

AN ARGUS SPECIALIST PUBLICATION

# electronics today

INTERNATIONAL

May 1983 85p

## SPECIAL AUDIO ISSUE

Four Audio Projects:

**Power  
Amplifier  
Using NDFL**

**Power Supply  
Upgrade from  
Linsley Hood**

**Balanced Line  
Amplifier**

**Compressor  
Limiter  
System**



**AUDIO PULL-OUT  
WE TELL YOU  
WHICH SYSTEM**

...AUDIO....COMPUTING....MUSIC...

ROBOTICS...



# Star sounds \*\*

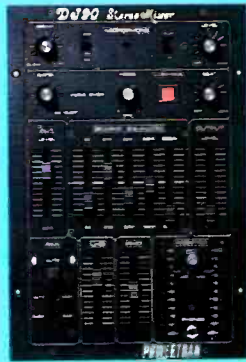
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# Star features \*\*

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**TRANSCENDENT 2000** — Although only a 3 octave keyboard the '2000' features the same design ingenuity, careful engineering and quality components of its larger brethren. The kit is well within the scope of the first time builder — buy it, build it — play it! You will know you have made the right choice.

Complete kit **£165.00 + VAT**

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from the factory.  
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**Digital Delay Line** — With its ability to give delay times from 1.6 mSecs to up to 1.6 secs. Many powerful effects including phasing, flanging, A.D.T., chorus, echo &



vibrato are obtained. The basic kit is extended in 400 mS steps up to 1.6 secs. Simply by adding more parts to the PCB.

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Output channel	<b>£18.50</b>	Pair of mahogany end cheeks	<b>£12.50</b>
Auxiliary channel	<b>£22.50</b>	Power Supply and cabinet	<b>£19.50</b>
Blank Panel	<b>£3.00</b>		

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tips, well  
illustrated.**

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**Chromathèque 5000** — a 5 channel lighting system powerful enough for professional discos yet controllable for home-effects. Sound to light, strobe to music level, random or sequential effects — each channel can handle up to 500W yet minimal wiring is needed with our unique single board design. Complete kit **£49.50 + VAT**

**ET1 VOCODER** — 14 channels, each with independent level control for maximum versatility and intelligibility. Two input amplifiers — for speech/excitation — each with level control and tone control. The Vocoder is a powerful yet flexible machine that is interesting to build and thanks to our easy to follow construction manual, is within the capability of most enthusiasts. Complete kit **£175.00 + VAT**

**SP2 200** twice the power with two of the reliable, durable and economic amps from the MPA 200, fed by separate power supplies from a common toroidal transformer. Superb finish and quality components throughout — up to (even over) the standard of high price factory-built units! Complete kit **£64.90 + VAT**



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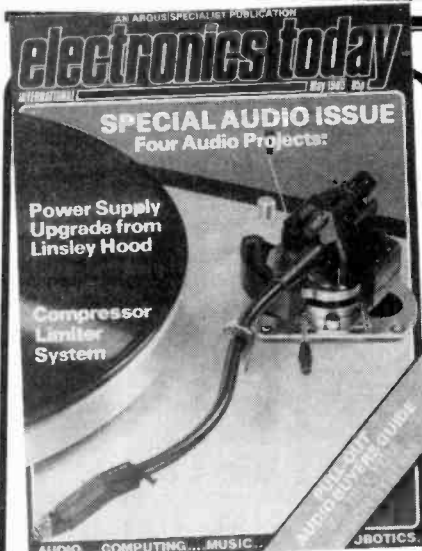


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INTERNATIONAL



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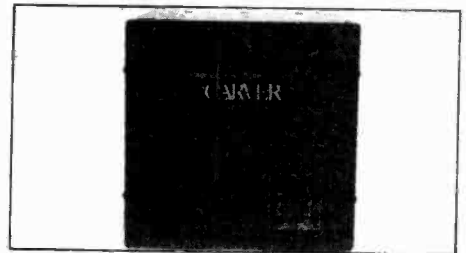
## FEATURES

**DIGEST** ..... 11  
 All the latest news on the electronics scene: computing, audio, engineering, hi-fi, energy, lectures, a collection of shorts and two or three *extremely* silly items.

**BUYER'S GUIDE TO HI-FI** ..... 43  
 An eight-page special feature for anyone dipping a toe into the hi-fi market — or, indeed, anyone contemplating total immersion. A series of complete disc-playing systems is listed, each having the ETI stamp of approval and ranging from the affordable to the ridiculous. There's also advice on compact discs, cassette decks, tuners, and everything you wanted to know about shopping for hi-fi.

**CONFIGURATIONS** ..... 63  
 When is a diode not a diode? When it's got a couple of extra semiconducting layers and becomes a thyristor, that's when. Ian Sinclair takes a look at four-layer devices and their uses.

**TECH TIPS** ..... 74  
 More circuit design ideas from our ever-inventive readership: this month we feature a simple stylophone and active circuitry for a bass guitar.



## PROJECTS

**STABILISED PSU** ..... 18  
 We welcome J. Linsley Hood to the pages of ETI with this article on the merits of stabilised power supplies, concluding with two designs that will give you the best from your hi-fi.

**60 W NDFL POWER AMP** ..... 24  
 After last month's feature on nested differentiating feedback loops, we present a 60 W, two-NDFL design with very low distortion. Use it as a module to upgrade your hi-fi or as the basis for a whole new power amp.

**COMPRESSOR/LIMITER** ..... 32  
 Banish the overload blues with our broadcast-quality compressor/ limiter. This unit uses common components but has a spec straight out of a professional studio.

**BALANCED LINE PREAMP** ..... 38  
 This balanced input differential preamp will allow the use of transducers having long leads, with low noise and low distortion.

**ZX81 MUSIC BOARD PART 2** ..... 54  
 To conclude this project we provide full listings and explanations of the software that enables you to use the music board to the full.

**ORGAN PART 4** ..... 67  
 Our final article in this very popular series describes the construction of the Victory organ and details all the parts and prices. A must for the serious musician.

**STAGE LIGHTING PART 4** ..... 70  
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## INFORMATION

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**PCB SERVICE** ..... 87







SWITCHES

TOGGLE: 2A, 250V SPST 33p DPDT 44p
SUB-MIN TOGGLE SPST on/off 54p SPST c/cover 60p SPDT centre off 85p SPDT biased both 105p SPDT moment 99p DPDT moment 145p
THUMBUTTON 6A with 10mm Button SPDT latching 99p DPDT latching 145p SPDT moment 99p DPDT moment 145p
Mini Non Locking Push to Make 15p Push to Break 25p

DIL SWITCHES

(SPST) 4 way 70p; 6 way 85p; 8 way 90p; 10 way 145p. (SPDT) 4 way 190p.
ROTARY SWITCHES: (Adjustable Stop type) 1 pole/2 to 12 way; 2p/2 to 6 way; 3 pole/2 to 12 way; 4p/2 to 3 way 45p
ROTARY: Mains DP 250V 4 Amp on/off 68p
ROTARY: (Makfa-switch) Make a multiway switch. Shafting assembly has adjustable stop. Accommodates up to 6 wafers (max. 6 pole/12 way + DP switch). Mechanism only 90p
WAFERS: (make before break) to fit the above switch mechanism. 1 pole/12 way; 2 pole/6 way; 3 pole/4 way; 4 pole/3 way; 6/2 way; Mains DP 4A Switch to fit 45p Spacers 4P. Screen 6p
ROCKER: 5A/250V SPST 28p ROCKER: 10A/250V SPDT 38p ROCKER: 10A/250V DPDT c/off 95p ROCKER: 10A/250V DPST with neon 85p
THUMBWHEEL Mini front mount. Decade Switch Module B.C.D. Switch Module Mounting Cheeks (per pair) 75p

VEROBOARD

0.1in clad plain 2 1/2 x 3 1/4 85p 2 1/2 x 5 100p 3 1/4 x 3 1/4 100p 3 1/4 x 5 115p 3 1/4 x 7 390p 4 3/4 x 17 455p Pkt. of 100 pins 55p Spot face cutter 150p Pin insertion tool 185p
VQ Board 195p DIP Board 395p Vero Strip 85p
PROTO DECS Veroblock 405p S-Dec 380p Eurobreadboard 520p Superstrip 575p Superstrip SS2 1350p
DALO ETCH RESIST PEN Plus spare tip 90p
ULTRASONIC TRANSDUCER 40KHz 325 p

VEN WIRING

PEN + spool 340p Spare spool 75p Combs 6p
FERRIC CHLORIDE 1 lb bag Anhydrous 195p + 50p P&P

COPPER CLAD BOARDS

Single sided 6 x 6 90p 6 x 12 150p Double sided 9.5 x 8.5 110p 9.5p S.R.B 195p

DIL SOCKETS

Low Wire Prof Wrap 8pin 14p 10pin 16p 16pin 10p 42p 18pin 16p 62p 20pin 22p 80p 22pin 22p 85p 24pin 25p 70p 28pin 28p 80p 40pin 30p 80p

EDGE CONNECTORS

2 x 15 way 140p 2 x 18 way 180p 2 x 22 way 200p 2 x 23 way 175p 2 x 25 way 225p 2 x 28 way 190p 2 x 30 way 245p 2 x 36 way 295p 2 x 40 way 315p 2 x 43 way 395p 2 x 75 way 650p

ANTEX SOLDERING IRON

C-15W 465p CX17W 475p CCN-15W 495p CX25W 510p Spare tips, assorted sizes 210p Spare elements 50p Iron Stand with sponge 185p

SIL SOCKETS

0.1" pitch 20 way 65p

ETI PROJECTS

We stock most of the parts
6 inches 165p 200p 300p 450p 12 inches 195p 215p 315p 465p 24 inches 210p 235p 340p 540p 36 inches 230p 250p 375p 595p

JUMPER LEADS

(Ribbon Cable Assembly) Length 14 pin 16 pin 24 pin 40 pin Single ended DIP (Header Plug) Jumper 145p 165p 240p 380p Double ended DIP (Header Plug) Jumper 165p 205p 300p 465p 20 pin 26 pin 34 pin 40 pin 200p 280p 300p 540p

ETI

198p

ICD

Female Header Socket Jumper Leads 24" 150p 300p 480p 525p Single ended 160p 370p Double ended 290p 370p 480p 525p

TRANSFORMERS

3-0-3V; 0-0-6V; 0-0-9V; 12-0-12V; 15-0-15V @100mA 85p
pcb mounting. Miniature, Split Bobbin
3VA: 2x1V-0.25A; 2x9V-0.15A; 2x12V-0.12A; 2x15V-0.1A 200p
6VA: 2x6V-0.5A; 2x9V-0.3A; 2x12V-0.25A; 2x15V-0.2A 270p
Standard Split Bobbin type:
6VA: 2x6V-0.5A; 2x9V-0.4A; 2x12V-0.3A 220p
2x15V-0.25A
12VA: 2x4.5V-1.3A; 2x5V-1A; 2x9V-0.6A; 2x12V-0.5A; 2x15V-0.4A; 2x20V-0.3A 290p (35p p&p)
24VA: 2x6V-1A; 2x9V-1.2A; 2x12V-1A; 2x15V-0.8A; 2x20V-0.6A 330p (60p p&p)
50VA: 2x6V-4A; 2x9V-2.5A; 2x12V-2A; 2x15V-1.5A; 2x20V-1.2A; 2x25V-1A; 2x30V-0.8A 460p (60p p&p)
Specially wound for Multirail Computer PSUs 50VA: Outputs -5V/5A +12V, +25V, +50V -12V at 1A
100VA: 2x12V-4A; 2x15V-3A; 2x20V-2.5A; 2x25V-2A; 2x30V-1.5A; 2x50V-1A 920p (75p p&p charge to be added over and above our normal postal charge).

VOLTAGE REGULATORS

1A TO220 Plastic Caseing
5V 7805 40p 7905 46p 12V 7812 40p 7908 46p 15V 7815 40p 7912 46p 18V 7818 40p 7915 46p 24V 7824 40p 7924 46p
100mA TO92 Plastic package
5V 78L05 30p 79L05 60p 6V 78L06 30p 7V 78L08 30p 12V 78L12 30p 79L12 80p 15V 78L15 30p 79L15 80p

SOLDERCON PINS

ideal for making SIL or DIL sockets
100 pins 75p 500 pins 350p

ALUM BOXES

3 x 2 x 1" 85p 4 x 2 x 2" 85p 4 x 2 x 2 1/2" 103p 4 x 4 x 2" 105p 4 x 4 x 2 1/2" 120p 5 x 4 x 2 1/2" 120p 5 x 4 x 2" 120p 5 x 2 1/2 x 2 1/2" 120p 6 x 4 x 2" 120p 6 x 4 x 3" 180p 6 x 4 x 3 1/2" 180p 8 x 6 x 3" 210p 10 x 4 x 3" 240p 10 x 7 x 3" 270p 12 x 5 x 3" 280p 12 x 8 x 3" 290p

'D' CONNECTORS

miniature 9 way 15 way 25 way 37 way
Male Solder lugs 80p 105p 180p 250p Angle pins 150p 210p 250p 385p PCB pins 120p 130p 185p 285p
Female Solder lugs 105p 180p 280p 335p Angle pins 165p 215p 290p 440p PCB pins 150p 180p 240p 320p
IDC 25 way 'D' Plug 385p; Socket 450p

25 way 'D' CONNECTOR (RS232)

Jumpe Lead Cable Assembly 18" long, Single end, Male 495p 18" long, Single end, Female 525p 36" long, Double Ended, M/M 1025p 36" long, Double Ended, F/F 1050p 36" long, Double Ended, M/F 995p

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Table with columns for part numbers and prices. Includes items like TL209 Red, TL211 Grn, TL212 Yel, TL220 2" Red, etc.

ISOLATORS

Table with columns for part numbers and prices. Includes items like IL74, IL704, IL707, etc.

REFLECTIVE

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Table with columns for part numbers and prices. Includes items like LS400C 255, OCP71 120, etc.

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RELAYS

10 way 80p 16 way 130p 20 way 145p 26 way 175p 34 way 205p 40 way 220p 60 way 235p
PCB Plugs with latch Female Header Pin Str. Angle 80p 95p 105p 110p 115p 120p Female Card Edge Connect 120p
EURO CONNECTORS
Female Socket Str. Angle Str. Angle Plug Angle Plug Angle
DIN41617 170p - - 175p
DIN41612 235p 320p 220p 285p
2 x 32 A+B 275p 340p 240p 300p
DIN41612 3 x 32 A+B+C 380p 385p 280p 335p
DIL PLUG (Header) Solder IDC 14pin 40p 95p 16pin 45p 105p 24pin 85p 170p 40pin 250p 255p
RIBBON CABLE price per foot Grey Color 10 way 15p 28p 16 way 25p 40p 20 way 30p 60p 24 way 40p 65p 34 way 80p 65p 40 way 70p 90p 50 way 100p 135p 64 way 120p 180p
ZIF DIL SOCKETS 24 pin 575p 28 pin 820p 40 pin 975p
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ULTRASONIC TRANSDUCER 40KHz 325 p
VEN WIRING PEN + spool 340p Spare spool 75p Combs 6p
FERRIC CHLORIDE 1 lb bag Anhydrous 195p + 50p P&P
COPPER CLAD BOARDS Single sided 6 x 6 90p 6 x 12 150p Double sided 9.5 x 8.5 110p 9.5p S.R.B 195p
DIL SOCKETS Low Wire Prof Wrap 8pin 14p 10pin 16p 16pin 10p 42p 18pin 16p 62p 20pin 22p 80p 22pin 22p 85p 24pin 25p 70p 28pin 28p 80p 40pin 30p 80p
EDGE CONNECTORS 2 x 15 way 140p 2 x 18 way 180p 2 x 22 way 200p 2 x 23 way 175p 2 x 25 way 225p 2 x 28 way 190p 2 x 30 way 245p 2 x 36 way 295p 2 x 40 way 315p 2 x 43 way 395p 2 x 75 way 650p
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25 way 'D' CONNECTOR (RS232) Jumpe Lead Cable Assembly 18" long, Single end, Male 495p 18" long, Single end, Female 525p 36" long, Double Ended, M/M 1025p 36" long, Double Ended, F/F 1050p 36" long, Double Ended, M/F 995p
SPECIAL OFFER 2764 1+ 50+ 450p 395p

RELAYS

SWITCHES TOGGLE: 2A, 250V SPST 33p DPDT 44p
SUB-MIN TOGGLE SPST on/off 54p SPST c/cover 60p SPDT centre off 85p SPDT biased both 105p SPDT moment 99p DPDT moment 145p
THUMBUTTON 6A with 10mm Button SPDT latching 99p DPDT latching 145p SPDT moment 99p DPDT moment 145p
Mini Non Locking Push to Make 15p Push to Break 25p
DIL SWITCHES (SPST) 4 way 70p; 6 way 85p; 8 way 90p; 10 way 145p. (SPDT) 4 way 190p.
ROTARY SWITCHES: (Adjustable Stop type) 1 pole/2 to 12 way; 2p/2 to 6 way; 3 pole/2 to 12 way; 4p/2 to 3 way 45p
ROTARY: Mains DP 250V 4 Amp on/off 68p
ROTARY: (Makfa-switch) Make a multiway switch. Shafting assembly has adjustable stop. Accommodates up to 6 wafers (max. 6 pole/12 way + DP switch). Mechanism only 90p
WAFERS: (make before break) to fit the above switch mechanism. 1 pole/12 way; 2 pole/6 way; 3 pole/4 way; 4 pole/3 way; 6/2 way; Mains DP 4A Switch to fit 45p Spacers 4P. Screen 6p
ROCKER: 5A/250V SPST 28p ROCKER: 10A/250V SPDT 38p ROCKER: 10A/250V DPDT c/off 95p ROCKER: 10A/250V DPST with neon 85p
THUMBWHEEL Mini front mount. Decade Switch Module B.C.D. Switch Module Mounting Cheeks (per pair) 75p
JUMPER LEADS (Ribbon Cable Assembly) Length 14 pin 16 pin 24 pin 40 pin Single ended DIP (Header Plug) Jumper 145p 165p 240p 380p Double ended DIP (Header Plug) Jumper 165p 205p 300p 465p 20 pin 26 pin 34 pin 40 pin 200p 280p 300p 540p
ETI PROJECTS We stock most of the parts
6 inches 165p 200p 300p 450p 12 inches 195p 215p 315p 465p 24 inches 210p 235p 340p 540p 36 inches 230p 250p 375p 595p
ICD Female Header Socket Jumper Leads 24" 150p 300p 480p 525p Single ended 160p 370p Double ended 290p 370p 480p 525p
TRANSFORMERS 3-0-3V; 0-0-6V; 0-0-9V; 12-0-12V; 15-0-15V @100mA 85p
pcb mounting. Miniature, Split Bobbin
3VA: 2x1V-0.25A; 2x9V-0.15A; 2x12V-0.12A; 2x15V-0.1A 200p
6VA: 2x6V-0.5A; 2x9V-0.3A; 2x12V-0.25A; 2x15V-0.2A 270p
Standard Split Bobbin type:
6VA: 2x6V-0.5A; 2x9V-0.4A; 2x12V-0.3A 220p
2x15V-0.25A
12VA: 2x4.5V-1.3A; 2x5V-1A; 2x9V-0.6A; 2x12V-0.5A; 2x15V-0.4A; 2x20V-0.3A 290p (35p p&p)
24VA: 2x6V-1A; 2x9V-1.2A; 2x12V-1A; 2x15V-0.8A; 2x20V-0.6A 330p (60p p&p)
50VA: 2x6V-4A; 2x9V-2.5A; 2x12V-2A; 2x15V-1.5A; 2x20V-1.2A; 2x25V-1A; 2x30V-0.8A 460p (60p p&p)
Specially wound for Multirail Computer PSUs 50VA: Outputs -5V/5A +12V, +25V, +50V -12V at 1A
100VA: 2x12V-4A; 2x15V-3A; 2x20V-2.5A; 2x25V-2A; 2x30V-1.5A; 2x50V-1A 920p (75p p&p charge to be added over and above our normal postal charge).

RELAYS

VEROBOARD 0.1in clad plain 2 1/2 x 3 1/4 85p 2 1/2 x 5 100p 3 1/4 x 3 1/4 100p 3 1/4 x 5 115p 3 1/4 x 7 390p 4 3/4 x 17 455p Pkt. of 100 pins 55p Spot face cutter 150p Pin insertion tool 185p
VQ Board 195p DIP Board 395p Vero Strip 85p
PROTO DECS Veroblock 405p S-Dec 380p Eurobreadboard 520p Superstrip 575p Superstrip SS2 1350p
DALO ETCH RESIST PEN Plus spare tip 90p
ULTRASONIC TRANSDUCER 40KHz 325 p
VEN WIRING PEN + spool 340p Spare spool 75p Combs 6p
FERRIC CHLORIDE 1 lb bag Anhydrous 195p + 50p P&P
COPPER CLAD BOARDS Single sided 6 x 6 90p 6 x 12 150p Double sided 9.5 x 8.5 110p 9.5p S.R.B 195p
DIL SOCKETS Low Wire Prof Wrap 8pin 14p 10pin 16p 16pin 10p 42p 18pin 16p 62p 20pin 22p 80p 22pin 22p 85p 24pin 25p 70p 28pin 28p 80p 40pin 30p 80p
EDGE CONNECTORS 2 x 15 way 140p 2 x 18 way 180p 2 x 22 way 200p 2 x 23 way 175p 2 x 25 way 225p 2 x 28 way 190p 2 x 30 way 245p 2 x 36 way 295p 2 x 40 way 315p 2 x 43 way 395p 2 x 75 way 650p
ANTEX SOLDERING IRON C-15W 465p CX17W 475p CCN-15W 495p CX25W 510p Spare tips, assorted sizes 210p Spare elements 50p Iron Stand with sponge 185p
SIL SOCKETS 0.1" pitch 20 way 65p
'D' CONNECTORS miniature 9 way 15 way 25 way 37 way Male Solder lugs 80p 105p 180p 250p Angle pins 150p 210p 250p 385p PCB pins 120p 130p 185p 285p Female Solder lugs 105p 180p 280p 335p Angle pins 165p 215p 290p 440p PCB pins 150p 180p 240p 320p IDC 25 way 'D' Plug 385p; Socket 450p
25 way 'D' CONNECTOR (RS232) Jumpe Lead Cable Assembly 18" long, Single end, Male 495p 18" long, Single end, Female 525p 36" long, Double Ended, M/M 1025p 36" long, Double Ended, F/F 1050p 36" long, Double Ended, M/F 995p
SPECIAL OFFER 2764 1+ 50+ 450p 395p

RELAYS

SWITCHES TOGGLE: 2A, 250V SPST 33p DPDT 44p
SUB-MIN TOGGLE SPST on/off 54p SPST c/cover 60p SPDT centre off 85p SPDT biased both 105p SPDT moment 99p DPDT moment 145p
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ETI PROJECTS

# Rapid Electronics

**MAIL ORDERS:**  
Unit 1, Hill Farm Industrial Estate,  
Boxted, Colchester, Essex CO4 5RD.  
**TELEPHONE ORDERS:**  
Colchester (0206) 36412.

**ACCESS AND  
BARCLAYCARD  
WELCOME**

## LINEAR

555CMOS	80	ICL7106	790
556CMOS	150	ICL7611	95
709	25	ICL7621	180
741	14	ICL7622	180
748	35	ICL8038	295
9400C	350	ICM722A	200
AY-3-1270	720	ICM722A	200
AY-3-8910	370	CM7555	80
AY-3-8912	540	LF351	45
CA3040	60	LF353	85
CA3080	65	LF356	90
CA3089	190	LM10	360
CA3190AQ	375	LM301A	25
CA3130E	85	LM311	70
CA3140E	36	LM318	120
CA3161E	100	LM324	100
CA3189	290	LM334Z	100
CA3240E	110	LM335Z	125

LM339	45	LM3911	120
LM348	60	LM3914	175
LM358	60	LM3915	195
LM377	170	LM3960	105
LM380	65	MC1496	68
LM381	120	MC3340	135
LM382	120	MF10CN	350
LM384	130	ML922	400
LM386	65	ML924	195
LM387	120	ML925	210
LM393	100	ML926	140
LM709	25	ML927	140
LM711	60	ML928	140
LM725	350	ML929	140
LM733	75	MM5387A	465
LM741	14	NE529	225
LM747	60	NE531	150
LM1458	40	NE544	205
LM2917	200	NE555	16
LM3900	45	NE556	45
LM3909	70	NE565	110

NE566	140	TL064	96
NE567	100	TL071	30
NE570	370	TL072	50
NE571	370	TL074	95
RC4136	55	TL081	25
RC4158	60	TL082	45
SL480	170	TL084	95
SL490	250	TL170	50
SN7601B	150	UA2240	120
SN76477	380	ULN2003	85
SP829	250	ULN2004	90
TBA1205	70	XR2206	290
TBA800	75	ZN414	100
TBA810	96	ZN423	135
TBA820	70	ZN424	135
TBA950	220	ZN425E	350
TDA1008	320	ZN427E	330
TDA1022	490	ZN426E	650
TDA1024	125	ZN428E	480
TL061	40	ZN459	285
TL062	60	ZN1034E	200

## TRANSISTORS

AC125	35	BC149	9
AC126	25	BC157	8
AC127	25	BC158	10
AC128	20	BC159	8
AC129	25	BC160	45
AC187	22	BC168C	10
AC188	22	BC169C	10
AD142	120	BC170	8
AD149	80	BC171	10
AD161	40	BC172	8
AD162	40	BC177	18
AF124	60	BC178	18
AF126	50	BC179	18
AF139	40	BC182	10
AF186	70	BC182L	8
AF239	75	BC183	10
BC107	10	BC183L	10
BC107B	12	BC184	10
BC108	10	BC184L	7
BC108B	12	BC121	7
BC108C	12	BC122	7
BC109	10	BC123	10
BC109C	12	BC213L	10
BC114	18	BC214	10
BC115	22	BC214L	8
BC117	18	BC237	8
BC119	35	BC238	14
BC137	40	BC308	12
BC139	40	BC327	14
BC140	28	BC328	14
BC141	30	BC337	14
BC142	25	BC338	14
BC143	25	BC477	39
BC147	8	BC478	30
BC148	8	BC479	30

BC517	40	BF337	40
BC547	7	BF402	23
BC548	10	BF403	23
BC549	10	BF404	23
BC558	10	BF405	23
BC570	18	BF406	23
BC571	18	BF407	23
BC572	18	BF408	23
BD1131	10	BF409	23
BD133	35	BF410	23
BD135	35	BF411	23
BD136	35	BF412	23
BD137	35	BF413	23
BD138	35	BF414	23
BD139	35	BF415	23
BD140	35	BF416	23
BD141	35	BF417	23
BD142	35	BF418	23
BD143	35	BF419	23
BD144	35	BF420	23
BD145	35	BF421	23
BD146	35	BF422	23
BD147	35	BF423	23
BD148	35	BF424	23
BD149	35	BF425	23
BD150	35	BF426	23
BD151	35	BF427	23
BD152	35	BF428	23
BD153	35	BF429	23
BD154	35	BF430	23
BD155	35	BF431	23
BD156	35	BF432	23
BD157	35	BF433	23
BD158	35	BF434	23
BD159	35	BF435	23
BD160	35	BF436	23
BD161	35	BF437	23
BD162	35	BF438	23
BD163	35	BF439	23
BD164	35	BF440	23
BD165	35	BF441	23
BD166	35	BF442	23
BD167	35	BF443	23
BD168	35	BF444	23
BD169	35	BF445	23
BD170	35	BF446	23
BD171	35	BF447	23
BD172	35	BF448	23
BD173	35	BF449	23
BD174	35	BF450	23
BD175	35	BF451	23
BD176	35	BF452	23
BD177	35	BF453	23
BD178	35	BF454	23
BD179	35	BF455	23
BD180	35	BF456	23
BD181	35	BF457	23
BD182	35	BF458	23
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BD185	35	BF461	23
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BD187	35	BF463	23
BD188	35	BF464	23
BD189	35	BF465	23
BD190	35	BF466	23
BD191	35	BF467	23
BD192	35	BF468	23
BD193	35	BF469	23
BD194	35	BF470	23
BD195	35	BF471	23
BD196	35	BF472	23
BD197	35	BF473	23
BD198	35	BF474	23
BD199	35	BF475	23
BD200	35	BF476	23

BF337	40	MPS56	60
BF402	23	TIP29A	60
BF403	23	TIP29B	55
BF404	23	TIP29C	37
BF405	23	TIP30A	35
BF406	23	TIP30B	15
BF407	23	TIP30C	37
BF408	23	TIP31A	35
BF409	23	TIP31C	35
BF410	23	TIP32A	35
BF411	23	TIP32C	37
BF412	23	TIP33A	50
BF413	23	TIP33C	75
BF414	23	TIP34A	60
BF415	23	TIP34B	60
BF416	23	TIP35A	105
BF417	23	TIP35C	125
BF418	23	TIP36A	125
BF419	23	TIP36C	135
BF420	23	TIP41A	45
BF421	23	TIP42A	45
BF422	23	TIP42B	45
BF423	23	TIP42C	90
BF424	23	TIP42D	90
BF425	23	TIP42E	90
BF426	23	TIP42F	90
BF427	23	TIP42G	90
BF428	23	TIP42H	90
BF429	23	TIP42I	90
BF430	23	TIP42J	90
BF431	23	TIP42K	90
BF432	23	TIP42L	90
BF433	23	TIP42M	90
BF434	23	TIP42N	90
BF435	23	TIP42O	90
BF436	23	TIP42P	90
BF437	23	TIP42Q	90
BF438	23	TIP42R	90
BF439	23	TIP42S	90
BF440	23	TIP42T	90
BF441	23	TIP42U	90
BF442	23	TIP42V	90
BF443	23	TIP42W	90
BF444	23	TIP42X	90
BF445	23	TIP42Y	90
BF446	23	TIP42Z	90
BF447	23	TIP43A	90
BF448	23	TIP43B	90
BF449	23	TIP43C	90
BF450	23	TIP43D	90
BF451	23	TIP43E	90
BF452	23	TIP43F	90
BF453	23	TIP43G	90
BF454	23	TIP43H	90
BF455	23	TIP43I	90
BF456	23	TIP43J	90
BF457	23	TIP43K	90
BF458	23	TIP43L	90
BF459	23	TIP43M	90
BF460	23	TIP43N	90
BF461	23	TIP43O	90
BF462	23	TIP43P	90
BF463	23	TIP43Q	90
BF464	23	TIP43R	90
BF465	23	TIP43S	90
BF466	23	TIP43T	90
BF467	23	TIP43U	90
BF468	23	TIP43V	90
BF469	23	TIP43W	90
BF470	23	TIP43X	90
BF471	23	TIP43Y	90
BF472	23	TIP43Z	90
BF473	23	TIP44A	90
BF474	23	TIP44B	90
BF475	23	TIP44C	90
BF476	23	TIP44D	90
BF477	23	TIP44E	90
BF478	23	TIP44F	90
BF479	23	TIP44G	90
BF480	23	TIP44H	90
BF481	23	TIP44I	90
BF482	23	TIP44J	90
BF483	23	TIP44K	90
BF484	23	TIP44L	90
BF485	23	TIP44M	90
BF486	23	TIP44N	90
BF487	23	TIP44O	90
BF488	23	TIP44P	90
BF489	23	TIP44Q	90
BF490	23	TIP44R	90
BF491	23	TIP44S	90
BF492	23	TIP44T	90
BF493	23	TIP44U	90
BF494	23	TIP44V	90
BF495	23	TIP44W	90
BF496	23	TIP44X	90
BF497	23	TIP44Y	90
BF498	23	TIP44Z	90
BF499	23	TIP45A	90
BF500	23	TIP45B	90

## CABLES

20 metre pack single core connect-	
ing cable ten different colours, 65p	
Speaker cable	10p/m
Standard screened	16p/m
Twin screened	24p/m
2.5A 3 core mains	23p/m
10 way rainbow ribbon	65p/m
10 way rainbow ribbon	120p/m
10 way grey ribbon	38p/m
20 way grey ribbon	80p/m

## HARDWARE

PP3 battery clips	8
Red or black crocodile clips	6
Black pointer control knob	15
Pr Ultrasonic transducers	350
Pr 6V Electronic buzzer	60
Pr 12V Electronic buzzer	75
Pr 220V Piezo transducer	75
Pr 64mm 64 ohm speaker	70
Pr 64mm 8 ohm speaker	70
20mm panel fuseholder	25

## CAPACITORS

Polyester, radial, leads, 250v, C280	
type: 0.01, 0.015, 0.022, 0.033 -	
6p; 0.047, 0.068, 0.1 - 7p; 0.15, 0.22 -	
9p; 0.33, 0.47, 1.3p; 0.68 -	
20p; 1u - 23p	
Electrolytic, radial or axial leads:	
0.47/63V, 1/63V, 2.2/63V, 4.7/63V	
10/25V, 7p; 22/25V, 47/25V - 8p;	
100/25V - 9p; 220/25V - 30p;	
470/25V - 22p; 1000/25V - 30p;	
2200/25V - 50p	
Tan end power supply electrolytics:	
2200/40V - 110p; 4700/40V - 160p	
2200/63V - 140p; 4700/63V - 230p	
Polyester, miniature Siemens PCB:	
1n, 2n, 3n, 4n, 7n, 10n, 15n, 22n,	
27n, 33n, 47n, 68n, 80n, 100n, 9p;	
150n, 11p, 220n, 13p, 330n, 20p;	
470n 26p; 680n, 29p; 1u 33p; 2u, 2,	
50n	
Tantalum bead:	
0.1, 0.22, 0.33, 0.47, 1.0 @ 35V -	
12p; 2.2, 4.7, 10 @ 25V - 20p;	
15/16V - 30p; 22/16V - 27p; 33/	
16V - 45p; 47/6V - 27p; 47/16V -	
70p; 68/6V - 100p; 100/10V	



# electronics today

INTERNATIONAL

NEXT  
MONTH

## PSEUDOROM

We know, we know — we promised it *last* month. Well, it's taken us about that long to figure out how to fit it all into that sleek, compact shape you'll notice if you move your eyes a couple of inches to the right. Assuming you did, and have returned, then you have just been looking at 8K of low-power, CMOS RAM plus a bit of address decoding and battery backup which can be write-protected and made to appear as four 2K by 8 blocks, two 4K by 8 blocks, or one 8K by 8. Now you can develop software on a device which is faster than a speeding ROM and a lot easier to reprogram.

## SWITCHED MODE POWER SUPPLY

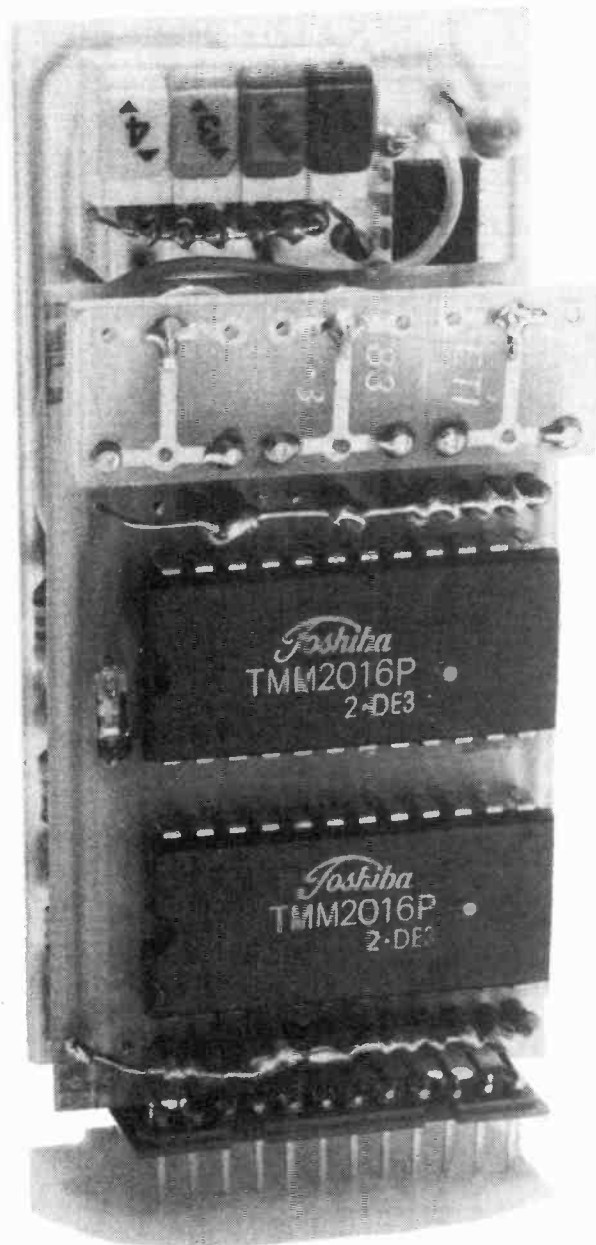
This professionally-designed unit is neat and compact, but it can deliver 12 V at 5 A without straining. Following on from our discussion of switched mode PSUs in the April issue, this project will shed more light on this seldom-discussed subject.

## DATA SHEET

With the runaway success of the Victory organ project that has been featured in the last four issues of ETI, have come requests for more information on the special chips used. Ever eager to oblige, next month's ETI contains a Data Sheet on both the M108 and the M208.

## COMPASS

This one's really something special. Not only does it display 16 points of the compass using an alphanumeric dot matrix read-out, but it uses a new kind of sensor that relies on an apparently new branch of number theory called cyclic binaries. It's pretty stylish and cheap, too. Get the next issue of ETI and you'll never lose your bearings in your boat or car.



DON'T MISS THE JUNE ETI

ON SALE 6th MAY

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





# CRICKLEWOOD — STOCKING PARTS OTHER STORES CANNOT REACH!

Items not fully covered on this list include: OPTO 7 seg LEDs, LCDs bezelled LEDs, Lamps, Lampholders, FUSES: 20mm 1/2 inch, slow or quick blow, Fuseholders, CONNECTORS: DIL, DIN, Phono, 1mm, 2mm, 4mm, Bulgun JSA, I.E.C. KNOBS: Plastic, Aluminium, Anodised, Collet, Pointer. SWITCHES: Toggle, Biased, Rocker, Rotary, Slide, Dip, Push. METERS: LCD, Analogue, Test and Panel. TOOLS: Pliers, Cutters, Strippers, Trimmers, Cable Cutters. And much, much more. All in stock items (that's 95%) posted same day, OFFICIAL ORDERS FROM SCHOOLS, GOVT DEPTS ETC WELCOME. OVERSEAS ORDERS WELCOME (CWO + ADEQUATE POSTAGE). QUANTITY DISCOUNTS BY NEGOTIATION. CRICKLEWOOD ELECTRONICS LTD., 40 CRICKLEWOOD BROADWAY, LONDON NW2 3ET. TEL: 01-452 0161. Telex 914977

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★ THE IDEAL WAY Call in and collect. We are on the main Edgware Rd (A5) just 1 1/2 miles from Staples Corner and approx 3 miles from Marble Arch.  
VAT Please add VAT at the current rate to all orders except books. VAT not chargeable abroad.  
POST, PACKING & INSURANCE Standard small order charge is 70p (more for heavier goods). Export orders minimum £1.50.

<p><b>TIS52</b> 46p <b>TIS64</b> 67p <b>TIS87</b> 60p <b>TIS88A</b> 62p <b>TIS90</b> 82p <b>TIS91</b> 30p <b>TIS92</b> 30p <b>TIS93</b> 54p <b>YN10KM</b> 80p <b>YN6AF</b> 80p <b>YN6AF</b> 80p <b>ZTX107</b> 10p <b>ZTX108</b> 10p <b>ZTX109</b> 12p <b>ZTX300</b> 13p <b>ZTX301</b> 15p <b>ZTX302</b> 23p <b>ZTX304</b> 15p <b>ZTX310</b> 35p <b>ZTX311</b> 32p <b>ZTX312</b> 35p <b>ZTX313</b> 34p <b>ZTX314</b> 24p <b>ZTX320</b> 35p <b>ZTX323</b> 35p <b>ZTX341</b> 35p <b>ZTX500</b> 14p <b>ZTX501</b> 14p <b>ZTX502</b> 17p <b>ZTX503</b> 17p <b>ZTX504</b> 24p <b>ZTX510</b> 34p <b>ZTX511</b> 24p <b>ZTX512</b> 24p <b>ZTX650</b> 46p</p> <p><b>DIACS</b> <b>BR100</b> 20p <b>ST2</b> 40p</p> <p><b>THYRISTORS</b> Sensitive Gate Small Signal <b>2N444</b> 1.80 <b>BT101</b> 500R 1.40 <b>BT106</b> 2.18 <b>BT107</b> 3.7p <b>BT108</b> 3.7p <b>BT109</b> 3.7p <b>BT110</b> 3.7p <b>BT111</b> 3.7p <b>BT112</b> 3.7p <b>BT113</b> 3.7p <b>BT114</b> 3.7p <b>BT115</b> 3.7p <b>BT116</b> 3.7p <b>BT117</b> 3.7p <b>BT118</b> 3.7p <b>BT119</b> 3.7p <b>BT120</b> 3.7p <b>BT121</b> 3.7p <b>BT122</b> 3.7p <b>BT123</b> 3.7p <b>BT124</b> 3.7p <b>BT125</b> 3.7p <b>BT126</b> 3.7p <b>BT127</b> 3.7p <b>BT128</b> 3.7p <b>BT129</b> 3.7p <b>BT130</b> 3.7p <b>BT131</b> 3.7p <b>BT132</b> 3.7p <b>BT133</b> 3.7p <b>BT134</b> 3.7p <b>BT135</b> 3.7p <b>BT136</b> 3.7p <b>BT137</b> 3.7p <b>BT138</b> 3.7p <b>BT139</b> 3.7p <b>BT140</b> 3.7p <b>BT141</b> 3.7p <b>BT142</b> 3.7p <b>BT143</b> 3.7p <b>BT144</b> 3.7p <b>BT145</b> 3.7p <b>BT146</b> 3.7p <b>BT147</b> 3.7p <b>BT148</b> 3.7p <b>BT149</b> 3.7p <b>BT150</b> 3.7p <b>BT151</b> 3.7p <b>BT152</b> 3.7p <b>BT153</b> 3.7p <b>BT154</b> 3.7p <b>BT155</b> 3.7p <b>BT156</b> 3.7p <b>BT157</b> 3.7p <b>BT158</b> 3.7p <b>BT159</b> 3.7p <b>BT160</b> 3.7p <b>BT161</b> 3.7p <b>BT162</b> 3.7p <b>BT163</b> 3.7p <b>BT164</b> 3.7p <b>BT165</b> 3.7p <b>BT166</b> 3.7p <b>BT167</b> 3.7p <b>BT168</b> 3.7p <b>BT169</b> 3.7p <b>BT170</b> 3.7p <b>BT171</b> 3.7p <b>BT172</b> 3.7p <b>BT173</b> 3.7p 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2584	CE1708 170 W 8 Mono	30.43
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**PS. THESE KITS AND MODULES ARE EXCLUSIVE OF VAT**

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2618	Pre-Amp Power Supply Kit	PSK	£17.39

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K2575	Microprocessor Doorbell 25 tunes	15.53
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K2032	Digital Panel Meter	15.53
K2557	Digital Thermometer	26.57
K2545	50Hz Crystal Time Base	11.39
K615	High Precision Stopwatch	43.13
	Description	Price

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**PS. ALL KITS INCLUDE VAT**

Some are easy some are hard

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K2574	Universal 4 Digit U/D counter with memory	34.16
K2577	Electric Motor Speed Control	7.59
K2579	Universal Start/Stop Timer	6.21
K2583	Heating Controller	75.00
K1682	Microprocessor Universal Timer (no case)	48.37
K2580	Electronic Power Switch Dimmer	10.00
K2551	Central Alarm Unit	18.70

## TELETEXT KIT

This unit will make your TV remote control (infra-red) and bring you closer to the amazing world of teletext. The kit can also be updated to incorporate full Prestel, and with a keyboard this can give you full message facilities for ordering foods or sending and receiving messages (E.G.) Booking your Holidays!

With a microcomputer as an alternative keyboard the world is even greater adding bulk updating to viewdata computers an receiving telesoftware for implementation to any personal computer.

Even without the Prestel option, Telesoftware from the Teletext pages free!

The full features of Teletext, including subtitles are all included in the basic kit.

An attractive stylish case is available to complement the finished kit.

Basic Teletext Kit (no box) £130 + VAT P/P £2.50  
 with box £144.95 + VAT P/P £3.00  
 box by itself £14.95 + VAT P/P 75p

## PRESTEL ADAPTOR

A Prestel micro computer adaptor to give full autodialing to your micro computer. All the usual Prestel facilities are added via this unit, plus many more, and, can operate to any viewdata computer.

You can shop from home, bank transmitt messages and receive software, which means that the uses your micro can be put to are limitless.

The unit is not restricted to just the UK, for at least 28 countries use the Prestel viewdata format, so you can also mail-order from anywhere. The Prestel unit is suitable for most micro computers even the ZX-81, so at the push of a button, the technology of tomorrow is in your home today.

## ANTEX

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X25	25W	5.30+
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C "iron"	15W	4.80+
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Wide range of bits and elements in stock now.		
Soldering iron stand 2.40		
We stock multicore solder for normal use or fine.		

Iso-tip Cordless Iron 31-90+  
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 All irons are 240V mains. Earth Leakage current is less than 3 ua.  
 The temperature controlled iron can be controlled within  $\pm 2\%$  temperature range from 200°C to 400°C.

## ORYX

## COMPONENTS

Device	Price
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Z80A PIO	3.20
Z80A CTC	3.20
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6810	3.00
6821	4.25
65022CPU	7.50
2114(200ns)	1.80
2708	3.00
2716	3.20
2732	7.50
2532	3.50
2764 (200ns)	11.00
ADC0816 (8 bit)	14.90

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The Bipolar Microcomputer Databook	4.50
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The TTL Data Book	8.50
MDS Memory Data Book	3.95
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*TTI Data Book Volume II	8.00

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# DIGEST



## Disc Jokey?

Despite the fact that LP records are a bit bulky when strapped to your waist, Audio Technica will be introducing (in April, or so we're led to believe) their AT 727 Sound Burger. Assuming this is not an April Fool's joke played on gullible journalists, details are as follows: the Sound Burger will play LPs or singles through its own headphones or an external amp and speakers, on any 'reasonably flat' surface, driven by its own batteries or an optional mains adaptor. The turntable is belt driven, the arm is dynamically balanced (we think that means springs), the cartridge is magnetic and the price is £89.95 (recommended, including VAT). As we said, it'll be appearing in April...

## No More Surveys!

We've been overwhelmed at the response to the survey in the February issue — the box containing the replies is too heavy to lift — but if you haven't sent yours back yet, please don't bother, as processing will have taken place by the time you read this and it will be too late to count. A special thank you to all the overseas readers who replied, many of whom went to the trouble of posting their forms by airmail.

## Satellite Colloquium

UNISAT-1, Britain's first TV broadcasting and business satellite, is to be the subject of a full day colloquium, organised by the Institution of Electrical Engineers, to be held at the IEE, Savoy Place, London WC2, on Tuesday, 17th May, 1983 (9.15am to 4.45pm). Non-IEE members are very welcome.

Speakers have been invited from BTI, BAe, Marconi, INTLSAT and the BBC. This meeting is designed to have wide appeal and is expected to be very popular. Admission is £17.25 to IEE members, £28.75 to non-members. For further information and booking contact: Karen Kimpton, IEE, Savoy Place, London WC2R 0BL (telephone 01-240 1871 ext. 308).

of an old favourite, the LE40 24 V temperature-controlled iron. LSDI say that they have now incorporated proportional control and that this much improves temperature control without temperature swing or overshoot.

Recently introduced is the SK18 kit which includes an LC18 iron with three bits of different sizes, tweezers, three double-ended soldering tools, desoldering braid and three metres of cored solder. Ordered direct from Light Soldering Developments Limited, 97/99 Gloucester Road, Croydon CR0 2DN, Surrey, the kit will cost you £14.55.

## Drawing The Line Somewhere

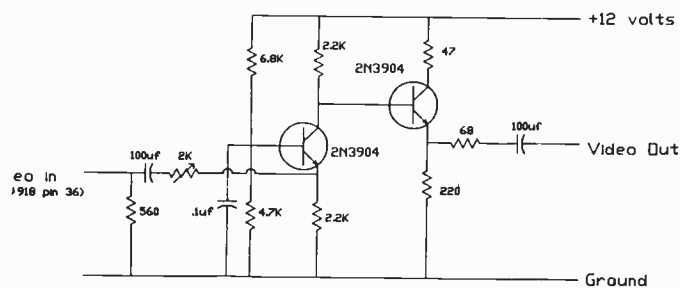
AutoCAD is a two-dimensional computer-aided drafting and design package which runs on 8-bit and 16-bit microcomputers under CP/M-80, CP/M-86 or MSDOS/PCDOS. It is a general-purpose package, suitable for a wide variety of applications, including architectural and landscape drawings, mechanical, electrical, chemical, structural, and civil engineering, and printed-circuit design. The AutoCAD package, complete with drivers for all currently-supported devices, is available in the UK from PO Box 100A, Surbiton, Surrey KT5 8HY (01-399

8530) for approximately £630. Special dealer and distributor/OEM prices are also available.

AutoCAD acts like a word-processor for drawings. It lets the user make drawings from simple components such as lines (of any width), circles, arcs, and solid-filled areas. Drawings may be annotated with text of any size, inserted at any point and at any orientation. The drawings can be stored on disc and in turn used as components in other drawings. The ability to define parts libraries simply by drawing them, and to write custom menus (via ordinary text files), allows specialised application systems to be easily developed under AutoCAD. Drawings may be created through keyboard commands, with a light-pen and on-screen menu, or from existing paper drawings via a digitizing

tablet. The large set of editing commands allows drawn objects to be moved, copied, modified, erased, rotated, and scaled vertically and horizontally. Repetitive patterns such as brick walls or memory arrays can be generated automatically. A full bi-directional zoom facility allows working on the drawing at any level of detail.

Drawings can be plotted to any desired scale at any point during the drawing process. Each drawing color may be assigned to a plotter pen and line type. Utilities supplied with the package can convert drawings to or from an ASCII text file. This allows user programs to process information entered in graphic form through AutoCAD, or, conversely, the viewing or editing with AutoCAD of drawings produced by data from user programs. If the quality of these samples is anything to go by (originals were A4-sized), then AutoCAD would be useful in our workshop, let alone a design studio.



All resistor values in ohms unless marked



(c) 1978 Frank Lloyd Wright Foundation used by permission

## Make Light Of Soldering

Two new products from Light Soldering Developments Limited are aimed at making soldering easier. First is not entirely new, but a modified version



# ELECTRONIC KITS

**ALL NEW**  
to the  
**VELLEMAN**  
**RANGE**

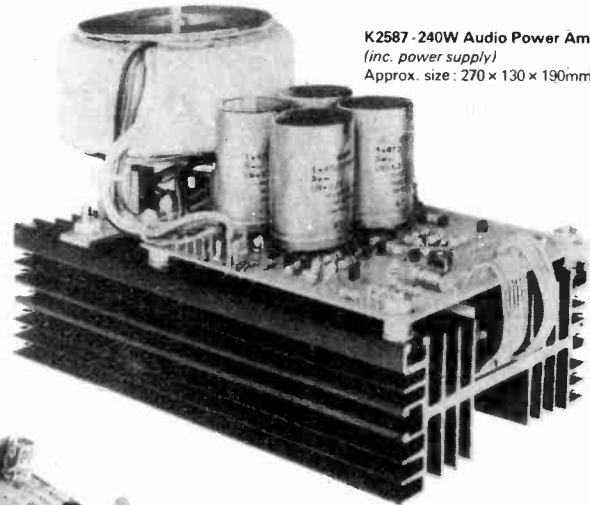
Velleman electronic kits have gained respect for their high quality and the varied range which covers many applications in the vast field of electronics. All kits are designed and developed using the latest technology, giving them appeal, not only to the hobbyist and enthusiast but also to the experienced engineer.

The fully illustrated Velleman Kit Journal is available free of charge upon request and has full technical specification on each kit in the range. All kits are graded by difficulty from 1 to 3 and can be purchased direct or from the stockists listed below.

... and remember, we have a 'rescue service' for instances where enthusiasm exceeds ability!

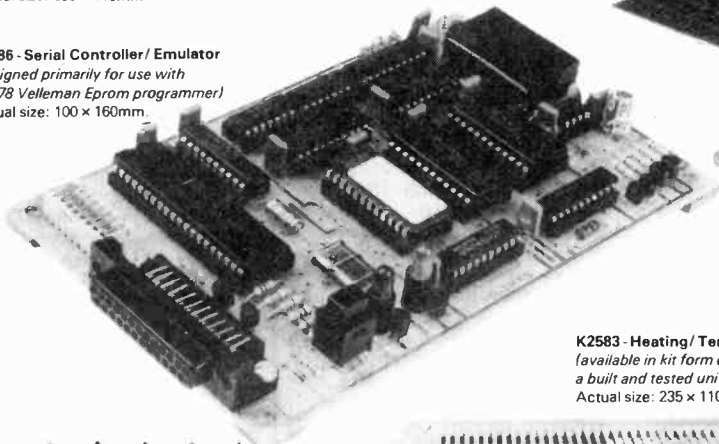


**K2584 - Precision timer**  
(timing from 1 sec  
to 99 mins 99 secs.)  
Actual size: 235 x 110mm

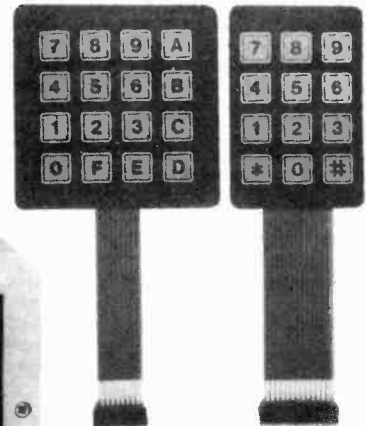


**K2587 - 240W Audio Power Amplifier**  
(inc. power supply)  
Approx. size: 270 x 130 x 190mm high

**K2586 - Serial Controller/ Emulator**  
(designed primarily for use with  
K2578 Velleman Eprom programmer)  
Actual size: 100 x 160mm.



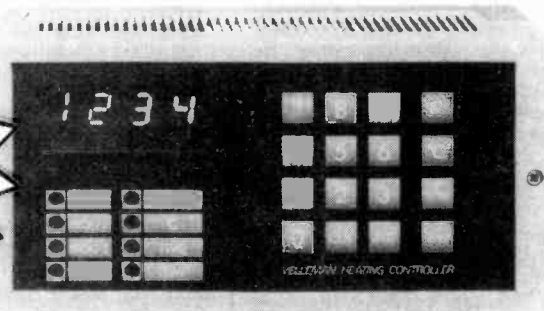
**K2583 - Heating/ Temperature Controller**  
(available in kit form or as  
a built and tested unit)  
Actual size: 235 x 110mm



**KBS16 and KBS12 - Membrane Keypads**  
(available with  
or without legend)  
Actual size:  
65 x 100mm  
100 x 100mm

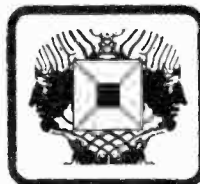
**OTHER NEW KITS  
recently introduced**

- K2580 Electronic powerswitch dimmer
- K2581 Stereo volume and tone control
- K2582 Stereo audio input selector
- K2585 Codeclock
- K2588 3 Channel sound to light unit



## VELLEMAN UK. Ltd

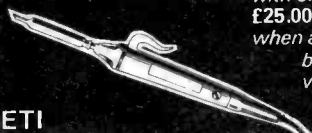
P.O. Box 30, St. Leonards-on-Sea,  
East Sussex TN37 7NL, England.  
Telephone: (0424) 753246



### VELLEMAN STOCKISTS

**Baxol Tele Exports Ltd.**, Ballinacash, Post Rathdrum,  
Co. Wicklow, Rep. of Ireland.  
**Bradley Marshall Ltd.**, 325 Edgware Road, London W2 1BN.  
**S & R Brewster Ltd.**, 86-88 Union Street, Plymouth, Devon.  
**Marshalls Electronics**, 85 West Regent Street, Glasgow, Scotland.  
*Retail outlets are required in most major towns and cities.  
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**FREE** SOLDERING IRON  
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£25.00 and over  
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ETI

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## Shorts

● For those of you who know what DIN 41612 is, Enclosure Technology Ltd (Unit G, Southampton Airport, Southampton SO2 2HG) have added a wide selection of these standard edge connectors to their range. (Those who don't know what DIN 41612 is might care to take a look at either the Analogue Board or Real Time Clock projects published in the last couple of ETIs).

● Oops! We gave you the wrong address for BICC-Vero's new catalogue. The address we should have given you is: BICC-Vero Electronics Ltd, Industrial Estate, Chandlers Ford, Hampshire SO5 3ZR. Direct your mail thence, please.

● 3D Digital Design and Development, 18/19 Warren Street, London W1P 5DB inform us that they have introduced an interface card for the BBC micro that makes it possible to connect said machine to their low-cost IN-LAB modular interface system. Cards already existed for using Commodore, Apple, Sharp, Sirius and other micros with the system.

● Use your Apple as a storage 'scope. Details of the Applescope made by RC Electronics Inc., are available from Pete & Pam Computers, New Hall Hey Road, Rossendale, Lancs BB4 6JG.

● A new portable computer is on the way from Texas Instruments. Called the CC-40, it features enhanced BASIC, 6K (expandable to 16K) user RAM, ex-

pansion port, and TI's Hex-bus expansion peripheral port, all for a suggested price of £169.95.

● Digithurst have added a graphics package to their Microsight computer vision systems. They can be found at Leaden Hill, Orwell, Royston, Herts, SG8 5QH, telephone 0223 208926.

● More news from Texas, this time to say that they have been busy with their M<sup>2</sup>C<sup>2</sup>MOS process for gate arrays. The first of a new series of products is the SCX6224 (for which a performance evaluation device is available with data sheet) which is a 2400 gate array with internal gate delay times of 1 nanosecond and input frequency capability of 125 MHz.

● Looking for a modem? Thorn EMI have published a shortform catalogue (that means it ain't got many pages) of their range, claimed to be the largest manufactured in the UK. Thorn EMI Datech Ltd, Spur Road, Feltham, Middlesex TW14 0TD.

● Those people at TI have been busy — there's another new computer, aimed at beginners and called the TI-99/2. Costing around £75, it will feature an elastomeric keyboard (ugh!), 16-bit processor, 4.2K (expandable to 36.2K) user memory and software on solid state cartridges as well as cassettes. TI Ltd, Manton Lane, Bedford MK41 7PA.

● Norbain Electro-Optics are getting into micros — waves, that is, not computers. They will be marketing the Microwave Associates Communications Inc. range of GaAs Gunn oscillators,

transceivers, detectors, and antennae. Norbain Electro-Optics, Norbain House, Boulton Road, Reading, Berkshire RG2 0LT.

● Turn your ZX Spectrum into a word processor using the new Sinclair to Centronics interface that allows you to use high-quality printers. Some software is provided with the device, that comes from Euroelectronics, Zin House, Oakfield Street, Cheltenham, Glos GL50 2UJ.

● Order one for your living room: Control Data's CYBER 205 Series 600 computer is capable of 792 million calculations per second, has eight million 64-bit words of real memory (two trillion words of virtual storage), and models start at the bargain price of a mere £3 million.

● RAM Electro Acoustics Ltd, The Granary, Bracondale, Norwich NR1 2EG have been appointed sole UK agents for the Harksound range of audio turntables.

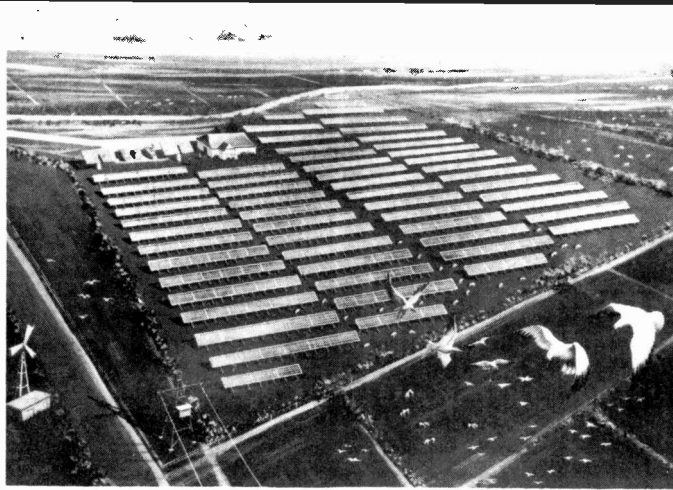
● 'Good morning campers' will probably not be the way you'll be woken up on one of Southampton University's Computer Holiday Camps. Details from Dr Lionel Wardle, Computer Holidays, 37 University Road, Southampton, SO2 1TL (send a large SAE).

● Salford University is also getting in on the act by organising machine-specific short courses. Details and dates from the Microprocessor Short Courses Unit, Dept. of Electronics and Electrical Engineering, University of Salford, Salford M5 4WT.

## North Sea Sun

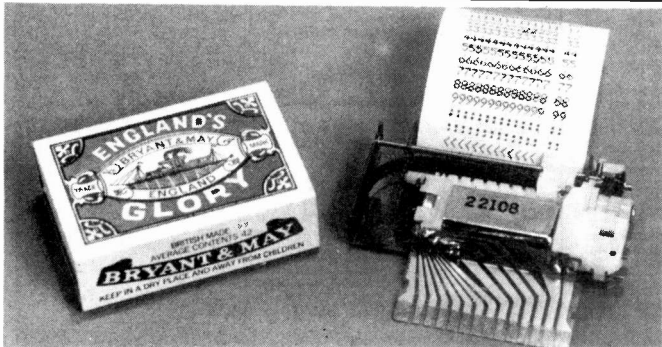
On the West German North Sea island of Pellworm the construction of the largest solar power plant of Europe has started: from July 1983 the sun will provide the recreation centre and surrounding houses with electricity. On an area of 16,000 square metres, (the area needed for two football fields), AEG-Telefunken (West Germany) will build up the 300 kW solar generator which will directly convert the sunlight into electricity. In order to be able to continue to farm the island's valuable grassland the solar generators will be installed on structures with a minimum height of one metre above the ground. This DM 11 million (£3 million) project is financed mainly by the German ministry for research and development and the EEC. During the test phase the plant will provide technical data necessary for planning of future solar power plants up to the MW range. To this end, the economy and low maintenance requirements are very important criteria. Until now the solar experts of AEG-Telefunken have derived their experience mainly from solar plants in countries of the Third World.

As the recreation centre needs most energy in the summertime, it is very well suited for the utilization of solar energy. Battery storage provides the power during the night and during bad weather periods. As there will be more energy available than required by the recreation centre the surplus energy will be fed into the utility grid of the Schleswig. Nowadays the price for one kilowatt-hour "solar energy" is still about DM 2 (55p). The scientists of AEG-Telefunken researching on solar energy at Wedel near Hamburg are confident to cut the cost by building up a mass production between 1986 and 1988. Altogether the EEC is supporting 16 projects on the development of photovoltaic sources of energy. Apart from the complete solar power plant on Pellworm, AEG-Telefunken is building solar generators for a dairy farm in Ireland (50 kW) and for a navigational school on the Netherland island Terschelling (50 kW). It all sounds good, but who gets the job of cleaning off the bird droppings?



## Pico Print?

Data Limited of Altrincham have recently renewed their agreement to distribute the Epson range of mini-printers which includes the world's smallest thermal printer, the M-30 series. Measuring 60.2 mm wide x 32.9 mm deep x 10.8 mm high and weighing just 30 g, the 16 column M-30 makes it possible to manufacture ultra thin, pocket-size calculators and other hand held devices with a printing function. Also available from Datac is the Epson M-25 13 column model which has a similar specification. For further information on either the M-30 or the M-25 contact Datac Limited, Tudor Road, Altrincham, Cheshire, WA14 5TN. Telephone: 061-941 2361.



## Free File

Forget about catalogues — Elkan Electronics have produced the Elkan File, which contains details of all the items they sell. Sounds rather like a catalogue, doesn't it? The difference is that there are no staples! This is a very cunning move because it means that the contents spread themselves all over your desk making it impossible to ignore them.

Featured in the catalogue, I mean file, are the Nanos quick

reference cards for the ZX80 and the ZX81. It is claimed that the format of a card, as opposed to a book, makes it easier to locate information when you're actually sitting in front of the computer. This does depend on how many cups of coffee you've spilt over them. Cards for other computers are available or in the pipeline from Elkan Electronics, 11 Bury New Road, Prestwich, Manchester M25 6LZ, telephone 061-798 7613 (24 hours). The cards cost £3.50 each, but the file is free.





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The above envelope was received by us at our offices a few days ago. We don't think further comment is necessary.



## Inductive Loop Amp Tech-Deck

**R**eder Sound Ltd have just introduced their model DL1 Inductive Loop Amplifier. The DL1 is the smallest in their range and is primarily intended for use in the home. It features a current output stage, which ensures a constant current into differing load impedances, internal AGC and inputs for tape recorder/TV or high impedance microphone. The only front panel control is the on/off switch with an indicator LED. The unit is designed to operate in rooms up to 4 metres wide.

The range is completed by the LA2 and LA3 amplifiers. Both feature current output stages, inputs for microphone (low impedance), auxiliary and loudspeaker line (all balanced and floating), internal limiter and full thermal protection. The LA2 is a 30 W 2 A maximum output unit

**T**echnics is expanding its range of cassette decks with the RS-M235X, which has three noise reduction systems. The new cassette deck features Dolby B and C and dbx noise reduction systems, making it compatible with any type of recording and offering excellent sound reproduction. In addition, the RS-M235X offers a built-in dbx disc decoder, increasing its versatility.

and the LA3 is a 60 W 3 A maximum output unit.

Reder Sound also manufacture PA equipment and accessories as well as inductive loop equipment. All inductive loop equipment is designed to be used in accordance with BS 6083 pt4. Reder Sound Ltd are at Premier Works, High Street, Sutton, Ely, Cambridge CB6 2RB (telephone Ely (0353) 777252).

## A Thorn In The Swede

**A** Swedish nuclear power station is to be equipped with the latest British radiation monitoring systems for routine personnel contamination checks under an order worth several million Swedish crowns (sounds much more impressive than £s) placed with Nuclear Enterprises Limited, of Beenham, near Reading.

As the world's most sensitive contamination monitoring system of its type, the Nuclear Enter-

prises IPM7 establishes Britain's leadership in this exacting technology. The system permits highly accurate checks to be carried out extremely rapidly to ensure personnel are free from contamination when leaving control areas. In a matter of seconds, workers' hands, feet and clothing are scanned by banks of electronic detectors inside the IPM7's specially designed 'walk-through' cubicle.

Nuclear Enterprises is a subsidiary of Thorn EMI Technology, one of the major divisions of Thorn EMI's Engineering Group.

## A Code To Bank On

**A**n unbreakable code, which should prove of great interest to banks, businesses and other institutions requiring the confidential transmission of information, has been developed by Professor Adi Shamir of the Weizmann Institute's Department of Applied Mathematics and Dr Ronald L. Rivest and Leonard Adelman of MIT in the States, reports Bank Hapoalim, the leading Israeli bank. The cryptographic system is based on an idea originally suggested by computer scientists Whit Diffie and Martin Hellman of Stanford University in the United States.

The idea was to develop a coding system where different keys would be required for encryption and decryption. In this way, a subscriber could reveal his encryption (encoding) key, so that all users could send him messages, while the decryption (decoding) key would be known only to the receiver, ensuring complete secrecy. The new system uses very large prime numbers. It takes only a fraction of a second for a microcomputer to multiply two 100-digit prime numbers to obtain their 200-digit

product. On the other hand, it would require four billion years to solve the reverse problem: that is, to determine which two 100-digit prime numbers were used to yield a given product.

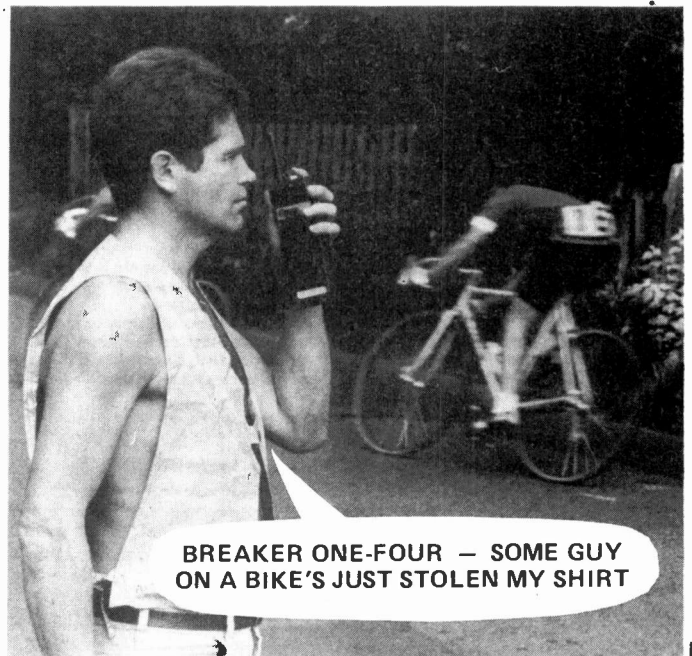
According to the system, a directory of registered subscribers will supply the public numbers of users. At the other end, the receiver will take the concealed communication and use his secret decryption key to obtain a comprehensible message. Because no prior exchange of secret information is necessary, the system is very convenient for widespread public usage. It also enables the transmission of legally binding 'signatures' to a message, so that contracts, purchase orders and cheques can be exchanged via telex.

With all conventional coding systems, both receiver and sender must possess the same confidential key. The new system, according to Professor Shamir, "is an entirely novel concept of public communication, one which we hope soon to see widely used." A prototype computer chip is now undergoing extensive testing in Boston. For further information contact: Department of Applied Mathematics, Weizmann Institute of Science, Rehovot, Israel.

dbx, the most powerful noise reduction system on the market, yields a signal to noise ratio of 92 dB with 100 dB dynamic range — more than enough to record any live performance, even a jet engine at take off! For simple operation, an auto-tape selector chooses the correct bias and equalisation for the type of tape being used. In addition, a new system of level and balance control features in the RS-M235X. A single master level slider adjusts both channels, while a separate

control balances left and right channels when necessary, permitting smooth fade-in/fade-out effects. Colour-coded, soft touch controls aid easy operation and wide range FL meters indicate signal response.

Slim in style, the RS-M235X is available in silver or black finish and is designed to co-ordinate with the new range of Technics hi-fi separates. Retailing at £176.95 the RS-M235X can be obtained from the Technics network of authorised dealers.



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## BARGAINS

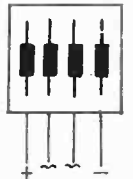
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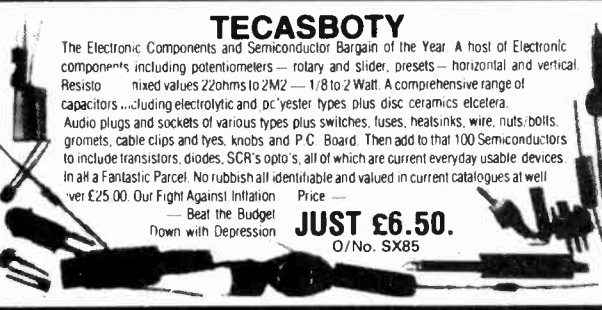
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BC115.6	18p	BD135	32p	2N2905	23p	748C	35p	3mm Y/LOW	10p	20 pin	14p	BC477	20p	C106D	24p																				
BC119 *	32p	BD136	32p	2N2905A	25p	CA3089	180p	5mm GREEN	11p	22 pin	14p	BC559C	5p	C206D	50p																				
BC139 *	30p	BD137	30p	2N2906	22p	CA3189	280p	Clips	2p	24 pin	16p	BD204	50p	C226D	60p																				
BC140	26p	BD138	35p	2N2906A	22p	ICM7556	150p	Rectangular	2p	28 pin	18p	BD206	50p	LF387N	95p																				
BC141	28p	BD139	35p	2N2907	23p	LF351 *	45p	Red	10p	40 pin	20p	TIP29C	30p	358N	45p																				
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BC173C	9p	BFX84	27p	2N3702	9p	LM311	60p	AA119	9p					1W 5% Carbon film E24 series	10 ohm-1M ohm 2p each.	METAL FILM	1W 1% E24 series	10 ohm-1M ohm 4p each.	SEND S.A.E. FOR FREE PRICE LIST																
BC177B	16p	BFX87	27p	2N3703	9p	LM324	40p	AA119	9p	10 ohm-1M ohm 1p each.																									
BC178C	16p	BFX88 *	23p	2N3704	9p	LM339	47p	AA119	9p	10 ohm-1M ohm 1p each.																									
BC179C *	17p	3FY50	24p	2N3706	9p	LM348	60p	AA119	9p	10 ohm-1M ohm 2p each.																									
BC182B	9p	3FY51	24p	2N3707	9p	LM358	50p	AA119	9p																										
BC183B/C	9p	3FY52	23p	2N3708	9p	LM380	68p	AA119	9p																										
BC184B/C	9p	3FY53	30p	2N3711 *	170p	LM382	115p	AA119	9p																										
BC212B	9p	3SV95A	22p	2N3712 *	175p	LM384	125p	AA119	9p																										
BC213B/C	9p	SU205	150p	2N3713 *	195p	LM386	65p	AA119	9p																										
BC214B/C	9p	BZ026 *	170p	2N3819	20p	LM393	72p	AA119	9p																										
BC237B	10p	SU208	155p	2N3903	10p	LM393	72p	AA119	9p																										
BC238B/C	10p	MJE340	48p	2N3904	10p	LM711 *	14p	AA119	9p																										
BC239B/C	10p	MJE520	65p	2N3906	10p	LM741	14p	AA119	9p																										
BC251	10p	MJE521	70p	2N4037	40p	LM748	58p	AA119	9p																										
BC257/8	14p	MJE2355	80p	2N4058 *	9p	LM1458	38p	AA119	9p																										
BC259	16p	MJE3055	65p	2N4061/2	10p	LM3900	47p	AA119	9p																										
BC301/2	40p	MPSA05	20p	2N4547	28p	MC1455	16p	AA119	9p																										
BC303/4	40p	MPSA06	20p	2N4548	27p	MC1458	33p	AA119	9p																										
BC307A/B	10p	MPSA12	24p	2N4549	24p	MC1748	35p	AA119	9p																										
BC308B/C	10p	MPSA13	24p	2N4550	23p	MC3302 *	72p	AA119	9p																										
BC309B/C	10p	MPSA55	22p	2N6027	20p	RC4558	44p	AA119	9p																										
BC327 *	12p	MPSA56	22p	2N6028	23p	SN76115	125p	AA119	9p																										
BC328	12p	TIP29A/B	30p	BRIDGE RECTIFIERS		SN76660	110p	AA119	9p																										
BC337 *	12p	TIP29C	34p	1.5 Amp		TDA1024	130p	AA119	9p																										
BC338	12p	TIP30A/B	30p	W005 *	18p	TDAX2002 *	38p	AA119	9p																										
BC384	15p	TIP30C	36p	W01	20p	TDAX2030	200p	AA119	9p																										
BC413C	10p	TIP31A/B	33p	W02	22p	400mW	6p	AA119	9p																										
BC414C	10p	TIP32A/B	33p	W03	20p	2V7-36V	5p	AA119	9p																										
BC415C	10p	TIP41A	42p	W04	24p	1.3V	5p	AA119	9p																										
BC416C	10p	TIP42A	45p	W05	22p	3V3-47V	12p	AA119	9p																										
BC477	25p	TIP3055	59p	W06	28p	SEMs		AA119	9p																										
BC478 *	25p	TIS43	30p	W07	30p	C106D	35p	AA119	9p																										
BC479	25p	TIS44	30p	W08	32p	C116D	70p	AA119	9p																										
BC484	10p	TIS45	30p	W09	30p	C126D	95p	AA119	9p																										
BC485	10p	TIS91	24p	W10	30p			AA119	9p																										
BC486	9p	TIS92 *	24p	W11	30p			AA119	9p																										
BC487	9p	2N1613	30p	W12	30p			AA119	9p																										
BC496	10p	2N2218A	25p	W13	30p			AA119	9p																										
BC557B	9p	2N2219A	25p	W14	30p			AA119	9p																										
BC558B	9p	2N2221A	24p	W15	30p			AA119	9p																										
BC559C *	9p	2N2222 *	18p	W16	30p			AA119	9p																										

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AC128	12p	BC214	6p	BF198	8p	2N914	10p	4007	8p	7409	7p	74125	25p	LM378	13p	ML928	300p
AC141	15p	BC214L	6p	BF200	15p	2N918	11p	4008	25p	7410	8p	74126	25p	LM386	15p	ML928	100p
AC142	7p	BC237	6p	BF244C	13p	2N1131	6p	4009	15p	7412	8p	74132	28p	LM390	18p	ML928	130p
AC153	18p	BC238	4p	BF257	11p	2N1132	6p	4010B	20p	7413	13p	74141	35p	LM380	55p	ML928	100p
AC176	15p	BC261B	5p	BF258	17p	2N1304	12p	4011B	9p	7416	10p	74145	30p	LM381N	80p	ML928	50p
AC187	10p	BC478	5p	BF259	10p	2N1306	16p	4012	8p	7417	10p	74147	85p	LM382N	70p	TBA641BX1	150p
AC188	12p	BC301	20p	BF339	10p	2N1308	20p	4013B	15p	7420	8p	74150	45p	LM1458N	30p	TBA651	100p
AD149	40p	BC328	5p	BF341	15p	2N2217	15p	4014	35p	7421	15p	74151	30p	LM1458N	35p	TBA800	60p
AF118	23p	BC477	15p	BFX29	25p	2N2222A	10p	4016	14p	7423	15p	74153	30p	LM13915	200p	TD1004	250p
AF124	30p	BC547	5p	BFX86	15p	2N2369	10p	4020B	35p	7425	15p	74156	20p	LM13600	95p		
AF125	30p	BC549	7p	BFX87	15p	2N2484	10p	4021	30p	7427	12p	74157	25p	MC1310N	65p		
AF139	20p	BC557	5p	BFX88	22p	2N2904	10p	4022	25p	7428	12p	74161	24p	MC1495L	350p	TDA1008	250p
AF186	40p	BC558	5p	BFY50	13p	2N2906	10p	4023	8p	7432	12p	74162	26p	MC1495L	350p	UAA170	80p
AS54	10p	BC559	10p	BFY52	15p	2N2907	10p	4025	8p	7433	10p	74163	35p	MC1496P	60p	ZN424E	120p
AS555	10p	BCY30	40p	BFY53	8p	2N2926G	8p	4027	15p	7437	10p	74164	35p	MK50398	400p		
BC107	6p	BCY34	40p	BU205	180p	2N3053	15p	4028	30p	7438	8p	74165	35p				
BC108	6p	BCY59	12p	BU208	115p	2N3055	32p	4030	9p	7440	8p	74167	45p				
BC109C	6p	BCY70	10p	MJ2955	65p	2N3702	5p	4035	40p	7441	45p	74173	35p				
BC117	8p	BCY71	18p	MPF104	20p	2N3703	5p	4041	35p	7442	20p	74174	40p				
BC119	10p	BCY72	10p	MPF105	20p	2N3705	5p	4043	30p	7443	30p	74175	20p				
BC142	20p	BD115	15p	MPF106	20p	2N3708	5p	4044	28p	7444	35p	74177	30p				
BC143	20p	BD121	30p	OC28	40p	2N3707	5p	4044	28p	7445	30p	74180	23p				
BC147	5p	BD123	30p	TIP29B	20p	2N3708	5p	4048	30p	7446	5p	74181	80p				

The power supply can make the difference between an adequate amplifier and a great one. In this article, J. Linsley Hood explains the advantages of a stabilised PSU, and concludes with a simple and novel circuit to upgrade your hi-fi.

# STABILISED HI~FI PSU

If you look inside the boxes of some of the top name hi-fi power amplifiers — the ones that get the rave reviews from the 'golden-eared' fraternity — you will find, more often than not, that the power supply units are stabilised, rather than being of the simple transformer, rectifier, reservoir capacitor variety. The reason for this is twofold. First, the presence of a stabilised PSU is an indication of the rather greater care that has gone into the building of these amplifiers, and if you aim at the top, as a hi-fi manufacturer, this is a necessary part of your philosophy; and second, because the stabilised PSU really does confer some valuable advantages in the operation of the equipment. Let us look at some of these.

The amount of power one can get from a power amplifier, for any given load impedance, increases rapidly as the DC power line voltage is increased. However, so does the cost of the output power transistors (in fact, all the transistors), as well as the capacitors used in the design. As an aside, the fact that 50 V capacitors cost a lot less than half that of the equivalent 100 V ones is the main reason for the popularity among the high power amplifier manufacturers of direct coupled (two power supply lines of half the voltage) output stages. If Joe Public thinks that they also sound better, so be it!

Unfortunately, the realities of

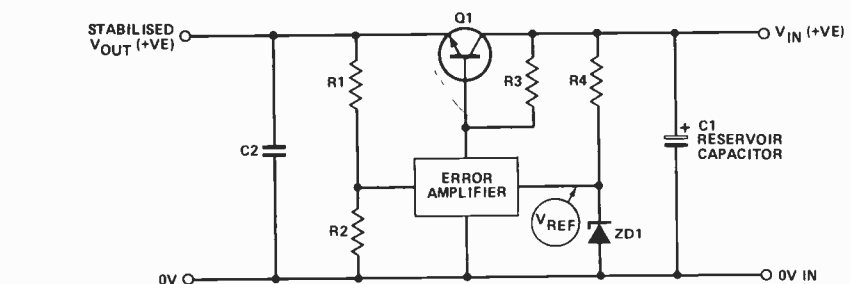


Fig. 1 Simple stabilised power supply.

life are not on our side. From the point of view of the power output, what is important is the actual supply line voltage at maximum load, but what the transistors have to support is the worst case condition of line voltage off-load, and the on-load voltage will always be a good bit less than this. If, on the other hand, one has a constant DC supply, one only needs to make sure that the transistors and capacitors will stand this, and this will also be the voltage available when one is driving to full power.

Just doing a cost assessment of stabilised versus cheap-and-cheerful gives a small overall cost advantage in favour of the simple system, which is why it is more commonly used. However, the stabilised PSU has other, more subtle, advantages which are of value to the discriminating user. These are those which follow from the low ripple level on the supply line of any properly designed stabiliser circuit, and its low supply line impedance. The first of these ensures that hum breakthrough is eliminated, not just at low power levels, which is easy, but also at high powers, when the voltage ripple on the reservoir capacitor is becoming significant. The second feature, that of the low line impedance, not only gives a

lower degree of LF breakthrough from one channel to another (at frequencies where the impedance of the reservoir capacitors is significant) but also gives a more firm and solid bass response. In fact, in my view, this is a more important contribution to the firmness of bass response than the absence of an output coupling capacitor in a 'direct coupled' system.

So, having reviewed the propaganda in favour of the use of constant, stabilised power supply lines two questions remain: can one upgrade an existing amplifier this way, and how simply could one be built? The answer to the first question is almost certainly 'yes' provided that one uses some care. The second I propose to explore. Since this will be done by starting with a basic circuit and adding components, the usual practice of numbering components from left to right and top to bottom will not be followed, so as to achieve continuity from figure to figure.

## The Stabilised PSU

These are normally designed along the lines shown in Fig. 1. In this a 'pass' transistor (Q1) is connected as an emitter follower



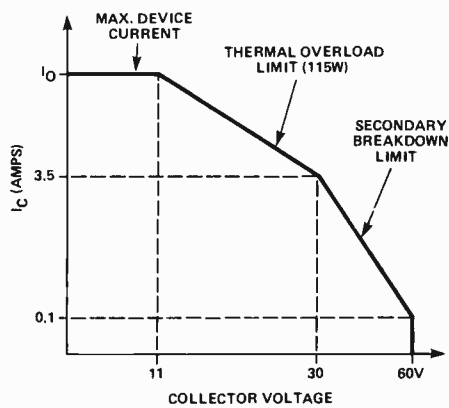


Fig. 2 Power transistor limiting values.

between the unstabilised DC input and the required stabilised DC output. The base drive current to this pass transistor is controlled by some form of error amplifier which compares some proportion of the output DC voltage with a reference voltage derived, perhaps, from a zener diode (ZD1) supplied through R4. Depending on the zener voltage, the controlled DC output can be adjusted, within the limits set by the DC input and the reference voltage, by a suitable choice of R1 and R2. A small capacitor is usually connected across the output to make sure that the output impedance remains low at HF.

This is a very good circuit arrangement, and is used in a very wide range of designs. Indeed, with a little more internal craftiness, very similar systems are employed in the 'three terminal' IC voltage regulators one can now buy for around fifty pence. However, there are snags.

In the case of the IC voltage regulators the main snags are that they are usually limited to input voltages less than 50 V, that the maximum output voltages are usually less than 35 V and that at these voltages the available output

currents will probably be less than 0.5 amps, which is rather too low to be of much use for audio power amplifiers. Nevertheless, where these can be used, they are the best possible solution in terms of performance in relation to cost.

In the case of DIY units of this kind built up from discrete components, though higher voltage and current operation can be organised, the most immediate problem is that of the 'safe operating area rating' or SOAR as shown in Fig. 2. This graph, which is that for a typical power transistor of the 2N3055 type, shows that there are limits on the permissible conditions of operation, and that, as a general rule, you cannot allow the transistor to pass much current at voltages above some 30 V without it blowing up, due to what is known as 'secondary breakdown'. (This arises because silicon diodes have a forward voltage which decreases as they get hotter. So, if enough current, at enough voltage, flows through the transistor the resultant heating will inevitably cause some localised area of the base-emitter 'diode' to get hotter than the remainder, and then all the transistor current will plough through this small area, with expensive and inconvenient results!)

Two ways of safeguarding against this snag are possible. The first (and simpler, if the amount of current needed is less than that permissible at the given input voltage  $V_{in}$ ), is simply to include a current limit circuit as shown in Fig. 3.

In this, Q2 is added, with R5. If the output current taken exceeds the amount needed for the voltage drop across R5 to turn on Q2, then this will 'steal' the base current from Q1 and hold the output current to the chosen limiting value.

However, circumstances often arise where this simple answer just isn't good enough, and then it is necessary to organise a rather more cunning scheme, known as 're-entrant' short-circuit protection. In this, the protection circuit is arranged so that the full, but limited, output current is allowable up to some prearranged voltage drop across the pass transistor Q1, which is known to be within safe operating limits. If the voltage across the pass transistor exceeds this value, some supplementary circuit comes into operation to instantaneously limit the current through the transistor to some lesser value appropriate to its new collector-emitter voltage drop.

This type of arrangement is a much better scheme, and allows stabilised PSUs to be built which will give quite large current outputs at the sort of voltages which would be of use in audio amplifier systems. Moreover, the fact that the output voltage and current will both collapse rapidly in the event of an overload can allow a good measure of protection, if the limit levels are set correctly, for both the amplifier itself and also things like loudspeakers used with it.

Of course, the usefulness of a stabilised power supply is not limited to improving audio amps. This was just one of the possible uses which might appeal to the hi-fi enthusiast in pursuit of an economical and sensible route to a rather higher-fi. Also, as it happens, it is an ingredient I have in mind for a future audio amplifier design for ETI, since I don't think that perfection in this field has yet been reached, or that the last word in cost effectiveness has yet been spoken.

## An Improved PSU

So — we want a simple PSU

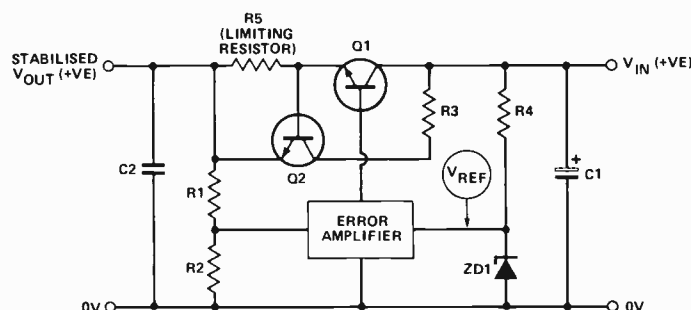


Fig. 3 A stabilised power supply with current limiter.

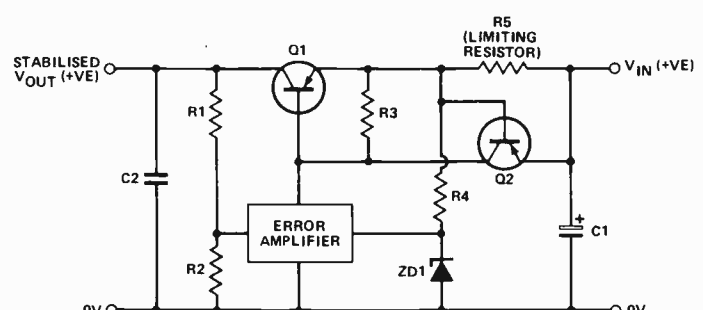


Fig. 4 An alternative arrangement to Fig. 3.

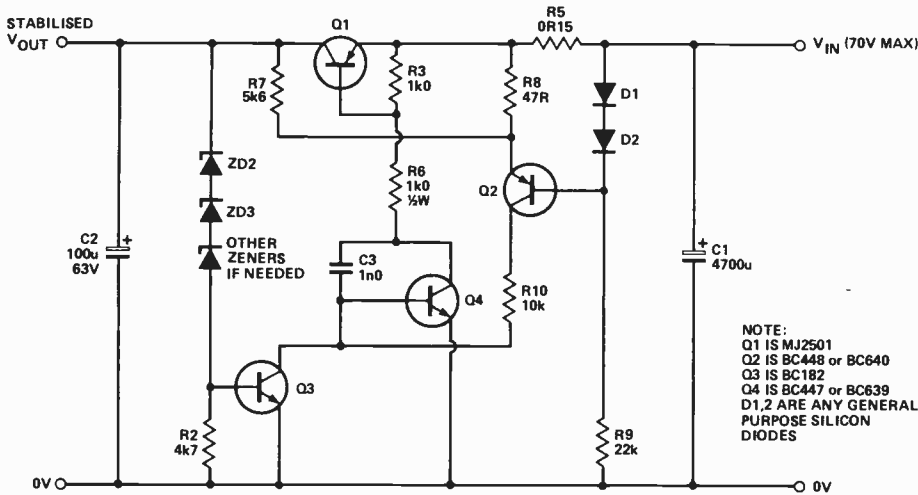


Fig. 5 A stabilised power supply unit with re-entrant short-circuit protection.

system, with an adequate degree of voltage stabilisation, and a re-entrant overload limit characteristic. How best can this be done?

The general scheme shown in Figs. 1 and 3 has several inherent snags, in spite of its popularity in the PSU circuit league. Of these snags, the first is that there must be a sufficient difference in voltage between  $V_{IN}$  and  $V_{OUT}$  for Q1 to be functional, and for an adequate current to flow through R3 to give the necessary output maximum current, with the lowest likely current gain in Q1. This would lead, say, in a 3 amp PSU to a value of R3 being chosen which would pass 100 mA at a 10 V input/output voltage drop. If we now have an input voltage of, say, 60 V, then when Q1 isn't asking for the full base bias current — as, for example, when the PSU was off load — the error amplifier will have to dissipate  $60 - 10 \text{ V} \times 100 \text{ mA} = 5 \text{ W}$ , with a further 1 W being dissipated in R3.

If, however, we turn Q1 the other way round, as in Fig. 4, then the base bias current can be supplied from the '0 V' line, which will mean that the minimum necessary voltage drop between  $V_{IN}$  and  $V_{OUT}$  can be reduced to, say, 3 V, which will reduce Q1's dissipation. Also, only as much current is fed into Q1's base as the output current calls for. This greatly reduces the quiescent dissipation in the error amp circuitry as well. Of course, we would then have to put the current limit transistor on the input side, if we were going to use the same kind of limiting system. We can, however, do a bit better than this — using the final circuitry

in Fig. 5.

In this circuit, I have shown a two-transistor error amplifier (Q3 and Q4) which uses the 0 V line as its voltage reference, allowing us to delete the reference voltage circuit R4 and ZD1. In this circuit, Q4 is turned on by current flowing into its base through R8, Q2 and R10. This causes an amplified current to flow in Q4's collector circuit and turn on Q1. However, when the output voltage rises to a high enough level, the zener diodes ZD2 and ZD3 conduct and start feeding base current into Q3. This promptly gobbles up the current that was previously flowing into the base of Q4 and prevents the voltage from rising further.

The use of one or more zener diodes in a chain to provide the necessary output voltage — the actual output controlled voltage will be about 0V5 greater than the sum of the zener voltages — gives a simple system if one specific output voltage is required. However, zener

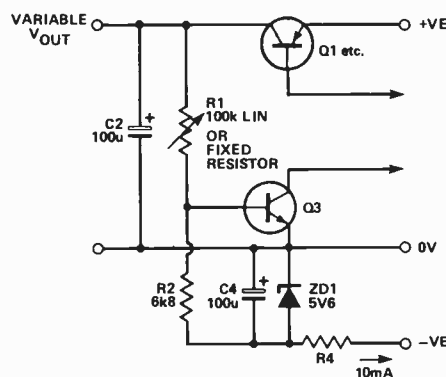


Fig. 6 This modification to the circuit of Fig. 5 allows a variable output voltage.

diodes are a bit noisy (especially if their individual breakdown voltages are high, which makes it preferable to use several lower voltage units in a string), so it may be advantageous to use the modified system shown in Fig. 6, if a convenient negative line is available, which would then allow the output voltage to be adjusted between 0V5 and some 3 V less than the available voltage.

Since the total amount of gain in the feedback circuit consisting of Q1, Q3 and Q4 is quite high, it is necessary to incorporate some HF stabilising element. In this case this function is performed by C3. The other part of the circuit, that of the 're-entrant' short circuit protection and current limiting action, is performed by Q2 with its associated resistors. The way this works is quite simple.

Assuming that there is no significant voltage drop across R8 and R5, Q2 will be turned on by current fed into its base by R9 (or R4 in Fig. 7), and an amplified current will be fed from the positive line into the base of Q4 via R5, R8, Q2 and R10. (R10 serves to limit the maximum current which can flow, and to reduce the amount of dissipation in Q2). The maximum forward bias potential which can be applied to Q2 is held to about 1V1 by the two forward biased diodes D1 and D2. So — if we try to take more current from the circuit than would produce a 0V6 drop across R5 then Q2 will lose its operating forward bias and no more current will be fed into Q4 or Q1, which will limit the possible output current to a level just a little less than this value.

However, this has ignored the contribution made by R7 and R8. If there is too much voltage across Q1, which, as we have seen above, would reduce its ability to handle large currents safely, part of this voltage will also appear across R8, and this will also tend to turn off Q2, or at least make it current-limit at lower levels of voltage drop across R5. This has the required effect of tying the output current limiting value to the voltage drop across Q1, and means that, under something approaching short-circuit conditions, only a much reduced output current will flow.

### Using The Circuit

So, here we have a fairly

# PROJECT: Stabilised PSU

simple, low quiescent dissipation stabiliser circuit which uses standard discrete components and transistors, and which can be used to stabilise a single positive DC supply line (or if its 'mirror image' circuit is built, as in Fig. 7, a negative supply line too!) up to the maximum input voltages and currents which the components can stand. How, then, can we use this to improve an existing audio amplifier, which just uses a simple transformer-rectifier-reservoir capacitor system, as envisaged at the start of this article?

A single line stabilised supply is shown in Fig. 5 and a twin positive and negative supply is shown in Fig. 7: the DC output voltages and currents can be determined from the values shown in the tables. Now let us envisage a possible application. Measurement shows that on a hypothetical amplifier 'A', all of the internal DC supplies are drawn from a single power supply source which has a quiescent output voltage level of 66 V, dropping to 55 V on full load. If, at half load, which is the worst case condition, the heatsinks don't get alarmingly hot (as we must hope), and the HT line voltage is, shall we say, 60 V, then we could assume that a fixed voltage input supply somewhere between 60 and 65 V would not over-stress the amplifier

components, and we could build this output voltage into the circuit of Fig. 5 by the use of an appropriate string of zener diodes.

Such a separate DC supply could then be housed in its own small box, with the DC feed being taken to the amplifier with which it is used. (This is assuming that there isn't room within the existing box for the larger, higher voltage transformer which will be needed, or for the other components.) What sort of benefits will this bring?

First, one would expect a significant reduction in the existing amplifier 'hum' level, if it is less than perfect in this respect. Second, one could expect an improvement both in the 'solidity' of the bass response, due to the lower LF dynamic impedance of the HT line in comparison with even a large value of supply line reservoir capacitor, and this should also give a lower level of LF channel crosstalk. This latter feature is also important because most of the crosstalk signal components are heavily distorted in typical transistor output stages. Third, one would obtain a greater immunity from consequential damage, such as loudspeaker units burning out if failure in the amplifier caused it to switch over to some unwanted high current mode; and finally, one

would get more power output from it.

This last consequence arises from the fact that output power is determined by the equation  $P = V^2/R$ , where  $V^2$  is the square of the RMS output signal voltage, and R is the loudspeaker load impedance. For a 30 W amplifier with an 8 ohm load and the HT supply voltage characteristic shown above, a change in full load HT voltage from 55 V to 65 V would give an increase in power from 30 to 45 W without the need for the replacement of any other components.

## PCB Layouts

It makes a tidier and more professional looking unit if the necessary small components are mounted on a printed circuit board, so I have shown two such suitable layouts, complete with component overlay, in Figs. 8 and 9. The circumstances in which a PSU of this type might be used to upgrade an existing audio amplifier are rather too varied for anything other than general guidance to be given. However, these circuit layouts also allow the experimentally inclined user to build himself a useful short-circuit protected bench supply, which is literally a unit with dozens of uses.

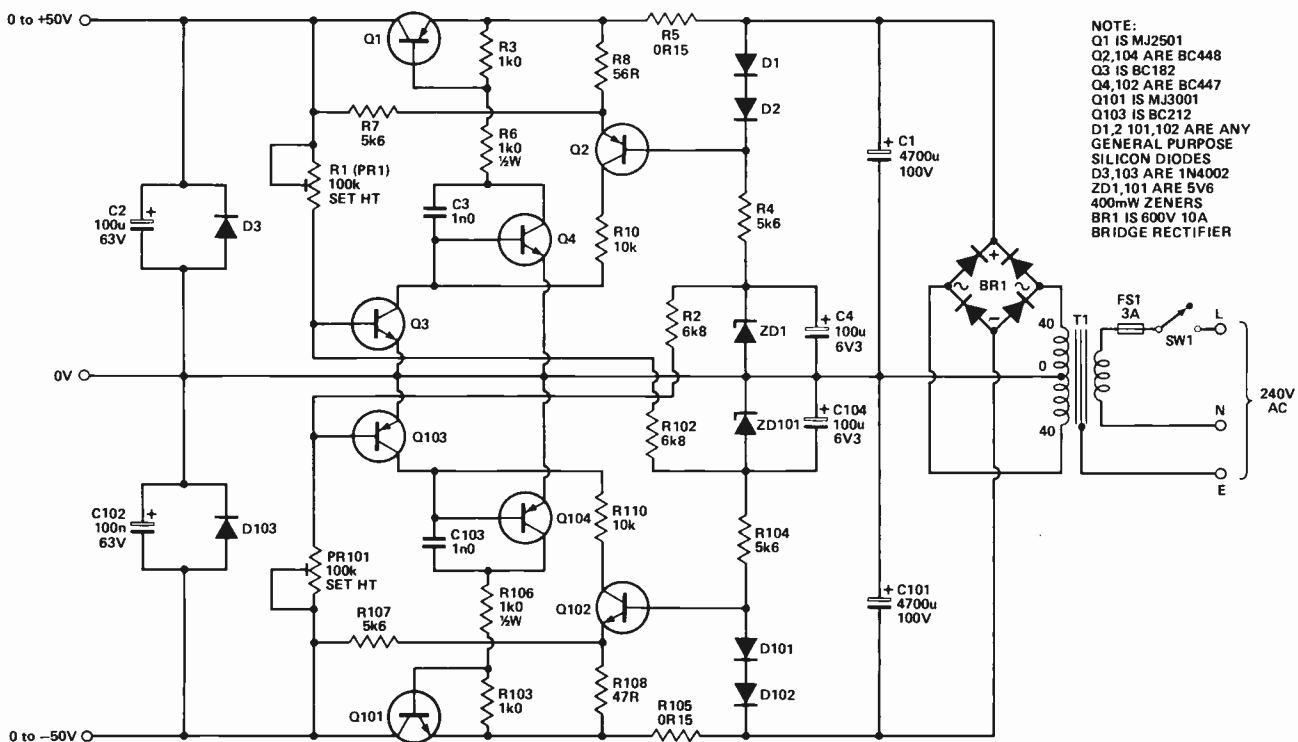


Fig. 7 Complete circuit for a twin stabilised power supply unit (current output 3 amps at 45 V).



# PROJECT: Stabilised PSU

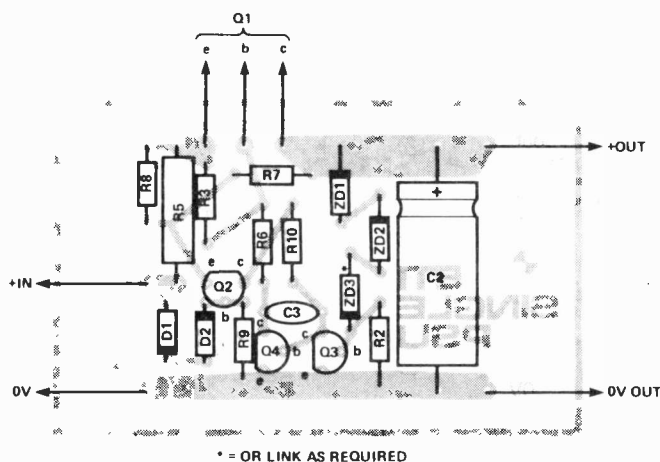


Fig. 8 Overlay for the circuit of Fig. 5.

**TABLE 1**

Maximum output voltage	Transformer voltage (per winding)	C1 minimum working voltage	R8
30	25	40	56R
40	33	50	56R
50	40	63	47R
60	48	80	43R

**TABLE 2**

Output current (amps)	Transformer secondary current rating (amps per winding)	R5
0.5	0.7	1R0
1	1.5	0R5
2	3	0R25
3	4.5	0R15
4*	6	0R12

\* (not recommended above 40 V)

## PARTS LIST

Resistors (all $\frac{1}{4}$ W, 5% except where stated)	C3	1n0 ceramic
R2	4k7	
R3	1k0	
R5	see Table 2	
R6	1k0 $\frac{1}{4}$ W	
R7	5k6	
R8	see Table 1	
R9	22k	
R10	10k	
Capacitors		
C1	4700uF electrolytic (see Table 1 for working voltage)	
C2	100uF 63 V axial electrolytic	
	Semiconductors	
	Q1	MJ2501
	Q2	BC448 or BC640
	Q3	BC182
	Q4	BC447 or BC639
	D1,2	general-purpose silicon diodes, eg 1N4148
	ZD2,3,etc	zeners to suit (see text)
	Miscellaneous	
	PCB (see Buylines); heatsink to suit.	
	See text for an explanation of the unusual component numbering.	

## BUYLINES

Two companies that can supply the transistors used in this project are Bradley Marshall, who advertise in this magazine, and Hart Electronics Ltd. of Oswestry, Shropshire. As a guide to price, Hart charge £1.50 plus VAT each for the MJ2501 and MJ3001, while the BC447 costs 20p plus VAT and the BC448 22p plus VAT. The PCBs can be obtained using the form on page 87.

## PARTS LIST

Resistors (all $\frac{1}{4}$ W, 5% except where stated)	
R1,101	suitable fixed resistor or (PR1,101) 100k miniature horizontal preset or off-board pot
R2,102	6k8
R3,103	1k0
R4,104,7,107	5k6
R5,105	see Table 2
R6,106	1k0 $\frac{1}{4}$ W
R8,108	see Table 1
R10,110	10k
Capacitors	
C1,101	4700uF electrolytic (see Table 1 for working voltage)
C2,102	100uF 63 V axial electrolytic
C3,103	1n0 ceramic
C4,104	100uF 6V3 axial electrolytic
Semiconductors	
Q1	MJ2501
Q2,104	BC448
Q3	BC182
Q4,102	BC447
Q101	MJ3001
Q103	BC212
D1,2,101,102	general purpose silicon diodes eg 1N4148
D3,103	1N4002
ZD1,101	5V6 400 mW zener
BR1	600 V, 10 A bridge rectifier
Miscellaneous	
PCB (see Buylines); heatsink to suit; centre-tapped transformer (see Tables 1 and 2); mains switch; 3 amp fuse and fuseholder.	

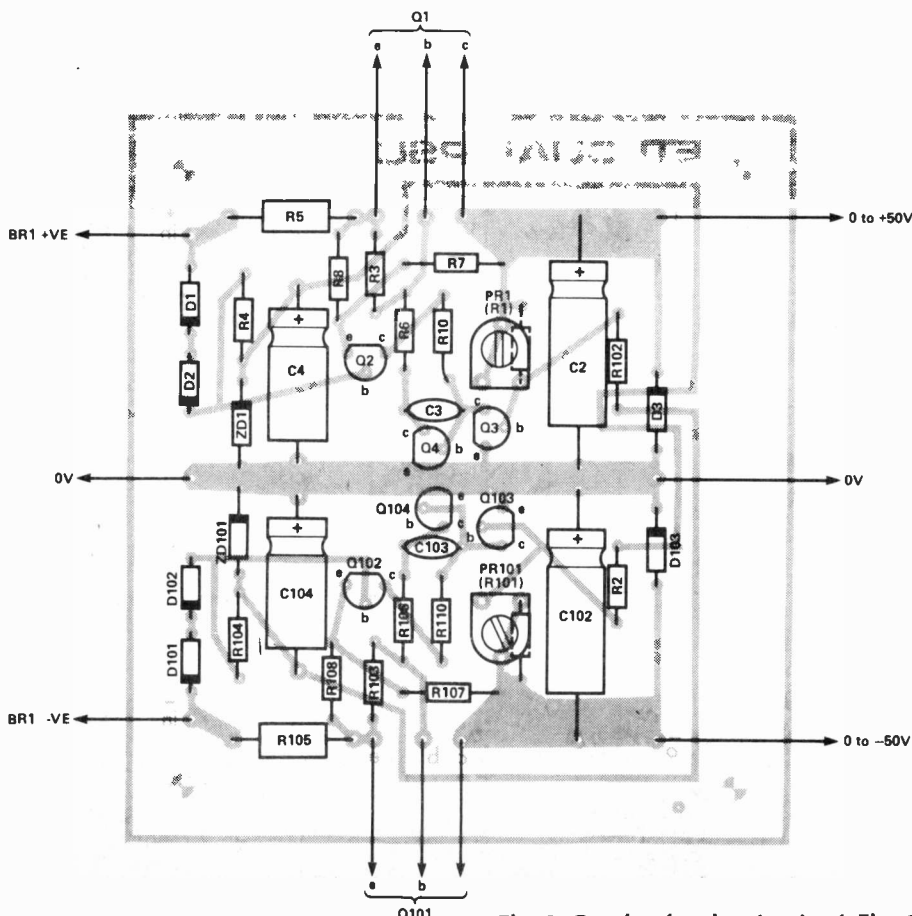


Fig. 9 Overlay for the circuit of Fig. 6.

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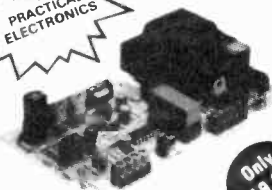
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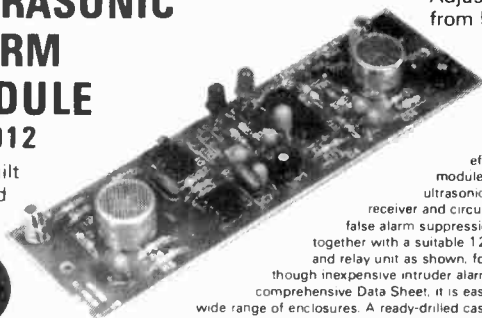
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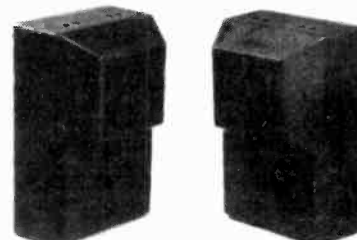
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# 60W NDFL AMPLIFIER

Following last month's article on nested differentiating feedback loops, here is a practical amplifier design, presented as a module, with very low distortion. Design by Edward M. Cherry, Associate Professor, Dept of Electrical Engineering, Monash University.

This amplifier will perhaps be of most interest to home constructors who want to rebuild an existing system and upgrade its performance without the expense of new major components. The power output transistors employed are the well-known types MJ802 and MJ4502 which have been around for several years and have proved their reliability. Indeed, the whole design is mature and home constructors should have no difficulty in making it work.

The theoretical basis for this amplifier was discussed in last month's ETI.

## Grounding

In any amplifier where the basic distortion has been reduced to a few parts per million, several distortion mechanisms not ordinarily considered may become significant. One such mechanism is associated with currents circulating in the ground leads and power-supply wiring.

Figure 1 explains the origin of this distortion. The current in each power transistor of a class B stage is a half-wave rectified version of the output. The two currents, drawn

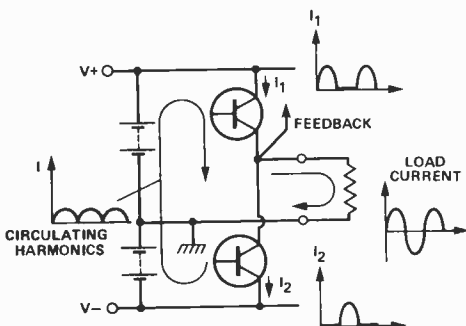


Fig. 1 Circulating even-harmonic current in a Class-B output stage.

## HOW IT WORKS

Figure 2 is the complete circuit of one channel of the amplifier; equations referred to in the explanation refer to last month's feature. The circuit is clearly based on Fig. 10 (last month's ETI), with major parameters

$$1/\beta = 32.9$$

$$\tau_x = 800 \text{ nS}$$

The value of  $\beta$  is set by the overall feedback resistors R11 and R12 (470R and 15k — see Equation 1).  $\tau_x$  is set by:

- R4 and R5 (330R) plus C6 and C8 (68p) in conjunction with the chosen value of  $\beta$  (see Equation 13);
- R15 and C7 (1k8 and 470p — see Equation 14);
- R32 and C14 (8R2 and 100n) plus the 8 ohm nominal load and L3 (6u8 H);
- R12 and C4 (15k and 33p) via the other constants in Equation 15.

The first stage requires little comment. Q1 and Q2 operate at 1.5 mA each, Q3 is a current source, Q4 is a common-base stage to equalize the quiescent voltages on Q1 and Q2; Q5 and Q6 constitute a current mirror. R1 and C2 form a 200 kHz low-pass filter against RF interference.

The Rush current amplifier operates at 3 mA, set by R18, and it incorporates a catching diode (D1) to accelerate recovery from overdrive. The pre-driver, Q10, operates at 8 mA; Q9 protects the stage against damagingly large currents under fault conditions. Driver quiescent current is 25 mA, set by R28.

Transistors Q12 and Q13 provide short-term protection for the power transistors. Short-circuit current is limited to about 4 A, and peak signal current is limited to 7 A. Long-term protection is provided by 2 A fuses in each supply rail; these should be 'ordinary' types, rather than delay or quick-blow. In the unlikely event of transistor failure, these fuses limit the loudspeaker current to 2 A, corresponding to 32 W into 8 ohms.

The common alternative of a single fuse in the loudspeaker lead is less satisfactory: it provides less protection for the amplifier; it provides less protection for the loudspeaker as the fuse must be rated to carry the full signal current, and it introduces distortion on large-

amplitude, low-frequency signals.

**LOW FREQUENCY COMPENSATION**  
A feature of Fig. 2 not discussed so far is a low-frequency compensating circuit, R13 and C5.

Amplifiers of the basic circuit topology of Fig. 2 (last month) have a group delay which is different for different signal frequencies. Some frequencies take longer or shorter times than others to pass through the amplifier. High-frequency group delay in NDFL amplifiers can be corrected, as described last month, by a small capacitor in the feedback network (see Equation 15). Errors in low-frequency group delay, in both Figures 2 and 10 (last month) are associated with the input coupling capacitor and the capacitor in series with R<sub>F1</sub>. Low-frequency square-wave inputs are reproduced with a 'tilt' as in Fig. 3a.

One approach to this problem is to use a truly direct-coupled amplifier, with no capacitors in series with the signal path; commercial audio power amplifiers of this type appeared in the 1970s. Unfortunately, such amplifiers are prone to drift. A significant DC voltage may appear at the output even when there is no input. Although it is possible to reduce drift in a power amplifier to an acceptable level, it is not possible with today's technology to build a system that is truly direct-coupled from pick-up input, through the RIAA network and the power amplifier.

In the last few years a generation of amplifiers has appeared which include some form of servo amplifier to correct the drift. All circuits known to the author re-introduce the problem of group delay, albeit in a lesser form.

The approach adopted in the design is to retain the coupling capacitors and thereby eliminate drift, but include a group-delay correcting circuit. Figure 4 shows the outline. Group delay is optically compensated if:

$$R_{F3} = 2 R_{F2}, \quad (16)$$

$$R_{F2} C_{F2} = R_{F1} C_{F1} \quad (17)$$

Figure 3b shows the improvement in square-wave response.

Low-frequency group-delay compensation could well be included in audio power amplifiers and preamplifiers other than NDFL types.



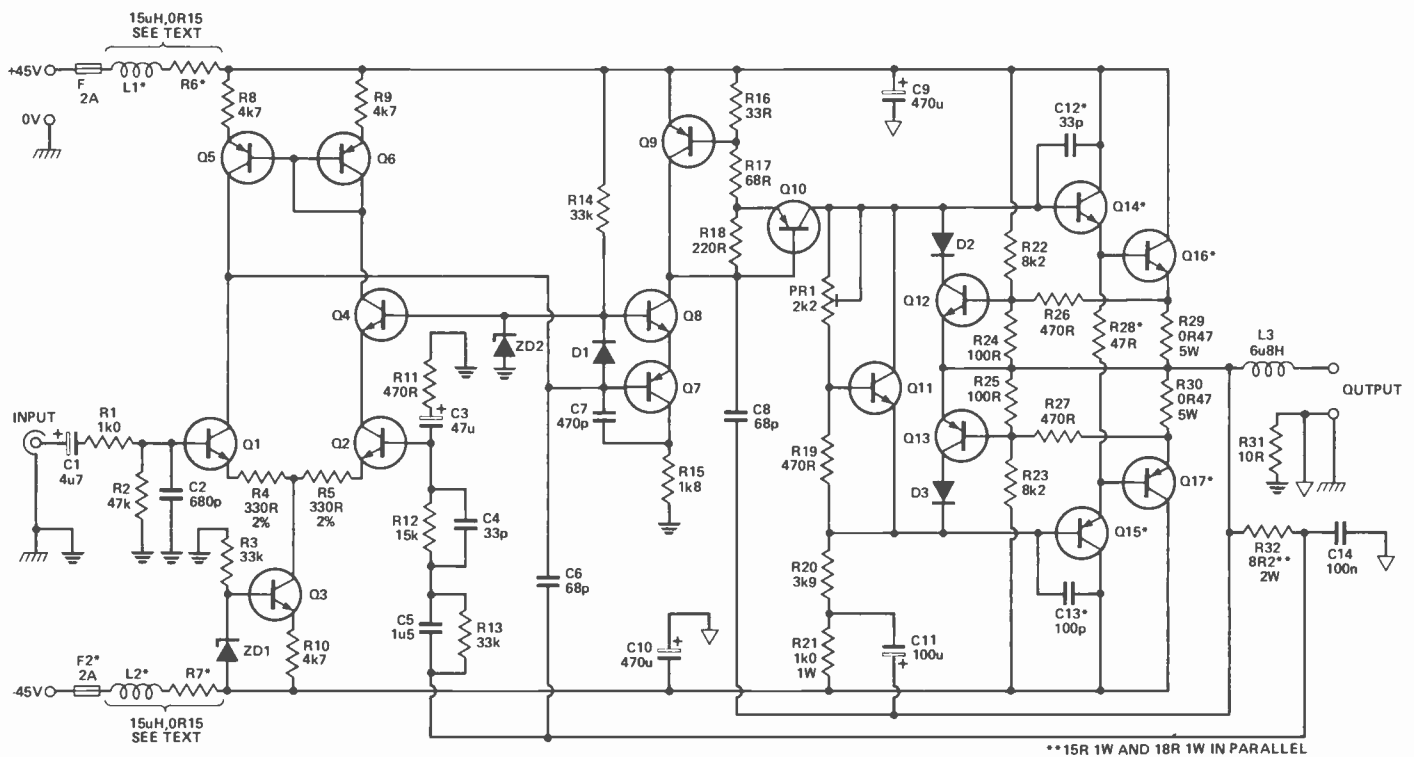


Fig. 2 Circuit diagram of the 60 W power amp. Components marked with a single asterisk are not mounted on the PCB.

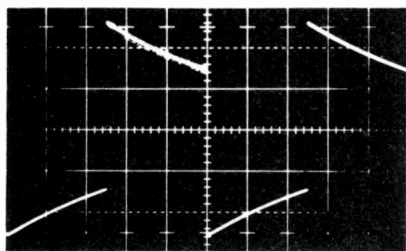


Fig. 3a Square wave response of the amp without group-delay compensation.

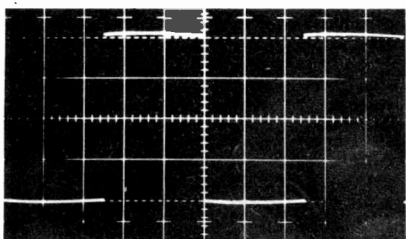


Fig. 3b Square wave response of the amp with group-delay compensation — note the improvement over Fig. 3a.

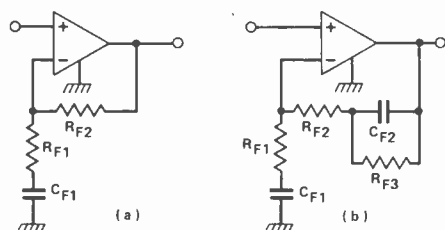


Fig. 4 Circuit for compensating low frequency group delay: (a) basic uncompensated circuit; (b) compensated circuit.

alternatively from the positive and negative supplies, are equivalent to a circulating full-wave rectified current and this is basically an even-harmonic distortion of the signal output. If there is any mutual inductance between the power-supply wiring (including the grounds) and the signal wiring (also including the grounds), then an even-harmonic distortion is induced in the amplifier and feedback is powerless to correct it.

The circuit board has been laid out so as to minimise this effect. The areas enclosed by some tracks are critical, and home constructors making their own PCBs are cautioned to follow the layout exactly; use the foil pattern on page 84, or, better still, purchase a ready made board.

Note that the circuit uses three distinct ground symbols.

- a) is the *quiet ground* track on the circuit board (one per channel).
- b) is the *noisy ground* track on the circuit board (one per channel).
- c) is the metal chassis ground (there are six connections to the chassis in total).

Each channel is connected to chassis ground at two points. The

input socket is connected to the chassis (rather than insulated from it), the input lead from socket to circuit board is screened, and the quiet ground track is connected to chassis ground at the input socket via the screen. Similarly, the ground output terminal is screwed into the chassis, the leads from the circuit board to the output terminals are a twisted pair and the noisy ground track is connected to chassis ground at the output terminals via the ground output lead. The remaining two connections to chassis are in the power supply (Fig. 5).

Note that a 10 ohm resistor, R31, links the quiet and noisy ground tracks. This resistor is short circuited at low frequencies by the input screen and neutral output wiring to chassis ground. However, the resistor takes over at high frequencies where wiring inductance become significant.

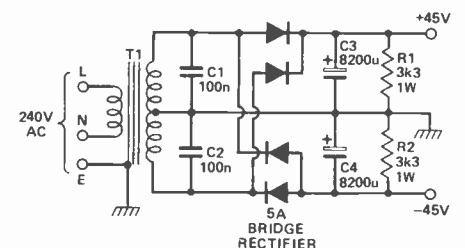


Fig. 5 Suggested PSU for the amplifier. Alternatively, see next month's ETI for a better choice.

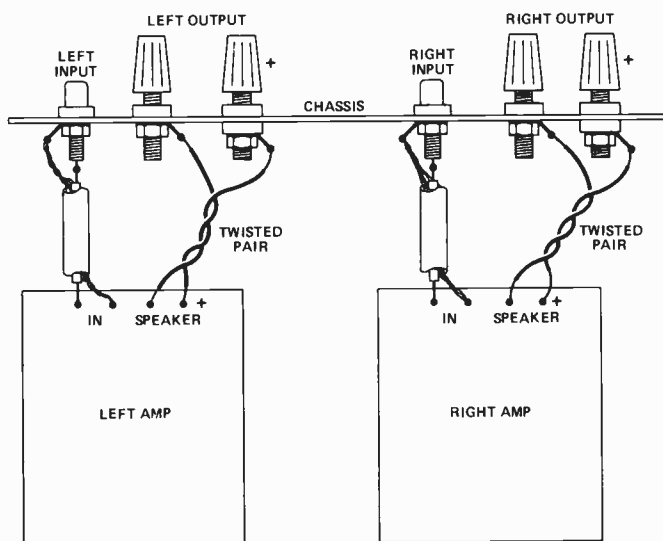


Fig. 6 Showing the general technique for connecting inputs, outputs and grounds to a stereo pair of modules.

The  $15\mu\text{H}$  filter inductors in the supply rails are also for suppressing circulating currents (R6 and R7 represent the winding resistances of L1 and L2).

This amplifier employs only two nested differentiating feedback loops and its distortion is not down to the ultimate limit. The benefit of including the filter inductors is therefore marginal. The author is not blessed with 'golden ears' and cannot hear the effect of removing the filters, although the difference is clearly measurable. The filters should certainly be included in amplifiers that use three or more NDFLs. As the inductors must be home-made, and therefore cost nothing but time, and as they do make a measurable (if small) improvement, most home constructors will probably wish to include them. Winding data is given in Table 1.

The precise values of inductance and resistance are not important —  $\pm 50\%$  is good enough — but do not use the 1.25 mm wire from L3 as something like 0.1 ohm series resistance is essential. For a similar reason, do not parallel the  $470\mu\text{F}$  bypass capacitors C9 and C10 with high-frequency types. Brass or steel mounting screws are perfectly satisfactory for the filter inductors, as linearity is not important.

### Critical Components

The majority of the components in this amplifier are not critical. Almost any small-signal diodes will do, such as the 1S44, 1N914, and 1N4148. Q1 and Q2 should be high-gain, low-noise types — BC109 and BC549 are among the cheapest available. The others could be

almost any small signal types: BC107 and BC547 are readily available NPN types, the BC177 and BC557 are suitable PNPs. The driver and output transistors should be the types shown: BD139 and BD140 for the drivers, MJ802 and MJ4502 for the power transistors. The biasing transistor, Q11, could be any NPN in a TO-126 pack that can be mounted on the heatsink: the BD135 and BD139 are readily available types that would suit.

Unless the contrary is indicated on the Parts List, resistors can be standard  $\frac{1}{2}\text{W}$  types and the capacitors can be the lowest available working voltage. A few components, however, do require special mention. A feedback amplifier cannot be more linear than its feedback network, so the various components that constitute the feedback network should have small voltage coefficients. Specifically:

- The overall feedback resistors R11 and R12 should be high-stability types, such as metal oxide or metal film;
- C4, C6 and C8 should be NPO ceramics, not high-K types (NPO means negative-positive zero, a low-K capacitor with a very low temperature coefficient; metallised plate ceramics, for example. Silvered mica capacitors are also suitable);
- C5 and C14 should be polycarbonate, polystyrene or polypropylene types, but not polyester (eg mylar types);
- C3 should be an ordinary cheap aluminium electrolytic, definitely not one of the relatively expensive resin-dipped tantalum types (this is not a misprint!).

TABLE 1

#### Formers

If a suitable type is not to hand, these may be turned from 25 mm diameter polystyrene rod to give 12 mm internal bobbin diameter with 7.5 mm winding space between cheeks.

#### Wire & Winding L1, 2

Take two 1680 mm lengths of 0.75 mm diameter enamelled copper wire and wind onto each former leaving 20 mm or so lead length at start and finish.

#### Wire & winding L3

Take a 1190 mm length of 1.25mm diameter enamelled copper wire and wind it onto the former. Leave 20 mm or so lead length at start and finish.

### HARMONIC ANALYSIS AT 1 kHz

Harmonic	Rated output	
	21V9 60 W	2V19 600 mW
2nd	19 ppm	5 ppm
3rd	14	3.5
4th	2.5	2.5
5th	3.0	1.5
6th	<1	<1
7th	1.8	1.8
8th	<1	<1
9th	1.0	<1
10th	1.8	<1

Notice how the harmonics drop away at small signal amplitude. In this regard a class-B NDFL amplifier is more like a conventional class-A amplifier than a class-B amplifier.

1 ppm = 0.0001%

### HARMONIC ANALYSIS AT 6 kHz

Harmonic	Rated output	
	21V9 60 W	2V19 600 mW
2nd	115 ppm	40 ppm
3rd	100	25
4th	32	15
5th	40	9

Harmonics higher than the 3rd are ultrasonic and hence inaudible.

### BUYLINES

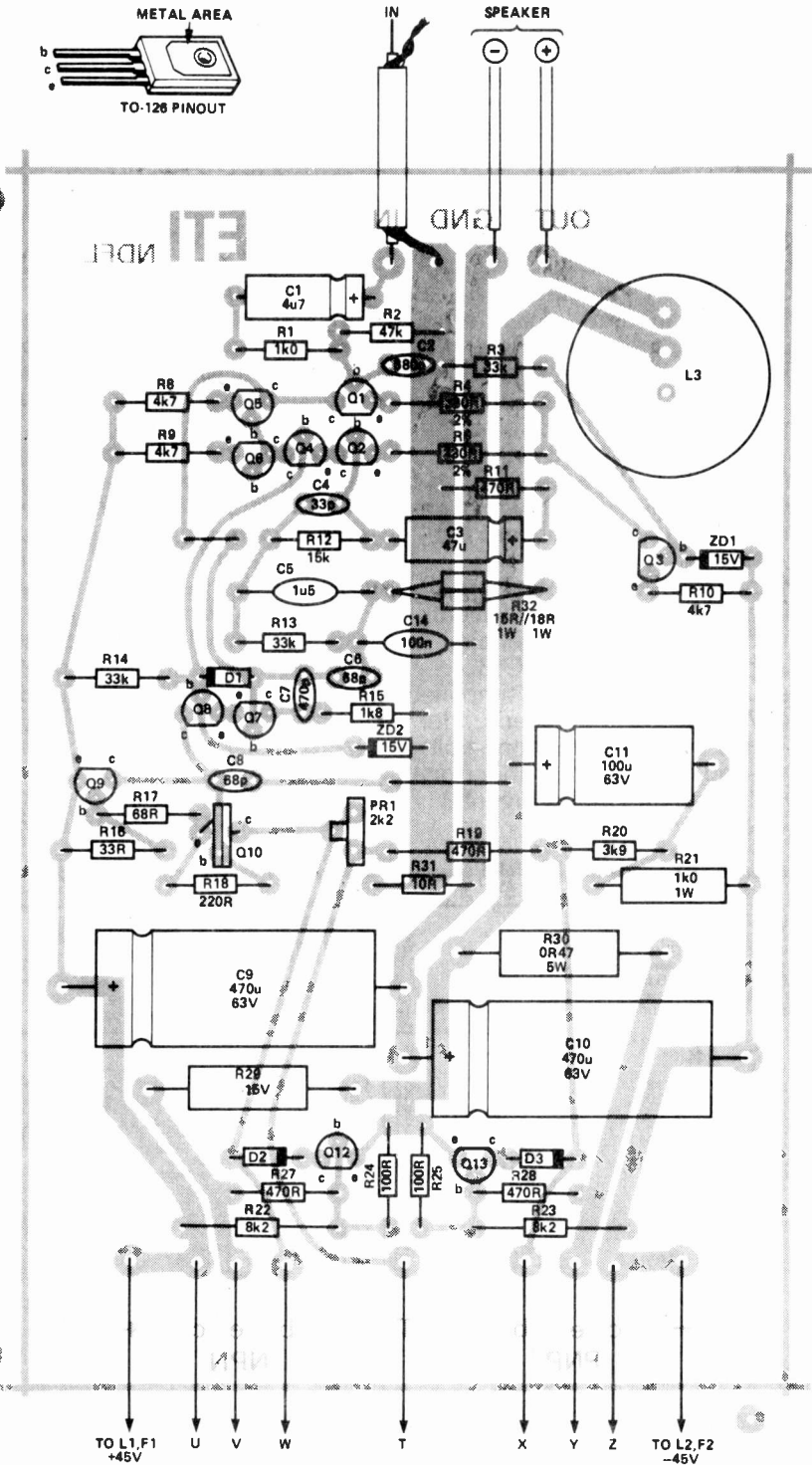
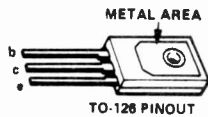
Amongst the semiconductors, only Q16 (MJ802) and Q17 (MJ4502) could possibly present problems: these are both available from Bradley Marshall, Cricklewood and Technomatic.

Some care will be needed in ordering the capacitors mentioned as critical, though the types should not be that hard to find. The PCB is available through the ETI PCB service on page 87.

### PATENT PROTECTION

The principle of nested differentiating feedback loops, on which this amplifier depends, is patented in Britain and principal overseas countries. Commercial enquiries should, in the first instance, be directed to the Legal Office, Monash University, Clayton, Victoria 3168, Australia.

# PROJECT: 60 W NDFL Amp



## PARTS LIST

Resistors (all 1/2W, 5% except where stated)	
R1	1k0
R2	47k
R3,13,14	33k
R4,5	330R 2%
R6,7	see text
R8-10	4k7
R11	470R metal oxide or metal film
R12	15k metal oxide or metal film
R15	1k8
R16	33R
R17	68R
R18	220R
R19,26,27	470R
R20	3k9
R21	1k0, 1 W
R22,23	8k2
R24,25	100R
R28	47R
R29,30	0R47, 5 W
R31	10R
R32	8R2, 2 W or 15R//18R, each 1 W
Potentiometer	
PR1	2k2 miniature vertical preset
Capacitors	
C1	4u7 axial electrolytic
C2	680pF ceramic
C3	47uF axial electrolytic
C4	33pF 100 V NPO ceramic
C5	1u5 polycarbonate
C6,8	68pF 100 V NPO ceramic
C7	470pF ceramic
C9,10	470uF 63 V axial electrolytic
C11	100uF 63 V axial electrolytic
C12,13	33pF 100 V ceramic
C14	100nF 100 V polycarbonate
Inductors	
L1, 2	15uH (see text and Table 1)
L3	6u8 H (see Table 1)
Semiconductors	
Q1,2	BC109, BC549 etc
Q3,4,8,12	BC107, BC547 etc
Q5-7,9,13	BC177, BC557 etc
Q11,14	BD139
Q10,15	BD140
Q16	MJ802
Q17	MJ4502
D1-3	1N4148, 1N914, 1544 etc
ZD1,2	15 V 400 mW zener
Miscellaneous	
F1,2	2 A standard fuse
PCB (see Buylines); one 4-way and one 5-way tagstrip; heatsink to suit (see text); PCB stakes; bobbins for inductors; wire, etc.	

Fig. 7 Component overlay for the power amplifier.

The 6u8 H inductor (L3) needs to be home-made. Winding data is given in Table 1. The bobbin should be mounted on the circuit board with a nylon screw; brass or steel must not be used, because of non-linear eddy current losses.

### Construction

Assembly of the PCB is quite straightforward. It is probably best to commence by soldering all the resistors in place. Note that R32

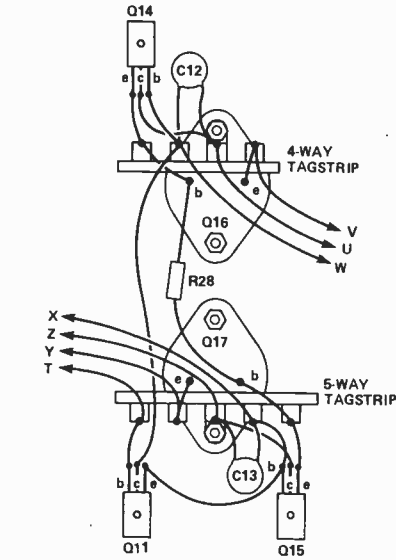
could be either a 2 W type (not common) or two 1 W resistors (15R and 18R) in parallel. Note that the emitter ballast resistors of Q16 and Q17 (R29 and R30) should have very low inductance and if you have trouble with high frequency instability, these resistors are likely to be the culprit. The best solution may be several carbon resistors in parallel. Mount R29 and R30 a few millimetres above the board.

Assemble the diodes next,

making sure you get them all the right way round. Install the links next. Follow with the capacitors. Note that C5 and C14 must be polycarbonate types and C4, 6 and 8 must be NPO ceramics. None of the other ceramic capacitors should be hi-K types, as mentioned earlier. When mounting C9 and C11, see that there is three or four millimetres between the capacitor body and the adjacent 5 W resistors (R29 and R30) to allow for



# PROJECT: 60 W NDFL Amp



**Fig. 8 Wiring diagram for the components mounted on the heatsink.**

convection around the latter.

The transistors may be mounted now. See that each is oriented correctly. Wind L3 next and mount it on the board. Details are given in Table 1. It is not necessary to strictly follow the former dimensions

given, but the inductance needs to be close to 6u8 H and wound from 1.25 mm wire at least, for low resistance.

Assembly of the components mounted to the heatsink comes next. The heatsinks in the original were a standard type sold by many companies and masquerading under such names as type 6W-1 (Maplin) or RS 401-807. Each heatsink has a thermal resistance to ambient of about 1°C/W, and other types could, of course, be substituted. The specified thermal resistance permits continuous operation at full power: smaller heatsinks (up to 2°C/W) could be substituted if the amplifier is to be used only for domestic sound reproduction. Use one heatsink per channel.

Three small components are mounted on the heatsink adjacent to the transistors to keep certain leads short: R28, C12 and C13. Construction is very much simplified if a 4-way tagstrip is installed under one of the collector mounting bolts of Q16 and a 5-way strip under one of Q17's mounting bolts. Figure 8 shows details.

The collector and emitter leads from each power transistor to the circuit board should be twisted. The base leads to Q14 and Q15 could be twisted in with the corresponding collector and emitter leads (although this is not necessary) and the base lead of Q11 can be kept separate. Note that all transistors must be insulated from the heatsink. Note also that the BD140 specified for Q10 needs its leads dressed to fit the board.

Quiescent current in the power transistors should be set to 40-60 mA by PR1. *Be warned* that this quiescent current is almost zero until PR1 is about three-quarters of its maximum resistance, after which the current increases very rapidly; be sure that PR1 is set to *minimum resistance* when the amplifier is turned on for the first time.

A convenient way to check the quiescent current is by means of the voltage drop across R29 and R30; this should be 40-60 mV (total) for zero signal input to the amplifier.

**See the June ETI for details of a complete NDFL amplifier system. ETI**

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556CMOS	140	LM3911	175	ZN1034E	200	4001	11	4520	48	LS01	11	LS155	29		5V1-75V 1.3W	14			
709	25	LM3914	120			4002	11	4521	90	LS02	11	LS156	33						
741	14	LM3915	195			4007	14	4522	105	LS03	11	LS157	25						
748	35	LM13600	105			4008	34	4526	55	LS04	12	LS158	27						
6400CJ	345	MC1496	68	AY-2376	590	4009	24	4527	55	LS05	12	LS160	30						
AT-3-1270	710	MC3340	120	MC1488	55	4011	11	4528	45	LS08	12	LS161	30						
AT-3-8910	370	MF10CN	350	MC1489	55	4011	11	4531	65	LS09	12	LS162	35						
AY-3-8912	540	ML924	195	MMS303	625	4012	14	4532	60	LS10	12	LS163	35						
CA3046	60	NE529	225	MMS307	1250	4013	20	4538	60	LS11	12	LS164	40						
CA3080	65	NE531	135	MMS58174	700	4015	39	4539	80	LS12	12	LS165	50						
CA3089	190	NE544	180	TMS6011	365	4016	20	4543	60	LS14	22	LS168	80						
CA3090AQ	370	NE555	16	ULN2003	75	4017	32	4555	35	LS15	12	LS170	70						
CA3130E	85	NE556	45	8T26	99	4020	42	4556	35	LS20	12	LS173	47						
CA3140E	38	NE565	110	8T28	120	4021	39	4561	100	LS21	12	LS174	36						
CA3161E	100	NE566	140	8T95	90	4022	39	4563	80	LS22	12	LS175	35						
CA3189	200	NE567	100	8T97	90	4023	39	4584	40	LS27	12	LS181	87						
CA3240E	170	NE570	370	81LS95	80	4024	32	4585	50	LS28	14	LS183	07						
ICL7106	680	NE571	370	81LS96	80	4025	12			LS30	12	LS190	05						
ICL7611	95	RC4136	55	81LS97	80	4027	20	COMPUTER ICs		LS32	13	LS191	35						
ICL7621	180	RC4558	45	81LS98	85	4028	37	1802	650	LS33	14	LS192	35						
ICL7622	180	SL490	250	6522	310	4029	43	2650A	1175	LS37	14	LS193	36						
ICL8038	290	SL76477	380	6532	675	4035	45	6502	320	LS40	12	LS194	32						
ICL8211A	150	SP8629	250	6821	110	4040	40	6800	220	LS42	28	LS195	32						
ICM72224	775	TBA120S	70	6845	650	4042	38	6802	250	LS47	35	LS196	43						
ICM7555	80	TBA800	75	6847	650	4043	40	6809	615	LS48	40	LS197	45						
LF353	85	TBA810	95	6850	110	4044	40	8035	345	LS49	50	LS221	50						
LF356	90	TBA820	70	6852	250	4049	22	8060	1090	LS51	14	LS240	55						
LM10	325	TBA950	220	6875	485	4050	22	8080A	250	LS54	14	LS241	55						
LM301A	24	TA100B	310	8155	350	4051	42	8085A	345	LS55	14	LS242	55						
LM311	70	TDA1022	480	8212	110	4052	48	Z80A	315	LS56	16	LS243	55						
LM318	120	TDA1024	115	8216	100	4053	48			LS74	14	LS244	55						
LM324	30	TL061	40	8224	110	4066	22	MEMORIES		LS75	16	LS245	70						
LM334Z	90	TL062	60	8226	250	4068	14	2101	395	LS76	16	LS251	28						
LM335Z	120	TL064	95	8228	220	4069	13	2114(220ns)	85	LS78	17	LS253	30						
LM339	45	TL071	25	8243	270	4071	13	2532	295	LS83	33	LS257	29						
LM348	60	TL072	45	8250	865	4072	13	2708	225	LS85	39	LS258	32						
LM358	55	TL074	95	8251	250	4073	13	2716(5V)	210	LS86	15	LS259	53						
LM377	165	TL081	24	8253	400	4075	13	2764	750	LS90	22	LS266	18						
LM380	65	TL082	45	8255	225	4076	44	2764	1000	LS92	25	LS273	53						
LM381	110	TL084	90	8257	400	4078	13	2708	225	LS93	21	LS279	30						
LM382	110	TL170	48	8259	395	4081	12	2764	750	LS95	36	LS283	38						
LM384	130	UA2240	115	8279	385	4082	12	4116(200ns)	80	LS109	20	LS290	40						
LM386	65	ULN2003	75	8832	250	4093	23	4118-3	325	LS112	20	LS293	40						
LM387	120	ULN2004	75	9602	220	4099	70	5101(450ns)	150	LS113	20	LS365	27						
LM389	95	XR2208	285	Z80ACTC	260	4502	50	5204	725	LS114	21	LS366	27						
LM711	60	ZN414	79	Z80ADART	775	4508	110	6116(150ns)	375	LS125	25	LS367	27						
LM725	325	ZN423	130	Z80ADMA	975	4510	45	6514	330	LS126	24	LS368	27						
LM733	69	ZN424	130	Z80AP10	270	4511	45	6810	115	LS127	25								
LM747	60	ZN425E	340	ZN425E8	320	4512	42			LS128	29	MICRO-MINI							
LM1458	40	ZN426E	290	ZN426E8	320	4514	110			LS136	23	100V CERAM							
LM2917	185	ZN427E	575	ZN427E8	575	4515	110			LS138	24	PLATE CAPS							
LM3900	45	ZN428E	395	ZN428E8	395	4516	50			LS139	27								
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75150 0.84  
75154 0.77  
75160 2.56  
75161 2.80  
75162 3.95  
75172 1.95  
75173 1.44  
75174 1.95  
75175 1.44  
75182 0.50  
75183 0.50  
75188 0.37  
75189 0.37

### 75451 0.22

75452 0.22  
75453 0.22  
75454 0.22  
75468 0.88  
75491 0.31  
75492 0.42  
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NE555CP 0.45  
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TL011 0.32  
TL012 0.34  
TL014 0.36  
TL021 0.34  
TL061 0.29  
TL062 0.48  
TL064 0.98  
TL066 0.29  
TL068 0.32  
TL071 0.29  
TL072 0.47  
TL074 1.00  
TL081 0.26  
TL082 0.46  
TL084 1.58  
TL091 0.40  
TL092 0.58  
TL094 1.34  
TL487 0.82  
TL489 0.82  
TL494 1.65  
TL496 0.60  
TL507 1.33  
725 1.60  
741 0.14  
747 0.48  
748 0.27

### REGULATORS

78L05 0.30  
78L12 0.30  
78L15 0.30  
7805 0.40  
7812 0.40  
7815 0.40  
7905 0.45  
7912 0.45  
7915 0.45  
7916 1.20  
LM309K 2.40  
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6M 0.88  
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98304 1.68  
196608 2.48

### OIL SOCKETS (TEXAS)

PINS TIN GOLD WW  
8 7 16 25  
14 10 28 35  
16 10 29 40  
18 13 33 50  
20 15 37 60  
22 17 38 65  
24 21 46 70  
28 24 55 80  
40 30 76 99

### ZIF SOCKETS (TEXTOL)

24 pin 5.75  
28 pin 8.20  
40 pin 9.75

### CMOS 4000

4000 0.10  
4001 0.10  
4002 0.12  
4006 0.42  
4007 0.14  
4008 0.32  
4009 0.24  
4010 0.24  
4011 0.10  
4012 0.16  
4013 0.20  
4014 0.40  
4015 0.36  
4016 0.20  
4017 0.32  
4018 0.36  
4019 0.36  
4020 0.36  
4021 0.40  
4022 0.40  
4023 0.13  
4024 0.32  
4025 0.13  
4026 0.74  
4027 0.20  
4028 0.32  
4031 0.94  
4033 0.86  
4034 0.94  
4035 0.38  
4040 0.38  
4041 0.36  
4042 0.34  
4043 0.36  
4044 0.36  
4045 1.35  
4046 0.42  
4047 0.70  
4048 0.36  
4049 0.23  
4050 0.23  
4051 0.38  
4052 0.44  
4053 0.44  
4054 0.85  
4055 0.85  
4060 0.39  
4063 0.85  
4066 0.24  
4068 0.14  
4069 0.14  
4070 0.13  
4071 0.13  
4072 0.13  
4073 0.14  
4075 0.13  
4076 0.43  
4077 0.13  
4078 0.15  
4081 0.13  
4082 0.13  
4085 0.50  
4086 0.44  
4093 0.20  
4502 0.46  
4507 0.32  
4508 0.96

### 4510 0.40

4511 0.41  
4512 0.40  
4514 0.98  
4515 0.96  
4516 0.40  
4518 0.40  
4519 0.27  
4520 0.40  
4521 0.90  
4522 0.52  
4526 0.52  
4527 0.52  
4528 0.41  
4532 0.72  
4541 0.50  
4543 0.50  
4553 1.57  
4555 0.35  
4556 0.35  
4585 0.75

### 74LS SERIES

00 0.11  
01 0.11  
02 0.11  
03 0.12  
04 0.12  
05 0.12  
08 0.12  
09 0.12  
10 0.12  
11 0.12  
12 0.12  
13 0.12  
14 0.25  
15 0.12  
20 0.12  
21 0.12  
22 0.12  
26 0.12  
27 0.12  
28 0.12  
30 0.12  
32 0.12  
33 0.12  
37 0.12  
40 0.12  
42 0.28  
47 0.35  
48 0.45  
49 0.12  
51 0.12  
54 0.12  
55 0.12  
73 0.18  
74 0.16  
75 0.18  
76A 0.17  
78A 0.18  
83A 0.38  
85 0.42  
86 0.12  
90 0.28  
91 0.60  
92 0.32  
93 0.22  
95B 0.40  
109A 0.27  
112A 0.20  
113A 0.20  
114A 0.22  
122 0.28  
123 0.36  
125A 0.24  
126A 0.25  
132 0.34  
136 0.25  
138 0.25  
139 0.27  
145 0.57  
148 0.70  
151 0.40  
153 0.40  
155 0.30  
156 0.35  
157 0.25  
158 0.30  
160A 0.32  
161A 0.35  
162A 0.35  
163A 0.35  
164 0.40  
165A 0.50  
166A 0.60  
173A 0.55  
174 0.40  
175 0.36  
181 0.90  
190 0.35  
191 0.35  
192 0.35

### 193 0.35

194A 0.35  
195A 0.35  
196 0.45  
197 0.45  
221 0.46  
240 0.55  
241 0.55  
242 0.55  
243 0.55  
244 0.55  
245 0.70  
248 0.55  
249 0.55  
251 0.30  
253 0.35  
257A 0.30  
258A 0.35  
259 0.55  
261 1.00  
266 0.20  
274 0.54  
279 0.30  
283 0.40  
290 0.39  
293 0.39  
365 0.27  
366 0.27  
367 0.27  
368 0.27  
373 0.62  
374 0.62  
375 0.35  
377 0.60  
378 0.80  
379 0.90  
386 0.35  
390 0.45  
393 0.45

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34 PIN 2.06  
40 PIN 2.32  
50 PIN 2.35  
60 PIN 3.20

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14 PIN 1.82  
16 PIN 2.10  
20 PIN 2.48  
26 PIN 3.24  
34 PIN 3.80  
40 PIN 4.90  
50 PIN 5.48  
60 PIN 6.38

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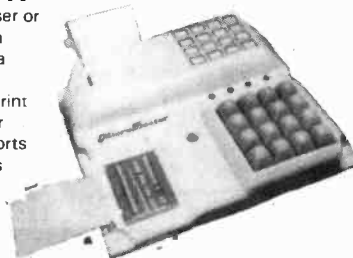
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7402	11p	74259	100p	74LS256	150p	4018	45p	74LS502	11p	74LS565	140p	74LS502	11p	74LS565	140p
7403	12p	74285	45p	74LS257	35p	4019	25p	74LS503	12p	74LS566	140p	74LS503	12p	74LS566	140p
7404	12p	74273	120p	74LS258	55p	4020	48p	74LS504	12p	74LS567	140p	74LS504	12p	74LS567	140p
7405	15p	74278	100p	74LS259	55p	4021	40p	74LS505	12p	74LS568	140p	74LS505	12p	74LS568	140p
7406	18p	74278	100p	74LS280	20p	4022	45p	74LS506	12p	74LS569	140p	74LS506	12p	74LS569	140p
7407	18p	74279	40p	74LS281	130p	4023	13p	74LS507	12p	74LS570	140p	74LS507	12p	74LS570	140p
7408	14p	74283	50p	74LS282	130p	4024	32p	74LS508	12p	74LS571	140p	74LS508	12p	74LS571	140p
7409	14p	74284	160p	74LS283	40p	4025	13p	74LS509	12p	74LS572	140p	74LS509	12p	74LS572	140p
7410	14p	74285	160p	74LS284	30p	4026	80p	74LS510	12p	74LS573	140p	74LS510	12p	74LS573	140p
7411	14p	74286	160p	74LS285	30p	4027	20p	74LS511	12p	74LS574	140p	74LS511	12p	74LS574	140p
7412	14p	74287	160p	74LS286	30p	4028	20p	74LS512	12p	74LS575	140p	74LS512	12p	74LS575	140p
7413	14p	74288	160p	74LS287	30p	4029	45p	74LS513	12p	74LS576	140p	74LS513	12p	74LS576	140p
7414	14p	74289	160p	74LS288	30p	4030	125p	74LS514	12p	74LS577	140p	74LS514	12p	74LS577	140p
7415	14p	74290	160p	74LS289	30p	4031	80p	74LS515	12p	74LS578	140p	74LS515	12p	74LS578	140p
7416	14p	74291	160p	74LS290	30p	4032	80p	74LS516	12p	74LS579	140p	74LS516	12p	74LS579	140p
7417	14p	74292	160p	74LS291	30p	4033	125p	74LS517	12p	74LS580	140p	74LS517	12p	74LS580	140p
7418	14p	74293	160p	74LS292	30p	4034	45p	74LS518	12p	74LS581	140p	74LS518	12p	74LS581	140p
7419	14p	74294	160p	74LS293	30p	4035	45p	74LS519	12p	74LS582	140p	74LS519	12p	74LS582	140p
7420	14p	74295	160p	74LS294	30p	4036	275p	74LS520	12p	74LS583	140p	74LS520	12p	74LS583	140p
7421	14p	74296	160p	74LS295	30p	4037	110p	74LS521	12p	74LS584	140p	74LS521	12p	74LS584	140p
7422	20p	74370	100p	74LS296	30p	4038	110p	74LS522	12p	74LS585	140p	74LS522	12p	74LS585	140p
7423	20p	74390	75p	74LS297	30p	4039	290p	74LS523	12p	74LS586	140p	74LS523	12p	74LS586	140p
7424	20p	74393	90p	74LS298	30p	4040	40p	74LS524	12p	74LS587	140p	74LS524	12p	74LS587	140p
7425	18p	74393	90p	74LS299	30p	4041	40p	74LS525	12p	74LS588	140p	74LS525	12p	74LS588	140p
7426	18p	74393	90p	74LS300	30p	4042	40p	74LS526	12p	74LS589	140p	74LS526	12p	74LS589	140p
7427	18p	74393	90p	74LS301	30p	4043	40p	74LS527	12p	74LS590	140p	74LS527	12p	74LS590	140p
7428	18p	74393	90p	74LS302	30p	4044	40p	74LS528	12p	74LS591	140p	74LS528	12p	74LS591	140p
7429	18p	74393	90p	74LS303	30p	4045	40p	74LS529	12p	74LS592	140p	74LS529	12p	74LS592	140p
7430	14p	74393	90p	74LS304	30p	4046	40p	74LS530	12p	74LS593	140p	74LS530	12p	74LS593	140p
7431	14p	74393	90p	74LS305	30p	4047	45p	74LS531	12p	74LS594	140p	74LS531	12p	74LS594	140p
7432	14p	74393	90p	74LS306	30p	4048	45p	74LS532	12p	74LS595	140p	74LS532	12p	74LS595	140p
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7447A	36p	74502	11p	74LS321	30p	4063	45p	74LS547	12p	74LS610	140p	74LS547	12p	74LS610	140p
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7471	25p	74515	12p	74LS345	30p	4087	14p	74LS571	14p	74LS634	140p	74LS571	14p	74LS634	140p
7472	25p	74515	12p	74LS346	30p	4088	14p	74LS572	14p	74LS635	140p	74LS572	14p	74LS635	140p
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7474	25p	74515	12p	74LS348	30p	4090	14p	74LS574	14p	74LS637	140p	74LS574	14p	74LS637	140p
7475	22p	74515	12p	74LS349	30p	4091	14p	74LS575	14p	74LS638	140p	74LS575	14p	74LS638	140p
7476	25p	74515	12p	74LS350	30p	4092	14p	74LS576</							

# COMPRESSOR/ LIMITER

When it comes to compressing those troublesome signals that are prone to overload, this ETI project really is the limit! Design by Ian Martin B.Sc.

Compressors and limiters have many uses in professional recording and broadcasting, and they can also be pretty useful to the amateur. Perhaps the single most important use is for overload protection: the limiter is set up so as to remain inactive until a signal occurs which would overload following circuits (perhaps a radio transmitter or power amplifier), at which point gain reduction cuts in and, without being very noticeable about it, the unit prevents blown fuses, gross distortion or worse.

The circuit described here has been designed to be capable of both the compressing and limiting actions — it all depends on the signal size you apply and the gains you set in the circuit. With the component values shown, the specification of this unit is very similar to devices currently in use in stereo radio broadcasting in the UK.

## On The Attack

In this circuit the attack has been made very fast indeed, the time constant being 220 microseconds: hence the time taken for the limiter to react fully to an

## HOW IT WORKS

The left and right channels of the unit are identical, so this description will be confined to the left-hand channel.

IC1 forms a buffer, and its gain is adjustable by PR1 so that it can be used to set the input sensitivity. The variable gain cell is made up from IC2 and IC7a and their associated components. The configuration used is slightly unusual: IC2 forms a conventional inverting amplifier, its gain being determined by  $R_{FB}/R_{IN}$  in the usual way. However, while  $R_{IN}$  is simply R2,  $R_{FB}$  is made up from R4 and IC7a which, as an operational transconductance amplifier, can be used as a current-controlled resistor. With the addition of a voltage-to-current converter to drive the control input of the LM13600, a complete VCA is formed which will produce a gain inversely proportional to the control voltage.

The first stage of the gain-control side chain is a full-wave rectifier made up from IC3a and IC6a. Q1 boosts the output current drive capability of the rectifier in order to produce a fast attack characteristic when charging C11.

From C11 onwards until the final voltage-to-current converters for the VCA, the two side chains are combined into one channel, the highest of the left or right input signals being registered on C11. In this way stereo ganging is achieved, and this prevents the stereo image from wandering from side to side during gain reduction (if the overload signal is

in one channel only). The adjustment of the decay time and limiting threshold for both left and right channels is achieved easily and equally by R32 and PR5. IC8b is used as a high impedance buffer for the control voltage held on C11, which is discharged by R31. The output of this buffer is fed to PR5, which controls the side chain gain and hence the limiting threshold.

The only problem with the particular VCA configuration chosen is that should the control voltage (and hence control current being fed to IC7a) fall to zero, the gain of the VCA will increase to the open-loop gain of IC2, probably resulting in the VCA output reaching one of the supply rails (as is usually the case when an IC amplifier loses its feedback). In order to prevent this from happening, the control voltage  $V_C$  is prevented from going below 0V5 by zener ZD1 and preset PR6. Thus the higher of either  $V_{MIN}$  or the output of PR5 is passed via D11 or D12 to the law-shaping amplifier IC8a.

The diode D13 and resistors R35, 36 are configured to make up for the voltage drop across D11 and D12, and maintain a tight compression ratio, typically 10:1. The output of the shaping amplifier provides a low source impedance to drive the voltage-to-current converter IC9a and Q3 (note that the left and right channels split again at this point).

TABLE 1

### Measured performance of the prototype.

Gain:	0 dB (adjustable)			
Bandwidth (3 dB points):	10 Hz and 30 kHz approximately			
Input impedance:	22k			
Output impedance:	100R			
Limiting threshold:	0 dB (adjustable)			
Compression ratio for signals exceeding the threshold:	10:1			
Crosstalk with non-speaking channel terminated with 600R (left-to-right or right-to-left):	100 Hz	1 kHz	10 kHz	20 kHz
	-70 dB	-70 dB	-68 dB	-65 dB
Noise with input terminated as above:	-70 dB			

(this is the gain required to make noise at the output peak to 0 dB on a standard broadcast peak program meter, ie this is the peak noise. Should a measurement be made with an RMS reading meter, this measurement may improve by as much as 6 dB).

Control voltage breakthrough onto non-speaking channel with 20 dB of gain reduction occurring on the other channel:	100 Hz	1 kHz
	-68 dB	-68 dB

### Tracking between channels during gain reduction:

better than 0.3 dB

### Distortion at 1 kHz:

Input	Output	Distortion
-8 dB	-8 dB	-66 dB
0 dB	-1 dB	-60 dB
+10 dB	0 dB	-58 dB

### Distortion at 100 Hz:

Input	Output	Distortion
-8 dB	-8 dB	-58 dB
0 dB	-1 dB	-45 dB
+10 dB	0 dB	-38 dB

NB. These figures for 100 Hz distortion were measured with a recovery time constant of 100 milliseconds (total recovery time approximately 220 milliseconds), hence a certain amount of distortion due to the compression of individual waveforms is to be expected. Increasing the recovery time constant as in the final design will improve the low frequency distortion measurements, until for long recovery times (greater than 3 seconds) they will approach the values obtained for 1 kHz.

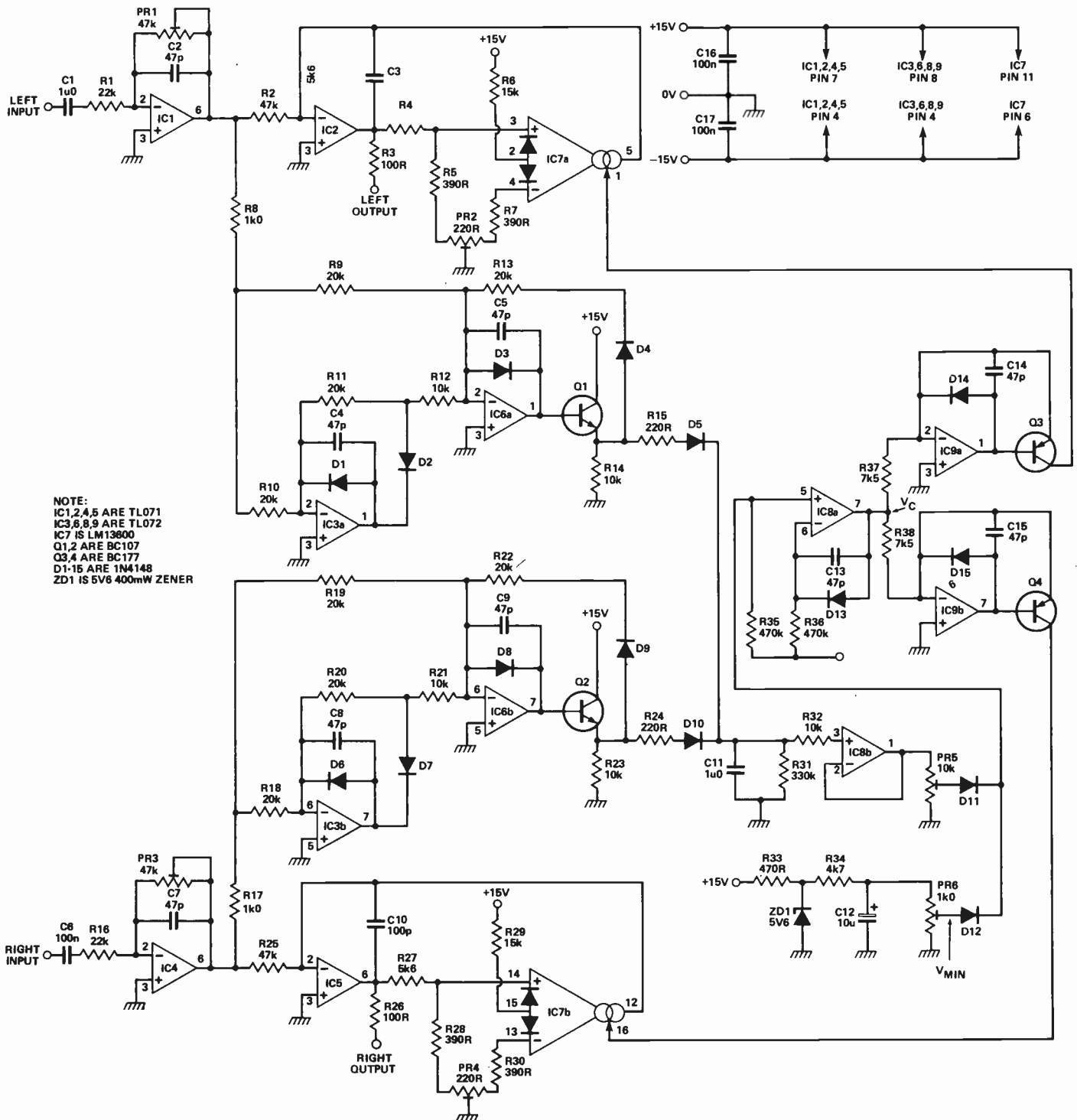


Fig. 1 Circuit diagram of the compressor/limiter.

overload above the limiting threshold is approximately 500 microseconds. The decay time was chosen to be 330 milliseconds; hence full recovery takes place approximately 700 milliseconds after the overload has been removed from the input. This recovery time was chosen after much subjective assessment, and is the fastest possible without undue distortion of low frequencies (this being a common problem in all

compressor/limiters). However, as this is a simple one-resistor adjustment it is easy to experiment and find the best compromise for different uses.

### Shaping Up

The need for the shaping amplifier built around IC8a arises because the side chain is, like most professional designs, an open loop system deriving its input from the incoming programme material and

not from the VCA output. This has the advantage that the limiting threshold and other dynamic characteristics may be altered easily and, if desired, other functions may be included. For example, de-essing could be implemented, where a treble boost in the side chain would lead to the gain reduction of high-energy, high-frequency sounds such as sibilants. It would also be possible to build a feedforward or overshoot limiter, by including a suitable delay



# PROJECT: Compressor/limiter

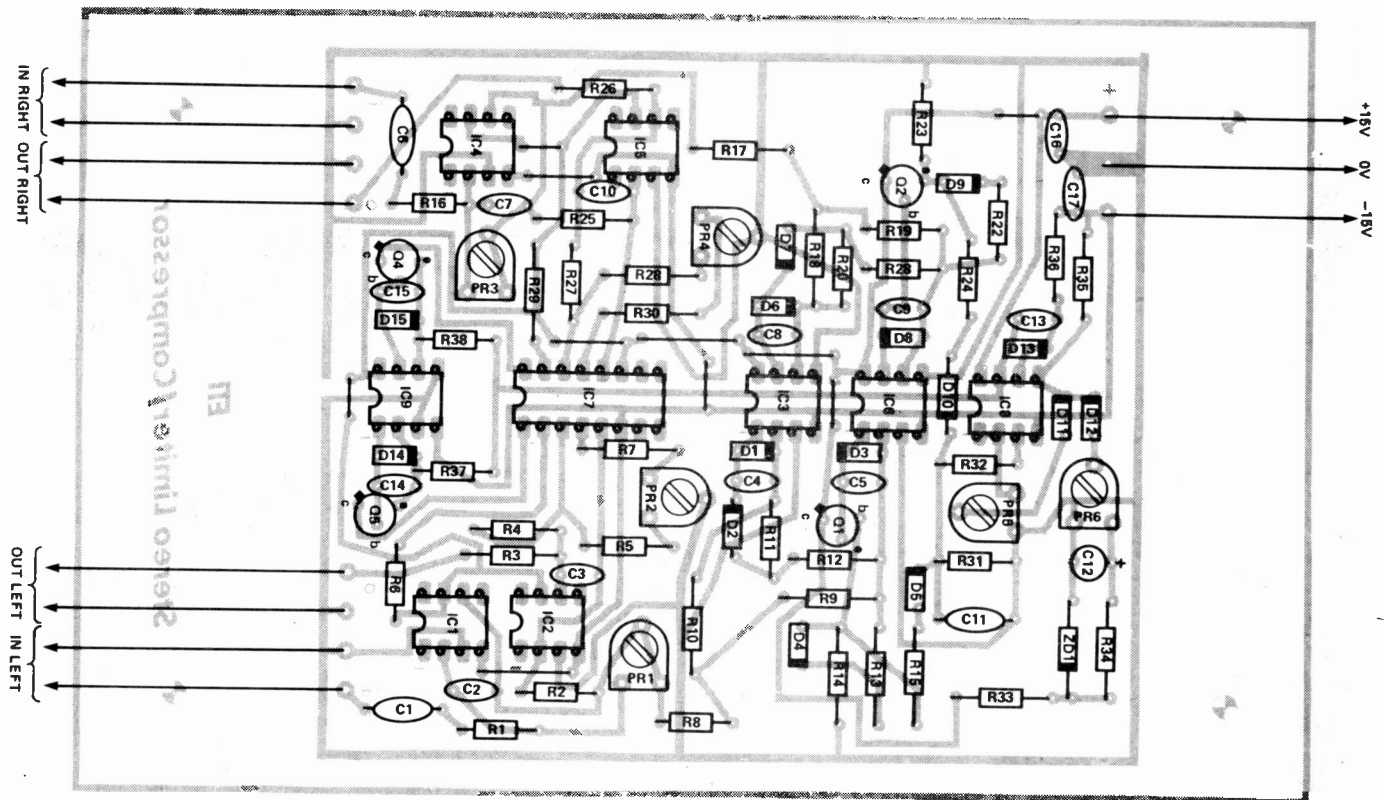


Fig. 2 Component overlay for the unit.

line in the main chain before the VCA. In this way gain reduction would take place before the programme material reached the VCA via the delay line and even the sharpest transient would be prevented from exceeding the limiting threshold at the output. However, in most applications this is not necessary, except in cases such as disc-cutting or radio broadcasting where an overload of even the shortest duration would have dire results.

The setting up procedure is very simple indeed. PR6 should be adjusted so that  $V_c$  is held at 0V5 with no input signal. PR1 and PR3 should then be adjusted to give the required gain from each channel (usually 0 dB). That concludes the static setting-up, except for PR2 and PR4 which should be adjusted for zero offset at the output of the VCA. This ensures minimal control voltage breakthrough onto the audio output during gain reduction. To set the compression

threshold, a high level signal (for example, +10 dB) should be applied to the input, and PR5 adjusted to give 0 dB at the limiter output.

If the above sequence is followed, the limiter will act as a normal unity-gain amplifier for all signals below 0 dB, and will reduce the gain of all signals above this threshold such that the output at no time exceeds 0 dB. Should the limiting threshold need to be reduced to, say, -10 dB to be more compatible with domestic equipment, then all that is required is an increase in the gain of the side channel by that amount. This is easily achieved by increasing R13 and R22 from 20k to, say, 47k. Should an indication of gain reduction be required, this is easily provided by buffering off  $V_c$ , the control voltage, by 1k0 or so to prevent any fault on the metering equipment affecting the operation of the limiter (for my own unit this metering equipment consists of a simple bargraph driver and LEDs).

## PARTS LIST

### Resistors (all $\frac{1}{4}$ W, 5%)

R1,16	22k
R2,25	47k
R3,26	100R
R4,27	5k6
R5,7,28,30	390R
R6,29	15k
R8,17	1k0
R9-11,13,	
18-20,22	20k
R12,14,21,	
23,32	10k
R15,24	220R
R31	330k
R33	470R
R34	4k7
R35,36	470k
R37,38	7k5

### Potentiometers

PR1,3	47k miniature horizontal preset
PR2,4	220R miniature horizontal preset

PR5	10k miniature horizontal preset
PR6	1k0 miniature horizontal preset

### Capacitors

C1,6,11	1u0 polycarbonate
C2,4,5,7-9,	
13-15	47pF ceramic
C3,10	100pF ceramic
C12	10uF 16 V tantalum
C16,17	100nF polycarbonate or ceramic

### Semiconductors

IC1,2,4,5	TL071
IC3,6,8,9	TL072
IC7	LM13600
Q1,2	BC107
Q3,4	BC177
D1-15	1N4148
ZD1	5V6 400 mW zener

### Miscellaneous

PCB (see Buylines); screened cable etc.

## BUYLINES

Although the design of this project results in top-notch performance, it uses components that are readily available and you should be able to find everything in the adverts in this issue. The PCB can be purchased from us using the order form on page 87.

# The Logic Probes

## Spend Less

## Test More



### LP-1 Logic Probe

The LP-1 has a minimum detachable pulse width of 50 nanoseconds and maximum input frequency of 10MHz. This 100 K ohm probe is an inexpensive workhorse for any shop, lab or field service tool kit. It detects high-speed pulse trains or one-shot events and stores pulse or level transistions, replacing separate level detectors, pulse detectors, pulse stretchers and pulse memory devices.

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Model LP 3 illustrated



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The LP-2 performs the same basic functions as the LP-1, but, for slower-speed circuits and without pulse memory capability. Handling a minimum pulse width of 300 nanoseconds, this 300 K ohm probe is the economical way to test circuits up to 1.5 MHz. It detects pulse trains or single-shot events in TTL, DTL, HTL and CMOS circuits,

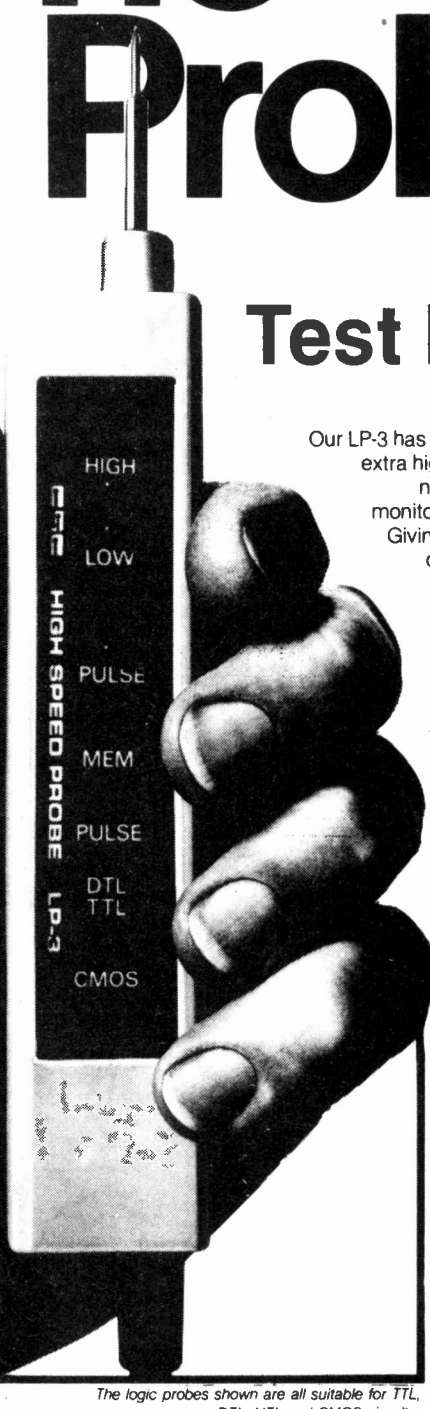
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Model LP 3 illustrated

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The logic probes shown are all suitable for TTL, DTL, HTL and CMOS circuits.

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Our LP-3 has all the features of the LP-1 plus extra high speed. It captures pulses as narrow as 10 nanoseconds, and monitors pulse trains to over 50 MHz. Giving you the essential capabilities of a high-quality memory scope at 1/1000th the cost.

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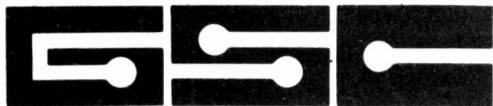
The Digital Pulser: another new idea from G.S.C. The DP-1 registers the polarity of any pin, pad or component and then, when you touch the 'PULSE' button, delivers a single no-bounce pulse to swing the logic state the other way. Or if you hold the button down for more than a second, the DP-1 shoots out pulse after pulse at 1000 Hz.

The single LED blinks for each single pulse, or glows during a pulse train. If your circuit is a very fast one, you can open the clock line and take it through its function step by step, at single pulse rate or at 100 per second. Clever! And at a very reasonable price.

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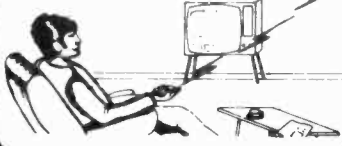
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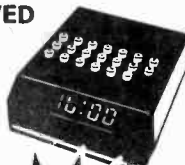
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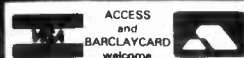
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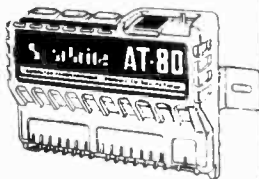
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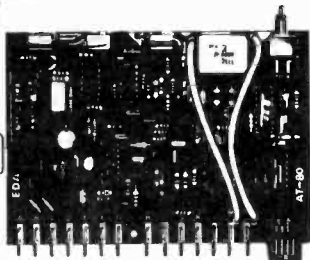
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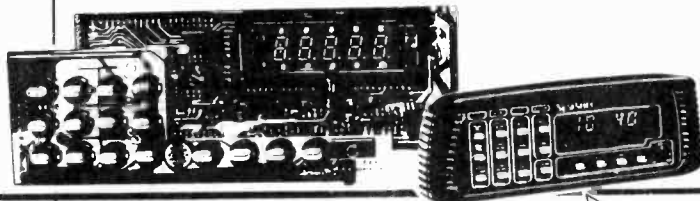
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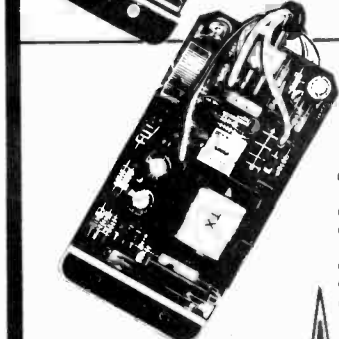
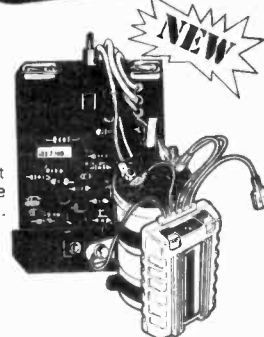


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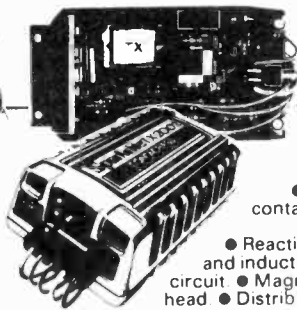
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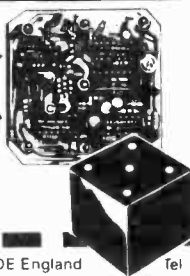


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# BALANCED INPUT PREAMP

This versatile little preamp has a host of applications in the audio-and-beyond range, not the least of which would be as a balanced mike preamp. Design by David Tilbrook.

Many transducers require a balanced or differential preamplifier rather than the simpler single input unbalanced type. Balanced microphones, for example, require a balanced preamplifier to ensure minimal susceptibility to extraneous noise sources. The concept in the balanced approach is fairly simple: the microphone, for example, is connected to the balanced preamp using three wires instead of two. Two of these wires carry signals and the other is a ground connection. The balanced source, in this case a microphone, generates a signal voltage on the two signal wires such that one of the signals is 180 degrees out of phase with the other. The two active lines are twisted together with the earth line, or a two-wire shielded cable is used to connect the mike to the preamplifier.

In this way any external noise or hum source will affect both inputs equally, producing a signal that is in phase on both of the signal wires. Such a signal is called a *common mode* signal. The balanced preamplifier however, is configured in such a way as to amplify only a differential signal. The preamp produces an output signal that is proportional to the

difference between its two inputs. Since the signal is generated out of phase, it is amplified. The noise source, however, is a common signal and is the same in both input wires. The difference between the noise signals on each of the input wires is therefore zero, and is not amplified. With this technique small signals can be sent over long lines, an otherwise impossible task due to the susceptibility of these lines to mains hum in particular.

## A Transformation

In audio the most common method employed to implement a balanced line is with transformers. The basic approach is shown in Fig. 1. The source may be a microphone or a small preamplifier inside the microphone, or simply the output from a mixer or other electronic device. This is connected to the input of a balancing transformer that is wound to represent the correct load to the driving stage. The output of this transformer consists usually of a bifilar-wound secondary connected as shown in Fig. 1. A similar transformer is used at the other end of the line to convert the

differential signal back into one that can be amplified by the single input preamp.

This technique has the advantage that the signal earth of the source need not be connected to that of the preamplifier. This can be a very useful feature at times, particularly when large numbers of cables are connected together at a common point such as at a mixing console. The ability to isolate the input earths of the various inputs enables complete freedom from hum loops, which otherwise can become almost impossible to remove.

Transformers have disadvantages, however. First, good ones are expensive as they must be carefully wound and shielded from external hum fields. Since the transformer is a coil of wire, wound specifically for good response over the complete audio spectrum, they are particularly susceptible to magnetic fields produced by power transformers and so on. The problems associated with isolating the transformers from power supply hum fields can be very real, if not impossible in some instances.

## SPECIFICATIONS

Frequency response (10k load):	12 Hz — 60 kHz $\pm$ 0.1 dB
THD (at 5 V RMS output):	<0.007% at 100 Hz <0.006% at 1 kHz <0.012% at 10 kHz
Distortion figures can be expected to decrease further at more realistic signal levels but become difficult to measure.	
Total equivalent input noise: (20 kHz bandwidth)	-124 dB (approx)
Input impedance:	Nominally 560 ohms to ground from each input.
Output impedance:	Nominally 260 ohms.
Common mode rejection ratio:	Depends on calibration but easily adjusted to 80 dB.

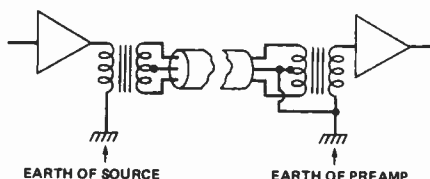


Fig. 1 Balanced line with transformer coupling.

It is often said that a transformer's ability to reject a common mode signal is inferior to that of a balanced preamplifier such as the one to be described in this project. Although this is true it is largely irrelevant, since the limit to common mode rejection is usually set by the shielded cable used to connect the input devices. Even the best quality cables seldom allow common mode rejections greatly in excess of 60 dB, a figure which is easily surpassed by most input transformers. The main advantage of differential preamps over transformers is cost and relative lack of susceptibility to hum fields. This makes it substantially easier to mount the preamp within the equipment to avoid degradation of

the signal-to-noise ratio by hum pickup. Another advantage of the preamp over transformers is that even the best transformers generate significant amounts of harmonic distortion in comparison to distortion figures easily obtained with an op-amp based balanced design.

## Construction

Construction of the unit is straightforward if the ETI PCB is used, since all components are mounted on the board. The usual precautions should be taken. The circuit employs several electrolytic capacitors so be certain these and the diodes and ICs are inserted with the correct orientation. The circuit is shown to run from a nominal  $\pm 20$  V supply. This ensures a clean

$\pm 15$  V supply to the op-amps giving the circuit good headroom. If this voltage is not available, however, the circuit will run perfectly well on a lower supply voltage. If the supply is clean regulated DC the on-board zeners can be eliminated. If not, replace them with a lower voltage type to suit the supply voltage.

Close tolerance resistors (1% or 2%) are specified for R6, 7, 8 and 9 so that any DC imbalance between the input stages, IC1 and IC2, can be balanced out by PR1.

It is a good idea to use low noise metal oxide resistors for the input resistors, R3 and R4, to get good noise performance. They cost little more than standard carbon deposition types. Indeed, metal oxide resistors could well be used

## DESIGN THEORY

The differential input needed is easy to implement with the help of operational amplifiers, since these have inverting and non-inverting inputs already. The simplest circuit that could be used and one that is adequate with microphones is shown in Fig. 2. This circuit is the standard differential op-amp circuit and offers good performance with most balanced sources. The resistor from the non-inverting input to ground is made the same value as the feedback resistor. In this way the gain of the stage is determined by the ratio of the resistors R2/R1. With the inverting input grounded, the gain of the op-amp is given by the standard formula

$$(R2 + R1)/R1.$$

In this case, however, the input resistor in series with the non-inverting input and the resistor from this input to ground form a potential divider and attenuate the signal by an amount given by:

$$V_i = V (R2/(R1 + R2))$$

So the total gain of the stage at the non-inverting input is

$$((R2 + R1)/R1)(R2/(R1 + R2))$$

or R2/R1, which is the same as the inverting input.

This circuit, however, has the disadvantage that the impedance to earth from each of the two inputs is very different. The impedance at the non-inverting input can usually be regarded as approximated by the series combination of the two resistors, ie R1 + R2. The impedance at the inverting input is simply that of the input resistor, since the inverting input is a virtual earth once feedback is applied in this way. This does not bother most balanced sources, since a true balanced source works independently of the ground connection.

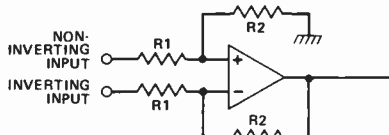


Fig. 2 Preamp stage with a simply-balanced input.

The impedance seen by the balanced source is a result of that due to both input resistors and the internal impedance from base to base of the input differential pair within the op-amp. In most circuits the resistance of the input resistors completely dominates and it is sufficiently accurate to quote the input impedance to balanced sources as  $2 \times R1$ .

A major disadvantage of this circuit is that the ability to reject common mode signals can be seriously degraded with some sources by differences in the source impedance to the two inputs. Remember that it is the matching of the two sets of resistors that determines the common mode rejection ratio. This is the ratio of the input signal to the output signal when a common mode signal is applied. It is usually quoted in dB. The value quoted earlier for shielded cables of around 60 dB is a relatively easy figure to obtain with the op-amp circuit so long as the driving source impedance is the same for both inputs. A mismatch of only one per cent will degrade the common mode rejection ratio (CMRR) of an otherwise well designed preamp by around 20 dB, and result in a figure that could easily be unsatisfactory.

Another disadvantage of this circuit is that it is not capable of delivering the full gain needed of the preamplifier and still give satisfactory distortion figures. If we take a nominal output signal level from a balanced microphone to be around 0.2 mV and the required output from the preamp to be around 100 mV, then a gain of 500 is required, or around 54 dB. The distortion figure obtained using the best op-amps available would be unsatisfactory. For example, an NE5534A at a gain of 500 would have a distortion figure around 0.15%, a poor figure by modern standards and well outside the capabilities of a good transformer. The solution is simply to decrease the gain of the stage and add a second stage to make up the difference. This, however, does not solve the problem of degradation of the CMRR on some sources. The real solution is to add a *third* op-amp to the design and implement a full instrumentation amplifier.

The basic circuit for an instrumentation amplifier is shown in Fig. 3. The second stage, formed by IC3, is the same

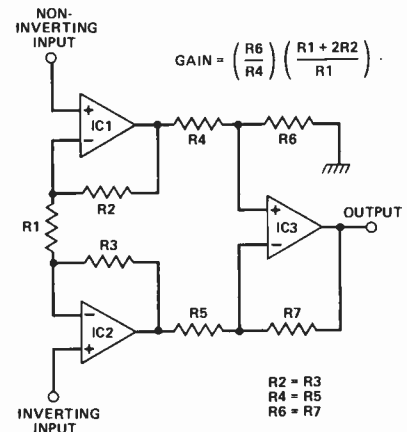


Fig. 3 The solution to the problem.

as the simple differential amplifier in Fig. 2, but its inputs are buffered by the input stages formed by ICs 1 and 2. Resistor pairs R2, R3 and R4, R5 and R6, R7 are made equal. The gain of the second stage is simply R6/R4 as derived above, but the gain of the first stage is given by the slightly more complex formula:

$$(R1 + 2R2)/R1$$

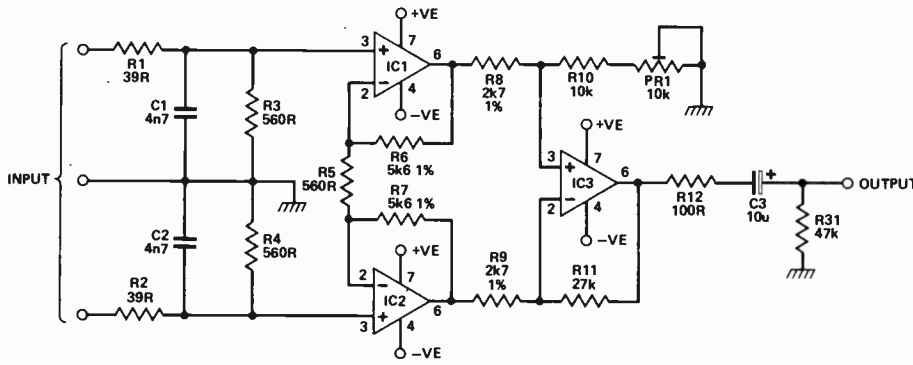
The overall gain is therefore

$$\frac{R6}{R4} \times \frac{R1 + 2R2}{R1}$$

If the value of R4 and R5 is made large in comparison to the estimated difference in the output impedances of the two input op-amps and if the gain of these two op-amps is the same then good CMRR will result.

A problem can occur on many instrumentation amplifiers in ensuring that the gains of the input op-amps are as close as possible to being the same. One feature of this circuit is that the CMRR is affected to a lesser extent by the matching of the resistors around the first stage. Furthermore, this will not be degraded by mismatch of the source impedance to the two inputs. The overall gain of the preamplifier is divided into two stages ensuring sufficient amounts of negative feedback to provide low distortion.

# PROJECT: Differential Preamp



NOTE:  
IC1,2 ARE NE5534A  
IC3 IS TL071  
ZD1,2 ARE 15V  
1W ZENERS

NOTE: EXTERNAL CONNECTION MUST BE PROVIDED BETWEEN POWER SUPPLY 0V POINT AND THE SIGNAL GROUND. SEE TEXT.

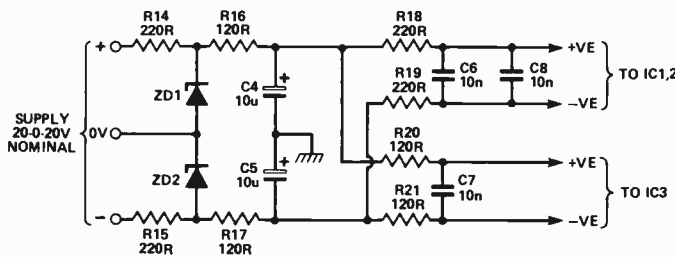


Fig. 4 Circuit diagram.

## HOW IT WORKS

The circuit is a relatively straightforward instrumentation amplifier. The main differential stage is formed by IC3, the TL071. This is a biFET op-amp with good common mode rejection ratio (CMRR) figures. This stage is buffered from the inputs by a pair of NE5534A op-amps that also provide additional gain and determine the overall noise performance of the preamp. As mentioned in the other box, the overall gain of the preamp is determined by the gain of the first and second stages. The gain of the second stage is determined by the ratio of R11 to R9, and is around 10. The gain of the first stage is approximately 20, giving an overall gain of about 200, or 46 dB. If you require a different gain to this, try to keep the ratios of gain in the first and second stages the same. The amount of gain provided here should be suitable for most microphones, providing around 100 mV output from a 0.5 mV input signal level.

The circuit is DC-coupled at the input. This assumes that the driving source will be transformer or capacitively coupled at the output, which should be a safe assumption. The input impedance of the stage is set by the two input resistors R3 and R4. To increase the input impedance, simply increase the value of these resistors.

The RC networks consisting of R1-C1 and R2-C2 are high frequency filters to reduce the circuit's susceptibility to RF interference. The split power supply is provided either from two zener regulators or from a well-regulated and filtered DC source. The supply pins to each IC are decoupled by 1kΩ resistors and 10n capacitors to prevent IC-to-IC interaction and possible feedback via the supply rails.

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throughout, without a significant cost penalty.

The PCB has been designed so that an external connection must be provided between the 0 V point on the PCB and the signal earth. The correct place for this connection is at the input to the preamplifier, ie on the input socket. A separate wire is run from the 0 V point to the signal earth point of the input socket. The signal leads from the input socket to the PCB should be shielded cable with the earth braid connected at both ends. The signal earth should not be connected to the chassis directly. RF shielding can be accomplished by connecting a 100nF capacitor between the signal earth at the input socket and the chassis. This will eliminate any problems with hum loops that might otherwise be formed around the mains earth line.

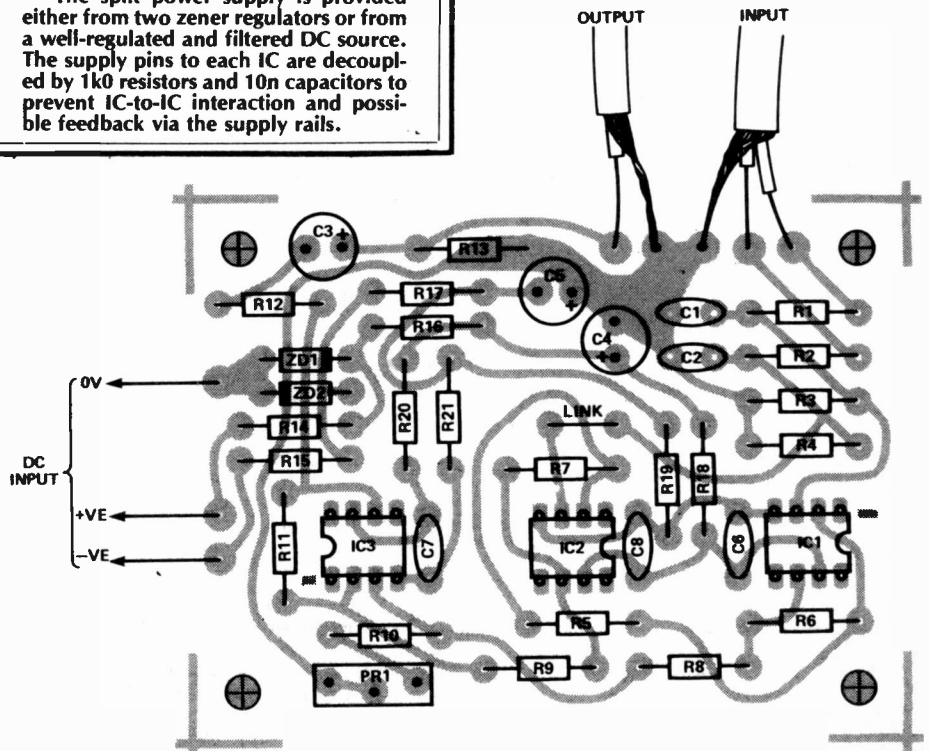


Fig. 5 Component overlay for the differential preamp.

## BUYLINES

We haven't used anything in this project that isn't commonplace in the advertisements of the mail order companies: even the NE5534A is becoming fairly well-stocked. The PCB can be ordered from our PCB Service on page 87.

## PARTS LIST

Resistors (all 1/4W, 5% except where stated)

R1,2	39R
R3-5	560R
R6,7	5k6 1%
R8,9	2k7 1%
R10	10k
R11	27k
R12	100R
R13	47k
R14,15, 18,19	220R
R16,17, 20,21	120R

Potentiometer

PR1	10k miniature vertical preset
-----	-------------------------------

Capacitors

C1,2	4n7 ceramic
C3	10u 35 V PCB electrolytic
C4,5	10u 16 V PCB electrolytic
C6-8	10n ceramic

Semiconductors

IC1,2	NE5534A (see text)
IC3	TL071
ZD1,2	15 V, 1 W zener

Miscellaneous

PCB (see Buylines)

ETI

ETI MAY 1983

# Play the AMBIT numbers game .....

The long awaited implementation of on-line order processing is with us at last, and whilst this means that orders for in-stock items can now be processed more efficiently, it also means that orders should be submitted using stock code results. Our current catalogue (75p) includes all order codes (watch out for the new expanded Spring edition), but here's an abstract from some of the more popular lines to use as a quick reference.

Remember that you can also access our catalogue via REWSHOP or REWTEL, which now includes on-line current price and delivery information. You need a 300 baud MODEM and RS232 terminal, (various suitable configurations based on popular micros have been published in recent past issues of Radio and Electronics World).

Prices shown here exclude VAT, and the P&P charge is currently 60p per order (unless otherwise indicated). Remember that our tele-sales service operates with human beings (not 'dumb' machines) from 8am to 7pm (and frequently later) Monday to Friday, and 9am to 6pm on Saturdays. REWSHOP operates 24 hours a day, 365 days a year with full price and delivery information.

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Type	Stock No.	Price	Type	Stock No.	Price	Type	Stock No.	Price	Type	Stock No.	Price	Type	Stock No.	Price	Type	Stock No.	Price	Type	Stock No.	Price	Type	Stock No.	Price	Type	Stock No.	Price	Type	Stock No.	Price	Type	Stock No.	Price	Type	Stock No.	Price			
4000B	23 04001	0.11	74C01	23 04073	4.28	74LS00	30 07400	0.11	LM1000	61 00010	3.88	74C02	29 07400	0.58	2SK134	60 00134	3.10	BA102	12 01025	0.30	2N2904	58 02904	0.25	2N2904	58 02904	0.25	2N2904	58 02904	0.25	2N2904	58 02904	0.25	2N2904	58 02904	0.25	2N2904	58 02904	0.25

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Optional accessories: Full technical manual £20.00 alone. £10.50 with drive. Refund of difference on drive purchase. DC and AC power connector and cable kit £8.45. 50 way IDC connector £5.50. 50 way ribbon cable £3.20 per metre.

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**12" CASED.** Made by the British KGM Co. Designed for continuous use as a data display station, unit is totally housed in an attractive brushed aluminium case with ON-OFF, BRIGHTNESS and CONTRAST controls mounted to one side. Much attention was given to construction and reliability of this unit with features such as, internal transformer isolated regulated DC supply, all components mounted on two fibre glass PCB boards - which hinge out for ease of service, many internal controls for linearity etc. The monitor accepts standard 75 ohm composite video signal via SO239 socket on rear panel. Bandwidth of the unit is estimated around 20 Mhz and will display most high def graphics and 132 x 24 lines. Units are secondhand and may have screen burns. However where burns exist they are only apparent when monitor is switched off. Although unguaranteed all monitors are tested prior to despatch. Dimensions approx. 14" high x 14" wide by 11" deep. Supplied complete with circuit, 240 volt AC operation. **ONLY £45.00 PLUS £9.50 CARR.**

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# BUYER'S GUIDE TO HI-FI SYSTEMS

And now we proudly present the Thinking Man's Guide to Buying Hi-fi. That is, ETI has done the thinking, now you go out and do the buying! Bring your own wallet (all sizes catered for).



**B**uying a hi-fi system is a harrowing experience, especially the first time out. After you've bought all the hi-fi mags for six months, thoroughly digested the conflicting and often lunatic advice given therein, listened to all your 'expert' friends disagreeing with each other and dared to cross the threshold of a shop . . . what then?

One word — LISTEN. It matters not a jot what anyone else tells you — us included — if you don't agree with the choice, don't buy it! You're going to have to live with it. However, it is a good idea to have a shortlist based upon reviews, price, but don't forget, most important of all are your own auditionings.

Reading the specialist audio press can be enlightening — but it can be mystifying too. At one time you could read through two or three different magazines and still be told that whether you were spending £500 or £5000 on a system, unless you bought a particular £300 turntable you were wasting your money! The field has to some extent sobered up of late, since crashing circulations and retreating advertisers have brought with them a certain measure of common sense. If you want a magazine reviewer's recommendation for 'which magazine' — mine would be *Hi-Fi For Pleasure*. It is a title that is not only a good read but has consistently demonstrated a sound technical understanding and displayed a commendable intelligence, when all around it were losing theirs!

(It's fun being an electronics-based magazine sometimes — we could never get away with saying things like that in the hi-fi press!)

In this supplement we're taking a different ap-

proach to the overall compatibility 'table' approach. Instead we have listed out eight full systems, from £350 to £8500 in price and which we have personally tried and tested (except one — and you'll see why . . .)

In this way each forms a perfectly good buy in itself — assuming you like the sound yourself, of course — or at the least will make a good starting point in the demonstration room when you're down to the final choice.

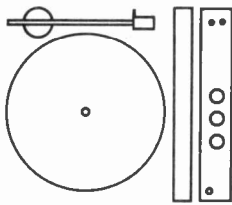
Each of the systems is for records only: no allowance is made in price for tape or tuner. Additions such as these we left until later. We have some advice to offer on those too, but in the form of a list of models which we have had through our hands at some point and have found to be good. A number of people have very expensive record playing systems but have tacked onto the end of them cassette decks of considerably lower-fi, to use as background music and so on. Because of this we have made no attempt to assign tape and tuner to the primary systems. You pick and choose as you like to fit your own individual needs.

A word of explanation about the system tables to be found overleaf. The first column contains details of our recommended system and the retail price (as far as we know — do shop around for bargains). The order of components is record deck, arm (if not included with the deck), cartridge, preamp/power amp combination, and speakers. Any alternatives are given in the second column with their prices bracketed.

We've also illustrated each of the systems to the best of our ability, but some companies were as compliant as concrete cantilevers, and the 'first class' post wasn't, so there are some unfortunate omissions. C'est la vie . . .

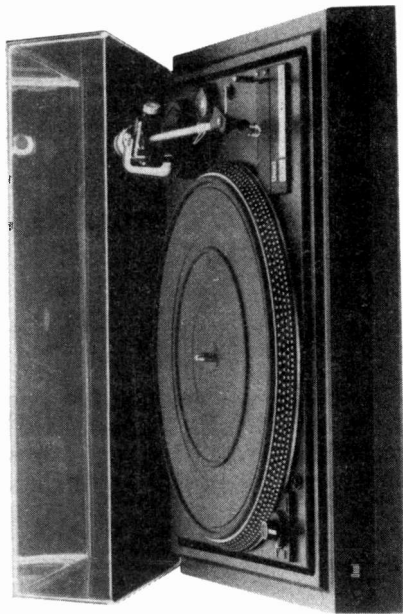
# SYSTEM 1

## £325

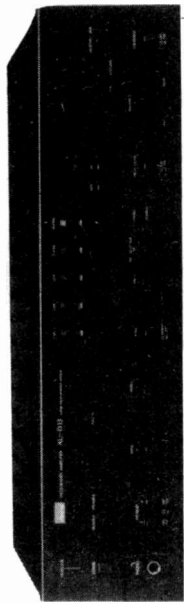
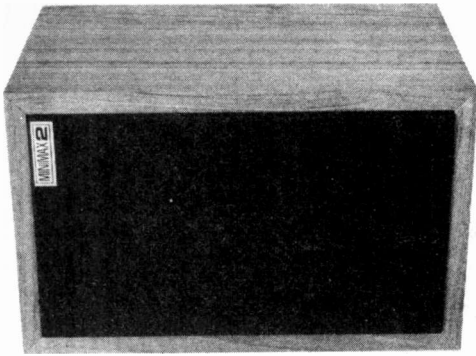


Dual CS505	80	There
Coral MC88E	25	Is
Sansui AU-D33	145	No
Videotone Minimax 2	75	Alternative!
<b>TOTAL</b>	<b>£325</b>	

With the rising costs of even the most basic system, the Dual CS505 is a godsend to the first time buyer. It offers very good performance for a reasonable cost. The Coral MC88E is a lively sounding moving coil unit, which needs a careful choice of speaker to make the most of its performance, and the new Minimax is an ideal match.

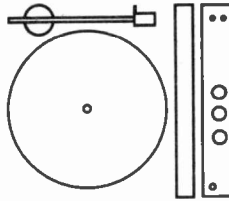


Overall the system provides a clean and slightly forward sound, with a good bass performance for its size. The Sansui offers a sound technical performance allied to a good power delivery and is ideal as the centre of a sound system designed for a wide range of music but a narrow wallet.

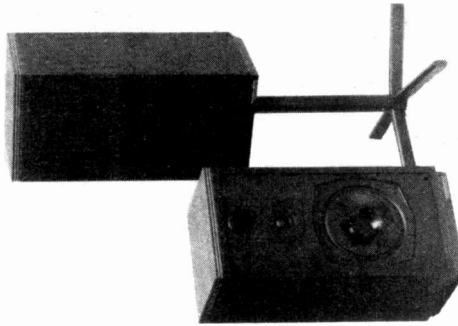
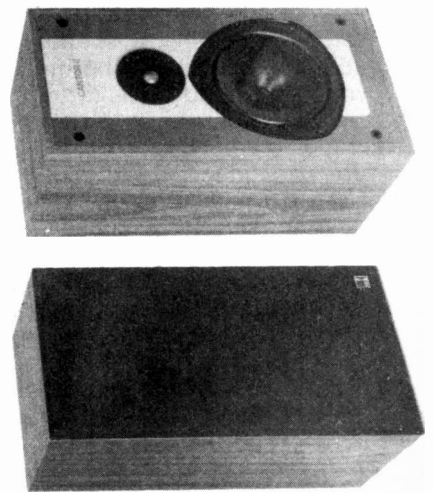
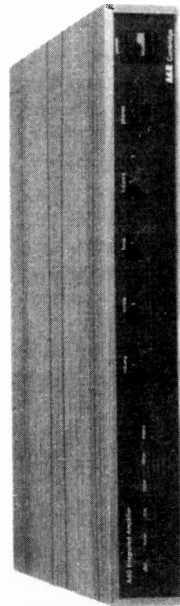


# SYSTEM 2

## £504

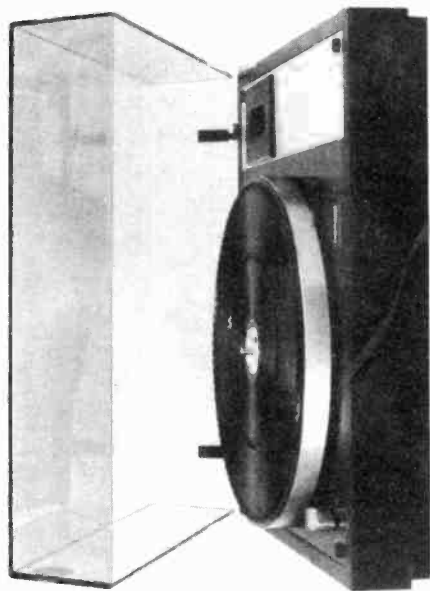


Systemdek II	115	Michell Focus 1 (105)
Linn Basik LV X	74	
A & R A60	195	NAD 3150 (98)
KEF Cantor 2	120	Mordaunt Short Festival 3 (150)
<b>TOTAL</b>	<b>£504</b>	



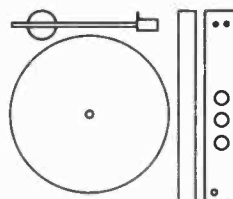
to provide as neutral result as can be obtained for this outlay. The A60 is a classic design and needs little introduction. It is probably the best of its kind for around £200 and you'll need to lay out a couple of hundred more to better this system for overall performance.

The Systemdek II is an individual approach to design — you'll either love it or hate it! Either reaction is catered for here by the use of the Focus One as an alternative. The Basik is well established as a cheap way of obtaining a good pickup. It will work well with the Cantor loudspeakers



# SYSTEM 3

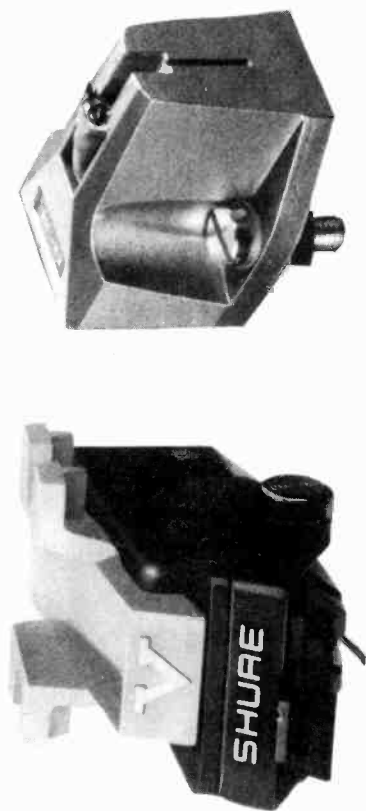
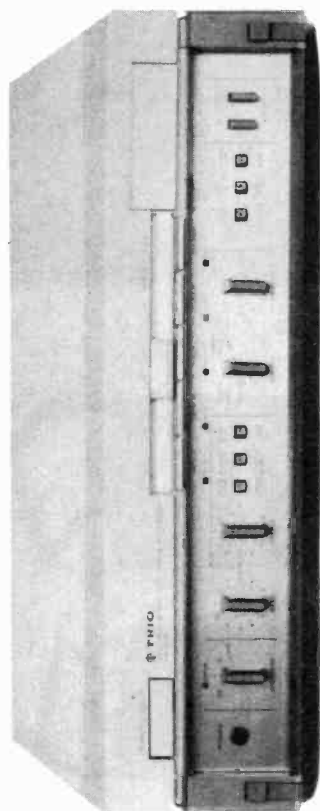
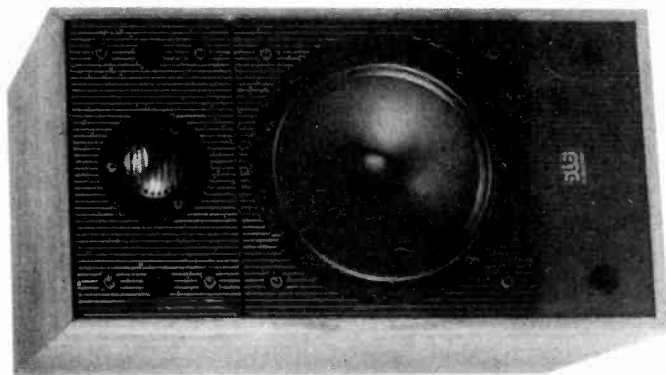
# £970



Thorens TD160S	175	
SME Series III	100	SME Series IIIS (80)
Shure V15V	105	Coral MC82 (120)
Trio KA-900	295	
Celestion SL6	295	Heybrook HB2 (185)
<b>TOTAL</b>		<b>£970</b>

The Thorens TD 160S is the basis for this system and although it does need very careful setting up — which any good dealer will carry out — it returns a performance which is far above that promised by the price of £175. It will consistently outperform decks costing £350 or more and as such is used in our next system upwards as well as in this one. The SME has become rather unfashionable of late, but is still THE best universal arm available. It matches high compliance designs particularly well and the V15V in particular.

With the Trio and the SL6, this adds up to a com-



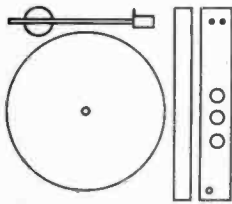
pact system capable of very high sound quality indeed and with a staggering bass response for its size (a trait born of the combination of V15V and SL6s). The alternative system is perhaps slightly smoother and would suit classical orientated taste a little better, although you will not get quite the same dynamics from the HB2s as with the Celestions.

Using the 'S' version of the SME will save you £20 or so and with the MC82 it is a better match anyway. Don't use this cartridge with SL6's, however; they do not work well together. The V15V, on the other hand, is a perfect complement.

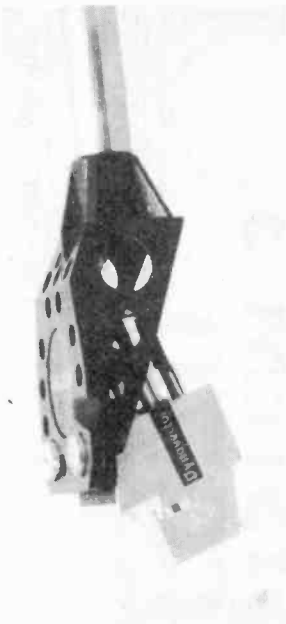


# SYSTEM 4

# £1368



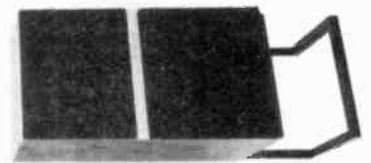
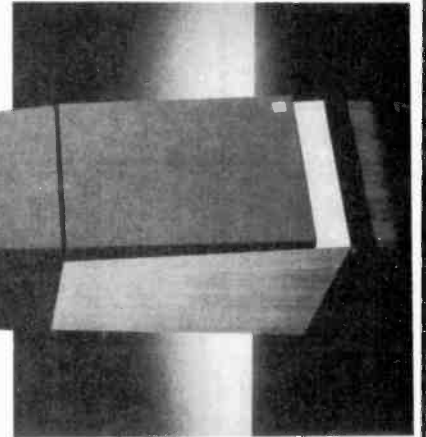
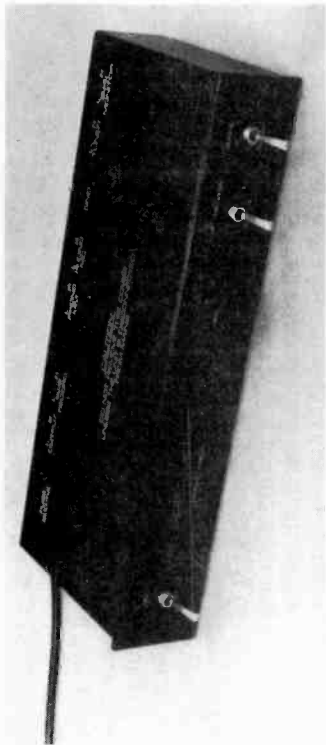
Thorens TD160S	175	
SME Series III	100	
Dynavector Karat Ruby	150	Shure V15V (105)
The Preamplifier/Carver M-400 (the Cube)	550	
Heybrook HB3	393	KEF 105 IV (500)
<b>TOTAL</b>	<b>£1368</b>	



Using the 160S/SME III combination once more, it is possible to construct a more 'up market' system which will provide greater power delivery and a much-improved bass response. Changing the speakers to Heybrook HB3s allows the use of the Karat Ruby from Dynavector and this will open out the mid-range to provide greater detail than before.

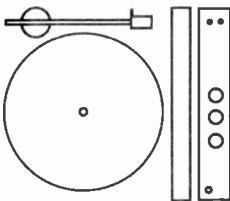
The Carver M-400 or 'Cube' is well-known for its phenomenal power delivery and miniscule dimensions. Unfortunately Carver do not yet market a preamp which is its equal in sound quality. The unit from Musical Fidelity is very well-designed and provides a good match.

If you have another £100 floating about spare, you could improve the system still further by substituting the excellent KEF 105 IV for the HB3. These are the smaller version of the illustrious 105 II and have many of that unit's admirable traits.



# SYSTEM 5

# £2840

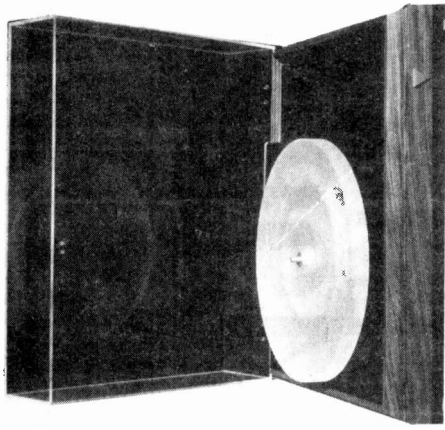
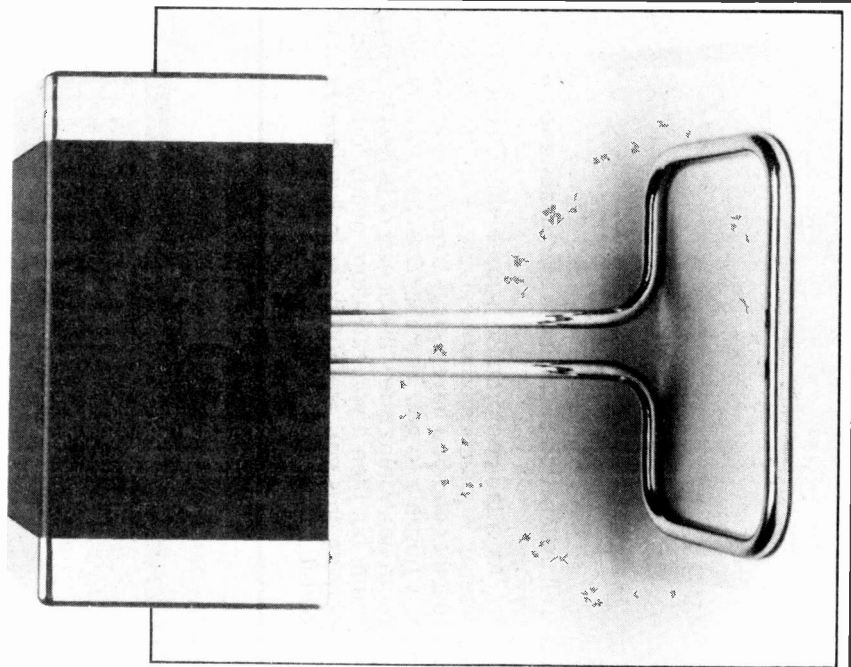
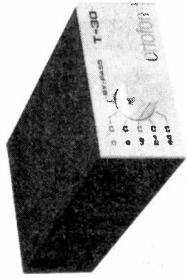
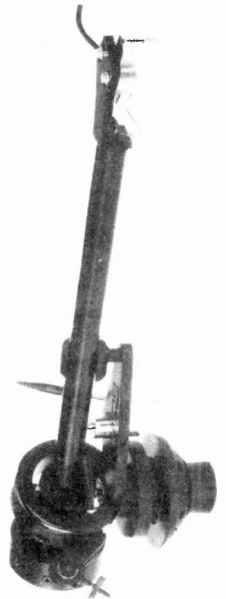


Oracle	600
SME Series III	100
Ortofon MC30/T-30	550
Elite 600/660	890
	NAC 32/NAP 20 (1100)
Gale 401	700
	KEF 105 II (900)
<b>TOTAL £2840</b>	

The Oracle is now accepted in many circles as the best-sounding turntable on the market. It is also one of the most expensive, at around £600. To obtain the absolute best from it, you need around £700 worth of cartridge and arm (see System 7) but the Oracle will still serve to improve less bank-breaking ambitions, provided care is exercised.

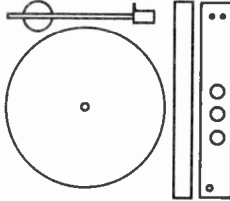
The Ortofon MC30 is a high compliance moving-coil unit of the highest quality. In our experience it does not work very well with the newer high-mass arms designed for moving-coil pickups. It does work superbly with the faithful SME Series III, however, with only the addition of the headshell weight. Use Ortofon's own step-up, the T-30, for optimum performance.

The KEF 105 II will provide a more neutral rendition than the Gale, but at a cost of around £200 more. Either speaker soaks up power like a sponge, and you may find the extra punch of the Naim more to your tastes, especially with the KEF.



# SYSTEM 6

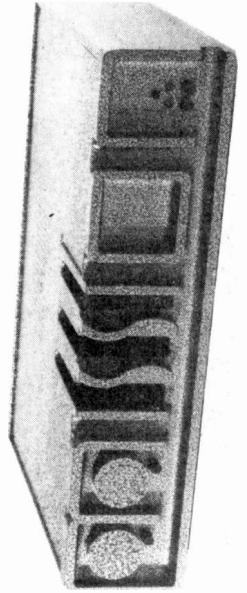
# £3071



Pink Triangle	398
Mission 774SM	157
	Alphason HR100S (195)
Dynavector Karat	
Diamond	516
NAIM NAC 32/ NAP 20	1100
KEF 105 II	900
<b>TOTAL £3071</b>	

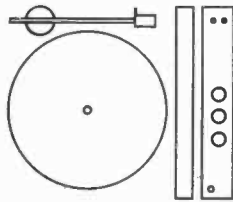
Based upon the Naim/105 combination this set-up brings you the benefits of the ultra-low compliance Dynavector Karat Diamond. This has a solid diamond cantilever and provides as good a way of extracting music from a disc as can be found anywhere. The Pink Triangle and Mission arm allow it to give of its best — no mean feat.

As an alternative amplifier, consider the Mission 776/777 combination. This is fairly new, but has already acquired an enviable reputation. The power amp in particular is excellent for the price.



# SYSTEM 7

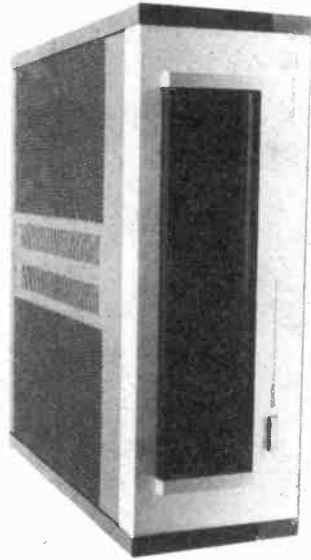
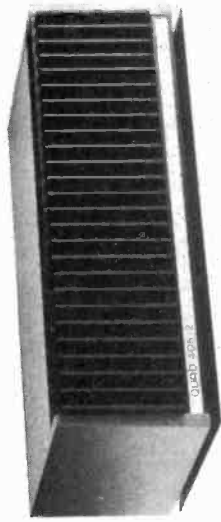
# £3393



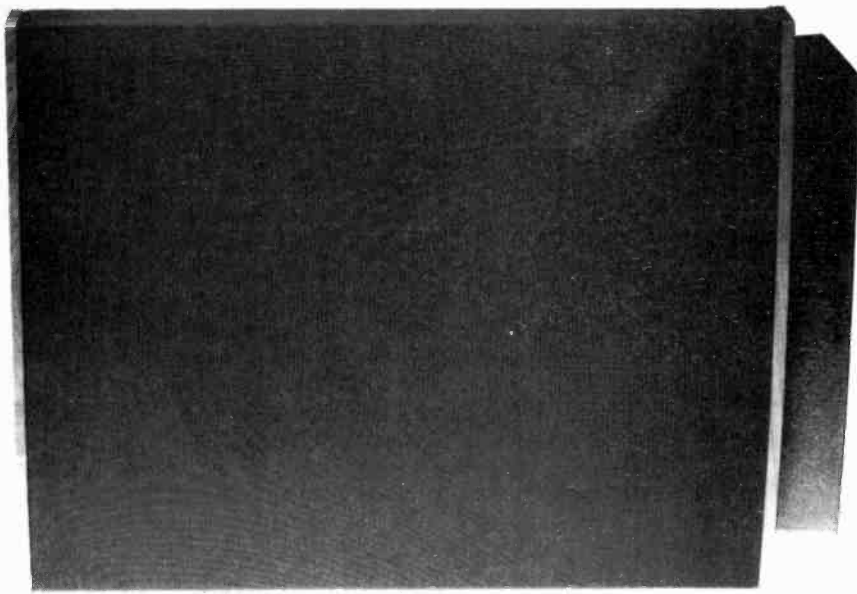
Oracle	600	
Fidelity Research FR 64	270	Linn Ittok (273)
Koetsu Silver	573	Linn Asak (207)
NAIM NAC 32/ Quad 405 II	750	NAC 32/Denon POA-3000 (2000)
Quad ELS-63	1200	
<b>TOTAL</b>	<b>£3393</b>	

**E**nter the Quad ELS-63 at £1200 the pair. If you want the best possible reproduction in the home, regardless of convenience or price then this is it. To drive them Quad's own 405 (now in Mk. 2 livery) takes some beating. It would appear that these two are designed to work together, since the 405 will lose units costing three or four times the price into the ELS-63's, and yet turn in a mediocre performance with some other speakers which are regarded as an easier load!

As an alternative the Class A Denon POA-3000 is



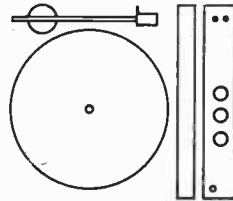
well matched to ESL-63 both electrically and for quality. As a no-compromise source the Oracle/FR 64 Koetsu is practically unbeatable. Put this little lot together and you have as high a quality disc system as it is possible to get. The ESL-63 is very touchy about room positioning and will not give of its best in a small room, but then if you can afford nearly four grand to play records you are not likely to live in a 12 x 12 bedsit . . . are you?



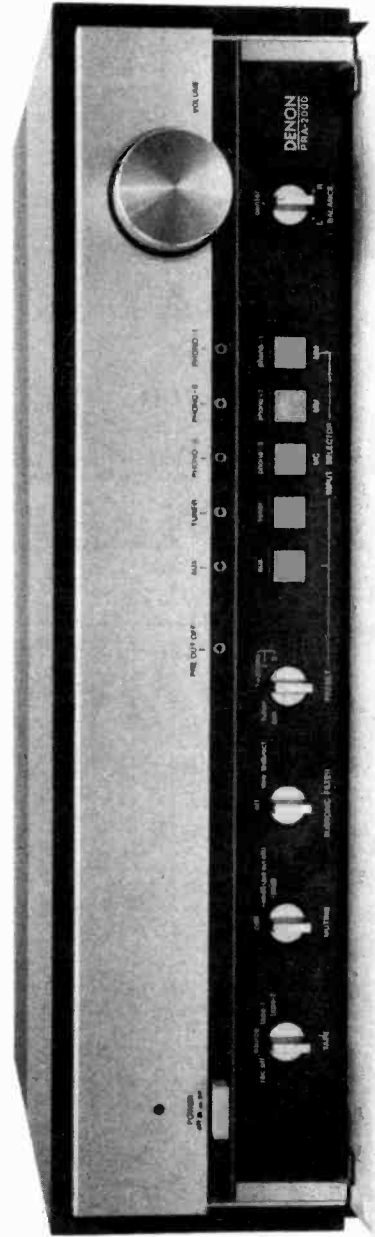
And just to be *really* silly . . .

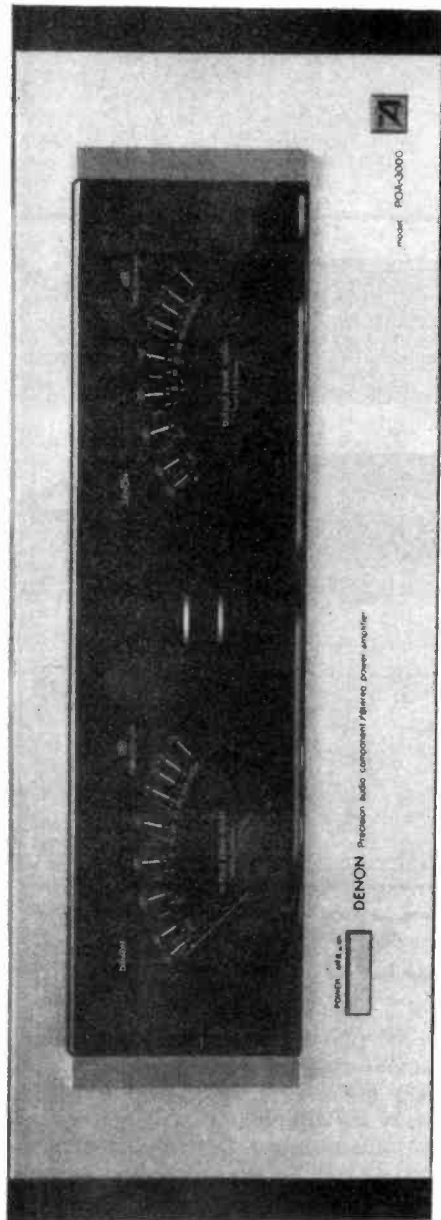
# SYSTEM 8

# £8498



Marantz Esotec 1000	1000	
Sumiko The Arm	798	
Koetsu Gold	900	
Threshold		Denon PRA-2000
FET1/5500	4600	POA-3000 (3500)
Quad ELS-63	1200	
<b>TOTAL</b>	<b>£8498</b>	

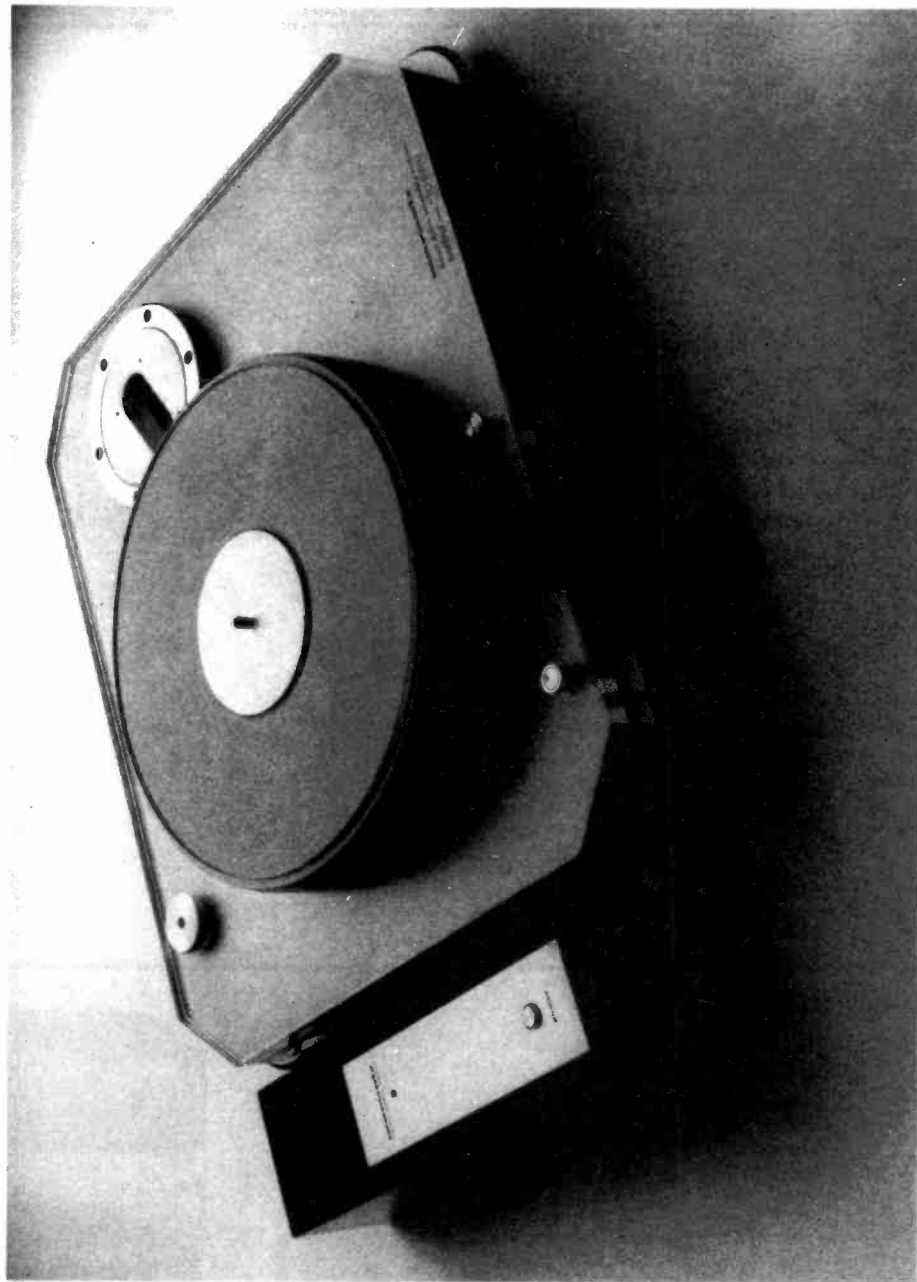




If you thought £3500 was expensive, try £8500! We must stress that we've never heard this precise arrangement of components and think it unlikely anyone else has either!

The Threshold amp is very highly regarded and on the occasions we've heard it, it is a very impressive piece of work indeed. Magnificent in all but generosity. £4600 is a lot of cash.

The (Sumiko) Arm is another supreme example of 'That Which Is Possible' — given no constraints on price as a starting point. If you ever get this system together we'd be only too pleased to come and have a listen — we'll even bring the beer!



# CASSETTES AND TUNERS

Once you move away from the basic record playing system into tape and/or radio, then technical compatibility assumes a greater-than-ever importance. Without going through every amplifier input and every tape/tuner output, there is no real way to guarantee complete compatibility. The only useful advice is to check the model you want against the amplifier you're thinking of using it with.

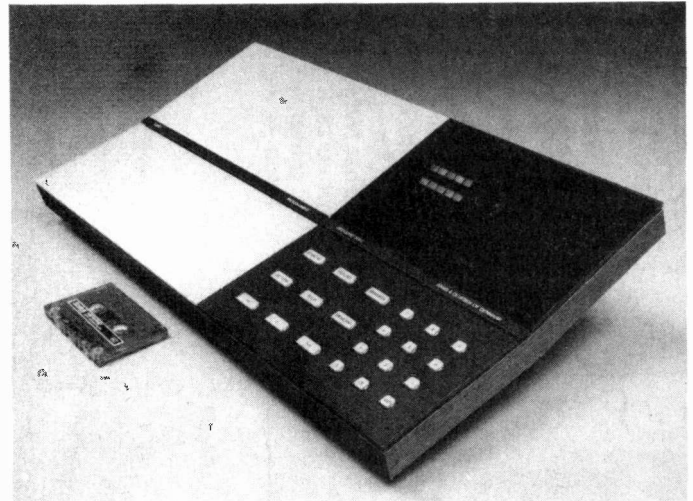
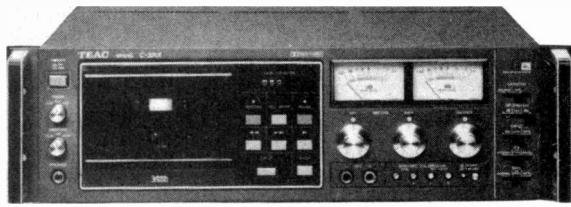
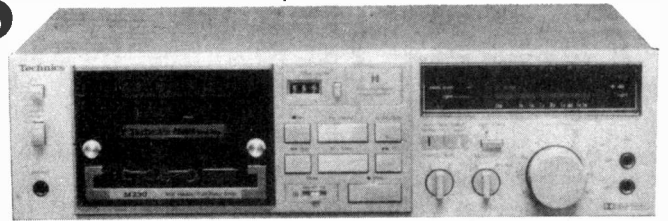
Feeding a low impedance into a high(er) value is OK. Anything else is not. Look for approximately equal sensitivity and output levels, so that you are not flogging some poor little input stage to death somewhere to obtain the level you want.

Here we are presenting a list of ETI approved models — which is not to say that nothing else is approvable! These just happen to be components of which we have had experience and can thoroughly recommend as good performers and good value. Check them over if you're buying into this market. How much you need to pay is entirely dependent upon how much you value that particular source. The more you pay, the better they get.



# CASSETTE DECKS

MODEL	£
Sony TEF 44	110
Technics RSM230	155
Alpage AL-100	173
Akai GX-F51	200
Pioneer CT7R	260
Teac C3X	360
Alpage AL-300	372
Bang and Olufsen Beocord 8002	459
Revox B710 II	943
Nakamichi 1000 ZXL	1000



# TUNERS



MODEL	£
Yamaha 7760	143
NAD 4150	159
Sugden T48 II	161
Lux T115	170
A & R T21	190
Sony ST-J75	200
Pioneer F9	200

# COMPACT DISCS?

Perhaps the most relevant question at present is whether or not you should buy an analogue disc system now at all, or go straight for the incoming Compact Disc systems. Our advice would be to wait. While the Compact Disc is of undoubtedly higher quality than any vinyl spinner, the price is horrendous at present, and the records are expensive and very limited in choice.

In about a year the players will be cheaper by far, the choice much wider and the software library five times the size. If you like the music offered and love the gadgets — go buy it. Which one you get is probably irrelevant, as there should not be a whole lot of difference in performance between properly designed units, despite the ad claims.

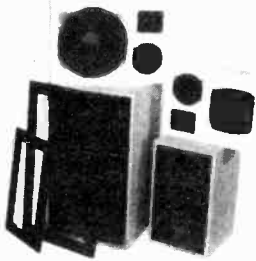
ETI



### MULLARD SPEAKER KITS

Purposefully designed 40 watt R.M.S. and 30 watt R.M.S. 8 ohm speaker systems recently developed by MULLARD'S specialist team in Belgium. Kits comprise Mullard woofer (8" or 5") with foam surround and aluminium voice coil. Mullard 3" high power domed tweeter. B.K.E. built and tested crossover based on Mullard circuit, combining low loss components, glass fibre board and recessed loudspeaker terminals. SUPERB SOUNDS AT LOW COST. Kits supplied in polystyrene packs complete with instructions. 8" 40W system — recommended cabinet size 240 x 216 x 445mm  
Price £14.90 each + £2.00 P & P.  
5" 30W system — recommended cabinet size 160 x 175 x 295mm  
Price £13.90 each + £1.50 P & P.

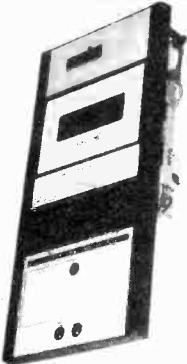
Designer approved flat pack cabinet kits, including grill fabric. Can be finished with iron on veneer or self adhesive vinyl etc.  
8" system cabinet kit £8.00 each + £2.50 P & P.  
5" system cabinet kit £7.00 each + £2.00 P & P.



### STEREO CASSETTE TAPE DECK MODULE.

Comprising of a top panel and tape mechanism coupled to a record/play back printed board assembly. Supplied as one complete unit for horizontal installation into cabinet or console of own choice. These units are brand new, ready built and tested.

Features: Three digit tape counter. Autostop. Six piano type keys, record, rewind, fast forward, play, stop and eject. Automatic record level control. Main inputs plus secondary inputs for stereo microphones. Input Sensitivity: 100mV to 2V. Input Impedance: 68K. Output level: 400mV to both left and right hand channels. Output Impedance: 10K. Signal to noise ratio: 45dB. Wow and flutter: 0.1%. Power Supply requirements: 18V DC at 300mA. Connections: The left and right hand stereo inputs and outputs are via individual screened leads, all terminated with phono plugs (phono sockets provided). Dimensions: Top panel 5 1/2" x 11 1/2". Clearance required under top panel 2 1/2". Supplied complete with circuit diagram and connecting diagram. Attractive black and silver finish.  
Price £26.70 + £2.50 postage and packing.  
Supplementary parts for 18V D.C. power supply (transformer, bridge rectifier and smoothing capacitor) £3.50.



### LOUDSPEAKERS

**15" 100 watt R.M.S. (HI-FI, P.A., DISCO, BASS GUITAR)** Die cast chassis, 2" aluminium voice coil, white cone with aluminium centre dome. 8 ohm imp., Res. Freq. 20Hz., Freq. Resp. to 2.5KHz., Sens. 97dB (As photograph). Price: £32.00 + £3 carriage.

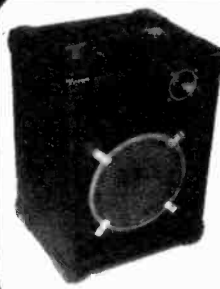
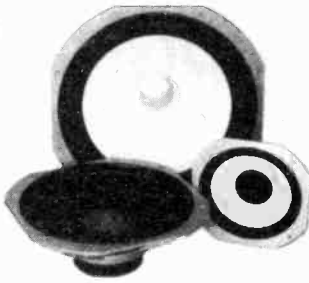
**12" 100 watt R.M.S. (HI-FI)** Die cast chassis. 2" aluminium voice coil. Black cone. 8 ohm imp., Res. Freq. 20Hz., Freq. Resp. to 4.5KHz. Sens. 95dB. (As photograph). Price: £23.50 + £3 carriage.

**8" 50 watt R.M.S. (HI-FI, P.A.)** 1 1/2" aluminium voice coil. White cone. 8 ohm imp. Res. Freq. 40Hz., Freq. Resp. to 6KHz. Sens. 92dB. Also available with black cone fitted with black metal protective grille. (As photograph). Price: White Cone £8.90, Black cone/grille £9.50 P&P £1.25.

**12" 85 watt R.M.S. McKENZIE C1285GP (LEAD GUITAR, KEYBOARD, DISCO)** 2" aluminium voice coil, aluminium centre dome, 8 ohm imp., Res. Freq. 45Hz., Freq. Resp. to 6.5KHz., Sens. 98dB. Price: £22.00 + £3 carriage.

**12" 85 watt R.M.S. McKENZIE C1285TC (P.A., DISCO)** 2" aluminium voice coil. Twin cone. 8 ohm imp., Res. Freq. 45Hz., Freq. Resp. to 14KHz. Price £22 + £3 carriage.

**15" 150 watt R.M.S. McKENZIE C15 (BASS GUITAR, P.A.)** 3" aluminium voice coil. Die cast chassis. 8 ohm imp., Res. Freq. 40Hz., Freq. Resp. to 4KHz. Price: £47 + £4 carriage.



### OMP 80 LOUDSPEAKER

The very best in quality and value. Ported tuned cabinet in hardwearing black vinylite with protective corners and carry handle. Built and tested, employing 10in British driver and Piezo tweeter. Spec: 80 watts R.M.S. 8 ohms; 45Hz-20KHz; Size: 20in x 15in x 12in; Weight: 30 pounds.

Price: £89.00 each, £90 per pair  
Carriage: £5 each, £7 per pair

### 1K.WATT SLIDE DIMMER

- Controls loads up to 1KW
- Compact size



4 1/4" x 13" x 2 1/2"  
16

- Easy snap in fixing through panel/cabinet cut out
  - Insulated plastic case
  - Full wave control using 8amp triac
  - Conforms to BS800
  - Suitable for both resistance and inductive loads
- Innumerable applications in industry, the home, and discos/theatres etc.

Price: £11.70 each + 50p P&P (Any quantity)

### KEYBOARDS



**MEMBRANE KEYBOARDS** manufactured from a tough polycarbonate film mounted on 1mm glass fibre printed circuit board assembly incorporating silver plated contacts.

**16 way numeric keyboard** Standard keyboard providing 0-9 and A-F functions.

Size: 100mm x 100mm x 2mm. Price: £5.99 + 35p p&p  
**Alpha Numeric Keyboard** Full size 55 key non encoded keyboard with the commonly required functions in a Qwerty array. Matrix output via a 16 pin DIL socket.

Size: 350mm x 100mm x 2mm. Price: £13.99 + 50p p&p

### BSR P256 TURNTABLE

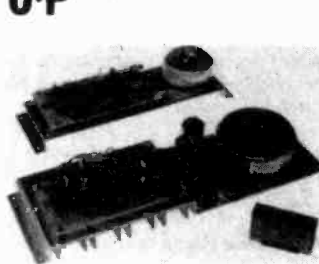
P256 turntable chassis ● S shaped tone arm

- Belt driven ● Aluminium platter
  - Precision calibrated counter balance ● Anti-skate (bias device) ● Damped cueing lever
  - 240 volt AC operation (Hz) ● Cut-out template supplied ● Completely manual arm.
- This deck has a completely manual arm and is designed primarily for disco and studio use where all the advantages of a manual arm are required.

Price £18.49 each + £3.00 P&P



### POWER AMPLIFIER MODULES



### 100 WATT R.M.S. AND 300 WATT R.M.S. MODULES

Power Amplifier Modules with integral toroidal transformer power supply, and heat sink. Supplied as one complete built and tested unit. Can be fitted in minutes. An LED Vu meter is available as an optional extra.

**SPECIFICATION:**  
Max Output Power: 110 watts R.M.S. (OMP 100) 310 watts R.M.S. (OMP 300)  
Loads: Open and short circuit proof. 4-16 ohms.  
Frequency Response: 20Hz — 25KHz ±3dB.  
Sensitivity for Max. Output: 500mV at 10K (OMP 100) 1V at 10K (OMP 300)  
T.H.D.: Less than 0.1%  
Supply: 240V 50Hz  
Sizes: OMP 100 360 x 115 x 72mm  
OMP 300 460 x 153 x 66mm  
Prices: OMP 100 £31.50 each + £2.00 P&P  
OMP 300 £89.00 each + £3.00 P&P  
Vu Meter £6.50 each + 50p P&P

### PIEZO ELECTRIC TWEETERS — MOTOROLA

Join the Piezo revolution. The low dynamic mass (no voice coil) of a Piezo tweeter produces an improved transient response with a lower distortion level than ordinary dynamic tweeters. As a crossover is not required these units can be added to existing speaker systems of up to 100 watts (more if 2 put in series). FREE EXPLANATORY LEAFLETS SUPPLIED WITH EACH TWEETER.

TYPE 'A' (KSN2036A) 3" round with protective wire mesh, ideal for bookshelf and medium sized Hi-fi speakers. Price £4.29 each.

TYPE 'B' (KSN1005A) 3 1/2" super horn. For general purpose speakers, disco and P.A. systems etc. Price £4.99 each.

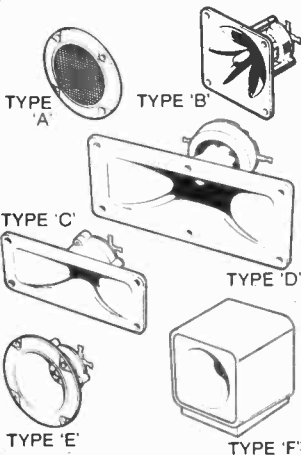
TYPE 'C' (KSN6016A) 2" x 5" wide dispersion horn. For quality Hi-fi systems and quality discos etc. Price £5.99 each.

TYPE 'D' (KSN1025A) 2" x 6" wide dispersion horn. Upper frequency response retained extending down to mid range (2KHz). Suitable for high quality Hi-fi systems and quality discos. Price £7.99 each.

TYPE 'E' (KSN1038A) 3 1/2" horn tweeter with attractive silver finish trim. Suitable for Hi-fi monitor systems etc. Price £4.99 each.

TYPE 'F' (KSN1057A) Cased version of type 'E'. Free standing satellite tweeter. Perfect add on tweeter for conventional loudspeaker systems. Price £31.35 each.

P&P 20p ea. (or SAE for Piezo leaflets).



### Matching 3-way loudspeakers and crossover

Build a quality 60watt RMS system 8ohms

Build a quality 60 watt R.M.S. system.

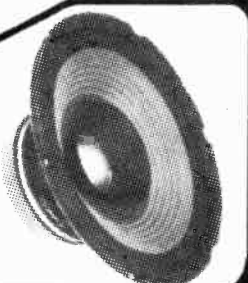
- ★ 10" Woofer 35Hz-4.5KHz
- ★ 3" Tweeter 2.5KHz-19KHz
- ★ 5" Mid Range 600Hz-8KHz
- ★ 3-way crossover 6dB/oct 1.3 and 6KHz

Recommended Cab-size 26" x 13" x 13"  
Fitted with attractive cast aluminium fixing es-cutchions and mesh protective grills which are removable enabling a unique choice of cabinet styling. Can be mounted directly on to baffle with or without conventional speaker fabrics. All three units have aluminium centre domes and rolled foam surround. Crossover combines spring loaded loudspeaker terminals and recessed mounting panel.  
Price £22.00 per kit + £2.50 postage and packing. Available separately, prices on request.



### 12" 80 watt R.M.S. loudspeaker.

A superb general purpose twin cone loudspeaker. 50 oz. magnet. 2" aluminium voice coil. Rolled surround. Resonant frequency 25Hz. Frequency response to 17KHz. Sensitivity 95dB. Impedance 8ohm. Attractive blue cone with aluminium centre dome.  
Price £17.99 each + £3.00 P&P.



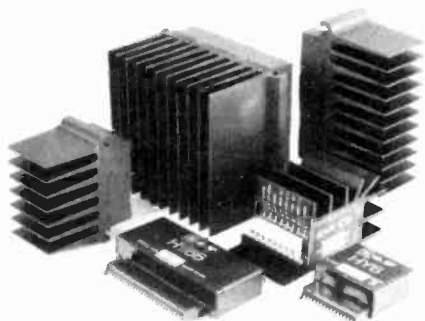
# B.K. ELECTRONICS

37 Whitehouse Meadows, Eastwood, Leigh-on-Sea, Essex SS9 5TY

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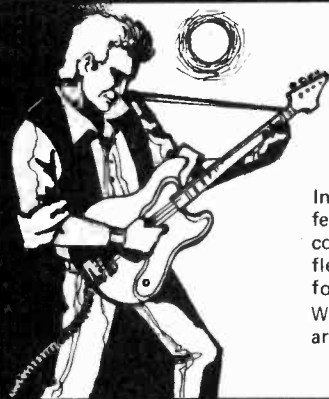


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#### BIPOLAR MODULES

Module Number	Output Power Watts rms	Load Impedance $\Omega$	DISTORTION		Supply Voltage Typ	Size mm	WT gms	Price inc. VAT
			T.H.D. Typ at 1KHz	I.M.D. 60Hz/7KHz 4:1				
HY30	15	4-8	0.015%	<0.006%	$\pm 18$	76 x 68 x 40	240	£8.40
HY60	30	4-8	0.015%	<0.006%	$\pm 25$	76 x 68 x 40	240	£9.55
HY6060	30 + 30	4-8	0.015%	<0.006%	$\pm 25$	120 x 78 x 40	420	£18.69
HY124	60	4	0.01%	<0.006%	$\pm 26$	120 x 78 x 40	410	£20.75
HY128	60	8	0.01%	<0.006%	$\pm 35$	120 x 78 x 40	410	£20.75
HY244	120	4	0.01%	<0.006%	$\pm 35$	120 x 78 x 50	520	£25.47
HY248	120	8	0.01%	<0.006%	$\pm 50$	120 x 78 x 50	520	£25.47
HY364	180	4	0.01%	<0.006%	$\pm 45$	120 x 78 x 100	1030	£38.41
HY368	180	8	0.01%	<0.006%	$\pm 60$	120 x 78 x 100	1030	£38.41

Protection: Full load line, Slew Rate: 15V/ $\mu$ s. Risettime: 5 $\mu$ s. S/N ratio: 100db. Frequency response (-3dB) 15Hz - 50KHz. Input sensitivity: 500mV rms. Input Impedance: 100K  $\Omega$ . Damping factor: 100Hz >400.

#### PRE-AMP SYSTEMS

Module Number	Module	Functions	Current Required	Price inc. VAT
HY6	Mono pre amp	Mic/Mag, Cartridge/Tuner/Tape/Aux + Vol/Bass/Treble	10mA	£7.60
HY66	Stereo pre amp	Mic/Mag, Cartridge/Tuner/Tape/Aux + Vol/Bass/Treble/Balance	20mA	£14.32
HY73	Guitar pre amp	Two Guitar (Bass, Lead) and Mic + separate Volume Bass Treble + Mix	20mA	£15.36
HY78	Stereo pre amp	As HY66 less tone controls	20mA	£14.20

Most pre-amp modules can be driven by the PSU driving the main power amp. A separate PSU 30 is available purely for pre amp modules if required for £5.47 (inc. VAT). Pre-amp and mixing modules in 18 different variations. Please send for details.

#### Mounting Boards

For ease of construction we recommend the B6 for modules HY6-HY13 £1.05 (inc. VAT) and the B66 for modules HY66-HY78 £1.29 (inc. VAT).

#### POWER SUPPLY UNITS (Incorporating our own toroidal transformers)

Model Number	For Use With	Price inc. VAT
PSU 21X	1 or 2 HY30	£11.93
PSU 41X	1 or 2 HY60, 1 x HY6060, 1 x HY124	£13.93
PSU 42X	1 x HY128	£15.90
PSU 43X	1 x MOS128	£16.70
PSU 51X	2 x HY128, 1 x HY244	£17.07

Please note: X in part no. indicates primary voltage. Please insert "0" in place of X for 110V, "1" in place of X for 220V, and "2" in place of X for 240V.

#### MOSFET MODULES

Module Number	Output Power Watts rms	Load Impedance $\Omega$	DISTORTION		Supply Voltage Typ	Size mm	WT gms	Price inc. VAT
			T.H.D. Typ at 1KHz	I.M.D. 60Hz/7KHz 4:1				
MOS 128	60	4-8	<0.005%	<0.006%	$\pm 45$	120 x 78 x 40	420	£30.41
MOS 248	120	4-8	<0.005%	<0.006%	$\pm 55$	120 x 78 x 80	850	£39.86
MOS 364	180	4	<0.005%	<0.006%	$\pm 55$	120 x 78 x 100	1025	£45.54

Protection: Able to cope with complex loads without the need for very special protection circuitry (fuses will suffice).

Slew rate: 20V/ $\mu$ s. Rise time: 3 $\mu$ s. S/N ratio: 100db

Frequency response (-3dB): 15Hz - 100KHz. Input sensitivity: 500mV rms

Input impedance: 100K  $\Omega$ . Damping factor: 100Hz >400.

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Robust construction.

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Frequency response (-3dB) 15Hz to 30KHz, T.H.D. 0.1% at 10w 1KHz

S/N ratio (DIN AUDIO) 80dB, Load Impedance 3 $\Omega$

Input Sensitivity and Impedance (selectable) 700mV rms into 15K $\Omega$ . 3V rms into 8 $\Omega$

Size 95 x 48 x 50mm. Weight 256 gms.

##### C1515

Stereo version of C15.

£17.19 (inc. VAT)

Size 95 x 40 x 80. Weight 410 gms.

Model Number	For Use With	Price inc. VAT
PSU 52X	2 x HY124	£17.07
PSU 53X	2 x MOS128	£17.86
PSU 54X	1 x HY248	£17.86
PSU 55X	1 x MOS248	£19.52
PSU 71X	2 x HY244	£21.75

Model Number	For Use With	Price inc. VAT
PSU 72X	2 x HY248	£22.54
PSU 73X	1 x HY364	£22.54
PSU 74X	1 x HY368	£24.20
PSU 75X	2 x MOS248, 1 x MOS368	£24.20

# WITH A LOT OF HELP FROM



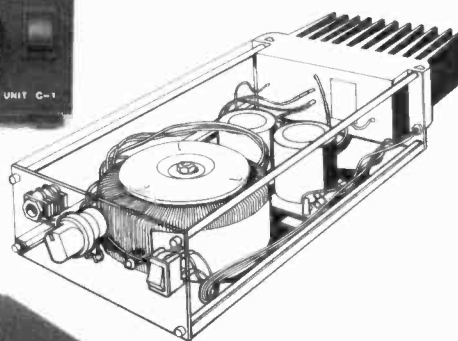
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Because of ILP's modular approach, "open plan" construction is used and final assembly of the unit parts forms a compact aesthetic unit. By this method construction can be achieved in under two hours with little experience of electronic wiring and mechanical assembly.



### Hi Fi Separates

**UC1 PRE AMP UNIT:** Incorporates the HY78 to provide a "no frills", low distortion, (<0.01%), stereo control unit, providing inputs for magnetic cartridge, tuner, and tape/monitor facilities. This unit provides the heart of the hi fi system and can be used in conjunction with any of the UP Unicase series of power amps. For ultimate hum rejection the UC1 draws its power from the power amp unit.

**POWER AMPS:** The UP series feature a clean line front panel incorporating on/off switch and concealed indicator. They are designed to compliment the style of the UC1 pre-amp. Performance for each unit which includes the appropriate power supply, is as specified on the facing page.

### Power Slaves

Our power slaves, which have numerous uses i.e. instrument, discotheque, sound reinforcement, feature in addition to the hi fi series, front panel input jack, level control, and a carrying handle. Providing the smallest, lowest cost, slave on the market in this format.

#### UNICASES

HiFi Separates					Price inc. VAT
UC1	Preamp				£29.95
UP1X	30 + 30W/4-8Ω	Bipolar	Stereo	HiFi	£54.95
UP2X	60W/4Ω	Bipolar	Mono	HiFi	£54.95
UP3X	60W/8Ω	Bipolar	Mono	HiFi	£54.95
UP4X	120W/4Ω	Bipolar	Mono	HiFi	£74.95
UP5X	120W/8Ω	Bipolar	Mono	HiFi	£74.95
UP6X	60W/4-8Ω	MOS	Mono	HiFi	£64.95
UP7X	120W/4-8Ω	MOS	Mono	HiFi	£84.95
Power Slaves					
US1X	60W/4Ω	Bipolar	Power	Slave	£59.95
US2X	120W/4Ω	Bipolar	Power	Slave	£79.95
US3X	60W/4-8Ω	MOS	Power	Slave	£69.95
US4X	120W/4-8Ω	MOS	Power	Slave	£89.95

Please note X in part number denotes mains voltage. Please insert 'O' in place of X for 110V, '1' in place of X for 220V (Europe), and '2' in place of X for 240V (U.K.) All units except UC1 incorporate our own toroidal transformers.

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# ZX81 MUSIC BOARD

With the circuit and construction covered last month, we now turn to the software routines that enable you to use this project to the full. Design and development by M. P. Moore.

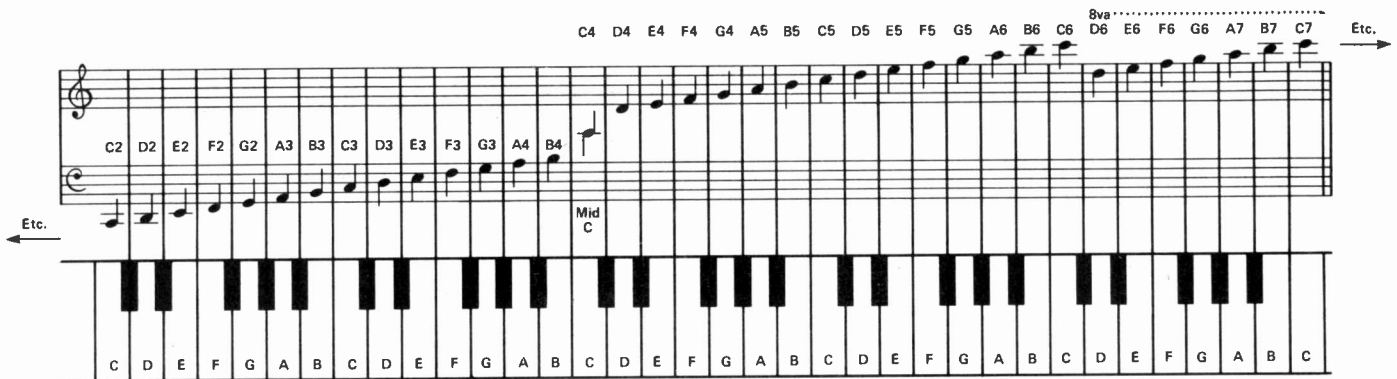


Fig. 1 Table of notes as used by the input routine.

## THE MUSIC

1	REM (our machine code)	158	IF N\$ < > "0" THEN GOTO	288	LET D = D + 1
2	CLS		163	289	POKE 16564, (PEEK D)
5	DIM H(7)	159	POKE D,0	290	LET D = D + 1
10	FOR N = 1 TO 7	160	POKE (D + 1),0	291	POKE 16565, (PEEK D)
15	LET H(N) = 76	161	PRINT "[6 SPC]";	292	LET D = D + 1
20	NEXT N	162	GOTO 170	293	POKE 16566, (PEEK D)
25	PRINT "CLEAR MUSIC SPACE	163	IF N\$ = "L" THEN GOTO	294	LET D = D + 1
	(Y OR N) OR PLAY (P) OR		350	295	RAND USR 16543
	LIST (L)?"	164	POKE D,N	296	PAUSE S
30	IF INKEY\$ = "N" THEN	165	POKE (D + 1),H	297	POKE 16437,22
	GOTO 55	170	GOSUB 2000	298	GOTO 282
31	IF INKEY\$ = "P" THEN	185	NEXT D	299	LET X = 16561
	GOTO 200	200	CLS	300	FOR D = 1 TO 6
33	IF INKEY\$ = "L" THEN	201	PRINT "SET VOLUMES (Y OR	305	POKE X,0
	GOTO 350		N), EDIT (E)", "OR LIST (L)?"	306	LET X = X + 1
35	IF INKEY\$ < > "Y" THEN	202	SLOW	307	NEXT D
	GOTO 30	205	IF INKEY\$ = "Y" THEN	308	SLOW
36	FAST		GOTO 215	310	RAND USR 16543
40	FOR N = 16670 TO 21670	206	IF INKEY\$ = "E" THEN	315	GOTO 200
45	POKE N,255		GOTO 136	350	CLS
50	NEXT N	207	IF INKEY\$ = "L" THEN	351	PRINT "LIST FROM LINE
51	SLOW		GOTO 350		NO.:";
55	PRINT "SHARPS?";	208	IF INKEY\$ = "N" THEN	355	INPUT Z
60	LET Z = 78		GOTO 265	360	PRINT Z
65	GOSUB 1150	210	GOTO 205	365	PRINT AT 21,0;Z;"[3 SPC]";
100	PRINT "FLATS?";	215	PRINT "A=";	366	FAST
105	LET Z = 74	220	INPUT S	370	LET X = 0
110	GOSUB 1150	225	POKE 16540,S	371	LET K = (Z - 1) * 6 + 16734
136	CLS	230	PRINT S;"B=";	372	FOR D = (Z - 1) * 6 +
137	PRINT "EDIT FROM LINE	235	INPUT S		16670 TO (Z - 1) * 6 +
	NO.:";	240	PRINT S;"C=";		16734 STEP 2
140	INPUT Z	245	POKE 16541,S	375	LET Y = 1
141	PRINT Z	250	INPUT S	380	LET L = PEEK D
142	PRINT AT 21,0;Z;"[3 SPC]";	255	POKE 16542,S	385	LET M = PEEK (D + 1)
143	LET X = 0	260	PRINT S	386	IF L = 255 AND M = 255
144	FOR D = (Z - 1)*6 + 16670	265	PRINT "SPEED?"		THEN PRINT " STOP "
	TO 21670 STEP 2	270	INPUT S	387	IF L = 255 AND M = 255
148	SLOW	271	PRINT "PLAY FROM LINE		THEN GOTO 491
149	COSUB 1000		NO.?"	388	IF L = 0 AND M = 0 THEN
150	IF N\$ < > "5" THEN GOTO	272	INPUT D	389	PRINT "[3 SPC]";
	155	275	LET D = (D - 1)*6 + 16670		IF L = 0 AND M = 0 THEN
151	LET Z = Z - 2	276	CLS	390	GOTO 470
152	LET D = D - 8	280	RAND USR 16514	395	LET L = L + M * 256
153	LET X = 2	281	FAST		IF L < 1966 THEN LET Y = Y
154	GOTO 170	282	IF PEEK D = 255 THEN		+ 1
155	IF N\$ = "R" THEN GOTO		GOTO 299	400	IF L < 1966 THEN LET L = L
	510	283	POKE 16561, (PEEK D)		* 2
156	IF N\$ = "E" THEN GOTO	284	LET D = D + 1	405	IF L < 1966 THEN GOTO 395
	136	285	POKE 16562, (PEEK D)	410	LET M = L/256
157	IF N\$ = "P" THEN GOTO	286	LET D = D + 1	415	LET M = INT M
	200	287	POKE 16563, (PEEK D)		

The music program allows the ZX81 to play up to three notes simultaneously. The range is from A octave 1 upwards, where middle C is C4 (see Fig. 1). There is sufficient memory space with a 16K expansion to enter 833 chords of music. Everything possible has been done to facilitate the entering of music. The key signature (sharps or flats) is set to begin with and remains set until changed; changes may be made during the entering of music; each of the three channels has an independently set volume; the same note repeated on one channel will give a continuous note, but if played on alternating channels, will give a repetitive note.

The symbols used are + (sharp), - (flat) and = (natural). The functions available are **EDIT**, which is used for entering and editing music already entered, and includes **BACKSPACE** and **REPEAT** functions;

**LIST**, which allows you to read the music entered, and **PLAY**.

Program "M" is very long and takes about five minutes to load. Having loaded the program the sequence of operations is as follows:-

Type **GOTO 2 NEWLINE**.

The computer will ask: **CLEAR MUSIC SPACE (Y OR N) OR PLAY (P) OR LIST (L)?**

The second and third functions don't interest us at the moment, and since the music space is clear to start with, type **N**.

The computer now asks **SHARPS?** if the key signature contains sharps, type them in (in any order) followed by **NEWLINE**.

If there are no sharps type **0 NEWLINE**.

The computer now asks **FLATS?**

Deal with the question as for sharps.

The computer asks **EDIT FROM**

## BUYLINES

Petron Electronics supply a full kit of parts for this project; we must apologise to them and any purchasers of the kit for the incorrect price given last month. The complete kit including PCB, all components, comprehensive user's manual and the software cassette containing this month's programs, costs £24.95 all inclusive. The board is also available ready-built together with manual and cassette, for £29.95, or in a smart ABS plastic case for only £34.90. Please state whether you require the board to be wired for mono or stereo. A demonstration cassette is available for 95p all inclusive, while the manual may be purchased separately for £1.25, refunded upon subsequent purchase of a kit. Petron Electronics may be found at 1 Courtlands Road, Newton Abbot, Devon.

## LINE NO.

Since you are starting from scratch enter **1 NEWLINE**.

The computer is now ready to accept up to 833 'lines' of music. A

## PROGRAM

420	IF L > = 256 THEN LET L = L - 256	561	LET D = (E - 2)	1100	LET H = INT H
425	IF L > = 256 THEN GOTO 420	562	SLOW	1105	IF N > = 256 THEN LET N = N - 256
430	POKE 16619,L	565	GOTO 185	1110	IF N > = 256 THEN GOTO 1105
435	POKE 16620,M	1000	INPUT N\$	1115	RETURN
440	LET L = USR 16608	1001	IF N\$ = "R" OR N\$ = "5" OR N\$ = "0" OR N\$ = "P" OR N\$ = "L" OR N\$ = "E" THEN RETURN	1150	INPUT H\$
445	LET L = L/4	1002	IF N\$(1) < "A" OR N\$(1) > "G" THEN GOTO 1000	1155	IF H\$ < "A" AND H\$ < > "0" OR H\$ > "G" THEN GOTO 1150
450	LET M = INT L - 19	1005	IF LEN N\$ < 2 THEN GOTO 1000	1160	IF H\$ = "0" THEN RETURN
454	LET M = INT M	1008	FAST	1165	FOR N = 1 TO LEN H\$
455	IF M = 37 AND INT L < > L THEN LET Y = Y - 1	1009	LET H = CODE N\$ - 37	1170	LET H = CODE H\$(N)
456	IF M = 37 THEN LET M = 44	1010	IF LEN N\$ 2 THEN GOTO 1030	1175	LET H = H - 37
460	PRINT CHR\$ M;	1015	IF N\$(2) = "-" THEN LET H(H) = 74	1180	LET H(H) = Z
465	IF INT L < L THEN PRINT "+";	1020	IF N\$(2) = "+" THEN LET H(H) = 78	1185	NEXT N
466	IF INT L = L THEN PRINT "=";	1025	IF N\$(2) = " " THEN LET H(H) = 76	1190	PRINT H\$
468	PRINT Y;	1030	LET N = CODE N\$	1195	RETURN
470	PRINT "[3 SPC]";	1035	LET N = N * 4	2000	LET X = X + 1
471	IF D = K THEN GOTO 491	1036	IF N = 160 AND H(H) = 74 OR N = 172 AND H(H) = 74 THEN LET N = N - 2	2005	IF X < 3 THEN RETURN
472	GOSUB 2000	1040	LET N = N + H(H)	2010	LET X = 0
490	NEXT D	1045	POKE 16581,N	2015	LET Z = Z + 1
491	SLOW	1050	LET N = USR 16567	2020	SCROLL
495	PRINT AT 0,0;	1055	PRINT N\$(1);	2025	SCROLL
496	IF INKEY\$ = "E" THEN GOTO 136	1057	IF H(H) = 78 THEN PRINT "+";	2030	PRINT Z; "[3 SPC]";
500	IF INKEY\$ = "P" THEN GOTO 200	1058	IF H(H) = 76 THEN PRINT "=";	2035	RETURN
501	IF INKEY\$ = "L" THEN GOTO 350	1059	IF H(H) = 74 THEN PRINT "-"		
505	GOTO 496	1060	IF LEN N\$ = 2 THEN LET H = CODE N\$(2)		
510	PRINT "REPEAT FROM LINE NO.?"	1065	IF LEN N\$ = 3 THEN LET H = CODE N\$(3)		
511	SCROLL	1066	PRINT CHR\$ H; "[3 SPC]";		
515	INPUT C	1067	LET H = H - 28		
516	LET E = D	1070	LET H = H - H - H		
517	FAST	1075	FOR H = H TO -1		
520	FOR C = C TO (Z - 1)	1080	LET N = N/2		
525	LET Q = (C-1) * 6 + 16670	1085	NEXT H		
530	FOR E = E TO E + 5	1086	LET N = N * 2		
531	IF E = 21670 THEN GOTO 200	1090	LET N = INT N		
535	POKE E,PEEK Q	1095	LET H = N/256		
540	LET Q = Q + 1				
545	NEXT E				
550	PRINT "DITTO";				
552	LET X = 2				
555	GOSUB 2000				
560	NEXT C				

Machine code at line 1:-

3E	07	D3	FF	3E	38	D3	F7
21	9C	40	01	08	03	79	D3
FF	0C	5E	7B	D3	F7	23	10
F5	C9	xx	xx	xx	21	B1	40
01	00	06	5E	79	D3	FF	7B
D3	F7	23	0C	10	F5	C9	xx
xx	xx	xx	xx	xx	3E	07	D3
FF	3E	78	D3	F7	3E	0E	D3
FF	01	FB	xx	78	04	D3	F7
3E	0F	D3	FF	ED	58	3E	0E
D3	FF	78	D3	F7	3E	0F	D3
FF	ED	50	D5	C1	C9	3E	07
D3	FF	3E	78	D3	F7	06	FE
21	xx	xx	7D	E6	80	6F	3E
0E	D3	FF	78	D3	F7	3E	0F
D3	FF	DB	FB	E6	80	BD	28
05	05	05	18	EA	00	3E	0E
D3	FF	04	78	D3	F7	3E	0F
D3	FF	DB	FB	BC	20	E9	05
48	06	00	C9				

Approximately 5,000 memory positions are reserved here for music.

## HOW IT WORKS — MUSIC PROGRAM

Array H is a one-dimensional seven-position array which is used to keep a record of whether each note A - G is natural, sharp or flat. Lines 5 to 20 load the value for natural (76) into each position of array H. Lines 25 to 35, depending on the answer typed in, make the computer jump accordingly or continue from line 36. Lines 36 to 51 clear the memory space set aside for music by POKING the stop code 255 to each memory location reserved. In conjunction with the BASIC subroutine at lines 1150 to 1195, lines 55 to 110 set the initial key signature by making the value of the appropriate position of H equal 78 for sharps and 74 for flats. Lines 137 to 142 make Z equal to the current line number for entering and editing music. Variable X is used to keep a record of which channel note you are currently entering. Line 144 sets up a loop using D where D starts with the address of the memory space corresponding to line number (Z) and ends with the value 21670, which is the last available music space. Line 149 calls the BASIC subroutine at line 1000. This subroutine inputs a key-press or series of key-presses which will either be note data, silence or one of the five available functions: REPEAT (R), BACKSPACE (S), PLAY (P), LIST (L) or EDIT (E). If silence or one of the functions is entered the computer returns to line 150.

If note data was entered the computer continues at line 1002 with a check that the data entered was in fact valid note data. Line 1009 makes variable H equal to the code of the note entered minus 37. If the data entered does not contain an appending sharp, flat or natural sign, line 1010 makes the computer jump to line 1030. Lines 1015 to 1025 adjust array H accordingly (sharp, flat or natural) depending on the second character of N\$ (ie N\$(2)). Lines 1030 to 1040 load the variable N with the code of the note entered (ie N\$(1)) and adjust this value together with corrective maths depending on the note (sharp, flat or natural) stored in array H to provide the address of the basic note data in the pre-programmed PROM. Lines 1045 to 1050 POKE this data to memory position 16581 and a machine code subroutine based at 16567 returns N with the basic tone period value of this note, ie the lowest octave. Lines 1055 to 1059 print the note and its sign on the screen. Lines 1060 to 1065 make variable H equal to the code of the octave number entered depending on whether N\$ is two or three characters long. Line 1066 prints the octave. Lines 1067 to 1075 correct the value of H and set up a loop using H where  $H = H - 1$ . This loop is used to divide the basic data in N by 2 (this has the effect of raising the note one octave each time N is divided by 2) until the correct tone period data is obtained. Line 1086 corrects the tone period value of N, otherwise it would be one octave too high. Lines 1095 to 1110 set H to equal the most significant byte of the note and N to equal the least significant byte.

Line 115 returns the computer from this subroutine at line 1001 because:-  
1) BACKSPACE function (S) was entered; it runs through lines 151 to 154 adjusting the values of Z, D and X to effect a backspace. Lines 155 to 157 check to see if the computer was returned with functions R, E or P and if so, it jumps

accordingly.

2) If 0 was entered, the computer runs through lines 159 to 162 entering silence in the current note position and printing spaces in that note position on the screen.

3) If L was entered, the computer jumps to line 350 to list data.

4) If P was entered, the computer jumps to line 200 to play the music.

5) If E was entered, the computer goes back to line 136 to restart the edit function.

6) If R was entered, the computer jumps to line 510.

7) If note data was entered, the computer runs through lines 164 and 165 which POKE the tone period data in the current memory position.

Line 170 calls a BASIC subroutine located at 2000. This subroutine simply checks whether or not the data just dealt with was the third note of a chord, and if so, scrolls the screen up two lines and prints a new line number before returning. Line 185 causes the computer to loop back to line 144 ready to enter the next string of music data. If all the available memory space were taken up, the computer would fall through line 185 and actuate the section of the program which plays music from line 200.

Had the R function returned the computer from the subroutine at 1002 the computer would have jumped to line 510 which puts the question FROM CHORD NO. ? Lines 511 to 565 perform a block copy of the lines specified and adjust the display accordingly. Lines 200 to 210 ask whether you want to set channel volumes, or edit or list. If the answer is E the computer jumps back to the EDIT program at line 136; if L is entered the computer jumps to the LIST program at line 350; if you didn't want to set the volumes so that the answer was N, the computer jumps to line 265. Lines 215 to 260 input volumes for the three channels A, B and C and POKE the volumes required to memory locations 16540, 16541 and 16542 respectively. Lines 265 to 270 input the value of the pause used in line 296 to regulate the speed at which music is played. Line 276 sets D to the address of the first memory position containing music data. Line 280 calls a machine code subroutine based at line 16514 which initialises the PSG for three channels of sound. This subroutine programs the PSG with the volumes held in memory locations 16540 to 16542. Line 282 checks the current music memory position for the STOP code (255) and if this position equals 255 it identifies this as the end of the music, and the computer jumps to 299. Lines 283 to 294 POKE to memory positions 16561 to 16566 the six bytes of tone period data for the next chord to be played.

It may be thought that memory space could have been saved by making lines 283 to 294 a loop. This proved, however, to have an unacceptable slowing effect on the maximum speed available (ie 0). Line 295 calls a machine code subroutine which relays the data in memory position 16561 to 16566 to the PSG, thus producing the next chord. Line 296 is the pause regulating the speed using the variable S and, since this program section is run in the FAST mode, line 297 POKES Sinclair's obligatory 255 to memory position 16437. Line 298 causes the computer to jump back to line 282 to

continue with the next chord. As we have seen, when the end of the music is reached, the computer jumps to line 299. Lines 299 to 307 load the silence value 0 to memory positions 16561 through 16566 and line 310 outputs this last set of data to the PSG using the above-mentioned machine code subroutine located at 16543. Line 315 then causes the computer to jump back to line 200.

The LIST (L) function starts at line 350. Lines 351 to 365 input and print the line number that is being listed which is held in variable Z. Variable X is used to keep a record of which channel data is being calculated. Line 371 sets the variable K to the memory address of the last note data to be listed in one full screen (providing a STOP code 255 is not encountered first). Line 372 sets variable D up in a loop, where D starts with the value of the first music location to be listed and thereafter holds the current memory position of data being calculated. Variable Y is used to keep a record of the octave as it is being calculated in lines 395 to 405. Lines 380 to 385 set variables L and M to the value of the data for the current note being listed. Lines 386 and 387 check for the STOP code 255 in variables L and M, and if it is detected the computer prints STOP and jumps to line 491. Lines 388 and 389 check for silence (0) and if detected the computer prints spaces and then jumps to line 470. Line 390 sets variable L to the value of the complete tone period. Lines 395 to 405 calculate the octave in Y by multiplying the value of L by 2 until it is within range of the basic octave values (ie greater than or equal to 1966).

Lines 410 to 425 reconstitute this new data into variables L and M. At this point the number held in L and M will be the same as a number in the basic octave of notes in the pre-programmed PROM. Lines 430 to 435 POKE this data to memory positions 16619 and 16620. Line 440 calls up a machine code subroutine which returns with L set to the memory position of the PROM where the note data POKED in lines 430 and 435 is to be found. Lines 445 to 455 reconstitute the value of L in variable M so that M contains the Sinclair code for the correct note A to G. Line 456 runs a check on variable M, so that if  $M = 37$  (ie G sharp) the computer, rather than printing 9, prints G (code 44). Line 460 prints the note thus calculated. Line 465 checks the value of L to see if it is a whole number. If it is not, due to the maths in lines 445 to 455, the note will be a sharp and line 465 prints + (sharp). Line 466 likewise checks to see if L is a whole number, and if it is, prints the sign for natural (=). Line 467 checks for the note being G sharp and corrects the octave value in Y accordingly. Lines 468 to 470 print the octave and the next three spaces. When a screen-full of data has been listed, D will equal K. Line 471 checks for this and if  $D = K$  the computer jumps to line 491. As with the EDIT function (E), the LIST function uses the subroutine at line 2000 to keep the VDU display correct. When it has finished listing music the computer continues at line 491. At lines 495 to 505 the computer waits for a further command EDIT (E), PLAY (P) or LIST (L), and jumps accordingly.

# PROJECT: ZX81 Music Board



THIS BAR SHOULD BE ENTERED AS FOLLOWS

LINE No.	Ch1	Ch2	Ch3
1	E4 NEWLINE	0 NEWLINE	0 NEWLINE
2	C5 NEWLINE	0 NEWLINE	0 NEWLINE
3	C5 NEWLINE	0 NEWLINE	0 NEWLINE
4	E4 NEWLINE	0 NEWLINE	0 NEWLINE
5	C5 NEWLINE	0 NEWLINE	0 NEWLINE
6	C5 NEWLINE	0 NEWLINE	0 NEWLINE
7	E4 NEWLINE	0 NEWLINE	0 NEWLINE
8	C5 NEWLINE	0 NEWLINE	0 NEWLINE

Fig. 2 Calculation of the number of lines in a bar.

'line' of computer music is a note (or silence) entered in each of the three channels A, B and C. Channels A and B are played through one audio output and C through the other if a stereo amplifier is used.

When copying music you must find the shortest note in the score: longer notes must be converted to the equivalent multiple of the shortest note to find the number of computer 'lines' in a bar (see Fig. 2). Notes 1, 3, 5 and 6 in the example are half the length of notes 2 and 4. The total number of computer 'lines' in the bar is therefore 8.

A note repeated on the same channel will sound as one continuous note. If the notes are to sound distinct, you must change from one channel to another (see Fig. 3).

Let us go back to our instruction **1 NEWLINE**.

The computer is now displaying 1 at the bottom left-hand corner of the screen. It is waiting for notes to be entered in channels A, B and C. Supposing you wish to enter A below middle C in channel A, silence in channel B, and E below middle C in channel C. Type:-

```
A4 NEWLINE
0 NEWLINE
E3 NEWLINE
```

The computer now displays on the screen:-

```
1 A = 4           E = 3
2
```

It is now waiting for the second 'line' of music.

Supposing the key signature has been set as 2 sharps (F and C) and the following is now entered:-

```
C4 NEWLINE
A3 NEWLINE
F3 NEWLINE
```

The computer now displays on the screen:-

```
1 A = 4           E = 3
2 C + 4         A = 3     F + 3
3
```

The computer has automatically made F and C into sharps, and is now waiting for 'line' 3 of music. If you now want to make C and F natural, type:-

```
C = 4 NEWLINE
A3 NEWLINE
F = 3 NEWLINE
```

The computer now displays on the screen:-

```
1 A = 4           E = 3
2 C + 4         A = 3     F + 3
3 C = 4         A = 3     F = 3
4
```

The computer is waiting for 'line' 4 of music. The same procedure applies, of course, for changing notes from flat to natural and vice-versa.

The **BACKSPACE** function enables you to backspace as required from any point in the music. The instruction is:- **5 NEWLINE**.

The **REPEAT** function allows the repetition of line(s) from the line specified to the line you have reached. Instruction:- **R NEWLINE**.

The computer will ask:- **FROM CHORD NO.**

Type in the line number from which you wish to repeat, followed by **NEWLINE**.

The computer will now repeat the line(s) requested.

**PLAYING** of music is effected through the instruction:- **P NEWLINE**

Wait for the screen to clear. The computer will now print:- **SET VOLUMES (Y OR N) OR EDIT (E) OR LIST (L)?**

If you want to play the music and have not already set the volumes, type **Y**.

The computer now prints:- **A =** Volumes range from 0 (silence) to 15 (loudest).

Type in the volume you require for channel A, followed by **NEWLINE**.

The computer repeats the question for channel B, and when dealt with, C. It will then print:- **SPEED?**

Speeds vary from 0 (fastest) upwards where 50 is approximately one second per computer 'line' or chord. Type in the speed you require, followed by **NEWLINE** and the computer will ask **PLAY FROM LINE NO. ?**

This question is answered by typing in the line number you wish the computer to start playing from. To start at the beginning type **1** followed by **NEWLINE**: the computer will now play the music you have entered.

When the music ends, the computer will ask:- **SET VOLUMES (Y OR N) OR EDIT (E) OR LIST (L)?**



LINE No.	Ch1	Ch2	Ch3
1	G4 NEWLINE	0 NEWLINE	0 NEWLINE
2	G4 NEWLINE	0 NEWLINE	0 NEWLINE
3	0 NEWLINE	G4 NEWLINE	0 NEWLINE
4	G4 NEWLINE	0 NEWLINE	0 NEWLINE
5	G4 NEWLINE	0 NEWLINE	0 NEWLINE
6	0 NEWLINE	G4 NEWLINE	0 NEWLINE
7	G4 NEWLINE	0 NEWLINE	0 NEWLINE
8	G4 NEWLINE	0 NEWLINE	0 NEWLINE
9	G4 NEWLINE	0 NEWLINE	0 NEWLINE

Fig. 3 Example of repetitive notes.

If you want to play the music again without changing the volumes, type **N** and the computer asks:- **SPEED?** Enter the speed as before and the music will be played again. If however you wish to change the volumes or one or more channels, type **Y** and proceed as before.

**LISTING** of music entered is effected by typing **L NEWLINE** and the computer will ask:- **LIST FROM LINE NO.** Type in the line you wish to start listing from, followed by **NEWLINE**.

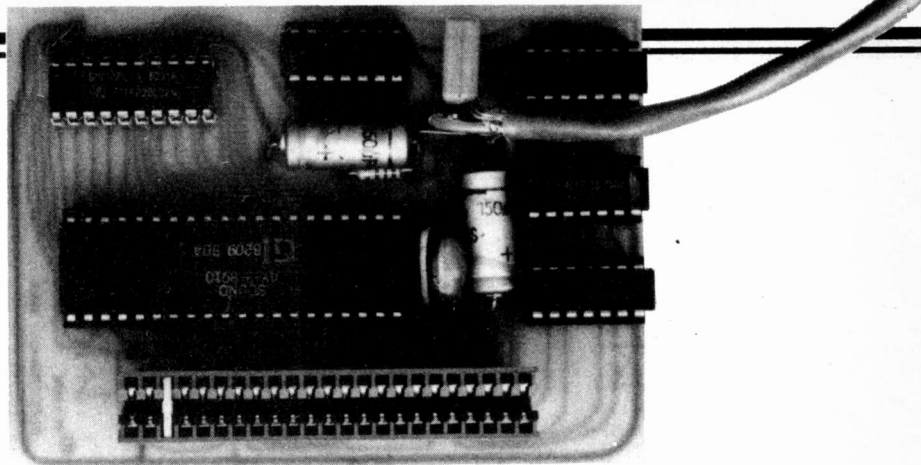
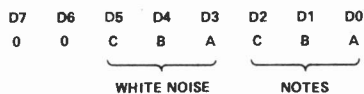
The screen will go grey for about 20 seconds and then the computer will have printed 11 lines of music, starting from the line number you typed. You may now type **P** or **E** or **L** depending on which function you wish to use; to continue listing type **L** and give the line number that would carry on from where the first listing ended; to make alterations to the music or to enter more music, type **E**, and to play the music, type **P**.

## Devising Your Own Sound Effects

The third program on the software cassette effectively gives you direct access to the registers in the PSG. These registers are programmed with data to build up sound effects. The following is a short summary of the registers used and their functions.

Registers 0 to 5 determine the pitch (frequency) of the three notes on channels A, B and C. Registers 0, 2 and 4 are used to fine-tune the frequency of A, B and C respectively. Registers 1, 3 and 5 coarse-tune the frequencies. Data to the fine tune registers can vary from 0 to 255, and data to the coarse tune registers from 0 to 15. Register 6 can vary from 0 to 31. This sets the pitch of any white noise to be included. Register 7 is the enable register. Bits D0 to D5 enable noise and/or sound on channels A, B and C. 0 in a bit of





**Fig. 4** The functions of the bits in PSG register 7.

this register enables a function, 1 disables it (see Fig. 4). Registers 8, 9 and 10 set the volumes of channels A, B and C respectively. These can vary from 0 (off) to 15 (loudest). If you send the number 16 to any of these registers, the volume of channels thus set will be varied according to data in registers 11, 12 and 13, the envelope generator, as follows. Register 11 is used to fine-tune the envelope period; data sent to this register can vary from 0 to 255. Register 12 is used to coarse-tune the envelope period and data to this register can also vary from 0 to 255. Register 13 selects the shape of the envelope generator's waveform (Fig. 5).

Now, connect up your amplifier, keeping the volume fairly low, and load the third program ("D") from the software cassette. Type **GOTO 2 NEWLINE**. The computer will now print:-  
**YOU HAVE A CHOICE OF:**  
**A (TO HEAR THE SOUND AGAIN)**  
**R (TO ENTER ALL NEW DATA)**  
**C (TO CHANGE SPECIFIC DATA)**  
**L (TO LIST DATA)**  
**S (TO SILENCE THE PSG)**

Since you have not yet entered any data, type **R**. The screen will clear and the computer now prints:-

**REGISTER 0 DATA?**  
 Type in **0** as the data for register 0, followed by **NEWLINE**. The computer will respond:-  
**REGISTER 1 DATA?**  
 Type in **0** as the data for register 1, followed by **NEWLINE**. The computer will continue to request data for all registers in this manner. As an example, give it the following:-

Reg. 0 1 2 3 4 5 6 7 8 9 10 11-12 13

Data  
 0 0 0 0 0 31 7 16 16 16 255 40 9  
 If you examine the data you have just entered, you will see how the computer generated the sound of cannon fire. This data for cannon fire is contained in the PROM. The computer now repeats the question at the beginning of the program. If you type **A**, the computer will repeat the sound and will again ask the same question.

Now type **C**. The computer will respond with:- **REGISTER?**

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Type **6 NEWLINE**. The computer will now ask:- **DATA?**  
 Type **8 NEWLINE**. In response to the next question **REGISTER?** type **12 NEWLINE** and in response to **DATA?** type **5 NEWLINE**. Now type **99 NEWLINE**. You have just changed the data in the computer to generate a rifle shot. If you now type **L** the computer will list the data for you. You can silence a continuous sound by entering 0 into all register locations. Since doing this would wipe out your sound data, the function **S** for silence is included which will switch the sound off without altering your data. If you wish to start the sound again, type **A**.

When you have perfected your sound, use the **LIST** function and copy out the data. You can use your own sounds in your own programs using the fourth program ("G") on the software cassette.

**Mixing User And PROM Effects**

Having loaded program "G", type **GOTO 10 NEWLINE**. This runs a short program which simplifies the entering of your sound data. The computer asks **HOW MANY SOUNDS?** Type in the number of different sounds of your own that you wish to include in your program, followed by **NEWLINE**. The computer display will now look like this:-

**HOW MANY SOUNDS?**  
**SOUND No. 1**  
**REG.0 DATA?**

Type in the data for register 0 in your first sound followed by **NEWLINE**. The display will now read:-

**HOW MANY SOUNDS?**  
**SOUND No. 1**  
**REG.1 DATA?**

Type in the data for register 1, sound 1 as before. When you have entered data for all 14 registers, the display will read:-

**HOW MANY SOUNDS? SOUND No.2 REG.0 DATA?**

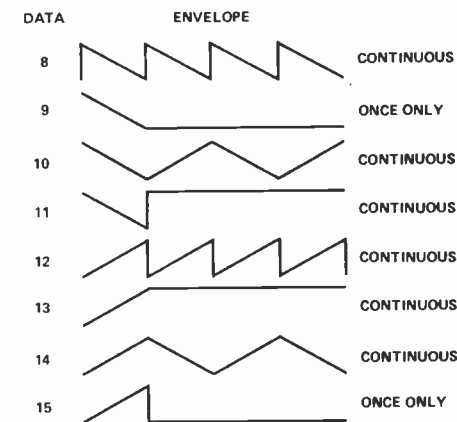
Continue entering data as before. When all the data for all your sounds has been entered the program will stop.

The user sound data is held in an array called **A**; in order not to lose this data do *not* use **CLEAR** or **RUN**. When you wish to run a program use the **GOTO** function. Do not use an array called **A** in your program and don't use variables **Y** and **Z**.

The fourth program consists of lines 1 to 9 and 10 through 21. **DO NOT ALTER LINES 1 through 9**, though if you wish, when you have entered your sound data, you can delete lines 10 through 21. When you wish to use your own sounds in your program simply insert the following two lines:-

**LET Z = x**  
 where x is the number of your sound,  
**GOSUB 2**

when your sound will be heard. You can of course mix your own sounds with the on-board sounds in your programs. Use the on-board sounds in the manner previously described — it is not necessary to load program "S" to do this if you have loaded program "G".



**Fig. 5** Envelope diagram for register 13.

# PROJECT: ZX81 Music Board

## HOW IT WORKS — USER EFFECTS

Line 2 dimensions a one dimensional array with 14 positions called A. This array is used to hold the data for the sound effects you are devising. Line 4 makes the computer jump to 200 where it is instructed to print the selection menu. Line 225 makes the computer jump to line 60. Lines 60 to 75 wait for an answer to this question and the computer jumps accordingly. If the function selected was R the computer jumps to line 5. Line 6 sets up a loop using variable D where D = 1 to 14. Line 10 prints the current register number which is held in D and asks what data you wish to go to that register. Lines 15 to 20 input and print the data. Line 25 causes the computer to loop back to line 6 until data for all 14 registers (0 to 13) has been entered. Line 35 again sets up a FOR NEXT loop using D where D equals from 1 to 14 (the PSG register numbers). Line 40 POKEs the register number to memory position 16515 and line 45 POKEs the data for that register to 16519. Line 46 calls a machine code subroutine based at 16514 which outputs to the PSG register (16515) data (16519). Line 50 causes a loop back to line 35 which continues until the data for all 14 registers (0 to 13) has been relayed to the PSG. Line 55 then causes a jump to 200 and a repeat of the initial question.

If the answer to the question at 200 is A, the computer again runs through lines 31 to 55 causing the PSG to repeat the sound. If the answer is C, the computer jumps to line 100. Lines 102 to 110 ask you the number of the register whose data you wish to alter. Line 110 inputs your answer in D and line 111 checks to see if your answer was 99, which would indicate that you had finished altering data for the time being and wished to hear the sound again — in which case the computer would jump to line 30. If your answer was not 99, the computer continues and lines 115 to 125 input and print your new data for the register you gave. Line 130 causes the computer to jump back to line 102 for you to change more data. If your answer

was L, you wished the computer to list register data and it would jump to line 150. At line 155 a loop is again set up using D. Line 160 prints the register number (D-1). Line 165 prints the data for that register. Line 170 causes the computer to loop back to line 160, which it continues to do until data for all 14 registers have been displayed. Line 180 makes the computer wait for you to type F, when it will jump to line 30 and your sound will again be heard. If your answer was S, ie the PSG was maintaining a continuous sound and you wished to silence it without losing your data, the computer would jump to 230. Lines 230 to 234 comprise yet another loop using D to output 0 to all PSG registers causing the PSG to become silent.

NOTE: (5 SPC) MEANS "5 SPACES"

```

1      REM (our machine code)
2      DIM A(14)
3      CLS
4      GOTO 200
5      CLS
6      FOR D = 1 TO 14
10     PRINT "REGISTER";
        D-1;"DATA?";
15     INPUT A(D)
20     PRINT A(D)
25     NEXT D
31     CLS
35     FOR D = 1 TO 14
40     POKE 16515,(D-1)
45     POKE 16519,A(D)
46     RAND USR 16514
50     NEXT D
55     GOTO 200
60     IF INKEY$ = "A" THEN
        GOTO 30
61     IF INKEY$ = "S" THEN
        GOTO 230
65     IF INKEY$ = "R" THEN
        GOTO 5
70     IF INKEY$ = "C" THEN
        GOTO 100
71     IF INKEY$ = "L" THEN
        GOTO 150
75     GOTO 60
100    CLS
101    PRINT "TYPE 99 AS A
    
```

```

REGISTER
NUMBER [5 SPC] WHEN
YOU WISH TO HEAR THE
SOUND."
102    PRINT "WHICH REGISTER?";
110    INPUT D
111    IF D = 99 THEN GOTO 30
112    LET D = D + 1
115    PRINT D - 1; " DATA? ";
120    INPUT A(D)
125    PRINT A(D)
130    GOTO 102
150    CLS
155    FOR D = 1 TO 14
160    PRINT "REGISTER";D - 1,
165    PRINT "DATA ";A(D)
170    NEXT D
175    SLOW
176    PRINT "PRESS ""F"" WHEN
        YOU HAVE FINISHED"
180    IF INKEY$ < >"F" THEN
        GOTO 180
190    GOTO 30
200    PRINT "YOU HAVE A
        CHOICE OF: "" A (TO HEAR
        THE SOUND AGAIN); "" R
        (TO ENTER ALL NEW
        DATA); "" C (TO CHANGE
        SPECIFIC DATA); "" L (TO
        LIST DATA); "" S (TO
        SILENCE THE P.S.G.)"
225    GOTO 60
230    FOR D = 1 TO 14
231    POKE 16515, (D-1)
232    POKE 16519,0
233    RAND USR 16514
234    NEXT D
235    CLS
236    GOTO 200
    
```

Machine code in line 1:

```

3E 07 D3 FF 3E 78 D3 F7
21 B4 40 E5 01 FB 0E C5
16 xx 3E 0E D3 FF 7A D3
F7 14 3E 0F D3 FF ED A2
20 F0 C1 E1 16 00 7A D3
FF 5E 7B D3 F7 23 14 10
F5 C9 xx xx xx xx xx
xx xx xx xx xx xx xx
3E xx D3 FF 3E xx D3 F7
C9
    
```

## HOW IT WORKS — USER/PROM SOUNDS PROGRAM

This program comprises a line of machine code, a subroutine at line 2 and a program to facilitate the entering of user sound data. This latter program is from line 10 to line 21. It sets up an array called A whose size depends on the number of different user sounds to be provided for. Lines 13 through 19 comprise a double loop which inputs the user's sound data into the appropriate position of array A.

The subroutine at line 2 is called when a sound, whose data is in array A, is to be heard. As has been explained, variable Z is set to the number of the user's sound. Line 2 sets up a loop using variable Y where Y = 1 to 14. Line 4 POKEs the register number (Y - 1) to memory position 16579 and line 5 POKEs the data for that PSG register which is already in array A(Z,Y) to memory position 16583. Line 6 calls a

machine code subroutine based at 16578. This subroutine outputs the number at memory location 16579 to the PSG to select a register and the number at memory location 16583 to the PSG as data for this register. Line 7 causes the computer to loop back to line 4 until data for all 14 PSG registers has been output. The user can insert instructions 3 FAST and 8 SLOW, but we recommend leaving these out since the operation of a program in FAST mode causes the computer to discontinue maintaining the video display. This would be annoying, especially in games programs.

```

1      REM our machine code
2      FOR Y = 1 to 14
3      POKE 16579, Y - 1
4      POKE 16583, A(Z,Y)
5      RAND USR 16578
6
    
```

```

7      NEXT Y
9      RETURN
10     PRINT "HOW MANY
        SOUNDS?"
11     INPUT S
12     DIM A (S,14)
13     FOR N = 1 TO S
14     FOR R = 1 TO 14
15     PRINT AT 1,0;"SOUND
        NO.":N
16     PRINT AT
        2,0;"REG.":"R-1;"" DATA? ""
17     INPUT A(N,R)
18     NEXT R
19     NEXT N
20     CLS
21     STOP
    
```

Machine code at line 1:

```

3E xx D3 FF 3E xx D3 F7
C9
    
```

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 Rin 30K  
 Vs max  $\pm$  70V



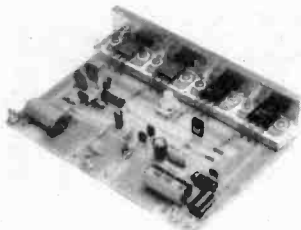
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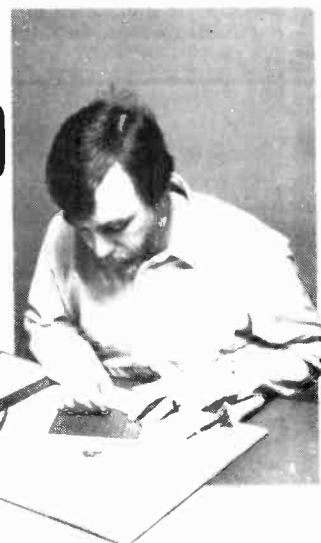
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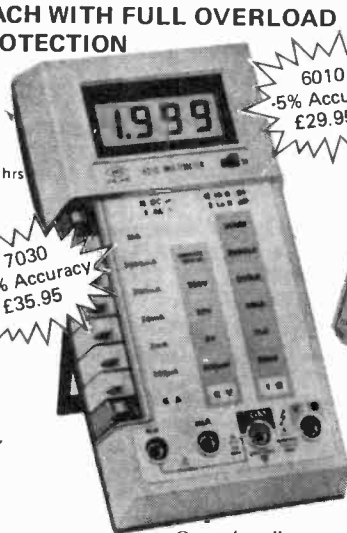
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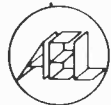
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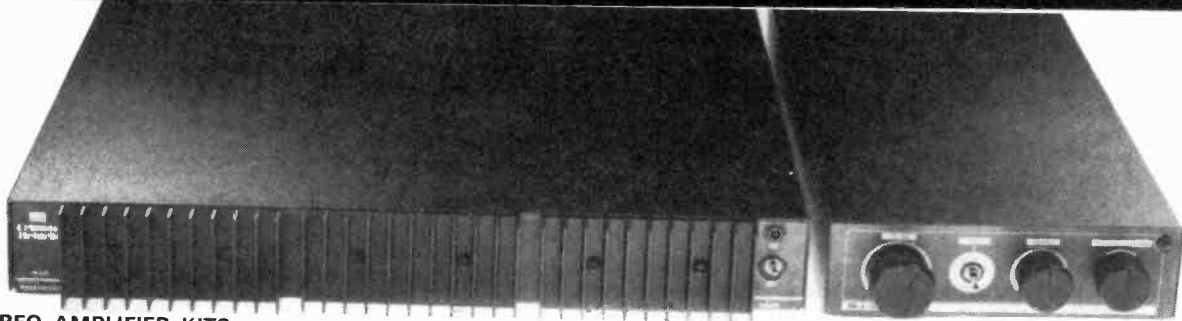
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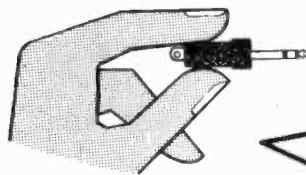
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# CONFIGURATIONS

And so to solid state switches. In this month's Configurations Ian Sinclair looks at the basic techniques involving the thyristor and its close relatives.

As a component, the thyristor is so closely related to the diode that thyristor circuits just had to follow the treatment of power supplies last month. Technically, the thyristor is a four-layer diode, but as far as we are concerned, it's a silicon diode that is switched into conduction by a signal at a third electrode, the **gate**, as shown in Fig. 1. In many respects, however, the action is very much that of a normal silicon diode; for example, it will not conduct in the reverse direction (cathode positive), and it has about 0V6 forward drop across the anode-cathode terminal when it conducts. The distinguishing feature is that the start of forward conduction only occurs when a **trigger** pulse arrives at the gate and **fires** the thyristor. Whatever you subsequently do to the gate, the thyristor will continue to conduct until the forward current falls below a value known as the **holding current**, at which point the thyristor will turn off. However, while the thyristor is on, it is as fully conducting as a silicon diode would be.

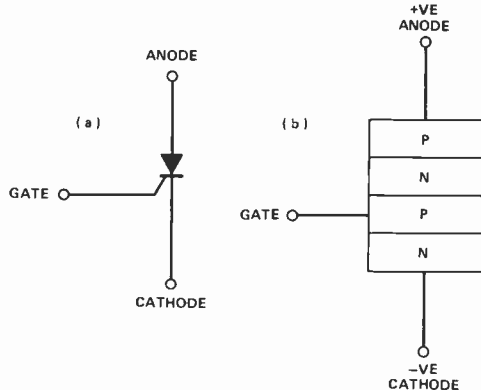


Fig. 1 The thyristor: (a) circuit symbol, (b) arrangement of semiconductor layers.

## Triggers Fingered

One point that is not always sufficiently understood is that the triggering requirements can vary enormously from one type of thyristor to another. A lot of small thyristors will trigger for a gate current of only a fraction of a microamp, so that interference signals will trigger the thyristor if the gate terminal is not 'earthed' to the cathode by a low-value resistor. A lot of false triggering of burglar alarms seems to be due to thyristor circuits in which the gate has too high a resistance to the cathode, making the gate circuit a very efficient aerial for any radiated energy! Even when quite low resistance values are used, thyristors can trigger in lightning storms or because of static discharges, so that some careful design of the gate circuit and extensive testing is needed if you are in the alarm business. The combination of low resistance and a suppressor ferrite bead placed at the gate terminal helps a lot! Large thyristors need rather more in the way of gate current, but even these can be triggered by a fraction of a milliamp.

Thyristors are most at home in circuits which use DC or unsmoothed (but rectified) AC. The use of rectified AC is particularly popular (Fig. 2) because the thyristor will

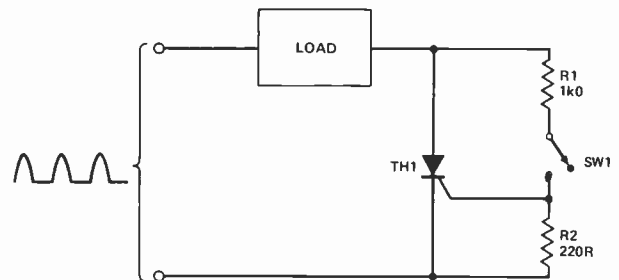


Fig. 2 Elementary switching circuit for use with rectified AC. When the switch is on, current will flow through the load.

switch off each time the supply voltage reaches zero, and all that we need to concentrate our attention on is the triggering which switches it on again. Where a thyristor is used in a DC circuit, there is the extra complication of reducing the voltage across the thyristor to zero in order to switch it off (Fig. 3).

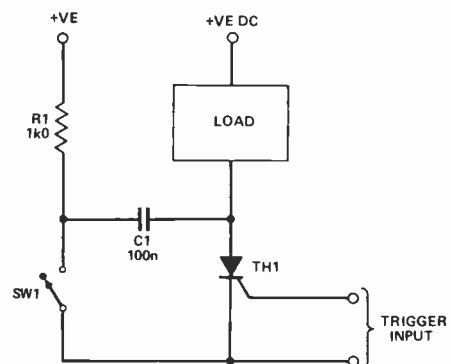


Fig. 3 Turning off a thyristor which is operated from DC. Pressing the switch will discharge the capacitor, pulsing the anode of the thyristor and so stopping the current. This is enough to prevent conduction until the gate is pulsed again.

## A Passing Phase

Down to configurations. The most useful basic triggering circuit is the phase-controlled thyristor fed with rectified AC as illustrated in Fig. 4. The load can be placed in the leads to the bridge rectifier, in which case the thyristor will control the average power dissipated in the load,

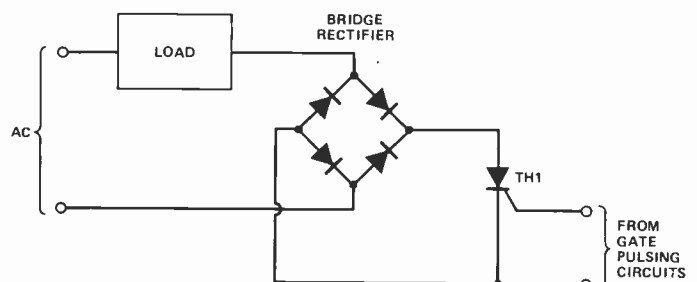
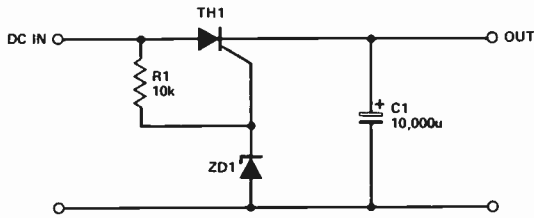
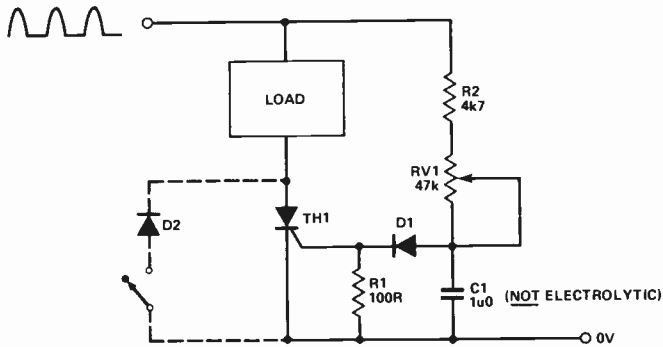


Fig. 4 Basic circuit for thyristor control of an AC circuit, using a bridge rectifier to supply the thyristor. The load, however, operates from AC.



**Fig. 5** A thyristor regulator. This makes a very useful pre-stabiliser circuit, or can be used as a stabiliser in its own right where very precise stabilisation is not needed.

despite the fact that the load is working on AC and the thyristor is controlling a rectified supply. An interesting option is to place a reservoir capacitor on the cathode side of the thyristor, giving a low-cost and low-dissipation form of voltage regulation (Fig. 5). The gate control can be obtained from a charging capacitor, as demonstrated in Fig. 6, or from a zener diode as in Fig. 5 — remember that there is no triggering until the gate voltage is about 0V6 above the cathode voltage.

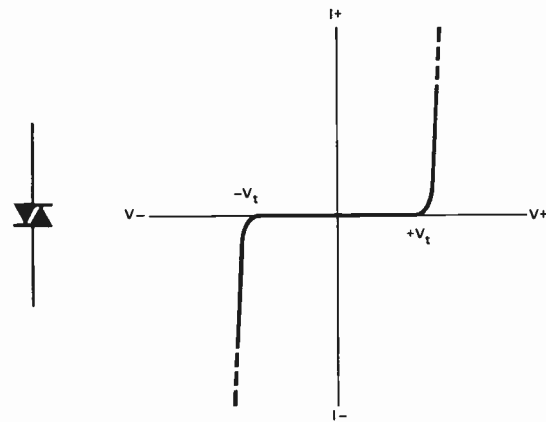


**Fig. 6** A typical phase control circuit for AC. The thyristor will conduct on only half of the input wave, so that a 'power-doubler' circuit, which switches a diode across the thyristor in the reverse conduction direction may be needed for a larger range of power control (shown dotted).

Simple triggering from a charging capacitor is never entirely satisfactory, because the thyristor cannot be relied upon to fire at exactly the same stage of charging in each cycle. To get round this, the simpler circuits make use of a trigger diode or diac which ensures more reliable triggering. The trigger diode has the curious characteristic that it will remain non-conducting while the voltage across it in either direction builds up, suddenly conduct at some voltage level which is determined by its construction, and remain fully conducting until the voltage across it has dropped almost to zero (Fig. 7). A diac wired between a charging capacitor and the gate of the thyristor, with a load of a few hundred ohms connected between the gate and the cathode to avoid unwanted triggering will serve nicely to make the triggering much more reliable. What you then have to be sure of is that you have enough voltage around to operate the diac — depending on type, you may need up to 15 V across it before it starts to conduct.

The very simple phase-control system operates well enough for a lot of applications, particularly for light dimming, but more care is needed where electric motors are being controlled, mainly because of the back-EMF that motors of the AC/DC type will generate. When any motor of this type is spinning, it will act as a generator of DC (even if the supply to the motor is AC), and the thyristor must be capable of withstanding a reverse voltage which consists of the peak reverse AC plus this additional voltage generated by the motor.

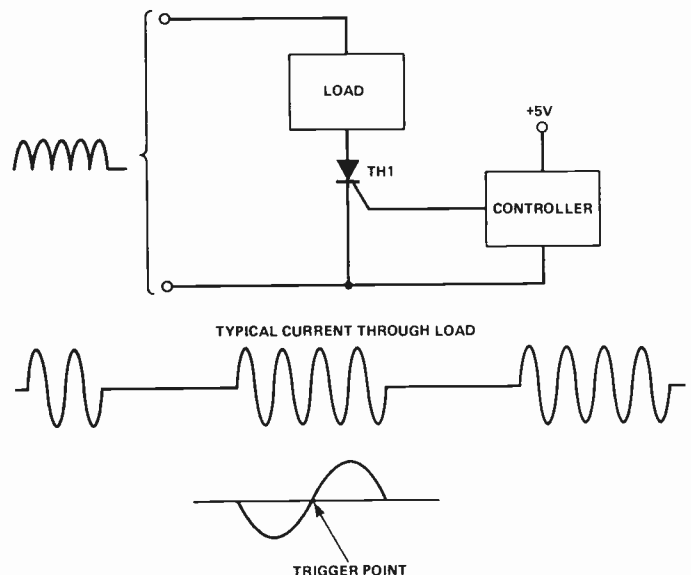
The methods that are used for thyristor control of the



**Fig. 7.** The diac, and its typical characteristic.

larger motors, larger than your domestic power drill/food mixer motor, are a lot more specialised. For these circuits, charging capacitors are simply not precise enough as a method of triggering the thyristor at the correct point in the waveform: more elaborate trigger circuits, synchronised to the mains frequency, have to be used. These pulse-generating circuits can be coupled to the thyristor circuitry by using small pulse transformers, so that the timing circuits need not be connected to the circuits that the thyristor controls. This is particularly important when thyristors are used in high-voltage three-phase circuits, because the thyristors may be operating at voltages well above or below earth, yet the control box needs to be earthed.

Radio interference is a continual problem for any thyristor circuit which makes use of phase control. Because the thyristor is being switched on when there is a substantial voltage across it, there are large current pulses which can be devastating for radio or TV receivers in the neighbourhood and which can also trigger other thyristors. It's essential, therefore, to design really effective pulse-transient suppression into the gate and anode circuits, and to ensure in the practical construction that the suppressors are placed as close as possible to the terminals of each thyristor. In general, small series inductors and



**Fig. 8** Principles of zero-voltage switching circuits. The controller (usually an IC) will switch the thyristor on at the point when the AC wave passes through zero. This ensures minimal RF interference, unlike the phase-control method.

parallel capacitors will do all that is needed, but they have to be capable of taking high peak currents, and must be wired close enough to prevent any wiring from acting as a radiating aerial.

## The Zero Option

The other way of controlling thyristors in energy-control circuits is seen much less in the small-scale circuits that we tend to be more familiar with. This alternative is zero-voltage switching, and it involves switching the thyristors on at the instant when the voltage between anode and cathode is zero. This has the advantage of generating no more interference than a silicon diode would, which is very much less than is generated by the phase-control circuit: but it can be used only with loads like water-heaters which have very long time constants. If you switch your electric drill motor on for 100 ms in each second, the speed will be rather erratic to say the least, but a water or room heater switched in this way does not cause noticeable fluctuations of temperature because the temperature does not shoot up rapidly when the heater is on, nor shoot down when the heater is off. Figure 8 shows an outline of a typical zero-voltage control circuit — there is an IC which can be used to govern the whole operation.

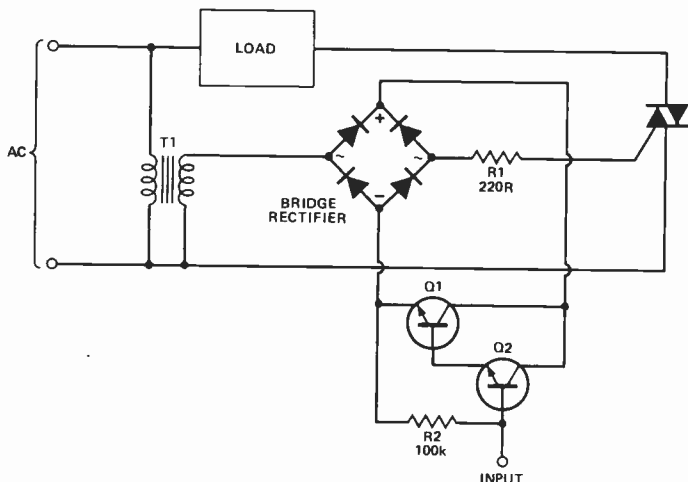


Fig. 9 Using a triac in a circuit where the switching signals are very small. Note that the whole circuit is live to mains.

## For My Next Triac . . .

The triac is a two-way equivalent of the thyristor, with the main circuit terminals labelled MT1 and MT2 rather than anode and cathode, since current can flow in either direction through the triac. Like the thyristor, the triac remains non-conducting until it has been triggered by a pulse at its gate terminal; the pulse can be of either polarity, but the minimum amplitude for firing is not the same for the two possible polarities. Again like the thyristor, the triac ceases to conduct when the current through it becomes too low to sustain conduction. Triacs are extensively used to switch raw AC because a triac circuit

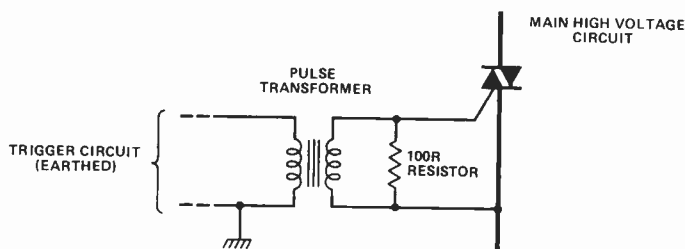


Fig. 10 Isolating the mains part of the circuit from the control part by using a pulse transformer.

represents a considerable saving on components as compared to a small thyristor circuit, even if the equivalent triac is more expensive than two thyristors. Figure 9 shows a typical triac circuit for AC use that can operate using a very small triggering input, such as from a microphone or photocell. The transformer supplies a low voltage for the gate circuit, and the rectifier bridge is arranged so that an unsmoothed full-wave rectified voltage is fed to the transistor amplifier circuit. When the transistor conducts, the current flowing in the bridge rectifier will also flow through the gate of the triac, triggering the triac on each half-cycle. The trigger current is AC because the gate is wired in the AC side of the transformer. Note that the whole circuit is connected to mains — if an isolated low-voltage circuit is needed, then the gate must be triggered by a circuit using a pulse transformer rather than directly as in this example, and the part-circuit shown in Fig. 10 is needed.

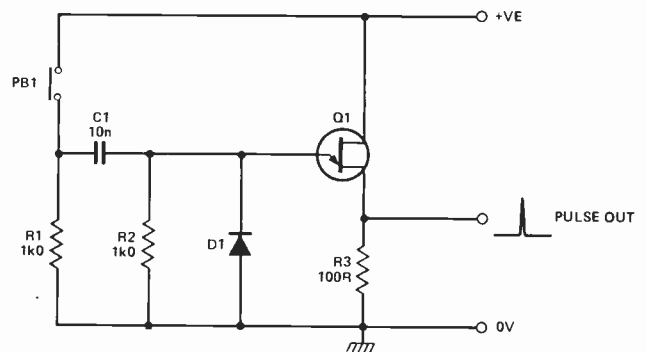


Fig. 11 The unijunction connected to provide a short pulse when a switch is pressed.

Triggering thyristors or triacs via a pulse transformer needs a fairly sharp spike waveform, and one of the devices that has traditionally been used to provide this type of waveform is the unijunction. As the name suggests, this uses one junction on an N-type silicon base whose doping normally ensures that the conductivity is low (resistance high). The junction is placed so as to provide an emitter terminal, and when the emitter voltage is raised to the conducting level, the injection of holes into the bar will make it highly conductive. This is the triggered state, which can be maintained only if a current continues to flow through the emitter. Unijunction circuits are arranged so as to prevent this continuous current, so ensuring a clean sharp pulse.

A unijunction 'one-shot' pulse generator is illustrated in Fig. 11. With the switch open, the emitter of the unijunction is earthed, and the device is non-conducting. Closing the switch contacts changes the voltage on one side of the capacitor from earth to the positive supply voltage, and the voltage on the other side will increase similarly, so triggering the unijunction. The conducting unijunction generates a positive-going spike at the earthy end of its circuit, and also charges the capacitor so that the end of the capacitor connected to the emitter is at about earth voltage. This process is very brief, and when the switch opens again, the emitter of the unijunction is protected from negative pulses by a diode.

The triggering voltage for a unijunction is a fixed fraction of the total voltage applied across the main terminals — the fraction is known as the 'intrinsic stand-off ratio', and is usually around 0.6, implying that the device will trigger when the emitter voltage is about 60 per cent of the supply voltage. Because this ratio is fixed, changes in the supply voltage do not make much difference to the frequency of the output.



# TOROIDALS

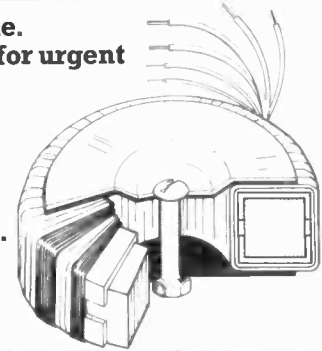
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TYPE	SERIES No	SECONDARY Volts	RMS Current	PRICE	TYPE	SERIES No	SECONDARY Volts	RMS Current	PRICE	TYPE	SERIES No	SECONDARY Volts	RMS Current	PRICE																														
<p><b>NEW!</b> <b>NEW!</b> <b>NEW!</b></p> <p><b>15 VA</b> 0x010 6+6 1.25                  62 x 34mm 0x011 9+9 0.83                  0.35Kg 0x012 12+12 0.63                  Regulation 0x013 15+15 0.50                  19% 0x014 18+18 0.42                  0x015 22+22 0.34                  0x016 25+25 0.30                  0x017 30+30 0.25</p> <p><b>£5.12</b>                  + p &amp; p £0.78                  + VAT £0.89                  TOTAL £6.79</p> <p>(encased in ABS plastic)</p>					<p><b>120 VA</b> 4x010 6+6 10.00                  90 x 40mm 4x011 9+9 6.66                  1.2Kg 4x012 12+12 5.00                  Regulation 4x013 15+15 4.00                  11% 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</p> <p><b>£7.42</b>                  + p &amp; p £1.72                  + VAT £1.37                  TOTAL £10.51</p>					<p><b>300 VA</b> 7x013 15+15 10.00                  110 x 50mm 7x014 18+18 8.33                  2.6Kg 7x015 22+22 6.82                  Regulation 7x016 25+25 6.00                  6% 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</p> <p><b>£10.88</b>                  + p &amp; p £2.05                  + VAT £1.94                  TOTAL £14.87</p>					<p><b>30 VA</b> 1x010 6+6 2.50                  70 x 30mm 1x011 9+9 1.66                  0.45Kg 1x012 12+12 1.25                  Regulation 1x013 15+15 1.00                  18% 1x014 18+18 0.83                  1x015 22+22 0.68                  1x016 25+25 0.60                  1x017 30+30 0.50</p> <p><b>£5.49</b>                  + p &amp; p £1.10                  + VAT £0.99                  TOTAL £7.58</p>					<p><b>160 VA</b> 5x011 9+9 8.89                  110 x 40mm 5x012 12+12 6.66                  1.8Kg 5x013 15+15 5.33                  Regulation 5x014 18+18 4.44                  8% 5x015 22+22 3.63                  5x016 25+25 3.20                  5x017 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</p> <p><b>£8.43</b>                  + p &amp; p £1.72                  + VAT £1.52                  TOTAL £11.67</p>					<p><b>500 VA</b> 8x016 25+25 10.00                  140 x 60mm 8x017 30+30 8.33                  4Kg 8x018 35+35 7.14                  Regulation 8x026 40+40 6.25                  4% 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</p> <p><b>£14.38</b>                  + p &amp; p £2.40                  + VAT £2.52                  TOTAL £19.30</p>					<p><b>50 VA</b> 2x010 6+6 4.16                  80 x 35mm 2x011 9+9 2.77                  0.9Kg 2x012 12+12 2.08                  Regulation 2x013 15+15 1.66                  13% 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</p> <p><b>£6.13</b>                  + p &amp; p £1.35                  + VAT £1.12                  TOTAL £8.60</p>					<p><b>225 VA</b> 6x012 12+12 9.38                  110 x 45mm 6x013 15+15 7.50                  2.2Kg 6x014 18+18 6.25                  Regulation 6x015 22+22 5.11                  7% 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</p> <p><b>£9.81</b>                  + p &amp; p £2.05                  + VAT £1.78                  TOTAL £13.64</p>					<p><b>625 VA</b> 9x017 30+30 10.41                  140 x 75mm 9x018 35+35 8.92                  5Kg 9x026 40+40 7.81                  Regulation 9x025 45+45 6.94                  4% 9x033 50+50 6.25                  9x042 55+55 5.68                  9x028 110 5.68                  9x029 220 2.84                  9x030 240 2.60</p> <p><b>£17.12</b>                  + p &amp; p £2.55                  + VAT £2.95                  TOTAL £22.62</p>				
<p><b>30 VA</b> 1x010 6+6 2.50                  70 x 30mm 1x011 9+9 1.66                  0.45Kg 1x012 12+12 1.25                  Regulation 1x013 15+15 1.00                  18% 1x014 18+18 0.83                  1x015 22+22 0.68                  1x016 25+25 0.60                  1x017 30+30 0.50</p> <p><b>£5.49</b>                  + p &amp; p £1.10                  + VAT £0.99                  TOTAL £7.58</p>					<p><b>160 VA</b> 5x011 9+9 8.89                  110 x 40mm 5x012 12+12 6.66                  1.8Kg 5x013 15+15 5.33                  Regulation 5x014 18+18 4.44                  8% 5x015 22+22 3.63                  5x016 25+25 3.20                  5x017 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</p> <p><b>£8.43</b>                  + p &amp; p £1.72                  + VAT £1.52                  TOTAL £11.67</p>					<p><b>500 VA</b> 8x016 25+25 10.00                  140 x 60mm 8x017 30+30 8.33                  4Kg 8x018 35+35 7.14                  Regulation 8x026 40+40 6.25                  4% 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</p> <p><b>£14.38</b>                  + p &amp; p £2.40                  + VAT £2.52                  TOTAL £19.30</p>					<p><b>50 VA</b> 2x010 6+6 4.16                  80 x 35mm 2x011 9+9 2.77                  0.9Kg 2x012 12+12 2.08                  Regulation 2x013 15+15 1.66                  13% 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</p> <p><b>£6.13</b>                  + p &amp; p £1.35                  + VAT £1.12                  TOTAL £8.60</p>					<p><b>225 VA</b> 6x012 12+12 9.38                  110 x 45mm 6x013 15+15 7.50                  2.2Kg 6x014 18+18 6.25                  Regulation 6x015 22+22 5.11                  7% 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</p> <p><b>£9.81</b>                  + p &amp; p £2.05                  + VAT £1.78                  TOTAL £13.64</p>					<p><b>625 VA</b> 9x017 30+30 10.41                  140 x 75mm 9x018 35+35 8.92                  5Kg 9x026 40+40 7.81                  Regulation 9x025 45+45 6.94                  4% 9x033 50+50 6.25                  9x042 55+55 5.68                  9x028 110 5.68                  9x029 220 2.84                  9x030 240 2.60</p> <p><b>£17.12</b>                  + p &amp; p £2.55                  + VAT £2.95                  TOTAL £22.62</p>																			
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# ORGAN PART 4

We conclude this excellent musical project with the constructional and setting up details, as well as the pricing for all the various bits and pieces. Design by Richard Watts.

**B**efore starting on the construction details for the organ, there is one section of circuitry remaining that needs to be explained — that of the swell pedal and glide control. Figure 2 in the February article contains the circuitry in question. The swell pedal performs the function of volume control for the whole organ and acts upon the signal which is output from the main mixer to the power amplifier. It operates by using an LDR (light dependent resistor), which is connected between ground and the signal line and which has a 12 V MES bulb mounted facing it. As the swell pedal is moved up and down, an optical filter is moved in the light path, allowing more or less light to reach the LDR and thus altering its resistance. This method of control is far superior to using potentiometers, which go noisy with age and wear and can produce fearful noises when connected to an amplifier input. The light operation ensures noise-free performance.

Attached to the side of the swell pedal is the glide switch. When operated, this switch causes the organ tuning to go flat by a semitone; when released, it allows it to slowly return to its original state. This effect is useful on all the voices and brings particular realism to those such as Hawaiian guitar and trombone.

When operated, the glide switch grounds the junction of D13 and D14: this discharges C18 through R34 (100R) and results in an immediate reduction in clock frequency, therefore flattening any audio currently being output. When released, the D13/D14 junction is again left open circuit, and C18 is allowed to return to its former state. The rate at which it returns is determined by the value of C18 and the amount by which the tuning is varied is determined by R33. The connection of D13 to the glide switch also causes the vibrato, if

selected, to be disabled by switching off IC8a for the duration of the glide switch operation. This adds to the effect of the glide.

## Construction

The main PCB is screen-printed with the component overlay and should present no constructional problems. A block diagram of the organ showing how all the remaining sections are interconnected to the main board is given in Fig. 1 as a guide to assembly.

The keyboard assembly comes as a complete unit, requiring only the contact assembly to be fitted. The keyboard chassis is fitted with end supports upon which both keyboards may be hinged up to facilitate access to the underside, where the contact assembly (the keyboard PCB) is fitted.

The keyboard is assembled as follows. First install and solder all the 1N4148 diodes with the cathodes (ringed) facing away from the bus bars. Next, with the board trackside up, install and solder all the track pins; one per diode and one per bus bar section. Ensure that the pins are pushed far enough into the PCB — the widest part of the

pin should be in contact with the track. Now, with the board 'diode side up', put a small solder blob on each of the pins just installed — this will help later. Next the Molex connector, through which all connections are made to the contacts and bus bars, is to be fitted and soldered. Install the connector from the component side, leaving the longest part of the pins uppermost, and solder the underside.

Now the bus bars can be fitted in turn as follows. Put two bus bar supports onto each bus bar section as shown in the diagrams and photograph. Use the upper of the two holes in the support. Align the bus bar supports with their locating holes in the PCB and mount the supports. A touch with a hot soldering iron to the protrusion below the board will secure the support; a spot of glue on the top side of the board is an alternative measure but take care not to get glue on the bus bars. Also keep your handling of the bus bars and contacts to a minimum as these are silver compounds and can get tarnished. Now slide the bus bar so that its left-hand end meets its associated pin and solder the bar to the pin. Take care not to use an excess of solder here since solder or flux running along to the contact area of the bus bar will impair the contact surface.

Insert the other 12-key bus bar sections and the 7-key section in the same way as described above. The top C key bus bar, since it handles one key only, has no bus bar support and is soldered directly to its pin at 90°. Check that no section of bus bar is touching any other section and check all joints on the underside of the board, as it is now to be mounted onto the keyboard chassis for insertion of the key contacts.

Insert the keyboard PCB spacers in the underside of the PCB as



The finished organ.

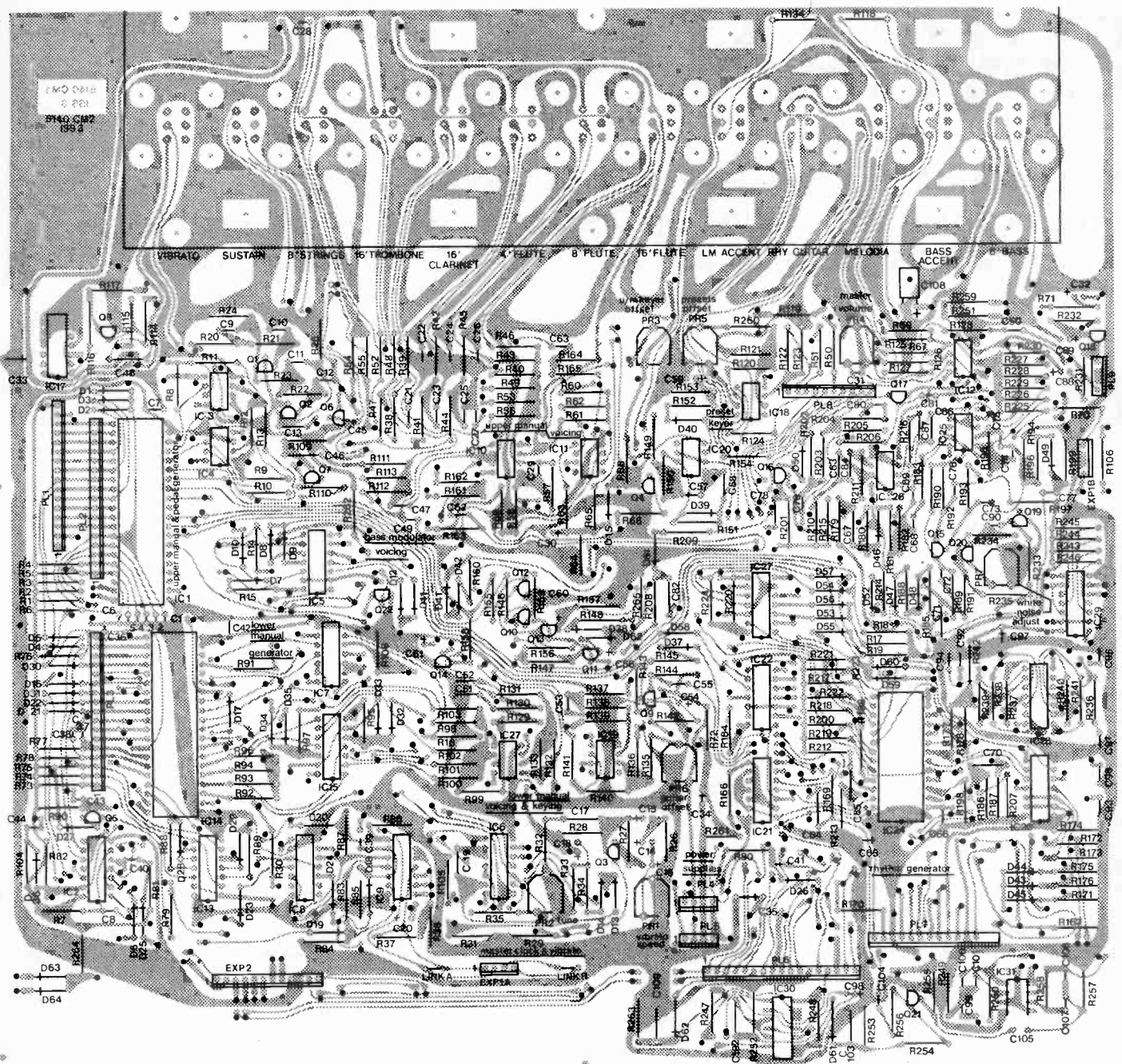


Fig. 2 (Above) The overlay for the main board. This is silk-screened on the finished item.

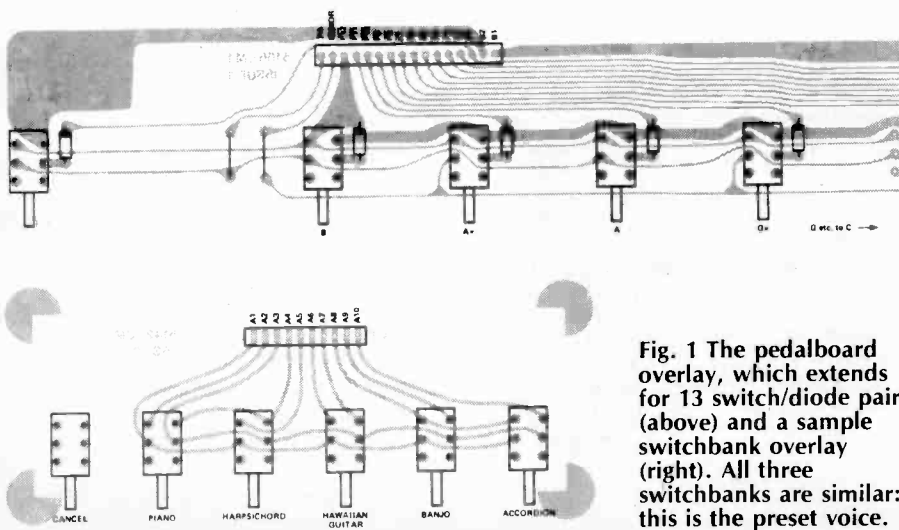
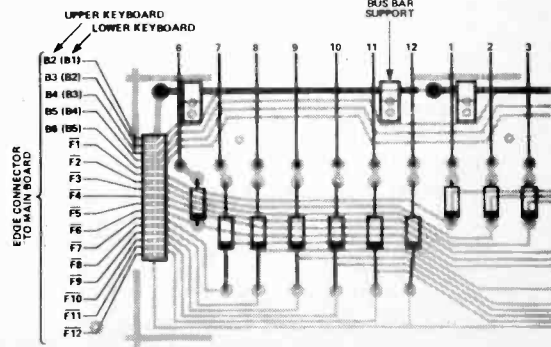


Fig. 1 The pedalboard overlay, which extends for 13 switch/diode pairs, (above) and a sample switchbank overlay (right). All three switchbanks are similar: this is the preset voice.

Fig. 3 (Below) The keyboard overlay.



## PARTS LIST

Resistors (all 1/4W, 5%)  
 R1-6,71,73, 74,76,90, 148 6k8  
 R7,14,16,30,60,63, 67,85,95,97,108, 111-113,126,127 100k  
 135,159,167, 170-176,201, 260,265 15k  
 R8-10,69,164,262 47k  
 R11,28,32,40,50,57, 70,99,105,110,116, 141,180,199,204, 213,225,227,232, 235,243-246,256 22k  
 R12,20-25,36,38,39, 41-46,53,55,68,83, 87,109,115,124,138, 146,147,155,156, 158,162,168,177-179, 181,184,186-188,193, 194,198,200,207-209, 212,214,217-224,226, 228,230,247,264 10k  
 R13,17,19,26,47,49, 54,58,75,77-79,88, 122,129,131,137,161, 165,169 4k7  
 R15,72,206,255,261 1M0  
 R27,80-82,104,144, 151,185,203,205, 254,263 1k0  
 R29,66,91-94,96, 100-103,152,182, 215 2M2  
 R31,37,234 68k  
 R33,130,133,134, 145,153,197 100R  
 R34,210,242 12k  
 R35,89 150k  
 R48,52,62,114,120, 140,251 33k  
 R51,154,229 220k  
 R56,64,84,86,142, 150,157,189,211,233, 236,237,252,259 470R  
 R59,61,121,123, 136,139,166,196 2k2  
 R65,98,106,117,119, 160,192,202,231 27k  
 R118,125 18k  
 R128 1k5  
 R143,163,249,257 820R  
 R149 470k  
 R183,216,253,258 4M7  
 R190 330k  
 R191 270k  
 R238-241 39k  
 R248 820k  
 R250

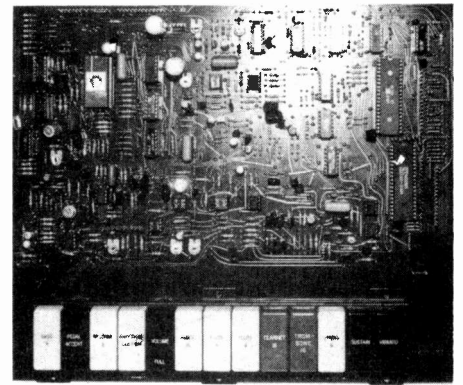
Potentiometers (all miniature horizontal presets)  
 PR1,2 4k7

PR3,5,6 47k  
 PR4 220k  
 PR7 10k

Capacitors  
 C1-6,36-38,43,96 220pF  
 C7,23-26,40-42,44, 62,66,79 47nF  
 C8,28,53,68,69,76, 81,90,91,105 10nF  
 C9,11,21,22,27,39,47, 49,50,55,63,104 22nF  
 C10,12,29,72-75,99 2n2  
 C13,51,52,58,70,71, 78,83,84,86,87,103 100nF  
 C14-16,20,32,45,54, 59,88,89,98 1u0  
 C17,46,48,64,82,85 470nF  
 C18,30,56,60,61 10uF  
 C19 27pF  
 C31 100pF  
 C33,35 1000uF  
 C34,57,65,97 100uF  
 C67,102 220nF  
 C77,80,100,101,106, 107 4n7  
 C92 270pF  
 C93 1n8  
 C94 180pF  
 C95 3n3

Semiconductors  
 IC1 M208  
 IC2,7,8,15 4016B  
 IC3,4,10,12,16,25, 26,31 1458  
 IC5,22,27,30 4001B  
 IC6,21 4069UB  
 IC9 4081B  
 IC11,18,19 3080E  
 IC13 4071B  
 IC14 M108  
 IC17 4013B  
 IC20 555  
 IC23 4025B  
 IC24 M258EP2  
 IC28 40106B  
 IC29 4070B  
 Q1-5,7,8,10-14, 16-22 2N3704  
 Q6,9,15 2N3703  
 D1-61 1N4148  
 ZD1 6V2 400mW zener

Miscellaneous  
 PL1 16-way Molex  
 PL2,3,6 17-way Molex  
 PL4,5,9 4-way Molex  
 EXP1A,EXP1B 12-way Molex  
 PL7,EXP2 10-way Molex  
 PL8 PCB; 13-way rocker tab unit, PCB-mounting.



A picture of the assembled main board.

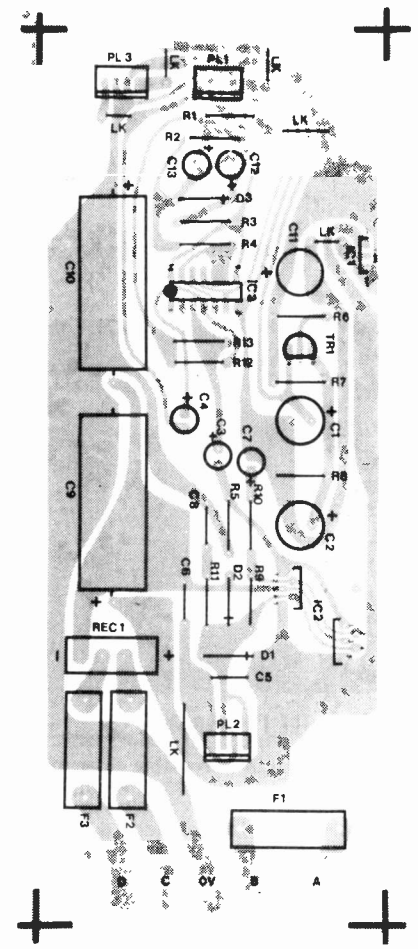
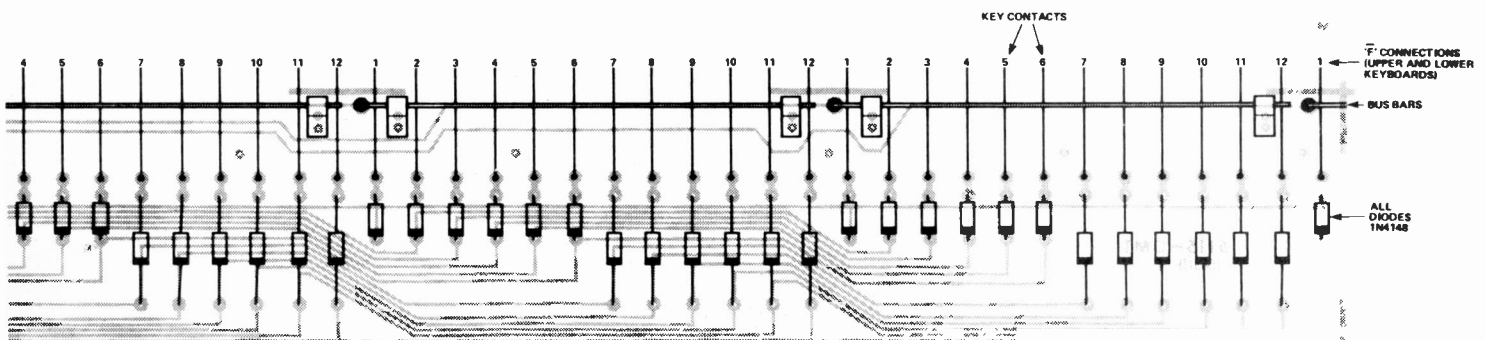


Fig. 4 (Above) The component overlay for the amplifier/power supply.





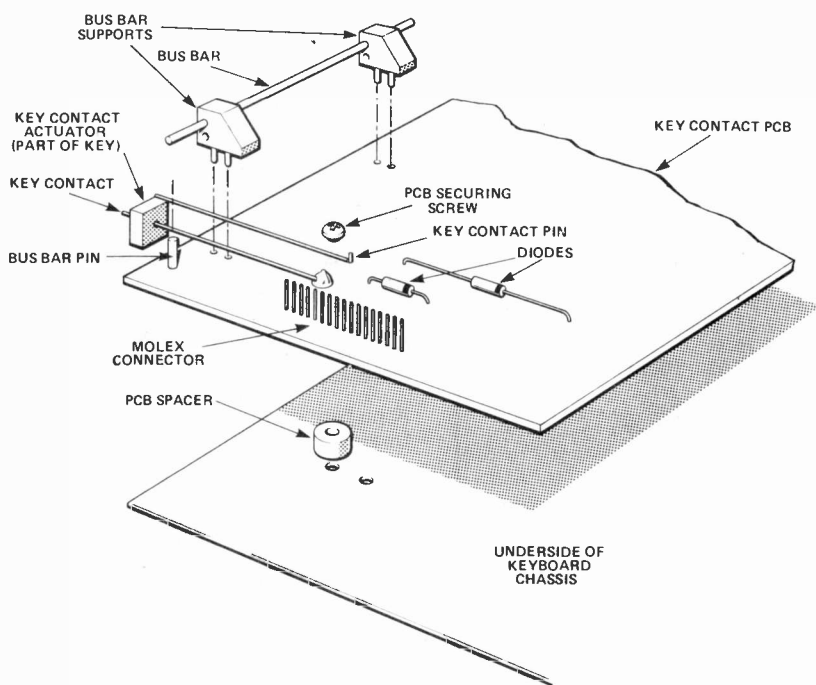
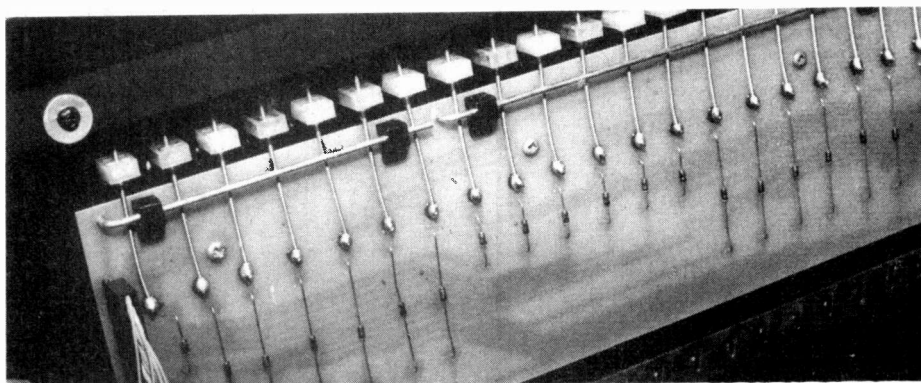
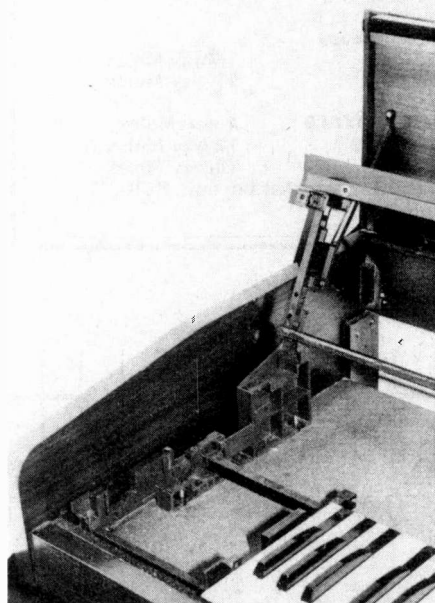


Fig. 5 Diagram showing the keyboard assembly. Compare with the photograph below.



## BUYLINES

The Victory organ is available either as a complete kit or as sub-kits. The sub-kits are as follows: Starter kit (all parts for upper manual organ sounds); £98.80: Presets kit (upper manual preset voices); £14.54: Lower manual and bass kit (the lower manual and bass voices); £71.64: Pedal board kit; £30.84: Rhythm unit kit (includes ROM with programmed rhythm and bass patterns); £24.74: Amp and power supply unit; £36.96: Swell pedal and speakers; £34.54. VAT must be added to all prices. The total for all the sub-kits is £312.06 plus VAT but if the complete Victory kit is ordered at one time the price is reduced to £280.54 plus VAT. If you wish to build the organ in the cabinet shown in the photographs, it costs £143 and is supplied ready assembled with pre-drilled holes for the keyboard assemblies. A demonstration tape is available for £1.70 plus VAT. Carriage on all kits is extra, and individual components may also be ordered: a leaflet from the suppliers contains full details of the prices. Contact Leighton Electronic Services Ltd, 17 Bridge Street, Leighton Buzzard, Beds. LU7 7AH (telephone 0525 382504, telex 826717) for more information.



For easy construction, the keyboards hinge up and lift off.

shown. These will force-fit the holes in the PCB but may be glued or held against the board by using a small amount of Vaseline if the force fit proves difficult. Insert a spacer in each hole. Next, invert the keyboard and support it at the ends. This protects the surface of the keys and also ensures that the black keys are not depressed, as would be the case if the keyboard were just inverted and placed on a surface. It can now be seen that there are two rows of PCB securing holes in the keyboard chassis running along its length. Using the row nearest the front of the keys, lower the contact PCB onto the chassis and secure it with the screws supplied.

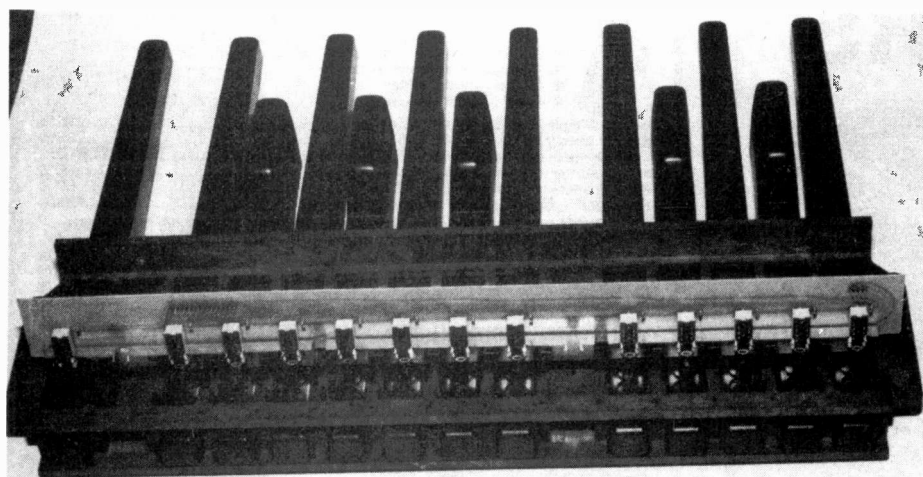
Finally the contacts can be fitted. Place a contact through the hole in the key contact actuator and move the wider end of the contact alongside its associated pin. Position the contact such that any excess length is through the contact's actuator and not at the pin end. Solder the contact to the pin. Repeat with all the contacts. Mechanical noise from the keyboard can be kept to a minimum by the insertion of a small amount of silicon grease or similar lubricant into the key contact actuator prior to the contact insertion.

## Cheeky Comments

The sidecheeks (the bits on the end of the keyboards) are injection mouldings supplied with the correct cut-outs, where required, for the mounting of the various switches and pots. The preset voices, rhythm and automatic function switchbanks are each mounted on a small PCB with a connector, and these assemblies are screwed onto mouldings on the underside of the sidecheek. The push-on button caps are secured to the switches with glue. It should be noted that the 'preset voices' switches have a slightly wider spacing than the other two switchbanks and have correspondingly larger push-buttons: be sure to have the correct ones before using the glue!

The voices/effects switchbank is mounted directly onto the main PCB; it comes complete with coloured and printed switch covers. The complete assembly of board and switchbank is then screwed to its sidecheek. The sidecheeks fit simply onto the keyboard chassis by clipping them in at the front and securing them at the back edge by two screws.

# PROJECT: Organ

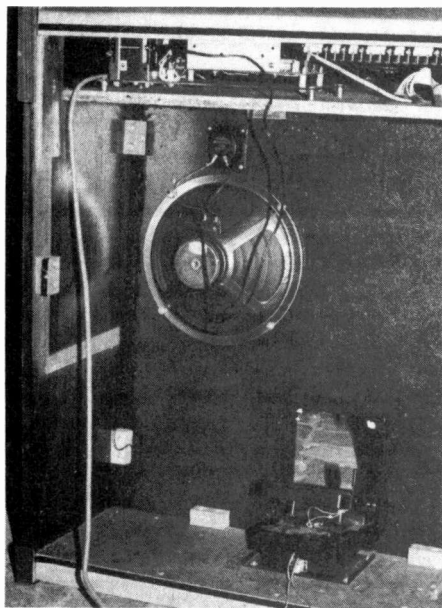


Here you can see the pedalboard PCB mounting arrangement.

All interboard connections are made using ribbon cable and insulation displacement connectors (IDC).

The pedalboard is a complete assembly requiring only the contacts to be fitted. These are in the form of two pole changeover switches (13 in all) which are mounted on a PCB with the associated pedal diodes and connector plug. The switches are then pedaled to the pedalboard and the pedalboard bolted into the cabinet using four bolts (see the photograph).

The swell pedal assembly requires only the wiring of power (+12 V) to the bulb, and the coaxial signal lead from the preamp output to be connected across the LDR. This unit is then secured by four screws through its base plate: these need not be removed for access to the swell pedal as the pedal can be



A view inside the organ cabinet showing the tweeter, and speaker and swell pedal.

slid out from the front of the organ. The single pole glide switch is part of the swell pedal assembly and requires only ground to one contact and the glide circuitry to the other.

The amplifier assembly consists of the chassis, the PCB and the mains transformer. The latter two items are mounted on the former, which is also used as the heatsink for the +12 V regulator and the power amplifier IC. The regulator does not need to be electrically isolated from the chassis as its tab is at ground, but the amplifier IC must be electrically isolated using a mica washer.

The output signal from the amplifier is taken via the headphone socket to the speaker and piezo tweeter. No crossover is necessary with this type of tweeter.

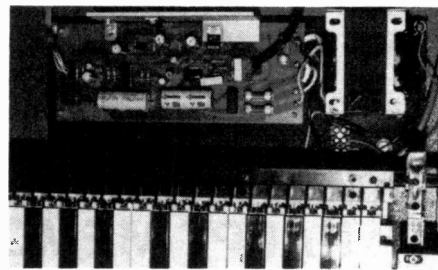
The cabinet to be supplied needs no assembly and readily accepts all the subassemblies described above. It has integral mounting nuts for the bolts that secure the pedalboard assembly and speaker; a cut-out for mounting the tweeter is incorporated, as is a headphone socket mounting hole. The cabinet is finished in real wood veneer and has a removable back and lid for easy access.

## Setting Up

The simplest method of tuning the organ is to select A above middle C (that's the sixteenth note down from the top) on the upper keyboard with 8' flute selected. The frequency of this note should be 440 Hz. It may be adjustable either by using an A tuning fork and listening for beats, or by monitoring pin 1 of IC4a with a scope or frequency counter. The tuning control is PR2. Alternatively, IC6d pin 8 may be monitored for 1000.12 kHz.

The vibrato oscillator frequency is not critical and is usually about 6 Hz. Adjustment is made using PR1 and it may be monitored at the collector of Q3. Alternatively you can select, say, clarinet with vibrator and play individual notes, adjusting PR1 for the most pleasing effect.

The upper keyboard VCA, in common with the other two (preset voices and rhythm guitar), needs to be balanced as the control current envelope does not automatically centre around signal ground. The result of any imbalance on the upper keyboard VCA is to produce an undesirable thump when a key is depressed. So, with no upper keyboard voice selected, depress any upper key and adjust PR3 to one end of its travel. Then, while repeatedly depressing the key, move PR3 through its travel. It will be noted that at the extremes of the preset travel the thump will be



The amplifier/PSU board.

loudest and there will be a point on the preset where it is minimal. The VCA is balanced at this point.

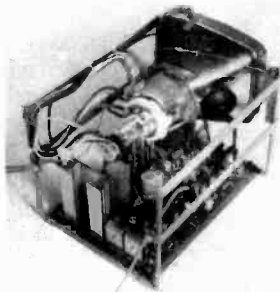
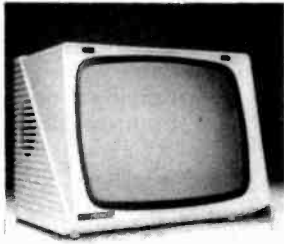
The preset voices VCA is balanced by selecting the banjo voice and playing any upper key. Adjustment of PR5 will eliminate the thump which will occur with the voice at the banjo oscillator rate.

The rhythm guitar VCA can be balanced by using PR6 while the rhythm guitar voice is selected and any rhythm is selected. It is not necessary to play any keys and the task will be made easier by turning the rhythm volume right down and also having the lower manual accent on.

To adjust the noise volume preset (PR7), select swing on the rhythm unit and set the tempo to mid-range. Turn PR7 fully clockwise, then turn it anticlockwise until the white noise tends to sound continuous. Now turn it back slightly until the organ is making the normal sound of a snare drum. PR7 may be further adjusted clockwise to suit individual taste.

Finally, the overall volume of the organ can be adjusted by using PR4.

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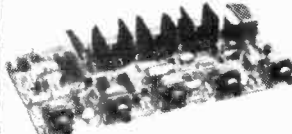
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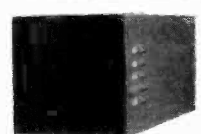
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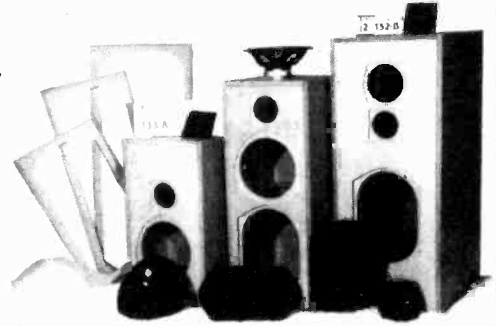
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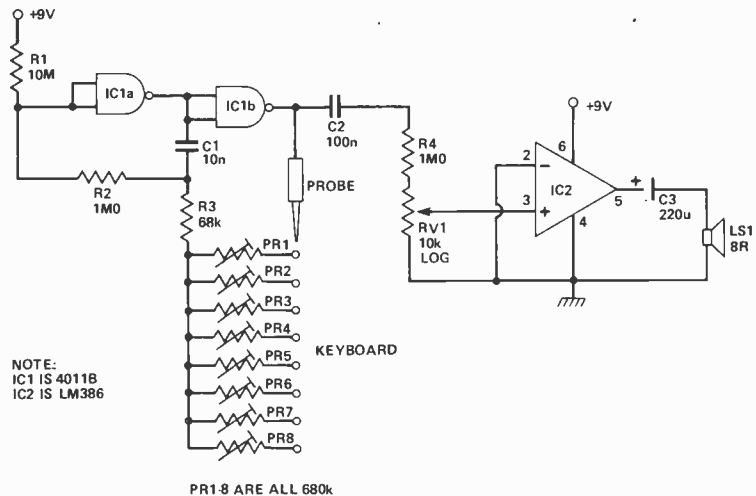
# TECH TIPS

## Simple Organ

J. P. Macaulay, Crawley

With the financial climate being what it is the following circuit may be of interest to harassed parents whose children want a stylophone. A simple oscillator is formed with two CMOS NAND gates (half a 4011B). Under quiescent conditions no sound is emitted. When the stylus is placed on the keyboard the circuit is made through the selected preset and the oscillator produces a square wave which is coupled to the output stage, an LM386. This IC is ideally suited to this application since its maximum output is limited to 200 mW and its quiescent current consumption is 3 mA. This, together with the fact that both ICs will work with battery voltages as low as 4 V, means that a fairly long battery life can be expected.

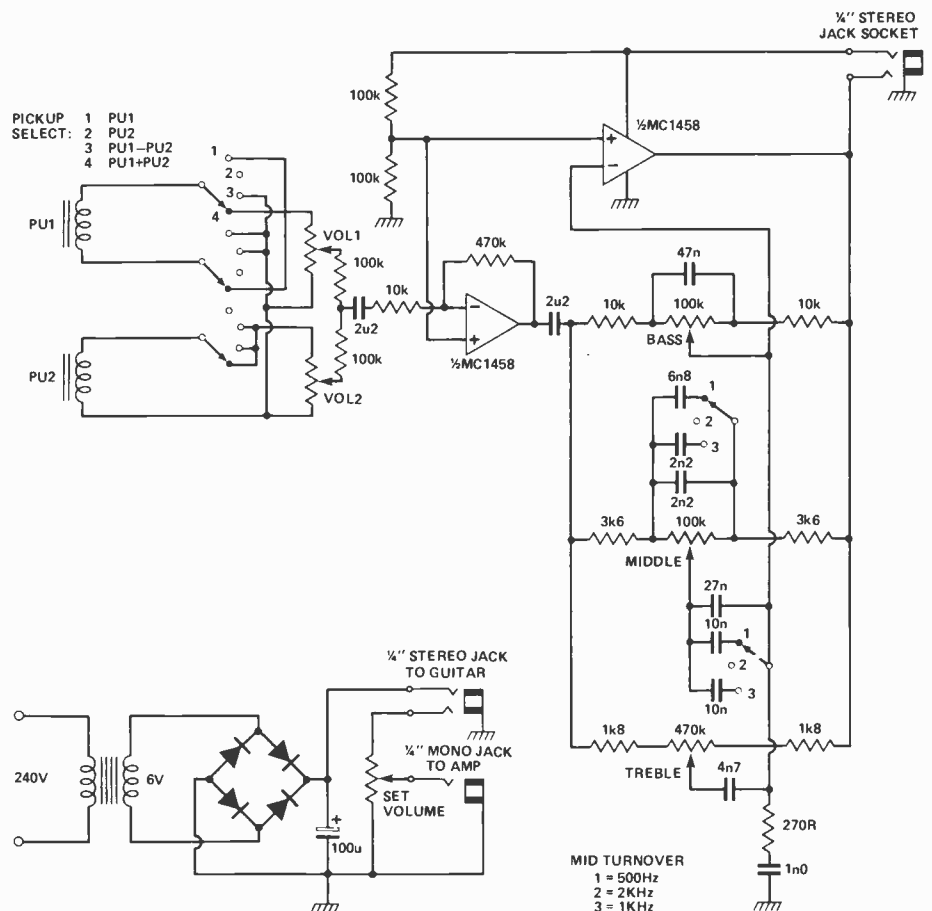
The organ will obviously require some form of keyboard. A simple one can be made from a piece of 0.15" matrix Veroboard with alternate tracks removed. Tuning is most easily done with the aid of a digital frequency meter; if all else fails the instrument can be tuned by ear against a piano.



## Electronic Guitar

Quentin Rice, Mitcham

The circuit shown here was fitted inside a friend's Rickenbacker bass to increase the versatility of the guitar. Its controls are as follows: pickup/phase select, volume 1 and 2, bass, middle and treble tone controls and middle turnover frequency. It has low current consumption and can be used either with a battery, or with the 'phantom' power supply connected to the jack socket. It seems likely that most guitars will feature active circuitry in the future, giving musicians greater flexibility during a live performance.



Tech-Tips is an ideas forum and is not aimed at the beginner. We regret we cannot answer queries on these items. ITI is prepared to consider circuits or ideas submitted by readers for this page. All items used will be paid for at a competitive rate.

Drawings should be as clear as possible and the text should be typed. Text and drawings must be on separate sheets. Circuits must not be subject to copyright. Items for consideration should be sent to ETI TECH-TIPS, Electronics Today International, 145 Charing Cross Road, London WC2H 0EE.

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74LS32	74LS183	120p	7430	BC146	4034	LM324
74LS33	74LS184	120p	7431	BC147	4035	LM332
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74LS38	74LS189	120p	7436	BC152	4040	LM380
74LS39	74LS190	120p	7437	BC153	4041	LM381N
74LS40	74LS191	36p	7438	BC154	4042	LM382
74LS41	74LS192	36p	7439	BC155	4043	LM384
74LS42	74LS193	36p	7440	BC156	4044	LM386
74LS43	74LS194	36p	7441	BC157	4045	LM387
74LS44	74LS195	36p	7442	BC158	4046	LM388
74LS45	74LS196	45p	7443	BC159	4047	LM389
74LS46	74LS197	45p	7444	BC160	4048	LM393
74LS47	74LS198	45p	7445	BC161	4049	LM390
74LS48	74LS199	45p	7446	BC162	4050	LM3909N
74LS49	74LS200	45p	7447	BC163	4051	LM3911
74LS50	74LS201	45p	7448	BC164	4052	LM3914
74LS51	74LS202	45p	7449	BC165	4053	LM3915
74LS52	74LS203	45p	7450	BC166	4054	LM3916
74LS53	74LS204	45p	7451	BC167	4055	LM13600
74LS54	74LS205	45p	7452	BC168	4056	NE531
74LS55	74LS206	45p	7453	BC169	4057	NE544
74LS56	74LS207	45p	7454	BC170	4058	NE565
74LS57	74LS208	45p	7455	BC171	4059	NE566
74LS58	74LS209	45p	7456	BC172	4060	NE564
74LS59	74LS210	45p	7457	BC173	4061	NE565
74LS60	74LS211	45p	7458	BC174	4062	NE566
74LS61	74LS212	45p	7459	BC175	4063	NE567
74LS62	74LS213	45p	7460	BC176	4064	NE571
74LS63	74LS214	45p	7461	BC177	4065	NE592
74LS64	74LS215	45p	7462	BC178	4066	NE534P
74LS65	74LS216	45p	7463	BC179	4067	NE534F
74LS66	74LS217	45p	7464	BC180	4068	TB810
74LS67	74LS218	45p	7465	BC181	4069	TB820
74LS68	74LS219	45p	7466	BC182	4070	ZN423
74LS69	74LS220	45p	7467	BC183	4071	ZN425E
74LS70	74LS221	45p	7468	BC184	4072	
74LS71	74LS222	45p	7469	BC185	4073	
74LS72	74LS223	45p	7470	BC186	4074	
74LS73	74LS224	45p	7471	BC187	4075	
74LS74	74LS225	45p	7472	BC188	4076	
74LS75	74LS226	45p	7473	BC189	4077	
74LS76	74LS227	45p	7474	BC190	4078	
74LS77	74LS228	45p	7475	BC191	4079	
74LS78	74LS229	45p	7476	BC192	4080	
74LS79	74LS230	45p	7477	BC193	4081	
74LS80	74LS231	45p	7478	BC194	4082	
74LS81	74LS232	45p	7479	BC195	4083	
74LS82	74LS233	45p	7480	BC196	4084	
74LS83	74LS234	45p	7481	BC197	4085	
74LS84	74LS235	45p	7482	BC198	4086	
74LS85	74LS236	45p	7483	BC199	4087	
74LS86	74LS237	45p	7484	BC200	4088	
74LS87	74LS238	45p	7485	BC201	4089	
74LS88	74LS239	45p	7486	BC202	4090	
74LS89	74LS240	45p	7487	BC203	4091	
74LS90	74LS241	45p	7488	BC204	4092	
74LS91	74LS242	45p	7489	BC205	4093	
74LS92	74LS243	45p	7490	BC206	4094	
74LS93	74LS244	45p	7491	BC207	4095	
74LS94	74LS245	45p	7492	BC208	4096	
74LS95	74LS246	45p	7493	BC209	4097	
74LS96	74LS247	45p	7494	BC210	4098	
74LS97	74LS248	45p	7495	BC211	4099	
74LS98	74LS249	45p	7496	BC212	4100	
74LS99	74LS250	45p	7497	BC213	4101	
74LS100	74LS251	45p	7498	BC214	4102	
74LS101	74LS252	45p	7499	BC215	4103	
74LS102	74LS253	45p	7500	BC216	4104	
74LS103	74LS254	45p		BC217	4105	
74LS104	74LS255	45p		BC218	4106	
74LS105	74LS256	45p		BC219	4107	
74LS106	74LS257	45p		BC220	4108	
74LS107	74LS258	45p		BC221	4109	
74LS108	74LS259	45p		BC222	4110	
74LS109	74LS260	45p		BC223	4111	
74LS110	74LS261	45p		BC224	4112	
74LS111	74LS262	45p		BC225	4113	
74LS112	74LS263	45p		BC226	4114	
74LS113	74LS264	45p		BC227	4115	
74LS114	74LS265	45p		BC228	4116	
74LS115	74LS266	45p		BC229	4117	
74LS116	74LS267	45p		BC230	4118	
74LS117	74LS268	45p		BC231	4119	
74LS118	74LS269	45p		BC232	4120	
74LS119	74LS270	45p		BC233	4121	
74LS120	74LS271	45p		BC234	4122	
74LS121	74LS272	45p		BC235	4123	
74LS122	74LS273	45p		BC236	4124	
74LS123	74LS274	45p		BC237	4125	
74LS124	74LS275	45p		BC238	4126	
74LS125	74LS276	45p		BC239	4127	
74LS126	74LS277	45p		BC240	4128	
74LS127	74LS278	45p		BC241	4129	
74LS128	74LS279	45p		BC242	4130	
74LS129	74LS280	45p		BC243	4131	
74LS130	74LS281	45p		BC244	4132	
74LS131	74LS282	45p		BC245	4133	
74LS132	74LS283	45p		BC246	4134	
74LS133	74LS284	45p		BC247	4135	
74LS134	74LS285	45p		BC248	4136	
74LS135	74LS286	45p		BC249	4137	
74LS136	74LS287	45p		BC250	4138	
74LS137	74LS288	45p		BC251	4139	
74LS138	74LS289	45p		BC252	4140	
74LS139	74LS290	45p		BC253	4141	
74LS140	74LS291	45p		BC254	4142	
74LS141	74LS292	45p		BC255	4143	
74LS142	74LS293	45p		BC256	4144	
74LS143	74LS294	45p		BC257	4145	
74LS144	74LS295	45p		BC258	4146	
74LS145	74LS296	45p		BC259	4147	
74LS146	74LS297	45p		BC260	4148	
74LS147	74LS298	45p		BC261	4149	
74LS148	74LS299	45p		BC262	4150	
74LS149	74LS300	45p		BC263	4151	
74LS150	74LS301	45p		BC264	4152	
74LS151	74LS302	45p		BC265	4153	
74LS152	74LS303	45p		BC266	4154	
74LS153	74LS304	45p		BC267	4155	
74LS154	74LS305	45p		BC268	4156	
74LS155	74LS306	45p		BC269	4157	
74LS156	74LS307	45p		BC270	4158	
74LS157	74LS308	45p		BC271	4159	
74LS158	74LS309	45p		BC272	4160	
74LS159	74LS310	45p		BC273	4161	
74LS160	74LS311	45p		BC274	4162	
74LS161	74LS312	45p</				

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David Parkins

P.S. Although this advert may sound a bit corny (we have to get your attention somehow) Interak 1 really is a serious, sensible system with thousands of cards sold, and in daily use. Cards, Manuals, all available separately, inc. circuit diagrams.

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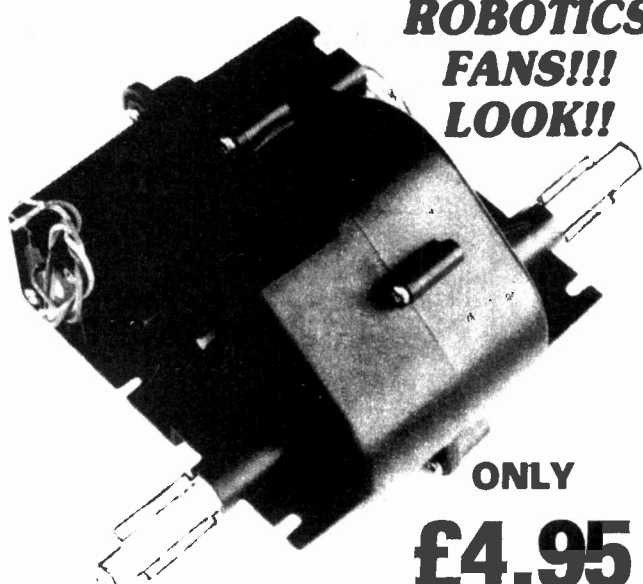
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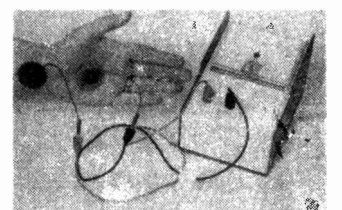
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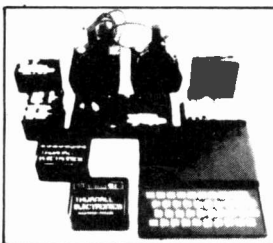
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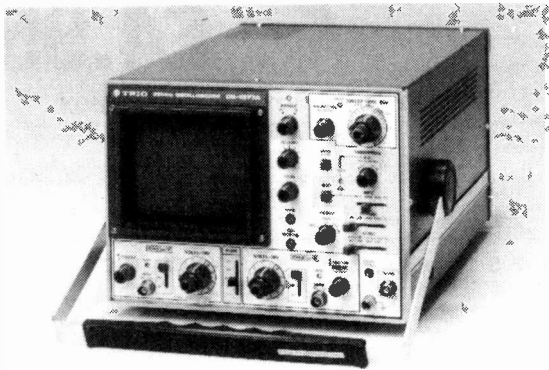


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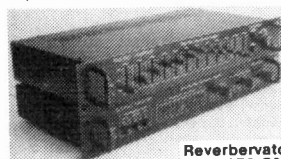


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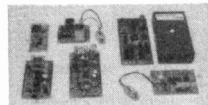
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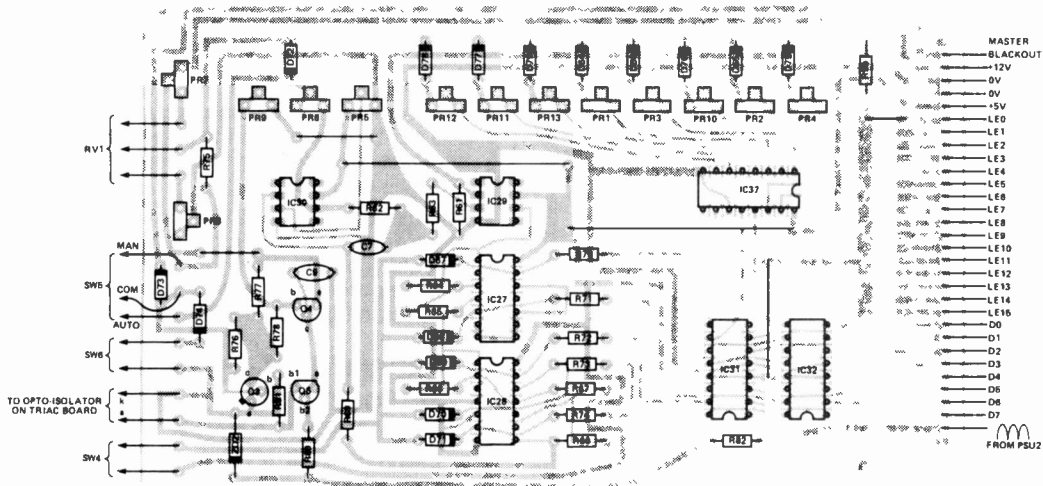
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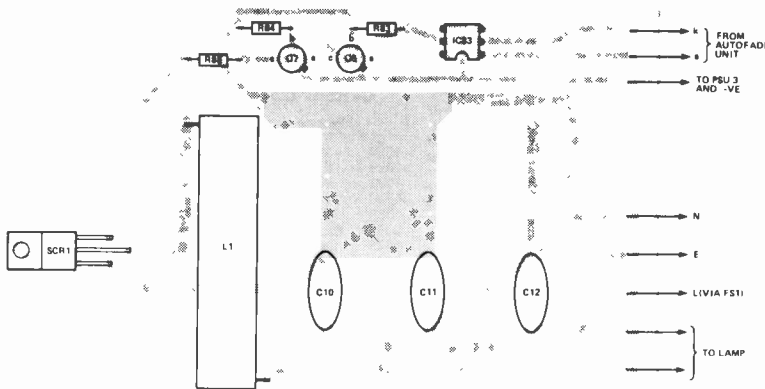
# STAGE LIGHTING

## PART 4

Design by David Colven and Ian Cleverley.



\*LINK SELECTS CHANNEL NUMBER  
CHANNEL 0 SHOWN SELECTED



Above is the overlay for one autofade card and left, the overlay for one of the triac boards. No PCBs are given for the power supplies as these consist of little more than strings of capacitors in parallel and methods such as Veroboard are cheap and easy to employ.

### PARTS LIST

Resistors (all 1/4W, 5%)

- R61,84 4k7
- R62,77 470R
- R63,75 100k
- R64,76 10M
- R65 4M7
- R66,78 2M2
- R67 1M2
- R68 560k
- R69 270k
- R70-74 10k
- R79 47k
- R80 330R
- R81,85 100R
- R82 1k0
- R83 120k

Potentiometers

- RV1 10k linear
- PR1-4,10-13 2k2 miniature vertical preset

- PR5 470k miniature vertical preset
- PR6,7 1M0 miniature vertical preset
- PR8 10k miniature vertical preset
- PR9 47k miniature vertical preset

Capacitors

- C7 4u7 16 V tantalum
- C9 100nF polycarbonate or similar
- C10 100nF mains-rated capacitor (eg IS or mixed dielectric)
- C11,12 47nF mains-rated capacitor

Semiconductors

- IC27,28 4016B

- IC29,30 741
- IC31,32 74LS75
- IC33 opto-isolator eg CNY17
- IC37 4028B
- Q3,6,7 BC108
- Q4 BC214L
- Q5 TIS43
- SCR1 TIC246D
- D64-79 1N4148
- ZD2 12 V 400 mW zener

Miscellaneous

- SW4,6 SPST toggle switches
- SW5 SPDT toggle switch
- L1 14 turns of 15 A cable on a 3/8" ferrite rod lamp to suit
- LP1 10 A fuse and fuseholder
- FS1 (see page 87)
- PCBs sheet aluminium for heatsink

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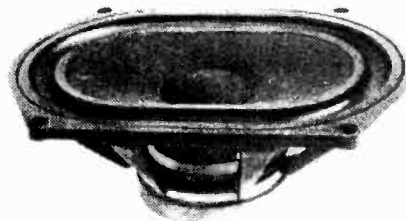
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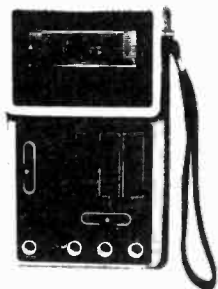
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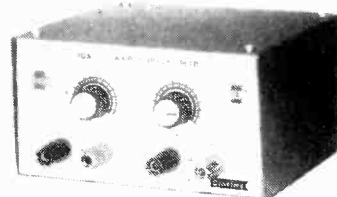
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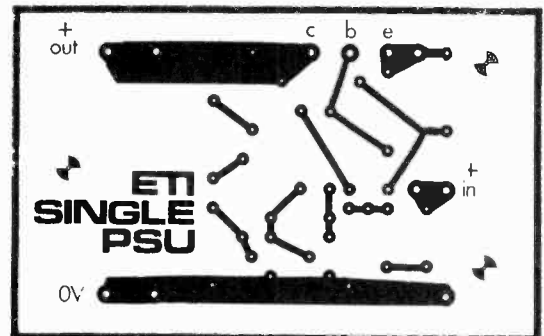
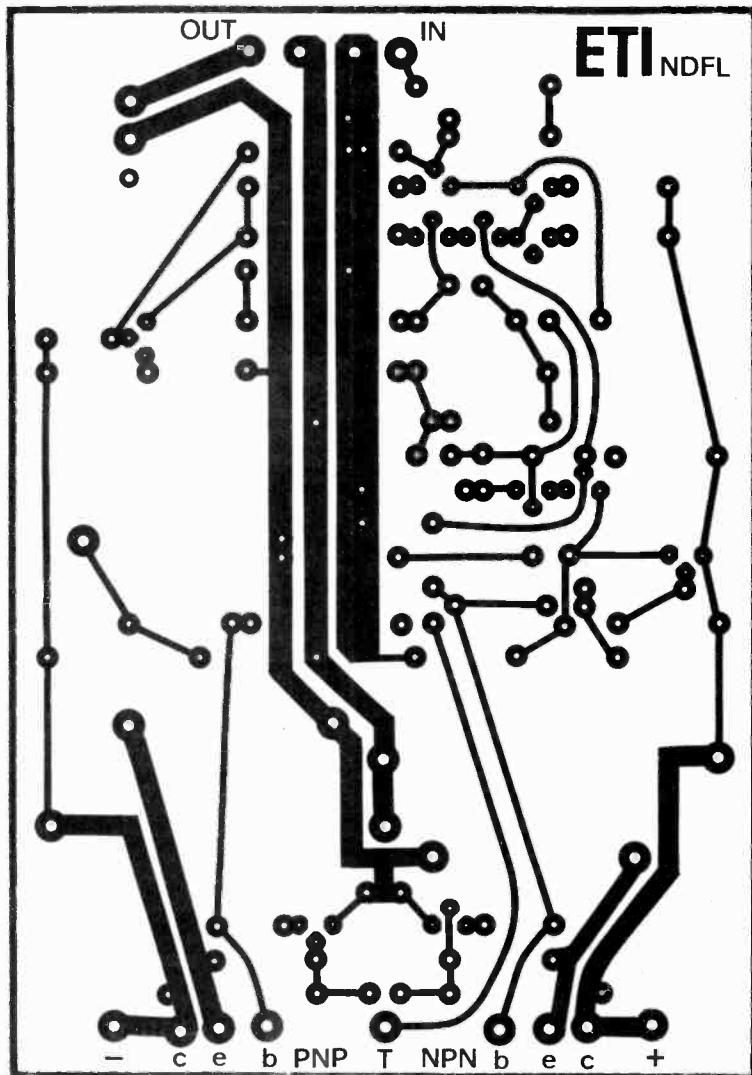
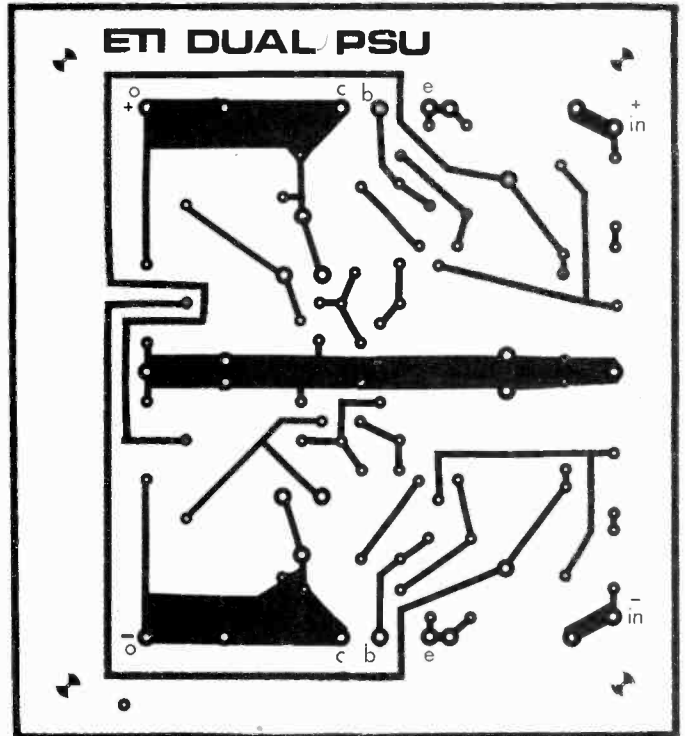
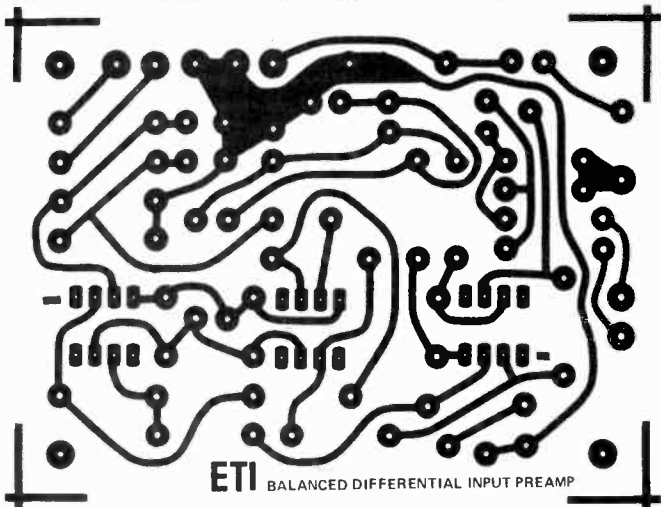
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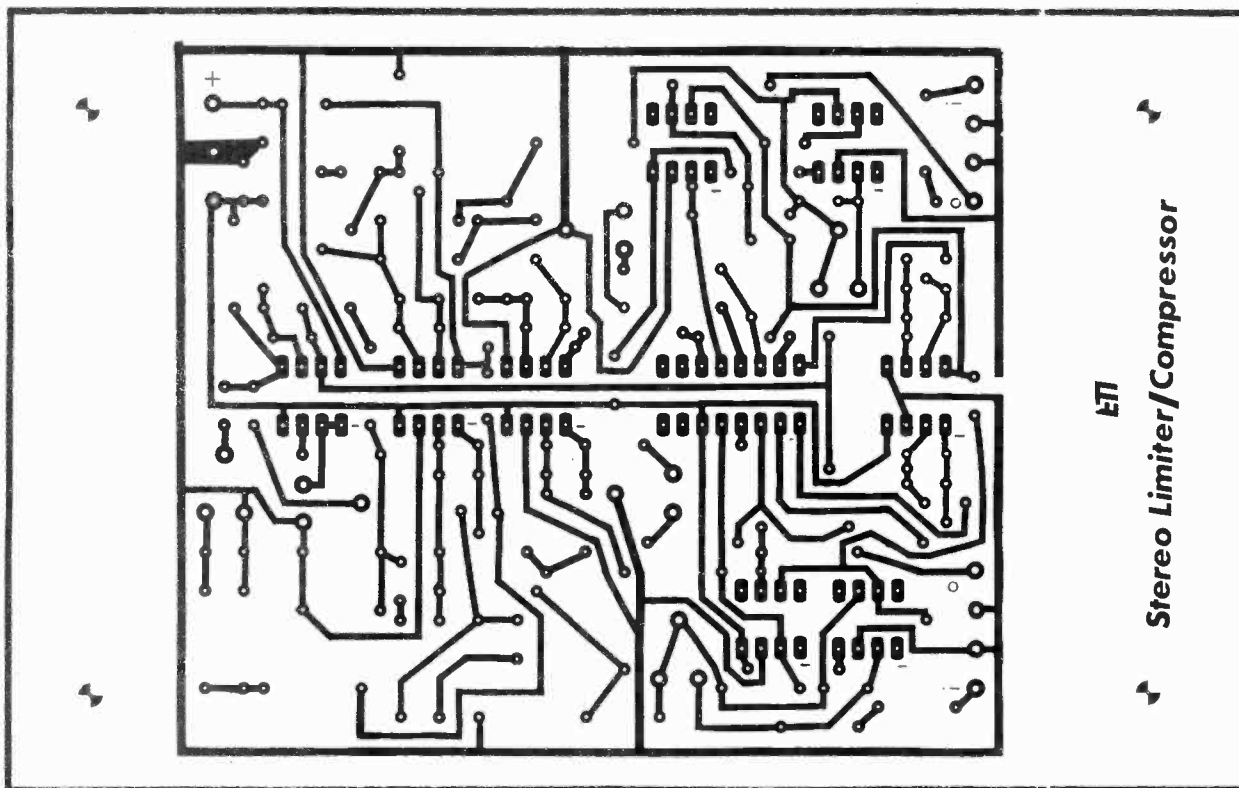
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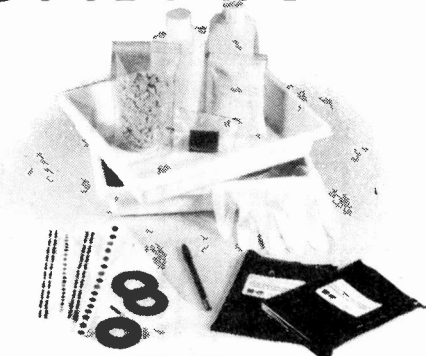
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<input type="checkbox"/> Cassette Interface	£2.93	<b>OCTOBER 81</b>		<input type="checkbox"/> ELCB	£2.41
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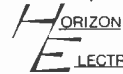
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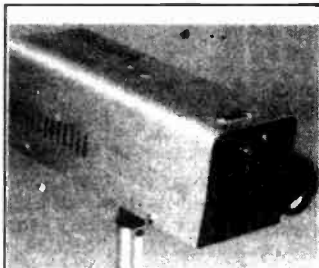
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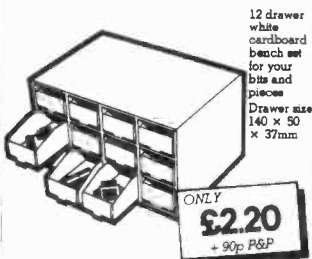
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# Get moving with these new developments in UK Robotics

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Hebot II is a turtle-type robot which takes programming out of the two dimensional world of the VDU into the real three dimensional world. Given a DC supply of 9-15V it can perform a bewildering number of moves under computer control — forwards, backwards, left and right — with each wheel independently controlled. It has blinking eyes, bleeps with a choice of two tones and has a solenoid operated pen to chart its progress. Touch sensors coupled to its shell return data, about its environment, to the computer for it to calculate evasive or exploratory action. Hebot II connects directly to an I/O port or alternatively with the universal interface board to the expansion bus of a ZX81 or other computer.



HEBOTT II

Up to the nano-second hard, firm and software developments embodied in a complete system. 1.2 Mega Hertz 16 bit CPU; 64K upwardly compatible DRAM; separate 16K video DRAM and 24K TI Power Basic with overwrite. Supports up to four Disc drives of mixed type with 16 serial I/O ports. Programmable Baud rate and comprehensive E Bus interface designed to support real world applications.

Very high resolution graphics gives 3D simulation in 16 colours on 36 prioritised planes of user definable characters. Software FORTH coming includes this trendy language along with NOS C/PM.

Hardware components available separately with details in Nov, Dec, and Jan issues of ETI. Software features include; Real time clock, full renumber command, buffered I/O to free machine whilst

Robotic experience is becoming as essential a subject as computing. MICROGRASP provides the lowest cost means of acquiring that experience but despite its ultra low price the robot has considerable versatility. There are 5 axes each using a servo motor and there is feedback from each of the arm movements. Control is by any computer with an expansion bus — the ZX81 being particularly suitable. Servoing is achieved with hardware on the interface board to keep programming simple and the robot is operated under BASIC commands with no computer specific software required. The interface board is memory mapped using only 64 bytes at any of 1024 switch selectable locations.

- MICROGRASP robot kit with power supply £145.00
- Universal computer interface board kit £48.50
- 23 way edge connector £2.50
- ZX81 peripheral/RAM Pack splitter board £3.00



MICROGRASP, INTERFACE BOARD AND ZX81

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Top of the range is the Genesis P102 which has dual speed control, continuous servo operation and double acting cylinders for increased torque on the wrist and arm rotation joints. The microprocessor based control system has additional memory position interrogation via the RS232C interface increasing the versatility of computer control and inputs are provided for machine tool interfacing.

6 axis system READY BUILT £1950.00  
Powertran CORTEX 16 bit 64K computer kit £295.00; READY BUILT £395.00  
(Electronics Today International December issue on CORTEX)



GENESIS P102 PROCESSOR BOX, HAND HELD CONTROLLER AND CORTEX COMPUTER

### Example prices and specifications

**Genesis S101**  
Base: 19.5" x 11" x 7.5"  
Lifting capacity: 1500gm  
Arm lift: 6.6"  
Weight: 29Kg  
4 axis model in kit form £425  
5 axis model in kit form £475

**Genesis P101**  
Base: 19.5" x 11" x 7.5"  
Lifting capacity: 2000gm  
Arm lengths between axes: 14.0"  
Weight: 34Kg  
4 axis model in kit form £675  
6 axis model in kit form £595

### Complete Systems as shown in Photograph above

**Genesis S101**  
4 axis system in kit form £681.50  
5 axis system in kit form £737.50  
5 axis system Ready Built £1450  
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6 axis system in kit form £945.00  
6 axis system Ready Built £1650

All prices exclusive of VAT

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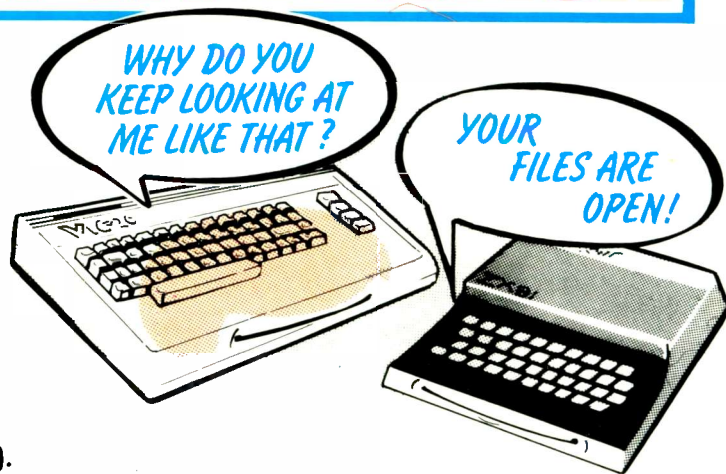
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Full construction details in Maplin Projects Book 6.

Price 70p. Order As XA06G (Maplin Mag Vol. 2 No. 6).



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Full details in Project Book 3 (XA03D) Price 60p.  
Complete kit (excl. case) £19.95. Order As LW72P.  
Case £4.95. Order As XG17T.  
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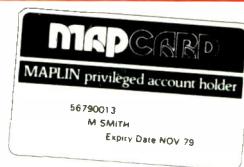
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