EVERYDAY ELECTRONICS and computer PROJECTS

JANUARY 1984 90p

GUARD AGAINST GAS & SMOKE HOME HAZARDS

CENTRAL HEATING PUMP DELAY UNIT

TEMPERATURE MEASUREMENT AND CONTROL SYSTEM FOR ZX COMPUTERS

GAMES SCOREBOARD • GUITAR TUNER

Australia $1.50 New Zealand $1.75 Malaysia $4.95 IR £1.38 (inc V.A.T.)

electronize

AUTO-ELECTRONIC PRODUCTS

KITS OR READY BUILT

TOTAL ENERGY DISCHARGE ELECTRONIC IGNITION

IS YOUR CAR AS GOOD AS IT COULD BE ?

THE BEST WINTER STARTER

★ Is it **EASY TO START** in the cold and the damp? Total Energy Discharge will give the most powerful spark and maintain full output even with a near flat battery.

★ Is it **ECONOMICAL** or does it "go off" between services as the ignition performance deteriorates? Total Energy Discharge gives much more output and maintains it from service to service.

★ Has it **PEAK PERFORMANCE** or is it flat at high and low revs. where the ignition output is marginal? Total Energy Discharge gives a more powerful spark from idle to the engines maximum (even with 8 cylinders).

★ Is the **PERFORMANCE SMOOTH**. The more powerful spark of Total Energy Discharge eliminates the "near misfires" whilst an electronic filter smoothes out the effects of contact bounce etc.

★ Do the **PLUGS and POINTS** always need changing to bring the engine back to its best? Total Energy Discharge eliminates contact arcing and erosion by removing the heavy electrical load. The timing stays "spot on" and the contact condition doesn't affect the performance either. Larger plug gaps can be used, even wet or badly fouled plugs can be fired with this system.

★ **TOTAL ENERGY DISCHARGE** is a unique system and the most powerful on the market - 3½ times the power of inductive systems - 3½ times the energy and 3 times the duration of ordinary capacitive systems. These are the facts.

Performance at only 6 volts (max. supply 15 volts)

SPARK POWER	— 140W,	SPARK ENERGY	— 36mJ
SPARK DURATION	— 500μS,	STORED ENERGY	— 135mJ

LOADED OUTPUT VOLTAGE
50pF load — 38kV, 50pF + 500k — 26kV

We challenge any manufacturer to publish better performance figures. Before you buy any other make, ask for the facts, its probably only an inductive system. But if an inductive system is what you really want, we'll still give you a good deal.

★ **All ELECTRONIZE electronic ignitions feature: EASY FITTING, STANDARD/ELECTRONIC CHANGEOVER SWITCH, STATIC TIMING LIGHT and DESIGNED IN RELIABILITY (14 years experience and a 3 year guarantee).**

★ **IN KIT FORM** it provides a top performance system at less than half the price of comparable ready built units. The kit includes: pre-drilled fibreglass PCB, pre-wound and varnished ferrite transformer, high quality 2uF discharge capacitor, case, easy to follow instructions, solder and everything needed to build and fit to your car. All you need is a soldering iron and a few basic tools.

Most **NEW CARS** already have electronic ignition. Update **YOUR CAR**

ELECTRONIZE ELECTRONIC CAR ALARM

HOW SAFE IS YOUR CAR ?

PROTECT YOUR CAR

More and more cars are stolen each week and even a steering lock seems little help. But a car thief will avoid a car that will cause him trouble and attract attention. If your car has a good alarm system - well there are plenty of other cars to choose from.

LOOK AT THE PROTECTION AN ELECTRONIZE ALARM CAN GIVE :

★ **MINIATURE KEY PLUG** A miniature jack plug attaches to your key ring and is coded to your particular alarm.

★ **2025 INDIVIDUAL COMBINATIONS** The key plug contains two 1% tolerance resistors, both must be the correct value and together give 2025 different combinations.

★ **ATTRACTS MAXIMUM ATTENTION** This alarm system not only intermittently sounds the horn, but also flashes the headlight and prevents the engine being started.

★ **60 SECOND ALARM PERIOD** Once triggered the alarm will sound for 60 seconds, unless cancelled by the key plug, before resetting ready to be triggered again

★ **30 SECOND EXIT DELAY** The system is armed by pressing a small button on a dashboard mounted control panel. This starts a 30 second delay period during which the owner can open and close doors without triggering the alarm.

★ **10 SECOND ENTRY DELAY** When a door is opened a 10 second delay operates to allow the owner to disarm the system with the coded key plug. Latching circuits are used and once triggered the alarm can only be cancelled by the key plug.

★ **L.E.D. FUNCTION INDICATOR** An LED is included in the dashboard unit and indicates the systems operating state. The LED lights continuously to show the system is armed and in the exit delay condition. A flashing LED indicates that the alarm has been triggered and is in the entry delay condition.

★ **ACCESSORY LOOP - BONNET/BOOT SWITCH - IGNITION TRIGGER** These operate three separate circuits and will trigger the alarm immediately, regardless of entry and exit delays.

★ **SAFETY INTERLOCK** The system cannot be armed by accident when the engine is running and the car is in motion.

★ **LOW SUPPLY CURRENT** CMOS IC's and low power operational amplifiers achieve a normal operating current of only 2.5 mA.

★ **IN KIT FORM** It provides a high level of protection at a really low cost. The kit includes everything needed, the case, fibreglass PCB, random selection resistors to set the code and full set of components etc. In fact everything down to the last washer plus easy to follow instructions.

fill in the coupon and send to: ☐ Please send more information

ELECTRONIZE DESIGN Dept C · Magnus Rd · Wilnecote · Tamworth · B77 5BY · tel 0827 281000

LOW MAIL ORDER PRICES

TOTAL ENERGY DISCHARGE (6 or 12 volt negative earth)

☐ Assembled ready to fit ~~£20.70~~ £16.95
☐ D.I.Y. parts kit ~~£16.50~~ £14.85

TWIN OUTPUT for cars and motorcycles with dual ignition

☐ Twin, Assembled ready to fit ~~£36.45~~ £29.95
☐ Twin, D.I.Y. parts kit ~~£28.55~~ £22.95

INDUCTIVE DISCHARGE (12 volt only)

☐ Assembled ready to fit ~~£15.95~~ £12.75

Goods normally despatched within 7 days.

Prices Include VAT £1-00 PP(UK) per Unit,

CAR ALARM (12 volt negative earth)

☐ Assembled ready to fit (All wires and connectors incl.) ~~£37.95~~ £29.95
☐ D.I.Y. parts kit ~~£24.95~~ £19.95

I enclose cheque/postal order OR debit my Access/Visa card

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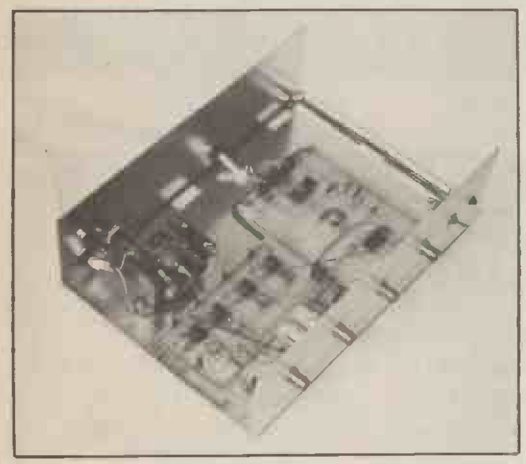
EVERYDAY ELECTRONICS and computer PROJECTS

VOL. 13 NO. 1 JANUARY 1984

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



SEASONAL GREETINGS TO ALL OUR READERS

PROJECTS

SERIES

FEATURES

Our February 1984 issue will be published on Friday, January 20. See page 39 for details.

TEACH-IN 84

Once again GREENWELD will be supplying a complete set of parts for this ever popular series — as we have done for all previous series.
Our experience in this field means your kit can be supplied from stock at the best possible price, so order with confidence.
Price for complete kit is only **£18.95** inc post and VAT.

MOTORIZED GEARBOX
These units are as used in a computerized tank, and offer the experimenter in robotics the opportunity to buy the electro-mechanical parts required in building remote controlled vehicles. The unit has 2 × 3V motors, linked by a magnetic clutch, thus enabling turning of the vehicle, and a gearbox contained within the black ABS housing, reducing the final drive speed to approx 50rpm. Data is supplied with the unit showing various options on driving the motors etc. **£5.95**. Suitable wheels also available: 3" Dia plastic with black tyre, drilled to push-fit on spindle. 2 for **£1.30** (limited qty). 3" dia aluminium disc 3mm thick, drilled to push-fit on spindle. 2 for **68p**.

TREAT YOURSELF TO A NICE NEW DIGITAL MULTIMETER!!
KD55C A DVN for the professional – this 3½ digit multitester has overload protection, low battery and over range indication. Full auto polarity operation.
AC Volts: 0.2-700
DC Volts: 0.2-1000
AC Current: 200uA-10A
DC Current: 200ua-10A
Resistance: 200R-200M
Total 28 ranges for just **£44.95**

THIS MONTH'S SPECIAL OFFER!!

SEAT BELT ALARM
Originally for sale at £8.95, these well made units 70×50×25mm provide both audible and visual alarms. Uses 2 IC's, PB2720 transducer, etc. Available ready built, with circuit and instructions for just **£4.95**. Also available as a kit, PCB + all components, box, wire, etc, together with instructions. Only **£3.95**.

RIBBON CABLE
Special purchase of multicoloured 14 way ribbon cable – 40p/metre; 50m **£18**; 100m **£32.00**; 250m **£65.00**.

TTL PANELS
Panels with assorted TTL inc LS types. Big variety. 20 chips £1.00; 100 chips **£4.00**; 1000 chips **£30.00**.

"THE SENSIBLE 64"
David Highmores new book on the Commodore 64 now available. **£5.95**.

THE 1984 GREENWELD CATALOGUE

Now in the course of production, the 1984 GREENWELD catalogue will be published in January. It's Bigger, Brighter, Better, more components than ever before. With each copy there's discount vouchers, Bargain List, Wholesale Discount List, Bulk Buyers List, Order Form and Reply Paid Envelope. All for just £1.00! *Order now for early delivery!*

COMPUTER GAMES
Z901 Can you follow the flashing light/pulsating tone sequence of this famous game? Supplied as a fully working PCB with speaker (no case) plus full instructions. Only **£4.95**

Z902 Probably the most popular electronic game on the market – based on the old fashioned pencil and paper battleship game, this computerized version has brought it bang up to date! We supply a ready built PCB containing 76477 sound effect chip, TMS1000 micro-processor chip, R's, C's etc. Offered for its component value only (board may be cracked or chipped, it's only **£1.95**. Instructions and circuit, **30p**.

PACKS! PACKS! PACKS!

K517 Transistor Pack. 50 assorted full spec marked plastic devices PNP NPN RF AF. Type numbers include BC114, 117, 172, 182, 183, 198, 239, 251, 214, 225, 320, BF198, 255, 394, 2N3904 etc etc. Retail cost £7+. Special low price **275p**

K523 Resistor Pack. 1000 – yes, 1000 ¼ and ⅓ watt 5% hi-stab carbon film resistors with pre-formed leads for PCB mounting. Enormous range of preferred values from a few ohms to a several megohms. Only **250p**. 5000 **£10**; 20,000 **£36**.

K520 Switch Pack. 20 different assorted switches – rocker, slide, push, rotary, toggle, micro etc. Amazing value at only **200p**

K522 Copper clad board. All pieces too small for our etching kits. Mostly double sided fibreglass. 250g (approx 110 sq ins) for **200p**

K541 It's back!! Our most popular pack ever – Vero offcuts. This has been restricted for some time, but we have now built up a reasonable stock and can once again offer 100 sq ins of vero copper clad offcuts, average size 4×3". Offered at around ¼ the price of new board **320p**

K530 100 Assorted polyester caps – all new modern components, radial and axial leads. All values from 0.01 to 1uf at voltages from 63 to 1000!! Super value at **395p**

K602 Electrolytics – all long leaded radial type – most values from 10uf to 1000uf, nearly all 10V, few 16V. Bag of 100 assorted **£3.50**

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ALL PRICES INCLUDE VAT; JUST ADD 60p P&P

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1	Electronic Continuity Tester	£6.45
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6	Electronic Metronome	£6.45
7	Sound Flash-Trigger	£12.25
8	B.F.O. Metal Locator	£7.95
9	Sound to Light Unit. Max 750 Watts	£6.95
10	Light Dimmer Module	£4.95
11	Variable Precision-Timer	£9.95
12	Model Train Speed Controller	£5.99
13	Electronic Touch-Switch	£5.99
14	3 Watts FM Transmitter. 85 to 115MHz	£9.95
15	250 MW FM Transmitter. 100 to 106MHz	£7.95
18	Deter Joyriders. Engine Fault Simulator Kit	£4.50
19	General Purpose Alarm. Seat Belt Reminder etc. Kit	£2.25
20	Car Radio Aerial Booster FM/MW. Built and Tested.	£4.95
21	Get ready for Winter. Ice Warning Alarm Kit	£3.95
22	Rear Window Heater Timer. Switches on when freezing, before you get into the car. Kit	£6.99
25	Zenon Timing Light Kit. Case and Cables not supplied	£9.95
26	Power Supply Module 240V AC in 9V 25mA out. 30×20mm	£1.25
27	Power Supply Module 240V AC in 12V 25mA out. 15 high + pins	£1.25
28	Remote Controlled Light Dimmer 300W. Complete Kit	£15.25
29	16K Ram Packs for ZX81 Kit	Only £15.95

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BI-PAK

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VP5	200	Assorted Capacitors All Types	£1.00
VP6	200	Ceramic Caps Miniature – Mixed	£1.00
VP7	100	Mixed Ceramic Disc. 1pf-56pf	£1.00
VP8	100	Mixed Ceramic Disc. 68pf-.015pf	£1.00
VP9	100	Assorted Polyester/Polystyrene Caps	£1.00
VP10	60	C280 Type Caps Metal Foil Mixed	£1.00
VP11	100	Electrolytics – All Sorts	£1.00
VP12	60	Bead Type Polystyrene Min Caps	£1.00
VP13	50	Silver Mica Caps Ass. 5.6pf-150pf	£1.00
VP14	50	Silver Mica Caps Ass 160pf-4700pf	£1.00
VP15	50	High Voltage Disc Ceramic 750v-8Kv Mixed	£1.00

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VP28	10	Rectangular 2" Green LED'S	£1.00
VP29	30	Ass. Zener Diodes 250mW-2W Mixed Vlts Coded	£1.00
VP30	10	Ass. 10W Zener Diodes Mixed Vlts. Coded	£1.00
VP31	10	5 Amp SCR's TO-66 50-400v Coded	£1.00
VP32	20	3 Amp SCR's TO-66 Up To 400v Uncoded	£1.00
VP33	200	Sil Diodes Switching Like 1N4148 DO-35	£1.00
VP34	200	Sil Diodes Gen. Purpose Like OA206 BAX13/16	£1.00
VP35	50	1 Amp IN4000 Series Sil Diodes Uncoded All Good	£1.00
VP36	8	Bridge Rects. 4 × 1 amp 4 × 2 Amp Mixed Vlts. Coded	£1.00
VP37	8	Black Instrument Type Knobs With Pointer ¼" Sld	£1.00
VP42	10	Black Heatsinks To Fit TO-3, TO-220 Ready Drilled	£1.00
VP43	4	Power - Fin Heatsinks 2 × TO-3 2 × TO-66 Size	£1.00
VP44	1	Large Power Heatsink 90 × 80 × 35 mm Drilled For Up To 4 TO-3 Devices	£1.00
VP45	50	BC107/8 Type NPN Transistors Good Gen. Purpose Uncoded	£1.00
VP46	50	BC177/8 Type PNP Transistors Good Gen. Purpose Uncoded	£1.00
VP47	10	Silicon Power Trans. Similar 2N3055 Uncoded	£1.50

IC BARGAINS

VP40	30	Assorted 74 Series TTL I.C's Gates, Flip-Flops & M.S.I's + Data Book. All New, Normal Retail Value Over £6.00. Our Price	£2.50
VP41	30	Assorted CMOS I.C's CD4000 Series. Pack Includes 00/09/12/14/18/21/23/25/28/30/35/44/68 AY/AE Types Plus Data Sheet Value Over £8.00. Normal retail	£2.50

YOU MAY ORDER any ONE TYPE of the above CMOS at £2.00 per 25 pieces. ORDER AS VP41 + type number required.

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Comprises 2 standard screwdriver blades 5 & 7mm size. 2 cross point size 4 & 6. 1 Ratchet handle. 5-in-1 Kit £1.45 each. O/No 329B.

VALUE PACKS

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VP18	30	Metres PVC Covered Multi Strand Wire Mixed Colours	£1.00
VP19	40	Metres PVC Single/Multi Strand Hook-Up Wire Mixed	£1.00
VP20	6	Rocker Switches 5 Amp 240v	£1.00
VP21	20	Pcs. 1-2 & 4mm Plugs & Sockets Matching Sizes	£1.00
VP22	200	Sq. Inches Total, Copper Clad Board Mixed Sizes	£1.00

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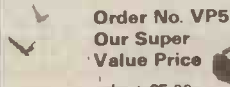

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VRM - 150 vlts
IFM - 1.5 Amps

Size: 1 inch square
10 off £1.00
50 off £4.50
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Red, Green, Yellow – .3/.5/.6 inch Mixed Types and colours NUMERIC & OVERFLOW Common Anode/Cathode. GaAsP/GaP. Brand New, Full Data incl.

10 pieces (our mix) £4.00
Normal Retail Value Over £10.00
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All Sorts Transistors. A mixed Bag NPN-PNP Silicon & Germ. Mainly Uncoded. You To Sort. Pack includes Instructions For Making Simple Transistor Tests. Super Value.
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AC + DC volts. DC current. 4 very useful resistance ranges. We've used it and we like it.

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30μA, 50μA, 100μA. **£6.75.** Post 50p.

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Led indicators charge-test switch. For PP3, HP7, HP11 & HP2 size betteries.
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240v Primary

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9-0-9v	250mA	**£1.33**

Post on above transformers 48p.

9-0-9v	1A	**£2.00**
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SIGNAL CONDITIONING AMP Sept 83 no case £8.98
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HIGH POWER INTERFACE BOARD Aug 83 no case £10.38
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EPROM PROGRAMMER Jun. 83 less software, TRS80 £44.99 Genie £45.73
ENVELOPE SHAPER Jun. 83 less case £12.33
REAL TIME CLOCK May 83 less software and cases.
Apple II £33.98 BBC £39.59 less power plug
MODEL TRAIN CONTROLLER May 83 £27.17
GUITAR HEADPHONE AMPLIFIER May 83 £7.92
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V.C.O. SOUND EFFECTS UNIT Apr. 82 £12.71

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6 part series E.E. Oct. 82–Mar. 83.
No soldering. Connections via screw terminal blocks. Very clear drawings showing how to connect components. Covers the basis of electronics.
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Book 1 by R. A. Penfold

Clear verobloc layouts and circuit diagrams. Includes fuzz box, radio, metronomes, timers, transistor checker, switches, etc. Introduction gives basic information on components including resistors, capacitors, I.C.s, transistors, photocells etc. Ideal for beginners as well as those with some experience.
Complete kit includes verobloc, book and components (less batteries) £27.55. Less book £25.30. Book only £2.25.

ADVENTURES WITH DIGITAL ELECTRONICS

Entertaining and instructive Includes details of some digital IC's and 8 projects: shooting gallery, 2 way traffic lights, electronic adder, computer space invaders game etc. No soldering.

Adventures with Digital Electronics Book £3.25

Component pack including Breadboards £45.50 less batteries

ADVENTURES WITH MICROELECTRONICS

Similar to 'Electronics' below. Uses I.C.s. Includes dice, electronic organ, doorbell, reaction timer, radio etc. Based on Bimboard 1 bread board.
Adventures with Microelectronics £3.20
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An easy to follow book suitable for all ages. Ideal for beginners. No soldering, uses an S-Dec Breadboard. Gives clear instructions with lots of pictures. 16 projects — including three radios, siren, metronome, organ, intercom, timer, etc. Helps you learn about electronic components and how circuits work. Component pack includes an S-Dec breadboard and all the components for the projects.
Adventures with Electronics £2.85. Component pack £20.98 less battery.

PREVIOUSLY ADVERTISED STILL AVAILABLE

Tape punch and reader	£22.50
Bench isolating transformer 250 watt	£7.75
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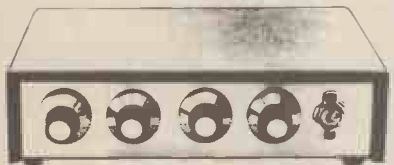
8 POWERFUL MODEL MOTORS (all different)

for robots, meccanos, drills, remote control planes, boats, etc. £2.95.



Complete kit of parts for a three channel sound to light unit controlling over 2000 watts of lighting. Use this at home if you wish but it is plenty rugged enough for disco work. The unit is housed in an attractive two tone metal case and has controls for each channel, and a master on/off. The audio input and output are by ¼" sockets and three panel mounting fuse holders provide thyristor protection. A four pin plug and socket facilitate ease of connecting lamps. Special price is £14.95 in kit form or £25.00 assembled and tested.

12 volt MOTOR BY SMITHS

Made for use in cars, etc. these are series wound and they become more powerful as load increases. Size 3½" long by 3" dia. They have a good length of ¼" spindle — Price £3.45.
Ditto, but double ended £4.25.
Ditto, but permanent magnet £3.75.

EXTRA POWERFUL 12v MOTOR

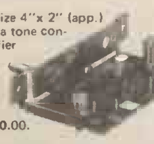
Probably develops up to ¼ h.p. so it could be used to power a go-kart or to drive a compressor, etc. £7.95 + £1.50 post.

THERMOSTAT ASSORTMENT

10 different thermostats. 7 bi-metal types and 3 liquid types. There are the current stats which will open the switch to protect devices against overload, short circuits, etc., or when fitted say in front of the element of a blow heater, the heat would trip the stat if the blower fuses; appliance stats, one for high temperatures, others adjustable over a range of temperatures which could include 0 — 100°C. There is also a thermostatic pod which can be immersed, an oven stat, a calibrated boiler stat, finally an ice stat which, fitted to our waterproof heater element, up in the loft could protect your pipes from freezing. Separately, these thermostats could cost around £15.00 - however, you can have the parcel for £2.50.

MINI MONO AMP on p.c.b., size 4"x 2" (app.)

Fitted volume control and a hole for a tone control should you require it. The amplifier has three transistors and we estimate the output to be 3W 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 10 for £10.00.



— BARGAIN OF THE YEAR —
The AMSTRAD Stereo Tuner.

This ready assembled unit is the ideal tuner for a music centre or an amplifier, it can also be quickly made into a personal stereo radio — easy to carry about and which will give you superb reception.

Other uses are as a "get you to sleep radio", you could even take it with you to use in the lounge when the rest of the family want to view programmes in which you are not interested. You can listen to some music instead.

Some of the features are: long wave band 115 — 270 KHz, medium wave band 525 — 1650KHz, FM band 87 — 108MHz, mono, stereo & AFC switchable, tuning meter to give you spot on stereo tuning, optional LED wave band indicator, fully assembled and fully aligned. Full wiring up data showing you how to connect to amplifier or headphones and details of suitable FM aerial (note ferrite rod aerial is included for medium and long wave bands. All made up on very comoact board.

Offered at a fraction of its cost: **only £6.00** + £1.50 post + insurance.

THIS MONTH'S SNIP

MAINS FILTER — Don't let mains interference muck up your program or game — up to 13 amp load. Mains filter type FEC. SNIP PRICE ONLY £3.99.

REVERSIBLE MOTOR WITH CONTROL GEAR

Made by the famous Framco Company this is a very robust motor, size approximately 7½" long, 3½" dia. 3/8" shaft. Tremendously powerful motor, almost impossible to stop. Ideal for operating stage curtains, sliding doors, ventilators etc., even garage doors if adequately counter-balanced. We offer the motor complete with control gear as follows:

1 Framco motor with gear box
1 manual reversing & on/off switch
1 push to start switch
2 limit stop switches
1 circuit diag. of connections

£19.50 plus postage £2.50

FOR SOMEONE SPECIAL

Why not make your greeting card play a tune? It could play 'Happy Birthday', 'Merry Christmas', 'Wedding March', etc, or 'Home Sweet Home', etc. Wafer thin 3 part assemblies, for making cards musical. Mini microchip speaker and battery with switch that operates as the card is opened. Please state tune when ordering. Complete, ready to work £1.25.

REEL TO REEL TAPE DECKS

Ex-Language Teaching School. Second, but we understand these are in good order; any not so would be exchanged. The deck is a standard BSR with normal record, replay facilities and an additional feature is tape rev counter. Nicely finished in teak type box. We have 30 only of these. Price £8.50 each + £3 carriage.

TELEPHONE ITEMS

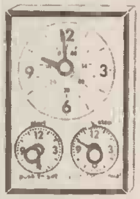
Plug and Wall socket — 4 pin or 5 pin	£3.45
Plugs only 4 pin or 5 pin	£1.15
Modern desk telephone	£7.50
Heavy black old type	£5.50
External bell unit	£6.50
Bell ringing power unit	£4.50
Pick up coil	£1.15

STABILISED POWER SUPPLY (Mains Input)

By LAMDA (USA) — Ideal for computer add-ons, d.c. output. Regulated for line volts and load current. Voltage regulation .1% with input variations up to 20% — load regulation 1% from no load to full load — or full load to no load. Complete in heavy duty case — Models available: 5v - 6A £17.25. 5v - 9A £23. 12v - 1.5A £13.25. 15v - 1.2A £13.25. 24v - 2A £23.

PRESTEL UNIT

— brand new and complete except for 7 plug in IC's — Price: £19.75 + £2.00 p&p.
Note: British Telecom may not connect this equipment as there is no manufacturer to guarantee it, however it is well worth buying for its immense breakdown value — sold originally at over £150.



WATERPROOF HEATING WIRE

100 ohms per yard, this is a heating element wound on a fibre glass coil and then covered with pvc. Dozens of uses — around water pipes, under grow boxes, in gloves and socks. Price: 23p per metre.

TIME SWITCH BARGAIN

Large clear mains frequency controlled clock, which will always show you the correct time + start and stop switches with dials. Complete with knobs FOR ONLY £2.50.
10 for £11.50!

ROPE LIGHT

6 metres of translucent plastic tube full of coloured bulbs makes a wonderful display — suitable indoors or out. £25 + £2 post.

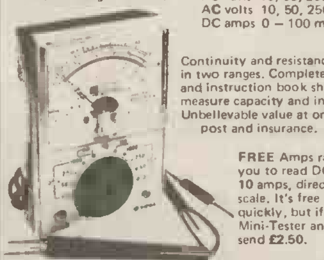
50 THINGS YOU CAN MAKE

Things you can make include Multi range meter, Low ohms tester, A.C. amps meter, Alarm clock, Soldering iron minder, Two way telephone, Memory jogger, Live line tester, Continuity checker, etc. etc., and you will still have hundreds of parts for future projects. Our 10Kg parcel contains not less than 1,000 items - panel meters, timers, thermal trips, relays, switches, motors, drills, taps, and dies, tools, thermostats, coils, condensers, resistors, neons, earphone/microphones, nicad charger, power unit, multi-turn pots and notes on the 50 projects.

YOURS FOR ONLY £11.50 plus £3.00 post.

MINI-MULTI TESTER

Deluxe pocket size precision moving coil instrument, Jewelled bearings - 2000 o.p.v. mirrored scale.
11 instant range measures: DC volts 10, 50, 250, 1000. AC volts 10, 50, 250, 1000. DC amps 0 — 100 mA.



Continuity and resistance 0 - 1 meg ohms in two ranges. Complete with test prods and instruction book showing how to measure capacity and inductance as well. Unbelievable value at only £6.75 + 60p post and insurance.

FREE Amps range kit to enable you to read DC current from 0 - 10 amps, directly on the 0 - 10 scale. It's free if you purchase quickly, but if you already own a Mini-Tester and would like one, send £2.50.

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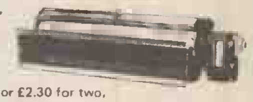
EXTRACTOR FANS — MAINS OPERATED

Woods extractor.
5" — £5.75, Post £1.25.
6" — £6.95, Post £1.25.
5" Plannair extractor £6.50. Post £1.25.
4"x 4" Muffin 115v. £4.50. Post 75p.
4"x 4" Muffin 230v. £5.75. Post 75p.
All the above ex-computer, those below are unused.
4" x 4" £8.50. Post 75p.
9" American made £11.50. post £2.00.
Tangential Blower 10x3 air outlet, dual speed £4.60. Post £1.50.

TANGENTIAL BLOW HEATER

by British Solartron, as used in best blow heaters. 2Kw approx 9" wide £5.95, 3Kw either 9" or 12" wide (your choice) £6.95 complete with 'cold' 'half' and 'full' heat switch, safety cut out and connection dig. Please add post £1.50 for 1 or £2.30 for two.



2.5 Kw KIT Still available: £4.95 + £1.50 post.

DISCO PANEL

Make your party or disco more thrilling — add to your record player or amp, a multi-coloured, sound-enhanced lighting display. Made for Amstrad, their ref. No. RP10. Mains operated stereo or mono controlled — has 48 coloured lamps (plus 4 spares) and light level controls. Brand new and unused — offered at a never to be repeated price of £5.75 plus £2.00 post.

BLEEP TONE These work off 12v and have an unusual and pleasant bleep. 69p each.

CONNECTING WIRE PACK 48 lengths of connecting wire, each 1 metre long and differently colour coded, a must for those difficult interconnecting jobs. 85p the lot.

RED LEDS 10 for 69p. 100 for £5.75. 1000 for £52.

IN LINE SIMMERSTAT Ideal heat controller for soldering iron and many other hand-held appliances. £2.30. 10 for £17.25.

VENNER TIME SWITCH

Mains operated with 20 amp switch, one on and one off per 24 hrs. repeats daily automatically correcting for the lengthening or shortening day. An expensive time switch but you can have it for only £2.95. These are without case but we can supply a plastic case - £1.75.
Also available is adaptor kit to convert this into a normal 24 hr. time switch but with the added advantage of up to 12 on/offs per 24 hrs. This makes an ideal controller for the immersion heater. Price of adaptor kit is £2.30.

IONISER KIT

Refresh your home, office, shop, work room, etc. with a negative ION generator. Makes you feel better and work harder — a complete mains operated kit, case included.
£11.95 plus £2.00 post.

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Short Wave Set — covers all the short wave bands using plug-in coils. Kit complete	£14.50
R C Bridge Kit	£9.95
3 Channel Sound to Light — with fully prepared metal case.	£14.95
Ditto — made up	£25.00
Big Ear, listen through walls	£9.50
Robot controller — receiver/transmitter	£9.50
Ignition kit — helps starting, saves petrol, improves performance	£13.95
Silent sentinel Ultra Sonic Transmitter and receiver	£9.50
Car Light 'left on' alarm	£3.50
Secret switch — fools friends and enemies alike	£1.95
3 — 30v Variable Power Supply	£13.80
2 Short & Medium wave Crystal Radio	£3.99
3v to 16v Mains Power Supply Kit	£1.95
Light Chaser — three modes	£17.50
Mullard Unilex HiFi stereo amplifier with speakers	£16.75
Radio stethoscope — fault finding aid	£4.80
Mug stop — emits piercing squark	£2.50
Morse Trainer — complete with key	£2.99
Drill control kit	£3.95
Drill control kit — made up	£6.95
Interrupted beam kit	£2.50
Transmitter surveillance kit	£2.30
Radio Mike	£6.90
FM receiver kit — for surveillance or normal FM	£3.50
Seat Belt reminder	£3.00
Car Starter Charger Kit	£15.50
Soil heater for plants and seeds	£16.50
Insulation Tester — electronic megger	£7.95
Battery shaver or fluorescent from 12v	£6.90
Matchbox Radio — receives Medium Wave	£2.95
Mixer Pre-amp — disco special with case	£16.00
Aerial Rotator — mains operated	£29.50
Aerial direction indicator	£5.50
40 watt amp — hifi 20hz — 20kHz	£9.50
Microvolt multiplier — measure very low currents with ordinary multitester	£3.95
Pure Sine Wave Generator	£5.75
Linear Power output meter	£11.50
115 Watt Amplifier 5Hz 25kHz	£13.50
Power supply for one or two 115 watt amps	£17.50
Stereo Bass Booster, most items	£8.95

EVERYDAY ELECTRONICS and computer PROJECTS

VOL. 13 NO. 1 JANUARY 1984

EARLY WARNING

HOME AND SAFE is a time honoured catch phrase. It is not wise however to take for granted the implied safety; vigilance and precautionary measures are always necessary. The electronics constructor has many opportunities to put his hobby to this purpose. As a further example this month we feature a valuable two-function monitoring system.

The *Four-Channel Gas and Smoke Sentinel* affords protection from two hazards: gas leaks and danger of fire. With respect to the second of these hazards, the following facts should be appreciated.

Any ignited substance emits smoke before bursting into flames. A smoke detector therefore has advantage over other types of fire detectors, because of the interval between the first emission of smoke and a conflagration. As many readers will have seen demonstrated on TV, foam filled furniture can easily become ignited by a match. The foam emits a highly poisonous and very dense smoke in the first stage, before heat or flame risk develops. The gas sensor will detect this smoke and sound the alarm, giving some precious minutes warning before the material bursts into flame.

With choice of appropriate sensors and their installation as recommended, early warning of the development of a dangerous situation can be prevented, throughout a house or other premises. For example, one channel could be assigned to gas detection with the sensor installed in the kitchen; and other sensors (up to three in number) could be used to detect smoke in various rooms or hallways.

Alternatively, where the nature of the building and kind of appliances installed suggest that gas leaks present the greater danger, more or all channels could be assigned to gas detection duty. Thus the system can be tailored to suit individual wishes and circumstances.

Making homes secure from hazards should be a matter of major concern for householders. But always of equal concern is the continuing rise in cost of running the essential services. With the Chancellor of the Exchequer casting avaricious eyes at the poor gas consumer, there is further incentive to make central heating systems as efficient and effective as possible. One novel way to effect economies is described in the *Central Heating Pump Delay* article. This particular idea can be applied to certain central heating systems that employ an electric pump to circulate the heating water.

Readers' Enquiries
We cannot undertake to answer readers' letters requesting modifications, designs or information on commercial equipment or subjects not published by us. All letters requiring a personal reply should be accompanied by a stamped self-addressed envelope.
We cannot undertake to engage in discussions on the telephone.

Component Supplies
Readers should note that we do not supply electronic components for building the projects featured in EVERYDAY ELECTRONICS, but these requirements can be met by our advertisers.

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TEMPERATURE MEASUREMENT AND CONTROL SYSTEM FOR ZX COMPUTERS

BY M. PLANT

THIS article describes how to build and use three interface units or "add-ons", which make it possible to use the ZX81 and the ZX Spectrum as the basis for sophisticated temperature measurement and control systems.

The three units are: (1) Analogue Thermometer Unit; (2) Analogue-to-Digital Converter (ADC) Unit; and (3) Relay Driver Unit. These units have been evaluated using a proprietary Input/Output Port board from Redditch Electronics. An in-out port is more generally known as a Peripheral Interface Adaptor or PIA and is essential when using these interface units. Connection details to the Redditch PIA are included in the second part of this article, which will appear next month.

This PIA is actually a programmable in-out port, but a similar or simpler PIA can be used provided it enables data sent to the PIA via the ADC unit to be read by the micro, and data sent by the micro to the write port to be latched there for use by the Relay Driver Unit.

BLOCK DIAGRAM

As Fig. 1 shows, the PIA handles a two-way flow of data and control information while it is capable only of being addressed by the microprocessor via the system's "highway", the microprocessor *bus.* This provides a common electrical connection for the three types of data between the microprocessor and the various interface units, both internal, for example, those required for data flow between microprocessor and memory, and external, for example, those required for data flow between the microprocessor and the units described in this article. Note that the data is transferred in 8-bit digital words (bytes), and it is called parallel data transfer, since all 8-bits are transferred simultaneously.

The three interface units are easily assembled using the p.c.b. layouts included in this article. Calibration of the Thermometer Unit and the ADC Unit is simple and when coupled to the micro via the PIA it turns the low-cost Sinclair micro into a sophisticated thermometer.

APPLICATIONS

The simplest application is to program the micro to display temperature variation with time graphically, either as a bar chart or as a line graph. It is equally simple to convert the micro into a max-min thermometer displaying the current temperature and the maximum and minimum temperatures over a period of time. And the use of the Relay Driver Unit makes temperature control applications possible.

Of course, these applications can be achieved using conventional microelectronic devices but the use of a microcomputer actually simplifies the design of the necessary circuits since it uses the concept of "deferred design". This concept means that the logical functions which the microprocessor is to perform is deferred so that the programmer can make the decisions as to what the microcomputer should do by writing an appropriate program for it.

For example, in the case of the thermometer, the programmer can decide how to make use of the information about temperature which is made available to the microprocessor via the in-out port: thus the temperature can be displayed graphically or in tabular form; readings can be taken at easily selected intervals; alarm signals can be generated at predetermined temperatures; and in conjunction with the Relay Driver, control of electrical devices such as fans and heaters converts the microcomputer into a programmable thermostat. The sample programs included in the second part of this article illustrate what is possible with the interface units.

ANALOGUE AND DIGITAL INFORMATION

Before describing the design and construction of these units, a few words about analogue and digital information is necessary.

The word "analogue" means "model of". Thus an analogue watch models the passing of time by using hands which move smoothly over its face. On the other hand, the word "digital" means "by numbers" so a digital watch displays the passing of time by means of numbers which change discretely, that is, every second, minute and hour.

A microprocessor is a digital device for it processes information which takes just two values, logic "high" which is assigned a binary value of "1" and logic "low" which is assigned a value of "0". These digital signals are generally represented by voltages, so that, in practical circuits with TTL logic devices, logic low would be voltage less than 0·8V and logic high a voltage greater than about 2·8V.

But, much of the information in the real world which we want the microprocessor to deal with is in analogue form. This means that information about wind speed, temperature pressure, and so on, can take a continuous range of values: temperature changes, for example, take place smoothly not in discrete steps. Furthermore physical quantities such as temperature are not in a suitable electrical form for the microprocessor to use.

Thus in order to deliver information about temperature to a microcomputer, interface units have to be designed to perform two functions: change the temperature to be measured into an electrical analogue signal which is the purpose of the Thermometer Unit; and convert the analogue signal from the Thermometer Unit into a digital form which is the job of the Analogue-to-Digital Converter Unit.

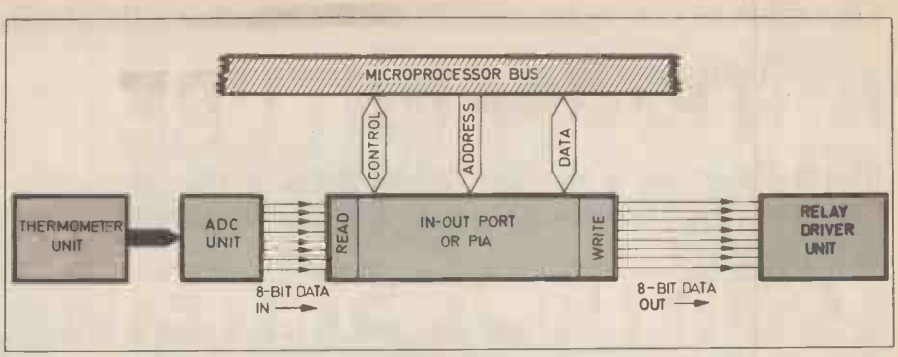
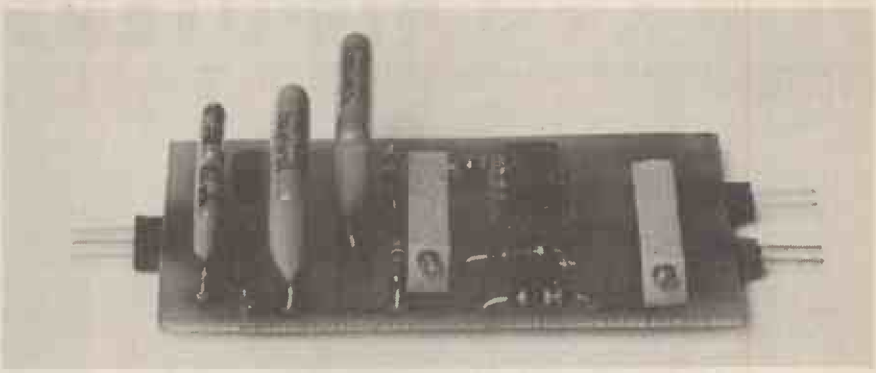
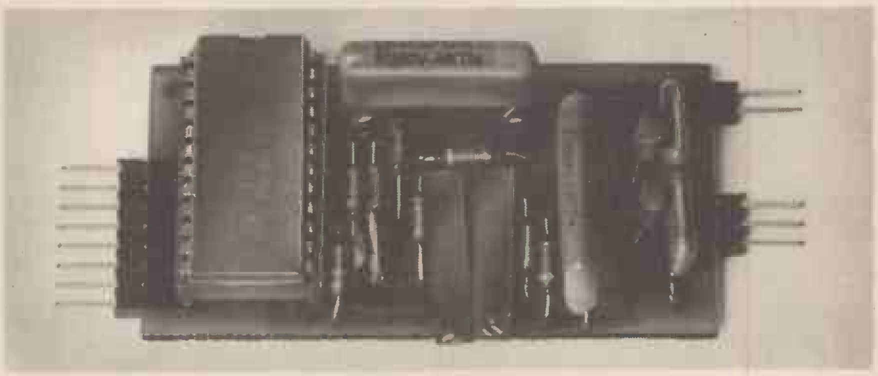


Fig. 1. Block diagram of the complete system.

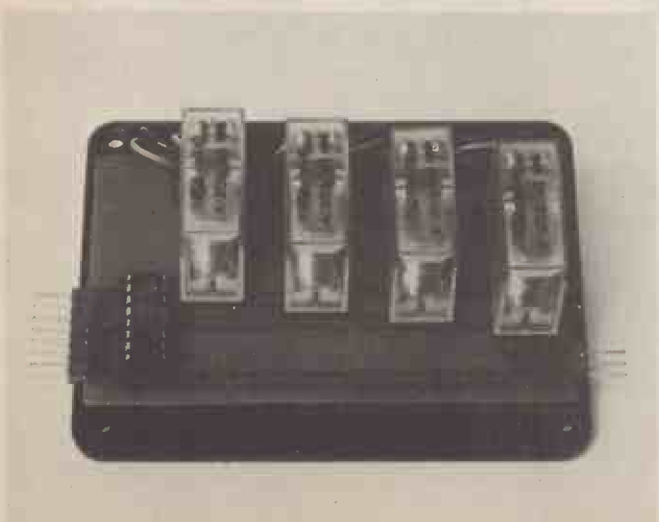


Close-up view of the completed ADC Unit prototype board.

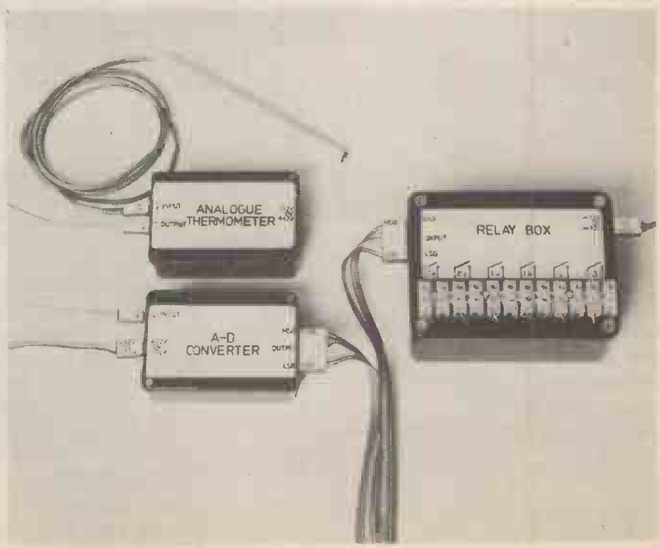


The completed relay board to be described next month.

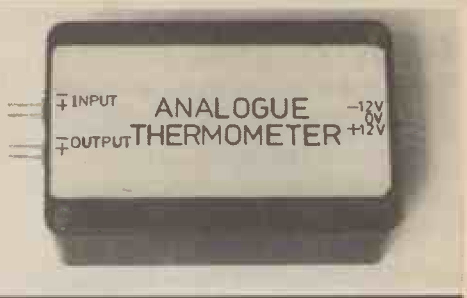
Close-up view of the completed prototype "Thermometer" board.



Setting up the three units and sensor.



ANALOGUE THERMOMETER UNIT



CIRCUIT DESCRIPTION

The Thermometer and ADC Units have been designed to provide accurate and stable data for the PIA to read. The sole purpose of the circuit shown in Fig. 2 is to produce a voltage which is proportional to temperature. This analogue voltage is fed to the ADC Unit for conversion to a digital form which can be read by the micro via the PIA.

The temperature sensor, IC1, produces a current proportional to absolute temperature and the op-amp, IC2, uses a feedback network to convert this current to a voltage. This type of sensor was chosen to reduce the noise pickup which can affect long cables connected to a resistive transducer such as a thermistor. IC1 is a three-lead device housed in a TO-52 metal case and looks rather like a transistor.

Although the circuit will happily operate from a ±12V supply, the two-voltage regulators, IC1 and IC2, provide a stabilised ±5V supply for the circuit which ensures that the output voltage is always compatible with the input requirements of the ADC Unit.

ASSEMBLY

The p.c.b. track design is shown in Fig. 3. This board is available from the *EE PCB Service*, Order code 8401-03. The component layout on the topside of the p.c.b. is shown in Fig. 4. Interconnections between this unit and the sensor, power supply, and ADC Unit are made using p.c.b. plugs and sockets. The sockets are soldered to leads, which are pushed on the plugs soldered to the copper tracks, terminating at the edge of the board. Thus the plugs overhang the edge of the board.

The rim of the base of the plastics box has three slots cut in it to accommodate the plastics base of these plugs when the p.c.b. is in place, component side facing towards the bottom of the box. When the lid is screwed down the plugs are held firmly in place and the p.c.b. requires no additional fixing, see Fig. 5.

SENSOR

The temperature sensor is mounted in a plastics pen case as shown in Fig. 6. The sensor has three leads: cut off pin 3 close to the metal case (this lead is electrically connected to the case and can be dispensed with) and cut off the pin location tag. Also cut off the end of the pen case at a point where its cross-section is just wide enough to allow the sensor to fit in tightly.

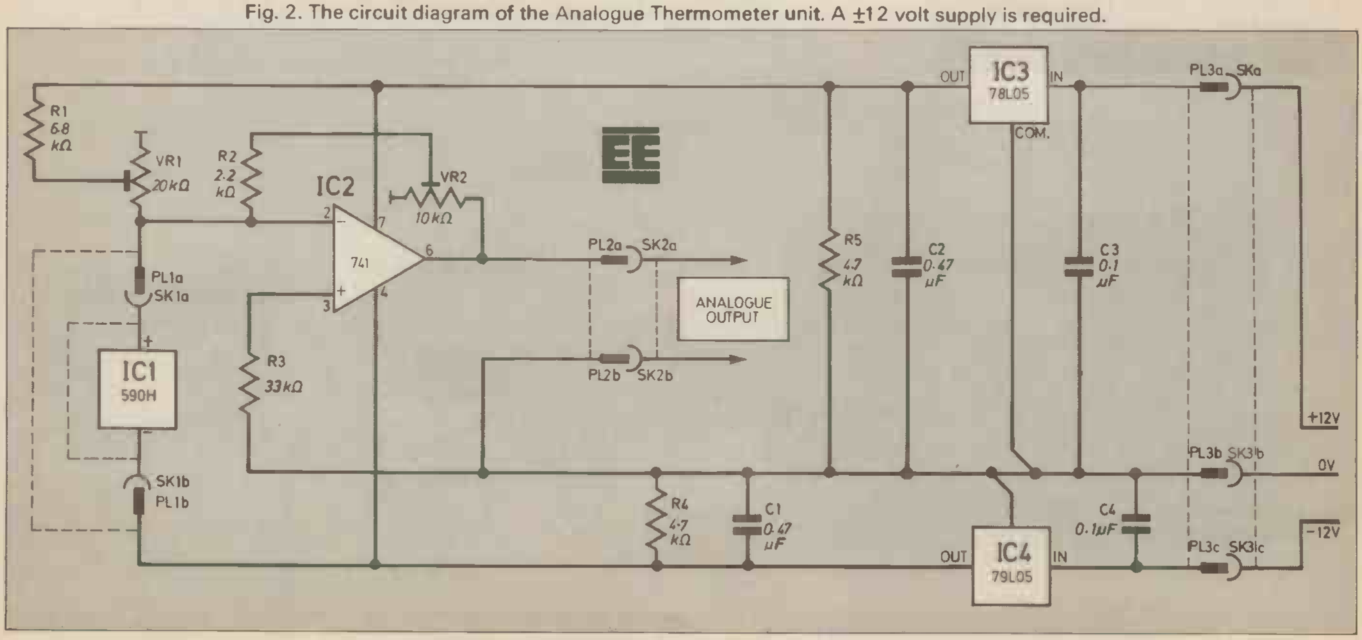
Solder two lengths of insulated wire (or use twin cable) to the sensor using heat shrink or p.v.c. sheathing to prevent the two leads close to the can from shorting together. If you use single wires, you should twist these together along their length and use different coloured wires to distinguish them.

The wires to the sensor may be six metres or so long, if you want to sense temperature remotely.

Pass the leads through the pen case and seal the sensor at one end and the leads at the other with Araldite. Solder the twin p.c.b. socket to the other end of the wire and label this socket + and – to ensure the sensor makes compatible connection to the corresponding polarities on the p.c.b. assembly. The Thermometer Unit is now ready for calibration.

The prototype temperature sensor.

Fig. 2. The circuit diagram of the Analogue Thermometer unit. A ±12 volt supply is required.



COMPONENTS

Resistors

R1	6·8kΩ	
R2	2·2kΩ	
R3	33kΩ	
R4	4·7kΩ	
R5	4·7kΩ	

All ¼W carbon ±5%

See **Shop Talk** page 16

Capacitors

C1,2	0·47µF polyester type C280
C3,4	0·1µF polyester type C280

Semiconductors

IC1	590kH precision temperature sensor i.c.
IC2	CA3140 MOS f.e.t. op-amp
IC3	78L05 +5V 100mA voltage regulator
IC4	79L05 −5V 100mA voltage regulator

Miscellaneous

VR1	20k 20-turn cermet preset (type ¾ inch)
VR2	10k 20-turn cermet preset (type ¾ inch)
SK1,2	2-way inter-p.c.b. socket (2 off)
SK3	3-way inter-p.c.b. socket
PL1,2	2-way inter-p.c.b. straight plug (2 off)
PL3	3-way inter-p.c.b. straight plug

Printed circuit board: single-sided, size 68 x 36mm, *EE PCB Service,* Order code 8401-03; 8-pin d.i.l. socket; plastics case, size 71 x 46 x 22mm, type T3; interconnecting cable (length to suit); sleeving; plastics tubing (biro pen case).

Approx. cost Guidance only **£14**

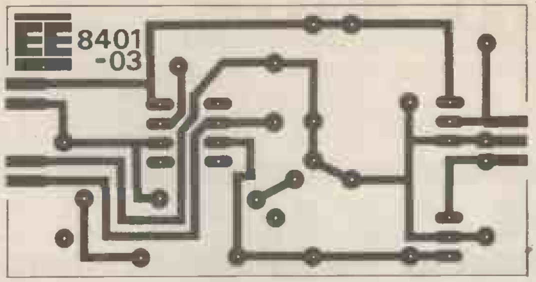


Fig. 3. The master p.c.b. pattern (actual size) for the Analogue Thermometer Unit. This board is available from the *EE PCB Service,* Order Code 8401-03.

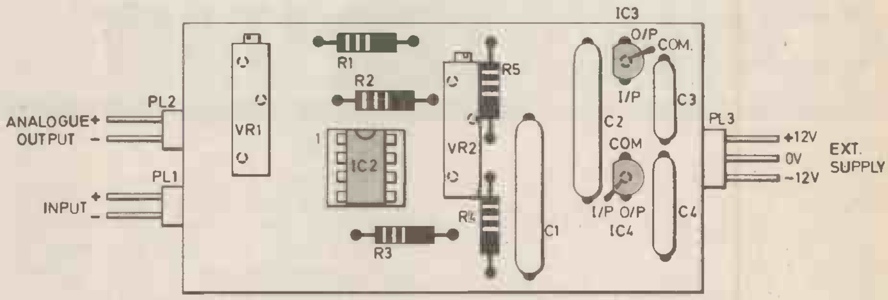


Fig. 4. The layout of the components on the topside of the "Thermometer" board. PL1 to PL3 are soldered directly to the tracks on the underside.

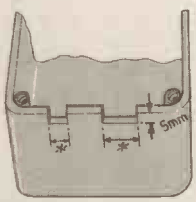


Fig. 5. Typical case cut-outs to accommodate the protruding plugs.

Shows how the "Thermometer" board is fitted in the case. No fixings are required.

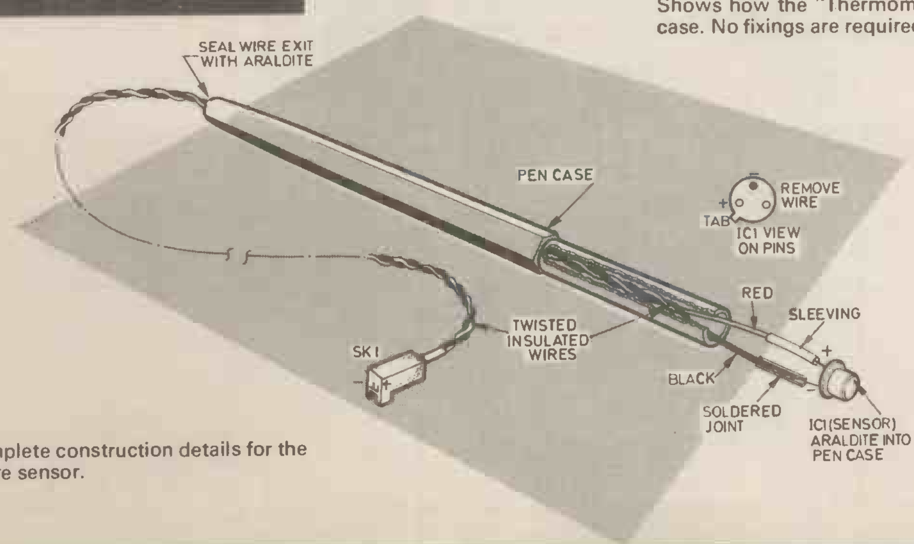


Fig. 6. Complete construction details for the temperature sensor.

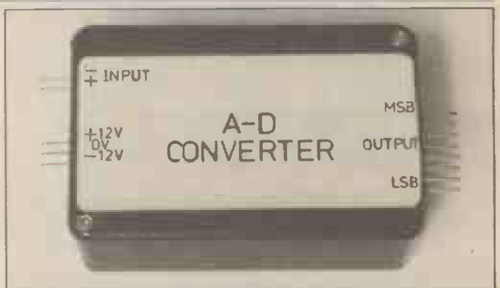
CALIBRATION

You will need a multimeter for this part preferably a digital type. Switch it to a 3V or 5V d.c. range and connect its leads to the output connections of the unit—observe polarity.

Place the temperature sensor in melting ice and adjust trimmer VR1 so that the output voltage reads 0V. Transfer the sensor to water at 100 degrees Centigrade and adjust trimmer VR2 so that the output voltage is 1V. Check the reading once again when the sensor is immersed in melting ice and adjust VR1 if necessary.

This calibration procedure sets up the circuit so that the analogue output voltage varies by 10mV per degree Centigrade. The digital voltmeter thus registers the actual temperature of the sensor, ignoring the decimal point, and makes the subsequent calibration of the ADC unit much easier.

ANALOGUE TO DIGITAL CONVERTER UNIT



ADC CIRCUIT

The circuit diagram for the ADC Unit is shown in Fig. 7 and is based on an integrated circuit, IC1, type 8703 which is housed in a 24-pin package. This device accurately converts an analogue input voltage to an 8-bit digital output voltage.

There are many different types of purpose designed i.c.s employing different techniques for the conversion process but the 8703, although more costly than many devices, uses a charge balancing technique in the conversion process and consequently has a high noise immunity; this choice has proved successful for the ADC Unit in association with the Thermometer Unit and provides a stable digital signal at the read port of the PIA.

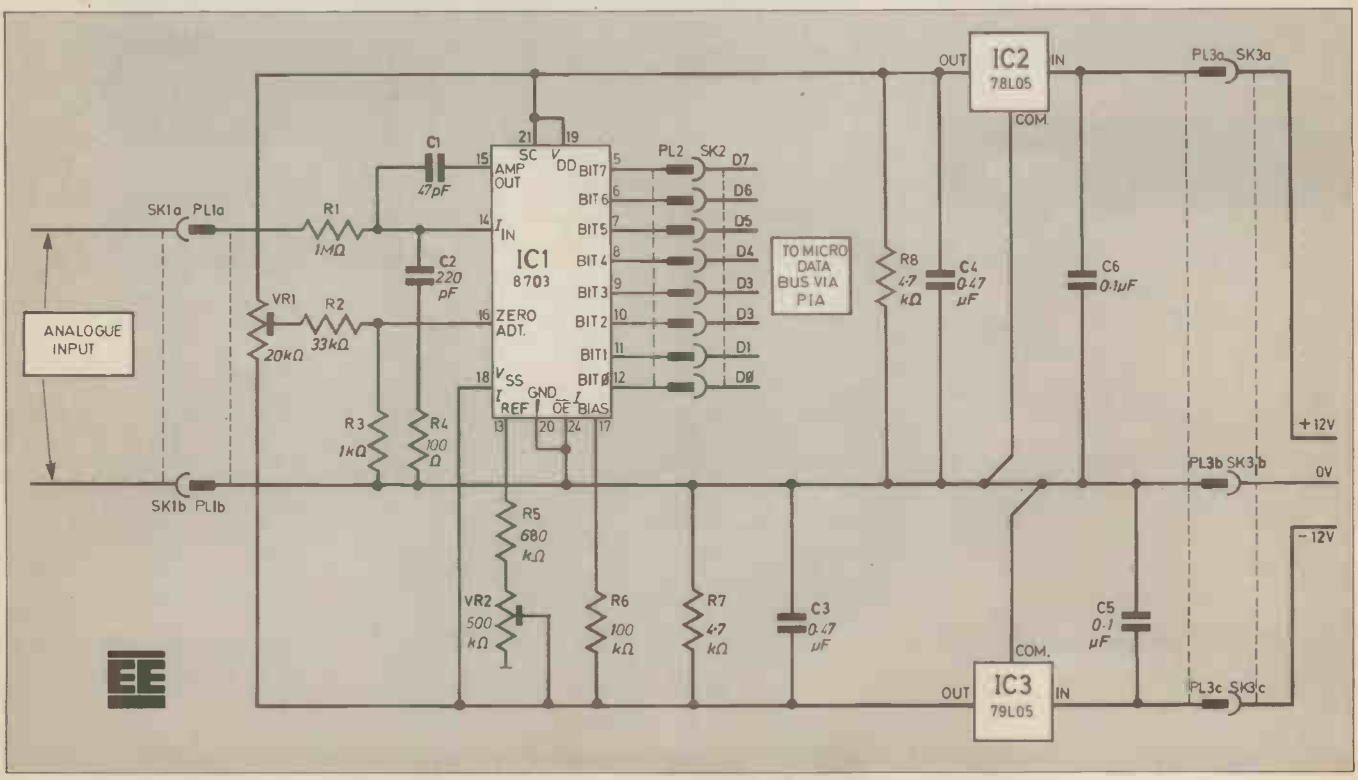
Note that the 8703 is a CMOS device so it should be handled carefully to prevent damage caused by static electricity, so leave the i.c. in its conducting foam until all the other components have been soldered in place and then insert it in its holder on the board *before* connecting power to the circuit.

The 8703 is connected so as to convert the analogue voltage fed to it continuously so that the microcomputer does not have to supply a strobe or clock signal in order to read data from the ADC Unit. Note, also, that the unit operates from a ±12V supply and the regulators, IC2 and IC3, provide the necessary ±5V supply for IC1.

ASSEMBLY

The printed circuit board track design is shown in Fig. 8. This board is available

Fig. 7. Circuit diagram of the ADC Unit. A ±12 volt supply is required.



from the *EE PCB Service* Order code 8401-04. The component layout on the board topside is shown in Fig. 9. Interconnections to power supply, PIA and the Thermometer Unit are made using inter-p.c.b. plugs and sockets. An 8-way length of p.c.b. plug is used to carry digital data to the PIA and these plugs are soldered to the board so as to project from the sides of the box; same method as used for the Thermometer Unit.

To be continued

COMPONENTS

Resistors

R1	1MΩ
R2	33kΩ
R3	1kΩ
R4	100Ω
R5	680kΩ
R6	100kΩ
R7	4·7kΩ
R8	4·7kΩ

All ¼W carbon ±5%

See **Shop Talk** page 16

Capacitors

C1	470pF ceramic plate
C2	220pF ceramic plate
C3,4	0·47μF polyester type C280 (2 off)
C5,6	0·1μF polyester type C280 (2 off)

Semiconductors

IC1	8703CJ 8-bit analogue-to-digital converter
IC2	78L05 +5V voltage regulator
IC3	79L05 −5V voltage regulator

Miscellaneous

VR1	20kΩ 20-turn cermet preset (¾ inch type)
VR2	500kΩ 20-turn cermet preset (¾ inch type)
SK1	2-way inter-p.c.b. socket
SK2	8-way inter-p.c.b. socket
SK3	3-way inter-p.c.b. socket
PL1	2-way inter-p.c.b. straight plug
PL2	8-way inter-p.c.b. straight plug
PL3	3-way inter-p.c.b. straight plug

Printed circuit board: single-sided, size 68 x 36mm, *EE PCB Service,* Order code 8401-04; 24-pin d.i.l. socket; plastics case, size 71 x 46 x 22mm, type T3; interconnecting cable; 8-way ribbon cable.

Approx. cost Guidance only £18

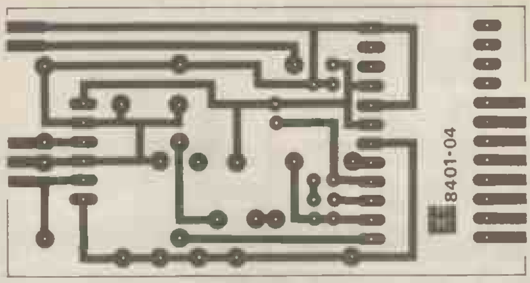


Fig. 8. The master p.c.b. pattern (actual size) for the ADC Unit. This board is available from the *EE PCB Service,* Order Code 8401-04.

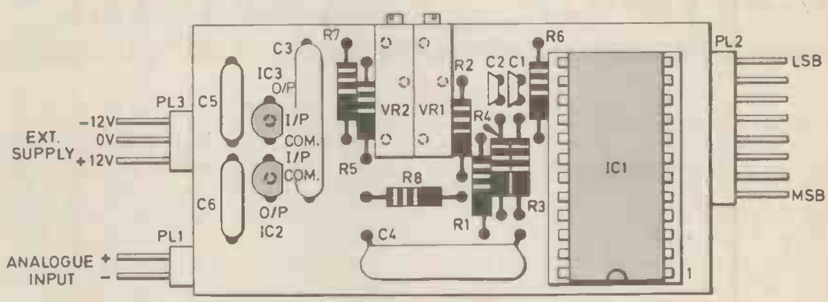
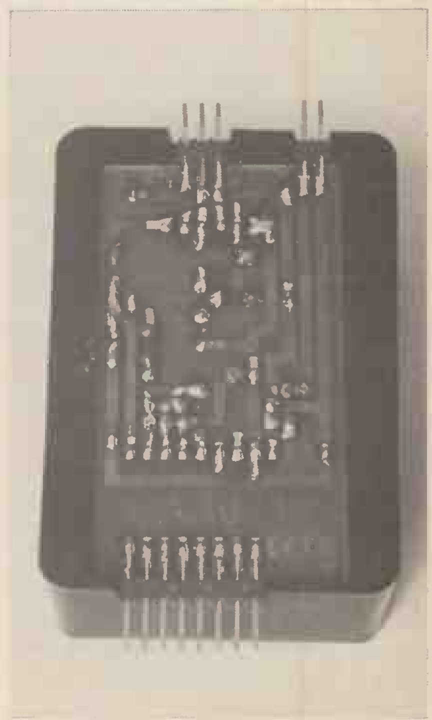


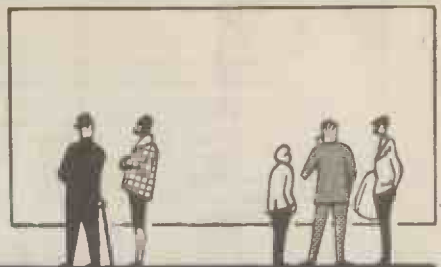
Fig. 9. Layout of the components on the topside of the ADC Unit board. PL1 to PL3 are soldered directly to the tracks on the underside.

Plan view of the completed ADC Unit board.



The ADC board fitted in its case. No fixings are required.

SHOP TALK



BY DAVE BARRINGTON

Catalogues Received

Two catalogues have landed on the editorial desk this month. They are the very first components catalogue from **Cricklewood Electronics** and the latest edition from **TK Electronics.**

For a first time effort, Cricklewood are to be congratulated on a neat 32-page catalogue that is easy to use and contains all prices on each page. Each page also contains a note that VAT must be added to the listed prices.

Just over half the catalogue is devoted to semiconductors and integrated devices. Apart from listing the code number of i.c. devices they also give their function. For example: 4060—14 Stage Binary Counter, 50p.

Other sections include: resistors, capacitors, tools, cables and connectors. The front cover carries the index of goods stocked.

Copies of the Cricklewood No. 1 Components Catalogue are available from **Cricklewood Electronics Ltd., Dept EE, 40 Cricklewood Broadway, London, NW2 3ET.** Price £1, including postage and packing.

Known as the "Green Catalogue", the 24-page catalogue from TK Electronics contains such items as books, batteries, connectors, cases, buzzers and switches, to name a few.

For home security, TK list pressure mats, door/window contacts, window tape, alarm bells and infra-red body detectors. The range of i.c.s carried is fairly extensive but the transistor section could be expanded.

There is a good range of kits varying from a combination lock to an infra-red garage door controller. Computers and computer software is also listed.

Copies of the TK Electronics Components Catalogue are available Free from **TK Electronics Ltd., Dept EE, 11–13 Boston Road, London, W7 3SJ.** A self-addressed envelope should be sent with request.

Coils

If any readers are experiencing difficulties in locating the Denco coils used in the *Short Wave Radio* published in the October 1983 issue, these can be purchased from **G. M. A. Powell, Dept EE, 8 Brunel Unit, Brunel Road, Gorse Lane Industrial Estate, Clacton-on-Sea, Essex.**

The price for these coils is £595 per set of 3.

Scope for Repair

With the demise of Scopex Instruments, readers who own one of these excellent oscilloscopes may be concerned about future repairs to their instruments should they break down.

We understand that **Mendascope** are able to undertake to carryout any repairs and servicing to the complete range of Scopex instruments. This includes collection and a free estimate.

For more details readers should contact: **Mendascope Ltd., Dept. EE, Otter House, Weston Underwood, Olney, Bucks MK46 5JS.**

CONSTRUCTIONAL PROJECTS

Guitar Tuner

The 4046BE phase-locked loop i.c. used in the *Guitar Tuner* is listed by Cricklewood Electronics and Enfield Electronics.

The 125–0–125µA "tune" meter used in our model was obtained from Maplin Electronic Supplies. Order as code: LB79L (Tuning Meter).

Central Heating Pump Delay

A Fujitsu relay type 111C was used in the prototype model of the *Central Heating Pump Delay* as it was already available. It is available from Farnell Semiconductors as 103–891, and RS Components as 346–615.

However, for longer life a slightly more expensive p.c.b. type could be used, for example RS 347–826. This needs a slightly different track layout.

We would point out that RS Components will not supply to the general public but must be ordered through a local recognised trader.

If flying leads are used for connection, almost any relay with a coil resistance over 500 ohms will do. Contacts should be 240V 2A minimum. For a 12V supply version similar comments apply but with a coil greater than 200 ohms.

Heat-resisting flex (usually butyl rubber) is available from good electrical suppliers or plumbing/heating DIY stores.

With 12V supplies, capacitor C3 can be dropped to 25V rating and diodes D3 to D6 can be 1N4001. Of course, with d.c. supplies D3 to D6 could be omitted altogether, but they are a useful protection against misconnection.

4-Channel Gas Sentinel

Although the parts list for the *4-Channel Gas Sentinel* looks a little hefty, most of the components used are commonplace and very few problems should be experienced. In fact, the cost of this project worked out at only slightly more than four commercial smoke alarms. The Gas Sentinel, though, is capable of sensing both gas *and* smoke.

Some substantial savings can be effected if the 12V d.c. version is built. For anyone with a caravan or can afford to run a reasonable boat or yacht the low voltage version is ideal. It should be pointed out that the 12V version has not been tried in a boat but there should be no problems.

The mains transformer used is listed by Electrovalue as type BR24-15, price £4.74 plus VAT. The recommended heatsink TO-3 is also stocked by them and is listed as type 2Y-TO3.

Concerning the miniature 3-core cable, it may be best to purchase a 50-metre drum.

The only source of supply for the gas sensors we have been able to locate is Bi Pak, Dept EE, PO Box 6, Ware, Herts, SG12 9AG. A single sensor (type TGS812 or TGS813) and socket will cost £7.76 inclusive.

Bi Pak are also able to supply a complete kit of parts for the sum of £52.85, including VAT (includes 4 sensors).

Games Scoreboard

We do not expect any purchasing problems for components used in the *Games Scoreboard* project.

The 2·1mm power socket SK1 is available from Maplin. Order as code number: HH85G (Power Skt 2.1).

Temperature Measurement & Control System for ZX Computers

Several components could prove troublesome to locate for the *Temperature Measurement & Control System for ZX Computers.*

The 590kH precision temperature sensor used in the *Analogue Themometer Unit* is, as far as we are aware, only available from RS Components. This carries the order code 308–809.

The analogue-to-digital converter i.c. type 8703 used in the *Analogue To Digital Converter Unit* is also available from RS Components; stock number 308–045.

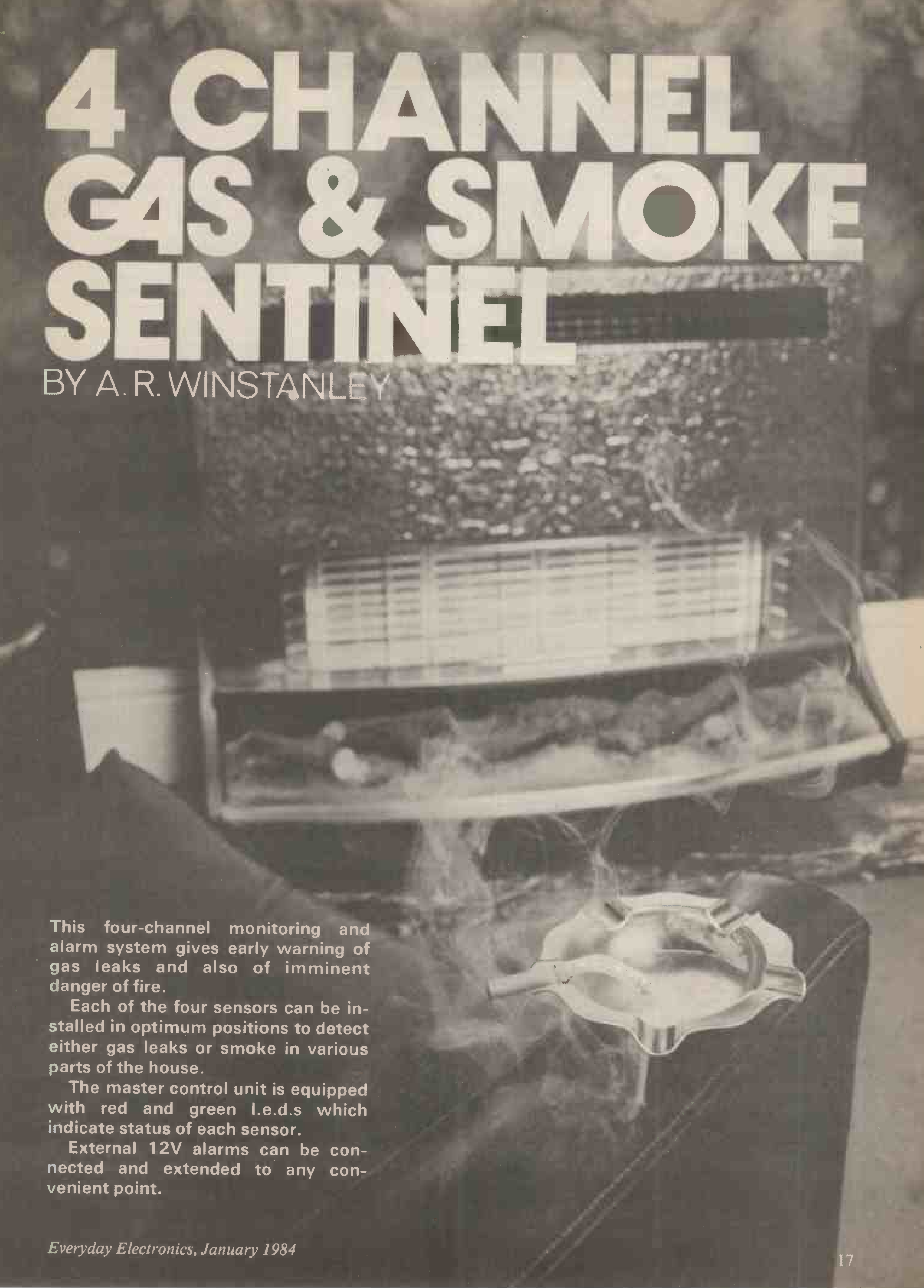
We would point out that RS will only supply to bona fide traders and readers will have to order through their local component supplier.

The inter-board printed circuit connectors are available from Maplin and are listed under the Minicon Latch range. Socket housing and Minicon terminals will also be required.

Microcomputer Interfacing Techniques

We cannot foresee any component purchasing problems for this month's installment of the *Microcomputer Interfacing Techniques.*

However, if readers should experience any trouble in locating the TIL111 opto-isolator used in the *Biological Amplifier*, the IL–74 device stocked by Bi Pak may be used instead.



4 CHANNEL GAS & SMOKE SENTINEL

BY A. R. WINSTANLEY

This four-channel monitoring and alarm system gives early warning of gas leaks and also of imminent danger of fire.

Each of the four sensors can be installed in optimum positions to detect either gas leaks or smoke in various parts of the house.

The master control unit is equipped with red and green l.e.d.s which indicate status of each sensor.

External 12V alarms can be connected and extended to any convenient point.

THIS four-channel gas and smoke detection system is an expanded version of the author's "Gas Sentinel" design which was published in EVERYDAY ELECTRONICS, April 1980. The arrangement described here comprises a master control unit into which are connected four remotely-located "TGS" type gas sensors, enabling four areas to be monitored simultaneously.

Each TGS detector is capable of sensing many gases: the system will respond to hydrocarbons (for example, bottled gas like butane and propane), alcohols (propanol, for example) and hydrogen cyanide (significant because this gas is emitted from burning foam-filled furniture and it is highly toxic).

FIRE WARNING

The Sentinel operates as a fire warning system in that it is capable of detecting accumulations of smoke (or, more specifically, carbon monoxide and any toxic gases contained in the smoke). In the case of burning foam-filled furniture, extremely toxic and very dense smoke containing hydrogen cyanide is emitted in the first instance and this smoke will be quite sufficient to trigger the alarm before the furniture has become totally enveloped in flames, providing that the sensor's sensitivity controls are set up sensibly.

Adjustable sensitivity controls are included in each channel and although they are uncalibrated it is possible to set up a triggering level which is well below the accumulation required to cause ignition.

TWO DETECTION MODES

It is therefore clear that the Gas Sentinel has two detection modes: as a gas **leakage detector** or as **a smoke alarm.**

When a sensor is employed to detect gas (preferably use the TGS813 for this) then the sensor should be placed low down, since the relevant gases in question are heavier than air and will accumulate at floor level; however at the same time the detector should be placed near to the gas apparatus where it will have most chance of detecting a leak at the earliest opportunity.

When used as a smoke alarm (TGS812 for this) then since smoke rises, the detector ought to be positioned on one wall about 1–2 feet from the ceiling. Cables can be hidden from view using attractive plastic conduit available for this purpose.

In terms of actual expenditure, the cost of the Four Channel Gas and Smoke Sentinel compares favourably with, say, the total cost of four commercially-available domestic smoke detectors at some £10–£15 each. The Sentinel however has the added attraction of being able to sense both gas *and* smoke.

FEATURES OF SYSTEM

The Gas and Smoke Sentinel has several advantageous features:

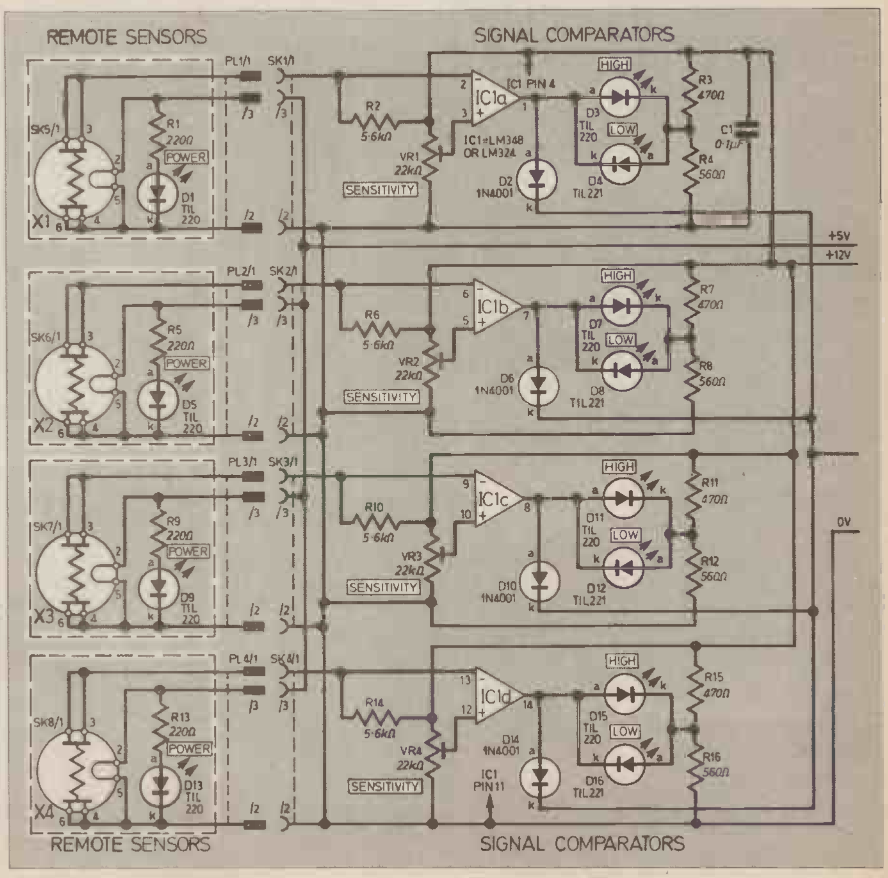
1. All controls and indicators have been brought together into one unit making the overall system very convenient to operate.
2. "Go-no-go" status monitors in the form of red and green lamps have been incorporated in each channel, giving a simple readout of the gas or smoke levels in all four locations.
3. External 12V alarms, whether lamps or buzzers, can be connected and extended to any convenient point.
4. It will respond to both smoke and gas: many readily-available units will detect smoke only.

Therefore, although there is the disadvantage that installation of this system may be a little trickier, since each sensor must be connected by 3-core cable, the many advantages which this design offers will more than compensate for any additional work involved.

CIRCUIT DESCRIPTION

Each of the four channels incorporated within the design is identical and the operation of channel number one will be described: the three remaining channels

Fig. 1. Circuit diagram of the Four-Channel Gas and Smoke Sentinel.



function in a similar manner. The circuit diagram appears in Fig. 1.

Each channel employs an operational amplifier, as in the original Gas Sentinel. Each op-amp is connected in the comparator mode, in which the op-amp compares the difference between the voltages at the non-inverting (+) input and the inverting (—) input.

If the potential at the + input is greater than that at the — input then the output swings high to roughly the same voltage as the positive supply rail. Similarly, if the voltages at both inputs should reverse, so that the non-inverting input is at a lower voltage than the inverting input, then the op-amp will greatly amplify this, the result being that the output swings from a high voltage to roughly zero volts.

OPEN-LOOP GAIN

The open-loop gain (the amplification factor of the op-amp without any feedback network being connected) is so high—usually too high to be of any use—that only a fraction of a millivolt difference need occur between the two inputs to make the op-amp output swing from one voltage to the other. The arrangement therefore is very sensitive.

Since four op-amps are of course needed, then rather than use four separate devices, one single package is employed, type LM348. This contains four general-purpose devices in one 14-pin d.i.l. outfit and is much more convenient to use.

Each op-amp has a selectable reference voltage derived from VR1 in channel one, VR2 in channel two, and so on, hooked up to the non-inverting input and this potentiometer can be adjusted to suit; in fact it forms the sensitivity control for each channel.

SPECIFICATION

POWER SUPPLY REQUIREMENTS
240V a.c. 24VA or 12V d.c. 1·5A maximum

NUMBER OF SENSORS
Four maximum

TYPE OF SENSORS
N-type Tin Oxide semiconductor resistance heated by internal 5V 130mA filament

SENSITIVE TO
Hydrocarbons (e.g. propane, butane)
Alcohols (e.g. ethanol)
Inorganic gases (e.g. carbon monoxide, hydrogen cyanide)
Smoke,
and others

ALARM SYSTEM
Built-in audible-warning device and l.e.d.; provision for externally-connected alarm

STATUS MONITORS
Red and green lamps continually illuminated to denote "status" of each channel (alarm level/normal)

AUTOMATIC WARM-UP TIMER
Disconnects alarm system for first 1½ minutes (approx.) immediately after switching on: prevents alarms from operating after power failure

The other input also has a voltage divider connected to it, this time in the form of a fixed resistor (R2) and a TGS sensor resistance element X1.

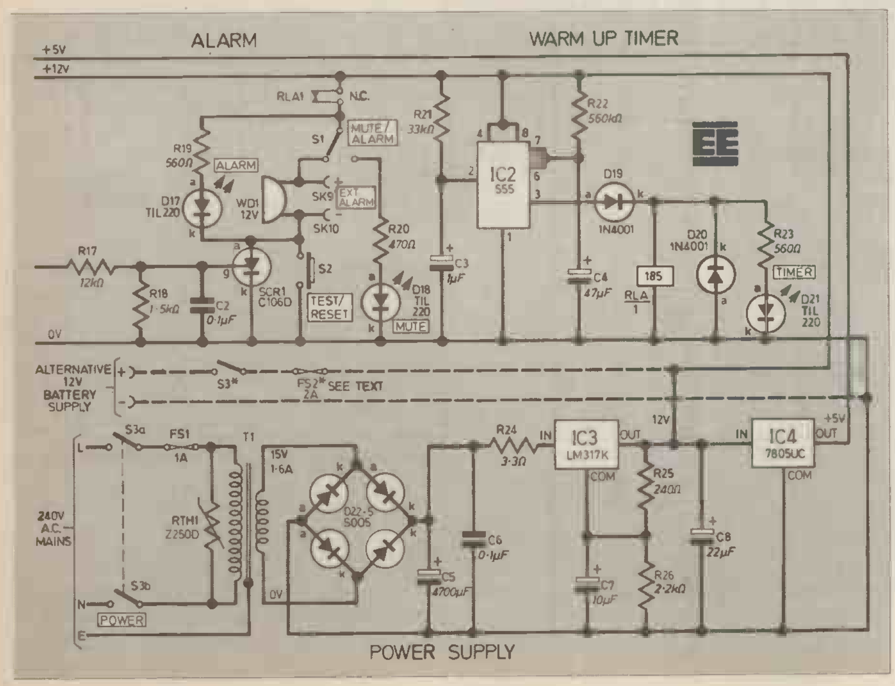
SENSING OPERATION

An increase in ambient gas levels around the TGS detector will bring about a reduction in the detector resistance and, by voltage divider action, means that the voltage at the inverting input (pin 2) of the op-amp will fall until such point when it is less than the voltage reference set up by VR1, when the op-amp output (pin 1) will switch high.

A red light-emitting diode, D3, is wired to the output—R4 being its series current-limit resistor—and this l.e.d. will illuminate to serve as an alarm indicator for channel one. Also a "high" triggering signal is transmitted through D2 and via the attenuator R17 and R18 to the gate terminal of the main alarm thyristor SCR1.

The thyristor is now able to conduct, and completes the circuit to the alarm buzzer WD1, which now sounds, and to the "alarm" indicator D17. An external alarm system (specification: 12V d.c. 500mA maximum current) can, if one wishes, be connected to SK9 (positive) and SK10 (negative), and this too will now operate. See "Application Notes" for further information on the external alarm.

Due to the continuous conducting action of SCR1, the alarm system will function until the gas level drops away again (D3 extinguishes) in which case it is possible to reset the alarm section either by temporarily removing the power or by closing S2, the alarm test/reset switch.



Note however, that once the thyristor is triggered, it *remains* in a conducting state until reset at S2; this in turn is only possible once the gas level has diminished, which will remove the constant triggering signal presented to the thyristor gate by the op-amp.

Also, when SCR1 is not conducting, the alarm circuitry will operate if S2 is closed—a useful "alarm test" function.

Until the gas level has dropped it is not possible to silence the alarm except by changing over S1, such that WD1 and any external alarms are removed from circuit. Then D18 (the "alarm mute" reminder lamp) will illuminate, although notice that the "alarm" l.e.d. D17 remains in circuit regardless of the setting of S1, and this will remind you whether the thyristor is conducting or not.

Triggering signals from channels two to four will be fed through diodes D6, D10 and D14, respectively into the thyristor gate attenuator as before.

STATUS INDICATORS

A further l.e.d. indicator has been added to each channel: the green lamp D4 lights when the gas level is "normal", that is, below a level determined by the setting of VR1. The green lamp will extinguish and the red lamp D3 will light when the op-amp output changes from low to high.

The coloured light-emitting diodes form a simple status monitor for each channel, green indicating "normal" and red "danger", and under normal conditions the operator will observe just a row of green lamps.

WARM UP TIMER

Each TGS sensor requires a brief warming-up period. When power is first applied to the TGS filament, the semiconductor resistance drops quite dramatically before rising back to its operating level. The Gas Sentinel would erroneously interpret this as an increase in the gas level and would therefore operate the alarm.

It is then necessary to silence the alarm during the warming-up period and this is achieved by IC2, an NE555 timer chip connected as a monostable. When power is first applied, IC2 is triggered into timing by R21 and C3, and commences timing, activating RLA. The normally-closed contacts RLA1 open and remove power from the whole alarm section for approximately $1\frac{1}{2}$ minutes, as measured on the prototype.

The red l.e.d., D21, lights when the 555 is timing and acts as a warm-up indicator; when the lamp extinguishes this signifies that the alarm system has been reconnected. By this time all four detectors should have warmed up and settled to their normal operating resistances.

This useful little timer section will also prevent the alarm from sounding after a power failure, since after resumption of power the sensor resistances could perhaps drop to a low level while warming up.

POWER SUPPLY SECTION

As each TGS filament demands some 150mA each at 5V d.c., it is necessary to substantially boost the original power supply section to enable it to supply this.

IC3 is an LM317K (TO-3 package) regulator set up by means of R25 and R26 to provide 12V d.c. at up to 1·5 amps. This is passed to the timer, op-amps and the alarm. IC4 further reduces the 12V to 5V d.c. regulated, and this feeds all four sensor filaments through pin 3 of the sensor DIN sockets.

It is essential that the regulators are adequately heatsinked for them to be able to cope with worst-case conditions, and the components list details the recommended heatsinks.

12V OPERATION

It should be possible to power the system from an external 12V d.c. supply as indicated in Fig. 1. Under quiescent conditions the complete system consumes roughly 800mA. A lead-acid battery will be able to supply this for fairly long periods before recharging is required, depending on the battery capacity, of course.

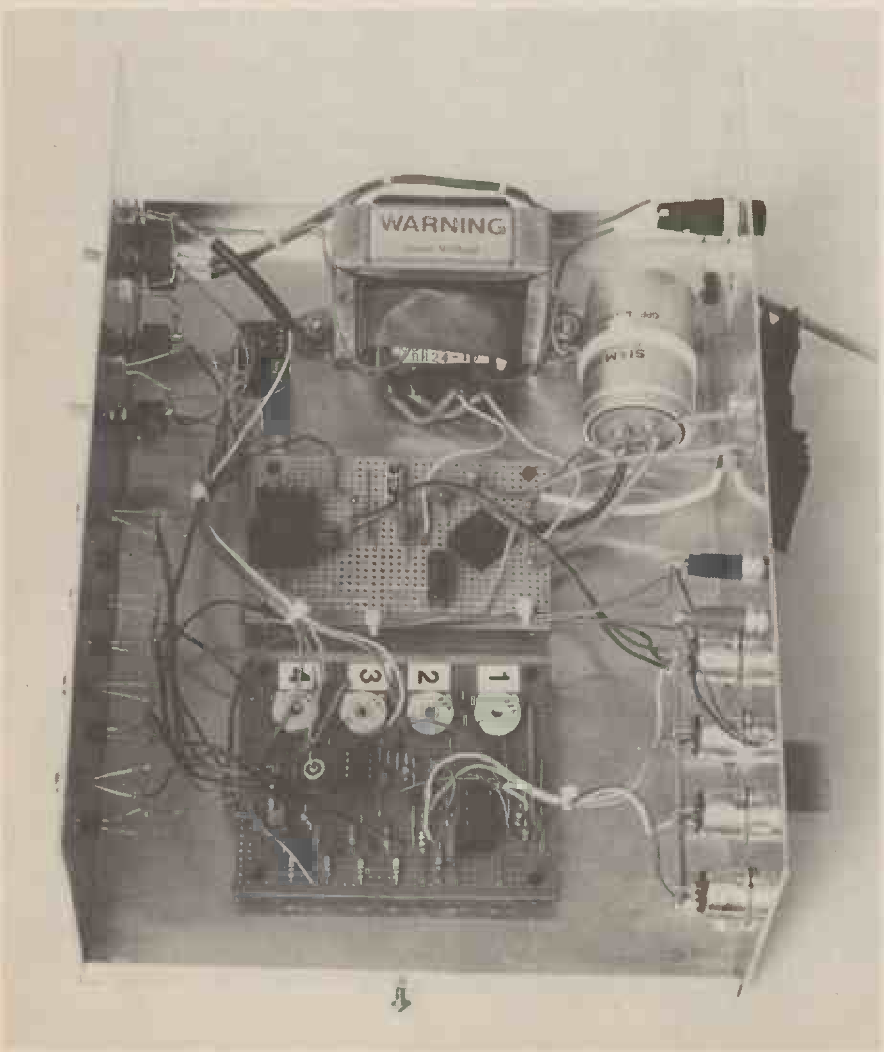
It is naturally essential that the battery is not completely discharged due to excessively long operating periods without being charged up again. A "low voltage" monitor could be incorporated to help prevent this, although such a device was not included on the prototype—there are enough lamps and switches already!

It is worth pointing out that the 12V battery-powered version can be built considerably cheaper than the mains-operated unit, since the expensive mains transformer and 12V regulator, amongst other items, can be dispensed with.

The necessary modifications required for a 12V operation are quite straightforward: simply omit all power supply components which are in circuit prior to IC4. A 12V d.c. input, therefore, should be taken through a single-pole on/off switch and 2-amp fuse directly to the input of IC2. C8 should be left in circuit.

REMOTE SENSOR UNIT

The remote sensor unit is connected by miniature 3-core wire to the master unit at a DIN plug and socket, SK1 and PL1. Cable length can exceed some 15 metres.



A visual indicator, D1, D5, D9, D13 is incorporated into the remote sensors to indicate the system is switched on, should the user happen to be able to glance at the sensor unit. The l.e.d. can be omitted if required.

CONSTRUCTION

The mains-powered model should be constructed in a metal case; that used on the prototype had an aluminium chassis for ease of working and measured 280 × 90 × 200mm. The battery-operated unit could be built into a much smaller case, possibly made of plastic.

There are no less than eleven light-emitting diodes and three switches to be mounted on the front panel. This may seem to be an excessive number and could be construed as overdoing things a little! However, with just a little planning in front panel layout it should be possible to arrive at a final design which is attractive in appearance and is easy to use.

The front panel, then, carries the three switches and eleven lamps. The light-emitting diodes can be fitted in with coloured lens-clips and if the recommended sub-miniature types are used the switches can be affixed through ¼in diameter holes.

POWER SUPPLY BOARD

Inside the main unit, two pieces of 0·1in matrix stripboard accommodate all the electronics. Firstly the power supply, with the exception of C1 and IC1, is assembled on a standard-sized stripboard of 24 strips × 37 holes, see Fig. 2.

The large smoothing capacitor, C5, is a "can" type and is fitted to the chassis with a horizontal mounting clip. Two flying leads should be made with 18 s.w.g. tinned copper wire insulated with pvc sleeving, and these connect C5 to the power supply board. The two wires should be kept as short as possible to keep their resistance to a minimum, and it is *essential* that the component is soldered the right way round in the circuit.

On the prototype the regulator IC4 was fixed, together with its heatsink, to the stripboard using a single 6BA bolt—no insulating kit is required for the regulator.

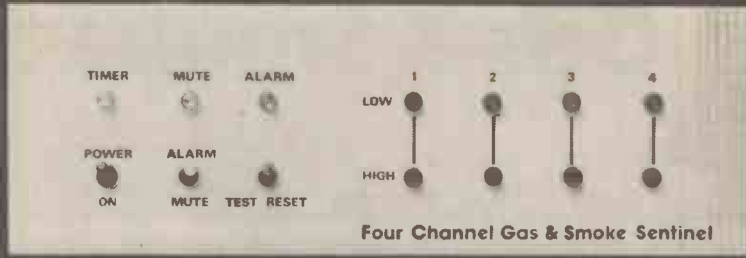
On the other hand the LM317K regulator, IC3, must be fully insulated from the chassis with a standard TO-3 insulating kit, comprising a mica washer and two bushes for the mounting bolts.

The only other point on the power board is that the wirewound resistor R24 should not be soldered flush with the stripboard, but should be stood off approximately 1cm, to enable it to dissipate heat more efficiently.

MAIN COMPONENT BOARD

The other stripboard is of dimensions 30 strips × 37 holes, 0·1in matrix. This carries the remainder of the electronics,

COMPONENTS



Resistors

R1	220Ω
R2	5·6kΩ
R3	470Ω
R4	560Ω
R5	220Ω
R6	5·6kΩ
R7	470Ω
R8	560Ω
R9	220Ω
R10	5·6kΩ
R11	470Ω
R12	560Ω
R13	220Ω
R14	5·6kΩ
R15	470Ω
R16	560Ω
R17	12kΩ
R18	1·5kΩ
R19	560Ω
R20	470Ω
R21	33kΩ
R22	560kΩ
R23	560Ω
R24	3·3Ω 7W w.w.
R25	240Ω
R26	2·2kΩ

All ¼W 5% carbon, except R24

Potentiometers

VR1–4	22kΩ horizontal skeleton preset (4 off)

Capacitors

C1	0·1µF polyester
C2	0·1µF ceramic tube
C3	1µF 35V tantalum bead
C4	47µF 25V elect.
C5	4700µF 40V elect.
C6	0·1µF polyester
C7	10µF 35V tantalum bead
C8	22µF 25V elect.

Semiconductors

D1,5,9,13	TIL220 0·2in red l.e.d. (4 off)
D2,6,10,14	1N4001 50 PIV 1A silicon diode (4 off)
D3,7,11,15	TIL220 0·2in red l.e.d. (4 off)
D4,8,12,16	TIL221 0·2in green l.e.d. (4 off)
D17	TIL220 0·2in red l.e.d.
D18	TIL223 0·2in yellow l.e.d.
D19,20	1N4001 50 PIV 1A silicon diode (2 off)
D21	TIL220 0·2in red l.e.d.
D22,23,24,25	S005 50 PIV 2A bridge rectifier
IC1	LM348 or LM324 quad op-amp
IC2	NE555V timer
IC3	LM317K 1·5A variable regulator, TO-3 pack
IC4	7805UC 5V 1A regulator, TO-220 pack
SCR1	C106D 4A thyristor

Switches

S1	sub-miniature s.p.d.t. toggle
S2	sub-miniature s.p.d.t. toggle, biased one way
S3	sub-miniature d.p.d.t. toggle 2A 250V a.c.

Connectors

PL1–4	3-pin DIN plug (4 off)
SK1–4	3-pin DIN socket (4 off)
SK5–8	TGS socket (4 off)
SK9,10	4mm, one red, one black (2 off)

Miscellaneous

FS1	1A 20mm panel fuseholder/quick-blow fuse
RLA	12V 185 ohm continental relay
T1	mains transformer, 240V primary, 2×15V 800mA secondaries (ITT BR24-15)
WD1	9V–12V 15mA audible warning device
X1–4	TGS812 or TGS813 low-voltage gas sensor (4 off)

0·1in matrix stripboard: one each, and 24 strips × 37 holes and 30 strips × 37 holes; instrument case "NORMAN" type 280 × 90 × 200mm; Verobox type 20124, 72 × 47 × 25mm (4 off); TO-220 heatsink TV5 drilled offset 17°C/W or better; 2Y-TO3 heatsink (Redpoint) 6·2°C/W or better (ElectroValue); TO-3 insulation kit; red lens clips (8 off); green l.e.d. lens clips (4 off); transparent l.e.d. lens clips (3 off); horizontal capacitor clip to fit C1; 8-pin d.i.l. socket; 14-pin d.i.l. socket; mains 6A 3-core cable; miniature 3-core cable, to suit; hook up wire, nuts, bolts, spacers, solder etc.

Gas & Smoke Sentinel

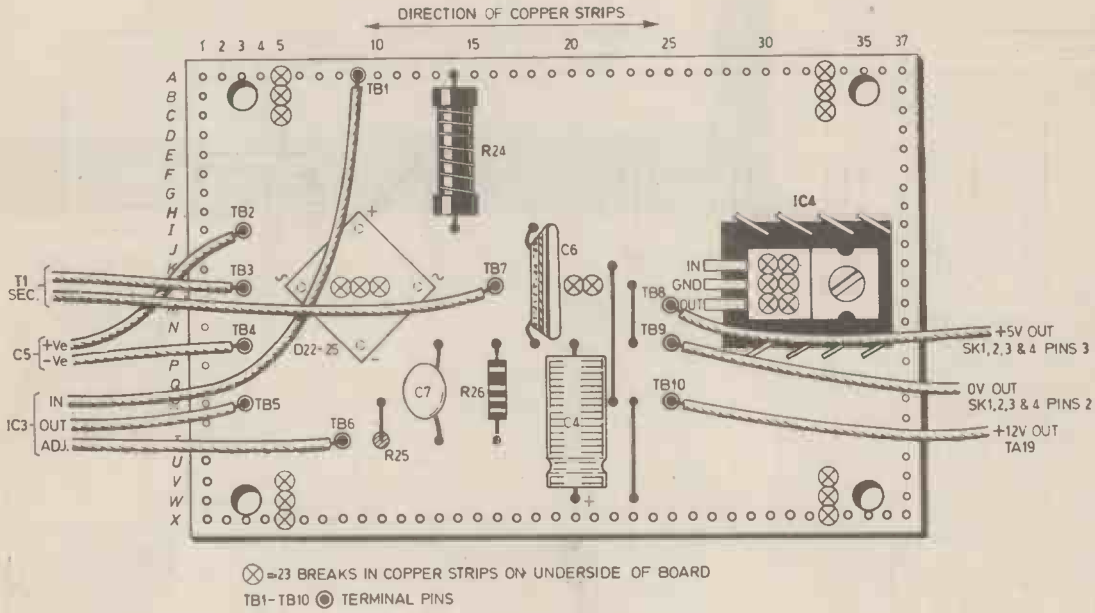
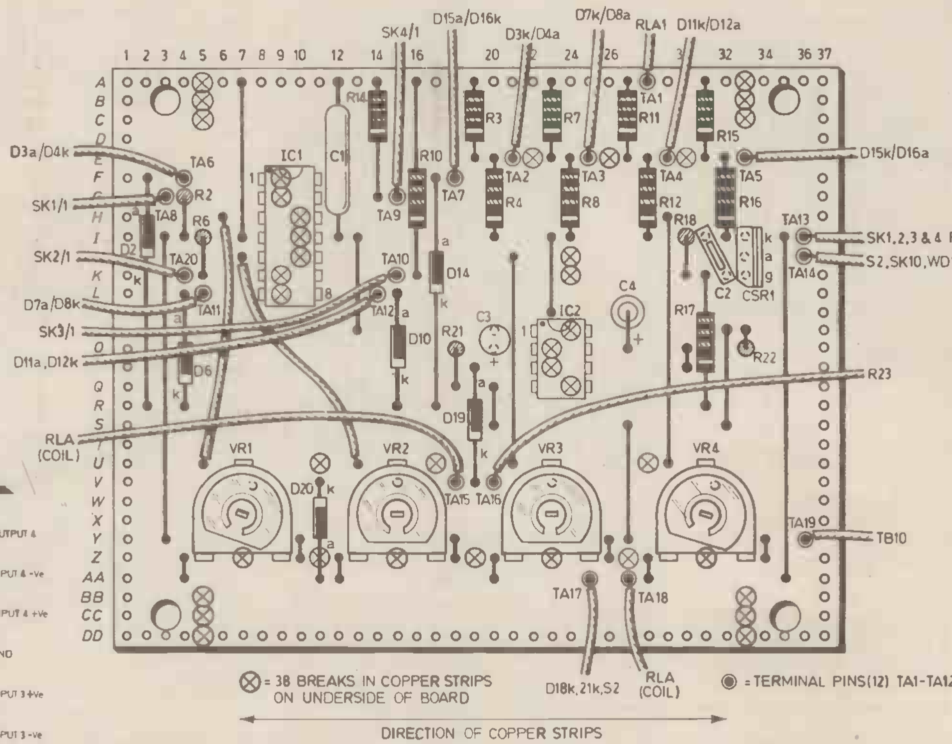


Fig. 2. Power supply board.



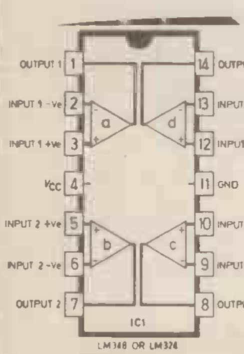


Fig. 3. Main component board.

Gas & Smoke Sentinel

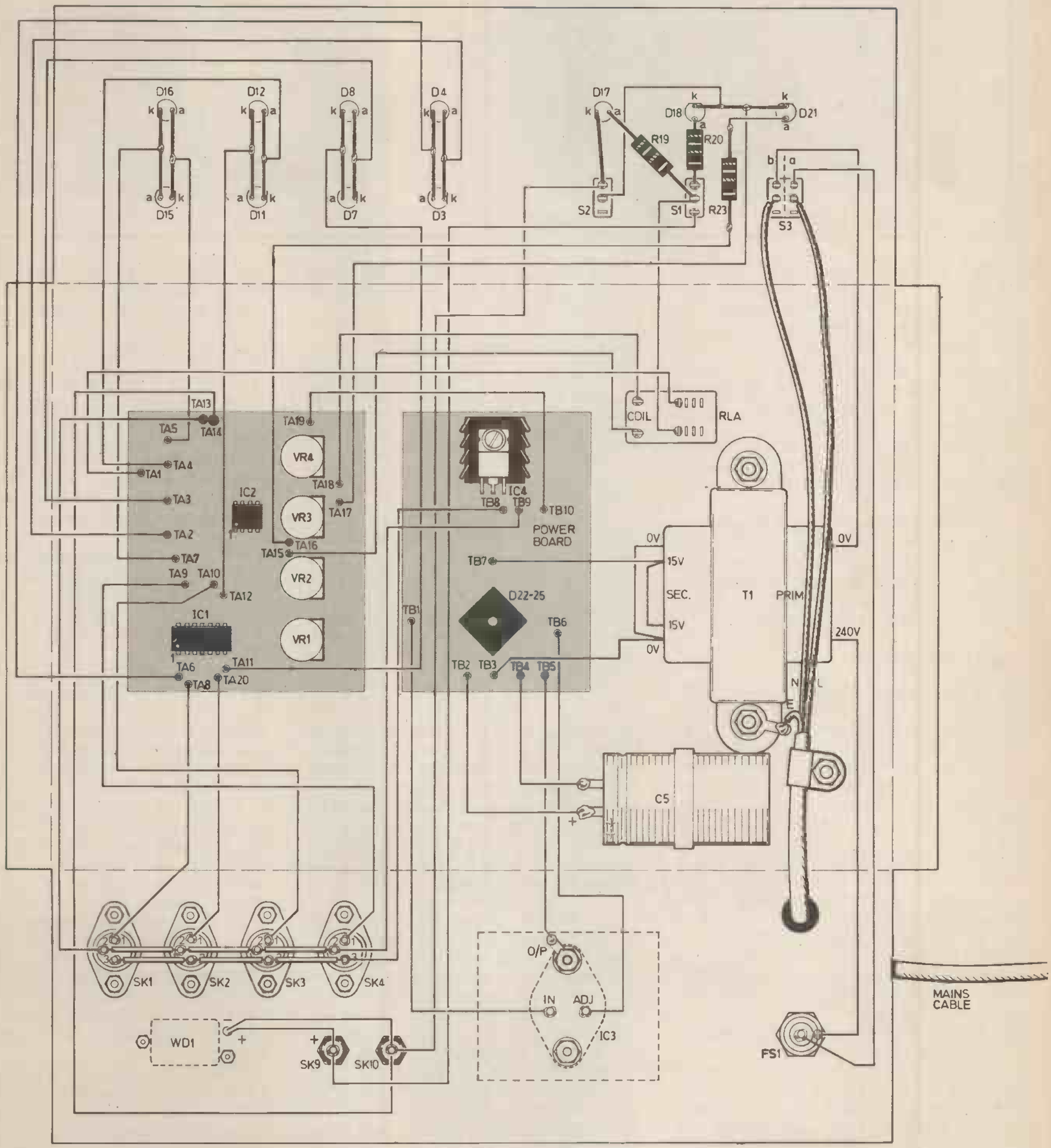


Fig. 4. Interwiring between the two boards and the chassis-mounted components.

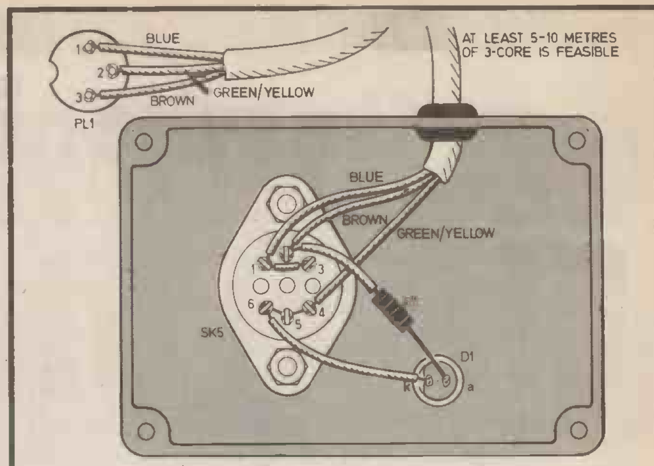


Fig. 5. Sensor unit assembly and wiring details.

including the four sensitivity controls. Assembly of this should be straightforward. Fig. 3 illustrates the layout used in the prototype but this is not critical.

Use d.i.l. sockets to carry the two integrated circuits in order that the devices will not be heated excessively during soldering. Also, it will be best to solder in the four preset potentiometers last of all, as this will enable you to insert the adjacent tinned copper jumper wires with little difficulty.

The relay RLA can simply be glued or stuck upside down to the chassis floor. When connecting the relay up, take extra care not to heat the relay contacts too much, since the plastic base into which they are moulded will melt quite easily.

INTERWIRING

Except where stated, all interwiring can be fabricated from standard pvc-insulated stranded-core hook-up wire. Use as many different colours as possible since there are rather a lot of interconnections to be made, and the use of colour-coded wires will speed up any checking that must be performed prior to switching on.

Mains wiring of course requires that a heavier-duty cable be used and for this the author recommends a rating of 6A wire, 24/0·2mm gauge. If *too thick* a wire is used, however, it will be impossible to make a safe soldered connection to the rather small solder tags on the rear of S3. Fig. 4 gives all interwiring details, and should be followed closely.

Note that the two secondary windings on T1 are wired in parallel.

It is important that the metal case (if used) is soundly earthed. This is achieved by soldering the earth input to a solder tag of appropriate size, and placing this under one of the transformer mounting bolts. It is further essential that the cable passes through a grommet in the rear panel and is secured properly with a nylon "P" clip or other cable strain relief clip. *This is most important.*

You may probably want to label the switches and lamps on the front panel, in which case use rub-down lettering which is then protected with a few coats of lacquer.

REMOTE SENSOR UNITS

Assembly of the remotely-located sensor units is illustrated in Fig. 5 and should be straightforward. The TGS units can be plugged either way round into their sockets once construction is complete.

TESTING AND SETTING UP

After having completed the not inconsiderable job of building this project it is wise to check out most thoroughly all of the system prior to switching on. Having done this, plug the four remote sensors into their respective DIN sockets on the main unit, set the four sensitivity controls to their midway positions and then apply the power.

On the front panel the "TIMING" l.e.d. (D21) should light and the four green status monitors should be glowing. Shortly afterwards the status monitors will temporarily change to red, although not necessarily simultaneously, and eventually revert to green. This is a correct indication that the sensors are warming up.

Once the timing l.e.d. extinguishes (you may hear the relay click out) then it is a matter of ensuring that all the switches and l.e.d.s function correctly.

It is possible to perform a simple test on the detectors by simply dampening a cotton-wool swab with some lighter fuel (for example) and then place this next to a particular TGS sensor. The vapour from the lighter fuel should cause the appropriate status lamps to change and the alarm should hopefully also function.

The setting-up procedure for each channel is rather a trial and error affair (to be expected in a simple circuit such as this) and consists of adjusting each preset over a period of about a week or more. The objective is to attain maximum sensitivity without there being any false alarms generated by cigarette smoke or similar.

The author's own tests showed that a control setting position for the preset potentiometers of $\frac{1}{4}$ to $\frac{1}{3}$ from the fully clockwise position produced a response time of 2 to 3 seconds in a steady stream of not-too-dense smoke.

APPLICATION NOTES

There are a few things to watch when positioning the four remote sensors. Firstly, many types of gases are heavier than air and will initially accumulate in pockets at floor level. It is best to position each sensor about 45–60cm above ground level, but in any case, where you think pockets of escaping gas may first gather.

Smoke, on the other hand, rises to the ceiling first; you may then have to compromise a little with the fixing points of the detectors to enable the system to sense both smoke and gas as effectively as possible.

Keep the TGS pick-ups away from sources of direct heat (engines, radiators, etc.) and steam or other excessive humidity. Also it is obviously important that they are not placed where they would continuously be knocked by passers-by or otherwise mechanically damaged.

If considering employing an external alarm unit connected to SK9 and SK10, then for maximum safety a spark-proof device should be used to avoid the risk of ignition if dense accumulations of gas should build up. This rules out electro-mechanical bells and buzzers: a device such as the author's "Siren Module" (EVERYDAY ELECTRONICS, January 1982) would be ideal in this application. Alternatively, a piezo-electric horn sounder such as Maplin Electronics XQ71N could be employed, as this appears to be spark-proof.

Finally, two types of low-voltage TGS detectors are available. The TGS812 is slightly more suited to being a smoke alarm as it is somewhat more sensitive to carbon monoxide. However, the TGS813 responds more desirably to hydrocarbons like butane and propane. It has a lower sensitivity to carbon monoxide—and smoke therefore—and so there is slightly less chance of causing a false alarm with cigarette smoke. If you cannot decide which type, then opt for the TGS813. □

Economical Electronics

BY L. J. STEAN

Reclaiming components from unserviceable or discarded consumer equipments can be a rewarding exercise, especially where time is not a consideration. Those with extended leisure, from whatever cause, should find this article particularly interesting and helpful.

IT CANNOT be denied that, in the present recession, substantial numbers of men and women are without regular full-time employment and this situation looks likely to be with us for some considerable time. For these people the problem of how to use their increased leisure time constructively may be met in a variety of different ways. Some may wish to pursue an interest in electronics at home, but may be dissuaded by the amount of money that this seems likely to involve.

The purpose of this article is to demonstrate that, by using some ingenuity, many projects may be undertaken and a substantial home workshop may be built up with a surprisingly small cash outlay. It must be acknowledged from the start that one may spend almost as much time dismantling equipment as in constructing it and therefore this article is principally aimed at those who have ample time to spare for this fascinating hobby.

A person who is starting from scratch will need to purchase a soldering iron and a reasonable multimeter. The latter may be the only item of test equipment that one will ever need to buy as other items can be constructed at home as required.

This magazine is not alone in providing constructional data for a variety of test equipment ranging from simple multivibrator signal injectors to a sophisticated oscilloscope. There are, of course, many good designs for home built multimeters but unless every component is carefully checked (and this will necessitate the use of another multimeter) or bought new, this will not be found to be worthwhile.

A good selection of screwdrivers, small spanners, pliers and wire cutters will be helpful when dismantling equipment and it will soon become apparent which hand tools are the most helpful in these applications. A desoldering pump (or solder wick) is a definite recommendation in helping to alleviate the "frizzled finger/frizzled component" syndrome.

DISMANTLING P.C.B.S

Desoldering components from printed circuit boards is a time consuming affair but the following observations may be of some help.

Use the desoldering pump first to clear most of the solder away from the joint. Then insert a small screwdriver between the component and the board and gently lever it up while applying the soldering iron to the joint.

Long-nosed pliers may be used to grip the component lead on one side of the board while the iron is applied to the joint on the other surface, see Fig. 1.

As well as assisting with the separating process the pliers or screwdriver acts as a heatsink and minimises damage to the component.

A vice or a small fixed clamp can be of inestimable value in holding the board steady while these operations are carried out. Plasticine may be (quite literally) pressed into service as a substitute.

REDUNDANT CONSUMER EQUIPMENT

Many commercially produced items of consumer equipment are available very cheaply, or indeed, free. It can be surprising how many offers will be forthcoming from friends and relatives when your needs are made known.

Transistor radios, cassettes and record-players that have become faulty and may be beyond economic repair will probably come your way accompanied often by a comment such as: "Oh, I'm glad it's of use to someone, I would have thrown it away otherwise." These items are often very useful acquisitions.

Those of American or British origin contain transistors and integrated circuits of the most common types often used in projects featured in this magazine. Components from the Far-East may in many cases be related to their Western counterparts by reference to a transistor equivalents book.

Other useful sources of supply are markets and jumble sales. There are also many shops (some of whom advertise in these pages) which specialise in offering cheap panels and components. In the case of ex-computer panels one may be sure that the components are manufactured to very high standards.

I have found some difficulty in identifying the characteristics of some of the solid-state devices used in these panels with unfamiliar type numbers. Perseverance with different equivalents' books may yield results. Alternatively some operational parameters (such as h_{FE} in transistors) can be easily ascertained with suitable test equipment.

It is possible to collect many pounds worth of components and ancillaries from old consumer equipment ranging from switches to integrated circuits (and even the odd three-pin plug if you are lucky); but it behoves me here to mention two guiding principles—organisation and discrimination.

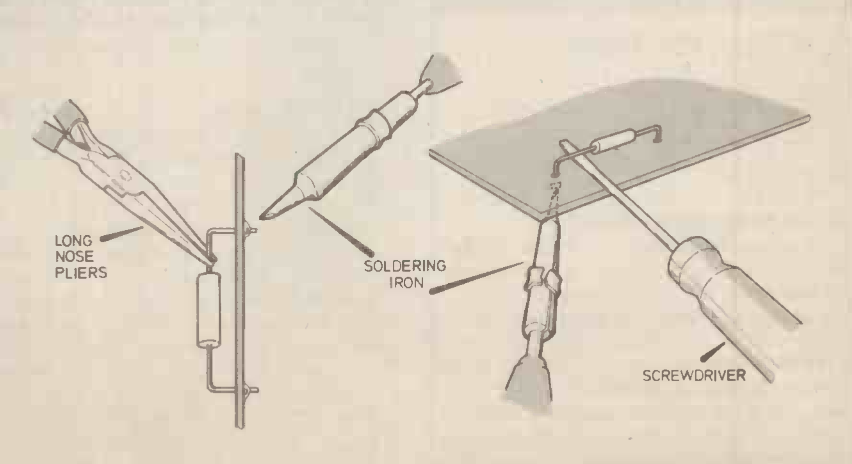


Fig. 1. Removal of components from printed circuit board.

COMPONENT STORAGE

It is a good idea to organise parts into separate storage facilities from the start, otherwise one becomes overwhelmed by boxes of assorted resistors, capacitors, jack sockets, connectors and neons—and of course it becomes a major undertaking to find the exact part you need when constructing a project. It is most annoying to go out and buy an expensive new component only to find later that it was "in the drawer" all the time. Old tobacco tins, glass jars and even egg boxes can all serve a useful purpose when storage of components is a consideration.

Discrimination is acquired by practice. Low wattage resistors are very cheap and easy to obtain new with long leads (and how these become prized) and it may not be considered worthwhile spending time disengaging these from their panels.

VALVE EQUIPMENT

One must also bear in mind that older equipment is liable to contain components from the valve era that are too large to use successfully when constructing a solid-state board and these components may have also deteriorated with age (particularly electrolytic capacitors).

It may be thought that the acquisition of valve equipment is of questionable value unless one is a valve enthusiast. This is true up to a point. Many components will be much larger than their present day counterparts and designed for use at high voltages. However, knobs, switches and connecting wire may all be found to be useful.

OLD TV SETS

Faulty TV receivers are often available from jumble sales and other sources. They are amongst the most highly complex items of equipment commonly available on the open market and can provide a host of useful components and ancillaries.

Before attempting to dismantle a television however, certain precautions should be observed. The cathode-ray tube may hold a charge of many thousands of volts even if the set has been standing for some time. To avoid the possibility of a nasty jolt use a long metal screwdriver with an insulated handle and touch it to the grey or black coating (aquadag) on the rear of the tube, letting the screwdriver rest against the metal chassis at the same time.

Do the same to the tags of any large electrolytic capacitor. The screwdriver provides a conductive path for any charge to run to earth and the apparatus should then be safe to handle.

Always take great care when handling c.r.t.s. because of the risk of tube implosion and the associated dangers of flying glass.

The wooden cabinets of older televisions are generally made of panels of veneered plywood. These may be carefully disassembled (often with an astounding yield of woodscrews) and shaped to make attractive cases for home built equipment.

LAYOUT AND DESIGN

The use of one's ingenuity becomes an integral part of this general approach towards the study of electronics. Many components and ancillaries may have larger dimensions than those specified in constructional articles although electrically they may be perfectly adequate. Therefore changes in board and case design are often necessary. The item may take longer to construct but the benefit is an increased appreciation of the principles of layout and design.

A wealth of knowledge on such matters as case design and construction, and circuit layout, can be obtained by careful study of the innards of professionally designed equipment.

TEST EQUIPMENT

Adopting a policy of constructing test equipment has the advantage that one can test components before using them in other designs. Audio and r.f. generators, transistors and diode checkers, capacitance meters and many variable power packs have all been built largely from reclaimed components by the author and have proved their worth.

It is usually found that one ends up having to buy a few components from the shops in order to complete a project. For example, an item such as the R53 thermistor, often used in Wien bridge designs for audio generators, is unlikely to be encountered in commercial equipment.

It is usually necessary to purchase a new circuit board. Modifying an existing printed circuit board stripped of components to take a new design has been attempted successfully by the author but the amount of time spent was such that this technique cannot wholeheartedly be recommended except as an exercise in "making do."

CONCLUSION

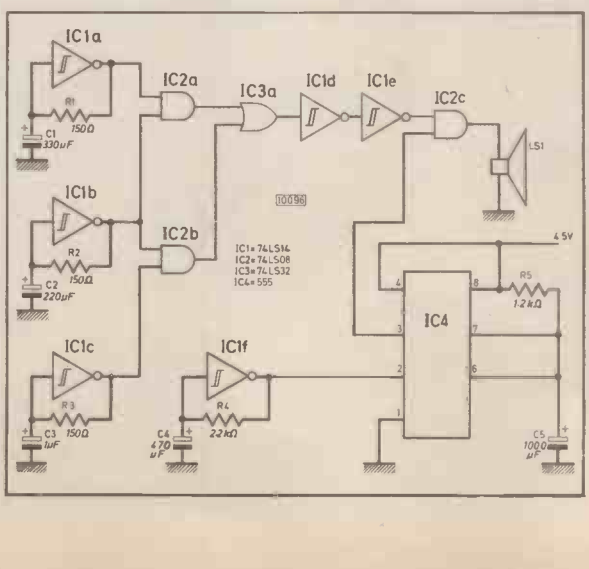
In putting forward the principles behind this approach to electronics my hope is to indicate how an ostensibly negative situation may be turned into a positive one.

Those who are in full-time work have a limited amount of time to spend on a hobby and buying new components in the normal way will have obvious advantages for them. However, "time is money" is an oft quoted truism and when unemployment is a factor, lack of money is balanced by an increase in leisure time.

This time can be turned to good account by using one's own resourcefulness to explore the world of electronics—a venture satisfying by itself and which may ultimately even provide the starting point for a new career. □

TRIMPHONE CHIRP

GATES IC1a and IC1c plus their associated components form two Schmitt trigger oscillators that act as the tone generators. IC1b, IC2a, IC2b and IC3a form a "pseudo mixer", mixing the two tones together. IC1d and IC1e buffer the resultant signal.



IC4 is connected as a monostable, which is "clocked" by yet another Schmitt trigger oscillator, this one constructed from IC1f, R4 and C4. The monostable gates the tone to the speaker thus producing a high pitched "burr-burr" sound similar to a trimphone.

By connecting the input to the speaker, to an amplifier, a suitable level of signal will be obtained to use the circuit as a doorbell. Imagine the confusion!

M. P. J. Ruddy,
Chorlton-cum-Hardy,
Manchester.

COUNTER INTELLIGENCE

BY PAUL YOUNG

Better Informed

Being by nature a contrary cuss, Paul Young always insists that the January issue is the Christmas number. Of course, he is going to be caught out one day when the January issue actually appears in January.

Ah! well, back to my brief which is to entertain inform and elevate. Let's face it, my column wouldn't elevate a cow but keep it to yourselves kind readers, I wouldn't like it to get back to the Editor.

Inform, whenever I hear that word I am reminded of the not very bright judge, who after an eminent barrister had given him a lucid explanation, turned to him and said: "Thank you Mr. 'X', but I am afraid I am none the wiser". To which the learned gentleman replied: "I regret My Lord that you are none the wiser, but at least you are better informed."

Having said all that, I will only add, that being Christmas calls for a lighter approach, which means accent on the entertainment.

Russian Chauffeur

Thinking back on the more humorous aspects of retailing, I call to mind one, just after the war. It was a week or two before Christmas and a large shiny black limousine pulled up outside our shop. It had a small red flag on the bonnet bearing a hammer and sickle.

In marched a uniformed chauffeur, a hammer and sickle badge on his cap. He saluted, bowed and said: "Seven lamp Philips?"

Radio sets in those days were like gold dust, but we had recently taken delivery of a large Philips mains set and remembering that the Russians were our gallant allies, we demonstrated it. The chauffeur stood and watched impassively.

When we had finished he merely said: "Seven lamp Philips?" Actually it only had six valves, but if you included the "Magic Eye" (a valve which gave a visual indication of correct tuning) it had seven.

So, with our hands on our hearts, and not really feeling guilty of deception, we replied: "Yes, seven lamp Philips". The chauffeur gave us his roubles and departed happily.

The sequel was not quite so satisfactory. Three months later he appeared again with the same request. By good fortune we had an identical model which we produced.

He looked at it and said: "Not seven lamp". We removed the back, and he counted the valves. "Not seven lamp," he repeated.

As our total command of Russian consisted of "Da" "Nyet" and "Pravda" and as the chauffeur could have played a "Heavy" in a *B*-type movie, or doubled as a night-club bouncer, we thought it best to avoid altercation. The chauffeur then marched out of the shop no doubt muttering to himself, "unscrupulous capitalists"

What is a Computer?

While I was cogitating on the tricky question of "What is a Computer?" I suddenly remembered a famous radio programme called "The Brains Trust". Those of you who are old enough to remember it, may remember the splendid answer that was given to the question: "What is a Poltergeist?" Back came the answer: "Any Geist which Polters".

A very funny answer, but applied to computers it might not be so far out. We therefore finish up with the answer, "anything that computes". Using that as my yardstick, I next asked myself, "how old are computers?" and now the answers become interesting.

The following week I was glancing at the *Radio Times* when I spotted a programme entitled: "Queen Nefertiti and the Computers". My imagination immediately went into top gear as I tried to visualise the world's most beautiful woman busy tapping away on her Spectrum.

Although it was an absorbing programme it was different from what I had expected. It was about an American professor who found an Egyptian temple at Karnak.

It had been razed to the ground; just thousands of stone blocks including a huge mural. By numbering and describing each stone, he was able to feed the results into his computer, and the computer was able to show him exactly how it should be erected.

Even so, Gerald Hawkins estimates that the Egyptians were well into computers, used for the purpose of celestial forecasting. Queen Nefertiti and King Akhnaton lived around 1400 BC.

This was a start, although I was certain we could go back much further, and I referred to Gerald Hawkins' book, "Beyond Stonehenge". He established beyond reasonable doubt that Stonehenge was a computer designed to forecast different phases of the Sun and Moon. Radio carbon dating puts the age of Stonehenge around 2000 BC.

It was during my search into the antiquity of computers that I suddenly thought of the Abacus. There may be a few readers who have never heard of the word, in which case I will level with you.

The only reason I know it, is this. Many years ago, when my father had a minor position in the Russian Trade Mission, he told me that when new Russian staff arrived they were given a booklet entitled: "A 1000 of the most common English words". And the first word on the list was, you've guessed it ABACUS!!! No wonder the East and West cannot communicate!

It is a wire frame with wooden beads, used for counting, used in Russia, China and certain parts of Europe. I find on further delving they were used by the Chinese as long ago as 6000 BC.

Finally, I come back to the thought that the first and finest computer is the human brain, which precedes all these artifacts by several million years.

Lighting Meter Readers

I was wondering if any of our readers can enlighten me on the following. As a consumer, who seems to be paying for lighting the entire street, I always watch the gentleman who reads our meters with great interest. He darts into the cupboard under the stairs with his torch and is out again in five seconds flat.

If I happen to be out, he leaves a card for me to read my own meter. The card has about six dials marked 0-10 to match the meter. Three are numbered clockwise and three are numbered anticlockwise.

Naturally I am inexpert, and it takes me at least six to seven minutes, but I defy anyone to match the speed of these chaps from the board. What is their secret?

Happy New Year.

SIMPLE COMPARATOR VOLTMETER

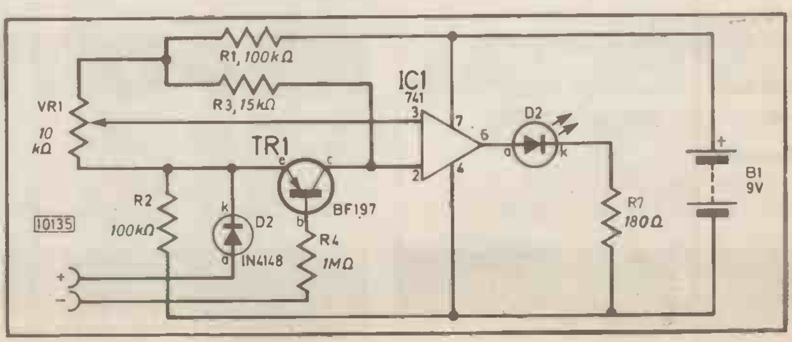
This circuit can measure up to about 15V and takes only a few milliamps from its 9V battery. The input has a diode to protect it from reversed polarity and an impedance of more than 1MΩ.

The heart of the circuit is the 741 op-amp in its comparator state. As the voltage across the emitter to base junction of TR1 gets bigger, the resistance between its collector and emitter gets smaller, so the voltage at pin 2 of IC1 becomes larger.

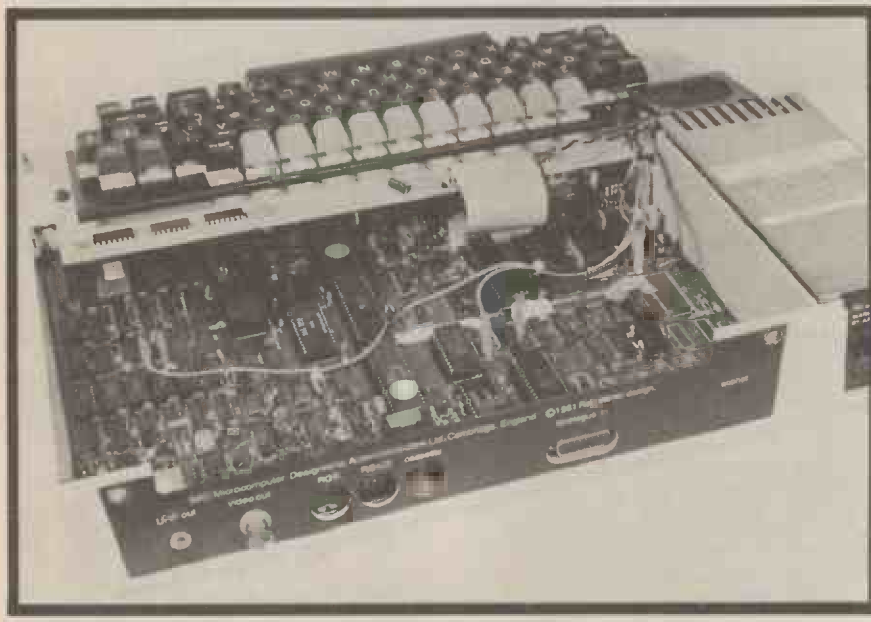
This means the wiper of VR1 has to be made more negative to keep pin 3 of IC1 at the same voltage as pin 2, and thus just switch off the l.e.d. Using known voltage sources, a calibrated scale can be drawn around VR1.

This voltmeter is definitely not suitable for use on mains voltage.

M. Pocock, Taunton, Somerset.



SPECIAL REPORT
BBC MICROCOM



The attractively packaged BBC model B Microcomputer and, below, a view with the top half of the case removed showing the rear panel-mounted connectors and the sophisticated printed circuit board assembly.

DESPITE being at the top of the price-range for home computers, the BBC Microcomputer model B has consistently been among the best-sellers. This could be partially due to the TV series in which it was prominently featured, and the use of "BBC" in its name, but its very full specification, and the BASIC language it uses (possibly the most powerful implementation of this language available to date) are probably the main reasons.

BBC BASIC

BBC BASIC is the first implementation of this language to allow full procedure handling. Procedures can be thought of as a more advanced form of subroutine, called by name rather than by line number, and with the big advantage that variables within the procedure can be declared "local", so that they cannot be used or changed by the rest of the program. Parameters can also be passed to a procedure in the same way that they are passed to user-defined functions found in other BASICS.

Functions in BBC BASIC are also more powerful than in most other BASICS, in that they can take more than one line, and include any BASIC statement.

Functions and procedures have the additional advantage that they execute faster than subroutines, especially if use is made of local variables.

The BBC computer also provides easy access to control of many of the computer's special effects, such as the rate of flashing colours, the keyboard auto-repeat delay and repeat rate, by *FX calls. These allow such things as flushing input/output buffers. This gives the programmer a very great deal of control of the computer without having to resort to PEEKs and POKEs.

ASSEMBLER

The BBC computer also has a built-in assembler for standard 6502 mnemonics. This is a particularly powerful assembler. There is a special version of the DIM statement that allows a block of memory to be reserved for the assembled machine code, and it is particularly easy to mix BASIC and assembly language in programs. Assembly language also has easy access to all the graphics and I/O routines used by BASIC.

Creation of data files is also a strong point, even in a "cassette environment", as the manual quaintly puts it! Most of the file handling statements usually available only to disc systems, such as OPEN#, CLOSE#, PRINT# and INPUT# are implemented also in the cassette system.

GRAPHICS

Seven display modes are provided, with varying resolutions and numbers of colours available, and using varying amounts of memory from 1K to 20K. Highest resolution is 640 × 256, with two colours only and 80 columns of text. Lowest resolution is 160 × 256, with 20 columns of text. (Text and graphics can be freely mixed in all graphics-supporting modes).

There are also three text-only modes, but one of these, mode 7, is a serial-attribute mode with teletext-style (and compatible) alpha-mosaic graphics. This mode allows 16 colours and 40 × 25 text, but uses only 1K of memory, making it useful for data-handling applications.

The graphics commands are comprehensive and flexible. MOVE moves the cursor to an absolute position on the screen, DRAW draws a vector from the current cursor position to the absolute position in the DRAW statement.

This method of specifying absolute co-ordinates is much easier to use than the method of relative co-ordinates used by Sinclair and Oric (among others). However, relative co-ordinates are also allowed for in the PLOT command, which also provides dotted lines, and the ability to plot and fill triangles with colour. All this allows very impressive graphics displays. There is, however, no simple CIRCLE command.

VDU STATEMENTS

The computer also has a range of VDU drivers, used for such things as defining text and graphics "windows" (that is, confining the text and graphics displays to specified areas of the screen), defining user-defined characters, and some aspects of colour control. Thus, in a four-colour mode like mode 1, although the "default" colours are black, white, yellow and red you can in fact have any four of the sixteen colours (eight steady and eight flashing) you wish.

In fact, all graphics statements can be encoded as VDU statements, with the advantage that they execute much faster, but you have to be more careful not to make errors, as to do so can be disastrous!

The VDU statement also provides for text to be written at the graphics cursor—useful on the one hand for smoothly-animated games, and on the other for exact positioning of labels on graphs and charts.

The GCOL statement which specifies the graphics colours allows the colour either to be plotted as specified, or ANDed, ORed, or EORed with the colour already there. This is a little hard to grasp, but it is invaluable in animation, as it allows a moving character to be able to pass in front of some "objects" on the screen and behind others for pseudo-3D effects. It is also very useful in graph plotting, to determine which of multiple traces appear "on top".

The actual colour quality is very good, with clean, bright colours, a steady display, and very little tendency to "weave", or for colours to spread at borders. On a black-and-white set, the colours appear as well-separated shades of grey.

INTERFACES

There is no shortage of plugs and sockets on this computer, and on the rear panel there are outputs for a TV set (colour or black and white), a colour monitor, and a monochrome monitor. Also on the rear of the machine is an RS423 interface (which is compatible with RS232 equipment such as some printers and modems), and a four channel analogue-to-digital converter.

The latter is a 12-bit type, although due to problems with noise it does not have guaranteed 12-bit accuracy. The fastest sampling rate is only once every 10ms, and as there is just one converter plus a four channel multiplexer the sample rate is reduced to once every 40ms per channel if all four are used.

Despite these limitations the analogue port is very useful indeed, and can be used for more complex and interesting add-ons than simple games, paddles, or joysticks.

There is just one other socket on the rear of the machine, and this is the cassette interface (which includes two motor control terminals). In early models of the computer there was a bug in the EPROM which corrupted data as it was being SAVEd. This gave the cassette interface a bad name which it does not deserve. I have had no problems at all, either with programs or data files, which could be blamed on the computer.

CONNECTORS

There are no less than six more connectors on the underside of the machine, although the disc drive interface is an optional extra, and on the standard model B the disc connector is unconnected internally.

The Tube enables a second processor to be added, which gives increased operating speed and extra memory (plus CP/M compatibility with the Z80 version).

The parallel printer port enables the machine to operate with a wide range of printers, and it seems to be free of bugs. It can also be used as eight output lines plus two handshake lines.

The user port gives eight lines which are individually programmable as inputs or outputs, plus two versatile handshake lines. With this port and the analogue port it is very easy to add a simple temperature interface or something of this type to the computer, and make it an attractive proposition for the DIY electronics enthusiast.

Further add-on capability is provided by the 1MHz bus which has the data bus, control bus, and address bus connections. The upper eight address lines are decoded by internal circuitry of the computer to give two pages for memory mapped input/output from FC00 to FDFF. Serial or parallel input/output ports could easily be added here, and there is great scope for expansion.

There is also an audio input so that audio signals from the add-ons can be reproduced through the machine's internal loudspeaker.

The power supply of the BBC computer is built-in, with a proper on-off switch, and a 5-volt output is available at both the analogue and user ports. There is also a power socket which provides +5V at 1·25A, +12V at 1·25A, and −5V at 75mA. This is obviously very useful for hardware add-ons, but unfortunately a matching plug for this socket is rather expensive and not very easy to obtain.

SIDEWAYS ROM

An unusual feature of the machine is its ability to take "sideways" ROMS which can replace the BASIC interpreter, and are selected from the keyboard using a simple command. This is obviously ideal for programs that will be used very frequently, and with something like a word processor it has the advantage of leaving the RAM free for data storage.

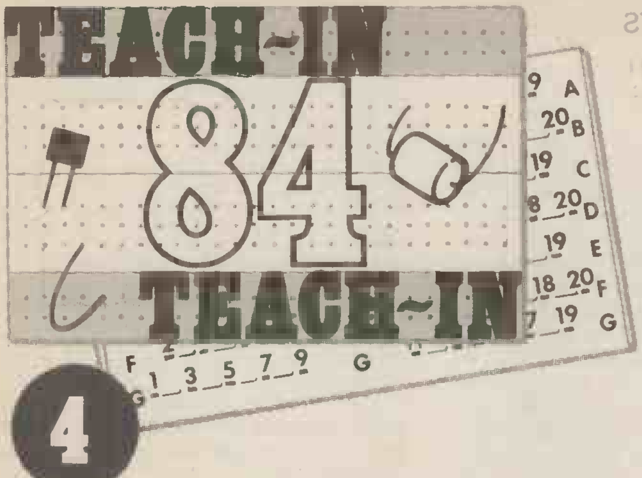
CONCLUSION

It is not surprising that the BBC Microcomputer is a best-seller. It has a powerful and flexible language and operating system, good display and sound, a reasonable amount of user-memory, and it is also one of the fastest home computers. Add to this the built-in interfaces and you have a computer that it would take a long time to out-grow.

About the only serious drawback of this computer is its price which is much higher than most of the other popular home-micros, but it is probably well worth the extra cost if you need most of the many facilities the machine provides. It may not be ideal for an absolute beginner, but it can be warmly recommended to anyone with a little experience. □

PUTER MODEL B

BY R. A. PENFOLD



A TWELVE-PART HOME STUDY COURSE IN THE PRINCIPLES AND PRACTICE OF ELECTRONIC CIRCUITS. ESSENTIALLY PRACTICAL, EACH PART INCLUDES EXPERIMENTS TO DEMONSTRATE AND PROVE THE THEORY.
USE OF A PROPRIETARY BREADBOARD ELIMINATES NEED FOR SOLDERING AND MAKES ASSEMBLY OF CIRCUITS SIMPLE.
THE IDEAL INTRODUCTION TO THE SUBJECT FOR NEWCOMERS. ALSO A USEFUL REFRESHER COURSE FOR OTHERS.

TRANSISTORS & CAPACITANCE

HELLO again. Glad to know you are keeping up. If you do find yourself having difficulties in following what I'm saying, write, explaining your problems. I'll do my best to clarify things.

For new readers who are just joining me, let me explain that this *Teach In* makes use of a commercial solderless breadboard, the EBBO system. As you can see from the photographs, components and wires just plug in. This breadboard and all components required for experiments described in this series can be obtained from several suppliers who advertise in this magazine.

TRANSISTORS: THE CONTINUING STORY

As we saw last month, a transistor can be turned on by applying to its base either a voltage or a current. For the BC107B *npn* silicon transistor we have so far been using, about 0·7V applied to base (strictly speaking, between base and emitter) turns on the collector current.

Alternatively, a current into the base of a few micro-amps also turns on the collector current.

Needless to say when the transistor is "current biased" in this way the flow of base current sets up the usual base-emitter voltage (0·7V approximately). And when the transistor is voltage-biased, applying the 0·7V base-emitter bias automatically causes the appropriate amount of base current to flow.

The base current is much smaller than the emitter current. So the transistor can be said to amplify its base current, the amplified version being the collector current (strictly, the collector-emitter current).

For the BC107B the collector current is typically around 300 times the base current.

This month we'll be looking at ways of biasing transistors so as to reduce the upsetting effects of variations in current amplification factor (h_{FE}) among nominally identical transistors. First, however, a look at a circuit element which is going to help us to use our transistor amplifiers when we've solved the biasing problem.

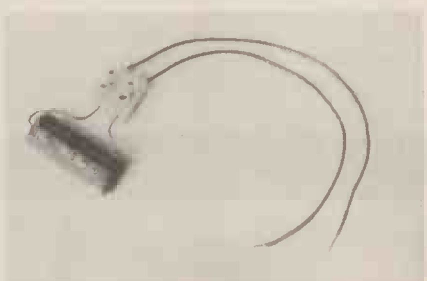
CAPACITANCE

The circuit element is capacitance, which is the ability to hold an electric charge. The component which embodies capacitance is the capacitor.

For our first experiment we use a polarised capacitor, that is one whose terminals are labelled positive and negative. It is essential to observe polarity, that is, to ensure that the positive terminal always faces positive battery and the negative terminal negative battery.

A capacitor is essentially a sandwich. The two slices of bread are metal plates and the filling is an insulator. The job of the plates is simply to conduct current to the insulator (which is called the dielectric).

The plates can be very thin, and are often just a coating of metal on the dielectric itself. Flexible dielectrics such as paper or plastic film are usually rolled up to make the capacitor compact, then encapsulated in wax or plastic for protection. The plates are connected to the outside world by two leads.



Components having leads too thick to fit into the EBBO Block should be connected to a piece of terminal block and leads of normal connecting wire attached to the opposite terminals.

EXPERIMENT 4.1

ELECTROLYTICS

Our first encounter with capacitance will make use of an electrolytic (polarised) capacitor of 1,000 microfarads (1,000μF) with a d.c. voltage rating of 16V or more. (The meaning of this jargon will soon emerge!)

A 1,000μF, 16V electrolytic is physically rather large and likely to have lead-outs too thick to insert comfortably into the EBBO discrete component breadboard. So mount it "off the board" on a piece of terminal block and connect to the board with wander leads of ordinary insulated connecting wire. It's helpful to mark the + and – leads red and black (with bits of sleeving) as a colourful reminder of polarity.

SWITCHES

Our first circuit (Fig. 4.1) contains two switches, marked S1 and S2. S1 is a changeover switch; it has two fixed contacts, 1 and 2, and a movable contact which can be connected to one or the other.

We are not going to use real switches. Instead, we'll use bits if wire for the movable contacts, and positions on the breadboard for fixed contacts. This is cheaper, and shows at a glance what position a switch is in. (Fig. 4.2.)

S2 is an on-off switch with one fixed and one movable contact. For the time being it is to be left in the "off" position as shown, leaving R1 disconnected.

CHARGE AND DISCHARGE

With S1 in position 1, the capacitor C1 charges. That is, current flows from the battery in the direction shown by the arrow labelled "Charge". This causes C1 more or less instantly to acquire a charge whose voltage equals the battery voltage. At this point current ceases to flow.

To empty the capacitor, S1 is put in position 2. Since we've left R1 out of circuit the only path for current from C1 is through the voltmeter. The meter registers a voltage which is initially equal to the battery but which immediately begins to fall as the capacitor discharges.

Try it. You'll see that the process of discharge goes on more and more slowly as the voltage falls. This makes sense if you remember that the meter has a resistance.

The KEW7S on its 10V d.c. range looks like 20kΩ to the capacitor. If the capacitor were charged to 10V this would push 0·5mA through the meter. At 5V, the charge can push only 0·25mA; at 1V, only 0·05mA (50μA), and so on.

The less voltage the less discharge current and the slower the discharge rate. In theory it takes forever to discharge a capacitance completely through a resistance.

Connecting R1 (100Ω) speeds up the process. Try various other resistances and see for yourself that the rule: less resistance, faster discharge, is right.

You might think that if both R1 and the meter were removed, C1 should stay charged forever. So it should, if C1 were a perfect capacitor. In practice, capacitors "leak". That is, they discharge slowly through their own internal resistance.

Electrolytic capacitors are rather bad in this respect. They leak appreciably. If too much voltage is applied the leakage increases enormously. Hence the need to keep within the rated working voltage.

Non-polarised capacitors, especially those with dielectrics of mica or plastic film, leak very little and can stay charged for a long time.

TIME CONSTANTS

Discharge C1 via R1. Then switch out R1 and recharge. Time how long it takes for the initial 9V to fall to 3V. Now set up the circuit of Fig. 4.3. Start with C1 discharged (S1 at "2"). On moving S1 to "1" the meter first reads the full battery voltage. The reading falls as C1 charges.

The reason for the fall is that the meter is reading the difference between the capacitor voltage and the battery voltage. As C1 charges this decreases. Time how long it takes for the meter reading to fall to 3V. (Use the same voltage range as before.)

You should find that both tests give about the same timing. In theory, with a KEW7S meter set to 10V d.c. the time should be about 14 seconds, but electrolytics have very wide tolerances so yours might take half as long or twice as long.

You have been measuring the time taken to charge C1 to about 2/3 of the battery voltage (or, in Fig. 4.1 to discharge it by 2/3). This is close to a quantity called the *time constant* of an RC (Resistance-Capacitance) circuit. The true time constant is the time needed to charge or discharge to 62·3 per cent of the battery voltage. It's very easy to work out. You just multiply R by C and the answer is the time constant in seconds.

PRACTICAL UNITS

In the "time constant" calculation, R should be in ohms and C in farads. A farad is the basic unit of capacitance. If a current of 1 amp flows into an uncharged capacitance of 1 farad (1F) it takes 1 second for the voltage to built up to 1V.

A farad is a very large amount of

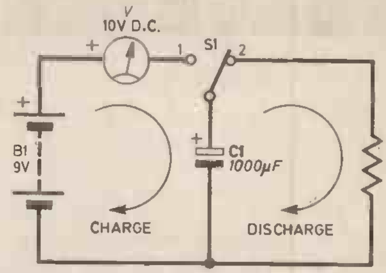


Fig. 4.3. The meter enables you to watch the capacitor charge.

capacitance, so large that only in recent years have 1F capacitance been made commercially (and they are still rare). One common unit of capacitance is the microfarad (μF): 1 million μF = 1F. (Nowadays you may find large capacitors like your's marked in millifarads (1,000mF = 1F). However, "mF" has also been used for "microfarad" so some makers prefer to stick to μF and avoid possible confusion.)

If a microfarad is too large it is divided into nanofarads (1,000nF = 1μF). If a nanofarad is too large it is divided into picofarads (1,000pF = 1nF).

The smallest capacitor value normally made is 1pF. But any two conductors which are insulated from one another act like the plates of a capacitor. If they are small or far apart the capacitance between them is very small.

Since a time constant is R times C, a small C can be compensated by a large R. Time constants come out in seconds when:

R is in megohms, C in μF
R is in kΩ, C in millifarads

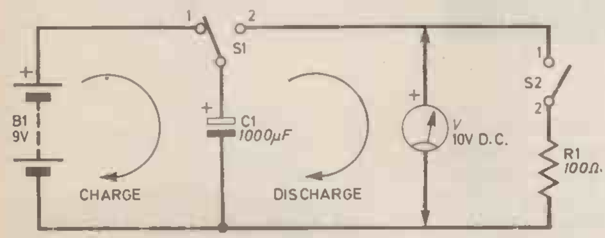
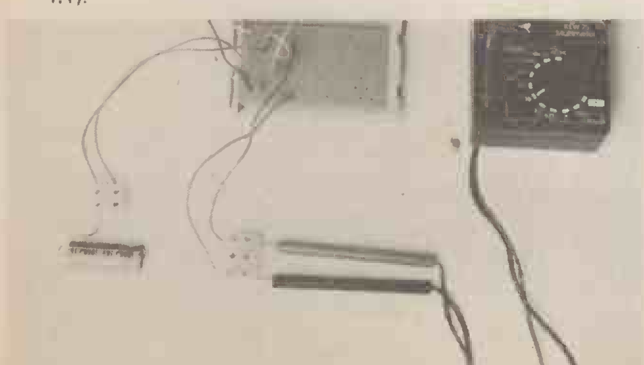


Fig. 4.1. Charging and discharging a capacitor (Experiment 4.1).



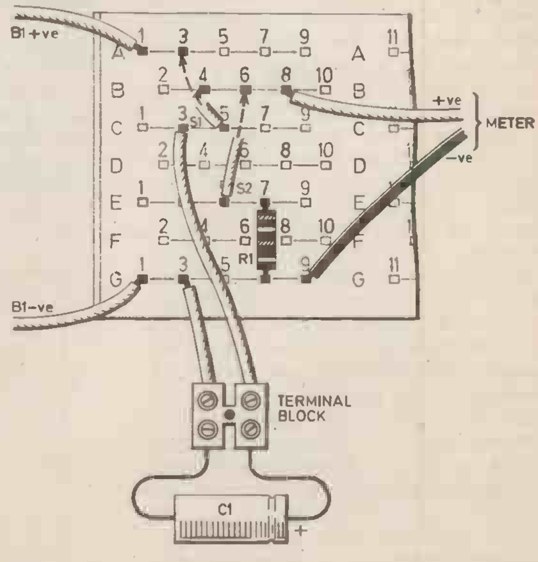


Fig. 4.2. The circuit of Fig. 4.1 assembled on the EBBO Block.

EXPERIMENT 4.2

CAPACITANCE AND A.C.

For your next experiment (Fig. 4.4), use a non-polarised capacitor of 100nF (=0·1µF). Watch the meter pointer closely. It gives a small "kick" every time C1 is charged (S1 to 1) and a backward kick when C1 is discharged (S1 to 2). Current evidently rushes into C1 during charge and out on discharge.

Current which travels first one way then the other is alternating current (a.c.). You are making a.c. by causing the d.c. from your battery to flow first into C1 then (after temporary storage) out the opposite way. This shows that to all intents and purposes a capacitor allows a.c. to flow through itself. But once charged it blocks d.c.

In transistor circuits, a capacitor is just what we need to get a.c. signals into and out of amplifiers without interfering with the steady d.c. voltages which must be present to make the transistors work.

AUTO BIAS

To get back to transistors, then. Last month we looked at some rather cumbersome ways of adjusting the bias voltages and currents needed to turn a transistor on. Now for some more practical methods.

What's needed is a reliable way of biasing which doesn't need adjustment. An early (and still much used) system is shown in Fig. 4.6. Here the resistances are labelled according to their circuit positions. Thus R_{CB} is connected from collector (*c*) to base (*b*). R_C is in the collector (*c*) circuit.

Current can flow from positive battery (V_{CC}+) via R_C to R_{CB}. It can then flow through R_{CB} to the base, and through the transistor to the emitter which goes to battery negative. The current through R_{CB} is base bias current and turns on the collector current, I_C.

Since I_C flows through R_C there is a voltage drop in R_C. The collector is not at V_{CC}+ but at some lower voltage as a result of this drop in R_C. Since it is the collector voltage which drives base current through R_{CB} the base current is restricted.

More base current, more collector current, *but* more collector current, less voltage to drive base current. It sounds as if the base current must keep rising and falling all the time. But in practice it just settles down at some fixed and steady value. The circuit stabilises itself.

If because of a fading battery or a change in the transistor the currents try to change, the action of the circuit then limits the amount of change that can occur. This action is called *negative feedback*. Feedback, because something which happens at the "output" part of the circuit (the collector) influences the "input" part (the base). Negative because the feedback *opposes* change.

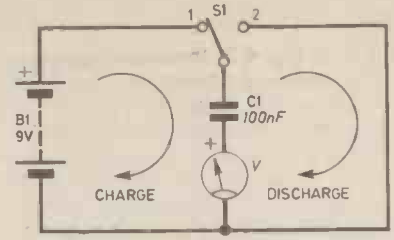


Fig. 4.4. The charge/discharge currents form a sort of a.c. (Experiment 4.2).

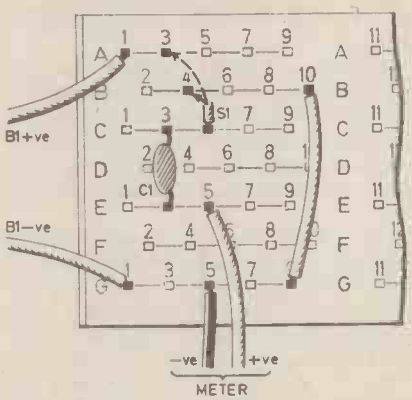


Fig. 4.5. The circuit of Fig. 4.4 assembled on the EBBO Block.

This particular circuit is often called an automatic bias (or auto-bias) circuit. Its effect is to set the collector-emitter voltage V_{CE} to some fraction of the supply voltage V_{CC} and try to maintain this fraction.

EXPERIMENT 4.3

RULE OF THUMB

It is often convenient to set V_{CE} to half V_{CC}. This can nearly be done by making R_{CB} equal to R_C times the d.c. amplification factor of the transistor, h_{FE}. So a quick design rule is, choose R_C then make the "bias resistance" R_{CB}, h_{FE} times as big.

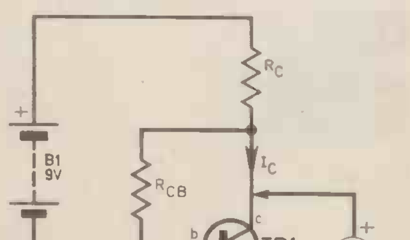
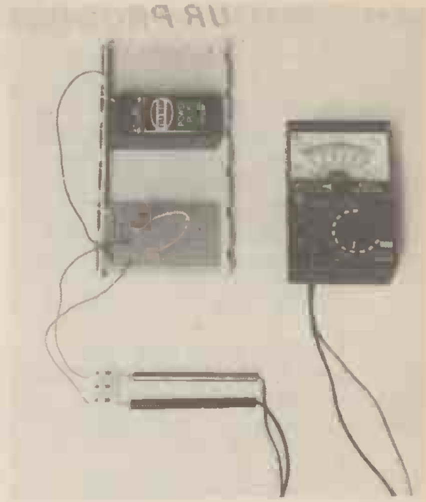
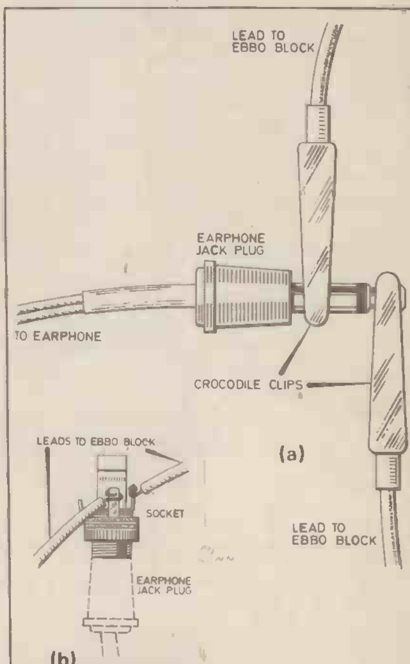


Fig. 4.6. Auto-bias circuit.



A plausible value of h_{FE} for our BC107B is 300, so if R_C = 1kΩ, R_{CB} = 300kΩ. A near value such as 330kΩ will do. (Fig. 4.7a). Try it.

If V_{CE} turns out to be too high, try a lower value for R2, and vice-versa. Connect C1 and C2 as shown and watch the meter kick when S1 is operated. Connect a crystal earphone across the output as



Connecting the crystal earphone to the EBBO Block.

Method (a). Crocodile clips fitted to 6-inch lengths of connecting wire are clamped to the body and tip, respectively, of the earphone jack plug.

Method (b). The bared ends of the connecting wires are wrapped tightly around the two tags on a jack socket. The earphone plug is then inserted into the socket.

CHECK YOUR PROGRESS

Questions on *Teach-In 84 Part 4*
Answers next month.

Q4.1 In Fig. 4.6, TR1 has an amplification factor (h_{FE}) of 100, $V_{CC} = 20V$, $R_C = 1k\Omega$, $R_{CB} = 100k\Omega$. What are the approximate values of:
a. V_{CE}
b. I_C
c. I_B

Q4.2 A 500μF capacitor is charged from a 12V battery via 10kΩ. Roughly how long does it take for the capacitor voltage to reach 8V?

Q4.3 In Fig. 4.9, what is the collector current of TR2, approximately?

Q4.4 In Fig. 4.9, the setting of VR1 that just allows the circuit to oscillate requires VR1 (c-b) to be 50Ω. What is the gain of the amplifier?

ANSWERS TO PART 3

Q3.1 Because additional base current would flow through the resistance of the meter itself and cause errors in the result.

Q3.2 (a) 1,000μA (=1mA)
(b) 1,010μA. (Base current and collector current add to make the emitter current.)

Q3.3 The beam is pointed at PCC1, whose resistance is thereby reduced to a value so low that the voltage drop across it (due to current via R1) is not enough to turn on the transistor. When the beam is broken, PCC1 resistance increases, the voltage across it rises, the transistor is turned on and the bell WD1 sounds.

Q3.4 200Ω. But this makes no allowances for the tolerance. It would be safer to use the next highest standard value, 220Ω.

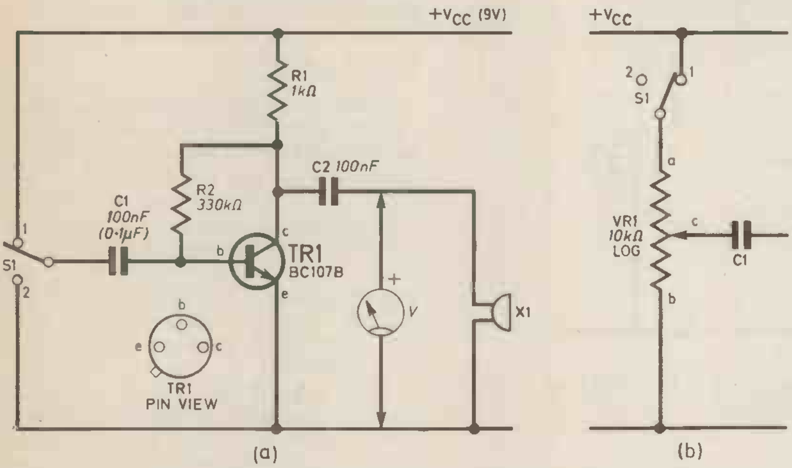
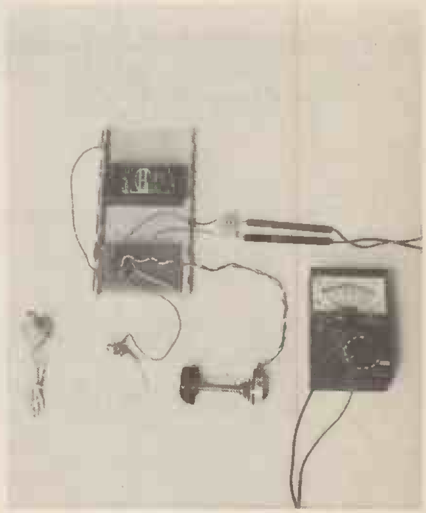


Fig. 4.7(a). Amplifier stage illustrating the passage of a.c. signals (Experiment 4.3); (b) Adding VR1 adjusts the input.



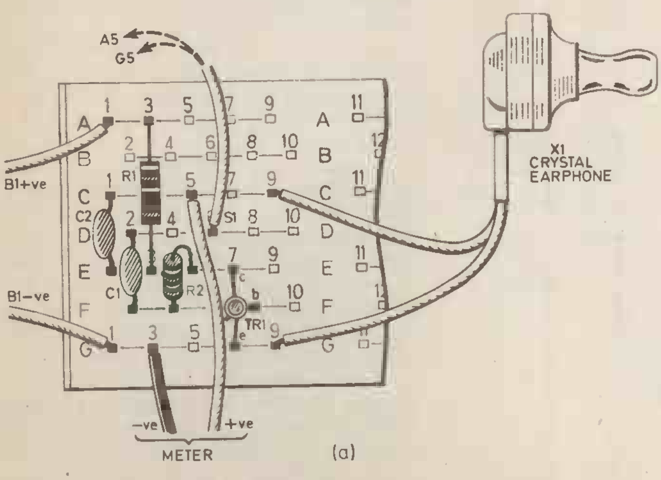


Fig. 4.8. The circuit of Fig. 4.7(a) assembled on the EBBO Block.

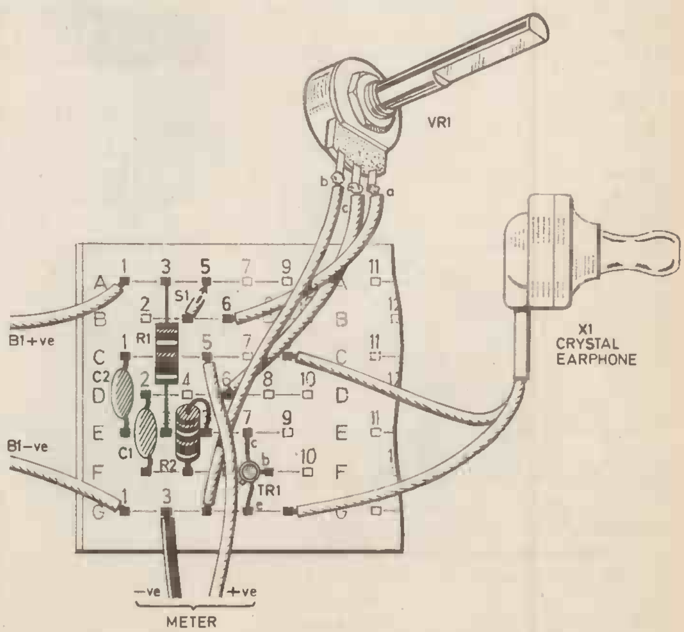


Fig. 4.9. The circuit of Fig. 4.7(b) assembled on the EBBO Block.

shown. You should hear a click every time S1 is changed over.

You are applying the full battery voltage to the input. This is a large signal. Try reducing it by tapping off a fraction with your 10kΩ volume control (Fig. 4.7b).

In most positions of the slider the gain of the transistor is enough to ensure that the signal is still heard. (There is now no need of contact 2. The lower section of VR1 provides a discharge path for C1, so you hear one click when contact 1 is "made" (C1 charging) and another when it is broken (C1 discharging).

EXPERIMENT 4.4

TWO-STAGE AMPLIFIER

If one transistor doesn't provide enough amplification two can be used. If the circuit you are using were duplicated, C2 could be connected to the base of the second transistor. This would pass a.c. signals from the output of the first stage of the amplifier to the input of the second. If each stage amplified 100 times, two would amplify 100 × 100 = 10,000 times.

We'll build a two-stage amplifier, but not like this. Our version saves the inter-stage coupling capacitor by using a direct connection instead (Fig. 4.10).

The bias circuit here is a bit more complicated but still uses negative feedback. R2 passes both collector current for TR1 and base current for TR2. The emitter current of TR2 sets up a voltage across R4 and this drives a current through R1 into the base of TR1. So TR1 gets its bias from TR2.

This circuit is even easier to design, because you don't need to have a very precise idea of the current amplification factors (h_{FE}) of the transistors. It's enough that they should be at least 100. TR1 is operated at a small collector current, which makes for low noise.

The action of the circuit is to stabilise the collector voltage of TR1 at about 1·3V. The voltage across R4 is stabilised at about 0·7V. Changing transistors or making quite large changes in R2 has little effect on this voltage.

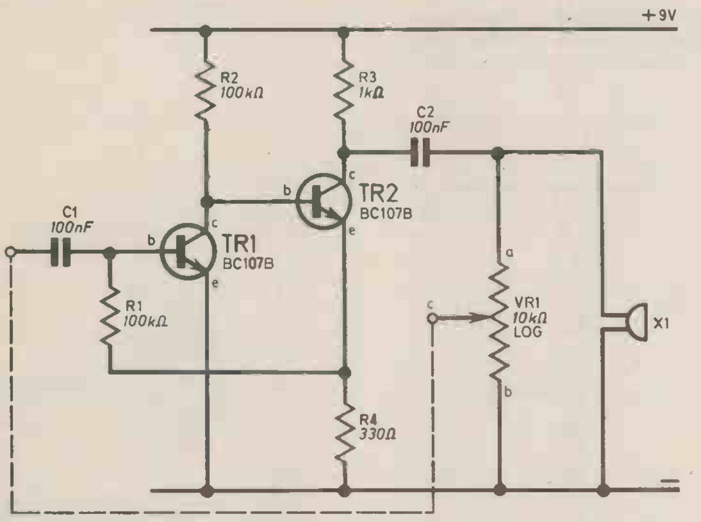


Fig. 4.10. Two-stage amplifier with direct coupling between stages. Adding VR1 turns it into an oscillator (Experiment 4.4).

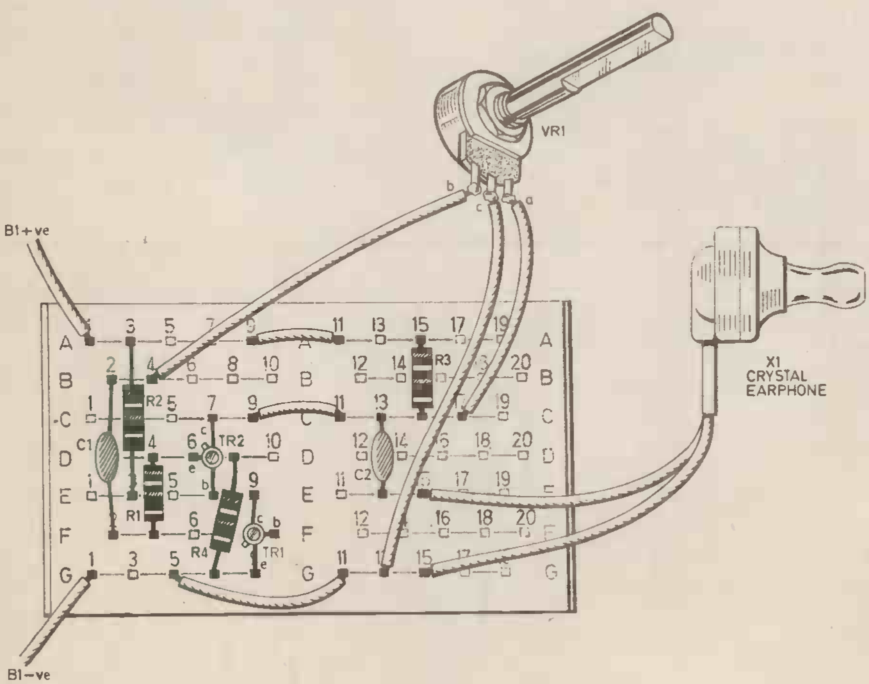


Fig. 4.11. The circuit of Fig. 4.10 assembled on the EBBO Block.

OSCILLATION

Make up the circuit as shown but leave out the connection between the slider (c) of the 10kΩ potentiometer VR1 and C1. Check the voltage across R4 (0·7V approximately) and between collector of TR2 and battery negative. This should be around 2V less than the battery voltage.

Connect a crystal earphone across the output as shown. Put in the link between C1 and VR1 (c). At most settings of VR1 the circuit will oscillate, producing a whistle or buzz.

What's going on? This is a case of *positive feedback*. Negative feedback tends to stabilise things. Positive feedback tends to unstabilise them. In this case, the voltages around the circuit keep changing at a fixed rate, which is the frequency of the oscillation. This changes as VR1 is adjusted, because this alters the amount of output fed back to input.

Only a.c. is fed back because C2 and C1 block d.c. So the circuit can still hang on to enough d.c. stability to go on working even though it is unstable as far as a.c. is concerned.

You can only have an output to feed back if there's first of all an input to give rise to the output. The answer, as we'll see next time, is that small noise voltages and currents exist in any amplifier circuit. Usually they are too small to notice. But in this circuit any noise which is at the output gets fed back, amplified, fed back again, amplified again, and so on.

If an amplifier has a gain of 100, then feeding back one hundredth of its output positively, will just make it oscillate. By adjusting your 10kΩ potentiometer to the "just oscillating" point, then disconnecting it without changing the setting, you can find what this critical fraction of feedback is, by measuring the resistance from c to b on VR1 and comparing it with the resistance of the complete track.

Next month: Audio Amplifiers

CIRCUIT EXCHANGE

This is the spot where readers pass on to fellow enthusiasts useful and interesting circuits they have themselves devised. Payment is made for all circuits published in this feature. Contributions should be accompanied by a letter stating that the circuit idea offered is wholly or in significant part the original work of the sender and that it has not been offered for publication elsewhere.

AUDIO EFFECTS GENERATOR

THIS circuit can produce many effects, most of which are sirens, but it can also produce a "laser fire" effect. This unit would be useful when making home movies or disco work, for an alarm system or for plays or even in toys.

The unit is based around the 556 i.c. In this circuit one low frequency oscillator controls another audio frequency oscillator.

The effect produced depends on the shape of the wave fed to IC1b (the audio frequency oscillator) and also the input to which it is fed. These can be changed by the switches S1 to S6. The switch positions are labelled with numbers from 1 to 13. This is so that when an effect is found the numbered positions of the switches can be noted.

The control oscillator is IC1a. Two outputs are provided from this part of the i.c., one at the output, pin 9 and the other from pin 13, the discharge pin. From pin 9 comes a square wave while from pin 13 comes a sawtooth wave. D1 is included to prevent interference with the action of IC1a.

S5 selects which input, if any, is fed to pin 3 the control voltage input of IC1b, the audio oscillator. The frequency of the output wave of this oscillator can be varied by the frequency control VR2.

If S1 is put to position 2 and S5 to position 8 a direct path will be made via R2 and R3 for the square wave to pass from pin 9 to pin 3. If, however, S4 is closed, R2 will become charging resistor for C2 with R3 its discharging resistor. This will convert the square wave to a triangular wave which will appear at pin 3. This will produce an American police car type siren noise.

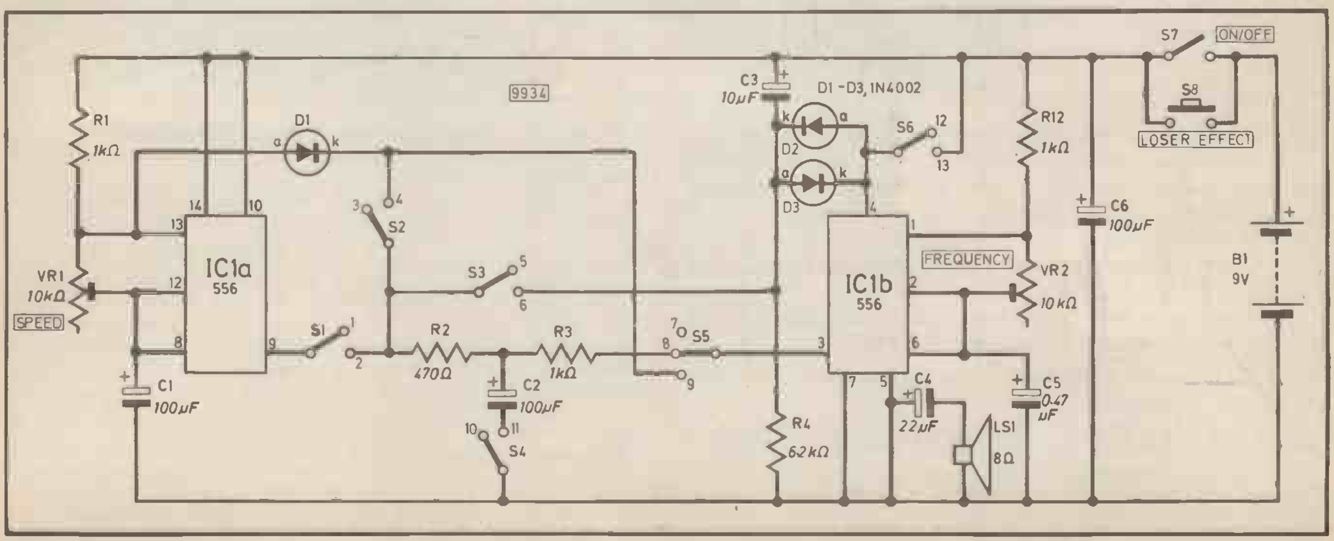
If S6 is closed this will pull the reset input of IC1b high and so the oscillator will function. If S6 is opened, when power is applied to the circuit, C3 will charge up and a falling voltage will appear across R4 and so pin 4.

When the voltage across R4 drops below 0·6V, conduction will stop through D3 and at −0·6V conduction will occur through D2. This will pull pin 4 low and so switch off IC1b. This has the effect of switching on the audio signal for a short period and then switching it off. D3 is included to provide a sharp switch off of IC1b and so avoid a short low frequency "bleep" at the end of this effect. D2 is included to pull pin 4 low at the required time.

If the switches are in positions 2-3-5-8-12 a decreasing tone will be heard and if at the right frequency this will sound like laser fire. Push button S8 is provided especially for this effect.

VR1 is the speed control. The output from the audio oscillator is through pin 5 and this is coupled to the speaker by C5. C6 is a supply decoupling capacitor. This prevents interaction of the two oscillators.

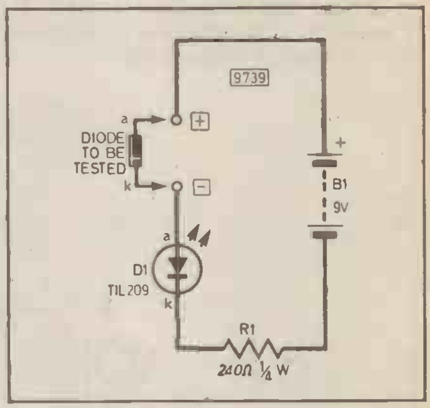
Anthony Kelly,
Carlow,
Ireland.



RAPID DIODE TESTER

THIS is a simple and inexpensive circuit for rapidly checking faulty diodes or checking their polarity. The diode to be tested is placed between the two contacts with the polarities as shown. If the diode is not faulty the l.e.d. lights up showing a circuit has been made. If the poles of the diode are not known, experimenting soon determines that. If the l.e.d. fails to light regardless which way round the diode is connected, then the latter is faulty. R1 is used so that the l.e.d. is not over-driven.

A. M. Khan,
Nottingham.



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PRODUCTS CHRISTMAS
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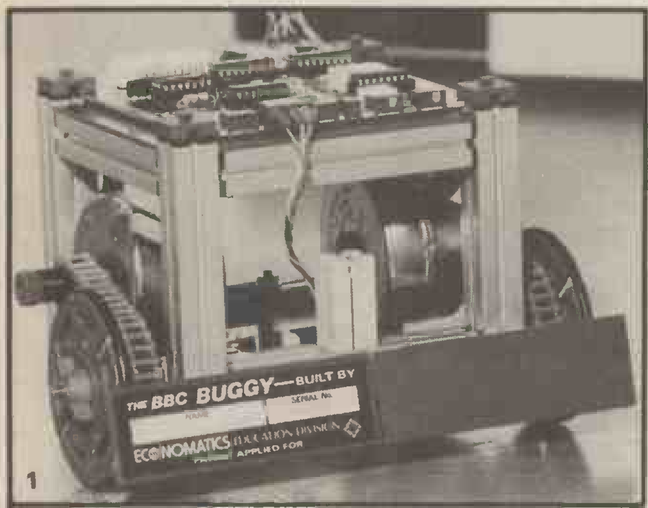

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WITH so many distractions hitting us from all corners of the "information" media, this year is proving probably one of the most difficult to choose just the right Christmas present for members of the family. It's not that we are limited in our choice, but more to the contrary, there is far too much to sway us from our original selection.

We have selected just a few items that have passed through our postbag in the last couple of months, in the hope that they may solve some of our readers' problems—at a price!

COMPUTER COMPANIONS

As the BBC Micro seems (although reports suggest that Sinclair holds 60 per cent of the market) to be the most popular user machine and heads most "pop charts" we have selected just a few items from the vast army of peripherals available.

1 The BBC Buggy is a three-wheeled robot controlled by a BBC Micro initially created by Economatics and MEP in conjunction with the Continuing Education Team at the BBC.

The Buggy pack, which sells for around £190, including VAT, consists of a simple-to-build Fischertechnik construction kit and all the program software. Assembly requires no special equipment.

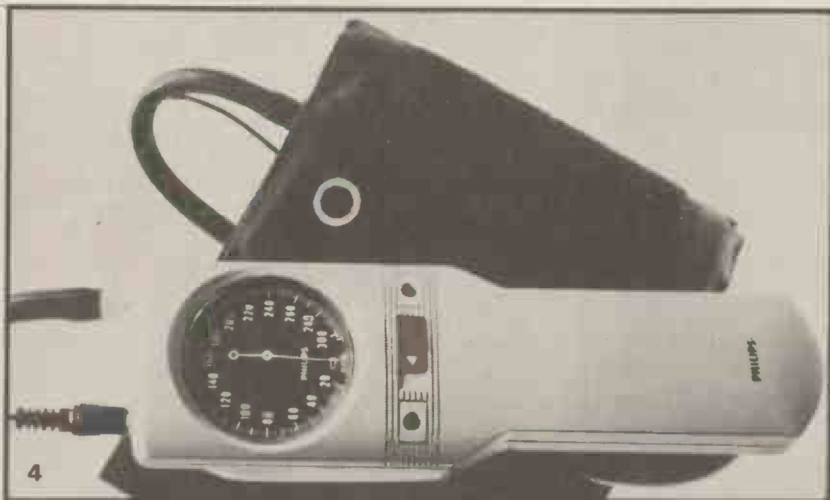
Available from: **Economatics Ltd., Dept EE, 4 Orgreave Crescent, Dore House Industrial Estate, Handsworth, Sheffield, S13 9NQ. Tel: 0742 690801.**

2 With a saving of some £10 to £15, we can recommend the **Network** NW900 cassette recorder. This recorder is computer compatible and identical to the BBC version but much cheaper.

It is available from any Argus shop and retails for £21.99. For nearest stockists contact: **Network Marketing Ltd., Dept EE, Sutherland House, Edgware Road, London, NW9 7BT. Tel: 01-202 0911.**

3 Available through such outlets as W.H. Smith and Spectrum UK, the **Cumana** slimline Disk Drive for the BBC Micro is supplied with

CHOICE



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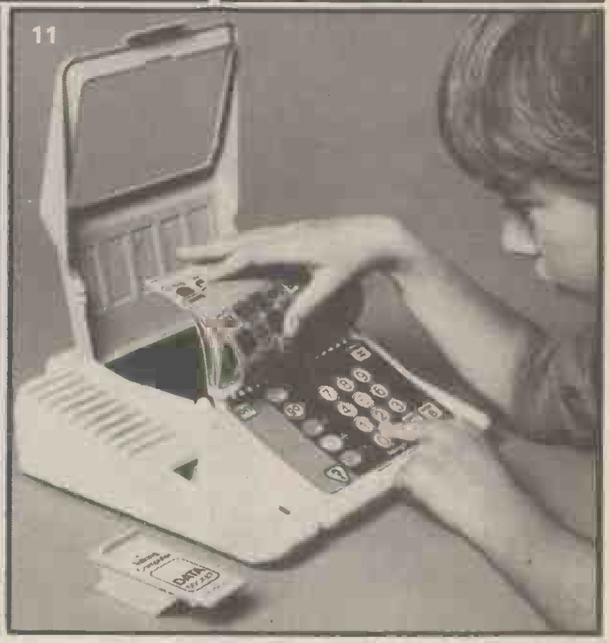

user manual, formatting diskette and mains power supply lead and plug. The recommended retail price is around £200 according to model.

For nearest stockists contact: **Cumana Ltd., Dept EE, Pines Trading Estate, Broad Street, Guildford, Surrey GU3 3BH. Tel: 0483 503121.**

6–POCKET CHESS

The games player will certainly find the Pocket Micro Chess from **CGL** a gift for all ages.

The folding magnetic chessboard, conceived and developed in UK, enables the players to interrupt a game at any stage, pack the game away, and re-start at a later date. Other features include: four levels of play; ability to change levels or sides during play; and random computer response.

The CGL Pocket Micro portable chess computer retails for around £32. For nearest stockists contact: **Computer Games Ltd., Dept EE, CGL House, Goldings Hill Loughton, Essex IG10 2RR. Tel: 01-508 5600.**

10, 11–TALKING PRESENTS

To keep the young and not so young amused during party time, **Electroplay** have developed a novel talking game called "Pass Me", an electronic version of the popular "pass-the-parcel" game.

Designed to test a player's memory, response and reasoning abilities, it communicates with speech, not with lights or pictures. Looking like a space satellite, it has a handle at each of six corners; the grips are covered with coloured conductive rubber and have a numbered end cap. The "handles" are connected to a speech chip with a vocabulary of twenty words and two tunes.

The idea is to grasp all six handles in the correct sequence, unfortunately the numbers on the end-caps change with each game!

To make learning fun Electroplay are also marketing "My Talking Computer", a computer for children and mothers that introduce "lessons" in a friendly voice.

The Pass Me game retails for approximately £19.95 and, at a introductory offer, My Talking Computer together with five talking programs will retail for about £60: **Electroplay Ltd., Dept EE, 93 High Street, Esher, Surrey KT10 9QA. Tel: Esher 67031.**

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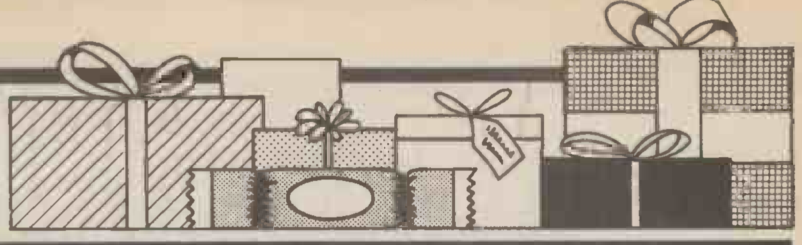
PRODUCTS

NEW · NEW · NEW · NEW



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13—HOT SOUNDS

For the would-be pop musician we offer the Synsonic Drum Synthesiser from **Mattel** at £99. About the size of a portable tape recorder and powered by battery or optional mains adaptor, it produces the same sounds as a full set of drums—snare, two tom-toms, cymbal and bass.

Microprocessor control allows preprogrammed drum effects to be stored. As well as preprogrammed effects, such as drum rolls, an infinite number of rhythms can also be "captured" either by tapping the pressure sensitive pads with hands or drumsticks, or by using the keys on the front panel.

One of the tom-toms can be tuned over a five-octave range and all drum sounds can be layered indefinitely in "record" mode.

Having seen a demonstration by Carmine Appice of Rod Stewart fame, and been hit by a cacophony of amazing sounds from what, at first sight, looked like a series of miniature cooker hot-plates we strongly recommend that a set of headphones be purchased.

The Synsonics Drum Synthesiser is available through **Harrod, Greens, Littlewoods** and from **Argos** showrooms.

4—FIRST AID

With jogging and "marathon fun running" now becoming a family sport, a gift that will appeal to the active family with a serious application are the blood-pressure meters from **Philips**. Used at home in conjunction with their doctor's advice, it enables anyone to read their blood pressure and take their pulse.

The HP5305 is simple to use, with digital display readings and retails for about £75. A similar blood-pressure meter, the HP5304, gives gauge readings instead and retails for about £39.95.

For details of stockists contact: **Philips Small Appliances, Dept EE, Dury Lane, Hastings, E. Sussex TN34 1XN.**

5—TAPE FOR LIFE

For the Video machine owner we have selected the very latest Scotch video tape from **3M** with a unique promise: "A lifetime quarantee of video recording and playback quality". They also claim that: "The new Scotch tape's picture quality will never deteriorate, no matter how many times TV programmes are *recorded* and *re-recorded* on it."

The new tape is available in all three formats, VHS, Beta and Video 2000. Anticipated retail prices are £6.60 to £7 for VHS three-hour tapes, a few pence more for the Beta equivalent.

7—CLOSE SHAVE

For the "Man In Town" we suggest the very latest in shaving from **National**, the ES-861. For around £30 he can have the best of both worlds with the world's first *electric* "Wet & Dry" Shaver.

It can be cleaned under running water, is powered by a rechargeable battery and comes complete with a charging unit.

The National ES-861 Wet-Dry should be available from most electrical stores.

8—ON YOUR BIKE

For those who use a bicycle for keeping fit, travelling to work or serious competitive training, and are looking for that gift with a difference, **Zemco** have introduced the Bicycle Computer.

On the road the computer is not only an electronic speedometer and quartz crystal clock, but will show average speed on trip and distance travelled. In stopwatch mode it reads hours, minutes, seconds and tenths of seconds. Lighting is provided for night use. A bargraph displays speed, other information is shown digitally.

Available from cycle shops or direct, the recommended retail price for the Zemco Bicycle Computer is £19.95 incl. VAT and P&P. **Zemco (UK) Ltd., Dept EE, 66 Earlsdon Street, Coventry CV5 6EJ. Tel: 0203 79969.**

9—RADIO BADGE—TURN ON

With the enormous popularity of the "Hip-Fi" personal tape recorders, **Planned Entertainments** have just marketed their version of a Badge Radio which should appeal to our younger readers.

Small enough to pin on the jacket, the four transistor m.w. earphone radio is powered from a single 1·5V battery (HP16). Reception on our model did leave a lot to be desired, but for only £4.99 you cannot expect to receive every world broadcast.

The volume and tuning controls are located on the rear of the badge. On the front of the badge are printed slogans such as: "Turn Me On", "I'm Getting An Earful" and "Shut Up I'm Listening".

The Badge Radio is available (mail order) direct from: **Planned Entertainments Ltd., Dept EE, 11 Heronslea Drive, Stanmore, Middlesex HA7 4QY.**

12—HOME ENTERTAINMENT

For those who can afford that touch of luxury and want to offer the lady of the house something special, we put forward the Beomaster 5000 system from **Bang & Olufsen**.

With its infra-red master control panel, together with a single-wire DataLINK system, you can have hi fi sound, selected from whichever source you want in the 5000, in any room in the home—perfect accompaniment for housework?

The Beomaster 5000 system is available from all large hi fi shops and retails for around £1150 complete system, including speakers. A Compact Disc player will cost an extra £595.

FEBRUARY FEATURES

EPROM PROGRAMMER FOR ZX81

A simple plug-in module which converts the basic ZX81 Personal Computer into an eprom blower for 2716 +5V rail eproms. Also functions as a ROM card for a 2K x 8-bit eprom which is situated in the unused memory area from 2ØØØH.

NEGATIVE ION GENERATOR

Ionisers are being widely used to counteract the negative ion depletion in air, which is commonly experienced in modern buildings with sealed windows and air conditioning. There are reliable indications that negatively charged air has a revitalising effect on many individuals and promotes a healthy and comfortable atmosphere.

Full details are given for building an ioniser that will cost far less than commercial units now available. Because of the high voltage generated certain precautions are essential during its assembly, but once finally secured within its plastic case, the ioniser is perfectly safe in normal use.

CAR LIGHT WARNING

Audible warning sounded if ignition is switched off and the car lights are left on. Easy to install. A real battery saver for the motorist.

SIGNAL TRACER

A useful project for the workshop. Enables faults to be traced in audio and radio equipment. Alternatively can be used as a signal injector.

EVERYDAY ELECTRONICS and computer PROJECTS

FEBRUARY 1984 ISSUE ON SALE FRIDAY, JANUARY 20

EVERYDAY news ... from the world of

RACE OF THE ROBOTS

IT took just 4·7 seconds for Cromwell, a tiny robot equipped with insect-like arms, to find and retrieve a small square cube and take Hinchingbrooke School, Huntingdon, into the £500 first prize spot in Britain's first "Race of the Robots" sponsored by BP Oil.

The Hinchingbrooke robot, designed and built by 17-year-olds John Higgins, Philip Thompson and Stewart Bromley, used electronic eyes in the back of its head to track down the cube and win its category in the "BP Buildarobot Competition" at the Army's School of Electronic Engineering, Arborfield.

The prototype of an industrial robot, based on the legs of an ancient cast-iron drawing board, won the £500 first prize in the open category of the competition for Mellow Lane School, Hayes, Middlesex.

Derek Case, Baljinder Dhanda and Michael Finnemore, all aged 16, developed a system called "Netvision" which could recognise the shape of any object on a conveyor belt, and then manipulate it into place.

All told, 21 schools from all over the country answered the oil company's challenge to design and build their own robot. Seventeen of them entered the "Race of the Robots"—in which they had to find and retrieve a small cube in the fastest possible time. And another four designed robots for a task of their own choice, ranging from talking heads to a chess-playing Anglepoise lamp.

Presenting the prizes, Mr. Kenneth Baker, Minister of State for Industry and Information Technology, said the future of Britain depended greatly on new technologies such as robotics.

Kenneth Baker MP, Minister of State for Industry and Information Technology, takes a close look at Britain's fastest school-built robot. With him are (from the left): Philip Thompson, Stewart Bromley and John Higgins. Looking on are some of the other finalists.

"We have to use them to find the jobs for the future and to create the wealth for the future," he told the entrants.

"It is important that Britain retains its capacity for inventiveness and its ability to change with the times."

Cosmic Telescope

The United States Space Shuttle *Spacelab 2* mission, due for launch in March 1985, will carry a Cosmic X-ray telescope developed in the University of Birmingham's Department of Space Research.

The instrument has been jointly funded by the Science and Engineering Research Council and the university. The launch opportunity, as well as the cost of integration into the space shuttle, will be provided free of charge by NASA.

In France the ORIC 1 was recently voted top micro system by the French professional press and out-sells all other microcomputer systems in the French market.

LYNX WITH LASKYS

Laskys have placed an order worth over £½ million with Camputers, makers of the Lyng series of microcomputers. The deal means they will take first deliveries of the new Lynx128 micro just in time for Christmas.

British Telecom £2 million emergency calls recording contract goes to Dictaphone.

The Secretary of State for the Environment, Mr. Patrick Jenkin, has announced that The Plessey Company had been offered an Urban Development Grant of £923,000 towards a £6·7 million scheme to expand "System X" production facilities at its Edge Lane site, Liverpool.

Sinclair Expansion

With its worldwide computer sales approaching 2,000,000 and further product range expansion planned, a new 32,500 sq ft warehousing centre has been opened for Sinclair Research at Frimley, Surrey by its sole UK distributor GSI (UK) Ltd.

GSI (UK) Ltd. is a wholly-owned subsidiary of the French-based General de Service Informatique a specialist in computer services with outlets throughout Europe.

Claims that proposed changes in the telecommunications systems of the United Kingdom will follow the American pattern, and that they will be disastrous, were strongly rejected by British Telecom.

The claims are made in a report issued by the British Telecom Unions Committee (BTUC) entitled: "The American Experience".

SUPERLIGHT

In many electrical shops this winter a free rechargeable torch will be offered to purchasers of Superswitch dimmer controls.

By sending the top of one dimmer blister pack, and an offer claim form available from the same shop, plus 20p to cover post and packing, purchasers will receive a free torch from Superswitch.

The torch is not available on normal retail sale. Its claimed approximate retail value is £6.

Import Duty

Compact disc hardware manufactured in Japan will be around £50 more expensive following the decision by EEC foreign ministers to double import duty as part of a new drive to curb Japan's overwhelming domination of the brown goods market.

The move follows pleas by Philips that, as inventors of the compact disc system, it was seeing its European sales dwarfed by imported machines.

The increase in duty effectively doubles the existing figure to about 19 per cent or 10 per cent on the cost of a Japanese compact disc player. This translates to about £50 in the shops.

A licence to use Matsushita patents and technology to make a new generation of thin-film, high-density recording tapes has been granted to BASF of Germany.

CABLE MUSIC

Developments in cable broadcasting are beginning to gather pace in readiness for the new "media" launch later this year. The latest news is the announcement that Yorkshire Television and The Virgin Group, known for their record and video interests, have merged their interests to form "The Music Channel".

The Music Channel will offer its customers round the clock entertainment and is in the process of negotiating the purchase of a 24-hour satellite transponder. The new service is claimed to be the only complete music channel available to European cable operators and customers.

The new channel will be broadcasting throughout Europe by June 1984, where it is in the process of forming joint ventures with major local media companies.

BREAKING THE CODE

Following reports in the press and on radio about the use of high-powered CB amplifiers known as "burners" to disrupt the operation of petrol pumps at filling stations, Mr. Alex Fletcher, Minister for Corporate and Consumer Affairs in the Department of Trade and Industry, issued the following warning:

"All use of radio transmitters in petrol stations is potentially hazardous. The Code of Practice for Citizen's Band radio (available free at Post Offices) specifically draws attention to this. The use of high power transmitters such as a CB set coupled to an illegal "burner" adds considerably to the risk of causing an electric spark close to the filling nozzle. An explosion could occur in some circumstances.

"The public are warned always to switch off transmitting equipment when entering a filling station forecourt and never to use CB "burners" in a vehicle which is being filled with petrol.

"The use of a CB set with a burner is in any case illegal because of the interference it causes to domestic radio and TV reception and to the emergency services; offenders may be imprisoned for up to three months and fined up to £1,000.

"The sale and possession of burners may be made illegal following the passage of the Telecommunications Bill at present before Parliament."

Tomorrow's World

The Chairman of British Telecom, Sir George Jefferson, in a speech to the annual conference of the Confederation of British Industry in Glasgow, stated:

"It is certain that an enterprising Britain, a commercial Britain competing in a toughening world market, will need two things from British Telecom.

"First, a communications and information technology service of the first order; and secondly, support for the domestic information technology industry . . ."

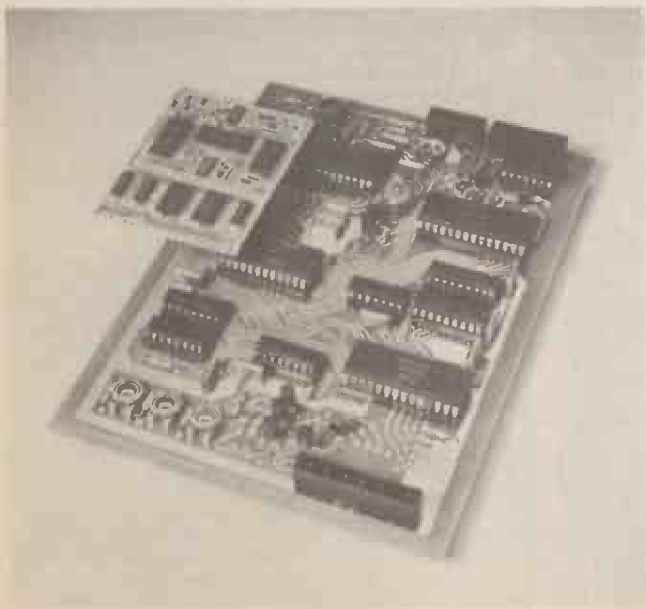
He completed his speech with the following message: *"In that spirit I urge all BT staff to recognise that tomorrow's jobs lie in tomorrow's world, with those who have the courage and the enterprise to go out and build them."*

Any third suggestion should be addressed to the "Letters' Page".

Shape Of Things To Come

THE larger p.c.b. in our photograph is a typical present day double-sided layout using familiar components which are mounted in drilled holes on the board prior to soldering at these locations. The smaller board, which fulfils the same electrical function, employs the latest assembly technique known as Surface Mounted Assembly, SMA.

The boards in the photograph fulfil identical functions. In general, Surface Mounted Devices (smaller board) require around one third of the board area that would otherwise be needed.



Specially designed components (Surface Mounted Devices, SMD) are necessary and an extensive range of resistors, capacitors, discrete and integrated semiconductors are already available.

These components have what could be called "feet" which make contact with printed tracks and are held in position by a special adhesive applied to the component body underside prior to soldering. Computerised machinery for the high-speed and accurate placement of the SMDs on the board has been developed by Philips.

This technique leads to the miniaturisation of equipment resulting in such things as portable TV cameras and v.c.r.s. It will also lead to the development of other equipment which possibly has not been considered commercially viable because of its size.

A series of seminars are currently being presented by Mullard Ltd. throughout the UK, to familiarise and explain the advantages, reliability and cost effectiveness to the many potential users of these devices and the associated assembly equipment.

The final stage of lowering a surface mounted device onto the p.c.b. substrate.

FOR YOUR ENTERTAINMENT

BY BARRY FOX

Lateral Thinking

Try lateral thinking sometimes. Don't always stick with the traditional approach.

Matsushita in Japan broke with tradition a few years ago with its new range of Technics SL turntables. These have a pick-up in the lid, which makes it possible to build a turntable no larger than a record sleeve.

Sony has now indulged in some lateral thinking, with Beta Movie, the new combined video recorder and camera. The mechanical body of the Beta Movie camcorder is not much larger than the Beta videocassette it holds.

To achieve this Sony licked what looked like an insuperable problem. The video head drum of a domestic Beta recorder is very large, 74·5mm in diameter. This gives a high writing speed, which is the speed at which the video heads sweep the tape. This in turn gives a wide bandwidth recording and clearer pictures.

But it's obviously impossible to cram a large drum into a small camcorder. So Sony have made the Beta Movie head drum smaller, just 44·7mm in diameter.

The clever part is making tapes recorded on Beta Movie, with a small drum, compatible with a conventional Beta machine, with a large drum. Here's how it's done?

On a conventional video machine the drum carries two heads and rotates at 25 times a second. The tape is wrapped round 180 degrees of the drum. So the drum records 50 tracks, or TV fields, per second.

In Beta Movie the small drum carries only one head, but rotates at twice the normal speed. So it too records 50 tracks per second. But the tape has to wrap round 300 degrees of the Beta Movie drum so that the track lengths on the tape are the same (117mm) as for a large drum machine.

This presents two problems; how to compress a full video picture into only 300 degrees of the drum revolution, and what to do with the 60 degree gap. Cleverly, Sony has altered the scanning time of the picture tube in the camera so that each video picture is scanned faster than usual.

A full picture is laid down in the incomplete wrap of tape. Clever isn't it?

The only snag is that you can't *replay* tapes on a Beta Movie camcorder. Sony takes advantage of this snag. Because you can't replay the tapes on a Beta Movie camera you don't need a picture tube or rewind function. This makes the camera more simple and saves on battery drain.

Replay

On the other hand the VHS manufacturers, led by JVC, have come up with a camcorder that replays as well as records. And it's even smaller than Beta Movie.

The VHS Video Movie uses the miniature VHS cassette (VHS-C) which is around the size of a packet of cigarettes. Like Beta Movie, VHS Video Movie has a smaller-than-standard video head drum and the tape is wrapped further round it to preserve standard track length.

Unlike Beta Movie, VHS Video Movie uses a standard camera scan rate. JVC has modified the speed of the drum and added more video heads to achieve the same time compression.

As a result VHS Video Movie can be used to replay tapes as well as record them. This is a bonus because you can check that you really are getting pictures onto tape. To save on battery drain the Video Movie replay picture tube is the smallest ever, just half an inch across, and viewed through a magnifying glass.

Whereas VHS Video Movie has a maximum playing time per cassette of 30 minutes, due to the small cassette, Beta Movie takes a standard Beta cassette that can run for over three hours. But the rechargeable battery that fits in the camera handle will only run for one hour. There's no known way yet of producing a battery that runs for three hours, but is still small and light enough to fit in a portable camera.

Battery Power

Talk of the battery power-weight ratio problem prompted an engineer's discussion recently over Sir Clive Sinclair's promise of an electric car. How can he build a car that is small and light, but carries enough battery power to cover any useful distance between re-charges?

Perhaps Sir Clive has been doing some lateral thinking. Does it have to be a battery?

Think laterally. The power source could be a compressed air cylinder that runs a dynamo. That would be light, cheap and clean. To compress the air, you use electric power from the mains.

This prompts yet another bit of lateral thinking. The oil companies currently spend vast amounts of money pumping crude oil out of the ground in the most unfriendly places, like Alaska and the North Sea.

They then send the oil down a pipeline to a refinery and fleets of tankers and lorries then transport it round the world. The transport costs a fortune and is a permanent pollution risk.

Some of the oil is finally used to produce electricity. Some of it is used to do jobs that could be better done by electricity.

What a ridiculous situation! How much simpler it would be if the oil were converted into electricity at the first possible opportunity, for instance at a refinery combined with a power station. The energy in the oil could then be sent down cables as electricity, rather than carried by transport that itself consumes yet more oil.

The more you think about this approach, the more sense it makes.

Satellite Broadcasting

There has been all manner of confusion recently over satellite TV, and the BBC's plans for DBS—that's Direct Broadcasting by Satellite. Some people seem to have got hold of the wrong end of the stick and concluded that the BBC could use a low power communications satellite instead of the much more expensive, high power *Unisat* bird which the Corporation will be renting for £24 million a year. It's here worth setting a few basic facts straight.

Communication satellites, which bounce telephone calls, computer data and television programmes across continents, currently use frequencies in the 4GHz and 6GHz band. The next generation of communication satellites will use frequencies in the 11GHz, 12GHz and 14GHz bands.

The transponders on the satellites, that's the equipment that receives a signal coming up from the earth and beams it down again at another frequency, are of very low power, less than 10 watts. Remember that power is at a premium up there in the sky. There's only solar power available and the satellite has to be as light as possible to make launching economic.

A communications satellite like *Intelsat* has 27 different transponders on board to be powered. So each transmits only a few watts.

Large Dish

To receive these low powered signals from the ground you need a very large dish and very efficient low noise amplification for the microwave frequencies. It's literally space age technology!

Even modern dish aerials like those to be installed next year by British Telecom, in London's dockland, are 13 metres (or 43 feet) across. Existing dishes for *Intelsat* are 30 metres in size! You also need to line the dishes up very carefully and keep them lined up despite heavy wind.

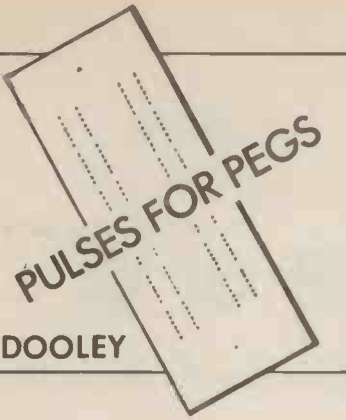
In future years there may be low noise microwave amplifiers good enough to make smaller dishes possible but so far it's cheaper to use a giant dish. In the US some enthusiasts install their own large dishes, but it's obviously an expensive and impractical approach.

DBS will use 12GHz frequencies. If it is to succeed, and British households are to receive satellite programmes direct off air, then we have to be able to use a small dish with a fairly cheap amplifier.

There is only one way out of this dilemma and that's to transmit down from the sky at high power. The *Unisat* satellite, which the BBC will use, has 200 watt transponders. Even so it will need a 0·9 metre reception dish, carefully aligned to accuracy of a degree, and fitted with expensive low noise electronics.

As amplifiers get better, more powerful and cheaper, the size of the DBS dish will get smaller. Already 0·6 metres looks possible. But, be very wary of any reports you read which suggest that the BBC could use a low power transmitter, and so save a lot of money. They naively overlook the problems of handling microwaves.

It's true that the BBC could save money by using a low power transmitter. But you the viewer would be paying for the BBC's economy. You'd have to pay more for a bigger and better dish and electronics installation, or pay for a local cable company to erect a professional aerial and distribute the BBC signals to you by hard wire. Or make do with very poor quality pictures!



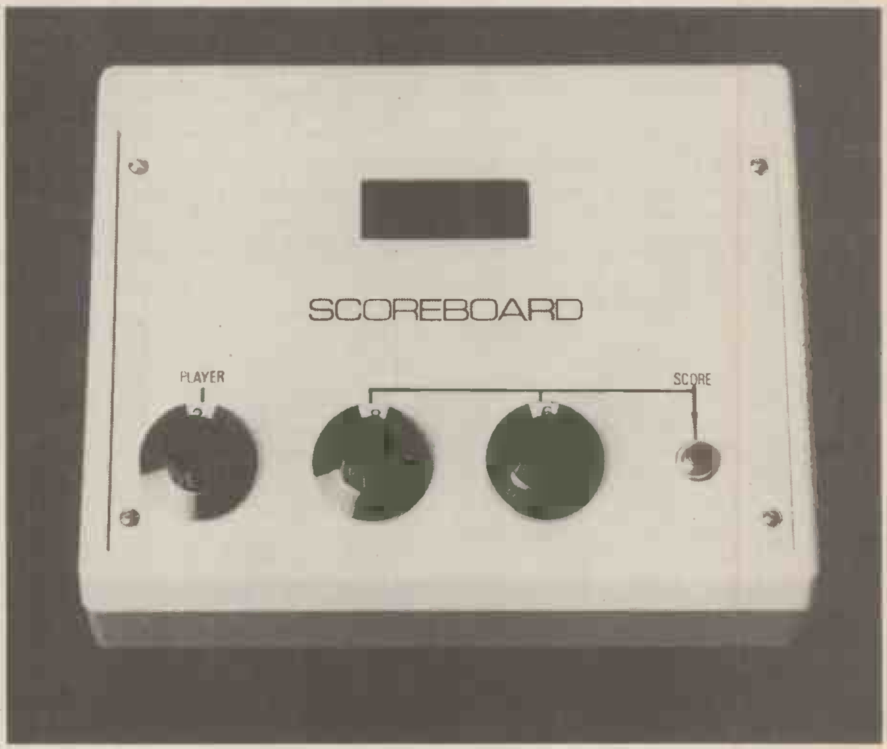
GAMES SCOREBOARD

BY P. DOOLEY

WHEN playing games in which running totals have to be kept, it is tedious to have to add these on a piece of paper, particularly if you have been elected scorekeeper. The Games Scoreboard is a unit which will add and store the totals for up to four players.

The player number is selected and the score to be entered (maximum 99) is set on the front panel switches and the operator then pushes the SCORE button to enter the count. That player's score is then incremented and the new total displayed on a 3-digit 7-segment read-out.

The unit is powered by a standard mains adaptor of the type used by TV games (supplying 9V d.c.).



CIRCUIT OPERATION

A block diagram of the system is shown in Fig. 1. When the latch is set by operation of the SCORE switch, the low frequency oscillator is enabled. This increments the 2-stage counter and the player display counter. When the count set by the switches is reached, the 2-stage counter and the latch are reset, but the count is held in the player display counter. The four player display counters are selected with a rotary switch.

The complete circuit diagram of the Games Scoreboard is given in Fig. 2. Two NOR gates, IC1a and IC1b, are connected as a bistable latch. C1 and R1 reset this latch at switch-on. When the SCORE switch S2 is pressed, pin 3 of IC1a goes high (logic 1) enabling the low frequency oscillator made from two NAND gates IC2a and IC2b. R5 and C3 set the frequency of oscillation.

The output of the oscillator clocks the 2-stage decimal counter, IC3 and IC4. These are CMOS 4017 decimal counters cascaded in series so as to count to a maximum of 99. The clock pulses are fed into pin 14 of the unit's counter (IC3) and each successive pulse will step the outputs sequentially, the selected output being high for one cycle.

On completion of the tenth pulse, a carry signal is generated at pin 12 and this is fed to the clock input (pin 14) of IC4, the ten's counter. The outputs of the two counters are directed through rotary switches S3 and S4 which can be set to any count from one to 99.

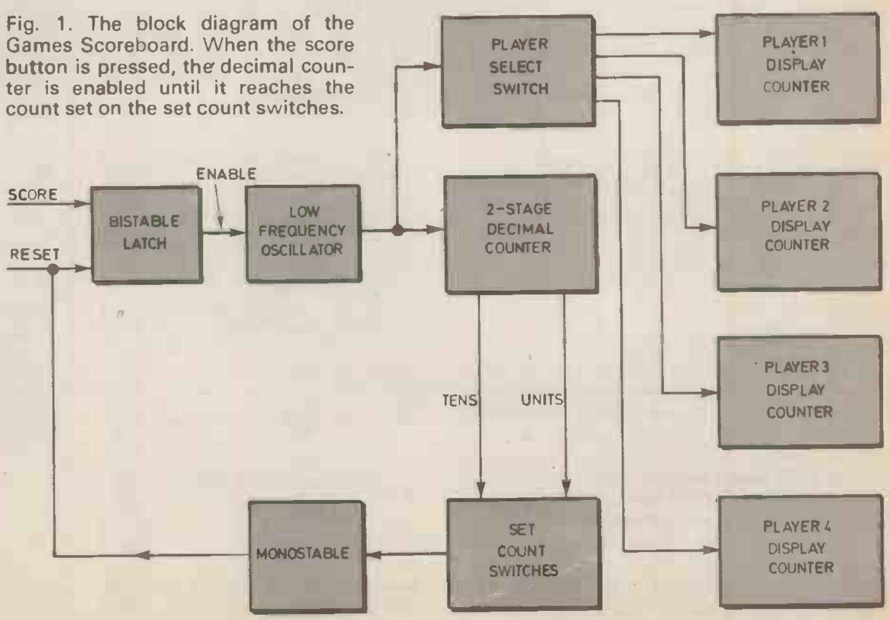


Fig. 1. The block diagram of the Games Scoreboard. When the score button is pressed, the decimal counter is enabled until it reaches the count set on the set count switches.

If for example, S3 was set to position "2" and S4 set to position "5", on the 25th pulse from the low frequency oscillator, the inputs to NAND gate IC2a (pins 1 and 2) would both be high. Pin 3 would therefore go low, this being inverted by IC2c to produce a logic high to enable monostable IC1c and IC1d.

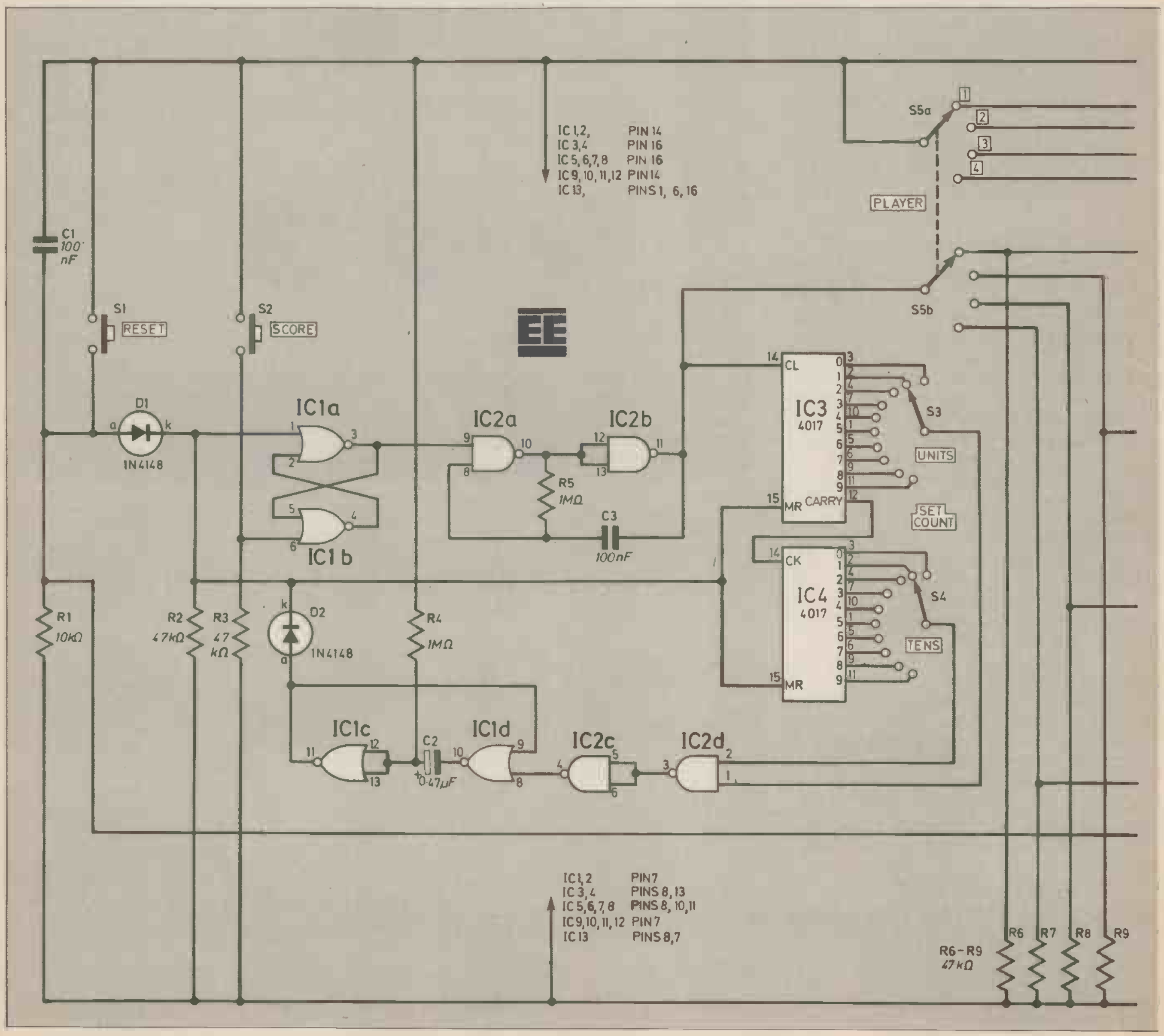
The monostable pulse resets the bistable latch thus disabling the low frequency oscillator and also resets the 2-stage counter. However, the 25 pulses have also gone, via switch S5b, to one of the player display counters to be stored—this will be described later.

The speed of the count has been set to run slowly for two reasons; the count can be seen incrementing on the display, and if the clock was to run too fast it would be possible to get a double count should the operator still have the SCORE switch pressed when the set figure is reached.

COUNTER AND DISPLAY

The four counters (IC5, 6, 7 and 8) are CMOS 4553 3-digit b.c.d. (binary coded decimal) counters which can store up to 999. The outputs are multiplexed, the scanning frequency being set by C4 on pins 3 and 4 of IC5. This scan oscillator is also used to control the multiplex frequency of the other three counters by feeding into pin 4 (the external clock input) of each.

Fig. 2. The complete circuit diagram of the Games Scoreboard unit. An external power supply via SK1 is required.



Switch S5b selects which counter is to receive the clock pulses and S5a activates the relevant CMOS 4066 quad bilateral switch (IC9, 10, 11 or 12). These i.c.s control the b.c.d. output data from the counters and the switches are opened by taking the control pins to logic high.

To prevent the control pins of the bilateral switches and the clock inputs of the counters from floating when not activated, resistors R6 to R9 and R10 to R13 respectively, hold these inputs low.

The counter output is interpreted by IC13, a CMOS 4543 b.c.d. to 7-segment decoder and displayed on X1 to X3, the common anode displays via current limiting resistors R17 to R23. The displays are multiplexed by the output from IC9 and driven by TR1 to TR3.

The RESET switch, S1, will reset the bistable latch, the 2-stage decimal counters and the 3-digit player display counters, ready for the next game.

CONSTRUCTION

MAIN CIRCUIT BOARD

With the exception of the displays, the circuit is assembled on one p.c.b., size 130 × 115mm and this is available from the *EE PCB Service,* Order code 8401-06. The component layout and track artwork is shown in Fig. 3.

There are 31 links and these should be fitted first. The spacing of these links permit the use of uninsulated tinned copper wire and although it is a laborious job fitting them, a little care will enhance the appearance of the completed board. When all links are fitted the i.c. sockets are installed followed by resistors, diodes and capacitors, taking care with the polarised components.

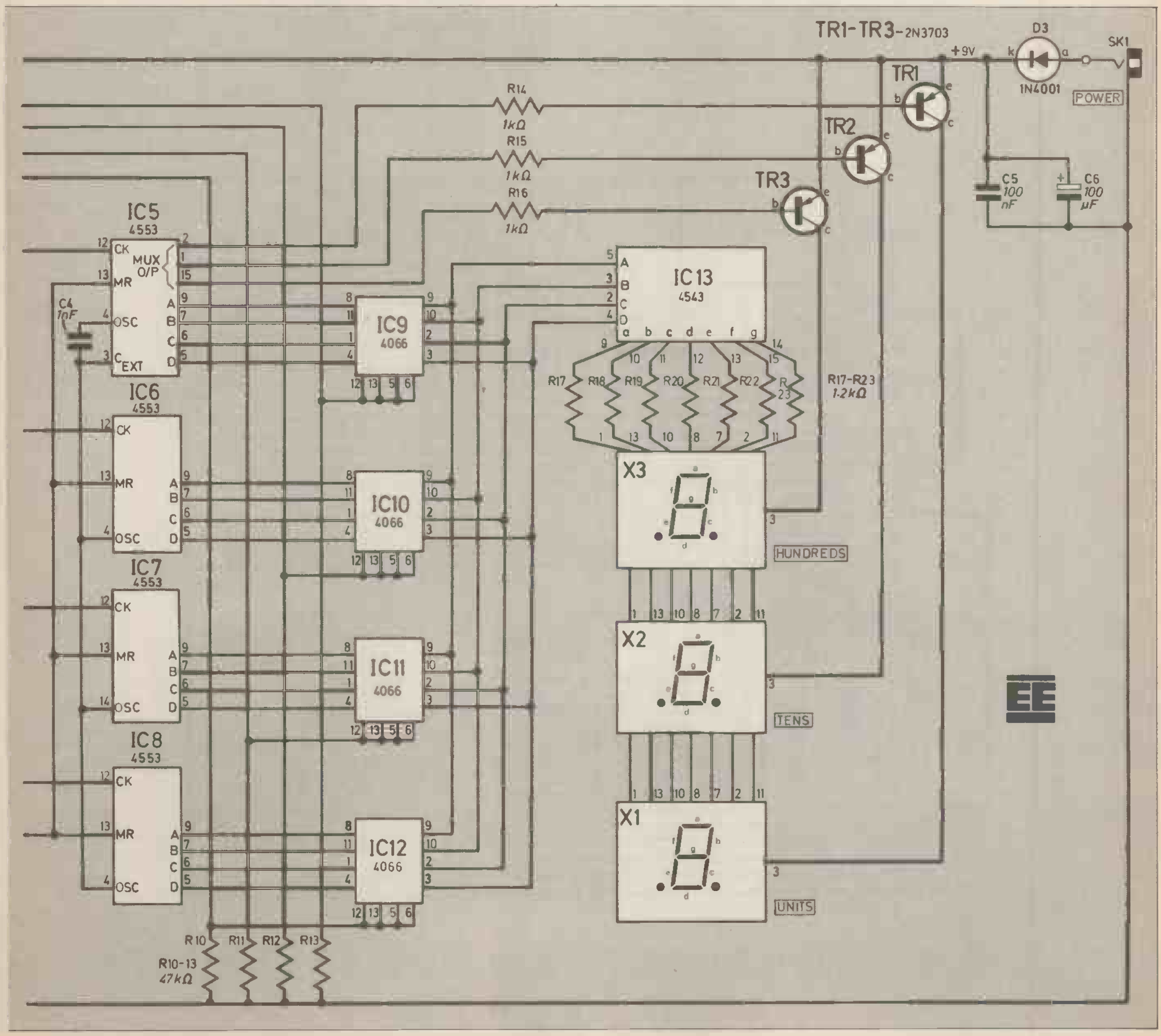
All i.c.s are facing the same way but should not be inserted at this stage. A piece of ribbon cable with nine conductors link the main p.c.b. to the display, and the rotary switches are wired with flying leads—this will be described later.

DISPLAY BOARD

The track layout and component assembly of the display p.c.b. is shown in Fig. 4. This board is also available from the *EE PCB Service,* Order code 8401-07.

The i.c. socket is fitted first, followed by the resistors and transistors, observing the pin-out of the latter. The terminal pins for the ribbon cable connection must be inserted from the component side to allow solder joints to be made on the trackside.

The 7-segment displays (X1 to X3) are fitted last and care must be taken to ensure that they are level and that the viewing face is higher than all other compo-



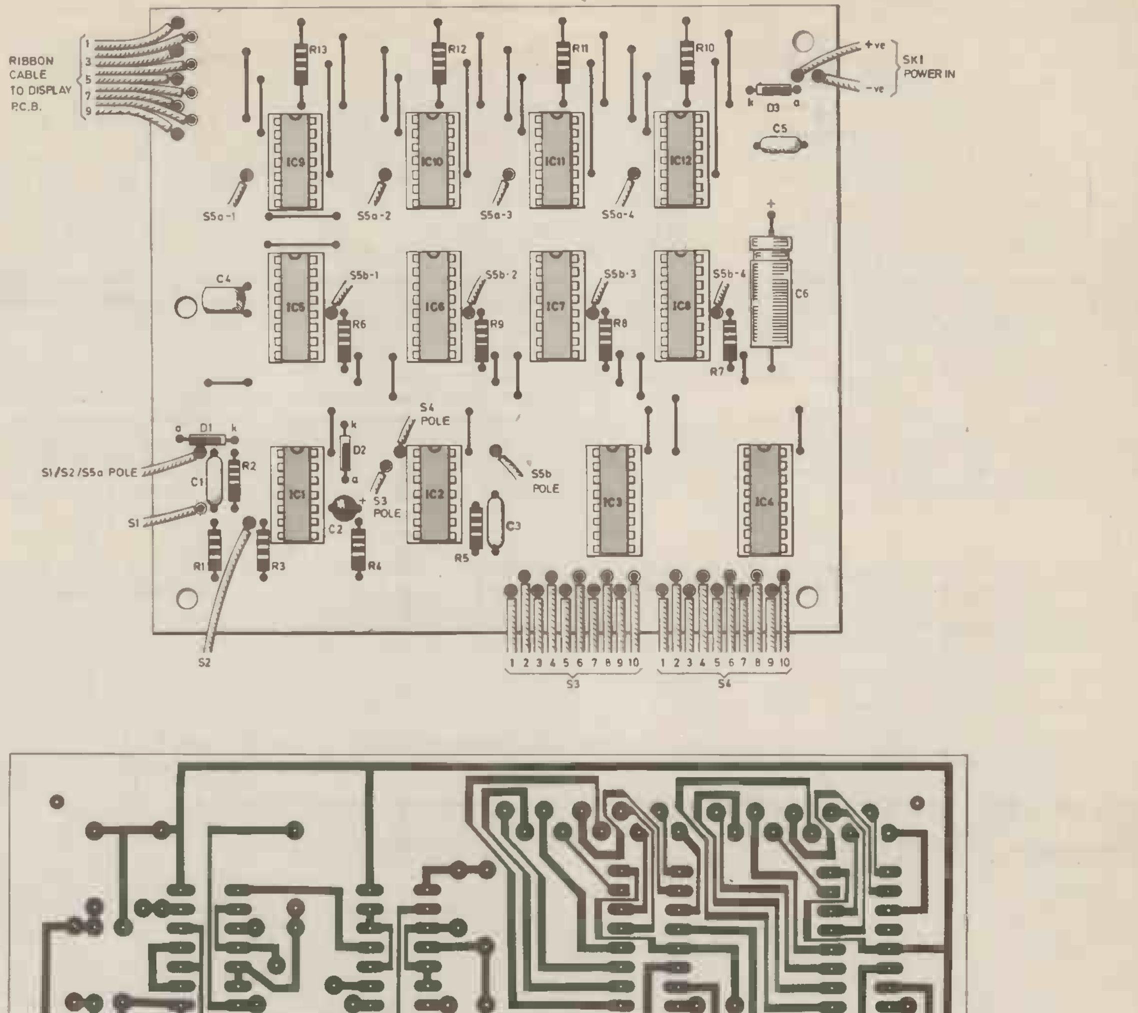


Fig. 3. The full-size p.c.b. artwork and component layout diagram of the main circuit board. All i.c.s are facing the same direction and all links can be bare tinned copper wire. Note that the connections to the display board (Fig. 4) are made with 9-way ribbon cable.

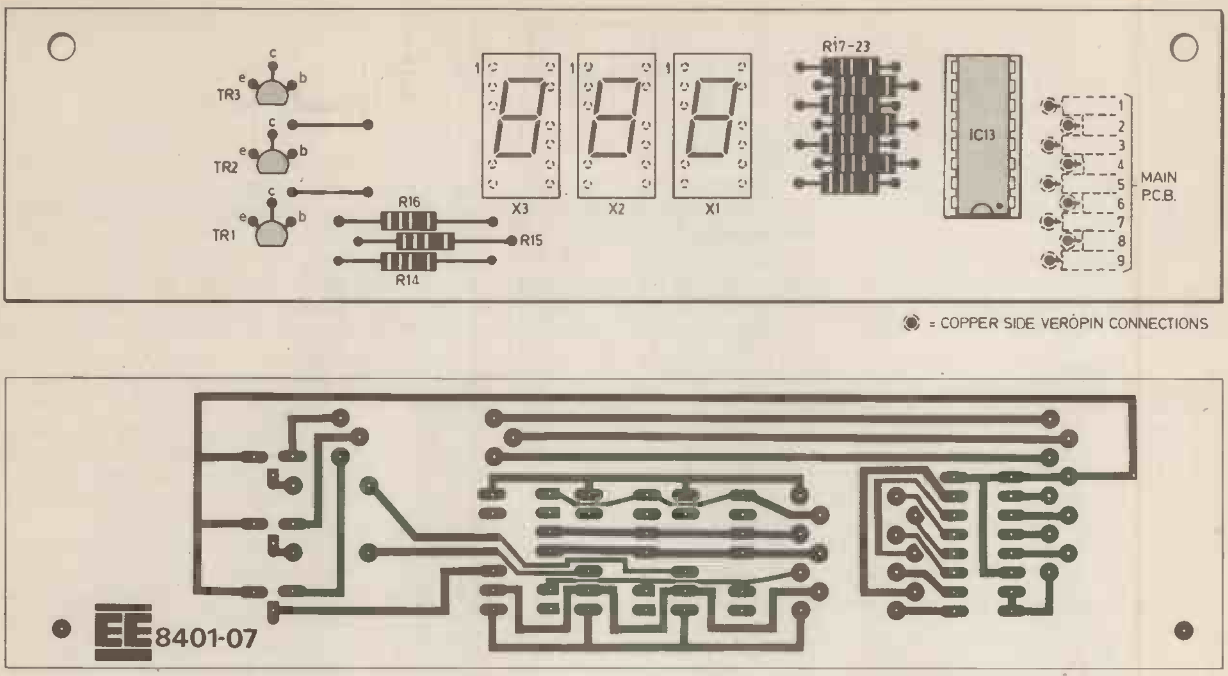


Fig. 4. The component layout and full-size p.c.b. artwork for the display board. The board is as wide as shown to utilise the mounting positions of the console case front panel. See Fig. 5 for the mounting of X1 to X3.

COMPONENTS

COMPONENTS approximate cost £36.00

See Shop Talk page 16

Resistors

R1,14,15,16	10kΩ (4 off)
R2,3,6–13	47kΩ (10 off)
R4,5	1MΩ (2 off)
R17–23	1·2kΩ (7 off)

All $\frac{1}{4}$W carbon ±5%

Capacitors

C1,3,5	100nF polyester (3 off)
C2	0·47μF 16V tantalum
C4	1nF mylar
C6	100μF 16V elect.

Semiconductors

D1,2	1N4148 silicon (2 off)
D3	1N4001 silicon
TR1–3	2N3703 *pnp* silicon (3 off)
IC1	4001B CMOS quad 2-input NOR gate
IC2	4011B CMOS quad 2-input NAND gate
IC3,4	4017B CMOS decade counter/divider (2 off)
IC5–8	4553B CMOS 3-digit binary counter with multiplexed output (4 off)
IC9–12	4066B CMOS quad bilateral switch (4 off)
IC13	4543B CMOS b.c.d. to 7-segment decoder
X1–3	common anode 0·3in 7-segment l.e.d. display (3 off)

Miscellaneous

S1,2	s.p. push-to-make miniature push-button (2 off)
S3,4	s.p. 12-way midget rotary—set to 10-ways (2 off)
S5	3-pole, 4-way midget rotary
SK1	2·1mm power socket

Printed circuit boards: single-sided size 130 × 115mm and 160 × 38mm, *EE PCB Service,* Order codes 8401-06 and 8401-07; console type case, size 170 × 120 × 75 (rear) × 40mm (front) Verobox type 202-21033A; knob kit (3 off—including collet knob, cap, stator, numbered skirt, slotted nut); 16-pin d.i.l. socket (7 off); 14-pin d.i.l. socket (6 off); red display filter; clip-on p.c.b. mounting pillars (4 off); 6mm spacers (2 off); 6BA × 1in screws plus nuts (2 off); 10-way ribbon cable; 7/0·2mm wire; tinned copper wire.

nents on the board. This can be achieved by placing the board on spacing blocks, just high enough to allow the display pins to protrude through the board and make a good solder joint. See Fig. 5.

CASE

The unit is housed in a console type case, 170 × 120 × 75 (rear) × 40mm (front). The Verobox type 202-21033A with an aluminium front panel is suitable.

The drilling details for the front panel are given in Fig. 6. The method used to make the cut-out for the display will depend on the facilities available to the constructor but the easiest way is to drill a small hole at one corner and saw out the waste with an Abrafile (a cross between a file and a saw held in a hacksaw frame). The slot can be cleaned up with a flat file.

When completed, the panel can be lettered and sprayed with a clear varnish. The red display filter is placed in position under the cut-out and secured with contact adhesive or tape.

The rear of the top half of the case houses the reset switch and the power input socket (see photo for approximate positions) and the base carries the main p.c.b. on clip-on pillars. The main p.c.b. can be used as a template (prior to any components being soldered on) to get the positions of mounting holes.

FINAL ASSEMBLY

The RESET push-button (S1) and the d.c. input socket (SK1) are fitted in position. SK1 on the prototype was a 2·1mm power jack to suit the 9V d.c. mains adaptor used, but it is advisable to check which type of connector is required.

The three rotary switches (S3, S4 and S5) are fitted to the front panel in accordance with Fig. 7. The knobs used are collet types with a numbered skirt and stator to indicate the player number and score to be entered. Note that S5 is set to 4-way and S3 and S4 are set to 10-way switches using the special washer supplied with the midget rotary switches.

The display board has been designed to use the two upper front panel mounting screws to secure it. The original screws are discarded and two one-inch long 6BA screws are fitted (together with the original bottom two screws). 6mm long spacers are placed over the protruding threads and the p.c.b. is fixed in place with 6BA nuts and washers.

WIRING

Wiring to the front panel is accomplished with 36 lengths of 7/0·2mm connecting wire (the display uses a 9-way ribbon cable, however). The main p.c.b. and front panel are positioned so that, when wired together in accordance with the information in Figs. 3 and 4, the wires can be tied into a loom using nylon tie-wraps or lacing cord (see photo). The ribbon cable is not tied into the loom.

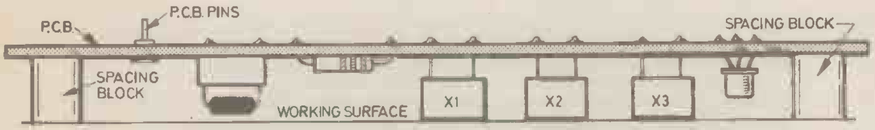


Fig. 5. Method of mounting displays X1 to X3 and p.c.b. pins.

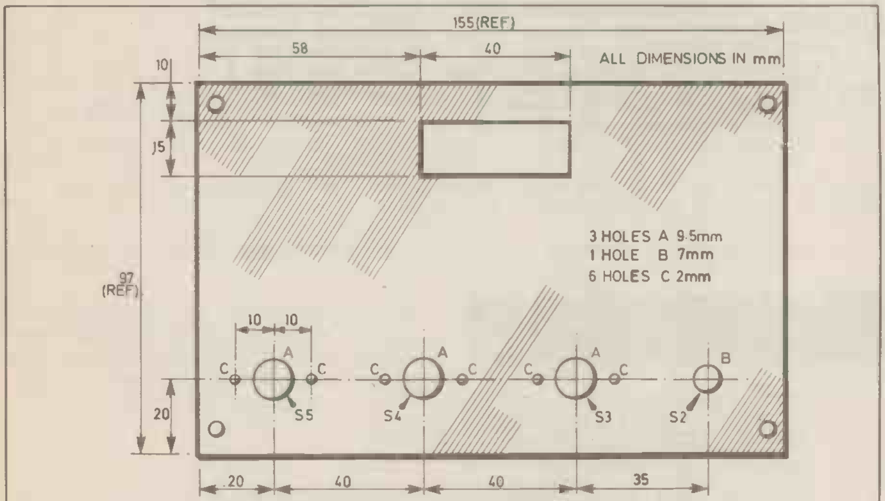


Fig. 6. Front panel drilling details and switch positions.

POWER SOCKET

Before wiring the power socket, check the polarity of the mains adaptor to be used. Some power units have a polarity reversal switch so either can be used but a quick check with a voltmeter will determine the positive connection on those which do not have this facility. No damage can occur through incorrect polarity connection due to the inclusion of D3.

After checking the wiring and making a final inspection of the boards, fit all i.c.s, and place the main p.c.b. into the lower case, locating the clip-on mounting pillars over the moulded bosses in the base. Place the upper case in position and apply power to the unit.

The display should read 000 on all four player positions. Select a count to be entered and press the SCORE button. The display should increment until the count set on the switches is reached. Select each player in turn and check that a count can be displayed and stored.

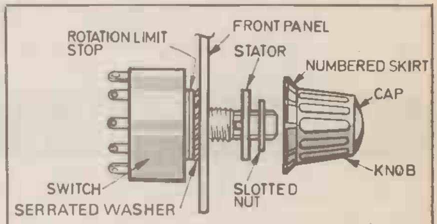


Fig. 7. Rotary switch and knob assembly. Note that numbered skirt is aligned to read "0" at switch position "1".

If all is found to be functioning correctly and the new scores are added to the previous score, the case can be assembled and screwed together. Should the count speed be too fast or too slow, then C3 can be altered; increasing the value will slow the count speed and decreasing the value will speed it up.

FAULT DIAGNOSIS

Should the unit fail to operate at all, check for approximately 9V on the main p.c.b. and display board. If the wrong count is entered, the wiring to switches S3 and S4 should be examined. Note that when the indicator skirt on the knob shows "0", the wiper is connected to contact "1" on the switch.

Should a fault occur on one or more player positions, test the wiring around S5. As there are four identical circuits in the main counter, comparisons of logic levels can be made to assist fault diagnosis. □

Photo (left) shows the wired prototype unit with cables formed into a loom. Note the positions of the power input (SK1) and the reset switch (S1).

RADIO WORLD

BY PAT HAWKER G3VA

Logging The Past

Recently the Federal Communications Commission, the American regulatory organisation for all forms of radio communications and broadcasting, removed the legal requirement for US radio amateurs to keep a detailed log of the stations they contact. Nevertheless, it seems likely that most amateurs interested in long-distance operation will continue to keep records, if only for the purpose of exchanging QSL cards or comparing results with different aerials, etc.

The UK licence requires that, except for mobile operation, a record be kept in a book (not loose-leaf) showing date, time of starting operation, callsigns of stations, times of making and ending contacts, the sending of CQ calls, frequency, mode, time of closing station, and so on. Logs have to be entered up in "real-time" without gaps between entries.

In practice most of us also keep notes of the location of each station contacted, name of the operator, and often details of his or her equipment. Although to some it may seem a chore, these requirements do mean that one has a permanent record of one's radio activities.

Recently I started on my thirteenth log book in a series that opened on 22 October, 1938 when I made several fruitless calls on 7060kHz and a contact with a local amateur not more than about a mile away! Things picked up next day with several contacts on 1745kHz and 1970kHz over distances up to 50 miles or so.

Nowadays it seems much easier going and the page I have now reached includes 7, 14 and 21MHz contacts with the USA, Brazil, Japan, Asiatic and European USSR, as well as British and West European amateurs, despite the simple long-wire aerial and equipment that mostly dates back several decades!

An Historic Era

The real pioneers of the shortwaves, of course, were those who in the 1920s first showed that long-distances could be covered at low-power using wavelengths around 110 metres and below. It is exactly 60 years since the French amateur Leon Deloy, F8AB, made the first (ever) two-way contact on short waves across the atlantic by contacting, in the early morning of 28 November, 1923, three pioneering American amateurs, John L. Reinartz, Ken Warner and Fred Schnell.

No professionals had accomplished such a feat. This followed months of testing equipment capable of working down to 100 metres, no easy matter in those days.

Just over a week later in the morning of 8 December, 1923, Jack Partridge, G2KF, with the assistance of Leon Deloy, made the first UK-USA contact with Ken Warner (U1MO) of ARRL. Three days later Jack Partridge turned a blind eye to British regulations by receiving third-party messages of greetings from A.R.R.L. addressed to Senatore Marconi and to the president of the R.S.G.B. The message to Marconi put it thus: "ARRL presents its respects and this evidence of Dawn of International Amateur Radio".

Simple Receivers

The three-semiconductor *EE Short Wave Radio* designed by R. A. Penfold (October 1983 issue), with a regenerative FET detector and plug-in coils, reminded me vividly of the receivers I used when I was first licensed. Although, in my case, I used two 2-volt filament valves complete with "accumulator" and h.t. battery.

Despite the simplicity and critical adjustment I succeeded in using such sets to contact amateur stations in North and South America, Southern Africa and Australia. I would not guarantee to repeat this successfully in the far more crowded band conditions today.

Nevertheless, the alternative and potentially much more selective form of direct-conversion receiver, using a synchronous rather than a regenerative detector, remains popular with those interested in Morse (c.w.) operation, although not suitable for listening to a.m. broadcast stations.

Flea Power

There is a growing number of enthusiasts who spend much time and effort seeking to make long-distance contacts using minimum transmitter power, often under 5 watts d.c. input. I personally usually recommend newcomers first to gain experience with power inputs of not less than about 15 to 25 watts, at least on the h.f. bands.

It is really surprising what can be done with low-power. The other day I had quite a shock when 4S7VK in Colombo, Sri Lanka, who was putting in a reasonable signal, told me his rig was a 3-watt transmitter and dipole aerial.

Back in the 1960s, the large American firm RCA developed a pocket 0·1-watt (100 milliwatts) transmitter intended to enable, for example, a pilot to signal his position after an emergency landing. By using a very elaborate and stable receiver with extremely narrow bandwidth it was shown that this tiny transmitter, sending information at a very slow rate, could be reliably heard at distances up to about 2000 miles when using frequencies between 13 and 16MHz.

I do not believe the system ever went into production but it certainly represented just about the ultimate in low-power h.f. operation.

Under The Grid

Channel 4's consumer programme "What It's Worth" recently described the headaches, giddy spells, lethargy and depressions ascribed by people living in Fishponds, Dorset to the presence of the 400kV, 50Hz electricity grid. It raised once again the highly controversial question of possible behavioural effects of non-ionised electromagnetic radiation at levels below those that provenly produce tissue heating and a potential danger to eyes.

During the past year the National Radiological Protection Board, none of whose experts appeared in the programme, have recommended a reduction in the safe limit for continuous exposure to r.f. radiation from 10 to 1mW/cm^2. This is only for frequencies between about 30 to 300MHz where the human body can act as a resonant half-wave dipole.

The NRPB now also accept that a few individuals can "hear" pulsed signals from high-power radar transmitters in the immediate locality, though there are no proven harmful effects. They seem to remain extremely sceptical of any hazard from non-thermal effects at the low-levels of radiation reported many years ago by Russian scientists.

It is extremely difficult to pin down the physical or mental causes of headaches, depression or fatigue. The symptoms are common enough also in people living well away from high-voltage power lines or radio transmitters.

Channel 4's programme concentrated on the work of Dr. Jean Monro and Dr. Cyril Smith who believe that some people develop an "allergy" to electromagnetic fields. It is difficult to dismiss their work, though for the time being I suspect most radio engineers will return a "not proven" verdict—though clearly further investigation seems called for.

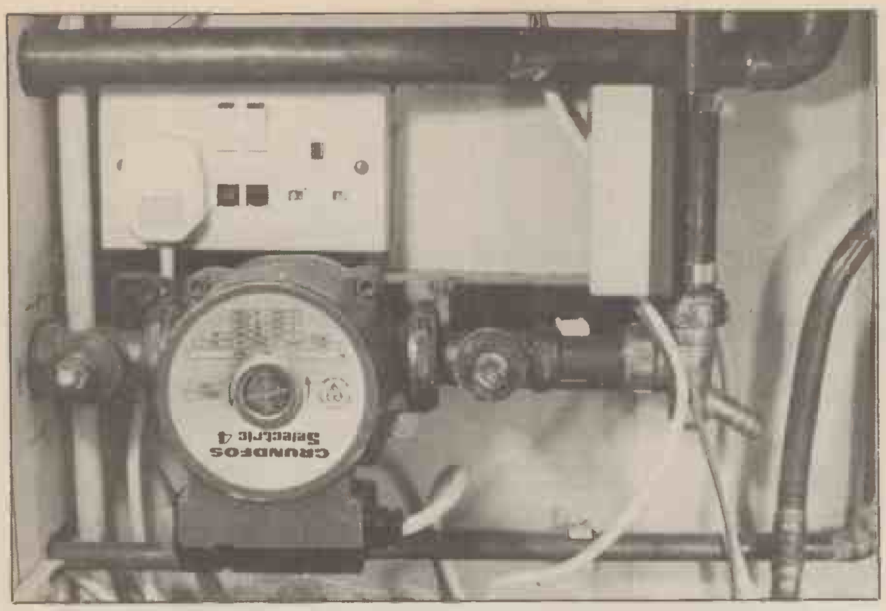
Power By Radio

At the beginning of the century, Nikola Tesla—that strange genius whose projects became increasingly grandiose and mysterious though his early work deserves to be ranked with that of the greatest pioneers of electricity—believed that communication by radio was relatively simple. He set himself the infinitely more difficult task of transmitting *power* without wires.

It was not until many years later, when it became possible to generate large amounts of microwave energy and send this along very narrow beams using highly-directive aerials, that the Tesla idea was resurrected. In the USA demonstrations were given during which a large model aircraft was kept flying with the aid of a microwave beam.

More recently there have been proposals for generating large amounts of solar power using solar cells in space and then beaming down microwave power to the ground; multi-channel "world radio" systems have similarly been proposed relying on electrical power beamed up from below. A more promising project is actually being worked on in Canada for the SHARP (Stationary High Altitude Relay Platform) project.

The "platform" will, it is hoped, consist of a lightweight "drone" (unmanned) aircraft at an altitude of about 20km carrying active or passive reflectors for communications or broadcasting. Power for the drone and any active equipment is expected to be sent up to it by means of a grid of high-power microwave transmitters.



CENTRAL HEATING PUMP DELAY UNIT

BY A. GRAY

Above—The Central Heating Pump Delay Unit shown clipped to the flow-pipe side of the pump. Below left—With the lid of the case removed, the single p.c.b. construction can be seen. Below right—Close-up showing the Terry clip mounting.

THIS simple electronic accessory can prevent the waste of heat that tends to occur every time the boiler is switched off for more than a few minutes. It is suitable for systems using gas or oil-fired boilers with circulation of heating water by electric pump.

In a typical installation it should recover its initial cost in one to two years and will continue to save money thereafter. With larger boilers, the savings will be greater. However, systems based on low water content wall-hung boilers are unlikely to benefit from the use of this unit.

CENTRAL HEATING SYSTEMS

A conventional central heating system is outlined in Fig. 1. Water is pumped through the boiler heat-exchanger block, through all the radiators, and back to the boiler for reheating and recirculation. The gas or oil supply to the burners is controlled by an electric solenoid valve via a thermostat that senses the heat-exchanger temperature.

In some systems, the heating coil of the domestic hot-water cylinder is connected just as if it were another radiator on the pumped circuit, but independently controlled by a motorised valve. In other systems, the heating coil has a separate pipe circuit to the boiler with gravity convection providing heating water circulation. The pump delay unit does not affect the operation of either of these arrangements.

TIME-SWITCH

The pump and boiler are usually controlled by a time-switch and, possibly, a room thermostat. Fig. 2 shows the usual wiring arrangement. When the time-switch is on, the pump runs continuously or under control of the room thermostat. The boiler thermostat opens the fuel solenoid whenever the circulating water falls below a preset temperature (normally in the range 55–80°C). The time-switch usually offers the options of hot water only (boiler on, pump off) or heating and hot water (boiler and pump on).

When the time-switch disconnects the boiler and pump, the water immediately stops circulating and the radiators cool rapidly. However, there is still a substantial amount of residual heat energy stored in the boiler heat-exchanger and some in the distribution pipes. The heat in the heat-exchanger is then lost, mostly as warm air escaping up the flue. The heat in the pipes may also be lost into wall and floor-ceiling cavities.

THE PUMP DELAY

The Central Heating Pump Delay unit controls the changeover contacts of a relay inserted in the original supply to the pump motor, as shown in Fig. 3. The unit senses the temperature of the circulating water as it leaves the boiler and, after the boiler has switched off at the end of the heating period, it keeps the pump running until the water has fallen below a preset temperature. This allows the radiators to extract most of the stored energy and deliver it as useful room heating.

It also evens out the residual heat distribution between radiators. In other words, radiators in cold places cool only a little more quickly than those in warmer places. So, the time-switch can now be set to turn off, say, 15 minutes earlier than before without shortening the period of effective heating. This means less fuel is used for the same level of heating.

SYSTEM DESCRIPTION

A block diagram of the unit is shown in Fig. 4. Most of the work is done by one integrated circuit, the LM3911. This is indicated by the shaded area of the diagram. It comprises a shunt regulator, a temperature-dependent voltage source and an op-amp.

A potential divider across the regulated supply produces a preset voltage that is applied to the op-amp inverting input. The non-inverting input is fed from the temperature sensor, which gives a negative-going output for increasing temperature.

The op-amp is operated without negative feedback so it acts as a comparator. When the preset voltage is less than the sensor output, the op-amp output is positive, and vice-versa. This gives us the switching characteristics of a thermostat. The op-amp output current is amplified to operate a relay capable of switching the pump supply.

FEEDBACK

A small amount of positive feedback speeds the transition between output states and introduces a small hysteresis corresponding to about 1°C. In other words, with rising temperature the output switches at a point about 1°C higher than that at which it switches back with falling temperature. This small "dead band" eliminates any tendency to rapid alternations of output state such as might be caused by electrical noise at the comparator inputs or by draughts on the temperature sensor.

CIRCUIT DETAILS

The complete circuit diagram is shown in Fig. 5. Diodes D3–D6 form a bridge rectifier delivering an unsmoothed d.c. supply for the relay coil. This supply is smoothed by C3, which is prevented by D1 from discharging back into the relay. R5 is a voltage dropper for the shunt regulator in IC1.

The regulator behaves like a Zener diode, maintaining about 6·8V across pins 1 and 4 of IC1. R5 is selected to pass about 2·5mA. If too much current flows in the shunt regulator, it will cause excessive self-heating of IC1 and degrade the temperature sensor's accuracy.

The preset voltage corresponding to switching temperature is derived from the R1, VR1 and R2 potential divider chain. R1 and R2 allow the adjustment range of

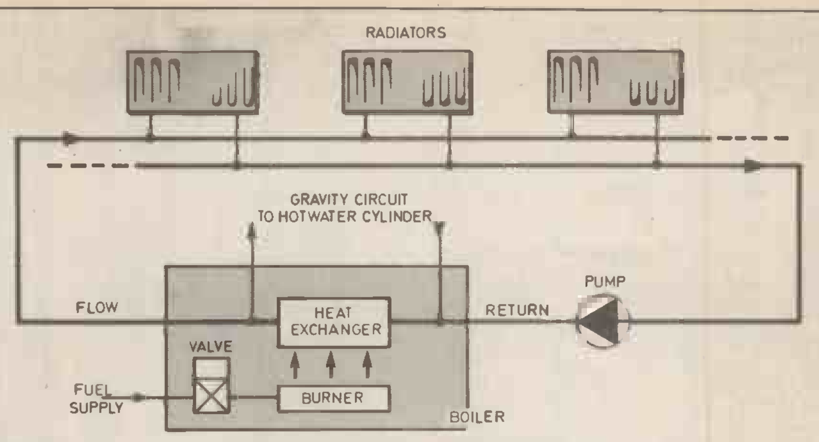


Fig. 1. Diagram of a typical gas or oil-fired central heating system. The gravity fed circuit heats the water in the hot-water cylinder.

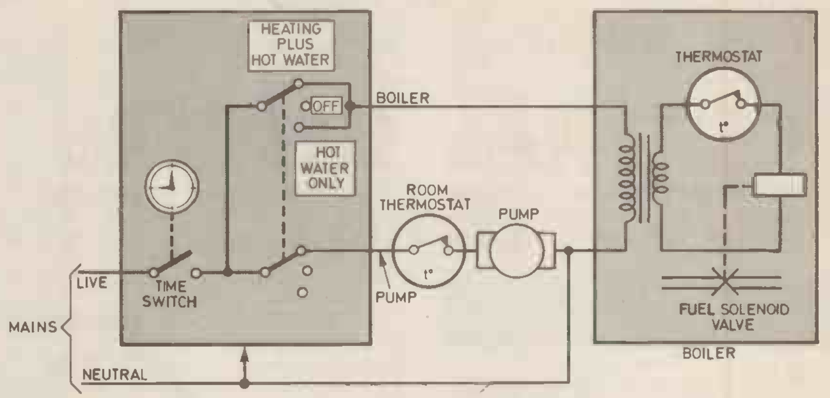


Fig. 2. Typical electrical wiring arrangement of the time-switch, pump and boiler.

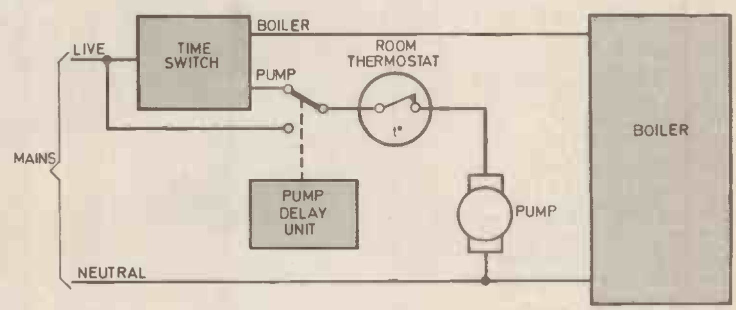


Fig. 3. Wiring of the Pump Delay Unit relay change-over contacts to the heating system to maintain power to the pump after the time-switch has turned off.

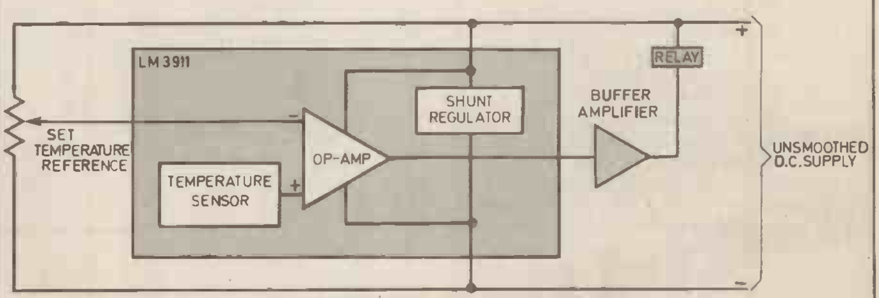


Fig. 4. Block diagram of the Central Heating Pump Delay with the LM3911 temperature controller i.c. The relay operates the contacts shown in Fig. 3.

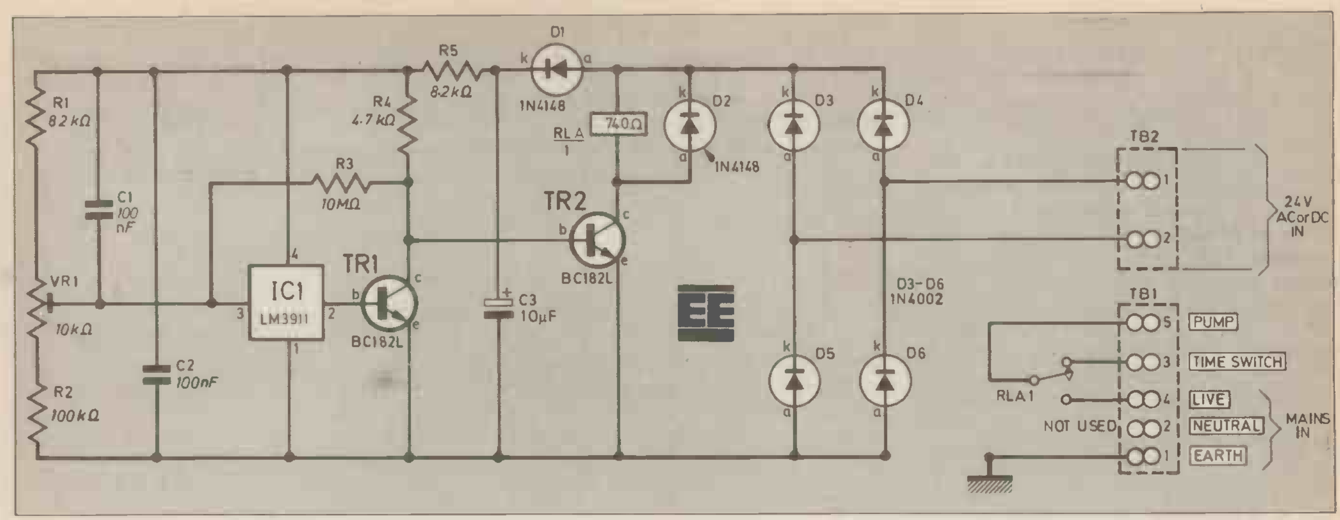


Fig. 5. The complete circuit diagram. Values shown are for 24V a.c. operation—see Table 1 for variations.

VR1 to be fully spread over the desired temperature range of 20–55°C. The negative end (towards R2) corresponds to maximum temperature.

Only pins 1 to 4 of IC1 are electrical connections. The remaining four pins are electrically isolated and are used for thermal input to the on-chip sensor. The output current of IC1 (typically 100µA) is amplified by TR1 and TR2. The full load current of the relay coil cannot be passed through IC1, again because of undesirable self-heating effects.

The positive input of the op-amp is not externally connected, so the positive feedback is provided by R3 feeding back from the inverted output at the collector of TR1 to the op-amp inverting input at IC1 pin 3. The feedback ratio is about 0·4 per cent which, at an absolute temperature of about 300 Kelvin (= 27°C), gives just over 1°C hysteresis. D2 protects TR2 from back e.m.f. transients produced by the relay coil at switch off. C1 and C2 decouple noise on the preset voltage input and on the regulated supply respectively.

COMPONENTS

See Shop Talk page 16

Resistors
- R1 82kΩ
- R2 100kΩ
- R3 10MΩ
- R4 4·7kΩ
- R5 see Table 1

all ¼W carbon film ±5%

Capacitors
- C1, 2 100nF ceramic disc (2 off)
- C3 10µF, 40V elect. radial lead

Semiconductors
- D1,2 1N4148 silicon (2 off)
- D3–6 1N4002 100V, 1A silicon rectifier (4 off)
- TR1,2 BC182L silicon *npn* (2 off)
- IC1 LM3911N temperature controller

Miscellaneous
- RLA See Table 1, contacts 240V, 2A min.
- VR1 10kΩ horizontal miniature preset
- TB1 5-way p.c.b. mounting screw terminals
- TB2 2-way p.c.b. mounting screw terminals

Printed circuit board: single-sided, size 95 x 42mm, *EE PCB Service*, Order code 8401-01; case 100 x 50 x 40mm, Verobox type 202-21028B; 8-pin d.i.l. holder; 22mm spring clips (Terry), metal spacers (4-6mm), nuts and screws to suit clips (2 off each); no. 4 self-tapping screws 6mm (4 off); grommet; varnish.

COMPONENTS approximate cost £12.00

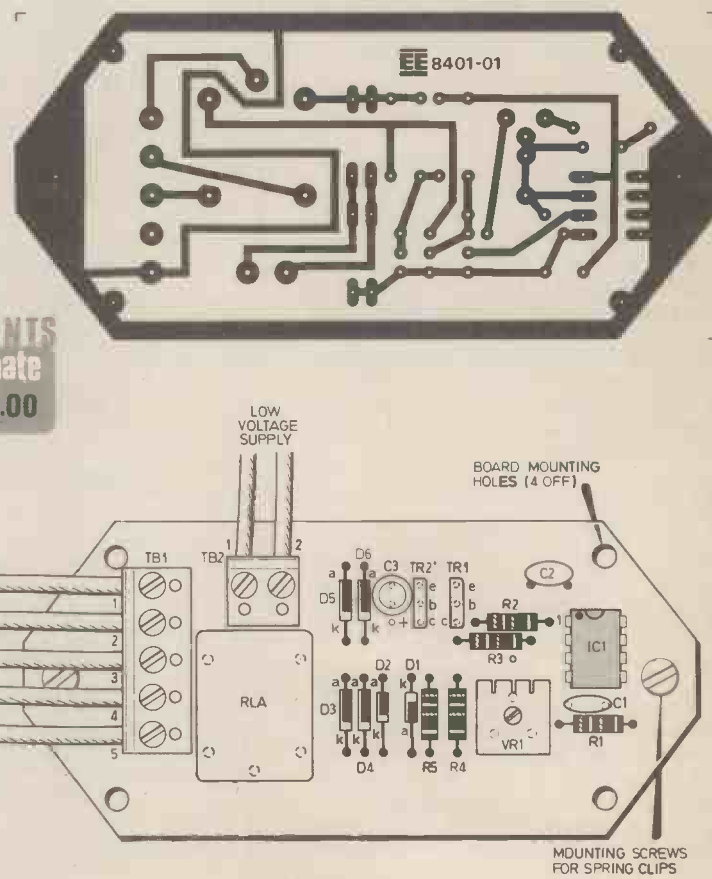


Fig. 6. Full-size p.c.b. artwork and component layout diagram. The two Terry spring clips are mounted on 6mm long spacers on the trackside with suitable screws.

CONSTRUCTION

CIRCUIT BOARD

Construction is on a single p.c.b., the layout and artwork of which is shown in Fig. 6. External connections are by means of printed circuit mounting screw terminals (TB1 and TB2). The low-voltage terminals are grouped separately from the mains connections.

The p.c.b. has been carefully designed to isolate the relay contacts from the rest of the circuit with suitable track spacing and a protective earth trace. This is *not* a substitute for correct external fusing of the pump circuit (usually by a 3A fuse), but is an additional safeguard.

Constructors modifying the p.c.b. layout for different relays or terminals should pay close attention to these details. The layout allows for most varieties of preset resistor in the VR1 position and is unlikely to need modification in this respect.

Ideally, IC1 should be soldered directly to the p.c.b. to minimise thermal resistance to pins 5–8, but this application is not particularly critical and the use of a good d.i.l. socket caused no problems in the prototype.

TESTING

When all components are in position, the board can be given a functional test as follows. Connect the low-voltage supply to the p.c.b. terminals. In a warm room the relay will be heard to operate as VR1 is adjusted near its positive end (clockwise towards R1).

In cooler places, set VR1 fully towards R1 and warm pins 5–8 of IC1 by briefly applying a soldering iron to the adjacent p.c.b. pad. After a few seconds the relay should pull in. A short time later it will release as IC1 cools.

If all is well, give the p.c.b. a good coating of varnish as protection against moisture and dirt which is likely to accumulate when the unit is left in place for (hopefully!) a very long time. Take care not to get varnish inside the terminals or on the track of VR2 before it is finally set.

TROUBLE SHOOTING

Check component positions and values carefully. If these are right there is not much that can go wrong when the p.c.b. is used. Check that the supply is reaching the bridge rectifier and that the expected d.c. voltage is developed across C3. If this is all right, measure the voltage between pins 1 and 4 of IC1. Pin 4 should be 6·7V to 6·9V positive of pin 1.

Measurements on the voltage at pin 3 should be made with a high-impedance meter (preferably greater than 10 megohm). VR1 should vary the pin 3 voltage from about −2·9V to −3·2V with respect to pin 4. Note that some variants of BC182L (for example, BC182C) have a different lead-out arrangement. If in doubt, consult your supplier.

INSTALLATION AND ADJUSTMENT

The p.c.b. is designed to fit a widely available Verobox type 202–21028B plastic case. Mount a Terry spring clip on a short (4–6mm) spacer at each end of the p.c.b. as shown in the photographs. Make suitable cut-outs at each end of the case to allow the spring clips to pass through and screw the p.c.b. into place on the four self-tapping screw mouldings provided in the case.

Clip the unit in position without the cover to allow adjustment. It should be on the central heating flow pipe between 500mm and 1500mm from the boiler outlet. One of the clips is purely for mounting, the other also acts as a thermal conductor from the pipe to IC1, so care is needed to ensure that it is in good thermal contact with the pipe and the p.c.b.

The clips should, of course, be of the correct size for the pipe. This is usually 22mm diameter. If you are unsure which pipe is the flow and which is return, feel both pipes a few minutes after the heating has come on from cold; the flow pipe will be hot whilst the return pipe will still be relatively cold.

Wire in the unit using heat-resisting flex (as should already be in use for the rest of the heating wiring.) Earth and neutral terminals are provided as a wiring convenience, although they do not actually supply the unit. An independent earth wire is advisable even though the unit may normally be earthed by the pipework.

After connecting the unit, switch on the supply and the central heating. Set VR1 fully clockwise towards R1. Check that the pump runs normally (feel for vibration or listen via a screwdriver to its case). After the system has fully heated (probably at least an hour from cold), switch it off to cool. The pump should continue to run. Feel the radiators every few minutes as they cool. When they are only a little warmer than room temperature, adjust VR1 slowly anticlockwise towards R2 until the relay has just released.

If a suitable thermometer is to hand, adjust VR1 as described when the radiators have cooled to about 30°C. There is no point setting the unit below this as any heat saving will be outweighed by electrical consumption and wear-and-tear of the pump. If the unit is set too near room temperature, the pump may stay on for excessive periods in warm weather.

When adjustments are complete, the unit should be closed up. The case holes for the spring clips and wiring can be closed with silicone rubber sealant as a protection against moisture and dust.

The prototype model showing how the spring clips protrude through two slots.

CONSTRUCTION OPTIONS

The values shown in the circuit diagram are for a 24V a.c. supply. Many gas-boilers run the solenoid valve from such a supply and can easily supply the small extra current needed for the pump delay unit. However, the unit is easily adapted to other voltages, a.c. or d.c. Table 1 gives suggested alternative components for other supplies.

If an external low voltage power supply is required, a low voltage transformer for example, it must be safely and suitably housed in an enclosed box. If there are no conveniently placed mains connections to wire to TB1 (for example, the mains input to the time-switch), then a separate mains lead to a **3A fused** and earthed 3-pin mains plug can be used.

In all cases, **extreme caution** must be exercised when dealing with potentially lethal mains. □

TABLE 1. POWER SUPPLY AND COMPONENT VARIATIONS

Supply	R5	Approx. voltage across C3	Minimum relay resistance
18V a.c. or 24V d.c.	5·6kΩ	22–25V	400Ω
12V a.c.	3·3kΩ	15–17V	300Ω
9V a.c. or 12V d.c.	1·8kΩ	10–12V	200Ω

Relay coil voltage should approximately match supply, whether a.c. or d.c.
In all cases, contacts to be rated at 240V, 2A minimum.

MICROCOMPUTER INTERFACING TECHNIQUES

INCLUDING MANY USEFUL CONSTRUCTIONAL PROJECTS

PART SEVEN: HUMAN AND PLANT PHYSIOLOGY SIGNAL PROCESSING

BY J. ADAMS B.Sc. M.Sc. & G.M. FEATHER B.Sc.

THE analysis of the electrical signals produced by muscular, brain and plant activity provides an interesting field of investigation, particularly as such data can be stored by a microcomputer and then displayed graphically.

This article describes the theory and construction of an amplifier capable of developing from these signals an output sufficient to interface directly with the single channel ADC described in an earlier article (High Speed A-to-D Converter, M.I.T. Part 3, September 1983).

It should be noted that this project will also interface directly with a commercially available bipolar ADC made by Philip Harris Ltd. The software is also suitable for direct operation with this ADC.

SIGNAL PROCESSING

The amplitude of such signals is generally very small indeed, usually within the order of a few microvolts or so, and it is clear that an amplifier with considerable gain is required if they are to be presented as analogue data to an analogue-to-digital converter.

In common with all high-gain amplification systems, the problem of interference—particularly from 50Hz mains signals arises. This can be particularly serious with data acquisition systems, in which the analogue signals are sampled repetitively, since it is possible for interference to heterodyne with the sampling frequency. This would give rise to very spurious results—an effect known as aliasing. Fortunately, the "biological signals" are generally of low frequency and filtering circuits can be included in the amplifier to attenuate interference and noise.

Such circuits are known as low pass filters and it is worthwhile considering some of the theory behind them.

LOW PASS FILTER CIRCUITS

Any electrical filter is a network that allows the passage of currents within a certain range of frequencies whilst stopping others, and a low pass filter permits the passage of currents below some pre-determined cut-off frequency. Currents of frequency above the cut-off value are not stopped entirely but are attenuated sharply as their frequency increases.

Fig. 7.1 shows the type of characteristic that we are looking for in a low pass filter.

A variety of simple resistor/capacitor networks can be employed for filter circuits but they inevitably introduce some overall attenuation of the signal (known as insertion loss) and extra gain is needed to make good the loss. A more effective solution is to employ an active filter design and a number of standard circuits, for these exist.

The exact theory of their operation is very complex but it is sufficient for our purposes to regard them as operational amplifier circuits with frequency sensitive networks (usually R/C combinations) in their feedback loops.

Fig. 7.2 shows the basic arrangement of one such circuit—the Butterworth low pass active filter.

This circuit has a small gain (4dB or roughly ×1·6) at frequencies within the pass-band; this falls to about half this value at the "cut-off frequency", whilst for frequencies above this, the gain decreases very rapidly, at about 12dB per octave.

So, for a cut-off frequency of 25Hz, a signal at 50Hz (which is double the cut-off value and hence one octave higher), the gain will be −12dB or about four times less than that for 25Hz signals.

The cut-off frequency is given by the formula:

$$f_c = \frac{1}{2\pi\sqrt{(R1 \times R2 \times C1 \times C2)}} \quad \ldots.(1)$$

Having decided on a value for f_c, we are faced with the problem of selecting values for R1, R2, C1 and C2. The easiest solution is to make R1 = R2 = R and C1 = C2 = C, so that the formula simplifies to:

$$f_c = \frac{1}{2\pi R C} \quad \ldots.(2)$$

The filters used in the biological amplifier are designed to have a cut-off frequency of 20Hz, and 220nF capacitors were selected for C1 and C2 so, rearranging formula (2) and inserting these values, we can calculate the required value of R:

$$R = 1/2\pi f_c C$$

$$= \frac{1}{2\pi \times 20 \times 220 \times 10^{-9}} = 36{\cdot}19k\Omega$$

A 36kΩ ±5% resistor is chosen for R.

R3 and R4 determine the gain of the network and this must be fixed at ×1·6 for correct operation of the circuit. Since the operational amplifier is used in the non-invert mode, its gain (G) is given by the formula:

$$G = (1 + R3/R4)$$

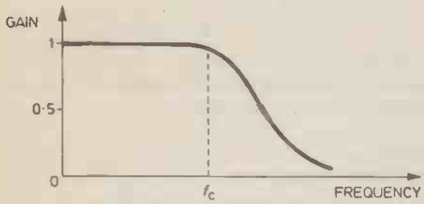


Fig. 7.1. Active low pass filter response.

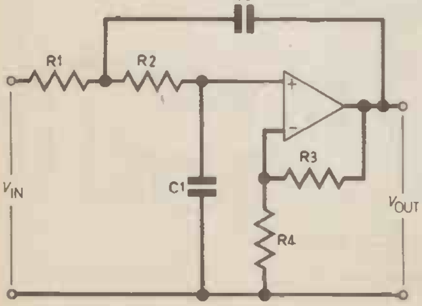
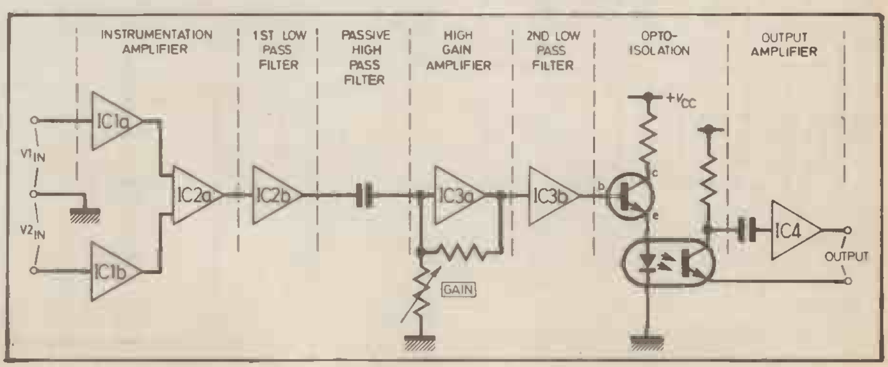


Fig. 7.2. Second-order Butterworth low pass filter.

Fig. 7.3. Block diagram of the Biological Amplifier.



so selecting a value of 20kΩ for R4, we see that

$$1{\cdot}6 = (1 + R3/20k\Omega)$$

giving a value of 12kΩ for R3. Again, close tolerance resistors should be used for these fairly critical components.

The design and construction of active filter networks, low pass, high pass and band pass is a complex, although useful, topic and interested readers will find much valuable information in the Active Filter Cookbook, published by Howard W. Sams.

CIRCUIT DESCRIPTION

Fig. 7.3 shows a block diagram of the complete Biological Amplifier. IC1(a) and (b) and IC2(a) form an "instrumentation amplifier" which offers an extremely high input impedance (about 10MΩ in this case). This is, of course, desirable if the signal source is not to be loaded seriously. The gain of this section is kept small (approximately ×6) so as to minimise the possibility of overdriving the next stage IC2(b). This is the first low pass filter and it removes any spurious signals present at the inputs.

The C/R combination following acts as a high pass filter and removes any d.c. voltage present at the output of the low pass filter.

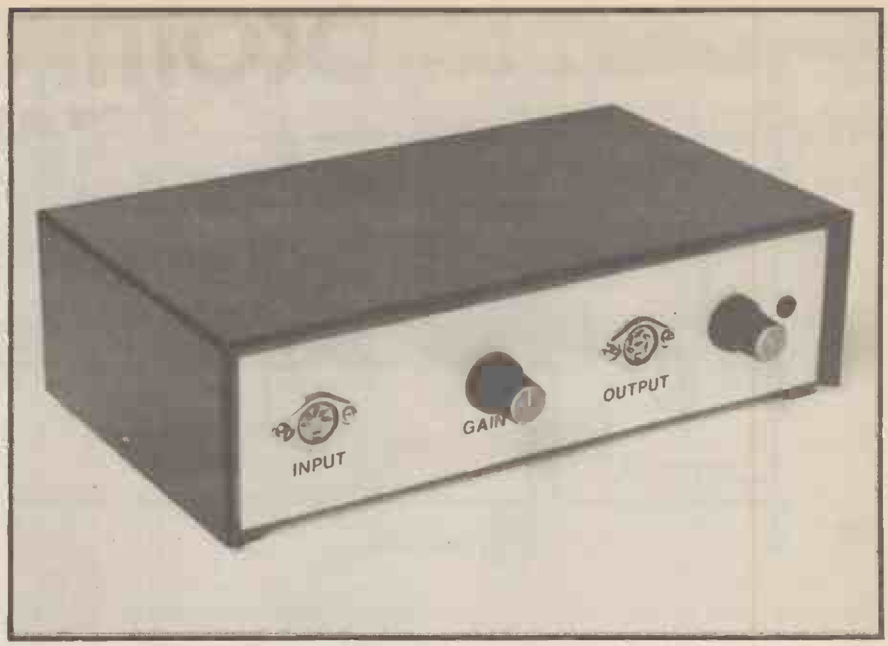
IC3(a) provides most of the circuit gain and comprises of a non-inverting operational amplifier with its gain variable by means of VR1. Another low pass filter follows in the form of IC3(b).

OPTO ISOLATOR

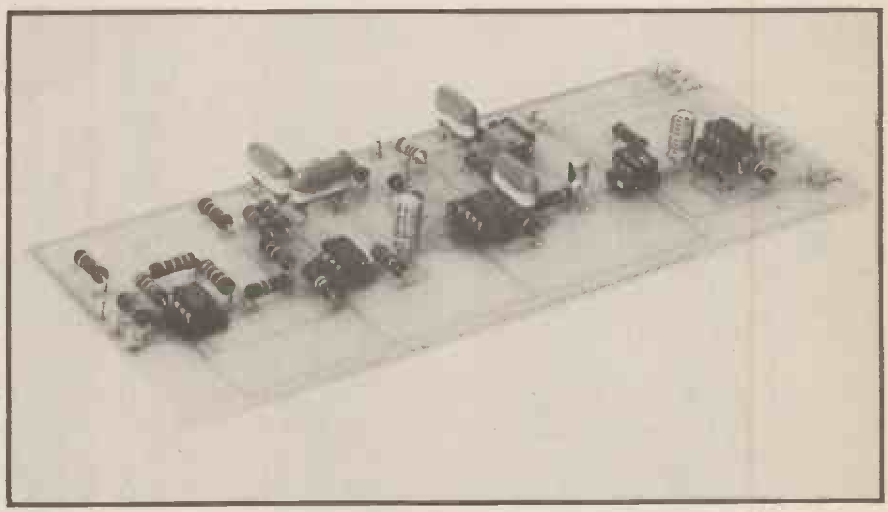
With this type of circuitry, absolute isolation from mains-driven equipment is essential for safety purposes and this is achieved by the opto-coupled arrangement of the final stages.

The output of IC3(b) is coupled to the base of TR1 which drives the l.e.d. section of the opto-isolator; the phototransistor detector section of this has its own supply and only this electrically separate section, of the circuit, is linked to any following mains-driven equipment, such as a c.r.o. or ADC. The output from the phototransistor is amplified by IC4 which provides the final output.

The complete circuit diagram is shown in Fig. 7.4.

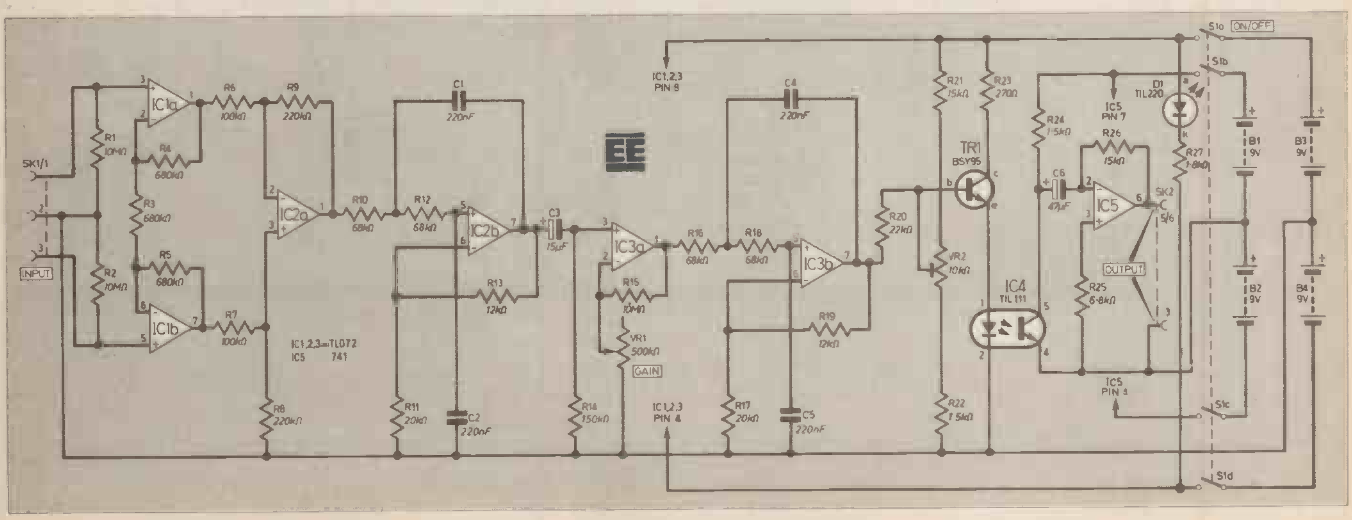


View of complete unit.



Close-up of the prototype assembled printed circuit board.

Fig. 7.4. The complete circuit diagram of the Biological Amplifier.



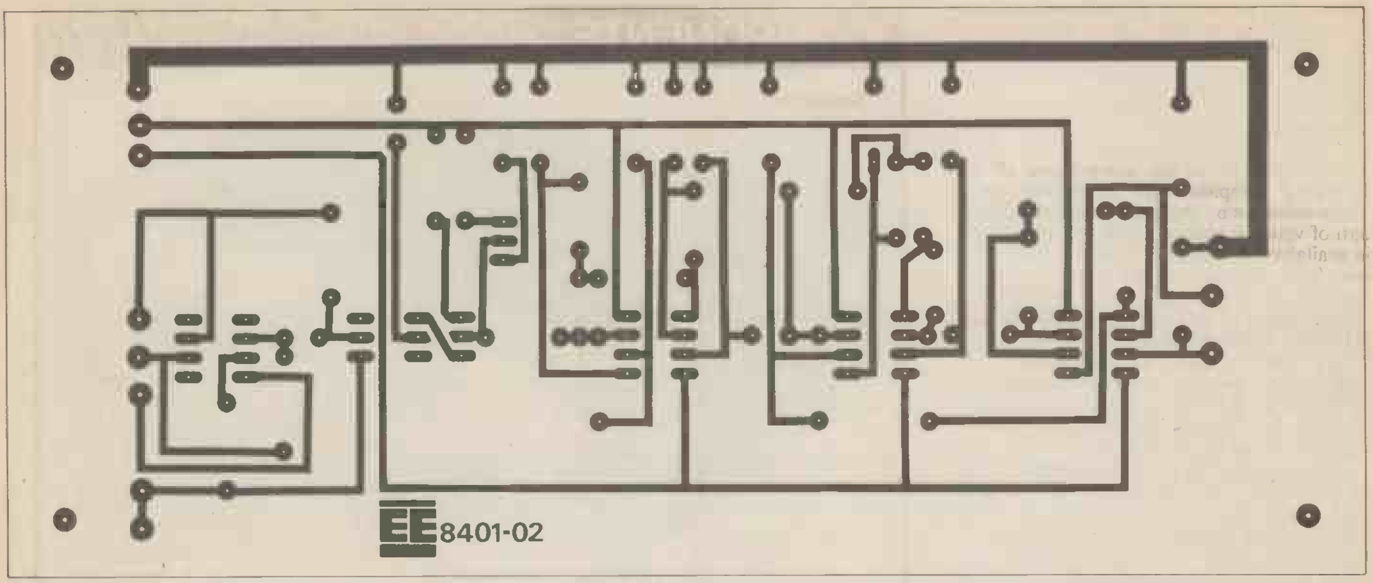


Fig. 7.5. Printed circuit board track pattern (actual size) for the Biological Amplifier. This board is available from the *EE PCB Service*, Order Code 8401–02.

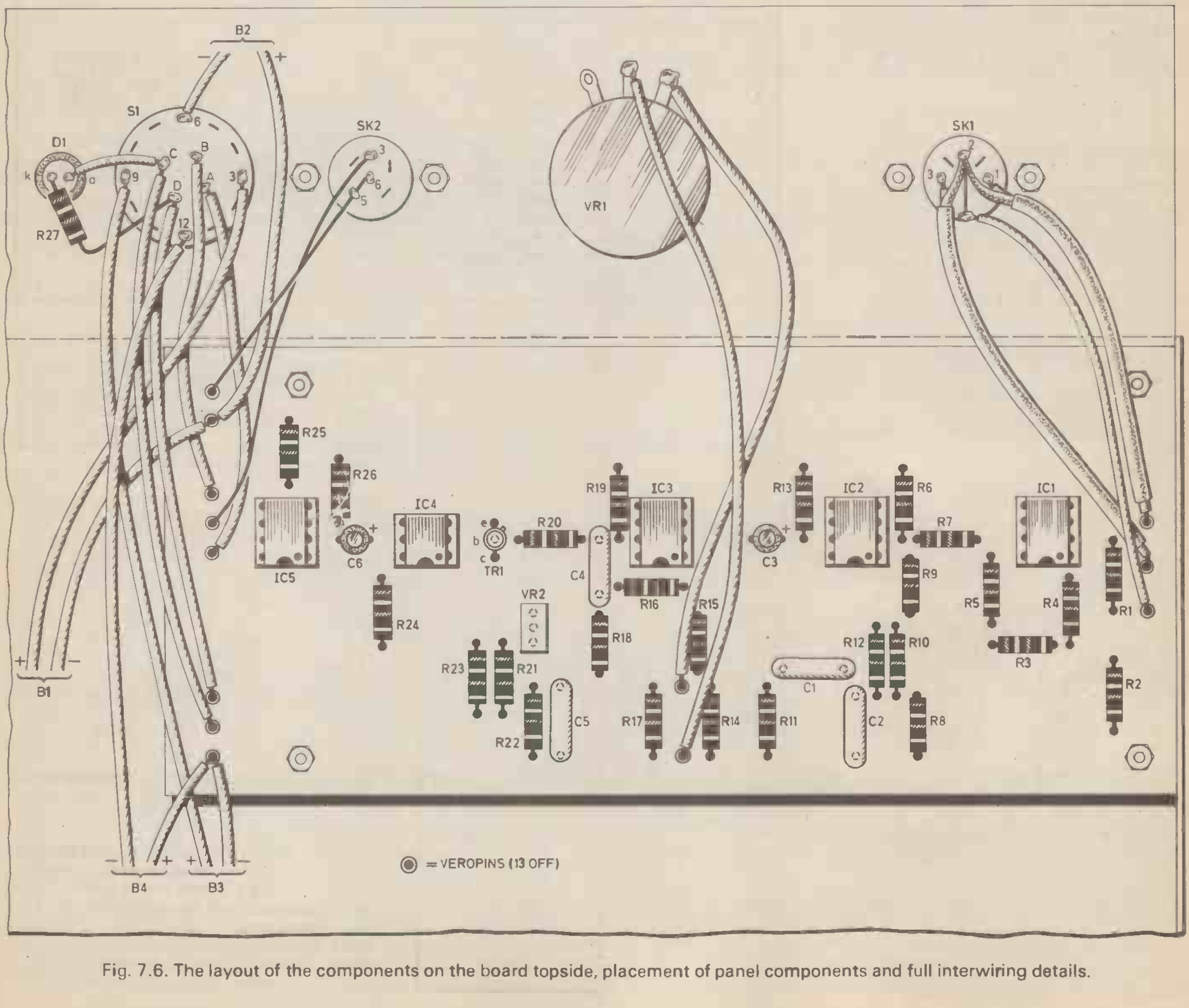


Fig. 7.6. The layout of the components on the board topside, placement of panel components and full interwiring details.

CONSTRUCTION

ASSEMBLY

The majority of the components of the Biological Amplifier are assembled on a single-sided p.c.b., the actual-size master pattern of which is shown in Fig. 7.5. This board is available from the *EE PCB Service*, Order code 8401-02, for those who do not wish or do not have the facilities to make p.c.b.s.

The layout of the components on the top-side of the board is shown in Fig. 7.6.

The four i.c.s and the opto-isolator are mounted in sockets and constructors are advised to do likewise.

Begin by inserting the thirteen Veropins followed by the i.c. holders. Do not insert the i.c.s until the construction is complete. Order of component assembly is unimportant, but care should be taken when fitting the electrolytic capacitors and the transistor to ensure that they are correctly orientated.

CASE

The case chosen for the prototype measured 225 × 127 × 63mm approximately. Prepare the case lower section to accept the front panel mounted components and the four p.c.b. fixings. Fit and secure the p.c.b. to the case using shake-proof washers, screws, nuts and 5mm long spacers to hold it rigid and clear of the base.

Fix the front panel components in place as shown in Fig. 7.6, and then interwire as indicated. Keep the leads as short as possible and use screened cable where shown. When complete, insert the i.c.s and opto-isolator in their respective sockets, paying special attention to orientation.

Four 9V batteries are required, type PP3 are suitable. These may be held in position on the case by using double-sided foam pads. Connect these to complete the project.

COMPONENTS

Resistors

R1	10MΩ	R10	68kΩ	R19	12kΩ
R2	10MΩ	R11	20kΩ	R20	22kΩ
R3	680kΩ	R12	68kΩ	R21	15kΩ
R4	680kΩ	R13	12kΩ	R22	1·5kΩ
R5	680kΩ	R14	150kΩ	R23	270Ω
R6	100kΩ	R15	10MΩ	R24	1·5kΩ
R7	100kΩ	R16	68kΩ	R25	6·8kΩ
R8	220kΩ	R17	20kΩ	R26	15kΩ
R9	220kΩ	R18	68kΩ	R27	1·8kΩ

All $\frac{1}{4}$ watt carbon ±5% or better

Capacitors

C1	220nF polyester type C280
C2	220nF polyester type C280
C3	15μF 10V elect.
C4	220nF polyester type C280
C5	220nF polyester type C280
C6	47μF 10V elect.

COMPONENTS approximate cost £18

Semiconductors

IC1,2,3	TL072 bi-fet op-amp (3-off)
IC5	741 op-amp
TR1	BSY95 silicon *npn*
IC4	TIL111 single transistor opto-isolator
D1	TIL220 red l.e.d.

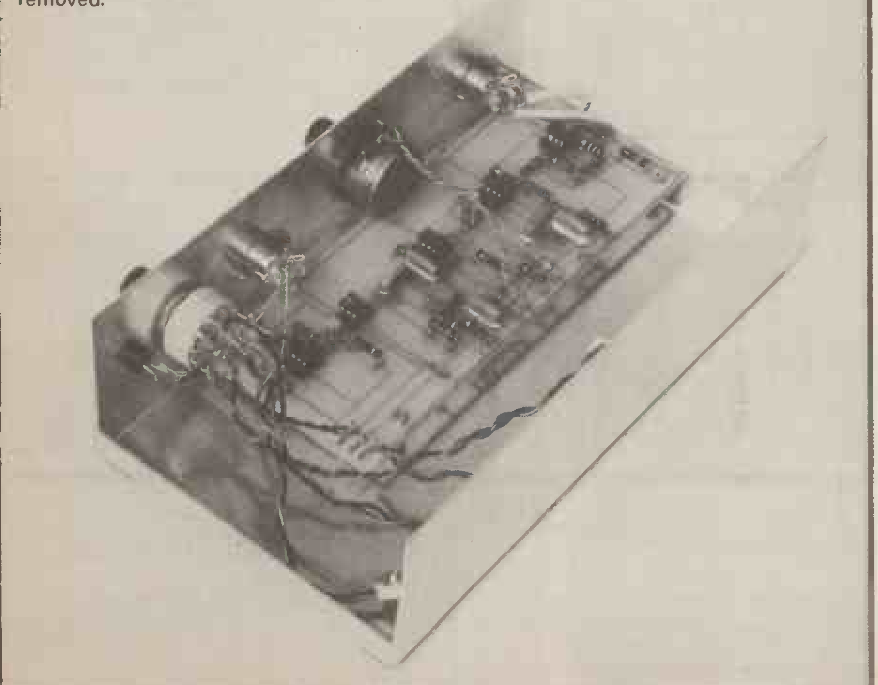
Miscellaneous

SK1	3-pin DIN chassis socket
SK2	5-pin 240° DIN chassis socket
S1	4-pole 3-way rotary switch
VR1	500kΩ lin. potentiometer
VR2	10kΩ $\frac{3}{8}$ inch cermet multiturn
B1–4	9V type PP3 (4-off)

See Shop Talk page 16

Printed circuit board: single-sided, size 178 × 74mm, *EE PCB Service*, Order code 8401-02; 8-pin d.i.l. socket (3 off); 6-pin d.i.l. socket; PP3 battery clips (4 pairs); 3mm screws, nuts, washers (8 sets); 5mm long spacers (4 off); case WB4 vinyl covered metal case, size 229 × 133 × 64mm or other similar sized case; self-adhesive rubber feet (4 off); screened cable; single-sided Veropins (13 off); control knobs (2 off).

The fully-assembled unit with lid removed.



ELECTRO-CARDIOGRAPHY

The Biological Amplifier can be used as a sensitive meter to monitor the electrical events associated with muscular contractions of the heart. Such electro-cadiographs can be stored by the microcomputer and the results can be represented as an electro-cardiogram.

Convention dictates that the connections to the biological amplifier are made in such a way so that the normal electro-cardiogram deflections are displayed, as shown in Fig. 7.7.

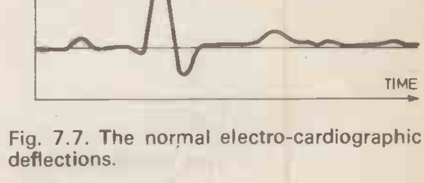


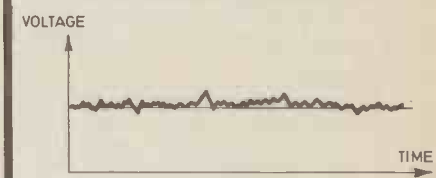
Fig. 7.7. The normal electro-cardiographic deflections.

Body electrodes used in professional systems employ self-adhesive pads, a conductive gel ensuring a reliable contact between the actual electrode and the patient's skin. For very simple work, however, the author has found that excellent results could be obtained with simple lint pads moistened with salt solution. These are held between the thumb and

ELECTRO-CARDIOGRAPH SOFTWARE FOR BBC MICRO

```
  700 REM ***M.I.T.PART 7:BIOLOGICAL AMPLIFER***
  800 REM ***By M. Feather & J. Adams***
  900 REM ***(C) EVERYDAY ELECTRONICS 1983***
 1000 REM ***ELECTRO-CARDIOGRAPH WITH HIGH SPEED ADC AND BBC MICROCOMPUTER***
 1100 ?&FE62=0:?&FE6C=&A0:X%=0:Y%=251
 1200 MODE4:VDU 19,2,4,0,0,0:VDU 19,1,3,0,0,0
 1300 PROCassemble
 1400 PROCtext("******ELECTRO-CARDIOGRAM******","INTERVAL CONTROL(1 - 65535) ","
TRIGGER LEVEL (127-255) "):PROCgrid:PROCtimer:PROCtrigger:PROClog:PROCplot
 1500 A=GET:RUN
 1600 DEF PROClog:CALL SCOPE%:ENDPROC
 1700 DEF PROCassemble:DIM SCOPE% 400:P%=SCOPE%
 1800 [OPT2:SEI:.begin STA &FE60:]:PROCnop(12):[OPT2:LDA &FE60:CMP&73:BCC begin:
.start STA &FE60:]:PROCnop(12)
 1900 [OPT2:LDA &FE60:STA SCOPE%+100,X:INX:LDA SCOPE%+98:STA &FE64:LDA SCOPE%+99
:STA &FE65:.wait BIT &FE6D:BVC wait:DEY:BNE start:CLI:RTS:]
 2000 ENDPROC
 2100 DEF PROCtext(T$,IC$,TR$):CLS:VDU5:GCOL0,1:MOVE100,975:PRINTT$:MOVE100,100:
PRINT IC$:MOVE100,50:PRINTTR$:ENDPROC
 2200 DEF PROCtimer:MOVE 950,100:INPUT IC%:IF(65535-IC%)*(IC%-1)<0THEN1400
 2300 ?(SCOPE%+98)=IC%MOD256:?(SCOPE%+99)=IC%DIV256:ENDPROC
 2400 DEF PROCgrid:FORX=0TO1250STEP125:MOVEX,128:DRAWX,896:NEXT:MOVE0,896:DRAW12
50,896:MOVE0,128:DRAW1250,128:FORI%=128TO896STEP77:MOVE0,I%:PLOT21,1250,I%:NEXT:
ENDPROC
 2500 DEF PROCtrigger
 2600 MOVE950,50:INPUTTR%
 2700 IF(255-TR%)*(TR%-127)<0THEN1400
 2800 ?&73=TR%:ENDPROC
 2900 DEF PROCplot
 3000 MOVE0,512
 3100 FORY=0TO250
 3200 V%=?(SCOPE%+100+Y)
 3300 DRAW0+Y*5,512+(V%-128)*3
 3400 NEXT:ENDPROC
 3500 DEF PROCnop(N):LOCAL I:FORI=1TON:[OPT2:NOP:]:NEXT:ENDPROC
```

Fig. 7.10. Plant physiology trace.

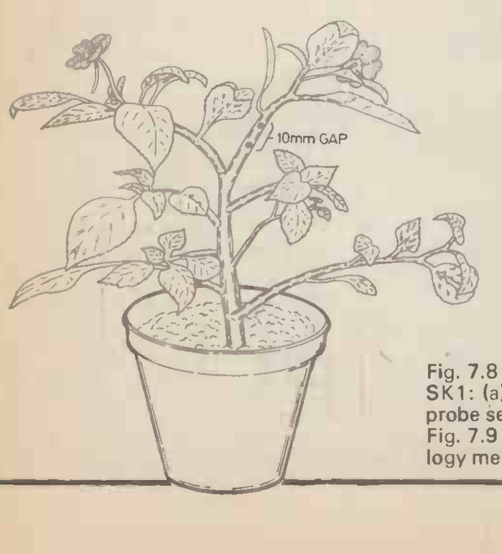


forefinger of each hand; the earthed reference electrode, if used, can be connected to the left ankle by a similar pad held in place by an old watch strap. See Fig. 7.8 for construction details for the "sensor".

It must be emphasised here that, **UNDER NO CIRCUMSTANCES SHOULD THE OPTO-ISOLATION SECTION OF THE CIRCUITRY BE MODIFIED OR BY-PASSED IN ANY WAY.** The possibility of break-through of high voltages is highly improbable, but the opto-isolation obviates it completely.

It should also be stressed that the detailed interpretation of electro-cardiograms is best left to those qualified to do so.

A "body" probe. The lint pads should be moistened with a saline solution.



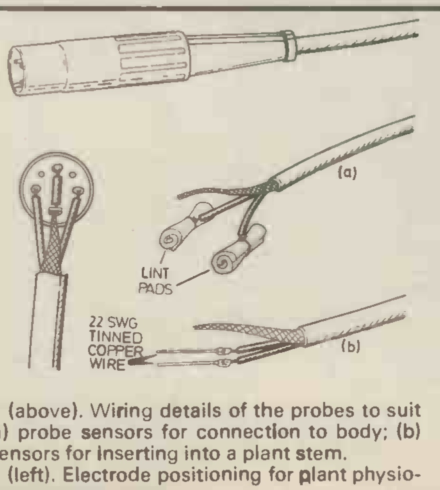


Fig. 7.8 (above). Wiring details of the probes to suit SK1: (a) probe sensors for connection to body; (b) probe sensors for inserting into a plant stem.
Fig. 7.9 (left). Electrode positioning for plant physiology measurements.

PLANT PHYSIOLOGY

The very tiny electrical signals associated with activity in plants can be monitored by the system if suitable electrodes are inserted into the plant stem. Simple electrodes can be made with 22 s.w.g. tinned copper wire and these should be arranged as shown in Fig. 7.9. A plant physiology trace is shown in Fig. 7.10.

An interesting investigation involves monitoring the reaction of the plant to a stimulus provided by a lamp in close proximity. Many other such experiments are possible and it is left to the reader to devise these.

SOFTWARE

The electro-cardiograph software for the BBC Micro Model B, listed above, is also available on cassette tape from the ***EE PCB Service***, see page 59. This allows the acquisition and graphical display of digital information provided by the biological amplifier allied with a bipolar single channel analogue-to-digital converter.

The electro-cardiograph software is currently being developed for the PET, VIC-20 and Commodore 64 machines.

A detailed analysis of the program is beyond the scope of this article. Suffice it to say that access involves a machine code procedure to "log" the digital values once a pre-determined "trigger" level has been achieved. The rate of data logging is dependent upon a value placed in one of the interval timers in an internal 6522 VIA provided on the BBC machine.

This program can also be used with the ADC as a relatively fast storage oscilloscope capable of logging at intervals as small as 50µs.

Next month: Direct Bus Interfacing

EVERYDAY ELECTRONICS SOFTWARE SERVICE

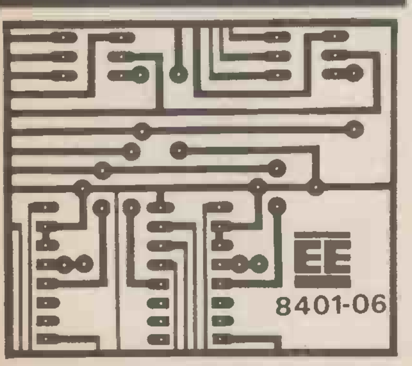
The EE Software Service provides an easy and reliable means of program entry for our computer-based projects. All programs have been tested by us and consist of two good quality copies of the working program on cassette tape. Certain program listings are also available.

All prices include VAT, postage and packing. Remittances should be sent to Everyday Electronics Software Service, Editorial Offices, King's Reach Tower, Stamford Street, London SE1 9LS. Cheques should be crossed and made payable to IPC Magazines Ltd.

PROJECT TITLE	CASSETTE CODE	CASSETTE COST	LISTING CODE	LISTING COST
ZX81 SPEED COMPUTING SYSTEM (Feb 83)	T001	£2.95	L001	£2.95
REAL-TIME CLOCK (*Apple II*) (May 83)	T002	£2.95	L002	£2.95
REAL-TIME CLOCK (*BBC Micro*) (May 83)	T003	£2.95	L003	£2.95
EPROM PROGRAMMER (*TRS-80 & GENIE*) (June 83)*	T004	£3.95	N/A	—
STORAGE 'SCOPE INTERFACE (*BBC Micro*) (Aug 83)	T005	£2.95	—	—
ELECTRO-CARDIOGRAPH (*BBC Micro*) (Jan 84)	T006	£2·95	—	—

* Includes Command List with examples.

EE PRINTED CIRCUIT BOARD SERVICE



Printed circuit boards for certain EE constructional projects are now available from the EE PCB Service, see list below. These are fabricated in glass-fibre, and are fully drilled and roller tinned. All prices include VAT and postage and packing. Remittances should be sent to: EE PCB Service, Everyday Electronics Editorial Offices, King's Reach Tower, Stamford Street, London SE1 9LS. Cheques should be crossed and made payable to IPC Magazines Ltd.

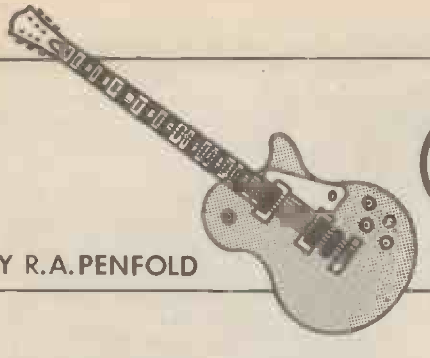
We regret that the ordering codes for the August projects have been incorrectly quoted in the Sept-Oct issues. Correct codes are given here.

Please note that when ordering it is important to give project title as well as order code.

Readers are advised to check with prices appearing in current issue before ordering.

PROJECT TITLE	Order Code	Cost
Eprom Programmer, TRS-80 (June 83)	8306-01	£9.31
Eprom Programmer, Genie (June 83)	8306-02	£9.31
Eprom Programmer, TRS-80 & Genie (June 83)	8306-03	£1.98
User Port Input/Output *M.I.T. Part 1* (July 83)	8307-01	£4.82
User Port Control *M.I.T. Part 1* (July 83)	8307-02	£5.17
Storage 'Scope Interface, BBC Micro (Aug 83)	8308-01	£3.20
Car Intruder Alarm (Aug 83)	8308-02	£5.15
High Power Interface *M.I.T. Part 2* (Aug 83)	8308-03	£5.08
Pedestrian Crossing Simulation *M.I.T. Part 2* (Aug 83)	8308-04	£3.56
Electronic Die (Aug 83)	8308-05	£4.56
High Speed A-to-D Converter *M.I.T. Part 3* (Sept 83)	8309-01	£4.53
Signal Conditioning Amplifier *M.I.T. Part 3* (Sept 83)	8309-02	£4.48
Stylus Organ (Sept 83)	8309-03	£6.84
Distress Beacon (Sept 83)	*8309-04	£5.36
Distress Beacon Pocket Version (Sept 83)	8309-05	£3.98
D-to-A Converter *M.I.T. Part 4* (Oct 83)	8310-01	£5.77
High Power DAC Driver *M.I.T. Part 4* (Oct 83)	8310-02	£5.13
Electronic Pendulum (Oct 83)	8310-03	£5.43
TTL/Power Interface for Stepper Motor *M.I.T. Part 5* (Nov 83)	8311-01	£5.46
Stepper Motor Manual Controller *M.I.T. Part 5* (Nov 83)	8311-02	£5.70
Digital Gauss Meter (Nov 83)	8311-03	£4.45
Speech Synthesiser for BBC Micro (Nov 83)	8311-04	£3.93
Car On/Off Touch Switch (Nov 83)	8311-05	£3.11
4-Channel High Speed ADC (Analogue) *M.I.T. Part 6* (Dec 83)	8312-01	£5.72
4-Channel High Speed ADC (Digital) *M.I.T. Part 6* (Dec 83)	8312-02	£5.29
TRS-80 Twin Cassette Interface (Dec 83)	8312-03/09	£7.43
Environmental Data Recorder (Dec 83)	8312-04	£7.24
Touch Operated Die (Dot matrix) (Dec 83)	8312-05/06	£4.34
Touch Operated Die (7-segment) (Dec 83)	8312-05/07	£4.34
Continuity Tester (Dec 83)	8312-08	£3.41
Central Heating Pump Delay (Jan 84)	8401-01	£3.33
Biological Amplifier *M.I.T. Part 7* (Jan 84)	8401-02	£6.27
Temp. Measurement and Control System for ZX Computers (Jan 84)		
Analogue Thermometer Unit	8401-3	£2.35
Analogue-to-Digital Unit	8401-4	£2.56
Games Scoreboard (Jan 84)	8401-06/07	£9.60

*Set of four boards. M.I.T.— Microcomputer Interfacing Techniques, 12-Part Series.



GUITAR TUNER

BY R.A. PENFOLD

Accurately tuning a guitar can be difficult at the best of times, but in a noisy environment, even if the user has a very good sense of pitch, this task can be practically impossible. However, using an electronic tuning aid which gives a visual tuning indication of some kind, precise tuning becomes very easy indeed.

The Guitar Tuner described here has an audio output for a crystal earphone, and six switched tones which correspond to the notes from the open strings of a guitar are available. These are only used as an aid to tune the strings to roughly the right pitches, and then a centre zero meter is used to indicate the tuning error for each string. By simply adjusting each string for zero reading on the meter accurate tuning is obtained.

BLOCK DIAGRAM

A phase-locked loop is used as the basis of the tuner, and Fig. 1 shows the unit in block diagram form.

The first stage is merely a preamplifier which boosts the input signal level to a suitable level to drive the subsequent circuitry.

The next stage is a trigger circuit, and the output of this circuit must either be high (virtually equal to the positive supply voltage) or low (almost at the negative supply potential) apart from the very brief transitions from one state to the other. Which state the output assumes depends on the input voltage, and the input must go to roughly two-thirds of the supply voltage to trigger the output to the high state, and then below one-third of the supply voltage to trigger it back to the low state again.

The purpose of having two trigger threshold values rather than just one is that it avoids instability and spurious operation with the input voltage close to one of the threshold values. Once the output has changed state it has a reluctance to switch back again, and noise on the input signal, or an irregular input waveform, should not cause spurious triggering.

PHASE-LOCKED LOOP

A conventional phase-locked loop is formed by the other three stages of the unit. A phase comparator is fed with the square-wave output from the trigger circuit and the output of the voltage controlled oscillator (v.c.o.). The latter is controlled by the output voltage of the phase comparator after this signal has been smoothed to a reasonably steady d.c. signal by a simple low-pass filter circuit. A centre zero tuning meter is also fed with this voltage.

Under quiescent conditions with no output from the trigger circuit the v.c.o. produces an output frequency which is the same as that of the note which is to be tuned with the aid of the unit. In practice the v.c.o. has six switched frequencies so that all six guitar strings can be tuned using the unit. An earphone can be fed with the output of the v.c.o. so that the note from the guitar can be aurally compared with the note from the v.c.o. The tuning meter is connected in a bridge circuit and adjusted so that it reads zero under quiescent conditions.

If the guitar is precisely in tune the two input signals to the phase comparator will be at the same frequency, there will be no

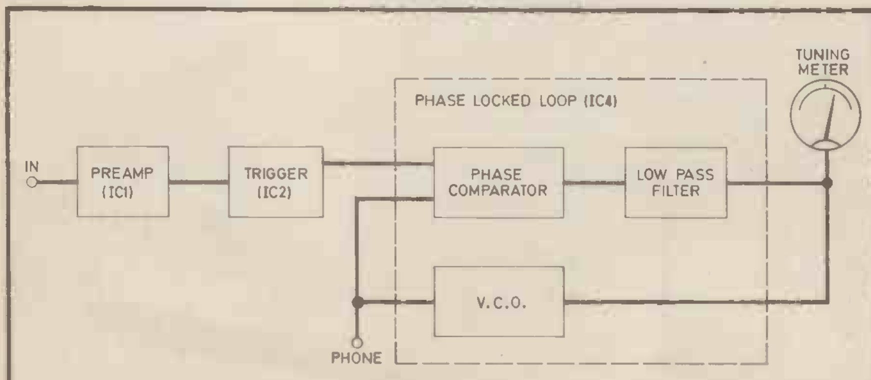


Fig. 1. Block diagram of the Guitar Tuner.

COMPONENTS

Resistors

R1,10	47kΩ (2 off)
R2,3,8,9	15kΩ (4 off)
R4	1MΩ
R5	10kΩ
R6	270kΩ
R7,14	22kΩ (2 off)
R11	1kΩ
R12,13	100kΩ (2 off)
R15	3·3kΩ
R16	220Ω
R17	1·5kΩ
R18	330Ω

All ¼W 5% carbon ±5%

See Shop Talk page 16

Potentiometers

VR1–3	470kΩ 0·1W horizontal preset (3 off)
VR4–6	220kΩ 0·1W horizontal preset (3 off)
VR7	2·2kΩ 0·1W horizontal preset

Capacitors

C1	100μF 10V axial elect.
C2	1μF 63V axial elect.
C3	10μF 25V axial elect.
C4	2·2μF 63V axial elect.
C5,6	100nF polyester (2 off)
C7	0·47μF 63V radial elect.

Semiconductors

IC1	1458C dual op-amp
IC2	741C op-amp
IC3	78L05 5V 100mA regulator
IC4	4046BE phase-locked loop
D1,2	1N4148 (2 off)

Miscellaneous

S1	6-way 2-pole rotary switch
S2	s.p.s.t. miniature toggle switch
B1	9-volt PP3 size
SK1	6·35mm standard jack socket
SK2	3·5mm jack socket
M1	125–0–125μA moving coil meter (Maplin)

Veroboard 50 holes by 23 strips; 16-pin DIL socket; 180 x 120 x 65mm Verocase; control knob; battery connector; wire; solder, etc.

Approx. cost Guidance only £16

significant change in the output voltage of the phase comparator, the tuning meter will remain at zero, and the frequency of the v.c.o. will stay unchanged.

If the guitar note is slightly sharp the resultant discrepancy in the input frequencies to the phase comparator results in an increase in its average output voltage. This results in the meter being deflected away from zero, and the v.c.o. rises in frequency to match the frequency of the signal from the guitar. Thus the tuning error is indicated by the tuning meter and a shift in the pitch of the v.c.o.

low a potential divider action across R7 and R10 tends to reduce the input voltage to the non-inverting input of IC2. Similarly, a potential divider action across these two resistors tends to increase the voltage at the non-inverting input of IC2 when the output is high. This gives the trigger circuit its reluctance to change state, or "hysteresis" as it is termed.

The phase-locked loop uses a 4046BE CMOS device (IC4). In order to obtain consistent and accurate results it is essential for IC4 to be powered from a very

the output signal by forming a simple low-pass filter in conjunction with the capacitance of the crystal earphone. This makes it easier to relate the output pitch of the tuner to the pitch of the guitar string.

C8, R14, ane whichever of the six preset resistors (VR1 to VR6) is selected using S1 determines the centre frequency of the v.c.o. In practice the presets are adjusted so that the six open string guitar frequencies are produced. The low-pass filter is formed by R13 and C7.

The meter circuit is driven from the

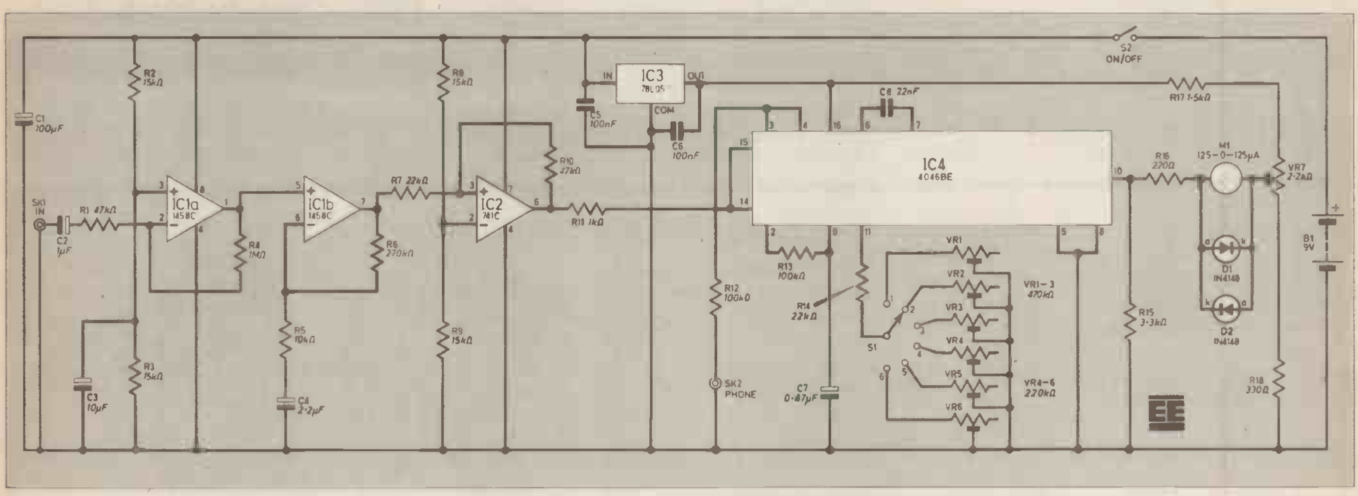


Fig. 2. Circuit diagram of the Guitar Tuner.

A similar thing happens if the note from the guitar is slightly flat, but the output voltage of the comparator stage decreases so that the deflection of the meter is in the opposite direction this time, and the v.c.o. goes low in frequency so that it locks onto the same frequency as the signal from the guitar.

The unit therefore gives both a visual and an aural indication of tuning error, and furthermore, the meter shows whether the tuning is sharp or flat, and gives a rough indication of the degree of tuning error.

THE CIRCUIT

The complete circuit diagram of the Guitar Tuner appears in Fig. 2.

There are two operational amplifiers in the preamplifier section of the circuit; IC1a is used as a simple inverting amplifier giving a voltage gain of about 26dB (20 times) and IC1b is connected as a non-inverting amplifier which is directly coupled to IC1a and gives a voltage gain of 29dB (27 times). The high combined gain of the two amplifiers ensures that the circuit has adequate sensitivity to function properly with low output guitar pick-ups.

IC2 is used as the trigger circuit, and the positive feedback through R10 gives the rapid triggering from one output state to the other. When the output of IC1 is

stable supply, and monolithic voltage regulator IC3 is therefore used to give a highly stable 5-volt supply.

R11 couples the output of IC2 to one input of a phase comparator in IC4, and in conjunction with an internal Zener diode of IC4, R11 ensures that the input voltage cannot be excessive. Pins 3 and 4 of IC4 are joined so that the output of the v.c.o. is coupled to the other input of the phase comparator.

R12 couples the output of the v.c.o. to the earphone socket, and this resistor filters the high frequency harmonics on

low-pass filter via an internal source follower buffer stage of IC4 which provides a suitably low output impedance. R15 is the discrete load resistor for this stage. The meter is connected in a straightforward bridge circuit, and VR7 is adjusted to zero the meter under quiescent conditions. D1 and D2 ensure that a severe overload of the meter cannot occur.

S1 is the on/off switch, and the current consumption of the circuit is only about 7·5mA. A small (PP3 size) battery is therefore suitable as the power source.

CONSTRUCTION

A Verocase having approximate outside dimensions of 180 × 120 × 65mm is used as the housing for the Guitar Tuner, but it would probably be possible to use any case of about this size, and the unit could be built into a somewhat smaller case if desired. The general layout of the unit can be seen by referring to the photographs.

Any centre zero meter having a full-scale sensitivity of about 100µA to 200µA can be used in the unit, and it is not necessary to use one of the large and expensive types. One of the small and inexpensive types intended for use as a tuning meter in an f.m. tuner is perfectly satisfactory.

Meters of this type often have no provision for screw mounting, and often have no apparent method of panel fixing at all. The meter in the prototype was mounted by first making a 19mm diameter hole using a chassis punch, filing this flat at the bottom to match the part of the meter that fits through the panel, and then the meter was simply glued in place.

COMPONENT PANEL

The component panel is based on a 0·1 inch matrix stripboard panel measuring 50 holes by 23 copper strips. This can conveniently be cut from a standard 5in × 3·75in or 5in × 2·5in board (both of which are the required 50 holes wide).

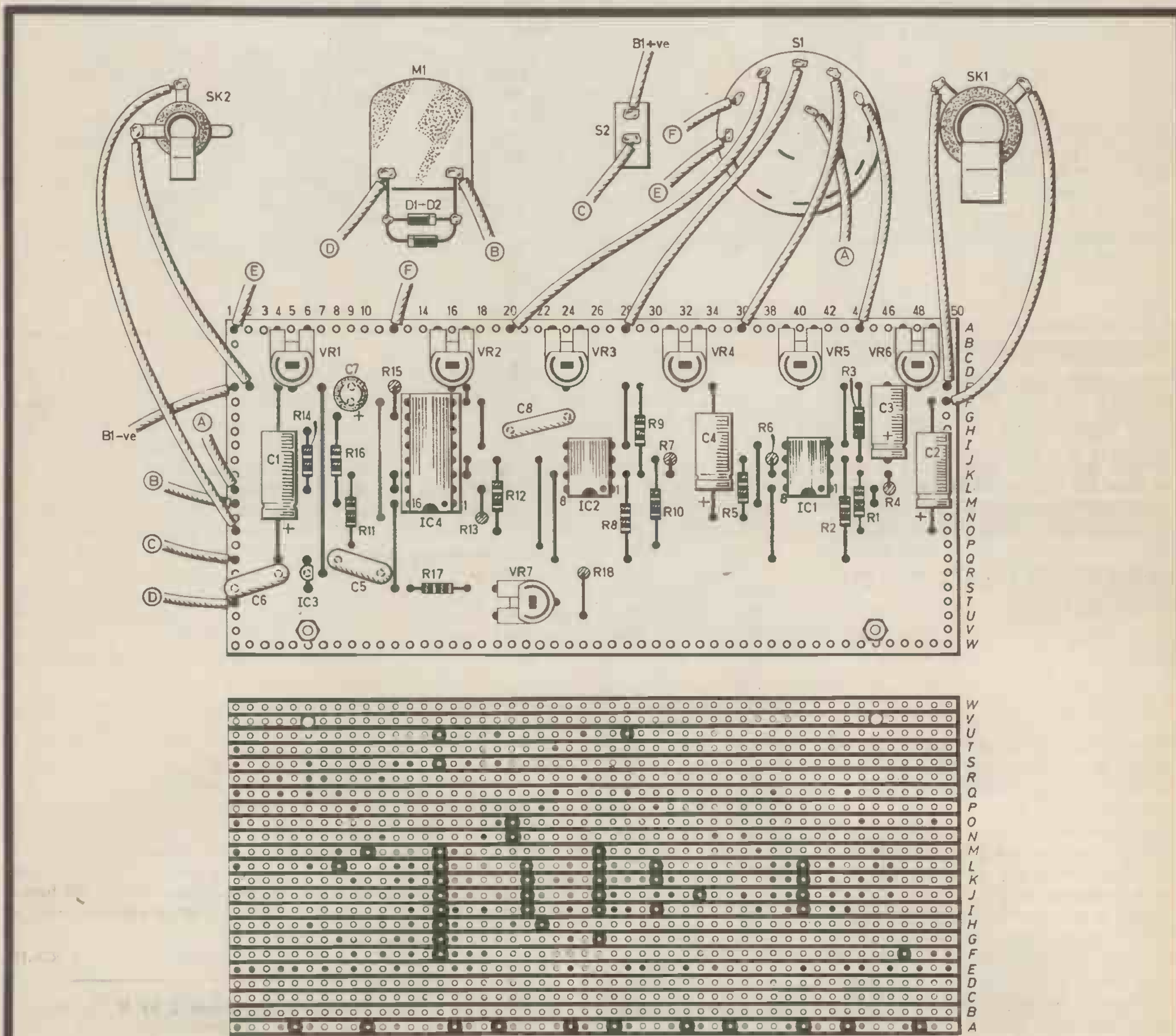
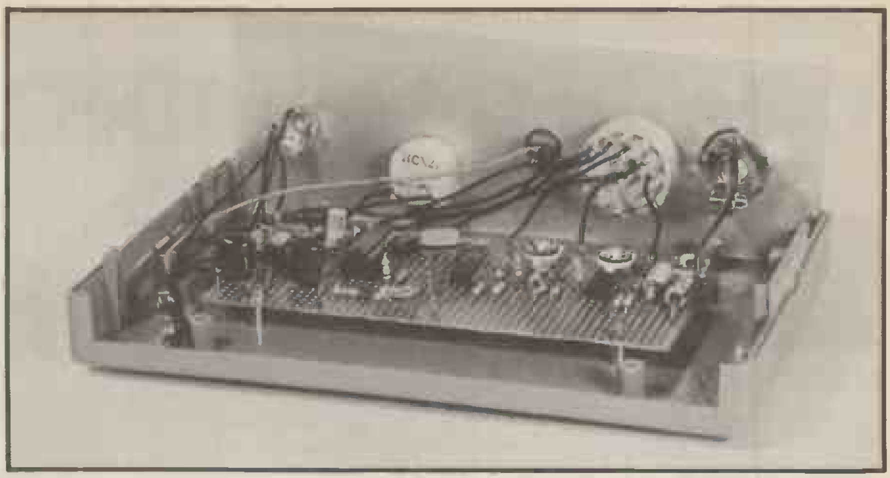


Fig. 3. Component panel and interwiring to panel-mounted components. Underside view of component panel shows required breaks in copper strips.

Details of the component panel and wiring of the unit are shown in Fig. 3.

The board is constructed in the normal way, but there are a substantial number of breaks in the copper strips and also a number of link wires, and care should be taken to avoid missing any of these. Note that IC4 is a CMOS device and it should therefore be fitted in a 16-pin DIL i.c. socket, it should not be plugged into the circuit until the unit is in other respects complete, and it should be handled as little as possible once it has been removed from its protective packaging.

Veropins are used at points on the board where it will eventually be connected to the controls, sockets, and meter. The completed board is mounted on the base panel of the case (with the six tuning presets towards the front) using 6BA fixings. The final wiring is then added using ordinary multistrand hook-up wire. Finally, D1 and D2, which are fitted direct cross the meter terminals, are wired into circuit.



ADJUSTMENT

With a crystal earphone connected to SK2 and the unit switched on, an audio tone should be heard from the earphone. The v.c.o. may be a little reluctant to operate, but it usually starts immediately if an input is connected to the unit, and should certainly start if a note from the guitar is played into the unit.

Switching the unit off and then switching it on again at once will also stimulate oscillation. If oscillation cannot be obtained switch off at once and recheck all the wiring.

Assuming all is well, the six preset resistors must be set to give the right notes and VR7 must be adjusted to zero the meter. Adjust VR7 first and zero the meter as accurately as possible.

One way of adjusting the tuning presets is to use a guitar that is accurately tuned. With S1 in position 1 (fully anticlockwise) VR6 is adjusted to give a tone from the earphone that is reasonably close to the note given by the open first string of the guitar. The tuning meter can then be used to indicate when VR6 is precisely "in tune".

A similar procedure is then used to set up the other five preset resistors against the remaining five open strings of the guitar.

Alternatively the presets can be tuned "by ear" against any musical instrument that is correctly tuned.

Another alternative is to use a frequency meter to measure the output frequency at SK2, and then set the presets for the appropriate frequencies (659, 494, 392, 294, 220 and 165Hz). However, it is essential to use a frequency meter that has adequate resolution for audio frequency measurements. Whatever method is used, strive for the best possible accuracy. □

BOOK REVIEWS

SERVICING HOME VIDEO CASSETTE RECORDERS

Author	M. Hobbs
Price	£9.85 limp
Size	247 × 176mm. 237 pages
Publisher	Hayden
ISBN	0-810-406-527

SINCE the launch of the video recorder, in two basic formats: the Beta and VHS formats, video recorders have been sold in significant quantities to warrant a book on home servicing. Contained within are ten chapters, the first a Background For Home Video Recording which covers the development of the home video from the early Ampex and Toshiba models. Note that the information provided in this book is for video recorders designed to handle NTSC Standard TV Signals.

The complete mechanical and electrical workings of the video, such as servo-system operation and system control operation are described in detail in the next five chapters. The easy to understand text is supported by clear, tidy diagrams which prove particularly useful when making adjustments to the unit.

The remaining chapters deal with servicing the unit and in particular care and maintenance of the tape feed mechanism and video head adjustment.

R.A.H.

THE PERSONAL COMPUTER HANDBOOK

Author	P. Rodwell
Price	£12.95 hard cover £8.95 limp
Size	280 × 210mm. 208 pages
Publisher	Dorling Kindersley
ISBN	0-86318-014-0

As the name suggests The Personal Computer Handbook is a reference book which will provide the newcomer with a priceless guide to computing. The comprehensive text is easy to follow and does go some way to unlocking the mysteries of the computer age.

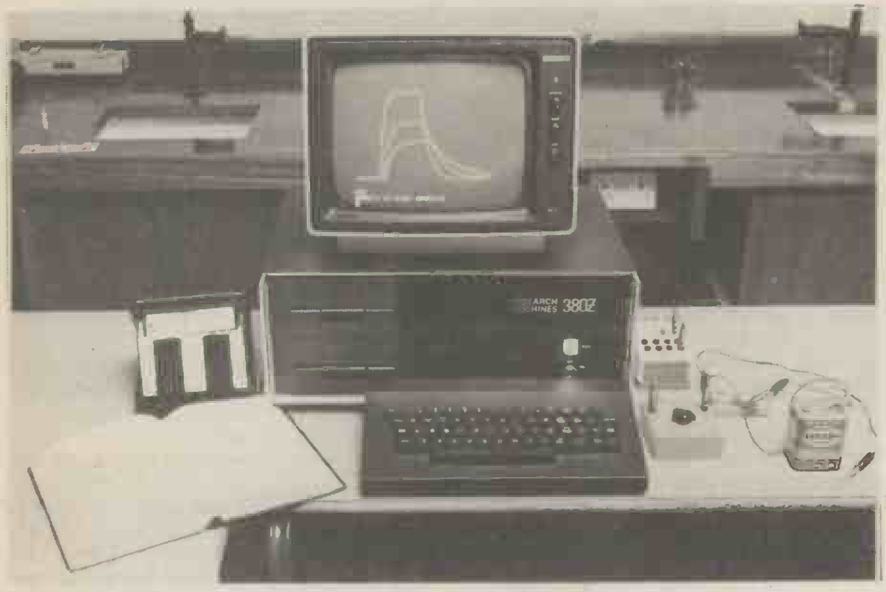
All aspects of computing are covered within the 208 pages, from a basic introduction to computing, to the more sophisticated software applications. There are seven chapters contained within the book including, How Computers Work, Hardware, Software Applications and Choosing Your Computer. Each of the seven chapters is easily explained with diagrams and pictures to support the text. The pictures in the last chapter are particularly useful when selecting your personal computer.

The information provided in the last chapter is a helpful buyer's guide and provides a brief description, specification, and price of the unit. Information has been provided for 26 home and business computers, which covers a small cross-section of the present market.

R.A.H.

30 Solderless Breadboard Projects—Book 2 by R. A. Penfold (Bernard Babani). Limp £2.25. A follow-up to the useful Solderless Breadboard Projects—Book 1, but unlike book 1 the projects are based on CMOS logic i.c.s. The easy to follow text is supported by clear informative diagrams such as a circuit diagram and component layout diagram.

COMPUTER AIDED EXPERIMENTS



BY A. A. CHANERLEY B.Sc. M.Sc.

4. CAPACITOR CHARGE/DISCHARGE WITH VARIABLE TIME CONSTANT

THIS experiment demonstrates the charge and discharge characteristics of a capacitor, which are monitored, stored and plotted by the RML380Z Microcomputer, via the A-to-D Converter described in EE, in the September 1983 issue.

It is evident that in this experiment the microcomputer acts as a storage 'scope, retaining the plots from previous experiments on the VDU.

There is no necessity to solder the circuit to a stripboard since the components are easily mounted on a solderless breadboard as shown in Fig. 4.5.

CHARGE/DISCHARGE CIRCUITS

Fig. 4.1 shows the basic charge and discharge circuits. Fig. 4.1(a) shows the charging circuit where the capacitor *C* receives charge from the battery through resistor *R*. In the process the voltage increases to a maximum value, across the capacitor, at which point it ceases to receive any more charge. The equation which describes this increase in voltage is:

$$V = V_0[1 - \exp(-t/CR)]$$

A graph of this curve is shown in Fig. 4.1(b).

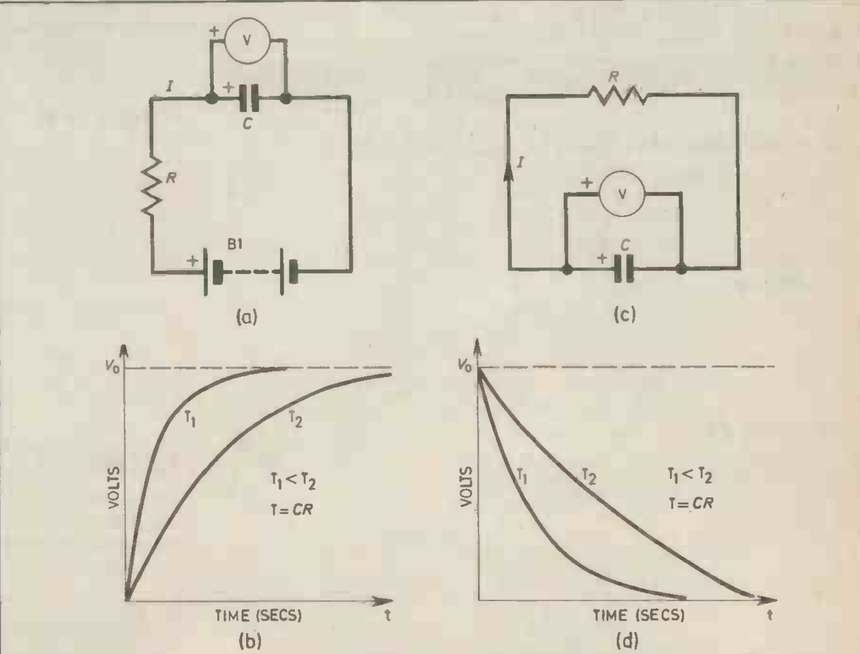


Fig. 4.1(a). Capacitor charging circuit; (b) plot of capacitor voltage versus time charging voltage applied; (c) capacitor discharging circuit; (d) plot of capacitor voltage versus time from when discharge current starts to flow.

The quantity of importance is the product of *CR*. The units of this product are in seconds and it is called the *time constant*. The greater the value of *C* and *R* in the circuit, the greater will be the time taken for the capacitor to charge to its maximum value. The plots in Fig. 1 show the situation with $T_2 > T_1$. This property of the capacitor can be used to provide a suitable time delay in a circuit.

Fig. 4.1(c) shows a basic discharging circuit, with the previously stored charge on the capacitor now being allowed to flow around the circuit through the resistor *R* with a consequent decrease in voltage across the capacitor. The equation which describes this decrease in voltage is given by:

$$V = V_0\exp(-t/CR)$$

A plot of this curve is shown in Fig. 4.1(d).

Again the product *CR* is the time constant. The greater the value of the time constant the slower the discharge of the capacitor.

EXPERIMENTAL CIRCUIT

The experimental circuit is given in Fig. 4.2. The "charging" resistor, 33kΩ, is kept fixed and is connected to the positive side of a PP3 (9V) battery. The 100μF capacitor is connected via a switch in series with the 33kΩ resistor.

In addition the discharge circuit is formed with a resistance substitution box in series with the input impedance of the analogue input of the A-to-D, this impedance is 22kΩ. The values of *R* used in the substitution box were: 10kΩ, 47kΩ, 100kΩ and 470kΩ, through which the capacitor discharges. The procedure is to fix the value of *R*, RUN the software and

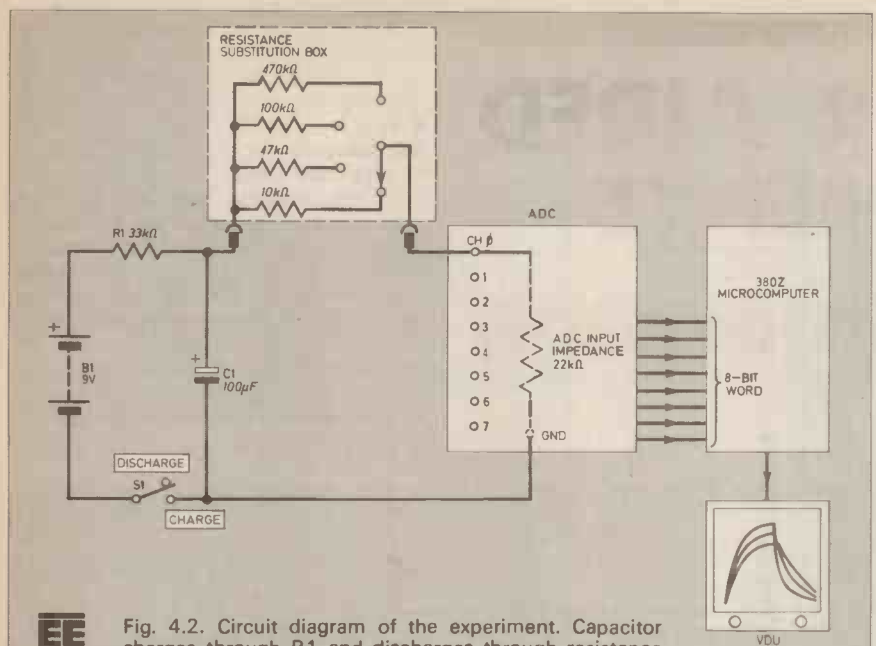


Fig. 4.2. Circuit diagram of the experiment. Capacitor charges through R1 and discharges through resistance box plus input impedance of ADC.

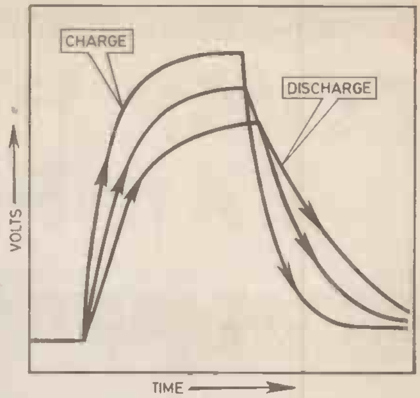
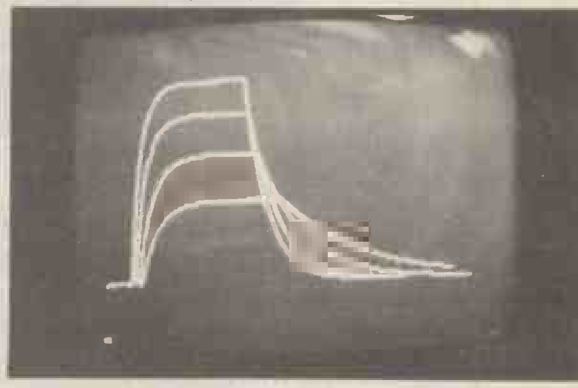


Fig. 4.3. Typical capacitor charge/discharge curves. See also Fig. 4.4 caption.

wait for the X– axis to start appearing at the bottom left hand of the VDU. Then close the switch and the plot will be seen to rise and level out at its maximum value. Then open the switch and the

Fig. 4.4. Photograph of VDU plots from four experiments. The shift in maximum levels results from the potential divider action of selected resistance in resistance box and input impedance of ADC.



COMPUTER AIDED EXPERIMENTS SOFTWARE: EXP. 4

CAPC/D

```
10 REM:this programme reads capacitor
15 REM:charge/discharge voltage
20 REM:input via the A-to-D and the
30 REM:380Z user port relocates the
40 REM:results and plots them.
50 GRAPH1:GRAPH0
60 CALL"RESOLUTION",0,2:REM:HR-graphics
70 CALL"PLOT",0,0,3
80 FOR I = 1 TO 300
90 POKE 64511,0:REM:set channel.
100 Y=PEEK(64511):REM:read channel.
110 PLOT 70,50,STR$(Y)+"    "
120 REM LIMITS OF SCREEN ARE 318,191
130 CALL"LINE",I,Y*2,3:REM:plot results
140 POKE(&6000+I),Y:REM:relocate results
150 FOR Z=1 TO 200:NEXT Z
160 NEXT I
170 PRINT "PRESS C TO CLEAR GRAPHICS"
180 G=GET()
190 IF G >90 THEN G=G-32
200 IFG=67  THEN CALL "RESOLUTION",0,2
```

POKER C

```
10 REM:this programme repokes
20 REM:the data back into memory
30 OPEN£10,"CAP.DAT"
40 FOR V=&6000 TO (&6000+300)
50 INPUT£10,ADDR,BYTE
60 POKE ADDR,BYTE
70 NEXT V
80 CLOSE£10
```

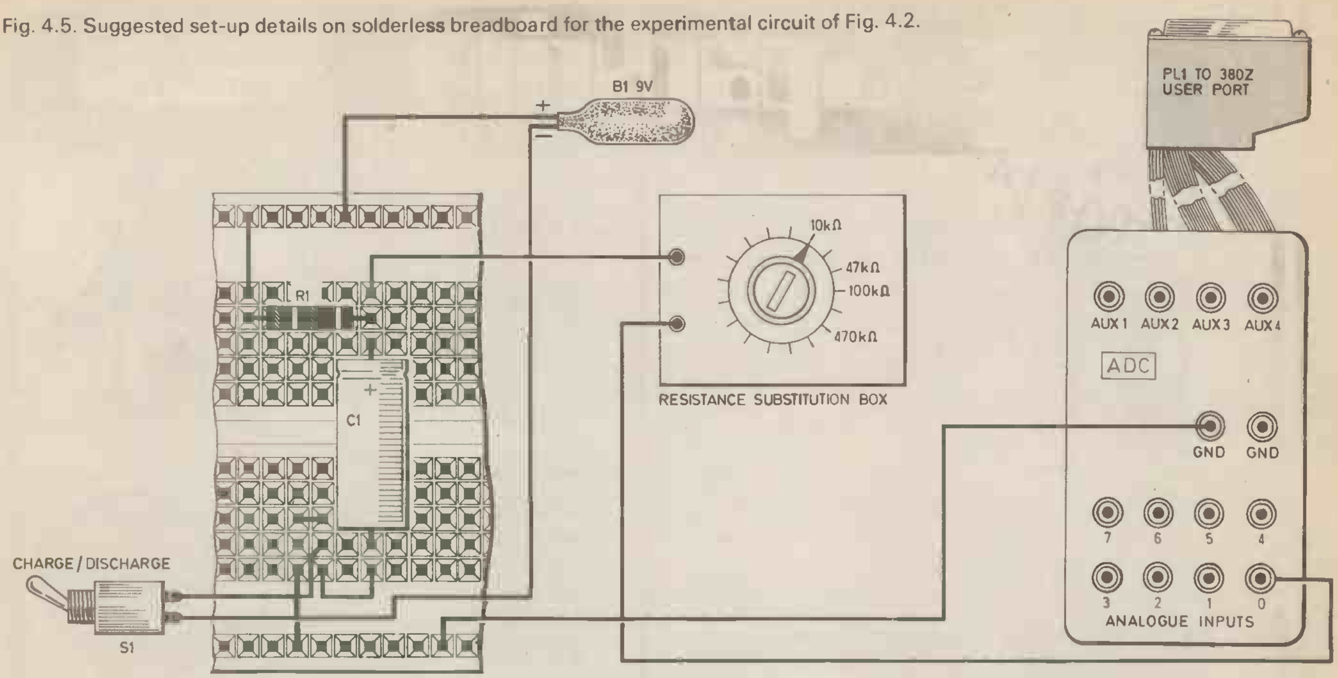
STORE C

```
10 REM:this programme stores the
20 REM:relocated results
30 REM:to disk-file
40 CREATE£10,"CAP.DAT"
50 FOR V=&6000 TO (&6000+300)
60 BYTE=PEEK(V)
70 PRINT £10,V;",";BYTE
80 NEXT V
90 CLOSE£10
```

GRAPH C

```
10 REM:This programme replots the
20 REM:previously repoked data
30 GRAPH 1:GRAPH 0
40 CALL"RESOLUTION",0,2
50 FOR I=2 TO 300
60 Y=PEEK(&6000+I)
70 CALL "LINE",I,Y,3
80 NEXT I
```

Fig. 4.5. Suggested set-up details on solderless breadboard for the experimental circuit of Fig. 4.2.



capacitor will discharge through the ADC, with the computer plotting the discharge characteristic simultaneously as shown in Fig. 4.3 and Fig. 4.4. The experimental layout on the breadboard and interwiring to the ADC is shown in Fig. 4.5.

SOFTWARE USAGE

The software is similar to that for earlier experiments for obtaining the interference pattern and the naphthalene cooling-curve. However, as last month, for the bi-polar transistor characteristic, a multiple plot can be obtained by deleting lines 5Ø and 6Ø of the program *after* the first experiment, so that high resolution graphics need not be re-initialised and so the previous plot will be retained on the screen when the program is re-RUN.

The net result is a series of charge/discharge curves with an increasing time constant in the discharge portion as *R* is varied from 10kΩ to 470kΩ. Each curve can be stored, using the STORE program, on disk, but under a different file-name for each plot and, of course, re-called when necessary for replotting.

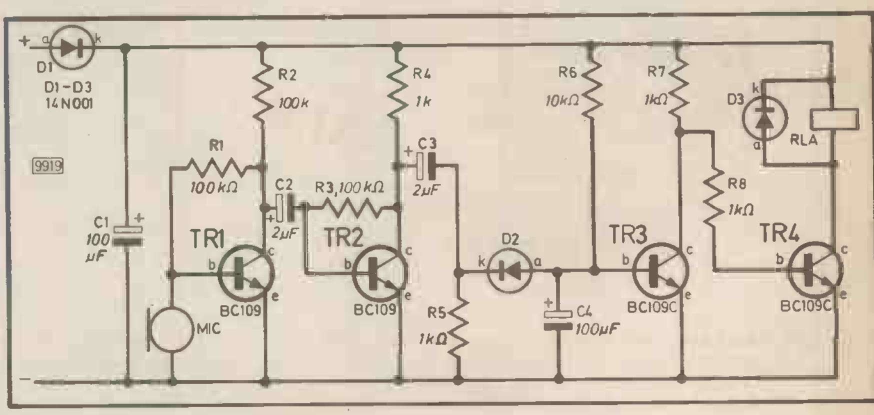
ADC UNIT

The ADC is the one featured in the September, 1983 issue of Everyday Electronics, but again this experiment can be repeated for any ADC providing the input voltages are duly attenuated or boosted depending on the type of ADC.

To be continued

CIRCUIT EXCHANGE

SOUND-OPERATED SWITCH



THIS circuit was primarily designed to eliminate the problem of the microphone wire of CB rigs wrapping around the gearstick when communicating and changing gear.

It works by operating the microphone when you speak and de-activating the microphone when you stop speaking.

The circuit has the microphone which is followed by an amplifier using two transistors. The a.c. signal from the mic. is now converted to a d.c. signal by a demodulator, which then activates a transistor switch. This pulls a relay into operation which in turn activates the CB mic. by means of the relay contacts.

The two microphones to the sound switch and the CB were positioned, in practice, in front of the driver's steering wheel. This makes it easier for the driver and prevents him having to speak louder or shout.

The circuit works from the 12V car battery and a switch, positioned near to the driver, was used in the +12V line to switch the unit on or off.

Russell Oakes,
Winstanley,
Wigan.

Step-by-step fully illustrated assembly and fitting instructions are included together with circuit descriptions. Highest quality components are used throughout.

Sparkrite

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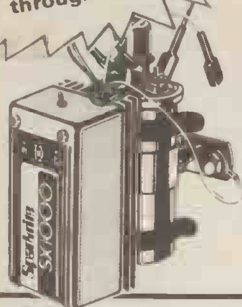


SX 1000 Electronic Ignition

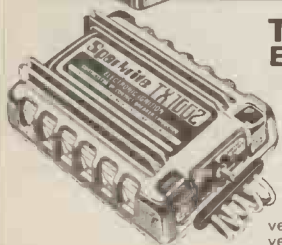
● Inductive Discharge ● Extended dwell circuit stores greater energy in coil ● Three position changeover switch ● Patented clip-to-coil fitting ● Easy to assemble, easy to fit ● Contact breaker triggered – includes bounce suppression circuit.

SUPER SAVE

SX 2000 Electronic Ignition

● Reactive Discharge ● Combines inductive & capacitive energy storage ● Gives highest possible spark energy ● Patented clip-to-coil fitting ● Easy assembly sequence ● Contact breaker triggered – includes bounce suppression circuit.

SUPER SAVE



TX 1002 Electronic Ignition

● Inductive discharge ● Extended dwell circuit stores greater energy in coil ● Three position changeover switch ● Contactless or contact breaker triggered ● Clip-to-coil or remote mounting ● Rugged die-cast case ● Contactless adaptors included for majority of 4 & 6 cylinder vehicles ● Easy to build ● For details of vehicles fitted by contactless trigger, ring Technical Service Dept on (0922) 611338-9.

TX2002 Electronic Ignition

● Two separate systems in one unit! ● Reactive Discharge OR Inductive Discharge, with three position changeover switch ● Gives highest possible spark energy ● Clip-to-coil or remote mounting ● Rugged die-cast case ● Contactless or contact breaker triggered ● Contactless adaptors included for majority of 4 & 6 cylinder vehicles ● For details of vehicles fitted by contactless trigger, ring Technical Service Dept on (0922) 611338-9.

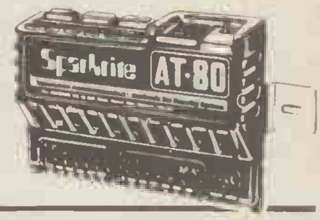
AT-40 Electronic Car Alarm

● Guards doors, boot, bonnet from unauthorised entry ● Armed/disarmed using concealed switch ● 30 second delay-to-arm: 7 second entry delay ● Can alternatively be wired to exterior key switch ● Flashes headlights & sounds horn intermittently for 60 seconds when activated ● Security loop protects accessories ● Low consumption C-MOS circuitry.

NEW

AT-80 Electronic Car Security System

● Guards doors, boot, bonnet from unauthorised entry ● Armed/disarmed from outside vehicle by magnetic key fob passed across sensor pad adhered to inside of windscreen ● Individually programmable code ● 30 second delay-to-arm ● Flashes headlights and sounds horn intermittently for 60 seconds when activated ● Security loop protects accessories ● Function lights to assist setting-up ● Low consumption C-MOS circuitry.



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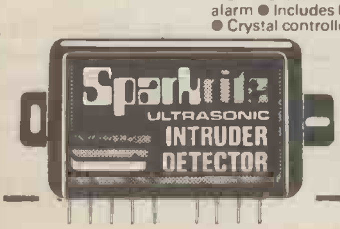
● Supplementary to AT-40 & AT-80 ● Will work in conjunction with any door switch input or voltage sensing alarm ● Detects attempted break-in and movement within passenger compartment & triggers alarm ● Includes high efficiency ultrasonic transducers ● Crystal controlled for low drift ● Ingenious sensitivity control allows freedom from false alarms ● Low current consumption



NEW

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● 12 functions centred on Fuel, Speed, Distance and Time ● Single chip microprocessor ● Large high brightness fluorescent display with auto-dimming feature ● High accuracy distance & fuel transducers included ● Displays MPG, L/100km and miles/litre at the flick of a switch ● Visual & audible warnings of excess speed, ice, lights-left-on ● Independent LOG & TRIP functions ● Low consumption crystal controlled circuitry.

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MAGIDICE Electronic Dice

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SERIES II

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COMPLETE WITH CASE

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This TV SOUND TUNER offers full UHF coverage with 5 pre-selected tuning controls. It can also be used in conjunction with your video recorder. Dimensions: 10½"x 7½"x 2½".

PRACTICAL ELECTRONICS STEREO CASSETTE RECORDER KIT

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• NOISE REDUCTION SYSTEM. • AUTO STOP. • TAPE COUNTER. • SWITCHABLE E.Q. • INDEPENDENT LEVEL CONTROLS. • TWIN V.U. METER. • WOW & FLUTTER 0.1%. • RECORD/PLAYBACK I.C. WITH ELECTRONIC SWITCHING. • FULLY VARIABLE RECORDING BIAS FOR ACCURATE MATCHING OF ALL TYPES.

Kit includes tape transport mechanism, ready punched and back printed quality circuit board and all electronic parts, i.e. semiconductors, resistors, capacitors, hardware, top cover, printed scale and mains transformer. You only supply solder & hook-up wire. Featured in April P.E. reprint 50p. Free with kit.

STEREO TUNER KIT

SPECIAL OFFER! £13.95 + £2.50 p&p.

This easy to build 3 band stereo AM/FM tuner kit is designed in conjunction with P.E. (July '81). For ease of construction and alignment it incorporates three Mullard modules and an I.C. IF System.

FEATURES: VHF, MW, LW Bands, interstation muting and AFC on VHF. Tuning meter. Two back printed PCB's. Ready made chassis and scale. Aerial: AM-ferrite rod, FM-75 or 300 ohms. Stabilised power supply with 'C' core mains transformer. All components supplied are to P.E. strict specification. Front scale size 10½"x 2½" approx. Complete with diagram and instructions.

BSR RECORD DECKS

3 speed, manual, auto, setdown; with auto return.

Fitted with viscous damped cue, tubular aluminium counter-weighted arm, fitted with stereo ceramic head. Ideally suited for home or disco use:

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Auto Changer model — takes up to six records with manual override. Also supplied with stereo ceramic cartridge.

£12.95 + £1.75 p&p.

PLINTH to suit BSR Record Player Deck (with cover). Size 16½"x 14¾"x 2¾". Cover size: £14½"x 13½"x 3¾". Due to fragile nature, Buyer collect only. Price: £8.95.

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The power amp kit is a module for high power applications - disco units, guitar amplifiers, public address systems and even high power domestic systems. The unit is protected against short circuiting of the load and is safe in an open circuit condition. A large safety margin exists by use of generously rated components, result, a high powered rugged unit. The PC board is back printed, etched and ready to drill for ease of construction and the aluminium chassis is preformed and ready to use. Supplied with all parts, circuit diagrams and instructions.

SPECIFICATIONS:
Max. output power (RMS): 125 W. Operating voltage (DC): 50 - 80 max. Loads: 4 - 16 ohm. Frequency response measured @ 100 watts: 25Hz - 20KHz. Sensitivity for 100w: 400mV @ 47K. Typical T.H.D. @ 50 watts, 4 ohms: 0.1%. Dimensions: 205x90 and 190x36mm.

ACCESSORIES: Stereo/mono mains power supply kit with transformer: £10.50 plus £2.00 p&p.

KIT £10.50 + £1.15 p&p. BUILT £14.25 + £1.15 p&p.

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AUDAX 8" SPEAKER £5.95 + £2.20 p&p.

High quality 40 watts RMS bass/mid. Ideal for either HiFi or Disco use this speaker features an aluminium voice coil and a heavy 70mm dia. magnet. Freq. Res.: 20Hz to 7kHz. Imp.: 8 ohms.

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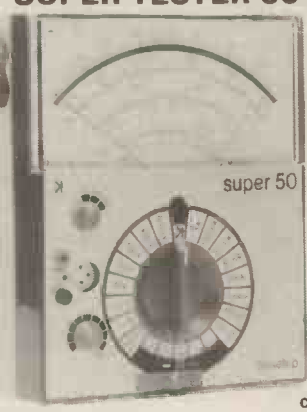

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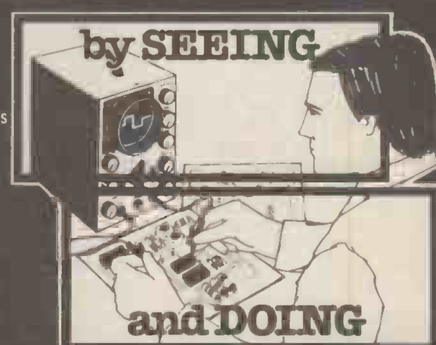

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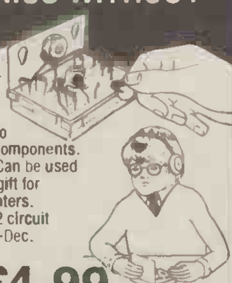

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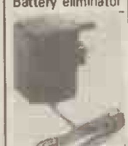

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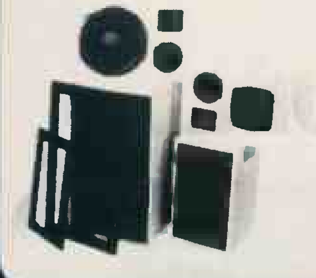

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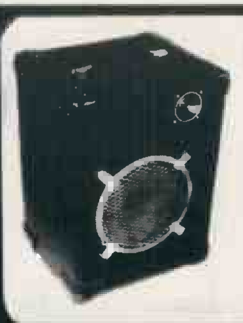

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Comprising of a top panel and tape mechanism coupled to a record/play back printed board assembly. Supplied as one complete unit for horizontal installation into cabinet or console of own choice. These units are brand new, ready built and tested.

Features: Three digit tape counter. Autostop. Six piano type keys, record, rewind, fast forward, play, stop and eject. Automatic record level control. Main inputs plus secondary inputs for stereo microphones. **Input Sensitivity:** 100mV to 2V. **Input Impedance:** 68K. **Output level:** 400mV to both left and right hand channels. **Output Impedance:** 10K. **Signal to noise ratio:** 45dB. **Wow and flutter:** 0.1%. **Power Supply requirements:** 18V DC at 300mA. **Connections:** The left and right hand stereo inputs and outputs are via individual screened leads, all terminated with phono plugs (phono sockets provided). **Dimensions:** Top panel 5⅛in × 11⅛in. Clearance required under top panel 2¼in. Supplied complete with circuit diagram and connecting diagram. Attractive black and silver finish.
Price £26.70 + £2.50 postage and packing.
Supplementary parts for 18V D.C. power supply (transformer, bridge rectifier and smoothing capacitor) £3.50.

PANTEC

HOBBY KITS. Proven designs including glass fibre printed circuit board and high quality components complete with instructions.

FM MICROTRANSMITTER (BUG) 90/105MHz with very sensitive microphone. Range 100/300 metres. 57 x 46 x 14mm (9 volt) **Price: £7.99p**

DIGITAL THERMOMETER -9.9 C to +99.9 C. LED display. Complete with sensor. 70 x 70 mm (9 volt) **Price: £27.60p**

3 WATT FM TRANSMITTER 3 WATT 85/115MHz varicap controlled, professional performance. Range up to 3 miles 35 x 84 x 12 mm (12 volt) **Price: £12.49p**

SINGLE CHANNEL RADIO CONTROLLED TRANSMITTER/RECEIVER 27MHZ Range up to 500 metres. Double coded modulation. Receiver output operates relay with 2amp/240 volt contacts. Ideal for many applications. Receiver 90 x 70 x 22 mm 9/12 volt) **Price: £16.49** Transmitter 80 x 50 x 15 mm (9/12 volt) **Price £10.29** P&P All Kits +50p. S.A.E. for complete list.

3 watt FM Transmitter

BSR P256 TURNTABLE

P256 turntable chassis ● S shaped tone arm ● Belt driven ● Aluminium platter ● Precision calibrated counter balance ● Anti-skate (bias device) ● Damped cueing lever ● 240 volt AC operation (Hz) ● Cut-out template supplied ● Completely manual arm. This deck has a completely manual arm and is designed primarily for disco and studio use where all the advantages of a manual arm are required.
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LOUDSPEAKERS POWER RANGE

THREE QUALITY POWER LOUDSPEAKERS (15", 12" and 8" See Photo) Ideal for both Hi-Fi and Disco applications. All units have attractive cast aluminium (ground finish) fixing escutcheons.
Specification and Prices.
15" 100 watt R.M.S. Impedance 8 ohms. 50oz. magnet. 2" aluminium voice coil. Res. Freq. 20 Hz. Freq. Resp. to 2.5KHz. Sens. 97dB. Price: £34.00 each + £3.00 P&P
12" 100 watt R.M.S. Impedance 8 ohms. 50oz. magnet 2" aluminium voice coil. Res. Freq. 25Hz. Freq. Resp. to 4 KHz. Sens. 95dB. Price: £24.50 each + £3.00 P&P
8" 50 watt R.M.S. Impedance 8 ohms. 20 oz. magnet. 1½" aluminium voice coil. Res. Freq. 40Hz. Freq. Resp to 6 KHz. Sens. 92dB Black Cone. Price: £9.50 each. Also available with black protective grille Price £9.99 each. P&P £1.50.

12" 85 watt R.M.S. McKENZIE C1285GP (LEAD GUITAR, KEYBOARD, DISCO) 2" aluminium voice coil, aluminium centre dome, 8 ohm imp., Res. Freq. 45Hz., Freq. Resp. to 6.5KHz., Sens. 98dB. **Price: £23.00** + £3 carriage.
12" 85 watt R.M.S. McKENZIE C1285TC (P.A., DISCO) 2" aluminium voice coil. Twin cone. 8 ohm. imp., Res. Freq. 45HZ., Freq. Resp. to 14KHz. **Price £23** + £3 carriage.
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Improved specification

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SPECIFICATION
Output Power:— 110 watts R.M.S.
Loads:— Open and short circuit proof. 4/16 ohms.
Frequency Response:— 15Hz - 30KHz -3dB.
T.H.D.:— 0.01%.
S.N.R. (Unweighted):— -118dB ±3.5dB
Sensitivity for Max Output:— 500mV @ 10K.
Size:— 360 x 115 x 72 mm Price:— £31.99 + £2.00 P&P. Vu Meter Price:— £7.00 + 50p P&P.

MOSFET versions available up to 300W. R.M.S.

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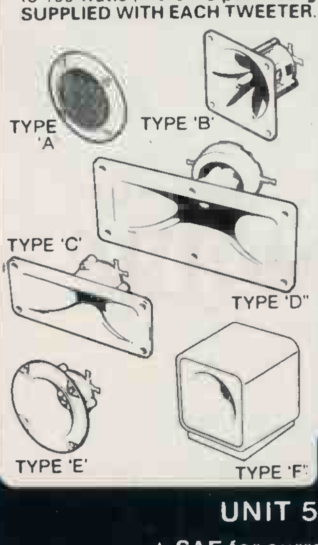

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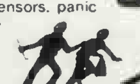

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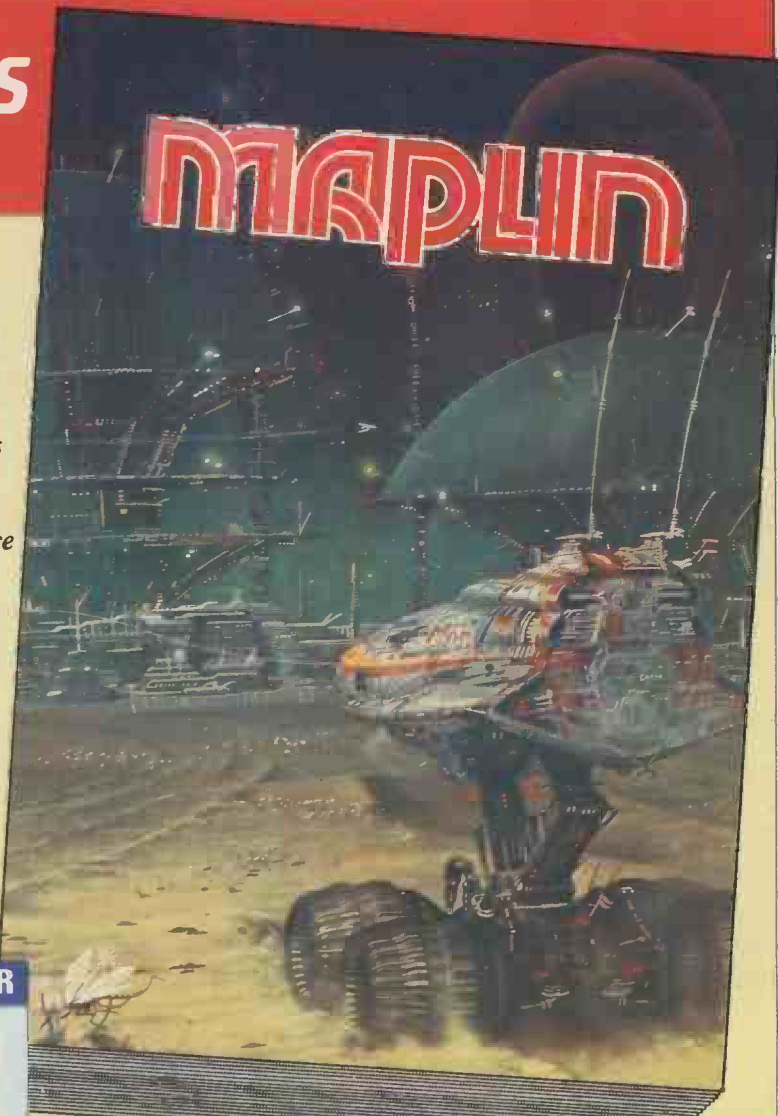

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