder the leads and the earth tags. Refit the modulator cover.

The following components are mounted on the reverse side of the p.c.b.:

R52 5k preset
R23 5k preset
R27 5k preset
R40 5k preset
C16 1µ 35V

Fig. 2.2. Equivalent input network



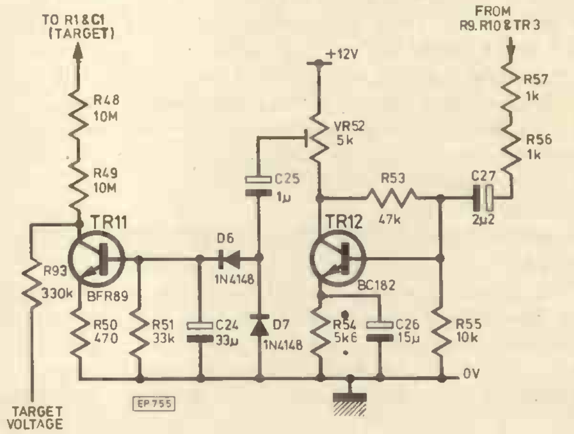
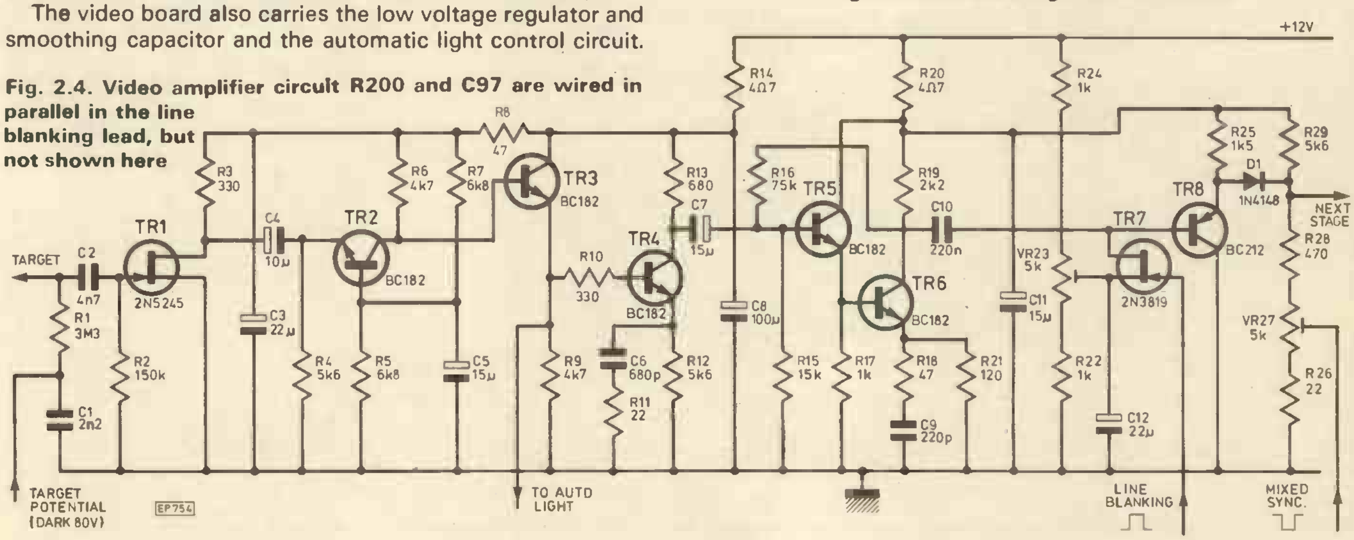


Fig. 2.3. Automatic light control circuit

Fig. 2.4. Video amplifier circuit R200 and C97 are wired in parallel in the line blanking lead, but not shown here



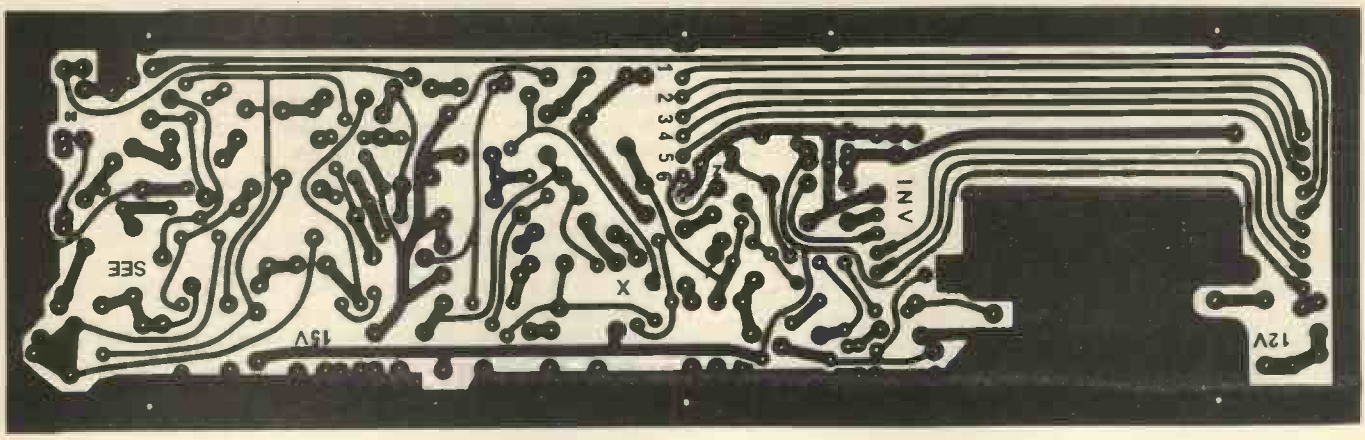
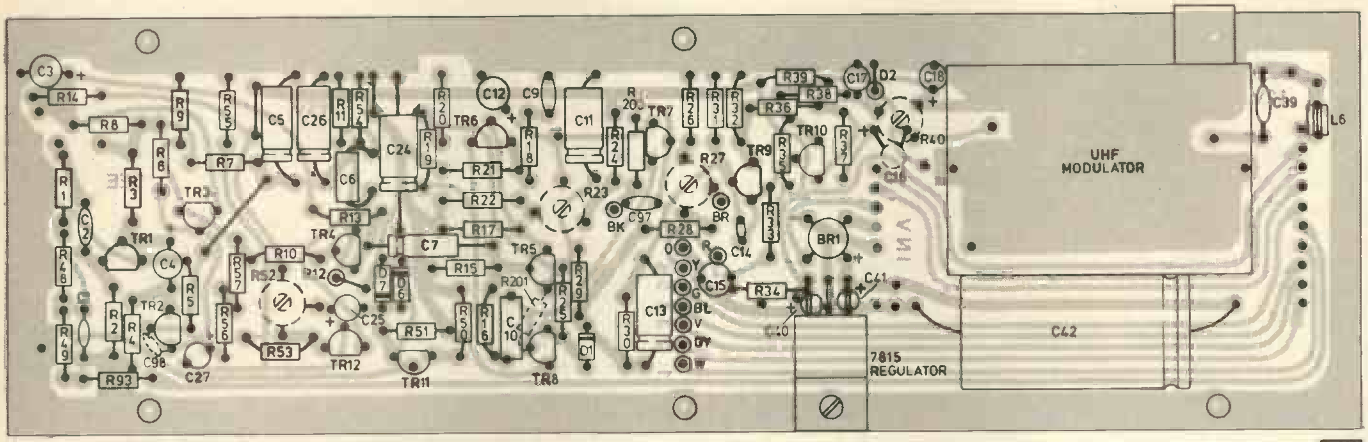


Fig. 2.5. Video Board p.c.b. (actual size)

Fig. 2.6. Video Board component layout



NOTE:COMPONENTS SHOWN IN BROKEN OUTLINE ON REVERSE SIDE

EA308

COMPONENTS . . .

VIDEO BOARD

Resistors

R1	3M3
R2	150k
R3	330
R4, R12, R29, R54	5k6 (4 off)
R5, R7	6k8 (2 off)
R6, R9	4k7 (2 off)
R8	47
R10	330
R11	22
R13	680
R14	4Ω7
R15	15k
R16	75k
R17, R22, R24, R33, R56, R57	1k (6 off)
R18	47
R19	2k2
R20	4R7
R21	120
R23	220k
R25	1k5
R26	22
R27	
R28, R36, R50	470 (3 off)
R30	680k
R31	560k
R32, R34	470 (2 off)
R35	56
R37	75
R38	3k9
R39	390
R48, R49	10M (2 off)
R51	33k
R53	47k
R55	10k
R93	330k
R200	220k
R201	27k

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

Potentiometers

VR1	5k cermet preset

Capacitors

C1	2200p
C2	4700p
C3	22µ/16V
C4	10µ/16V
C5	15µ/15V
C6	680p
C7	15µ/16V
C8	220p
C9	220p
C10	220p/63V
C11	15µ/16V
C12	22µ/16V
C13	15µ/16V
C14	22p
C15	47µ/16V
C18	4µ7/35V
C24	33µ/16V
C25	1µ/35V
C26	15µ/16V
C27	2µ2/35V
C39	150p
C40	1µ/35V
C41	1µ47/35V
C42	1000µ/25V
C95	10n
C96	2200p
C97	22n
C98	10p

Semiconductors

TR1	2N5245
TR2–6, TR9, TR12	BC182 (7 off)
TR7	2N3819
TR8	BC212
TR10	BC212
TR11	BFR89
IC1	7815 regulator

Miscellaneous

Printed circuit board
Varelco connectors
Copper screen
M3 screws, spacers and washers

Two wire links must be soldered across points 1-1 and 2-2 in Fig. 2.6. The link 2-2 needs to be insulated wire, and link 1-1 must be raised clear of the p.c.b. tracks.

Strip, twist and solder the 10-way ribbon cable to the insulated connectors. Screw the 7815 regulator to the aluminium bar using a 5mm screw. Fit the copper screen over the components using a nut and washer on each of S1, S2, S3 and S4.

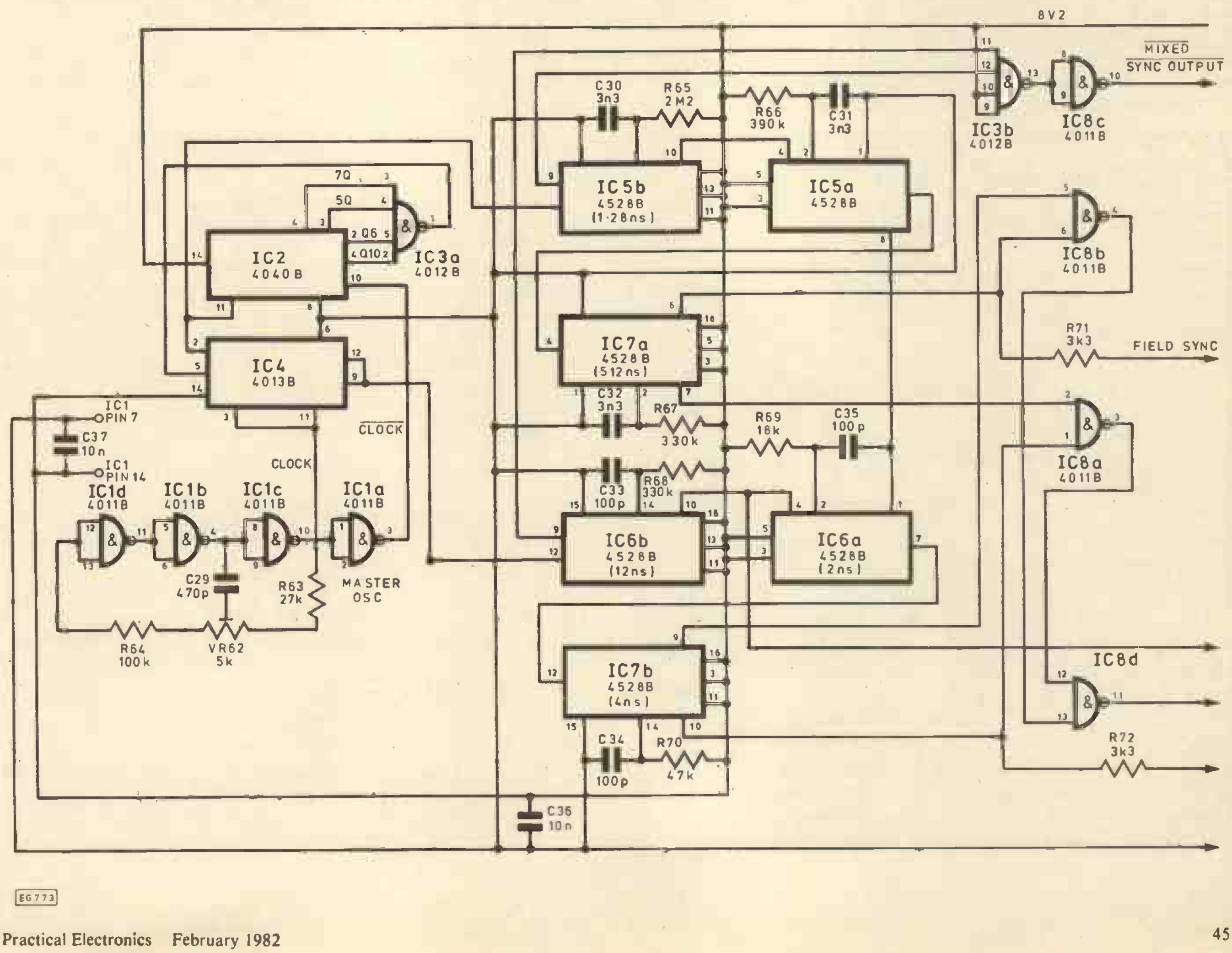
LOGIC BOARD

The logic board in the Seescan camera can be conveniently divided into separate functional areas. First, is the digital processing logic, this comprises the heart of the camera electronics, creating all the necessary timing and synchronisation pulses required by the rest of the camera. The remainder of the board carries the necessary electronics for scanning the beam from side to side and up and down, and a constant current regulator for driving the vidicon focus coil. In the following text, each part of the board will be dealt with separately, and it will be shown how the individual parts fit together and perform the task of controlling the vidicon tube to produce the video signal.

DIGITAL LOGIC

This camera uses nine C-MOS digital integrated circuits in its timing circuits, see Fig. 2.7. In the basic camera, the master oscillator used is a simple astable oscillator. Though the stability is not good when compared to a crystal oscillator, it is quite satisfactory for domestic purposes used with a TV receiver, and its very low cost dictated its use in this project. Anti-phase (18Ø degrees) square waves at twice line frequency (2×15,625Hz) are available from pins 1Ø and 3 of IC1. The actual frequency may be adjusted using VR62; other television scanning standards may be accommodated by adjusting this control and changing C29. One half of IC4 a dual type D flip-flop is wired as a divide by two counter, the output being taken from pins 9 and 12. This 15,625Hz square wave is fed to IC9 wired as a divide by two counter, which provides outputs 180 degrees out of phase at half line frequency from pins 1 and 2 which are used to drive the inverter. The line frequency square waves are also taken to IC6, a dual monostable where the line blanking interval of 12 micro-seconds is formed by the time constant set by C33/R68. The other half of IC6 is triggered off the leading edge of this pulse and creates a two microsecond delay, programmed by C35/R69. The falling edge of this pulse from pin 7 IC6 is used to trigger a third monostable—half of IC7 to create the line sync. pulse of four microseconds duration. Thus, the overall wave forms produced are shown in Fig. 2.10; the line sync. pulse fitting correctly within the line blanking interval.

The twice-line frequency output from the master oscillator pin 3 is taken to the twelve stage counter, IC2 (4Ø4Ø). IC3, a four input nand gate, is wired to decode count 624. At the next positive going edge of the clock, IC4, a type D flip-flop transfers the high decoded at state 624 to its output at pin 2. Thus the combination of IC3 and IC4 decodes count 625 and creates a negative going reset pulse 32 microseconds long which is used to reset the counter IC2. Thus for ever 625 pulses applied to IC2, 3 and 4, one output pulse of 32 microseconds duration is created. As the input frequency from the master clock was 2×15,625Hz the output frequency is 5ØHz—i.e. frame repetition rate. This signal is applied to IC's 5 and 7, and in the same way as in the line sync. circuits, forms the field blanking and sync. signals. R65/C3Ø set the duration of the blanking interval, R66/C31, the equalisation delay, and R67/R32, the field blanking period.



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Negative going line and field blanking signals from pin 9 IC6 and pin 9 IC5 respectively are mixed together in the second half of IC3. The output from this gate is positive going mixed blanking, and this is inverted by one quarter of IC8 (pins 8, 9 and 10) to provide negative going mixed blanking required by the cathode blanking circuits.

Positive going line and field sync. pulses are taken directly from the outputs of IC's 5 and 7. Three gates from IC8 are used to combine these sync. signals to form a mixed sync. output with negative going line sync. pulses superimposed on the field pulses to maintain line scanning during the field sync. pulse interval to prevent jitter. The CMOS logic circuitry is decoupled from the main supply and is run at 8V2 to minimise radiation and ensure long reliable service.

LINE SCAN CIRCUITS

The line scan stage is built around transistors TR19 and TR2Ø, all the components being mounted on the logic printed circuit board. See Fig. 2.8. TR19 is the driver transistor which is switched into saturation or is cut off by the output of the CMOS logic. The line sync pulses have a duration of 4 microseconds, and drive the collector of TR19 between supply rails. R88 couples this to the gate of TR2Ø, a VMOS output transistor. The collector load of TR2Ø is made up of R91, R47, L4 and the scan coils L2. Adjustment of R47 allows control of line amplitude (width). C5Ø provides a signal earth at line frequency to prevent excessive current being drawn through R47. During the flyback period (i.e. during a sync pulse), the e.m.f. in the dummy line load L4 collapses creating a large voltage spike >8ØV. As this voltage swings below the zero line, D4 conducts, protecting TR2Ø and finishing the line scan. C23 provides d.c. isolation from the scan coils which would cause a shift in picture position and couples the scan energy to the line coils, L2.

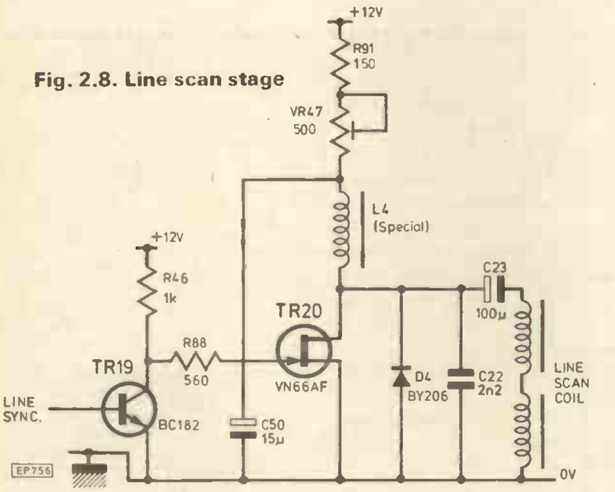
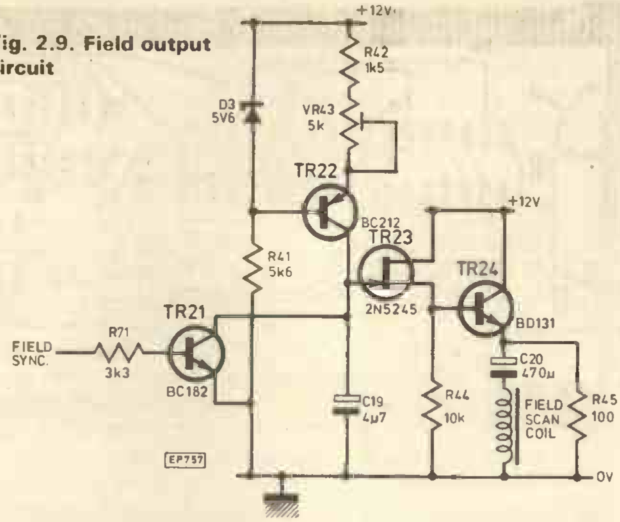


Fig. 2.8. Line scan stage

FIELD OUTPUT CIRCUIT

Switch TR21 is non-conducting in the absense of sync. pulses, and capacitor C19, a 4μ7 tantalum is allowed to charge up via the constant current generator built around TR22, D3. See Fig. 2.9. The setting of R43 determines the rate at which C19 is charged. As this capacitor is charging from a constant current source, the voltage across it will rise linearly with time until a sync. pulse arrives, when it will be very rapidly discharged by TR21 conducting to ground. F.e.t. TR23 is wired as a source follower, characterised by a very high input impedance and low output impedance. It therefore serves to buffer the saw-tooth ramp, high impedance signal on C19 into the low impedance base of the output transistor TR24. This transistor is mounted on one of the aluminium support bars to conduct away heat.

Fig. 2.9. Field output circuit



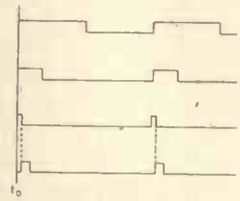


Fig. 2.10. Generation of line sync. pulse

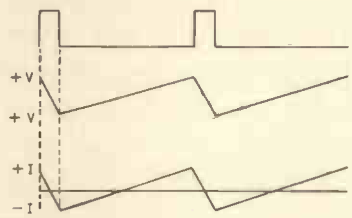


Fig. 2.11. Field scan waveforms

MAGNETIC FOCUS CIRCUIT

Transistor TR18 is configured as a constant current source for the magnetic focus coil, the magnitude of the current being set by the position of R6Ø (magnetic focus preset). The 1N418 diode wired in the base, is held in close thermal contact with the transistor and is used to offset thermal drift. A typical value of focus current through the scan coils would be 95mA.

NEXT MONTH: Assembly, setting up.

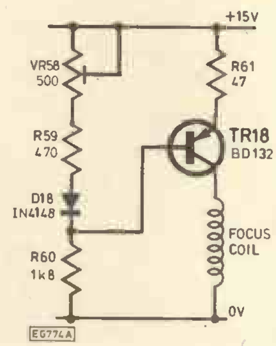


Fig. 2.12. Magnetic focus circuit

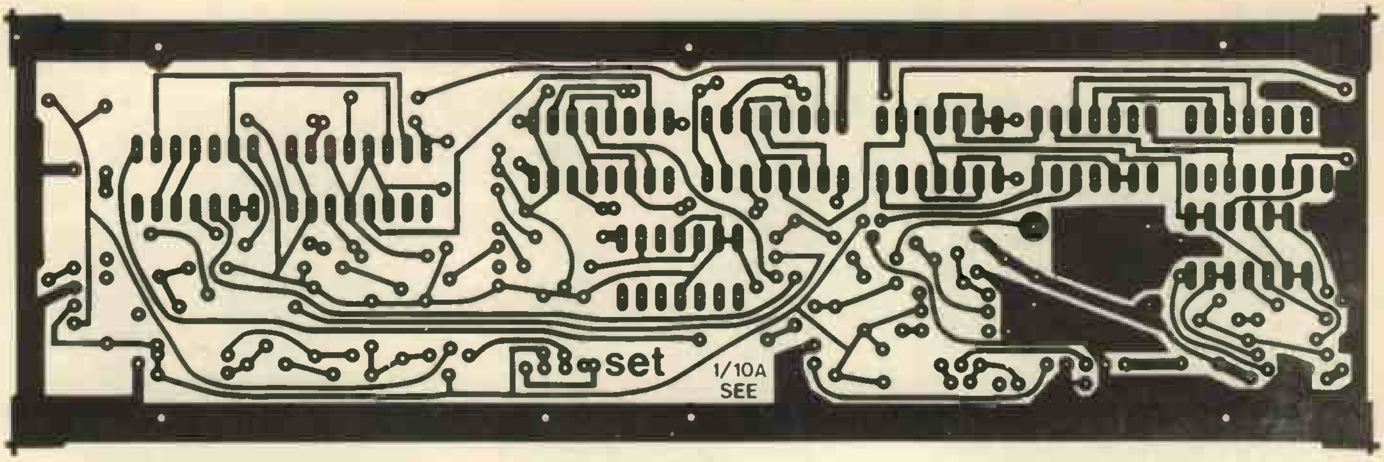
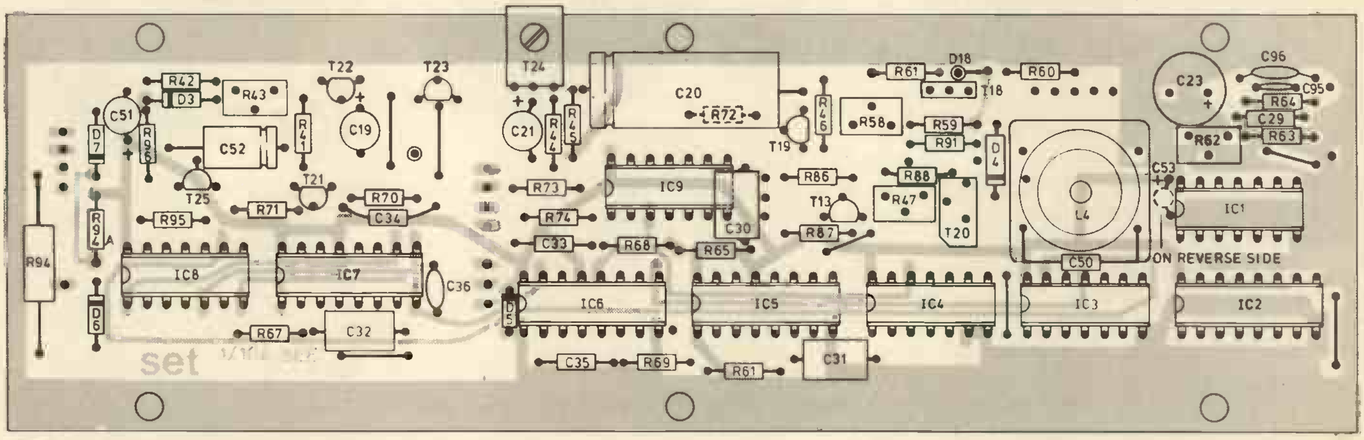


Fig. 2.13. Logic Board p.c.b. (actual size)



EA307

Fig. 2.14. Logic Board component layout

COMPONENTS . . .

LOGIC BOARD

Potentiometers

VR43, VR62	5k cermet preset (2 off)
VR47, VR58	500 cermet preset (2 off)

Capacitors

C1	10n ceramic
C2	2n2 ceramic
C19	4μ7/35V tant.
C20	470μ/25V elect.
C21	22μ/16V tant.
C23	100μ/10V elect.
C29	470p polystyrene
C30, C31, C32	3300p polystyrene
C33–35	100p
C36	10n polyester
C51	100μ/10V tant.
C52	33μ/16V elect.
C53	1μ/35V tant.

Resistors

R41	5k6
R42	8k2
R44	10k
R45, R94A	100 (2 off)
R46, R86	1k (2 off)
R59	470
R60	1k8
R61	47
R63	27k
R64	100k
R65	2M2
R66	390k
R67	330k
R68	150k
R69	18k
R70	47k
R71–74, R95	3k3
R87	1k5
R88	560
R91	150
R94	680 2W5 w.w.
R96	1k5

Transistors and Diodes

D3	5V6 Zener
D4	BY206
D5	8V2 Zener
D6, D7	1N4001
D18	1N4148
TR13, TR19, TR21, TR25	BC182
TR18	BD132
TR20	VN66AF f.e.t.
TR22	BC212
TR23	2N5245
TR24	BD131

Integrated Circuits

IC1, IC8	4011B (2 off)
IC2	4040B
IC3	4012B
IC4, IC9	4013B (2 off)
IC5–7	4528B (3 off)

Miscellaneous

Printed Circuit board
Molex connectors
Varelco connectors

PE RANGER BASE STATION

Michael Tooley B.A.
David Whitfield M.A. M.Sc.

PART TWO

THE Base and Mobile Adaptor is housed in a similar enclosure to that used for the basic portable Ranger transceiver. The majority of the components are mounted on a single sided p.c.b. with the controls, input and output sockets, l.e.d.s and meter mounted on an aluminium front panel. The p.c.b. layout is, in common with that used for the Ranger transceiver, quite critical and no attempt should be made to use any form of construction since this will almost certainly degrade the stability of the unit. Care should also be taken to ensure the correct placement and orientation of the components on the p.c.b. The p.c.b. layout viewed from the copper foil side is shown in Fig. 2.1 together with the corresponding component layout given in Fig. 2.2. It is recommended that components be fitted to the p.c.b. in the following order:

1. Inductors and transformers
2. Variable capacitors and resistor
3. Fixed resistors
4. Fixed capacitors
5. Transistors, diodes, and integrated circuit
6. Test points and links
7. Relay

Winding data for the inductors is given in the Table 1. L5 is a choke which may conveniently be wound on the body of 1W carbon resistor and the exact diameter is not critical. TR2 and IC1 must be mounted on a heatsink, the constructional details for which are given in Fig. 2.3. Note that TR2 requires an insulating kit which consists of a plastic bush and mica washer. This is needed in order to prevent contact between the collector tab and heatsink which should be earthed by soldering its two fixing nuts to the copper foil earth plane of the p.c.b. Once the p.c.b. assembly is complete, both sides of the board should be carefully examined. The copper foil side should be checked for dry joints, broken or damaged tracks, and solder splashes. The component side should be checked for the correct orientation of components, paying particular attention to electrolytic capacitors, diodes and transistors. The p.c.b. should then be fixed to the base of the case by means of four self-tapping screws which locate with the moulded pillars. The controls, l.e.d.s, meter, input and output sockets should then be mounted on the front panel. Once complete, this is located in the recessed slot in the base of the case. The ancillary socket and the d.c. input connector are then respectively mounted in the rear and side walls of

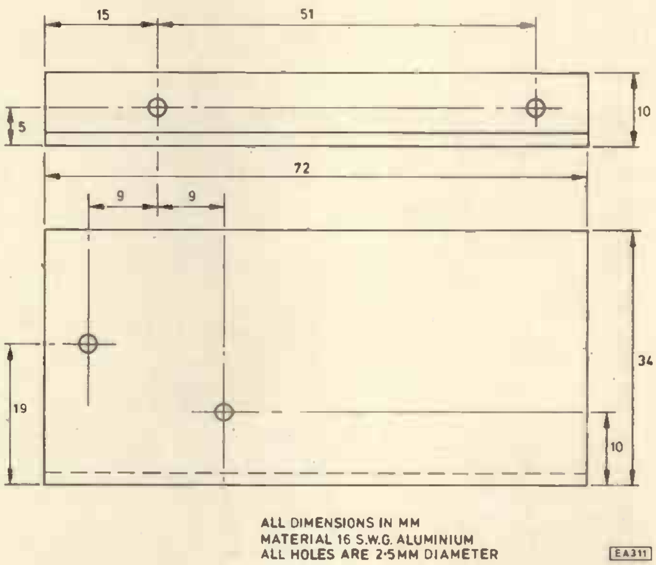
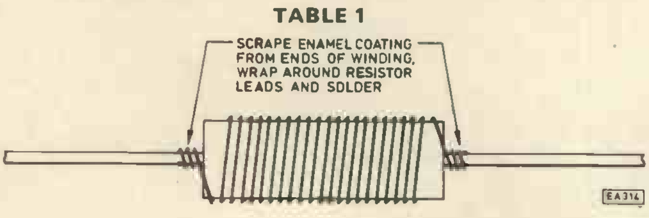


Fig. 2.3. Constructional details of the heatsink

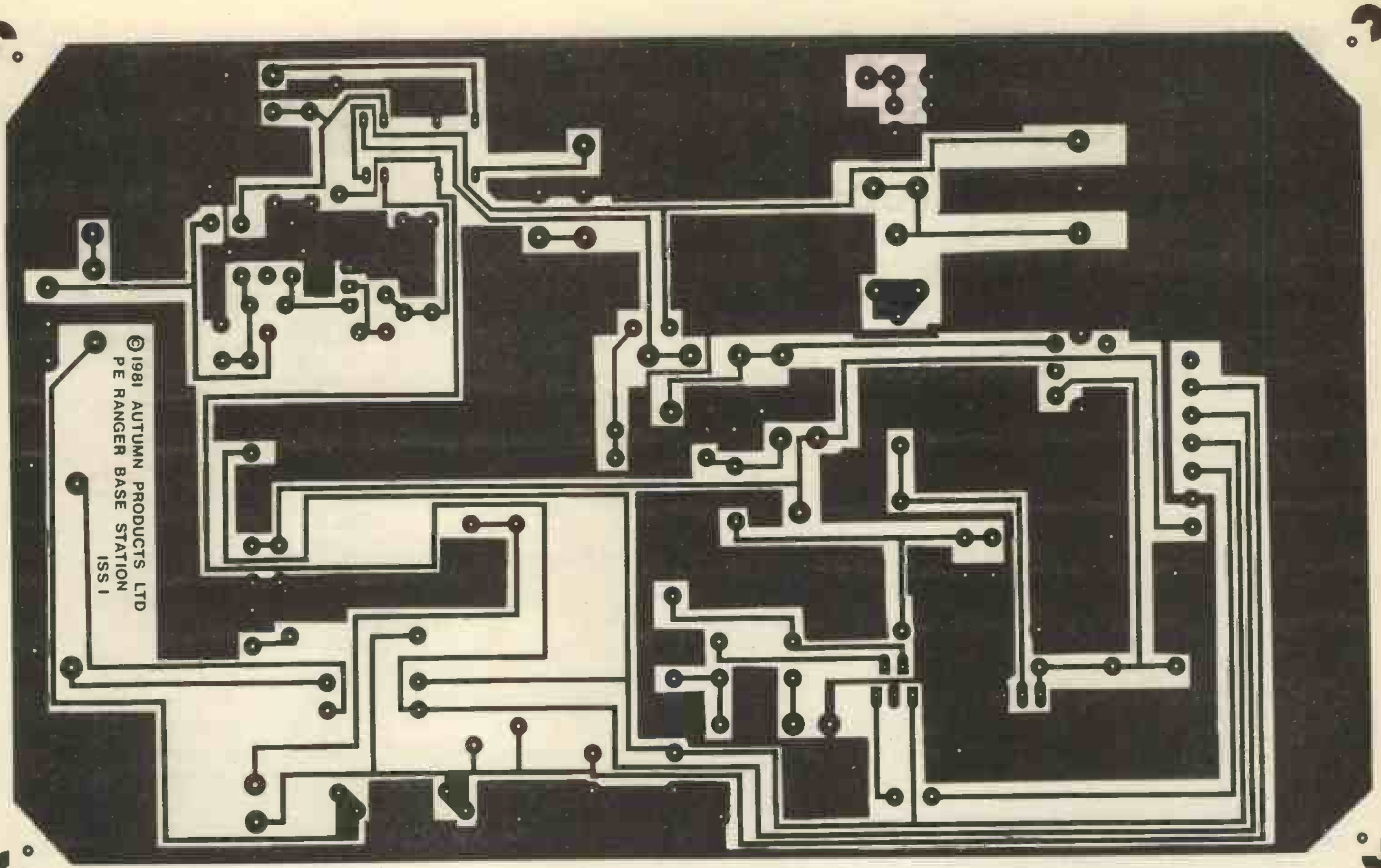
INDUCTANCE DATA

L4 10uH RF choke (ITT SC 10/10)
L5 30 turns 30 s.w.g. enamelled copper wire closewound on a 10k 1W carbon resistor (i.d. approx 4mm)
L6 16 turns 18 s.w.g. enamelled copper wire closewound, no former, i.d. 7mm, winding length approx 18mm.

TABLE 1

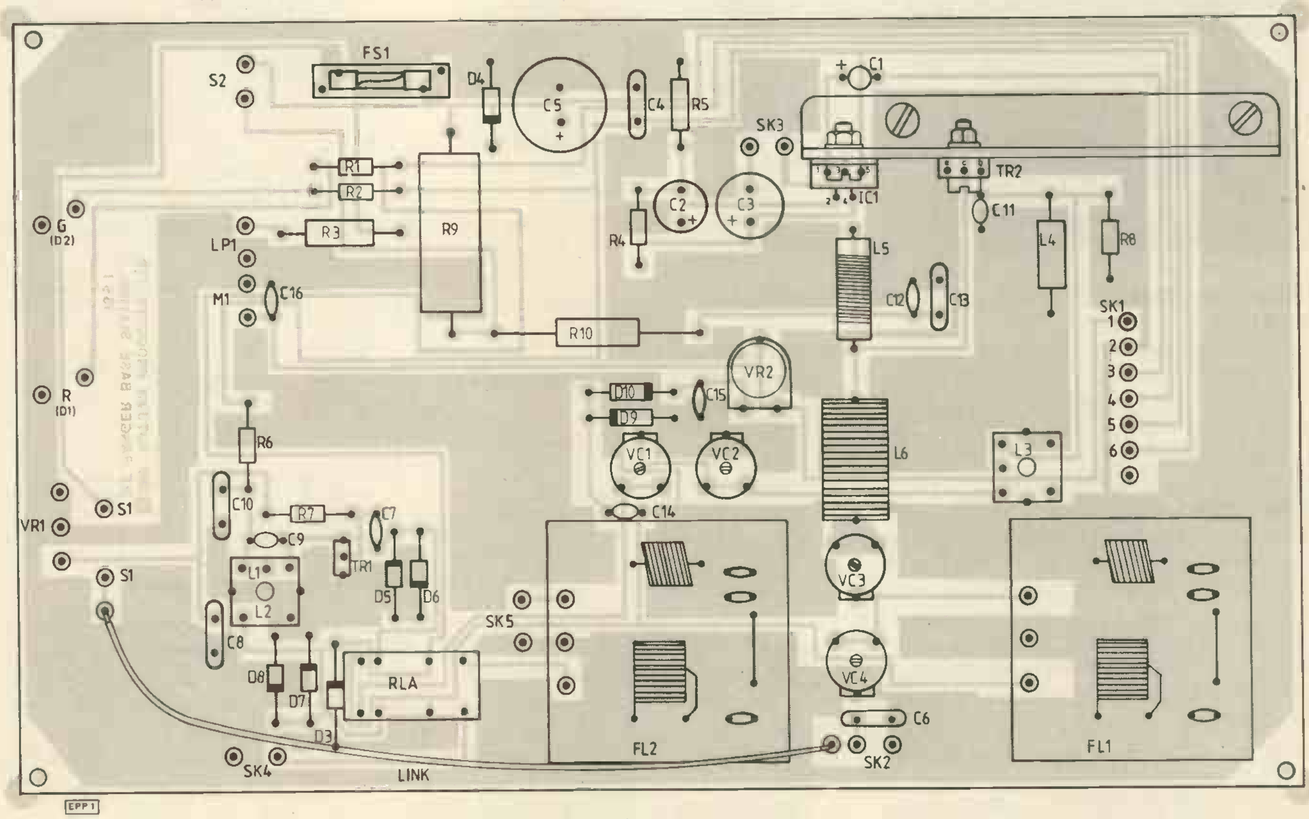


CONSTRUCTIONAL DETAILS L5:



EC56

Fig. 2.1 P.c.b. design for the Base Station



EPP1

Fig. 2.2. Component layout

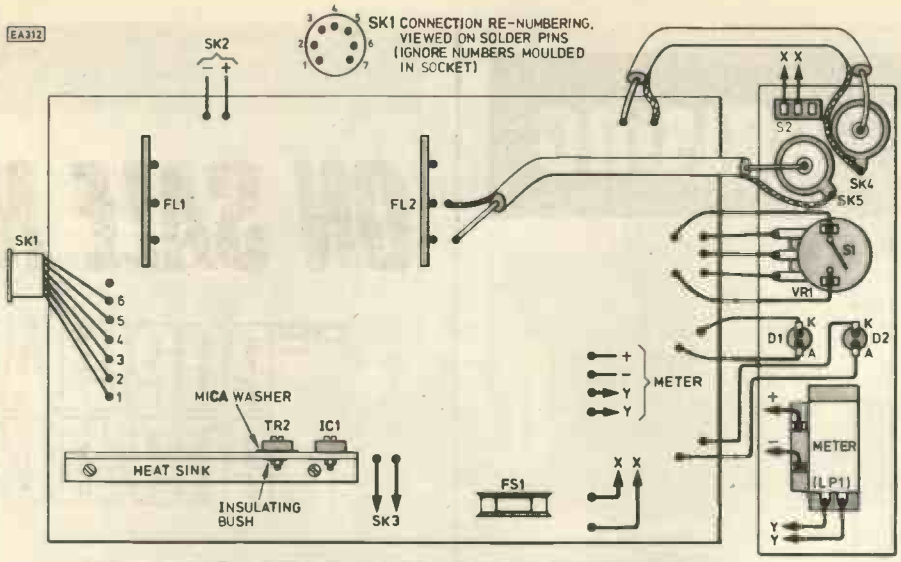
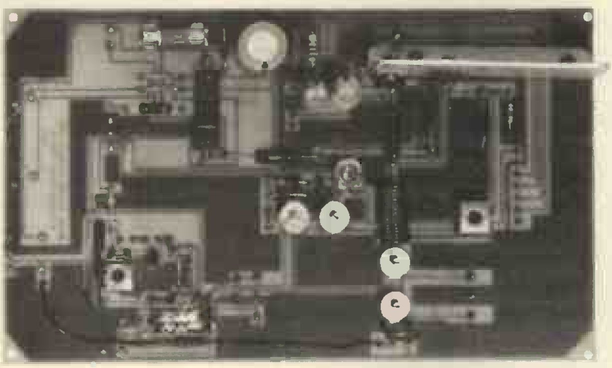


Fig. 2.4. Wiring diagram for the Base Station

the case. The front panel interconnections should then be wired to the p.c.b. taking care to keep all connecting wires as short and direct as possible. 50 ohm coaxial cable must be used for connections to the input and output sockets, SK4 and SK5, respectively. Note that it is essential to ensure a good earth connection to the front panel via the braid of the two coaxial cables. The ancillary and d.c. input sockets can then be wired to the p.c.b. front panel again taking care to keep the wiring as direct and short as possible. The complete wiring diagram for the Base and Mobile Adaptor is shown in Fig. 2.4.



MODIFICATIONS TO THE RANGER ANCILLARY SOCKET

Some early versions of the Ranger were supplied with a 5-pin DIN socket for SK203. This is, or course, quite satisfactory for an external d.c. input but, where the Ranger is to be used in conjunction with the Base and Mobile Adaptor, it should now be replaced by a 7-pin socket. The original connections for SK203 (using a 6-pin DIN socket) were shown in the circuit diagram, Fig. 1.2, on pages 44 and 55 of September PE. the following changes are necessary:

(a) since the 'scan' facility is not required, pin 1 should no longer be connected to C124/R115. Instead it should be taken to the output of the S-meter module (see later section). If the S-meter facility is not required and the module is not fitted, pin-1 should be left unconnected.

(b) To increase the level of audio to the base station and effectively reduce the level of audio from the Ranger's own internal loudspeaker without necessitating switching it out of circuit, pin-3 should be disconnected from the junction of R120 and R121 and taken instead to the 'live' side of the loudspeaker. Where an external speaker socket has been fitted connection can be conveniently made to this point, alternatively it may be taken to the 'LS output' on the p.c.b. (pin nearest the centre of the p.c.b.). The internal loudspeaker should not be disconnected since this will render the unit inoperative in the portable mode. There are no changes to the other pins (2, 4, 5, and 6) but, if these have not been previously wired they must now be connected to the appropriate points. In any event it would be beneficial to check the other connections to SK203 and, to recapitulate, these are listed below:—

Pin Number	Connection	
1	Output of S-meter module (where fitted)	
2	Common 0V or 'GND'	see Fig. 2.7 on page 53 of October PE
3	LS output (+ve)	
4	+12V on 'receive'	
5	+12V on 'transmit'	
6	+12V input	
7	n.c.	

MAINS POWER UNIT

Where an a.c. mains supply is available the Base and Mobile Adaptor can derive its d.c. input from the simple power unit shown in Fig. 2.5. The transformer should be rated at 12V and the rectifier should be a plastic encapsulated 2A bridge. The transformer and rectifier can be conveniently mounted in a moulded ABS case measuring approximately 57×92×63 mm which incorporates pins so that it will plug directly into a 13A mains outlet. A kit of parts (including transformer, case, rectifier and connecting lead) is available from Autumn Products as an optional accessory for the Base Station unit.

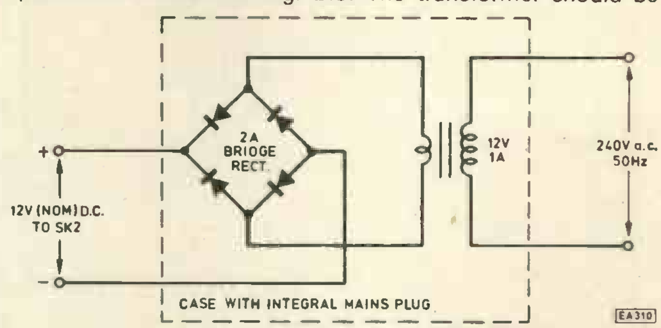
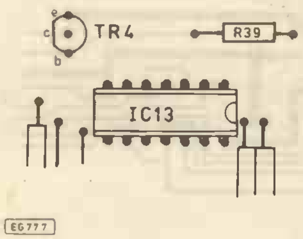


Fig. 2.5. Circuit diagram of the main power unit

NEXT MONTH: Testing and alignment

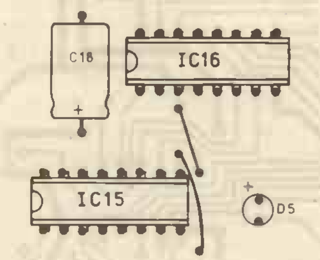
POINTS ARISING

SPACE EVADERS *(DECEMBER 1981)*

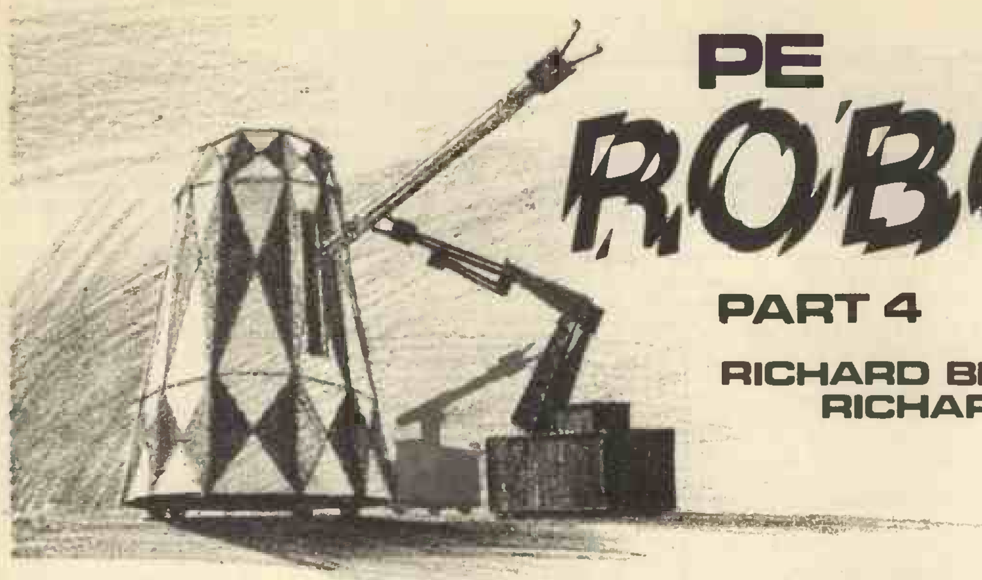


The outline of TR4 was shown incorrectly in Fig. 4. The correct outline is shown in Fig. 1 opposite.

In the circuit diagram (Fig. 2) pins 9 and 10 of IC15 should be reversed. Pin 10 should be connected to the 11·5V rail and pin 9 should go to pin 11 of IC18.



In order to reverse pins 9 and 10 of IC15 the two links in Fig. 6 should be altered as shown in Fig. 2. The positive end of C18 should be connected to IC15 pin 16.



PE ROBOTS

PART 4

RICHARD BECKER · TIM ORR
RICHARD MONKHOUSE

WHEN recording and editing start by clearing the sequence and then enter the edit mode. Once a position has been reached that one wishes to remember, simply press INSERT. Suppose that you insert three or four different positions. Each time you now press STEP- the robot will automatically move back to the previous position until it is at the first position entered. Similarly, STEP+ allows one to step forward through the sequence.

The DELETE button deletes the current event from the sequence, and the robot will move on to the next position in the sequence. If one has just deleted the last event in the sequence, the robot cannot move to a subsequent event, so in this special case it will move to the previous event.

DELETE and INSERT may be used to correct mistakes in a sequence. Insert always inserts AFTER the current position.

If one enters edit mode on a sequence that already has a recording in it, the robot will move initially to the first event in the sequence.

It is sometimes useful to be able to make the robot *wait* for a while at the end of a move: to achieve this the WAIT button should be pressed a number of times before pressing INSERT to insert the event. On replay, each pressing of WAIT will generate approximately half a second wait signified by a warbled bleep (up to 255 waits per event may be recorded).

MEMORY FULL WARNING

There are 32 steps available in each sequence store, when there are less than 8 steps left in the current sequence, the memory warning LED will light (bottom l.e.d.).

PLAY

To play the current sequence once, simply press PLAY. The green l.e.d. will light in play mode.

To repeatedly play a sequence over and over, press LOOP.

PAUSE

To make the robot stop in either play or repeat-play modes, press PAUSE. The "hands-up" symbol will be displayed, and the robot will stop; a second pressing will allow the robot to continue its sequence from where it left off.

If you do not want the robot to continue from where it left off, the RESET button can be used instead to escape from play mode

MOBILE CONTROL

To take manual control of the drive motors on the mobile version of the robot, press the MOTOR button. Mobile control will be signified by all three l.e.d.s being on. In this mode the slider acts as a seven position speed and forward/reverse control, whilst the rotary pot. acts like a steering wheel.

HOW THE KEYBOARD DATA IS SENT

The data coming from the keyboard is encoded into a serial stream of 56 bits with a gap of 8 bits transmitted serially about 10 times a second. All the data is encoded in the form of thin pulses. At the start of each bit time a 'marker' pulse is sent. If the bit to be transmitted is a '1', a second pulse is sent exactly Half way through the bit time, if the bit is a 0, no such second pulse is sent. This method of encoding is used since it enables direct compatibility with a remote infra-red link where the transmission is in the form of thin pulses to enable the transmitter infra-red diodes to be pulsed with a high power without excessive average current drain from the battery.

SAY WHEN

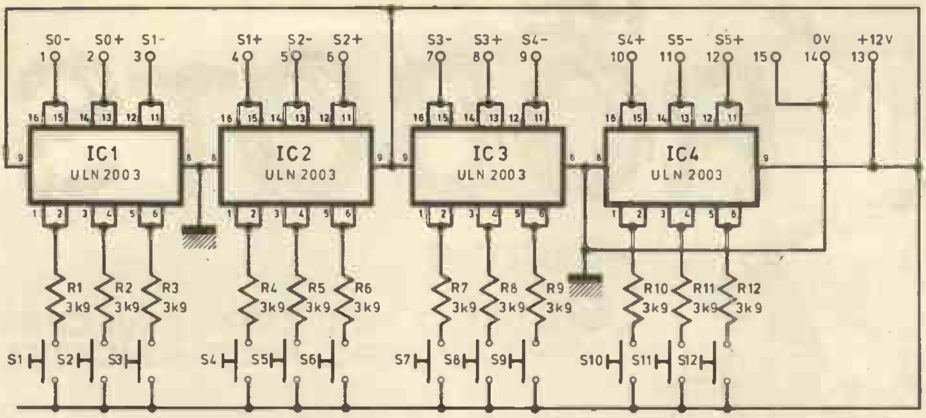


Fig. 4.1. Direct solenoid controller, for simple manual operation of the robots

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.

Some sample prices are as follows . . .
Genesis M101 4 axis model (excluding wheel base) £295.00
Genesis M101 5 axis model (excluding wheel base) £345.00
Genesis M101 wheel base £79.00
Genesis P101 4 axis model £450.00
Genesis P101 6 axis model £545.00
Genesis S101 4 axis model £355.00
Genesis S101 5 axis model £405.00

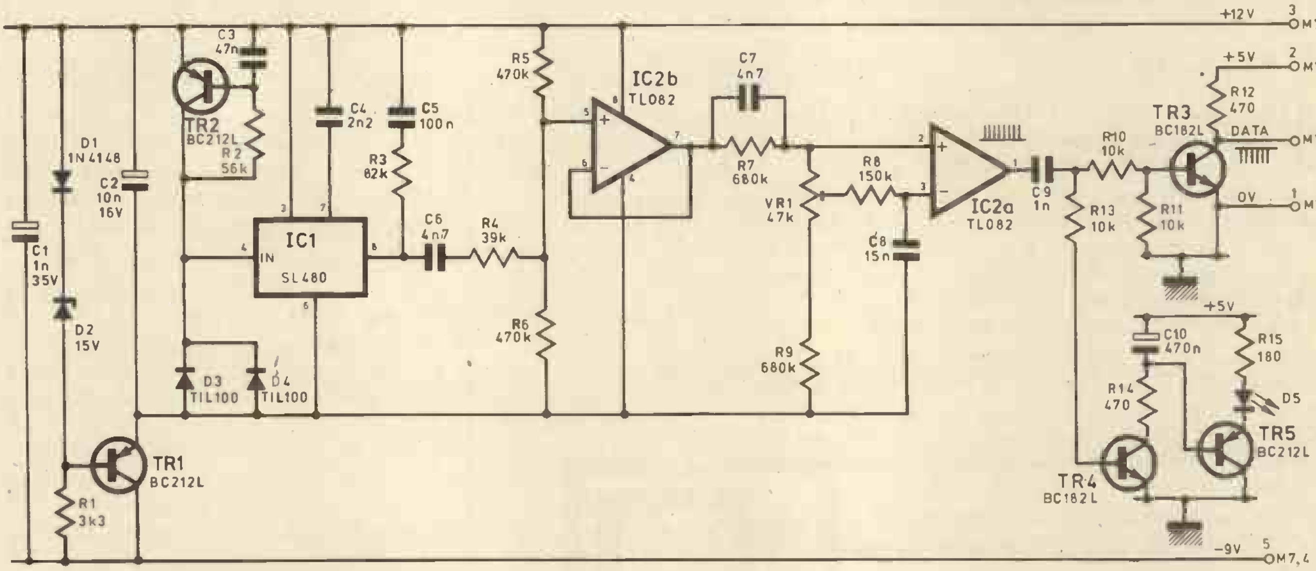


Fig. 4.2. Infra-red receiver circuit

NOTE: The photograph at the foot of page 69 in Part 3 (January) is *incorrect*, in that a P101 robot system is shown with a close-up view of an M101 controller front panel. Although substantially similar, the three types being based on the same p.c.b., the M101 control box has controls which are irrelevant to the P101 robot.

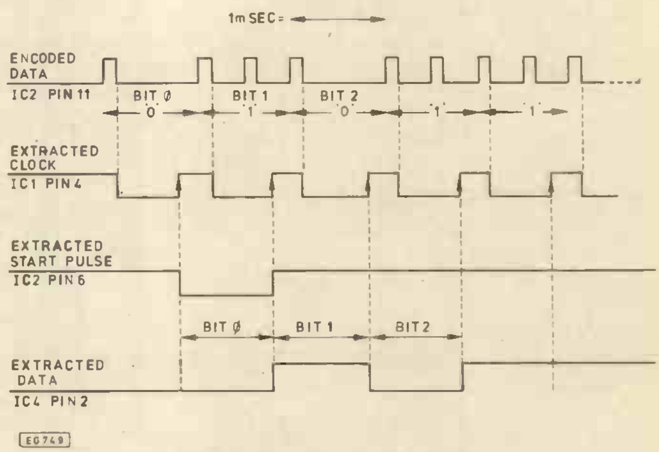


Fig. 4.3. Keyboard decoder waveforms

HOW THE KEYBOARD DATA IS RECEIVED

The keyboard decoder extracts three signals—clock, data, and start-bit—from the input pulse stream (see E1, 2, 3, 4 of the interface Board. The pulse stream is obtained either directly in the case of a cable link to the keyboard, or via the infra-red receiver in the case of the infra-red link. The principle of decoding is as follows:—

A 750 microsecond non-retriggerable monostable separates the clock edges from the pulse stream. At the start of each bit time, a flip-flop (consisting of two nand gates) is cleared; if a second pulse occurs on the data pulse stream within 750µs (i.e. the data bit was a '1'), this flip-flop is then set. At the end of the 750µs period, the output of this flip-flop is sampled by a D-type flip-flop, and represents the data presented to the microprocessor interface. A 2ms monostable is used to detect the gap at the end of each keyboard scan, and is used indirectly to generate the start bit indication also presented to the interface. See Fig. 2.2.

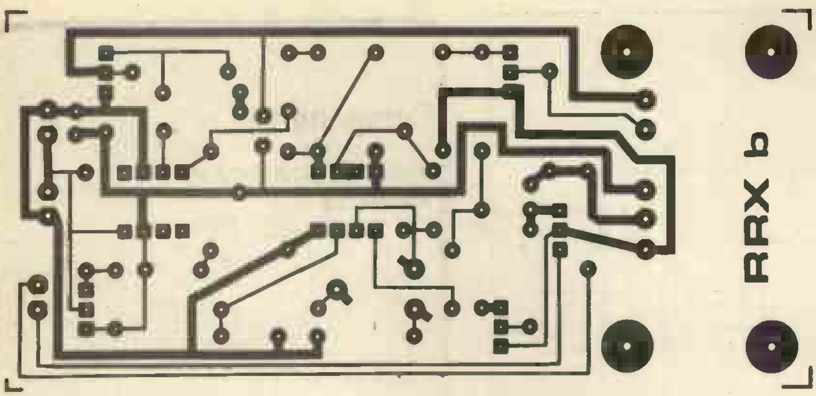


Fig. 4.4. Infra-red receiver board p.c.b. (actual size)

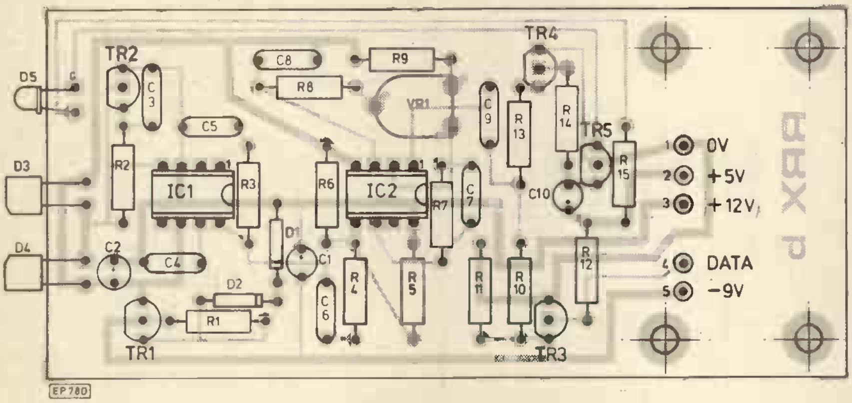
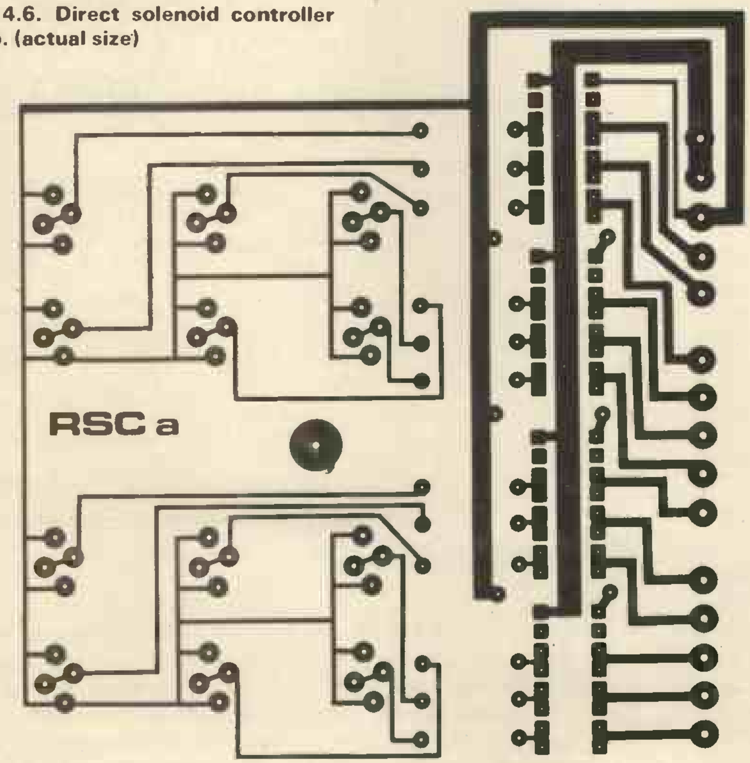


Fig. 4.5. Infra-red receiver board component layout

Fig. 4.6. Direct solenoid controller p.c.b. (actual size)



Components . . .

INFRA-RED RECEIVER

Resistors

R1	3k3
R2	56k
R3	82k
R4	39k
R5, R6	470k (2 off)
R7, R9	680k (2 off)
R8	150k
R10, R11, R13	10k (3 off)
R12, R14	470
R15	180

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

Potentiometers

VR1 47k preset

Capacitors

C1	1μ/35V tant.
C2	10μ/16V tant.
C3	47n Siemens B37560
C4	2n2 Siemens B37560
C5	100n Siemens B37560
C6, C7	4n7 Siemens B37560 (2 off)
C8	15n Siemens B37560
C9	1n Siemens B37560
C10	470n/35V tant.

Transistors and Diodes

D1	1N4148
D2	15V Zener
D3, D4	TIL100 (2 off)
D5	Red l.e.d.
TR1, TR2, TR5	BC212L (3 off)
TR3, TR4	BC182L (2 off)

Integrated Circuits

IC1 SL480
IC2 TL082

Miscellaneous

Printed circuit board
8-pin d.i.l. sockets (2 off)
Mounting pillars (4 off)
5-way Molex shell
Molex terminals (5 off)

Components . . .

ROBOT SOLENOID CONTROLLER

Resistors

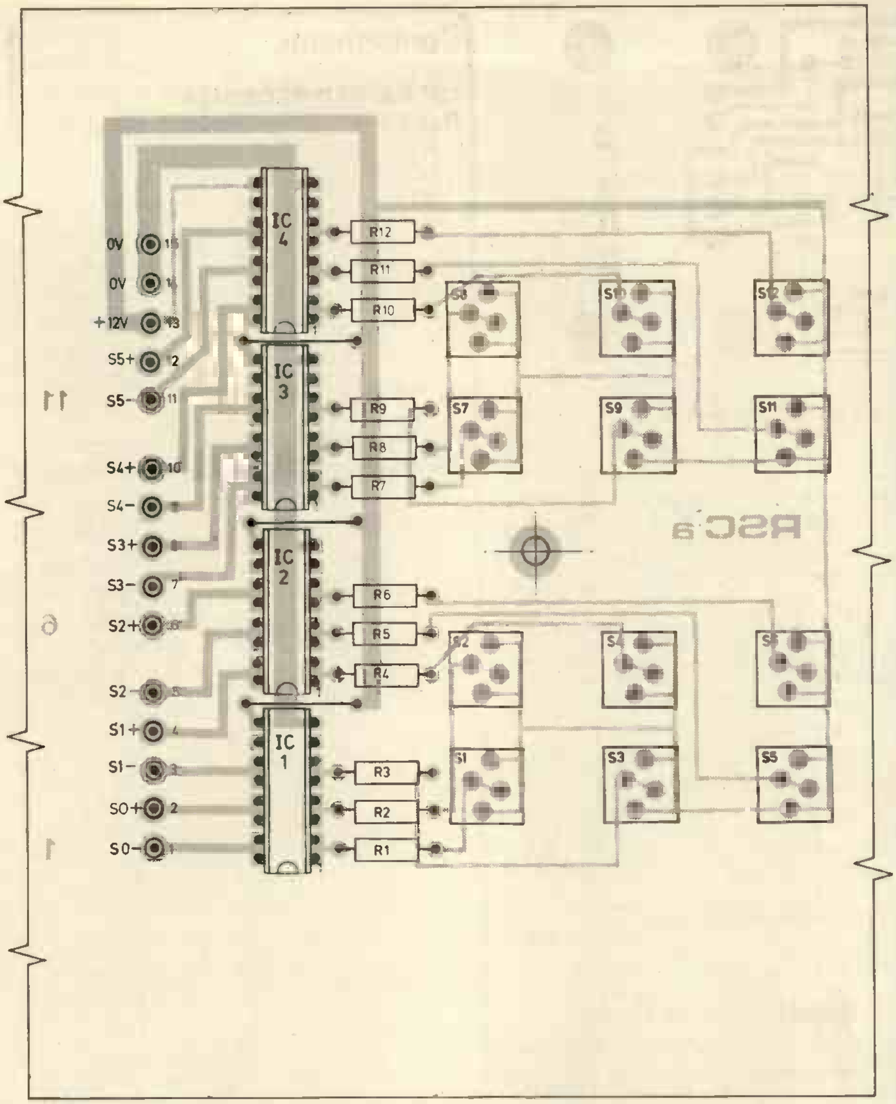
R1–R12 3k9 (12 off)

Integrated Circuits

IC1–4 ULN2003 (4 off)

Miscellaneous

Printed Circuit Board
Case
Switches (12 off)
16-pin d.i.l. sockets (4 off)
14-way lead
5-way Metway p.c. terminal block (3 off)



Components . . .

PROCESSOR BOARD

Resistors

R1, R3, R7–12	10k (8 off)
R2	150
R4	2k7
R5, R6	1M (2 off)
R13	10M

Capacitors

C1	10μ/16V tantalum (4 off)
C3–7, C10	47n disc. ceramic (6 off)
C11, C12	22p Piher ceramic

Transistors and Diodes

D1–3	1N4148 (3 off)
D4	OA47
TR1	BC212L
TR2, TR3	BC182L

Integrated Circuits

IC1	6802
IC2	74LS00
IC3	74LS42
IC4	74LS08
IC5	6850 *
IC6	6821
IC7	2732
IC8	—
IC9	—
IC10	HM6116
IC11	MC14411*
IC12	1489 *
IC13	1488 *
IC14	74LS74

Miscellaneous

X1 4·00 MHz crystal
X2 1·8432 MHz crystal *
Printed circuit board (RPU)
Reset switch
p.c.b. mounted battery
10-way ribbon connectors (3 off)
10-way Molex terminals
5-way Molex terminals
Vero-pins
Test point pins (9 off)
40-pin d.i.l. socket (2 off)
24-pin d.i.l. socket (6 off)
14-pin d.i.l. socket (5 off)
16-pin d.i.l. socket (1 off)

* Not necessary if no RS232 link

MICRO PROCESSOR BOARD CIRCUIT OPERATION

The microprocessor board is separate, and could be used for many other control applications. See Fig. 4.8. It contains the following:

6802 microprocessor (this is code compatible with a 6800, but contains an on-chip clock generator and 128 bytes of RAM).

Room for 4K bytes of battery backed-up CMOS RAM, and up to 8K bytes of EPROM (2716 or 2732's).

An ACIA with switchable Baud rate with a full RS232 interface. Lastly a PIA (peripheral interface adapter), giving 20 programmable input/output and interrupt lines. In the case of the robot, this constitutes the interface with the interface board. Because all the data is moved via this PIA the microprocessor board could, if preferred, be replaced by an alternative microprocessor board or an entire computer making the connection to the interface board via the PIA on that board or computer. **NEXT MONTH:** μP board construction.

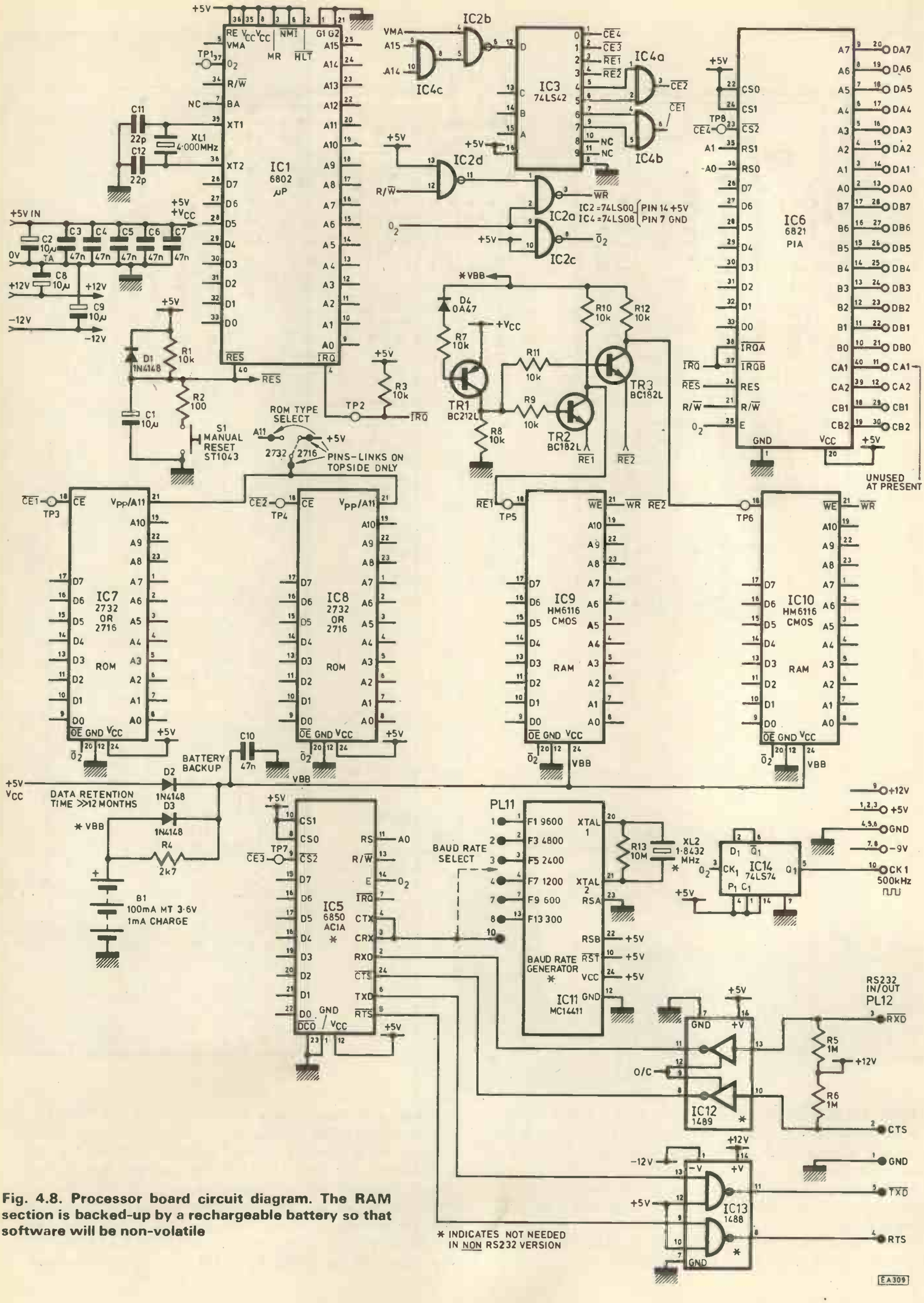


Fig. 4.8. Processor board circuit diagram. The RAM section is backed-up by a rechargeable battery so that software will be non-volatile

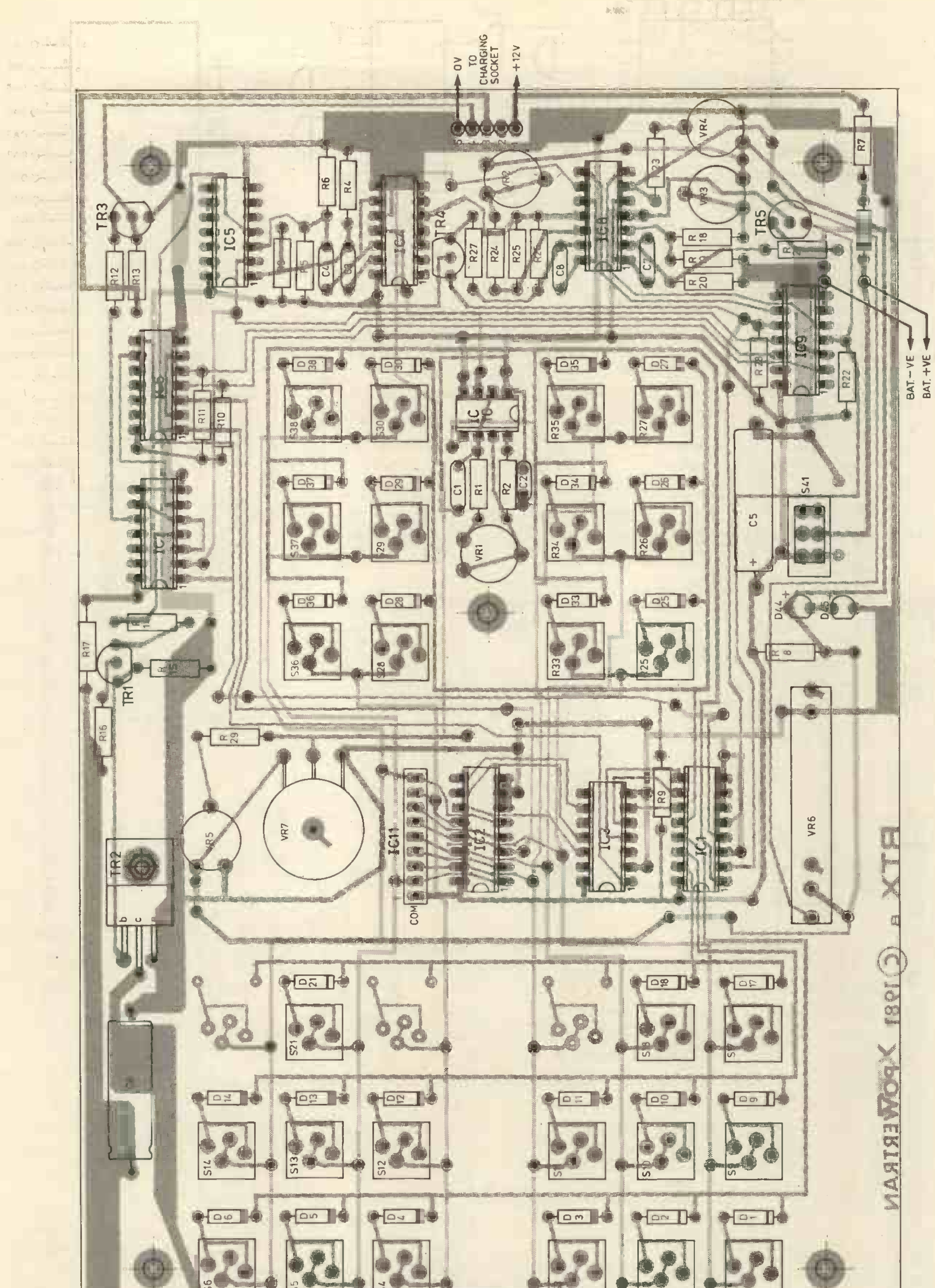


Fig. 4.9. Control box p.c.b. Component layout for mobile unit M101

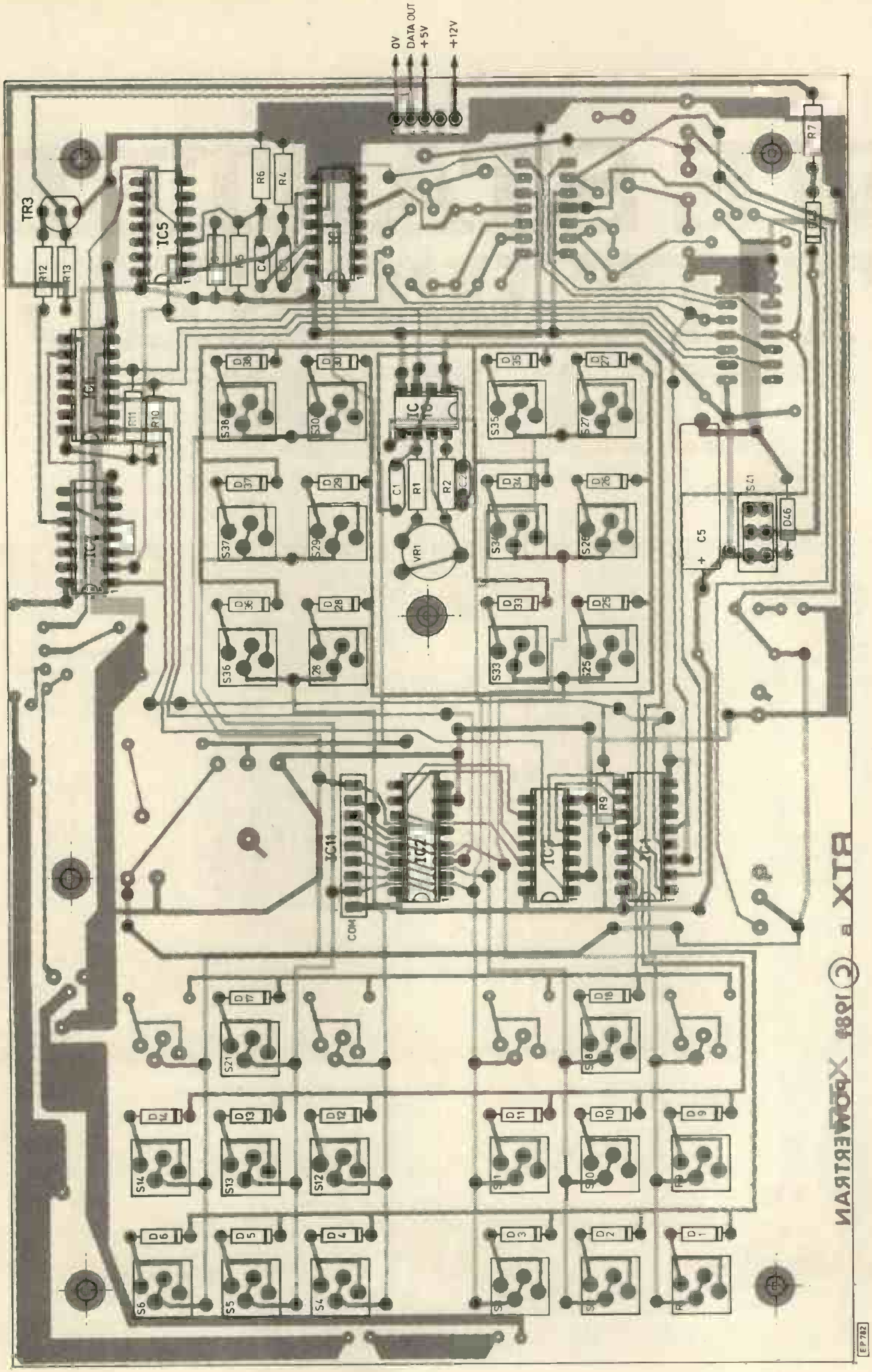


Fig. 4.10. Control box p.c.b. Component layout for P101 and S101 units

MICRO PROMPT

The hardware and software exchange point for PE computer projects

KEYBOARD INTERFACE

Sir—The circuit shown in Fig. 1 enables a standard keyboard with parallel ASCII output to be connected to the UK101. It centres around the MC6821 PIA, which has two I/O ports. The B-side port drives eight l.e.d.'s via buffers as an output port, but may be used for input if required. The A-side is committed as an input-only port, for which purpose eight toggle switches are provided. However, if all the switches are set to "1" then overriding inputs may be applied—this is where the keyboard is connected. Power-on and manual resetting is provided, as well as a PIA-enable switch. Decoding is accomplished by a 74LS27, and situates the PIA within 1K of spare memory-area, at D4ØØ-D4Ø3H. Interfacing to the main board is accomplished by just twenty-one wires. It is advisable to obtain the MC6821 data-sheet before attempting to use the PIA.

For the computer to recognise the new keyboard, a certain amount of software is required. For the old monitor, the necessary program is shown in Fig. 2. The keyboard must be connected such that the seven-bit ASCII code forms the inputs KBØ-KB6, and a negative-going strobe is KB7. For the new monitor, however, the program is considerably more complicated in order to maintain full editing facilities and flashing cursor. This is shown in Fig. 3, and also incorporates a clock; the author would welcome a shorter solution. (CB1 should be connected to C15 of the counter chain to enable the clock to work.)

For the first program, set memory size to 8Ø91 (for the 8K machine), and type:

POKE536,194: POKE537,31

For the second program, set memory size to 747Ø, and type:

POKE11,46: POKE12,29: X = USR(X)

Enter the time (on the new keyboard) in the format HH:MM:SS (hours/minutes/seconds). The computer will then accept commands from the new keyboard in the normal manner.

R. G. Stubbs,
Dartford,
Kent.

Fig. 2. Old monitor

```
$1FB3  LDA $Ø212
       BNE $1FD7
       LDA $D4ØØ
       CMP #$Ø3
       BNE $1FD7
       JMP $A636
       BIT $Ø2Ø3
       BPL $1FDB
$1FC7  LDA $D4ØØ
       CMP #$2Ø
       BEQ $1FD8
       LDA $FØØØ
       LSR A
       BCC $1FC7
       LDA $FØØ1
$1FD7  RTS
$1FD8  INC $Ø2Ø3
$1FDB  LDA #$1F
       STA $Ø21D
       LDA #$B3
       STA $Ø21C
       LDA #$ØØ
       STA $D4Ø1
       STA $D4ØØ
       LDA #$Ø4
       STA $D4Ø1
$1FF2  LDA $D4ØØ
       BPL $1FF2
$1FF7  LDA $D4ØØ
       BMI $1FF7
       STA $Ø213
       RTS
```

Fig. 1. Circuit diagram

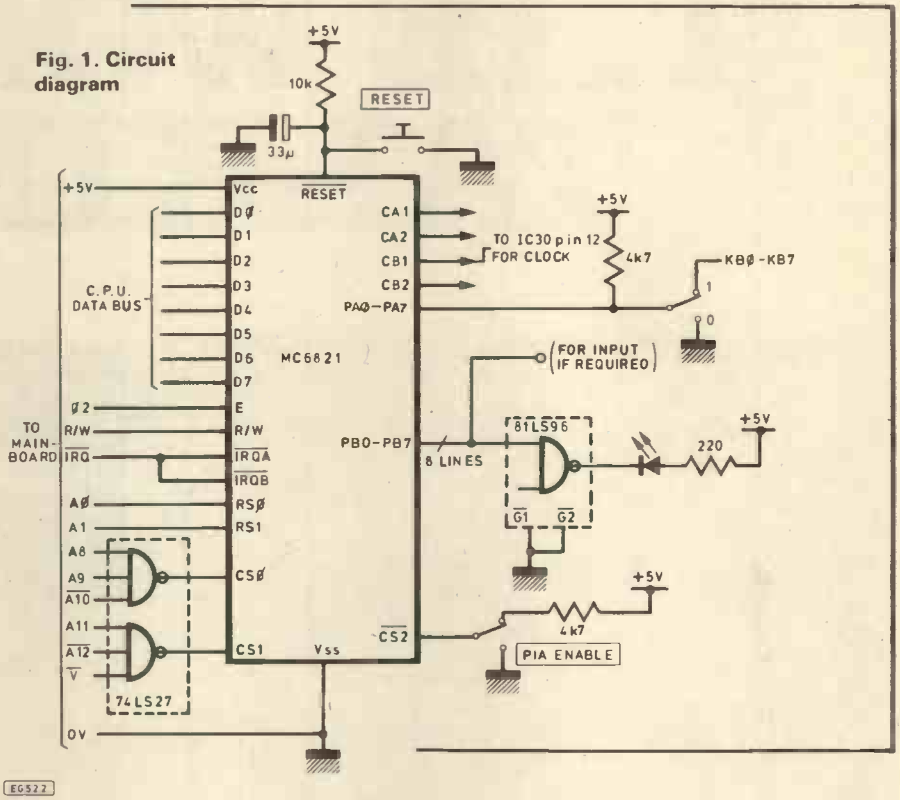


Fig. 3. New monitor

```
$1D2E  SEI
       LDX #$2Ø
       STX $ED
       STX $E4
       DEX
       STX $Ø21B
       LDX #$ØA
       STX $Ø21A
       LDX #$3Ø
       STX $EE
       STX $EF
       LDX #$1Ø
$1D46  LDA $1EØ3,X
       JSR $FFEE
       DEX
       BNE $1D46
       STX $Ø222
       STX $Ø223
       STX $D4Ø3
       DEX
       STX $D4Ø2
$1D5C  INX
$1D5D  JSR $1F3F
       CMP #$3B
       BCS $1D5D
       CMP #$ØD
       BEQ $1D73
       CMP #$3Ø
       BCC $1D5D
       STA $E5,X
       JSR $FFEE
       BNE $1D5C
$1D73  LDX #$Ø7
       STX $D4Ø3
       LDA #$84
       STA $Ø226
       LDA #$1D
       STA $Ø227
       CLI
       RTS
$1D84  PHA
       LDA $D4Ø2
       LDA $Ø222
       BNE $1EØ2
       INC $EF
       INC $EF
       LDA $EF
       CMP #$3A
       BNE $1EØ2
       TXA
       PHA
       LDX #$3Ø
       STX $EF
       INC $EE
       LDA $EE
       CMP #$3A
       BCC $1DF1
       STX $EE
       INC $EC
       LDA $EC
       CMP #$3A
       BCC $1DF1
       STX $EC
       INC $EB
       LDA $EB
       CMP #$36
       BCC $1DF1
       STX $EB
       INC $E9
       LDA $E9
       CMP #$3A
       BCC $1DF1
       STX $E9
       INC $E8
       LDA $E8
       CMP #$36
       BCC $1DF1
       STX $E8
       LDA #$3A
       STA $E3
       INC $E6
       LDA $E5
       LSR A
       LSR A
       BCC $1DDF
       LDA #$34
       STA $E3
$1DDF  LDA $E6
       CMP $E3
       BCC $1DF1
       STX $E6
       LDA $E3
       INC $E5
       CMP #$34
       BNE $1DF1
       STX $E5
$1DF1  LDA $Ø223
       BNE $1EØØ
       LDX #$ØA
$1DF8  LDA $E3,X
       STA $DØ32,X
       DEX
       BNE $1DF8
$1EØØ  PLA
       TAX
$1EØ2  PLA
       RTI
$1EØ4  .BYTE 2Ø,3F,53,53,3A,4D
       .BYTE 4D,3A,48,48,2D,45
       .BYTE 4D,49,54,ØC
$1E14  JSR $1E2D
       CPX #$ØØ
       BEQ $1E2C
       LDA #$16
       STA $Ø21A
       LDA #$85
       STA $Ø218
       LDA #$1E
       STA $Ø219
       LDA #$ØD
$1E2C  RTS
$1E2D  TXA
       PHA
       TSX
       LDA $Ø1Ø5,X
```

```
        CMP #$A3
        BEQ $1E3C
        PLA
        TAX
        PLA
        PLA
        RTS
$1E3C   JMP $FF62
$1E3F   LDA $0212
        BNE $1E95
        LDA $D400
        CMP #$03
        BNE $1E95
        JMP $A636
$1E4E   TXA
        PHA
        TYA
        PHA
        LDA $020E
        BNE $1E66
        LDA $020D
        BEQ $1E77
        INC $020E
$1E5F   JSR $FE6D
        CMP #$02
        BNE $1E5F
$1E66   JSR $FE6D
        CMP #$03
        BNE $1E96
        LDA #$0D
        DEC $020E
        DEC $020D
        BEQ $1E96
$1E77   JSR $1F1B
        CMP #$05
        BNE $1ECC
        PLA
        TAY
        PLA
        TAX
        JMP $1E14
$1E85   JSR $1FB9
        LDA #$A1
        STA $0218
        LDA #$1E
        STA $0219
        LDA $0201
$1E95   RTS
$1E96   STA $0213
$1E99   PLA
        TAY
        PLA
        TAX
        LDA $0213
        RTS
$1EA1   CPX $020B
        BEQ $1EA9
        JMP $F95A
$1EA9   TYA
        PHA
        LDA $0209
        STA $0207
        LDA $020A
        STA $0208
        DEC $0208
        LDA #$20
        STA $0201
        LDA #$0A
        STA $021A
        LDA #$1F
        STA $021B
        JMP $F9A0
$1ECC   CMP #$1C
        BEQ $1ED9
        CMP #$0C
        BNE $1E99
        JSR $FA57
        BPL $1E77
$1ED9   PLA
        TAY
        PLA
        TAX
        DEX
        BPL $1EE2
        INX
        RTS
$1EE2   DEC $0E
        TXA
        PHA
        TYA
        PHA
        LDA $E3
        PHA
        LDA $E4
        PHA
        JSR $FB8D
        LDA #$20
        JSR $FB1D
        JSR $FA05
        JSR $FB8D
        LDA #$9A
        JSR $FB1D
        PLA
        STA $E4
        PLA
        STA $E3
        JMP $1E77
$1F0A   PHA
        LDA #$4E
        STA $0218
        LDA #$1E
        STA $0219
        PLA
$1F16   AND #$7F
        JMP $FBD4
$1F1B   BIT $0203
        BPL $1F35
$1F20   LDA $D400
        CMP #$20
        BEQ $1F32
        LDA $F000
        LSR A
        BCC $1F20
        LDA $F001
        BCS $1F5B
$1F32   INC $0203
$1F35   LDA #$3F
        STA $021C
        LDA #$1E
        STA $021D
$1F3F   LDA #$00
        STA $D401
        STA $D400
        LDA #$04
        STA $D401
        LDA $020F
        BEQ $1F5F
$1F51   LDA $D400
        BPL $1F51
$1F56   LDA $D400
        BMI $1F56
$1F5B   STA $0213
        RTS
$1F5F   LDA $0217
        STA $0210
        TXA
        PHA
        TYA
        PHA
        LDA $E3
        PHA
        LDA $E4
        PHA
        JSR $1F78
        STA $0200
        JMP $F971
$1F78   LDY #$01
$1F7A   STY $E3
        LDY $0210
$1F7F   LDX #$50
$1F81   LDA $D400
        AND #$80
        BEQ $1F8B
        STA $0211
$1F8B   LDA $0211
        BEQ $1F9C
        LDA $D400
        AND #$80
        BNE $1F9C
        STA $0211
        BEQ $1F56
$1F9C   DEX
        BNE $1F81
        DEY
        BNE $1F7F
        LDA $E3
        BNE $1FB4
        JSR $FB8D
        LDA ($E3),Y
        STA $0201
        LDA #$80
        STA ($E3),Y
        BNE $1F78
$1FB4   JSR $FB17
        BEQ $1F7A
$1FB9   TXA
        PHA
        TYA
        PHA
        LDA $E3
        PHA
        LDA $E4
        PHA
        LDA $0207
        STA $0209
        LDA $0208
        STA $020A
        LDX #$08
$1FD1   LDA $F802,X
        JSR $FA57
        DEX
        BPL $1FD1
$1FDA   JSR $1F78
        CMP #$0C
        BEQ $1FDA
        CMP #$1C
        BNE $1FEA
        JSR $F924
        BPL $1FDA
$1FEA   CMP #$0D
        BEQ $1FFD
        BPL $1FF5
        JSR $FA57
        BPL $1FDA
$1FF5   JSR $F903
        JSR $FA57
        BPL $1FDA
$1FFD   JMP $F85B
```

Fig. 4. Useful Locations:

$020F — Flashing-cursor flag.
$0217 — Flash rate.
$0222 — 0 = enable clock.
$0223 — 0 = enable display of clock.
$1FAF — Character used for cursor.

To input a character from the keyboard under program control:

POKE11,235:POKE12,255:X=USR(X)

SMART ANSWER

Sir—I also experienced the Smart 2 problem described by Roger Cannon (PE—Sept. 81) in trying to expand my UK101 from 8K to 24K RAM. After a lot of searching I found the answer to be quite simple once the problem had been located. The following may be of general use to your readers:

With the Smart 2 board powered-up but not connected to the UK101, apply logic signals as listed in Table 1 to pins 1, 2 and 3 of IC V. Note the resultant logic states on pins 1 and 2 of IC X.

If, as I suspect, no change is found from a constant logic 1 on pins 1 and 2 of IC X, apply the logic signals as listed in Table 2. If the logic states at IC X are now changing then the Smart 2 board is wired up for expansion from 24K–40K and not 8K–24K as required.

To make the Smart 2 board compatible with your requirements the links adjacent to IC M have to be reset as shown in the diagram of Fig. 1.

My Smart 2 had arrived with the correct links set for 8K–24K expansion. However the kit instructions informed me that I had an unmodified board and the links should be changed. After having the same problem as Roger Cannon I tried to sort out the problem from the schematic diagrams supplied with the kit. After numerous hours of searching for a solution I returned my Smart 2 board to the suppliers (Chromasonics) for checking as I could not detect any soldering faults and there seemed to be no logical explanation for the lack of start-up. Chromasonics relieved me of £15 and after 6 weeks and several phone calls the board was returned. Nothing had been changed but it was stated that the board had been checked, tested and was serviceable. It was only after I found that the board was still apparently incompatible with the UK101 that I delved into the manufacturer's data books and solved the problem.

Flight Lieutenant D. C. Tilford,
RAF Bawtry,
Doncaster.

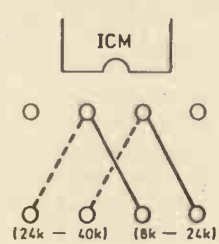
Table 1

	inputs—IC V			IC X	
Pins	1	2	3	1	2
	0	1	0	1	0
	1	0	0	0	1

Table 2

	inputs—IC V			IC X	
Pins	1	2	3	1	2
	0	0	1	1	0
	1	1	0	0	1

Fig. 1. Smart 2 link settings



PE BAND-BOX

PART 4 A.J.BOOTHMAN

THIS final part concerns operating and composition procedures.

MASTER RHYTHM SYNCHRONISATION

This control copes with the variable manner in which the Master Rhythm may be programmed on different rhythm selections. Each section is broken into equal time intervals commonly described as measures. Depending on the Rhythm Select position, the number of measures available in a section is 12, 16, 24 or 32, which also equals the number of pulses produced by the Master Rhythm during a single passage through the section. The operator has various options in deciding how many measures or pulses shall constitute a musical beat and will commonly choose 3, 4, 6 or 8 measures per beat, the larger numbers giving the ability to increase the complexity of the drum and cymbal pattern, for example, the use of high speed drum rolls.

When chord sequences are programmed into the Band-Box this rhythmic consideration is ignored and a single score can therefore be replayed on any of the Master Rhythm patterns producing a wide variety of feel from the same chord sequence, but it is necessary to define the number of measures per beat in use by the Master Rhythm during playback by positioning the synchronisation control to suit the rhythm selected. The Band-Box counts the pulses coming out of the Master Rhythm and converts them into beats according to the sync control position, and then translates the coded length of programmed chords in the score store into beats.

OPERATING PROCEDURES

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 two most important keys are Reset and Enter. The former may be used at any time to return the machine to the beginning of its operating sequence and may be used should the operator become confused, without affecting any scores which may have been composed. The Enter key is usually used to tell the machine that a number, for example a score page number, which has previously been keyed and reflected in the displays should be accepted by the machine.

SWITCH ON AND PLAY

When mains is applied to the unit, an automatic Reset operation occurs to produce a caption in the display indicating that correct operation of the Band-Box Microcontroller has commenced. If the caption does not appear correctly the Reset key should be pressed.

The last part of the caption is the two letter abbreviation "En." which is a request for the operator to press the Enter key. The display then changes to the request "En. Page No." A number between zero and 34 will be acceptable since, as stated earlier, the capacity of the machine is 35 pages (0 to 34). When the number is keyed it will appear in the right-hand display pair and when correct (e.g. 03) the Enter key should be pressed. The display will now change to "En. LINE No." Each Page has 100 lines labelled 0 to 99 and the required line number (e.g. 15) should be keyed followed by Enter.

The selected score is now ready to play and the display will read 03–GO–15, which means that playback will commence with the contents of the score at Page 3 Line 15 as will have been noted in the Index. Play is initiated by depression of the Play key on the Master Rhythm and stopped by depression of the Rest key or by the coda procedure described later.

During playback the display is blank and the Band-Box will play the chord sequence which has previously been entered starting at Page 3 Line 15 of the score store until that score reaches its natural end or playback is stopped by the operator. When play stops the display will reappear and the tune can be repeated if required. To select a new score the Reset button is pressed and the new page and starting lines are entered.

THE SCORE STORE

It is now necessary to understand the score store in greater detail to further appreciate the operating procedures. The score store is a memory into which all the information regarding a composition is put by the operator who at this stage is acting as a composer. The simplest way to provide the required information for the store is to take a piece of music which contains chord symbols and translate it into a set of instructions acceptable to the store.

SCORE INSTRUCTIONS

The table in Fig. 15 lists all the instructions which can be understood by the store. The store has 3,500 cells, each of which can contain one instruction, and it will be seen from the next section that a complete score might use as little as 15 cells or considerably more if it is complex.

The first type of instruction combines both the chord type and its duration in beats and will be the most frequent instruction used.

In order to give a large chord type capacity the second instruction allows selection of any one of 12 chord groups, moving up in semitones to give choice from approximately 120 chords. An attempt has been made to arrange the table such that likely related chords appear within the same group to reduce the need to hop between groups, but this is so dependent on the style of music involved that a wide variation in efficiency of memory utilisation will be experienced, hence one reason for the wide range of 40–120 tunes suggested as the capacity of the basic machine.

The third instruction (Segno) sets the point from which a tune will be repeated when a Dal Segno, which is the fourth instruction, is encountered. If the Segno instruction, abbreviated to S, is omitted then the start of the tune will be taken as the point from which to repeat. The main value of Segno is to identify the end of an introductory chord sequence before the main theme, and Dal Segno, abbreviated to d., will cause the main theme to be repeated an unlimited number of times from Segno until the coda key is pressed. This requires momentary action for two beats during playback and will cause the Band-Box to ignore the following Dal Segno instruction, moving to the next part of the score. A genuine coda may follow the main theme in which case instruction five Fin will terminate play at the end of the coda. Alternatively, Fin may immediately follow Dal Segno without a coda and stop playback when Dal Segno is jumped, or as a third option Dal Segno may be followed by an optional coda, a new introduction to a second tune, perhaps an inspired key modulation, a further Segno and the main theme of a second tune. The process can continue for a sequence of any number of tunes provided that the total capacity of the machine is not exceeded.

THE INDEX

The Index is a convenient way of logging, particularly the start and finish points of all scores put into the unit by the "composer". It is recommended that a log book is kept which covers all the tunes that have been composed. Two formats are possible, one of which lists the contents of every line recorded, and the other simply notes the tune titles together with page and line numbers for start and finish. For maximum use of the score memory space, a new tune can follow on the next line after completion of the previous tune so that complete flexibility is possible in score length and no memory need be wasted.

COMPOSITION PROCEDURE

Composition combines the functions of inspecting the score store to see what, if anything, has been entered on a previous occasion, making small alterations, and entering a complete new score.

The sequence of events is shown in Fig. 16, commencing with depression of the Reset key. When the usual caption appears the Enter key is normally pressed to go through the playback procedure; however, the compose procedure is initiated by pressing the key marked with the forward pointing arrow. The display will ask for both page and line numbers corresponding to the point at which inspection of the score store is required, but after entry of the line number, instead of the usual "go" message, the display will command the operator to Reset.

This is designed as an electronic lock to deter and confuse the unauthorised operator who will, of course, find himself back at the beginning of the machine sequence if he carries out the Reset command. To continue with the composition procedure the "9" key and "0" key should be pressed in that order; any other combination will cause the same effect as Reset.

After successfully unlocking the system, the display will read "En. Chrd. Gp." This is an abbreviation of the request to enter the number of the chord group, within the table, which is required first. The group should contain the first chord of the composition plus the maximum number of following chords before a change of chord group becomes unavoidable. The group chosen will be heavily influenced by the musical key of the tune. For example, the operator may have access to the sheet music of a favourite tune which has chord symbols on the sheet and is written in the key of F major. The chord sequence might commence FM(2), Dm(2), Gm7(2), C7(2), where the figures in brackets are numbers of beats for each chord, and since they are all in chord group 5 of the chord table the chord changes can all be programmed without the need to change between chord groups if the choice for the first chord group is 5.

Important feature—Although the operator is entering the score in the key of F major, it will later be possible to play back the tune in any key fixed by the position of the playback key control. Playback key is independent of the key chosen during composition. The Band-Box completely understands transposition!

INSPECTING THE SCORE STORE

The selection of the required opening chord group is followed by depression of the Enter key which immediately causes display of the contents of the store at the page and line selected. The format of this is to show the line number in the first two displays, the current chord group in the third display, the chord identity in the sixth and its length in beats in the eighth display. When the instruction is other than a chord, display six contains the number 0 and display eight contains 0–11 for an instruction to change to a new chord group (0–11), or the symbols S., d., J. or F. corresponding to Fig. 15.

It is now possible to inspect the next line by pressing > or the previous line by pressing <. The change in line number will be shown in the first two displays and the whole score store could be inspected by repeatedly pressing the direction keys. After line 99 the display will change to 00 for the first line on the next page and in reverse 00 will become line 99 for the previous page. Inspecting the score store in this manner will not alter the contents of the store. It will be noted that the chord group number in display 3 will respond to a "Change chord group" instruction during this inspection procedure and ensures that the operator is always aware of the chord group currently in use.

TO CHANGE A LINE

An individual line in the store may be altered at any time during the inspection procedure. A pointer next to display 6 indicates that depression of a key in the composition key row will put it into display 6 and replace the previous value in the score store after depression of the Enter key. The pointer then moves to display 8 next indicating that this value may be changed if required using one of the composition keys. To register the full change in the score store the > key should be pressed which will also bring the next line into the display. Changes to a line in the store should always be followed by the forward key.

A COMPLETE COMPOSITION

An example composition of no musical significance is shown in Fig. 17 commencing at page 0, line 0. For simplicity, the key of C is used but as stated earlier any key could be used without affecting playback which is purely determined by the position of the twelve position Key Control.

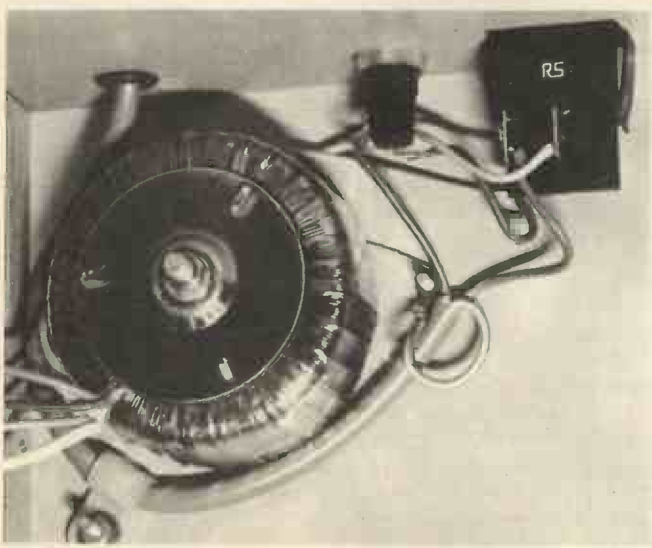
In order to demonstrate the Segno (S.), Dal Segno (d.) and Fin (F.) instructions a four bar intro, and a coda, have been incorporated in the example.

DETAILING THE CONTENT

Following the procedure outlined above, page 0 and line 0 are selected in the composition mode. Chord group zero is chosen to start and the display will read 00 0 'X X after the chord group has been entered. The crosses denote information which has randomly been programmed into the store previously and is no longer wanted. The first action working from the chord table is to key "1" for the CM chord in group 0, and press Enter. This moves the arrow next to the beat display indicating it may be changed. The number 4 is keyed into this position and the > key pressed to move onto line 01 having recorded the correct instruction into line 00. Steadily working through the score in this manner, chord group changes are inserted when required and in moving to the next line the chord group display will be seen to have followed. The Segno instruction is inserted in line 04, the D.S. instruction in line 15, and the Fin instruction in line 20 which is the end of the score.

PLAYBACK

On playback from page 00, line 00, bar 1 to 4 will play once after which bars 5 to 8 will repeat *ad infinitum* until the coda key is pressed (or Rest on the Master Rhythm which stops playback instantly). The coda request will be remembered and the next time D.S. is encountered after bar 8 the Band-Box will ignore it and jump to bar 9 playing through to bar 12 which is followed by the Fin instruction and causes play to cease. One point to notice is that the beginning and end of a repeat section should have the same chord group to prevent key changes on each repeat, even if it means including an extra chord group change instruction just before D.S. This sequence has used seven different chords, sixteen chord changes, and twenty lines in the score store.



Showing the power supply transformer

INTERNAL TUNE FACILITIES

The Band-Box has a pre-recorded blues which is accessed by pressing the Enter key three times, once after the opening caption has been displayed by the operation of the Reset key, once as an answer to En. Page No., and once as an answer to En. Line No. The display will read 00 — GO — 00 which is not the same as Page 00, Line 00. A second internal facility is a continuous major chord used for tuning purposes. The chord can be in any key determined by the rotary key control and the tuning of the Band-Box is carried out by turning the single screw accessed through a hole in the bottom of the unit with a small screwdriver. To obtain the tuning chord press Enter after the opening caption, I.P. (Internal Page) after the page number request, and enter 20 after the line number request. The display will read 00 — GO — 20 which is not the same as Page 0, Line 20. Initial tuning can be carried out by selecting key "A" and using a tuning fork at A-440 and the setting can be altered at any time to tune into, for example, a flat piano. A single semitone range is all that is necessary since the Band-Box can be set to play in a different key to match other instruments which might be grossly out of tune from concert pitch.

OPERATIONAL EXPERIENCE

Operation of the Band-Box to date has shown that the playback procedure gives quick accessibility to the required score and that drum style synchronisation to the Master Rhythm is soon understood. Composition procedures have naturally been found more complex and three points are worth mentioning.

INTRODUCTIONS

All compositions benefit by introductions, even if they consist of tacet chords with just the drums sounding. This is particularly useful when a tune has a lead chord of say two or three beats duration, and allows the composer to extend this to a four bar introduction to synchronise sequence operation of the Master Rhythm in a logical fashion. It is often useful to place the Segno before the lead-in bar which is likely to be the same as the bar seen before the usual repeat at the end of the chorus, and is usually modified on the last time of playing.

DUMMY INSTRUCTIONS

Mistakes can be made in composition, and sometimes experimentation may be required in the middle of a tune. This makes it desirable to insert dummy instructions say every ten lines which may later provide the required extra space for an adjustment using extra lines. The best form of "dummy" is to make a chord group change to the same chord group already in operation giving a nil change.

ENDINGS

Crisp endings can be a challenge, and are often a problem with a live trio. In the early stage of experience some experimentation will be necessary, by the operator, and to assist in this an extra instruction has been incorporated into the monitor which gives a half beat duration. To obtain the half beat a chord length is entered as zero, and will produce the letter H in the display.

The enormous interest which has already been shown in the Band-Box concept promises to establish the unit as a musician's tool to give both valuable aid to study and performance and to increase the facility for creative musical enjoyment. ★

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	1X011	9+9	1.66		
	1X012	12+12	1.25		
	1X013	15+15	1.00		
	1X014	18+18	0.83		
	1X015	22+22	0.68		
	1X016	25+25	0.60		
	1X017	30+30	0.50		
50 VA 80 x 35mm 0.9 Kg Regulation 13%	2X010	6+6	4.16	£5.83 +£1.10 P/P	£4.93 +£1.10 P/P
	2X011	9+9	2.77		
	2X012	12+12	2.08		
	2X013	15+15	1.66		
	2X014	18+18	1.38		
	2X015	22+22	1.13		
	2X016	25+25	1.00		
	2X017	30+30	0.83		
	2X028	110	0.45		
	2X029	220	0.22		
	2X030	240	0.20		
80 VA 90 x 30mm 1 Kg Regulation 12%	3X010	6+6	6.64	£6.51 +£1.43 P/P	£5.47 +£1.43 P/P
	3X011	9+9	4.44		
	3X012	12+12	3.33		
	3X013	15+15	2.66		
	3X014	18+18	2.22		
	3X015	22+22	1.81		
	3X016	25+25	1.60		
	3X017	30+30	1.33		
	3X028	110	0.72		
	3X029	220	0.36		
	3X030	240	0.33		
120 VA 90 x 40mm 1.2 Kg Regulation 11%	4X010	6+6	10.00	£7.55 +£1.43 P/P	£6.38 +£1.43 P/P
	4X011	9+9	6.66		
	4X012	12+12	5.00		
	4X013	15+15	4.00		
	4X014	18+18	3.33		
	4X015	22+22	2.72		
	4X016	25+25	2.40		
	4X017	30+30	2.00		
	4X018	35+35	1.71		
	4X028	110	1.09		
	4X029	220	0.54		
	4X030	240	0.50		
160 VA 110 x 40mm 1.8 Kg Regulation 8%	5X011	9+9	8.89	£9.92 +£1.43 P/P	£8.44 +£1.43 P/P
	5X012	12+12	6.66		
	5X013	15+15	5.33		
	5X014	18x18	4.44		
	5X015	22+22	3.63		
	5X016	25+25	3.20		
	5X012	30+30	2.66		
	5X018	35+35	2.28		
	5X026	40+40	2.00		
	5X028	110	1.45		
	5X029	220	0.72		
	5X030	240	0.66		

TYPE	SERIES No	SECONDARY Volts	RMS Current	PRICE inc VAT	PRICE ex VAT
225 VA 110 x 45mm 2.2 Kg Regulation 7%	6X012	12+12	9.38	£11.83 +£1.73 P/P	£10.06 +£1.73 P/P
	6X013	15+15	7.50		
	6X014	18+18	6.25		
	6X015	22+22	5.11		
	6X016	25+25	4.50		
	6X017	30+30	3.75		
	6X018	35+35	3.21		
	6X026	40+40	2.81		
	6X025	45+45	2.50		
	6X033	50+50	2.25		
	6X028	110	2.04		
	6X029	220	1.02		
	6X030	240	0.93		
300 VA 110 x 50mm 2.6 Kg Regulation 6%	7X013	15+15	10.00	£13.67 +£1.73 P/P	£11.66 +£1.73 P/P
	7X014	18+18	8.33		
	7X015	22+22	6.82		
	7X016	25+25	6.00		
	7X017	30+30	5.00		
	7X018	35+35	4.28		
	7X026	40+40	3.75		
	7X025	45+45	3.33		
	7X033	50+50	3.00		
	7X028	110	2.72		
	7X029	220	1.36		
	7X030	240	1.25		
500 VA 140 x 60mm 4 Kg Regulation 4%	8X016	25+25	10.00	£18.17 +£2.05 P/P	£15.53 +£2.05 P/P
	8X017	30+30	8.33		
	8X018	35+35	7.14		
	8X026	40+40	6.25		
	8X025	45+45	5.55		
	8X033	50+50	5.00		
	8X042	55+55	4.54		
	8X028	110	4.54		
	8X029	220	2.27		
	8X030	240	2.08		
625 VA 140 x 75mm 5 Kg Regulation 4%	9X017	30+30	10.41	£25.10 +£2.20 P/P	£21.54 +£2.20 P/P
	9X018	35+35	8.92		
	9X026	40+40	7.81		
	9X025	45+45	6.94		
	9X033	50+50	6.25		
	9X042	55+55	5.68		
	9X028	110	5.68		
	9X029	220	2.84		
	9X030	240	2.60		

IMPORTANT: Regulation — **All voltages quoted are FULL LOAD. Please add regulation figure to secondary voltage to obtain off load voltage.**

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PATENTS REVIEW...

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NEVER BEFORE?

British patent application 2 064 266 was filed by Dual of Germany, and dates back to March 1979. The patent, which claims a loudspeaker cross-over network, seems to be based on a very simple idea. But the British Patent Office Examiner has been unable to find ANY prior documents to cite against the Dual application as a possible anticipation. Does this mean that the Dual idea is as new as claimed, or that the British Patent Office filing system is inadequate?

The aim is to smooth out the considerable variations in impedance which occur in the transition regions of a multi-driver loudspeaker system. It is, of course, advantageous to smooth out impedance variations, because they produce corresponding load variations on the amplifier. Dual also aim for a single inventory loudspeaker system, capable of connection to either an 8ohm or a 4ohm amplifier output, without risk of overload damage.

Figure 1 shows the basic system. LF driver 2, and MF/HF driver 1, are connected by conventional frequency divider networks 3, 4 to common input 5, 6. Resonant circuit of inductor 7 and capacitor 8 is connected across the input. The resonant frequency of this L/C circuit, is tuned to the transitional frequency between drivers 1, 2. Resistor 9 attenuates so that what the inventor calls "the resulting impedance course" is the mirror image of the impedance curve for dividers 3, 4 at the region of transition between drivers 1, 2.

Figure 2 shows the single inventory speaker system design. A third input terminal 10 connects with input 5 via series resistor 11. Resistor 12 is temperature variable, with a positive temperature coefficient, and bridges fixed resistor 11. An amplifier designed for a 4ohm system is connected to inputs 5, 6 and an 8ohm amplifier is connected between inputs 10, 6. At normal room temperatures resistor 12 has a low value (0·6Ω) which effectively short circuits the resistor 11. But any overload increases the value of resistor 12 and so puts resistor 11 in series with the amplifier output. Dual claim that the provision of resistor 11 "does not have any disadvantageous effect on the frequency response curve", but audio purists may wonder about the effect on damping factor of putting a resistor in series with the amplifier output.

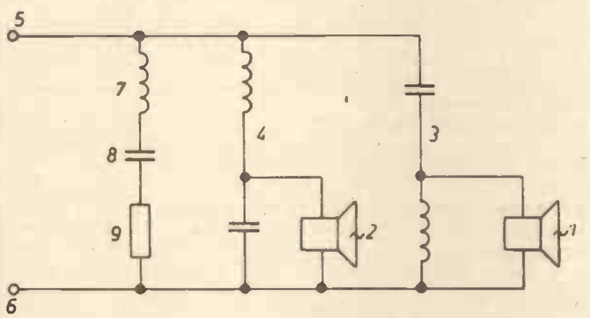

Fig. 1.

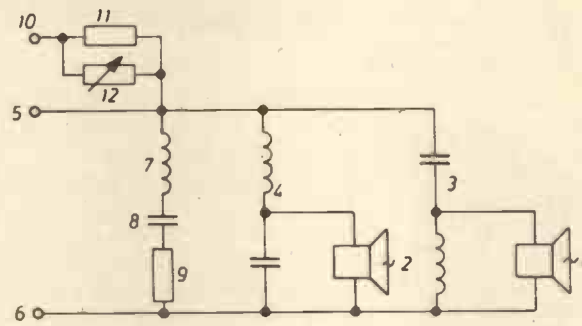

Fig. 2.

SPEAK AND SPELL

Recently published British patent application 2 058 522 comes from Texas Instruments of Dallas. The patent, which has 50 sheets of diagrams and 30 pages of text (all for the basic price of £1.45) describes the logic and speech synthesis circuitry used by Texas for the "Speak and Spell" toy. (Incidentally "Speak and Spell" has now been followed in America by new Texas toys such as "Speak and Math" and "Speak and Read".) The Texas patent offers a valuable bibliography of previous work on speech synthesis, for instance the technique of linear prediction and digital lattice filters. The patent also explains the logic circuits used in Speak and Spell and details the compression technique used to store sufficient data for a large vocabulary in a small memory. New parameters are inputted into the speech synthesiser at a rate of 50Hz. There are 12 parameters in ten bit digital words. So if each parameter were updated with a full word fifty times a second this would require a bit rate of 6000 bits per second. This is impractical from a memory of reasonable capacity so Texas compress the data rate to around 1000 bits per second.

Essentially, data frames of different lengths are used, depending on the amount of information which is essential. For instance repeat frames are used when there has been no significant change during a 20 millisecond period. Where there is a change to be reproduced, a coded parameter is inputted and converted to a 10 bit parameter. In this way the bit stream is kept down to the most economical level possible.

It is interesting to note that the Texas patent claims, which define the scope of legal monopoly sought by Texas, are very broad. If the Patent Office accepts the claims made by Texas in this patent application, the company will have a monopoly on any system for generating synthetic speech which includes a memory, digital filter, excitation generator, multiplier, digital-to-analog converter and audio reproducer. Whether such a broad legal claim is justified in the light of previous work in this field remains to be seen, but whatever the legal outcome, British patent 2 058 522 will make good reference material for anyone interested in the Texas approach to speech synthesis.

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HY 60	30w/4-8Ω	0.015%	<0.006%	±25±30	76×68×40	240	£9.58	£8.33
HY 120	60w/4-8Ω	0.01%	<0.006%	±35±40	120×78×40	410	£20 10	£17 48
HY 200	120w/4-8Ω	0.01%	<0.006%	±45±50	120×78×50	515	£24.39	£21.21
HY 400	240w/4Ω	0.01%	<0.006%	±45±50	120×78×100	1025	£36 60	£31.83

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HY 120P	60w/4-8Ω	0.01%	<0.006%	±35±40	120×26×40	215	£17.83	£15.50
HY 200P	120w/4-8Ω	0.01%	<0.006%	±45±50	120×26×40	215	£21 23	£18.46
HY 400P	240w/4Ω	0 01%	<0 006%	±45±50	120×26×70	375	£32.58	£28.33

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.

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HD 200	120w/4-8Ω	0.01%	<0.006%	±45±50	120×78×60	620	£31 49	£27.38
HD 400	240w/4Ω	0.01%	<0.006%	±45±50	120×78×100	1025	£44 42	£38 63

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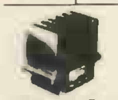
Model No.	Output power Watts rms	DISTORTION T.H.D. Typ at 1kHz	DISTORTION I.M.D. 50Hz/7kHz 4.1	Supply voltage Typ/Max	Size mm	Wt gms	Price inc VAT	Price ex VAT
HD 120P	60w/4-8Ω	0.01%	<0 006%	±35±40	120×26×50	265	£22.82	£19.84
HD 200P	120w/4-8Ω	0.01%	<0.006%	±45±50	120×26×50	265	£27 17	£23.63
HD 400P	240w/4Ω	0.01%	<0 006%	±45±50	120×26×70	375	£39.42	£34.28



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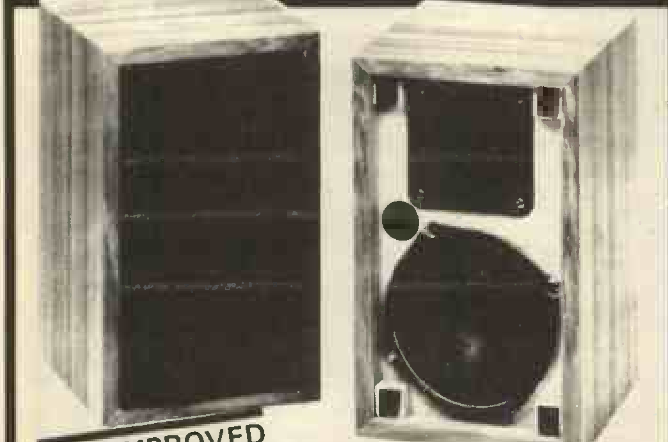

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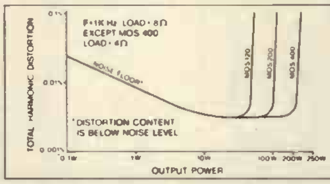

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MOS 400	240w/4Ω	<0 005%	<0.006%	±55±60	120×78×100	1025	£52 20	£45.39

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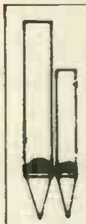

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89	10	20	18.98	1.84
90	12	24	21.09	O.A.
91	15	30	24:18	O.A.
92	20	40	32.40	O.A.

50 VOLT RANGE (Split Sec) Pri 120/240V
Sec Voltages available 5, 7, 8, 10, 13, 15, 17, 20, 33, 40 or 20V-0-20V or 25V-0-25V.

Ref.	Amps 50V	Amps 25V	Price	P&P
102	.5	1	3.75	1.20
103	1	2	4.57	1.20
104	2	4	7.88	1.44
105	3	6	9.42	1.60
106	4	8	12.82	1.72
107	6	12	16.37	1.84
118	8	16	22.29	2.20
119	10	20	27.48	O.A.
109	12	24	32.88	O.A.

MAINS ISOLATORS (SCREENED)
Pri 0-120; 0-100-120V (120, 220, 240V) Sec 0-CT-120V twice.

Ref	VA	Price	P & P
*07	20	4·84	1.20
149	60	7·37	1.20
150	100	8·38	1.44
151	200	12·28	1.72
152	250	14·61	2.04
154	500	22·52	2.20
155	750	32·03	O.A.
156	1000	40·92	O.A.
157	1500	56·52	O.A.
158	2000	67·99	O.A.
159	3000	95·33	O.A.

*Pri 0-240V Sec 115 or 240V only. State sec. volts required.

CASED AUTO TRANSFORMERS
240V cable in 115V USA flat pin outlets

VA	Price	P & P	Ref
20	6·55	0.95	56W
75	8.50	1.20	64W
150	11·00	1.44	4W
250	13·39	1.44	69W
500	20·13	2.04	67W
1000	30.67	2.20	84W
2000	54.97	O.A.	95W

60 VOLT RANGE (Split Sec)
Pri 120/240V. Voltages available 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 or 24V-0-24V or 30V-0-30V.

Ref	Amps 60V	Amps 30V	Price	P&P
124	·5	1	4.27	1.20
126	1	2	6.50	1.20
127	2	4	8.36	1.60
125	3	6	12.10	1.72
123	4	8	13.77	1.96
40	5	10	17.42	1.84
120	6	12	19.87	2.04
121	8	16	27.92	O.A.
122	10	20	32.51	O.A.
189	12	24	37.47	O.A.

12 OR 24V OR 12-0-12V
Pri 220-240 volts

Ref	Amps 12V	Amps 24V	Price	P&P
111	0 5	0·25	2·42	0.95
213	1·0	0·5	2·90	1.00
71	2	1	3·86	1.00
18	4	2	4·46	1.20
85	0·5	2·5	6·16	1.20
70	6	3	6·99	1.20
108	8	4	8·16	1.44
72	10	5	8·93	1.60
116	12	6	9·89	1.60
17	16	8	11·79	1.72
115	20	10	15.87	1.84
187	30	15	19.72	2.04
226	60	30	40.41	O.A.

SCREENED MINIATURES

Ref	mA	Volts	£	P&P
238	200	3-0-3	2·83	0.50
212	1A, 1A	0-6, 0-6	3·14	1.00
13	100	9-0-9	2·35	0.50
235	330, 330	0-9, 0-9	2·19	0.60
207	500, 500	0-8-9, 0-8-9	3·05	0.95
208	1A, 1A	0-8-9, 0-8-9	3·88	1.20
236	200, 200	0-15, 0-15	2·19	0.60
214	300, 300	0-20, 0-20	3·08	1.00
221	700 (OC)	20-12-0-12-20	3.75	1.00
206	1A, 1A	0-15-20 (x2)	5.09	1.20
203	500, 500	0-15-27 (x2)	4.39	1.20
204	1A, 1A	0-15-27 (x2)	6.84	1.20
239	50	12-0-12	2·88	0,50
234	500	6-0-6	2·19	0·44

Send 20p stamps for Catalogue. Prices correct 21/4/81.

AUTO TRANSFORMERS
Voltages available: 105, 115, 190, 200, 210, 220, 230, 240, for step up and step down.

Ref.	VA (Watts)	£	P&P
113*	15	2.73	1.00
64	80	4.41	1.20
4	150	5.89	1.20
53	350	10.00	1.44
67	500	12.09	1.84
84	1000	20.64	2.20
93	1500	25.61	O.A.
95	2000	38.31	O.A.
73	3000	65.13	O.A.
80	4000	84.55	O.A.
57	5000	98.45	O.A.

*0, 115, 220, 240.

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Clean mains to computers/peripherals
250 VA £98.00
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15V CT Range (7.5V-0-7.5V)

Ref			P & P
171	500 mA	2·30	0.60
172	1A	3·26	1.00
173	2A	3·95	1.00
174	3A	4·13	1.20
175	4A*	6·30	1.20

96/48/36V RANGE
Pri 0-120/240V
Sec 2 windings 0-36-48V to give 36-0-36V or 48-0-48V or 72V or 96V.

Amps 72v/96v	Amps 36v/48v	Ref.	Price	P&P
1	2	431	8.12	1.44
2	4	432	13.35	1.22
3	6	433	16.17	1.96
4	8	434	20.65	2.04
5	10	435	29.30	2.20
6	12	436	36.69	O.A.
8	16	437	40.03	O.A.

Split Bobbin Type. Sec Voltages available 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24, 30V, or 12-0-12V or 15-0-15V. 1 amp (09) £2.06 + 98p. PP 2 amp (10) £4.11 £1.10p PP + VAT.

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100W Soldering Gun includes bulb for spot-on joints **£5.39** + VAT.

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43mm	43mm	82mm	78mm
0 50μA	6·20	0 50μA	7·37
0 500μA	6·20	0 500μA	7·37
0 1mA	6·20	0 1mA	7·37
0 30V	6·20	0 30V	7·37

Educationmetre. 10 amp 30V at **£4.50.** P&P 66p + VAT. Size 75 x 78mm Scaler.

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400V	4A	£0.98	P&P 20p
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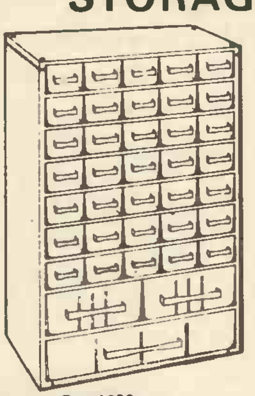

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50 Way	575p	450p	—	330p

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100p Locking Lever 100p

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	Solder type	IOC type
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16 pin	60p	140p
24 pin	100p	200p
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24" Ribbon Cable with headers

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1 end	145p	165p	240p	380p
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2 ends	290p	385p	490p	540p

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(for 2×32 Way specify a+b or a+c)

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★ ZX80/81. USER PORT ★

(As described in Oct/Nov PCW)

Port module plugs directly into ZX80/81 to provide 8 input and 8 output lines. These allow input of data from switches, photocells, sensors, joysticks etc and control of 8 relays. Also 7 segment displays and LED may be used — "VARIABLE TONE AUDIO OUTPUT CAN PRODUCE YOUR OWN SOUND EFFECTS." Port access is by simple PEEK & POKE COMMANDS.

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★ TELETEXT DECODER ★

A complete kit, as described in "ELEKTOR Nov. 81" including the Keyboard Kit, containing the PCBs, ICs, switches and all other components as listed in the constructional article plus sockets for all ICs.
(Note the kit does not include components or pcbs listed in Dec. issue of Elektor.

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Two board interface system plugs directly into computer expansion socket to provide wide facilities accessible from BASIC or MACHINE CODE.

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P&P 0.75p/Kit

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TECHNOMATIC TECHNOMATIC TECHNO

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