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NOVEMBER 1993

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PRINCIPLES**

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**Demo Disc Launch Offer**





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**UNTESTED AMSTRAD PC BASE UNITS COMPLETE WITH MOTHER -BOARD, VIDEO CONTROLLER, DISK CNTRLR, & 5.25" DRIVE(S).** (Keyboard, Mouse, PSU & DOS not supplied)

AMSTRAD 1512SD	£19.00	REF: EV/AM19P1
AMSTRAD 1512DD	£25.00	REF: EV/AM25P1
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AMSTRAD 1640DD	£30.00	REF: EV/AM30P1

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AMSTRAD 1640SD	£69.00	REF: EV/AM69P1
AMSTRAD 1640DD	£79.00	REF: EV/AM79P1

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OFFERING EITHER 512K OR 640K MEMORY.

FLIP UP GREEN SUPERTWIST LCD SCREEN.

FULL 'QWERTY' KEYBOARD,

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RUNS ON BATTERIES/

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AMSTRAD PPC 1512 DD (512k memory Two 3.5" disc drive)	£109.00	EV/AM109P1
AMSTRAD PPC 1640 SD (640k memory one 3.5" drive modem)	£129.00	EV/AM129P1
AMSTRAD PPC 1640 DD (640k memory two 3.5" drive modem)	£139.00	EV/AM139P1

MAINS POWER SUPPLY FOR ALL ABOVE LAPTOP UNITS ONLY £10.00

## AMAZING COMPUTER BARGAINS

**IBM COMPATIBLE LAPTOPS FROM ONLY £99.00 (PLUS VAT)**

**COMPUTER BASE UNITS FROM ONLY £19.00 (PLUS VAT)**

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REF: EV34P2

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**£33.95** (plusVAT)

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**SPECIAL OFFER £49.99** (plus vat)

**NEVER OFFERED BEFORE.....** We can now supply a unique handheld personal portable **Gamma and X-Ray detector**. This **Radiation detector** contains **two Geiger Tubes** has a 4 digit LCD display with a piezo speaker, giving an audio visual indication. The radiation detectors detect high energy electromagnetic quanta with an energy from 30KeV to over 1.2MeV and a measuring rate 5-9999 UR/h (sampling rate 2555) or 10-99990 NR/h (sampling rate 2.55) Sources of radiation could be Granite Kerbstones old Luminous Watch dials or even a Jewellery shop where mineral ore is sold to rock collectors. A piece of uranium Ore would be ideal.....

**Only £49.99 Each** Ref: EV50P1

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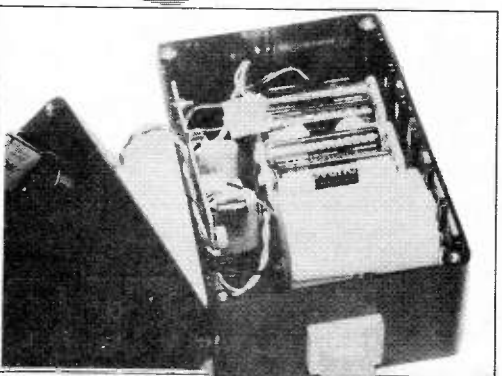
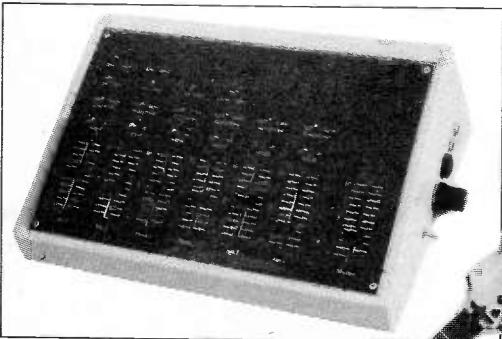
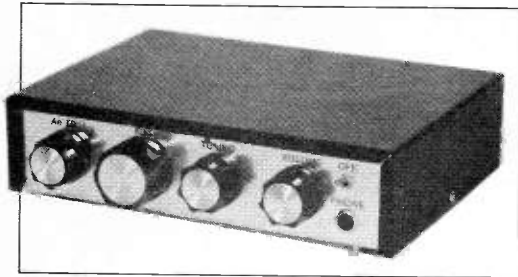
INCORPORATING ELECTRONICS MONTHLY

VOL. 22 No. 11 NOVEMBER 1993

The No. 1 Independent Magazine for Electronics, Technology and Computer Projects

ISSN 0262 3617

PROJECTS ... THEORY ... NEWS ... COMMENT ... POPULAR FEATURES ...



## Projects

- PORTABLE MINIGUARD** by T. R. de Vaux-Balbirnie **816**  
Protect those unguarded areas, others cannot reach, with this passive infra-red (PIR) alarm
- TRACKTRONICS PROJECTS** by Will Toner and Richard Taylor **826**  
Use your *free*, cover mounted, gift to build a simple Night Light, Thyristor Latched L.E.D. Display or a Twin Input Status Indicator
- 20 METRE DIRECT CONVERSION RECEIVER** by Robert Penfold **830**  
Listen in to the world of amateur radio
- INSIDE THE ELECTRIC GUITAR** by John Chatwin **838**  
Making good vibrations – “customise” the sound of your guitar
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Our December '93 Issue will be published on Friday, 5 November 1993. See page 803 for details.

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## LOW COST PC SPECIALISTS - ALL EXPANDABLE - ALL PC COMPATIBLE

### 8088 XT - PC99



- 256k RAM - expandable to 640k
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### 286 AT - PC286



- 640k RAM expandable with standard SIMMS
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- EGA driver on board
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- Co-processor socket
- Enhanced 102 key keyboard
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BRAND NEW AND BOXED!

## Only £249.00 (F)

The Philips 9CM073 is suggested for the PC286 and the CM8873 for the PC386. Either may use the SVGA MTS-9600 if a suitable card is installed. We can fit this at a cost of £49.00 for the PC286 and £99.00 for the PC386.

### 386 AT - PC386



- 2 meg RAM expanded by slots
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- 40 meg hard disk
- 1.2 meg 5-1/4" floppy
- VGA card installed
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- MS-DOS 4.01
- Co-processor socket
- Enhanced 102 keyboard
- Kwik Disk Accelerator Software - FREE

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## Only £425.00 (F)

### MONITORS

- 14" Forefront Model MTS-9600 SVGA multisync with resolution of 1024 x 768. 0.28 pitch. "Text" switch for word processing etc. Overscan switch included. Ideal for the PC-386 or PC-286 with SVGA card added. Also compatible with BBC, Amiga, Atari (including the monochrome high resolution mode), Archimedes etc. In good used condition (possible minor screen burns). 90 day guarantee. 15" x 14" x 12". Only.....£159(E)
- 14" Philips Model CM8873 VGA multisync with 640 x 480 resolution. CGA, EGA or VGA, digital/analog, switch selectable. Sound with volume control. There is also a special "Text" switch for word processing, spreadsheets and the like. Compatible with IBM PC's, Amiga, Atari (excluding the monochrome high resolution mode), BBC, Archimedes etc. Good used condition (possible minor screen burns) 90 day guarantee. 15" x 14" x 12". Only.....£139(E)
- Philips 9CM073 similar (not identical) to above for EGA/CGA PC and compats. 640 x 350 resolution. With Text switch with amber or green screen selection. 14" x 12" x 13-1/2".....£99(E)
- KME 10" high definition colour monitors. Nice tight 0.28" dot pitch for superb clarity and modern styling. Operates from any 15.625 khz sync RGB video source, with RGB analog and composite sync such as Atari, Commodore Amiga, Acorn Archimedes & BBC. Measures only 13.5" x 12" x 11". Also works as quality TV with our HiFi Telexbox. Good used condition. 90 day guarantee. Only.....£125 (E)
- KME as above for PC EGA standard.....£145 (E)
- Brand new Centronic 14" monitor for IBM PC and compatibles at a lower than ever price! Completely CGA equivalent. Hi-res Mitsubishi 0.42 dot pitch giving 669 x 507 pixels. Big 28 Mhz bandwidth. A super monitor in attractive style moulded case. Full 90 day guarantee. Only.....£129 (E)
- NEC CGA 12" IBM-PC compatible. High quality ex-equipment fully tested with a 90 day guarantee. In an attractive two tone ribbed grey plastic case measuring 15" L x 13" W x 12" H. The front cosmetic bezel has been removed for contractual.....£69 (E)

20", 22" and 26" AV SPECIALS  
Superbly made UK manufacture. PIL all solid state colour monitors, complete with composite video & sound inputs. Attractive teak style case. Perfect for Schools, Shops, Disco, Clubs. In EXCELLENT little used condition with full 90 day guarantee.  
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### 19" Rack Cabinets

### Massive Reductions

### Virtually New, Ultra Smart! Less Than Half Price!

Top quality 19" rack cabinets made in UK by Optima Enclosures Ltd. Units feature designer, smoked acrylic lockable front door, full height lockable half louvered back door and removable side panels. Fully adjustable internal fixing struts, ready punched for any configuration of equipment mounting plus ready mounted integral 12 way 13 amp socket switched mains distribution strip make these racks some of the most versatile we have ever sold. Racks may be stacked side by side and therefore require only two side panels or stand singly. Overall dimensions are 77-1/2"H x 32-1/2"D x 22"W. Order as:  
Rack 1 Complete with removable side panels.....£275.00 (G)  
Rack 2 Less side panels.....£145.00 (G)

### FLOPPY DISK DRIVES

5 1/4" from £22.95 - 3 1/2" from £21.95!  
Massive purchases of standard 5 1/4" and 3 1/2" drives enables us to present prime product at industry beating low prices! All units (unless stated) are removed from often brand new equipment and are fully tested, aligned and shipped to you with a 90 day guarantee and operate from standard voltages and are of standard size. All are IBM-PC compatible (if 3 1/2" supported).

- 3.5" Panasonic JU363/4 720K or equivalent £29.95(B)
- 3.5" Mitsubishi MF355C-L 1.4 Meg. Laptops only £29.95(B)
- 3.5" Mitsubishi MF355C-D 1.4 Meg. Non laptop £29.95(B)
- 5.25" EXTRA SPECIAL BRAND NEW Mitsubishi MF501B 360K. Absolutely standard fits most computers £22.95(B)
- \* Data cable included in price.
- Shugart 800/801 SS refurbished & tested £175.00(E)
- Shugart 851 double sided refurbished & tested £275.00(E)
- Mitsubishi M2894-63 double sided switchable hard or soft sectors- BRAND NEW £250.00(E)

Dual 8" drives with 2 mbyte capacity housed in a smart case with built in power supply! Ideal as exterior drives! £499.00(F)  
End of line purchase scoop! Brand new NEC D2246 8" 85 megabyte of hard disk storage! Full CPU control and industry standard SMD interface. Ultra hi speed transfer and access time leaves the good old ST506 interface standing. In mint condition and comes complete with manual. Only.....£299 (E)

### THE AMAZING TELEBOX!

Converts your colour monitor into a QUALITY COLOUR TV!!



### TV SOUND & VIDEO TUNER!

The TELEBOX consists of an attractive fully cased mains powered unit, containing all electronics ready to plug into a host of video monitors made by manufacturers such as MICROVITEC, ATARI, SANYO, SONY, COMMODORE, PHILIPS, TATUNG, AMSTRAD and many more. The composite video output will also plug directly into most video recorders, allowing reception of TV channels not normally receivable on most television receivers (TELEBOX MB). Push button controls on the front panel allow reception of 8 fully tuneable 'off air' UHF colour television or video channels. TELEBOX MB covers virtually all television frequencies VHF and UHF including the HYPERBAND as used by most cable TV operators. Composite and RGB video outputs are located on the rear panel for direct connection to most makes of monitor. For complete compatibility - even for monitors without sound - an integral 4 watt audio amplifier and low level Hi Fi audio output are provided as standard.

- Telexbox ST for composite video input monitors £32.95
- Telexbox STL as ST but with integral speaker £36.50
- Telexbox MB as ST with Multiband tuner VHF-UHF-Cable. & hyperband For overseas PAL versions state 5.5 or 6mhz sound specification. £69.95
- Telexbox RGB for analogue RGB monitors (15khz) £69.95
- Shipping code on all Telexboxes is (B)
- RGB Telexbox also suitable for IBM multisync monitors with RGB analog and composite sync. Overseas versions VHF & UHF call. SECAM/NTSC not available.

### No Break Uninterruptable PSU's

Brand new and boxed 230 volts uninterruptable power supplies from Densel. Model MUK 0565-AUAF is 0.5 kva and MUD 1085-AHBB is 1 kva. Both have sealed lead acid batteries. MUK are internal, MUD has them in a matching case. Times from interrupt are 5 and 15 minutes respectively. Complete with full operation manuals.....MUK.....£249 (F) MUD.....£525 (G)

### POWER SUPPLIES

- Power One SPL200-5200P 200 watt (250 w peak) Semi open frame giving +5v 35a, -5v 1.5a, +12v 4a (8a peak), -12v 1.5a, +24v 4a (6a peak). All outputs fully regulated with over voltage protection on the +5v output. AC input selectable for 110/240 vac. Dims 13" x 5" x 2.5". Fully guaranteed RFE. £85.00 (B)
- Power One SPL130. 130 watts. Selectable for 12v (4A) or 24 v (2A). 5v @ 20A. ±12v @ 1.5A. Switch mode. New. £59.95(B)
- Astec AC-8151 40 watts. Switch mode. +5v @ 2.5a. +12v @ 2a. -12v @ 0.1a. 6-1/4" x 4" x 1-3/4". New £22.95(B)
- Greendale 19AB0E 60 watts switch mode. +5v @ 6a, ±12v @ 1a, +15v @ 1a. RFE and fully tested. 11 x 20 x 5.5cms. £24.95(C)
- Conver AC130. 130 watt hi-grade VDE spec. Switch mode. +5v @ 15a, -5v @ 1a, ±12v @ 6a. 27 x 12.5 x 6.5cms. New. £49.95(C)
- Boshert 13090. Switch mode. Ideal for drives & system. +5v @ 6a, +12v @ 2.5a, -12v @ 0.5a, -5v @ 0.5a. £29.95(B)
- Famell G6/40A. Switch mode. 5v @ 40a. Encased £95.00(C)
- Famell G24/5S. As above but 24v @ 5a. £65.00(C)

### BBC Model B APM Board

£100 CASH FOR THE MOST NOVEL DEMONSTRABLE APPLICATION!

BBC Model B type computer on a board. A major purchase allows us to offer you the PROFESSIONAL version of the BBC computer at a parts only price. Used as a front end graphics system on large networked systems the architecture of the BBC board has so many similarities to the regular BBC model B that we are sure that with a bit of experimentation and ingenuity many useful applications will be found for this board! It is supplied complete with a connector panel which brings all the I/O to 'D' and BNC type connectors - all you have to do is provide +5 and ±12 v DC. The APM consists of a single PCB with most major ic's socketed. The ic's are too numerous to list but include a 6502, RAM and an SAA5050 teletext chip. Three 27128 EPROMS contain the custom operating system on which we have no data. On application of DC power the system boots and provides diagnostic information on the video output. On board DIP switches and jumpers select the ECONET address and enable the four extra EPROM sockets for user software. Appx. dims: main board 13" x 10". I/O board 14" x 3". Supplied tested with circuit diagram, data and competition entry form.

## Only £29.95 or 2 for £53 (B)

### SPECIAL INTEREST

- Trio 0-18 vdc bench PSU. 30 amps. New £ 470
- Fujitsu M3041 600 LPM band printer £2950
- DEC LS/02 CPU board £ 150
- Rhode & Schwarz SBUF TV test transmitter 25-1000mhz. Complete with SBTF2 Modulator £6500
- Calcomp 1036 large drum 3 pen plotter £ 650
- Thurlby LA 160B logic analyser £ 375
- 1.5kw 115v 60hz power source £ 950
- Anton Pillar 400 Hz 3 phase frequency converter 75Kw POA
- Newton Derby 400 Hz 70 Kw converter POA
- Nikon PL-2 Projection lens meter/scope £750
- Sekonic SD 150H 18 channel Hybrid recorder £2000
- HP 7580A A1 8 pin high speed drum plotter £1850
- Kenwood DA-3501 CD tester, laser pickup simulator £ 350

### BRAND NEW PRINTERS

- Microline 183. NLQ 17x17 dot matrix. Full width. £139 (D)
- Hyundai HDP-920. NLQ 24x18 dot matrix full width. £149 (D)
- Qume LetterPro 20 daisy. Qume QS-3 interface. £39.95 (D)
- Centronics 152-2 9 x 7 dot matrix. Full width. £149 (D)
- Centronics 159-4 9 x 7 dot matrix. Serial. 9-1/2" width £ 99 (D)

1992 Winter Issue of Display News now available - send large SAE - PACKED with bargains!

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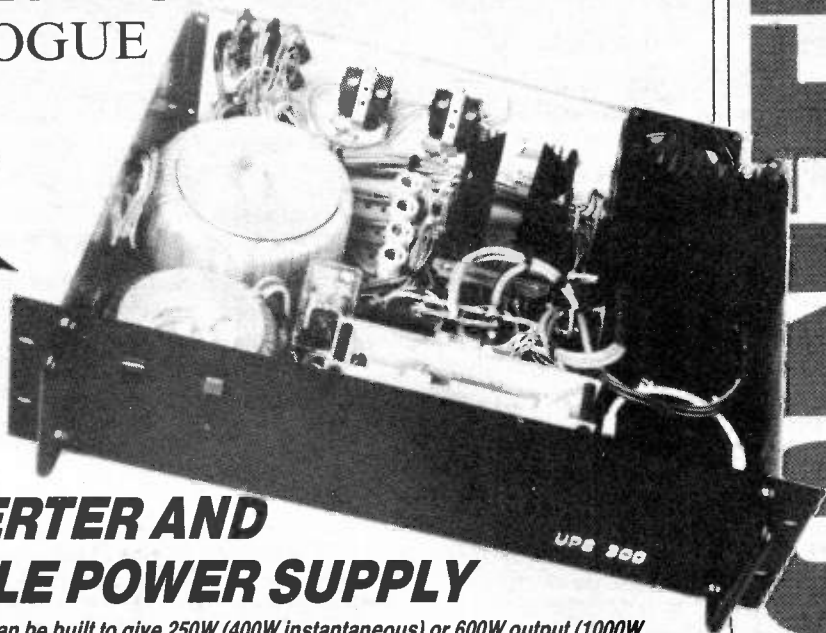
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# BULL ELECTRICAL 1994 CATALOGUE

**FREE**

INSIDE  
EVERY ISSUE



## 250W/600W INVERTER AND UNINTERRUPTABLE POWER SUPPLY

A high quality battery to mains inverter that can be built to give 250W (400W instantaneous) or 600W output (1000W instantaneous) at 50Hz or 60Hz from a 12V battery. There is an uninterruptable power supply add-on which will provide ten minutes supply from internal batteries with zero change-over time – just right for protecting your computer data in the event of mains failure.



## THREE-WAY CHRISTMAS TREE LIGHTS

Christmas tree lights are notorious for ceasing to work the moment they are switched on, especially after having been carefully placed decoratively – or otherwise – over the newly acquired tree, complete with sticky pine needles.

The reason for their failure is often because of the sudden inrush of current from the mains during switch on. If you add to this a basic flashing light circuit, the chance of premature failure is increased many times.

This Christmas tree light flasher not only switches three sets of lights on in a pleasing order (not simply one set after the other) but also uses zero switching for longer bulb life.

## SAFETY FIRST!

**Staying alive with electrical equipment.**

The first part of a short series covering various safety aspects of electronics and general electrical work in the domestic environment. The series covers everything from regulations and basic first aid to chemical hazards from modern components and materials.

**EVERYDAY**  
WITH **PRACTICAL**  
**ELECTRONICS**

DECEMBER ISSUE ON SALE FRIDAY, NOVEMBER 5th

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# SURVEILLANCE PROFESSIONAL QUALITY KITS

## No. 1 for Kits

Whether your requirement for surveillance equipment is amateur, professional or you are just fascinated by this unique area of electronics SUMA DESIGNS has a kit to fit the bill. We have been designing electronic surveillance equipment for over 12 years and you can be sure that all of our kits are very well tried, tested and proven and come complete with full instructions, circuit diagrams, assembly details and all high quality components including fibreglass PCB. Unless otherwise stated all transmitters are tuneable and can be received on an ordinary VHF FM radio.

### UTX Ultra-miniature Room Transmitter

Smallest room transmitter kit in the world! Incredible 10mm x 20mm including mic. 3-12V operation. 500m range.....£16.45

### MTX Micro-miniature Room Transmitter

Best-selling micro-miniature Room Transmitter  
Just 17mm x 17mm including mic. 3-12V operation. 1000m range.....£13.45

### STX High-performance Room Transmitter

Hi performance transmitter with a buffered output stage for greater stability and range. Measures 22mm x 22mm including mic. 6-12V operation, 1500m range.....£15.45

### VT500 High-power Room Transmitter

Powerful 250mW output providing excellent range and performance. Size 20mm x 40mm. 9-12V operation. 3000m range.....£16.45

### VXT Voice Activated Transmitter

Triggers only when sounds are detected. Very low standby current. Variable sensitivity and delay with LED indicator. Size 20mm x 67mm. 9V operation. 1000m range...£19.45

### HVX400 Mains Powered Room Transmitter

Connects directly to 240V AC supply for long-term monitoring. Size 30mm x 35mm. 500m range.....£19.45

### SCRX Subcarrier Scrambled Room Transmitter

Scrambled output from this transmitter cannot be monitored without the SCDM decoder connected to the receiver. Size 20mm x 67mm. 9V operation. 1000m range.....£22.95

### SCLX Subcarrier Telephone Transmitter

Connects to telephone line anywhere, requires no batteries. Output scrambled so requires SCDM connected to receiver. Size 32mm x 37mm. 1000m range.....£23.95

### SCDM Subcarrier Decoder Unit for SCRX

Connects to receiver earphone socket and provides decoded audio output to headphones. Size 32mm x 70mm. 9-12V operation.....£22.95

### ATR2 Micro Size Telephone Recording Interface

Connects between telephone line (anywhere) and cassette recorder. Switches tape automatically as phone is used. All conversations recorded. Size 16mm x 32mm. Powered from line.....£13.45

### UTLX Ultra-miniature Telephone Transmitter

Smallest telephone transmitter kit available. Incredible size of 10mm x 20mm!  
Connects to line (anywhere) and switches on and off with phone use.  
All conversation transmitted. Powered from line. 500m range.....£15.95

### TLX700 Micro-miniature Telephone Transmitter

Best-selling telephone transmitter. Being 20mm x 20mm it is easier to assemble than UTLX. Connects to line (anywhere) and switches on and off with phone use. All conversations transmitted. Powered from line. 1000m range.....£13.45

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### TKX900 Signalling/Tracking Transmitter

Transmits a continuous stream of audio pulses with variable tone and rate. Ideal for signalling or tracking purposes. High power output giving range up to 3000m. Size 25mm x 63mm. 9V operation.....£22.95

### CD400 Pocket Bug Detector/Locator

LED and piezo bleeper pulse slowly, rate of pulse and pitch of tone increase as you approach signal. Gain control allows pinpointing of source. Size 45mm x 54mm. 9V operation.....£30.95

### CD600 Professional Bug Detector/Locator

Multicolour readout of signal strength with variable rate bleeper and variable sensitivity used to detect and locate hidden transmitters. Switch to AUDIO CONFORM mode to distinguish between localised bug transmission and normal legitimate signals such as pagers, cellular, taxis etc. Size 70mm x 100mm. 9V operation.....£50.95

### QTX180 Crystal Controlled Room Transmitter

Narrow band FM transmitter for the ultimate in privacy. Operates on 180 MHz and requires the use of a scanner receiver or our QRX180 kit (see catalogue). Size 20mm x 67mm. 9V operation. 1000m range.....£40.95

### QLX180 Crystal Controlled Telephone Transmitter

As per QTX180 but connects to telephone line to monitor both sides of conversations. 20mm x 67mm. 9V operation. 1000m range.....£40.95

### QSX180 Line Powered Crystal Controlled Phone Transmitter

As per QLX180 but draws power requirements from line. No batteries required. Size 32mm x 37mm. Range 500m.....£35.95

### QRX180 Crystal Controlled FM Receiver

For monitoring any of the 'Q' range transmitters. High sensitivity unit. All RF section supplied as a pre-built and aligned module ready to connect on board so no difficulty setting up. Outpt to headphones. 60mm x 75mm. 9V operation.....£60.95

### A build-up service is available on all our kits if required.

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Individual Receiver DLRX.....£37.95

### MBX-1 Hi-Fi Micro Broadcaster

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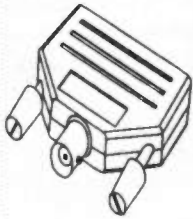
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Up to 24kHz sampling rate from a 386/33MHz machine  
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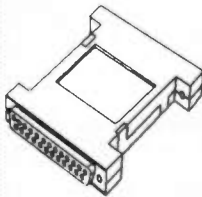


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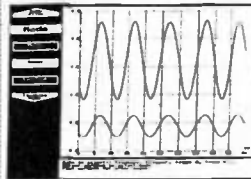


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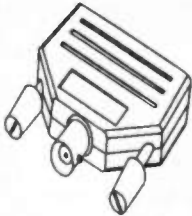


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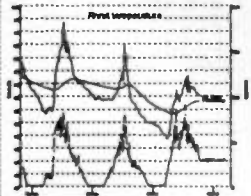


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Typical application	ADC-10	ADC-11	ADC-12	ADC-16
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Voltmeter	●	●	●	●
Spectrum analyser	●	●	●	
Audio sampling	●		●	
Chart recorder emulation		●		●
Temperature measurement	●	●	●	●
Pressure measurement	●	●	●	●
Chromatography				●
Automotive monitoring		●		●
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**Kit 2. LCD TEMPERATURE METER** Introduces 3 1/2 digit LCD and the very popular 7106 IC. This IC has been used in low-cost multimeters for over 13 years. We use it to measure temperature using an ordinary signal transistor as the sensor. Data sheets provided. Breadboard area so you can extend the circuit to build your own voltmeter, ammeter, resistance meter or extended-range temperature meter. Takes away the mystery of how multimeters work. Box provided. 9V battery operation. £29.80

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**Kit 34. GENERAL PURPOSE 3 1/2 DIGIT PANEL METER** Make this general design 3 1/2 digit LCD panel meter into your own voltage or current meter. Or custom make it to measure input from a transducer. Full details given in the

documentation. LCD may be cut from the main circuit board and mounted separately. £23.84

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**Kit 38. INTRODUCTION TO MICRO-CONTROLLERS** Learn to program micro-Controllers without going to technical college. This Kit introduces the Motorola 68HC705K1, an 8 bit, 16 pin micro-controller released in 1992. The Kit is a down counter from 60 or 90 seconds with beeps every 10 seconds. All the software code is supplied and fully explained. See how easy it is to change the time and beep settings by simple changes in the software program. You can judge for yourself how using micro-controllers is a huge advance over using logic ICs. On/off switch and pull-down resistors on input lines are all built into the K1 and are under software control. 9V battery powered. All the information about how to continue learning to programming these 'computers on-a-chip' is supplied. The tools to program the K1 are available at very low cost (under \$US 200) from Motorola. The K1 is the simplest 8-bit microcontroller available. £37.80

**Kit 40. MICROCONTROLLER REACTION TIMER** Over the years there have been many logic circuits published for simple reaction timers - the logic shows which of two contestants was first to press a button after a sound or light stimulus. However, none of them has ever shown how many milliseconds both the winner and the runner-up took to press their buttons. The use of microcontrollers again demonstrates how software can replace logic ICs to give a smaller and much more versatile electronic circuit. The software is an extension of that already presented in Kit 38. The major change is the addition of a crystal controlled oscillator instead of an RC network. Pressing either button turns the unit on. '000' is displayed on a single-unit 3-digit LED display. Press either key again and a beep sounds a few random seconds later. The display starts to count in msec. The exact time when both persons press their buttons (if within 999 msec) is recorded and displayed alternately on the display. The unit will power down automatically after one minute. There is no off/on switch. It is built into the Motorola 68HC705K1 chip. 9V battery powered. £41.40

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- 1 X 0-1mA PANEL METER full vision face 70mm square. Scaled 0-100. Order Ref. 756.
- 2 X LITHIUM BATTERIES 2.5V penlight size. Order Ref. 874.
- 2 X 3M TELEPHONE LEADS with BT flat plug. Ideal for phone extensions, fax, etc. Order Ref. 552.
- 1 X 12V SOLENOID has good 1/2" pull or could push if modified. Order Ref. 232.
- 4 X IN-FLEX SWITCHES with neon on/off lights, saves leaving things switched on. Order Ref. 7.
- 2 X 6V 1A MAINS TRANSFORMERS upright mounting with fixing clamps. Order Ref. 9.
- 2 X HUMIDITY SWITCHES, as the air becomes damper the membrane stretches and operates a microswitch. Order Ref. 32.
- 5 X 13A ROCKER SWITCH three tags so on/off, or change-over with centre off. Order Ref. 42.
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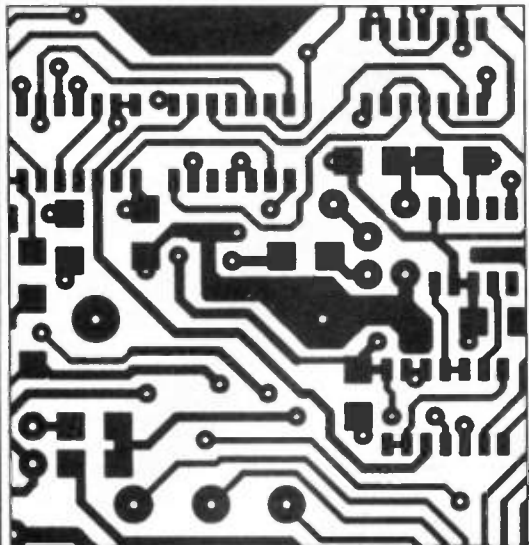
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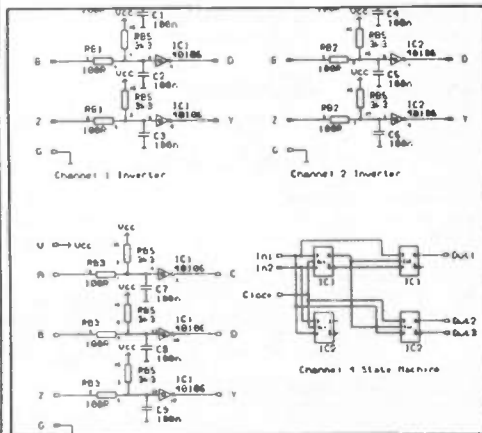
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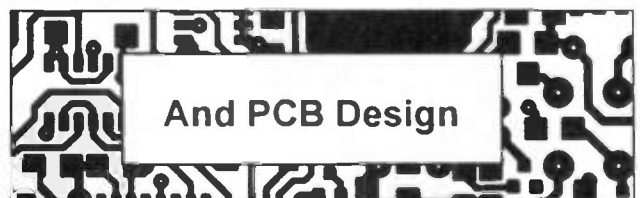
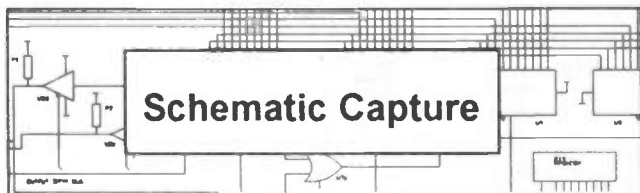


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MB5	150	100	60	£2.35
MB6	220	150	64	£3.95
MB7	177	120	83	£3.42
MB8	150	80	50	£2.22

All sizes are in millimetres

### MICRO SWITCH roller arm operation spdt 40p each

#### MINIATURE TOGGLE SWITCHES

spdt	60p each	spdt 3 position c/o/f	70p each
dpdt	70p each	dpdt 3 position c/o/f	80p each
spdt biased	60p each	spdt 3 position c/o/f biased both ways	70p each
		dpdt 3 position c/o/f biased one way	80p each

#### MINIATURE PUSH TO MAKE SWITCH

DIL RELAYS 5 volt dp/changeover		60p 10 for £5.00
12 volt dp/changeover		80p 10 for £6.00

#### RELAY 10 amp contacts sp/changeover 12 volt coil

CAR HORN RELAY in metal can with fixing lug, s/pole on 10 amp contacts	£1.00 each 6 for £5.00
20 AMP RELAY dp on 12 volt coil	£1.50 each 4 for £5.00
REED RELAY 12 volt	50p each 10 for £4.00
240 VOLT AC RELAY, 3-pole c/o 10 amp contacts	£1.50 each 4 for £5.00

#### SEMICONDUCTORS - TRANSISTORS - ICs - DIODES - REGULATORS - ETC

VOLTAGE REGS 7812/7805/7912/7905	all 35p each, any 4 for £1.20
AD592An Temperature Sensor i.c. mounted on 1.5m screened lead complete with data and application notes	£1.50 each
LM3914/LM3915 Bargraph iCs	£2.95 each
78512 12V +VE 2amp regulator	50p each
78505 5V +VE 2amp regulator	50p each
MICRO IC'S - Z80A CPU £1.20; Z80A PIO £1.50; Z80B SIO -1 £4.00	

#### OPTO DEVICES - LEDS - ETC

5mm rnd red/yellow/green/amber	10p each 12 for £1.00 any mix
5mm rnd high brightness red/green	20p each 6 for £1.00 any mix
5mm rnd flashing	red 60p each, yellow/green 70p each
5mm rnd bi-colour	35p each, tri-colour 45p each
LED mounted in chrome bezel red, yellow or green	30p each, 4 for £1
LED mounted in a black bezel red only	25p each, 5 for £1.00
PLASTIC BEZEL for 5mm rnd leds	10 for 40p
High brightness bi-colour l.e.d., rectangular, red/green, two leads	40p each

#### RESET TIMER PCB

Gives a timed relay closure following a momentary input. Requires 12V d.c. supply SP c/o relay output LED indication. 19 different time intervals from 25sec to 35min 20sec. £5.98 each.

#### UNIVERSAL BELL TIMER

10 or 20 minute bell cut off +ve or -ve trigger\* timed relay contacts. £4.96

#### ALARM CONTROL UNIT

Single zone alarm control unit built into a domestic light switch box. Ideal for home, caravan, boat, garage, shed etc.

Facilities: - Normally closed loop for pir sensors, door/window contacts etc. Normally open loop for pressure mats. 24-hour loop for personal attack button Visual indication that the system is operational.

Automatic entry/exit delay.  
Automatic system reset.  
Alarm output cmos logic level.

#### PRICE COMPLETE WITH FULL INSTRUCTIONS SUB-MINIATURE PASSIVE INFRA-RED SENSOR ONLY £5.95

Brand new passive infra-red sensor, measures only 33mmW x 24mmH x 29mmD. Logic level output. Full data and application notes supplied.

**EX INSTALLATION SENSORS tested working.**  
Type 1. Measures 180 x 112 x 70mm with walk test led, relay output and tamper protection. 12 volt dc supply required £8.50 each  
Type 2. As above but a smaller unit 123 x 62 x 50mm £11.75 each  
Type 3. Ceiling mounting passive, infra red sensor 360° detection, 12V d.c. supply relay output, tamper circuit and pulse count option. Data supplied. £15.70 each

<b>DOOR/WINDOW CONTACTS</b> Surface or flush mounting, white	£1.10 each
<b>JUNCTION BOX</b> white 6 way	60p

**DUAL TECH SENSOR** Microwave and passive infra-red combined. Separate led indication for each function. Measures 120 x 75 x 50mm. 12 volt d.c. supply. Relay output. Tamper protection. £29.95 each

#### ALARM CONTROL PANEL ST3000

"Wire free alarm control panel, detectors communicate with the panel by means of radio transmitters". Speech synthesis for programming and general operating guidance". Built in user programmable telephone dialler. Up to 32 transmitters can be used". Programmable exit/entry and bell timers". Programmable user codes. Full installation data supplied, the only thing that has to be handwired is the output to the siren/bell unit (not supplied)". These control panels cost over £300.00. Yours for only £59.95. Suitable **PASSIVE INFRA SENSOR/TX £25.85**  
Battery operated, available in 8m range, 10m range or 25m range.

#### UNIVERSAL TX

For connection of normally open or closed contacts e.g. door/window switches, pressure mats etc. £17.63

### BREADBOARDS - CAPACITORS - SOLAR CELLS - HEATSHRINK - ETC

**SOLAR CELL** 2 volt 150mA max, size 60 x 100mm £1.35 each 5 for £6  
**BNC SOCKETS** 50 ohm single hole fixing 50p each 10 for £4.00

**MERCURY TILT SWITCH**  
Standard on/off £1.00 each  
4 Contact (Directional) £1.50 each  
**PIEZO VIBRATION SENSOR**  
with data sheet £1.00 each

**BREADBOARD**  
173 X 65mm 840TP £5.25 each  
**TEXTTOOL ZIF SOCKET**  
28 pin zero insertion socket £5.95 each

**6 VOLT NI-CAD PACK** 5AA NI-CADS, fast charge type £3.95  
**CAPACITOR** 10,000 mfd 25 volt with fixing clip 60p each  
**EPROMS** 27C256 - 30 27C512 - 25. Once programmed but never used eprom. Mounted on a plastic carrier, can easily be removed from the carrier or used with a low insertion force socket.  
27C256 £1.00 each 6 for £5.00 27C512 £1.20 each 5 for £5.00  
Suitable low insertion force socket 28 pin 40p each 3 for £1.00  
**MULTITURN PRESETS** 20mm RECT. 500R, 1K, 5K, 10K, 20K, 50K, 100K 1MO. 40p each, 3 for £1.00

**CAR CIGAR LIGHTER ADAPTER (DUAL SIZE)**  
mounted on two metres of cable £2.00 each  
**100db PIEZO SOUNDER**  
2KHz note, 3-12V d.c. 40mA, 45mm dia. x 26mm £1.76 each  
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## £1.00 BARGAIN PACKS

### SUB-MINIATURE TOGGLE SWITCHES

P.C.B. Mounting

- BO1 S.P. on 4 for £1.00  
BO2 D.P. on 3 for £1.00  
BO3 3 x D.P. 3 pos. centre off  
BO04 DIL SWITCHES 4-way S.P. on 3 for £1.00  
BO05 DIL SWITCHES 3-way S.P. on 2 for £1.00  
BO06 DIL SWITCHES 12-way 90° sp on 2 for £1.00  
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BO10 as above but 29mm dia. 3 for £1.00  
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BO12 4 x 28-WAY TURNED PIN DIL SOCKET  
BO13 15 x 12 VOLT WIRE-ENDED LAMPS  
BO14 8 x 2 PIN DIN PLUGS screw terminal connection  
BO15 2 x LIGHT DEPENDENT RESISTOR Less than 200 ohms in daylight, greater than 10 megohms in darkness  
BO16 1 x KEYPAD 20-key in 5 x 4 matrix bubble type switch contacts  
BO17 2 x PIEZO BUZZERS approx 3 to 20 volt d.c.  
BO18 5 x 78M12 VOLTAGE REGULATORS positive 12V 500mA  
BO19 4 x TL082CP bi-fet op-amps  
BO20 20 x ASSORTED LEDS full spec. various shapes and sizes  
BO21 3 x INFRA-RED DIODE TX/RX PAIRS made by Honeywell (no info)  
BO22 4 x CONSTANT CURRENT LED 5mm round, red 2-18V d.c. or a.c. nominal 14mA  
BO23 50 x IN4148 diode  
BO24 2 x INFRA-RED TRANSISTOR FPTS1533  
BO25 5 x DIACS  
BO26 3 BDY33C 10 amp 100V npn transistor  
BO27 12 x 2N3702 Transistor  
BO28 12 x 2N3904 Transistor  
BO29 12 x BC337 Transistor  
BO30 4 x LM317T Variable regulator mounted on a small heatsink  
BO31 2 x MAM6610 2 digit 0.6" 7 segment display Com anode, amber  
BO32 3 x PHONO TO PHONO LEAD 63cm long  
BO33 15 x RECTANGULAR RED LEDs 6 x 6 x 2mm stackable  
BO34 1 x PHOTO SENSITIVE SCR mounted on a PCB, data sheet supplied  
BO35 4 x IEC Panel Mounting Mains Plug Snap fit  
BO36 5 x ASSORTED PIEZO TRANSDUCERS  
BO37 5 LENGTHS OF HEATSHRINK SLEEVING 8mm dia. 400mm long  
BO38 25 x CERAMIC DISC CAPACITORS 0.1 mfd 63V  
BO39 15 x MONOLITHIC CERAMIC CAPACITORS 0.1 mfd 63V, in a dll package  
BO40 25 x ASSORTED ELECTROLYTIC CAPACITORS PCB mounting useful values  
BO41 25 ASSORTED PRE-SET RESISTORS  
BO42 6 x 3.5mm LINE JACK SOCKETS (mono)  
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BO44 8 x 3.5mm CHASSIS SOCKET (mono)  
BO45 2 x TRIACS 800 volt 8 amp  
BO46 12 x BC213L Transistor  
BO47 12 x MIN SLIDE SWITCH dpdt  
BO48 15 x MIN CERMET TRIMMER POTS (good range of values)  
BO49 1 x PCB WITH TWO LARGE LEDS 15mm square, one red and one green  
BO50 1 x 12V DC RELAY 4-pole c/o with plug in base  
BO51 4 x LM324 quad op-amps  
BO52 4 x 555 Timer  
BO53 5 x 741 op-amp  
BO54 25 x IN4001 diode  
BO55 20 x IN4007 diode  
BO56 1 x SLOTTED OPTO  
BO57 1 x DAC08 Digital to analogue convertor with data  
BO58 4 x OPTO ISOLATOR  
BO60 3 x C106D Thyristor

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- POWERFUL COIL DRIVE

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- 190mm SEARCH COIL
- NO 'GROUND EFFECT'

KIT 815.....£45.95

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A versatile thermostat using a thermistor probe and having an I.C. display, MIN/MAX memories, -10 to 110 degrees celsius, or can be set to read in Fahrenheit. Individually settable upper and lower switching temperatures allow close control, or alternatively allow a wide 'dead band' to be set which can result in substantial energy savings when used with domestic hot water systems. Ideal for greenhouse ventilation or heating control, aquaria, home brewing, etc. Mains powered, 10A SPCO relay output. Punched and printed case.

KIT 841.....£29.95

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A 1000W per channel chaser with Zero Volt Switching, Hard Drive, and full inductive load capability. Built-in mic. and sophisticated 'Beat Seeker' circuit - chase steps to music, or auto when silent. Variable speed and mic. sensitivity control, I.e.d. mimic on front panel. Switchable for 3 or 4 channels. P552 output socket. Suits Rope Lights, Pin Spots, Disco, and Display lighting.

KIT 833.....£32.13

### SUPERHET LW MW RADIO

At last an easy to build SUPERHET AM radio kit. Covers Long and Medium waves. Built in loudspeaker with 1 Watt output. Excellent sensitivity and selectivity provided by ceramic IF filter. Simple alignment and tuning without special equipment. Supplied with pre-drilled transparent front panel and dial, for interesting see-through appearance.

KIT 835.....£17.16

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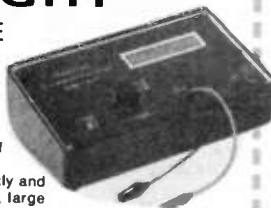
A very popular project which picks up vibrations by means of a contact probe and passes them on to a pair of headphones or an amplifier. Sounds from engines, watches, and speech travelling through walls can be amplified and heard clearly. Useful for mechanics, instrument engineers, and noseys parkers!

KIT 740.....£19.98

## KIT HIGHLIGHT

### DIGITAL CAPACITANCE METER KIT 493

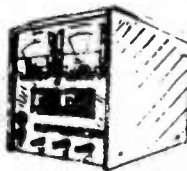
This has been one of Megenta's best ever kits. It provides clear readings of capacitance values from a few pF up to thousands of µF. It is ideal for beginners as there is no confusion over the placing of the decimal point, and it allows obscurely marked components to be identified quickly and easily. Quartz controlled accuracy of 1%, large clear 5 digit display and high speed operation make it a very useful instrument for production and testing departments. The kit is now supplied with a punched and printed front panel as well as the case. All components and top quality printed circuit board. When assembled it looks a really professional job. For a limited time this kit is offered at a new low price.



PRICE  
£39.95

### MOSFET VARIABLE BENCH POWER SUPPLY 25V 2.5A

Our own high performance design. Variable output Voltage from 0 to 25V and Current limit from 0 to 2.5A. Capable of powering almost anything. Two panel meters indicate Voltage and Current. Fully protected against short-circuits. The variable Current limit control makes this supply ideal for constant current charging of NICAD cells and batteries. A Power MOSFET handles the output for exceptional ruggedness and reliability. Uses a toroidal mains transformer.



KIT 769.....£56.82

### ULTRASONIC PeST SCARER

Keep pets/pests away from newly sown areas, fruit, vegetable and flower beds, children's play areas, patios etc. This project produces intense pulses of ultrasound which deter visiting animals.



- KIT INCLUDES ALL COMPONENTS, PCB & CASE
- COMPLETELY INAUDIBLE TO HUMANS
- EFFICIENT 100V TRANSDUCER OUTPUT
- UP TO 4 METRES RANGE
- LOW CURRENT DRAIN

KIT Ref. 812.....£14.81

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A highly efficient mains powered Negative Ion Generator that clears the air by neutralising excess positive ions. Many claimed health benefits due to the ioniser removing dust and pollen from the air and clearing smoke particles. Costs virtually nothing to run and is completely safe in operation. Uses five point emitters.

KIT 707.....£17.75

### BAT DETECTOR

An excellent circuit which reduces ultrasound frequencies between 20 and 100 kHz to the normal (human) audible range. Operating rather like a radio receiver the circuit allows the listener to tune-in to the ultrasonic frequencies of interest. Listening to Bats is fascinating, and it is possible to identify various different types using this project. Other uses have been found in industry for vibration monitoring etc.

KIT 814.....£21.44

### 12V EPROM ERASER

A safe low cost eraser for up to 4 EPROMs at a time in less than 20 minutes. Operates from a 12V supply (400mA). Used extensively for mobile work - updating equipment in the field etc. Also in educational situations where mains supplies are not allowed. Safety interlock prevents contact with UV.

KIT 790.....£28.51

### EE TREASURE HUNTER

Our own widely acclaimed design. This sensitive Pulse Induction metal detector picks up coins and rings etc up to 20cm deep. Negligible 'ground effect' means that the detector can even be used with the head immersed in sea water. Easy to use, circuit requires only a minimum of setting up as a Quartz crystal provides all of the critical timing. Kit includes search-head, handle, case, PCB and all components.

KIT 815.....£45.95

### INSULATION TESTER

A reliable and neat electronic tester which checks insulation resistance of wiring and appliances etc., at 500 Volts. The unit is battery powered, simple and safe to operate. Leakage resistance of up to 100 Megohms can be read easily. A very popular college project.

KIT 444.....£22.37

### 3 BAND SHORT WAVE RADIO

Covers 1.6 to 30MHz in three bands using modern miniature plug-in coils. Audio output is via a built-in loudspeaker. Advanced stable design gives excellent stability, sensitivity and selectivity. Simple to build battery powered circuit. Receives a vast number of stations at all times of the day.

KIT 718.....£30.30

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Digital lock with 12 key keypad. Entering a four digit code operates a 250V 16A relay. A special anti-tamper circuit permits the relay board to be mounted remotely. Ideal car immobiliser, operates from 12V. Drilled case, brushed aluminium keypad.

KIT 840.....£19.86

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A powerful 23kHz ultrasound generator in a compact hand-held case. MOSFET output drives a special sealed transducer with intense pulses via a special tuned transformer. Sweeping frequency output is designed to give maximum output without any special setting up.

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KIT 560.....£22.41

### LIGHT RIDER 9-12V CHASER LIGHTS

A low voltage DC powered end-to-end type chaser that can be set for any number of lights between 3 and 16. The kit is supplied with 16 I.e.d.s but by adding power transistors it is possible to drive filament bulbs for a larger brighter display. Very popular with car customisers and modellers. I.e.d.s can be randomly positioned and paired to give twinkling effects.

KIT 559.....£15.58

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### HAMEG HM203-7 20 MHz DUAL TRACE OSCILLOSCOPE & COMPONENT TESTER

Western Europe's best selling oscilloscope - It is RELIABLE, HIGH PERFORMANCE, & EASY TO USE. Sharp bright display on 8 x 10cm screen with internal graticule. A special extra feature is the built-in component tester which allows capacitors, resistors, transistors, diodes and many other components to be checked. The quality of this instrument is outstanding, and is supported by a two year parts and labour warranty. If you are buying an oscilloscope - this is the one. - It costs a fraction more than some other 20 MHz scopes but it is far far superior. Supplied with test probes, mains lead, and manual.

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### EDUCATIONAL BOOKS & PACKS

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Book & Components £28.95, Book only £6.25

#### FUN WITH ELECTRONICS

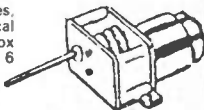
An Osborne book, wonderfully illustrated in colour. Component pack allows 6 projects to be built and kept. Soldering is necessary. Age 12 on, or younger with adult help. Book & Components £20.88, Book only £2.95

#### 30 SOLDERLESS BREADBOARD PROJECTS

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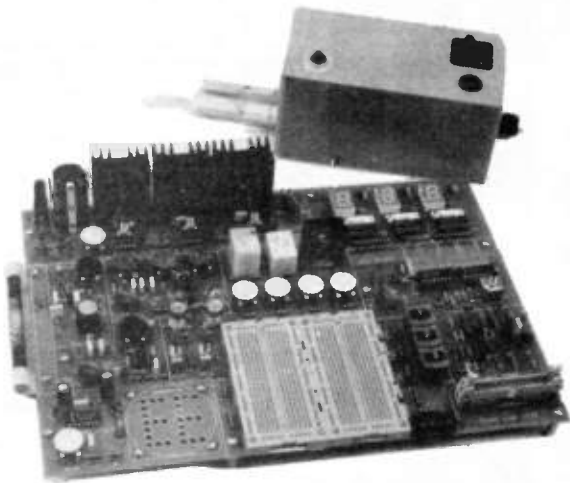


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For computer control via standard 4 pole unipolar drivers.  
MD35% - standard 48 steps per rev.....£12.99  
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## Teach-In '93



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ALL COMPONENTS TO ASSEMBLE THE EPE MINI LAB ARE AVAILABLE FROM MAGENTA.

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- KIT ML2 All Components for Part 1 less p.c.b.....**£39.95**
- KIT ML3 Power Supply components.....**£19.95**
- KIT ML4 Transformer unit.....**£21.45**
- KIT ML5 L.E.D. Voltmeter, signal generator, audio amplifier and 555 timer.....**£33.95**
- KIT ML6 Logic probe, display, radio tuner.....**£17.95**

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INCORPORATING ELECTRONICS MONTHLY

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## VOL. 22 No. 11 NOVEMBER '93

### ON THE RIGHT TRACK

Another exciting issue and another mark in the development of the magazine for two reasons. Firstly because we are giving away a fairly new product – Tracktronic stick on wiring.

The stick on copper track, when used with the circuit card, is an excellent way for the novice to get into electronics by building and learning as you go along. The beauty of the system is that you can easily relate the circuit diagram to the circuit board because, in most cases, the constructional layout follows the circuit diagram layout exactly. There is no mirror image p.c.b. or complicated stripboard layout to worry about.

Tracktronic is also very useful for the more experienced constructor, the system can be used to make up a prototype circuit very quickly and the track could also be helpful when repairing p.c.b.s, etc. Try it – we are sure you will find it works well.

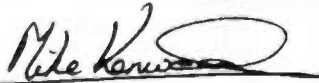
### GOING SOFT

The second milestone is the launch of the EPT Educational Software *Electronics Principles* software package. I know I went on about this last month – and there is a whole eight page supplement on it this month – so I won't say much more. Just make sure that if you have any interest in learning about electronics theory, or teaching it, you get a demo disc (it's "almost free") and see for yourself just how good this package is.

### VAT AVOIDANCE

It seems increasingly likely that there will be VAT on magazines, books and newspapers from the autumn this year. For UK and residents of ECC countries this will of course add to the price of EPE. There is an easy and legal way to avoid this increase – pay in advance. There probably has never been a better time to take out a subscription, the total cost to UK readers is less than the years cover price and that includes postage.

By paying for a years subscription now you could save about £4 over the monthly cover price if VAT goes on at 17.5%. We are of course happy to accept subscriptions for two years (just double the payment) and you will then also be immune to any cover price increase (as well as VAT) for that period – subscription details are given below, or see page 820. The same principle also applies to books – buy now!



### SUBSCRIPTIONS

Annual subscriptions for delivery direct to any address in the UK: £22. Overseas: £28 (£45.50 airmail). Cheques or bank drafts (in £ sterling only) payable to Everyday with Practical Electronics and sent to EPE Subscriptions Dept., 6 Church Street, Wimborne, Dorset BH21 1JH. Tel: 0202 881749. Subscriptions start with the next available issue. We accept Access (MasterCard) or Visa payments, minimum credit card order £5.

### BACK ISSUES

Certain back issues of EVERYDAY ELECTRONICS, PRACTICAL ELECTRONICS and EVERYDAY with PRACTICAL ELECTRONICS (from Nov '92 onwards) are available price £2.20 (£3 overseas surface mail) inclusive of postage and packing per copy – £ sterling only please. Visa and Access (MasterCard) accepted, minimum credit card order £5. Enquiries with remittance, made payable to Everyday with Practical Electronics, should be sent to Post Sales Department, Everyday with Practical Electronics, 6 Church Street, Wimborne, Dorset BH21 1JH Tel: 0202 881749. In the event of non-availability one article can be photostatted for the same price. Normally sent within seven days but please allow 28 days for delivery. We have sold out of Jan, Feb, Mar, Apr, May, June, Oct, & Dec 88, Mar, May & Nov 89, Mar 90, April, Aug & Sept 91 Everyday Electronics, and can only supply back issues from Jan 92 to Sept 92 (excluding Mar 92) of Practical Electronics. Dec 92, Jan 93 and Feb 93 Everyday with Practical Electronics are also unavailable.

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# PORTABLE MINIGUARD

T. R. de VAUX-BALBIRNIE

Room-guard - Greenhouse-guard - Shop-guard - Car-guard

A portable PIR alarm - take it  
wherever you go!



**T**HIS portable PIR (passive infra-red) intruder alarm is a miniature version of the larger systems now often found in homes and commercial premises. However, Miniguard differs from its larger counterpart in being totally self-contained with integral batteries and sounder.

It is therefore entirely safe in operation and may be carried from place to place as the need arises. Arming and disarming is carried out by means of a key-operated switch and there are built-in time delays which allow this to be carried out without the user setting it off.

Miniguard operates a siren when a person walks into the protected zone. The detection range is at least 8 metres (26ft approximately) which will be found sufficient for most purposes.

Depending on use, it may be necessary to provide some security for the alarm itself - possibly by placing it out of easy reach or fixing it into position in some way. This will prevent it from being thrown to the ground by an intruder before it has had time to sound sufficient warning.

## SOUND-OFF

The audible warning device used is of the familiar *yelping* type. This is very loud while having only a small current require-

ment. In some situations it may be necessary to connect the siren itself *outside* - perhaps to protect a shed or outbuilding. Some weather-proofing may therefore be required.

For outside use, it would be possible to use a full-size household alarm siren but readers would need to check that this will operate satisfactorily from a 6V supply - many do but some need 12V. A hybrid system may also be used where a low-power warning sounds inside the unit itself and a further *slave* sounder operates in the house or outdoors. The slave siren could be situated any reasonable distance from the main unit and connected to it using inexpensive twin wire (e.g. bell wire).

Passive infra-red detectors make a convenient basis for an alarm. Other types of intruder detector often rely on fixed wiring and permanent installations such as magnetic reed switches set in door and window frames, pressure mats or interrupted light beams. However, PIR units work by detecting *heat - infra-red radiation* - given off by the human body.

Any warm object naturally emits infra-red. This is a light-like radiation but of a much longer wavelength - typically between 0.7m and 1000 $\mu$ m (1 $\mu$ m is one millionth of a metre). The present sensor

detects infra-red in the range 4 $\mu$ m to 20 $\mu$ m which is ideal for the purpose.

## OPERATING TIME

The Portable Miniguard Alarm has an adjustable cut-off time so that, once triggered, the sounder will not operate continuously and cause undue disturbance. The prototype unit has been tested with operating times between 20 seconds and two minutes approximately. A timing of up to two minutes will be found adequate for most purposes but it could be easily extended if required.

The power supply for the alarm consists of eight AA size alkaline cells in two separate four-cell (6V) battery packs. The current requirement while on standby is around 100 $\mu$ A for one pack and 70 $\mu$ A for the other and this may be regarded as negligible.

The specified batteries will give about one year of service providing the alarm is not called upon to sound very often. Even so, for maximum reliability, it is advisable to test-trigger the unit every month for a few seconds and replace the batteries each year as a matter of routine. This should be carried out more frequently in the pack operating the siren if the alarm has sounded for long periods.

## PYROELECTRIC SENSOR

The specified detector is of the *multi-zone* type containing a special pyroelectric sensor element situated behind a plastic lens. The lens focuses the infra-red radiation emitted by the target on to the detector surface.

Triggering occurs only when the infra-red passes from one of 20 *detection zones* to an adjacent one fairly quickly (see Fig. 1). Steady sources such as light bulbs or the sun should therefore have no effect.

With each zone covering an angle of eight degrees, the total acceptance angle of the device is 160 degrees so, with careful positioning of the unit, excellent coverage can be obtained. Note that the performance of the sensor is most efficient when it directly faces the target and when the object moves *across* the detection field rather than towards or away from it.

The detector is obtained as a ready-made hermetically-sealed module which also contains some of the essential circuitry. While no infra-red is being picked up, its output remains substantially high (nominally +6V) with a few short random

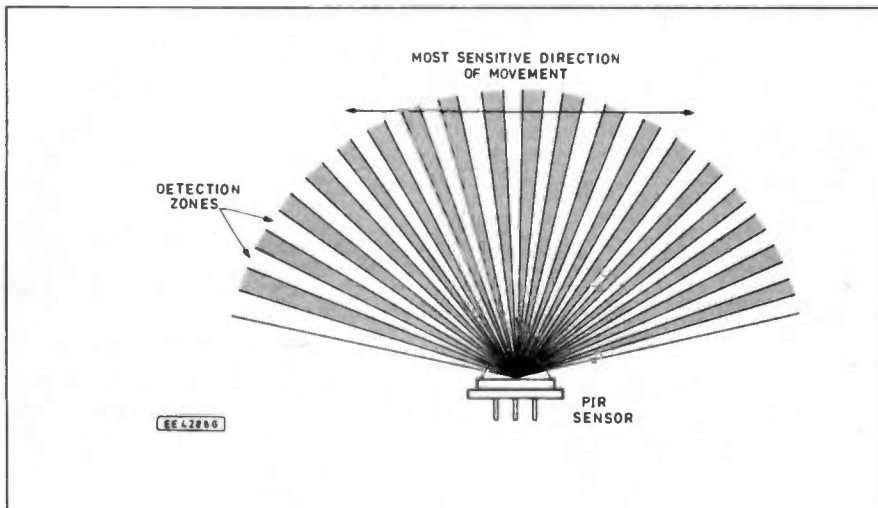


Fig. 1. Detection zone "fan" showing the 20-zones making up the 160 degree coverage.



low pulses. When an infra-red emitting object is detected, the output provides a regular chain of *low* square-wave pulses. It is this change which triggers the rest of the circuit.

## FALSE TRIGGERING

The PIR unit as it stands is sensitive to the pick-up of any stray infra-red radiation which may cause false triggering. Although it might happen only occasionally, this is thought to be unacceptable in the present type of circuit.

To avoid such false operation, some additional circuitry is required. In the present system, this arranges for prolonged triggering signals to be delivered by the PIR unit within a certain time before the alarm sounds. This part is adjustable for the required degree of sensitivity.

In tests on the prototype unit, there was

ward-biased diode. Current then flows to the main circuit based on IC1.

Fixed resistors R2 and R3 together form a potential divider connected across the supply. With the choice of values shown, there will be 60 per cent of the supply voltage – 3V approximately – developed across R3.

Neglecting the effect of PIR1 for the moment, the voltage across capacitor C1 would gradually rise to this nominal value (since it is connected in parallel with R3) as it charged through resistor R2. This would take a few seconds.

## A HOLE IN MY BUCKET

However, the presence of sensor PIR1 modifies the behaviour. With battery B2 connected, and with the occasional *low* transition of PIR1 output pin 3, capacitor C1 is allowed to discharge to some small

criterion for it to be interpreted as *Logic '1'* by IC1 trigger input, pin 2, to which it is connected and there is no further effect.

When infra-red is detected and on regular pulsing of PIR1 output, capacitor C1 is allowed to discharge to a greater degree than previously and the voltage across it soon falls to a level less than one-third that of the supply. This is interpreted as *Logic '0'* by IC1 trigger input.

The time taken for this to happen will depend on the rate at which the voltage across C1 falls which, in turn, depends on the adjustment of preset VR1. In this way, pulses will need to be produced at PIR1 pin 3 over a prolonged period – that is, for several seconds – for triggering to occur.

This situation may be likened to filling a bucket (capacitor C1) with water (electric charge) through a hosepipe (R2) but the bucket has a hole (VR1) in the bottom. Preset VR1 therefore acts as the *sensitivity*

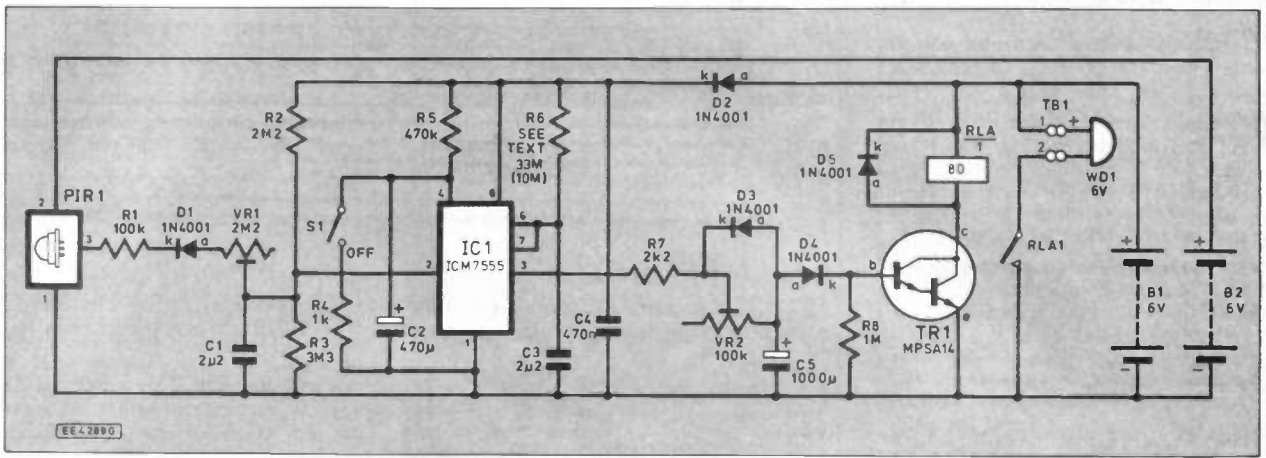


Fig. 2. Complete circuit diagram for the Portable Miniguard alarm.

no incidence of false operation over a one month trial period. However, there is inevitably an element of compromise in the adjustment – if the alarm is set at too low a sensitivity then operation will be excessively sluggish or it may fail to work at all. If it is set too high, false triggering may possibly result.

A further point to bear in mind is that certain animals such as pet dogs and cats may operate the alarm. However, careful positioning of the unit and attention to the sensitivity setting should practically eliminate this. Open fires and moving curtains in sunlight may cause flickering infra-red on the detector and cause false operation.

## CIRCUIT DESCRIPTION

The complete circuit diagram for the Portable Miniguard is shown in Fig. 2. The PIR sensor, PIR1, itself needs a stable 5V to 6V supply. The only satisfactory way of providing this, consistent with the required extremely low current requirement, is to use a dedicated battery pack, B2.

Attempts to use the same supply as the rest of the circuit tends to cause false triggering due to the sudden drop in supply voltage which occurs when the siren operates. B1 is a further similar 6V battery pack responsible for powering the control circuit and siren.

With battery B1 connected, current flows through diode D2. This provides a supply of 5.3V – that is, the nominal battery voltage less the voltage drop across the for-

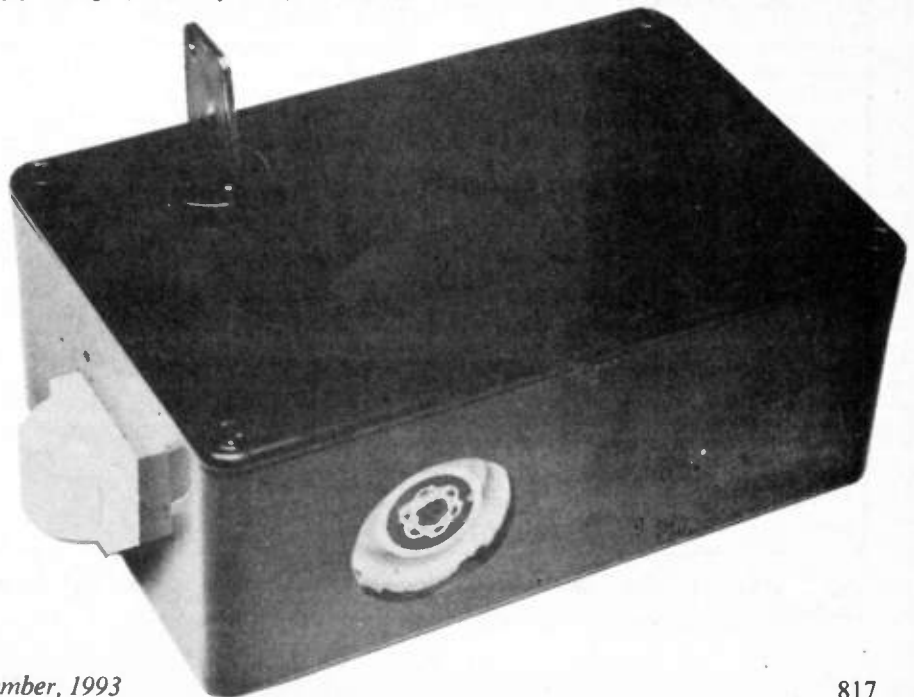
ward-biased diode. Current then flows to the main circuit based on IC1.

Capacitor C1 has a large enough value to smooth out any occasional low transitions and this results in the full steady-state voltage of near 3V being developed across it – that is, while no infra-red is being detected. This voltage is more than one-third supply voltage (nominally 1.8V). This is the

*control* (plugging the hole to some extent) and will be adjusted for best effect at the end of construction. Diode, D1, prevents current flowing back into C1 from the detector output when it goes high which would alter the operating characteristics.

## DARLINGTON DRIVER

In this circuit IC1, a CMOS 555 timer, is connected as a *monostable multivibrator*.



Assume for the moment that the reset input, pin 4, is kept *high* through resistor R5 – that is, with key-operated switch S1 in the position shown. Thus, when actuated by making the trigger input low, the output, pin 3, switches on (becoming *high*) for a certain time then reverts to *low*. The time period is related to the values of fixed resistor R6 and capacitor, C3.

With the output high (positive supply voltage) and with the effect of capacitor C5 ignored for the moment, current enters the base of the Darlington transistor TR1 through fixed resistor R7 and preset potentiometer VR2 connected as a variable resistor. Note that diode D3 is reversed-biased and therefore has no effect.

Relay RLA subsequently operates due to collector current flowing through its coil. Audible warning device, WD1, then sounds by current flowing from battery B1 via the relay normally-open contacts RLAI.

A Darlington device is really two transistors contained in the same package. These are connected together internally to provide a single component with extremely high current gain. Thus, only a very small base current is required to turn on a relatively large collector current.

Diode D5 prevents the possible destructive effect of the reverse high-voltage spike which occurs when the magnetic field in the relay core collapses on switching off.

## DELAYED ACTION

The purpose of preset potentiometer VR2 and capacitor C5 is to hold-off operation of TR1 for a few seconds after IC1 has been triggered. This allows the user time to switch off the alarm without causing it to operate i.e. it forms the entry delay. This section works in the following way.

When the alarm is triggered and IC1 pin 3 becomes high (positive supply voltage), current flows through fixed resistor R7 and preset potentiometer VR2 to charge capacitor C5. The voltage across this component then gradually rises until it reaches the level necessary to turn on the Darlington transistor TR1.

Since it requires 1.4V at the base of a Darlington transistor to operate and since there is a further loss of 0.7V due to the forward voltage drop of diode, D4, the voltage across C5 will need to rise to some 2.1V before TR1 switches on. With the component values chosen this will take from almost zero to 20 seconds approximately depending on VR2 adjustment.

This hold-off time will be set for best effect at the setting-up stage. It will need to be sufficient to allow the user to approach the unit and cancel operation before the alarm sounds yet not be so long as to jeopardise security.

When IC1 pin 3 goes low, capacitor C5 discharges fairly quickly through R7 alone (quickly because R7 has a relatively low value) and charge sinks into IC1 pin 3. Note that diode D3 is now forward biased and effectively by-passes preset potentiometer, VR2.

Switch S1 can make IC1 pin 4 (reset input) either *high* or *low* according to its position – this performs the *arm/off* function. With S1 open, as shown, pin 4 is kept high via resistor R5 and the circuit is enabled. It then operates as described previously. When S1 is closed, pin 4 is made *low* via resistor R4 and the circuit is disabled.

When switch S1 is moved from the *off*

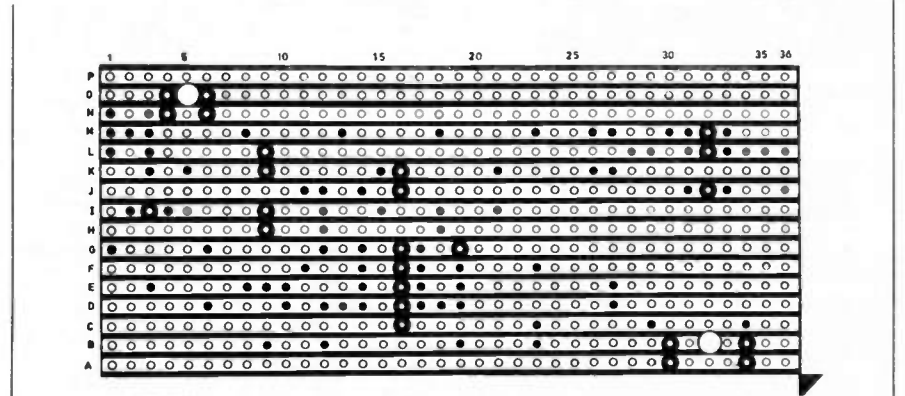
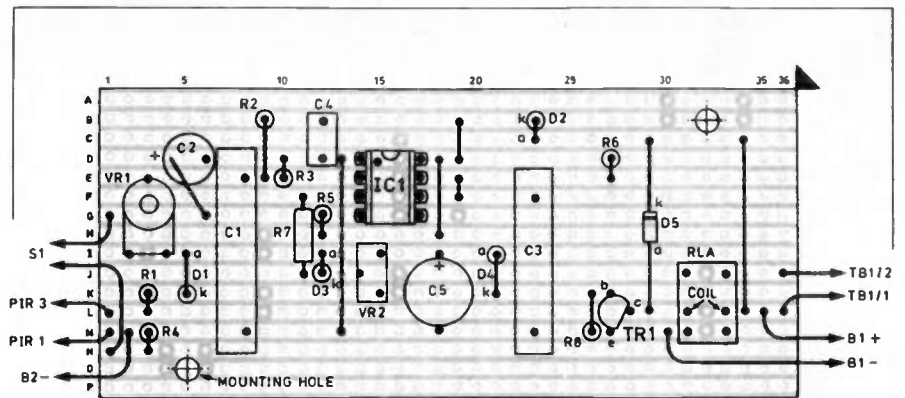
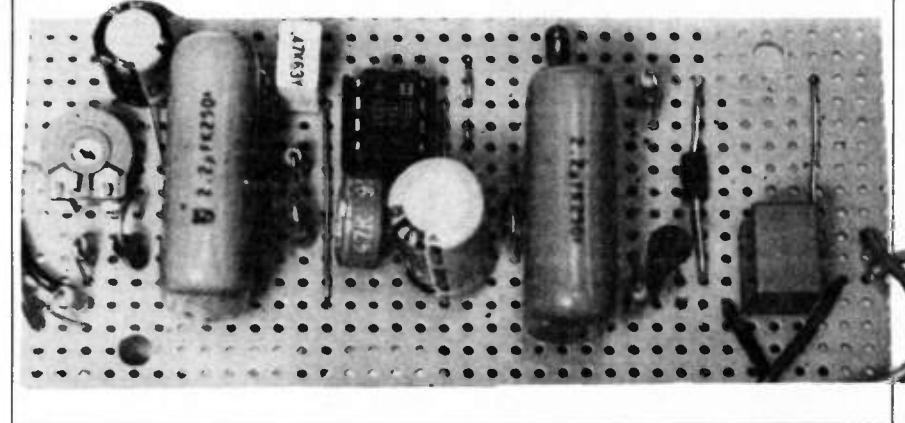


Fig. 3. Stripboard topside component layout and details of breaks required in the underside copper tracks. The completed circuit board is shown below.



to the *armed* position, IC1 pin 4 will not become high immediately. This is because capacitor C2 charges through R5 and the voltage across it – and hence at pin 4 – will gradually rise until it is interpreted as *high* by IC1. This will take 30 seconds approximately. This forms the exit delay. When the switch is returned to the *off* position, capacitor C2 discharges quickly through the relatively low-value resistor, R4.

It should be noted that although apparently *off* when S1 is in the *off* position, the circuit consumes the same current as it does while armed. If the unit is not to be used for a matter of weeks or months, it is therefore advisable to remove the batteries from the unit.

An on-off switch could be provided if it is well hidden – this would need to be of the double-pole type connected so as to break *both* battery circuits. However, for security reasons no on-off switch was fitted in the prototype.

## CONSTRUCTION

Construction of Miniguard is based on a main circuit panel made from a piece of

0.1-in. matrix stripboard, size 16 strips x 36 holes. Fig. 3 shows full topside component layout and details the breaks required on the copper strip side.

Begin construction by cutting the material to size and drilling the two mounting holes in the positions indicated. Make all track breaks and inter-strip links then add the soldered on-board components including the i.c. socket.

Resistor R6 has a temporary value of 10 megohm which is suitable for testing and setting-up purposes. Take care to observe the polarity of the five diodes and of electrolytic capacitors, C2 and C5. Take care also over the connections and orientation of the Darlington transistor TR1.

Before proceeding, make certain that there is no "bridging" of adjacent copper tracks with stray pieces of solder or scraps of wire. Check also that all breaks in copper strips are complete.

Next adjust preset VR1 so that its sliding contact is about three-quarters of its total travel *clockwise*. Adjust VR2 fully *anti-clockwise* (as viewed from the left-hand edge of the circuit panel). This will provide

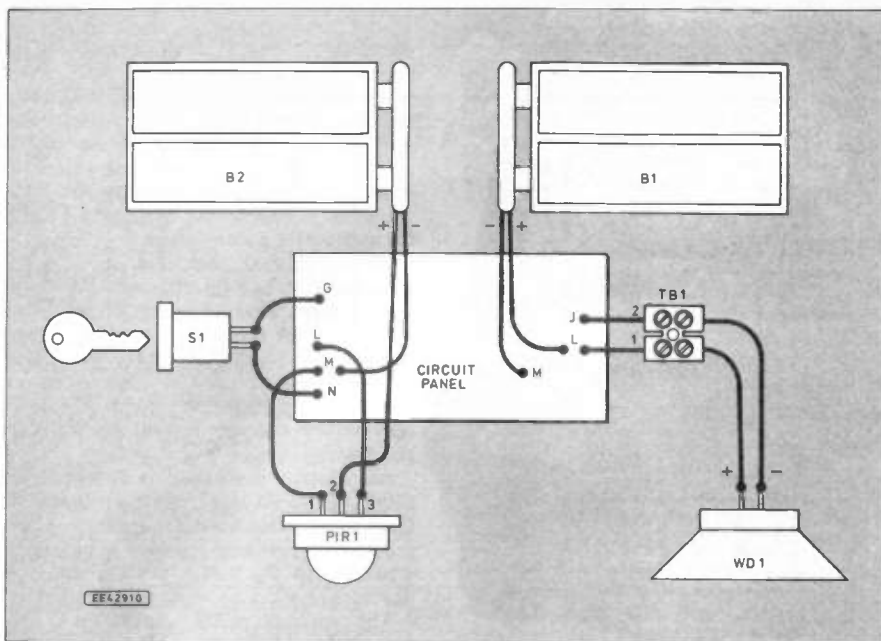


Fig. 4. Interwiring of off-board components. The sensor PIR1 connection must be via a 3-pin socket.

a medium sensitivity of the PIR unit and almost zero hold-off time. These settings are convenient for testing purposes.

Solder 20cm pieces of light-duty stranded connecting wire to strips G, L, M and N on the left-hand side of the circuit panel. Solder similar pieces of wire to strips J and L on the right-hand side. Solder B2 negative battery connector wire to strip M, B1 positive wire to strip L and the negative one to strip M as shown.

Insert IC1 into its socket taking care over the orientation. IC1 is a CMOS device and, in theory at least, vulnerable to damage by static charge which may exist on the body. It is therefore wise to avoid holding the pins when inserting it. You should also touch something which is earthed (such as a water tap) first.

## PREPARING THE CASE

Prepare the box to receive the circuit panel and other components. The hole for the PIR sensor in the end panel can be made by carefully measuring its size and drawing the outline on the plastic face.

Several holes should be drilled around

this line which may then be joined together using a small hacksaw blade. The work is then smoothed off with a file. The hole should be made a tight push fit for the PIR unit.

Use a similar method for making the hole in the side for WD1 sound to pass through – for maximum output this should cover the full area of the front of the sounder, see photograph. Make the hole for key-operated switch S1 in the lid and for an on-off switch if one is to be fitted. Drill the small holes in the base for WD1 mounting bracket.

Hold the circuit board in place temporarily and mark the position of the mounting holes. Drill these in the side of the case and, referring to Fig. 4, complete the interwiring.

Leave sufficient slack in switch S1 wiring for the lid to be removed without causing strain. Also, leave enough slack in the circuit board wires so that the panel may be rested on the top of the box with the lid removed for testing purposes.

Note the 2-way piece of screw terminal block, TB1, to which a temporary 6V "test" bulb is connected instead of the sounder so that testing may be carried out

in peace and quiet. The terminal block simply lies loose in the case.

Mount the circuit panel loosely for the moment using only one small fixing. Attach the sounder using self-tapping screws through the holes in the bracket – make sure these are not so long as to puncture the case. Mount the key-operated switch and the on-off switch if one is to be used. Fit the base of the box with self-adhesive plastic feet if necessary.

## PIR CONNECTIONS

It is strongly advised not to solder wires directly on to the pins of the PIR module. This is because heat from the soldering iron could cause damage to internal components. Instead, use a 3-pin single in-line (s.i.l.) socket. If this is not available, make one by cutting down an 8-pin d.i.l. socket.

## COMPONENTS

### Resistors

R1	100k	See <b>SHOP TALK</b> Page
R2	2M2	
R3	3M3	
R4	1k	
R5	470k	
R6	10M plus further timing resistor (see text)	
R7	2k2	
R8	1M	

All 0.25W 5% carbon

### Potentiometers

VR1	2M2 sub-min. enclosed preset, horiz.
VR2	100k sub-min. enclosed preset, vert.

### Capacitors

C1, C3	2 $\mu$ 2 polyester (2 off)
C2	470 $\mu$ radial elect. 16V
C4	470n polyester layer or ceramic
C5	1000 $\mu$ p.c.b. radial elect. 16V

### Semiconductors

PIR1	Sub-miniature passive infra-red sensor, type FIRM-287 (size 33 x 24 x 29 mm) – see <i>Shop Talk</i>
D1 to D5	1N4001 1A 50V rect. diode (5 off)
TR1	MPSA14 <i>npn</i> Darlington transistor
IC1	ICM7555 CMOS timer

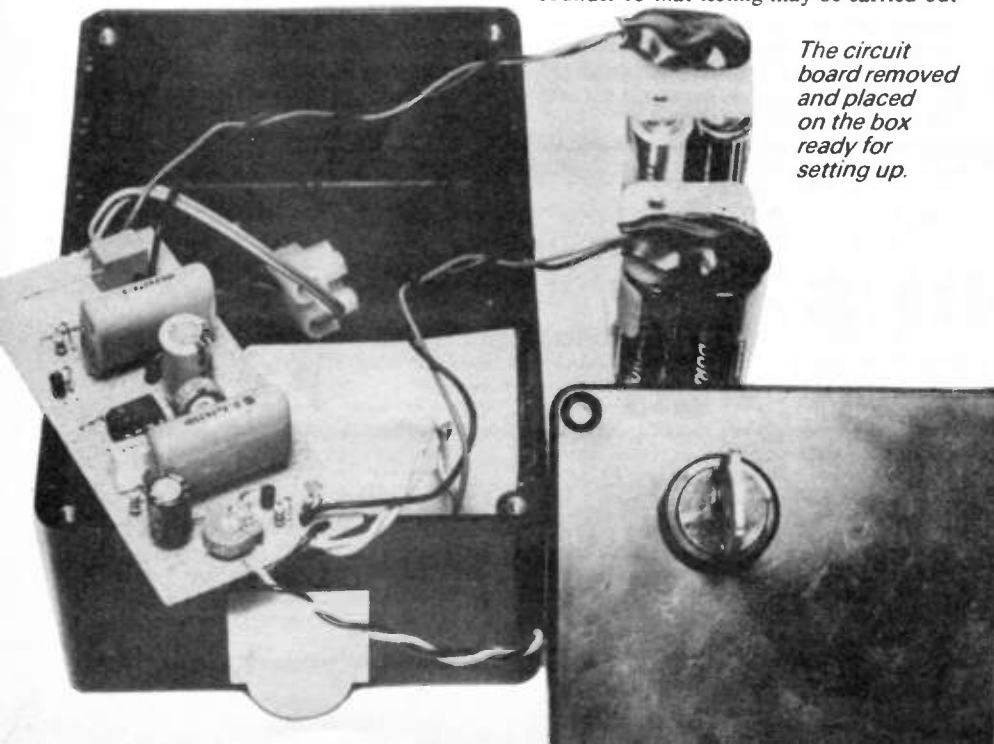
### Miscellaneous

B1, B2	AA size alkaline cells (8 off)
S1	Miniature s.p.s.t. key-operated switch
RLA	Miniature relay, 6V 80 ohm coil, with normally-open contacts rated at 1A
WD1	Audible warning device (solid-state siren) 6V 150mA operation. 110dB at 1m minimum – see text.

Stripboard 0.1 in matrix, size 16 strips x 36 holes; plastic case, size 150mm x 100mm x 60mm approximately external; 8-pin d.i.l. socket; 3-pin s.i.l. socket (see text); cell holders for 4AA size cells (2 off); PP3 type connectors or as required for cell holders (2 off); 6V 0.06A lamp and lamp holder for testing; stranded connecting wire; small fixings; plastic feet (4 off); solder, etc.

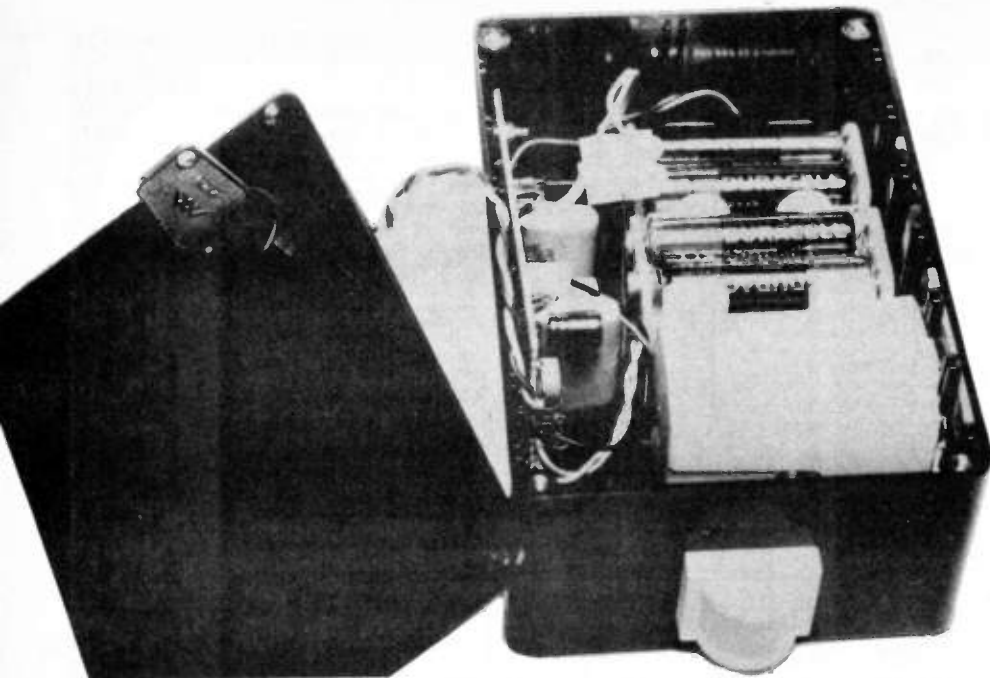
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The circuit board removed and placed on the box ready for setting up.





Layout of components inside the case. Note that the circuit board is mounted on one side panel and the key-switch on the lid.

Solder the connecting wires leading to strips *L* and *M* on the circuit panel to tags 3 and 1 respectively on the socket. Connect sensor pin 2, via the 3-pin socket, to the positive lead of battery connector B2. Push the socket gently home on the sensor pins and press the PIR unit into place in the hole in the box – if necessary, use a little glue to hold it securely.

Make certain that the numbering of the pins (as marked on the sensor plastic body) is correctly followed. *Take care here* – incorrect polarity is likely to cause permanent damage to the PIR unit.

Switch S1 to the off position. Connect a 6V 0.06A bulb, mounted in a suitable lamp holder, to the 2-way terminal block TB1.

### TESTING

A basic test should now be made and the sensitivity and hold-off time set. Do this in a room where there are no other people or infra-red emitting objects.

Remove the circuit panel and lay it in an accessible position on the box. Connect the batteries. Now keep out of the detection zone and leave things as they are for a minute or two to allow the PIR unit to stabilize. Under household conditions this is likely to take only a minute or so but under extreme conditions it can take much longer. With S1 switched on (armed), the lamp should remain off. Wait for one

minute (for the exit delay to time out) then move a hand across the detection zone. The unit should trigger and the light remain on for around 20 seconds. If it fails to work, adjust VR1 sliding contact slightly clockwise.

Check the sensitivity adjustment by resetting S1 (it will take up to one minute for the unit to become active again) and walking across the detection zone at a distance of 3m approximately. The setting is correct when the alarm does not trigger immediately but when a suitable amount of movement is needed to make it do so.

This will depend to some extent on conditions and personal requirements. Make further small adjustments to VR1 as necessary – clockwise rotation increases the sensitivity.

### HOLD-OFF TIME

The entry hold-off time should now be set. This should be kept fairly short for best security. Begin by adjusting preset VR2 sliding contact to approximately mid-track position – this provides a delay of 10 seconds and was found to be sufficient in the prototype unit.

Adjusting VR2 is difficult due to the presence of the large capacitors situated on each side of it. However, a suitable tool can be made using a short piece of plastic rod such as the end of a knitting needle with the tip filed to a screwdriver shape.

On triggering, the lamp should now be found to come on after the entry delay for about 10 seconds (that is, IC1 time period of 20 seconds less the hold-off time of 10 seconds approximately). Note that when switch S1 is used to cancel the alarm, it is normal for it to take about one second to switch off. This is because the charge in capacitor C5 maintains transistor TR1 in the on state for a short while.

When satisfied with the adjustments, resistor R6 should be replaced with one of appropriate value allowing 10 megohms for each 20 seconds operating time required. Since 10 megohms is the highest easily-obtainable resistor value, for a timing greater than 20 seconds it will be necessary to connect several similar components in series.

An alternative method is to use a so-called "high voltage" resistor obtainable from certain mail-order suppliers. These are made in very high values – 33 megohms was used in the prototype unit and this provides about one minute of operation.

The circuit panel should now be mounted in permanent position with short plastic spacers on the bolt shanks.

### ON-SITE

Some thought should now be given as to the best siting for the unit and a few tests made. A good method is to point the unit slightly downwards from a height of about 2.5m (8ft approximately).

After a period of trial and re-adjustment to the presets as may be necessary, the test lamp should be removed and WD1 connected to the terminal block observing the polarity. Miniguard may then be put into permanent service.

### REMOTE SOUNDER

If a sounder is to be connected externally, then the wires should be led in through a hole in the side of the box and connected to terminal block TB1, observing the polarity. Alternatively, a small plug and socket could be used. The route for the wiring should be chosen to prevent it from being easily cut or pulled free by an intruder.

A smaller audible warning device (solid-state buzzer) could also be situated inside the box. This would need to be of a type which does *not* require external drive circuitry or it will not work.

Connect any such sounder to TB1 so that this and the main one appear in parallel. A total loading of up to 1A is possible. Note that electronic sounders are polarity sensitive so will not work if they are connected the wrong way round.

You will always enjoy peace of mind with Miniguard!

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# New Technology Update

*Ian Poole investigates gallium arsenide chip development and laser storage device innovations.*

**T**wo ideas this month. Gallium arsenide has long been hailed as the successor to silicon in certain applications. However its use has never taken off in the way that many have expected. With developments being undertaken at the moment this could have come a stage nearer so that these i.c.s might become used more widely.

The second piece of news relates to computer storage techniques. As computers become ever larger and their enormous thirst for storage increases, ideas for packing more data into smaller spaces become increasingly attractive.

## Gallium Arsenide Wins Through

Gallium arsenide has many advantages over silicon. It has a much higher electron mobility and this gives it a much better high frequency performance than a silicon equivalent. This feature makes gallium arsenide devices popular for radio frequency applications as well as some specialised high speed digital i.c.s.

Apart from the obvious advantages of improved frequency response gallium arsenide also offers advantages of lower power consumption. Again this is of particular importance at high frequencies where silicon solutions often consume large amounts of power. This can often lead to problems with heat dissipation in the chips themselves as well as in the overall equipment. In addition to all these advantages gallium arsenide has some unique optical properties, enabling it to be used for i.e.d.s.

## Production Drawbacks

Despite all of these advantages gallium arsenide has some major drawbacks, generally associated with its production. One obvious one is the arsenic content which means that stringent safety precautions have to be maintained during manufacture. Cost is also very important.

General difficulties in manufacture mean that it is not as easy to process as silicon. It is partly for this reason that three major manufacturers of gallium arsenide chips, Harris, AT&T, and IBM are reported to be disposing of their gallium arsenide production facilities. However, if these problems could be overcome then the way might be open for it to become a standard semiconductor material. One step towards this may have been taken already. One of the main production problems is that it has not been easy to form a stable oxide layer on its surface.

In silicon it is relatively easy to grow a surface oxide layer. It is also very im-

portant because it serves a number of functions. In the first instance it acts as an insulator, allowing different parts or layers of the chip to be isolated from one another. The oxide also protects the silicon from impurities. This is very useful after manufacture when it prevents the ingress of impurities which might alter or destroy the properties of the circuit. In addition to this it performs the same function during manufacture.

A layer of oxide is grown and then selectively etched away in certain areas. Chemical impurities can then be diffused through the holes in the oxide layer to create *p* or *n* areas as required.

## Nitride Layer

To create an equivalent layer on gallium arsenide requires the use of other methods. Unfortunately, these often involve high temperatures which can damage the crystal structure. To overcome these problems a new method of creating a protective layer is being developed. Instead of using an oxide layer the technique involves growing a nitride layer instead.

The first step in the process removes any traces of oxide on the surface of the gallium arsenide. This is critical to the process and therefore three stages are used to ensure that even the smallest traces are removed. Initially most of the oxide is removed using acid bath. Next the wafer is exposed to bromide gas in methanol. Finally a hydrogen chloride/hydrogen etch mixture is used to remove the last of the oxide in the surface of the wafer.

Once this process has been completed the arsenic must be removed from the surface of the semiconductor to leave just the gallium. This is accomplished by passing a mixture of hydrogen and hydrogen chloride gas over the wafers at a temperature of around 350 degrees C. With the arsenic removed from the surface the nitride layer can be grown. This is normally about 100Å thick and it is produced by using a mixture of hydrazine in argon. Unfortunately the process is slow and takes an hour to complete.

The basic processes have now been proved and work is progressing to optimise it for commercial use. Most of this is centred around ensuring that the nitride layer is not contaminated by any oxides. Currently it is thought that the problems are associated with the cleaning techniques which are used.

Once the problems have been overcome and the process is in production it is likely to be another step on the road to cheaper and more widely used gallium arsenide i.c.s

## Lasers See Blue

Lasers are now becoming widely used in a variety of storage applications. Possibly one of the widest uses is in reading data from compact discs. However they are also used in computer optical storage applications as well. Such storage has the advantage for large systems that it gives a very cost effective form of storage. The cost per bit is much lower than many other forms. However optical storage does have the disadvantage that it is slower than the more traditional forms, even so it is becoming more widely used.

In view of the enormous market which is envisaged, research is progressing to endeavour to increase the storage capacity. Currently infra red laser light is used, this has a relatively long wavelength which reduces the capacity. To improve on this it is necessary to shorten the wavelength. However existing laser technology does not easily lend itself to the generation of very short wavelength light. Currently IBM have been undertaking some research and they have developed a laser which generates blue light.

To produce the light a high power infra red laser is used as the primary source. Light from this with a wavelength of around 860nm is passed into a potassium niobate crystal. This crystal is mirrored and acts as a resonator tuned to 430nm. This doubles the frequency of the signal, which in turn means that its wavelength is reduced by half, giving the required blue light.

## Efficiency

Whilst the basic idea is not totally new, great improvements have been made by significantly improving the efficiency to a point where it is commercially viable. In fact the efficiency of the frequency doubling process approaches 50 per cent, and the whole system from the input of the electrical energy to the final output of the blue light is around 10 per cent, a very high figure for a system of this nature.

These results have been achieved by the use of an innovative feedback system. This tunes the frequency of the laser so that it is at exactly half the resonant frequency of the potassium niobate crystal. By doing this the losses are minimised and the optimum efficiency is achieved.

The use of blue light gives a great improvement. It enables the data storage density to be increased by a factor of four. In addition to being used in computer storage systems the blue laser is also likely to find a number of other uses in a wide variety of fields.



# Innovations

A roundup of the latest  
Everyday News from the  
world of electronics

## Spy-in-the-Sky

### HARD TIMES AHEAD FOR LORRY HI-JACKERS

by Hazel Cavendish

**AN AMAZING** new state-of-the-art system which makes use of the latest satellite technology has been launched in Britain this summer by a Banbury firm, Alcatel Network Systems. The system enables owners of lorry fleets to track their vehicles through Europe, communicate with their drivers throughout a journey, issue alterations to a schedule and assist a driver who has mistaken the route.

Described as an ingenious combination of spy-in-the-sky and spy-in-the-cab, it also offers protection to the hi-jacked driver, who can send a "Mayday" call to his base on an emergency network, the lorry will then be tracked by the operator who can pass the driver's position directly to Interpol. The system, known as Euteltracks, covers vehicles anywhere in the UK and Europe, including most of Russia, and the Middle East, and claims to be accurate within 300 metres.

With the number of valuable lorries currently being stolen and whipped across the Channel, this advantage should have obvious appeal to fleet owners smarting from substantial lorry thefts. Passenger coach services, racehorse and valuable livestock transportation and potentially dangerous cargoes can all be monitored and tracked by this innovative development.

Colin Darkin, Director of Mobile Communications for Alcatel says "We aim to offer our customers in the UK a complete 'one-stop shopping solution' to their fleet management needs. Equipment provision, system integration installation, billing, training and maintenance will be provided through us."

A significant advantage of the service is that it can be integrated into existing computerised management systems, enabling operators to have total control over all aspects of their fleet management from a centralised system.

It is also capable of some sophisticated extras. The temperatures of refrigerated cargoes can be monitored and controlled by



the dispatcher over the satellite link. For what is known as "just-in-time" deliveries, drivers can report back delivery confirmation using a bar code reader.

While drivers may leave home shores feeling secure with their "panic button" available to alert their employer to an emergency situation, not all will rejoice in the fact that their every diversion will be charted. No more the unofficial detour to the girl-friend in Central France, and the couple of hours enjoying a kip and a cuppa on a hot day may raise some questions on return. The fleet owners will appreciate the savings effected by eliminating wasted journeys, and the likely gains in increased freight opportunities, by being able to divert drivers on the Continent, will help to ensure payback of the initial investment.

Anticipating that many fleet owners in a recession might hesitate at the full capital cost of permanent installation in all their

vehicles, a leasing operation has been added by the Company which will enable an operator to try out the service with a particularly valuable cargo for a specified length of time.

#### HOW IT WORKS

The Euteltracks System makes use of the Eutelsat satellites, and customer security and access to the system is through Service Provider Network Management Centres. Security features require user identification by means of a special access code and an individual password. To dissuade the clever criminal the line will be disconnected if there should be three unsuccessful sign-on attempts.

The customer's dispatch terminal is a standard IBM PS/2 or compatible Personal Computer, running with QTRACS proprietary software to provide all the necessary functions to the customer for message transfer

and position reporting. QTRACS provides simple menus for sending and receiving 62 pre-formatted MACRO messages or unlimited free-form messages to any vehicle or group of vehicles in the customer's fleet; it will also create or change messages and acknowledge them, giving the time and date.

Most valuable of all it provides a visual map for immediate vehicle location. The customer terminal also displays vehicle locations in text format, giving distances and directions to the nearest landmark and large city, as well as graphically on a road map covering the whole of Europe. It will show the approximate distance from a selected vehicle to any city or landmark at any time, enabling the dispatcher to send an immediate "arrive time" message if he desires, and it will zero-in on a specific vehicle or landmark, or show on the map specific locations (warehouses, client's premises, etc).

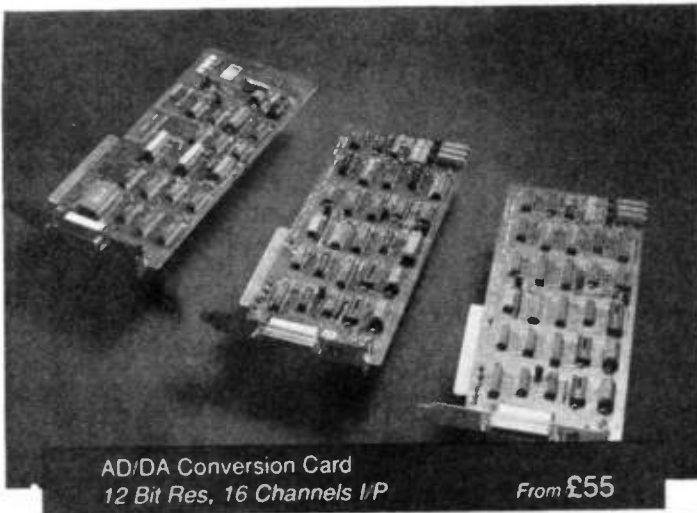
Should a vehicle get lost the system has the ability to display up to 100 previous positions for that vehicle on the map. A useful little extra is the "mouse interface" which, when pointed at a vehicle on the map, will immediately show the most recent message from that driver.

The Euteltracks service is based on satellite capacity on board the Eutelsat spacecrafts. Two satellite transponders on orthogonal polarisations are needed for the message service, one for the forward message transmission and one for the return message transmission. For position-reporting a ranging beacon is transmitted to a second satellite.

The mobile unit mounted on vehicles consists of three parts: an "outdoor" unit protected by a radome, containing the receive and transmit equipment which also houses the antenna; an "indoor" unit performing the modem and codec functions, and the timing function for determining location, together with a display/keyboard unit to receive and reply to messages.

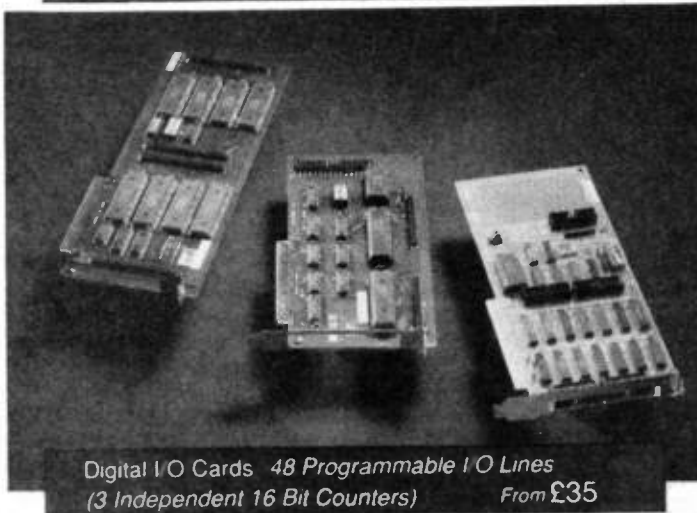
The location of every vehicle within a fleet is advised to the central base automatically every hour. More frequent updates can be obtained by sending blank messages to the mobile unit.





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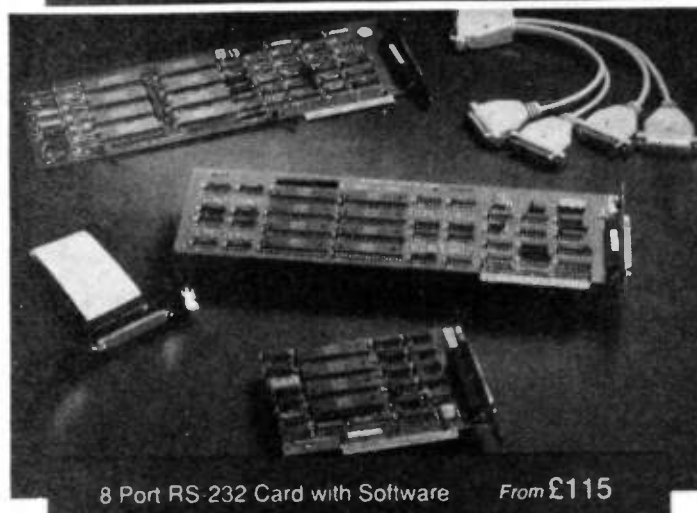
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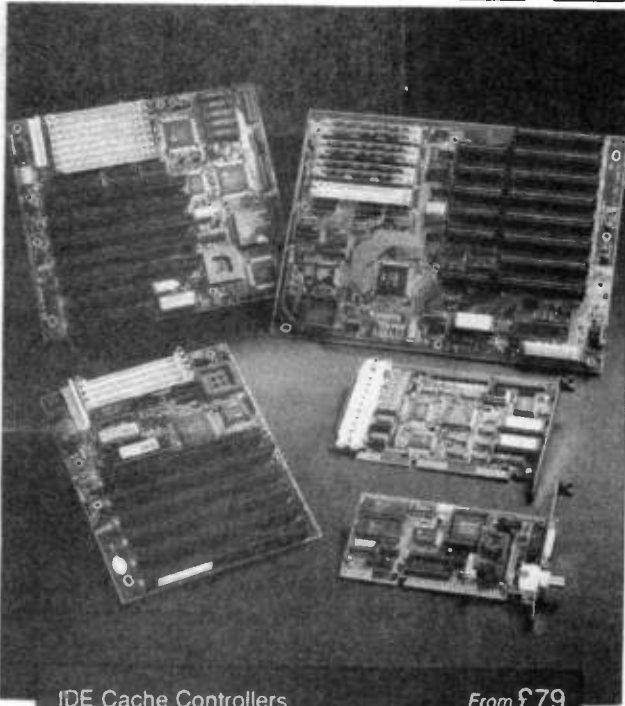
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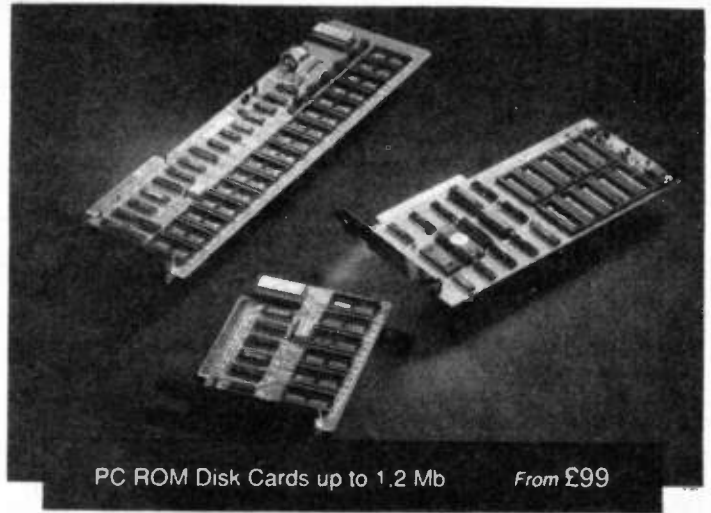
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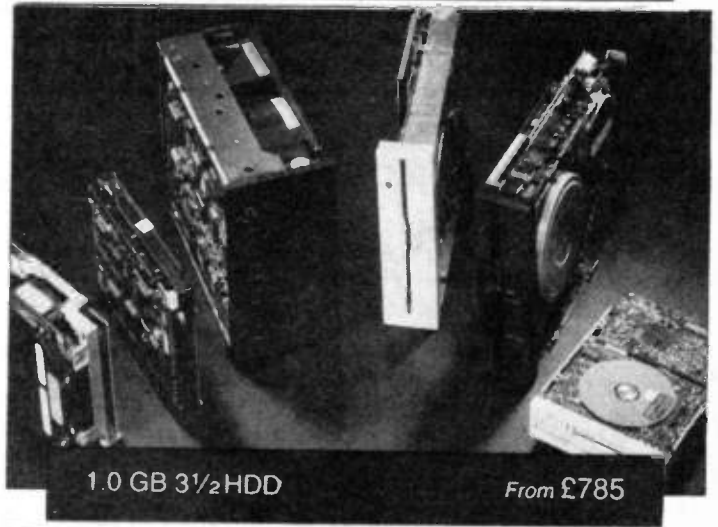
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# A FAST TRACK TO ELECTRONICS

**WILL TONER and RICHARD TAYLOR**

How to construct the Tracktronics circuit samples presented Free with this month's issue.

**I**N THE September issue T. R. de Vaux-Balbirnie reviewed a new circuit-building system for Technology students. This system, called *Tracktronics*, uses self-adhesive copper track for linking components. In this article we explain how to construct the three free sample Tracktronics circuits and describe the growing range of Tracktronics products available.

## WHAT IS TRACKTRONICS?

The basic process for developing a Tracktronics circuit is very simple:

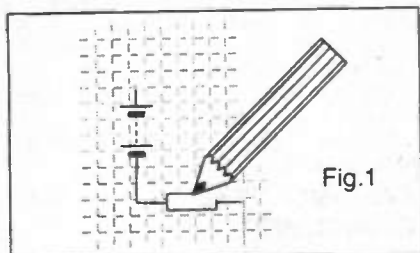


Fig. 1

1. The circuit diagram is drawn using component symbols (Fig. 1)

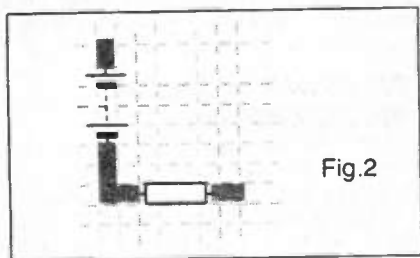


Fig. 2

2. Copper track is applied to the connections between the components (Fig. 2).

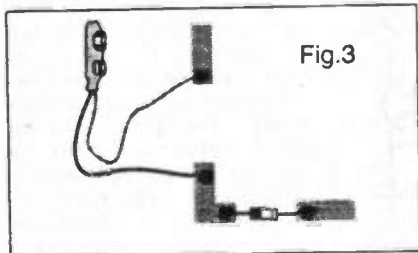


Fig. 3

3. The components are then soldered across the gaps in the copper track (Fig. 3).

This "surface mounting" system has many advantages in both speed of production and simplicity of understanding. Prototype circuits can be quickly developed and tested without the time consuming frustrations associated with printed circuit board etching.

For the electronics novice the circuit has the advantage of being a direct impression of the circuit diagram rather than a mirror image or complicated breadboard or Veroboard transposition.

In the Tracktronics books a final form of layout is also shown in which component icons are used to replace the circuit symbols. In this way the component position and orientation is clearly indicated. This is the format in which the three free samples have been provided.

## CIRCUIT CARDS

The three Tracktronics circuits presented free with this issue are a Night Light, a Thyristor Latched Display and a Twin Input Status Indicator.

## NIGHT LIGHT

The Night Light circuit (Fig. 4) switches a bulb on automatically as dusk falls, this providing an automatic light. The circuit uses a light dependent resistor (l.d.r.) to sense changes in light levels. The circuit consists of a lamp LP1, a transistor switch and a potential divider (VR1 and l.d.r. R1). The resistor R2 protects the base of the transistor.

When the switch S1 is closed the voltage at the base of the transistor is dependent upon the light falling upon the l.d.r. When the voltage is greater than 0.6V the transistor switches on and the bulb lights. The resistance of the l.d.r. varies with light intensity, the darker it is the greater the resistance.

Potentiometer VR1 is used to adjust (fine tune) the balance of the potential divider for different light levels.

## BUILDING AND TESTING THE CIRCUIT

The Free copper track can be used to make any one of the circuits on the cards supplied. If you wish to build more than one circuit then see the details about supply of more track etc., given at the end of this article. If you want to build both of the

## COMPONENTS

### Night Light

#### Resistors

R1 1k  
R2 OPR12 light dependent resistor

#### Potentiometer

VR1 100k preset

#### Semiconductors

TR1 BFY51 silicon npn transistor

#### Miscellaneous

S1 S.P.S.T. slider switch  
LP1 6V M.E.S. bulb  
B1 9V PP3 battery  
Battery clip; bulb holder; solder etc.

circuits that are shown back to back on the circuit cards then you must photostat one of them onto a similar piece of card before starting construction.

The copper track has an adhesive backing which will stick firmly to the circuit cards. Cut the track to the required length with scissors, remove the brown protective paper and stick the track down where indicated, do not try to remove the track once it is stuck, so make sure you get it right first time.

To build the circuit follow the simple steps given here:

1. Peel of the backing and stick the self-adhesive copper track to the Tracktronics circuit in the positions indicated.
2. Tin the copper track at the positions where components are to be attached.
3. Tin the copper track at all points where two pieces of track meet to make

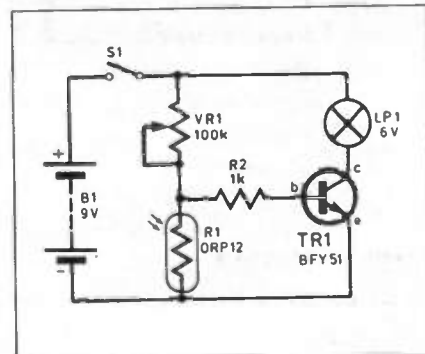


Fig. 4. Complete circuit diagram for the Night Light.

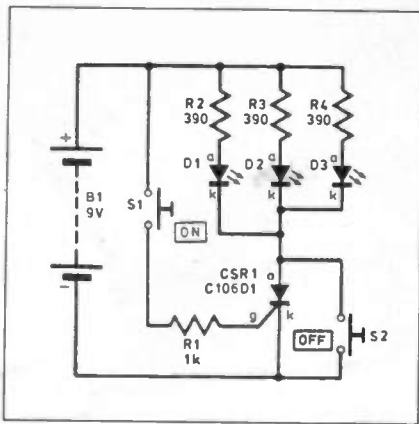


Fig. 5. Complete circuit diagram for the Thyristor Latched I.e.d. Display.

sure they are electrically in contact with each other.

4. Solder the components in the positions indicated on the Tracktronics circuit taking care to ensure that the transistor is connected the correct way around.

5. Connect the battery, switch on S1. Carefully adjust VR1 so that the light just goes out (taking care not to shade the l.d.r.).

6. Shade the l.d.r. and the bulb should light.

### THYRISTOR LATCHED I.E.D. DISPLAY

The Thyristor Latched L.E.D. Display circuit (Fig. 5) uses a thyristor and "membrane switches" to control an l.e.d. display. This circuit can be employed where it is necessary to latch on indicator lamps, using one switch, so that they can only be turned off by using a different switch. A simple intruder detector could be formed if S1 was replaced with a door or window magnet switch. The circuit can be used to monitor if the switch has been operated and can only be cancelled by operation of S2 or by disconnecting the battery.

The thyristor is used to latch the circuit so that when the "membrane switch" S1 is pressed the display will remain on until cancelled. The display consists of three l.e.d.s connected in parallel. Each l.e.d. has a separate resistor to protect it against excess current. The resistor R1 protects the gate (g) of the thyristor.

"Membrane switch" S2 is used to cancel the latching effect of the thyristor and switch off the display.

## COMPONENTS

### Thyristor Latched L.E.D. Display

#### Resistors

R1 1k  
R2, R3, R4 390 (3 off)  
All 0.25W 5% carbon film

#### Semiconductors

CSR1 TIC106D thyristor  
D1, D2, D3 5mm l.e.d.s (3 off)

#### Miscellaneous

S1, S2 see text  
B1 9V PP3 battery  
Battery clip; solder

## BUILDING AND TESTING THE CIRCUIT

1. Peel off the backing and stick the self-adhesive copper track to the Tracktronics circuit in the positions indicated. Be sure to include the two strips of copper track which form the membrane switches.

2. Tin the copper track at the positions where components are to be attached.

3. Tin the copper track at all points where two pieces of track meet to make sure they are electrically in contact with each other.

4. Solder the components to the positions indicated on the Tracktronics circuit. Ensure that the thyristor and l.e.d. are connected the correct way round.

5. Carefully cut out the two small squares which form part of the membrane switches.

6. Cut the four lines and fold as indicated.

7. Connect the battery.

8. Press membrane switch S1 – the l.e.d. display should light and remain lit after S1 is released.

9. Press membrane switch S2 – the l.e.d. display should remain lit until S2 is released. The display should then switch off.

## TWIN INPUT STATUS INDICATOR

The Twin Input Status Indicator (Fig. 6) combines two circuits similar to Fig. 4, the Night Light. In this case one potential divider includes an l.d.r. and is connected to TR2. The other potential divider, which is connected to TR1, includes a thermistor.

The display part of this circuit uses a tricolour l.e.d. The tricolour l.e.d. has a common cathode (k) and two anodes (a). In many ways it functions like two l.e.d.s combined together. One anode lights the red, the other green, with both on together the colour is amber.

In the circuit diagram the tricolour l.e.d. has been drawn, for convenience, as a double l.e.d. labelled D1.

## BUILDING AND TESTING THE CIRCUIT

The steps to build the circuit are:

1. Peel off the backing and stick the self-adhesive copper track to the Tracktronics circuit in the positions indicated.

Take care with the section where the copper tracks cross each other. This is marked with a black box, use insulating tape to ensure that the two tracks do not connect and short circuit.

2. Tin the copper track at the positions where components are to be attached.

3. Tin the copper track at all points where two pieces of track meet to make sure they are electrically in contact with each other.

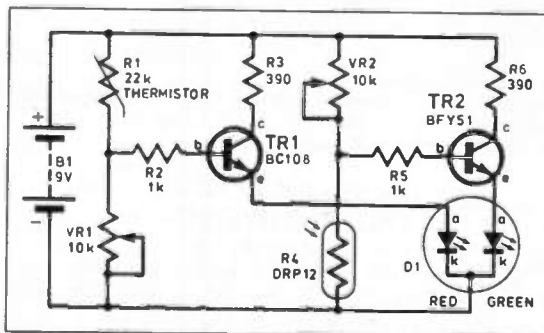


Fig. 6. Circuit diagram for the Twin Input Status indicator.

## COMPONENTS

### Twin Input Status Indicator

#### Resistors

R1 22k thermistor  
R2, R5 1k (2 off)  
R3, R6 390 (2 off)  
R4 ORP12 l.d.r.

#### Potentiometer

VR1, VR2 10k carbon preset (2 off)

#### Semiconductors

D1 Tricolour l.e.d. (common cathode)  
TR1 BC108 npn transistor  
TR2 BFY51 npn transistor

#### Miscellaneous

B1 9V PP3 battery  
Battery clip, insulation tape; solder.

4. Solder the components in the positions indicated on the Tracktronics circuit. Do not connect VR2 yet.

5. Ensure that the transistors and tricolour l.e.d. are connected the correct way round. The centre terminal on the tricolour l.e.d. should be the common cathode (k).

6. Connect the battery.

7. Adjust VR1 so that the tricolour l.e.d. just shows red.

8. Hold the thermistor (R1) between your fingers to warm it up. The l.e.d. should glow bright red.

The first part of the circuit is now adjusted correctly.

9. Solder VR2 in position.

10. Turn VR2 so that the l.e.d. glows green. Now adjust it until the l.e.d. no longer lights. Be careful not to shade the l.d.r. whilst adjusting VR2.

11. The l.e.d. should now glow green when the l.d.r. is shaded.

The second part of the circuit is now adjusted correctly.

## USING THE CIRCUIT

This circuit could be used to monitor the temperature inside a fridge and indicate if the fridge door has been left open. Table 1 summarises the fridge's condition and the tricolour outputs with the circuits adjusted correctly.

## TRACKTRONICS PRODUCTS

There is a range of Tracktronics products designed to support practical designing and building with electronics.

These include: Copper track – more of the sticky-back copper track (as given away with this issue), this comes as a 33 metre reel and costs £4-64.

Tracktronics – opportunities for design using electronics. Pupil and teacher books. These were reviewed in the September issue; Trackpacks – electronic component packs for the above books; Trackpads – blank design grids to assist in planning Tracktronics layouts.

Due for publication this Autumn are two new products:

1. A large resource of pre-designed Tracktronics layouts called Tracktronics Circuit Masters. Included within this are a wide variety of circuits

Table 1. The status of the tricolour i.e.d.

Condition	L.D.R.	L.E.D. Status	Comment
COLD	DARK	GREEN	Fridge O.K.
COLD	LIGHT	OFF	Door Open
WARM	LIGHT	RED	Door open too long
WARM	DARK	AMBER	Door closed - possible fridge failure

covering communications, games, timing and detection. The **Trackronics Masters** book provides a range of circuits similar to those included here, to more sophisticated layouts such as radios, intercoms and electronic organs.

2. **Trackronics - Circuit Designer.**

Computer software for the PC and Archimedes range of computers. This CAD package enables the user to design, on screen using standard circuit symbol format. The computer automatically generates a Trackronics layout (complete with copper track and icons). Alterna-

tively the user may design in Trackronics mode with the computer automatically generating the circuit diagram. The user may switch between these two modes at any time. A simple costing spreadsheet is also provided for the circuit designer.

Trackronics Products are only available from: **Commotion Ltd**, Dept EPE2, Unit 11, Tannery Road, Tonbridge, Kent TN9 1RF

There is also a telephone hotline on 0732 773399 (line opens on October 1).

**COMPONENTS**

The components for the three circuits on the *free* Circuit Cards can also be purchased from Commotion by cheque or Visa by dialling the hotline. The kit contains everything except solder, insulating tape and batteries. The price, including postage and VAT is £8.45.

# SHOP-TALK

with David Barrington

**Portable Miniguard**

Looking down the list of parts required to construct the *Portable Miniguard* a couple of components stand out as possible "hard to find locally" devices. However, in most cases your usual component supplier may be able to offer suitable alternatives.

The specified multi-zone pyroelectric sensor module used in the prototype model was purchased from **Mailtech** (☎ 058 474475) and is their sub-miniature FIRM-287 type. This is currently priced at £8.95 plus 75p postage.

The 6V 80 ohm miniature relay was obtained from **Maplin** and is, in fact, from their micro-miniature range, code FM89W (Micro-Min Relay 6V). Other relays can, of course, be used provided they have identical or better (contacts) electrical ratings. Using different relays may mean altering the board layout as pinouts invariably differ from the one specified.

The warning siren is another device were your supplier may offer a different one to that specified. Provided it has an identical specification to that listed it should work in this circuit, you may find that you will have to mount it outside the case. The siren used in the model is a low current type with a rapid rising and falling tone. This was ordered from **Maplin** and is their Micro Piezo Siren, code JK42V.

**20 Metre DIRECT CONVERSION RECEIVER**

One or two items called up in the *20 Metre Direct Conversion Receiver* project will almost certainly cause local supply difficulties. Also some of the prices for parts seem to vary quite a lot, and it might be worth shopping around.

The SL1640C double-balanced mixer i.c. took some tracking down and the only source we have found so far is from **Cirkit** (☎ 0992 44111). When ordering quote stock code 61-01640. This is a fairly expensive device and the use of an i.c. socket is recommended for this i.c.

For a receiver of this type it is important that the variable capacitors/trimmer should be good quality air spaced components, such as the Jackson C804 type specified. Inexpensive, surplus air spaced types might be suitable, but these are often awkward to fit and have not been tried in the model.

The Jackson variable capacitors are stocked by a number of our advertisers and should be readily available. Experience shows that the prices for these items varies quite considerably, by as much as £2 each, and it might pay to shop around.

The r.f. transformers and inductor coils used in the model are all from the Toko range and were purchased from **Cirkit**, the main UK distributor. The specified 10RB range of inductors are almost certainly the cheapest type that will work in this circuit. The use of alternatives is not recommended.

The receiver printed circuit board is available from the *EPE PCB Service*, code 848. Finally, try to keep all wiring as short as possible and keep to the front panel component layout. Remember to keep the wiring to the headphone socket away from the tuning capacitors.

**Multi-Purpose Audio System - Six-Channel Stereo Mixer**

If you are constructing the large board version (last month), the only items that need careful consideration when buying parts for the *Six-Channel Stereo Mixer* are the case, centre-off switches and slider potentiometers.

The dual (stereo) slider "pots" for which the large p.c.b. is designed were purchased from **Maplin** (code JM87U) and must have metal bodies and be p.c.b. mounting types. Most advertisers only seem to stock "mono" types. The centre-off switches came from the same source and are type F from their sub-Min range.

Suitable plastic console cases, with sloping aluminium front panels, are stocked by advertisers, but prices do vary quite considerably and it might be worth "shopping" around. The large p.c.b. (last month) and "separate" pre-amp boards are obtainable from the *EPE PCB Service*, codes 845 (large), 846 Mic. Pre-amp and 847 RIAA Pre-amp (see list on page 867).

**Trackronics Projects**

If you require additional supplies of the self-adhesive copper track, used in the simple Night Light, Thyristor Latched L.E.D. Display and Twin Input Status Indicator demonstration projects, you should contact *Commotion Ltd*, see address and hotline number at the top of this page. They are also supplying a kit for the three circuits containing all parts except solder, insulating tape and batteries.

**Circuit Surgery**

The Piezoelectric buzzer used in the *Simple Room Alarm* circuit, this month's *Circuit Surgery*, can be any of the type that contains its own built-in drive circuit and has a wide low voltage operating range.

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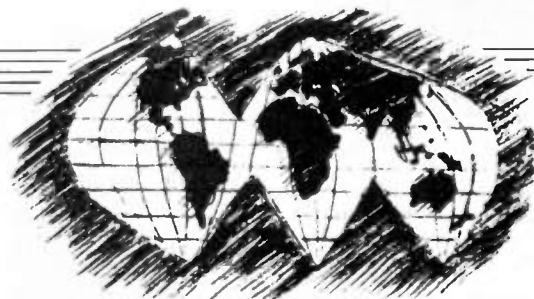
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# 20 METRE DIRECT CONVERSION RECEIVER

ROBERT PENFOLD

Here is your chance to "tune in" to amateur radio stations from all over the world.

**A**N ARTICLE describing a direct conversion receiver for the 80 metre amateur band appeared in the June 1990 issue of *Everyday Electronics*. The project featured here is firmly based on that design, but it has been modified for operation on the 20 metre amateur band.

Although it was anticipated that extensive modifications to the front-end of the receiver would be required, the set performs well on the 20 metre band with relatively minor modifications. In fact it is basically just a matter of changing the coils and altering some of the tuning capacitances.

## PROPAGATION

The characteristics of the 80 and 20 metre amateur bands are very different. The 80 metre band provides reception over fairly short distances in the daytime, with a maximum range that is normally no more than a few hundred miles.

At night signals that were previously absorbed by the upper atmosphere are instead reflected back to earth. This permits the signals to negotiate the earth's curvature, and the maximum range is extended to a few thousand miles.

In fact worldwide reception is possible via multiple reflections from the atmosphere to the earth, back to the atmosphere, and so on. However, at the relatively low frequencies involved here (3.5MHz to 4MHz) reception over long distances is relatively difficult.

Reception on the 20 metre band is in many ways the opposite of 80 metre reception. During daylight hours the radio waves are reflected from the upper atmosphere, and long distance reception is possible. The signals are reflected from a very high layer of the atmosphere, enabling very long distances to be covered on each "bounce". The groundwave tends to be absorbed by the earth, giving little reception of signals via the direct route.

These two factors combine to give very good long distance reception. Distances of several thousand miles can usually be covered, and even with quite simple

receiving equipment it is often possible to pick up stations on the other side of the world.

The situation tends to be very different once darkness has fallen. The atmosphere may no longer reflect the radio waves, and with no significant ground wave present the band can (and sometimes does) fade out altogether.

Reception tends to be at its best during summer when the days are long and the nights are short. It may then be possible to receive stations 24 hours a day. Results also tend to be better when the eleven year sunspot cycle is near to its maximum.

Results are at their worst during the winter and when the sunspot cycle is in a period of low activity. The band may then only be open for several hours a day. Propagation on the short wave bands is far from totally predictable though. Bands can fade out or provide exceptionally good reception at unexpected times.

The 80 metre band was chosen for the original design as this band will virtually always provide reception of some amateur stations. The same is not true of the 20 metre band, but the disadvantage of its more frequent blank periods is offset to a large degree by the better prospects of long distance reception when the band is open.

## S.S.B. RECEPTION

The two main types of transmission used on the short wave amateur bands are c.w. (continuous wave - a type of Morse code transmission), and s.s.b. (single sideband - a type of voice transmission). It is important to realise that tuning in an s.s.b. signal is very different to tuning to an ordinary a.m. or f.m. broadcast station. A basic understanding of s.s.b. is a definite asset for anyone who tries their hand at short wave amateur band reception.

An ordinary a.m. (amplitude modulation) transmission consists of a carrier wave at the basic transmission frequency, plus sidebands above and below this. Fig. 1 shows this general scheme of things. The carrier wave is always present, but the sidebands are produced by the voice signal or other audio modulation.

In the example of Fig. 1 the carrier is at 14.3MHz, and one of the audio input frequencies is at 1kHz. It therefore produces an upper sideband component 1kHz above the carrier frequency, and a lower sideband component 1kHz below it. There is another audio input signal at 1.5kHz, giving sideband components 1.5kHz above and below the carrier frequency. This input signal is stronger than the 1kHz signal, and accordingly it produces stronger sideband components.

In reality the audio input signal is a complex one which contains numerous frequencies of different strengths, with the exact frequencies present and their strengths changing from one instant to the

Table 1: Amateur Band Frequency Limits

Band	Frequency Range
160 Metres	1.8MHz to 2MHz
80 Metres	3.5MHz to 3.8MHz (3.5MHz to 4MHz in some countries)
40 Metres	7MHz to 7.1MHz (7MHz to 7.3MHz in some countries)
30 Metres	10.1MHz to 10.15MHz
20 Metres	14MHz to 14.35MHz
17 Metres	18.068MHz to 18.168MHz
15 Metres	21MHz to 21.45MHz
12 Metres	24.89MHz to 24.99MHz
10 Metres	28MHz to 29.7MHz

next. This gives complex sideband signals, but these signals are always symmetrical about the carrier wave.

In order to recover the audio signal it is not necessary to "capture" both sidebands, since they contain the same information. Removing one sideband has the advantage of permitting twice as many stations to be crammed into a crowded band. It does not matter which sideband is removed.

## CARRIED AWAY

The carrier wave is not essential either, as this signal can be provided by an oscillator at the receiver. In fact removing the carrier wave has the advantage of enabling all the transmitter's power to be concentrated on the remaining sideband.

This gives an effective power boost to the transmitter. However, there is a slight drawback in that the receiver must be tuned very accurately so that the oscillator precisely replaces the suppressed carrier wave.

Suppose that an upper sideband station is being received and that the carrier is made too low in frequency. The sideband components will all be offset too far from the oscillator frequency, giving a boost in all the audio output frequencies.

This will raise the pitch of all the frequencies in a voice signal, giving what is

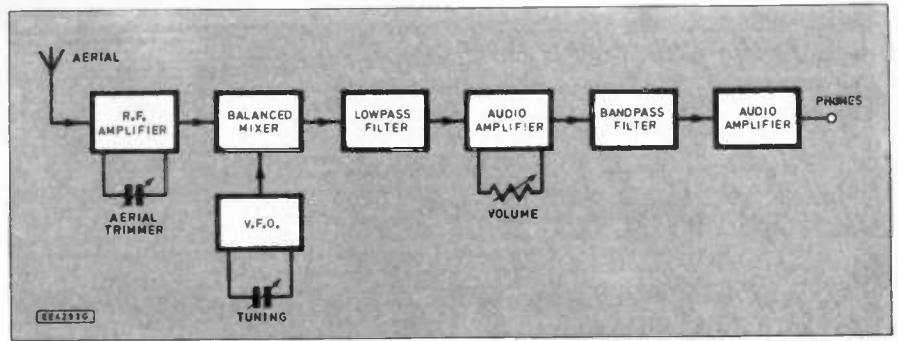


Fig. 2. The 20 Metre Direct Conversion Receiver block diagram.

the tuning for the most natural sounding result. If the output is at a suitable pitch, but it is scrambled, you must tune through the signal to place the carrier on the other side.

Note that there will be some drift in the receiver's tuning, and possibly some drift in the transmitter's frequency as well. Occasional readjustment of the tuning is therefore needed in order to keep received signals at a suitable audio pitch.

Reception of c.w. signals is more straightforward. The Morse key simply switches the carrier wave on and off (there

## DIRECT CONVERSION

Ready-made short wave receivers are virtually all of the superhet variety. A set of this type can give excellent performance, but is quite complex, and can be difficult to set up correctly.

The receiver described here is a *direct conversion* type, which is a more simple type of receiver, but one that can give good results on the short wave amateur bands. The block diagram of Fig.2 shows the general make up of the receiver.

The aerial signal is amplified by an r.f. amplifier, and this stage has an aerial trimmer control. The latter enables the r.f. amplifier to be set for peak performance at any frequency within the 20 metre band.

The amplified r.f. signal is fed to one input of a balanced mixer. The other input of the mixer is fed from a v.f.o. (variable frequency oscillator). A balanced mixer processes the input signals to produce sum and difference frequencies at the output. In this case it is the difference frequencies that are required.

If the v.f.o. is tuned to the same frequency as the suppressed carrier wave at the transmitter, the difference signal will give the required audio signal. Consequently, the tuning control for the v.f.o. also acts as the tuning control for the receiver as a whole.

The sum signal, plus any breakthrough of the two input signals, are removed by a lowpass filter at the output of the mixer stage. This leaves only the audio signal, which is fed to the volume control and a high gain audio amplifier.

The next stage is a high quality bandpass filter which provides most of the receiver's selectivity. Without this filter the set has a very wide bandwidth, and with the crowded conditions on the 20 metre band it would tend to pick up several stations at once.

Even with the bandpass filter included, there is likely to be a certain amount of interference from stations on adjacent

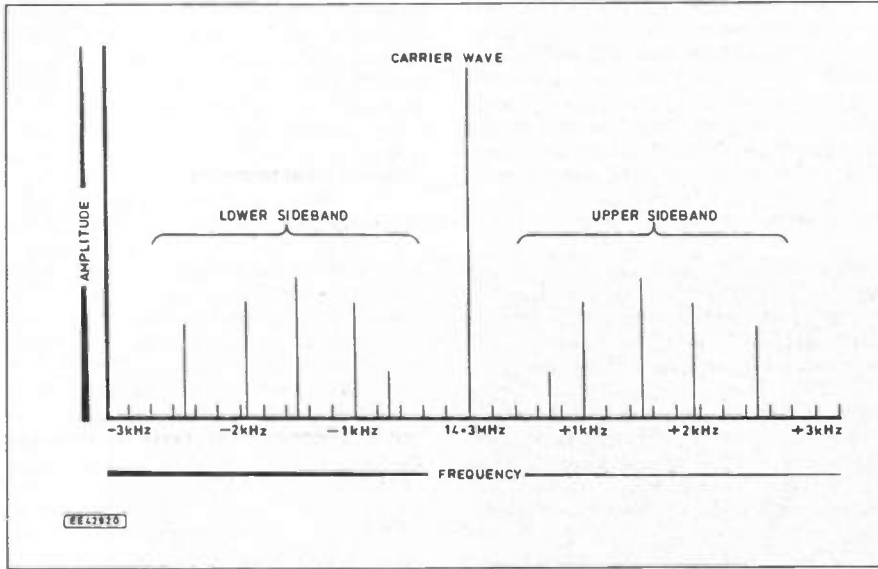


Fig. 1. An ordinary a.m. signal consists of the basic carrier wave plus symmetrical upper and lower sidebands.

sometimes called the "Donald Duck" effect. Shifting all the frequencies upwards by even just a couple of hundred hertz can give some very odd sounding results, and may seriously impair the intelligibility of the audio output.

An error in the opposite direction is more serious. A very small error will simply reduce all the audio frequencies by a certain amount. A larger error will result in the carrier frequency effectively being placed within the sideband components. This totally scrambles the signal, giving an unintelligible audio output.

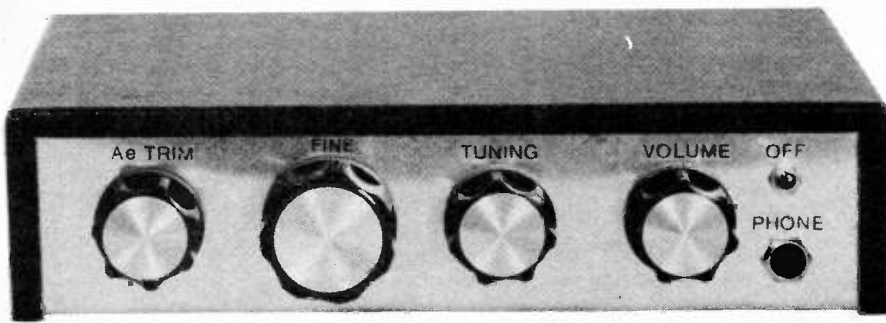
Placing the carrier on the wrong side of the sideband also gives a scrambled output signal, with the high frequencies being turned into low frequencies, and vice versa. The audio output signal is recognisable as a voice type, but in most cases not even the occasional word is understandable!

When tuning in an s.s.b. signal it is essential to listen carefully to the pitch of the audio output, and to carefully adjust

are no sideband signals). The receiver can be tuned to either side of the c.w. signal in order to produce an audio tone, and it does not make much difference what particular pitch is produced. Tuning control settings are far from critical with this type of signal.







channels. However, you soon learn to concentrate on the main signal, and ignore the so-called "monkey chatter" in the background.

It is only fair to point out that there is a slight flaw in the direct conversion approach, in that a set of this type responds equally well to stations a few kilohertz above and below the v.f.o. frequency. There is no upper/lower sideband switching, because the receiver is able to resolve signals of either type.

While you are listening to a station on one side of the v.f.o. frequency, one just on the other side could produce a lot of interference. In practice this does not seem to be a major problem, and a direct conversion receiver can produce very good results provided it has good audio filtering.

The final stage of the receiver is another high gain audio amplifier. With a receiver of this type the gain ahead of the demodulator is quite low, and the gain in the audio stages therefore has to be very high in order to compensate for this.

The output is for headphones, which are generally accepted as being better than a loudspeaker for short wave reception. Also, with a direct conversion receiver there are often feedback problems if a loudspeaker is used.

## CIRCUIT OPERATION

The full circuit diagram for the 20 Metre Direct Conversion Receiver is shown in Fig. 3. The aerial couples to a small winding on transformer T1, while the main winding of T1 forms the input tuned circuit in conjunction with capacitor C1 and variable capacitor VC1. The latter is the aerial trimmer control.

The field effect transistor (f.e.t.) TR1 and low noise transistor TR2 are used in a cascode arrangement, and act as the r.f. amplifier. Further r.f. selectivity is provided by a tuned circuit (r.f. transformer T2 and capacitor C2) at the output of this stage. This has a broader response than the input tuned circuit, and preset tuning is used here.

The balanced mixer is based on IC1, which is an integrated circuit that is specifically designed for applications of this type. IC1 requires a 6V supply, which is derived from the main 9V supply via dropping resistor R5 and decoupling capacitor C7. Another field effect transistor, TR3 is used in a simple v.f.o. circuit which has frequency selective negative feedback provided by an r.f. oscillator transformer T3.

Tuning capacitor VC2 is the coarse tuning control, and trimmer capacitor VC3 is used for fine tuning. A value of five picofarads (5p) is needed for VC3, but suitable components do not seem to be available. Therefore, capacitor C13 has been added in series with VC3 to reduce its effective maximum value from 10p to 5p.

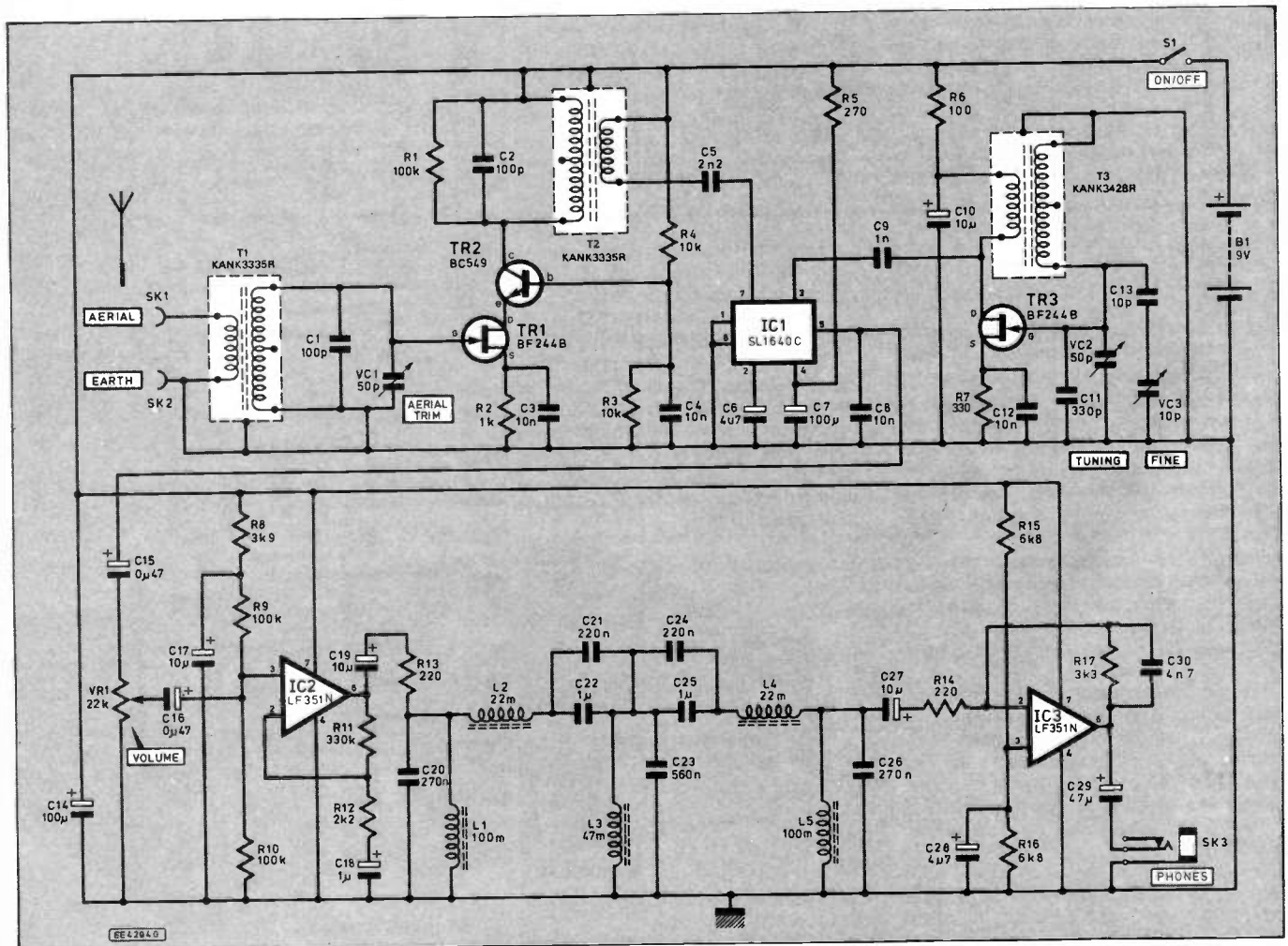
Capacitor C8 provides r.f. filtering at the output of the mixer stage (IC1 pin 5), and from here the audio signal is coupled to Volume control VR1. The first audio stage uses IC2 in the non-inverting mode with a voltage gain of over 40dB (100 times).

The bandpass filter (L1 to L5 network) is a multi-stage passive L-C type which provides a very high level of performance. The -6dB points are at about 300Hz and 2.5kHz, and the filter has a very flat passband. The -60dB points are at about 100Hz and 10kHz.

Note that inductor coils L1 to L5 must be types that are suitable for operation at audio frequencies. The specified type 10RB inductors are almost certainly the cheapest type that will work well in this circuit. The use of alternatives is not recommended.

The final amplifier stage is based on IC3. This is an inverting mode circuit, again having over 40dB of voltage gain.

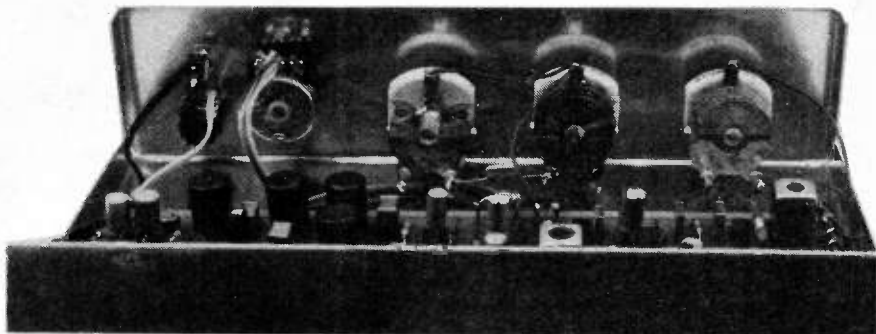
Fig. 3. Complete circuit diagram for the 20 Metre Direct Conversion Receiver.



## CONSTRUCTION

Apart from the controls, sockets, battery, and capacitor C13, all the components fit onto the printed circuit board (p.c.b.). Full details of the p.c.b. topside component layout and full size underside copper foil master pattern are given in Fig.4: This board is available from the EPE PCB Service, code 848.

It is a good idea to fit all the resistors and capacitors first, remembering to get the electrolytic capacitors the right way round. The polyester capacitors should be printed circuit types having 7.5mm lead spacing. Other types are suitable from the electrical



# 20 METRE AMATEUR BAND RECEIVER CIRCUIT BOARD

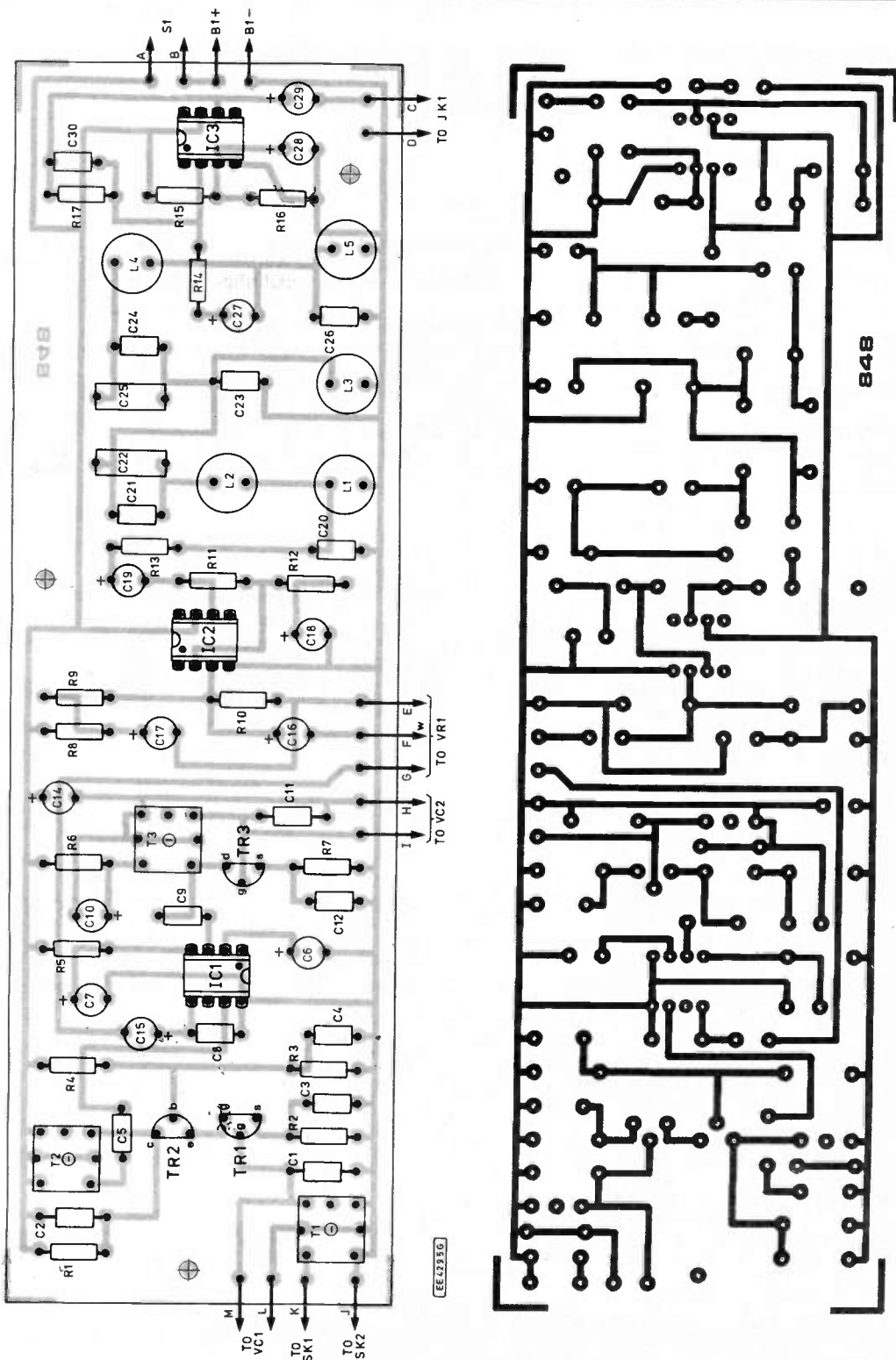
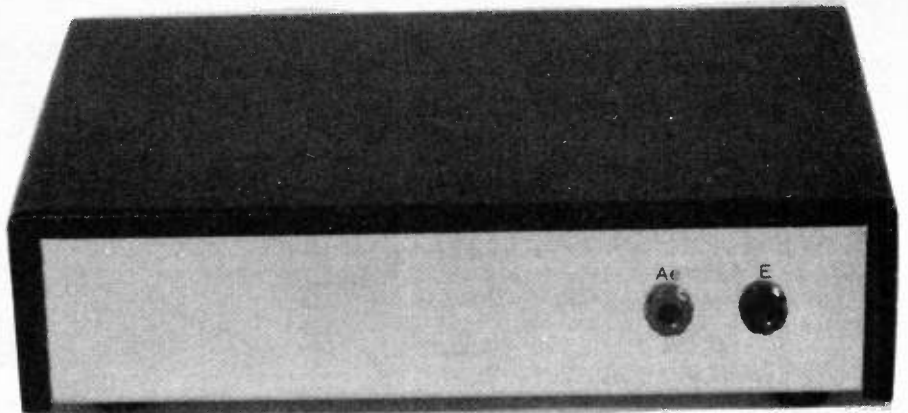


Fig. 4. Printed circuit board component layout and full size underside copper foil master pattern. Take particular care when mounting the inductors as they are very brittle. Note that IC1 is inserted into its holder with opposite connection to the other two.

point of view, but it could be very difficult to physically fit then into this component layout.

Next fit the inductors, the r.f. transformers, and lastly the semiconductors. The inductors are wound on a form of ferrite pot core. Ferrite is a very brittle material, and these components should be treated with due care. Dropping them onto a hard floor is definitely not a good idea.

None of the semiconductors are static-sensitive devices, but it is still advisable to fit the integrated circuits in holders. We would strongly urge the use of a holder for ICI, which is a relatively expensive device. Note that ICI has the opposite orientation to the other two integrated circuits. Fit single-sided solder pins to the board at



The aerial and earth sockets are mounted on the rear panel.

## COMPONENTS

### Resistors

R1, R9, R10	100k (3 off)
R2	1k
R3, R4	10k (2 off)
R5	270
R6	100
R7	330
R8	3k9
R11	330k
R12	2k2
R13, R14	220 (2 off)
R15, R16	6k8 (2 off)
R17	3k3

All 0.25W 5% carbon film

### Potentiometer

VR1	22k rotary carbon, log.
-----	-------------------------

### Capacitors

C1, C2	100p polystyrene (2 off)
C3, C4, C8, C12	10n polyester (4 off)
C5	2n2 polyster
C6, C28	4µ7 radial elect. 63V (2 off)
C7, C14	100µ radial elect. 10V (2 off)
C9	1n polyester
C10, C17, C19, C27	10µ radial elect. 25V (4 off)
C11	330p polystyrene
C13	10p silver mica
C15, C16	0µ47 radial elect. 63V (2 off)
C18	1µ radial elect. 63V
C20, C26	270n polyester (2 off)
C21, C24	220n polyester (2 off)
C22, C25	1µ polyester (2 off)
C23	560n polyester
C29	47µ radial elect. 10V
C30	4n7 polyester
VC1, VC2	50p air spaced Jackson C804 (2 off, see text)
VC3	10p air spaced Jackson C804

### Inductors

T1, T2	Toko KANK3335R (2 off)
T3	Toko KANK3428R
L1, L5	100mH type 10RB (2 off)
L2, L4	22mH type 10RB (2 off)
L3	47mH type 10RB

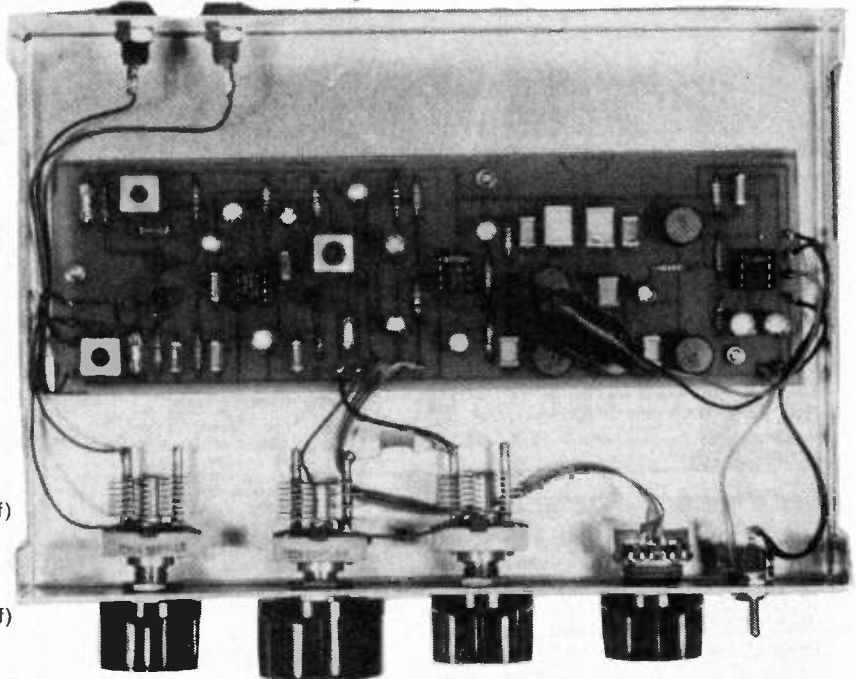
### Semiconductors

TR1, TR3	BF244 n-channel j.f.e.t. (2 off)
TR2	BC549 npn low noise, silicon transistor
IC1	SL1640C double balanced mixer
IC2, IC3	LF351N bi.f.e.t. op.amp (2 off)

### Miscellaneous

S1	s.p.s.t miniature toggle
SK1	red 4mm socket
SK2	black 4mm socket
SK3	3-5mm insulated jack socket
B1	9V battery pack (six HP7 cells in holder)

Printed circuit board available from *EPE PCB Service, code 848*; aluminium case, vinyl-covered top, size 210mm x 150mm x 52mm approx; 8-pin d.i.l. i.c. holder (3 off); battery connector (PP3 type); control knob (3 off); large control knob; medium impedance headphones, with 3-5mm plug; wire; solder, etc.



(Below). Layout of components inside the metal case. Keep the wiring to the headphone socket away from VC2 and VC3

See  
**SHOP  
TALK**  
Page

the positions where connections to the off-board components will be made.

### ALL-METAL CASE

The case should be of all-metal construction, and an instrument type case is probably the best choice. The prototype is fitted in a case which measures about 210mm by 150mm by 52mm, and this represents something close to the smallest size that will accommodate everything.

It is recommended that the front panel layout of the prototype is followed fairly closely, as this is one that enables all the r.f. wiring to be kept quite short. This is essential, as long wiring could make it impossible to tune the right frequency range, reduce the set's performance, and could even produce instability that would prevent the set from functioning at all.

From left to right the controls are VC1, VC3, VC2, VR1, and S1. Sockets SK1 and SK2 are mounted on the rear panel, roughly opposite VC1. SK3 is mounted below switch S1.

For a receiver of this type it is important that the variable capacitors are good quality air spaced components, such as the Jackson C804 type. Inexpensive surplus air spaced components should be suitable, but these often have awkward mounting

Approx cost  
guidance only

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(excl phones)



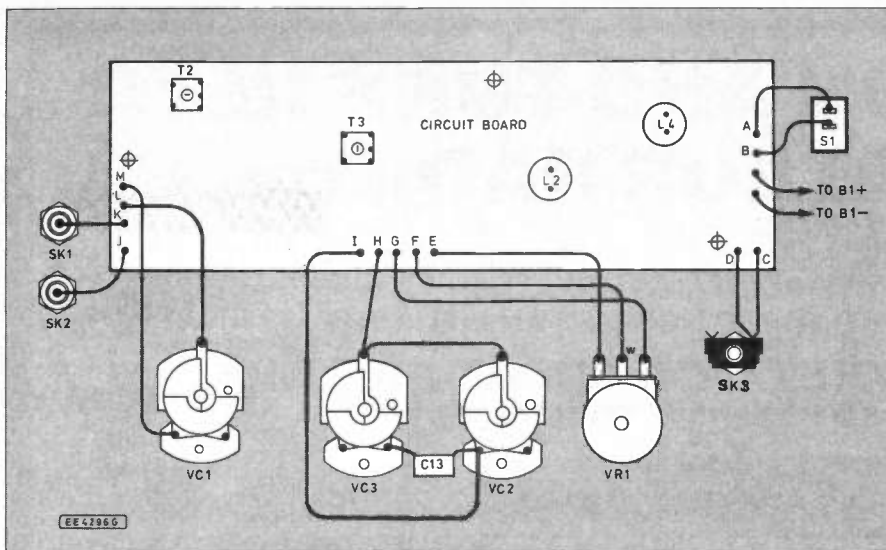


Fig. 5. Details of the interwiring from the circuit board to the case mounted components. Wiring to the tuning capacitors should be kept as short as possible.

arrangements which could make them difficult to use. Solid dielectric types are unlikely to have adequate stability for this application.

Mount the printed circuit board across the middle of the case, close to the controls, with transformer T1 close to the aerial trimmer VC1. The board is mounted on the usual plastic stand-offs, 6BA fixings, or metric M3 fixings. If mounting bolts are used, include spacers about six millimetres long to ensure that the underside of the board is kept clear of the metal case.

There should be sufficient space for the battery pack to the rear of the circuit board. Connections to the plastic battery holder are via an ordinary PP3 type connector.

### INTERWIRING

Full details of the "hard wiring" are shown in Fig.5. Keep the wiring to the three variable capacitors as short as possible. Capacitor C13 is connected directly across VC2 and VC3, as shown.

The audio wiring is less critical, but long meandering leads should still be avoided. In particular, to avoid problems with instability due to "stray" feedback, keep the wiring to socket SK3 well away from VC2 and VC3. It is preferable to use an insulated socket for SK3 as this avoids slight instability at high volume levels due to a feedback loop.

### ADJUSTMENTS

Most types of earphone and headphone can be used with this receiver. With high

impedance headphones it is best to have the phones wired in parallel. These days low or medium impedance types are a more likely choice, and these should be used with the phones connected in series.

Probably the best low cost choice is a pair of medium impedance headphones of the type sold as replacements for use with personal stereo units. A crystal earphone is also quite cheap, but will give quite good results with this receiver. Low impedance magnetic earphones are *not* suitable for operation with this set.

If an "Earth" connection is available it can be connected to socket SK2. However, an earth will not make much difference to results on a high frequency band such as 20 metres.

An aerial must be connected to socket SK1, and even a simple indoor aerial should provide reception of numerous stations. Better results will be obtained using about 10 metres of aerial wire strung outdoors, as high as possible, and preferably well clear of any buildings.

The three r.f. transformers must be aligned properly before the set will work efficiently. **Only use a proper trimming tool to adjust the cores of these components.** A metal screwdriver blade can produce detuning effects, and it can also damage the brittle ferrite cores.

With the receiver set up and turned on it will probably be possible to receive some transmissions, although these will not necessarily be from amateur stations. Bear in mind the information given previously

about 20 metre band propagation. The best time for initial testing and setting up is in the afternoon, preferably at the weekend when there should be plenty of amateur stations on the air.

By adjusting the cores of T1 and T2, and by adjusting the aerial trimmer VC1, it should be possible to peak the received signals. If access to a suitable r.f. signal generator is available, the core of T3 can be adjusted to give full coverage of the 20 metre band (14.0MHz to 14.35MHz). Otherwise, it is just a matter of using trial and error.

Try the ferrite core of T3 at various settings in an attempt to find one that provides amateur band transmissions over a wide range of tuning control settings. Bear in mind that the bottom half of the band contains mainly c.w. signals, while the top half contains mainly s.s.b. transmissions. Tuning controls VC2 and VC3 provide a significant excess of coverage, so there is some latitude available in T3's setting.

Once a suitable setting has been found, set all three variable capacitors for half maximum capacitance. Then adjust the cores of T1 and T2 to peak any received signals, or to peak the background noise level if no signals are present. The receiver is then ready for use.

### TUNING-IN

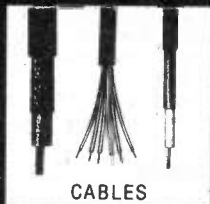
As already explained, the tuning must be adjusted very accurately in order to produce a proper audio output signal from an s.s.b. transmission. It is predominantly upper sideband that is used on the 20 metre band. Consequently, it is best to start at the low frequency end of the band and work your way up to the high frequency end (i.e. start with the vanes of VC2/VC3 fully meshed together).

As you move in on a signal the pitch of the audio output will steadily fall to a suitable level. If you scan the band in the opposite direction, you will have to tune right through each station and then adjust the tuning for a suitable audio pitch.

Tuning in c.w. signals is much easier. It is just a matter of using any tuning setting that gives an audio tone somewhere in the middle audio range.

If interference from a signal on an adjacent channel is a problem, try shifting the tuning up or down slightly, or tuning to the other side of the signal in an attempt to reduce the interference. Remember that significant changes in the setting of VC2 will necessitate readjustment of VC1 in order to keep the set at maximum sensitivity. □

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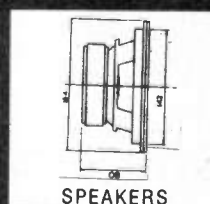
CABLES



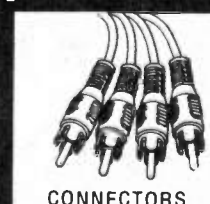
CAPACITORS



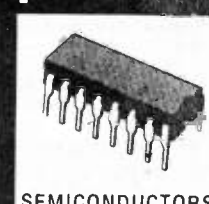
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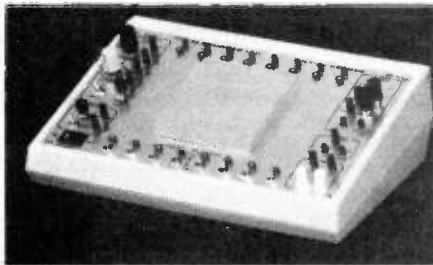
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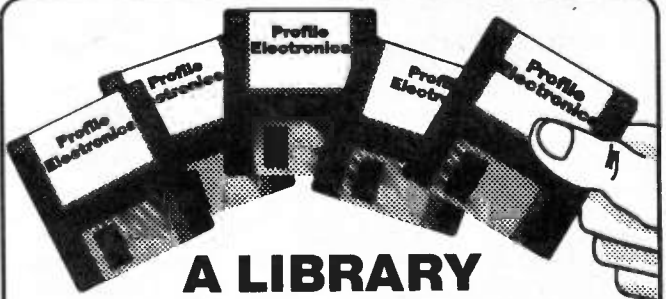
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# Introducing ELECTRONICS PRINCIPLES

Mike Tooley BA

*This supplement is presented FREE with  
Everyday with Practical Electronics, November 1993*

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## FOREWORD

Having reviewed a dozen, or more, educational software packages designed to "teach" electronics, I was more than a little sceptical when I first heard about *Electronics Principles*; there seemed to be little that could be done that has not been done elsewhere. When I started to use the package my views changed. Indeed, I was so impressed with it that I quickly came to the conclusion that *Everyday with Practical Electronics* readers should have an opportunity to try the package out for themselves!

As a result of my suggestion, the authors (E.P.T. Educational Software) have kindly agreed to release a special demonstration version of the software to be made available to *Everyday with Practical Electronics* readers at purely nominal cost. This version has several of the menu options removed but nonetheless it will allow you to explore the package and make full use of a variety of the facilities which it offers. So, if you are looking for a means of improving your knowledge of the

basics of electronics this could well be just what you have been waiting for!

This supplement has been put together in order to help you get the best out of the package. The supplement shows you how to install the software and, once up and running, how to find your way around inside it. In addition, the supplement will guide you gently through several of the major topic areas, with suggested further work and problems to test your knowledge and understanding. Finally, a number of tips have been included within the text. Not only are these useful "short-cuts" but they often include information which is not contained in the program.

I really believe that this is another "first" for *Everyday with Practical Electronics* and I do hope that you take time to send for the demonstration disk.

Mike Tooley



# ABOUT THE SOFTWARE

**E**LECTRONICS PRINCIPLES is a series of "user friendly" programs that will enable you to study electronics from the comfort of your own armchair. The full package has over two hundred menu driven screens with interactive graphics, enabling a "learning by doing" approach to encourage experimentation.

The software has been produced by E.P.T. Educational Software, a company which specialises in producing educational programs. The author of Electronics Principles has, in fact, had considerable experience both in industry and in education and has spent more than a year developing the program.

*Electronics Principles* is ideal for the student and hobbyist because it assumes no previous knowledge of the subject. In addition, the program has been designed to accept input data in various formats. For example, a 1.5kilohm resistor value can be input as 1500, 1k5 or 1.5k.

Outputs are generated in an easy to understand format (e.g.,  $\mu\text{F}$ , nF and pF for capacitance and Hz, kHz and MHz for frequency). This helps to avoid the confusion which may arise using scientific notation or where long strings of zeros may be present. Wherever possible, user errors have been anticipated and correcting routines included.

**TIP:** *Electronics Principles* will not accept zero inputs - these will always be converted to a "1". This helps to prevent overflow errors on division as well as non-sensical results when you inadvertently press the return or enter key without typing an input value.

## A quick tour of the full package

Your investigation begins with plotting the structure of some common atoms for materials used in electronics and the differences between insulators and conductors. D.C. circuits are analysed beginning with

Ohm's Law and series/parallel circuits, power calculations, voltage and current dividers. There is also a resistor colour code test.

A.C. circuits are explored starting with basic concepts, a.c. series voltages and phase angles. Capacitive and inductive reactance is explained

reverse biased conditions. Transistor operation is explained and both switching and linear amplifier circuits are discussed. The program constructs load lines for amplifier circuits and it allows users to experiment with the operating conditions used in common emitter amplifier stages, calculating a full set of component values for each circuit.

Logic gates and basic digital techniques are introduced. The operation of a number of digital circuits is simulated. These circuits include combinations of the basic logic gates, adders, decoders and memories.

Experimentation is encouraged by allowing users to input a wide range of values in response to input prompts. In addition, sets of recommended "test data" are provided as a starting point. You can use these or choose your own data. Alternatively, you could keep all but one of the "test data" values and vary just one in order to note the effect on the circuit in question.

Of necessity, text has been written in "note" form and has been designed to support the graphics and make the calculations understandable. Large amounts of text would, in any event, detract from the benefits of the graphics. All user instructions appear at the bottom of the screens and you may exit at any time to select other menus.

## System requirements

The *Electronics Principles* demonstration program, requires a PC (or fully compatible system) with an 80286, '386 or '486 processor and VGA (ideally colour) graphics. In addition you must have a hard disk with at least 1.3Mbytes of free space (the full program requires 4Mb of disc space), a high density (1.44Mbyte) floppy drive and at least 640Kbytes of RAM.

**TIP:** We strongly recommend the use of a mouse with the *Electronics Principles* program. All selections can be made by pointing and clicking, leaving the keyboard only for entering numerical values, when necessary.

**Table 1: Option topics available on the demonstration disk**

Major topic	Options
Introduction	None
D.C. Circuits	Introduction to D.C. Circuits D.C. Ohm's Law and Power Resistors in Series Resistors in Parallel Voltage Divider Current Divider Series/Parallel Resistors
Capacitance and Inductance	Introduction to Capacitance and Inductance Capacitance Capacitor Charging Waveforms and Time Constants Inductance Inductance Voltage and Current Waveforms
The P-N Junction Diode	Introduction to Semiconductors The P-N Junction Diode Characteristics Reverse Biased Diode Forward Biased Diode Half Wave Rectifier Full Wave Rectifier
Transistors	Introduction to Transistor Theory NPN Transistor Construction Transistor Principle Setting DC Operating Conditions Transistor Switch A Simple Audio Amplifier Audio Amplifier DC Conditions The AC Signal Path
Logic Gates	Introduction to Logic Gates AND Gate NAND Gate OR Gate NOR Gate Exclusive-OR Gate NOT Gate An Equivalent OR Gate An Equivalent NAND Gate
Combinational Logic	Introduction to Combinational Logic Half Adder Full Adder Parallel Adder 2-4 Line Decoder

**NB: PLEASE REMEMBER THAT THE FULL PACKAGE HAS MANY MORE OPTIONS FOR YOU TO EXPLORE!**

as is impedance and series and parallel circuits comprising combinations of resistance, inductance and capacitance. Waveforms and phase angles are plotted along with phasor diagrams and tuned circuit response curves.

Semiconductors are explained and the *p-n* semiconductor junction is demonstrated under forward and

## What's on the disk?

The *Electronics Principles* demonstration program is supplied on a single 3.5 inch disk. The disk contains 20 files occupying approximately 1.3Mbytes of disk space.

Several of the smaller files present are "batch files" used in the installation process, other files are responsible for loading the program, displaying the main menu and the menu selection routines. Files beginning with "x" are associated with the sub-programs which are executed from the main menu.

## Installing the program

Boot your system in the normal way and wait until the normal DOS prompt appears (in most systems this will be C:\ >). If your system loads a graphical shell (e.g., Windows) you may find it easier to exit to DOS in order to install the program. If, however, you are familiar with installing programs from Windows, you can proceed in the usual way.

Place the disk in drive A: and type CD A: followed by the return or enter key. After a second or two the DOS prompt should change to A:\ >. When this appears you should type INSTALL followed by the return or enter key (you can use either upper or lower case).

The drive will start up and the drive l.e.d. should become illuminated (if this doesn't happen check that you have typed the command correctly, that the disk is in the correct drive, and that you have remembered to finish the command using the return or enter key).

The installation program will display a copyright message before asking you to specify the hard drive on which you want to load the software. You can select from C, D or E.

Select the required drive by pressing an appropriate key (you don't need a return or enter here!) after which the installation program will confirm the target drive that you have chosen.

The installation program will create a new directory (called DEMOELEC) on your hard drive before it copies files from the floppy disk to the hard drive. Finally, you will be presented with the DOS prompt again, this time indicating that the current directory selected is DEMOELEC. To start the program, you can simply type DEMOELEC (followed by return or enter) – but don't do this yet!

**TIP:** If you need to remove the program from your hard disk, you can make use of the DOS ERASE command. Simply change to the DEMOELEC directory, enter the command ERASE \*.\* and then follow the DOS prompts (DOS will warn you that you are about to erase all of the files present in the

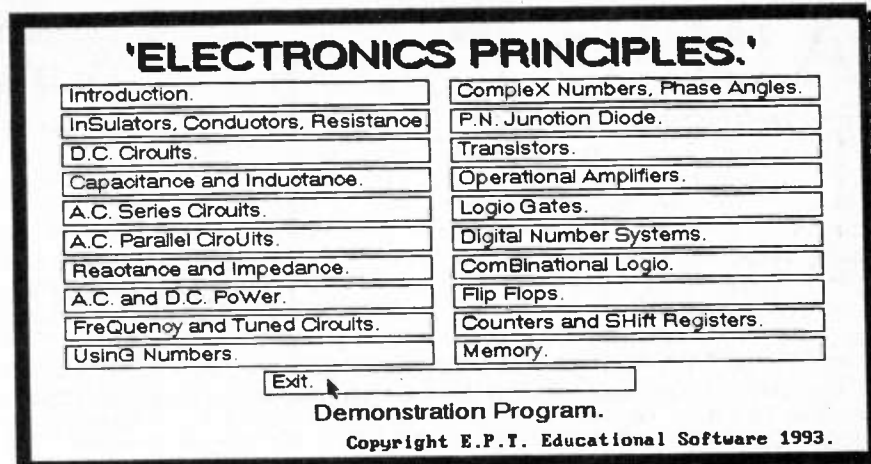


Fig. 1. The Electronics Principles Main Menu screen (note that the mouse cursor has been placed on the Exit button).

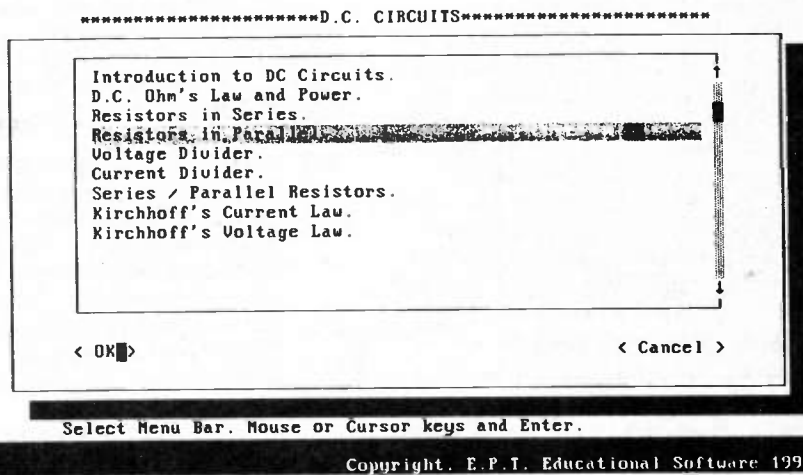


Fig. 2. The D.C. Circuits sub-menu (note that the Resistors in Parallel option has been highlighted).

DEMOELEC directory). Finally, type CD (followed by return) to move back to the directory then RD DEMOELEC to erase the directory (note that DOS won't let you erase a directory if there are any files in it!).

## Finding your way around

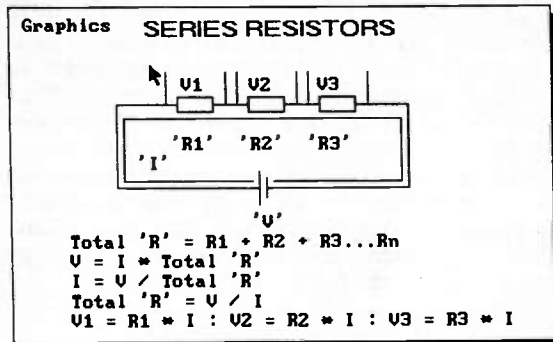
The *Electronics Principles* program makes extensive use of menu screens. When you first launch the program you will be presented with a Main Menu screen. This is the "home base" which you use to select from a list of twenty major topics (see Fig. 1).

**TIP:** If you look closely, you will see that seven of the Main Menu options are printed in normal text whilst the remaining thirteen only appear in outline. These latter options are not present in the demonstration program. The options that are available (listed in Table 1) should, however, give you plenty of scope to experiment with the program and make good use of its facilities.

When you select a major topic (such

as D.C. Circuits) the screen will change and you will be presented with a sub-menu (see Fig. 2). This sub-menu allows you to select from a list of sub-topics. If you are new to a particular topic, it is worth working through the sub-topics in strict order. If, on the other hand, you want to "brush up" your understanding of a topic, you can move directly to the point on which you need information.

When you have selected a sub-topic, you can move from screen to screen quite easily using the buttons provided. These will allow you to move on to the next screen, return to the previous screen, or exit to the sub-menu. Other buttons will appear (where appropriate) to let you enter values (and perform calculations), operate switches, change circuit conditions and re-run animated sequences. Fig. 3 shows a typical example which explains how resistors behave when connected in series. The two selector buttons on this screen are labelled **Calculations** and **Next**. Table 2 on page 8 summarises the functions of the various selector buttons which you will encounter as you work through the program.



**Results**

Series Resistors Calculations

To find 'U1 U2 and U3'

U = 25V  
 R1 = 4.7kΩ  
 R2 = 2.5kΩ  
 R3 = 1kΩ  
 Total R = 8.2kΩ

I = 3.0488mA

U1 = 14.3293V  
 U2 = 7.622V  
 U3 = 3.0488V

**Test Data.** U = 25 : R1 = 4k7 : R2 = 2k5 : R3 = 1k.  
 The total circuit resistance of 'n' resistors connected in series can be found by adding the values together. Current (electron flow) is common for all values of R1, R2 and R3. As the current flows each resistor will develop a voltage across it calculated by Ohm's Law. The individual resistor voltage drops when added will equal the applied (battery) voltage.

Calculations.      Next

Fig. 3. The first of the Series Resistors graphics screen.

## Making a selection

*Electronics Principles* will allow you to select option buttons using either the keyboard or the mouse. When you use the mouse, simply move the mouse pointer over the button and click the left-hand mouse button.

If you prefer to use the keyboard, simply press the key of the letter that appears in white. For example, to select **Introduction** from the Main Menu, you can just press the "I" key.

## Getting started

Select **Introduction** from the main menu (remember that you can use the mouse or simply press the "I" key). The screen will change and you will be presented with some text to read. You should notice that this screen is "1 of 9" and that you can select from the following options by means of the buttons that appear at the bottom of the screen; **Continue**, **Go-Back**, and **Exit**.

Select **Continue** (remember that you can use the mouse or the "C" key) to move to the next screen ("2 of 9"). Keep on reading through the introductory screens, each time moving to the next screen using **Continue**. If you need to return to the previous screen you can use the **Go-Back** button. When you reach the last screen ("9 of 9") select **Exit** to return to the Main Menu.

## D.C. Circuits

To start your investigation of *Electronics Principles* select **D.C. Circuits** from the main menu. The screen will change and you will be presented with another menu screen, the first option of which (**Introduction to D.C. Circuits**) will appear highlighted. You can move the selected option up and down using the mouse or cursor keys. To select the option, simply select <O.K.> with the mouse.

**TIP:** You can move between the <O.K.> and <Cancel> choices by using the TAB key on your keyboard.

Select **Introduction to D.C. Circuits** and read carefully through each of the five text screens before selecting <Exit> to return to the D.C. Circuits sub-menu.

**TIP:** *Electronic Principles* gives you a chance to repeat the theory screens. If you are unsure about anything or would just like to go through the theory a second time, simply select the **Repeat** option. To return to the D.C. Circuits menu, just select the **Menu** option.

Next, select **D.C. Ohm's Law and Power** from **D.C. Circuits** sub-menu (you will have to move the highlight with the mouse and keyboard before selecting the <O.K.> button). A graphics screen will be displayed like that shown in Fig. 4. This screen is typical of the graphics screens that you will encounter when using *Electronics Principles* and thus it is well worth taking a few minutes to familiarise yourself with its layout.

The upper portion of the screen is divided into two windows. The window on the left is the graphics window whilst that on the right is used for displaying the results of circuit calculations (initially it will be blank). Immediately beneath the graphics window you will find a list of recommended "test data". The values specified are; R = 1k5, V = 30V, and I = 20mA.

A brief text note is displayed below the two windows (you should read this before you study the graphic in any detail). Four selector buttons appear at the bottom of the screen. These are labelled **Voltage**, **Current**, **Resistance**, and **Next** - but don't make a selection yet!

**TIP:** You can make your selection using the highlighted selector button letters. Thus, to select **Voltage** you can press the "V" key, to select **Current** you should press the "C" key, and so on.

Carefully read through the text and study the diagram. The text tells you that a simple d.c. circuit consists of a current source (the battery) connected across a resistor. It informs you that electrons are propelled by the electromotive force (voltage) of the battery and that they are expelled from the negative terminal (marked "-") and attracted by the positive terminal (marked "+"). Using Ohm's Law, the voltage, current or resistance can be found (i.e., if we know any two of these quantities we can calculate the remaining one). Finally, the relationship between voltage (V), current (I), and resistance (R) is linear.

Now take a second look at the graph and the equations. The graph is a straight line (showing that the law which relates current and voltage is linear). The slope of the graph (i.e., the change in voltage divided by a corresponding change in current) is equal to the resistance, R.

Hence we can deduce that:

$$\frac{\text{Voltage (V)}}{\text{Current (I)}} = \text{a constant}$$

This constant of proportionality is known as Resistance (R). Hence:

$$R = \frac{V}{I}$$

We can rearrange this equation to make I or V the subject:

$$I = \frac{V}{R} \text{ and } V = I \times R$$

**TIP:** *Electronics Principles* uses "\*" to represent the usual multiply sign (x). This helps to avoid confusion which might arise between the lower case letter x and the normal symbol used to indicate multiplication.

Now select the **Voltage** option (remember that you can simply press "V" or use the mouse to operate the selector button). By selecting **Voltage** you have asked the program to perform a voltage calculation. The program will prompt you to enter values for the other two quantities that it needs in order to perform this calculation.

The program will prompt you to:

"Enter a value for I in mA"

Type in 20 followed by enter or return (note that this is the same value as specified in the test data). The program will then generate a further prompt:

"Enter a value for R in Ω, kΩ or MΩ"

Type in 1k5 (it doesn't matter whether you use lower or upper case for the "k") followed by return or enter.

**TIP:** When inputting data you don't need to specify the units (mA, A, V, etc). You must, however, remember to press the enter or



return key when you have completed the numerical input.

Now look at the results window. You should have a display which looks exactly like that shown in Fig. 4. This shows you that "20mA x 1k5Ω = 30V" (i.e., when 20mA flows in a 1.5kΩ resistor a voltage drop of 30V will be produced).

Select **Voltage** for a second time. This time enter a value of 65mA for I and 270Ω for R. The program should calculate the voltage as 17.55V.

**PROBLEM 1:**

A current of 3.75mA flows in a 4700Ω resistor. What voltage drop will be produced? (answers appear on page 8)

**TIP:** You can enter 4700 as 4k7. These two are the same as far as *Electronics Principles* is concerned!

Next select **Current**. You will be asked to:

"Enter a value for V in volts"

Use the test data again and type in 30 (followed by enter or return). Next the program prompts you to:

"Enter a value for R in Ω, kΩ or MΩ"

Enter a value of 1k5 and then look in the result window. This shows you that "30V/1.5kΩ = 20mA".

**TIP:** If you don't enter a value (or press return or enter too early) *Electronics Principles* will input a value of "1" for you.

Select **Current** for a second time. This time enter a value of 15V for V and 68k for R. The program should calculate the current as 220.5882μA.

**PROBLEM 2:**

A 390Ω resistor is connected to a 9V battery. What current will be supplied? (answers appear on page 8)

**TIP:** To convert from mA to μA (or A to mA) you must move the decimal point three places to the right, and vice versa.

Now move on to the third selector button, **Resistance**. Again use the test data (30V and 20mA) and check that the resistance, R, is 1.5kΩ. Then enter a value of 2.7V for the voltage, 0.75mA for the current and check that the resistance is 3.6kΩ.

**PROBLEM 3:**

A 240V supply delivers a current of 15mA. What is the resistance of the load connected to the supply? (answers appear on page 8)

When you are ready to move on, select **Next** to move on to the second graphics screen. Read the text and examine the graphic display before entering the test data to determine the power (dissipated as heat) in the 1.5kΩ resistor. Check that your results agree with those shown in Fig. 5.

Then select **Voltage** to determine the voltage and power when I=135mA and R=47Ω; **Current** to determine the current and power when V=50V and R=470kΩ; and finally **Resistance** to determine the resistance and power dissipated when V=1.5V and I=290mA. You should obtain the following answers; 6.345V, 856.575mW; 0.106mA, 5.3191mW; and 5.172Ω, 435mW.

**PROBLEM 4:**

A power supply is rated at 6V, 400mA. What value of load resistor would be required to test the supply at its full rated output and what power would be dissipated in the resistor?

**PROBLEM 5:**

Find the power dissipated in a 1.2kΩ resistor when a voltage of 27V is applied to it. (answers appear on page 8)

Now select **Exit** to return to the D.C. Circuits menu. and work through the remaining topics, **Resistors in Series and Resistors in Parallel, Voltage Divider and Current Divider** (note that the sections dealing with Kirchhoff's Laws are *not* included in the demonstration version). In each case, test the circuits using first the test data supplied and then your own values. Then have a go at the problems that follow:

**PROBLEM 6:**

Three resistors, 390Ω, 220Ω and 100Ω, are connected in series across a 12V power supply. Calculate the voltage dropped across each resistor and the current taken from the power supply.

**PROBLEM 7:**

A 35V supply is connected to a series arrangement of three resistors; 3.9kΩ, 1.2kΩ and 6.8kΩ. Find the power dissipated in each resistor and the total power supplied to the series circuit.

**PROBLEM 8:**

Two resistors, 680Ω and 120Ω, are connected in series across a 12V d.c. power rail. What voltage will appear across the 120Ω resistor?

**Graphics DC AND OHM'S LAW.**

$V = I * R$   
 $I = V / R$   
 $R = V / I$

ohms = Volts / Amps (A)  
 kohms = Volts / milliAmps (mA)  
 Mohms = Volts / microAmps (uA)

Test Data. R = 1k5 : V = 30v : I = 20mA.

A simple dc circuit consists of a current source (the battery) connected across a resistor. Electrons are propelled by the electromotive force (voltage) of the battery. Expelled from the negative terminal (-) and attracted by the positive (+). Using Ohm's Law the circuit voltage, current or resistance can be found. The relationship between V, I and R is linear.

Voltage	Current	Resistance	Next
---------	---------	------------	------

**Results Ohm's Law Calculations To find 'U'**

I = 20mA  
 R = 1.5kΩ

20mA \* 1.5kΩ = 30V

Fig. 4. D.C. and Ohm's Law graphics screen.

ohms = Volts / Amps (A)      **OHM'S LAW and DC POWER.**

kohms = Volts / milliAmps (mA)

Mohms = Volts / microAmps (uA)

To find 'U'

**Formulae**

$V = I * R$	$P = I^2 * R$
$I = \frac{V}{R}$	$P = \frac{U^2}{R}$
$R = \frac{V}{I}$	$P = U * I$

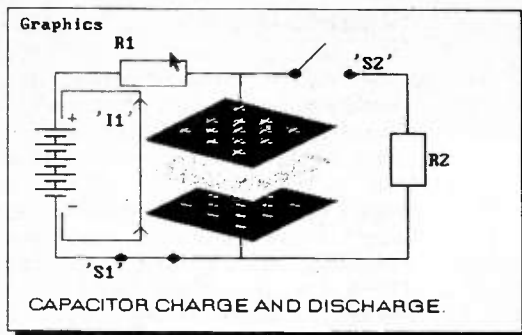
I = 20mA  
 R = 1.5kΩ  
 .02 \* 1500 = 30  
 V = 30V  
 Power rating of 'R'  
 .02 \* .02 \* 1500  
 = .6  
 P = 600mW

Test Data. R = 1k5 : V = 30v : I = 20mA.

When a current of 1 amp causes one volt to be developed across a resistor, that resistor will have a value of one ohm. One watt of power will be dissipated in the resistor as heat (symbol 'P' and measured in Watts). From the given Ohm's Law formulae I, U, or R can be found. Power will increase, proportional to the square of the current.

Voltage	Current	Resistance	Exit
---------	---------	------------	------

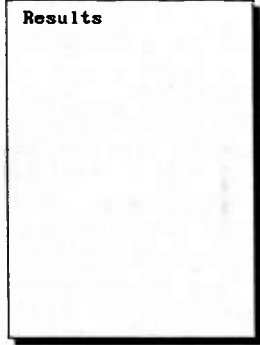
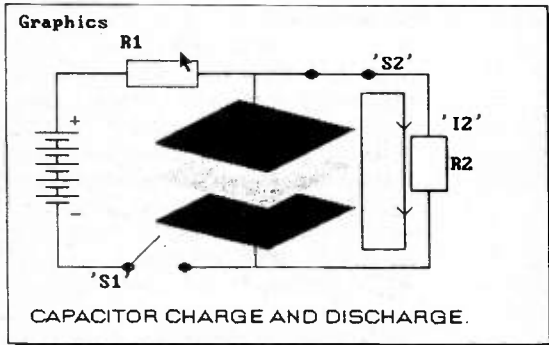
Fig. 5. Ohm's Law and D.C. Power graphics screen.



A capacitor is a device able to store an electric charge. It consists of two metal plates separated by an insulator called a dielectric. A charge is stored across the plates by closing switch 'S1', negative (surplus) electrons are forced onto one plate and an electron (deficiency) is caused on the other as electrons are attracted away by the battery (+ve).

Open 'S1'

Fig. 6. Capacitor charging.



The larger the value of R2 and the slower the capacitor will be discharged. Reversing the battery voltage will charge the capacitor in the opposite direction. If the battery were replaced by a continuously varying ac voltage the charge across the capacitor would be reversed for each half cycle of the ac waveform.

+ - Battery    |    - -> Battery    |    Continue    |    Exit

Fig. 7. Capacitor discharging.

**PROBLEM 9:**

The following resistors are connected in parallel; 180Ω, 180Ω and 56Ω. The parallel combination is then supplied from a 15V battery. Determine the power dissipated in each resistor and the total power supplied to the circuit.

(answers appear on page 8)

When you have completed the available options and solved the problems you should have a good understanding of the behaviour of d.c. circuits so you may want to take a well earned break before moving on to the next major topic! Just select **Cancel** from the D.C. Circuits menu and this will return you to the Main Menu. From there you can select the **Exit** button to return to the DOS prompt.

**Capacitance and Inductance**

When you are ready to move on to the next major topic, select **Capacitance and Inductance** from the Main Menu. Then choose **Introduction to Capacitance and Inductance**, the first of the sub-menu options. Read through each of the introductory text screens

before selecting < **Exit** > to return to the Capacitance and Inductance sub-menu.

Next select **Capacitance** from the sub-menu and follow the graphic sequence which explains how a capacitor charges and discharges (see Figs. 6 and 7). Then investigate the relationship between the physical dimensions of a capacitor (plate area and separation), dielectric constant and the value of capacitance.

**TIP:** Try making a specific value of capacitance (say 1nF) using different plate areas, separations and dielectric materials. See how close you can get to the desired value by varying the spacing and dielectric whilst keeping the plate area constant!

**PROBLEM 10:**

Calculate the capacitance of a ceramic dielectric capacitor which has a plate area of 20 square cm. and a spacing of 0.4mm.

**PROBLEM 11:**

Find the charge in a 22μF capacitor when it has a potential difference of 50V across its plates. (answers appear on page 8)

Select **Capacitor Charging Waveforms and Time constants** from the **Capacitance and Inductance** sub-menu. View the animated sequence as switches S1 and S2 open and close, alternately charging and discharging the capacitor (see Fig. 8).

There are a number of important things to note from this diagram. At the instant switch S1 closes, a high value of current flows as the capacitor is initially uncharged. The current falls exponentially back to zero as the capacitor becomes charged. At the same time, the voltage builds up exponentially.

Some time later, S1 opens and S2 closes. This starts the discharge part of the cycle. Here the capacitor current becomes reversed (current flows out of the positive plate rather than into it). Both the current and the voltage fall exponentially as the capacitor discharges through the resistor. Repeat the animated sequence a few times and you will quickly understand how the circuit works!

Return to the sub-menu and select **Inductance**. View the graphic sequence that illustrates how energy is stored in an inductor. Next return to the sub-menu and choose **Inductance Voltage and Current Waveforms**.

Watch the animated sequence as switches S1 and S2 open and close (see Fig. 9). Compare the waveforms with those that you saw earlier for a capacitor charging and discharging. You should notice a similarity between the capacitor charging current and the inductor voltage, and vice versa!

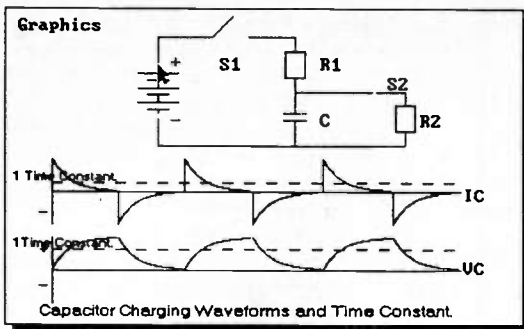
**The p-n junction diode**

Select **PN Junction Diode** from the Main Menu Work through the **Introduction to Semiconductor Diodes**, then select **PN Junction, Diode Characteristics, Forward Biased Diode, and Reverse Biased Diode**. The graphics screens will give you a basic understanding of the operation of semiconductor diodes.

Now move on to the **Half Wave Rectifier** and **Full Wave Rectifier** options (see Fig. 10). These will allow you to experiment with simple d.c. power supplies, changing circuit conditions and component values and examining the ripple voltage produced.

**PROBLEM 12:**

Determine the ripple voltage produced by half-wave and full-wave power supplies when the rectifiers are fed with a 17V peak a.c. supply having a source resistance of 10Ω if the reservoir capacitor has a value of 470μF and the load is 500Ω. (answers appear on page 8)

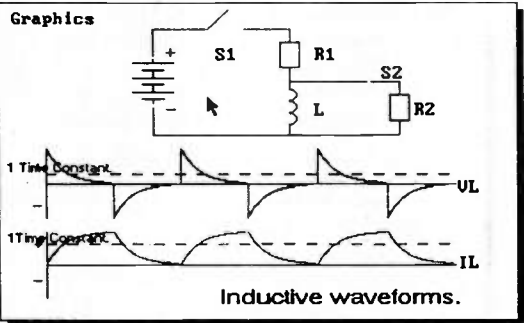


**Results**

Applied U = 100V  
 C = 10µF  
 R = 10Ω  
 IC = 10A  
 C,R Time constant = 100µs  
 Full Charge 500µs  
 UC @ 1 \* time const. = 63V  
 IC @ 1 \* time const. = 3.7A

**Test Data.** U = 100volts : C = 10µF : R = 10kohms. Time Constant 20ms.  
 As switches S1 and S2 are alternately closed 'C' charges via R1 and discharges via R2. As R1 = R2 the charge and discharge times are the same. Initially IC flows through R1, as the charge builds up the voltage is reduced across R1 and 'C' charges more slowly. Hence the exponential waveforms. One time constant is calculated to be 63% UC or 37% of IC.

Fig. 8. Capacitor charging waveforms.

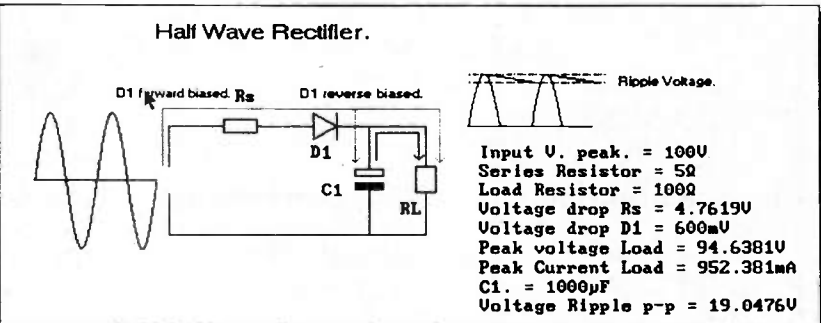


**Results**

Inductive waveforms.  
 Applied U = 100V  
 L = 250mH  
 R = 500Ω  
 IL = 200mA  
 L,R Time constant = 500µs  
 To steady state. = 2.5ms  
 UL @ 1 \* time const. = 37V  
 IL @ 1 \* time const. = 126mA

**Test Data.** U = 100v : L = 250mH : R = 500ohms : t = 1ms.  
 The moment 'S1' is closed IL cannot instantly flow through L but gradually builds up to its maximum, determined by Ohm's Law by which point UL has fallen to zero. Opening 'S1' and Closing 'S2' causes the magnetic field to decay and energy to be dissipated through R2. A time constant for the L,R circuit is calculated to be at 63% of IL or when UL has reduced by 63%.

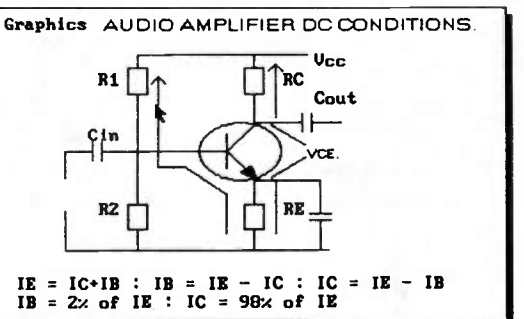
Fig. 9. Inductor waveforms.



Input U. peak. = 100V  
 Series Resistor = 5Ω  
 Load Resistor = 100Ω  
 Voltage drop Rs = 4.7619V  
 Voltage drop D1 = 600mV  
 Peak voltage Load = 94.6381V  
 Peak Current Load = 952.381mA  
 C1 = 1000µF  
 Voltage Ripple p-p = 19.0476V

**Example Inputs.** Vin peak 100volts : Rs 5ohms : Rload 100ohms : C1 = 1000µF.  
 Positive half cycles > 0.6volts cause the diode to conduct and current flows into the load, also charges C1. During the negative half cycles the diode is cut-off, and C1 discharges via RL. Until the next positive pulse arrives. The charge stored in C1 can be increased by making it larger. This decreases the ripple voltage. Rs limits the diode forward current.

Fig. 10. Half-wave rectifier.



**Results**

Vcc = 9V  
 UC = 6.2973V  
 UE = 1.3514V  
 UCE = 4.9459V  
 IE = 1.5mA  
 RC = 1.8386kΩ  
 RE = 900.9009Ω  
 UB = 1.9514V  
 IB = 30µA  
 R1 = 21.3595kΩ  
 R2 = 6.5045kΩ

**Test Data.** : Vcc = 12v : IE = 5mA.  
 To ensure the output signal is not distorted, the transistor DC bias conditions must be applied. The collector voltage must be set so the superimposed ac output signal is not clipped. RC and RE are calculated have a 2 : 1 relationship using UC and UE. To ensure a stable base v IR2 is made 10 times IB. R1 = R2 current plus IB. Therefore IR1 = IB

Fig. 11. NPN transistor switch (shown in the "on" state when the transistor is saturated).

## Transistors

The last of our sample investigations deals with transistors. Select **Transistors** from the Main Menu. As usual, you should work through the introductory text (**Introduction to Transistor Theory**) before moving on to the graphics screens. Select **NPN Transistor Construction, Transistor Principle, Setting DC Operating Conditions, and Transistor Switch**. Note in the last case that you can turn the switch symbol "on" and "off" using the **Close switch** and **Open switch** selector buttons (see Fig. 11).

The **Simple Audio Amplifier** option will introduce you to transistor amplifiers whilst **Audio Amplifier D.C. Conditions** develops this theme further and allows you to experiment with operating conditions and calculate component values for a practical common emitter stage (see Fig. 12).

Load lines will give you a thorough understanding of amplifier operation. *Electronics Principles* will construct a.c. and d.c. load lines for you based on values that you supply (see Figs. 13 and 14).

**TIP:** *Electronics Principles* marks the quiescent (no-signal) point on the d.c. and a.c. load lines. When the amplifier stage is driven (i.e., when a signal is applied to it) the collector current (IC) and collector voltage (VC) moves up and down along the load line. You can use the load line to predict corresponding values of IC and VC at any point on the collector signal waveform.

### PROBLEM 13:

Determine the resistance values for a common emitter transistor amplifier operating from a 9V d.c. supply if the recommended emitter current is 1.5mA.  
 (answers appear on page 8)

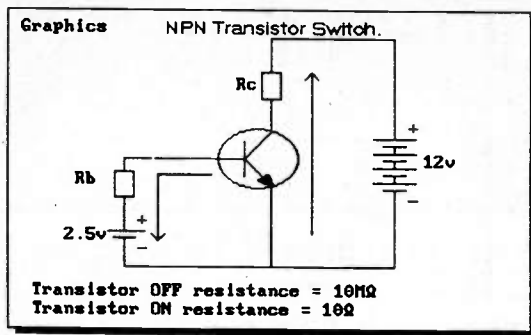
## What next?

Having completed the introductory exercises you should now be a reasonably confident user of *Electronics Principles*. We have left two remaining topics, **Logic Circuits**, and **Combinational Logic** for you to explore on your own. We hope that you enjoy these and that they whet your appetite sufficiently to want to invest in the full package!

## Ordering information

The full Electronic Circuits package is available from the *Everyday with Practical Electronics Direct Book Service* for £49.95. Add £1 to your order for postage and packing (overseas readers please add £2.00 for countries in Europe, or £3 for all





**Results**

Calculations  
To show IC and UC

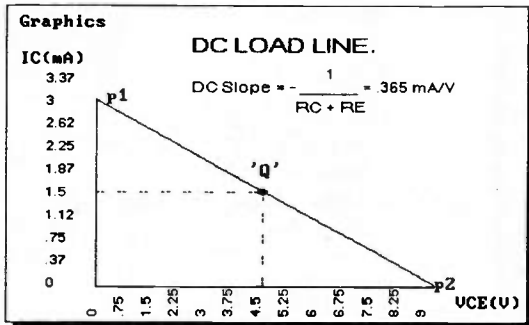
Rb = 1kΩ  
Base voltage = 600mV  
Base current = 1.9mA

Rc = 250Ω  
Collector current = 40mA  
Collector voltage = 480mV

Increase the base current and the transistor can be made to saturate. Maximum IC will flow, and collector volts fall to a low value (that developed across the ON resistance), determined by Rc. Open the switch, collector volts rise to the applied voltage less the transistor leakage current \* Rc. The transistor is either saturated or cut-off.

Close switch. Open switch. Exit

Fig. 12. Audio amplifier d.c. conditions.



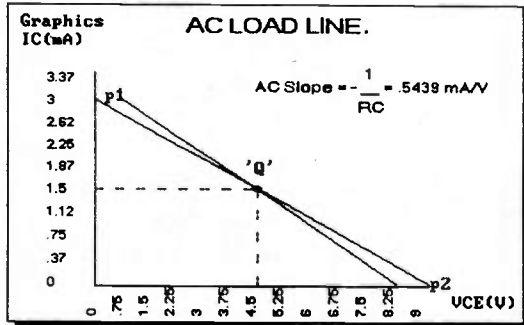
**Results**

Ucc = 9V  
UC = 6.2973V  
UE = 1.3514V  
UCE = 4.9459V  
IE = 1.5mA  
RC = 1.8386kΩ  
RE = 900.9009Ω  
UB = 1.9514V  
IB = 30μA  
R1 = 21.3595kΩ  
R2 = 6.5045kΩ

Test Data. : Ucc = 12v : IE = 5mA.  
The DC load line is a graphical representation of dc conditions of the transistor circuit, (bias range). Biased to p1 the transistor would be saturated maximum current flowing for the selected resistor values, RC and RE. UCE being zero. At p2 the transistor is cut off with only leakage current flowing. For class A output, point 'Q' being the ideal.

Menu. Repeat

Fig. 13. D.C. load line.



**Results**

Ucc = 9V  
UC = 6.2973V  
UE = 1.3514V  
UCE = 4.9459V  
IE = 1.5mA  
RC = 1.8386kΩ  
RE = 900.9009Ω  
Frequency = 1kHz  
Cin = 10μF  
Kcin = 15.9236Ω  
Cout = 10μF  
Kcout = 15.9236Ω  
CE = 100μF  
Kcout = 1.5924Ω

Test Data. Ucc=12v : IE=5mA : Freq=3kHz : Cin=1uF : Cout=10uF : CE=100uF.  
The slope of the AC load line is calculated as change in mA/V. Capacitors are considered to be short circuit to ac signals, therefore the emitter is grounded. The load line is calculated using RC only. As the collector current changes so does the output voltage by an amount expressed in mA/V. The amplifier behaves differently when an ac signals are applied.

Menu. Repeat

Fig. 14. A.C. load line.

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Please also note that the full program is supplied on three 3.5 inch high density disks and requires a total of approximately 4Mbytes of hard disk space.

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Table 2: Functions of the selector buttons

Button legend	Function
Calculations	Allows you to enter values and calculate circuit conditions
Continue	Selects the next screen in a sequence
Decrease bias	Reduces voltage/current applied to a component
Exit	Return to the menu selection screen
Go-back	Return to the previous screen
Increase bias	Increases voltage/current applied to a component
Menu	Return to the sub-menu
Next	Move on to the next graphics screen
Repeat	Repeat a calculation (so that new values can be entered)

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## Answers to problems

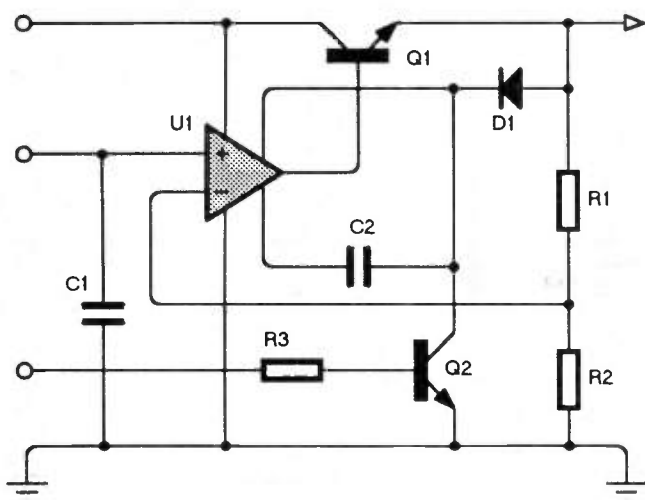
1. 17.625V; 2. 23.0769mA; 3. 16kΩ; 4. 15Ω, 2.4W; 5. 607.5mW; 6. 6.5915V, 3.7183V, 1.6901V, 16.9014mA; 7. 33.737mW, 10.3806mW, 58.8235mW, 102.9412mW; 8. 1.8V; 9. 83.333mA, 83.333mA, 267.857mA, 434.5238mA; 10. 442.0866pF; 11. 0.011C; 12. 1.418V (half-wave) and 672.3405mV (full-wave); 13. RC = 1.8386kΩ, RE = 900.9009Ω, R1 = 21.3595kΩ, R2 = 6.5045kΩ

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# INSIDE THE ELECTRIC GUITAR

JOHN CHATWIN



*With a little knowledge it is possible to improve the sound and tonal variety of most guitars*

**G**UITAR players tend to take one look in the back of a guitar and quickly decide they don't want anything to do with it. This is usually the point when people like us get to have a go at sorting things out. It's not as complicated as it looks though, and with a little understanding of how the electronics work you can not only make repairs, but also modify the circuits to improve or customise the sound an instrument makes.

Most, if not all, electric guitars and basses are simply a set of strings stretched across a piece of wood with some means of converting the vibrations that the strings

make into electrical impulses (Fig. 1). These impulses are fed out through a lead to an external amplifier which changes the electrical energy back into sound vibrations and makes the, usually loud and sometimes annoying, guitar sound.

The shape of the instrument has very little effect on the sound – what is important is the type of pick-up or transducer, the state of the strings, and to a lesser degree, the wood the guitar is made of. Some electric guitars are made of carbon fibre, but this is more for the stability of the instrument than the sound. Wood tends to move about depending on how hot it is,

and how much moisture there is in it. If you want a truly stable guitar, better make it out of cast iron or concrete!

## PICKUPS

The heart of any guitar is the pickup (Fig. 2), because no matter how well made and beautiful an instrument is, if the pickup isn't any good, the guitar will sound awful. All a pickup consists of is a row of small magnets with several thousand turns of fine copper wire wound round them. The strings are made of steel so when they vibrate near the magnets small currents are induced in the coil. These can then be amplified.

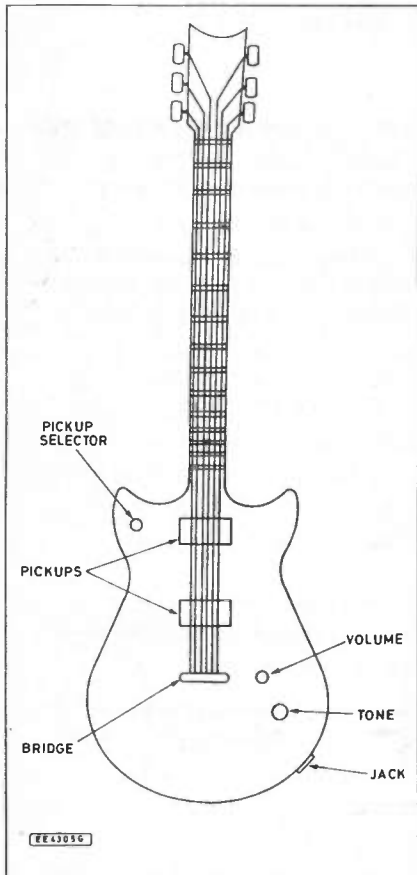


Fig. 1. Basic controls on a guitar.

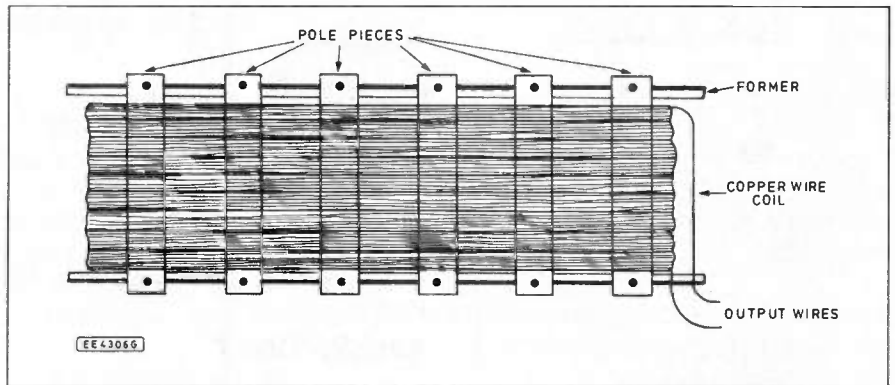
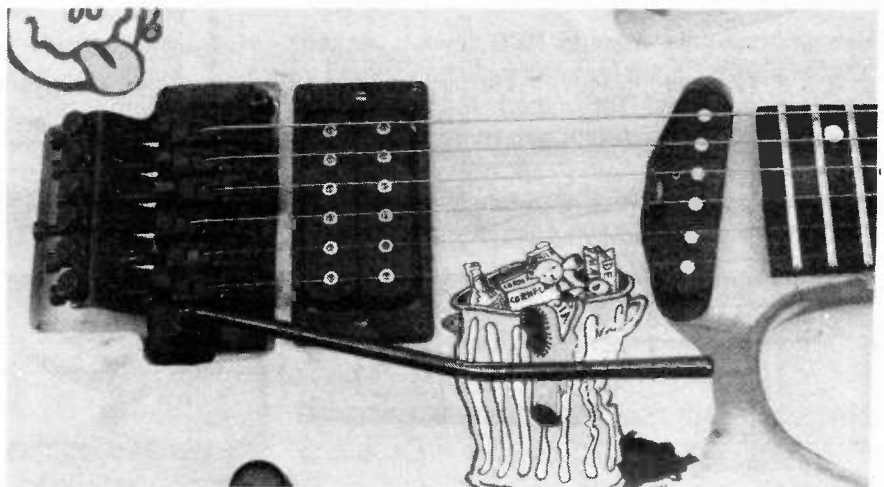


Fig. 2. Single pickup internal view.





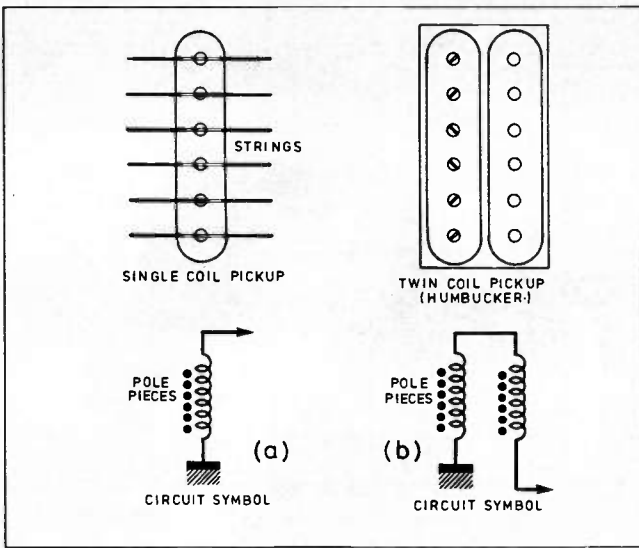


Fig. 3. Format and circuit symbol for (a) single pickup coil and (b) twin coil (humbucker) pickup.

Guitars usually have a couple of pickups so that the different tonal qualities of the strings can be selected and mixed. For a full "bassy" sound the pickup can be near the middle of the guitar where the string vibration is widest. Treble sounds are best achieved by having the pickup closer to the bridge.

There are two main types of pickup (Fig. 3), "single coil" and "humbucker". Single coil pickups have a clear, clean sound but

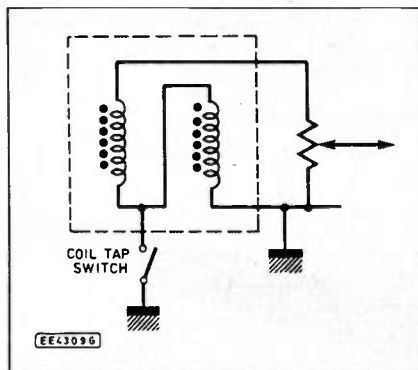


Fig. 5. Wiring a coil tap.

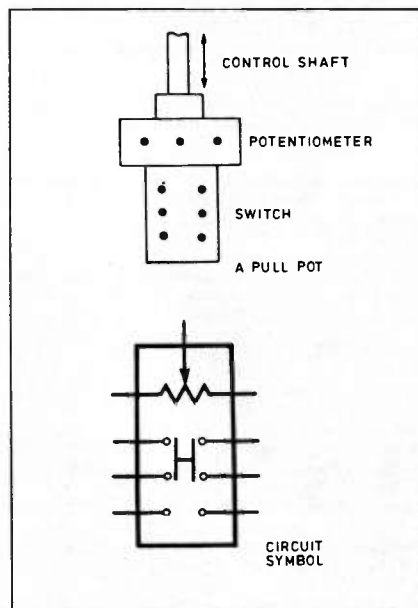


Fig. 6. A pull pot. with its circuit symbol.

are susceptible to hum and noise. Humbuckers have two similar coils side by side, connected in series. This arrangement tends to cancel out induced interference, and because of the two coils, has a higher output.

If a guitar has a number of pickups the next stage in the circuit is a selector switch which allows you to choose the coil output you want to use. A two pickup guitar might have a three position switch so you could use the front pickup on its own, the back pickup, or a combination of both. The output from the switch goes to the volume control which is just a potentiometer (pot.) connected across the coil so that more or less of its output is shorted to earth.

Tone controls (Fig. 4) are often included on guitars, but seem to have little use as they are only simple filters which merely "dampen" the sound. Most guitarists leave them open all the time.

Tone controls consist of a capacitor and pot. arrangement connected so that the higher frequency component of the sound can be progressively bled off. They are usually connected across the output of the instrument, but may also be positioned after the pickup.

Values for tone and volume controls can range from around 22k to 1M. Linear pots. tend to get used for tone and log. for volume.

### COIL TAP

One of the easiest modifications you can make to a guitar circuit is the coil tap. You can only do this if the pickups are *twin* coil units. What a coil tap does is short one of

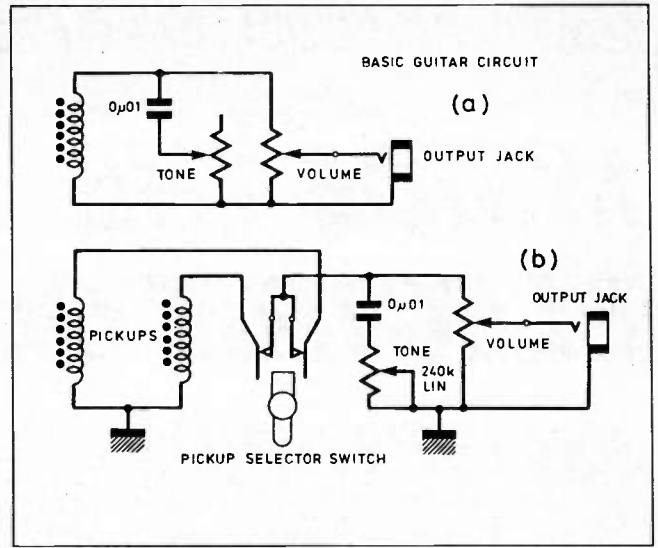


Fig. 4 (a). Basic guitar circuit. (b) Two pickup guitar circuit.

the coils to earth making the pickup into a single coil (see Fig. 5) thus giving you a cleaner output as well as the normal humbucking sound. The output of the guitar will fall slightly if only one coil is used and there may be an increase in noise levels.

You can use a small s.p.d.t. switch mounted near the other controls, or if you don't want to drill holes in your guitar you can use a "pull pot." which is a combination pot and switch. When the shaft is pulled out the switch is activated. You can replace a volume or tone control with a pull pot. (Fig. 6).

To wire a coil tap you may have to take the pickup apart to get to the connection between the coils. Some pickups have separate wires for each coil. If you have to remove the cover be careful not to damage the wires in the coil as they are usually around 42 gauge, or thinner, that's less than the thickness of hair, and very easy to break.

### PHASE REVERSE

Another simple modification you can make is the phase reverse (see Fig. 7). This works best with twin coil pickups but can be done with single coils. It makes a great deal of difference to the sound and when combined with a coil tap gives a vast range of tonal options that very few commercially produced instruments have. The phase reverse switches the polarity of one pickup in relation to the other.

The wiring for a two pickup guitar with dual phase reverse, coil taps and controls is shown in Fig. 8.

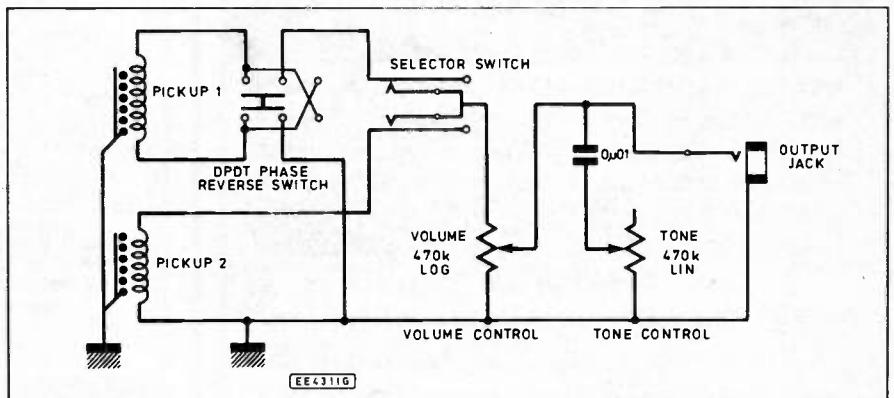


Fig. 7. Two pickup guitar circuit with phase reverse switch.

## REDUCING NOISE

Because the pickups in guitars are connected to the inputs of amplifiers, they tend to act as aerials if not properly screened, this goes for all the circuitry in the guitar. If you are going to make any modifications make sure you use wire runs that are as short as possible, and always make a good earth connection. It's best to use one central earth point - the back of a pot, for instance - and take separate leads from there.

One effective noise reduction method is to line all the pickup and control cavities with foil. This can be earthed, and makes a good screen. Remember to put the foil on the underside of control covers as well, make sure there is good electrical contact. This will be especially useful on guitars that have single coil pickups, and should always be done if any form of active circuitry is to be used.

## IMPROVING TREBLE RESPONSE

A lot of guitars loose high frequency response because the volume control tends to load the pickups. There are two ways to get around this, one is to fit a by-pass switch to cut out the volume control which is fine as long as you don't need to reduce the output level. The other is to wire a small value capacitor across the wiper and volume input (see Fig. 9). This capacitor lets the high frequencies through even when the volume is turned down and compensates for any losses. The value of the capacitor should be around  $0.01\mu$  to  $0.001\mu$  and can be chosen depending on how much treble response is required.

It is also often a good idea to experiment with the value of the capacitors fitted to tone controls as they can vary in different guitar circuits. Swapping one capacitor for another might make a big difference to the sound. Values to try can range from  $0.1\mu$  to  $0.001\mu$ .

An interesting variation on the normal tone control circuit can be wired across the mid-point of a twin coil pickup (see Fig. 10). It acts as a sort of semi coil tap and sounds very smooth and effective. The only drawback with this circuit is that you need a separate control for each pickup.

As with most subjective sound electronics the best way to achieve results is to start with the various circuits and adapt them to your own requirements. Guitar electronics are basically simple, but a little experimentation can be very rewarding. □

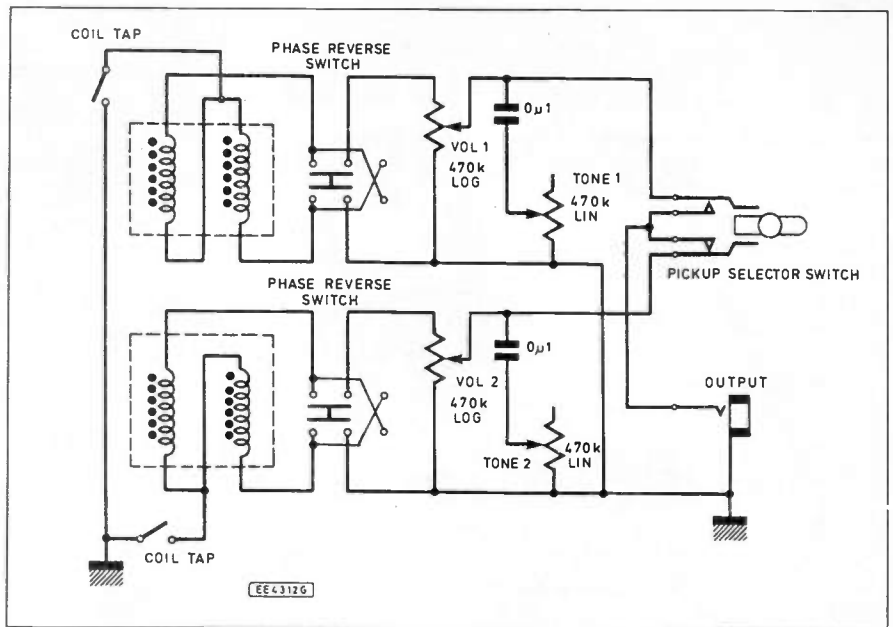


Fig. 8. Two pickup guitar circuit with dual phase reverse and coil taps.

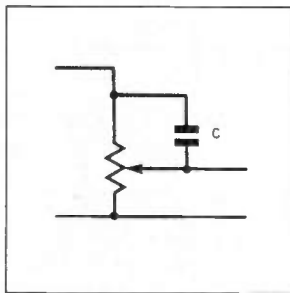


Fig. 9. Fitting a volume bypass capacitor.

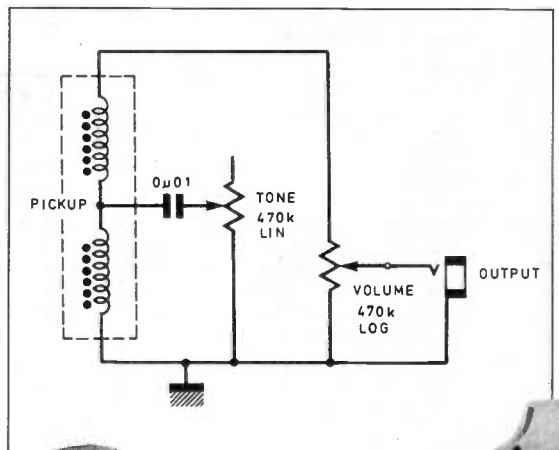
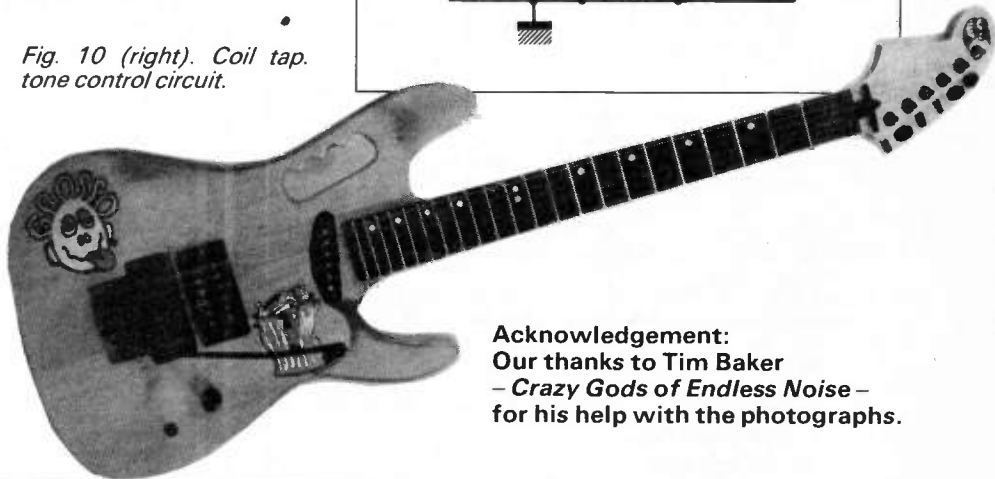


Fig. 10 (right). Coil tap tone control circuit.



**Acknowledgement:**  
Our thanks to Tim Baker  
- Crazy Gods of Endless Noise -  
for his help with the photographs.

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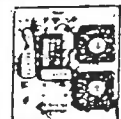
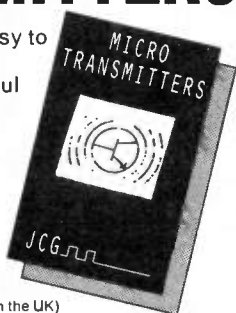
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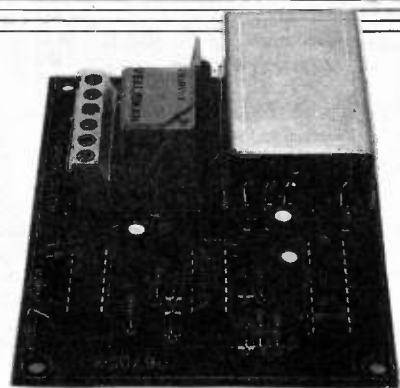
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# THE VELLEMAN VIEW

T. R. de VAUX-BALBIRNIE

A look at electronic kits – Belgian style



ANYONE who keeps up-to-date with the electronics literature can hardly fail to have seen advertisements for Velleman, their kits are available from a wide range of UK retailers. Perhaps a full-page display ad. for the K4000 valve amplifier caught their eye. Maybe just the sheer range of kits which Velleman supply. A decision was taken to pay them a visit to see some product lines at first hand, examine their marketing strategy and – very importantly – to look at the philosophy behind their operations.

## CLOSE TO HOME

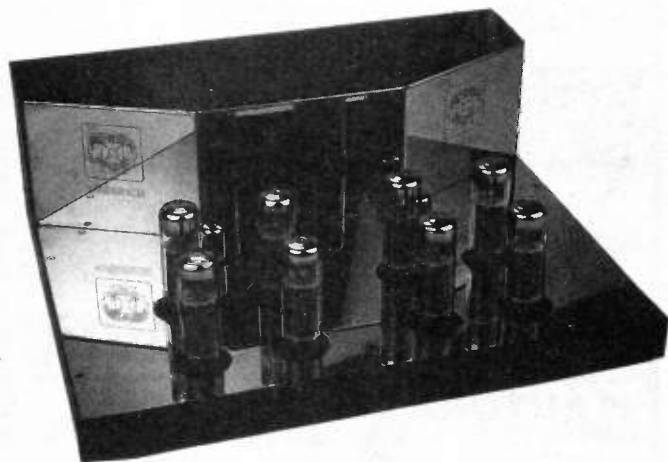
Judging (inexpertly) from the name, I had assumed that I would be visiting Germany, Austria or Switzerland. It came as a surprise, therefore, to learn that Velleman are based closer to home – just on the other side of the English Channel in Belgium. Velleman is a totally Belgian enterprise with their hub of operations situated at Gavere, near Ghent. Here, Mr. Velleman himself maintains full involvement in the day-to-day running of the company. Really, I should say *companies* because – this was my next surprise – Velleman is not just one company but *four*. However, all share the same location and, to some extent, their activities overlap. We shall look in more detail at their business structure presently.

The companies are small enough to have a *family feel* and all employees are encouraged to suggest new product lines. When this is done, a feasibility study is made. The idea is then developed if it is considered that future sales volume would justify it.

This goes for members of the public too – Velleman will listen to any suggestions made. These may be forwarded through the national distributor which, in the UK, is Maplin Electronic Supplies (who supplied the photographs used in this review) in Rayleigh, Essex (see the Maplin advertisement in *Everyday with Practical Electronics*). Remember this, constructors!

## PHILOSOPHY

My particular interest was in the philosophy behind *Velleman Kit* – one of the four companies referred to above. This was explained in impeccable English by my host – Velleman's export manager, Johnny Verstraeten. Philosophising took some time and it turned



The Velleman K4000 valve amplifier.

out that my own views were very much in accord with those of Velleman.

Answering the question, *what is electronics?* would probably bring as many different responses as the number of people asked. This is because electronics can be looked at on several planes and in many different ways – all of them valid. Taking the *theoretical knowledge* aspect – do you need to know Ohm's Law to "understand" electronics? Do you need to be able to *design* and *construct* circuits to be an electronics expert? Is pleasure to be gained by making something which simply works well and looks good without understanding much of the theory? Does it even need to look attractive so long as it does its job effectively?

Of course, all elements of electronics are important in their way and they are all inter-related. So, how can we approach such a subject vast as it is? Certainly, theory on its own can be very boring and there is a lot to be said for picking it up *after* interest has been aroused. This can only be done by constructing a useful circuit which is guaranteed to work (although possibly not first time).

Self-designed circuits thought-up without the necessary theoretical knowledge usually fail to work and much time can be wasted – not to mention the cost of component damage which sometimes ensues. Often, such circuits have multiple faults – some due to incorrect component values coupled, perhaps, with problems caused by poor construction. It may be that the circuit fails to work even when several mistakes are rectified. The end result will be total disillusionment and a wish never to "try electronics" again!

## INTRODUCTION

A good way forward is to remove the uncertainty from the design and allow the user to concentrate on the *construction* aspect. If he or she knows that help is at hand should difficulties arise, this will boost confidence, help to build up practical skills and promote a *feel* for the subject. Some will see this as an end in itself and derive great satisfaction from saying, *I made that!* – especially if the finished artefact looks good as well as doing its job efficiently. However, there will be some who are prompted to modify published circuits – gently at first – and to go on to learn the theory which will enable them eventually to design their own.

This is where magazines such as *Everyday with Practical Electronics* and kit manufacturers such as Velleman have such an important role to play. And not only in the purely *hobby* side but in the future of our nation and Europe. Designs published in *EPE* contain all the information needed to build a full working circuit but, of course, a beginner would be foolish attempting one of the more complicated ones – these will follow later. Part of the fun can be in gathering together the entire set of components needed, possibly from several sources, soldering-up the circuit, testing it and correcting faults then, finally, building it into a good-looking case.

## GUARANTEED RESULTS

Another approach is to use a kit. With a reputable one, results are guaranteed and the final result looks professional. This is the promise made by Velleman Kit. Let us see what *guaranteed* means in practice. The contents of the box are guaranteed to contain all the correct components – and there will be no "near values" either. If the manual specifies a 22k resistor you won't find a 27k one instead!

At the factory, all components of the various types are counted before packaging begins. At the end of the session there must be none left over and no shortages found. If there are, something is wrong and the batch must be re-checked. In parallel with this is a rolling process of random sampling as part of quality control.

Regarding the components themselves, no one could expect Vel-

leman – or indeed anyone else – to test every component supplied. This would add greatly to the cost of the kits and is unnecessary. Components as bought-in from manufacturers are extremely reliable. In practice, this means that virtually no assembled kits fail to work on account of a faulty component. Failure is almost always due to incorrect assembly and/or faulty construction work.

With a Velleman kit, incorrect assembly is virtually eliminated. The manual provided with each one shows the outline of each component so even an absolute beginner will not mistake a transistor for a transformer! Details for checking its value (such as the resistor colour-code) and its precise location on the circuit panel are also indicated. The manual is clear, well-presented and properly printed – not cheaply duplicated as with some suppliers. Poor-quality printing not only presents a bad image but often leads to assembly errors.

At the time of writing, Velleman are introducing an automated system whereby components are supplied in the form of a strip and presented in assembly order. This will make it even less likely for an error to occur. Of course, all components cannot be supplied in this way – it would be practically impossible with a switch or a transformer, for example. However, for axial-lead components such as resistors, most capacitors, diodes, etc. the technique promises to be a valuable one.

## BACK-UP

Inevitably, there will be the occasional finished project which does not work. When this happens, the distributor – or Velleman themselves – will solve the problem in either of two ways. Firstly, the distributor (of which there is a list in each manual) can attempt to solve the problem free of charge by telephone. Naturally, this may not be possible so sometimes the device itself needs to be returned to be examined.

The most usual fault is a poorly-soldered joint or “bridged” copper tracks (even though there is soldering advice given for anyone who has never actually constructed a circuit before). If this turns out to be the case, the fault will be corrected and the project returned either free of charge or for an agreed nominal fee. If there is a more complex fault – possibly resulting in damage to a circuit component – then this will be replaced at a nominal fee. Johnny Verstraeten told me that this fee did not reflect the full cost of the repair but was a goodwill service which would boost confidence in building Velleman kits in the future.

Velleman are very conscious of maintaining their *quality* image and have no wish to enter the *cheap and cheerful* end of the market. For example, the printed circuit panel is always of high-quality glass-fibre construction, accurately pre-drilled and ready to accept solder. With larger kits such as those in the hi-fi section, the housings are also supplied. This gives the finished device a professional appearance. The front panel will be planned to harmonise with other members of the range – amplifier with tuner, equalizer and so on. Special care has been taken over external components such as control knobs and switches so that they look good together and with the case.

Many constructors do not have the necessary aesthetic judgement to make an otherwise good project into a professional-looking one. It also sometimes happens that a row of holes drilled in the front panel of an amateur product do not make a perfectly straight line. This can ruin the appearance of an otherwise good piece of equipment.

There is something for everyone in the Velleman range – audio equipment, intruder alarms, car devices, light effects, etc. There are now some 135 items ranging from the extremely simple to the fairly complicated. As a rule, kits are not withdrawn from the list although

*The power supply and switching module for the Velleman equaliser kit. Heading photo shows the infra-red receiver for the code lock kit.*

this may be necessary if, for example, a certain i.c. become unavailable. In this case, the kit is usually re-vamped using the equivalent current component. This will also give an opportunity to make any small improvements. Another reason for withdrawing a kit is when its need no longer exists – a project for an obsolete computer, for example.

## EXPENSIVE

The most expensive kit in the current Velleman range is the K4000 valve (or *tube*) amplifier. This has an impressive specification and is selling well. There is something of a revival in this type of valve technology although it has always had its adherents. The K4000 is made to be *looked at* as well as *listened to* because the valves themselves are on view. This can make it a talking point and the focus in a living room. Although expensive (you can expect only 5p change out of £550), it is a popular kit but perhaps not one for the beginner!

The least expensive one is probably the tiny one-chip 7W audio amplifier costing only £7.45. All kits are sold in a good-looking box which is sturdy enough to find a use for something else – such as to store components later.

The Velleman Kit catalogue (showing a colour photograph of each device) lists products in ten categories – from *Household Applications* to *Power Supplies*. There are also some ready-made car alarm extension modules – an ultrasonic detector, for example. Although no prices are shown, I am told that the next issue may well be priced. Note, however, that individual suppliers' catalogues are priced. One interesting point is that the smart black anodised aluminium housings used for many of the larger Velleman kits (audio equipment, etc.) are now listed and available separately. With these, the amateur designer can enhance the appearance of his or her finished product.

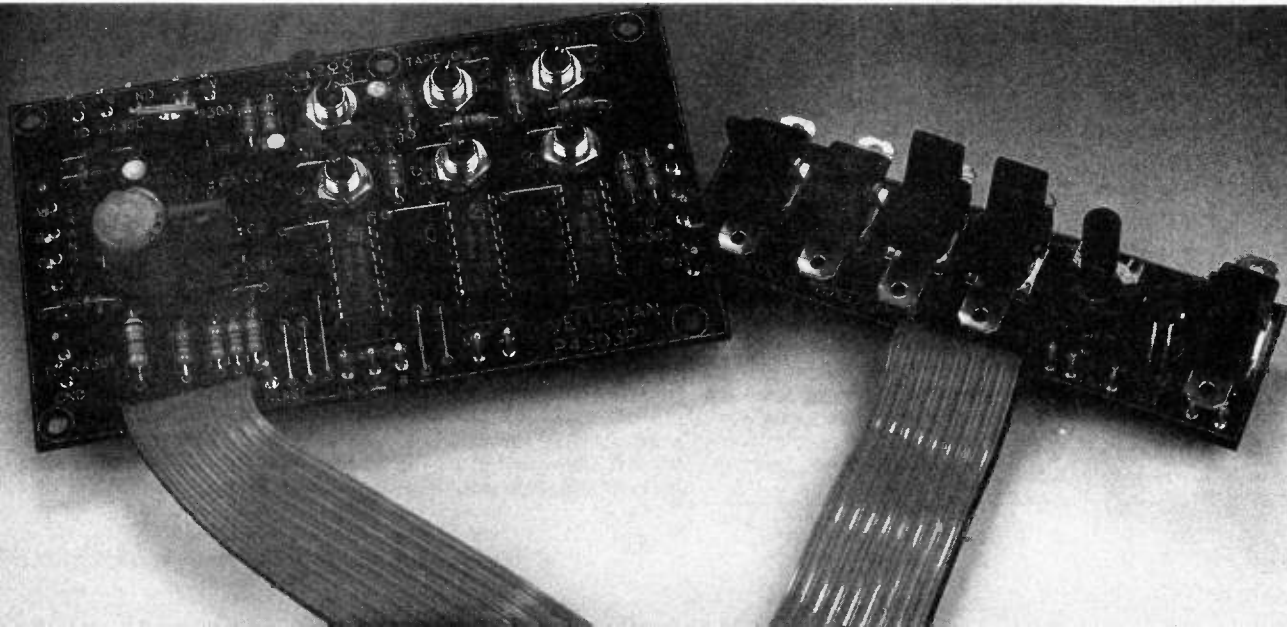
## COMPANY STRUCTURE

As mentioned previously, there are four companies in the Velleman organisation – Velleman Kit, Velleman Components, Velleman Engineering and Velleman Switch. In practice, it is the kit side of the operation with which the average reader is more likely to come into contact. However, there will be indirect associations with the others. For example, *Velleman Switch* produce the tactile switches used on remote control handsets and elsewhere in the range of kits. This avoids possible problems with poorly-made bought-in devices. *Velleman Components*, as their name suggests, distribute basic electronic devices while *Velleman Engineering* are concerned with the design and production of controllers for industrial and agricultural processes.

Velleman Kit are now firmly established in the UK and throughout Europe. There are strong sales in Switzerland, Germany, Austria and throughout Scandinavia, Spain and Portugal. There is also an agent in Israel.

Trading takes place through a single national distributor in three possible ways – by mail order outlets, through shops, or by a mixture of both. How this is done in a particular case will depend largely on the tradition which that country enjoys. In the UK and Germany electronic retailing takes place by mail order and through shops while the Benelux countries – Holland, Belgium and Luxembourg – are exclusively shop oriented. France, Denmark, Italy, Spain, Portugal and Greece also favour shops while Norway and Sweden are equally split.

My host was enthusiastic about possible new opportunities. He was off on a tour of distributors the following day. He was also visiting Hungary to see what could be achieved in that new, exciting market. □



# Techniques

## ACTUALLY DOING IT!

by Robert Penfold

IN THE previous *Actually Doing It* article we looked at some simple home made cases which did not require any metal bending. In this month's article we will consider some simple techniques for producing cases that do involve some metal folding.

If you proceed carefully and accurately it is possible to turn some sheets of aluminium into very professional looking cases. A lot of ready-made cases are, after all, just pieces of aluminium which have been folded and painted. It is not too difficult to produce good quality home made copies of these cases.

On the other hand, it must be admitted that folding sheet metal properly is a bit awkward if you do not have the right equipment for the job. Various metal bending gadgets are available, but with the cheapest ones costing around £80 they are only a worthwhile proposition if you intend to make a lot of folded metal cases.

Most metal folding can be done without one of these devices, but only if you settle for 18s.w.g. or 20s.w.g. aluminium. Bending 16s.w.g. aluminium without the right equipment is very difficult.

Producing neat folds in even thin sheet steel is virtually impossible without the right tools for the job. Fortunately, 18 s.w.g. aluminium is sufficiently rigid for all but the largest of cases. If a large case should turn out to be a bit wobbly, adding a few stiffeners usually cures the problem.

### TIGHT CORNERS

One way of folding metal is to produce a home-made equivalent of a ready-made metal bending machine. This is no doubt possible, but I must admit that my attempts at this have never been very successful. Putting folds in medium size pieces of 18s.w.g. aluminium seems to put tremendous strains on the metal bending device. This makes it difficult to produce a metal folder that will not come apart in your hands on about the third fold. Improvised methods seem to be longer-lived.

Putting folds in sheet aluminium is easy enough, but producing really good right angled corners is another matter. Ideally

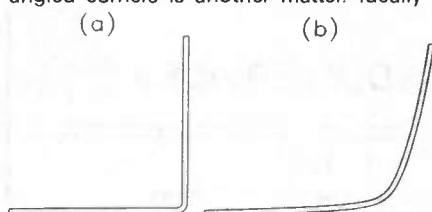


Fig. 1. Folding sheet metal should produce a well defined corner, as in (a). The poorly defined corner of (b) is of no practical use.

the corners should have a minimum of rounding, as in Fig.1(a). A small amount of rounding is inevitable incidentally. However, with 18s.w.g. aluminium it is possible to produce quite tight corners.

If your improvised metal folding equipment and techniques are not up to the task, the result will be something similar to Fig.1(b). The main problem with a fold of this type is that the corners are too rounded. Matters are made worse by the fact that the metal is far from flat for quite a distance on each side of the fold. Even with a lot of filing and trimming, with a poor quality fold of this type it is unlikely that the pieces of a case would ever fit together properly.

### ON THE TABLE

In order to produce good quality folds it is essential that the metal on one side of the fold is clamped between two pieces of wood or particle board. The best arrangement is to use a work bench or table top and a piece of good quality particle board or timber, as shown in Fig.2. There is a likelihood of wear and damage to the table over a period of time, so only use one that is at the "work top" stage of its life.

Ideally there should be four "G-clamps", one at each corner of the board. You can get by with two clamps, one at each end. However, this gives a much greater risk of something shifting slightly when you start to bend the piece of metal. The sheet of aluminium might be ruined if something should slip out of place while it is being worked. The clamps therefore need to be tightened quite firmly.

An alternative to using clamps is to have a helper hold down the piece of board. In fact someone sitting on the piece of board is a very effective way of holding it in place. This may sound like a rather crude way of tackling the problem, but I have found it to be very effective. It is my preferred method of working when dealing with wide folds, where there is a big advantage in having plenty of pressure towards the middle of the workpiece. If you use clamps when folding large sheets it is essential to use fairly large, heavy duty types.

### PRESSURE

It is possible to produce the fold by simply pressing down with your hands on the piece of metal that protrudes from the edge of the table. In most cases though, this will give a fold that is not tight enough. It is better to use another piece of particle board or timber, positioned as shown in Fig.2. This enables plenty of pressure to be applied close to the fold. It also spreads the pressure along the whole length of the fold.

Although in electronics it is almost invariably best to adopt a "softly softly" approach, this is one exception. It is neces-

sary to exert quite a lot of force in order to get a good quality fold.

You may find that a fold of adequate quality is produced without any further work being needed. If a really tight corner is needed though, some further manipulation will be required.

The traditional approach is to use a large wooden mallet to reduce the curvature near the fold, but this is rather more difficult than you might expect. A slight lack of skill can produce tighter corners, but in a rather battered piece of metal!

A safer method is to place a block of wood along the fold, and then apply the mallet to the block. The block helps to spread the pressure from the blows across the width of the fold, and this avoids putting any serious dents into the workpiece. The mallet must be applied quite firmly, very tight and neat folds can be produced using this method.

It is a good idea to try folding some scraps of aluminium before going to work on large and expensive pieces. It is also a good idea to make some small cases first, and then progress to larger ones. In general, the longer the folds, the more difficult it is to produce good results.

It is possible to make folds in quite wide sheets of aluminium using the methods outlined here. Using these methods I have produced some sizeable cases for short wave receivers, oscilloscopes, etc. Sometimes folds over 500 millimetres long were required, and these were produced successfully. Folds this long are actually beyond the capacity of some metal bending machines.

### CASE DESIGNS

There are several styles of case that can be produced from pieces of folded aluminium. A case formed from two "U-shaped" sections, as in the sketch of Fig.3, is simple to make but should give an excellent end result. Four large folds are needed, plus two smaller ones for the flanges to which the top section is bolted.

The two smaller folds are easily made incidentally. Simply fix a flange into the jaws of a small vice and bend them round. With small folds of this type there should be no difficulty in producing tight corners, and no need for any work with a mallet.

The lid is fixed to the bottom section using two self-tapping screws, or four self-tapping screws for a large case. It is best to drill the mounting holes in the lid section first. This can then be used as a template to accurately locate the positions of the holes in the flanges on the base section. This should avoid any problems with the two sets of holes not matching up properly.

Some case designs require top, bottom, and two side panels to be folded back from the front panel (like inexpensive ready-made folded aluminium boxes). This is a bit awkward to achieve, and with the ready-made equivalent costing so little would seem to be barely worth the effort. However, it can be achieved using simple equipment.

First fold back the top and base panels in the normal way. Then clamp one of the side panels between two pieces of particle board. The two boards should be the same width as the side panel, and should completely cover it on both sides. The side panel is then bent back into place. The original two folds should prevent any major curvature of the front panel, and the boards will keep the side panel flat. Then repeat this procedure for the other side panel.



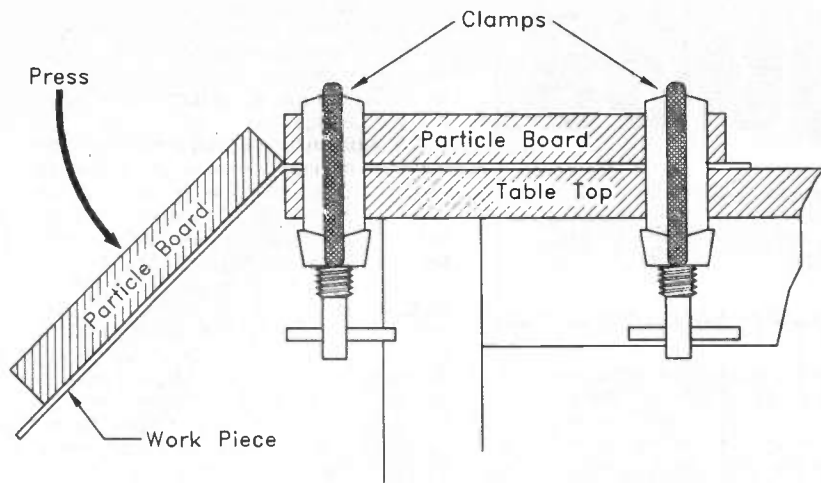


Fig. 2. An improvised metal bending setup that can give excellent results.

### FINISHING OFF

Aluminium cases look at their best if at least the outer casing is painted. As I have pointed out on previous occasions, simply applying a couple of coats of paint to a raw metal panel is unlikely to give long-lasting results. In fact it usually gives a finish that can be rubbed off with your fingers, particularly at the edges.

Some modern paints will adhere quite well to metals, but only if the surfaces to

be painted are scrupulously clean. Clean the panels just before they are about to be painted, not a day or two earlier (which would give the surface time to oxidize). Some paints will only stick to aluminium properly if a coat of metal primer is added first. Make sure that the primer is suitable for use with aluminium, as some are not recommended for use with non-ferrous metals. It is really a matter of finding

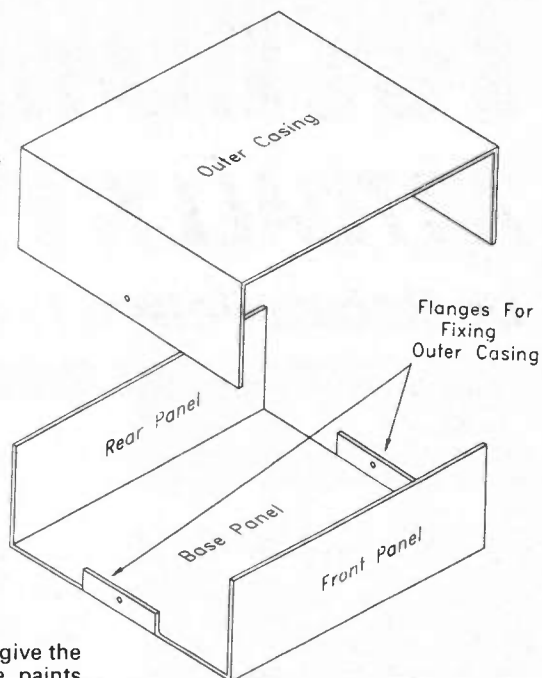


Fig. 3. A simple folded metal case design. a tough enamel paint of the required colour, and then following the manufacturer's instructions "to the letter."

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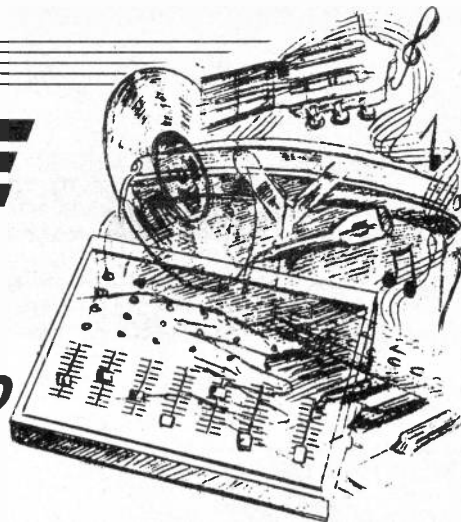
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## Part 2 - SIX-CHANNEL (12 MONO) STEREO MIXER - ASSEMBLY & TESTING



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**L**AST month we described the various circuits that make up the Six-Channel (12 mono) Stereo Mixer and progressed as far as the construction of the large printed circuit board (p.c.b.). This month we complete the wiring, assembly and testing. We also present small individual boards for the Microphone Pre-Amp and RIAA (Phono) Pre-Amp.

### CONNECTORS

The interwiring details from the p.c.b. to the input and output sockets is shown in Fig. 11. Mono 1/4in. jacks are suggested for the microphone inputs, and phono connectors for all the other inputs and the output sockets.

A single bare wire may be used to link all the ground connections of the input sockets to 0V on the power connector. This saves using a ground lead for each of the 24 input/output connections. Where screened cables are used between the sockets and the p.c.b., the screen wire may be joined to ground at the socket end of the lead and cut off at the p.c.b. end.

### CHANNEL HUM

When the selector switch of a microphone channel is set to "Mic", and either microphone input is left open (unconnected), hum is likely to be present when the slider control is raised. This is not a problem if *both* left and right sides of each microphone channel are used, or if one is used and the input switch is set to "mono".

However, if it is ever necessary to leave a single microphone input open circuit and active, an extra mono jack plug should be inserted in the spare active socket, with the signal and screen connections of the plug joined by a wire link. If this is a frequent requirement a switch could be added to short-circuit the spare active input to ground (0V) when it is not required.

### REMAINING CONNECTORS

The wiring diagram Fig. 11 also shows the power sockets, headphone socket,

Volume control VR8 and master supply On/Off switch S19 in detail. Again the 0V lead is connected to all the 0V or negative tags as shown.

A second "power output" socket is suggested so that other modules - the tone control in particular can be powered without using additional power units. The p.c.b. headphone output may be connected directly to the headphone socket, or connected as shown in Fig. 11 via VR8 which is a one kilohm "log" stereo potentiometer.

### TESTING

If testing is performed before the input sockets are installed, be sure to make a temporary connection to link the input signal "ground" to 0V in the circuit.

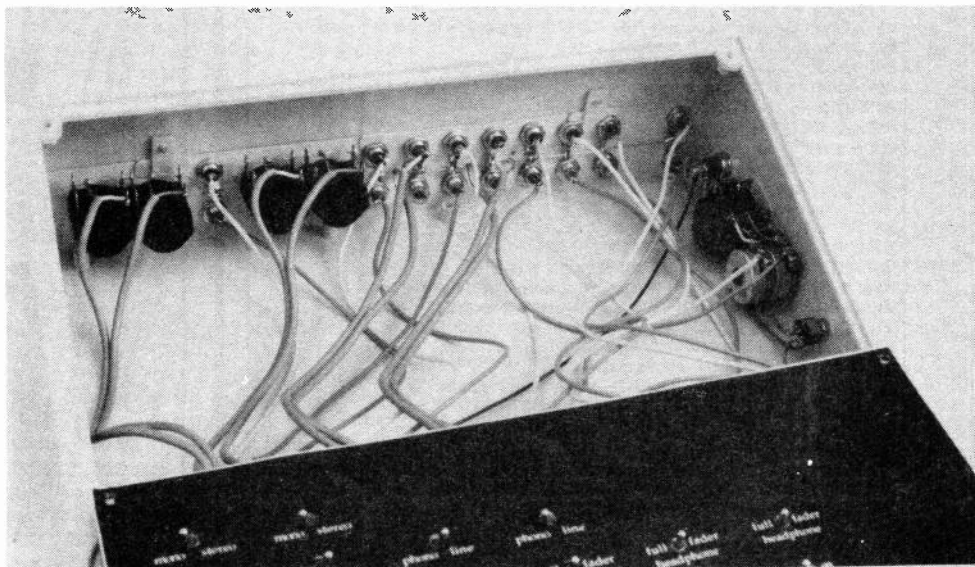
Testing audio circuits is very easy if a signal generator and oscilloscope are available, but if this is not the case use an audio source such as a cassette recorder (the headphone or line output will do), and

a pair of headphones as a monitor - or better still, the amplifier which will eventually be connected to the main mixer output.

Connect the project to a 12V supply, click all the toggle switches to their right hand sides, move the sliders to their upper positions and test Channel 6 (i.e. Aux 2). Test the other channels, moving the selector switches to "Aux." Assuming all is well, try a microphone and/or record deck in the appropriate channels.

If the circuit fails to work, touch your finger against an input socket centre "live" pin whilst listening to the output with the headphone. You should hear some "mains hum". Simply touching parts of the circuit in this way can identify the source of trouble; for example, touching either side of capacitors C1 to C12 should produce an output "hum" in the appropriate channel.

If the problems persist, check the voltages on the i.c. pins using a good quality



*Wiring to the rear mounted input and output sockets and headphone and power components (right)*



Layout and labelling of the rear input and output sockets.

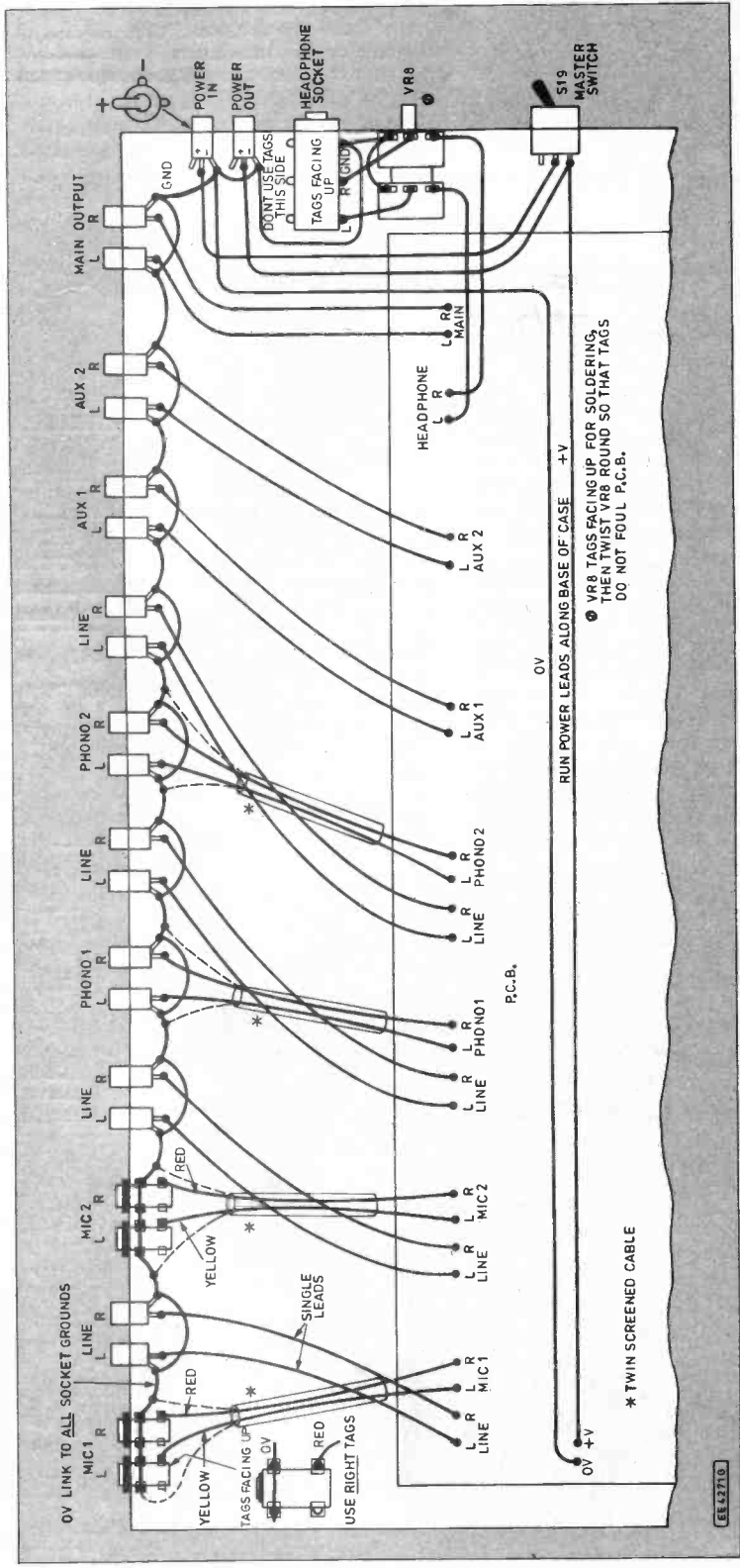
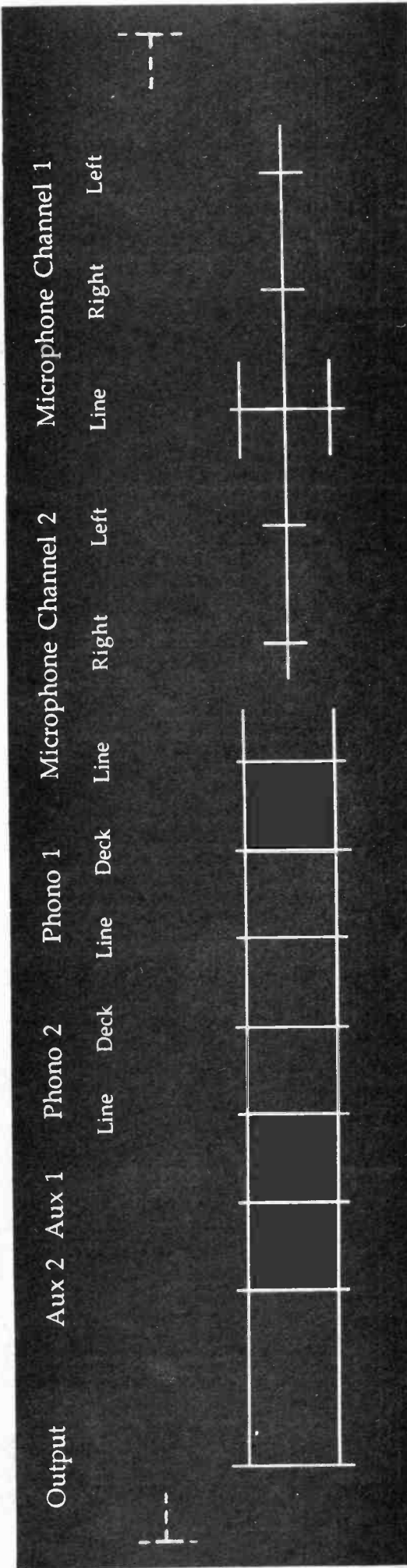
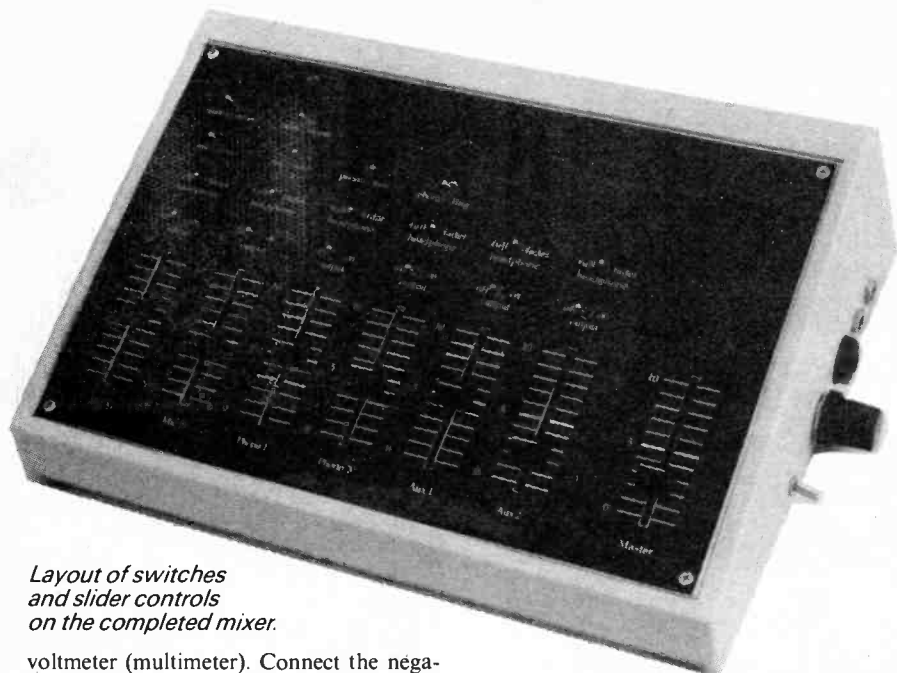


Fig. 11. Interwiring from the large, combined, mixer printed circuit board to the input and output sockets, power supply sockets and headphone components. The screen braid of the twin screened input cables should be connected to the 0V common or "bus" line at the input socket end and trimmed off at the board end.

Fig. 12. Full size drilling template for the rear input/output sockets. The template can be separated at the dotted lines to form an identification label for sticking on the rear of the case, see photograph.





*Layout of switches and slider controls on the completed mixer.*

voltmeter (multimeter). Connect the negative lead of the voltmeter to negative (called 0V) in the circuit, and use the positive lead of the voltmeter as a probe.

Touching the probe on pin 8 of any of the i.c.s should result in a reading of about 12V. Pin 4 should produce a reading of 0V. Pins 1, 2, 3, 5, 6 and 7 should produce a reading of about 6V. Failure in any of these readings indicates a fault in the connections or resistors (e.g. a wrong value or dry joint) in that area of the circuit.

If problems persist check again that the input signal ground is connected to 0V in the circuit, and that if any sliders are omitted the pads labelled "G" are not isolated from 0V.

### **CASE DETAILS**

The size of the p.c.b. is designed for the case listed. Begin the preparation of the case by drilling holes for all the connecting sockets at the rear of the case, taking some care with spacing. A drilling template is given in Fig. 12.

The sockets should not be too high or they may foul the p.c.b., and they should

not be so low that external connecting leads lift the rear of the case. It is common practice to use red phono sockets for the right hand channel (and black for left), and to mount the red sockets *below* the left.

The power supply socket and main on/off switch are mounted at the side. An additional power socket may be fitted to power other modules, such as the tone control project. The headphone output socket should also be mounted at the side along with the headphone volume control VR8 if required.

A template is provided for the front panel (Fig. 13) to ensure that the switches and pots align perfectly. If a photocopier is used, double check that the photocopier has produced an identical image. (Many photocopiers have a habit of stretching or reducing the image – which is very unhelpful!)

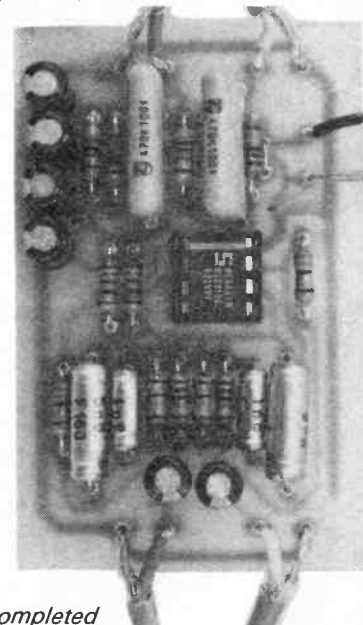
The first copy of the template could be used as a drilling guide, and a second copy could be coated with self-adhesive book covering plastic, and used as the front

panel. If any of the switches are omitted, mask out the appropriate lettering with Tippex and make a photocopy using a low density setting.

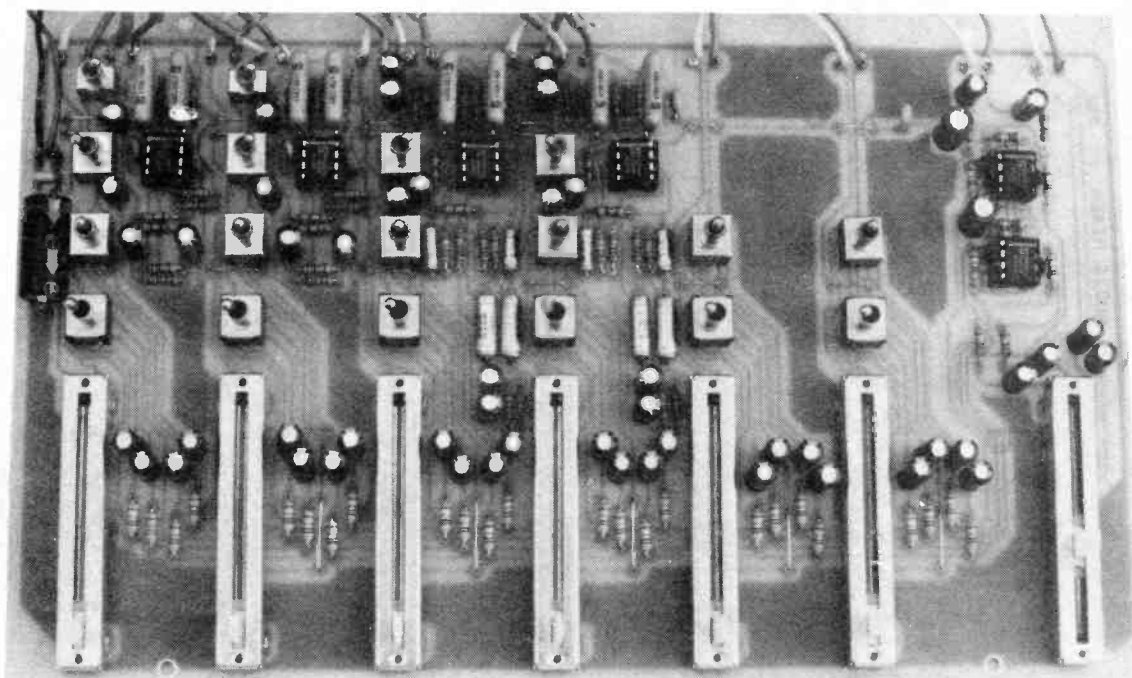
The aluminium front panel should be drilled and filed according to the template. The holes for the switches are designed to allow the front panel to rest at the point where the lever or dolly enters the switch.

The more awkward channels for the slider should be drilled then filed. Extreme accuracy is not required since the second photocopied front panel will cover all the irregularities. The switch openings in this photocopy may be cut using a cork borer, and the channels cut using a craft knife.

The printed circuit board may be fastened to the front panel by means of M3 nuts, bolts and spacers. The switch dollies should project through the front panel, as should the slider control tangs onto which knobs may be fitted. Two of the bolts should make contact with 0V on the p.c.b. to ensure that the aluminium front panel is tied to 0V. This will help screen the circuit against interference.



*Completed RIAA Pre-Amp board.*



*Layout of components on the large printed circuit board. This board is bolted behind the aluminium front panel.*



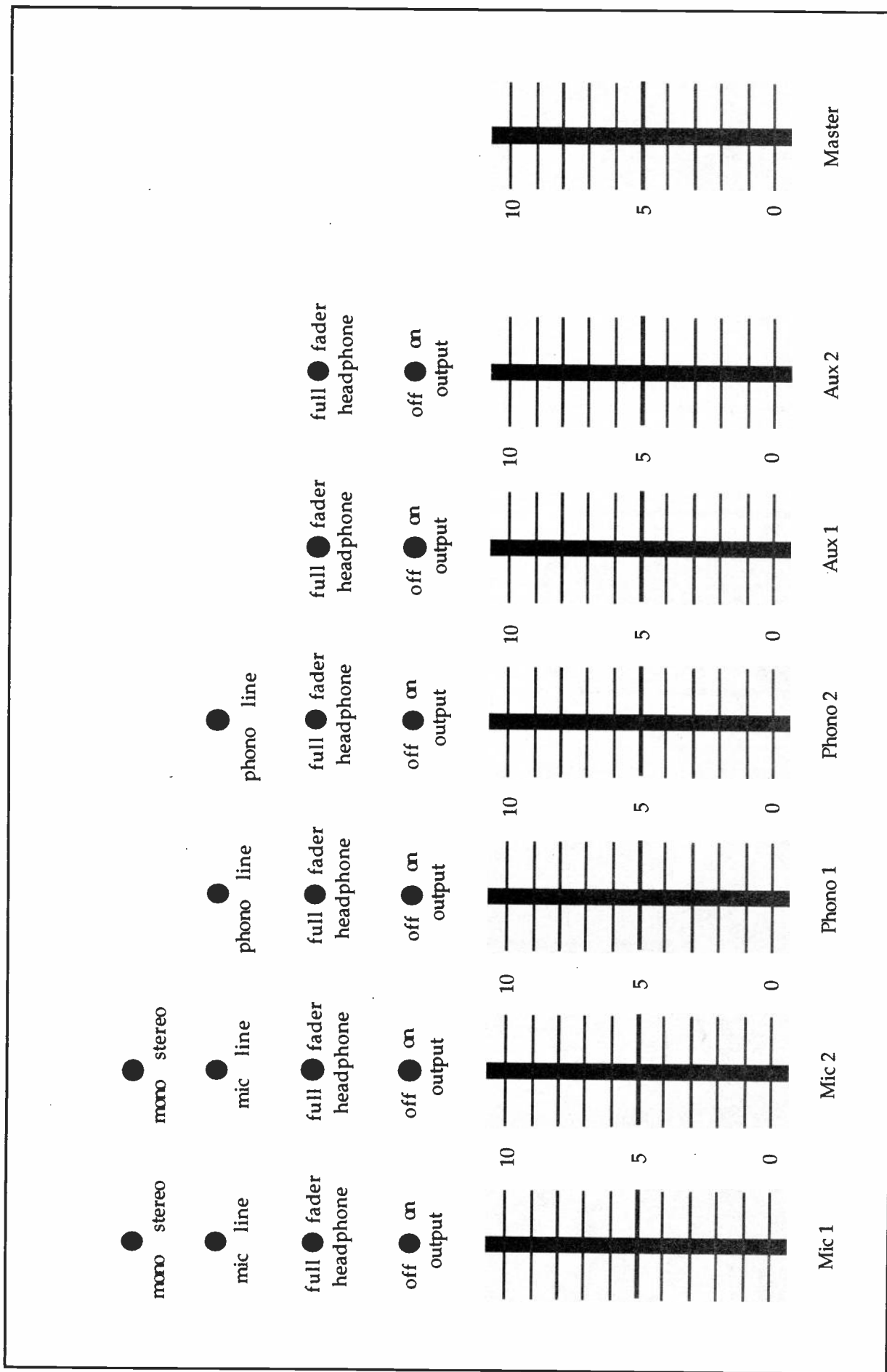


Fig 13. Full size front panel drilling template, with control legends. A copy of this could be made and glued over the drilled panel.

## STEREO MICROPHONE PRE-AMP

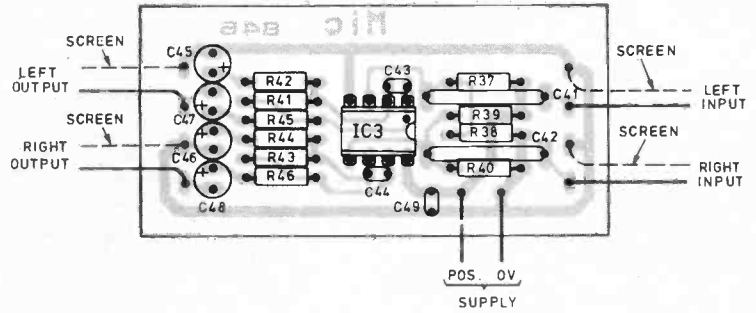
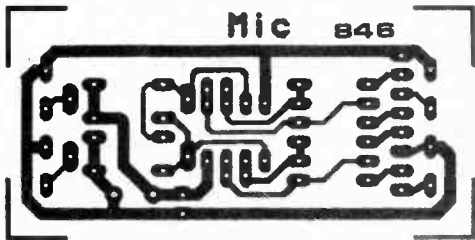


Fig. 14. Component layout and full size copper foil master for the separate Stereo Microphone Pre-Amp. This board is available from the EPE PCB Service, code 846.

## STEREO RIAA PRE-AMP

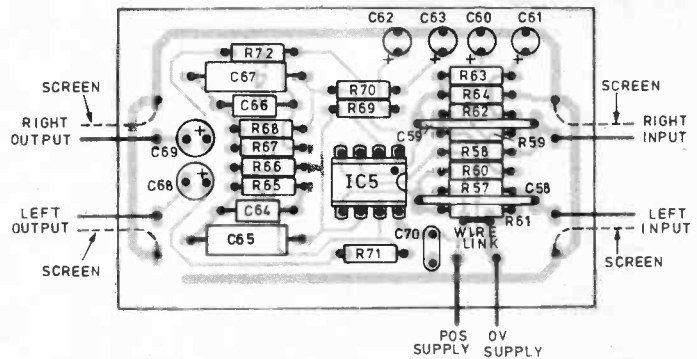
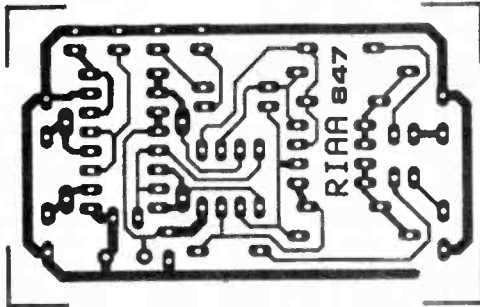
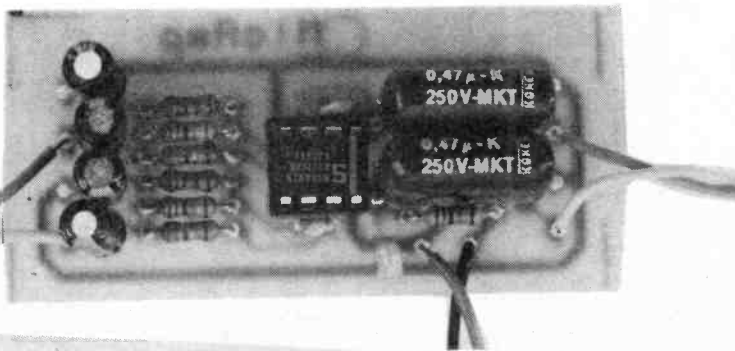


Fig. 15. Full size p.c.b. copper foil master pattern and layout of components for the Stereo RIAA (Phono) Pre-Amp board. The board is also available from the EPE PCB Service, code 847.

Components mounted on the individual Mic. Pre-Amp board



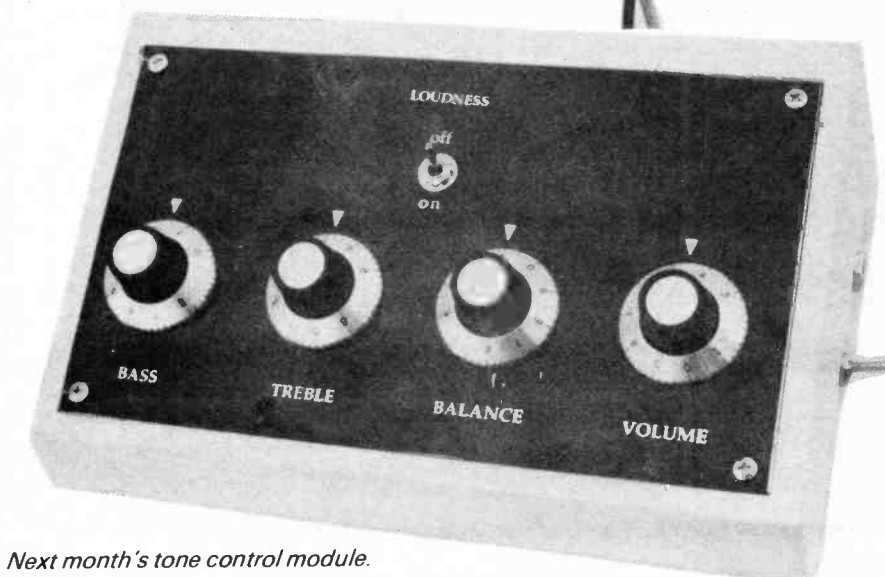
## SEPARATE MIC. AND RIAA PRE-AMP BOARDS

The separate p.c.b.s for additional microphone and RIAA record (phono) inputs are shown in Fig. 14 and Fig. 15, and house all the components shown in the circuit diagrams Fig. 8 and Fig. 9. Note however that the selector switches are not included and the boards are quite compact as a result. Follow the directions already given when constructing the large p.c.b. (last month), noting that the smallest components should be fitted before the larger capacitors etc.

Decoupling is provided by 0.1µF capacitors. It is assumed that power is provided from a supply already decoupled by a larger capacitor, such as C19 on the main p.c.b. If this is not the case a capacitor of say 100µF should be connected across the supply rails at a convenient point.

The input connecting leads should be screened types to prevent interference, particularly mains hum. The output leads may also be screened, although this is less important particularly if they are not unduly long.

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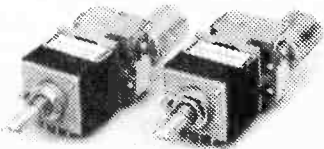
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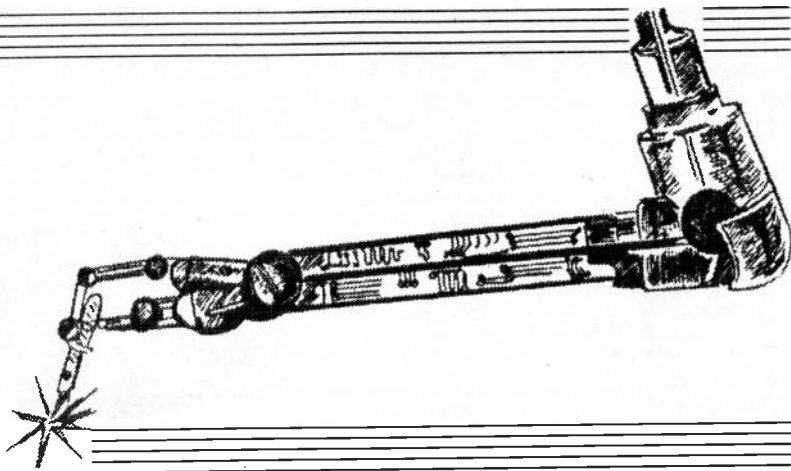
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# CIRCUIT SURGERY

MIKE TOOLEY B.A.



Welcome once again to Circuit Surgery, our regular clinic devoted to readers' problems. This month we describe a Simple Room Alarm. We also describe the dangers of electrostatic discharge (ESD) and how to avoid this destructive hazard. We begin with a question about noise . . .

## Figuring out noise

Regular reader *Dave Stone* has asked me to explain the significance of "noise figure" in the design of transistor amplifiers. Dave writes:

*"I've heard that a low noise figure is important in high quality audio systems. Can you explain why it's important and why it depends on how an input stage is matched."*

Noise figure seems to be one of the closely kept secrets of the audio world and I doubt whether you are alone, Dave, in wondering what all the fuss is about. Actually, noise figure is probably one of the most important considerations in the design of low-level amplifier circuits (by "low-level" I mean circuits that work with signal levels of less than a few millivolts).

The input circuit of an amplifier inherently contains some thermal noise contributed by the resistive elements in the input device. All resistors generate a small amount of random noise power as a result of thermal activity. This power is about 160dB below one watt in a nominal 10kHz bandwidth.

Unfortunately, when an input signal is amplified the thermal noise present in the input circuit is also amplified (the noise in later stages tends to be correspondingly less significant). If the ratio of signal power to noise power (S/N) is the same in the output circuit as in the input circuit, the amplifier is "perfect" as far as noise is considered and the amplifier would be said to have a noise figure of unity (0dB).

In practical circuits, however, the ratio of signal power to noise power is inevitably impaired during amplification as a result of the generation of additional noise in the circuit elements (transistors, resistors, etc). A measure of this degree of impairment is called the noise figure of the amplifier.

Noise figure is expressed as the ratio of signal power to noise power at the output ( $P_{so}/P_{no}$ ) divided by the ratio of signal power to noise power at the input ( $P_{si}/P_{ni}$ ), i.e.

$$\text{Noise figure} = (P_{so}/P_{no}) / (P_{si}/P_{ni})$$

Expressed in decibels (dB) the noise figure is equal to ten times the logarithm of the power ratio. For example, an amplifier with a 1dB noise figure decreases the signal-to-noise ratio by a factor of 1.26, a 3dB noise figure by a factor of 2, a 10dB noise figure by

a factor of 10, and a 20dB noise figure by a factor of 100.

In high-quality audio amplifiers, it is desirable that the noise figure be kept very low (less than a dB, or so). With transistor amplifiers, a minimum value of noise figure is obtained when the emitter (e) current is less than about 1mA and the collector (c) voltage is less than two volts with a signal source resistance of between 300ohms and 3kilohms.

If the input impedance of the transistor is actually matched to the impedance of the signal source, the lowest value of noise figure that can be attained is 3dB. Generally, the best noise figure is obtained using a transistor input impedance approximately 1.5 times the source impedance.

However, this condition is difficult to realise in practice because most input transducers are *reactive* rather than resistive. In addition, other requirements such as circuit gain and signal-handling capability (dynamic range) also have to be taken into account, but that's another story . . .

## Simple Room Alarm

Regular readers may recall *Anton Sutton's* request for a Simple Room Alarm System based on the CD4001. Apparently, Anton needs to protect his room from the unwanted attentions of his sister and your

scribe has spent some time researching the problem.

The difficulty, as always, with simple alarm systems is how to sense the presence of an unwanted intruder. Commercial intruder alarms may use infra-red, ultrasonic or microwave sensors - all of which can be prohibitively expensive if you happen to be on a fairly restricted budget. The least expensive types of sensor is the humble light dependent resistor (LDR) and, with only simple circuitry, these devices can be used to make quite an effective alarm.

My first attempt at solving Anton's problem is shown in Fig. 1. This circuit used three of the four available two-input NOR gates in a single 4001B device. IC1c and IC1d act as a gated oscillator (the frequency of which is governed by capacitor C1 and resistor R2).

A *pnp* transistor, TR1, drives a d.c. operated piezoelectric warning device, WD1. Since WD1 requires only about 10mA, almost any small signal *pnp* transistor can be used for TR1. Alternatively, if the piezoelectric device is replaced with a relay (for driving a bell or klaxon) then TR1 should be suitably rated for the relay operating current.

The light threshold of the circuit is made adjustable by means of potentiometer VR1 (this helps to compensate for different levels

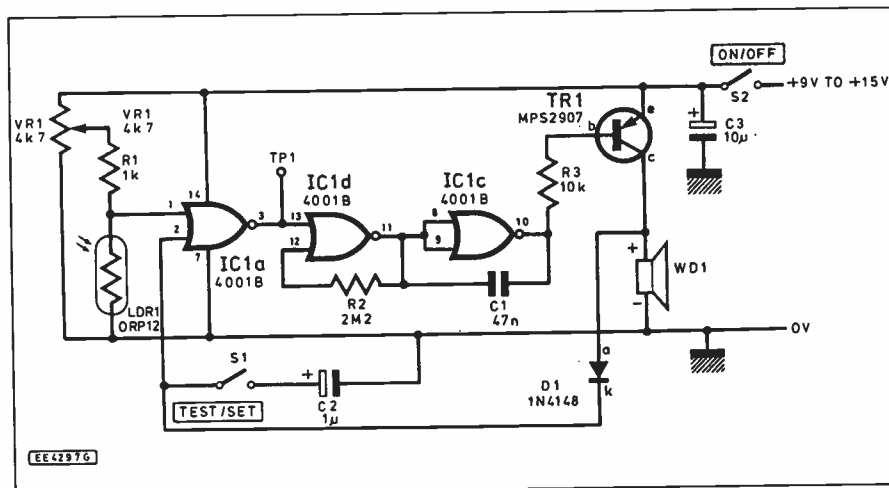


Fig. 1. Basic light-operated room alarm circuit.



of room lighting) whilst switch S1 allows the unit to be tested without latching into the "on" state and sounding the alarm continuously. If the unit is mounted permanently (e.g. on a wall) then S2 could be a key-operated switch.

The light sensor, LDR1, should be placed in a position in which the light level will fall whenever a person (or a sister) enters or crosses the room. Once triggered by a fall in light level at the LDR, the alarm will continue to sound until switch S2 is switched to the "off" position (the unit is "re-armed" simply by switching "on" again).

The simple circuit of Fig. 1 has a few disadvantages. Firstly, it will be triggered whenever the ambient light level in the room falls significantly (even when there isn't an intruder).

This may not be problem when the area to be protected is permanently illuminated by artificial light. However, if the room is mainly illuminated by sunlight, there will undoubtedly be quite large changes in the level of ambient light. Secondly, the unit could usefully be a little more sensitive so that it will respond to even the smallest change in light level.

The circuit diagram shown in Fig. 2 overcomes the second of these problems. This circuit uses an operational amplifier, IC2, connected as a comparator in order to sense very small changes in light level. The unused gate, IC1a, is also pressed into service for no other reason than I felt that I ought to put it to some use!

The modified alarm circuit works well and readily senses a person moving about in a small room, however the circuit requires a fairly constant level of ambient light. Furthermore, if the light level increases (e.g., when the sun comes out) the circuit becomes less sensitive to movement.

### Ultimate solution

The circuit of Fig. 3 cures all of these problems. This circuit uses a second sensor (LDR2) to sense the ambient light level. This circuit remains "in balance" maintaining a virtually constant sensitivity for quite wide variations in light level.

The circuit also uses an extra NOR gate (stolen from another 4001B, IC3) to detect both rising and falling changes in light level. This arrangement ensures that the alarm cannot be "beaten" by shining a light into the sensor!

Finally, it is worth experimenting with the location of the two sensors, LDR1 and LDR2. These should be placed reasonably close together but with LDR2

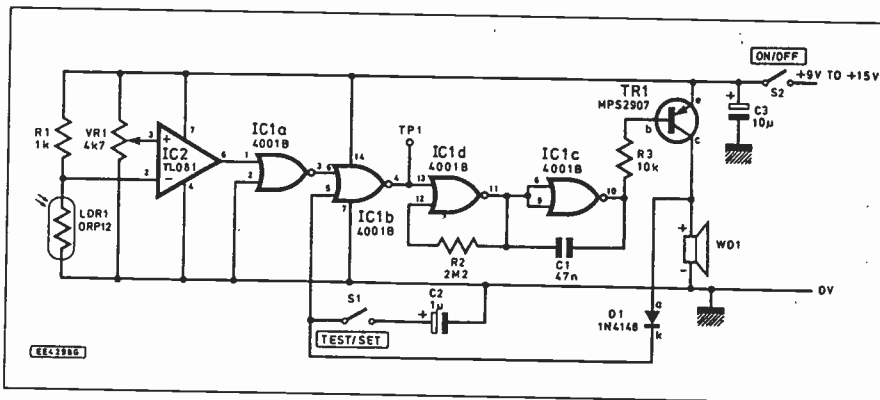


Fig. 2 Room alarm with increased sensitivity to falling light level.

looking towards the centre of the room and LDR1 towards a doorway or other point of entry.

### ESD – and how to avoid it!

Alan Liscombe writes from Devon with an interesting point:

"I have often seen packaging which indicates that components (mainly semiconductors) are prone to electrostatic discharge. Can you explain what this is and how I can avoid it? Also, is it really a serious problem as I don't seem to have damaged any components this way yet!"

Well, Alan, it really is a serious problem! Electrostatic damage (ESD, for short) can potentially damage a wide range of components, not just MOS (metal-oxide semiconductor) devices. Nowadays nearly all manufacturers provide warnings when their semiconductor devices are prone to this sort of damage and usually these are clearly printed on the packaging.

The most vulnerable types of device are MOS transistors and integrated circuits. This is because such devices exhibit inherently high impedances which do not allow any static charges which may be present to safely drain away.

Also prone to damage are microwave transistors (due to the very small junction separation and low breakdown voltages), laser diodes, and CMOS integrated circuits generally. Even metal film resistors, Schottky input devices (e.g., the popular 74LS TTL series) and many types of small signal diode can fail due to the presence of stray electrostatic charges.

Electrostatic charges can be produced by many, seemingly innocent, sources, such as polythene bags, plastic combs, nylon over-

## COMPONENTS

### Simple Room Alarm (Fig. 3)

#### Resistors

R1	1k
R2	2M2
R3	10k
R4	2k2
LDR1, LDR2	ORP12 light dependent resistor (2 off)

All 0.25W 5% carbon film, except LDR's

#### Potentiometer

VR1	2k2 carbon preset, linear
-----	---------------------------

#### Capacitors

C1	47n low-voltage ceramic
C2	1µ axial elect. 63V
C3	10µ axial elect. 35V

#### Semiconductors

D1	1N4148 signal diode
TR1	MPS2907 (or any small-signal pnp transistor)
IC1, IC3	4001B quad 2-input NOR gate (2 off)
IC2	TL081 or TL071 low noise op.amp

#### Miscellaneous

S1	S.P.S.T. p.c.b. mounting toggle switch
S2	S.P.S.T. key-operated switch
WD1	d.c. operated piezoelectric sounder

Matrix board (approx. 60mm x 80mm); 8-pin low-profile d.i.l. socket; 14-pin low-profile d.i.l. sockets (2 off); battery holder (for 9V battery); solder pins (11 off); connecting wire; solder, etc.

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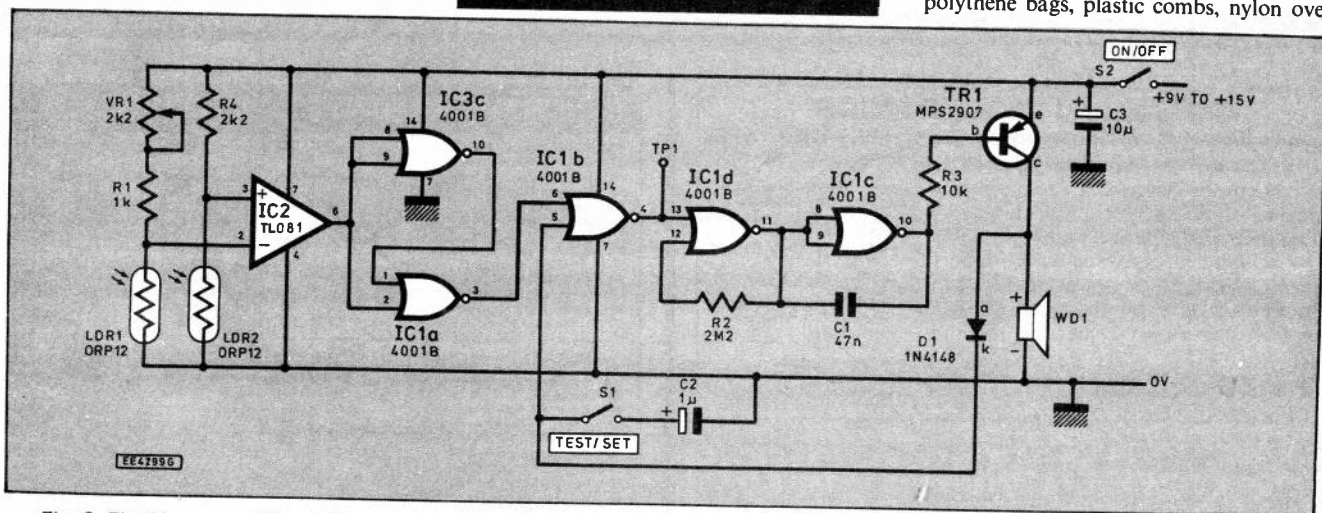


Fig. 3. Final improved Simple Room Alarm circuit using a second light dependent resistor (LDR2) and extra NOR gate (IC3).

## Variable mark:space ratio?

Dr R. G. Ticehurst writes from North Yorkshire to ask for some information concerning the Simple Pulse Generator in August's *Circuit Surgery*. Dr Ticehurst writes:

"I have read, with interest, *Circuit Surgery from the August issue of EPE and wish to comment on the Simple Pulse Generator. I have constructed the circuit on a breadboard and I changed the 10nF capacitor (C1) to a 10µF capacitor which slowed the frequency down so that I could appreciate the high and low intervals of the mark:space ratio.*

*So far so good, but for what purpose can anybody want a pulse generator with variable mark:space ratio? I have been studying electronics for about 10 years and I cannot think of any uses for the circuit apart from connection to a stepper motor."*

Thanks for this one! You will find that most pulse generators allow you to adjust the pulse width (or pulse duration) and pulse repetition frequency.

Our Simple Pulse Generator works slightly differently as it allows you to vary the mark (high) and space (low) times separately. The overall result is, however, exactly the same (you just need to remember that the time for one complete cycle is the sum of the mark and space times).

There are, in fact, very many applications for a pulse generator in which the high and low times are adjustable. To give you some idea, here are just three of them:

1. Testing logic circuits where logic signals must pass through a number of logic gates and where there may be different propagation delays depending upon the actual path taken.

Complex logic arrangements will often fail to respond to pulses of less than a certain duration or where logic level changes arrive by different paths. Such circuits can be tested with various pulse trains (including increasingly narrow pulses and longer repetition times) to check that unwanted states ("race hazards") don't occur.

2. Testing components (and circuits) under pulsed conditions where continuous operation could greatly exceed manufacturers' ratings.

A good example of this is the laser diode. At normal forward currents such devices behave like conventional light emitting diodes. However, to produce laser light, the device must be repeatedly pulsed with an appreciable forward current but flowing for only a very short duration (to avoid destroying the device).

A typical laser diode operates with forward currents of about 1A but only in 50ns pulses. The output power (and device dissipation) is dependant upon the mark:space ratio and this must be adjusted for optimum performance without the risk of destroying the device. To operate or test one of these devices you would almost certainly have to adjust the mark:space ratio for optimum results.

3. Simulating interference and impulse noise generated by engine ignition systems. Electrical noise generated by ignition circuits can be greatly reduced by means of circuits which detect interference pulses and prevent them from being further amplified within the circuits of radio receivers. The nature of such interference tends to vary with engine speed and type and a pulse generator with variable mark:space ratio can be used to simulate the noise produced by such sources.

alls, floor mats, and plastic enclosures (including those which you actually use to store your components!). Even the action of walking across a carpet wearing rubber soled shoes can generate static voltages on your body of well in excess of 1kV. If, having walked across the room, your next action is to reach for that latest CMOS i.c., you may well find that you destroy it as soon as you make contact with it!

Most of us have learned to live with ESD the hard way. So, if you wish to avoid potential agony and heartache, here are a few simple precautions:

1. Store components that are susceptible to ESD in their original packaging, using electrically conductive containers or conductive plastic foam.
2. Avoid contact with the pin connections of a device whenever it is "out of circuit".

3. Regularly discharge your body before handling components or circuits. You can very easily do this by simply touching a grounded point (such as the metal case of an oscilloscope or power supply) with first one hand and then the other.
4. Ensure that you have a "grounded area" in which to work. A rubber "earth mat" makes an ideal area in which to keep your devices and circuits while you work on them.
5. Avoid the use of all static producing materials. In particular it is worth keeping polythene bags and other plastic materials well away from your work area.
6. Make use of a low-voltage soldering iron and ensure that the metal parts of the iron are properly "earthed". It is also worth checking that all of your other mains operated equipment is properly grounded.
7. If, like me, you have a computer in your workshop it is important to keep the display well away from static sensitive circuitry. Very high static voltages (usually well in excess of 10kV) are present in the vicinity of a cathode ray tube.
8. Finally, if you regularly handle static sensitive devices, you might even consider using an earthed wrist strap!

## Next month

Regrettably due to lack of time, this is my last *Circuit Surgery*. From next month, the column will be in the capable hands of Alan Winstanley (another regular contributor to *EPE*). Putting the *Surgery* together over the last eighteen months has been great fun and has certainly given me a great deal to think about.

Unfortunately, I have consistently received many more queries than space has allowed me to cover. Often questions have been very detailed or may have required answers that just could not fit on one or two pages. I do apologise if your particular query has not been answered however I will be passing the "Surgery File" on to Alan so that his "in tray" gets off to a flying start!

In the meantime, if you have any comments or suggestions for inclusion in *Circuit Surgery*, please drop Alan a line care of: Everyday with Practical Electronics, 6 Church Street, Wimborne, Dorset BH21 1JH.

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# FOX

# REPORT

by Barry Fox



## ON CHARGE

"Yes, new battery charger really does work", pronounced the London *Evening Standard* newspaper in August.

Well shiver my timbers. Someone has discovered, once again, that throwaway dry cell batteries can perfectly well be recharged, provided you use the right kind of charger. And once again the battery manufacturers have helped generate publicity for dry cell charging by ignorantly maintaining that "it won't work", and is "potentially dangerous".

The simple truth is that chargers designed for use with NiCads or Lead Acid cells will not work with dry cells. These chargers push straight d.c. back through the cell. Whereas the chemicals inside a NiCad or Lead Acid will reform in orderly fashion, the chemicals inside a Zinc Chloride or Alkaline cell will reform as a disorderly, bulky mess that may well burst the cell wall, to cause leakage or explosion.

For dry cell charging, the trick is to push a mix of a.c. and d.c. back through the cell. When low voltage a.c. is superimposed on the d.c. it stops the metal in the cells from reforming as dendrites which grow too large and flake off. This trick works for a dozen or so recharge cycles, provided that the battery was not too flat to begin with.

Back in autumn 1991, *Everyday Electronics* caused quite a stir with a constructional project. Alan Tong described how to build a dry cell charger from components costing about £8.50. The *Mail on Sunday* newspaper picked up on the story, and told how a "schoolboy project is causing fury in Britain's £250M battery industry". The *Independent* ran a report in rather more measured tones.

I followed through with a piece in *EE* reminding that the idea was not just old theory, but had in 1981 been developed into a product by British company Fidelity Radio. Their Battery Saver was a portable mains/battery radio which incorporated a dry battery charger. When plugged into the mains the charger fed a mixture of a.c. and d.c. power back into the batteries.

Fidelity fed the mixed a.c./d.c. charge as a variable trickle, over a long period of time, the charge current automatically falling from a high of around 24 milliamps to zero, as the 9 volt battery returned to a nominal voltage of 8.7 volts.

Several readers wrote to me reminding of previous gadgets that had gone on sale, long before Fidelity's. All have one thing in common. They sank without trace.

They worked but most were too much trouble to use. People have to remember to start charging before the cells are too flat, and then keep a track on which cells are still good for charging. Fidelity's automatic system was the neatest solution, but Fidelity ran into financial trouble and the name was bought by Amstrad.

Then, as briefly mentioned in my recent report from the *Consumer Electronic Show* in Chicago, an exhibitor called Innovations was offering another dry cell charger, the

Battery Manager, for sale in the USA. Now Innovations has launched the Battery Manager in the UK.

The Innovations charger is claimed as a "breakthrough" which "at last" "can extend the life of ordinary batteries by up to ten times". Models cost 30 or 40 pounds. Predictably the popular press, with their usual short memories have got very excited about this "revolutionary" new idea.

The figure now put on battery sales has risen to a £1 million a day, and of course the new product can conveniently be dubbed green or environmentally friendly because it lets people avoid throwing away batteries if they are prepared to take the trouble to recharge them, and remember to put batteries on charge before they are too flat.

Innovations does acknowledge, in the middle of its press release, that the "principle of recharging ordinary batteries has been known for many years" but "recent advances in electronic technology, along with many years of research" now provide the control that makes the charger safe and reliable.

## HOW IT WORKS

So how does the new charger differ from all those old ones?

"An intelligent monitoring system controls the charging cycle of each battery and automatically switches off should the battery be unsuitable for re-charging ... this system has undergone rigorous performance and safety testing by two independent testing laboratories".

Innovations will, if asked, identify the laboratories, and promises to make reports available to anyone who asks for them. I found Innovations rather less keen to supply the reports when I asked for them, but I did get them.

The reports show that in March 1993 Rowland Laboratories ran preliminary tests on an experimental circuit board provided by Innovations to see if there were any safety hazards and check whether Innovations was right in saying that alkaline dry cells could be charged up to ten times and retain at least 30 per cent of their as "new" capacity.

The experimental circuit worked well with Philips AA size alkaline cells, but there were problems with Ever Ready Gold Seal cells so the test was aborted.

In July 1993, Essex Electronic Consultants of Chingford, finished testing a production model Battery Manager. This included a modification; whereas the early prototype charged the cell with a 50 per cent duty cycle, the later unit puts a load across the cell which slightly discharges it when the charging current is off.

For safety, the charger does not try to pass current through any cell with a voltage of less than 1 volt, and it switches off when the voltage reaches 1.45 volts.

Essex found the unit safe and that it successfully recharged Duracell, Boots and Ever Ready batteries.

So what makes the Battery Manager different?

Andy White, Innovations' Product Development Manager is cagey. He clearly gauges his answers to what he thinks the enquirer already knows, saying more when challenged on novelty.

Is the charging current a mix of d.c. and a.c.? No. So what is it? It is a high frequency a.c. voltage, with d.c. offset; a shaped, and controlled, waveform, of frequency between 200 and 400kHz, and variable mark/space ratio. But isn't that just another variation on the old theme of mixed a.c. and d.c.?

"No", says White, becoming a little more frank, "It's slightly different". How long has White been working on the idea? Around two years. If the charger is successful, Innovations can be sure to expect competition.

Innovations has filed a patent application for protection, but this is a two-edged sword. Details of inventions are laid bare for anyone to read, when patent applications are published, 18 months after filing.

In most countries, including the UK and Europe, a patent application is only valid if it is filed before the device is shown publicly. Innovations first unveiled the charger at the *Consumer Electronics Show* which opened in Chicago on 3 June, 1993. The public records of the British Patent Office show that Innovations filed its patent application on "a dry cell recharger" on the same day.

So the application is not jeopardised by the Chicago showing. And by filing on the last possible day, they have ensured that competitors will not be able to read the description of how the charger works, until Christmas 1994.

But any competent electronics engineer should easily be able to analyse the charging signal, by measuring it with a voltmeter and displaying its mark/space waveform on the screen of an oscilloscope. Competitors can then build their own circuit to mimic the waveform.

So why file a patent at all? Provided that Innovations can win the grant of a patent, by convincing the Patent Office examiners that its "breakthrough product" and "complex state of the art technology" is genuinely novel compared to the many previous designs, the company will be able to sue mimics for infringement.

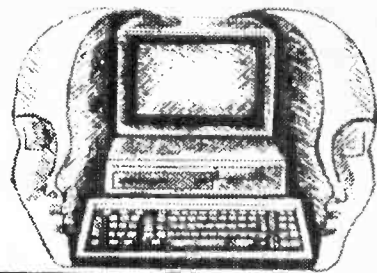
An inventor can only sue when the patent is granted, and under normal circumstances can only claim damages back to the date of publication. By delaying filing until the last day, and thereby delaying publication, Innovations risks giving competitor mimics a clear run until the end of 1994.

There are two possible further twists to the tale. Innovations can ask for early publication of its application, to increase damages. Or if Innovations threatens a competitor with legal action, the competitor can ask the Patent Office for a sight of the patent papers. Either way Innovations wins the chance of more damages, but sacrifices its privacy.



# INTERFACE

**Robert Penfold**



**T**HE range of low cost printed circuit design software seems to be growing at an ever faster rate. New software of this type for PCs has been particularly plentiful over the last year or so. I have reviewed several printed circuit design programs for PCs in recent *Interface* articles, and these have all been freeware, shareware, or public domain programs.

The latest printed circuit design program for the PCs has been released as normal commercial software, but at a price of only £49.00. This price is an all inclusive one – there are no additional VAT or postage charges.

## Windows PCBs

As far as I am aware, "PCB Designer" is unique in that it is aimed specifically at electronics enthusiasts, rather than educational or professional users. It is one of the few printed circuit programs that is designed to operate under Microsoft Windows. It is a proper Windows style program, complete with button bars, drop-down menus, on-line help, etc.

A drawback of using the Windows environment is that the program will not run on a basic PC. It requires a minimum of a 80286 PC with two megabytes of RAM and a V.G.A. display, plus Windows 3.0 or 3.1. Apparently the program can be installed on a high density disk, making it easy to run it on a borrowed computer.

A further drawback of using Windows is that it is relatively slow. Screen redraw-

ing with PCB Designer is not particularly sluggish using a 33MHz 80386DX PC, but seems to be around one tenth as fast as some of the MS/DOS based competition. Many of these programs can pan and zoom almost instantly even with a large board design loaded.

A big advantage of using Windows is that it avoids hardware incompatibility problems. If your super V.G.A. screen, mouse, and printer all work properly with Windows, then they will work properly with PCB Designer. The MS/DOS based printed circuit programs I have tried were all supplied with a range of super V.G.A. drivers, but none would work with my "Trident" super V.G.A. cards. I had no problems in using PC Designer at resolutions of 800 x 600 pixels and 1024 x 768 pixels.

The program is supplied on one 3.5 inch 720k disk, and installation is very easy as there is the usual Windows style "Setup" program to handle the process for you. Thankfully, there is no copy protection, but you do have to type in a registration number in order to persuade the "Setup" program to install the software. This part of the program is very professional, and it can generate a PCB Designer program group in "Program Manager". Once within Windows, you then simply double-click on the appropriate icon to launch the program.

## Tutorial

When the program is first run you are

taken through a simple and helpful on-line tutorial. Once into the main program you are presented with a typical Windows layout. This includes the usual scroll bars for panning around the drawing, a menu bar, and a row of push-buttons complete with icons.

Along the bottom of the screen there is a coordinate display in thousandths of an inch, and a line of hint text. The latter gives helpful messages. For example, if you place the cursor over one of the push-buttons, it will give a brief explanation of the button's function.

Some functions are available via both the push-buttons and the menu bar. However, many are only available using one or other of these. The main functions are available via the push buttons, including those needed for actually drawing up the board. The menu gives access to features such as the snap grid size, the on-line help, and track/pad sizes.

## Drawing Boards

In use the program provides something close to a computer equivalent of a conventional drawing board (Fig. 1). Individual pads or integrated circuit clusters are placed onto the drawing area, and then the tracks are added. Four sizes of pads and four track widths can be used, and the sizes of these are all user selectable.

Any normal d.i.l. integrated circuit clusters can be produced, and they can be flipped through 90 degrees if necessary. There are also some transistor clusters, surface mount

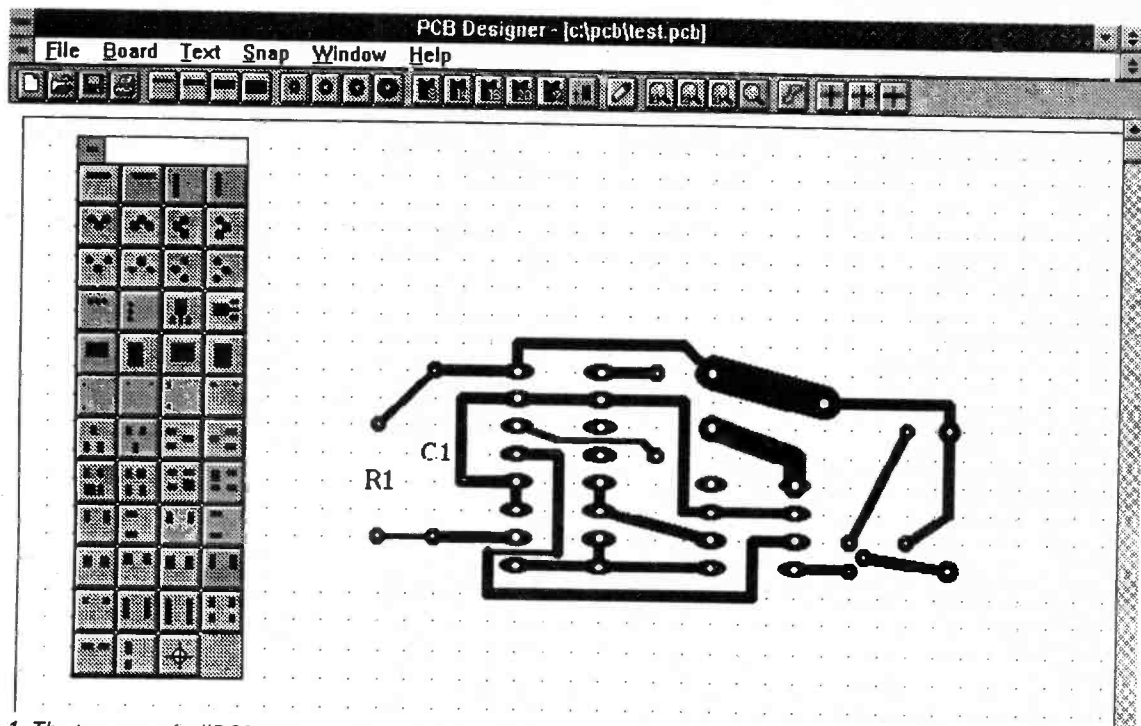


Fig. 1. The top part of a "PCB Designer" screen dump. Note the floating toolbox towards the left-hand side of the screen.

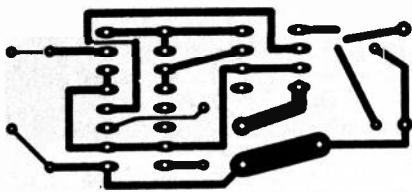


Fig. 2. Sample printout using a 300 d.p.i. laser.

pads, and edge connector "fingers" available. These are available via the push-buttons and a floating toolbox.

The drawing process is very simple indeed, and it takes a negligible amount of time to learn to use this part of the program. Editing layouts is equally simple. To move an "elbow" in a track you simply "click" on it and drag it to the new position. Pads and clusters are just as easy to move, and deleting objects is also very straightforward. There is no difficulty in closing up an area of the board where there is wasted space, or opening up an area where too little space has been left.

There are three preset zoom levels, but it is also possible to zoom in on a selected area of the screen. This area zoom feature is a useful one, but is a facility which is often lacking on printed circuit design software. Panning is achieved using the scroll bars.

Completed drawings can be printed or plotted actual size or twice actual size. Drawings can be mirror-imaged if required. The printing process is quite fast and the printout quality is excellent provided your printer or plotter is up to the task. The sample printout (Fig. 2) is at 1:1 and was produced using an enhanced 300 d.p.i. laser printer.

## Omissions

I must have tried over a dozen printed circuit design programs in the last few years, and "PC Designer" is certainly the easiest to learn and use. Most users will probably find that they can start drawing up their first board almost at once, with no significant learning time being required. Ease of use is an important consideration for amateur users, who will probably make only occasional use of the program. There is little risk of forgetting how to use "PC Designer" during the gap between sessions.

One reason for the program's ease of use is that it is well thought out, and makes full use of the Windows environment. Another is that the program is very simple. In fact it is extremely basic when compared to most other printed circuit design programs. The program has definite limitations, and you may or may not be able to live with these.

When printing out designs there is no fine scaling facility available. If your printer produces hard copy that is one or two percent smaller than it should be (a common problem with laser printers), there is nothing you can do about this. Double-sided layouts can be produced, but this is one respect in which the program is rather more clumsy than most of the competition. With some other programs it is much easier to weave tracks across the layout. Of course, many amateur users will not under-

take double-sided boards anyway, and this factor will be of no consequence to them.

The program does not use netlists in any form, which makes it difficult to comprehensively check the more complex layouts. However, I doubt if many home constructors would use such a facility anyway. It is a facility that only becomes really worthwhile when producing large and complex boards.

There is no printed manual, or even an on-disk manual which can be printed out by the user. The only assistance is the on-line help and tutorial. This would not normally be an acceptable state of affairs, but as the program is so easy and straightforward to use, it is actually quite easy to get by without a manual. It is essential to explore all the menu options to discover exactly what facilities are available.

## Symbols

The most obvious omission from the program is the ability to use symbols. With all the other printed circuit design software I have encountered it has been possible to draw-up components, complete with overlay outlines, and call these up into drawings as and when required. Some programs are supplied complete with large libraries of symbols. Apart from the inclusion of d.i.l. and transistor clusters, PCB Designer has no symbol facility. In fact it is not possible to produce even the most simple of component overlays.

This would be a fatal flaw if it was not for the fact that text can be added. The text facility can be used to indicate which component fits into each set of holes, which should avoid confusion and consequent errors. When producing single-sided boards it would presumably be possible to make use of the top copper side to produce a simple overlay.

The omission of an overlay facility was a deliberate one, as it was presumed that amateur users would simply not need this facility. I am not entirely convinced that this is the case. I think that simple symbol and component overlay facilities would be more than a little helpful.

## Conclusions

There is a real problem for anyone trying to sell printed circuit design software to amateur users. There are now some good freeware programs available for next to nothing! If all you require is a genuine no-fuss program that will enable small to

medium size boards to be drawn up quickly and easily (as many people do), then PCB Designer is probably just what you have been waiting for. It is even quicker to learn and easier to use than the Protel "Easytrax" program reviewed last month. It represents excellent value at the inclusive price of £49.00. At that price many users will probably find it preferable to the freeware competition, or the more expensive commercial alternatives.

The full PCB Designer program and a demo version are available from: Niche Software, The Bannut Tree, Kerrys Gate, Hereford HR2 0AG.

## Program Potential

Continuing on last month's EPROM programming theme, one of the main problems when producing an add-on EPROM programmer for a computer is generating the programming potential needed at pin 1 of a 2764/128 EPROM. Apart from a few old and obsolete devices, a potential of 12.5 volts is needed at pin 1 during the programming procedure. The tolerance on this voltage is only plus and minus 0.3 volts, and the absolute maximum voltage rating for pin 1 is only 14 volts.

This means that a well regulated supply is needed, but series voltage regulators need about 15 volts or more in order to give a regulated output at 12.5 volts. A suitable supply potential is not available from most computers. One solution to the problem is to use a voltage step-up and regulator circuit to produce 12.5 volts from a standard 5 volt supply. This is not difficult to achieve using a switching regulator, and is something we will consider in detail next month.

An alternative method is to give the programmer its own mains power supply unit. There is no fixed voltage monolithic voltage regulator that will provide an output of 12.5 volts, but an adjustable regulator will do the job well. Fig. 3 shows the circuit diagram for a 12.5 volt mains power supply which is based on an LM317L adjustable regulator.

The maximum current drain from the supply is 50 milliamps, so the "L" version of the LM317 is sufficient. This can handle output currents of up to 100 milliamps. Transformer T1 should have a current rating of 200 milliamps or more. The output voltage of the supply is monitored using a multimeter, and VR1 is then adjusted for an output potential of 12.5 volts.

**Next month:** The subject of EPROM programming will be given detailed coverage.

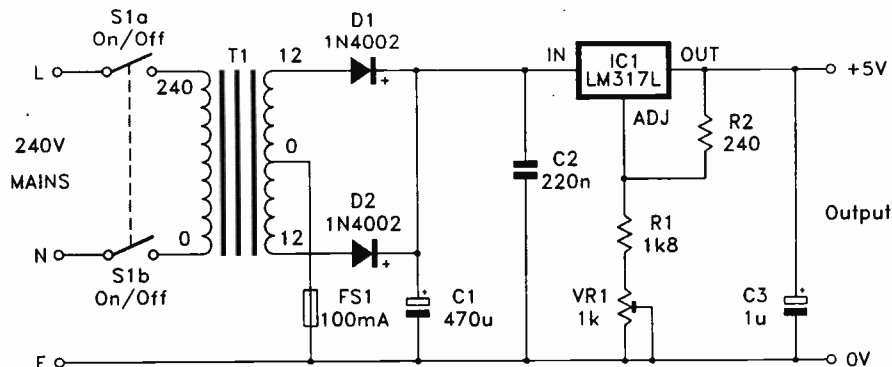
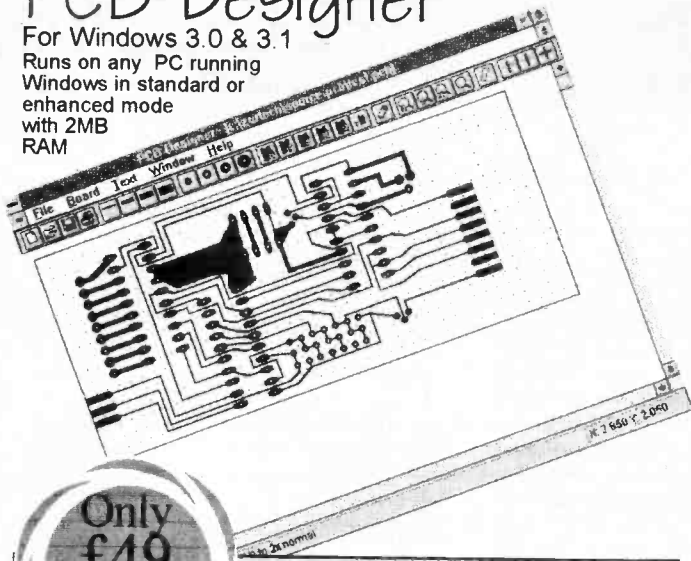


Fig. 3. A mains powered supply circuit that will produce 12.5 volts at up to 50mA.

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PCB Designer allows you to produce single and double sided printed circuit boards. It is easy to use and makes use of the best features from Windows. Features such as Button bars and Hint text are all present. Note that the price is all inclusive, no VAT, no Postage. What You See Is What You Pay (WYSIWYP).

## Niche Software

The Bannet Tree, Kerrys Gate, Hereford, HR2 OAG

Please Note: Since PCB designer is so easy to use, and to keep costs down, PCB Designer has an On-Line manual, in Windows Help format. A tutorial is also supplied online. No paper manual is supplied.

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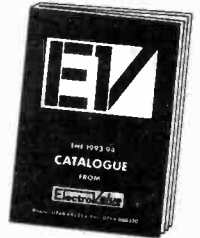
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# Home Base

Jottings of an electronics hobbyist - Terry Pinnell

## Striking Conclusion

Last month I listed the waking-up device options I considered for my Deaf Alarm, based on an old mechanical alarm clock, and concluded by abandoning the sound detection idea. I ask you: the idea of turning mechanical movement into audio and then using the audio to generate a mechanical movement!

Instead, I decided to swing right over towards ultra-simplicity and make a modification to the striker mechanism so that it repeatedly opened and closed an electric contact. As the clock's guarantee was at least a decade out of date I had no hesitation about mangling it. In fact I gather that even the original manufacturer, Westclox, has now disappeared, absorbed into French-owned Moulinex Swan.

So this modified striker became a crude electronic switch - a clock within a clock, as it were - operating at about 20Hz and driving the d.c. motor via a pair of npn transistors as shown in the circuit diagram of Fig.1.

The alarm clock was mounted on top of a home made wooden box, chosen to house the four D-type batteries in a standard plastic holder and the very simple electronics mounted on a piece of perforated board. A jack plug and socket were used to connect the circuit's output signal to the motor unit via a pair of wires about a metre long. An l.e.d in parallel with the socket provided a supplementary indication, and was very useful for testing, especially given the high current usage of the motor.

Detailed improvisation of these electrical contacts will of course vary with the type of clock. In my case it was a matter of epoxy gluing a strip of tin inside the casing, isolated electrically by the glue, so that the hammer could strike it without hindrance. A wire was soldered to the tin and the other switch contact was taken from the clock case itself, which in my Westclox was common with the striker.

## Circuit

The circuit employed is very simple as you can see from Fig.1. When the alarm clock goes off (a peculiar expression that - surely even in bygone times alarms never sounded like bombs?) the newly installed contacts open and close at about 20Hz. While closed, a brief positive pulse is delivered to the base of the Darlington pair arranged as an emitter follower. If the plug is in place then the motor will "vibrate". In any case the l.e.d will light, making testing economical on the four 1.5V heavy duty HP2 or similar batteries

Looking at the circuit, you'll see that if the striker contacts remained closed when the spring ran down, then the motor should continue to vibrate until the batteries ran out ... definitely not a desirable design feature. But fortunately in practice the contacts always finished apart. (A coin with similar characteristics would be quite

handy for toss-you-for-it bets.) But although it somehow proved mechanically impossible on the prototype, so that the full current could never flow when the clock was supposed to be OFF, it would clearly be necessary to check that this was so with a particular clock.

Trial and error with a breadboard gave the component values shown, but all are far from critical. The electrolytic capacitor value was a compromise. The motor must receive large enough current pulses for adequate vibration, even when the battery voltage has fallen to say 4V. Note that after allowing for the total of the two base-emitter drops this means a little under 3V to the motor. But the motor must also stop quickly when the alarm clock OFF button is pressed; it wouldn't do for it to take another minute or so to fade away during that precious period when you are luxuriating in the softness of the pillows.

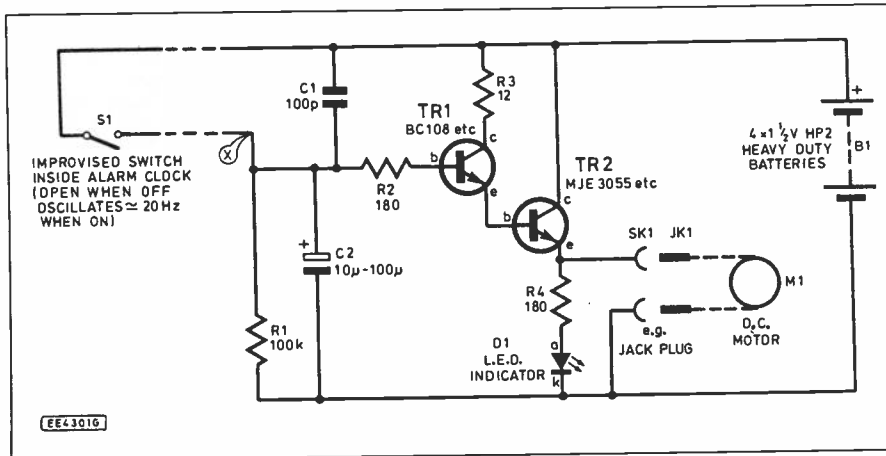


Fig. 1. Circuit diagram of the Deaf Alarm.

The low value capacitor was added to remove v.h.f oscillations on switch-off that became apparent with my 'scope, but motors aren't noted for being electronically clean so this purist measure was possibly redundant.

Quiescent current was negligible, but in any case no additional ON/OFF switch was necessary in practice. The existing mechanical one on the clock served the purpose, but of course an electronic switch could be incorporated if you wanted a 100 per cent guarantee that there would be no impromptu operation in the middle of the night. Poltergeists apart, that is.

## Battery Life

Had I been making this for my own family's use I would have had no compunction about powering it from the mains. It would have been perfectly safe, with effectively three levels of isolation: the step-down transformer, the wooden case and the remote cable to the motor. And in the long term it would have saved a lot on battery costs. But in this case there was the psychological factor to consider, not to

mention the high cost of a transformer. The initial battery supply was admittedly also a cost factor, but at least replacements were down to my friend, not to me.

However, in this case the question arose as to what life could be expected from the batteries. I wanted to avoid the embarrassment of the thing running out of steam in a couple of weeks, with my friend then either returning it to me or relegating it to a dark cupboard.

Generalising, I've found that this issue often crops up with circuits which involve intermittent operation, especially when high currents are involved. Manufacturers' published battery specifications might give you some idea of the capacity of a battery in ampere-hours, but that's not a lot of help in projects like these. Yet it can be important, given the high cost of batteries. A topic on my mind, incidentally.

## Battery usage simulator

I bought a portable stereo radio/cassette the other day; the unit itself (four channel radio, two tape units, removable speakers) cost £79.99; the six D-type and two AA batteries, all alkaline, cost an additional £12.57. Over 15 per cent of the hardware cost! So with a day or two's digression in mind I decided to design and build a circuit

to simulate battery usage for such projects.

As you can see from Fig.2 the circuit consists of two conventional CMOS astables, plus a gate in which their signals are combined, and an emitter follower output to lower the impedance and provide buffering. The long period asymmetric astable allows about ten seconds of pulses from the 20Hz astable to reach the base of the npn transistor TR1 every ten minutes or so, and the output is then taken to the Deaf Alarm (point X in Fig.1).

I made an assumption that ten minutes was a reasonable recovery time between calling on the batteries to deliver their full power. Clearly this was far from an exact simulation, being rather more demanding than expected in practice, when the recovery interval would be 24 hours, and the operational time probably much less than ten seconds. But there would not be a lot of merit in a simulator that took six weeks to find out that the batteries would last six weeks!

Experience shows that although CMOS can in theory work with impedances up in the hundreds of megohms, for reliable operation an upper limit of say 10M is



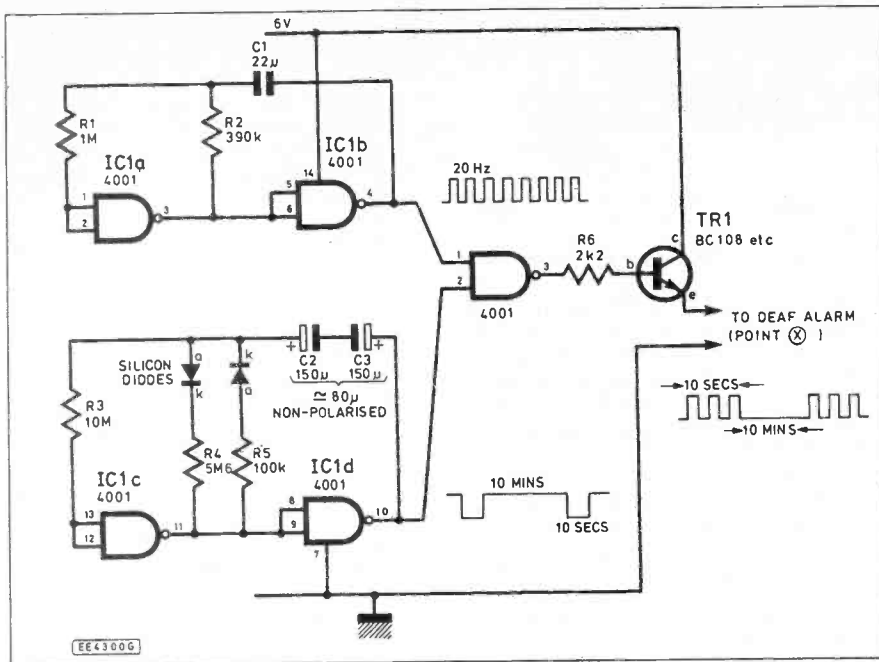


Fig. 2. Circuit diagram for the Battery Usage Simulator.

advisable. So in order to get the ten minute period a large capacitor was clearly necessary. The timing capacitor in this configuration must be non-polarised, but this is easily met by using a pair of equal value electrolytics in series, back-to-back. The resultant capacitance is half the value of each of the individual ones (and the voltage rating is doubled.)

The very low duty cycle was achieved by using two steering diodes and widely varying discharge resistors. After a bit of

theory, trial and error was again the best way of homing in on the final component values.

To test the Deaf Alarm specifically, the Simulator was rigged up on a breadboard.

But for more general use it could of course be constructed as a permanent project and housed in a proper case. That would mean replacing the resistors R4 and R5 by potentiometers or presets, so that a wide range could be covered.

Assuming that the device was to be used six times a week (with a Sunday lie in) battery voltage at the end of every hour of the simulation should therefore correspond approximately to their state at the end of each week of real usage. The results of the test on the prototype, showing the battery voltage measured at the end of certain times, in each case when under load towards the end of the ten seconds, is shown in Table 1. A life of at least six months seemed confidently predictable.

## Wound Up!

Luckily my friend's daughter hadn't got married and left home by the time I presented him with the finished unit. Over a coffee I advised him that unconventional though it was, it was simplicity itself to use. Just make sure the alarm clock was fully wound in the usual way, set the wake-up time, and slip the unit under the pillow.

I was naturally delighted to hear that it performed very well in practice. But the unhappy ending was that about six months later it got dropped from a shelf, disintegrating beyond easy repair. At least, that's what he told me!

After number of hours:	0	1	3	6	8	10	26
= No. of weeks:	0	1	3	6	8	10	26
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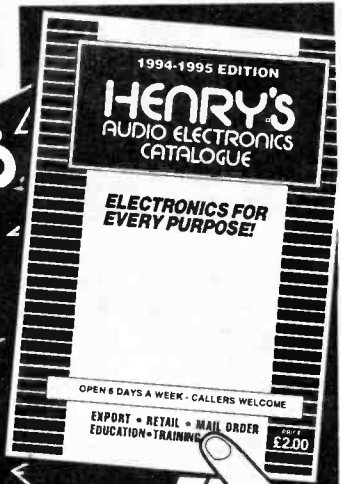
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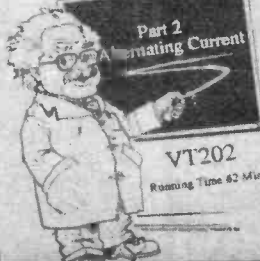
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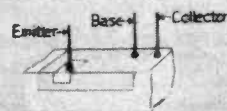
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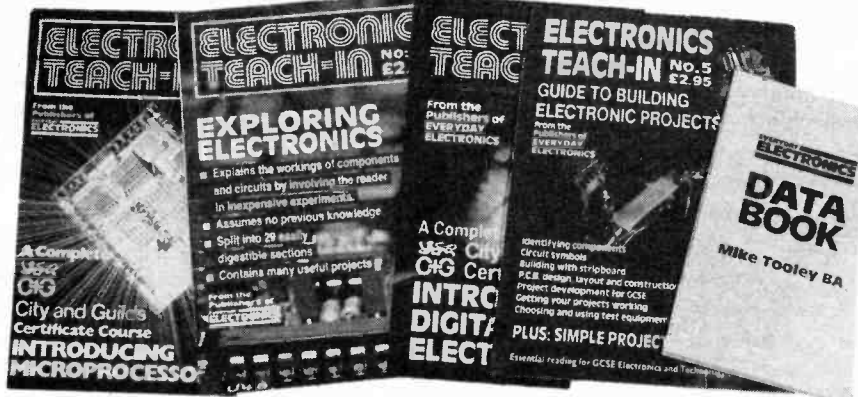
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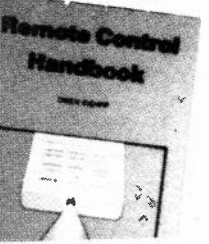
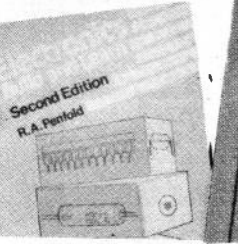
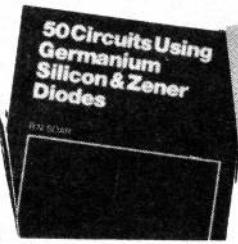
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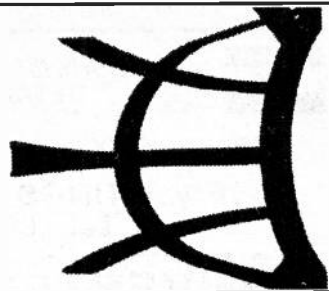
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# REPORTING AMATEUR RADIO

**Tony Smith G4FAI**



## PRESIDENT PRAISES SAREX

During the STS-57 space shuttle mission in June, President Clinton held a telephone conversation with the crew. He commended the astronauts, the SAREX (Shuttle Amateur Radio Experiment) team and the Amateur Radio community for their outstanding support to students around the world.

He said "...I understand later in the mission (you) are going to be talking to school children around the world ... I want to tell you how much I appreciate the fact that you're making an international educational project out of this mission."

Crew member Brian Duffy, N5WQW, responded, "Mr President, we find that using amateur radio is an excellent way of communicating with children all around the world... and by letting them see space and science in action we're able to excite them and hope they'll study harder."

The President finished, "... you may be on this mission creating thousands of scientists for the future just by the power of your example and by this direct communication. I think sometimes we underestimate the impact that human contact in an enormously impressive setting like this can have on children all across the world - not only those with whom you'll talk, but millions of others who will just see it and know that it happened." (*W5YI Report*).

During SAREX flights, amateur radio station WA3NAN, at the Goddard Space Flight Center, operates round the clock providing information and re-transmitting live Shuttle air-to-ground audio. It broadcasts simultaneously on five different amateur bands, usually on frequencies of 3.860, 7.185, 14.295, 21.395 and 28.395MHz. Transmissions on the lower frequencies may not be heard in the UK, but depending on propagation conditions those from 14MHz up may be receivable.

## CANADIAN MERGER

For the last 25 years Canada has had two national amateur radio societies, the Canadian Radio Relay League (originally the Canadian Division of America's ARRL) and the Canadian Amateur Radio Federation. After many failed negotiations over the years, members of the two societies voted by large majorities for a merger, and a new single society came into being this year called "Radio Amateurs of/du Canada" (RAC).

However, possibly because of the previous existence of two competing organisations and the consequent dilution of their effectiveness as representatives of the amateur community, the new combined organisation has little more than 8,000 members out of Canada's 37,000 amateur licensees.

Amateur radio needs strong negotiating power at government levels, since the very existence of the hobby depends on official support and approval within the regulatory structure. RAC's first priority, therefore, is

to build up its membership and strength to ensure the best possible representation at national level.

Almost starting from scratch, it will be interesting to follow the progress and achievements of the new society in pursuing this aim in the years ahead.

## AMATEUR RADIATION STUDY

Last month I reported on proposals by the Federal Communications Commission to upgrade radiation safety requirements for FCC controlled transmitters. The problems of radiation safety are a matter of concern as much in amateur as in professional applications and, in 1990, the Environmental Protection Agency and the FCC conducted a joint study of several amateur radio installations in Southern California.

The objective was to obtain information on the potential impact of r.f. fields on amateur operators and others who might be in the immediate vicinity of the station, "... where it is reasonable to assume that persons who might not have control or knowledge of their exposure could have access"; and the conclusions of the study are just as relevant to the UK as the USA, despite the permitted higher power levels in the US.

Nine stations were studied, having a variety of antennas and transmitting equipment, with powers ranging from 100 watts or less to 1400 watts, and an attempt was made to use high power levels to create "worst case" scenarios.

The results showed that while some field strengths at h.f. frequencies can be relatively high, the potential hazard may be less than for lower field strengths at v.h.f. frequencies where the highest specific absorption rates occur in human beings. Ground level field strength readings were actually low. It was necessary to be in the main "beam" path to obtain significant radiation levels.

It appeared that vehicle-mounted amateur antennas which are closer to the ground created the greatest possibility for significant exposure in publicly accessible areas. There were several cases where the peak levels of r.f. exposure exceeded the limits recommended for "uncontrolled" environments.

It was found that dipole antennas, often strung just above a roof or garden, also presented high field strength readings; but generally, field strengths encountered inside "ham shacks" were well below IEEE recommended exposure limits.

The study concluded that "Precautionary measures should be sufficient to prevent exposure of the amateur operator and other persons to r.f. levels in excess of protection guidelines. Examples of such measures would be:

- using the minimum power necessary for a transmission;
- minimizing transmission time so that time-average exposures are acceptable;

- determining where high-field areas exist and restricting access to them during transmissions and;
- mounting antennas as high above ground as practical." (*W5YI Report*).

## A FEW STATISTICS

It's always interesting to compare amateur radio populations in different countries. As at last September (1992), for instance, Australia had 18,701 amateur licensees. The most populous state was New South Wales, with 5,461, followed by Victoria with 5,002. There are 28 beacon and 320 repeater licences, 85 of the latter being in NSW, 84 in Victoria and 70 in Queensland.

By contrast, at the same date, there were 1,242,550 licensed radio amateurs in Japan, representing 15.5 per cent of all licensed radio transmitting stations. In the three months up to September, the number of amateurs increased by 20,336. On that basis, Japan's amateur population could be said to increase by the total amount of that in the UK (approximately 60,000) every nine months!

Apparently, over one million of these licensees use 10 watts on the h.f. amateur bands with no-code licences, i.e., without a Morse test requirement. It appears that Japan has interpreted the International Radio Regulations as permitting such operation provided it does not cause interference to other countries.

Ten watts is in fact capable of worldwide communication on the h.f. bands as proved by the achievements of amateur QRP operators using even lower power (5 watts or less). Presumably there are frequency and antenna restrictions on the Japanese no-code stations to prevent them doing the same thing. If anyone happens to have more precise details please write to me c/o the Editor.

## NEW LICENSING ARRANGEMENTS

The Radiocommunications Agency has announced new renewal procedures for Amateur Radio and Citizens Band licences. As from 1st October 1993, licence renewal notices will be sent to licensees six weeks before the annual renewal date, instead of four weeks as previously, to give licensees more time to effect payment.

However, if payment is not received within those six weeks, and a final notice is ignored, the licence will be cancelled. Anyone seeking to renew their licence after such a cancellation will be treated as a new applicant and will have to produce relevant documents to support the application, such as an RAE pass certificate (for licences class A and B) and a Morse test pass slip (class A only).

Further information about the new arrangements can be obtained from the Radiocommunications Agency on 071-215 2263 or from Subscription Services Ltd on 0272 258333.





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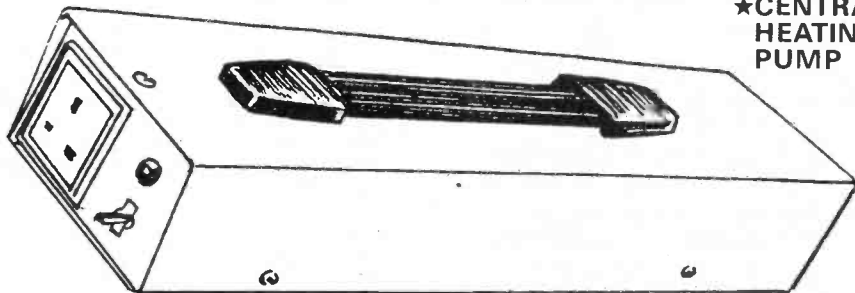
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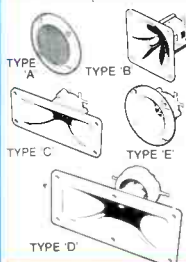


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RES. FREQ. 49Hz, FREQ. RESP. TO 6KHz, SENS 100dB.  
12" 100 WATT R.M.S. ME12-100LT (TWIN CONE) WIDE RESPONSE, P.A., VOCAL, STAGE MONITOR. RES. FREQ. 42Hz, FREQ. RESP. TO 10KHz, SENS 98dB. PRICE £36.67 + £3.50 P&P  
12" 200 WATT R.M.S. ME12-200 GEN. PURPOSE, GUITAR, DISCO, VOCAL, EXCELLENT MID. PRICE £46.71 + £3.50 P&P  
RES. FREQ. 58Hz, FREQ. RESP. TO 6KHz, SENS 98dB.  
12" 300 WATT R.M.S. ME12-300GP HIGH POWER BASS, LEAD GUITAR, KEYBOARD, DISCO ETC. PRICE £70.19 + £3.50 P&P  
RES. FREQ. 47Hz, FREQ. RESP. TO 5KHz, SENS 103dB.  
15" 200 WATT R.M.S. ME15-200 GEN. PURPOSE BASS, INCLUDING BASS GUITAR. PRICE £50.72 + £4.00 P&P  
RES. FREQ. 46Hz, FREQ. RESP. TO 5KHz, SENS 99dB.  
15" 300 WATT R.M.S. ME15-300 HIGH POWER BASS, INCLUDING BASS GUITAR. PRICE £73.34 + £4.00 P&P  
RES. FREQ. 39Hz, FREQ. RESP. TO 3KHz, SENS 103dB.

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RES. FREQ. 40Hz, FREQ. RESP. TO 7KHz, SENS 97dB.  
10" 50WATT EB10-50 DUAL IMPEDANCE, TAPPED 4/8 OHM BASS, HI-FI, IN-CAR. PRICE £13.65 + £2.50 P&P  
RES. FREQ. 40Hz, FREQ. RESP. TO 5KHz, SENS. 99dB.  
10" 100WATT EB10-100 BASS, HI-FI, STUDIO. PRICE £30.39 + £3.50 P&P  
RES. FREQ. 35Hz, FREQ. RESP. TO 6KHz, SENS 96dB.  
12" 100WATT EB12-100 BASS, STUDIO, HI-FI, EXCELLENT DISCO. PRICE £42.12 + £3.50 P&P  
RES. FREQ. 26Hz, FREQ. RESP. TO 3 KHz, SENS 93dB.  
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5 1/4" 60WATT EB5-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC. PRICE £9.99 + £1.50 P&P  
RES. FREQ. 63Hz, FREQ. RESP. TO 20KHz, SENS 92dB.  
6 1/2" 60WATT EB6-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC. PRICE £10.99 + 1.50 P&P  
RES. FREQ. 38Hz, FREQ. RESP. TO 20KHz, SENS 94dB.  
8" 60WATT EB8-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC. PRICE £12.99 + £1.50 P&P  
RES. FREQ. 40Hz, FREQ. RESP. TO 18KHz, SENS 89dB.  
10" 60WATT EB10-60TC (TWIN CONE) HI-FI, MULTI ARRAY DISCO ETC. PRICE £16.49 + £2.00 P&P  
RES. FREQ. 35Hz, FREQ. RESP. TO 12KHz, SENS 98dB.

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PHOTO: 3W FM TRANSMITTER

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