EVERYDAY ELECTRONICS

OCTOBER 1990

INCORPORATING ELECTRONICS MONTHLY 3 Royden £1.50

FREQUENCY METER/TACHO

Measures from 10Hz to 100kHz plus rotating speed

FRIDGE ALERT

Keep your food at a safe temperature

GHOST WAKER

A fun project for Halloween

ISSN 0262-3617

The No.1 Magazine for Electronic & Computer Projects

ONE POUND PACKS

All packs are £1 each. Note the figure on the extreme left of the pack ref number and the next figure is the quantity of items in the pack, finally a short description.

BD2	5	13A spurs provide a fused outlet to a ring main where devices such as a clock must not be switched off.
BD9	2	6V 1A mains transformers upright mounting with fixing clamps.
BD13	12	30 watt reed switches, it's surprising what you can make with these—burglar alarms, secret switches, relay, etc., etc.
BD22	2	25 watt loudspeaker two unit crossovers.
BD30	2	Nicad constant current chargers adapt to charge almost any nicad battery.
BD32	2	Humidity switches, as the air becomes damper the membrane stretches and operates a microswitch.
BD42	5	13A rocker switch three tags so on/off, or change over with centre off.
BD45	1	24hr time switch, ex-Electricity Board, automatically adjust for lengthening and shortening day. original cost £40 each.
BD49	5	Neon valves, with series resistor, these make good night lights.
BD56	1	Mini uniselector, one use is for an electric jigsaw puzzle, we give circuit diagram for this. One pulse into motor, moves switch through one pole.
BD67	1	Suck or blow operated pressure switch, or it can be operated by any low pressure variation such as water level in water tanks.
BD103A	1	6V 750mA power supply, nicely cased with mains input and 6V output leads.
BD120	2	Stripper boards, each contains a 400V 2A bridge rectifier and 14 other diodes and rectifiers as well as dozens of condensers, etc.
BD132	2	Plastic boxes approx 3in cube with square hole through top so ideal for interrupted beam switch.
BD134	10	Motors for model aeroplanes, spin to start so needs no switch.
BD137	1	6½ inch 4 ohm speaker 10W rating.
BD139	6	Microphone inserts—magnetic 400 ohm also act as speakers.
BD148	4	Reed relay kits, you get 16 reed switches and 4 coil sets with notes on making c/o relays and other gadgets.
BD149	6	Safety cover for 13A sockets—prevent those inquisitive little fingers getting nasty shocks.
BD180	6	Neon indicators in panel mounting holders with lens.
BD193	6	5 amp 3 pin flush mounting sockets make a low cost disco panel.
BD199	1	Mains solenoid, very powerful, has 1in pull or could push if modified.
BD201	8	Keyboard switches—made for computers but have many other applications.
BD211	1	Electric clock, mains operated, put this in a box and you need never be late.
BD221	5	12V alarms, make a noise about as loud as a car horn. Slightly soiled but OK.
BD252	1	Panostat, controls output of boiling ring from simmer up boil.
BD259	50	Leads with push-on ¼in tags—a must for hook ups—mains connections etc.
BD263	2	Oblong push switches for bell or chimes, these can mains up to 5 amps so could be foot switch if fitted into pattress.
BD268	1	Mini 1 watt amp for record player. Will also change speed of record player motor.
BD305	1	Tubular dynamic mic with optional table rest.
BD653	2	Miniature driver transformers. Ref. LT44. 20k to 1k centre tapped.
BD548	2	3.5V relays each with 2 pairs changeover contacts.
BD667	2	4.7 µf non-polarised block capacitors, pcb mounting.

There are over 1,000 items in our Catalogue. If you want a complete copy please request this when ordering.

METAL PROJECT BOX Ideal for battery charger, power supply etc. Sprayed grey size 8" x 4" x 4½". Louvred for ventilation. Price £3.00. Ref. 3P75.

FLOPPY DISCS 5¼" pack of 10 £5.00 Ref 168 3½" pack of 15 £10.00 Ref 10P88

PERSONAL STEREOS Again customer returns but complete and with stereo head phones. A bargain at only £3.00 each. Our ref 3P83

MICROWAVE CONTROL PANEL Mains operated, with touch switches. This unit has a 4 digit display with a built in clock and 2 relay outputs — one for power and one for pulsed power level. Could be used for all sorts of timer control applications. Only £6.00. Our ref 6P18

EQUIPMENT WALL MOUNT Multi adjustable metal bracket ideal for speakers, lights, etc. 2 for £5.00. Our ref 5P152

NEW MAINS MOTORS 25 watt 3000 rpm made by Framco. Approx 6" x 3" x 4". Priced at only £4.00 each. Our ref 4P54.

SHADED POLE MOTORS Approx 3" square. Available in 24V and 240V AC. Both with threaded output shaft and 2 fixing bolts. Price is £2.00 each. 24V Ref 2P65, 240V Ref 2P66.

SUB-MIN TOGGLE SWITCH Body size 8mm x 4mm x 7mm SBDT with chrome dolly fixing nuts. 3 for £1. Order ref BD649.

COPPER CLAD PANEL for making PCB. Size approx 12in long x 8½in wide. Double-sided on fibreglass middle which is quite thick (about 1 16in) so this would support quite heavy components and could even form a chassis to hold a mains transformer, etc. Price £1 each. Our ref BD683

POWERFUL IONISER

Generates approx. 10 times more IONS than the ETI and similar circuits. Will refresh your home, office, workroom etc. Makes you feel better and work harder – a complete mains operated kit, case included. £18. Our ref 18P2.

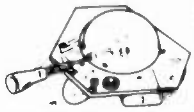
2KV 500 WATT MAINS TRANSFORMERS. Suitable for high voltage experiments or as a spare for a microwave oven etc. £10.00 Ref 10P93

REAL POWER AMPLIFIER for your car, it has 150 watts output. Frequency response 20hz to 20Khz and signal to noise ratio better than 60dB. Has built in short circuit protection and adjustable input level to suit your existing car stereo, so needs no pre-amp. Works into speakers ref. 30P7 described below. A real bargain at only £57.00. Order ref: 57P1.

REAL POWER CAR SPEAKERS. Stereo pair output 100W each. 4Ohm impedance and consisting of 6½" woofer, 2" mid range and 1" tweeter. Ideal to work with the amplifier described above. Price per pair £30.00. Order ref 30P7.

VIDEO TAPES These are three hour tapes of superior quality, made under licence from the famous JVC Company. Offered at only £3 each. Our ref 3P63. Or 5 for £11. Our ref 11P3. Or for the really big user 10 for £20. Our ref 20P20.

ELECTRONIC SPACESHIP. Sound and impact controlled, responds to claps and shouts and reverses when it hits anything. Kit with really detailed instructions. Ideal present for budding young electrician. A youngster should be able to assemble but you may have to help with the soldering of the components on the pcb. Complete kit £10. Our ref. 10P81



COMPUTER KEYBOARDS Brand new, uncased. £3.00 each. ref 3P89.

12" HIGH RESOLUTION MONITOR. Amber screen beautifully cased for free standing, needs only 12V 1.5 amp supply. TTL input separate syncs. Brand new in makers cartons. Price £22.00. Order ref 22P2

SINCLAIR C5 WHEELS

Including inner tubes and tyres. 13" and 16" diameter spoked poly carbonate wheels. Finished in black. Only £6.00 each.
13" Ref 6P10, 16" Ref 6P11

COMPOSITE VIDEO KITS These convert composite video into separate H sync, V sync and video. Price £8.00. Our ref 8P39.

LINEAR POWER SUPPLY Brand new +5v 3A, +/-12v 1A. Complete with circuit diagram. Short circuit protected. Our price £12.00 Ref 12P21

3½in FLOPPY DRIVES We still have two models in stock: Single sided, 80 track, by Chinon. This is in the manufacturers metal case with leads and IDC connectors. Price £40, reference 40P1. Also a double sided, 80 track, by NEC. This is uncased. Price £60.00, reference 60P2. Both are brand new.

10 MEMORY PUSHBUTTON TELEPHONES These are customer returns and "sold as seen". They are complete and may need slight attention. Price £6.00. Ref. 6P16 or 2 for £10.00. Ref. 10P77. BT approved.

INDUCTIVE PROXIMITY SWITCHES These will detect ferrous or nonferrous metals at approx. 10mm and are 10-36V operation. Ideal for alarms position sensors, etc. RS price is £64.00 each! Ours £12.00. Ref. 12P19.

BOSCHERT SWITCHED MODE POWER SUPPLIES -5V at 15A, -12V at 3A, -12V at 2A, +24V at 2A. 220V or 110V input. Brand new and guaranteed. Retail price is £180!! Ours £20. Ref 20P30

TV SOUND DECODER. Nicely cased, mains powered with 8 channels. Will drive a small speaker directly or could be fed into HI FI system etc. £12.00 each Ref 12P22

PC POWER SUPPLIES Brand new with built in fan and power switch on the back. -5, +5, -12, +12V 150 watt made by AZTEC £25.00 each. Ref 25P18

VERY POWERFUL 12 VOLT MOTORS. ⅓rd Horsepower. Made to drive the Sinclair C5 electric car but adaptable to power a go-kart, a mower, a rail car, model railway, etc. Brand new. Price £20. Our ref 20P22.

AS ABOVE with gearbox. Phone for price and availability

PHILIPS LASER

This is helium-neon and has a power rating of 2mW. Completely safe as long as you do not look directly into the beam when eye damage could result. Brand new, full spec. £35. Our ref 35P1. Mains operated power supply for this tube gives 8kv striking and 1.25kv at 5mA running. Complete kit with case £15.

PANEL METERS 270 deg movement. New. £3.00 each. Our ref 3P87

SURFACE MOUNT KIT Makes a super high gain snooping amplifier on a PCB less than an inch square! £7.00. Our ref 7P15.

CB CONVERTERS Converts a car radio into an AM CB receiver. £4.00 Our ref 4P48

GEIGER COUNTER KIT Includes PCB, tube, loudspeaker, and all components to build a 9v battery operated geiger counter. Only £39. Our ref 39P1.

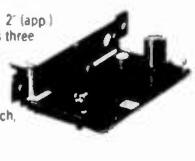
12V TO 220V INVERTER KIT This kit will convert 12v DC to 220v AC. It will supply up to 130 watts by using a larger transformer. As supplied it will handle about 15 watts. Price is £12. Our ref 12P17

SPECTRUM AND COMMODORE SOFTWARE Pack of 5 different tapes only £3.00. Ref. 3P96 for Spectrum and 3P97 for Commodore 64.

HIGH RESOLUTION MONITOR 9in black and white, used Philips tube M24/360W. Made up in a lacquered frame and has open sides. Made for use with OPD computer but suitable for most others. Brand new. £20. Our ref 20P26

12 VOLT BRUSHLESS FAN. Japanese made. The popular square shape (4½in x 4½in x 1¾in). The electronically run fans not only consume very little current but also they do not cause interference as the brush type motors do. Ideal for cooling computers, etc., or for a caravan. **£8 each.** Our ref 8P26

MINI MONO AMP on p.c.b. size 4" x 2" (app.) Fitted Volume control. The amplifier has three transistors and we estimate the output to be 2W rms. More technical data will be included with the amp. Brand new, perfect condition, offered at the very low price of £1.15 each, or 13 for £12.00



BULL ELECTRICAL

Dept. EE 250 PORTLAND ROAD, HOVE, BRIGHTON, SUSSEX BN3 5QT.

VISA

MAIL ORDER TERMS: Cash, PO or cheque with order. Monthly account orders accepted from schools and public companies. Please add £2.50 postage to orders. Minimum order £5.
Phone (0273) 203500 Fax No. (0273) 23077

POPULAR ITEMS — MANY NEW THIS MONTH

MAINS FANS Snail type construction. Approx. 5" x 4" mounted on a metal plate for easy fixing. New. £5.00 each. Our ref 5P166.

MICROWAVE TURNTABLE MOTOR Complete with weight sensing electronics that would have varied the cooking time. Ideal for window displays, etc. Only £5.00. Our ref 5P165.

JOYSTICKS for BBC, Atari, Dragon, Commodore, C64 only. All £5.00 each. All brand new, state which required.

PC STYLE CASES 18" X 18" X 6" Complete with fan and grill illuminated power switch and IEC filtered power input plug. Priced at only £15.00 Ref 15P38

SUB-MIN PUSH SWITCHES Not much bigger than a plastic transistor but double pole PCB mounting. 3 for £1.00. Our ref BD688.

AA CELLS Probably the most popular of the rechargeable NICAD types. 4 for £4.00. Our ref 4P44

20 WATT 4 OHM SPEAKER With built in tweeter. Really well made unit which has the power and the quality for hifi 6½" dia. Price £5.00. Our ref. 5P155 or 10 for £40.00 ref. 40P7.

MINI RADIO MODULE Only 2in square with ferrite aerial and solid dia. tuner with own knob. It is superhet and operates from a PP3 battery and would drive a crystal headphone. Price £1.00. Our ref. BD716.

BULGIN MAINS PLUG AND SOCKET The old and faithful 3 pin with screw terminals. The plug is panel mounted and the socket is cable mounted. 2 pairs for £1.00 or 4 plugs or 4 sockets for £1.00. Our ref. BD715, BD715P, or BD715S.

MICROPHONE Low cost hand held dynamic microphone with on/off switch in handle. Lead terminates in 1 3.5mm and 1 2.5mm plug. Only £1.00. Ref. BD711

MOSFETS FOR POWER AMPLIFIERS AND HIGH CURRENT DEVICES 140V 100 watt pair made by Hitachi. Ref 2SJ99 and its complement 2SK343. Only £4.00 a pair. Our ref 4P51

TIME AND TEMPERATURE LCD MODULE A 12 hour clock a Celsius and Fahrenheit thermometer a too hot alarm and a too cold alarm. Approx 50x20mm with 12.7mm digits. Requires 1AA battery and a few switches. Comes with full data and diagram. Price £9.00. Our ref. 9P5.

REMOTE TEMPERATURE PROBE FOR ABOVE. £3.00. Our ref. 3P60.

PAPST fan 80 x 80mm 230V Our ref 9P7 Price £9

PAPST fan 120 x 120mm 230V Our ref 6P6 Price £6

600 WATT AIR OR LIQUID MAINS HEATER Small coil heater made for heating air or liquids. Will not corrode, lasts for years. Coil size 3" x 2" mounted on a metal plate for easy fixing. 4" dia. Price £3.00. Ref. 3P78 or 4 for £10.00. Our ref. 10P76.

EX-EQUIPMENT POWER SUPPLIES Various makes and specs, ideal bench supply. Only £8.00. Our ref. 8P36.

ACORN DATA RECORDER Made for the Electron or BBC computer but suitable for others. Includes mains adaptor, leads and book. £12.00. Ref. 12P15

PTFE COATED SILVER PLATED CABLE 19 strands of .45mm copper will carry up to 30A and is virtually indestructible. Available in red or black. Regular price is over £120 per reel. Our price only £20.00 for 100m reel. Ref. 20P21 or 1 of each for £35.00. Ref 35P2. Makes absolutely superb speaker cable!

NEW PIR SENSORS Infra red movement sensors will switch up to 1000W mains. UK made, 12 months manufacturers warranty. 15-20m range with a 0-10mm timer, adjustable wall bracket. Our ref 25P16. Price £25

GEARBOX KITS Ideal for models, etc. Contains 18 gears (2 of each size), 4 x 50mm axles and a powerful adjustable speed motor. 9-12V operation. All the gears, etc. are 2mm push fit. £3.00 for the complete kit. Ref. 3P93.

MINI HIFI SPEAKERS Made for televisions, etc. Two sizes available. 70mm x 57mm 3W 8 ohm, 2 for £3.00. Ref 3P99. 127mm x 57mm 5W 8 ohm, 2 for £3.00. Ref. 3P100.

BBC JOYSTICK INTERFACE Converts a BBC joystick port to an Atari type port. Price £2.00. Our ref. 2P261.

TELEPHONE EXTENSION LEAD 5m phone extension lead with plug on one end, socket on the other. White. Price £3.00. Our ref. 3P70 or 10 leads for only £19.00! Ref. 19P2.

LCD DISPLAY 4½" digits supplied with connection data £3.00. Ref. 3P77 or 5 for £10. Ref. 10P78

CROSS OVER NETWORK 8 Ohm 3 way for tweeter midrange and woofer nicely cased with connections marked. Only £2.00. Our ref. 2P255 or 10 for £15.00. Ref. 15P32

BASE STATION MICROPHONE Top quality uni-directional electret condenser mic 600r impedence sensitivity 16-18KHz – 68db built in chime complete with mic stand bracket. £15.00. Ref. 15P28.

MICROPHONE STAND Very heavy chromed mic stand, magnetic base 4" high. £3.00 if ordered with above mic. Our ref. 3P80.

SOLAR POWERED NICAD CHARGER 4 Nicad AA battery charger. Charges 4 batteries in 8 hours. Price £6.00. Our ref. 6P3

YUASHA SEALED LEAD ACID BATTERIES. 6V 10AH only £9.00 each or 2 for £15.00. Ref 15P37

STC SWITCHED MODE POWER SUPPLY. 220V or 110V operation giving 5v at 2A, -24V at 0.25A, -12V at 0.15A and -90V at 0.4A £12.00 each. Ref 12P27

SOLDERING IRON STAND Price £3.00. Our ref. 3P66.

INCAR GRAPHIC EQUALIZER/BOOSTER Slimline 7 band with built in 30 watts per channel amplifier. 12V operation, twin 5 LED power indicators, 20-21KHz with front and rear fader plus headphone output! Brand new and guaranteed. Only £25.00. Ref. 25P14.

CENTRONICS ADAPTER KIT Converts plotter/printer to Centronics compatible. Price £4.00. Our ref 4P57

CAR IONIZER KIT Improve the air in your car, clears smoke and helps prevent fatigue. Case req. Price £12.00. Our ref. 12P8.

NEW FM BUG KIT New design with PCB embedded coil 9v operation. Priced at £5.00. Our ref. 5P158.

NEW PANEL METERS 50UA movement with three different scales that are brought into view with a lever. Price only £3.00. Ref. 3P81

STROBE LIGHTS Fit a standard edison screw light fitting 240V 40/min. flash rate available in yellow, blue, green and red. Complete witb socket. Price £10 each. Ref. 10p80 (state colour required).

ELECTRONIC SPEED CONTROL KIT Suitable for controlling our powerful 12v motors. Price £17.00. Ref. 17P3 (heatsink required).

EXTENSION CABLE WITH A DIFFERENCE It is flat on one side making it easy to fix and look tidy. 4 core, suitable for alarms, phones etc. Our price only £5.00 for 50m reel. Ref. 5P153

1990 CATALOGUE NOW AVAILABLE PLEASE SEND 6" X 9" SAE FOR FREE COPY

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ABC

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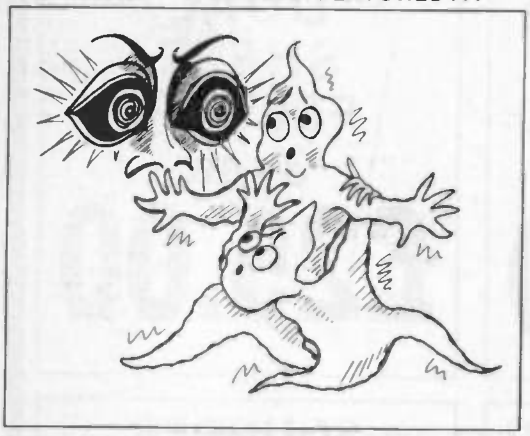
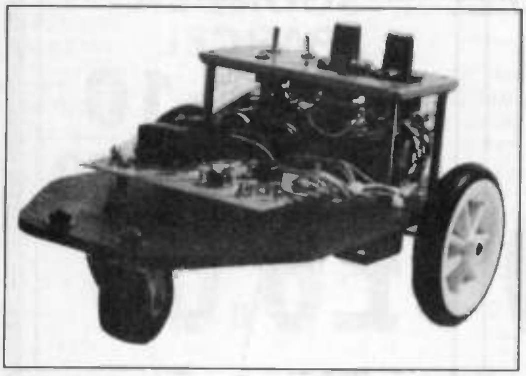
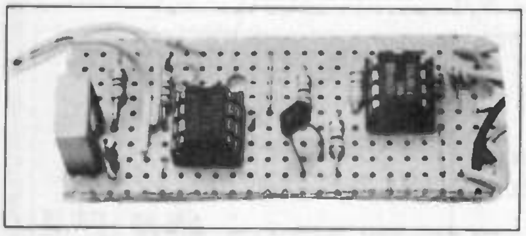
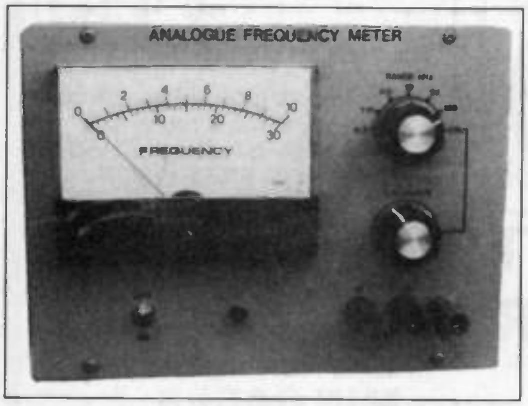
PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .









Our November '90 issue will be published on Friday, 5 October 1990. See page 627 for details.

Projects

Series

Features

FREE WITH THIS ISSUE

Marco Trading 1991 catalogue, banded to all copies

NEXT MONTH

THE EE MUSKETEER

"One for all and all for one"

A complete home entertainment controller in ONE handheld unit!

If you own a television set, video cassette recorder, midi hi-fi unit, graphic equaliser, satellite TV decoder etc., then you probably have a small arsenal of remote control units as well! What would you say to a single device which could replace up to four separate controllers whilst retaining all the commands of each one? The EE Musketeer will do this, so you only need one controller on the armchair.

FREE WITH THIS ISSUE OF EE

1990 GREENWELD ELECTRONIC COMPONENTS CATALOGUE

132 PAGES OF BARGAINS WORTH £1.50

A special FREE EASIWIRE offer is included for EE readers

IN-LINE DIMMER

As well as adding a touch of luxury, a dimmer saves energy and greatly extends the life of the bulb. This circuit acts as an in-line switch as fitted to many types of table lamp. Built in a small plastic box it provides full-power operation plus three levels of dimming using two rocker switches. The In-Line Dimmer may be used to control all filament bulbs up to 250 watts rating used on a.c. mains supplies.

CYCLE REAR LIGHT MONITOR

Riding a bicycle at night is a hazard especially if the lights are not working properly. This circuit monitors the efficiency of the rear light and signals the rider with a pulsed high-pitched tone if a fault develops.

EVERYDAY ELECTRONICS

NOVEMBER ISSUE ON SALE FRIDAY 5TH OCTOBER 1990

ELV

Technik für Kenner - Made in Germany

We deliver from stock - The fastest way to order is a fax !

ULTRASONIC CAR ALARM

This system is specially designed to protect your car and its contents against potential thiefs. Low current consumption and high noise immunity are just two of its distinguishing features.

Complete kit including case
44.367BKL .... £ 30.40

In addition the system has a voltage sensing device i.e. the alarm is also triggered if appliances are switched on by an unauthorised person (e.g. the interior lighting when the door is opened).

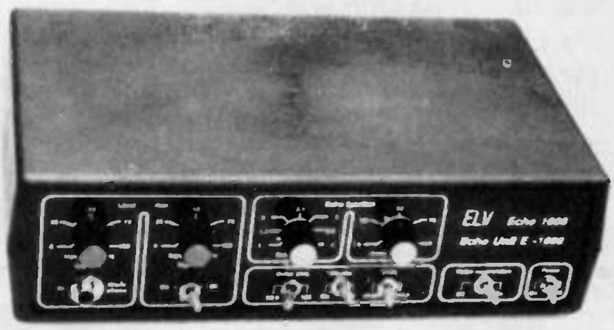
DIGITAL PROFESSIONAL ECHO 1000

(Elektor Electronics June 89)

This low cost echo unit is certain to impress music lovers - amateur and professional - everywhere. Excellent specification and top performance make the EU 1000 a winner and despite meeting professional requirements the unit will not make too big a hole in your pocket.
Working on the delta modulation principle on a digital base, delay times up to one second are possible at full bandwidth and large signal to noise ratio.

Complete kit
44.255BKL .... £ 99.50

Ready assembled module
44.255F .... £ 134.50



Specification

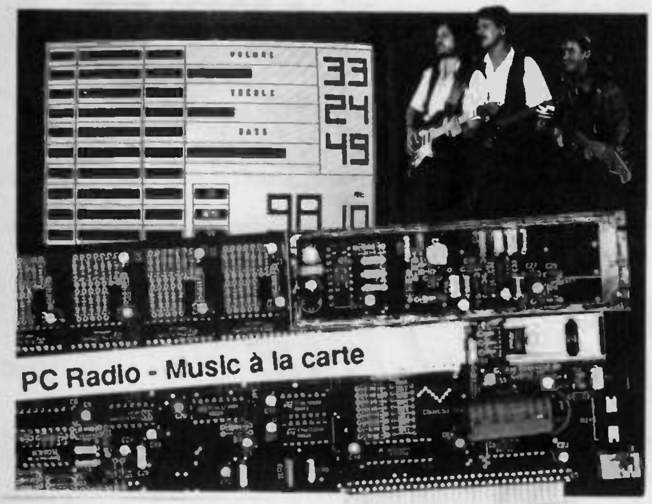
Input sensitivity:
Input 1 : 2 mV
Input 2 : 200 mV

Dealy Time:
variable from 60 ms to 1 s

Bandwidth :
100 Hz to 12 kHz

Additional features:
- inputs mixable
- single and multiple echo
- adjustable delay level
- switchable vibrator
- switch-controlled noise suppression

PC Radio (Elektor Electronics Febuary 1990)



This FM radio consists of an insertion card for IBM PC-XTs, ATs and compatibles and is available as a kit or a ready-built and aligned unit. The radio has an on-board AF power amplifier for driving a loudspeaker or a headphone set, and is powered by the computer. A menu-driven program is supplied to control the radio settings.

Complete kit
44.544BKL .... £ 82.75

Ready assembled module
44.544F .... £ 137.30

VM 1000 Video-Modulator (Elektor Electronics March 90)

Many inexpensive or older TV sets lack a SCART or other composite video input, and can only be connected to a video recorder or other equipment via an RF modulator. The modulator operates at a UHF TV channel between 30 and 40. Use is made of a single-chip RF modulator that couples low cost to excellent sound and picture quality.

Complete kit
44.546BKL .... £ 36.90

Ordering and payment:

- all prices excluding V.A.T. (french customers add 18.6%T.V.A.)
- send Euro-cheque, Bank Draft or Visa card number with order. Please add £ 3.00 for p & p (up to 2 kg total weight)
- postage charged at cost at higher weight Air/Surface -
- we deliver worldwide except USA and Canada
- dealer inquiries welcome

RFK 700
RGB-CVBS Converter

(Elektor Electronics October 89)

Nearly all computers supply as an output signal for colour monitors RGB signals. With the help of the RFK 7000 it is possible to record this signals with a videorecorder or to give them onto a colour TV (This is only possible, if the computer delivers a vertical sync. of 50 Hz and a horizontal sync. of 15.625 Hz).
The voltage supply is gained from a 12V/300mA-DC voltage mains adaptor.

Complete kit
44.525BKL .... £ 66.50

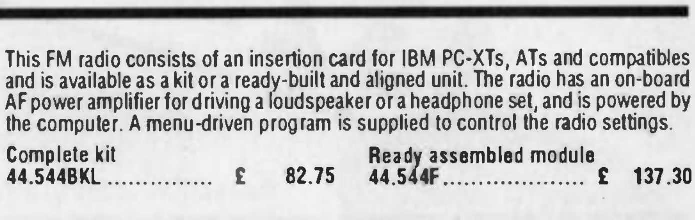
Ready assembled module
44.525F .... £ 119.50

FRK 7000
CVBS-RGB Converter

With the help of the FRK 7000 e.g. it is possible to use a cheap clour monitor with RGB input on a video recorder.
The voltage supply is gained from a 12V/300mA-DC voltage mains adaptor.

Complete kit
44.509BKL .... £ 66.50

Ready assembled module
44.509F .... £ 119.50



ELV France - B.P. 40 - F-57480 SIERCK-LES-BAINS - France - Tel.: (33) 82.83.72.13 - Fax: (33) 82.83.81.80

Technik für Kenner - Made in Germany ELV

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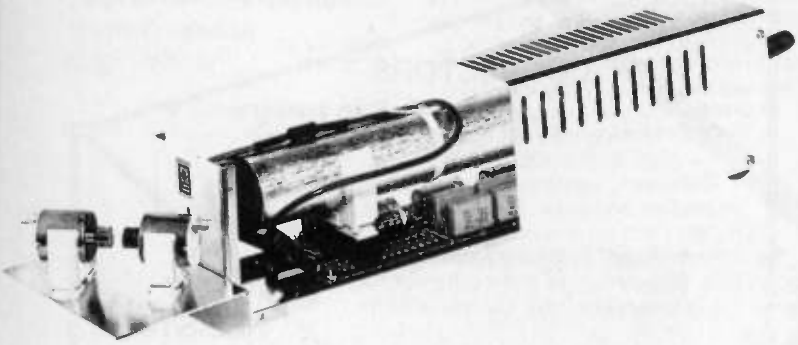
LPS 8000 / LC 7000 Low Cost Show Laser

(Electronics The Maplin Magazine Dec 88 + Feb-Mar 90)



An almost infinite number of circular patterns can be projected onto a wall or ceiling with this super laser show equipment.
The complete project includes a laser tube and accompanying power supply, housed in a metal case, and a laser controller, LC 7000. The laser controller drives the accompanying deflection unit, fixed onto the laser power supply case, which produces the numerous configurations.
Naturally the laser tube, together with the power supply, can produce beams without the laser controller and the controller can be used with other, similar lasers.

LPS 8000 Laser Power Supply, complete kit
Version 240 Volts AC
44.428BKL220 .... £ 86.90
Version 220 Volts AC
44.428BKL240 .... £ 86.90

LPS 8000 Laser Power Supply, ready assembled module
Version 240 Volts AC
44.428F240 .... £ 156.50
Version 220 Volts AC
44.428F220 .... £ 156.50

LC 7000 Laser Controller, complete kit
Version 12 Volts DC
44.427BKL .... £ 60.80

LC 7000 Laser Controller, ready assembled module
Version 12 Volts DC
44.427F .... £ 104.30

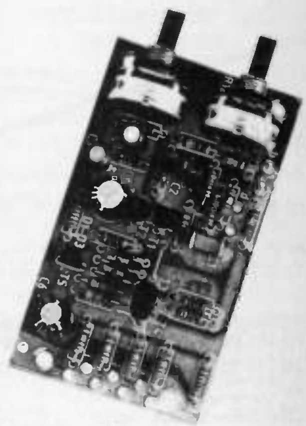
H-N Laser Tube 2 mW
44.428LR .... £ 60.80

Laser Motor-Mirror Set, complete kit
44.506M .... £ 22.95

VIDEO RECORDING AMPLIFIER

(Elektor Electronics April 89)

Losses can easily occur when copying video tapes resulting in a distinct reduction in quality. By using this video recording amplifier, with no less than four (!) outputs, the modulation range is enlarged and the contrast range of the copy increases.
Two level controllers for edge definition (contour) and amplification (contrast range) allow individual and precise adaptation.

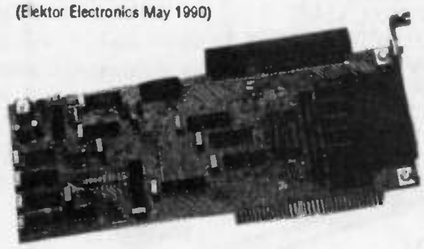


Complete Kit
(including Box, PCB and all parts
44.324BKL .... £ 14.75

IBM PC Service Card

(Elektor Electronics May 1990)

This card was developed for assistance in the field of service, development and test. The card is used as a bus-extension to reach the measurement points very easy. It is also possible to change cards without having a "hanging computer".



Complete kit
44.517BKL .... £ 77.95

Ready assembled module
44.517F .... £ 137.95

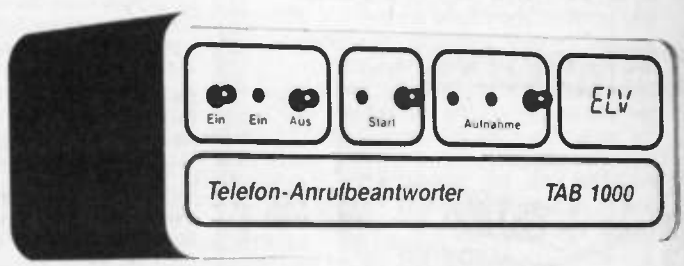
TA 1000 Telephone Answering Unit

(Elektor Electronics January 1990)

This automatical telephone answering unit uses a 256-kbit voice recording circuit to store and replay your spoken message of uo to 15 seconds. Noteworthy features are that it is available as a complete kit, providesd a battery backup facility and does not require alignment. No provision is made, however, to record incoming calls.

Complete kit
44.433BKL .... £ 45.65

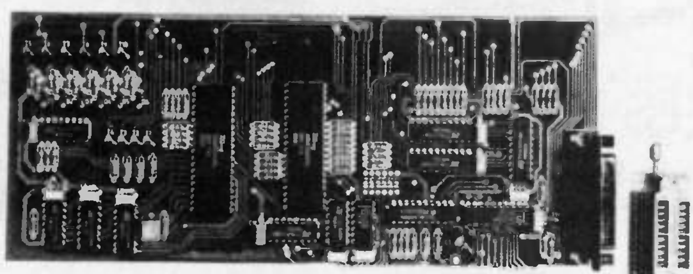
Ready assembled module
44.433F .... £ 87.25



IC TESTER for IBM-PC-XT/AT

(Electronics The Maplin Magazine Jun-Jul 89 +
Elektor Electronics December 89)

With the ELV IC tester logic function tests can be carried out on nearly all CMOS and TTL standard components, accommodated in DIL packages up to 20 pin. The tester is designed as an insertion card for IBM-PC-XT/AT and compatibles. A small ZIF test socket PCB is connected via a flat band cable. Over 500 standard components can be tested using the accompanying comprehensive test software.



Complete Kit Including Textool sokket, connectors, sockets, Flat band cable, PCB, Software
44.474BKL .... £ 60.85

Ready Assembled Module
4.474F .... £ 113.00

Software, single
44.474SW .... £ 17.85

ELV France - B.P. 40 - F-57480 SIERCK-LES-BAINS - France - Tel.: (33) 82.83.72.13 - Fax: (33) 82.83.81.80

RTVC HAVE DONE IT AGAIN!

We have secured all stocks of nearly new factory refurbished car stereos, manufacturer approved, at unrepeatable prices. We also offer a 6 month guarantee with all units (this only applies to products marked ★ on this page

Alba digital auto reverse push button AM/FM / LW car stereo with separate bass/treble control APPSS on tape. 25 watts per channel output, with line output for car components use.

★£79.40 + £2.30 pp

Sparkomatic Phoenix Digital auto reverse AM/FM/LW car stereo, with tape volume and balance control. 9 watts output per channel

★£52.40 + £2.80 pp

Sparkomatic Auto reverse AM/FM car stereo with tone, volume and balance control

★£44.20 + £2.80 pp

IN-CAR STEREO BOOSTERS

In-Car Stereo Hi-power booster ampifiers. 300W output. 150W x 2 inputs for low power car stereos and phono inputs short circuit protection

£94.95 + £2 pp

150W output 75 x 2 inputs as above

£43.00 + £2.00 pp

IN CAR WOOFERS

6½" 40W Nominal, 60W Max, 4 ohm Goodmans woofer. **£9.95** + £1.90 pp

8" 60W Nom. 90W Max, 4-5 ohm Richard Allen woofer **£33.80** + £3.50 pp

10" 100W Nom. 150W Max 4-5, ohm Richard Allen woofer **£41.50** + £3.50 pp

12" 100W Nom. 250W Max, 4-5 ohm Richard Allen woofer **£43.50** + £4 pp

15" 100W Nom. 250W Max, 4-5 ohm Richard Allen woofer **£79.35** + £5 pp

TWEETERS AND MID RANGE FOR IN-CAR USE

4½" 100W 4-5 ohm sealed back mid range. Goodman **£5.50** + £1.50 pp

2¼" 65W 4-5 ohm Ferro fluid cooled dome tweeter with housing. Audax **£5.00** + £1.20 pp

3½" 100W 8 ohm Ferro fluid cooled dome tweeter for 4-8 ohm use **£8.95** + £1.20 pp

ACOUSTIC REAR PARCEL SHELF

To get the best sound from your car woofers, replace your rear hatchback parcel shelf with one of these 18mm thick fibreboard units, tailor made for your car, supplied with grille cloth and fixings. When ordering please state make, model, and year of reg. **£39.80** + £6 pp

ROSS PUSH BUTTON RADIO

Mains and battery operated.
High quality VHF/FM,
Medium and Long Wave reception.
6 pushbutton selected preset stations
Fully retractable telescopic aerial.
Headphone/earphone jack socket.
Size 230H x 150W x 65D
Ref RE-5500
Brand new.
Listed price over £30.00

£14.95 + £2.80 pp

MAIL ORDER £1 BARGAIN PACKS BUY 20 GET 1 FREE

Please state pack(s) required

No.	Qty. per pack	
BP015B	1	30W dome tweeter. Size 90×66mil *JAPAN made*
BP016	6	2200µf can type Electrolytic 25V d.c. computer grade *made in UK by PHILIPS*
BP017	3	33000µf 16V d.c. electrolytic high quality computer grade *UK made*
BP019	20	20 ceramic trimmers
BP020	4	Tuning capacitors, 2 gang dielectric a.m. type
BP021	10	3 position, 8 tag slide switch 3 amp rated 125V a.c. *made in USA*
BP022	5	Push-button switches, push on push off, 2 pole change over. PC mount *JAPAN made*
BP023	6	2 pole 2 way rotary switch
BP024	2	Right angle, PCB mounting rotary switch, 4 pole, 3 way rotary switch *UK made by LORLIN*
BP025	4	3 pole, 3 way miniature rotary switch with one extra position off (open frame YAXLEY type)
BP026	4	4 pole, 2 way rotary switch *UK made by LORLIN*
BP027	30	Mixed control knobs
BP029	6	Stereo rotary potentiometers
BP030	2	10k wire wound double precision potentiometers *UK made*
BP031	6	Single 100k multitune pots, ideal for varicap tuners *UK made by PHILIPS*
BP032	4	UHF varicap tuner heads, unboxed and untested *UK made by PHILIPS*
BP033	2	FM stereo decoder modules with diagram *UK made by PHILIPS*
BP033A	4	6"×⅜" High grade Ferrite rod. *UK made*
BP034	3	AM IF modules with diagram *PHILIPS UK made*
BP034A	2	AM-FM tuner head modules. *UK made by Mullard*
BP034B	1	Hi-Fi stereo pre-amp module inputs for CD, tuner tape, magnetic cartridge with diagram. *UK made by MULLARD*
BP035	6	All metal co-axial aerial plugs
BP036	6	Fuse holders, panel mounting 20mm type
BP037	6	In line fuse holders 20mm type *UK made by BULGIN*
BP038	20	5 pin din, 180° chassis socket
BP039	6	Double phono sockets, Paxolin mounted
BP041	3	2.8m lengths of 3 core 5 amp mains flex
BP042	2	Large VU meters *JAPAN made*
BP043	30	4V miniature bulbs, wire ended, new untested
BP044	2	Sonotone stereo crystal cartridge with 78 and LP styli *JAPAN made*
BP045A	2	Mono Cassette Record and play heads
BP046A	2	606 Mains transformers, PCB mounting. Size 42×33×35
BP047	1	24V 0.3VA mains power supply. Brand new boxed *UK made by MULLARD*
BP047A	1	25V DC 150mA mains adaptor in black plastic case with flying input and output leads new units made for famous sound mixer manufacturer. Size 80×55×47
BP049	10	OC44 transistors. Remove paint from top and it becomes a photo-electric cell (ORP 12) *UK made by MULLARD*
BP050	30	Low signal transistors n.p.n., p.n.p. types
BP051	6	14 watt output transistors. 3 complimentary pairs in T066 case *(Ideal replacement for AD161 and 162s)*
BP052A	1	Tape deck pre-amp IC with record/replay switching No LM1818 with diagram
BP053	5	5 watt audio ICs. No TBA800 *(ATEZ)*
BP054	10	Motor speed control ICs, as used with most cassette and record player motors
BP055	1	Digital DVM meter I.C. *made by PLESSEY* as used by *THANDAR* with diaoram
BP056	4	7 segment 0.3 LED display (red)
BP057	8	Bridge rectifiers, 1 amp, 24V
BP058	200	Assorted carbon resistors
BP059	1	Power supply PCB with 30V 4V/A transformer. MC7818CT IC & bridge rectifier: Size 4"×2¾"
BP061	5	6.35mm Mono jack plugs
BP063	5	6.35mm stereo switched jack sockets
BP064	12	Coax chassis mount sockets
BP065	1	3mtr Euro-mains lead with chassis socket

MULTIBAND RADIO

VHF 54-176 MHz + AM CB BANDS 1-80
Listen to: AIR TRAFFIC CONTROL, AIRCRAFT, RADAR PUBLIC UTILITIES RADIO AMATEURS AND MANY MANY MORE
SQUELCH CONTROL
"RUBBER DUCK AERIAL"

£17.95 POSTAGE £2.85

HAND HELD WALKIE TALKIES

Ideal for sports or any outdoor activities. Built-in call button and separate volume control. Range 1.2km maximum. 49MHz crystal control superhet circuit with built-in condenser mic. and speaker. Unit supplied with vinyl carrying case and personal earphone.

£32.90 a pair + £2.60 P&P

RADIO AND TV COMPONENTS ACTON LTD
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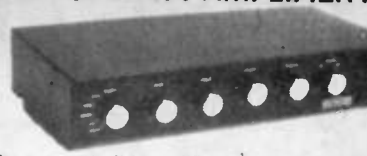
30+30 WATT AMPLIFIER KIT



An easy to build amplifier with a good specification. All the components are mounted on the single P.C.B. which is already punched and backprinted.

- 30W×2 (DIN 4 ohm)
- CD/Aux, tape I, tape II, tuner and phono inputs.
- Separate treble and bass
- Headphone jack

Size (H.W.D.) 75×400×195mm
Kit enclosed: case, P.C.B., all components, scale and knobs £36.80. post £3.50
(Featured project in *Everyday Electronics* April 1989 issue). Reprint Free with kit.

AMPHONIC 125+125 POWER AMPLIFIER

125 watt per channel stereo power amplifier with independent volume controls, professional 19" rack mount and silent running cooling fan for extra reliability.

Output power	125W RMS max. per channel
Output impedance	4 to 16 ohms (max. power into 4 ohms)
Sensitivity	450V at 22K ohms
Protection	Electronic short-circuit and fuses
Power	220-240V a.c. 50Hz
Chassis dim	435×125×280mm

£142 + £7.00 p&p

STEREO MIXER

5-channel stereo disco mixer in racking case which can handle up to a total of 10 phono, line and mic inputs, switchable on front panel. Twin 5-band graphic equalizer with insert/bypass switch. Cross fader between channels 1 and 2. Mic channel with low Cut filter and talkover switch. Separate L and R master controls. Output for amp, tape and headphones.

Input Mic	0.3mV 600 ohms
Phono	2.5mV 50K ohms
Outputs: Amp & Tape	1.2V
Headphone	50mV @ 75 ohms
Equalizer control frequencies	60, 250, 1k, 3.5k, 12kHz
Equalizer control range	±12dB boost or cut
Size	350 x 280 x 90mm

£118.90 + £5.80 P&P

BELT-DRIVE QUICKSTART VARISPEED DISCO TURNTABLE

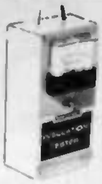
- ★ Quick start ideal for scratching
- ★ Pitch control
- ★ Pop-up target lamp
- ★ Strobe lamp
- ★ Counterweighted tubular tone arm with plug-in headshell
- ★ Full manual control
- ★ Remote start/stop
- ★ 7.5kg

£112.00 + £7.00 P&P

28.0.28V 4 AMP MAINS TRANSFORMERS

With a 5.5V at 0.5A mains input 110-240. Size 90 x 105 x 75 fitted with copper screening band; made for famous HIFI Co. £6.50 each. Postage £2.80. It's weight is 2.7Kg! Brand new and unused condition.

INSULATION TESTER



EE APRIL 85

A reliable electronic tester which checks insulation resistance of wiring 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. One of our own designs and extremely popular.

KIT REF 444

£21.89

PET SCARER

EE MAY 89

Produces high power ultrasound pulses. L.E.D. flashes to indicate power output and level. Battery powered (9V–12V or via Mains Adaptor).

KIT REF 812

Mains Adaptor £1.98

£14.49

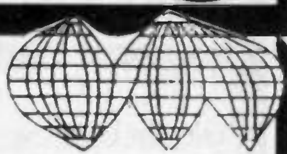
DIGITAL CAPACITANCE METER

EE DEC 85

Simple and accurate (1%) measurement of capacitors from a few pF up to 1,000 μF. Clear 5-digit LED display indicates exact value. Three ranges – pF, nF, and μF. Just connect the capacitor, press the button and read the value.

KIT REF 493

£46.46



3 BAND SHORT WAVE RADIO

EE AUG 87

Covers 1.6–30 MHz in 3 bands using modern miniature coils. Audio output is via a built-in loudspeaker. Advanced design gives excellent stability, sensitivity and selectivity. Simple to build.

KIT REF 718

£29.66

DIGITAL FREQUENCY 200 MHz METER

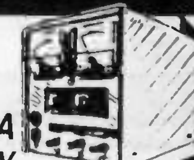
EE NOV 86

An 8 digit meter reading from AF up to 200 MHz in two ranges. Large 0.5" Red LED display. Ideal for AF and RF measurements. Amateur and C.B. frequencies.

KIT REF 563

£69.95

MOSFET VARIABLE BENCH 25V 2.5A POWER SUPPLY



EE FEB 88

A superb design giving 0.25V and 0-2.5A. Twin panel meters indicate Voltage and Current. Voltage is variable from zero to 25V. A Toroidal transformer MOSFET power output device, and Quad op-amp IC design give excellent performance.

KIT REF 769

£55.61

MINI STROBE

EE MAY '86

A hand held stroboscope which uses 6 "ultra bright" LEDs as the light source. Designed to demonstrate the principles of stroboscope examination, the unit is also suitable for measuring the speed of moving shafts etc. The flash rate control covers 170–20,000 RPM in two ranges.

KIT REF 529

£15.50

ACOUSTIC PROBE

EE NOV '87

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 nosey parkers!

KIT REF 740

£19.58

4 CHANNEL LIGHT CHASER

EE Jan '90

A 1000W per channel chaser with zero volt switching, hard drive, inductive load capability, mic sound sensor and sophisticated 'beat' detector. Chase steps to music or auto when quiet. Variable speed and mic. sens. LED mimic on front panel. Switchable for 3 or 4 channels. P552 output. Ideal for rope lights, pin spots, disco and display lighting.

KIT REF 833

£31.45

EE EQUALISER

EE MAY '87

A mains powered Ioniser with an output of negative ions that give a refreshing feeling to the surrounding atmosphere. Negligible current consumption and all-insulated construction ensure that the unit is safe and economical in use. Easy to build on a simple PCB.

KIT REF 707

£17.37

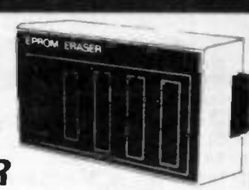
MUSICAL DOORBELL

EE JAN '86

This project uses a special I.C. pre-programmed with 25 tunes and 3 chimes. A Magenta design, the circuit is battery powered and only draws current whilst producing sounds. Two rotary switches select the tune required. Provision is made for three bell pushes, each of which sounds a different tune, so that three points of entry can be identified.

KIT REF 497

£20.95



EPROM ERASER

EE OCT '88

Safe low-cost unit capable of erasing up to four EPROM's simultaneously in less than twenty minutes. Operates from a 12V supply. Safety interlock. Convenient and simple to build and use.

KIT REF 790

£27.90

LIGHT RIDERS

EE OCT '86

Three projects under one title – all simulations of the Knight Rider lights from the TV series. The three are a lapel badge using six LEDs, a larger LED unit with 16 LEDs and a mains version capable of driving six main lamps totalling over 500 watts.

KIT REF 559 CHASER LIGHT	£15.25
KIT REF 560 DISCO LIGHTS	£21.93
KIT REF 561 LAPEL BADGE	£11.40

EE TREASURE HUNTER

EE AUG '89

A sensitive pulse induction Metal Detector. Picks up coins and rings etc., up to 20cms deep. Low "ground effect". Can be used with search-head underwater. Easy to use and build, kit includes search-head, handle, case, PCB and all parts as shown.

KIT REF 815 £41.95

Headphones £1.99

STEPPING MOTOR INTERFACE

EE AUG '85

This interface enables 4 phase unipolar stepping motors to be driven from four output lines of any computer user port. The circuit is especially suitable for the ID35 motor and our MD200 which are commonly used in buggies and robot arms. Supplied complete with ribbon cable and connector for the BBC user port.

KIT REF 464

£9.40

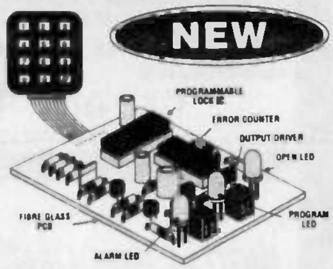
TK FOR KITS

GUARD DOG KIT

One of the best burglar deterrents is a guard dog and this kit provides the barking without the bite! Can be connected to a doorbell, pressure mat or any other intruder detector and produces random threatening barks. Includes mains supply and horn speaker.
XK125 £21.95

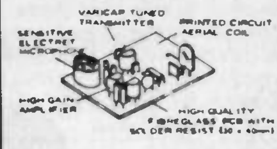
PROGRAMMABLE ELECTRONIC LOCK KIT

NEW



Keys could be a thing of the past with this new high security lock. Secure doors to sheds, garages, even your home or prevent the unauthorised use of computers, burglar alarms or cars. One 4–digit sequence will operate the lock while incorrect entries will sound an alarm. The number of incorrect entries allowed before the alarm is triggered is selected by you. Further entries will be ignored for a time also set by you. Only the correct sequence will open the lock and switch off the alarm. The sequence may easily be changed by entering a special number and code on the supplied keyboard. Kit includes; keyboard, alarm buzzer, high quality PCB and all electronic components. Supply 5–15V DC. Will drive our Latch Mechanism (701 150 @ £18.98) or relay directly.
XK131 **£19.95**

SUPER–SENSITIVE MICROBUG



Only 45x25x15mm, including built–in mic. 88–100MHz (standard FM radio). Range approx. 300m depending on terrain. Powered by 9V PP3 (7mA). Ideal for surveillance, baby alarm etc. **XK128** £6.35

DISCO LIGHTING KITS

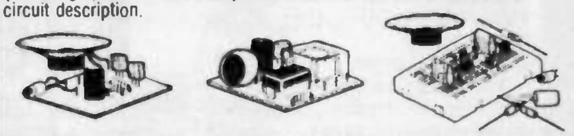
DL8000K 8–way sequencer kit with built–in opto–isolated sound to light input. Only requires a box and control knob to complete £39.95
DL1000K 4–way chaser features bi–directional sequence and dimming 1kW per channel .. £23.95
DLA/1 (for DZ1000K) Optional op-to input allowing audio beat/light response 95p
DL3000K 3–channel sound to light kit, zero voltage switching, automatic level control and built–in mic. 1kW per channel £19.55
XK139 Uni-directional chaser. Zero switching and built-in audio input £12.95

POWER STROBE KIT

Produces an intense light pulse at a variable frequency of 1 to 15Hz. Includes high quality PCB, components, connectors, 5Ws strobe tube and assembly instructions. Supply: 240V ac. Size: 80x50x45.
XK124 STROBOSCOPE KIT. £17.25

SIMPLE KITS FOR BEGINNERS

Especially aimed at the beginner. Have fun with your project even after you have built it and also learn a little from building it. These kits include high quality solder resist printed circuit boards, all electronic components (including speaker where used) and full construction instructions with circuit description.



SK1 DOOR CHIME plays a tune when activated by a pushbutton £4.50

SK2 WHISTLE SWITCH switches a relay on and off in response to whistle command £4.50

SK3 SOUND GENERATOR produces FOUR different sounds, including police/ambulance/fire–engine siren and machine gun £4.50

XK118 TEN EXCITING PROJECTS FOR BEGINNERS this kit contains a solderless breadboard, components and a booklet with instructions to enable the absolute novice to build ten fascinating projects including a light operated switch, intercom, burglar alarm and electronic lock. Each project includes a circuit diagram, description of operation and an easy to follow layout diagram. A section component identification and function is included, enabling the beginner to build the circuits with confidence £17.25

NEW

REMOTE CONTROL DIMMER KIT

Imagine controlling the brightness of your lights or switching them on or off from the comfort of your armchair! This kit contains all the components from front panel to the last screw to enable you to do just that and fit the shallowest wall boxes. Max power 300W (not fluorescents).
XK132 .... £19.95

IR TRANSMITTER KIT

Designed for use with the XK132 and comes complete with a pre drilled box. A PP3 9 volt battery is required.
MK 6 .... £4.95

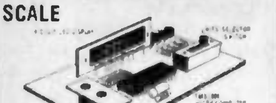
XK136 TOUCH DIMMER KIT £12.95

VERSATILE REMOTE CONTROL SYSTEM

These kits can switch up to 16 pieces of equipment on and off or control 16 functions depending on the keyboard selected for the MK18 transmitter. MK12 receiver has 16 logic outputs and operates from 12 to 24V d.c. or 240V a.c. via the transformer supplied. The MK18 requires a 9V battery and keyboard. Great for controlling lights, TVs, garage doors etc.

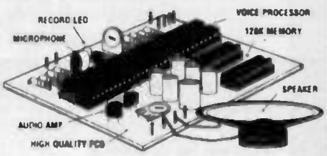
MK12 IR Receiver	£19.55
MK18 Transmitter	£8.95
MK 9 4-way Keyboard	£2.75
MK10 16-way Keyboard	£7.95
601 133 Box for transmitter	£2.95

ELECTRONIC WEIGHING SCALE



Kit contains a single chip microprocessor. PCB, displays and all electronics to produce a digital LED readout of weight in Kgs or Sts/Lbs. A PCB link selects the scale-bathroom/two types of kitchen scales. A low cost digital ruler could also be made.
ES1 £8.25

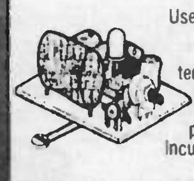
VOICE RECORD/ PLAYBACK KIT



This simple to construct and even simpler to operate kit will record and playback short messages or tunes. It has many uses – seatbelt or light reminder in the car, welcome messages to visitors at home or at work, warning messages in factories and public places. In fact anywhere where a spoken message is announced and which needs to be changed from time to time. Also suitable for toys – why not convert your daughter's £8 doll to an £80 taking doll!!

Size .... 76 x 60 x 15mm
Message time .... 1–5 secs normal speed, 2–10 secs slow speed
XK129 £25.95

PROPORTIONAL TEMPERATURE CONTROLLER KIT



Uses "burst fire" technique to maintain temperature to within 0.5°C. Ideal for photography, incubators, wine making, etc. Maximum load 3kW (240V AC). Temperature range up to 60°C. Size 50x40x25mm. **XK140** £8.95

TK ELECTRONICS

TK ELECTRONICS
13 Boston Road
London W7 3SJ
Tel: 081-579 9794
Fax: 081-566 1916

ORDERING INFORMATION All prices INCLUDE VAT. Free P & P on orders over £60 (UK only), otherwise add £1.15. Overseas Customers divide total order by 1.15 then add P & P: Europe £3.50, elsewhere £10.00. Send cheque/PO/Visa/Access No. with order. Giro No. 529314002. Local Authority and educational institutions orders welcome. Shop Open: Tuesday–Thursday 10 am – 5 pm. Saturday 10 am – 4 pm.

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EVERYDAY ELECTRONICS

INCORPORATING ELECTRONICS MONTHLY

The Magazine for Electronic & Computer Projects

VOL. 19 No. 10 October '90

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DESIGN

With our popular *Micro In Control* series coming to an end next month, it is time to look at what will follow. We are often asked to tell readers how to design an XYZ for their next project, as many readers are aware it is not quite that simple! However, our new *Circuit Design Teach-In* series starting in the December issue, will do just that. The series has been written for us by Mike Tooley, who should be well known to most readers, and Mike's words describe the series very well:

"This ten part series is designed for the beginner. It not only aims to dispel some of the perceived mystery of electronic circuits but it also shows how even the relative newcomer to electronics can, with the right approach, design and realise quite complex circuits.

Each part will incorporate a design problem together with a complete practical project. The practical project will stand on its own and thus may appeal to those who may not necessarily be following the series, whilst the design problem has been designed to give readers some scope for experimentation.

The series will employ an absolute minimum of mathematics. Futhermore, the traditional analytical approach (based on circuit theorems) will largely be replaced by experiential learning. The overall aim being that of fostering an intuitive approach."

TEACH-IN FOUR

While on the subject of Teach-Ins our new publication *Teach-In No. 4. Introducing Digital Electronics*, will be on sale on 21st September so watch out for that too. It is a complete course for City & Guilds 726/301 (Introductory Digital Electronics) and will be invaluable to anyone taking up the hobby or getting involved in study for C&G or other qualifications, including G.C.S.E. courses.

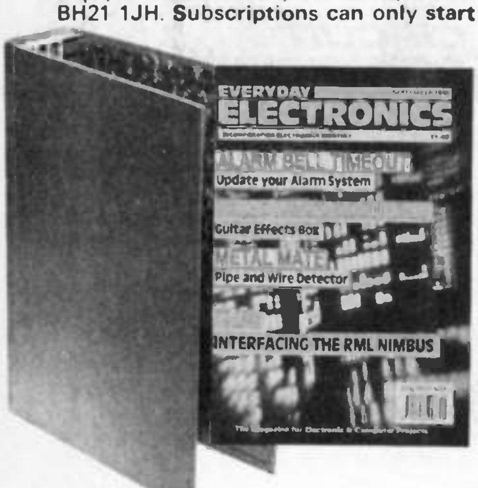
PRICE

No doubt you will have noticed that from this issue EE will cost you £1.50. It has been 18 months since our last price rise and our costs – particularly paper prices – continue to rise. I believe EE is no more expensive than any of our rivals (cheaper than some) and still offers the best value for money of any of the monthly electronic hobby magazines. **You can avoid this price rise for a year if you are quick!** See page 667.

Mike Kenward

SUBSCRIPTIONS

Annual subscriptions for delivery direct to any address in the UK: £16.00. Overseas: £19.50 (£37 airmail). Cheques or bank drafts **(in £ sterling only)** payable to Everyday Electronics and sent to EE Subscriptions Dept., 6 Church Street, Wimborne, Dorset BH21 1JH. **Subscriptions can only start with the next available issue.** For back numbers see below.



BACK ISSUES

Certain back issues of EVERYDAY ELECTRONICS are available price £1.50 (£2.00 overseas surface mail) – **£ sterling only please** – inclusive of postage and packing per copy. Enquiries with remittance, made payable to Everyday Electronics, should be sent to Post Sales Department, Everyday Electronics, 6 Church Street, Wimborne, Dorset BH21 1JH. 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 Sept., Oct. & Dec. 85, April, May, Oct. & Dec. 86, Jan., April, May & Nov. 87, Jan., March, April, June & Oct. 88, & March 90.**

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Binders to hold one volume (12 issues) are available from the above address for £4.95 (£6.95 to European countries and £9.00 to other countries, surface mail) inclusive of post and packing. *Normally sent within seven days but please allow 28 days for delivery.* **Payment in £ sterling only please.**

READERS' ENQUIRIES

We are unable to offer any advice on the use, purchase, repair or modification of commercial equipment or the incorporation or modification of designs published in the magazine. We regret that we cannot provide data or answer queries on articles or projects that are more than five years old. Letters requiring a personal reply must be accompanied by a **stamped self-addressed envelope or a self addressed envelope and international reply coupons.**

All reasonable precautions are taken to ensure that the advice and data given to readers is reliable. We cannot however guarantee it and we cannot accept legal responsibility for it.

COMPONENT SUPPLIES

We do not supply electronic components or kits for building the projects featured, these can be supplied by advertisers.

We advise readers to check that all parts are still available before commencing any project in a back-dated issue.

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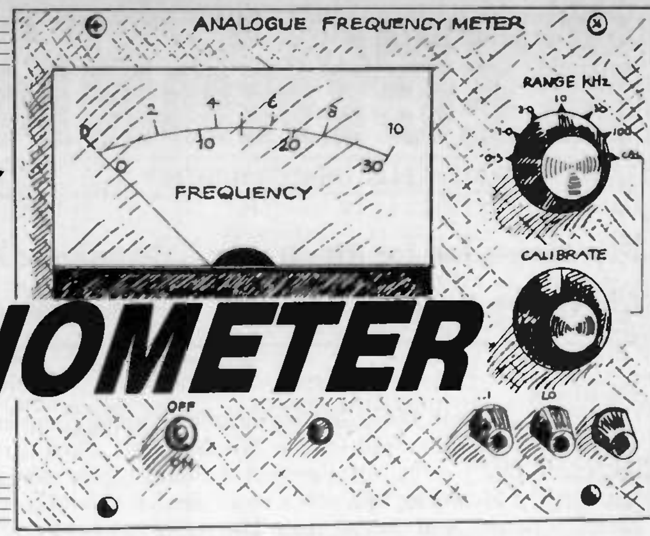
Constructional Project



FREQUENCY METER/TACHOMETER

STEVE KNIGHT

A straightforward, inexpensive but accurate frequency meter. Measures from 10Hz to 100kHz.

A SHORT while ago a colleague who operated a small engineering plant, knowing I dabbled in things electronic, asked me if I could make up for him a box of tricks (as he put it) which would measure the speed of rotating shafts. The design criteria, apart from a reasonable accuracy, simplicity of operation and cheapness, being that no mechanical contact was to be made to any of the shafting under investigation, neither was any mechanical switching to be involved.

Well, a few weeks work produced a unit which did the job adequately and had an accuracy of well within one per cent. What turned up was basically a photodiode sensor with a self-contained light source, which illuminated and then detected by reflection the passage of black and white stripes painted on to part of the shafting being looked at.

This gave a square wave output corresponding to the transitions between the light and dark areas on the shaft. The output was then fed into a simple frequency counter which provided a direct indication on the scale of an analogue meter, of the number of square wave cycles per second and hence (knowing the number of stripes painted on the shaft) the rotational speed of the shaft.

This original instrument had a single frequency measuring range of 1kHz and when used for the purpose for which it was designed, that is, a Tachometer, it was useful for measuring the speeds of rotating mechanisms well beyond 10,000 revolutions per minute.

On thinking this project over afterwards, it seemed logical that since the end effect was the measurement of frequency, then a design could be made up of two separate units: A Frequency Meter part, which could be extended in frequency to at least 100kHz to make it into a self-contained addition to the home experimenters' laboratory instruments. A useful optical sensor unit which could be used with the frequency meter to form a Tachometer, or used in its own right as a beam-break detector, or as a tape or punch card reader, to name just a couple of applications.

As such, either or both designs might be of interest to home constructors, so the extended and modified forms of both the original frequency meter (this month) and the optical Sensor/Tachometer will be described over the next two issues.

FREQUENCY MEASUREMENT

An analogue frequency meter may seem rather like a restricted or even antiquated piece of equipment in this age of digital devices but there is a maxim I have always followed over very many years in the electronics game: "*never make a thing more complicated than it has to be to do the work you want it to do.*"

That way, a lot of expense and frustration is avoided and egos are less likely to get dented. If a piece of equipment does a particular job, who cares whether there are just a couple of transistors inside the box or fifty integrated circuits?

So, although the Frequency Meter we are talking about here has an upper frequency limit of 100kHz (this can be extended by frequency division as it is in a digital meter) and an accuracy of two per cent, we mustn't dismiss it as old hat. What it does have, and this is important for most of us, is cheapness and simplicity and a usefulness in the fact that most home workshop measurements are needed over the audio range where an accuracy of one or two per cent is perfectly adequate. With an upper limit of, say, 100kHz, it will cover ninety-five per cent of everything a home experimenter gets up to.

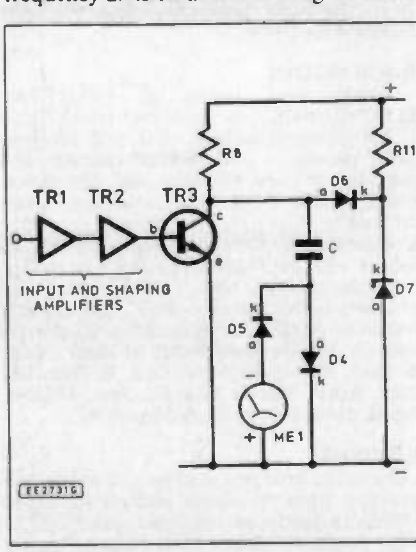


Fig. 1. Basic operation of the Frequency Meter.

This simple part of the project, which of course can be used in its own right, will give you a frequency measuring range from about 10Hz up to 100kHz with an accuracy, with care, of better than ± 2 per cent. With the meter scale being linear, the accuracy is unaffected by the input wave shape and input amplitudes down to 0.2V can be measured. There are six switched frequency ranges and a built-in calibration system which enables the circuit to be set up to the correct operating conditions every time it is used.

Protection is provided against excessive input levels and against d.c. voltages which might be inadvertently applied. The input "LO" terminal SK2 is also isolated from the case of the instrument (if a metal box is used) which is a useful feature in conditions where earthed input levels "ain't necessarily so".

The use of the frequency meter as a tachometer is accomplished by the attachment of the second unit which is a photodiode and light source, plus amplifier, and this will be discussed in due course.

CIRCUIT PRINCIPLES

The principle on which the Frequency Meter is based is shown in Fig. 1. The input waveform is first converted to a rectangular pulse train by a two-stage saturating amplifier.

This waveform is then used to switch transistor TR3 on and off on each of the alternate half cycles appearing at its base. For convenience, the component numbering is the same as that used in the full circuit diagram of Fig. 2. given later.

During the negative half cycle of input, TR3 is turned off and capacitor C charges by way of resistor R8 and diode D4. The cathode (k) of diode D6 is held at a reference potential determined by the

Zener diode D7 (9.1V) and any attempt by the collector of TR3 (and hence the potential on the upper plate of *C*) to rise above about 9.3V causes D6 to conduct and clamp the collector at that level. The capacitor consequently charges always to the same level irrespective of signal amplitudes elsewhere in the circuit.

On the following half cycle, TR3 switches hard on and capacitor *C* discharges through the transistor, diode D5 and the meter movement ME1. For a given value of *C*, the mean current through the meter will be a function of the extent to which *C* is discharged and this will be directly related to the input frequency. Hence the meter reading is proportional to frequency.

CIRCUIT DESCRIPTION

The complete circuit diagram of the Frequency Meter is given in Fig. 2. The input transistor TR1 is a junction-gate f.e.t. preceded by a voltage limiter. This arrangement provides a high input impedance to the instrument (of the order of one megohm) and overload protection.

Switch bank S1b merely keeps the positive terminal of the meter ME1 "earthed" for the six range positions selected on S1a and so provides the discharge path for the appropriate range capacitor as detailed in the notes to Fig. 1. On the seventh position however, the meter and a preset resistance, VR1, are switched across the Zener reference diode D7.

This preset is adjusted during setting-up to give full scale deflection of the meter which is then correctly calibrated for that reference level. This is necessary as Zener diodes themselves have a five per cent tolerance. Once set, this calibration is thereafter controlled from a front panel potentiometer VR2 and holds for all frequency ranges.

The power supply source is quite conventional. A bi-phase rectifier, diodes D8 and D9, provide a d.c. output of about 24V across reservoir capacitor C13 from a 15V-0-15V, 250mA miniature mains transformer, and this is further smoothed and filtered by resistor R12 and capacitor C12. Resistor R11 is the Zener protection resistor and transistors TR1 and TR2 are further decoupled by the R5, C3 combination.

PRINTED BOARD

All components except the meter, the range switch and the calibration control are mounted on a single printed circuit board which itself is screwed directly on to the rear of the meter, using the meter terminals as the fixing points. This board is available through the *EE PCB Service*, quote code EE704.

The board measures 137mm by 103mm (5³/₈in by 4in) and should preferably be of the fibreglass form as the mains transformer is also mounted on it. The brittle bakelite-based board can be used but is best avoided.

The component layout and full size copper foil master pattern is shown in Fig. 3. The two meter fixing holes at points M+ and M- suit the *specified* meter; if you use an alternative meter these positions may need to be adjusted accordingly.

You may have to adjust the hole positions to suit or, in the event of extreme variation, run two leads from the board to the meter and mount the board in some other fashion. A note should also be made of the polarity of the terminals of any alter-

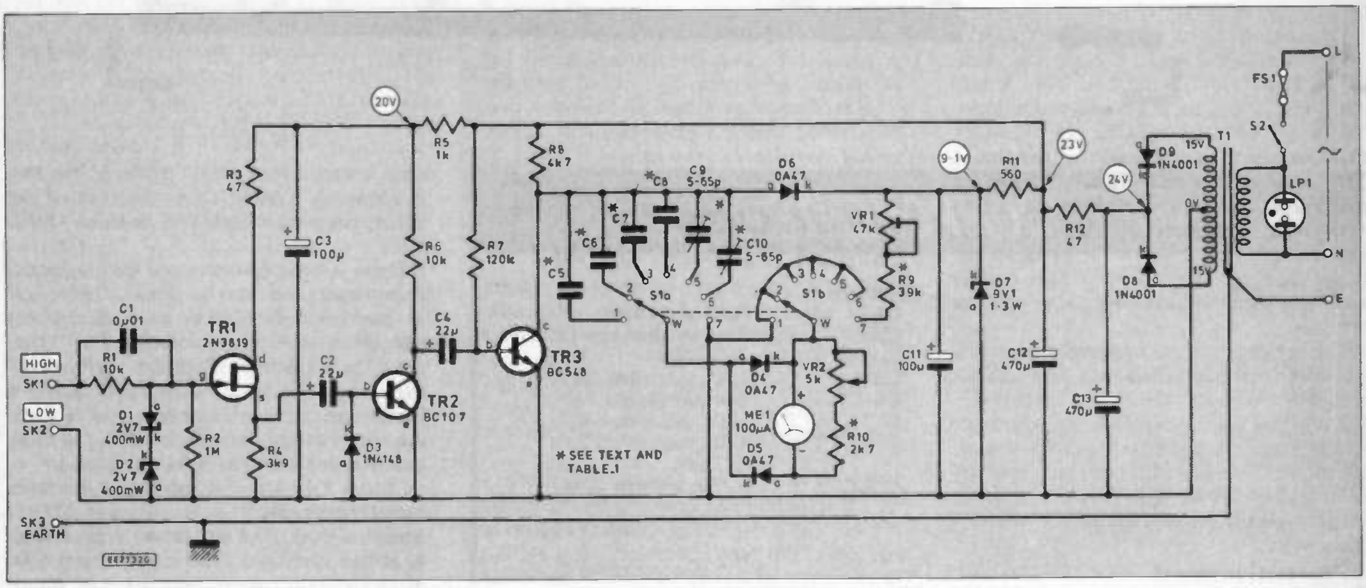
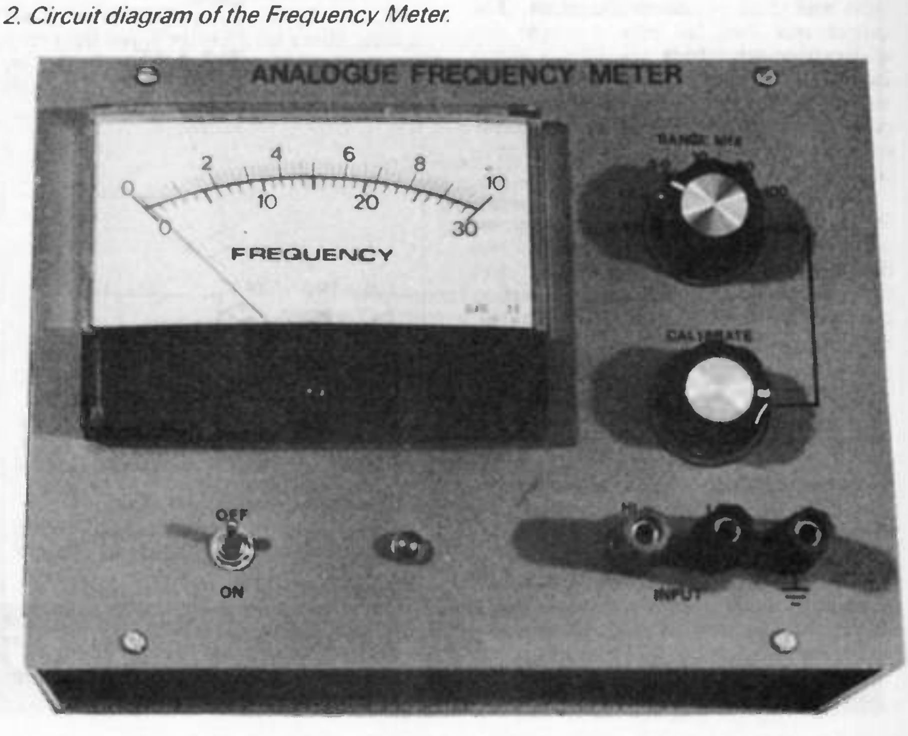


Fig. 2. Circuit diagram of the Frequency Meter.

The maximum amplitude of the signal applied to the gate of the f.e.t. is limited to about ±2.7V by the action of Zener diodes D1 and D2 together with resistor R1. If the signal exceeds this level in either polarity, the appropriate Zener will break down and the excess voltage will be developed across R1. Capacitor C1 provides some high frequency compensation.

The f.e.t. itself is used as a source follower and the output across the source load R4 is an in-phase version of the input signal. Transistor TR2 is a simple squaring amplifier whose output switches TR3 on and off in accordance with the description already given.

The charging capacitors for each of the six frequency ranges are selected by the switch bank S1a. These capacitors have to be highly stable and of close tolerance, and although shown as single components in the diagram, are mostly made up from two paralleled components. Capacitor C5, for example, is made up from a 39n and an 8n2, a total capacity of 47n2, while C10 is made up from 100p and a 5-65p trimmer. We will return to this matter in the alignment details later.



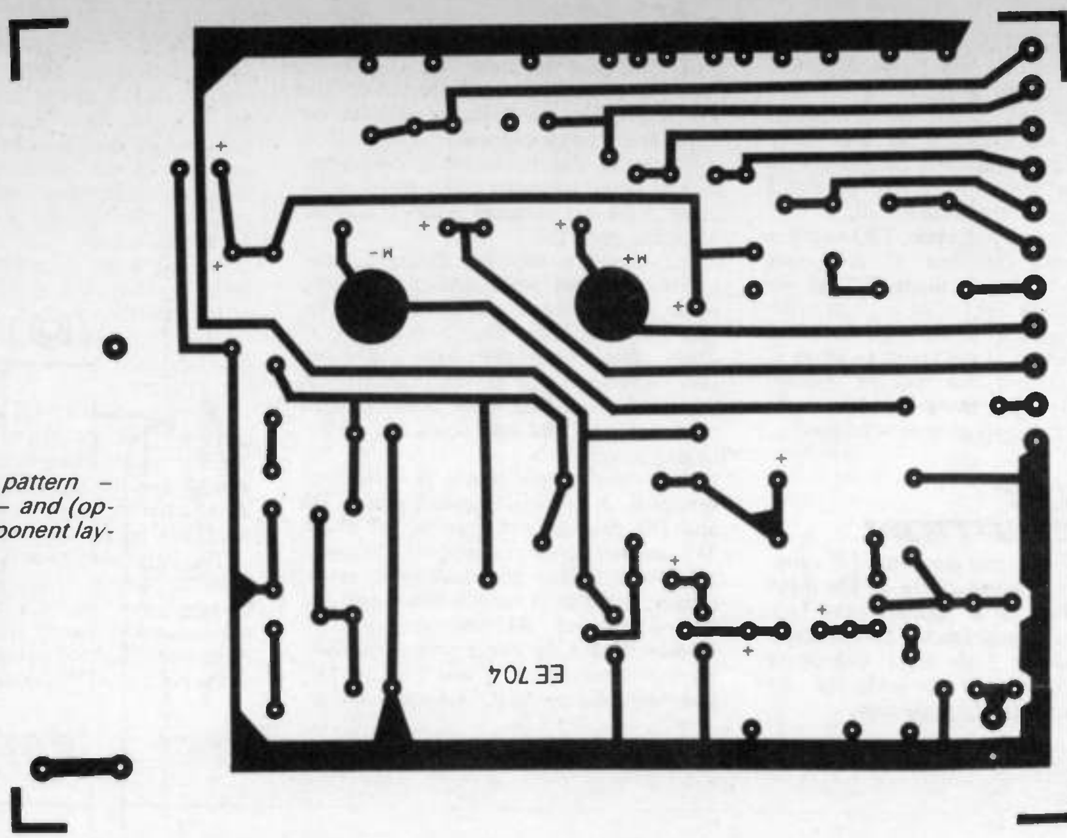


Fig. 3. P.C.B. pattern – shown full size – and (opposite) the component layout and wiring.

COMPONENTS

Resistors

R1, R6	10k (2 off)	
R2	1M	
R3, R12	47 (2 off)	
R4	3k9	
R5	1k	
R7	120k	
R8	4k7	
*R9	39k	
*R10	2k7	
R11	560	

All ½W 5% carbon or better

Capacitors

C1	0µ01 polyester
C2,C4	22µ tantalum bead 25V (2 off)
C3	100µ axial elec. 25V
*C5-C10	See text (Table. 1)
C11	100µ radial elec. 25V
C12,C13	470µ radial elec. 25V (2 off)
*C9,C10	5-65p trimmer (2 off)

Potentiometers

VR1	47k min. preset, horiz
VR2	5k rotary carbon, lin.

See SHOP TALK Page

Semiconductors

D1,D2	2.7V Zener, 400mW (2 off)
D3	1N4148 signal diode
D4,D5,D6	0A47 germanium diode (3 off)
D7	9.1V Zener, 1.3W
D8,D9	1N4001 1A 50V rec. diode (2 off)
TR1	2N3819 *n*-channel field effect transistor
TR2	BC107 *npn* silicon, signal
TR3	BC548 *npn* silicon, signal

Miscellaneous

ME1	100µA 4in. moving coil panel meter
S1	Two-pole 12-way wafer switch (2 wafers)
S2	Mains On/Off toggle or slide switch
T1	Mains 10VA min. transformer; 0V-15V, 0V-15V 330mA sec.
LP1	250V neon indicator lamp
FS1	500mA fuse, with panel mounting fuseholder

Printed circuit board available from *EE PCB Service*,code EE704; metal case, approx. 203mm x 152mm x 100mm (see text); 4mm screw/socket terminal (3 off – red, black, green); control knobs (2 off); mains cable; plastic sleeving; connecting wire; mains cable clamp/grommet; solder tags (4 off); solder; nuts, bolts and washers etc.

*Resistors R9 and R10 may need modification if an alternative meter is used.

Capacitors C5 to C10 are paralleled pairs. All values above (and including) 1000p (1n) are 1 per cent tolerance, high stability types. Capacitors below 1n may be nominal 2½ per cent polystyrene.

Approx cost guidance only **£25** *plus case*

nate meter even if the terminal spacing is identical. Viewed from the rear of the meter, the positive terminal must be on the left.

There is little to say about mounting the components on to the board. There are a number of diodes and electrolytic capacitors and the polarities of these must be carefully observed, particularly capacitors C2 and C4 which are tantalum beads and the markings on some of these are notoriously indistinct. Make doubly sure you get them the right way round.

Diodes D4, D5 and D6 are germanium types, preferably OA47s although OA91s may be used. The miniature transformer is bolted directly to the board using 6BA screws and the connections from the secondary winding made with short wires down to the appropriate copper pads.

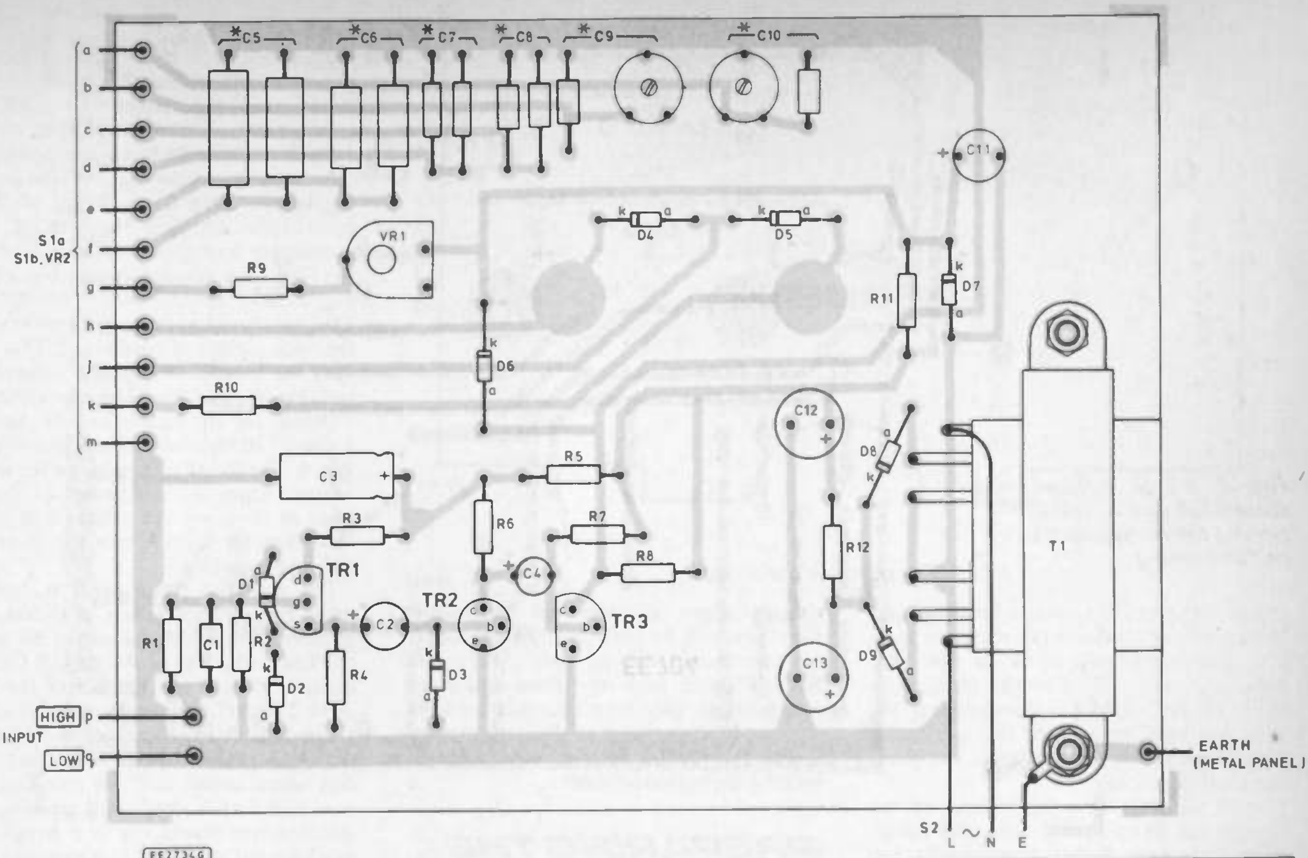
When mounting the transformer T1, put a thin washer *between* the transformer and the board as Fig. 4. shows. This prevents the slight deformation of the board which might occur as the transformer screws are tightened up. *Do not overtighten them in any event.*

FREQUENCY SELECTION

The frequency range capacitor selection, C5 to C10, are positioned along the top edge of the board. These enable the range 10Hz to 100kHz to be covered in six switched stages.

Frequencies below 10Hz are seen as rapid vibrations of the meter pointer and are not accurately readable; the upper limit is determined by the smallest value of capacitor which adequately swamps out the effect of circuit strays. It is possible to get up to about 250kHz with care, but above some 150kHz the reading is not entirely reliable, hence the decision to make the upper limit 100kHz for this design.

As the board diagram shows, provision is made for each capacitor position to accept a paralleled arrangement of two com-



ponents; this makes the final adjustments very much easier.

Table. 1. shows the capacitor combinations used in the prototype and these gave an accuracy within ±2 per cent. However, because of circuit tolerances and variations, some slight adjustments may well be needed in copy models and this is where the idea of using paralleled capacitors comes in.

The C5 position may be a single 47n ±1 per cent component *or* a 39n in parallel with an 8n2. No adjustment is needed on this frequency range (0-300Hz) as it is set up against the calibration circuit; and for capacitors C9 and C10 the addition of a 5-65p trimmer capacitor makes the final adjustment on the two upper ranges (0-30kHz and 0-100kHz) very easy.

To start off, then, solder *all* the capacitors for the C5, C9 and C10 positions into place, but use solder pins into the positions for C6, C7 and C8 and solder only the *larger* valued capacitor of each pair to these for the time being; that is, the 10n for C6, the 3n9 for C7 and the 1n for C8. The additional paralleled capacitors to each of these will be connected to the unused pins during alignment later on.

When you have reached this stage in the board assembly, double check on the polarities of the electrolytics and the diodes and go over your soldering to make certain that there are no bridges across tracks or poor joints. Now solder 75mm (3in) lengths of insulated wire, preferably of different colours to avoid later confusion, to the points along the left-hand side of the board which will connect to the switch S1 and calibration control VR2 (points *a* through *m*) and two similar lengths to the input pads (points *p* and *q*). Finally, don't forget to bridge the tags on the mains transformer primary winding which connect the separate parts of this winding together.

TABLE 1

Cap.	Main capacitance	Parallel capacitance
C5	39n	8n2
C6	10n	3n9
C7	3n9	250p
C8	1n0	330p
C9	390	5-65p trimmer
C10	100p	5-65p trimmer

RESCALING THE METER

The specified meter is scaled 0-100µA and this needs to be changed. This is because we are effectually measuring frequency and not microamps and the ranges go up in steps of 3 and 10 units i.e. 300Hz, 1000Hz, 3000Hz etc. So we need to add a 0-30 scale on to the existing 0-100 one and put the word "Frequency" somewhere.

The readjusted scale is shown in Fig. 5. and anyone with an artistic bent and a

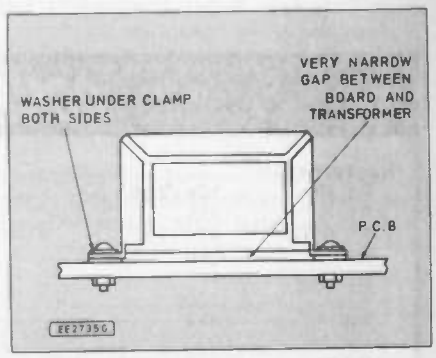
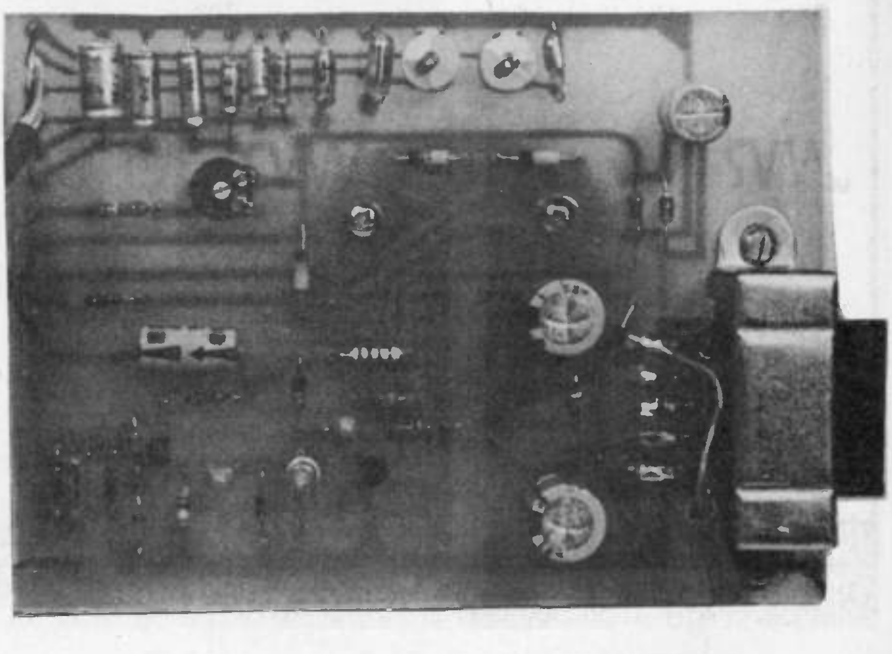


Fig. 4. Transformer mounting.



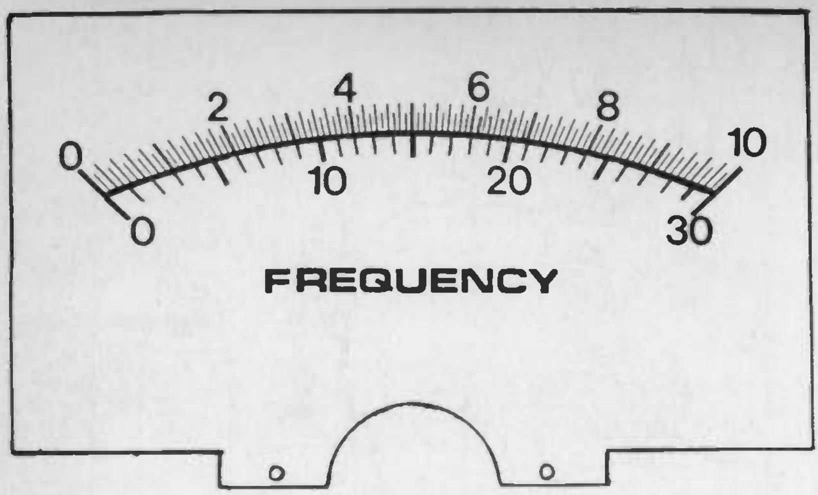


Fig. 5. The required meter scale.

steady hand can use rub-on lettering and Indian ink to fabricate the scale for himself. However, many of us do not have either the steady hand or the bent; so to make life not altogether discouraging, the scale has been reproduced full size and a photocopied scale can be cut out and glued to the existing scale.

To fit the scale, first gently prise off the transparent plastic cover from the meter, using only your fingers and thumbs, *not* screwdrivers or the like, or the plastic may be damaged. And make sure the surroundings are clean and dust free. Remove the existing scale by unscrewing the two fixing screws and *slide* it out from beneath the pointer.

Cut out the photocopied scale to the outline, apply a suitable adhesive thinly to the back of the metal scale and by aligning the top edges of metal and paper carefully you will be able to stick the paper scale accurately and smoothly to the metal. Slide the scale back into place and screw into position, then snap the cover back on, starting by engaging it at the bottom edge. Check the pointer zeroing adjustment by turning the button adjuster.

PREPARING THE FRONT PANEL

At this point I have a confession to make. The case I used for this project was one I had had collecting dust on the workshop shelf for a number of years. It was a one-off case in the first place and so is not to be had from anywhere else.

However, as the whole assembly of board, meter and the other parts go on to a single front panel, it might be worth looking round for a box having a minimum panel size 203mm by 152mm (8in by 6in) as this carries the component parts quite comfortably. A minimum depth of about 100mm (4in) for the box is adequate.

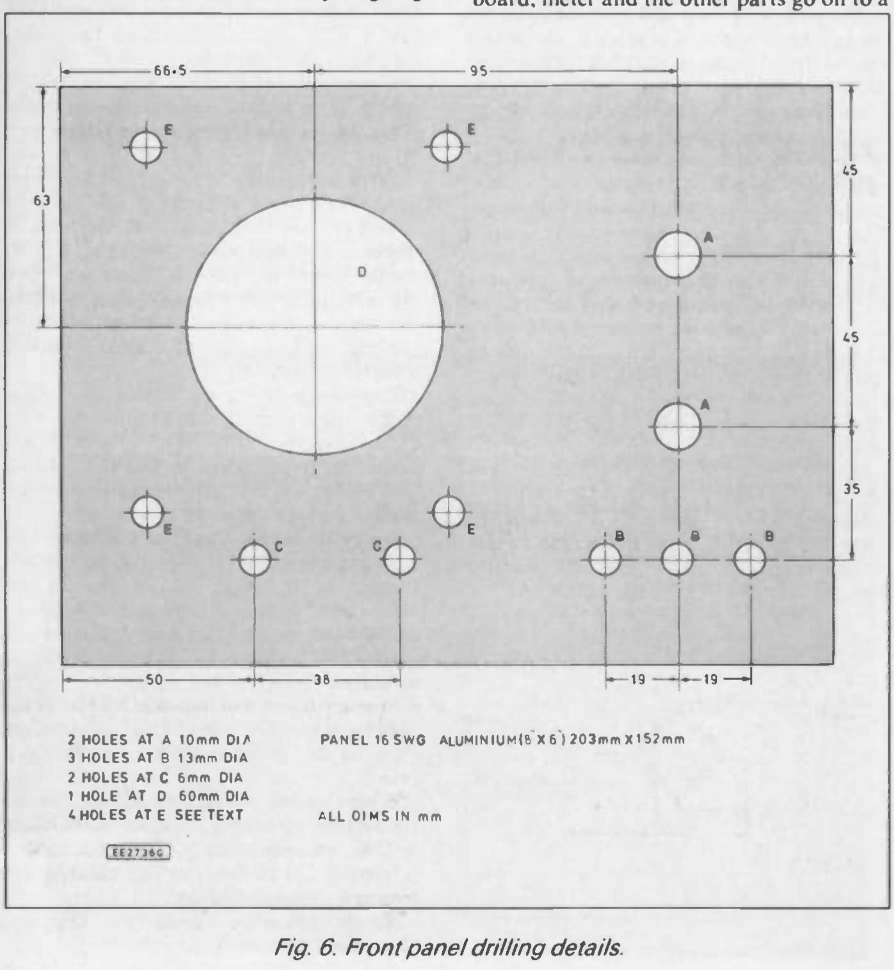


Fig. 6. Front panel drilling details.

Perhaps it might not be unreasonable to suggest using a panel size of 203mm by 152mm cut from a piece of 16swg aluminium and then making a case up in the form of a simple wooden box measuring 203mm by 152mm by 100mm deep. The sides could be made from plywood and the back a piece of hardboard. This would save the trouble of hunting around for a suitable case and would be a lot cheaper.

Details for the panel cut-outs, assuming a size of 203mm by 152mm, are shown in Fig. 6. The four fixing holes on the top and bottom edges are not shown as the positions of these are not critical and have to suit whatever form of box the front panel will finally screw to.

The way the front panel is legended, using rub down lettering, is shown in the photographs. The actual size of the circular marked scales for the Range and Calibrate controls should suit the size of the knobs used; 25mm (1in) diameter are about right.

The four fixing holes for the meter are always a problem to position, but in the box which comes with the specified meter you will find a cardboard packing piece which serves excellently as a template for marking out the fixing holes relative to the large centre hole. Cut out the large circle *first* and then mark and drill the fixing holes.

A fretsaw is useful for cutting the meter hold if you haven't a punch. If you use a drop of paraffin or turps as a lubricant, you will find a fretsaw cuts 16swg aluminium with no great difficulty at all.

The input terminals SK1-SK3 are 4mm screw/socket types and are coloured red(HI), black (LO) and green (earth). You can if you wish go your own way here and use a BNC connector although this does not isolate the "earthy" input SK2 (LO) from the metal panel. With the socket terminals, don't forget the locating spigot on the terminal moulding.

ASSEMBLY

Once the front panel is ready, the meter, range switch, calibration potentiometer, input terminals and the mains switch and indicator can be mounted. The range switch is a two-wafer assembly and uses a pair of 1-pole 12-way wafers with the stop mechanism adjusted so that only the first seven positions are used.

Although standard size wafers and mechanism were used on the prototype, there is no reason why miniature wafers cannot be used, and this would in fact allow a little more room between switch and board. The switch mechanism has a projection on its front face which acts as an anti-rotation feature; a hole should be drilled in the panel so that this projection engages in it when the switch fixing nut is tightened up.

Put a tag under one of the lower fixing nuts of the meter and run a wire from this to the Earth terminal on the input grouping; also leave a few inches floating from this same tag to make connection to the transformer frame after the board has been fitted.

When the above points have been seen to, the board itself should be screwed to the meter terminals at positions M+ and M−.

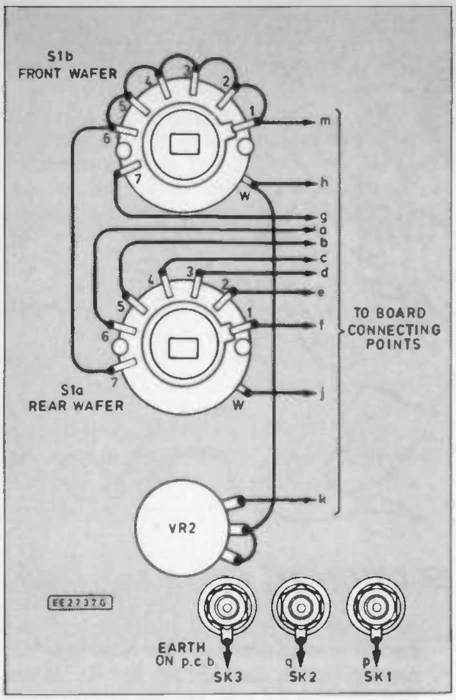
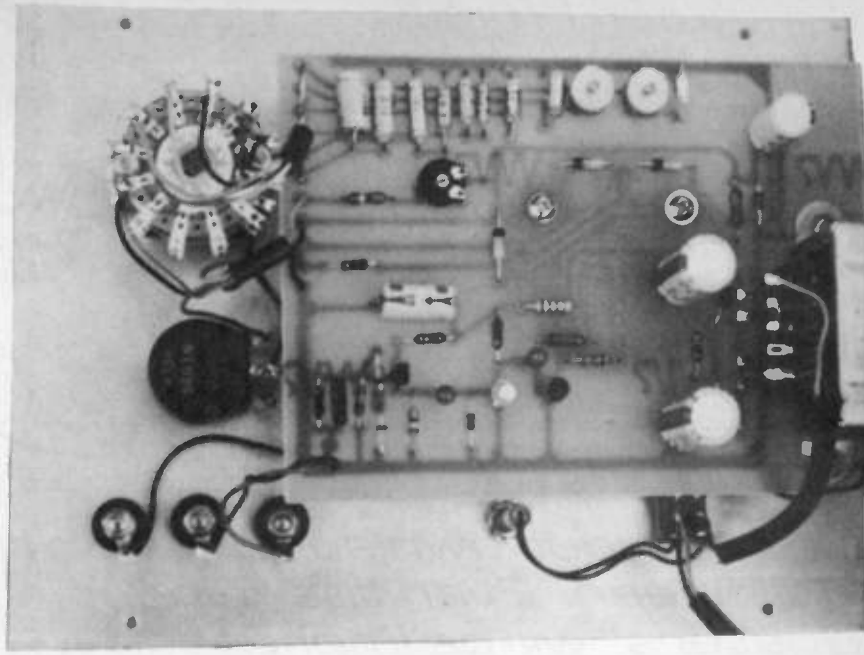


Fig. 7. Control and socket wiring.



The screws supplied with the meter can be used but they are a bit on the short side particularly if you put a washer under each head (as you should); if you can find two others with an extra eighth-inch of thread, use them.

INTERWIRING

Now wire up the range switches and the calibration potentiometer as detailed in Fig. 7. Contacts not used on the switch wafers are not shown. The actual position of the sliding contact on the wafers my differ from that illustrated, depending upon whether you use standard or miniature wafers, or other makes of switch. Loop the wires from the board to the switch contacts neatly and do not make them so short that they are tight anywhere.

Now wire up the transformer T1 primary via the on-off switch, not forgetting the neon indicator. You must stick some tape over the primary terminals and the switch tags, so that they are insulated and out of harms way while you carry out the calibration.

CALIBRATION

To get the best possible accuracy from the project, you need a Signal Generator covering the range 300Hz to 100kHz; failing that, if you can get hold of a 300Hz source of good accuracy, plus an oscillator which will go up to 100kHz even if it is not calibrated or particularly accurate, the work is not difficult.

First of all, set the front panel Calibrate control fully anticlockwise and the preset potentiometer (VR1) on the p.c.b. to about mid-position. Switch on the Frequency Meter and turn the Range switch to CAL.

The meter should not indicate anything on the frequency range positions of the switch but on the CAL position it should give a reading which should be adjustable over a small range by the Calibration control. The exact variation and its value is unimportant. If it does this and there are no other signs of circuit discontent, things are probably working out correctly.

Assuming now that you have or can lay your hands on a known source of frequency in the range 300Hz to 100kHz, proceed as follows: connect the signal source to the frequency meter input HI and LO terminals and set the output of the source to 300Hz at a level of a volt or so.

Turn the Range switch on the project to 0.3kHz and adjust the front panel Calibration control for full scale deflection (f.s.d.) of the meter. This should occur somewhere about the centre position of the control.

Now, *without* disturbing the Calibrate setting, switch the Range selector to CAL and adjust the preset potentiometer on the p.c.b. (VR1) to again provide f.s.d. on the meter. Switch back to the 0.3kHz position and check that the f.s.d. is unaffected.

This frequency range is now correctly set up. Check the range and operation by progressively reducing the input frequency from 300Hz down to 15Hz or so; the meter reading should accurately follow this variation.

What we now have to do on the next *three* ranges is to find the appropriate capacitor to parallel with those already mounted on the board to give us a correct frequency reading in each case. This might sound as though things are going to get difficult and tedious, but in practice the job is done fairly quickly and is well worth a bit of patience.

Here is the drill for the 1kHz range, and the rest follow similarly:

Temporarily connect a 3n9 capacitor (you can leave the leads full length at this stage) in parallel with the 10n already mounted in the C5 combination on the board, using the appropriate solder pins. This value is in accordance with Table. 1. of values given earlier.

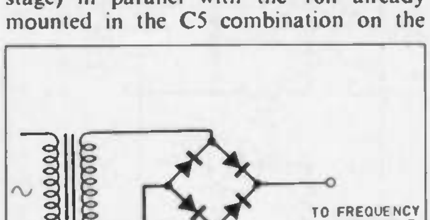


Fig. 8. Basic calibration circuit.

Switch the Range selector to 1kHz and set the signal source to 1kHz output; if you are lucky the meter will read full scale (equal to an input of 1kHz in frequency). If the reading is worse than ± 2 per cent or whatever accuracy you are settling for, you will need to make some adjustments.

If the reading is too low *add* a further capacitor in parallel with the 3n9; until you get about two per cent change in the reading per 100p added. If the reading is too *high*, replace the 3n9 with a 3n3 and add, say, a 470p so that you get an equivalent which is a little below the first 3n9 value.

When you get things right, solder the added capacitor(s) securely to the pins. None of these additional capacitors need be more accurate than five per cent.

Carry on in the same way for the 3kHz and 10kHz ranges, starting off with the added capacitor value as that indicated in Table. 1. and making any necessary adjustments to get the correct frequency reading. On the top two ranges, simply adjust the trimmer capacitors to bring the meter reading to the correct f.s.d. of 30kHz and 100kHz respectively.

Everything hinges on getting the 300Hz range right; after that, if you have no means of calibrating otherwise, the capacitor values given in Table. 1. should give you a not unreasonable overall accuracy to the other ranges.

The 50Hz mains supply can be used as a stop-gap measure in aligning the 300Hz range; put a bridge rectifier across the secondary of a low voltage transformer, 2V or 3V being enough, see Fig. 8. The output from this bridge will then be a 100Hz waveform which when connected to the frequency meter will indicate 100Hz on the 300Hz range. Do your initial calibration, then, at this point instead of at the f.s.d. point.

Whenever the instrument is used, the intial setting up simply consists of switching to CAL and adjusting the Calibrate control (if necessary) to f.s.d. before making any frequency measurements.

Next Month: Add-on Optical Sensor Tachometer.

Halloween Project

GHOST WAKER

MAX HORSEY

Create your own surprise on the night of Halloween. Even the "Ghost Busters" will be impressed

THIS is an ideal project for Halloween, but sound operated devices also have many other applications. The circuit employs a miniature microphone which causes a pair of eyes inside a mask to flick open for a short time. A pair of green l.e.d.s in the nostrils add to the eerie effect, particularly in subdued lighting.

PRINCIPLE OF OPERATION

Sound is picked up by the microphone (Fig. 1), and amplified by a simple op-amp pre-amplifier. The output from the op-amp is rectified (i.e. changed from a.c. to d.c.) and used to control a Darlington power amplifier. When the power amplifier switches on, a large current flows through the solenoid and l.e.d.s.

CIRCUIT DESCRIPTION

The microphone is an electret type, which is small, inexpensive, and particularly sensitive. Unlike ordinary dynamic types it requires a d.c. supply, and this is provided via R1 – see Fig. 2. The small alternating current from the microphone is fed via C1 to the non inverting input of IC1. Capacitor C1 is necessary in order to isolate the d.c. voltage level at the lower end of R1, from the voltage at the junction between R2 and R3. This latter voltage is set at half the supply voltage.

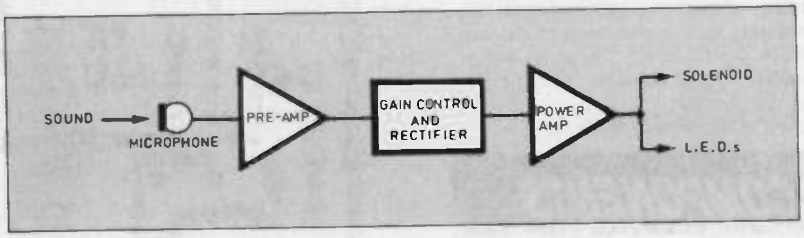


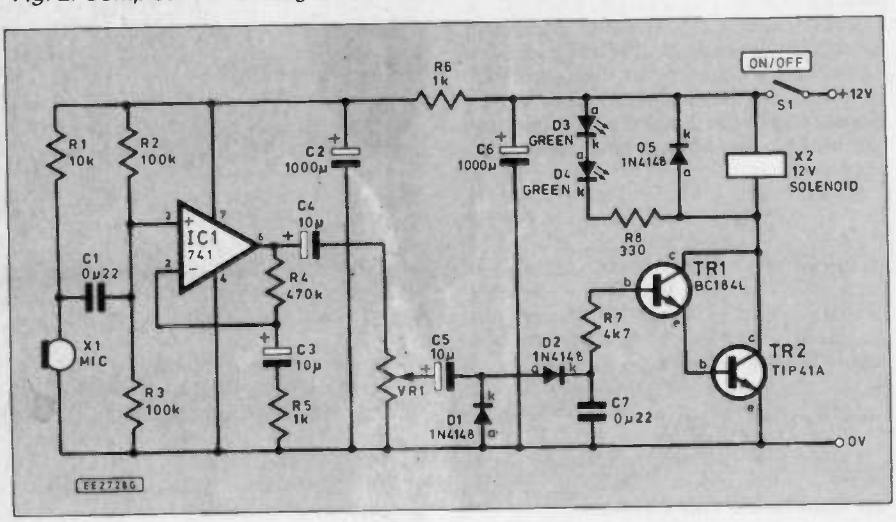
Fig. 1. System block diagram for the sound-operated "Mask".

The d.c. voltage at output pin 6 should equal the voltage at pin 3, and this is ensured by means of negative feedback, where R4 couples pin 6 to the inverting input pin 2. If the d.c. output voltage changes slightly, the change is inverted via pin 2, causing the output voltage to return to its correct value. Capacitor C3 blocks any flow of d.c. and therefore has no effect on these d.c. voltage levels. Capacitor C4 also blocks the flow of d.c. to the 0V rail.

Alternating currents are – in general terms – able to flow through capacitors, and since the audio signal produced by the microphone is alternating, the signal can flow through C1 and into the non-inverting input pin 3. This causes a similar, but amplified alternating signal at output pin 6. In other words, the previously steady d.c. level is now fluctuating at the same frequency as the original sound wave.

Since resistor R4 connects the output back to the inverting input, the a.c. output would be cancelled out. However, capacitor C3 provides an a.c. path to 0V via R5. Now only part of the a.c. output arrives at pin 2, and the output is therefore only partially reduced. The ratio of R4 to R5 sets the approximate maximum a.c. gain achieved by the circuit.

Fig. 2. Complete circuit diagram for the Ghost Waker mask.



POWER AMPLIFIER

The a.c. signal passes via C4 to VR1. The position of the slider on VR1 determines the signal level passed to the next stage. Diodes D1 and D2 act as a voltage doubler and rectifier, charging capacitor C7 to a d.c. voltage level which depends upon the amplitude (size) of the a.c. signal flowing via C5.

The value of C7 determines the time for which the eyes remain open after the sound has stopped. Resistor R7 regulates the discharge of C7 into the transistors (TR1 and TR2), which are connected as a Darlington pair. The gain achieved is determined by multiplying the gain of TR1 by the gain of TR2.

When the Darlington pair turns on, current flows via the solenoid, through TR2 to 0V. The l.e.d. D3 is wired in series with D4 and current limiting resistor R8. Diode D5 prevents damage caused to the transistors by back e.m.f. produced by the solenoid.

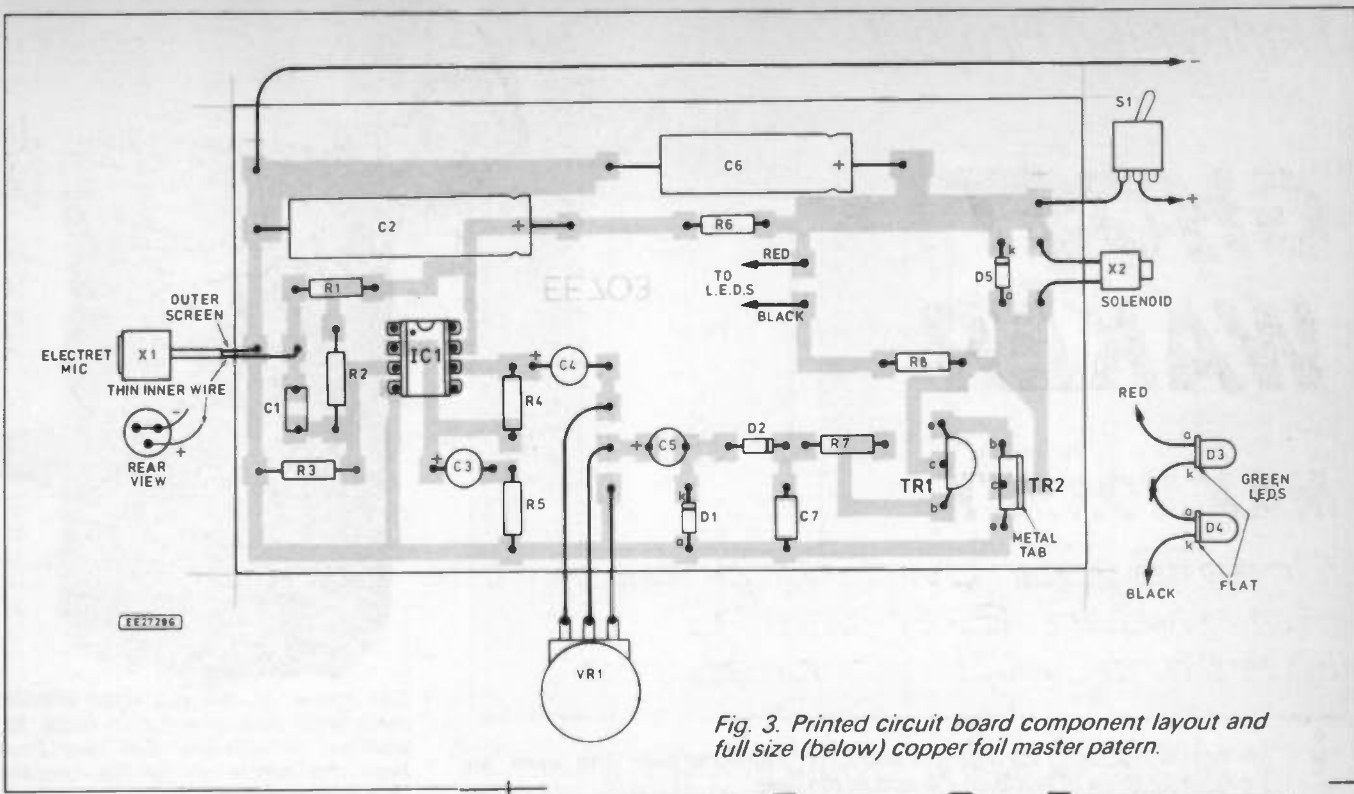
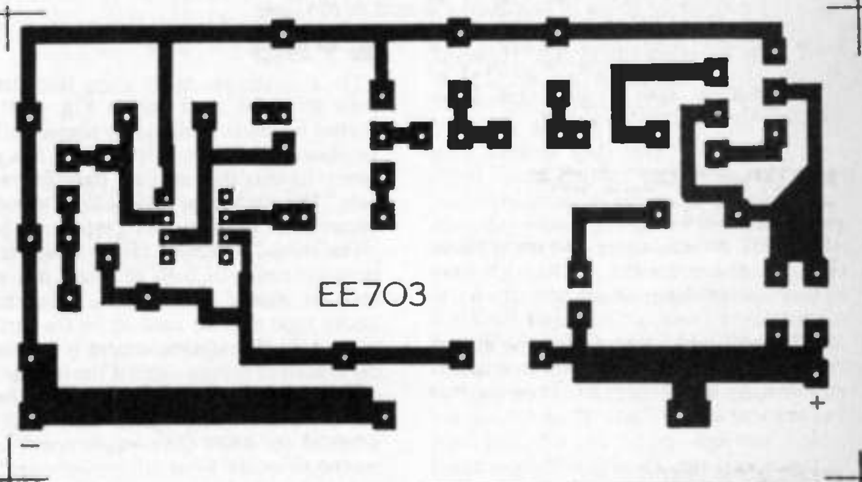


Fig. 3. Printed circuit board component layout and full size (below) copper foil master patern.



DECOUPLING

The solenoid requires quite a large current, and this can cause voltage fluctuations which would upset the operation of the sensitive pre-amplifier. Resistor R6 is provided to partly isolate the power rails between the pre-amplifier, and power amplifier stages. Capacitor C2 helps to ensure a steady supply voltage for the pre-amp, and C6 provides general decoupling for the circuit.

COMPONENTS

Resistors

R1	10k
R2, R3	100k (2 off)
R4	470k
R5, R6	1k (2 off)
R7	4k7
R8	330

All 0.25W ± 5% carbon

See SHOP TALK Page

Potentiometer

VR1	47k lin

Capacitors

C1, C7	0μ22 polyester (2 off)
C2, C6	1000μ axial elect. 25V (2 off)
C3 to C5	10μ radial elect. 25V (3 off)

Semiconductors

D1, D2, D5	1N4148 diode (3 off)
TR1	BC184L *npn* transistor
TR2	TIP41A *npn* transistor
D3, D4	l.e.d. green standard (2 off)

Miscellaneous

X1	microphone, electret type
X2	solenoid (small 12V type)
S1	on/off toggle switch

Printed circuit board, available from the *EE PCB Service*, order code EE703; case; screw for solenoid; Meccano or Fishertechnik type axle; Meccano supports, nylon thread, elastic thread, table tennis balls (2 off); thin cardboard; mask; beard, etc.; connecting wire; battery holder or main adaptor (see text); fixings etc.

Approx cost guidance only **£20**

CONSTRUCTION

The circuit is constructed on a p.c.b. shown in Fig. 3. Begin by soldering in the smallest components and i.c. socket. Check that the diodes and transistors are fitted the correct way round, and that a BC184L is used for TR1, and not a BC184 which has leads in a different order. Capacitors C2 and C6 are axial types, which lie flat against the p.c.b. Ensure that capacitors C2, C3, C4 and C6 are fitted the correct way round.

Connect wire leads for the microphone, l.e.d.s, solenoid and power supply. Switch S1 may be omitted if the circuit is to be powered from a mains power unit. Finally push the 741 i.c. into its socket, ensuring that pin one is in the correct corner. This i.c. is not sensitive to static electricity, and can be handled without precautions.

THE CASE

Any type of housing may be employed; some constructors may prefer to mount the circuit on a block of wood, with the

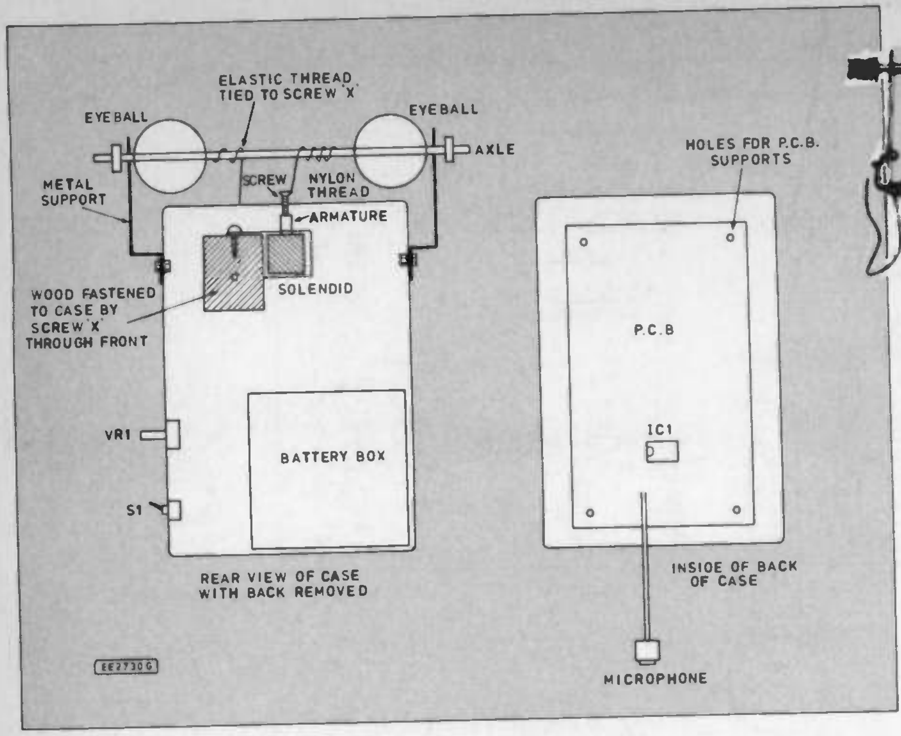
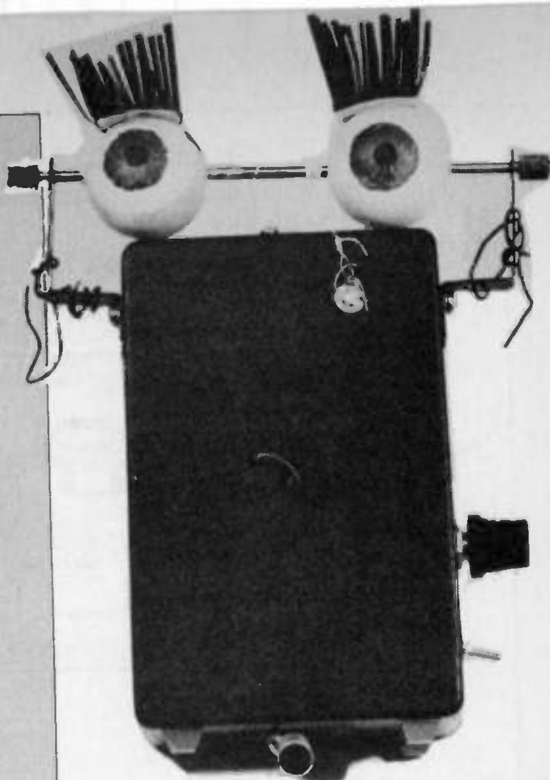


Fig. 4. Method of mounting the solenoid and p.c.b. inside the case. The "eyes" are held in position by strips of metal on the side of the case.



The screw on the top right anchors the elastic thread and also holds the solenoid in position. The two leads from the centre go to the "nostril" l.e.d.s.

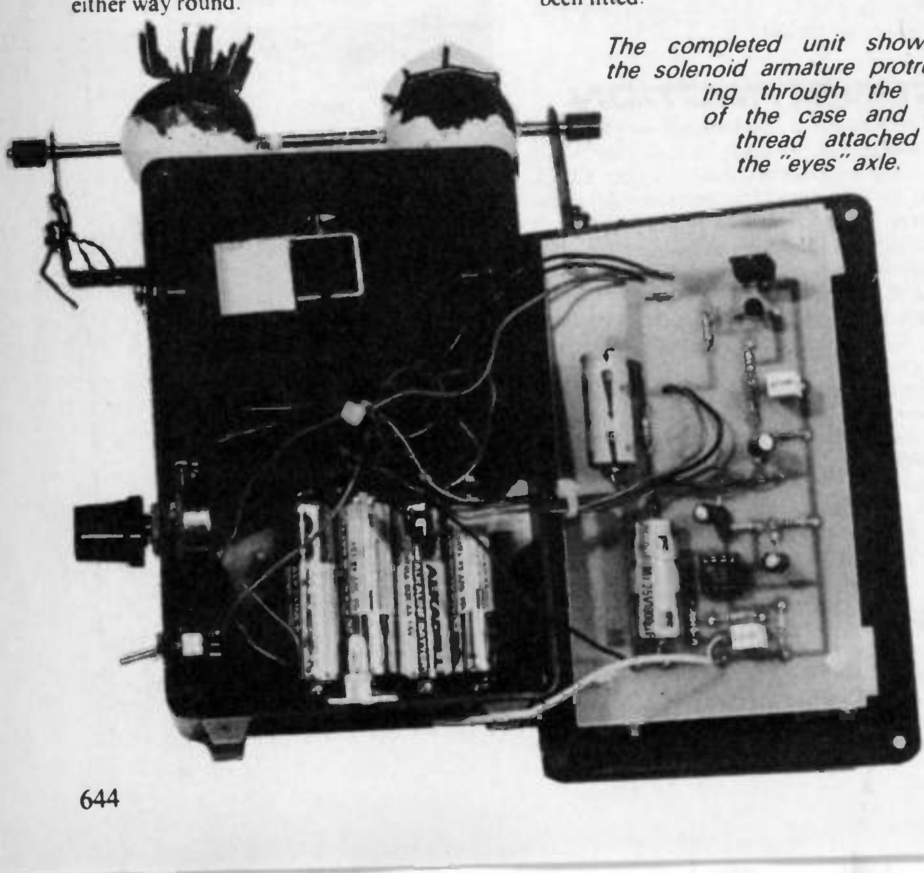
mask fully covering the circuit. However, the prototype was based around a standard plastic case, which houses the circuit, solenoid and batteries. All the awkward mechanical parts were then secured, enabling the mask to be fitted later. Begin by drilling holes for the solenoid armature screw, solenoid mounting block, axle supports, VR1, S1, and the leads for the l.e.d.s and microphone, see Fig. 4. The p.c.b. may be fastened by means of self adhesive p.c.b. supports.

Most solenoids allow a screw (e.g. size M6) to be inserted into the soft iron armature. Strong nylon thread is then used to link the screw to the axle which houses the table tennis ball "eyes". The solenoid must be positioned very carefully, using a small block of wood as shown. It should then be connected to the circuit, with the wires either way round.

EYES

The eyeballs are made using table tennis balls arranged as shown in Fig. 4. Holes should be made in the table tennis balls (a veroboard track cutter is ideal for this purpose), so that they make a tight fit on the axle. The prototype axle was a standard Meccano or Fischertechnik type.

The thread attached to the solenoid armature causes the balls to rotate one way, and the elastic thread pulls them back. Sticky tape may be used to fix the threads to the axle. The eye movement is limited by the armature resting against the top surface of the case when the eyes are closed, and by the armature being pulled fully into the solenoid coil when the eyes are open. Long eyelashes made from thin cardboard are fastened to the eyeballs using double sided sticky tape, or glue, AFTER the mask has been fitted.



The completed unit showing the solenoid armature protruding through the top of the case and the thread attached to the "eyes" axle.

Long insulated leads should be fitted to the p.c.b., and inserted through the hole in the case BEFORE the l.e.d.s are connected. Ensure that the l.e.d.s are connected the correct way round – colour coding the wires will help avoid mistakes. The l.e.d.s may then be pushed into holes made in the mask, just before the mask is put in position.

MICROPHONE

The microphone may be positioned inside the case, however there is a danger that it may pick up noise from the solenoid. The best position is probably below the project case, just behind what will become the beard of the ghost. In this case screened wire should be used to connect the microphone to the circuit.

Certain suppliers provide microphones with screened cable already fitted, but otherwise follow the diagram (Fig. 3.) very closely to ensure that the microphone is connected the correct way round.

POWER SUPPLY

A set of eight 1.5V (AA type) batteries is suggested. However, for long term use a mains adaptor could be employed; these cost little more than a couple of sets of batteries, but be sure to select an adaptor which can supply enough CURRENT to drive the solenoid, about 500mA in the prototype.

The adaptor need not be regulated, since any voltage between 12V and 20V is satisfactory. However, voltage fluctuations may cause the circuit to become unstable, resulting in the eyes continually opening and closing! This may be cured by using either a proper voltage regulator, a power supply with a larger current output, or a very large capacitor across the supply rails. Experiment for the best results!

TESTING

If a voltmeter is available, it is helpful to check the voltage across the supply rails immediately the power is applied. Any drop much below 12V indicates a serious fault, and the supply can be switched off before damaging the circuit, or running down the batteries.

Assuming that S1 is switched on, and all is well, wait a few seconds for C3 to charge, and the pre-amp to begin to operate. Turn VR1 to full gain (fully clockwise if wired correctly), and make a sound. The l.e.d.s should light and the solenoid operate for a short time. If nothing happens, try turning VR1 fully anti-clockwise in case it is connected incorrectly.

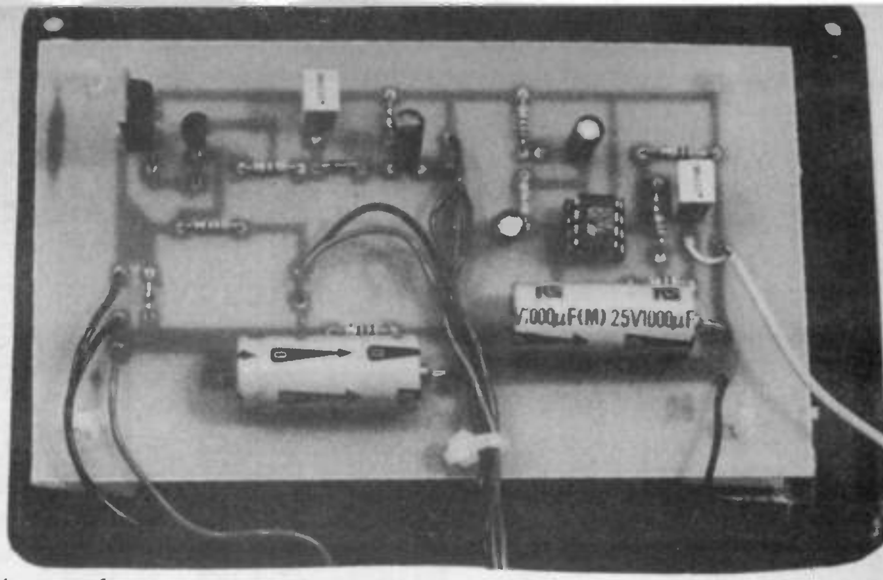
FAULT FINDING

Common mistakes include connecting the microphone the wrong way round, and connecting the l.e.d.s, diodes, transistors and capacitors the wrong way. Check all these items, then check for poor soldered joints, or bridged connections, particularly around the i.c. Note that the spare pins, 1, 5, and 8 must NOT be connected to any other part of the circuit.

Check the voltage across pins 7 and 4 of IC1. You should obtain a reading of about 12V. Now connect the negative lead of the voltmeter to 0V on the circuit, and use the positive lead as a probe. You should obtain the following readings to within about a volt:

Pin 7 of IC1	: 12V
Pin 3 of IC1	: 6V
Pin 6 of IC1	: 6V
Junction between R1 and microphone	: 3V to 10V

The failure of any test indicates a fault in that area – perhaps a wrong resistor value, or a poor connection.



Layout of components on the completed printed circuit board. The screened lead on the right-hand edge of the board connects to the microphone.

The junction between D2, R7 and C7 provides a useful test point. The voltage at this point should be below 1.2V when the solenoid is off, and above 1.4V when the solenoid is on. A further crude, but helpful test is to join this point directly to positive, using a piece of wire. The l.e.d.s and solenoid should operate. If this fails, the power amplifier section is at fault.

Beyond this, an oscilloscope will determine whether the microphone is providing an alternating signal at pin 3 of IC1. An amplified signal should be present at pin 6. Note that the output signal may be distorted (clipped), but this is of no consequence in this type of circuit.

Masks vary so much that only a general guide is possible. It will probably be necessary to enlarge the eyes to accommodate the table tennis eyeballs. The mask may be fitted to the supports holding the axle, using stiff wire. Any gaps around the eyeballs can be filled with hair, eyebrows etc. A beard will conceal the bottom of the case and microphone, and long eyelashes are fitted as described earlier. Any further refinements can be left to the imagination of the constructor.

The overall effect is quite eerie, and may alarm unsuspecting visitors. At any rate, it will provide an amusing talking point, and help get the party going! □

TRANSISTORS

AAY32	9p
AC107	40p
AC125	25p
AC126	25p
AC127	21p
AC128	21p
AC128K	26p
AC141K	30p
AC142K	30p
AC176	22p
AC176K	28p
AC187	21p
AC187K	28p
AC188	21p
ACY18	48p
ACY19	48p
AD149	60p
AF124	50p
AF125	50p
AF126	50p
AF127	50p
AF139	30p
AF239	30p
AF379	45p
BA145	10p
BA148	10p
BA154	6p
BA157	12p
BB105B	18p
BB205B	24p
BC107	8p
BC108	8p
BC109	8p
BC109C	10p
BC115	10p
BC118	11p
BC140	20p
BC141	20p
BC142	20p
BC143	20p
BC147	8p
BC148	8p
BC149	8p
BC157	8p
BC159	8p
BC160	30p
BC171	10p
BC172	10p
BC177	14p
BC178	14p
BC179	14p
BC182	7p
BC182L	7p
BC183	7p
BC183L	7p
BC184	7p
BC184L	7p
BC212	7p
BC212L	7p
BC213	7p
BC213L	7p
BC214	7p
BC214L	7p
BC237	7p
BC238	7p
BC239	7p
BC300	20p
BC301	20p
BC302	20p
BC303	20p
BC304	25p
BC308	10p
BC327	7p
BC328	7p
BC337	7p
BC338	7p
BC441	28p
BC446	8p
BC449	15p
BC461	28p
BC477	18p
BC478	18p
BC479	18p
BC489	20p
BC490	18p
BC516	22p
BC528	22p
BC537	25p
BC546	8p
BC547	8p
BC548	8p
BC549	8p
BC550	8p
BC556	8p
BC557	7p
BC558	8p
BC559	8p
BC560	8p
BC637	20p
BC638	20p
BC639	20p
BC640	20p
BCY32	200p
BCY33	200p
BCY34	200p
BCY70	16p
BCY71	16p
BCY72	16p
BD115	30p
BD124P	50p
BD124	110p
BD131	25p
BD132	25p
BD133	50p
BD135	20p
BD136	20p
BD137	20p
BD138	20p
BD139	20p
BD140	20p
BD142	45p
BD150	30p
BD157	38p
BD158	38p
BD166	30p
BD175	30p
BD177	30p
BD179	32p
BD181	45p
BD182	60p
BD184	60p
BD187	30p
BD201	33p
BD202	38p
BD203	42p
BD204	42p
BD222	31p
BD225	31p
BD232	31p
BD233	32p
BD234	32p
BD235	28p
BD236	30p
BD237	21p

BD238	24p
BD239	30p
BD240	40p
BD241A	40p
BD243A	50p
BD244	50p
BD245	50p
BD246A	50p
BD265	45p
BD267	45p
BD269	45p
BD278	50p
BD311	100p
BD312	100p
BD313	100p
BD314	100p
BD315	150p
BD316	150p
BD317	150p
BD318	150p
BD331	40p
BD332	40p
BD361	60p
BD362	60p
BD370	30p
BD371	30p
BD410	50p
BD433	28p
BD434	30p
BD435	31p
BD436	30p
BD437	28p
BD438	36p
BD439	40p
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BD442	40p
BD520	60p
BD533	50p
BD534	38p
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BD649	50p
BD651	50p
BD675	40p
BD676	40p
BD677	38p
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BD680	40p
BD679	40p
BD681	45p
BD682	45p
BD705	50p
BD707	50p
BD709	50p
BD711	50p
BD736	50p
BD826	50p
BD828	50p
BD875	50p
BD897	50p
BD899	50p
BD901	50p
BD977	50p
BDX32	100p
BDX33	60p
BDX53	60p
BDX65	80p
BDW23	55p
BDW24	55p
BDW93	50p
BDW94	50p
BDY20	100p
BDY92	100p
BF137	35p
BF154	25p
BF167	30p
BF173	40p
BF178	30p
BF180	16p
BF181	18p
BF183	20p
BF185	20p
BF194	7p
BF195	7p
BF196	8p
BF197	10p
BF198	10p
BF199	8p
BF200	16p
BF225	30p
BF240	16p
BF245	25p
BF254	15p
BF255	12p
BF256	18p
BF257	18p
BF258	18p
BF259	18p
BF262	25p
BF263	25p
BF270	18p
BF273	15p
BF311	21p
BF324	25p
BF336	20p
BF337	20p
BF338	20p
BF355	28p
BF362	30p
BF367	13p
BF371	17p
BF392	18p
BF420	16p
BF421	18p
BF422	21p
BF423	25p
BF450	20p
BF455	14p
BF458	19p
BF459	19p
BF461	60p
BF462	52p
BF469	30p
BF470	28p
BF471	28p
BF472	28p
BF479	30p
BF493	18p
BF494	16p
BF495	16p
BF506	25p
BF595	16p
BF596	16p
BF615	30p
BF617	30p
BF757	40p
BF758	41p
BF759	40p
BF760	40p
BF763	40p

BF869	22p
BF870	22p
BF871	22p
BF872	23p
BF960	38p
BF961	35p
BF963	40p
BF964	38p
BF966	40p
BFR40	25p
BFR79	25p
BFR90	52p
BFR91	99p
BFT37	130p
BFT42	30p
BFT43	30p
BFT84	30p
BFW92	35p
BFX29	20p
BFX84	20p
BFX85	20p
BFX87	15p
BFX88	15p
BFX89	60p
BFY17	30p
BFY18	40p
BFY50	14p
BFY51	14p
BFY52	14p
BFY56	25p
BFY64	25p
BFY90	45p
BLY48	85p
BR100	14p
BR101	43p
BR103	37p
BR303	85p
BRY39	55p
BRY49	38p
BRY56	33p
BS574	33p
BSX20	15p
BSX26	18p
BSX29	19p
BT100A	70p
BT106	180p
BT109	90p
BT116	80p
BT119	100p
BT138	60p
BT145	99p
BT151	58p
BTY79	140p
BU100A	110p
BU104	100p
BU105	80p
BU108	100p
BU109	100p
BU110	110p
BU111	140p
BU124	60p
BU126	70p
BU180	150p
BU184	100p
BU204	75p
BU205	70p
BU206	100p
BU208	70p
BU208D	80p
BU209	140p
BU225	190p
BU226	190p
BU312	120p
BU325	55p
BU326	75p
BU406	85p
BU406D	95p
BU407	60p
BU407D	95p
BU408	85p
BU408D	95p
BU409	95p
BU426A	75p
BU500	110p
BU508A	85p
BU508D	90p
BU536	150p
BU526	80p
BU546	140p
BU608	150p
BU626	150p
BU636	150p
BU801	95p
BU806	80p
BU807	75p
BU902	130p
BU903	130p
BU920	130p
BU921	130p
BU922	130p
BU930	130p
BUT11A	90p
BUT56A	250p
BUX80	180p
BUX82	180p
BUX84	50p
BUX85	50p
BUY69A	200p
BUY71	300p
C106D	28p
MEO411	38p
MEO414	125p
ME3001	12p
ME4103	12p
ME6001	12p
ME6002	15p
ME8001	15p
ME9021	12p
MJ802	350p
MJ900	200p
MJ1000	200p
MJ1001	200p
MJ10012	300p
MJ15001	325p
MJ15002	300p
MJ15003	325p
MJ15004	370p
MJ15022	400p
MJ2501	110p
MJ2955	55p
MJ3000	115p
MJ3001	115p
MJE29A	30p
MJE30A	30p
MJE340	25p
MJE350	80p
MJE520	30p
MJE2955K	90p
MP8111	40p
MP8112	46p
MP8113	55p
MP8512	50p
MPS65781	20p
MPS9012	20p
MPS9013	20p
MPS9014	20p

MPS9015	20p
MPSA05	15p
MPSA06	15p
MPSA13	15p
MPSA20	15p
MPSA42	15p
MPSA43	15p
MPSA65	25p
MPSA66	25P
MPSA70	15p
MPSA92	20p
MPSA93	20p
MR510	35p
MR856	36p
OC28	250p
OC29	250p
OC35	250p
OC36	250p
OC45	50p
OC71	30p
OC72	50p
OC200	180p
OT121	120p
R2008B	100p
R2010B	100p
S2800D	52p
S2800M	72p
T2800D	52p
T2800M	72p
TIP29	15p
TIP29A	22p
TIP29C	25p
TIP30	25p
TIP30C	30p
TIP31A	24p
TIP31C	30p
TIP32	24p
TIP32A	24p
TIP32C	28p
TIP33	50p
TIP33C	60p
TIP34	50p
TIP34C	60p
TIP35C	65p
TIP36C	65p
TIP41A	22p
TIP41C	25p
TIP42A	22p
TIP42C	25p
TIP47	40p
TIP48	40p
TIP49	45p
TIP50	60p
TIP51	120p
TIP52	120p
TIP53	120p
TIP54	140p
TIP105	65p
TIP106	65p
TIP107	65p
TIP110	47p
TIP111	50p
TIP112	40p
TIP115	45p
TIP116	45p
TIP117	50p
TIP120	43p
TIP121	46p
TIP122	47p
TIP125	47p
TIP126	56p
TIP127	56p
TIP130	30p
TIP131	30p
TIP132	30p
TIP141	90p
TIP142	90p
TIP145	65p
TIP146	90p
TIP147	100p
TIP150	90p
TIP151	90p
TIP2955	42p
TIP3054	45p
TIP3055	42p
TIS44	40p
TIS61	15p
TIS90	15p
TIS91	18p
VK1010	88p
VN10KM	60p
VN66AF	100p
VN88AF	115p
ZTX107	11p
ZTX108	11p
ZTX109	12p
ZTX212	27p
ZTX300	13p
ZTX301	16p
ZTX302	16p
ZTX303	24p
ZTX304	17p
ZTX320	29p
ZTX500	13p
ZTX501	13p
ZTX502	18p
ZTX503	18p
ZTX504	25p
ZTX550	24p
2N.696	26p
2N.697	22p
2N.698	40p
2N.706	22p
2N.708	22p
2N.914	28p
2N.930	18p
2N.1131	28p
2N.1132	28p
2N.1613	24p
2N.1711	24p
2N.1893	30p
2N.2102	50p
2N.2218A	24p
2N.2219	24p
2N.2221	23p
2N.2222	23p
2N.2369	15p
2N.2484	20p
2N.2646	40p
2N.2904	20p
2N.2905	20p
2N.2906	18p
2N.2907	18p
2N.2926	8p
2N.3019	28p
2N.3053	18p
2N.3054	40p
2N.3055	38p
2N.3055H	50p
2N.3440	58p
2N.3442	85p
2N.3583	90p
2N.3585	120p
2N.3702	9p
2N.3703	9p
2N.3704	9p

2N 3705	9p
2N 3706	9p
2N 3707	9p
2N 3708	9p
2N 3710	12p
2N 3711	12p
2N 3771	85p
2N 3772	90p
2N 3773	110p
2N 3799	18p
2N 3819	29p
2N 3866	68p
2N 3903	11p
2N 3904	11p
2N 3905	11p
2N 3906	11p
2N 4031	25p
2N.4036	25p
2N.4037	25p
2N 4062	12p
2N 4064	100p
2N 4401	12p
2N.4403	12p
2N.4443	76p
2N.5061	20p
2N.5088	20p
2N.5163	45p
2N.5192	50p
2N.5241	500p
2N.5245	45p
2N.5294	30p
2N.5296	30p
2N.5320	90p
2N.5321	60p
2N.5366	25p
2N.5401	12p
2N.5448	12p
2N 5496	80p
2N 6107	40p
2N.6109	40p
2N 6254	110p
2N 6292	40p
2N.6384	120p
2N.6385	120p
2N 6403	160p

DIODES RECTIFIER DIODES

BY100	40p
BY103	32p
BY126	6p
BY127	8p
BY133	8p
BY164	40p
BY179	35p
BY184	32p
BY196	20p
BY206	11p
BY207	11p
BY208	18p
BY210	22p
BY225	120p
BY226	18p
BY227	19p
BY228	32p
BY296	20p
BY298	26p
BY299	28p
BYX10	15p
BYX55/350	30p
BYX55/600	30p
BYX70/500	32p
BYX70/800	36p
OA91	8p
OA200	7p
OA202	7p
IN.914	2p
IN.4001	4p
IN.4002	4p
IN.4003	4p
IN.4004	4p
IN.4005	4p
IN.4006	4p
IN.4007	5p
IN.4148	2p
IN.5400	9p
IN.5401	10p
IN.5402	10p
IN.5403	11p
IN.5404	11p
IN.5405	12p
IN.5406	13p
IN.5407	13p
IN.5408	13p
SKE4F2/06	50p
SKE4F2/08	70p
SKE4F2/10	90p

I.C. SOCKETS

8 PIN	6p
14 PIN	8p
16 PIN	9p
18 PIN	12p
20 PIN	14p
22 PIN	16p
24 PIN	18p
28 PIN	20p
40 PIN	25p

ZENER

400 MV BZY88 RANGE 2V7 TO 39V	6p
1.3W BZX61 RANGE 2V7 TO 39V	12p

VOLTAGE REGULATORS

7805	35p
7806	35p
7808	35p
7812	35p
7815	35p
7818	35p
7824	35p
7905	35p
7906	40p
7908	40p
7912	40p
7915	40p
7918	40p
7924	40p
78L05	28p

78L08	28p
78L12	28p
78L15	28p
78L18	28p
78L24	28p
79L05	40p
79L08	40p
79L12	40p
79L15	40p
7818KC	100p
7824KC	100p
LM309K	100p
LM317K	220p
LM317T	180p
LM323K	420p
LM723	40p
78HGKC	570p
78H05KC	800p
78H12KC	700p
78GU1C	190p
79GU1C	215p
79HGKC	800p

L.E.D.'S

LED 3MM RED	5p
LED 3MM YELLOW	10p
LED 3MM GREEN	10p
LED 5MM RED	5p
LED 5MM YELLOW	10p
LED 5MM GREEN	10p

RECTANGULAR L.E.D.'S

RED	10p
GREEN	15p
YELLOW	15p

LINEAR IC's

LF-347	110p
LF-351	45p
LF-353	48p
LF-355	60p
LF-356	60p
LF-357	70p
LF-398	300p
LM-301	26p
LM-307	42p
LM-308CN	70p
LM-311	35p
LM-318	120p
LM-319	165p
LM-324	35p
LM-334Z	115p
LM-335Z	120p
LM-337	250p
LM-339	37p
LM-348	55p
LM-358	45p
LM-377	220p
LM-380	100p
LM-381	150p
LM-382	130p
LM-384	130p
LM-386	85p
LM-387	100p
LM-392	100p
LM-393	55p
LM-709DIL	30p
LM-710	45p
LM-711	85p
LM-723	40p
LM-733	60p
LM-741DIL	18p
LM741MET	45p
LM-747	58p
LM-748	35p
LM-1458	33p
LM-1889	400p
LM-3900	40p
LM-3909	80p
LM-3911	160p
LM-3914	250p
LM-3915	255p
LM-3916	290p
MB-3515	240p
MB-3614	180p
MB-3712	140p
MB-3713	130p
MB-3714	270p
MB-3715	250p
MB-3722	310p
MB-3730	200p
MB-3731	300p
MB-3756	230p
MB-3759	200p
MB-8719	360p
MC-1310P	130p
MC-1455	45p
MC-1458	33p
MC-1469	290p
MC-1488	65p
MC-1489	65p
MC-1496	65p

MC-3302	70p
MC-3401	45p
MC-3403	60p
MC-3423	75p
NE-531	115p
NE-544	170p
NE-555	20p
NE-556	40p
NE-565	110p
NE-566	130p
NE-567	115p
NE-570	360p
NE-571	290p
NE-592	85p
NE-5532P	140p
NE-5534P	110p

74 SERIES

7400	20p
7401	16p
7402	18p
7403	20p
7404	35p
7405	10p
7406	36p
7407	36p
7408	25p
7409	20p
7413	30p
7414	45p
7416	40p
7417	32p
7420	22p
7421	25p
7425	15p
7430	25p
7437	28p
7438	32p
7442	38p
7447	60p
7450	22p
7451	10p
7454	25p
7470	30p
7473	25p
7474	35p
7475	25p
7481	90p
7482	60p
7485	28p
7486	28p
7489	75p
7490	35p
7492	45p
7493	35p
7495	48p
7497	80p
74107	30p
74111	52p
74116	85p
74119	85p
74122	40p
74123	20p
74125	40p
74126	45p
74132	42p
74141	55p
74145	70p
74153	45p
74155	45p
74157	45p
74160	50p
74164	50p
74167	35p
74173	50p
74174	60p
74175	65p
74176	45p
74180	50p
74182	45p
74192	40p
74196	40p
74197	45p
74393	70p

74LS SERIES LOW POWER SCHOTTKY T.T.L.

74LS00	12p
74LS01	12p
74LS02	12p
74LS03	12p
74LS04	12p
74LS05	12p
74LS08	12p
74LS09	14p
74LS10	12p
74LS11	12p
74LS12	12p
74LS13	20p
74LS14	24p
74LS15	14p
74LS20	14p
74LS21	14p
74LS22	14p
74LS24	35p
74LS26	14p
74LS27	14p

74LS28	14p
74LS30	14p
74LS32	15p
74LS33	15p
74LS31	15p
74LS38	15p
74LS40	15p
74LS42	25p
74LS47	52p
74LS48	48p
74LS51	13p
74LS54	13P
74LS55	15p
74LS73	24p
74LS74	18p
74LS75	24p
74LS76	24p
74LS78	24p
74LS83	37p
74LS85	37p
74LS86	25p
74LS90	26p
74LS91	55p
74LS92	32p
74LS93	26p
74LS95	41p
74LS96	52p
74LS107	28p
74LS109	28p
74LS112	28p
74LS113	28P
74LS114	28p
74LS122	35p
74LS123	35p
74LS124	85p
74LS125	30p
74LS126	30p
74LS132	30p
74LS133	30p
74LS136	30p
74LS138	28p
74LS139	28p
74LS145	65p
74LS147	90p
74LS148	75p
74LS151	27p
74LS153	31p
74LS154	78p
74LS155	36p
74LS156	36p
74LS157	22p
74LS158	27p
74LS160	38p
74LS161	38p
74LS162	38p
74LS163	36p
74LS164	36p
74LS165	50p
74LS166	55p
74LS168	60p
74LS169	55p
74LS170	68p
74LS174	30p
74LS175	32p
74LS190	47p
74LS191	43p
74LS192	41p
74LS193	41p
74LS194	41p
74LS193	44p
74LS196	45p
74LS197	42p
74LS221	45p
74LS240	45p
74LS241	45p
74LS242	43p
74LS243	50p
74LS244	40p
74LS245	40p
74LS247	40p
74LS248	40p
74LS249	70p
74LS251	24p
74LS253	36p
74LS256	52p
74LS257	32p
74LS258	35p
74LS259	50p
74LS260	30p
74LS266	22p
74LS273	44p
74LS279	33p
74LS280	88p
74LS283	51p
74LS290	26p
74LS293	26p
74LS365	26p
74LS366	31p
74LS367	28p
74LS368	30p
74LS373	45p
74LS374	45p
74LS375	46p
74LS390	42p
74LS393	37p
74LS399	68p
74LS629	95p
74LS641	88p
74LS642	105p
74LS644	106p
74LS645	105p
74LS670	62p
74LS674	310p
74LS687	250p

COMPUTER IC'S

2114	200p
2532	330p
2716	200p
2732	280p
2732A	300p
2764	240p
27C64	550p
27128	310p
27256-25	400p
41256-15	240p
4116	75p
4164-15	150p
6116	150p
6264-12	300p
6502	300p
6502A	400p
65C02	930p
6503	570p
6520	170p
6522	330p
6532	460p
6545	880p
6551	530p
6800	210p
6802	220p
6803	800p
6808	500p
6809	600p
6810	150p
6818	380p
6820	140p
6821	140p
6840	310p
6845	620p
6850	110p
8080A	400p
8085A	300p
8086	500p
8088	500p
8155	360p
8156	300p
81LS95	120p
81LS96	130p
81LS97	130p
81LS98	130p
8224	240p
8226	240p
8243	250p
8250	850p
8251	270p
8253	230p
8255	200p
8256	1200p
8257	220p
8259	280p
8271	3400p
8279	270p
8284	440p
8288	650p
8748	1100p
8755	1400p
AY3-1015	290p
SP0256AL2	500p
Z80ACPU	150p
Z80BCPU	400p
Z80ADMA	500p
Z80AP10	220p
Z80BP10	340p
Z80ACTC	200p
Z80BCTC	320p
Z80AS10	460p
Z80AS10-1	580p
Z80AS10-2	580p
Z80ADART	500p

SPECIAL OFFER DRAMS

4164-15	150p
4164-12	175p
41256-10	260p
41256-12	240p
41256-15	220p
41464-12	360p
41464-10	430p
256KX4	1000p
1MBRAM-8	1080p
1MBRAM-10	1000p

SIPP

256KX9-10	3000p
256KX9-8	3800p
256KX9-7	5200p
256KX9-6	6500p

SRAMS

6264LP15	250p
6264LP12	280p
6264LP10	300p
32KX8-12	800p
62256-12	800p
27512	580p

SIMMS

1MX9-10	9500p
1MX9-8	9800p
1MX9-7	10500p
2MX9-10	39000p
4MX9-80	78000p

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a regular feature for the Spectrum Owner...

by Mike Tooley BA

LAST MONTH we described some applications for our SAM Coupé S-Channel ADC. This month, in our sixty-eighth and last *On Spec*, we shall be rounding off the series by dealing with a number of odds and ends, hints and tips, and queries sent in by readers.

We shall begin, however, by indulging in a little nostalgia as we look back over the past six years at some of the milestones in the development of the Spectrum and SAM computers.

Swan Song

Sir Clive Sinclair's vision of low-cost computing for the masses astonished many of the pundits a decade ago. Until the advent of the ZX-81 (and later the Spectrum) computers suitable for "home use" were either "bottom-of-the-range" (but nevertheless expensive) CP/M machines or were systems which were put together as kits (remember the UK-101?) by those having already gained some expertise in electronics.

In 1982, the idea that a colour computer with 16 or 48K of RAM could be available at less than £100 was nothing short of amazing! Nevertheless, it was Sir Clive's foresight and imagination that took this concept into reality and a whole new generation of computer users was borne overnight.

Furthermore, the Spectrum went from strength to strength. Improvements to the basic 16K machine included the Spectrum 48K, Spectrum Plus, 128K, Plus Two, and later the Amstrad/Sinclair Plus Three machine.

During this time a large number of software houses and third party hardware suppliers were busy climbing onto an unstoppable rolling bandwaggon. Not surprisingly, some of these companies failed but others went on to become major international concerns employing hundreds of hardware and software engineers. One such company (which was involved at the beginning) was Miles Gordon Technology. It was their bold decision to further develop the Spectrum line with a revolutionary new home computer, the Sam Coupé.

Owners of the Coupé (me included) can be justifiably proud of this machine. It corrects many of the shortcomings of the Plus Two and Plus Three machines and provides a performance which rivals many of today's 16-bit home computers. One can only hope that the development of this machine continues and that further support will be forthcoming from software developers eager to take advantage of the power of this machine.

On Spec Awards

Whilst the Spectrum was a bold new concept, it is undeniably true that the machine would not have gained so much popularity without the enthusiastic support of a great many third party hardware and software developers. In such a small space, it is unfortunately impossible to mention all of those concerned: so, with tongue in cheek, I have drawn up my own personal list of *On Spec Awards* for excellence in support of the Spectrum.

Regrettably, many of today's computer products (both software and hardware) get "hyped" into the market by over-enthusiastic sales promotion. For this reason, my personal accolade is based on innovation rather than commercial success. Here are the "winners":

ON SPEC AWARDS

Best peripheral hardware: MGT's **Disciple** interface.

Best productivity software: Joint winners, Kemsoft's **PCB Designer** and Besoft's **Electrodraw**.

Best software development tool: Ocean's **Laser Genius** machine code development system. Laser Genius was written by Chris Smith, Andrew Foord and Kevin Hambleton.

Best Spectrum programming language: Betasoft's **BETA BASIC**.

Best Spectrum book: **Understanding your Spectrum – BASIC and Machine Code Programming** by Dr Ian Logan (published by Melbourne House ISBN 0 86161 111 X).

Points from the post

H. De Groot writes from Pretoria South Africa with a useful snippet for owners of early versions of the Spectrum. Mr de Groot writes:

"Recently I have had two Spectrum Issue Two for repair. Both had the same fault: R56 (56 ohm) resistors in the – supply circuit burnt out. This voltage is only used in the 16K RAM. The question was, which chip had failed?

Your articles in On Spec *May and December 1989 were very helpful. Somebody told me that the 4116 are very unreliable and they can be replaced with 4164 after making a few on-board modifications as follows:*

(a) Leave pin-1 of each RAM disconnected (I bend the pin upwards)

(b) Pin-8 should be connected to VCC (+5V not +12V)

(c) Pin-9 should be connected to ground.

Mr de Groot suggests that a large number of RAM problems can be eliminated with this modification. The modification effectively uses half of the available memory capacity of the 4164 (the upper half is unused as the A7 input on pin-9 is held permanently low by grounding).

The 4164 employs only a single +5V supply rail, rather than the three rails (–, +5 and +12V) required by the 4116. I am uncertain as to whether the 4116 is any less reliable than the 4164 however, since the latter device uses only a single supply rail, the equipment has to be very much more reliable since it will be very much less susceptible to faults which arise from the power supply rails!

Also on the topic of 4116 RAMs, ***Walter Wirth*** writes from Colombo Sri Lanka to describe a fault which recently occurred to his Spectrum Plus. Walter writes:

"I write with reference to your On Spec *column in the December issue of* Everyday Electronics. *The day after this issue arrived, my Spectrum Plus went faulty from mains fluctuation. On power-up the computer partially initialised and locked up. I was left with a yellow screen, some randomly distributed "set" pixels and, instead of the Sinclair copyright message, some gibberish consisting of partially formed and garbled letters.*

After much testing, I traced the fault to "open" 4116 DRAM chips IC9 and IC13. These are in the lower 16K RAM. Because this area holds the System Variables and screen display data, a fault in lower RAM can cause all sorts of problems. "Open" chips do not overheat so can be a great pain to troubleshoot. The fault was finally detected by "piggyback" substitution of good RAM chips.

For your readers' reference Television *magazine ran an excellent series of articles by Ken Taylor on servicing Sinclair computers in the May to October 1986 issues.*

Walter Wirth is trying to make contact with several UK based manufacturers of peripherals, including RAM Electronics and Quasar Software. If any reader can provide an up to date address, fax or telephone number for either of these firms please drop me a line so that I can pass on the information.

High Price

Chris West has sent me a very interesting letter from Canterbury in which he bemoans the relatively high price of non-games software for the Spectrum. Chris writes:

"I was pleased to read your recent reviews of some of the electronic CAD packages available for the Speccy. Unfortunately, these are somewhat expensive compared to the games software which I normally buy. Can you explain why this is? How easy would it be for me to write my own CAD program and would I have to use machine code?"

Well, Chris, I must confess that I just don't agree with you concerning the price of the CAD packages recently reviewed in *On Spec*. Both Kemsoft's PCB Designer and Besoft's Electrodraw are first class packages offered at a fraction of the cost of similar offerings designed to run on a PC.

Furthermore, just because these programs run on a humble Spectrum they should not be regarded as in any way inferior. For the enthusiast working at home, they both provide an affordable route into electronic CAD!

As regards writing your own package, I certainly hope that you have plenty of time available! Spectrum BASIC would almost certainly be far too slow for the time critical routines associated with manipulation of screen images and thus a good starting point would be the acquisition of a good book on machine code, an assembler and monitor, and a disk drive (and interface) to remove some of the tedium associated with software development in a cassette based environment. All of this will cost many times more than a ready made electronic CAD package even without considering the hundreds of hours needed to perfect the software!

MGT

Several readers have asked for further information concerning the demise of MGT and, in particular, for details of where to go for support for the Sam Copé. I am, therefore, very happy to report that, by the time that you read this, the "Sam Coupé Hotline" should be up and running. This service will provide all the latest news, hints and tips for Sam owners updated every week.

The material will be produced by Alan Miles and Bruce Gordon (creators of the Coupé) and should certainly prove invaluable to users. The service is available on ☎ 0898 299380 and calls are charged at 25p per minute at the "cheap rate" and 38p per minute at other times. For further information contact Bruce Everiss on ☎ 0926 640137.

And finally . . .

In closing this series, I would like to extend a very sincere thank you to all those readers who have taken the time and trouble to write with hints, tips, and queries.

When I started writing the first *On Spec* (some six years ago) I little thought that the series would run for so long. At the time, I recall suggesting to Mike Kenward that the series would stand or fall on the level of interest from readers (without a regular injection of ideas and material I certainly did not think I could keep *On Spec* going for very long)!

In reality, the support from readers has been truly amazing, indeed in the early years each day's post seemed to bring in something new from an *On Spec* reader. It is this, more than anything else, that has made the series worthwhile for me.

Finally, if you have any suggestions for inclusion in a possible future series, please don't hesitate to drop me a line at the address below. I regret that I cannot answer letters on an individual basis but rest assured that your comments will be noted and passed on to the Editor.

Mike Tooley, Faculty of Technology, Brooklands College, Heath Road, Weybridge, Surrey KT13 8TT.

FOR YOUR ENTERTAINMENT

by Barry Fox

Musical Notes

The music you hear from around 50 per cent of British radio stations is now selected by a computer. The market leader, called Selector, was on demonstration at the *Radio Academy Festival* held in Glasgow earlier in July.

Selector is a program that runs on a desk-top PC. It stores a list of all the records in common use, along with tell-tale information on each, such as the length of each tune, whether it is vocal or instrumental, the tempo in beats per minute, how long the musical introduction runs before anyone sings, whether there is a fade-out at the end and so on.

The station then enters its own set of "rules", largely derived from market research amongst listeners. These dictate what mood of music can be played at each hour of the day, on each day of the week.

The computer then juggles all the information and rules to jigsaw tunes of the right mood and right length to fill up each hour of programming. It takes five minutes to programme a full day's selection. At the same time the computer spews out play lists for the payment of fees to the various copyright agencies.

I watched it in action, and asked about some of the short-hand codes used for the rules displayed on screen.

What does BW stand for? we asked innocently. "B stands for Black and W stands for Wimpy", we were told.

So BW means wimpy music played by a black artist. "B two in a row" means that the station audience is happy to have two tunes by black artists played in a row. White Wimpy is far less popular.

I particularly liked the rule for A Capella music, a vocal ramble without musical accompaniment much favoured by pretentious pop stars. This is ruled as "no more than one every 900 minutes."

Play Time

I review jazz compact discs for a hifi magazine, and recently had the National Youth Jazz Orchestra's recording *"Big Band Christmas"* (NYJ CD 009).

NYJO is best described as the unofficial university of non-classical music in Britain. Over the last quarter century many musicians have started successful careers with NYJO.

The Big Band Christmas recording came out of a concert tour, for which NYJO founder and leader Bill Ashton pulled in arrangements of Christmas standards from well known arrangers.

When reviewing I routinely check the playing time. You would be surprised how many CDs short change the listener with well under the hour that has become the ballpark time for a CD.

The CD player read out the playing time as 76 minutes 35 seconds. Surely this is longer than the theoretical maximum playing time available from a CD? Microsoft's tome on CD and CD-ROM technology "The new Papyrus" quotes maximum playing time for an audio CD as 74 mins 33 secs, derived from a maximum of 335,475 data frames running at the standard rate of 75 per second.

I checked the disc on another player and it gave the same playing time readout. So I then checked the actual playing time with a stopwatch. And it confirmed 76 mins 35 seconds timing.

I checked with Philips and they say that pressing plants are finding they can now go further out towards the edge of the disc, thereby extending playing times well past previously accepted limits. No-one now seems to know what the real 100 per cent limit is for CD playing time.

Power Cut

The Inland Revenue and Customs and Excise have legendary Draconian powers. But so, I recently discovered, do the Electricity Boards.

Earlier this year a video and TV shop in North London closed suddenly. Post piled up inside the door, with no one moving it. Some were obviously bills. There was unsold stock inside too, including prestige TV sets from a major manufacturer.

Eventually a notice appeared on the door saying that the LEB had moved in and changed the locks. The shop's owner could call at the LEB's office, with proof of identity, to collect the keys–after paying all unpaid bills, of course.

So far the locks remain and the post continues to pile up.

This raises an interesting question. How does a manufacturer retrieve unsold stock on which payment is due, if the LEB has changed the locks on the premises? It's something for suppliers to think about.

Off-Side

Although the 1990 football World Cup is now over (to the undisguised relief of those who are bored with endless talk of soccer) the run-up to the next World Cup, to be held in the US in 1994, has already begun. And already storm clouds are gathering.

TV is the cause. Although North Americans play soccer at high school, they soon forget about it and spend the rest of their lives watching American football or baseball. These two games have one thing in common, interrupted action. The interruptions are filled by advertising commercials on TV.

The referee is in radio contact with the TV crew during the game to synchronize breaks. Live in the stadium, giant TV screens display action replays, close-ups of the players, endless statistics about the teams and digital clock count-downs of the time remaining in the game.

By a string of good fortunes, I sat with some American visitors in the Olympic Stadium in Rome watching the World Cup final, and they were very soon predicting doom for 1994. Although FIFA (Federation Internationale de Football Association) allows two large video screens in the stadium to show close-ups of the teams before and after the game, it prohibits any video coverage during the game. Match time is shown by an old-fashioned analogue clock, which gives no clue to how much time is left on the referee's stop watch, after extensions for injury etc.

What really shook the Americans, was the non-stop play, 45 minutes each half, with absolutely no time for commercial breaks in a live TV transmission. If all the commercials are crammed into the 15 minute half time interval, viewers will simply switch stations, go to the toilet and make coffee.

The US TV networks now want FIFA to change the rules of soccer to suit TV sponsors, by breaking the game down into four quarters instead of two halves. FIFA is confidently expected to tell the Americans to get lost.

Divine Act

Incidentally there was one delightful incident at the end of the World Cup match which the TV cameras never covered. Official sponsors, such as Canon, Coca-Cola, Fuji, JVC and Philips pay FIFA a small fortune to have their names displayed round the pitch and thus be seen on TV.

As the match drew to a close a hot air balloon emblazoned with advertising for non-sponsors Hitachi floated into the Roman night sky from a hill a couple of kilometres away and for a while looked as if it would drift into the open top of the stadium, just as the Cup was being awarded. This would have grabbed Hitachi free world TV coverage.

Instead the balloon stopped dead at a religious statue on the hill, apparently snagged on the figure's outstretched arm. There it hung, until the crowd had gone home, out of sight of the TV cameras and seen only by a few spectators restless with the presentation ceremony.

Special Series

MICRO IN CONTROL

JOHN HUGHES

Part Eleven

Starting from very basic principles this series quickly builds through logic to simple microprocessor control.

Outward Bound!

T We've learnt how to make our system detect the operation of a switch, so we could detect the closure of any contacts, such as a reed switch. Now we should consider how to send out signals as well as receive them.

S *The VIA will do this, I assume.*

T Yes. As we mentioned previously, the eight pins of Port A can be programmed to be either inputs or outputs as we wish. The 6522 has a second register associated with Port A. It's called the Data Direction Register for the Port. We can refer to it as DDRA. Its address is C003 (two up on the Port itself).

S *Why TWO up?*

T Well, the VIA chip has two ports, A and B, and two direction registers, DDRA and DDRB. They are located next to each other, like this:

Location 0 . . . Port B
Location 1 . . . Port A
Location 2 . . . DDRB
Location 3 . . . DDRA

Don't ask me why this is the order, but so it is. The chip also has a dozen more registers which make it so very versatile, as we'll see.

Now, the trick in using a DDR is to remember that a logic 1 in any bit will make the CORRESPONDING bit in the Port into an OUTPUT, while a 0 in a DDR bit makes the Port bit an INPUT. After a RESET, all bits are inputs. This makes for safety, as an unexpected output from a controller could have some alarming effects!

S *If we wanted some outputs, then, we'd write a 1 into each required bit of the data direction register?*

T Exactly. Let's say we wished to have pin 0 (the right-hand one) of the eight to act as an output pin; to drive a relay circuit, for instance. What value would we put in location C003 (DDRA)?

S *0000 0001/01 in hex.*

T Right. If we proceed to write a routine which, say, causes a switching signal to be sent to it, we could check that the signal was there, using a voltmeter, or an indicator from our logic kit. Let's try:

Exercise 19 Spot the flasher!

There is a sub-routine at FB9E which is just a delay routine. In other words, it slows things down for an appreciable second or so, to give us a chance, for without such delays, our micro rips through its instructions in literally millionths of a second. The delay uses the value (22 hex, remember) stored at 0006. It also includes the display subroutine within itself.

Our program can first set up the port to have one output, then switch over this output by simply adding 1 to it. If we then call "delay and display" and loop back to start again, that should do it. Care to try to write it out before looking at my version of it?

S *Give us a few minutes, then.*

T Well, just a few. I'll use 0200 as my start address. It has to be in RAM, remember. (after a pause) Here goes:

START	0200	A9	01		LDA 01	I	Set up DDRA with 01.
	0202	8D	03	C0	STA	C003	
SWITCH	0205	EE	01	C0	INC	C001	switch bit 0, Port A.
	0208	20	9E	FB	JSR	FB9E	use delay/display s/r.
	020B	4C	05	02	JMP	0205	Back to switch again.

S *I see, the adding "one" in the third line ALWAYS switches from 0 to 1 or from 1 to 0.*

T Yes. There are many quaint little tricks like that. You could use the ADC instruction instead to add one.

S *I did!*

T You may now like to study, or even try out, if you rig up the necessary hardware, some of the control examples in ROM. There's one, you may have noticed, for a model train control, if you add the sensors (reed switches) and use the outputs to control relays for stop/go, forward/reverse, and slow/fast. You'll find it uses pins 6 and 7 as inputs, and 0, 1 and 2 as outputs. The others are unused. (Fig. 11.1)

Less hardware is needed for some of the other programs in ROM, worth studying because the techniques they use can be applied to many control systems.

Exercise 20 Analogue and Digital - Again

Early in our discussions, we moved from analogue circuits, such as amplifiers, whose output signal is proportional (we hope) to the input signal, and concentrated on digital (logic) signals which are always ON or OFF (5V or 0V). However, the real world is more akin to an analogue system, isn't it, in the way things vary?

S *Yes, it gets warmer or colder gradually, not in a step / and daylight dawns slowly, and it gets dark gradually.*

T Exactly. For some control applications we need to deal with signals which follow such a variable pattern. Can you think of an example?

S *The output of an electronic thermometer / or a car speedo / or a light dimmer control.*

T Good. And no doubt you can think of others. Well, as with all control systems, there are INPUTS and there are OUTPUTS, *from* sensors and *into* drivers, with the processing circuit between (Fig.11.2). We've already rigged up such systems using all analogue circuits with a transistor as an amplifier (doing the "processing"). An LDR as input sensor, with a milliammeter as output device would form a light-level meter, wouldn't it (Fig. 11.3)?

S *Or our light "dimmer", with a variable resistor in the base circuit of the transistor driving the lamp (Fig. 11.4).*

T Right. In fact, most radios and tape recorders are based on analogue signals,

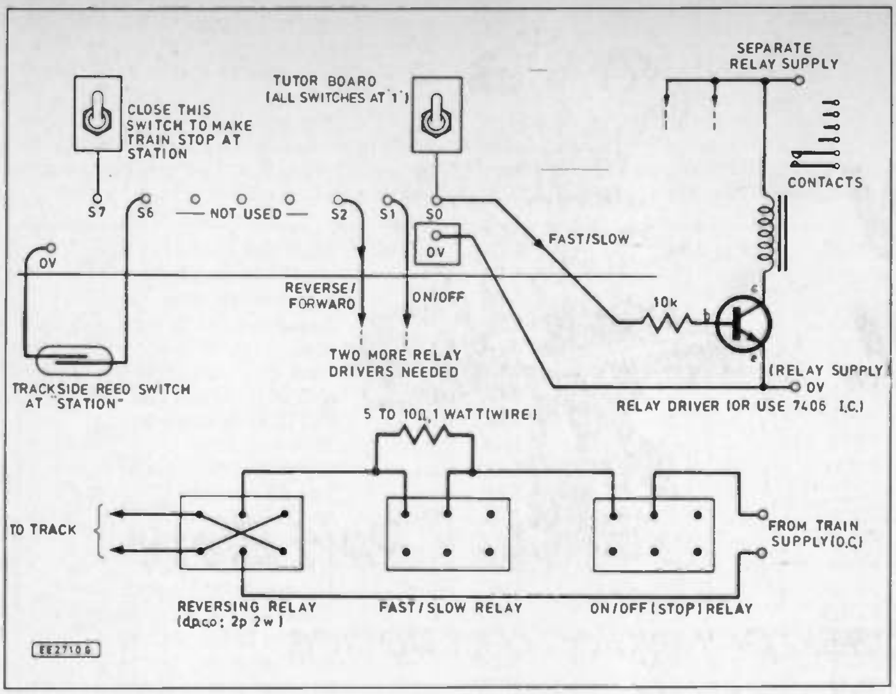


Fig. 11.1. Control of model train. Example in ROM:
It may be possible to lay one's hands on a toy electric train set, and the hardware shown here can be added to a very basic layout with a single loop of track having one model train running on it. The diagram shows a circuit for a relay linked to an output from the micro. Three such circuits are needed, as indicated, using PA0, PA1 and PA2.
The three transistors could be replaced by an open-collector driver chip such as the 7406, which has six such drivers in it. No inputs are essential for the demonstration program, but it can take account of inputs to PA7 and PA6, if a trackside reed switch, operated by a magnet on the train, is linked as shown to PA6. Then, during the run, if switch 7 (or an external switch linked to PA7) is closed, the train will stop at the reed switch position (station?). Remember to leave board switches at logic 1.
The sample ROM program (START ADDRESS FF40) sends out a series of "action" codes, each lasting for a certain "duration". There are eight of them here, but the program allows for changes, which will be discussed later.
(The program can, of course, be tried out without any hardware other than three indicators for the outputs, but it is strongly recommended that some external circuitry be built and tested. THIS IS THE WAY TO LEARN HOW A REAL CONTROL SYSTEM WORKS.) A separate relay supply is best.

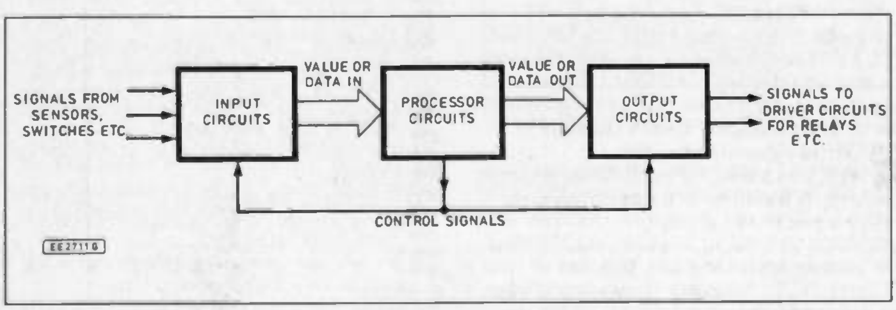


Fig. 11.2. Arrangement for control system. (In this case no feedback is shown.) It could represent a digital or an analogue system

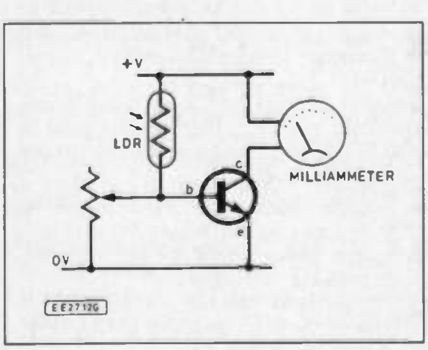


Fig. 11.3. A very simple "light meter" arrangement (analogue).

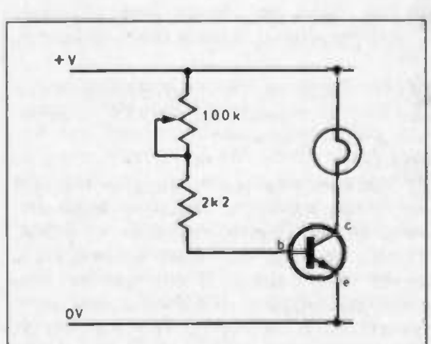


Fig. 11.4. A "dimmer" for a small lamp.

though digital techniques are well on the way to taking over nowadays.

S *How can the two be linked?*

S *(another) There are conversion circuits, aren't there? Probably in the form of i.c.s.*

T There are. In fact, that's what we shall have to look at for our control systems if we wish to use microprocessor control of analogue signals ("computer control", in other words). Here's an example with the 6502 system:

Exercise 21 Swinging the LED...

At first sight, it may seem that, while analogue signals can change gradually from one value to another, our digital signals cannot; however, we can arrange a series of digital signals to cause changes in tiny steps, becoming very like an analogue signal. As you guessed, there are chips to do just this; we'll meet them in due course.

S *Won't we notice the steps?*

T If we only have a few big steps, yes, though this may not matter in some cases. But if we use a large number of very tiny steps, it's virtually impossible to distinguish them from a steady change.

S *Doesn't the quantum theory mean that all changes take place in infinitesimally small steps, anyway?*

S *(others) What's he on about / He's right / etc . . .*

T I agree. If you think about any measurement, quite apart from theory, it's impossible to carry it out to more than a limited precision. So . . . a lot of small steps, OK?

S *But how many, though?*

T With eight bits, we can have . . ?

S *256 steps, as there are 256 different values possible.*

T That's right, values from 0 to 255 are available. This can give quite a smooth change.

S *How can we make a suitable circuit?*

T We must distinguish between inputs, which require a conversion from analogue to digital signals (A to D), and outputs, which need the opposite, D to A conversion. Let's consider the latter to start with, as there are a couple of programs in the Tutor ROM to demonstrate it immediately. At least, they demonstrate one easy way to do the conversion. Consider an output signal from a digital line. It can have two values. What are they?

S *(chorus) 0 volts and 5 volts, or thereabouts.*

T Of course. Now suppose we use such a signal to drive a l.e.d. and cause the signal to be switched ON for half the time, OFF for half the time, at a fast frequency.

S *Like in the "organ" multivibrator we made.*

T Exactly. How will the l.e.d. appear?

S *Dimmer / it'll be getting half the full signal / on average, that is.*

T Right again. Now suppose we could alter the "mark to space" ratio, so that it's ON longer than OFF, or vice versa.

S *It would be brighter / or dimmer / we could make it as bright or dim as we like / between zero and maximum.*

S *(others) IF we can arrange the switching patterns.*

T Good. Well, with a suitable program we can do just that. The start address of the first program is at FDC0, but FIRSTLY, you will need to enter two numbers into locations 0001 and 0002, to set the desired ratio. Right?

S *So, first, we go to location 0001, that's: 0000 0000 0000 0001 and enter a number as its DATA. Any number?*

T I suggest you enter FF into BOTH locations to start with (enter the first, use INC, and enter the second). Then go to the start FDC0 (1111 1101 1100 0000) and press GO to see the display l.e.d. flashing.

S *This will be the slowest speed.*

T Right. Use RST to stop it, then change ONE of the values (the one in 0001 for ON, the other for OFF) to see the effect when you run it again. Then try two equal but SMALL values to make the flashing so rapid that the l.e.d. will appear to be lit steadily. Try a few more combinations of small but unequal values to "adjust" the l.e.d. to any brightness you wish.

S *(later) It takes a lot of entering! / not too bad with the keypad.*

T It does, so let's make the micro do the changing of the values. There are two programs which you can just RUN and watch: The first is at FDEA, so go to this start address and GO.

S *(after watching for a few moments) The l.e.d. starts off flashing slowly and gradually speeds up / then repeats it.*

T Yes. The program makes the ON time shorter, the OFF time longer, in steps, then jumps back to start again. The other program starts at FE0D, and does the same, but at a higher speed, so the l.e.d. appears to dim smoothly.

S *Could we make it come on gradually, too?*

T Of course, with some more programming. If you wish to try, you could study the ROM routine for this one and see how it might be altered or extended. The earlier mark/space setting program, and both the slow and fast D/A examples use another "delay and display" subroutine (a shorter one) at FDDB. We could learn a little more by studying this subroutine, so here it is, labelled D/D:

FDDB	D/D	A5	00		LDA	00	Take value at 0000
FDDD		85	10		STA	10	Into 0010 as timer
FDDF	LOOP	20	87	F8	JSR	F887	Call display s/r
FDE2		C6	10		DEC	10	Count down timer
FDE4		D0	F9		BNE	FDDF	Until zero, then
FDE6		60			RTS		Return to main prog.

Note the backwards branch, to LOOP, which occurs each time until the timer value at 0010 (whatever it was as copied from 0000) has dropped to zero as a result of the decrement at each loop. The branch value F9 is a negative number and means "branch back seven places".

S *That is, FF, FE, FD, FC, FB, FA, F9.*

T Right. So it goes back from where it is, at FDE4 (containing the F9), to FDDE. Then it moves on, as usual, to the next location, FDDF, and carries out the instruction (JSR in this case) which it finds there. On zero result, it drops through in the normal way to the next instruction at FDE6.

We can also note that this subroutine, like many others, calls another subroutine ("Display") within itself. They are said to be "nested subroutines" and there is a limit (quite a high one, fortunately) upon how many can be nested within each other. It is the job of the STACK POINTER register in the 6502 (refer back to the "programmer's model" if you've forgotton about it) to keep track of the moves in and out of the various sub-routines. Luckily, most of this "housekeeping" is done automatically by the CPU, but we may, later, meet some instructions which allow us to put our oar in as well. For now, we can let the 6502 get on with it.

S *Could we look at one of the main programs as well?*

T Of course. Here is the ROM version of the fast D/A demonstration we just used. Notice how it starts with small timer values so as to avoid flicker effects in the l.e.d.:

FE0D	Fast D/A	A9	00		LDA	00	Start with l.e.d. OFF for
FE0F		85	F0		STA	F0	short, On for longer,
FE11		85	01		STA	01	still shortish, time,
FE13		A9	20		LDA	20	by putting 0 in 01 (and
FE15		85	02		STA	02	in display), 20 in 02.
FE17	LOOP	A5	01		LDA	01	Give OFF value from 01
FE19		85	00		STA	00	into 00 for timer, and
FE1B		20	DB	FD	JSR	FDDB	call D/D subroutine.
FE1E		C6	F0		DEC	F0	Now switch bit 1 . . .
FE20		A5	02		LDA	02	copy ON time from 02
FE22		85	00		STA	00	into 00 (for s/r)
FE24		20	DB	FD	JSR	FDDB	and call s/r again
FE27		C6	02		DEC	02	Decrement ON value,
FE29		F0	E2		BEQ	FE0D	if zero, back to start.
FE2B		E6	01		INC	10	Increment OFF value.
FE2D		EA			NOP		These are "pass" codes
FE2E		EA			NOP		used by the programmer
FE2F		EA			NOP		to fill up space, or
FE30		EA			NOP		to adjust timing loops.
FE31		C6	F0		DEC	F0	Switch bit 1 again . . .
FE33		F0	E2		BEQ	FE17	and use it to loop round again.

So the program alterately loops round the ON and the OFF states, one time being lengthened, the other shortened, at each loop. It will continue indefinitely until stopped with the RESET key. The NOP codes here suggest that, as often may happen, the program was altered during de-bugging. The empty spaces were just filled in to avoid re-writing the final instructions into new locations. An assembler would do this automatically. Sometimes, however, NOPs are used for fine adjustment of the time taken by a loop in, for example, a clock program.

S *It means "No Operation" other than to move on, then?*

T That's it. Take no action, but carry on with the next instruction. As it's difficult to make space in our programs (with no assembler at present to do it for us) it's not a bad idea to sprinkle a few bunches of two or three NOPs here and there, just in case we may need to insert an extra instruction when we test our work. But don't go mad, as they do slow things down a little.

S *And use up memory space.*

T Yes. Next, we should look at ways of deriving digital signals from analogue ones.

S *The opposite of what we've been doing.*

T Yes, and don't forget that the conversion, either way, can be carried out by ready-made chips. We have been using a "software solution" to our problem. A "hardware solution" may sometimes be preferable. In all control projects, a balance has to be struck between hardware and software. It's sometimes called the "hardware/software trade-off", and applies, as we've seen, to many aspects of logic control, not just to A/D and D/A conversions. That's why, ideally, a design engineer should know a good deal both about electronic circuitry and also about programming techniques, so as to be able to select appropriately.

S *Hardware solutions are faster, aren't they?*

T As a rule, yes. Software solutions are much more flexible and sometimes less expensive. But not if you have to buy a micro just to, say, dim a lamp!

Exercise 22 Soft(ware)-Centred?

In this Exercise we shall build an A/D converter circuit, but, as we are using a micro anyway, we'll not use too much hardware, though we can meet a very useful type of chip. The LM339 (not a member of the 74 series) contains a type of circuit called an op-amp (operational amplifier), a type originally developed for performing the mathematical operations of an "analogue computer". This works, as its name implies, along quite different lines from our digital system, and merits close study (another time!) in its own right. The LM339 is designed to be used as a "comparator", which, as this implies, compares two input signals (analogue signals) and gives an output which is suitable for using as a digital input.

S *Like the outputs from the 74 series chips.*

T Just so. In fact, the 74 series and all other logic chips, really contain such op-amp circuits, but used with switched signals not slowly changing ones.

S *We saw the same transistor circuit doing both in our very first Exercises.*

T Good. Now the LM339 will work quite well with our 5V supply, so set up the circuit shown here (Fig. 11.5) using a bread-board linked to the Tutor sockets. The value of R2 can be altered slightly to give bigger or smaller voltage steps, but the maximum input signal cannot exceed about 4V.

Resistor R1 may not be needed if a low impedance source is being used, and it could form part of an input divider for use with higher voltages.

S *Will the circuit act as a sort of digital voltmeter?*

T It will, with suitable software, though the display we are using is more akin to an analogue display! The measurement is made digitally, anyway, so that you can see how it may be done.

S *Analogue displays (I mean pointers) are often easier to read, I think. / Such as a car speedometer / or clock.*

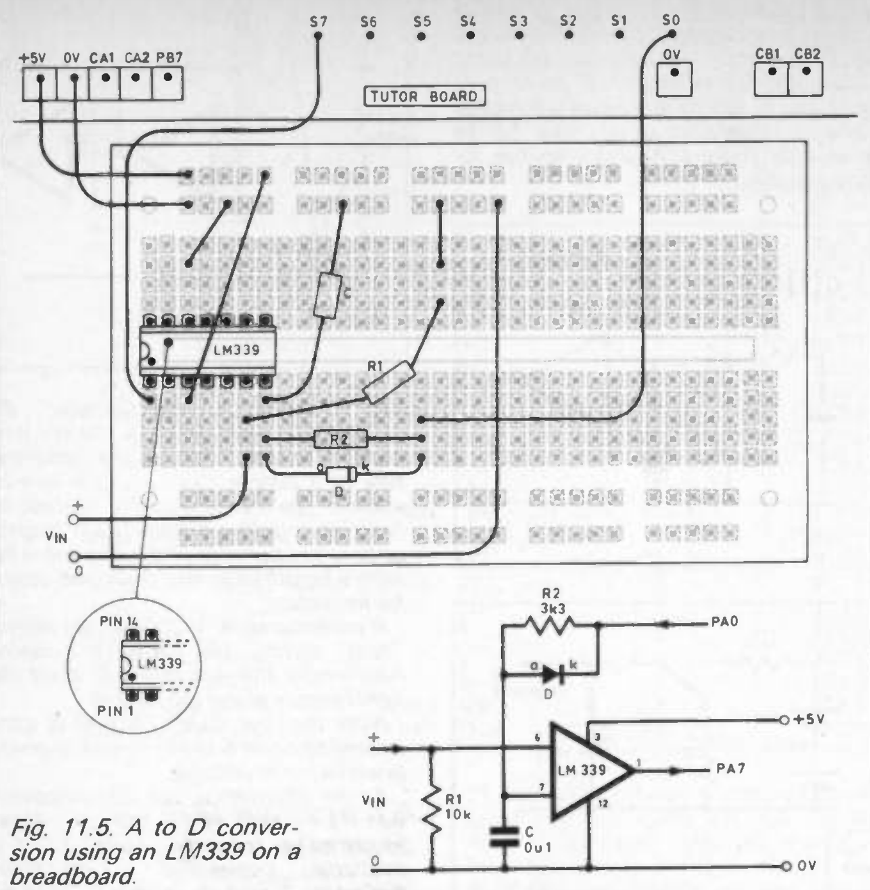


Fig. 11.5. A to D conversion using an LM339 on a breadboard.

Table 11.1. Second part of 6502 Instruction Set. (There are 56 mnemonics in all, with 13 possible modes)

MNEM	Description (Total bytes)	IMM 2	ACC 1	ABS. 3	Z/P 2	IMP. 1	ABS,X 3	ZP,X 2
		MODES:						
ASL	Arith. Shift LEFT		0A	0E	06		1E	16
BIT	Test bits 6 and 7			2C	24			
CPX	Compare X value	E0		EC	E4			
CPY	Compare Y value	C0		CC	C4			
DEX	Decrement X					CA		
DEY	Decrement Y					88		
INX	Increment X					E8		
INY	Increment Y					C8		
LDA	(additional codes)			AD	A5		BD	B5
LDX	Load into X register			AE	A6			
LDY	Load into Y register	A9		AC	A4		BC	B4
LSR	Logic Shift RIGHT	A2	4A	4E	46		5E	56
NOP	No operation	A0				EA		
ROL	Rotate LEFT		2A	2E	26		3E	36
ROR	Rotate RIGHT		6A	6E	66		7E	76
STA	(additional codes)			8D	85		9D	95
STX	Store from X register			8E	86			
STY	Store from Y register			8C	84			94
TAX	Copy (Transfer) Acc. to X reg.					AA		
TAY	Copy Acc. into Y reg.					A8		
TSX	Copy Status into X reg.					BA		
TXA	Copy X value into Acc.					8A		
TXS	Copy X value into Status					9A		
TYA	Copy Y value into Acc.					98		

The modes are, (altogether) immediate, absolute, zero-page, accumulator, implied, (indirect, X), (indirect), Y, zero-page, X, absolute, X, absolute, Y, relative, absolute-indirect, and zero-page, Y.

T Agreed, on the whole. Changing values are easier to follow, aren't they? But each has its uses. Let's carry on.

S *What about the program? I expect it's in the ROM.*

T Yes it is. It's part of the system "firmware" remember? That is the programs (software) permanently fixed. What do you need to know?

S *Its START ADDRESS/Any preparation before running it/How to interpret the outcome.*

T OK. It starts at FA93, and you can use Card 4 as a sort of scale for it. The idea is that, if you apply a small d.c. voltage (say from a small cell) between the 0V line and the lead to pin 6 of the chip, one l.e.d. lights up and "runs" along the scale to indicate the voltage. Again, use RST to stop the program. But note, to run it again, you will have to re-enter the START ADDRESS, as it will have been cleared.

S *(after setting up) My l.e.d. can't decide where to stop.*

T It's quite sensitive and fast acting. There may be a poor contact in the input leads. Or it may be "between" two values. A more elaborate program could prevent this, but it has its uses, for instance in following a "sound" signal from a microphone amplifier.

S *Can we try that?*

T Yes. There are some suggestions here (Fig. 11.6).

S *(later still) How does it work?*

T I was waiting for that, for it allows us to study some further 6502 instructions, of a very important kind. Remember the INDEX REGISTERS in the Programmers' Model?

S *There were two, X and Y, weren't there?*

T Yes. They are similar, but can play slightly different roles. For our purpose we could use either, but we shall use the X register for now. Our program will, in fact, include just three new instructions involving the X index register. here they are:

LDX, which we shall use in immediate mode. It copies from the following location, a value into X just as LDA copies into the accumulator. The op-code for immediate LDX is A2.

S *Does it have other modes?*

T Yes, you can see them in the full instruction set, but here's an extension to our earlier version. (Table 11.1.)

Then there's DEX, which, of course, decrements the X value and thirdly, one of a range of "indexed instructions" for which the registers are mainly intended. It is STA,X although we don't write it quite like that in a program, as you'll see. The idea to grasp is that, when it receives and indexed op-code, the micro goes, not to the address in the date byte(s), but to the address X places further along in memory.

S *So, if we alter X, it will use different locations?*

T It will, and we can make it move up or down a table of values, as we shall see when we analyse this program later.

S *And there seems to be a LDA,X instruction, too.*

T Plus a few more using X and Y in this way. Can you see why they can be so useful?

S *Because the X value can be changed by the program.*

T Good thinking. Yes, it enables the programmer to send the micro, as it were, to different locations (to STORE or to LOAD) using the SAME sequence of instructions, by changing the value in the X register for each occasion the sequence is used.

S *It might be a subroutine / or affected by a key press / or an input signal from a sensor.*

T Exactly. All good examples. In our case, we shall use the INDEXED mode of STA to send logic 1 to the LEFTMOST bit of each display register (that's F3, F2, F1 and F0) in turn, so that our "voltmeter" program starts with only the extreme left-hand l.e.d. lit, and makes the "lit" l.e.d. move along to the right as the input voltage is increased.

S *I can imagine how it might change from one register to the next, by changing X, but how can we make it move along each individual display register?*

T Good question. Well, one more new instruction needed. It's one of several which use the "shift register" function we saw with our row of bistables. Remember?

S *When a pattern can be shifted by each clock pulse along the row of flip-flops?*

Fig. 11.6. Extensions to Circuit using "voltmeter".

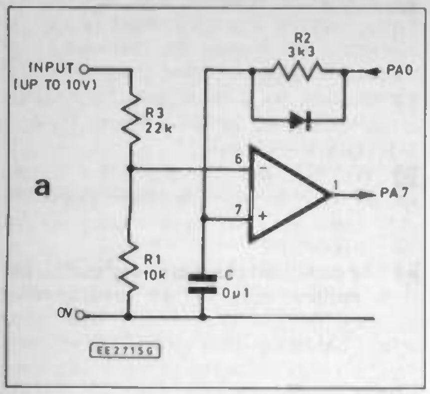


Fig. 11.6 (a) Measuring Higher voltages. A "potential divider" circuit, using two fixed resistors R3 and R1 (already connected) allows a high voltage to be applied to the new input terminals, because only a fraction R1/(R1 R3) of the total voltage is actually applied to the converter input. Thus, to extend the range to say 10V, R3 would need to be about twice R1, i.e. 22K. By using a variable resistor, we could, within limits, measure any higher voltage we wished.

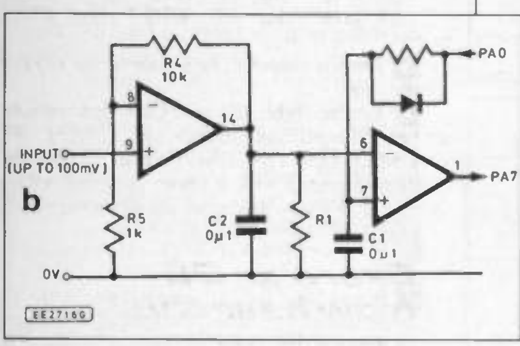
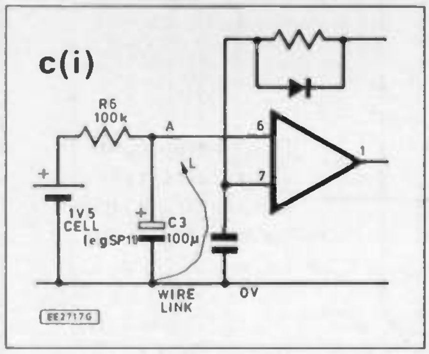


Fig. 11.6 (b) Measuring Lower voltages. An operational amplifier (op-amp) is needed to increase the small input voltage to our 3V range; a section of the LM339 might be used, though not primarily designed for this purpose. The suggested circuit shown here uses the standard method of setting the gain to the ratio R4/R5; with the values shown, signals of up to 0.1V (100mV) could be indicated. The same gain, if preferred, could be obtained by using 100k and 10k respectively, as long as the ratio is ten to one. A much higher ratio is suggested in example (d) to give a far more sensitive amplifier for tiny signals.



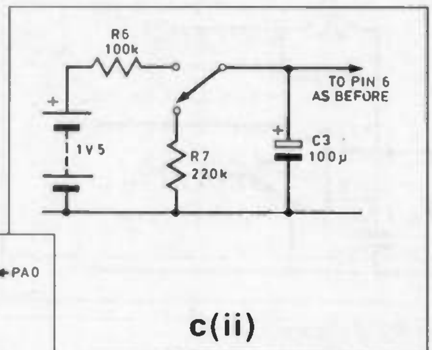


Fig. 11.6 (c) Demonstrating the action of a capacitor. In (i) the voltage across the capacitor is displayed as the capacitor is charged up through a high value resistor R6 (try 100k to start with, and use a 100 microfarad electrolytic capacitor for C3).

It will be necessary to short-circuit the capacitor with a wire link L to repeat the demonstration. In (ii) the charge and discharge can both be observed by using a two-way switch. As well as C3, the values of both R6 and R7 can be changed, and their effect on the "time constant" observed.

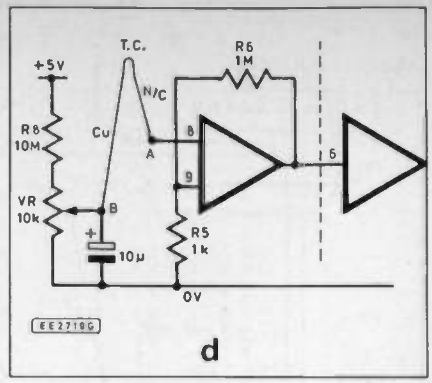


Fig. 11.6 (d) A "thermometer". By using higher sensitivity in the op-amp section of the LM339, the temperature of a simple thermocouple can be shown. The thermojunction is made by twisting together tightly 15cm lengths of bare copper wire and nichrome wire, with a length of sleeving slipped over it for insulation.

A potentiometer P (10k or so) allows "zero" setting; the flame of a match held under the junction will send the light quickly along the l.e.d.s!

Note the that COPPER end is connected to point B in the circuit to give a positive input voltage.

As an alternative, the thermocouple can be removed and a small loudspeaker (or microphone, if one is available) connected in its stead between A and B; it should then be possible to detect sounds as in a VU meter! (despite the a.c. nature of the output).

T That's it. The instruction we'll use is:

LSR, which means Logical Shift Right. (Op-code for indexed zero-page mode is 56.)

S *So if we've lit up the left-hand l.e.d. only, this instruction will "shift" the light along, one place at a time.*

T Just the job. In fact, in our program, it too is indexed, so there are really four instructions involving X.

S *Are there any more new instructions in the program?*

T Just one. And we don't really need this one. It's to test the comparator (the LM339) output. We COULD use the CMP instruction from our original set (followed by a branch), but the 6502 has a special instruction for testing a register.

BIT is its mnemonic, op-code for z-p is 24.

It saves having to tell the micro what to compare with, or having to load the accumulator (which, of course, overwrites what's already there - it may matter). BIT has also to be followed by a suitable branch instruction.

S *Does this program use any subroutines?*

S *(another) It'll have to use the DISPLAY s/r, and perhaps a delay timer.*

T Right you are. It uses yet another delay and display subroutine, which has a fixed delay, but which also saves the value of X, so that it isn't lost during the subroutine itself (which also uses the X index register). Here's the subroutine, labelled DDX. You'll notice that, as you suspected, it too calls the display s/r.

S *It adds one more X instruction, STX / opposite of LDX.*

T Yes. Now for the main A/D conversion program (List 11.1). Most A to D conversions (including this one) are carried out by starting with a D/A conversion. The system generates an analogue signal from a digital value which is changed until it is equal to the input signal to be measured (Fig.11.7). Then the program says "That's it!" and the digital value tells us what the input is. The comparator chip, of course, gives the "stop" signal; in our case into PA7 (bit 7 of Port A). The digitally generated value for comparison is sent out from PA0 to pin 7 of the comparator.

S *Which compares it with the input on its pin 6?*

T Yes. Then the program makes the "LED ON" bit move very rapidly along the "scale" and at the same time the digital value varies from zero upwards, until it matches the "mystery" signal. This causes the output to switch, stopping the process.

S *So the position of the lit l.e.d. indicates the value.*

T Right. It's not unlike a "pass-the-parcel" game in some ways, is it?

S *And presumably the whole process, as usual, is repeated indefinitely. The micro does it all extremely quickly; it appears almost instantaneous.*

FA28	DDX s/r	86	DC		STX	DC		Save X value (in 00DC)
FA2A		A9	50		LDA		50	set fixed speed, using
FA2C		85	DF		STA	DF		00DF as timer location
FA2E	LOOP	20	87	F8	JSR	F887		Include display s/r in
FA31		C6	DF		DEC	DF		timing loop, branch to
FA33		D0	F9		BNE			FA2E until zero, then
FA35		A6	DC		LDX	DC		restore X value and
FA37		60			RTS			return.

List 11.1. A/D conversion "voltmeter" programme: (Hardware required as described in text)

FA93	START	A9	00		LDA	00	Clear Port A
FA95		8D	01	C0	STA	C001	
FA98		A9	0F		LDA	0F	Set up DDRA
FA9A		8D	03	C0	STA	C003	
FA9D		A9	00		LDA	00	Clear all displays
FA9F		85	F0		STA	F0	
FAA1		85	F1		STA	F1	
FAA3		85	F2		STA	F2	
FAA5		85	F3		STA	F3	
FAA7		A9	01		LDA	01	Send charging signal
FAA9		8D	01	C0	STA	C001	to capacitor circuit
FAAC		EA			NOP		and comparator input.
FAAD	LHBYTE	A2	03		LDX	03	Set X = 3 for LH disp.
FAAF	LHBIT	A9	80		LDA	80	and light LH l.e.d.
FAB1		95	F0		STA	F0,X	(starting at F0 + X = F3)
FAB3	TEST	2C	01	C0	BIT	C001	Is comp. output 1 yet?
FAB6		30	05		BMI	FAC2	If so, display l.e.d., if
FAB8		EA			NOP		not, shift to l.e.d. one
FAB9		56	F0		LSR	F0	place to the right.
FABB		D0	F6		BNE	FAB3	Repeat until byte done
FABD		CA			DEX		then reduce X for next
FABE		10	EF		BPL	FAAF	Repeat for all bytes,
FAC0		D0	D1		BNE	FA93	four in this case,
FAC2	DISP	20	28	FA	JSR	FA28	Call DDX display s/r,
FAC5		4C	93	FA	JMP	FA93	and do it all again.

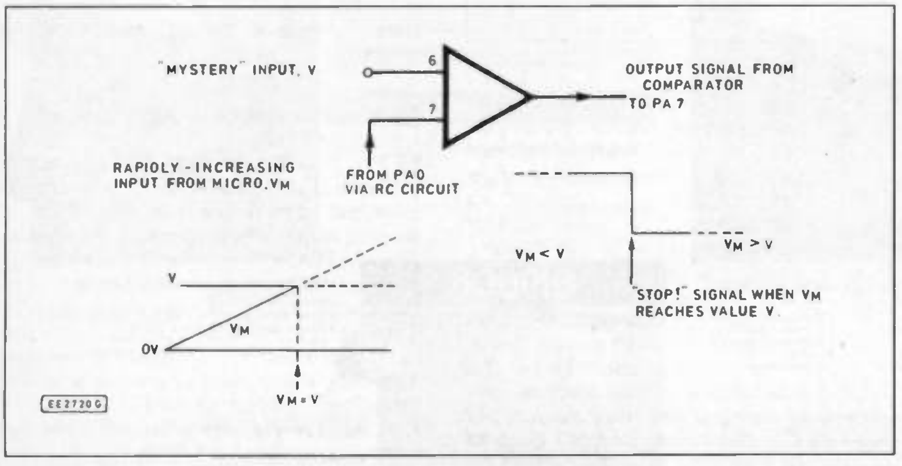


Fig. 11.7. How comparator output switches when both inputs become equal.

T That's right, though it's too slow for some jobs, believe it or not.

Have you spotted the new instruction types in the program? Notice how index X is first loaded with 3, then the value 80 (in hex, remember) is loaded into the accumulator. Anyone care to carry on with the tale?

S *The next instruction STA,X F0 puts this value, which is 1000 0000 in binary, into location F0 plus X (which is 3) that is, into F3 (00F3), the left-hand display register.*

T Very well put. This is how the extreme left-hand l.e.d. is lit to start with. Can anyone else take up the story?

S *(others) The BIT instruction tests PA7 / if it's a 1 the value is negative and the BMI instruction causes a branch / to the DDX subroutine / then the whole thing is repeated by the JMP back to the start.*

T This will give a steady "reading" won't it?

S *Yes, so this must be when the signals are equal / the output from the comparator must be zero to start with / so the BMI branch WON'T happen / and the LSR instruction will make the next l.e.d. light up.*

T Good. Any questions?

S *Yes. I can't see how the program makes the digital voltage increase while the l.e.d. gallops along the scale.*

T That's the key question. In fact, the steady increase in "digital" voltage isn't provided by the program. It could be, and in some more elaborate (and expensive) chips, a real digital to analogue conversion is carried out. We may have time to study a typical purpose-built chip later. Here, we have used the gradual charging of a capacitor to provide the growing signal.

S *So it's not a digital one at all / a cheat!*

T Well, not entirely. In the program you'll see that the signal out from PA0 is switched to zero at the start of the program (and thus at each rapid loop). But, starting at location FAA7, two instructions switch it ON (to about 5V or so, right?), whereupon the capacitor starts to charge via resistor R2. The values are chosen to suit the speed at which the l.e.d. bit races along the scale (which is pretty fast). The diode allows a quick discharge at the start of each program loop.

S *In other words, the scale shows the TIME the capacitor took to reach the "mystery" voltage value?*

T That's it. It's a fairly simple way to arrange to measure an analogue voltage with a digital system. Agreed?

S *Well, OK. But you should show us the specialised chips soon / but these simple circuits can keep costs down when strict accuracy isn't vital.*

T The dedicated chips are very useful, but they require little or no programming as they do the conversions with their own "hardware solutions". We've used very strongly software-oriented solutions, to gain the practice.

I'd like to dwell for a while on this business of indexed instruction modes, as they can be useful in several ways. For example, the monitor "knows" which key has been pressed because each has its own "key value" when depressed (because of the way they are wired to Port B, the one we can't use, as the CPU monopolises it!). To cut a long story short, what we need to know, to make use of this, is that, if NO KEY is being pressed, the key value is 08

GO gives value	00	A/S	gives 04
DA gives value	01	X/Y	gives 05
AH gives value	02	INC	gives 06
AL gives value	03	SHIFT	gives 07

S *There's bound to be a subroutine to read the keys!*

T You're right. It's at FC60, but remember, like all subroutines, IT CAN'T BE USED ON ITS OWN. But it can be demonstrated with a short program starting at FCAA (or you could write your own).

Exercise 25
Now hear this!

First, use the demonstration routine just mentioned, starting at FCAA, to confirm the above values. Just run the program, see 08 in the status display l.e.d.s, then press each key in turn and hold it while you check the value on the l.e.d.s. In binary of course, as usual.

We can use these values to make the keys act in whatever way we wish.

S *Wasn't this done in the "Thief!" game we saw earlier?*

T It was; you could now follow the design of that game if you wished to, or make up your own. What I suggest, though, is that we try to make the keys act as the keys of a sort of primitive "organ"; not unlike the digital equivalent of the "cheapo" version we looked at when we discussed multivibrators. The "mini-wurlitzer", right?

S *That used a variable resistor pitch control, with graphite as the resistor.*

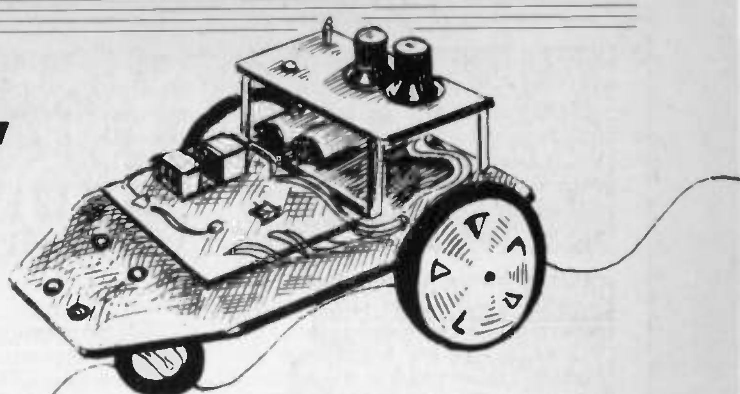
T Yes. Now we'll look at a program to make the keys set the pitch. It will bring to our notice the use of a "look-up table", a very useful technique to add to our bag of tricks. In fact it's also used, as you can imagine, in the "Train Control" program we described earlier.

S *You said the train program could be modified. Can we try?*

T OK. We'll look at it after we've done the tune player program, which is a little simpler to start with.

Next month: The final part deals with the "tune player" and a three floor lift program

Constructional Project



MOBILE LINE TRACKER

CHRIS WALKER

There is no likelyhood of a fuel crisis with this vehicle, and it will keep to the route you set out for it!

ROBOTICS is a fascinating branch of electronics for the home constructor as it adds that extra dimension of *motion* to his or her projects. Flashing lights and tuneful bleeps are always popular but if the thing actually moves and does something, well that will attract attention!

The Mobile Line-Tracker described here is a simple reflex action robot which will optically follow a meandering line on the floor. A control is provided to enable the unit to cope with a wide range of contrasts between floor and line. In addition, it can choose between following a white or black line and can handle quite severe bends.

This experimental project illustrates some basic "sense-and-control" concepts which form important building blocks in a robot system. The Mobile Line-Tracker can be built as described to produce a fully independent "buggy" which will provide hours of fun and fascination. Alternatively, readers may rather incorporate the sense-and-control system into part of a larger robot assembly.

ON THE LINE

Line-following robots are being used more and more to carry goods around warehouses and factories and to deliver mail within an office building. Unlike a train, these robots are not restricted to rails so they can follow the same routes used by the human workers. Home users might employ one to carry drinks to their guests, and act as a sort of butler!

The industrial versions of these "trollies" usually follow a line of magnetic material embedded into the floor. Optical line followers which actually "look" at a visible line are more prone to interference from ambient lighting (with the resultant risk of losing the line), but they offer much more scope for experimentation for the home enthusiast.

In practice, suitable lines can be easily and cheaply laid using masking tape or something similar. This method also ensures quick removal at the end of the day. The prototype model will even successfully follow a line chalked onto concrete, and when you stop to look closely at all the gaps and breaks in the line, you realise what an achievement this is!

IN GEAR

The problem with many automated and robotic projects is that they require some degree of skill to construct drive units such as gearboxes, bearings and wheels etc. It is often difficult for the average constructor to manufacture a small gearbox with reliably-meshing gears, as the author knows too well. Ready built drive assemblies are available on a limited market but, since they are often aimed at the radio-controlled model builder, they can be expensive.

The Mobile Line-Tracker was built using easily available combined motor/gearboxes and popular electronic components. Little difficulty should be found in reproducing a similar unit.

SYSTEM OPERATION

How the two side-by-side optical sensors view the "tracker line" from above is illustrated in Fig. 1. A small lamp is used to illuminate the line in the area of the sensors. For the sake of argument, let's assume that the vehicle is following a white line on a dark coloured floor.

If both sensors are over the line as in Fig. 1a then both receive similar amounts of light reflected off the line and the vehicle proceeds straight ahead. If the tracker veers left (or if the line bends to the right) then the right-hand sensor receives more light than the left, since the latter has now moved off the white line (Fig. 1b.).

If this light level difference is above a level set by the Contrast control then the *right* hand drive motor is switched *off* and the left motor steers the vehicle towards the right and back onto the line. Excessive movement to the right (Fig. 1c.) causes the *left* hand motor to stop and the vehicle is steered back onto the line until both sensors receive a similar level of reflected light once more.

Thus a simple feedback loop is established whereby the control of the drive motors is continuously adjusted to try and maintain even illumination of both light sensors, i.e. the vehicle follows the white line.

In order to follow a *black* line drawn on a light coloured surface it is necessary only to interchange the control signals to each motor. If, for example, the vehicle moves left off the black line then the left hand sensor receives more light from the pale floor. Rather than switching off the left motor, the *right* hand motor is arrested and this swings the buggy towards the right and back onto the black line.

A changeover switch is used to select whether the vehicle follows a black or white line.

SENSORS

The complete circuit diagram for the Mobile Line-Tracker is given in Fig. 2. Two TIL78 phototransistors, TR1 and TR2, form the "eyes" of the robot, each one being mounted in a length of tubing so

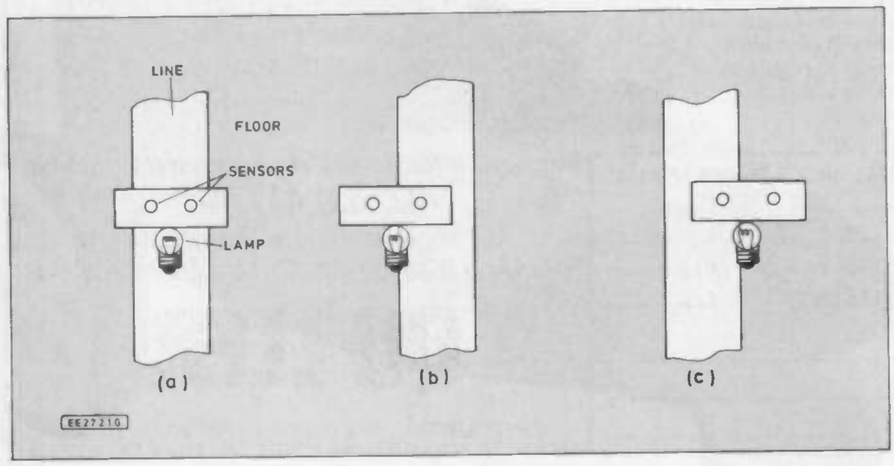


Fig. 1. How the optical sensors view the "illuminated" line from above.

that they have a narrowed-down field of view and only receive light reflected from the floor.

Phototransistors are used in preference to light dependent resistors (l.d.r.s) for this application because they are generally smaller, cheaper and faster to respond to changes in dim light. The latter being one important feature if the robot is not to lose the line on a sharp bend.

The *npn* phototransistors TR1, TR2 pass a current from collector to emitter which is proportional to the light intensity falling on their semiconductor junction. This "photocurrent" flows through resistors R1 and R2 which develop a potential difference across them which is proportional to this current. Therefore, the voltage at the emitter of each phototransistor rises as more light is detected.

by an amount dependent on the setting of VR2. The gain is adjustable from zero to 100.

The op-amp IC1 is run from a split-rail power supply of +9V and -9V relative to the zero volt (0V) line. Therefore, the output of the op-amp (pin 6) can swing *positive* and *negative*.

A positive output voltage (greater than about 2V) will light one half of the bi-colour l.e.d. D1, whilst a negative output will light the complimentary colour. Two separate l.e.d.'s connected "back-to-back" would achieve the same effect.

Thus the magnitude of the output voltage from IC1 depends on the illumination *difference* between TR1 and TR2 and also on the setting of the Contrast control VR2. If the contrast between the line and floor is high (e.g. a white line on a black floor) then

RELAYS

A *positive* output from IC1 signifies that TR1 is illuminated more than TR2. Current flows into the base of the transistor TR3 which switches on and energises the coil of relay RLA.

Similarly a *negative* output indicates that TR2 is receiving more light than TR1 and this switches on the transistor TR4 which energises relay RLB. Each relay coil operates a single changeover contact, RLA1 or RLB1.

However, in order to stop the relays from continuously operating for small illumination imbalances, Zener diodes D2 and D5 ensure that no base current flows into transistors TR3 or TR4 until the amplifier ouput rises above about ±4.7V. Signal diodes D3 and D6 prevent the base/emitter

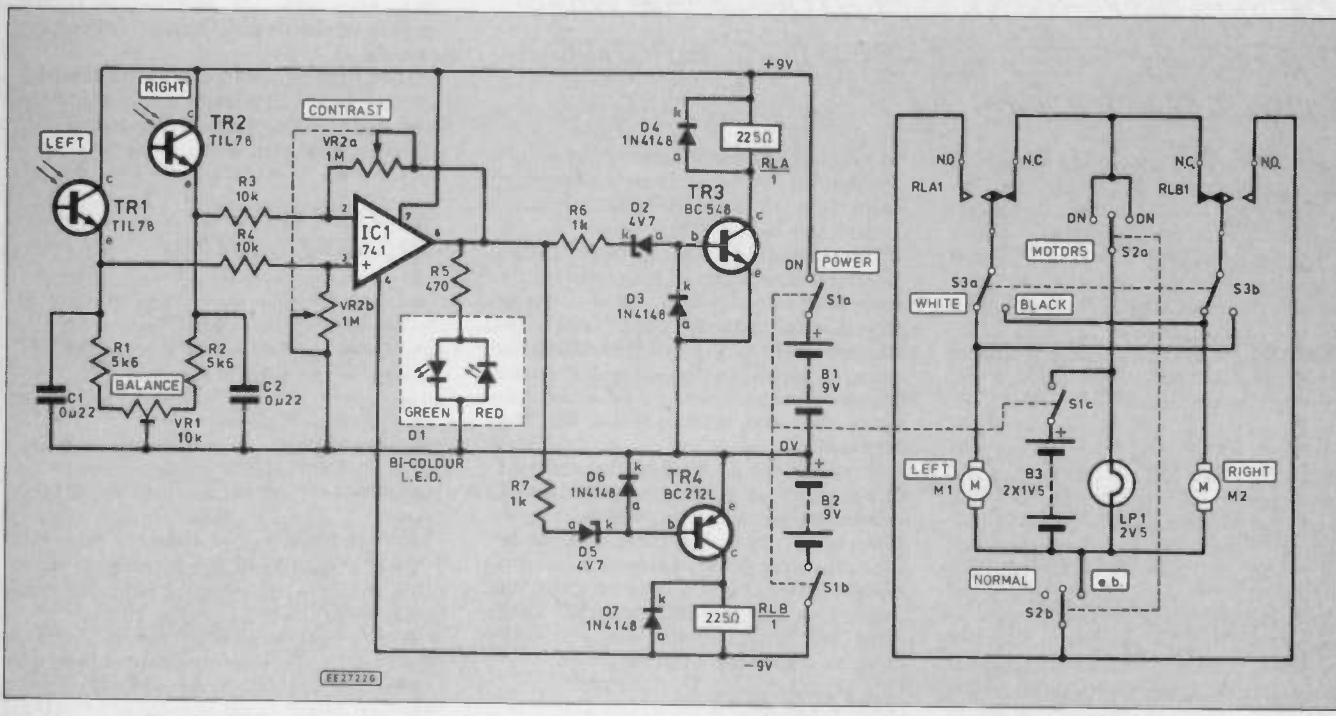


Fig. 2. Complete circuit diagram for the Mobile Line-Tracker. The phototransistors TR1 and TR2 are mounted on the underside of the vehicle and form the sensor "eyes".

Present potentiometer VR1 is used to "balance" the sensory circuit and compensate for component tolerances so that the emitter voltages can be made equal when both phototransistors are positioned over a white surface. Capacitors C1 and C2 help to remove electrical noise picked up by the wires running to each phototransistor, especially noise generated by the drive motors. It is worth noting that the TIL78 phototransistor has a peak response in the infra-red region but it is sufficiently sensitive to visible light to be of use in this application.

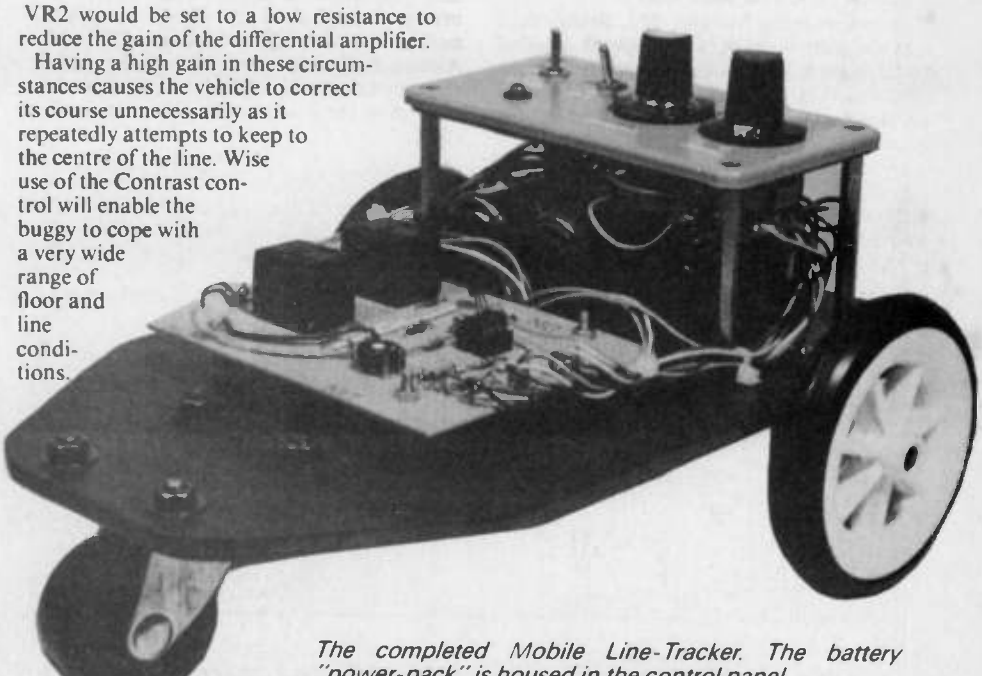
DIFFERENTIAL AMPLIFIER

The good old 741 operational amplifier is put to good use in this circuit. It is cheap, easily obtainable and performs its job admirably making the use of a more "up-market" chip pointless!

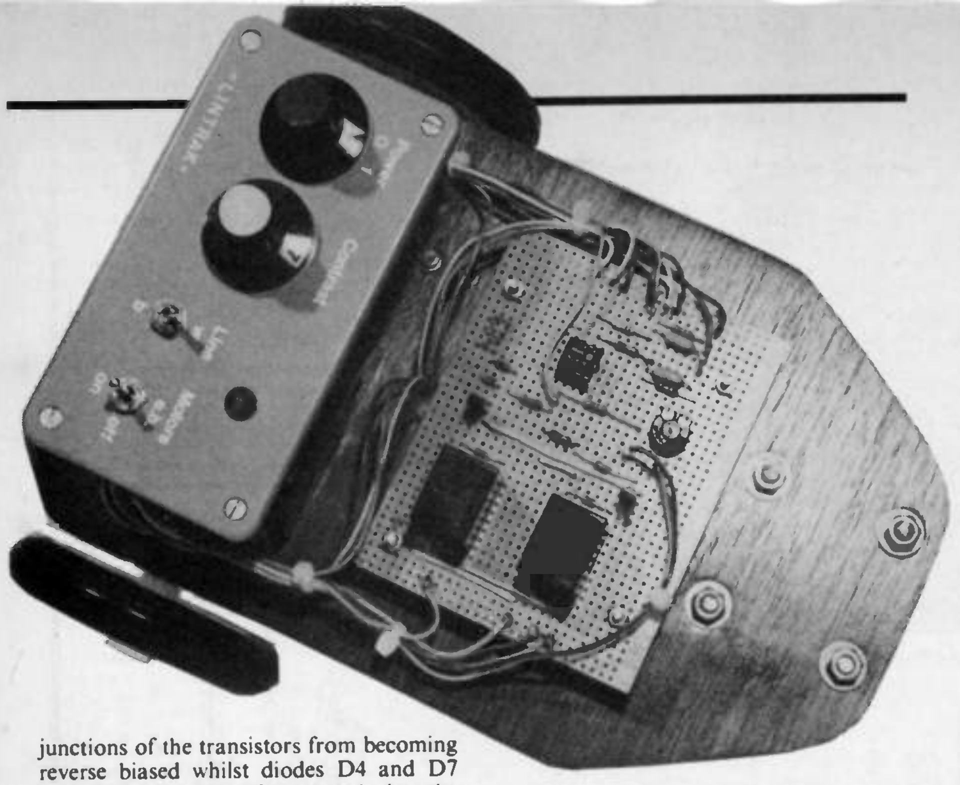
Resistors R3 and R4, together with the double-ganged Contrast control potentiometer VR2, develop the op-amp into a differential amplifier which subtracts the voltage at TR2 emitter from the voltage at TR1 emitter and amplifies this difference

VR2 would be set to a low resistance to reduce the gain of the differential amplifier.

Having a high gain in these circumstances causes the vehicle to correct its course unnecessarily as it repeatedly attempts to keep to the centre of the line. Wise use of the Contrast control will enable the buggy to cope with a very wide range of floor and line conditions.



The completed Mobile Line-Tracker. The battery "power-pack" is housed in the control panel.



junctions of the transistors from becoming reverse biased whilst diodes D4 and D7 quench the "back-emf" generated when the relay coils are switched off.

Switch S1 is a 3-pole ON/OFF switch. S1a and S1b switch the +9V and -9V power from batteries B1 and B2 whilst S1c controls power to the motors. When the relays are not energised, current consumption is about 1mA from each 9V battery but this rises to about 50mA as the relays switch on.

Obtaining relays with a reasonably high coil resistance (in order to reduce the operating current and prolong battery life) proved a difficult task. Eventually a 9V 225 ohm coil type was found and worked successfully. A more easily obtainable 6V 100 ohm coil could be used but the drain on the PP3 batteries would be substantially higher and it may be economical to consider using rechargeable Ni-Cad types.

DRIVE MOTOR CONTROL CIRCUIT

Battery B3, consisting of two 1.5V cells in series, supplies power via switch S1c to the line-illuminating filament lamp LP1 and the drive motors M1 and M2. Switch S2 is a 3-position ON/OFF/ON type which enables the motors to be switched off independently of the power to the sensory circuit. In either ON position S2a links the positive terminal of battery B3 to the normally closed contacts of the relays.

Providing the relays are not energised, current is fed to the motors via switch S3a and S3b. The position of S3 determines which motor is controlled by which relay, i.e. this switch provides the option of "Black line" or "White line" tracking.

If, due to an illumination imbalance between the phototransistors, one of the relay coils switches on the normally closed contact opens and power to the relevant motor is interrupted. Thus the motor stops and the vehicle is steered back onto the line.

One problem that robot designers frequently encounter is that of "overshooting". If the phototransistors sense that the tracker is veering off the line and switches off one motor, that motor will not stop instantly but its inertia causes it to run on for a short time (about 0.5 seconds in the prototype). This slow response may cause the vehicle to lose the line, depending on the severity of the bend.

However, if the motor terminals are short circuited whilst the motor is turning then the induced e.m.f., generated by the motor coil rotating in its magnetic field, will cause a current to flow in the coil which tries to oppose the movement (remember Lenz's law?). In a nutshell, the motor is rapidly brought to rest, its kinetic energy dissipated as heat in the coil and shorting wires. A similar arrangement is often used on electric trains and heavy road vehicles to assist braking; the technique is know as electromagnetic braking (e.b.).

If switch S2b is closed, then as each relay contact changes- over the appropriate motor is electromagnetically braked because the motor terminals are shorted via the normally open relay contacts.

It is useful to provide the option of having the motors running with or without electromagnetic braking because the latter inherently makes the "buggy" follow a jerky path, since the motors switch on and off very rapidly. Electromagnetic braking will be needed if the vehicle is to encounter sharp bends at high speeds.

CHASSIS CONSTRUCTION

A detailed description of the chassis layout is not given because exact positioning of wheels etc. is unimportant. A look at the photographs should give some ideas for a starting point.

The prototype model was constructed on a piece of 5mm plywood cut to a size of 150mm × 240mm. The motor/gearboxes, sensors and lamp are mounted on the underside of this chassis together with a single front castor to allow the buggy to steer left and right.

On the top side goes the circuit board, batteries and control panel. 4BA and 6BA nuts, bolts and washers are used extensively to anchor various components to the chassis. The prototype was left uncased to allow spectators to marvel at the workings!

The motor/gearboxes are purchased as a single unit and are available in a large (MGL) and a small (MGS) version. The large type is recommended for longer life. Two such units will be required.

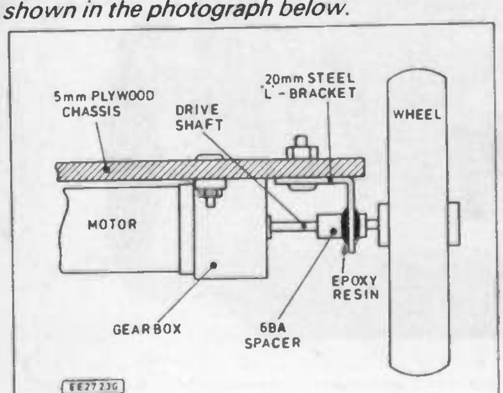
Instructions for assembling are supplied but only four of the possible six gear wheels are used (*plus* the output gear). When the motor is run from a 3V supply this results in an output shaft speed of 30r.p.m. Using 8cm (3¼in.) diameter wheels gives a forward speed of about 12 centimetres per second.

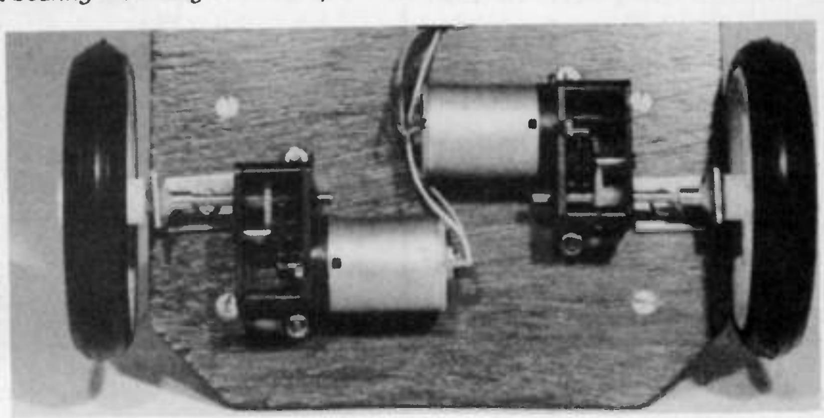
These gearboxes are quite robust but simply placing a drive wheel on the output shaft and allowing the soft plastic shaft bearings to support the weight of the vehicle would soon cause distortion. A very effective bearing can be fashioned from a 12.5mm (0.5in.) long 6BA brass spacer as shown in Fig. 3.

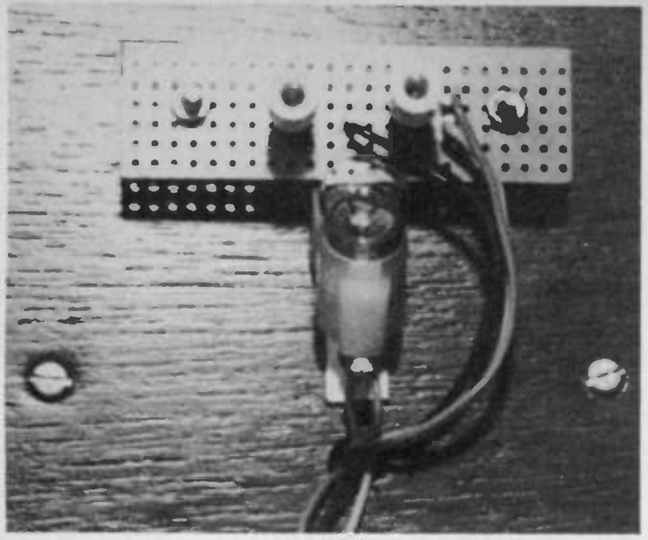
The spacer should be held in a vice and drilled through with a ¼in. bit so that the output shaft is a close fit through the tube. The spacer is then mounted through a 20mm steel L- bracket (from the hardware shop) as shown. The screw hole in the bracket may need enlarging to accommodate the spacer but make it a tight fit and further anchor it with epoxy-resin (Araldite).

A little jiggling may be required to match the heights of the bearing and shaft, use packing washers as needed. A *little* oil should periodically be applied to bearings and gears.

Fig. 3. Details of the motor/gearbox and drive shaft bearing mounting. A close-up of the underside chassis and drive motors is shown in the photograph below.







The completed sensor assembly showing the positioning of the lamp.

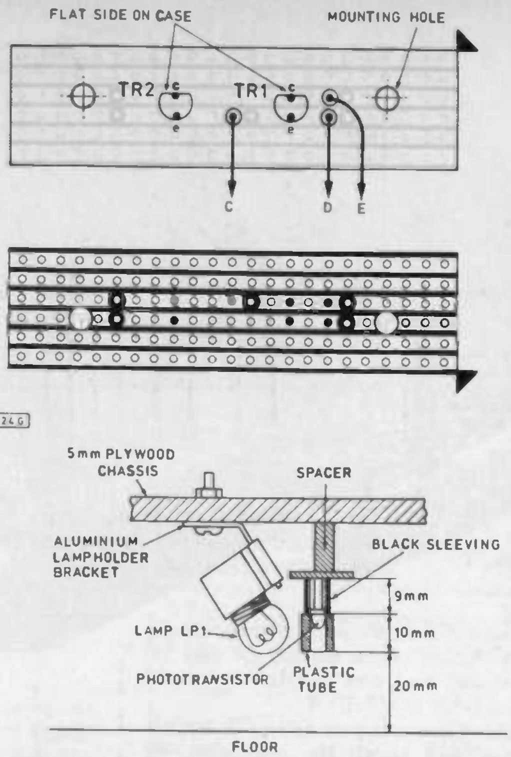


Fig. 4. (right). Details of the line sensor assembly. The sensor is mounted beneath the vehicle – see text.

COMPONENTS

Resistors

R1,R2	5k6 (2 off)
R3,R4	10k (2 off)
R5	470
R6,R7	1k (2 off)

See SHOP TALK Page

Potentiometers

VR1	10k miniature preset, horiz.
VR2	1M double-ganged rotary lin.

Capacitors

C1,C2	0µ22 polyester (2 off)

Semiconductors

D1	Bi-colour l.e.d.
D2,D5	4V7 Zener (2 off)
D3,D4 D6,D7	1N4148 signal diode (4 off)
TR1,TR2	TIL78 phototransistor (2 off)
TR3	BC548 *npn* silicon
TR4	BC212L *pnp* silicon
IC1	741 op.amp.

Miscellaneous

RLA, RLB	9V 225ohm coil relay, contacts: single-pole changeover, rated at least 1A (see text) (2 off)
S1	3-pole 4-way rotary switch
S2	d.p.d.t. toggle switch, with centre-off position
S3	d.p.d.t. toggle switch
M1, M2	combined motor and gearbox, type MGL
LP1	2V5 200mA MES type torch bulb

Stripboard (two pieces) 0.1in matrix, size 29 strips x 39 holes and 6 strips x 23 holes; 8cm diameter wheels (2 off); 5mm plywood 150mm x 240mm; 20mm steel L-brackets and 6BA brass spacers (2 off each); 8-pin d.i.l. socket; terminal pins; clip-on MES bulb holder; plastic tube and sleeving for sensors; knobs (2 off); material for control panel; battery holder for B3 (2 x C-size); PP3 battery clips (3 off); batteries, PP3 (2 off) and C-size (2 off); flexible connecting wire; 4BA and 6BA nuts, bolts, washers and spacers; small furniture castor.

Approx cost guidance only **£25**

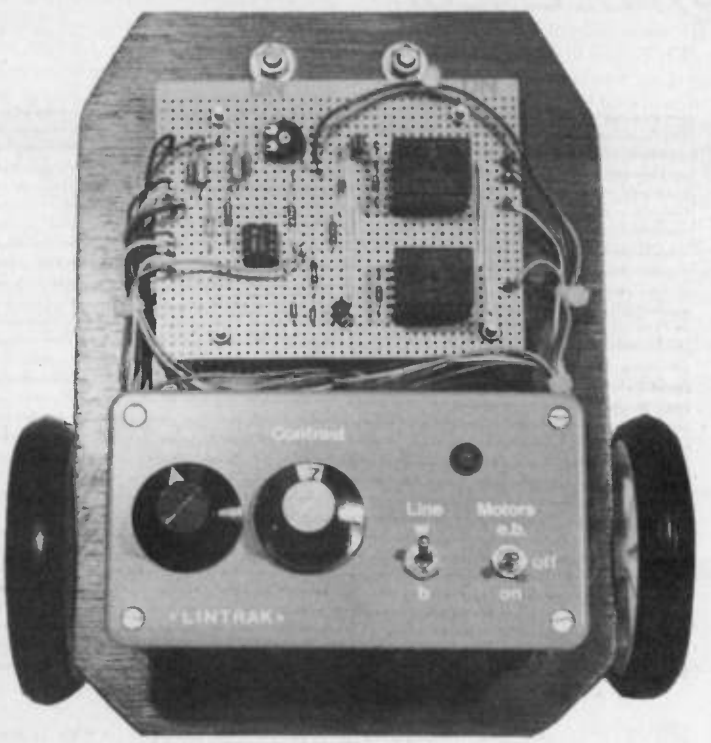
SENSOR ASSEMBLY

The relative position of the wheels and sensors and the height of the latter above the line has an important influence on the behaviour of the vehicle. Feel free to experiment, but start by placing the sensors at a distance in front of the rear axles which is roughly equal to half the distance between the rear wheels.

The phototransistors are each mounted in one end of a 10mm length of opaque plastic tube. The open end of this tube should be mounted about 20mm above the ground. A suggested method is shown in Fig. 4., the sensors are soldered to a piece of stripboard, size 6 strips by 23 holes.

Black sleeving placed over the phototransistor leads between the stripboard and plastic tube prevents light entering through the back of the transistor case, this is important. Remember that the TIL78 is sensitive to infra-red and some apparently opaque plastic tubes are actually quite transparent to IR. A layer of self-adhesive foil tape wrapped around the tube will make it completely "light-proof".

Lamp LP1 is positioned just behind the sensors using a clip-on type MES bulb holder. Avoid light shining directly into the ends of the tubes.



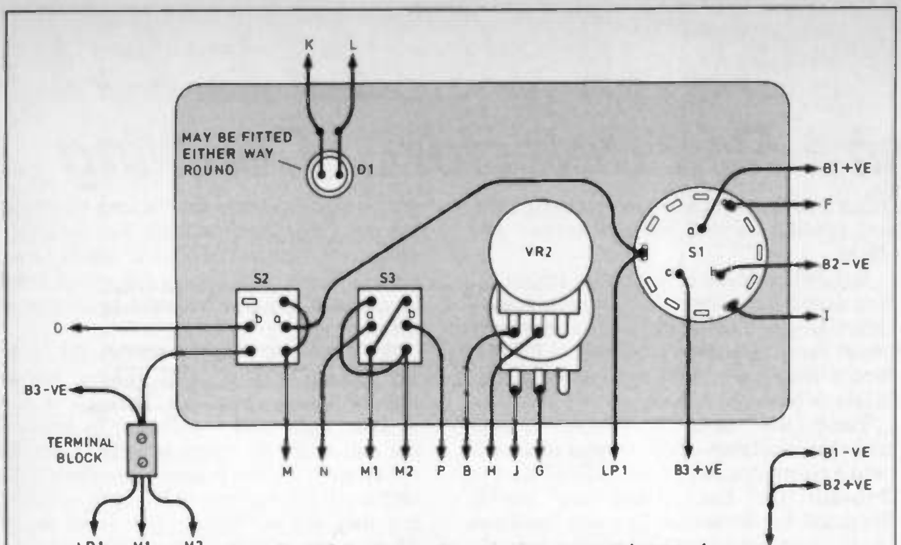


Fig. 6. Wiring details of the control panel components. The leads go to identical letters on the board below.

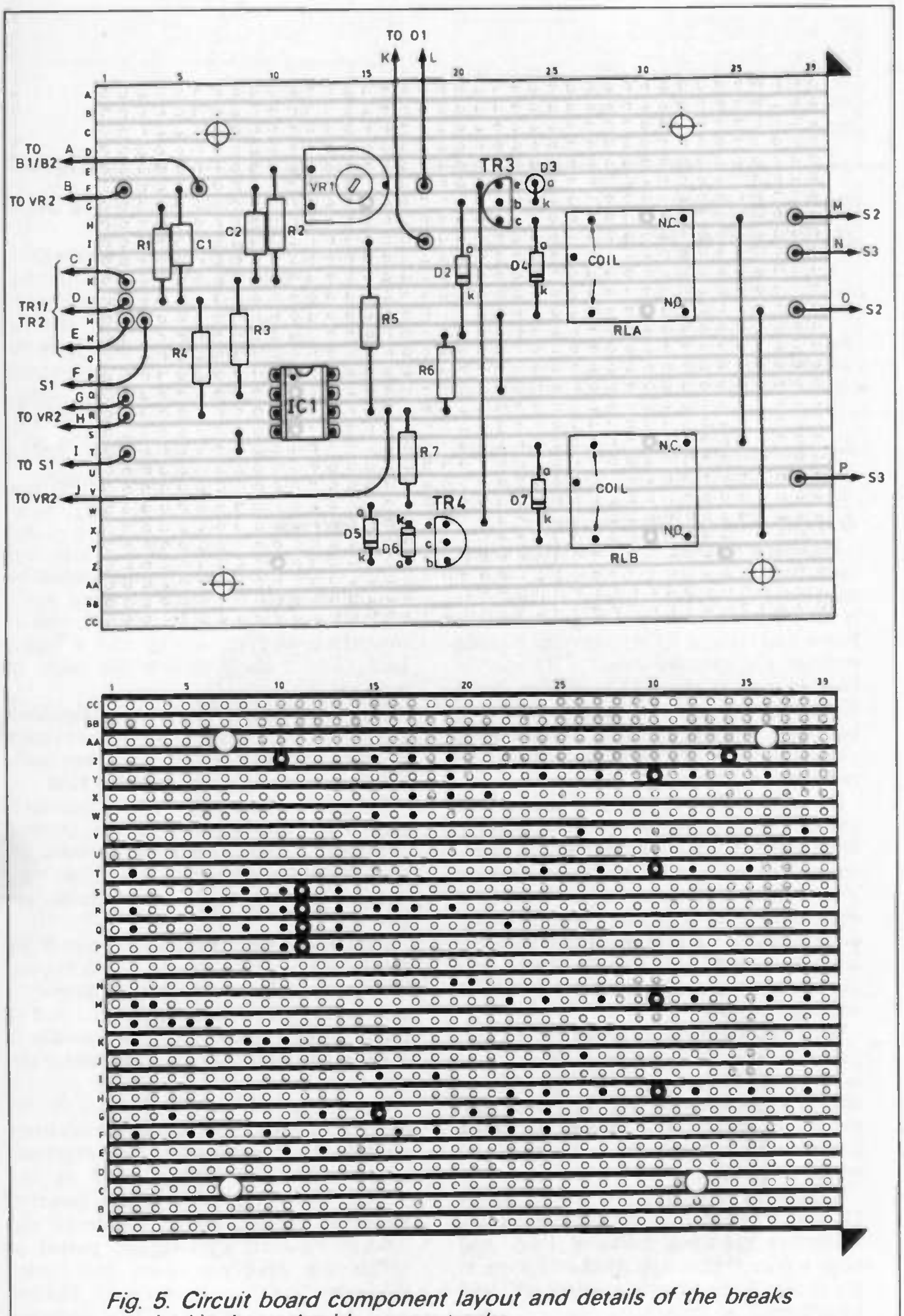


Fig. 5. Circuit board component layout and details of the breaks required in the underside copper tracks.

CIRCUIT BOARD

The three switches, potentiometer VR2 and l.e.d. D1 are mounted on a control panel which can be supported on four 50mm pillars above the batteries, the latter being held on the chassis by double-sided sticky pads.

The remainder of the electronic components are mounted on a piece of 0.1in. matrix stripboard, size 29 strips by 39 holes. Prepare this board by drilling the four mounting holes and then making the 11 breaks in the copper tracks as shown in Fig. 5.

Solder in the five wire links and then fit the remainder of the components as shown in Fig. 5., taking care not to overheat the semiconductors when soldering. Also, take care not to confuse the Zener diodes (D2 and D5) with the 1N4148 signal diodes.

All diodes and transistors on this board need to be inserted the correct way around. Use an 8-pin d.i.l. socket for IC1, do not solder it directly to the board.

The relays used in the prototype had pins which were not spaced on the usual 0.1in. grid and these required careful bending before they would fit on the stripboard. The use of terminal pins for all flying lead connections makes point-to-point wiring easier later on.

Once the board is completed the interconnections between motors, sensors, lamp, circuit board, batteries and control panel can be made according to Fig. 6. Do not make these flying leads unnecessarily long or else interference pickup from the motors may be a problem.

SETTING-UP

Turn the Contrast control VR2 fully clockwise (minimum resistance) and switch on S1. Lamp LP1 should light. Switching the motor switch S2 to either "ON" position should cause both motors to run. If either wheel turns backwards, reverse the connections to that motor.

Now switch S2 OFF, turn the Contrast control to about mid-position and place the Mobile Line-Tracker on a large white surface, e.g. a large sheet of paper. Make sure that the ambient lighting is even and then adjust preset VR1 until the l.e.d. D1 is NOT lit.

Turning the preset VR1 either way from this "null point" should make D1 light up either green or red. With careful adjustment, it should be possible to null the circuit even with the Contrast control turned fully anticlockwise (maximum resistance).

If it is not possible to extinguish the l.e.d. by this method then first double check that the phototransistors have been orientated correctly, the flat side of the device indicates the collector (C). If you are convinced that there are no errors in construction then try moving the position of LP1 to gain a more even illumination under each sensor.

USE

The Mobile Line-Tracker should now happily follow a line which, as mentioned previously, can be laid using masking-tape, insulating-tape or chalk, for example. Find out by experiment what is the best setting for the Contrast control under a certain set of conditions and whether or not electromagnetic braking of the motors is required to prevent the vehicle overshooting on corners. □

BEEBMICROBEEB

... Counting ... Infra-Red Detector ... Counting ...

Two subjects that seems to crop up in readers' letters from time to time are those of batch counting, and what might be termed "people detecting". In the first case you have objects passing by on a conveyor belt, and some means of counting them is required. Things are not always in quite this form, and the objects to be counted might actually be something like people passing into an entrance or out of an exit.

The object of the exercise might not be to count people at all, and it might simply be necessary to detect their presence in order to activate a security system. Thus, although these two subjects may seem to have little in common, they are really much the same. Many methods of detecting objects work equally well with people, for use in security systems, or whatever.

For any form of batch counting a computer makes a good basis for the equipment. Apart from simply keeping a running count, it can be programmed to sound an audible warning when a certain number is reached, or it could perhaps be used to switch off a process once a certain count had been reached. Sometimes circuitry is needed in order to avoid spurious counts, but with a computer based system it may well be possible to use software deglitching, thus enabling simpler detector circuitry to be used.

Computers are also good as the basis of security systems. They permit sophisticated features to be included at low cost, since these features can often be implemented simply by making some additions to the software.

Count On It

There are various ways of detecting objects or people, but the most simple and universally applicable are the opto-electronic systems. These consist basically of *broken* beam circuits and *reflected* beam circuits.

With the former, a light beam is shone from one side of the conveyor belt (or whatever) to a photocell on the opposite side. As objects pass by on the conveyor belt they briefly break the light beam, producing pulses from the photocell that can be counted.

With reflected beam systems there is again a beam of light shone across the conveyor belt, but the photocell is alongside the light source, "looking" in the same direction. It picks up the light reflected from the objects passing along the conveyor belt, again producing pulses that can be counted.

This second method is more convenient in that it keeps all the electronics in one box rather than having two units on opposite sides of the conveyor belt. It is more difficult to implement in practice though, as the amount of light reflected from the objects being counted may not be very great.

It is also something that might be inconsistent, depending on just what is being counted. The broken beam circuits are generally more simple and give better reliability.

Broken light beam units can be based on simple torch bulb and photo-resistor circuits, but these are often unreliable. The main problem is that of the ambient lighting tending to hold the unit in the "off" state.

Infra-red circuits give greater reliability, but simple d.c. systems do not provide very great range. For some applications very short range operation is all that is needed, and a simple d.c. infra-red system is then likely to be the best choice.

There are actually "slotted" opto switches available, which consist of a l.e.d. and a photo-detector in one unit with a slot between the two. These are mainly intended for operation in r.p.m. counters and a few other specialised applications. As the slot is only a few millimetres wide, they would seem to be unsuitable for most batch counting etc.

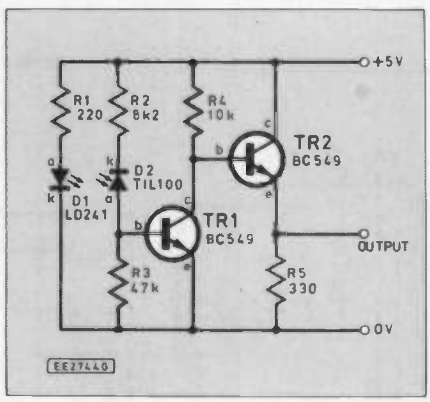


Fig. 1. The circuit diagram for a simple infra-red beam detector.

Infra Red Detector

Making a discrete version having longer operating range is not difficult, and a suitable circuit appears in Fig. 1. Diode D1 is an infra-red l.e.d. which generates the beam, and resistor R1 is its current limiting resistor. The specified value of R1 sets the l.e.d. current at about 15 milliamps, but a higher current can be used in order to boost the range of the unit. Do not use a value lower than 56 ohms (which gives a 50 milliamp l.e.d. current).

D2 is an infra-red detector diode, and like any diode it has a high reverse resistance under normal conditions. The infra-red radiation from D1 causes its leakage level to rise to a much higher level than normal, causing transistor TR1 to switch on. Transistor TR2 simply acts as an emitter follower buffer stage at the output, and this enables the circuit to drive normal five volt logic inputs.

With TR2 normally switched on, the output is at logic 0. If the beam from D1 is interrupted, D2 reverts to a high leakage level, TR1 switches off, and the output goes to logic 1. The circuit therefore produces a low output under standby conditions, and a high output level when it is activated.

Although I have specified an LD241 for D1 and a TIL100 for D2, any similar five millimetre diameter infra-red l.e.d. and large infra-red photo-diode should work in the circuit. Some suppliers simply sell these components as large infra-red l.e.d.s and photo-diodes, rather than selling them under particular part numbers. For optimum range it is best to use a l.e.d. which has a narrow beam, but getting the optics lined up correctly is easier if a wider beam type is utilized.

The value specified for resistor R3 (47k) will probably give good results, but a slightly lower value can be used if the ambient light level is sufficient to activate the unit when the beam is blocked. Infra-red systems are less prone to problems with ambient light than are visible light systems, but they are not totally free from them. There is a certain amount of infra-red light in a normal environment, and tungsten lighting is quite a good generator of infra-red.

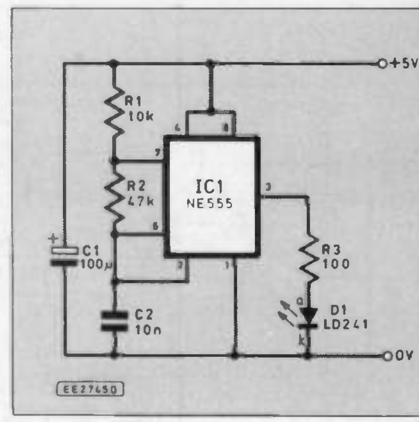


Fig. 2. The pulsed transmitter. This is basically just a standard 555 astable.

Pulsing

A simple d.c. circuit of this type will not provide a particularly large maximum operating range. A range of up to about 150 millimetres should be possible, or with everything carefully set up and a higher l.e.d. current about double this might be achievable.

This is sufficient for some applications, but for others a range of a metre or two is required. Ranges of this order are easily achieved using pulsed infra-red circuits.

The point of using a pulsed transmitter is that the receiver can be an a.c. coupled amplifier. The d.c. output level from the photo-diode is unimportant, and can vary widely without any ill effects being apparent.

The use of coupling capacitors is to block the d.c. signal, but allow the pulses to pass. This permits large amounts of amplification to be used, with the pulses (or lack of them) being detected using a rectifier, a smoothing circuit, and a level detector circuit.

There can still be problems with the ambient infra-red level, but this is relatively unlikely. The normal infra-red background level varies only slowly, and is not pulsed. The exception is mains powered tungsten lighting, which produces significant amounts of infra-red pulsed at 100Hz (i.e. once per mains half cycle). However, this can normally be blocked from the photo-diode, and the receiver will be insensitive to it anyway due to the relatively low pulse frequency.

The circuit diagrams for the pulsed infra-red transmitter and receiver are shown in Fig. 2 and Fig. 3 respectively. The transmitter is basically just a standard 555 astable circuit operating at around 1kHz. Resistor R3 sets the l.e.d. current, and can be reduced somewhat in value if greater range is required.

In the receiver, Fig. 3, diode D2 detects the infra-red pulses and produces electrical pulses that are fed to the input of a simple two stage amplifier. The low values of the coupling capacitor roll-off the low frequency response of the circuit and combat potential problems with mains "hum".

Capacitor C7 rolls-off the very high frequency response of the amplifier, and is needed in order to combat instability. The output of the amplifier is fed to a conventional two diode rectifier and smoothing circuit.

circuit drops to zero and the output of the unit goes to the high state.

The maximum range of this circuit is a metre of so, but this can be extended a little by using a higher l.e.d. current. A better way of boosting the unit's range is to use a lense in front of the receiving diode.

This does not need to be a good quality type, and the inexpensive Maplin 30mm diameter plastic lens is perfectly satisfactory. The lens must be mounted ahead of the photocell at a distance that is equal to the focal length of the lens (80 millimetres in the case of the Maplin lens).

The effect of the lens is to gather up the infra-red energy over a relatively large area and concentrate it onto the smaller area of the photo-diode. This will often boost the range of the system by a factor of five or more, but the increase obtained obviously depends on the characteristics of the lens used.

A side effect of adding the lens is that it gives the receiver a very narrow angle of

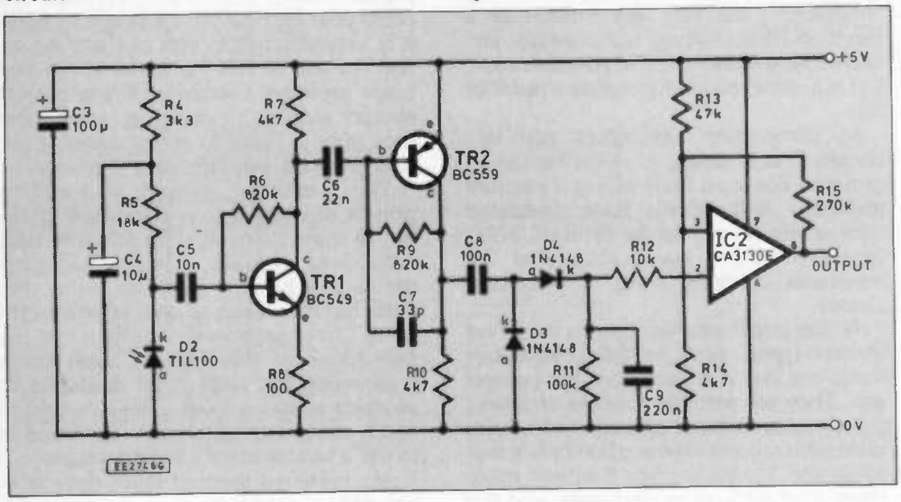


Fig. 3. The circuit diagram for the infra-red pulsed receiver.

IC2 acts as an inverting trigger circuit, and its output triggers to the high state when the input voltage falls below a certain threshold level. Normally the unit is receiving infra-red pulses, and the output from the smoothing circuit is above the threshold level. However, when the beam is blocked, the voltage from the smoothing

view. The unit must therefore be accurately aimed at the transmitter if the system is to function properly.

The range can be further boosted by adding a lens in front of the transmitting l.e.d. as well. Quite long operating ranges can be obtained in this way, but optical alignment of the system becomes very critical

Interfacing

The user port of the BBC computer permits several interfacing options. For a counting application the obvious one is the 6522 VIA in the mode where it counts pulses from an external source.

This may not be the best choice though, since the detector circuit is quite likely to generate a few spurious pulses. This would result in grossly inflated counts. If this method is used, it will almost certainly be necessary to add a monostable at the output of the detector circuit in order to provide "debouncing".

Using an ordinary digital input to monitor the output of the detector, and a loop to repeatedly read the output level in order to detect a change to the high state, there is a slight risk of pulses being missed. In reality this is probably not a very great risk, since the pulses from the detector would normally be fairly long, and the loop would presumably monitor the detector's output a few hundred times per second. However, this possibility can be removed altogether by using a "handshake" input set to respond to low-to-high transitions.

If "deglitching" is required in order to prevent spurious counts, this can be provided by the software. For the sake of this example, assume that the count rate will never exceed two per second.

The routine that detects pulses from the detector could include a delay loop to ensure that something close to 0.5 seconds elapses after one pulse is detected, before the output is monitored again. Any spurious pulses after an initial transition will then not be counted, because the software will be idling when they occur, and will ignore them.

There can sometimes be problems with false counts due to something like a moth flying through the beam, or electrical interference from lighting etc. These "false alarms" will usually provide very short output pulses, and can be detected by suitable software routines.

After the initial detection of the pulse, it is just a matter of having a loop routine to provide a suitable delay before checking the output level from the detector again. If it is still high, then the output pulse is a proper type. If not, then it is a spurious pulse.

SHOP TALK

with David Barrington

Please Note

The diodes used in the power supply bridge arrangement in the *Valve Distortion Unit* should be **1N4007's**. The 4001's are underated and should NOT be used.

Car Heater Thermostat

We have been unable to find any source for the rod thermistor VA1067S used in the *Car Heater Thermostat*. According to our information this device is rated at 150k at 25°C and 2k5 at 150°C.

An alternative suggestion is to use a bead type thermistor, which seems to be more readily available, and adapt the water sensor assembly to suit. A suitable bead thermistor is stocked by **Maplin**, order code FX43W.

Most advertisers should stock a suitable 12V 16A relay. These are listed for automobile applications and the most popular ones have a coil resistance of about 200 ohms.

Ghost Waker

A suitable mask for the *Ghost Waker* project should be stocked by "high street" joke shops or from a theatrical costume supplier.

The microphone used in the prototype model was purchased from **Maplin**, code QY62S. Miniature 12V solenoids are reasonably expensive and it may be worth "shopping around". One similar to the type used is the 12V 48 ohm coil from Maplin (YR88V).

The small printed circuit board is available from the *EE PCB Service*, code EE703 (see page 692).

Mobile Line-Tracker

The only items that could cause local purchasing problems for constructors undertaking the *Mobile Line-Tracker* are the motor/gearbox and possibly phototransistor.

The combine low voltage d.c. motor/gearbox unit is listed by **Magenta** (☎ *0283 65435*) and the larger MGL (£4.55) unit should be purchased. They are also able to supply the TL78 phototransistor and the 3in dia. wheels.

The front wheel "castor" and the plywood chassis should be available from DIY stores. Most component suppliers should be able to offer suitable p.c.b. relays, but check the contact pin arrangement before wiring onto the circuit board and adapt as necessary.

Frequency Meter

The meter used in the *Frequency Meter* is the 4in. 100μA moving coil panel mounting type from **Maplin**, code YJ96E. The trimmer capacitors (code WL72P) and the mains transformer (code LY03D) were also purchased from the same company.

The printed circuit board is available from the *EE PCB Service*, code EE704 (see page 692).

Fridge Alert

The only component called for in the *Fridge Alert* that is likely to cause some local difficulties is the glass bead thermistor GL16.

The glass types are fairly expensive, but most of our advertisers should be able to offer a suitable equivalent. The GL16 is rated at one megohm at 20°C and has a minimum resistance of 170 ohm.

In case of difficulty in purchasing the i.c.s, the ICL7611 is currently listed by Cricklewood and the ICL8211 by Maplin.

ACTUALLY DOING IT!

by Robert Penfold

THE TREND in modern commercial electronics is to have as many of the components as possible on the main circuit board. Along with the resistors, semiconductors, capacitors, etc., there are printed circuit mounted controls, sockets, and even larger items such as mains transformers.

In the commercial electronics world this method of construction has the advantage of keeping down production costs. Designs for the amateur electronics enthusiast make relatively little use of printed circuit mounting controls, sockets, and the like.

Using these components generally simplifies the electronics side of construction, as well as reducing the risk of errors. It is rather restrictive though, in that it usually ties you down to using the particular case that the circuit board was designed to fit. Making even a few minor modifications to the project, such as repositioning a few controls slightly, might be impossible.

Actually this is not quite true, since in most cases there is no difficulty in having ordinary potentiometers, sockets, or whatever, mounted off-board, and wiring them to the circuit board. For the absolute beginner it is probably best not to do this, as it increases the risks of errors.

However, for the complete beginner there is a lot to be said in favour of reasonably simple projects that have all or virtually all the components mounted on a (ready made) custom printed circuit board. This method of construction leaves a minimal amount of scope for errors! For the slightly more experienced constructor though, using off-board controls and sockets should not give too many problems, and gives you plenty of scope to do your own thing

The hobby of electronic project construction need not consist of producing exact clones of published designs. Customising projects, or simply adapting them slightly to suit the particular components to hand are well established practices. Eventually you might start "borrowing" sections of published designs in order to put together your own designs, perhaps ultimately progressing to projects that are genuinely all your own work.

HARD WIRING

The wiring from controls etc. to a printed circuit board is known by such names as "point-to-point", "hard", and "spaghetti" wiring. I think it is true to say that most constructors find that this point-to-point wiring helps to make building a project more interesting.

Mounting components on a printed circuit board is generally easier and more "foolproof", but can lack interest as a result of this. Wiring up controls etc. takes a little more time and concentration, but is a more rewarding task as a result of this.

In component catalogues you will usually find a variety of wires for use in projects. For most hard wiring a medium thickness multi-strand p.v.c. insulated wire is the most popular type. A 7/0.2 type (which has seven strands of 0.2 millimetre diameter wire) is the usual choice.

In the larger catalogues you may find thinner types, such as 7/0.1 wire, but these are just a bit too thin for general use. They are actually capable of taking the currents in most projects, where the maximum current flow is often only a few milliamps. However, their thinness make them a bit difficult to deal with, and the 7/0.2 type is much easier to use.

Most electronic component catalogues list at least one thickness of single strand connecting wire. The advantage of the single strand variety is that it can easily be formed into the desired shape so that it can be neatly and easily routed around a project. It tends not to be very popular as it has a tendency to break.

The whole point of multi-strand wire is that by having a number of very thin wires it is flexible and has good resistance to breaking due to metal fatigue. Also, if when stripping the insulation from a multi-strand wire it should be accidentally nicked slightly, it is likely that only one or two of the strands will be damaged and break, leaving five or six strands intact. This is less than ideal, but the five or six unbroken strands of wire should be sufficient to do the job properly.

If a single strand wire should be nicked slightly when the insulation is being stripped, it will be rendered very vulnerable to breaking at that point, and will probably snap before too long. In my experience single strand connecting wire has always been more trouble than it is worth, and I would certainly not recommend it for general project wiring.

In some component catalogues you may find some thicker connecting wires listed. These are only required for projects such as large power supplies and high power audio amplifiers where large currents are involved in certain parts of the circuit.

The resistance in thinner wires could cause a reduction in the performance of the circuit, and in an extreme case there would be the risk of the wire burning out (possibly causing a fire in the process). If a heavy duty connecting wire is needed, this should be pointed out in the book or article in which the project is featured.

Wires of this type should only be used when they are really necessary. Apart from their relatively high cost, they are a bit large and cumbersome to use.

PROJECT WIRING

Project wiring mainly consists of small groups of wires running from an off-board component to a set of solder pins on the circuit board. This type of wiring can be added in as several totally separate wires, but this is not likely to give particularly neat results.

Neatness of the wiring is not just a matter of making the interior of the project look pretty so that you can impress your friends. With a tangle of wires it is very difficult to sort out any errors, and the risk of making errors in the first place probably increases. If the project should require servicing at some later date, this is likely to prove easier if the wiring is neat, tidy, and easy to follow.

The traditional method of handling groups of wires is to use separate wires, but to route them side-by-side into neat collections of wires. The wires in each group can be tied together using thin cord, but this is not as easy as you might think. I have seen some very neat looking cableforms of this type in ready-made equipment, but have never managed to produce passably neat cables myself! A much easier and quite neat alternative is to use a few bands of insulating tape.

My preferred method these days is to use ribbon cable. As its name suggests, it is a flat ribbon-like cable that is effectively a number of pieces of thin multi-strand connecting wire laid side-by-side and moulded together. It is generally only sold as cables having ten or more leads, but it is easily pulled apart so that a piece having the required number of leads can be removed.

The grey type is a bit cheaper than the multi-coloured "rainbow" type. However, the latter is much better as it makes it more difficult to misidentify wires and get connections accidentally swapped over. For this application the multi-coloured type is probably well worth the extra expense. The thin ribbon cable intended for use with IDC connectors is the most widely available, but for present purposes the slightly thicker types are a bit better.

STRIPPING

As already pointed out, nicking a wire when stripping the insulation from it is likely to seriously weaken the wire. Using multi-strand wire minimises the problem, but it is important to strip insulation without damaging the wire if maximum reliability is to be obtained.

I make no apologies for giving the much repeated advice not to use knives or scissors as wire strippers. Even if we ignore the very real danger of cutting yourself when using these methods, there is still the problem of the wire getting damaged. Proper wire strippers do not cost a great deal, are very quick and easy to use, and provided they are set correctly there is little risk of damaging the wire.

Wire strippers vary somewhat in design, but they generally have two semicircular cutting blades plus some sort of adjustable stop mechanism which prevents the blades from fully closing. The idea is to have the blades adjusted so that when closed on a wire they will cut through the sleeving but will not start to cut into the wire.

In practice it is not usually possible to get everything adjusted quite as precisely as this, and the wire strippers are adjusted so that they do not quite cut right through the insulation. If you close the blades over a wire and then pull it away from the strippers, the insulation will invariably break, with the unwanted piece coming away with the strippers. This invariably leaves the wire totally undamaged.

TINNING

The ease with which the vast majority of components can be soldered onto a printed circuit board can give you a false sense of security when carrying out the hard wiring. In order to avoid problems with "dry" joints it is essential to "*tin*" both surfaces to be joined with a generous amount of solder. In order to do this, first apply the iron to the tag, end of a lead, or whatever, and then apply some solder.

From time to time you will encounter an awkward tag or lead that will not tin properly. This happens when the surface is contaminated with oxide, grease, or dirt of some other kind. The solder will go into blobs which run straight off the tags or lead.

Instead of leaving a shiny and nicely tinned surface that will solder easily, the result is usually a blackened surface covered with burnt flux from the solder. Producing good soldered joints with one or both surfaces like this is impossible.

The cure for this problem is to clean the lead or tag by scraping it with some very fine sandpaper, a small file, or the blade of a pen knife. Once the shiny metal is showing through nicely, there should be no difficulty in tinning the lead or tag.

If a component shows obvious signs of corrosion, or any contamination that is likely to prevent it being tinned properly, it makes sense to clean away the contamination before trying to tin the component, rather than waiting until problems have arisen. Even if you should mange to tin a doubtful looking component, you might find that it has not taken the solder very well, and that a weak soldered joint will be produced as a consequence.

With both surfaces properly tinned, actually completing the soldered joints should not be at all difficult. The ends of leads are hooked around tags of the type that have holes, or wrapped a few times around the type that do not.

This second method is also used when making connections to solder pins in printed circuit boards. I would strongly urge the use of solder pins rather than making off-board connections direct to the pads of the board.

Using pins will give a finished assembly that is very much tougher. It usually makes wiring up a project very much easier as well.

Run plenty of solder onto the joints. Very little solder will give a good electrical connection, but a more generous amount will produce a joint that is also physically strong.

SCREENING

A slight complication with some projects (mainly audio types and test equipment) is the need for some of the wiring to be of the screened variety. A screened lead consists basically of an inner conductor, a layer of plastic insulation around that, a layer of braided wire around that, and then finally an overall layer of insulation, see Fig. 1.

The idea is for the outer conductor to be connected to the earth rail of the circuit. The inner conductor is then screened, and will not pick up mains "hum" or other electrical interference. Screening can be used in much the same way to prevent a wire from radiating a signal.

There are multiple screened leads, and the type you are most likely to use is a twin type for stereo equipment. The overall screened leads have two insulated leads sharing a common outer conductor. These tend to give significant amounts of stray coupling from one lead to the other, rendering them considerably less than ideal for many applications. The other type is so-called "figure of 8" style cable, which is effectively just two single screened leads laid side-by-side and fixed together.

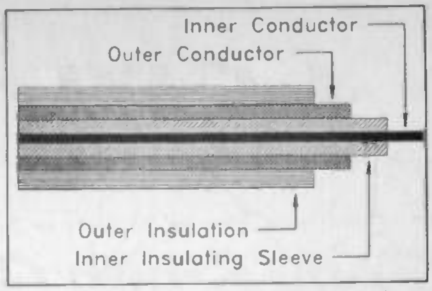


Fig. 1. Cross section through a screened cable. The outer conductor screens the inner one.

Screened leads can be a bit awkward to deal with. Unless a particular type is specified, it is probably best to opt for one of the thinner cables. The outer insulation of these can easily be removed with the aid of most wire strippers.

The thicker screened cables defeat most wire strippers, and the outer cladding has to be removed by carefully cutting through it using a modelling knife. Go as slowly and carefully as necessary to avoid any serious damage to the braiding. If you should damage the braiding, cut off the end section of the cable and try again.

You should find that the braiding can be combed out with the aid of a fingernail, and then it is tightly twisted together to form a lead. Next it is heavily tinned with solder to prevent it from unwinding. If any little bits of wire are missed and left sticking out, cut them off so that they cannot accidentally short circuit to something.

Finally, a small piece of insulation is removed from the inner conductor, and the exposed lead is tinned with solder. The lead is then ready for connection.

REPORTING AMATEUR RADIO

Tony Smith G4FAI

NOVICE LICENCE UPDATE

The RSGB reports good progress on the proposed Novice Licence. The basic idea is that those wishing to obtain the new licence will have to attend a course given by an RSGB registered Instructor. Normally Instructors will deal with just four students at a time although special arrangements can be made for disabled or geographically isolated students.

During the 30-hour course all the basics will be taught, including etiquette and operating disciplines. On satisfactory completion of a course a student can take the 90 minute Novice multiple choice examination which will be held every three months. This will have 10 questions on licensing conditions and a further 35 covering other aspects included in the course.

A Novice Training Manual has been prepared and during the next few months all proposed books for students should be completed. Everything seems on course to introduce the new licence within the DTI's target date of early 1991.

ISRAEL RESTRICTIONS LIFTED

Last month I mentioned a 1987 broadcast by Kol Israel, the *Voice of Israel*, which referred to the fact that except for Egypt, there were no amateur exchanges allowed between Israel and the surrounding countries in the Middle East.

Circumstances have now changed dramatically and, according to the W5YI REPORT of July 1, Israeli operators may now freely contact amateurs in Algeria, United Arab Emirates, Bahrain, Tunisia, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Sudan, Syria, Oman, Iraq, Saudi Arabia, Quatar, and both Yemens.

WW2 AMATEUR OPERATIONS

In wartime, restrictions on possible means of communication with the enemy are inevitable and amateur radio operation is closed down. Nevertheless some German amateur stations remained on the air throughout WW2, and were "worked" by a number of mysterious British stations towards the end of the war. According to an article in *Morsum Magnificat*, winter 1989, by Michael Ockenden, G3MHF, some 150 German amateur stations operated mainly on the 80 and 40 metre bands trying to persuade the outside world that life in Germany was continuing normally!

Contacts with American stations continued until 1940 when the "Ws" were forbidden to work stations operating from the war zone. A few licences were issued for stations in Hungary and Czechoslovakia, and German amateurs with D-calls operated from France, Greece, North Africa, Norway, and Spain. It was naturally suspected that these stations were set up for political or intelligence purposes but, according to the author, despite their propaganda purposes there was nothing sinister about the operators or the QSOs (contacts) which passed between them.

In 1945, a number of British stations using G7 calls appeared on the bands. The Germans thought these stations were on the east coast of England and contacts with them were prolonged in the hope of identifying them. The QSOs were conducted in a polite and correct manner and all logs were sent to the authorities in Berlin.

No official explanation has ever been given about these G7 stations although they must have been specially authorised to operate, possibly for intelligence purposes. Pirate stations using G4 and G9 calls were also heard by the Germans around this time so another possibility is that the G7s were set up to help track down the pirates. Perhaps, one of these days, someone will reveal what was really going on!

Incidentally, *Morsum Magnificat*, "which records the story of Morse telegraphy right back to the time when Samual F. B. Morse first dreamed of communication by means of dots and dashes," has a new editor. He is Geoff Arnold, G3GSR, who publishes *Radio Bygones* and who was previously editor of *Practical Wireless*.

Further details can be obtained from *Morsum Magnificat*, 8A Corfe View Road, Corfe Mullen, Wimborne, Dorset BH21 3LZ.

INTRODUCTION TO VHF/UHF

"Amateur radio is often associated with the HF bands below 30MHz ... However, the area where there is probably more activity and growth is actually in the VHF (very high frequency) and UHF (ultra high frequency) portions of the spectrum which lie between 30MHz and 3000MHz."

So begins the introduction to a new book, *An Introduction to VHF/UHF for Radio Amateurs*, by Ian Poole, G3YWX. Intended to be of use to both newcomers and experienced radio operators it provides a general survey of the amateur bands in this wide range of spectrum and the variety of characteristics and activities within these bands.

For most people entering amateur radio via the full Radio Amateurs' examination or for those coming in via the new Novice Examination, the 2 metre VHF band, will probably provide their first experience on the air. This small (94 pages) book will tell them most of what they need to know to get started and will help them to extend their activities to additional modes and bands in due course.

It covers such matters as propagation; bands and bandplans; receivers and transmitters; aerials; mobile and repeater operation; Dxing; data communications; and scanners, and there is a short but useful appendix containing abbreviations and codes. Its size prevents it from going to deeply into any particular aspect, but that is exactly what is required from an "Introduction" to any subject. My sole reservation is that a bibliography for the benefit of those wishing to read further would have been helpful.

If one tunes around the VHF bands at present, the book reference to "activity and growth" might be doubted as there is currently an apparent decline in activity. The present excellent conditions on the HF bands around the peak of the sunspot cycle have resulted in thousands of class A licensees deserting VHF to enjoy themselves on HF Dx bands below 30MHz.

These operators will return in force when HF conditions deteriorate and long-term growth in VHF and UHF will then continue. It is often claimed that the one remaining area left for true amateur experimentation and development is at UHF – but this type of activity is still in the future for those at the stage where they have a need for this introductory book!

SCANNERS

Although scanners and scanning are not strictly part of amateur radio, the book includes an interesting chapter on this subject because it is an "aspect of the VHF/UHF arena which is becoming increasingly popular." It points out, however, that the law about receiving different transmissions varies widely from country to country and that it is wise to investigate the current position.

In the UK, the Wireless Telegraphy Act states that the public may only listen to broadcast stations, standard frequency transmissions and licensed radio amateurs, although "it is quite easy to obtain a license to pick up transmissions from weather satellites." In spite of these restrictions, "scanners are widely available and are on sale quite openly ... *it is necessary to be aware of the restrictions because people have been prosecuted for listening to police transmissions.*"

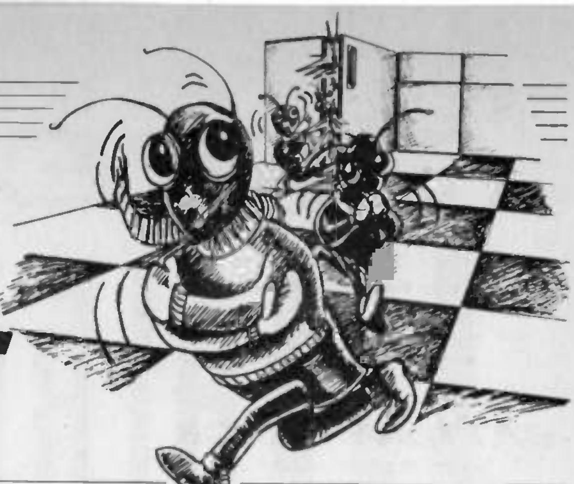
The book describes the development of scanners from the earliest models, which used crystal controlled local oscillators (needing one crystal per channel), which could only monitor ten or fifteen channels. In contrast, it discusses today's models, using frequency synthesisers, which cover large numbers of channels and incorporate large banks of memories and other features.

A section on operation describes the functions of the various controls found on a typical scanner, and the wide range of services to be found throughout the spectrum including a list of the major frequency allocations between 30 and 1000MHz.

**An Introduction to VHF/UHF for Radio Amateurs*, by I. D. Poole, is published by Bernard Babani (publishing) Ltd, price £3.50. Available from *EE Direct Book Service*.

Constructional Project

5°C FRIDGE ALERT



T. R. de VAUX-BALBIRNIE

Keeps harmful germs at bay

RECENT statistics reveal that only 1 in 10 people ever check the temperature of their fridge. This is unfortunate since, unless it is cool enough, bacteria multiply rapidly and can cause food poisoning. This is true for everyone, but especially so where babies and elderly people are involved due to their limited resistance to infection.

It is generally agreed that the temperature of a fridge should be kept below 5°C. However, human nature being what it is, regular checking with a thermometer will soon be abandoned after an initial burst of enthusiasm. During warm weather, the cabinet temperature often rises and can reach a dangerous level unless the thermostat is re-adjusted

FRIDGE ALERT

The circuit to be described here gives a continuous check and warns the user of a rise in temperature for whatever reason. In use, the 5°C alert is placed inside the fridge – perhaps in a door compartment where it will be seen each time the fridge is opened. A red l.e.d. (TEMP!) will flash if the temperature rises above a preset level.

The circuit is self-contained with everything, including battery and sensor housed inside a small plastic case. You will need a mercury thermometer for setting-up purposes but this can probably be borrowed.

Since the circuit is switched on continuously, it is important to minimise the standby current requirement. Care over design has kept this to less than 5μA. The specified lithium battery should provide years of service providing the l.e.d's are not called upon to light very often.

There is a battery check facility – it is suggested, however, that the battery be replaced as a matter of course every 2 years. Using the specified battery is important for, although other types are cheaper, they will perform less satisfactorily.

Not only do lithium batteries have a very long life and high capacity for their size, they maintain a fairly steady terminal voltage over a long period of time and this helps in providing precise operation. However, in tests on the prototype, operation remained within one degree for any battery voltage between 6 and 10 volts.

CIRCUIT DESCRIPTION

The complete circuit diagram for the 5°C Fridge Alert is shown in Fig. 1. This comprises two sections. The first centres on IC1 and forms the temperature sensor. The other consists of IC2 and associated components and is the battery condition warning.

This latter section is only called into play when push-to-test switch S1 (BATTERY TEST), is operated. This keeps current drain to a minimum. There was thought to be no point in providing an on-off switch for the circuit as a whole.

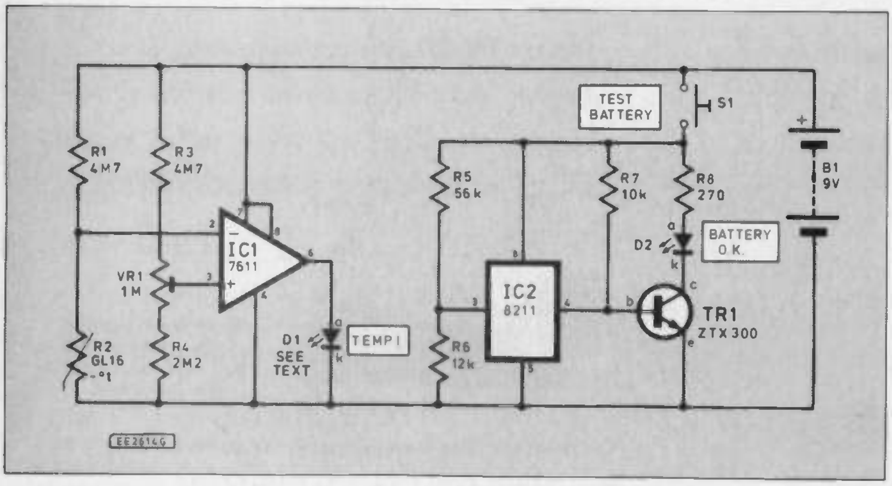
The temperature-sensing section operates in the following way. IC1 is a CMOS operational amplifier which, under quiescent conditions, requires only 12μA approximately. This makes it ideal for the present purpose.

The non-inverting input, pin three, receives a voltage whose value depends on the potential divider action of preset, VR1, in conjunction with resistors, R3 and R4. With the values specified VR1 will allow voltage adjustment between nominal limits of 2.5V and 3.6V.

The inverting input, pin two, also receives a voltage from the potential divider consisting of resistor R1 in the upper section and the thermistor R2 in the lower one. The thermistor is a miniature "bead" type whose resistance falls as its temperature rises.

At 5°C the voltage at pin two will be approximately 3V and VR1 will be adjusted at the setting-up stage so that the voltage at pin three is just less than this. The op-amp will then be off with the output, pin six,

Fig. 1. Complete circuit diagram for the 5°C Fridge Alert.



COMPONENTS

Resistors
R1, R3 4M7
R2 *GL16 min bead thermistor
R4 2M2 (see text)
R5 56k
R6 12k
R7 10k
R8 270
All 0.6W 1% metal film
*1M at approx. 20°C

See SHOP TALK Page

Potentiometer
VR1 1M sub-miniature vertical preset

Semiconductors
D1 5mm flashing red l.e.d. (3.5V to 12V operation with no series resistor required)
D2 5mm green l.e.d.
TR1 ZTX300 *npn* silicon
IC1 ICL7611 CMOS op-amp
IC2 ICL8211 voltage indicator

Miscellaneous
B1 Lithium battery (PP3), with connector
S1 Miniature push-to-make switch
Stripboard 0.1in. matrix, size 9 strips x 24 holes; plastic case, size 107mm x 53mm x 18mm (internal); 8-pin d.i.l. socket (2 off); connecting wire; solder etc.

Approx cost guidance only **£12** excl. Bat.

low (negative supply voltage). The flashing l.e.d, D1, will therefore be off.

When the temperature of R2 rises, its resistance falls and so does the voltage across it. The voltage at the inverting input is now less than the non-inverting one and the output, pin six, goes high (positive supply voltage). This operates D1, the flashing l.e.d. (see components list). An ordinary (non-flashing) one could be used, but the effect would not be so eye-catching and it would require a series current-limiting resistor of 390 ohms.

BATTERY CHECK

The battery checking section, operates in the following way. IC2 is a voltage detector integrated circuit which responds to the voltage applied to the threshold input, pin three. If this is less than the internal reference voltage of 1.15V, the output pin four, can "sink" current from the positive line. This current is limited to 7mA by on-chip circuitry.

When Battery Test switch, S1, is pressed, IC2 receives power from the supply, B1, to pin eight. The potential divider consisting of resistors R5 and R6 are connected directly across the supply.

With the specified values and a battery voltage of 7V approximately and above, the voltage applied to pin three will exceed 1.15V. Current then flows through resistor, R7 and turns on transistor, TR1. Thus the green l.e.d. (Battery OK) operates through current-limiting resistor, R8. When the battery voltage is less than 7V, the voltage at IC2 pin three is less than 1.15V and TR1/D2 will be off.

This method gives positive indication that the battery is sound. This is thought to be better than the l.e.d. lighting when the battery is low since general failure – even a very discharged battery – would do this as well. A further advantage of the present system is that the l.e.d. imposes a current drain and the terminal voltage of the battery is measured "on-load".

CONSTRUCTION

Most of the components are fitted on a piece of 0.1in matrix stripboard, size 9 strips x 24 holes. Details of the component layout on the board is shown in Fig. 2.

Cut a piece of board to size and make all track breaks and inter-strip links as indicated. Drill the single mounting hole. Solder all on-board components into position.

Note that the full length of the thermistor (R2) wires should be used. Sleeve them using insulation removed from scrap connecting wire and solder this component into position quickly to avoid heat damage. Do not insert the i.c.s into their holders until the end of construction.

The reason for the bead thermistor being board-mounted is to make it relatively slow at responding to the fridge temperature. If it protruded through a hole in the case, it would respond rapidly to a rise in temperature when the door was opened. This would cause unnecessary on-off switching and waste the battery life.

Solder 5cm pieces of light-duty stranded connecting wire to strips *A*, *B*, *E*, *G*, *H* and *I* along the right-hand side of the completed circuit panel as indicated. Solder the battery connector to strip *A* (positive) and strip *I* (negative).

Prepare the box by drilling holes for D1, D2 and switch S1 as shown in the photograph. The l.e.d's may be a tight

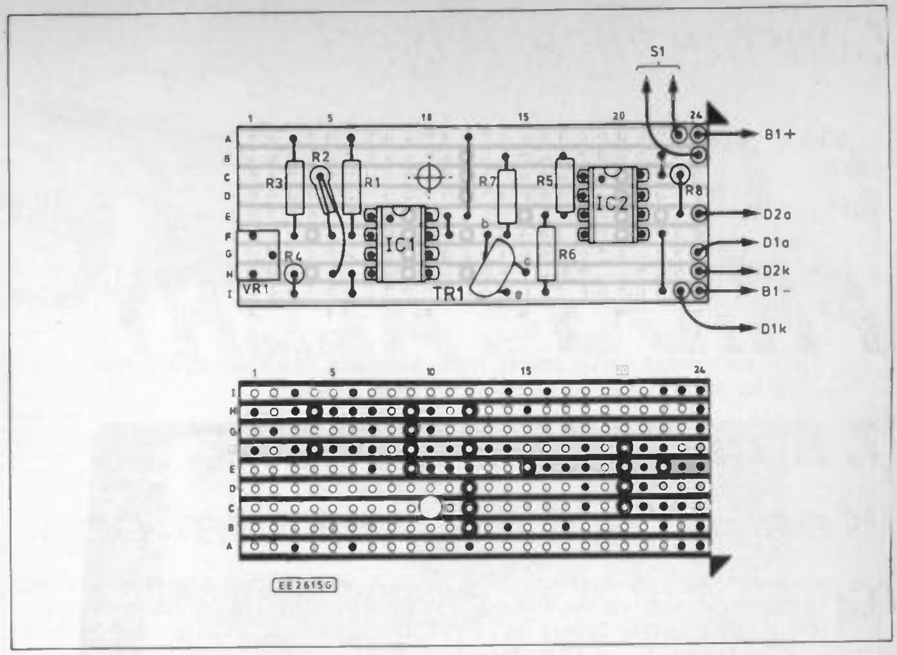


Fig. 2. Stripboard component layout and details of breaks required in the underside copper tracks.

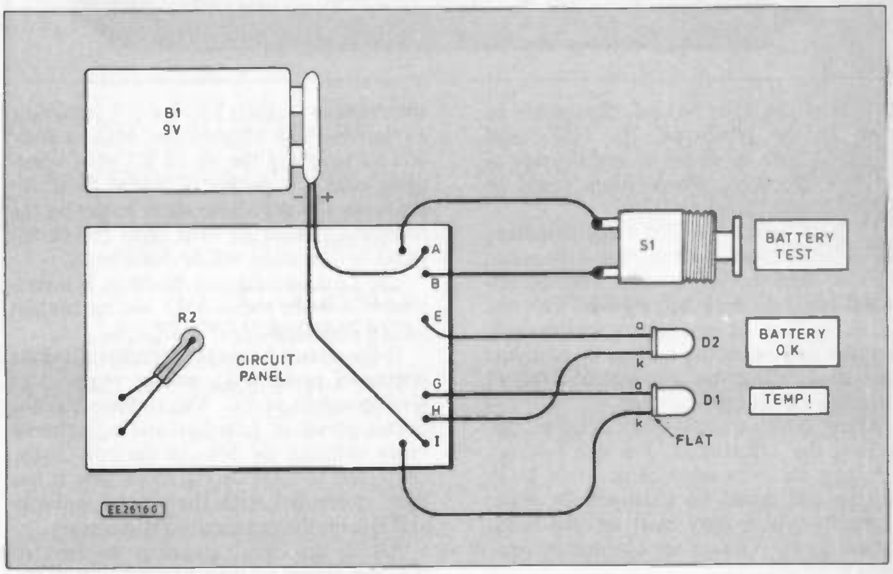
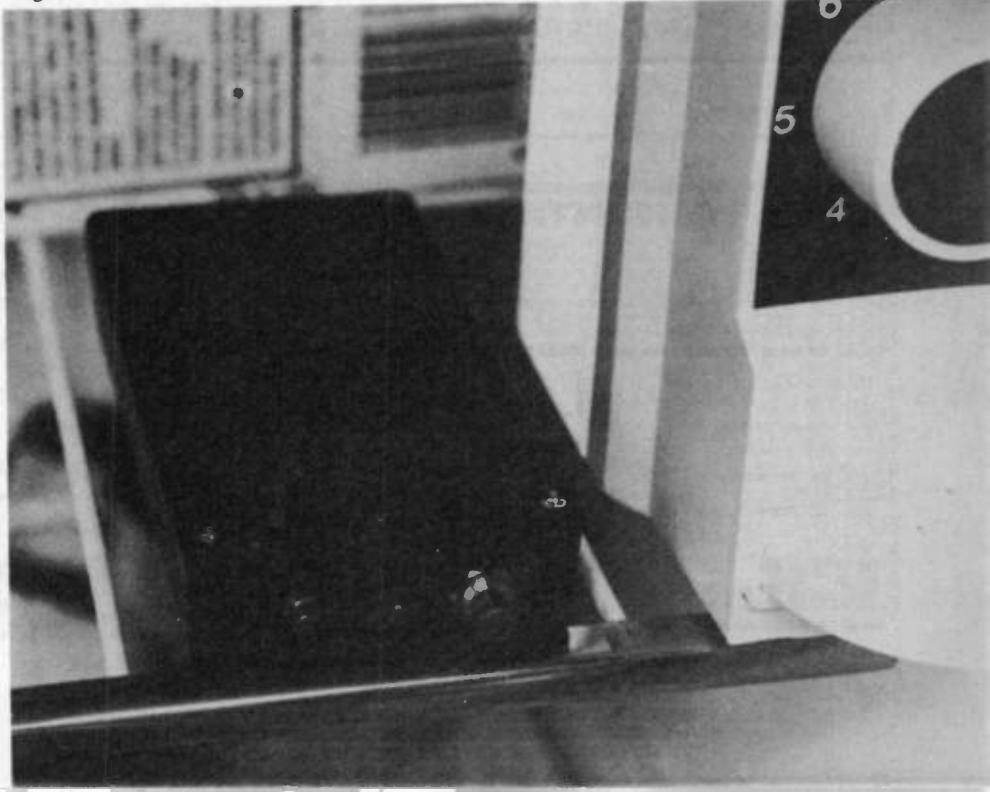
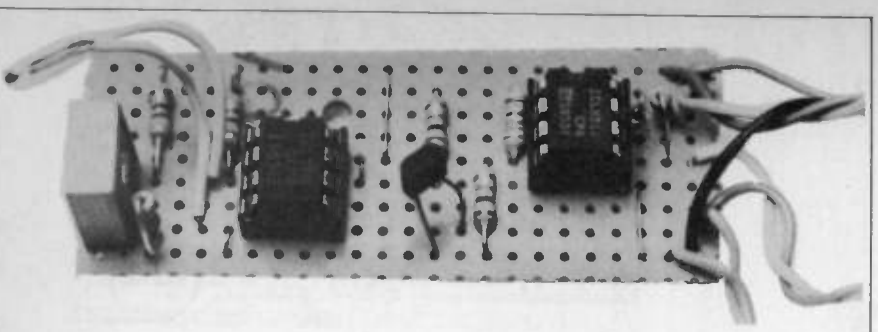
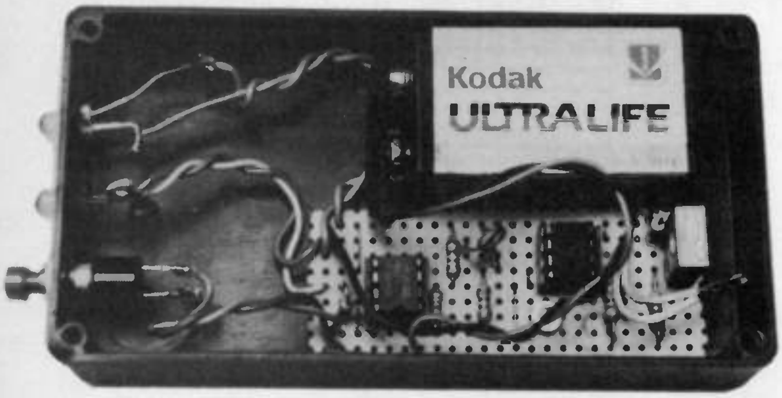


Fig. 3. Interwiring from the circuit board to the battery, test switch and the two "condition" l.e.d.s. (below) The completed alert placed on a shelf inside the fridge.





The completed circuit board, with thermistor, is shown above and the layout of components inside the case, below.



push fit in the holes or l.e.d. clips could be used. In the prototype, the l.e.d's and switch S1 were mounted on a short side of the box. However, the positions could be altered to suit the application.

Drill the hole for circuit panel mounting and a further small hole to align with preset VR1 so that this component may be adjusted using a small screwdriver with the lid in position. Mount all remaining components and, referring to Fig. 3, complete the wiring. Solder the l.e.d. wires quickly to prevent possible heat damage.

Insert both i.c's into their holders, observing the orientation. Do this without touching the pins since these are CMOS devices and could be damaged by static electricity which may exist on the body. Adjust preset VR1 to approximately mid-track position.

TESTING

With the circuit panel removed from the case, connect the battery – D1 (TEMP!) should flash – this is because it is signalling a relatively high temperature. Make a basic test by touching the tip of R2 with something cold – a packet of frozen food, for example. Do not allow water to get on the connecting leads or drip onto the circuit panel or operation will be disturbed.

The l.e.d. should stop flashing. If it continues to flash, rotate VR1 sliding contact until it does stop.

If the circuit behaves correctly, accurate setting of preset VR1 will be required to give operation at 5°C. This is done with the circuit panel in position and adjustment made through the hole in the box. If the l.e.d. fails to flash at all, check that it has been connected with the correct polarity and reverse the connections if necessary.

Attach the circuit panel to the base of the case using a small fixing through the hole drilled for the purpose. Secure the battery using an adhesive fixing pad. Fit the lid, checking for trapped wires and short-circuits – especially between the l.e.d. connections.

Place the box inside the fridge near the centre of the cabinet. For setting-up use a mercury thermometer. The best type will cover a narrow range, zero to 50°C for example, but the more usual −10° to 110° one will do.

Adjust the fridge thermostat over a period to provide a cabinet temperature of between four and five degrees. This cannot be done quickly, you will need to wait for the temperature to stabilize after each adjustment.

The temperature inside the refrigerator varies. A higher temperature is found on the top shelf compared with the base, typically four degrees. It is important to realize this when adjusting the operating temperature since it will affect the positions where various kinds of food are stored.

Adjust preset VR1 so that l.e.d. D1 is just off. Clockwise rotation (as viewed from the edge of the circuit panel) raises the switching temperature. The lid of the case may be left off to speed up the response time between adjustments. Each adjustment must be made quickly so that R2 does not rise in temperature significantly while the door is open. Check that the correct setting has been obtained and make minor adjustments as necessary.

If l.e.d. D1 either remains on or off despite VR1 adjustment, it will be necessary to alter the value of resistor R4. If D1 remains on despite total clockwise rotation of VR1, reduce the value from 2.2M to 1M. if the opposite is the case, that is, if the l.e.d. remains off despite complete anticlockwise rotation of VR1 sliding contact, increase R4 to 3.3M.

BATTERY CHECK

The battery check facility should now be tested. The easiest way to do this is to use any PP3 battery known to be in poor condition but still serviceable. When this is connected and switch S1 pressed, the green l.e.d., D2, (Battery OK) should *fail* to light. With a new battery in place it *should* light up. An alternative method is to use a 6V supply (4 off AA cells, for example) – this will be too low to operate D2. If the l.e.d. fails to light, check its polarity and reverse the connections if necessary.

There were no problems in the prototype unit due to moisture, from the "fridge", condensing on the circuit panel tracks. This would cause erratic behaviour. A light spray of water-repellent silicone grease would cure this. □

INTERFACING THE RML NIMBUS

ANDREW CHANNERLEY

Part 2

The Nimbus is replacing the BBC micros in many schools, we take a look at it and its BBC-type parallel card.

THE Nimbus I/O bus interface consists of a multiplexed address and data bus, very much like the 80186 itself, except that the data bus-bandwidth is only 8-bits. The pin allocation is given in Table 1 (shown at the end of the article) and physically the bus is distributed by a 40-way ribbon cable inside the Nimbus casing, with IDC-type headers. Four card slots are available inside the casing, for four peripheral boards connecting to the bus.

We have already discussed the **chip-select unit**, the address allocations of the chip-selects are given below. These chip-selects are brought out of the I/O bus connector via a 74LS244 buffer, as five, I/O mapped, selects designated BUS $\overline{CS0}$, BUS $\overline{CS1}$, BUS $\overline{CS2}$, BUS $\overline{CS3}$ and BUS $\overline{CS4}$. The bi-directional data bus comprises AD0-AD7 and is buffered through a 74LS245, it is 8-bit wide and therefore all port addresses are **even**, this is illustrated on Fig. 9. The usual control signals are also available.

The bus signals include an 8MHz clock, as well as an asynchronous **ready** input to insert **wait** states, though it should be pointed out that all I/O cycles have two-wait states automatically inserted. The bus operates at TTL levels, driven by the line driver devices.

The allocation of chip selects is as follows:

Address range	chip select card	
600-67Fh	4	Tape controller
580-5FFh	3	
500-57Fh	2	I/O research
480-4FFh	**1**	**BBC printer/user port**
400-47Fh	0	DBC
0F8-0FFh		reserved
00-F7h		reserved

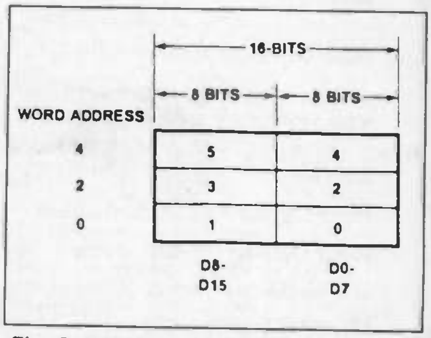


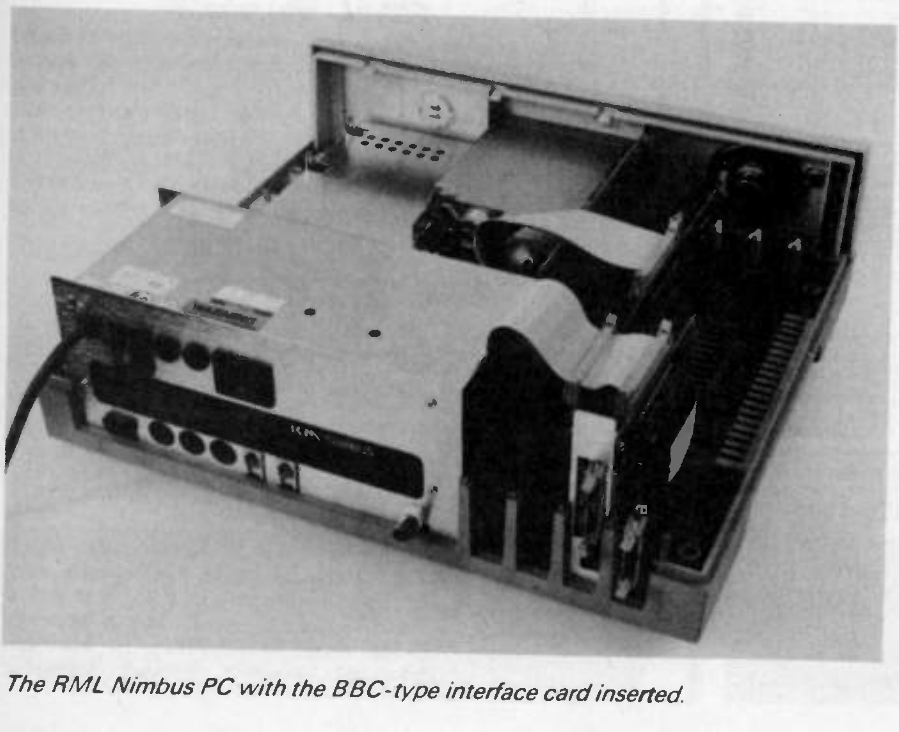
Fig. 9. Relation of word/byte to addres space allocation.

Interrupt vectors and priority allocation:

Channel	Request	Vector	Priority
0	BINT0	80h	6.7
1	BINT1	82h	6.6
2	BINT2	0Fh	9(programmable)

The BBC printer/user port vector is 0Fh.

At this point, it's probably time to examine the **BBC printer/user port parallel card**, designed for continuity and ease in interfacing equipment/circuitry previously applied to the BBC. This is important, in particular in schools, where lots of interface equipment has been obtained at quite a high cost.



The RML Nimbus PC with the BBC-type interface card inserted.

BBC-Type Printer and User Port

The BBC-type interface card slots into the Nimbus case and clips on to the I/O bus cable previously described (see photos). To the user, the card appears at the back of the Nimbus as two IDC sockets. One is a pin compatible, BBC type, 26-way IDC socket which is the parallel printer port. The other is a pin compatible, BBC-type, 20-way IDC socket which is the user port. The card is obtainable from RML, the manufacturers of the Nimbus PC.

In hardware terms, this card provides an identical BBC printer and user port environment. The original BBC printer and user ports are defined by a customized chip, the 6522 VIA (Versatile Interface Adapter). The Nimbus card has an identical 6522 VIA, a block diagram is shown in Fig. 10. Furthermore, it has a substantial software-support base. There is Richard Russell's version of BBC Basic for the Nimbus called BBCBasic(86), available from RML, with an interactive 80186/8086

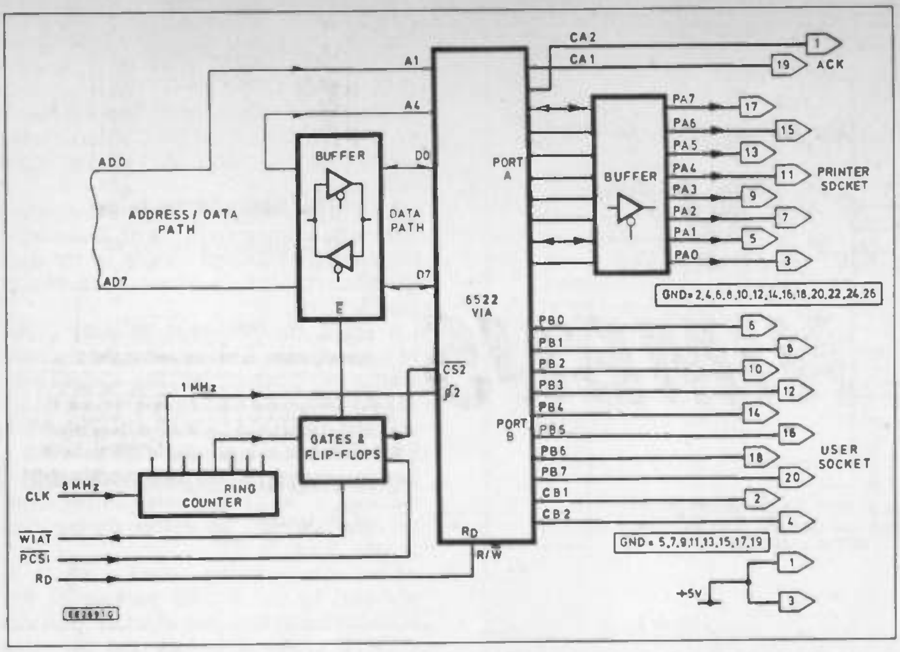


Fig. 10. Block diagram of the BBC Printer/User Port card for the RML Nimbus PC.

PROGRAMMERS MODEL OF 6522 VIA ADDRESS ASSIGNMENT

BASE ADDRESS = 0480 HEX	HEX OFFSET ADDRESS
Input/Output Port B (User)	00
Input/Output Port A (Printer)	02
DDRB (Data Direction B)	04
DDRA (Data Direction A)	06
Timer 1/Counter Low Byte	08
Timer 1/Counter High Byte	0A
Timer 1 Low Latch	0C
Timer 1 High Latch	0E
Timer 2/Counter Low Byte	10
Timer 2/Counter High Byte	12
Shift Register (SR)	14
Auxiliary Control (ACR)	16
Peripheral Control (PCR)	18
Interrupt Flag (IFR)	1A
Interrupt Enable (IER)	1C
Input/Output Port A (No Handshake)	1E
←—BYTE WIDE —→	

Fig. 11. Programmers model of 6522 VIA address assignment.

assembler, also, RML's Basic2 and the RML/MESU Logo-controller. We'll look at a hardware/software application subsequently.

Referring to the block diagram the printer port is buffered as on the original Beeb, making it a byte-output port only. The user port is a programmable byte/bit output or input port, which is accessible through a register set mapped to 16 I/O addresses and decoded using address signals A1 to A4. The register map is given in Fig. 11, these are even addresses since the VIA is connected to the lower data-byte path AD0-AD7.

The schematic of the timing-frame for a read cycle shows (Fig. 12) the T-states of the main CPU clock which runs at 8MHz. In order to operate the 6522VIA, this frequency has to be divided by eight giving the VIA operating frequency of 1MHz. The card is accessed during reads or writes at the address ranges 0480h-04FFh. In this address range the peripheral chip-select, PCS1, is driven low selecting the card, and activating the wait-state logic for the required number of clock cycles. Wait-states, Tw, basically extend read or write cycle such that peripherals which operate at low frequencies are given time to synchronize their logic with that of the higher frequency CPU's.

The current cycle, read or write, is extended by inserting more T-states, labelled Tw, into the cycle. A normal I/O-segment-read, for example, will take 10 T-states to complete, but with extra wait-states, Tw, can be extended to 18 or more T-states. The 1MHz clock simulates the operating frequency of a 1MHz 6502 CPU, data transfer occurs during VIA CS2 active (VIA chip-select active low) and the falling edge of the phi-2 clock. The RD (read) signal is active when high on the I/O bus. Frequency division is provided by a standard ring counter. Once wait is de-asserted, the cycle terminates 3T states later.

Software Support for the BBC Card

RML provides two main versions of Basic with which to access the Parallel I/O card. These versions are:

RML Basic2 : for user familiar with RML's 380Z/480Z

RML BBC Basic(86) : for users familiar with Acorn's BBC Basic

RML BBC Basic(86) is a version of **BBC Basic**. Users may know that the processor driving the Beeb is the 6502 and the Acorn Basic has an interactive assembler which is directly accessible from BBC Basic. The RML version of BBC Basic has an interactive 8086/80186 assembler, since the Nimbus is driven by the 80186 CPU, which too is accessible from Basic, hence the name **BBC Basic(86)**. It's worthwhile, though not essential, creating an AUTOEXEC.BAT file such that when booting the system MS-DOS automatically loads BBC Basic(86), or else just type **BBCload** at the MS-DOS prompt.

In communicating with the parallel printer/user card it's necessary to invoke PROC's and CALL's to assembled routines from within BBC Basic(86). Users have to code the CALL's themselves.

In addition, RML sends a parallel printer/user driver, PN 19140, on disk, called PARALLEL.SYS. This file you should transfer to your main boot/BBCload disk, such that when booting up the system, the default setting on the parallel card will be: **printer port as output** and **user port as input** (as on the Beeb). Otherwise it means writing additional code to set up the 6522 VIA.

RML Basic2

RML also produce their own Basic, RML Basic2, which has some configuration files appended to it and which facilitate access to the BBC parallel printer/user ports, without the necessity of preparing special purpose code. These configuration files are designated **!EXT.LCPP** and occur under **EXTNS.BCF** so that when loading Basic, the command is:

>BASIC EXTNS.BCF

Typical commands are:

userport send data byte x, for output to the user port

y:=userport receive byte( ), for input to the user port

Examples of uses in both Basic's are given in the listings for the A-to-D applications.

Interfacing an A-to-D

Let's look now at an application which will interface with the BBC parallel card user port. The circuit diagram is shown in Fig. 13. The A-to-D converter used is an 8-bit device which, in addition, has eight separate, software selectable

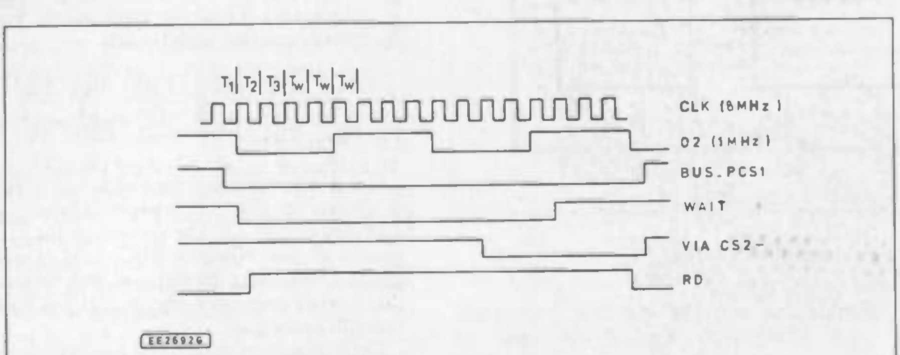


Fig. 12. Timing frame for a VIA read cycle.

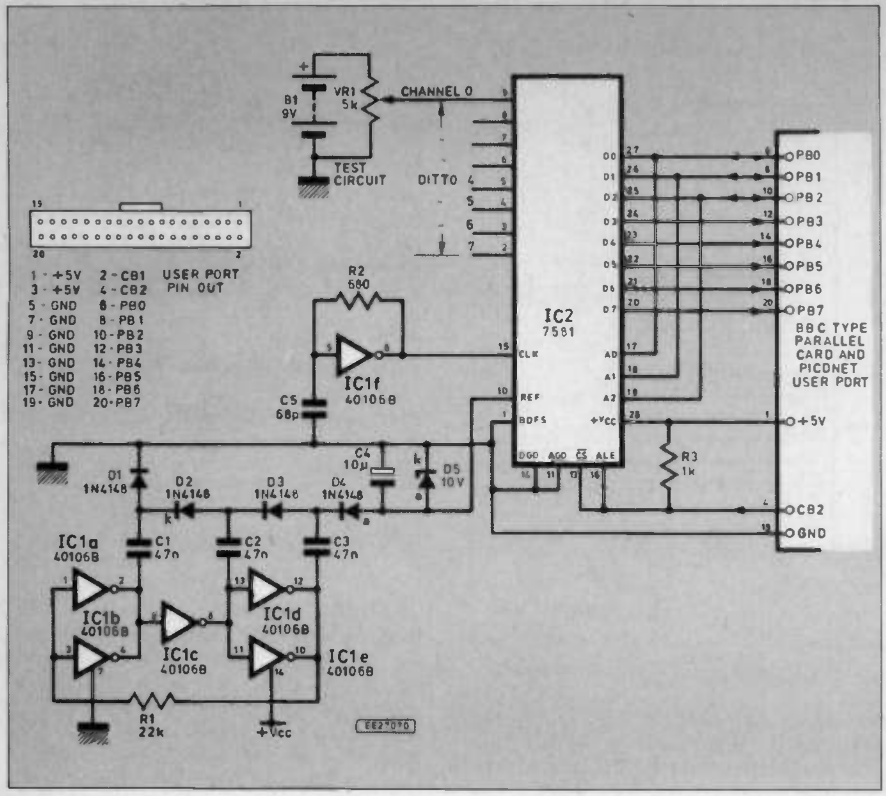


Fig. 13. Analogue to digital converter for the RML Nimbus BBC compatible user ports at the parallel card and the Piconet parallel interface.

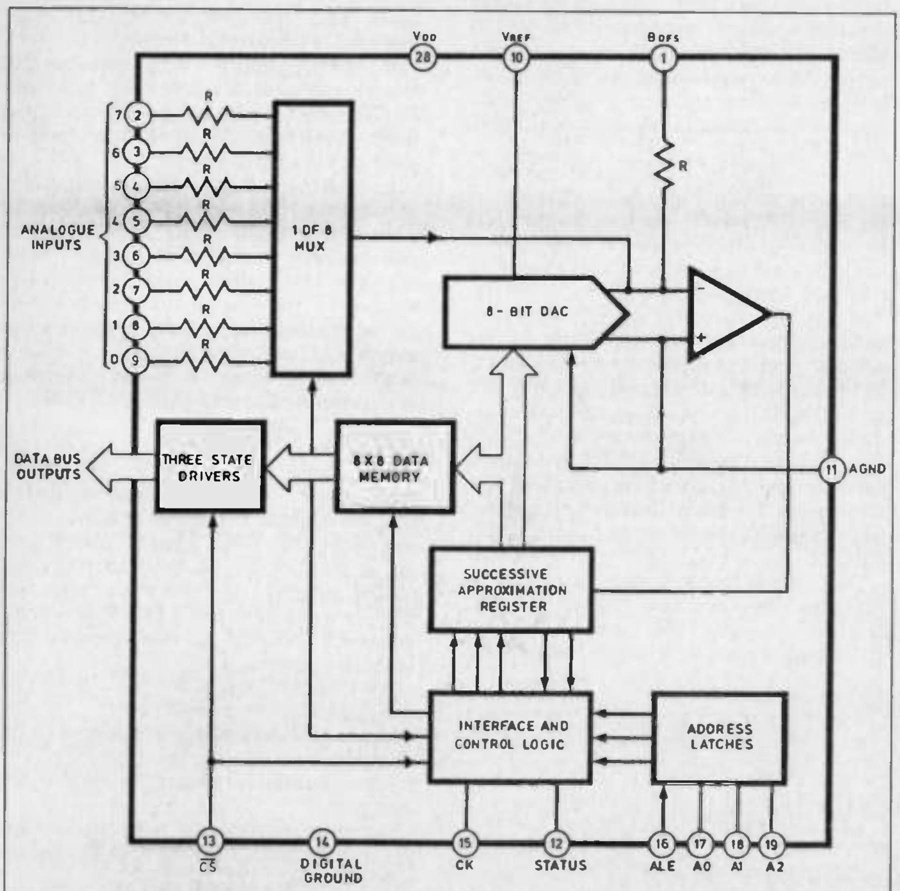


Fig. 14. Block diagram of the 7581 analogue to digital converter.

analogue channels. The voltage range at each analogue channel is between 0V to 10V.

The device digitizes using the technique of successive approximation. Conversion is continuous and the digitized byte from each channel is loaded into one of 8-memory locations, these locations are in fact addressable and, under programme control, select the required data cell from which to read the current, digitized byte. Fig. 14. is a block diagram of the device showing the salient features. The 8-bit DAC turns on/off the SAR bits in response to the comparator output. This output (0 or 1) depending on the DAC voltage being greater or less than the analog input voltage.

After eight successive trails, the digitised byte is transferred from the SAR to one of the memory cells and output to the data bus when the tri-state drivers are enabled at pin 13.

A single channel takes 80 clock cycles to convert, therefore for all eight channels taking 640 clock cycles. The address pins A0, A1, A2 select the required memory cell and are connected to data pins PB0, PB1, PB2 of the user port. Pin CB2 provides a latching signal for the addressable 8 byte memory, as well as a disable during channel selection and an enable during data output.

The synchronizing clock input is provided by the 40106B package of hex Schmitts (inverters) one of which provides a 1MHz conversion clock and the other five derive the necessary -10V reference voltage using a diode pump arrangement.

This particular A-to-D converter was also used on the 380Z/480Z, the Oric Atmos, Spectrum and BBC and interfaced to a large number of school science experiments.

Operational Software

The operational software comes in two listings:

(a) the listing of Fig. 15. is in RML BBC Basic(86). This Basic has an in-built 8086/80186 assembler. Communication with the 6522 VIA on the Parallel card is in 8086/80186 code.

(b) the listing of Fig. 16. is in RML Basic2 and uses the procedures provided by the extensions. It is user friendlier since all the VIA registers are accessible from high-level Basic. But... once a machine coder always a machine coder.

Construction

The complete A-to-D converter can be prototyped on a Euroboard, see Fig. 17. and the photograph. The only soldering required for this approach is in connecting the 20-way ribbon cable to 2 x 10-way headers which fit into the breadboard slots as shown in Fig. 17. The other end of the ribbon cable is attached to an IDC 20-way plug. This has a set of shearing pins which cut into the ribbon insulation, when pressed against the pins, and make a connection.

Of the 20-ribbon strands, only 12 are in fact required for actual soldering to the 10-way header. These are given below, with the ribbon number underneath:

GND	PB7	PB6	PB5	PB4	PB3
19	20	18	16	14	12
PB2	PB1	PB0	CB2	CB1	5V
10	8	6	4	2	1

The pin designation on the actual board is shown in Fig. 17. and on the circuit diagram of Fig. 13. The pin out of the IDC socket at the Nimbus BBC card is also given. These form the physical link between the A-to-D converter circuit and the Nimbus BBC user port.

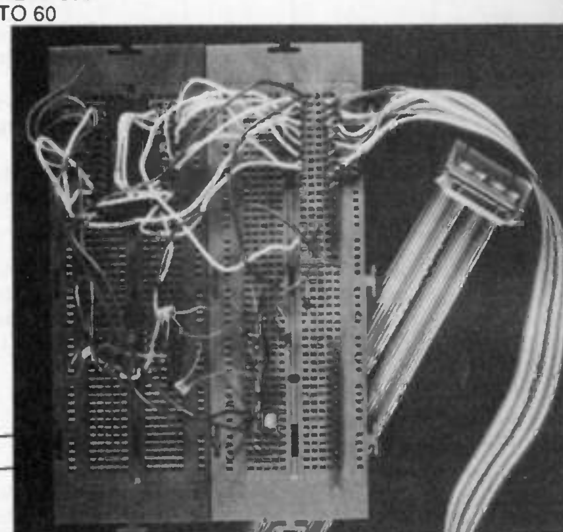
The Euroboard comprises a central channel, on either side of which are 40 rows of five inserts, each row is at right angles to

Fig. 15. RML BBC Basic(86) operational software.

```
10 REM This listing uses the 80186/8086 assembler from
20 REM BBCBasic(86) in a procedure which sets up the User
30 REM port as output to select the analog channel on the
40 REM 7581, 8xchannel, Analog-to-Digital converter.
50 REM The handshake line CB2 is used to latch the channel
60 REM address and to enable/disable the 7581 ADC.
70 REM The remainder of the software plots the bytes.

80 PROC_ASSEMBLE:REM assemble code
90 MOVE 0,0
90 MODE 4
100 V=0
110 REPEAT
120 V=V+1
130 CALL read:REM read data byte to G
140 Y=?G:REM read G
150 DRAW V,Y*4:REM plot it
160 PRINT TAB(35,2);STR$(Y)+"  ":REM also display onscreen
170 FOR T=0 TO 10:NEXT T:REM wait
180 UNTIL V>1200
190 GOTO 90
200 END

210 DEFPROC_ASSEMBLE
220 HIMEM=&4000
230 FOR Z=0 TO 2 STEP 2
240 P%=&4000
250 [OPT Z
260 .G DB 0\reserve data byte
270 .read
280 MOV AL,&FF:LEA DX,&0480[04]:OUT DX,AL\User port output
290 MOV AL,&E0:LEA DX,&0480[&18]:OUT DX,AL\CB2 high
300 MOV AL,0:LEA DX,&0480[0]:OUT DX,AL\select channel 0
310 MOV AL,&C0:LEA DX,&0480[&18]:OUT DX,AL\CB2 low
320 MOV AL,0:LEA DX,&0480[04]:OUT DX,AL\User port input
330 LEA DX,&0480[0]:IN AL,DX:MOV [G],AL\read byte
340 .end RETF
350 ]
360 NEXT Z
370 ENDPROC
```

Fig. 16. RML Basic2 operational software.

```
10 REM This listing is in RMLBASIC2 with EXTNS.BCF which
20 REM contains !EXT LCPP.EXT. It works just like the
30 REM listing in BBCBasic(86), with CB2 latching the
40 REM channel address and turning the ADC on/off.
45 REM Communication is through the Parallel Card
48 REM User port socket.

50 SET MODE 80
60 SET ORIGIN 0,0
70 CLS
80 X:=0
90 SET USERPORT_DDR 255:REM User port output
100 SET LCPP_REGISTER 12,224:REM make CB2 high
110 USERPORT_SEND_DATA_BYTE 0:REM select channel 0
120 SET LCPP_REGISTER 12,192:REM make CB2 low
130 SET USERPORT_DDR 0:REM User port input
140 REPEAT
150 X:=X+1:REM dummy time axis
160 Y:=USERPORT_RECEIVE_BYTE ():REM read user port
170 LINE X,Y:X,Y
180 UNTIL X>638
190 GOTO 60
```



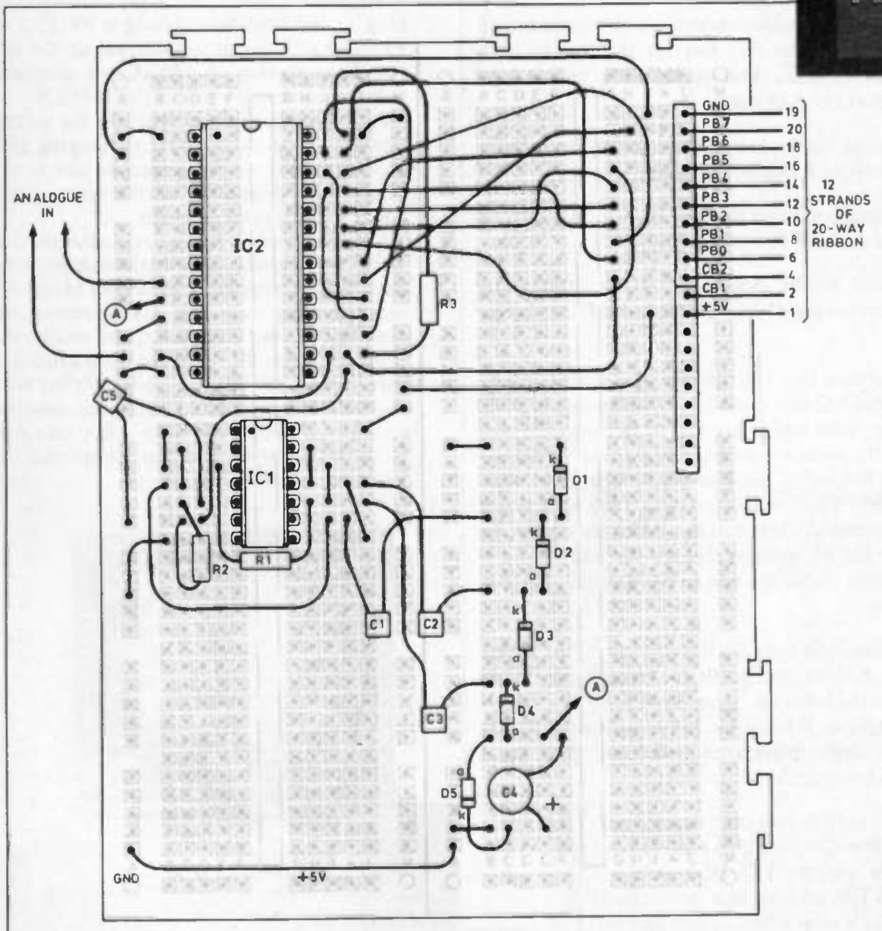


Fig. 17. Construction of the A to D coverter.

COMPONENTS

Resistors

R1	22k
R2	680
R3	1k

All ¼W ± 5% carbon

See SHOP TALK Page

Potentiometer

VR1 5k linear

Capacitors

C1, C2, C3	47nF ceramic (3 off)
C4	10µ tantalum 10V
C5	68p silvered mica

Semiconductors

D1 to D4	1N4148 or 1N4001 diodes (4 off)
D5	10V Zener diode 1.3W
IC1	40106 Hex Schmitt
IC2	7581JN ADC

Miscellaneous

0.1 inch pitch, 10-way p.c.b. header (2 off); 20-way IDC plug; plug in breadboards (2 off); ribbon cable; 9V PP3 battery; connecting wire.

Approx cost guidance only **£25** plus breadboards

TABLE 1
RML NIMBUS BUS SPECIFICATION

Pin Name	Pin No.	Pin Type	Signal Description
12V	1, 2	O	+ 12V Power distribution connections
5V	3, 4, 5, 6	O	+ 5V Power distribution connections
GND	7, 12, 17, 19, 26, 32, 38	O	System ground. The 0V return for 5V, 12V and signal ground current
I/O GND	39, 40	O	I/O Ground. Noise free ground for peripherals, connected directly to the system star ground point. Must not be used to carry signal or power return currents.
$\overline{\text{RESET}}$	25	O	Reset indicates that the BCU is being reset at power up, or that the reset output of the System GA has been activated under program control. Reset is active low.
$\overline{\text{CLK}}$	18	O	The buffered, inverted '186 clock output 8MHz with 50 per cent duty cycle.
$\overline{\text{DMA REQ}}$	33	I	$\overline{\text{DMA REQ}}$ is driven low by a peripheral board to initiate a DMA transfer.
$\overline{\text{BINT0}}$ $\overline{\text{BINT1}}$ $\overline{\text{BINT2}}$	34 35 36	I I I	Bus interrupt request lines are driven low to request an interrupt.
AD7 AD6 AD5 AD4 AD3 AD2 AD1 AD0	16 15 14 13 11 10 9 8	B B B B B B B B	Address/data bus. This time multiplexed I/O address and data bus is used exclusively for I/O byte wide transfers between mainboard and peripheral boards on the I/O bus. The AD bus is true (active high).
$\overline{\text{ALE}}$	20	O	Address latch enable. Addresses are guaranteed to be valid on the AD bus for the low to high transition of $\overline{\text{ALE}}$. This signal may be used to demultiplex the AD bus.
RD	21	O	Read strobe indicates that the current bus activity is a read cycle. RD is active high.
WR	22	O	Write strobe indicates that the current bus activity is a write cycle. WR is active high.
I/O REQ	23	O	I/O request strobe indicates that the current bus cycle is an access of I/O space. I/O REQ is active high
$\overline{\text{WAIT}}$	24	I	$\overline{\text{WAIT}}$ informs the '186 that the device accessed by the current I/O bus cycle is not ready to complete the cycle. Wait states are added between T3 and T4, and the cycle extended. The cycle terminates 3 T states following the first positive transition of CLK after WAIT is de-asserted. Two wait states are automatically inserted in all I/O bus cycles, so WAIT must be inactive before the end of T3 if further wait states are not to be inserted. $\overline{\text{WAIT}}$ is active low.
BUF DIR	37	O	Buffer Direction indictes the driving status of the AD bus buffers on the BCU mainboard. When high, the AD bus is being driven by the mainboard drivers. When low, the mainboard drivers are in a high impedance state and peripheral boards have control of the AD bus.
$\overline{\text{CS4}}$ $\overline{\text{CS3}}$ $\overline{\text{CS2}}$ $\overline{\text{CS1}}$ $\overline{\text{CS0}}$	31 30 29 28 27	O O O O O	Buffered peripheral chip select outputs of '186. Chip select is made active when the current I/O bus cycle accesses an I/O address in a pre-defined range. Each chip select is decoded for a block of 128 I/O addresses. Chip selects are active low.

the length of the board. Each insert in a row of five is connected with the other four, but each row is not connected to any other row on the board. In addition, there are two columns of inserts which run the length of the board, close to the board edges. Each insert along such a column is connected with the other inserts, but each column is not connected with the other, nor with any rows. These columns usually form the power and ground rails.

Clip two such boards together as shown in the diagram. The two chips forming the A-to-D converter are inserted across the central channel of the prototype board, see the wiring diagram of Fig. 17. Note that the main A-to-D chip, the 7581LN, is inserted at the top end, the same as the ribbon cable and the 40106B hex-Schmitt's further down. Pin 1, of the 7581LN, is at the top left and pin 28 is at the top right. The data pins from the chip are then facing the corresponding pins of the 10-way headers.

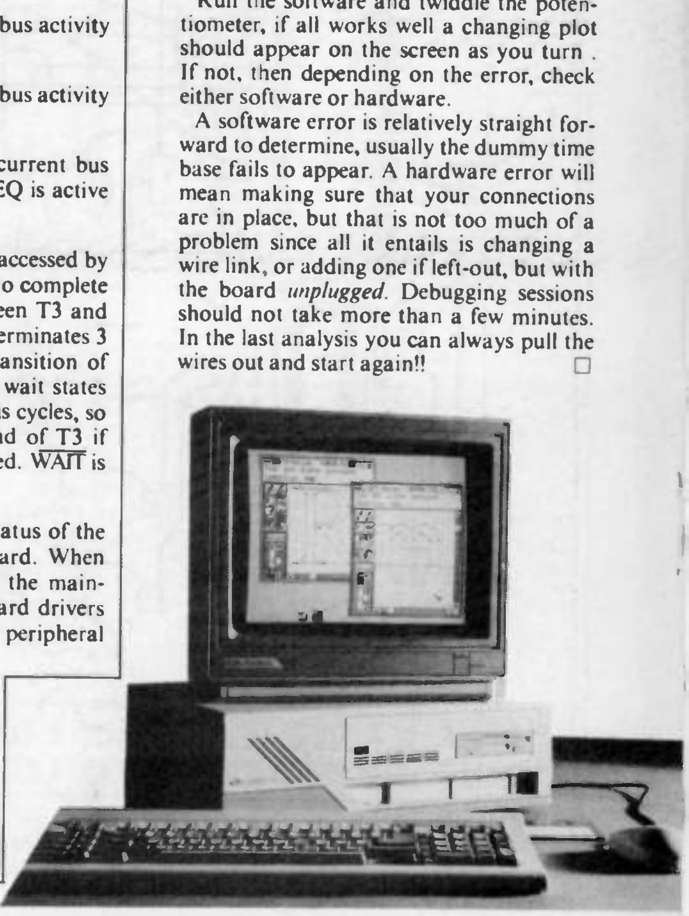
Initially, choose two of the column inserts to act as supply rails and using a piece of insulated wire, bared at both ends, connect the appropriate pins together as shown on the circuit diagram. Some examples are given on the wiring diagram. Be methodical in your wiring, tick-off each connection on the circuit diagram which then becomes a record of connections in place. The circuit may look like a spaghetti junction, but that does not matter. The advantages of this method over immediate soldering is that mistakes can be easily rectified.

Testing

Once all connections are in place, key-in the software, either in BBC Basic(86) or RML Basic2 and connect the 20-way IDC plug to the user port. Using a 9V PP3 or PP9 and a 5k potentiometer, set up the test circuit as shown on the circuit diagram, using channel 0 at pin 9 of the 7581LN.

Run the software and twiddle the potentiometer, if all works well a changing plot should appear on the screen as you turn . If not, then depending on the error, check either software or hardware.

A software error is relatively straight forward to determine, usually the dummy time base fails to appear. A hardware error will mean making sure that your connections are in place, but that is not too much of a problem since all it entails is changing a wire link, or adding one if left-out, but with the board *unplugged*. Debugging sessions should not take more than a few minutes. In the last analysis you can always pull the wires out and start again!! □



Constructional Project

CAR HEATER THERMOSTAT

T. R. de VAUX-BALBIRNIE

Luxury control for in-car comfort

ON A COLD morning, we want to get the car heater working as quickly as possible. Trying the booster fan results in icy blasts until the water in the cooling system is hot enough. Once the heater is working, the car interior soon becomes too hot and a juggling act with the heater controls is needed to keep the temperature steady and comfortable.

The present circuit puts the heater under thermostatic control. This it does by preventing the booster fan from operating until the water is hot. It then switches on until the interior reaches the required temperature and cycles as necessary to maintain this.

The circuit is housed in a plastic box mounted on the dashboard with air temperature control, l.e.d. indicators and a terminal block to which external connections are made. An on-off switch and auto/manual switch are also provided (see photograph).

The l.e.d's show the status of the system thus, when the ignition is switched on, a green one lights and goes off when the radiator water is hot and a red one operates when the car interior has reached the required temperature. Two sensors are used – one is attached to the engine block to monitor water temperature while an air sensor is housed in a small plastic box situated in the rear of the car.

CIRCUIT DESCRIPTION

The circuit diagram for the Car Heater Thermostat is shown in Fig. 1. The design centres around IC1, a dual operational amplifier integrated circuit. One section of this, IC1a, monitors the cooling system water temperature while IC1b is responsible for the air temperature inside the car.

Thermistors, R1 and R2 sense "air" and "water" temperatures respectively. These are negative temperature coefficient devices, on a rise of temperature, their resistance falls. Costs have been reduced here by using miniature rod thermistors instead of the more expensive bead type.

Consider thermistor R2 which forms a potential divider with resistor R4 and preset VR2. As the water temperature rises, its resistance falls resulting in a decreasing voltage being applied to the non-inverting input (pin 2) of IC1a. The inverting input (pin 1) meanwhile receives a fixed voltage of 4V approximately by the potential divider action of resistors R7 and R8 in conjunction with Zener diode, D4 and its series resistor, R11.

With the water temperature low, therefore, the voltage at the non-inverting input exceeds that at the inverting one and the op-amp is on with pin 12 high (positive supply voltage). This operates the green light-emitting diode D2 (WATER COOL), through resistors R12 and R13.

When the water reaches some higher temperature dependent on the adjustment of preset VR2, (ADJ. WATER TEMP) the voltage at the non-inverting input will fall below that at the inverting one and the op-amp will switch off with pin 12 going low (negative supply voltage). Light-emitting diode D2 then goes off.

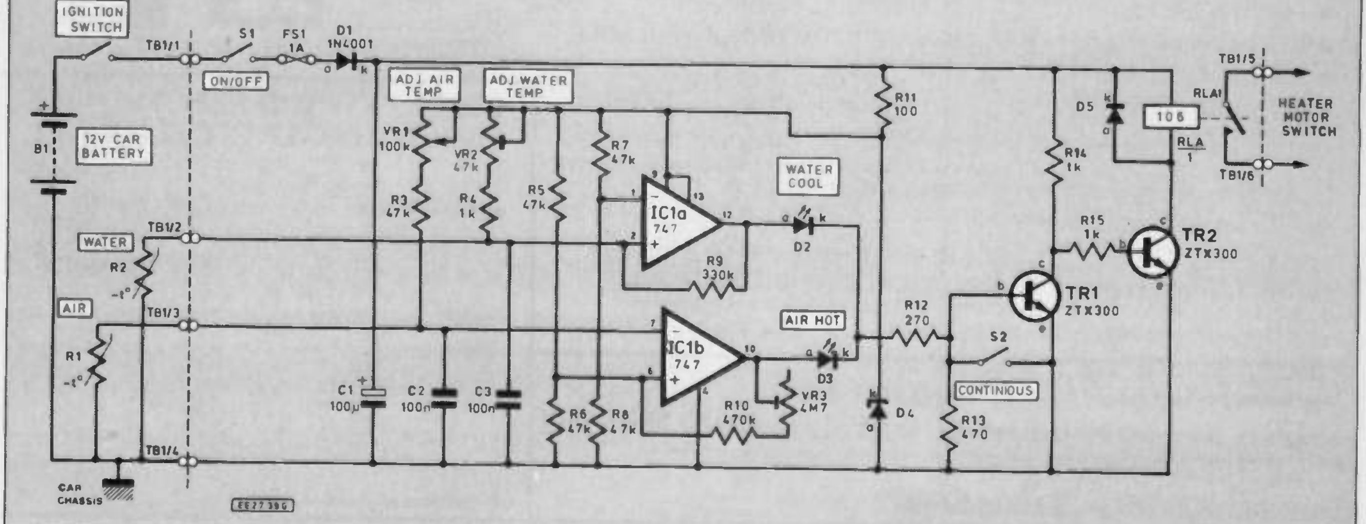
A similar situation occurs with R1 and IC1b but operates in the opposite sense. Note that R1 forms a potential divider with resistor R3 and control VR1. Thus, with air cool, R1 has a high resistance and hence a high voltage across it.

This voltage is applied to IC1b inverting input (pin 7). The non-inverting input (pin 6) voltage is set to 4V approximately by the potential divider action of R5 and R6 together with Zener diode, D4.

With low air temperature, therefore, the non-inverting input voltage exceeds the inverting one and IC1b is off, with pin 10 low. As the air temperature rises, the voltage at IC1b pin 7 falls and at some point determined by the setting of VR1 (ADJ. AIR TEMP), becomes less than that at the non-inverting one. IC1b then switches on with pin 10 high. Red light-emitting diode, D3, (AIR HOT) then comes on operating through R12 and R13.

In conditions of low water temperature or high air temperature the corresponding op-amp is therefore on. Current is then directed from either, or both, op-amp outputs through light-emitting diode, D2 or

Fig. 1. Complete circuit diagram for the Car Heater Thermostat.



D3 as appropriate and resistor R12, to the base of transistor TR1 which, providing switch S2 is off, switches on with its collector low.

This low state is applied to TR2 base via R15 which therefore remains off. The relay coil RLA/1 thus receives no current and the normally-open contacts, RLA1, remain open. No current therefore reaches the heater motor.

In conditions of both hot water and cool air, both the op-amp outputs will be off so no current reaches transistor TR1 base and the collector remains high. This turns on TR2 and operates RLA/1 coil. The normally-open contacts therefore close and operate the heater fan motor.

Capacitors C2 and C3 allow any a.c. pickup arriving at the op-amp inputs through the thermistor connecting wires to be bypassed, this could otherwise cause faulty operation.

FEEDBACK

Resistor R10 and preset VR3 apply a small amount of positive feedback from IC1b output (pin 10) to the non-inverting input (pin 6). This has the effect of introducing a little backlash into the system making the "on" temperature slightly higher than the "off" one.

This makes for "clean" operation and avoids rapid on-off switching (relay chatter) which could occur close to the operating temperature. Preset VR3 allows some adjustment here and will be set for best results at the end of construction. In the water temperature section, positive feedback is similarly applied to IC1a pin 2 through resistor R9 and this is not adjustable since the operating temperature difference is not thought to be particularly critical.

Diode D1, in conjunction with capacitor C1, produces a smooth supply from the car charging circuit. Zener diode, D4, in combination with R11, stabilises the supply and this helps in providing precise operating temperatures. Diode D5 bypasses the high-voltage "spike" which appears when the relay switches off, this could otherwise damage semiconductor components.

Switch S2 (CONTINUOUS), turns off transistor TR1 whatever the states of the op-amp outputs. This it does by connecting the base to the negative line. This has the effect of switching on TR2 hence RLA/1 and operating the heater motor continuously. S1 is the on-off switch and fuse, FS1, provides protection in the event of overload or short-circuit.

CONSTRUCTION

The circuit panel for the Car Heater Thermostat is made from 0.1in. matrix stripboard, size 13 strips x 38 holes. The component layout and details of breaks required in the underside copper tracks are shown in Fig. 2.

Begin construction by cutting the board slightly too large then filing it to fit the slots of the plastic box securely. File off the small sections at the three corners as indicated.

Follow with all track breaks and interstrip links as indicated. Check particularly that the link beneath RLA/1 position has been made.

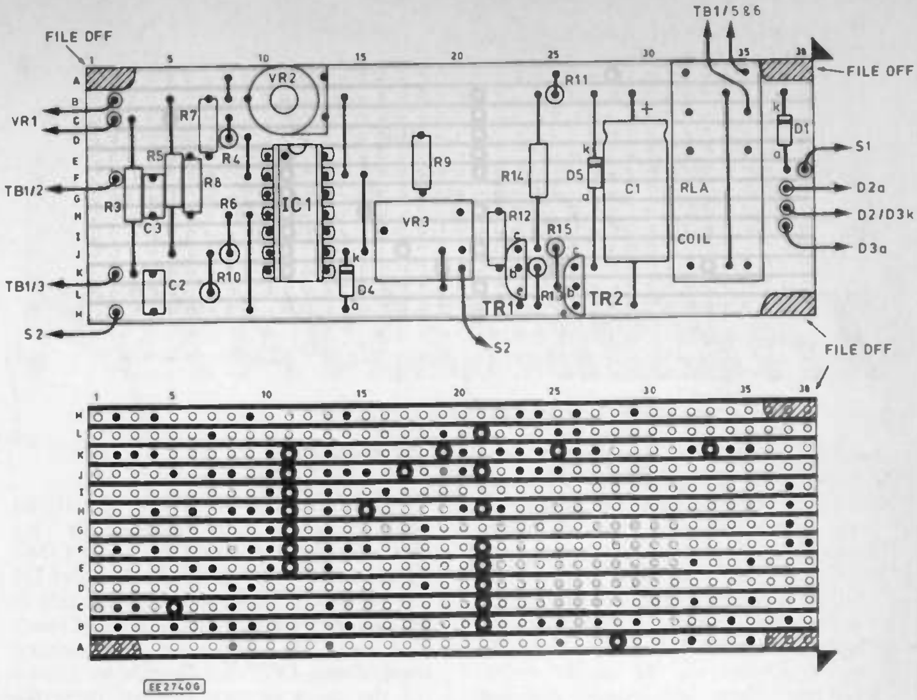


Fig. 2. Stripboard component layout and details of breaks required in the underside copper tracks. Note the wire links under VR3 and the relay.

COMPONENTS

Resistors

R1, R2	VA1067S rod thermistors (2 off)
R3,R5,R6 R7,R8	47k (5 off)
R4,R14, R15	1k (3 off)
R9	330k
R10	470k
R11	100
R12	270
R13	470

All 0.6W metal film.

See SHOP TALK Page

Potentiometers

VR1	100k rotary carbon, lin.
VR2	47k sub-min. preset, horiz.
VR3	4M7 sub-min. preset, horiz.

Capacitors

C1	100μ axial elec. 16V
C2,C3	100n polyester layer (2 off)

Semiconductors

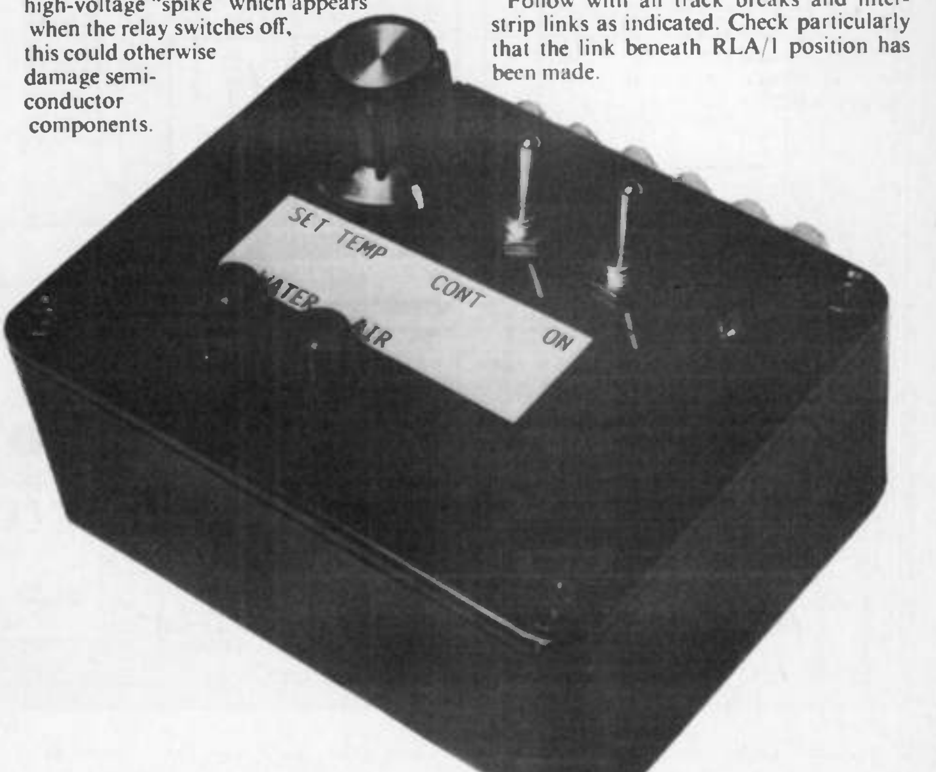
D1,D5	1N4001 1A 50V rec. diode (2 off)
D2	5mm green l.e.d.
D3	5mm red l.e.d.
D4	BZY88C 7V5 Zener
TR1,TR2	ZTX300 *npn* silicon
IC1	747 dual op.amp

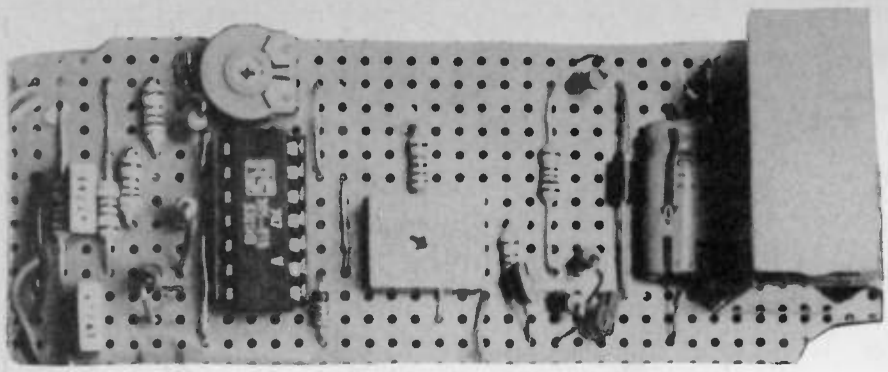
Miscellaneous

RLA	12V 106ohm coil min. relay, with 16A changeover or make contacts
S1	Min. s.p.s.t. rocker switch
S2	Min s.p.s.t. rocker switch
FS1	1A 20mm fuse, with chassis fuseholder

Stripboard 0.1in matrix, size 13 strips × 38 holes; plastic case, size 100mm × 76mm × 41mm (MB2); small plastic box for air sensor thermistor; 14-pin d.i.l. socket; 5A 8-way screw terminal block (TB1 6-way, TB2 2-way); thin sheet copper or aluminium for water temp. sensor, size 25mm × 50mm approx; light-duty twin stranded wire; 5A auto-type wire; auto-type connectors (Scotchlok); solder etc.

Approx cost guidance only **£19**





Layout of components on the completed circuit board.

Solder the on-board components into position paying particular attention to the polarities of all diodes and of capacitor C1. Make a careful check for errors, especially for adjacent copper strips which may have become accidentally "bridged" with solder.

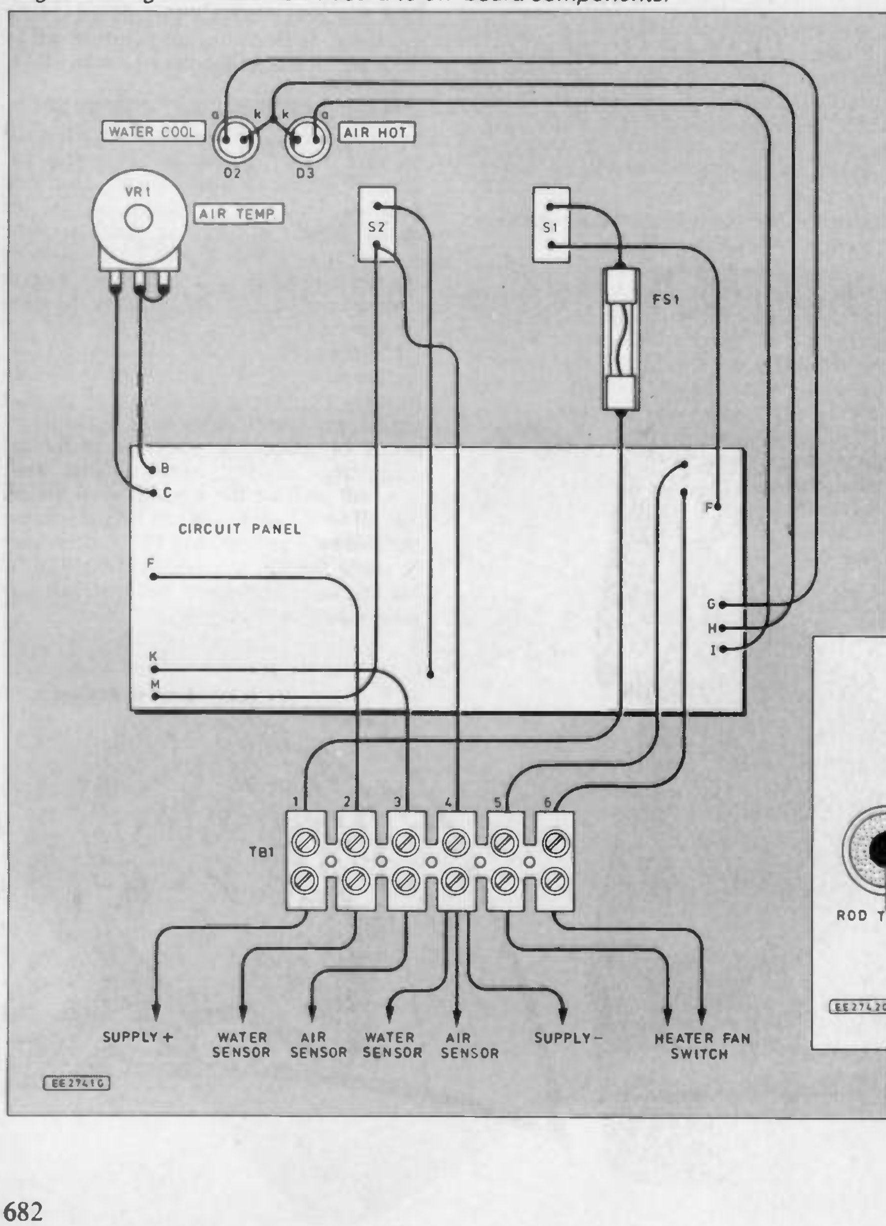
Solder 15cm pieces of auto-type wire of *5A rating minimum* direct to the normally-open contacts of RLA/1 – *do NOT make these connections via the copper strips.* Solder 15cm pieces of light-duty stranded connecting wire to copper strips *B, C, F, K* and *M* along the left-hand side of the circuit panel and to *F, G, H* and *I* along the right-hand side. Adjust the sliding contacts of VR2 and VR3 to approximately mid-track position.

BASE

Prepare the box to receive the circuit panel by drilling holes in the lid for VR1 (SET TEMP). S1 (ON-OFF). S2 (CONTINUOUS). l.e.d. indicators D2 and D3 also for fuse, FS1. Drill holes in the side of the box for the 6-way screw terminal block TB1 mounting and secure all remaining components. Drill two 5mm holes nearby for the wires passing through from the circuit panel.

Refer to Fig. 3 and complete all internal wiring. "Rainbow" ribbon cable was used for some of the wiring in the prototype unit. This keeps the wires neat and the colours help to avoid mistakes.

Fig. 3. Wiring from the circuit board to off-board components.



Connections to D2 and D3 should be soldered quickly since l.e.d's are easily damaged by excessive heat. Note also that they are polarized, the shorter wires are the cathode.

With the circuit panel in position route the wires leading from relay RLA/1 normally open contacts underneath and through the section filed off for this purpose. Slowly move the lid into position and check carefully that no components, especially FS1, cause short circuits at the copper tracks or elsewhere.

TEMPERATURE SENSORS

Referring to Fig. 4. make the water temperature sensor. The prototype used a piece of thin copper size 25mm x 50mm approximately. Aluminium would probably work just as well.

Cut this to size and bend it around a 5mm twist drill to provide a cavity for the rod thermistor. Sleeve the wire ends of the thermistor and secure it in position using quick-setting epoxy resin adhesive. Make sure that device is centrally-placed in the cavity and insulated from the metalwork with adhesive.

Measure a piece of light-duty twin stranded wire long enough to reach the sensor from the main unit position. Attach this wire to the sensor as shown.

Carefully clean and roughen an area of the vehicle engine block which becomes hot in operation and attach the thermistor sensor using epoxy-resin adhesive. The site must be clear of all moving parts and shielded from draughts as will occur when the car is moving.

Route the connecting wire to the main unit and connect it to TB1/2 and TB1/4 (polarity unimportant). Where the wire passes through a hole in metal, a rubber grommet must be used.

AIR SENSOR

Next make up the air sensor unit as outlined in Fig. 5. Attach the 2-way screw terminal block TB2 using a single fixing. Sleeve the wire ends of the thermistor and attach them to the terminal block as shown (see photograph).

Drill a matrix of holes in the lid so that air can circulate freely and allow the thermistor to respond quickly to changes in temperature. Drill a small hole in the box for the connecting wires to pass through.

Site the air sensor in some part of the car out of the main heater airflow. Somewhere in the rear of the car is probably best, perhaps on the parcel shelf.

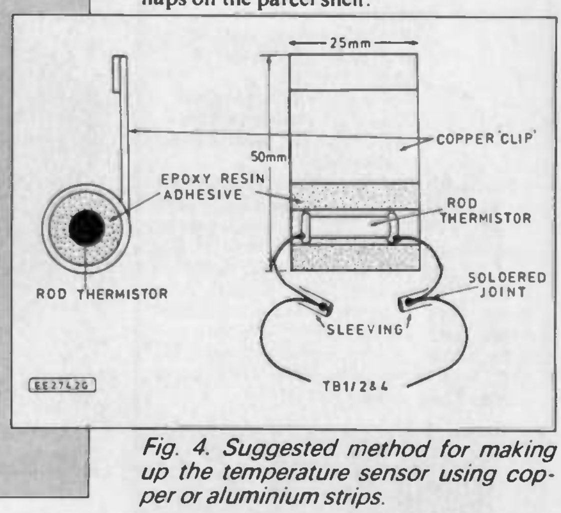
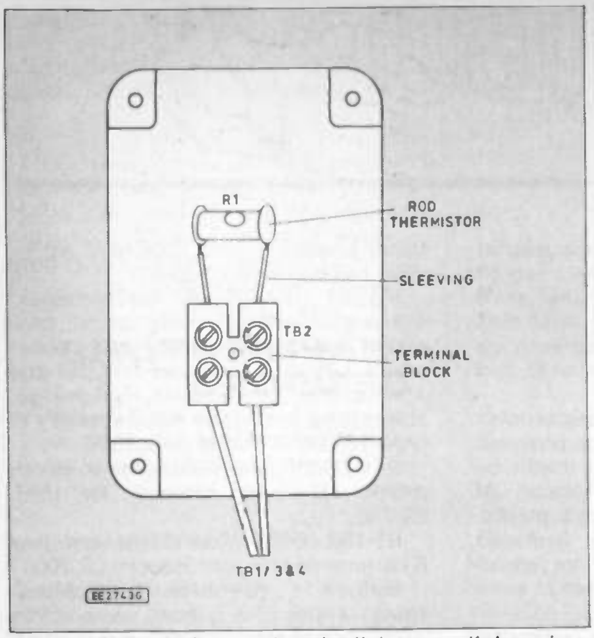


Fig. 4. Suggested method for making up the temperature sensor using copper or aluminium strips.



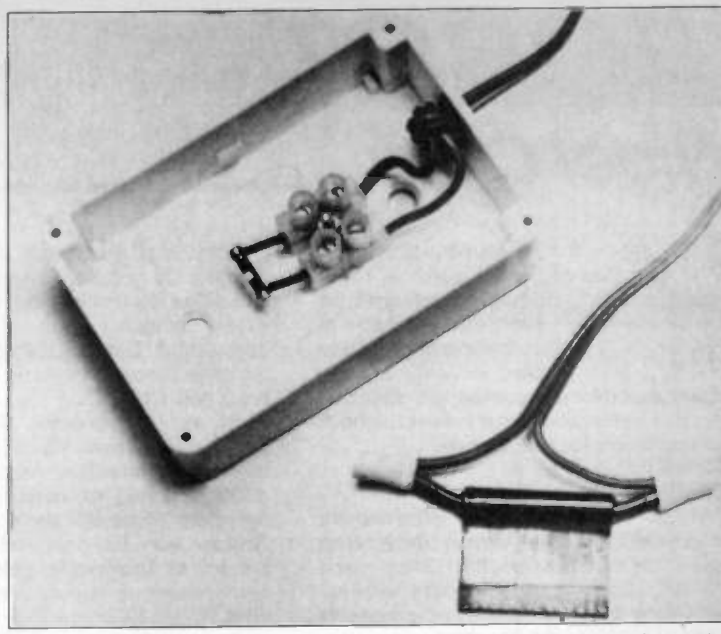


Fig. 5. Method of mounting the "air sensor" thermistor in a small case. A matrix of holes should be drilled in the case lid so that air can circulate freely. The photograph shows the two completed sensors illustrating the use of insulated sleeving covering the leads from the thermistors.

Using light-duty twin wire, connect it to TB1/3 and TB1/4 (polarity unimportant). Fix a strain relief clip or grommet inside the sensor box to provide strain relief. Secure the "air" sensor unit in position using an adhesive fixing pad.

ADJUSTMENT

Auto-type wire of 5A minimum rating MUST be used for the remaining TB1 connections. Connect TB1/5 and TB1/6 to the heater motor switch (polarity unimportant) *leaving existing connections intact.* "Scotchlok" connectors are best for this job, these can make connections to existing wires without actually breaking them. In any case, proper connectors MUST be used – not taped joints.

It is probably better to use the low speed (less noisy) position if the heater has a twin speed motor. However, a final decision on this as well as the optimum positions of the other controls can be made later.

Connect TB1/1 to a fuse which is live only when the vehicle ignition is switched on and TB1/4 to a nearby "earth" point (car chassis). Note that TB1/4 now carries three external wires.

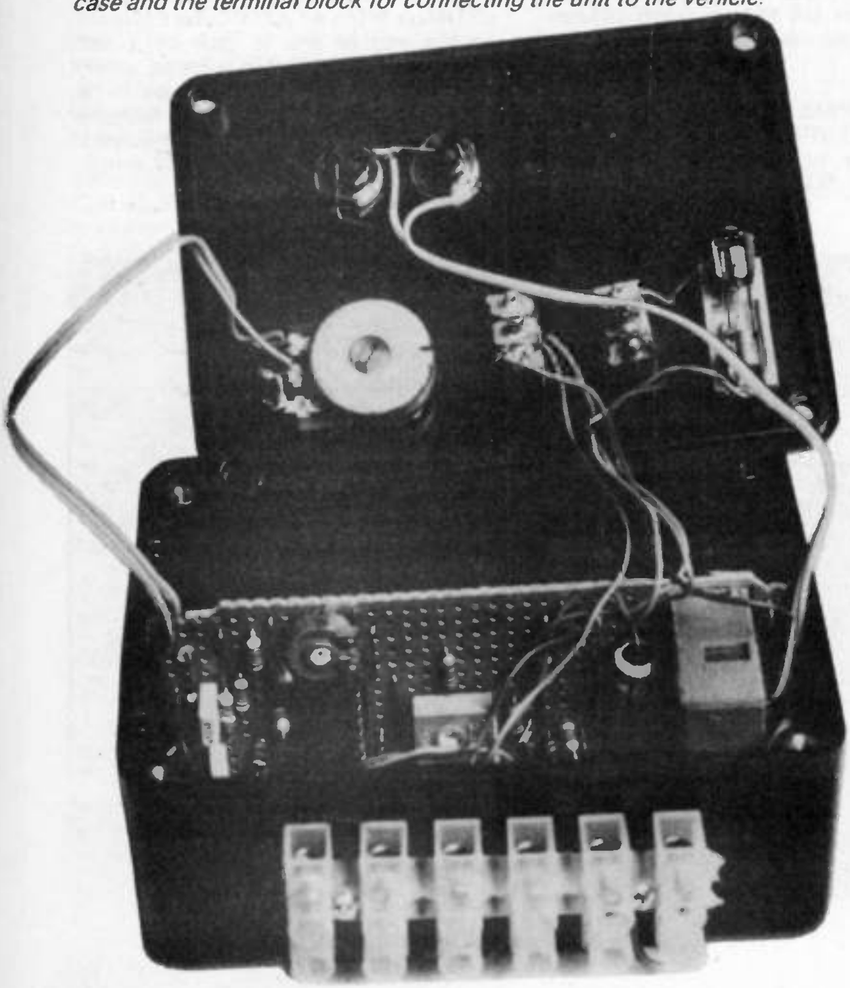
It now remains to adjust VR1, VR2 and VR3 for correct operation. When the lid of the unit is removed for adjustment to VR2 and VR3, *the ignition MUST be switched OFF and only switched ON when the screwdriver has been removed.*

Run the car until the engine is warm enough for the heater to operate and adjust VR2 (WATER TEMP) until the green l.e.d. just goes off. With VR2 adjusted fully clockwise the operating temperature will be 40°C and when fully anti-clockwise, 100°C approximately.

Switch S2 to manual so that the heater fan is heard to operate. Run the car until the air has reached a comfortable temperature and adjust VR1 until the red l.e.d. just goes off. Switch S2 to automatic, the fan motor should continue to operate. Note that it is normal for the l.e.d.s to dim slightly when they are both on, this is a consequence of them both sharing the same current-limiting resistors, R12 and R13.

The thermostat should now operate correctly and it only remains to mount the unit securely on the dashboard. Over a trial period, preset VR3 may be adjusted to increase or reduce the backlash in the air temperature control, anti-clockwise rotation will increase the separation of the on and off temperatures. When fully clockwise this will be approximately 1°C. A scale may be made for VR1 control calibrated in °C but this was not thought worthwhile in the prototype unit. □

The completed unit, with lid removed, showing the circuit board slotted into the case and the terminal block for connecting the unit to the vehicle.



ROBOT ROUNDUP

Nigel Clark

THIS year's annual round-up of what is available in the educational robot market shows a number of changes on this time last year. Every effort is made to ensure that the information is accurate but the prices (quoted ex-VAT) are approximate and most companies offer discounts for education so it is best to check with suppliers for exact prices.

ARMS

Alpha II **(UMI)** 5-axis plus variety of grippers, stepper motor drive with steel cable transmission, lift 1.36kg, reach 467mm. Control by on-board processor using teach pendant or computer through RS232 port. £10,800

Armdroid HS 1B **(Hasfield Systems)** 5-axis gripper, bi-polar stepper motor drive with steel-reinforced belt transmission. Lift 1kg, reach 480mm. Control by BBCs, Commodores, IBM and Nimbus. £1,500

Atlas II **(LJ Technical Systems)** 5-axis plus gripper, stepper driven with toothed belts. Lift 1kg. On-board micro and teach pendant for stand-alone systems. Wide range of operating software. Controllable from BBC and IBM-compatible machines. Work cell available. Arm costs £3,000, IBM Interface £350.

Beasty Plus **(Commotion)** 3-axis plus gripper, servo-driven, lift 75gms. Supplied in kit with instructions on how to build four different configurations and comprehensive user guide. Kit costs £120, Interface £35 extra.

Cyber 310 **(Computer Voice)** 5-axis plus gripper, stepper driven with belt and cable transmission. Lift 250gms. Software for all usual micros and has work cell. Robot £700.

EMU **(LJ Technical Systems)** 4-axis plus gripper, servo-driven with direct mechanical linkages, lift 100gms, software for BBC and LJ's Emma. £350, work cell extra.

Gamma **(Hasfield Systems)** 5-axis plus gripper, stepper motor drive with toothed belt transmission. Lift 1kg, reach 560mm. Pneumatic gripper optional. £10,000.

HRA 934 **(Feedback Instruments)** 5-axis plus gripper, hydraulically-powered (oil). Lift 2.5kgs. On-board processor and can be controlled by BBC, Apple, C64. Made only to order. Price on quotation in region of £3,300.

MA 2000 **(TQ Intl)** 6-axis plus gripper, servo-driven with toothed belt transmission, pneumatic gripper. Lift 1kg. Software for BBC, IBM and Open University's Hektor, was developed for Open University courses.

Gripper is fitted to take pneumatic tools and wired for sensors. Can be linked with MA 3000. Sells at £5,500 for export including basic software, discounts available for UK.

MA 3000 **(TecQuipment)** 5-axis arm plus gripper. Larger but simpler version of MA 2000. Can be linked with MA 2000 as part of system. £11,400.

Mentor **(Cybernetic Applications)** 5-axis plus gripper. Servo-driven can lift 1kg. Can be controlled by small-scale model simulator. Software for BBC, IBM and Apple. Can be networked with up to three other Cybernetic machines and work cell. £1,030.

Naiad **(Cybernetic Applications)** 5-axis plus gripper, lift 500gms, powered by water hydraulics. All axes driven by different kinds of hydraulic piston, all cylinders made of see-through plastic. Gripper can be powered by hydraulic system or pneumatic piston for which compressed air supply provided at extra cost.

As with Mentor it can be controlled by simulator and networked with up to three other Cybernetic machines and work cell. Software for BBC, IBM and Apple. £1,800.

Neptune I **(Cybernetic Applications)** 5-axis arm plus gripper. Electro-hydraulically powered (water). Lift 2.5kgs. Software for BBC, IBM and Apple and on-board processor. As with Mentor can be controlled by simulator and networked with up to three other Cybernetic machines and work cell. £4,280.

Neptune II **(Cybernetic Applications)** 6-axis plus gripper. Rest of specifications same as for Neptune I with addition that it can be controlled by touch sensors on all axes. £5,600.

TeachMover **(UMI)** 5-axis plus gripper, stepper motor drive with steel cable transmission. Lift 454gm, reach 444mm. On-board processor with teach pendant. £2,650.

SCARA ARMS

IVAX 901 **(Feedback Instruments)** 4-axis plus pneumatic gripper, servo-driven, lift 500gms, software for on-board processor, IBM, BBC and Apple. Work cell available. £3,950.

PW801 **(Feedback Instruments)** 4-axis plus gripper, servos on all axes except end rotation which has a stepper motor. Lift 2kgs. Software for IBM and Apricot. Work cell available, interchangeable gripper jaws. Only made specially to order £8,000 with IBM pack £350.

RTX **(UMI)** 6-axis plus gripper, servo-driven, lift 4kgs, software for IBM. £8,200.

RT 100 **(UMI)** More robust version of RTX, intended for light industry £9,800.

Serpent I **(Cybernetic Applications)** 4-axis plus gripper, servo-driven with pneumatic power for vertical movement of gripper, height of arm set manually, software for BBC, IBM and Apple. Can be networked with up to three other Cybernetic machines and work cell. £2,865.

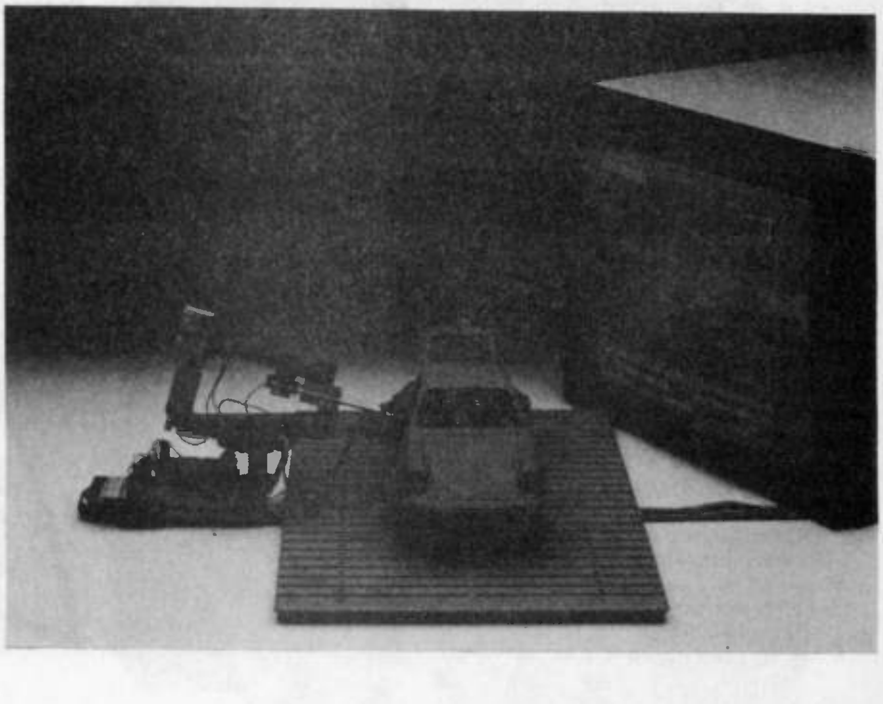
Serpent II **(Cybernetic Applications)** Same as Serpent I except that it has a longer reach. £2,900.

OTHERS

Kestrel **(Cybernetic Applications)** Gantry supported arm with 4 axes plus gripper, stepper driven, works in *x*, *y* and *z* co-ordinates, lift 2kgs, vacuum or two-fingered pneumatic gripper. Software for IBM can network with up to three other Cybernetic machines and work cell. £4,550.

PERCI **(Proops Distributors)** Simple arm controlled by microswitches and relays. Runs a routine using a magnet on the end of arm to pick up a ball bearing and placing it in a chute, down which it rolls to its initial position to be picked up again. Developed by Reading University's Department of Cybernetics to show what can be done with simple technology. In kit £60.

Fischertechnik spot welder simulation.



Petra (**LJ Technical systems**) pneumatic/electronic training systems: collection of conveyors, pick and place arm with pneumatic gripper component dispensor and sensors. Intended as introduction to hybrid electronic/pneumatic devices. £2,800.

MOBILES

Jessop Turtle (**Jessop Microelectronics**) also known as the Edinburgh Turtle, it looks like an upturned mixing bowl, one of the earliest turtles controlled by a version of Logo. Powered by servos with optical encoders, includes pen.

Linked to computer by umbilical cord. Software for BBC, Apple, RML Nimbus and IBM. Developed 'Turtle Trails'. £200, Turtle Trails £20.

Lego Buggy (**Lego and Resource**) Two-wheeled servo-driven, built from Lego kit with Resource control board attached. Maze following, detecting obstacles, speed control and bar code reading can be done. Software in Buggy Basic. Control and Control IT. Kit and board £80, board £50.

PIP (**Swallow Systems**) Battery-powered stand-alone mobile uses Logo-like language. Two-wheeled driven by stepper motors.

Can store 39 program steps which can be extended by REPEAT function. Plays simple music. BBC and Nimbus leads for saving and downloading programs. Can be "dressed up", pencil holder included. £170.

Roamer (**Valiant Technology**) Two-wheeled, servo-driven stand-alone mobile, uses Logo-like language with instructions entered by a keypad on top of the Smartie-shaped machine. Pen holder. Appearances can be customized with kits, control box supplied extra. £70.

Trekker (**Clwyd Technics**) Two-wheeled servo-driven with pen, remote controlled via infra-red link, designed to resemble a turtle. Uses version of Logo and software for BBC, Apple and IBM. Microworlds being created in which it can be used. £260.

CONTROLLERS

Ezi-Dunn Controller (**Commotion**) One input and six outputs which can control up to three motors with simple on-off and reverse switches. L.E.D.S. on all channels. No memory.

SEQ (**ProCom**) Battery-powered with power supply alternative. Logo-like instructions entered by keypad, up to 40 instructions can be stored. All outputs and inputs have indicators. £90, power supply extra.

KITS

There are many types of modelling materials from which robotic devices can be built, for example Mecccano and Plawcotech and even old cardboard boxes but most need the addition of electronic parts to allow them to be controlled. The manufacturers mentioned here all supply kits with their own controllers designed for robotic projects.

The most well known are **Lego** with its lego Technic series and **Fischertechnik**. Lego provides a variety of kits covering a range of complexity. Control can be provided by a simple hand held controller with no memory as well as computer control from a BBC.

It has also developed kits for all levels of schooling complete with teacher packs and worksheets. The models which can be built include arms, an x-y plotter and a buggy.

Fischertechnik was one of the first to develop kits for computer-controlled models. Including collections developed on behalf of **Economatics**, its main UK distributor, it offers a large range with some special kits to be used for the teaching of the "Craft and Design Technology National Curriculum".

There is also Nimbus and BBC software for the designing of control systems on screen. The kits include d.c. motors, potentiometers and switches to make a number of devices including arms, a buggy and an ingenious simulation of a spot welder.

Testbed Technology is a new name which provides a similar array of components and a BBC Interface in its Polymek range. Course materials have been developed with pupil texts and teacher guides. The models can be controlled using Control Logo, Control IT as well as Testbed's own Micro Control Language, available on ROM chip for the BBC.

Stevenage Adventure Workpacks offers collections of motors, gears and switches along with plans for building devices and a circuit diagram for a BBC Interface, The kits are intended as introductions to control technology.

Ezi-Dunn (**Commotion**) has a basic kit of electronic and mechanical components and a special board which allows components to be connected without soldering.

ADDRESSES

Clwyd Technics, Antelope Industrial Estate, Rhydynwyn, near Mold, Clwyd.

Commotion, Redbourn House, Stockingswater Lane, Enfield EN3 7TD.

Computer Voice, Cherry Trees, Milwich, Stafford ST18 0EG.

Cybernetic Applications, West Portway Industrial Estate, Andover, Hampshire S10 3LF.

Economatics, Epic House, Darnall Road, Attercliffe, Sheffield S9 5AA.

Ezi-Dunn, 56 Malvern Drive, Hilltops, Stoney Stratford, Milton Keynes, MK11 2AE.

Feedback Instruments, Park Road, Crowborough, East Sussex TN6 2QR.

Hasfield Systems, The Old Rectory Stables, Hasfield, Gloucester GL19 4LG.

Jessop Microelectronics, Unit 6A, 3 Long Steet, London E2 8HJ.

LJ Technical Systems, Francis Way, Bowthorpe Industrial Estate, Norwich.

ProCom, 5 Churchill Road, Tavistock, Devon PL19 9BU.

Proops Distributors, Heybridge Estate, Castle Road, London NW1 8TD.

Resource, Exeter Road, off Coventry Grove, Doncaster DN2 4PY.

Stevenage Adventure Workpack, 29 Lytton Fields, Knebworth, Herts SG3 6BA.

Swallow Systems, 32 High Street, High Wycombe HP11 2AQ.

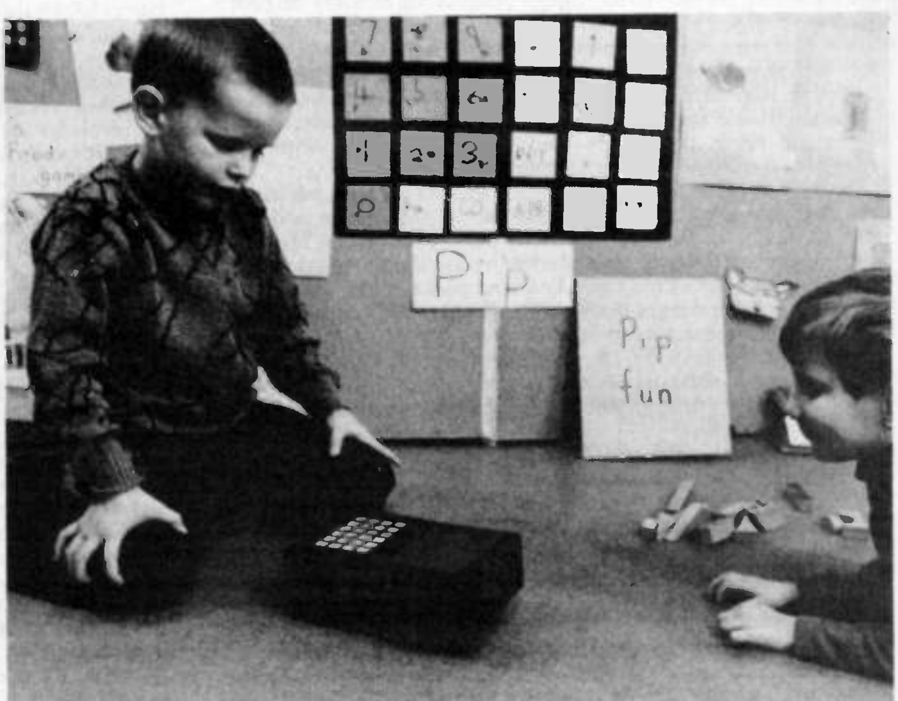
Testbed Technology, The Science Park, Hutton Street, Blackburn BB1 3BY.

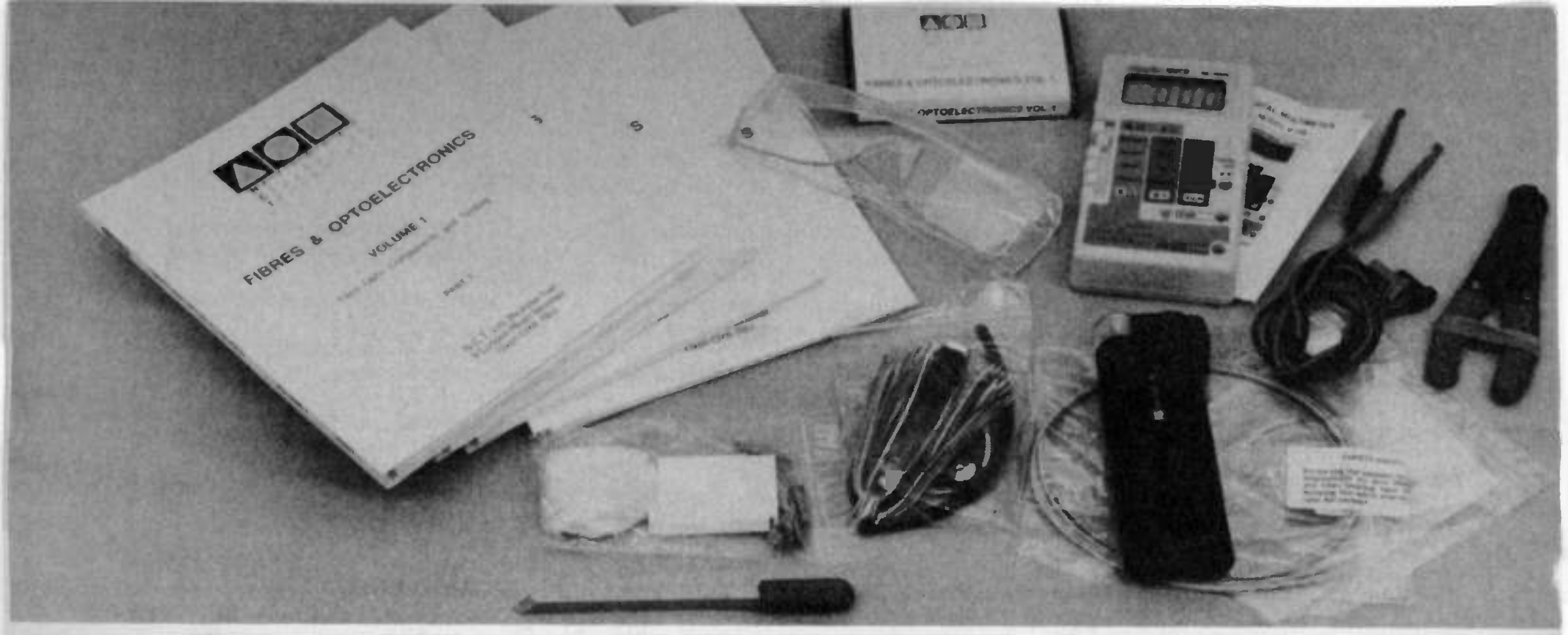
TQ International, Bonsall Street, Long Eaton, Nottingham NG10 2AN.

UMI, UMI House, 9-16 St James Road, Surbiton, Surrey.

Valiant Technology, **Gulf House, 370 York Road, Wandsworth, London SW18 1SP.**

PIP from Swallow Systems in action.





FIBRES AND OPTOELECTRONICS

REVIEWED BY Mike Tooley B.A.

SOME time ago, I was lucky enough to be asked to review two Open Learning packages published by the National College of Technology (NCT Ltd). These packages (entitled *Digital Electronics – Volume I* and *Electronic Circuits – Volume I*) proved both to be of excellent quality and thus I was very pleased to be asked to take a look at another package from the same stable. This latest offering is entitled *Fibres and Optoelectronics – Volume 1*.

Like its predecessors, *Fibres and Opteolectronics* aims to provide students with approximately 45 hours of study. The learning process is again based upon a number of student centred practical assignments. The approach adopted by NCT is ideal for those who may prefer to learn from "hands on" experience. For those (like me) who may have left the classroom behind many years ago, this is a most effective method of learning. It places particular emphasis on real-world practical applications and can be put to use wherever and whenever necessary.

Open Learning

For those who may be new to the concept of Open Learning, the aim is simply to provide an independent student with sufficient learning support to complete a programme of study without having to attend a conventional instructional class. With today's acute shortages of skilled personnel in most areas of technology, this technique is becoming increasingly important as a means of updating engineers and technicians in several specialist areas. Typical of these specialisms is optoelectronic transmission where fibres are being increasingly used to replace the conventional coaxial and multi-core cables of yesteryear.

As with any Open Learning venture, success depends primarily on two factors; commitment on the part of the student and the overall quality of the Open Learning package. The first of these is a matter for the individual student whilst the second depends upon the provider of the Open Learning package and, more particularly, on the extent of the back-up offered to the student. In this respect, NCT courses score very highly as they are not only well thought out but they are very well presented and fully supported with tutorial assistance, assessment and certification. The NCT tutorial support (via a telephone "hotline") is available at a small additional charge.

In order that students can check their understanding, the course contains three "open-book" assessments which students can use to check their progress. For those who wish to gain a recognised qualification, students who successfully complete the programme (including assessments and workbook assignments) are eligible for the award of a Business and Technical Education Council (BTEC) Certificate of Achievement.

Since Open Learning courses require a good deal of self-discipline on the part of the student, a regular study plan makes a good starting point. To emphasise this point, Sylvia Merrett (one of the two audio tutors) advises that: "Your very first task is to sit down and work out your weekly timetable."

Course content

Fibres and Optoelectronics – provides a comprehensive introduction to electronic circuits and assumes no previous knowledge of the subject on the part of the student. The course is pitched at about BEC Level II/City and Guilds part 2 levels and covers the following topics; electromagnetic spectrum, wavelength/frequency relationship, transmission windows, safety with fibre, fibre handling, primary buffer, cladding and core details, PCS fibre, AS fibre, HCS fibre, TIR, refraction and reflection, refractive index, critical angles, Snell's law, numerical aperture, acceptance angle, use of stripping tool, use of microscope, stepped index multimode fibre, stepped index single mode fibre, graded index fibre, transmission delay times, working with 50/125µm fibre, working with 200pcs fibre, working with 1mm fibre, stripping, connector fitting, use of epoxy, cable assembly, lapping and polishing, cable design, inspection of fibre samples, loose buffered cable, tight buffered cable, twin zip cable, manufacturers' specifications, a photodiode, irradiation, losses in fibres, connector losses, microbending losses, and practical tests on fibres.

As with other NCT programmes, *Fibres and Optoelectronics* moves backwards and forwards between the workbooks and audio cassette and this provides some useful variety in the study programme. Self-test questions are provided within the workbooks and students are encouraged to attempt these before referring to the answers provided. Such questions are designed so that students can evaluate their own progress through the course and assess their comprehension of each of the major topics.

It should, perhaps, be mentioned that the course contains some mathematics. This, however, is dealt with sympathetically such that the feint hearted need not worry. Formulae are only used when they are essential to understanding. As an example, the student gets to grips with some basic trigonometry in Part 1 as Snell's Law is introduced. Part 2, logarithms are used when decibels first appear.

Learning kit

The package supplied with the *Fibres and Optoelectronics* course comprises three spiral-bound workbooks, a spiral bound book containing solutions to the self test questions (STQ's) and student centred assignments (SCA's), a prototype breadboard, a pack of links and components, a sealed bag containing optical fibre, lapping and polishing equipment, safety glasses, an illuminated microscope, a cleaving tool and cable strippers, a digital multimeter, and an audio cassette. The only additional items required are a 9V PP9 battery, a light source (torch or Anglepoise lamp), a small quantity of epoxy resin based adhesive, and an audio cassette recorder.

Several of the items supplied within the *Fibres and Optoelectronics* package (notably the multimeter and microscope) should be regarded as something of an investment since they will undoubtedly be useful when the course has been completed. An optional video which illustrates some of the visual concept of optical transmission is also available for free short-term loan to students who have registered for the NCT tutor service.

As the *Fibres and Optoelectronics* course progresses, students are involved with making measurements on a number of simple electronic circuits. There is no better way of doing this than with a modern digital multimeter and NCT provide such an instrument as part of the package. The meter employs a 3½ digit l.c.d. display and offers d.c. voltage, d.c. current, a.c. voltage, and resistance ranges. Accuracy on the d.c. ranges is ±0.5% with a maximum resolution of 1mV and 1μA on the d.c. voltage and current ranges respectively. The multimeter will undoubtedly prove to be extremely useful to students long after successful completion of the NCT study programme!

Workbooks

The three workbooks incorporate text regularly interspersed with details of the student-centred assignments. Each workbook should be regarded more as a personal reference of progress through the course rather than as a conventional textbook. Furthermore, since the course is highly structured, the workbooks should be followed in exact sequence. Each workbook contains between 83 and 101 pages and the workbook for Part 3 contains an index of topic references for all three parts of the course.

The standard of the workbooks is generally good, with "chatty" text and neatly presented computer-generated diagrams. The division of the course into three separate modules (each with its own text) is both logical and helps to make the material a little more manageable than if it had all been presented in one book.

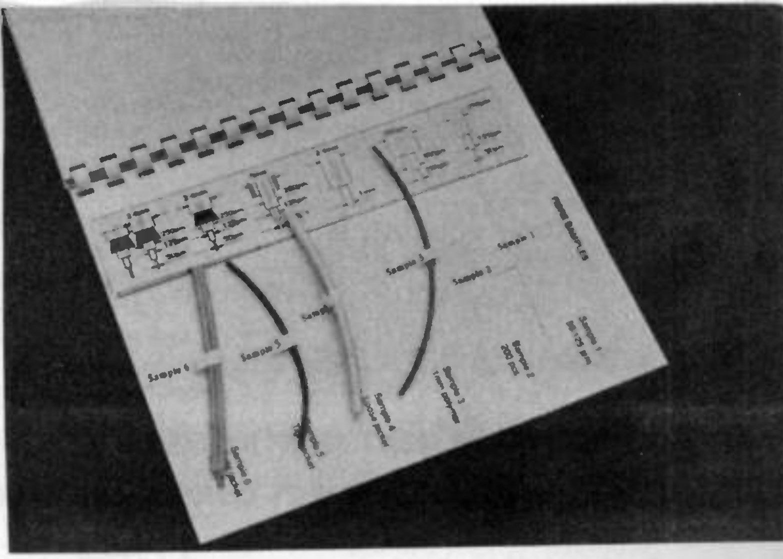
The satisfactory completion of each of the workbooks represents a goal in its own right. Students can, therefore, build on their successes and steadily gain in confidence as they progress through the *Fibres and Optoelectronics* course.

The numerous "student centred assignments" present students with a series of tasks to carry out. Representative tasks include measuring the forward and reverse resistance of several light emitting diodes, constructing a CMOS astable oscillator which drives a pair of light emitting diodes, cutting and stripping optical fibres, transmitting the signal produced by the astable oscillator via a fibre, cleaving and inspecting fibres, fitting connectors, investigating lapping and polishing techniques. The final assignment (Assignment 17) should provide readers with some idea of the practical skills which are developed within the course. Students are informed that:

This assignment should take you about 6 hours to complete and you should then be able to:

1. Determine from test the numerical aperture (NA) of a fibre.
2. Observe losses due to connectors.
3. Record the effect of microbending.
4. Test and plot the results of linear coupling displacement, separation loss.
5. Test and record the effect due to losses due to angular displacements.
6. Test and plot the transmission losses due to lateral displacement.

For those who may run into difficulties, each student centred assignment is supplied with a solution which is described in a separate booklet. Students are thus not left completely in the dark when things don't work out as planned!



A range of fibre samples is attached to the inside back cover of one of the workbooks.

Cost

Fibres and Optoelectronics – Volume 1 is priced at £199 (excluding VAT). Two levels of tutorial support are offered and both require a supplementary fee. In order to gain an NCT Certificate, students have to pay a further £17.50 whilst support to gain a BTEC Certificate of Achievement (including BTEC Registration) is priced at an additional £32 (both excluding VAT).

If the initial cost of the package is beyond your budget, many company training departments and Further Education Colleges are investing in Open Learning and it would be well worth contacting your Training Officer or the Open Learning Co-ordinator of your local college to see whether this package is available, or if it will soon be available.

In conclusion

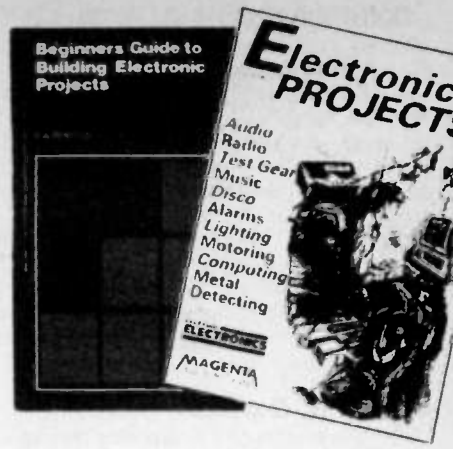
Fibres and Optoelectronics meets a very definite need. Anyone wishing to get to grips with this new area of technology should find this package extremely useful. The course is both well structured and well supported and exemplifies the best of today's Open Learning offerings.

Having taught the principles of fibre optics to groups of electronics and computing students over the past five years, I feel that NCT have produced a most worthwhile package which completely de-mystifies a subject which is often felt to be rather "difficult". The package is comprehensive and very professionally presented, and ideally suited to those with no previous knowledge of the subject.

NCT Ltd are at Bicester Hall, 5 London Road, Bicester, Oxon OX6 7BU. Telephone: (0296) 613067.

DIRECT BOOK SERVICE

The books listed have been selected as being of special interest to everyone involved in electronics and computing. They are supplied by mail order direct to your door. Full details are given on the last book page.
For another selection of books see next month's issue.



MORE BOOKS NEXT MONTH — MORE BOOKS NEXT MONTH

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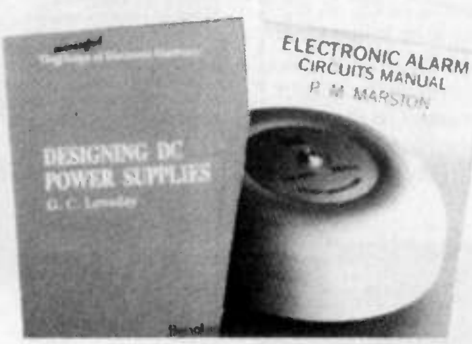

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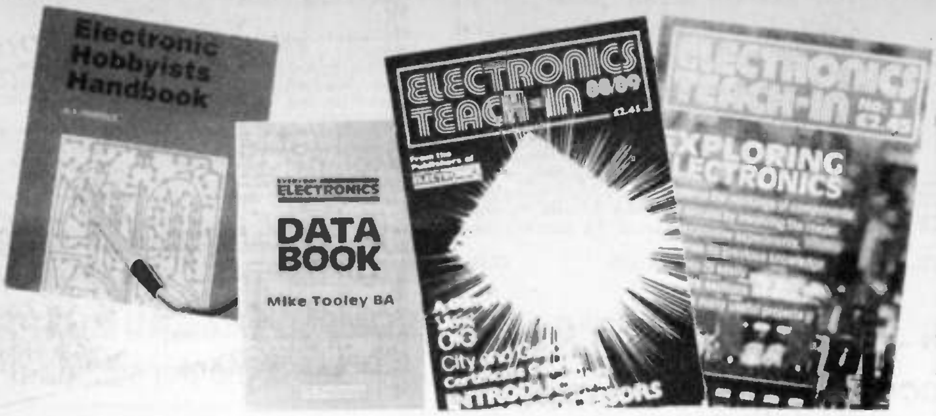

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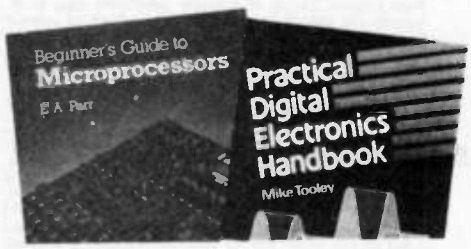

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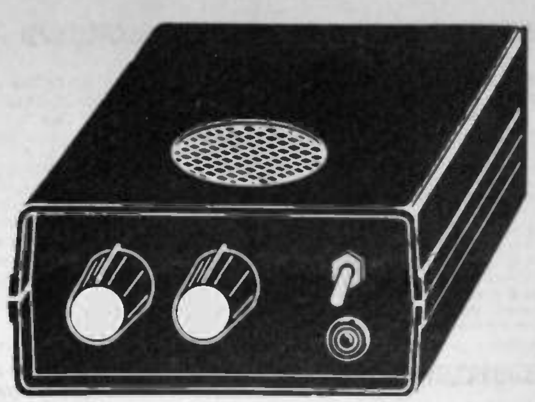
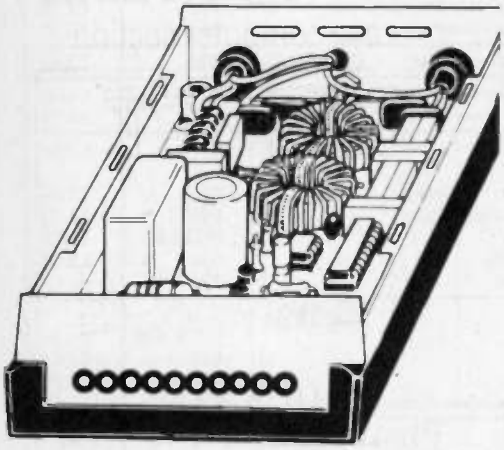


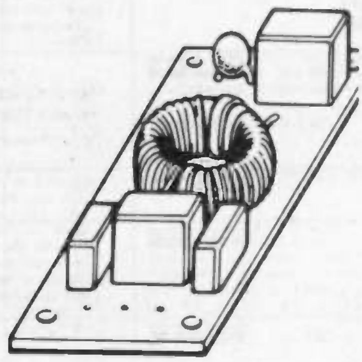


◁ POWER CONDITIONER

You don't have to be a hi-fi nut to notice the huge improvement in sound quality when you run your music system from a clean mains supply. How do you describe the difference? It's as if all this time your favourite artists have been playing and singing inside a wardrobe . . . and someone just opened the door and let them out. You could spend twenty times as much on special cables, plugs, mats and stuff without achieving a tenth of the difference. But don't take my word for it. Try it for yourself.

The sophisticated circuitry of the Power Conditioner begins with a bank of six VDRs to eliminate impulsive spikes. Then comes a massive filter with thirteen capacitors and two current-balanced inductors to smooth away every trace of noise and interference. A ten LED logarithmic display flicks up and down as each spike is eliminated, and gives a second by second account of the interference removed. Maximum load 1.5kW.

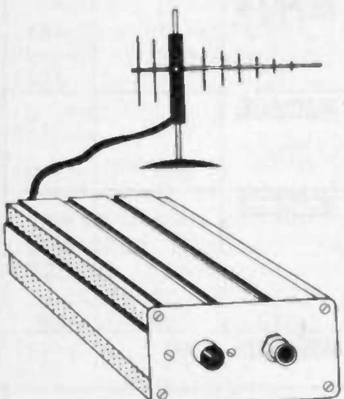
POWER CONDITIONER PARTS SET **£34.27**



MAINS CONDITIONER ▷

A general purpose workhorse for cleaning up the mains supply to computers, hi-fi, television sets, and any other electronic equipment that might be disturbed by mains interference. The solid, no-nonsense circuit will handle loads up to 1kW, and the PCB can be built into the equipment to be protected or housed in the optional case.

MAINS CONDITIONER PARTS SET (no case) **£6.21**
RUGGED CASE (optional) **£2.07**



◁ AERIAL BOOSTER

Good TV pictures from an indoor aerial, from a caravan aerial, or in areas of poor reception. This booster ranks with the very best, giving wideband operation from 10MHz to 1.4GHz (it will boost FM radio signals too), mid-band gain of up to 26dB, and a wide supply voltage range of 9V to 26V. It will run from car batteries for caravanners, dry batteries for campers, or a battery eliminator for use in the home.

There are two parts sets for the project. AA1 gives you the PCB, hybrid amplifier, components and instructions. AA2 is the optional case set: rugged screened box, front and rear panels, waterproofing gaskets, feet, sockets and hardware.

AA1 PARTS SET **£14.72** AA2 PARTS SET **£5.52**

KNIGHT RAIDER ▷

The ultimate lighting effect for your car. Picture this: eight powerful lights in line along the front and eight along the rear. You flick a switch on the dashboard control box and a point of light moves lazily from left to right leaving a comet's tail behind it. Flip another switch and the point becomes a bar, bouncing backwards and forwards along the row. Now try one of the other six patterns. An LED display on the console lets you see what the main lights are doing.

The Knight Raider parts set contains the case and all components for the control box. The pattern generator and lamp driver is supplied as a PCB with all components for you to mount anywhere convenient. We supply the electronics, you supply the lamps (from any car accessories shop).

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PCB SERVICE

Printed circuit boards for certain constructional projects are available from the PCB Service, see list. These are fabricated in glass fibre, and are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £1 per board for overseas airmail. Remittances should be sent to The **PCB Service, *Everyday Electronics*, 6 Church Street, Wimborne, Dorset BH21 1JH.** Cheques should be crossed and made payable to *Everyday Electronics* **(Payment in £ sterling only).**

Boards for some older projects – not listed here – can often be obtained from Magenta Electronics, 135 Hunter St., Burton-on-Trent, Staffs DE14 2ST. Tel: 0283 65435 or Lake Electronics, 7 Middleton Close, Nuthall, Nottingham NG16 1BX. Tel: 0602 382509.

NOTE: While 90% of our boards are now held in stock and are dispatched within seven days of receipt of order, please allow a maximum of 28 days for delivery – overseas readers allow extra if ordered by surface mail. Please check price and availability in the latest issue before ordering. We can only supply boards listed in the latest issue. Boards can only be supplied on a payment with order basis.

PROJECT TITLE		Order Code	Cost
Noise Gate	SEP'87	577	£4.41
Transtest	OCT'87	580	£3.32
BBC Sideways RAM/ROM	NOV'87	585	£4.10
Stereo Noise Gate	APR'88	597	£6.65
Pipe & Cable Locator		598	£3.00
Inductive Proximity Detector		574	£3.00
Multi-Channel Remote Light Dim	MAY'88		
Transmitter		599	£3.00
Receiver		600	£3.07
Door Sentinel		605	£3.00
Multi-Chan Remote Light Dim	JUN'88		
Relay/Decoder		601	£4.86
Dimmer Board		602	£3.07
Power Supply		603	£3.00
Headlight Reminder		611	£3.00
Video Wiper	JUL'88	612	£6.75
Isolink		613	£4.21
Tea Tune	AUG'88	609	£3.00
Time Switch		614	£4.84
Suntan Timer		610	£3.07
Car Alarm		615	£3.12
Breaking Glass Alarm	SEP'88	617	£4.27
Amstrad PIO		618	£6.77
EPROM Eraser	OCT'88	620	£4.07
Doorbell Delay	NOV'88	616	£3.56
Micro Alarm		621	£3.12
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Display		624	£3.05
Seashell Sea Synthesiser		625	£4.84
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Display Board		627	£3.00
Downbeat Metronome		629	£4.84
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Phasor		631	£5.64
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Light Sentinel	APR'89		
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4-Channel Auto-Fade Interface		642	£6.80
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Electron A/D Interface		645	£4.84
Spectrum EPROM Programmer	JUN'89	628	£7.87
Bat Detector		647	£4.95
Programmable Pocket Timer	JUL'89	648	£3.82
Electronic Spirit Level	AUG'89	649	£3.85
Distance Recorder		651	£5.23
Treasure Hunter		652	£3.73

PROJECT TITLE		Order Code	Cost
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Probe Pocket Treasure Finder		653	£4.12
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Variable Voltage		655	£4.48
Music on Hold	OCT'89	646	£3.85
Power Supplies – 25V 700mA		656	£4.35
30V 1A		657	£4.55
EE Seismograph – Control		658	£4.08
Detector		659	£4.22
Lego/Logo & Spectrum		660	£6.49
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Processor		662	£4.56
Power Supplies – 1.5V-25V 2A		663	£4.78
Logo/Lego & Spectrum Interface		664	£5.60
EEG Electrode Impedance Meter	DEC'89	665	£3.98
Biofeedback Signal Generator	JAN'90	666	£4.08
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Quick Cap Tester	FEB'90	668	£3.92
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Hand Tally	SEP'90		
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Display		699, 700	£10.95
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Mains Appliance Remote Control			
Temperature Controller (p.c.b. only)		702	£5.20
Ghost Waker	Oct'90	703	£4.32
Frequency Meter		704	£5.25

Please note it is important to give project title as well as order code.

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