EVERYDAY ELECTRONICS

NOVEMBER 1987

INCORPORATING ELECTRONICS MONTHLY

£1·20

Free Inside

GREENWELD 88 PAGE CATALOGUE

ACCENTED BEAT METRONOME

BBC SIDEWAYS RAM

ACOUSTIC PROBE

The Magazine for Electronic & Computer Projects

£1 BAKERS DOZEN PACKS

Price per pack is £1.00.* Order 12 you may choose another free. Items marked (sh) are not new but guaranteed ok.

1 – 5 13 amp ring main junction boxes
2 – 5 13 amp ring main spur boxes
5 – 3 flush electrical switches
7 – 4 in flex line switches with neons
8 – 2 80 watt brass cased elements
9 – 2 mains transformers with 6V 1A secondaries
10 – 2 mains transformers with 12V ½A secondaries
11 – 1 extension speaker cabinet for 6½" speaker
12 – 5 octal bases for relays or valves
13 – 12 glass reed switches
14 – 4 OCP 70 photo transistors
16 – 4 tape heads, 2 record, 2 erase
17 – 1 ultrasonic transmitter and 1 ditto receiver
18 – 2 15000 mfd computer grade electrolytics
19 – 2 light dependent resistors
20 – 5 different micro switches
21 – 2 mains interference suppressors
22 – 2 25 watt crossover units 2 way
23 – 1 40 watt 3 way crossover unit
28 – 1 6 digit counter mains voltage
30 – 2 Nicad battery chargers
31 – 1 key switch with key
32 – 2 humidity switches
34 – 96 x 1 metre lengths colour-coded connecting wires
36 – 2 air spaced 2 gang tuning condensors
37 – 2 solid diaelectric 2 gang tuning condensors
38 – 10 compression trimmers
41 – 6 Rocker Switches 10 amp mains SPST
43 – 5 Rocker Switches 10 amp SPDT Centre Off
44 – 4 Rocker Switches 10 amp DPDT
45 – 1 24 hour time switch mains operated (s.h.)
46 – 1 6 hour clock timeswitch
48 – 2 6V operated reed switch relays
49 – 10 neon valves – make good night lights
50 – 2 x 12V DC or 24V AC, 4 CO relays
51 – 1 x 12V 2C O very sensitive relay
52 – 1 12V 4C relay
55 – 1 locking mechanism with 2 keys
56 – Miniature Uniselector with circuit for electric jigsaw
57 – 5 Dolls' House switches
60 – 5 ferrite rods 4" x 5/16" diameter aerials
61 – 4 ferrite slab aerials with L & M wave coils
62 – 4 200 ohm earpieces
63 – 1 Mullard thyristor trigger module
64 – 10 assorted knobs ¼ spindles
65 – 5 different themostats, mainly bi metal
66 – Magnetic brake – stops rotation instantly
67 – Low pressure 3 level switch
69 – 2 25 watt pots 8 ohm
70 – 2 25 watt pots 1000 ohm
71 – 4 wire wound pots – 18, 33, 50 and 100 ohm
73 – 4 3 watt wire wound pots 50 ohm
77 – 1 time reminder adjustable 1-60 mins
78 – 5.5 amp stud rectifiers 400V
85 – 1 mains shaded pole motor ¾" stack – ¼ shaft
86 – 2 5" ali fan blades fit ¼" shaft
87 – 2 3" plastic fan blades fit ¼" shaft
88 – Mains motor suitable for above blades
89 – 1 mains motor with gearbox 1 rev per 24 hours
91 – 2 mains motors with gearbox 16 rpm
93 – 4 11 pin moulded bases for relays
94 – 5 B7G valve bases
95 – 4 skirted B9A valve bases
96 – 1 thermostat for fridge
98 – 1 motorised stud switch (s.h.)
101 – 1 2½ hours delay switch
103 – 1 6v mains power supply unit
104 – 1 4½ V mains power supply unit
105 – 1 5 pin flex plug and panel socket
107 – 1 5" speaker size radio cabinet with handle
109 – 10 ¼" spindle type volume controls
110 – 10 slider type volume controls
112 – 1 heating pad 200 watts mains
114 – 1 1W amplifier Mullard 1172
115 – 1 Wall mounting thermostat 24V
118 – 1 Teak effect extension 5" speaker cabinet
120 – 2 p.c.b. with 2 amp full wave and 17 other recs
122 – 10 mtrs twin screened flex white p.v.c. outer
132 – 2 plastic boxes with windows, ideal for interrupted beam switch etc
155 – 3 varicap push button tuners with knobs
188 – 1 plastic box, sloping metal front, 16 x 95mm, average depth 45mm
241 – 1 car door speaker (very flat) 6½" 15 ohm made for Radiomobile
243 – 2 speakers' 6" x 4" 15 ohm 5 watt made for Radiomobile
266 – 2 mains transformer 9V ½ A secondary split primary so OK also for 115V
267 – 1 mains transformers 15V 1A secondary p.c.b. mounting
330 – 2 6V 0.6V mains transformer .3a p.c.b. mounting
350 – 40 double pole leaf switches
365 – 1 7uf 660V 50hz metal cased condenser
453 – 2 2¼ in 60 ohm loudspeakers
454 – 2 2¼ in 8 ohm loudspeakers
463 – 1 mains operated relay with 2 sets c/o contacts
464 – 2 packets resin filler/sealer with cures
465 – 3 5A round 3 pin plugs will fit item 193
466 – 4 7 segment l.e.d. displays
470 – 4 pc boards for stripping, lots of valuable parts
480 – 1 3A double pole magnetic trip, saves repairing fuses
498 – 4 1000uf 25V axial electrolytic capacitors
504 – 1 Audax PM 8" speaker 15 ohm 5 watt rating
515 – 100 4BA 1½" cheesehead plated screws and 100 4BA nuts
541 – 1 pair stereo tape head as in cassette recorder/players
546 – 1 bridge rectifier 600V international rectifier ref 3SB100
548 – 2 battery operated relays (3-6v) each with 5A c/o contacts 2 pairs
553 – 2 lithium 3V batteries (everlasting shelf life)

TELEPHONE BITS

Master socket (has surge arrestor – ringing condenser etc) and takes B.T. plug	£3.95
Extension socket	£2.95
Dual adaptors (2 from one socket)	£3.95
Cord terminating with B.T. plug 3 metres	£1
Kit for converting old entry terminal box to new B.T. master socket, complete with 4 core cable, cable clips and 2 B.T. extension sockets	£11.50
100 mtrs 4 core telephone cable	£8.50

COMPACT FLOPPY DISC DRIVE EME-101

The EME-101 drives a 3" disc of the new standard which despite its small size provides a capacity of 500k per disc, which is equivalent to the 3½" and 5¼" discs. We supply the Operators Manual and other information showing how to use this with popular computers: BBC, Spectrum, Amstrad etc. All at a special snip price of £27.50 including post and VAT. Data available separately £2, refundable if you purchase the drive.

MULLARD UNILEX AMPLIFIERS

We are probably the only firm in the country with these now in stock. Although only four watts per channel, these give superb reproduction. We now offer the 4 Mullard modules – i.e. Mains power unit (EP9002) Pre amp module (EP9001) and two amplifier modules (EP9000) all for £6.00 plus £2 postage. For prices of modules bought separately see TWO POUNDERS.

CAR STARTER/CHARGER KIT

Flat Battery! Don't worry you will start your car in a few minutes with this unit – 250 watt transformer 20 amp rectifiers, case and all parts with data case £17.50 post £2.

THIS MONTH'S SNIP

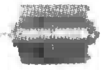
is a 2½ kW tangential heater, metal box to contain it and 3 level switch to control it. Special price £7.50 post paid.

VENNER TIME SWITCH

Ex-Electricity Board. Guaranteed 12 months.

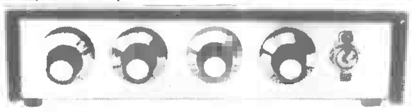
Mains operated with 20 amp switch, one on and one off per 24 hrs. repeats daily automatically correcting for the lengthening or shortening day. An expensive time switch but you can have it for only £2.95 without case, metal case – £2.95, adaptor kit to convert this into a normal 24hr time switch but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

12 volt MOTORS BY SMITHS



Made for use in cars, etc. these are very powerful and easily reversible. Size 3½" long by 3" dia. They have a good length of ¼" spindle – 1/10 hp £3.45
1/8 hp £5.75. 1/6 hp £7.50

SOUND TO LIGHT UNIT



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.

9" MONITOR

Ideal to work with computer or video camera uses Philips black and white tube ref M24/306W. Which tube is implosion and X-Ray radiation protected. VDU is brand new and has a time base and EHT circuitry. Requires only a 16V dc supply to set it going. It's made up in a lacquered metal framework but has open sides so should be cased. The VDU comes complete with circuit diagram and has been line tested and has our six months guarantee. Offered at a lot less than some firms are asking for the tube alone, only £16 plus £5 post.

LIGHT BOX

This when completed measures approximately 15" x 14". The light source is the Philips fluorescent 'W' tube. Above the light a sheet of fibreglass and through this should be sufficient light to enable you to follow the circuit on fibreglass PCBs. Price for the complete kit, that is the box, choke, starter, tube and switch, and fibreglass is £5 plus £2 post, order ref 5P69.

TANGENTIAL HEATERS

We again have very good stocks of these quiet runnng instant heat units. They require only a simple case, or could easily be fitted into the bottom of a kitchen unit or book case etc. At present we have stocks of 1.2kw, 2kw, 2.5kw, and 3kw. Prices are £5 each for the first 3, and £6.95 for the 3k. Add post £1.50 per heater if not collecting.
CONTROL SWITCH enabling full heat, half heat or cold blow, with connection diagram, 50p for 2kw, 75p for 3kw.

FANS & BLOWERS

5" £5 + £1.25 post. 6" £6 + £1.50 post
4" x 4" Muffin equipment cooling fan 115V £2.00
4" x 4" Muffin equipment cooling fan 230/240V £5.00
9" Extractor or blower 115V supplied with 230 to 115V adaptor £9.50 + £2 post.
All above are ex computers but guaranteed 12 months.
10" x 3" Tangential Blower. New. Very quiet – supplied with 230 to 115V adaptor on use two in series to give long blow £2.00 + £1.50 post or £4.00 + £2.00 post for two

TELEPHONE LEAD

3 mtrs long terminating one end with new BT, flat plug and the other end with 4 correctly coloured coded wires to fit to phone or appliance. Replaces the lead on old phone making it suitable for new BT socket. Price £1 ref BD552 or 3 for £2 ref 2P164.

POWERFUL IONISER

Generates approx. 10 times more IONS than the ETI and similar circuits. Will refresh your home, office, shop, work room etc. Makes you feel better and work harder – a complete mains operated kit, case included. £9.50 + £3 P&P.

J & N BULL ELECTRICAL

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

MAIL ORDER TERMS: Cash, P.O. or cheque with order. Orders under £20 add £1 service charge. Monthly account orders accepted from schools and public companies. Access & B/card orders accepted. Brighton (0273) 734648 or 203500.

NEW ITEMS

Some of the many described in our current list which you will receive with your parcel.

£2 POUNDERS*

2P120 – 1 combined clockwork switch and thermostat for boiler control
2P122 – 1 30a rotary switch, surface mounting with pointer knob
2P123 – 1 25a rotary switch, surface mounting, cover engraved, high, medium low and off
2P124 – 1 28kv .001 mfd block condensor
2P127 – 1 30a bridge rectifier assembly on heat sinks
2P129 – 1 10rpm motor 115V so supplied with adaptor for 230V
2P131 – 1 Crouzet motor 230V fits the Crouzet gearbox
2P132 – 1 ceiling heat-stat for fire warning or protection
2P133 – 1 Circuit breaker 20a, Crabtree ref C50
2P134 – 1 9V 500mA psu, plugs into 13a socket
2P135 – 10m 10 conductor intercom cable
2P136 – 1 2½ kw element made for tangential blowers
2P137 – 1 Thermo couple, stainless steel tipped for measuring internal heat
2P138 – 1 Mains transformer 20V-0-20V 1a upright mounting
2P141 – 1 rechargeable battery D size (4 AH) solder tag ended
2P142 – 10m 4 pair intercom cable White PVC outer
2P144 – 1 mains operated relay with 4 x 8a c/o contacts
2P145 – 1 10,000 uf 70V d.c. smoothing capacitor
2P146 – 1 7,800 uf 150C d.c. smoothing capacitor
2P148 – 1 Technical information on 3" FDD refundable if you buy fdd
2P149 – 5 diff battery operated model motors
2P150 – 1 PSU chassis with all components for 24V 2A d.c. unwired
2P151 – 1 Metal box 14½ x 14 x 4 with lid add £2.00 post
2P152 – 1 Motor start capacitor 80uf 250V
2P153 – 1 Two station intercom unused but line reject
2P154a – 1 Nicad charger – plug into 13a socket 5.2V .7UA output
2P154b – 1 Nicad charger – plug into 13a socket 6V .9V A output
2P155 – 1 Mains transformer giving 16, 17, 18 & 20V 60W
2P158 – 1 Oven thermostat with temp calibrated knob
2P159 – 1 9V 500ma cased with mains lead and output lead
2P160 – 1 13a plug adaptor fused takes 3 x 3a plugs
2P161 – 1 6" diagonal side cutters
2P162 – 1 Stereo Matrix PCB mounting deemphasis K35
2P163 – 1 AC Working capacitor 12uf 660V AC or 1500V dc
2P164 – 3 Phone leads 3 mtrs long tags one end B.T. plug other end

£3 POUNDERS*

3P7 – 1 DC voltage, doubler or halver for 12V to 24V 12 to 6V 24 to 12V
3P8 – 1 24hr time switch Sangamo, new condition Guaranteed 1 year
3P9 – 12V 500mA psu plugs in 13a socket regulated
3P10 – 1 Mains transformer 50V 2A with 6.3 pilot light winding, upright mounting, fully shrouded plus £1 post
3P13 – 1 Noise filter to fit in mains lead of appliance up to 25a
3P15 – 1 waterproof case will take 150 watt transformer
3P16 – 1 signal box, 3 lamps on face plate of metal box size 5½ x 3½
3P17 – 1 choke and starter to work 8" fluorescent tube at 125W
3P18 – 1 22V 3a mains transformer with bridge rect fitted on top panel
3P20 – 1 0-5a ammeter 3½ ac/dc ex equipment
3P21 – 1 power factor correction condenser 35uf 350ac
3P22 – 1 200va – auto transformer 230 to 115V torroidal encapsulated £1.50 post
3P23 – 1 36V-0-36V tapped 20V-0-20V 100va
3P24 – 1 3" floppy disc for Amstrad etc.
3P25 – 1 7" Electricians pliers

£4 POUNDERS*

4P12 – 50m low loss co-ax 75ohm + £1 post
4P13 – 3 Horstmann time and set switches 15amp
4P14 – 1 150w mains transformer "c" core 43V 3.5A secondary
4P15 – 1 powerful motor 2" stack fitted with gearbox final speed 60rpm mains operated, could operate door opener etc.
4P17 – 1 Uniselector 3 pole 25W, 50V coil standard size
4P18 – 1 Volt meter with digital display (DIGIVISOR)
4P19 – 1 12V dc motor will fit to gearbox 4P20
4P20 – 1 Gear train giving speed reduction

£5 POUNDERS*

5P86 – 1 Transformer upright mounting 230/240V primary 2 x 100 1a secondary
5P88 – 1 Transformer in waterproof metal box 24V 5A add £2 post
5P89 – 1 4 bank heating element each 2kw ideal convector heater
5P90 – 1 18" long tangential blower with motor at one end
5P91 – 1 14" blower, motor in middle
5P92 – 10m Audio co-ax double screened 75ohm super low loss for TV
5P93 – 1 6" Alarm bell 24V dc or ac
5P94 – 1 Current transformer 14V out with 1a dc input
5P95 – 1 Vintage photo cell
5P97 – 1 Impedance matching transformer 0-4-5-8-160 ohm 100 add £1.50 post
5P98a – 1 0-90a ammeter for mounting outside control panel
5P98b – 1 0-180a ammeter for mounting outside control panel
5P99 – 1 Mains operated blower centrifugal output size app. 5" x 1½"
5P100 – 1 Mains splitter 45a switch 3 x 15a fused circuits
5P101 – 1 Model motor 1 rpm from 6V reversible

£7 POUNDERS*

7P1 – 1 Instant heat solder gun – mains with renewable tip and job light

£8 POUNDERS*

8P1 – 1 Charger transformer 10a upright mounting 230/240 primary 16v 10a secondary
8P2 – 1 6" underdome alarmbell suitable for a fire alarm or burglar alarm mains operated.
8P3 – 1 heat sink big powerful so ideal for power transmitter
8P5 – 1 ⅓ hp motor 900 rpm capacitor run
8P6 – 1 24hr time switch – 2 on offs 16a c/o contacts 3" x 3" x 1½"
8P7 – 1 Silent sentinel invisible ray kit
8P8 – 1 Papst fan 3½ x 3½ x 1½ 230V metal bodied

£10 POUNDERS*

10P13 – 1 reversible motor with gearbox 104 rpm Parvalux
10P14 – 1 100a time switch 1 on/off per 24hr extra triggers £1 per pair
10P15 – 1 Max demand meter 230 ac mains
10P16 – 1 powerful air mover 2 small type blowers with motor in middle
10P18 – 1 mains operated klaxon
10P19 – 1 12V alarm bell really loud, mains operated, in iron case + £5 post
10P22 – 1 sensitive volt meter relay
10P23 – 1 fruit machine heart 3 fruit wheels each stepper motor operated add £3 post
10P24 – 1 big panel meter face size 4¾ x 2½ 200uA movement scaled 1-10
10P26 – 1 "Secretary" phone auto-dialer complete untested sold as such
10P29 – 1 12V engine cooling fan
10P30 – 1 instrument psu on pcb has 4 outputs .12V/.5V 6A/12V .5A/5V .5A
10P31 – 1 7 day time switch 16a c/o contacts sep switches for each day
10P32 – 1 68 rpm 1/6th hp motor reversible

£15 POUNDERS*

15P1 – 1 kit for 115W hi fi amp
15P2 – 1 kit for psu to supply one or two 15P1 amps
15P3 – 1 time switch battery or mains operated – 16a c/o contacts, 7 day programmable has 36hr reserve

LIGHT CHASER KIT motor driven switch bank with connection diagram, used in connection with 4 sets of xmas lights makes a very eye catching display for home, shop or disco, only £5 ref 5P56.

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INCORPORATING ELECTRONICS MONTHLY
ABC

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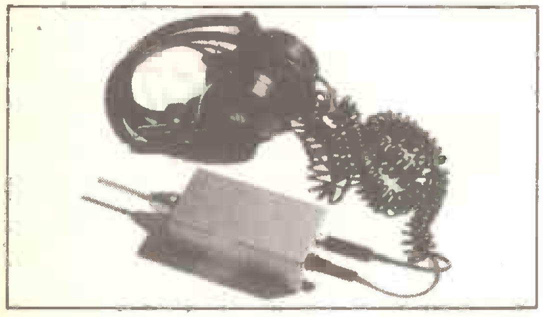
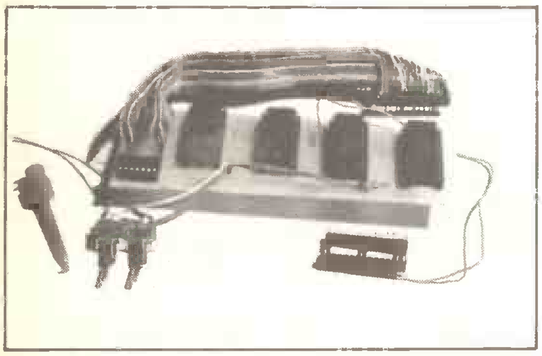
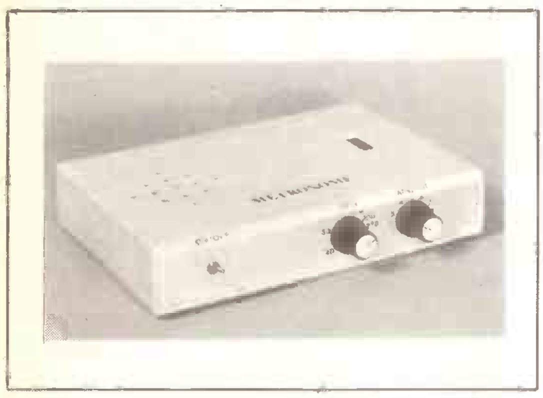
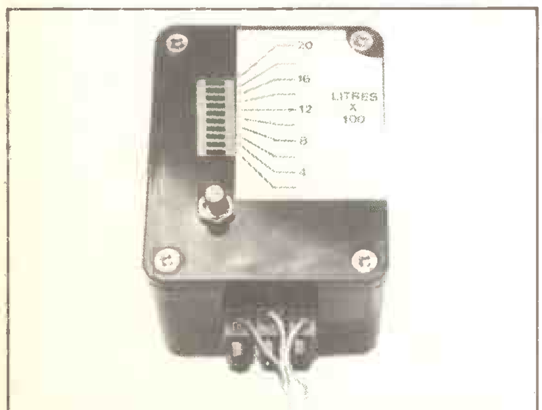
PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .









Projects

Series

Features

Our December 1987 issue will be published on Friday, 13 November 1987. See page 614 for details.

JUST ARRIVED!!

A major electronic distributor's discontinued lines all being sold off at LESS THAN HALF PRICE!! – Boxes, cases, connectors, LEDs, switches, DIP boards, cable ties, etc. All goods detailed in a 16 page supplement, available now, FREE!!

Examples:

Briefcase type combination locks **£4.71** per pair. Sloping front cases: 161 × 96 × 57/39mm **92p**; 215 × 130 × 73/47mm **£1.49**. Plastic box with PCB slots 190 × 110 × 60mm **£1.40**. Large steel case 336 × 269 × 148mm **£15.45**. 'Tidyman' Kits: contain a wide variety of support pillars, stand offs, cable straps and clamps, etc (46 diff) all in attractive plastic case. Small: (201 total) **£7.80**; Large (708 total) **£13.00**. Full details in Supplement. (Post on all above **£2**).

NewBrain

Z494 Motherboard microprocessor panel 265 × 155mm. Complete PCB for computer. Z80, char EPROM, etc. 68 chips altogether + other associated components, plugs, skts, etc. **£5.50**

~~**Z495 RAM** panel. PCB 230 × 78mm~~ with 14 × MM5290 – 2 (4116) (2 missing) giving 28k of memory. Also 8 LS chips. These panels have not been soldered, so chips can easily be removed if required. **£5.00**

'NEWBRAIN' PSU

BRAND NEW Stabilized Supply in heavy duty ABS case with rubber feet. Input 220/240V ac to heavy duty transformer via suppressor filter. Regulated DC outputs: 6.5V @ 1.2A; 13.5V @ 0.3A; – 12V @ 0.05A. All components readily accessible for mods etc. Chunky heatsink has 2 × TIP31A. Mains lead (fitted with 2 pin continental plug) is 2m long. 4 core output lead 1.5m long fitted with 6 pole skt on 0.1" pitch. Overall size 165 × 75 × 72mm. **£5.95 ea 10 for £40**

Z679 KEYBOARD 62 keys on ally chassis 260 × 90mm. No PCB. **£6.50**

Z670 HANDBOOK 204pp. Useful appendix (about ½ the book) gives some tech info. **£5.00**

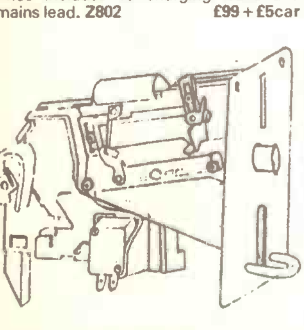
Z674 DATA PACK. Interfaces and connector pin-out, i/p, o/p, port map, cct diagram + data on COP420C **£2.00**

Z672 MOTHERBOARDS Complete but probably faulty. **£3.50**

VIDEO FANS!!

Here's your chance to never be without power again!! We're offering a set of 10 6V 3A sealed lead acid rechargeable batteries, together with a mains powered charger that takes all 10 batts at an unbeatable price! They can be wired up in parallel/series combination to provide 6V 30A or 12V 15A, thus giving over 20hrs recording time on most camcorders. Limited stocks, so order now!

Price includes 10 charging leads and mains lead. **Z802** **£99 + £5car**



Z652 COIN ACCEPTOR MECHANISM

Made by Coin Controls, this will accept various size coins by simple adjustment of 4 screws. Incorporates various security features – magnet, bent coin rejector etc. Microswitch rated 5A 240V. Front panel 115 × 64, depth 130mm. Cost £10.85. Our Price **£4.00**

NEW THIS MONTH

SOLAR CELLS

Giant size, 90mm dia giving 0.45V 1.1A output. £4 each; 10 + **£3.50**

Mega size – 300 × 300mm. These incorporate a glass screen and backing panel, with wires attached. 12V 200mA output. Ideal for charging nicads. **£24.00**

CREAM DISPENSER

Z801 Coin operated machine for dispensing hand cream. Cabinet 620 × 365 × 200mm, wt 10kg, contains coin mech, PCB, counter, pump mech consisting of high torque geared 6V motor driving cam that pumps cream and sensing components, all powered by internal 6V 2.6A rechargeable battery **£15 + £5 carr.**

Parts available separately. See list 30

SPEECH CHIP

Z733 SPO256A + index chip + ULA chip as used in Currah microspeech. Cct and info for using SPO256 with Spectrum, ZX81, BBC, VIC & C64. No info on other 2 chips. All 3 for **£3.00**

AUTO DIALLER

Sloping front case 240 × 145 × 90/50 contains 2 PCB's: one has 4 keypads (total 54 switches) + 14 digit LED display, 2 × ULN2004, ULN 2033 and 4067; the other has 12 chips + 4 power devices etc. Case contains speaker. 8 core cable 2m long with plug. For use with PABX **£9.00**

SWITCHED MODE PSU

Astec type AA7271. PCB 50 × 50mm has 6 transistor cct providing current overload protection, thermal cut-out and excellent filtering. Input 8-24V DC. Output 5V 2A. Regulation 0.2% **£5.00**

PANELS

Z620 68000 Panel. PCB 190 × 45 believed to be from ICL's 'One per Desk' computer containing MC68008P8 (8MHz 16/8 bit microprocessor, + 4 ROMs, all in skts; TMP5220CNL, 74HCT245, 138, LS08, 38 etc. **£5.00**

Z625 32k Memory Board. PCB 170 × 170 with 16 2k × 8 6116 static RAMs. Also 3.6V 100 mA memopack nicad, 13 other HC/LS devices, 96w edge plug, 8 way DIL switch, Rs, Cs etc. **£4.80**

SOLDER SPECIAL!!

★ **15W 240V ac soldering iron**
★ **High power desolder pump**
★ **Large tube solder**

ALL FOR

£7.95

DIODE BARGAINS

Minimum 10 of any one type: 20 for £1; 50 for £2; 250 for £8; 1000 for £25.00. Types available: BAX12, BAX12A, BAX16, BY206, BYX55-300, BY207, CV8308, LR75C, MR817, MV1404, VSK140, 1N659, 1N4933.

sinclair

MICROVISION

CASES!!!

We now have a supply of cases, complete with aerial at the special low price of £5.00.

We have a quantity of these units in varying states. From labels attached to some of the PCBs it seems after assembly on the production line they did not function correctly. No attempt has been made to repair them, though – instead the following parts were removed:

a) RF Tuner
b) Vol control and switch
c) ZN401E chip

Z666 2 × PCB in good condition with 2 × CRT that have been removed, but may be repairable. Conductive paint (15ml bottle £3.45) will probably be needed to remake contacts. With diagram and notes. **£6.95**

RF Tuner **£6.95**; ZN401 chip **£9.95**; Vol control + switch with knob **£1.00**

GREENWELD ELECTRONIC COMPONENTS

All prices include VAT; just add 60p P&P
Min Access order £5. Official orders from schools etc. welcome – min invoice charge £10.
Our shop has enormous stock of components and is open 9-5.30 Mon-Sat. Come and see us!!!

READERS DISCOUNT SCHEME EE

443D Millbrook Road, Southampton SO1 0HX. Tel. (0703) 772501/783740

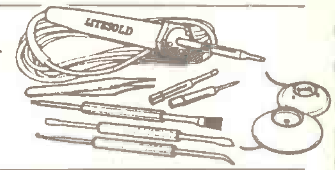
JOIN UP WITH LITESOLD

Professional Soldering Equipment at Special Mail-Order Prices.

EC50 Mains Electronic Iron. £33.16

Features spike-free, solid state proportional electronic temperature control inside the handle. Adjustable 280° to 400°C. Burn-proof 3-wire mains lead. Fitted 3.2mm Long-Life bit. 1.6, 2.4 and 4.7mm available. 240v a.c.

SK18 Soldering Kit. £16.70



Build or repair any electronic project. LC18 240v 18w iron with 3.2, 2.4, and 1.6mm bits. Pack of 18 swg flux-cored 60/40 solder. Tweezers. 3 soldering aids. Reel of De-Solder braid. In PVC presentation wallet.

ADAMIN Miniature Iron £7.67

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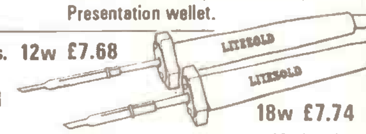

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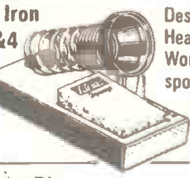

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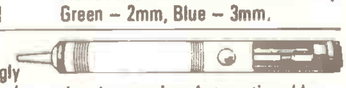

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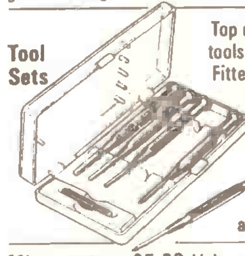

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The Magazine for Electronic & Computer Projects

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ESOTERIC

These days virtually everyone needs to know about electronics and digital systems — even if it is just how to program the video or the central heating — and more and more people need to know a little about computing. However after the first flush of learning, computing can be pretty esoteric and not really much fun, unless you get high from programming!

Of course, electronics can extend the hobby of computing into the real world in two ways:

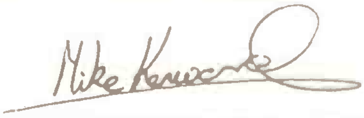
1. Computer interfaces can be built to enable any microcomputer to control virtually any electronic, electrical or mechanical system.
2. A computer (or microprocessor) can form the heart of an electronic project — to provide a dedicated control unit which can be built into other systems or equipment.

For these reasons many computer hobbyists are now turning to electronics to add a new dimension to their hobby — to put the fun back if you like. While *EE* has never given over large sections of the magazine to software we have tried to cater for the computer fanatic who wants to use his micro as a piece of test gear or to play music, etc. Our regular *On Spec* and *BBC Micro* pages look at those areas of using computers which employ electronics and which are most often overlooked by the popular computer magazines.

TRUMPET

As you may have noticed I have recently been "blowing our own trumpet" about circulation and market leadership. No doubt some of the new found circulation increases are a direct result of boredom with playing computer games and writing endless software.

Initial response to our City and Guilds series on Microprocessors has been very satisfying and we know a number of colleges will be using *EE* to back up their C & G courses. It is also interesting to see so many hobbyists taking up this course either to expand their knowledge for their own satisfaction or to enhance their job prospects. For a few years computing has distracted the electronics hobbyist, it now seems to be encouraging him.



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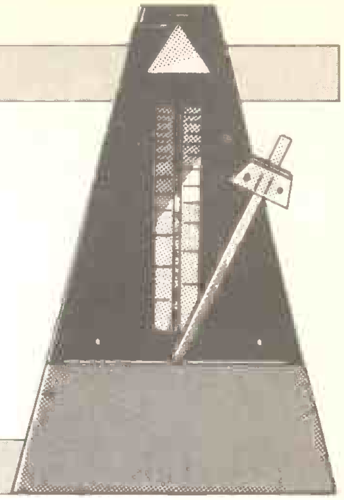


ACCENTED BEAT METRONOME

ROBERT PENFOLD

Accentuate the positive, eliminate the negative, that's how to stay in tune!

ALTHOUGH purely electronic, the Accented Metronome is a modern equivalent to the traditional pendulum style mechanical type and has even been designed to give the same sort of "click" sound to indicate each beat.

Some mechanical metronomes also have a bell which can be used to give an accented beat, and this unit has a similar facility. This is in the form of an additional circuit which enables a longer and deeper "thud" sound to be used to accent anything from every second beat to every tenth beat. The accentuation can be switched out altogether when it is not required.

The unit also has a bargraph display which gives a visual indication of the beat sequence, and is the equivalent of being able to see the pendulum of a traditional metronome. However, the ten l.e.d. bargraph shows exactly which beat is the current one in the sequence, even when (say) only every sixth or eighth beat is accentuated.

The unit is self-contained with power being provided by an internal 9V battery, and it is quite simple and inexpensive despite the fact that it provides both an accented beat facility and an l.e.d. display. It covers a wide beat range of around one every two seconds to about five per second.

SYSTEM OPERATION

A clock oscillator, two monostable multivibrators and a digital divider circuit form the basis of the metronome, as can be seen from the block diagram of Fig. 1. The clock oscillator is a low frequency type which has its output frequency made adjustable by means of a variable resistor. The frequency range covered by the unit governs the beat rate range of the metronome, and is therefore about 0.5Hz to 5Hz.

The output of the clock oscillator drives the input of a monostable multivabrator. The direct output of the oscillator is less than ideal for driving the loudspeaker as it is virtually a squarewave signal, whereas a short pulse signal is needed to produce each "click" sound.

The monostable is a non-retriggerable type which acts as a pulse shortener, and provides an output pulse of suitable duration regardless of how long the input pulse duration happens to be. The output pulses from the monostable are fed into a mixer circuit, and from here they are coupled to an output stage which provides the fairly high drive current needed to get good volume from the loudspeaker.

This gives the basic metronome function, but some extra stages are needed in order to give the accented beat facility. The main one of these is a divide by "N" counter, and this has a division rate which under switch control can be set to any integer from two to ten.

The output of the divider drives a second monostable multivibrator, but obviously this monostable will only be triggered on every second clock cycle, third clock cycle, or whatever the selected division rate dictates. The output pulses from this second monostable are mixed with the signal from the first one, but as the loudspeaker is already driven with the maximum output current that the output stage can provide, this does not in itself provide any significant accentuation of the basic "click" sounds.

The accentuation is provided by having the output pulse duration of the second monostable several times longer than the pulse length of the first one, so that the accented beats are indicated by what are really longer output pulses. These are perceived by listeners as deeper sounds which have an apparently higher volume level, and which are clearly distinguishable from the ordinary "click" sounds.

DISPLAY

The divider circuit has ten outputs which can be used to directly drive the bargraph display, and no special decoder or driver circuit is needed here. In fact the display is not a true bargraph type, which would have the first l.e.d. lit to indicate the first beat, l.e.d.s one and two switched on to indicate the second beat, and so on.

This display operates in what is generally known as the "dot" mode, where the first l.e.d. lights up to indicate the first beat, the second l.e.d. (and only the second l.e.d) switches on to indicate the second beat, the third l.e.d. turns on to mark the third beat, and so on. A "dot" type display perhaps gives a slightly less clear indication, but it is the only type that can be easily used with the driver circuit available in this case, and it also has the great advantage of providing the unit with a much lower level of current consumption.

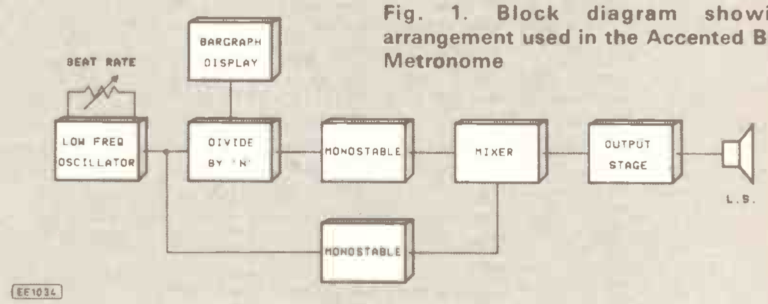


Fig. 1. Block diagram showing arrangement used in the Accented Beat Metronome

CIRCUIT OPERATION

The complete circuit diagram of the Accented Metronome appears in Fig. 2.

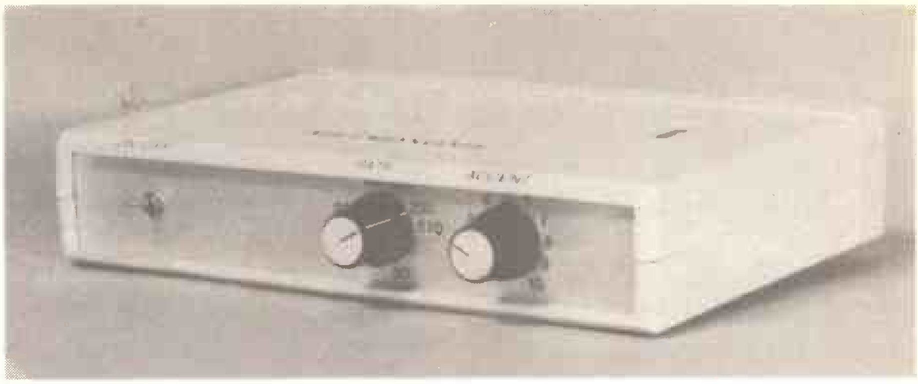
A 555 astable circuit generates the clock signal, but in order to keep the current consumption of the circuit down to an acceptable level a low power version of the 555 such as the ICM7555 or L555P is recommended for IC1. Potentiometer VR1 is the frequency control, or the Beat Rate control as it should more correctly be called in this case.

The timing capacitor C2 should be a tantalum bead component. An ordinary electrolytic type capacitor is considerably less than ideal for this application where the poor tolerance rating could give a frequency range which was well away from the desired one, and the high leakage level could result in even worse frequency accuracy or even the circuit failing to oscillate at all at the low frequency end of the range.

Both monostables are based on two of the CMOS 2-input NOR gates of IC3 and use what is a standard configuration. IC3a and IC3b have capacitor C3 and resistor R4 as their timing components, and the approximate output pulse duration is 0.2 milliseconds. This gives the higher pitched "click" sound. IC3c and IC3d have C4 and R6 as their timing components, and with an output pulse duration of about 0.8 milliseconds or so this gives the lower pitched "thud" sound.

The two sets of output pulses are mixed by resistors R7 and R8 which form a simple passive mixer circuit. The pulses drive TR1 hard into conduction so that a heavy but brief current is driven through the loudspeaker LS1.

The peak power level fed to the loudspeaker is actually quite high and constitutes a considerable overload, but as the output pulses are very brief and infrequent the average power fed to LS1 is quite low, and there seems to be no danger of it being damaged. A high impedance (about 64 ohm) loudspeaker would appear to be better suited to this type of output stage, and although loudspeakers of this type will work quite well in the circuit, they provide a substantially lower volume level than low impedance types.



DIVIDER

The divider IC2 is a CMOS 4017BE, which is a decade counter and one of ten decoder. In this case the ordinary divide by ten ("carry out") output at pin 12 is of no interest and is ignored. It is the other ten outputs that are of use, and these are numbered from "0" to "9".

When the device is reset, output "0" goes high and all the other outputs take up the low state. On the next clock pulse output "0" goes low and output "1" assumes the high state. The next clock pulse takes output "1" low again and sets output "2" high.

This sequence of events continues until output "9" goes high. In the next clock pulse output "9" returns to the low state and output "0" goes high again. This takes things back to the beginning again, and the device cycles indefinitely in this manner.

At least, it does if it is allowed to. In this circuit the Reset input at pin 15 of IC2 is coupled by switch S1 either to one of the outputs, or in the tenth position it is simply tied to the 0 volt rail. It is therefore only in position 10 of switch S1 that IC2 provides the standard divide by ten action. In the other switch positions at some stage in the sequence the output to which the reset input is connected will go high, and IC2 will immediately be reset to the initial state where output "0" is high.

For example, in position 2 output "0" will go high in the normal way, followed by output "1" on the next clock cycle. However, when output "2" goes high IC2 is reset and output "0" goes high again. A divide by 2 action is therefore obtained, and by selecting the appropriate switch position any division rate from two to ten can be obtained.

The "0" output of IC2 is coupled to the input of the second monostable via resistor R5, and an "accented beat" is therefore produced each time a new cycle recommences. The l.e.d.s of the bargraph display (D1 to D10) are driven from the ten outputs of IC2, and the appropriate l.e.d. for the current beat in the sequence is switched on since its output, and only its output, will be in the high state. As only one l.e.d. at a time will be switched on, a common current limiting resistor (R3) can be used for all ten l.e.d.s.

In position 0 of switch S1 the reset input is tied to output "0", and this holds the device permanently in the reset state with the clock pulses consequently having no effect on IC2. This results in the first l.e.d. in the bargraph being switched on continuously, and with no input pulses fed to the second monostable the accentuation is disabled.

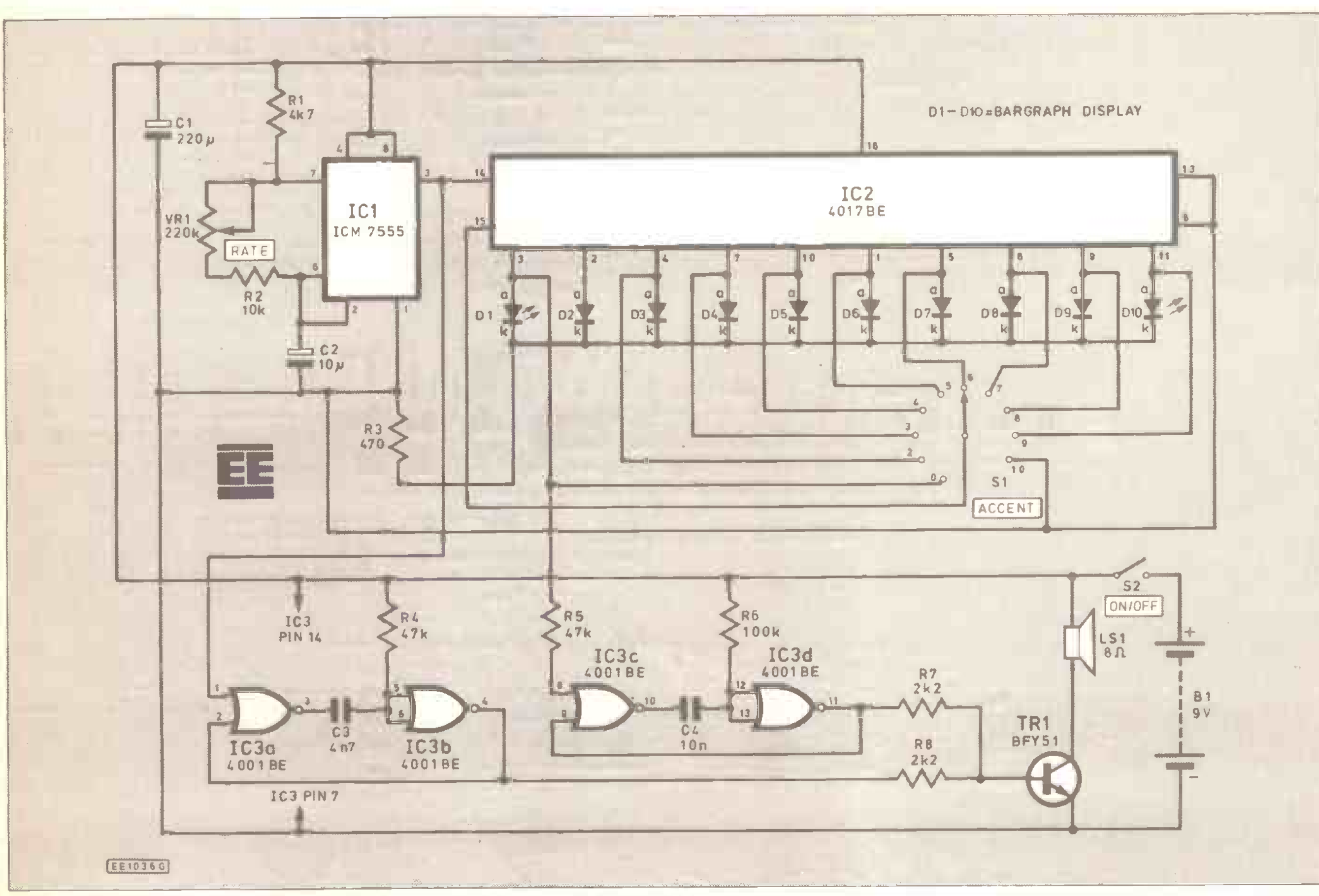
Power is obtained from a 9V battery, and the current consumption of the circuit is only about 8 milliamps. A small type such as a PP3 is therefore adequate as the power source, but a higher capacity battery such as six HP7 size cells in a plastic holder is preferable if the unit will receive a lot of use.

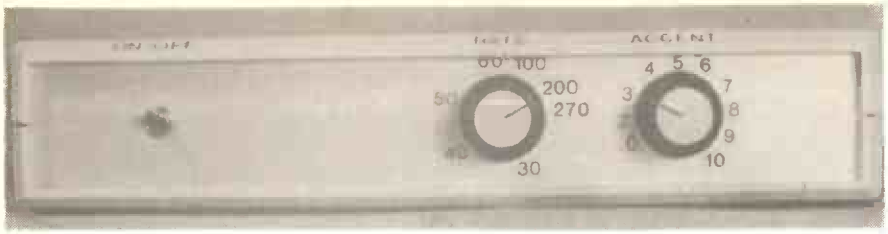
CONSTRUCTION

Although this is potentially a rather awkward project, the printed circuit design and component layout shown in Fig. 3 helps to make matters much more straightforward. This board is available from the *EE* PCB Service, code 582 (see page 628).

Construction of the board is not difficult, but bear in mind that IC2 and IC3 are both CMOS types, and that the normal anti-static handling precautions should be observed when

Fig. 2. Complete circuit diagram for the Accented Beat Metronome





dealing with these. This basically means using integrated circuit holders for these components, and not fitting them into place until the unit has been completed in all other respects.

Until then they should be left in their anti-static packaging (plastic tubes, conductive foam, or whatever) and they should be handled as little as possible when it is time to plug them into their holders. Avoid getting them anywhere near any obvious source of strong static charges.

Although IC1 is also a CMOS device, it does not require any special handling precautions as it has very effective internal protection circuits which render them unnecessary. As neither the L555P or the ICM7555 integrated circuits are very inexpensive types I would still recommend that an integrated circuit holder is used for IC1.

It is assumed in Fig. 3 that the bargraph display is of the type which has a 20-pin DIL package, and this will plug straight into a 20-pin DIL integrated circuit holder mounted on the board. This socket is not just needed to prevent possible heat damage to the device when fitting it into circuit, but is also required to physically raise the display to a more suitable height. The socket should *NOT*, therefore, be omitted.

With this type of display there usually seems to be nothing to indicate which way round it should be fitted, but if necessary the correct orientation can be found by trial and error, and the display will not sustain any damage if it is fed with power of the wrong polarity.

Of course, if preferred the bargraph display can be formed from ten ordinary panel mounting l.e.d.s fitted on the front panel of the unit, and this could actually give a much clearer display. On the other hand, it would increase

COMPONENTS

Resistors

R1	4k7
R2	10k
R3	470
R4, R5	47k (2 off)
R6	100k
R7, R8	2k2 (2 off)

All 0.25W 5% carbon

See Shop Talk page 617

Potentiometer

VR1 220k lin.

Capacitors

C1	220μ radial elec 10V
C2	10μ tantalum bead 16V
C3	4n7 polyester
C4	10n polyester

Semiconductors

IC1	ICM7555 or L555P CMOS timer
IC2	4017BE decade counter
IC3	4001BE quad 2-input NOR gate
TR1	BFY51 *npn* silicon transistor
DI to D10	10 l.e.d. bargraph

Miscellaneous

S1	12-way 1-pole rotary switch, with end stop
S2	Sub-min s.p.s.t. toggle switch
LS1	8 ohm loudspeaker, 76mm diameter

Case about 205mm × 145mm × 40mm; printed circuit board, available from *EE* PCB Service, order code 582; 8-pin DIL i.c. holder; 14-pin DIL i.c. holder; 16-pin DIL i.c. holder; 20-pin DIL i.c. holder; 9V PP3 battery and battery clip; display window material; control knob (2 off); solder pins; wire; stand-offs, etc.

Approx. cost Guidance only £12.50 (excluding case)

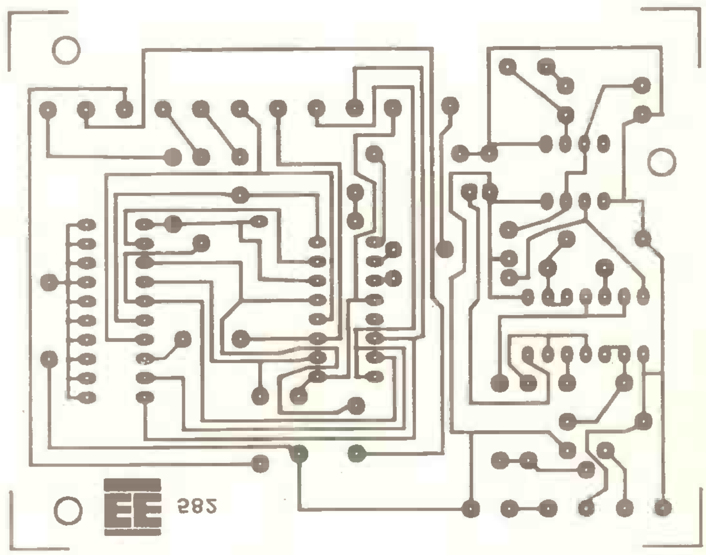
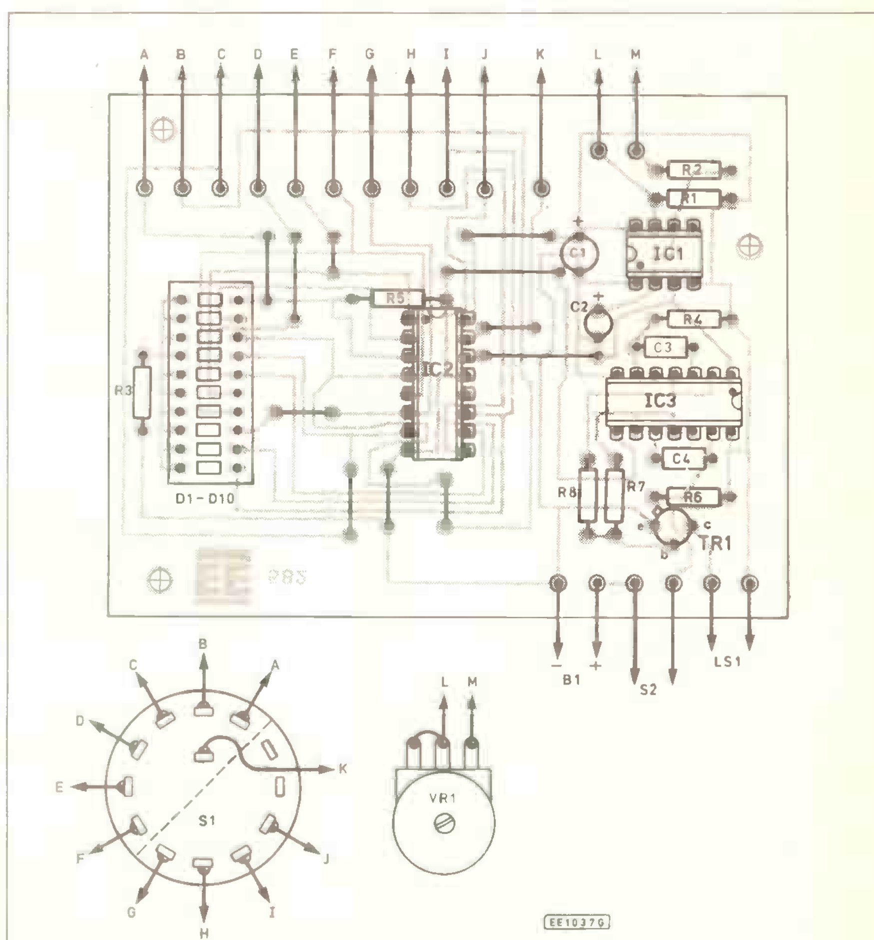


Fig. 3. Full size printed circuit board master foil pattern, component layout and interwiring for the metronome. Note that a 20-pin d.i.l. socket must be used for mounting the bargraph display.



the amount of hard wiring required and would make construction of the unit much more difficult.

CASE

The case used for the prototype is a plastic type having an aluminium front panel and approximate outside dimensions of 205mm by 145mm by 40mm. The unit could actually be fitted into a much smaller case if desired, although this might necessitate the use of a smaller loudspeaker with a consequent reduction in volume, and it could prove difficult to mount the printed circuit board in a way which brings the display into a suitable position.

Assuming that the metronome is built along the same lines as the prototype, the three controls are mounted on the front panel and the loudspeaker is fitted towards the left-hand side of the top panel or case "lid".

A speaker grille of some kind is needed, and the most simple way of producing one of these is to drill a matrix of holes about 5 millimetres in diameter. Be very careful with the placement of the holes though, as it is not quite as easy to make a neat job of this as one might think.

Miniature loudspeakers rarely have any provision for screw fixing, and it is normally necessary to glue them in place. Any good general purpose adhesive will do, but try to avoid smearing any onto the diaphragm.

The printed circuit board is mounted on the base panel towards the right-hand side of the unit, and it is mounted on spacers which give a stand-off of about 20 millimetres from the base panel. This is to bring the display to a suitable height, so that it is immediately underneath a display window cut at the appropriate position in the top panel of the case.

The rectangular cutout can be made using a coping saw or a fret saw. A piece of red display window material is glued in place behind the cutout.

To complete the metronome the hard wiring is added, and this is shown in Fig. 3. The wiring from the board to the Rate control (VR1) and the Accent switch (S1) is carried out by wiring from point "A" to point "A" and then the two point "B"s are connected together, and so on. Ordinary multistrand connecting wire is used, and there should be no real difficulty here provided the pins, component tags, and the ends of the leads are properly tinned with solder prior to making each connection.

There is ample space for the battery, and this can be held in place with a double-sided adhesive pad. If six HP7 size batteries in a holder are used, a standard PP3 style battery clip is needed to make the connections to the holder.

IN USE

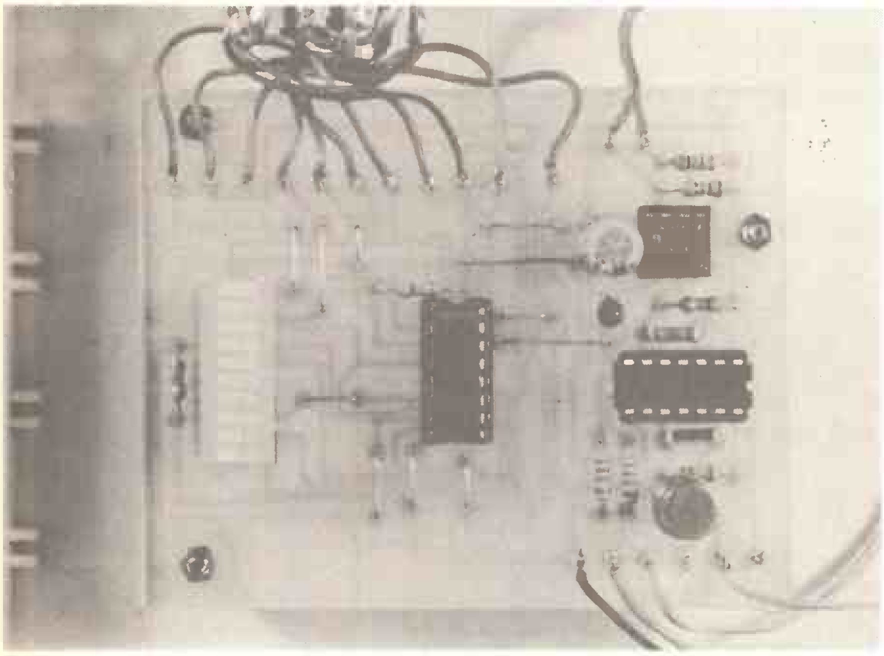
Give the finished unit a thorough check for errors before switching it on and testing it. Once switched on it should produce a regular "clicking" sound at a rate controlled by VR1, and by setting S1 to introduce the accentuation the appropriate sounds and responses from the display should be obtained. If there is any sign of a malfunction, switch off at once and recheck all the wiring.

If the metronome is to be adjusted "by ear" there is no need to mark a scale around the control knob of VR1, but many users will require some sort of beat rate scale. There is no real difficulty in finding calibration points by counting the number of beats in a certain period of time, and using trial and error to fine tune VR1 to the correct settings. These can then be marked using rub-on transfers.

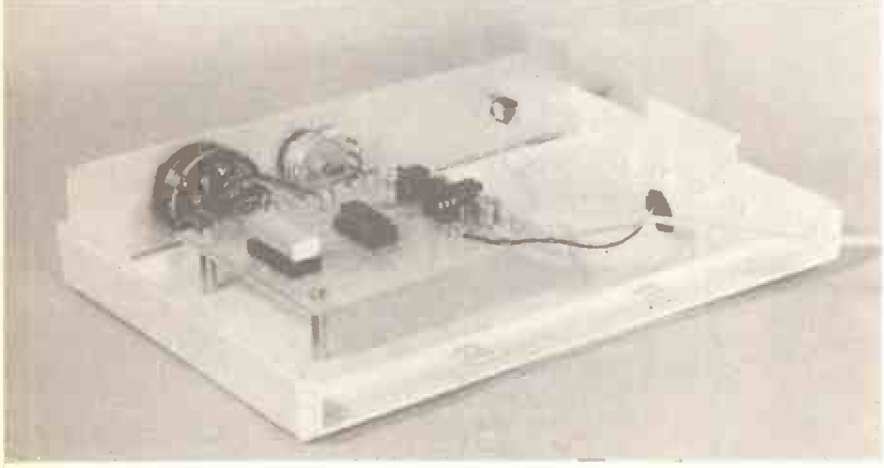
It can be difficult to mark a really accurate scale as the calibration points tend to become cramped at the high frequency end of the range. This problem can be eased by using a "logarithmic" potentiometer for VR1 and connecting it in reverse so that clockwise adjustment gives a reduction in the beat rate. This gives something approximating to a linear scale, but it is reverse reading of course.

Using a large control knob also helps to space out the calibration points and make precise adjustment easier. □

The completed metronome showing the speaker "grille" matrix and the display cutout.



The finished circuit board showing all the semiconductor devices mounted in i.c. holders. The photograph below shows the board mounted on spacers to one side of the case to allow room for the speaker and battery.



ACOUSTIC PROBE

A.J. FLIND

A relatively simple diagnostic tool which can provide excellent results on everything from watches to car engines

How many times have you raised your car's bonnet to investigate some new and worrying noise, only to be faced with a bewildering array of whirring and clattering machinery amongst which it is quite impossible to identify the offending sound? It might be tappets tapping, big ends on their way out, or simply a noisy alternator bearing.

On one memorable occasion a qualified mechanic identified a noise in the author's car as "big ends" and would have stripped the engine, had a more experienced colleague not chanced to hear it and identify a faulty water pump. To pinpoint such noises, some kind of "stethoscope" is invaluable. Sometimes a skilled mechanic will use a long screwdriver for the purpose, but this is not very satisfactory, and for the amateur not entirely safe. One can get one's ears caught in the fan belt that way!

An electronic "stethoscope", easily built by any electronics enthusiast, is a far better solution. This can easily be applied to any part of the engine, the volume adjusted, and of course full-size padded headphones will help block out some of the general racket in favour of the sound being traced. The accuracy of such a tool can be surprising; in a test with the prototype it was found that not only could the alternator of a friend's car be identified as the source, but there was no doubt whatsoever about which bearing was faulty.

Of course the instrument is not limited just to automotive applications. It can be used for almost any mechanical noise location, from clockwork to cental heating systems. It is sensitive enough to pick up the tick of the author's watch, an analogue quartz model with a tiny stepping motor. Finally, for those who live in terraced accommodation and enjoy listening to the neighbours fighting, it beats a glass pressed to the wall hands down!

CIRCUIT

In principle this project is very simple. All that is required is a microphone on the end of a rod (probe), and a high-gain amplifier. The "microphone" is rather special, and will be described in detail later.

The full circuit of the Acoustic Probe appears in Fig. 1, and operates as follows. Since the microphone is a crystal device with high output impedance, it is buffered by the source follower f.e.t. TR1. The output from this goes to amplifier TR2 which, in the configuration shown, provides a voltage gain of about thirty five. The gain is actually set by the ratio of R5 to R6, less a bit for losses, and can be altered if desired by changing the value of R6. Increasing the gain here will raise the circuit noise level a little though.

The output from TR2 is buffered by emitter follower TR3, and then fed, via volume control VR1, to output amplifier IC1. The positive supply for the preamplifier stages of the circuit are decoupled from supply variations by R8 and C1.

The amplifier i.c. is the well-known TBA820M audio chip. This is available in a compact 8-pin d.i.l. package, has ample power

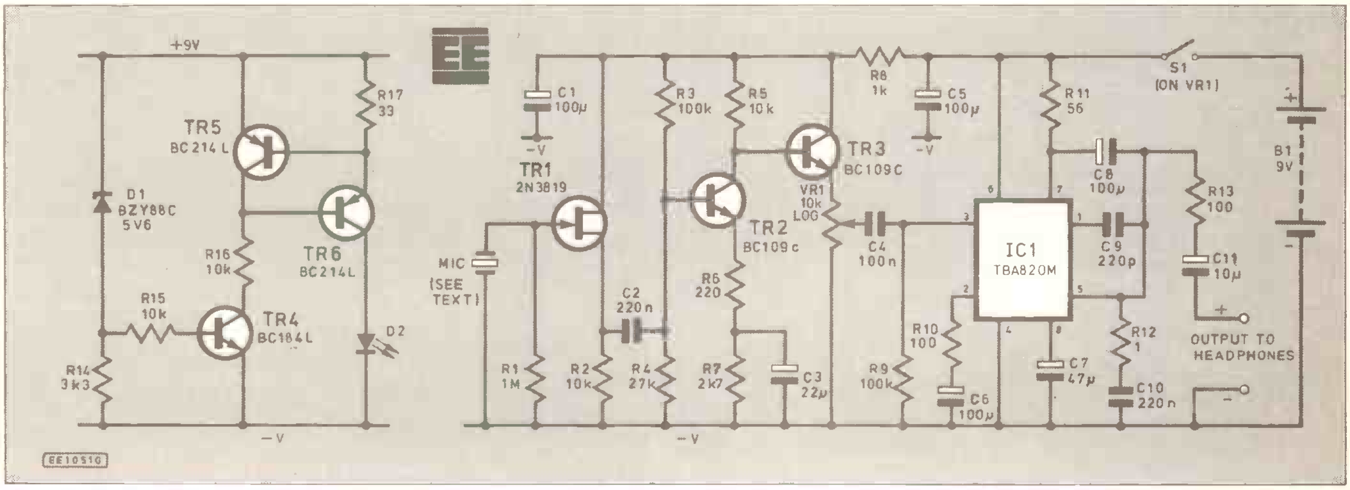


Fig. 1. Complete circuit diagram of the Acoustic Probe.

COMPONENTS

Resistors
- R1, 1M
- R2, R5, R15, R16 10k (4 off)
- R3, R9 100k (2 off)
- R4 27k
- R6 220
- R7 2k7
- R8 1k
- R10 100
- R11 56
- R12 1
- R13 100 (see text)
- R14 3k3
- R17 33

Shop Talk
See page 617

Potentiometer
- VR1 10k log carbon with switch (S1)

Capacitors
- C1, C5, C6, C8 100μ axial elect. 10V (4 off)
- C2, C10 220n polyester layer (2 off)
- C3 22μ axial elect. 25V
- C4 100n polyester layer
- C7 47μ axial elect 16V
- C9 220p ceramic plate
- C11 10μ axial elect. 25V

Semiconductors
- D1 BZY88C5V6 400mW 5.6V Zener diode
- D2 red l.e.d. 3mm type.
- TR1 2N3819 f.e.t.
- TR2, TR3 BC109C silicon *npn* (2 off)
- TR4 BC184L silicon *npn*
- TR5, TR6 BC214L silicon *pnp* (2 off)
- IC1 TBA820M i.c. power amplifier

Miscellaneous

Printed circuit board, available from *EE PCB Service*, order code EE584; 8 pin d.i.l. i.c. holder; case, diecast alloy box, 120 × 65 × 40mm; PP3 battery and connector; knob; standard stereo jack socket; 27mm piezo transducer element; assorted hardware for transducer — see text; connecting wire, etc.

Approx. cost Guidance only £13

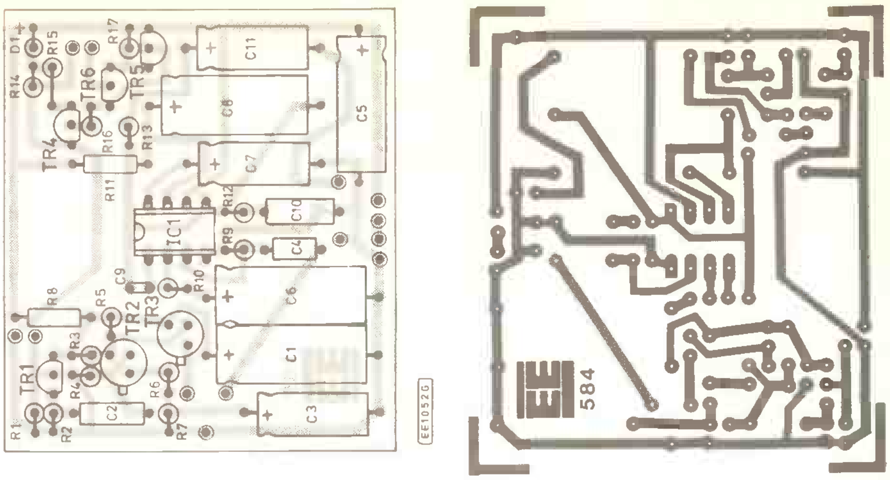


Fig. 2. Printed circuit full size master pattern and component layout

for driving ordinary stereo headphones, and can operate from as little as three volts with a typical quiescent drain of only four milliamps, making it ideal for operation from a single PP3 battery supply. About the only drawback is that its recommended circuit uses rather a lot of electrolytic capacitors, which take up most of the space on the p.c.b.

The voltage gain of this stage is about twenty but it can be adjusted slightly if required, by alteration of R10. To ensure stability the "Zobell" network, R12 and C10, has been included. The value of C11 may seem rather small to readers used to audio work, but it proved perfectly adequate in this design as headphones are the only load and the frequencies of interest are normally quite high. The resulting reduction of output current at low frequencies also helps to maintain stability.

The output is taken to a stereo socket wired so as to connect the two phones in parallel. R13 sets the maximum output, the value shown may need some adjustment to suit the headphones actually used.

An indicator l.e.d. is useful, to show that the unit is switched on and the battery is healthy. This goes a little further than usual in that l.e.d. D2 is supplied with a constant current by TR5 and TR6, which are in turn biased from TR4, which receives base current from Zener D1. So long as the supply voltage is high enough for current flow through D1 and the base-emitter junction of TR4, D2 glows with constant brightness. Once the voltage falls below this critical point it goes out quite sharply. It will probably flicker with strong input signals when battery replacement is due.

CONSTRUCTION

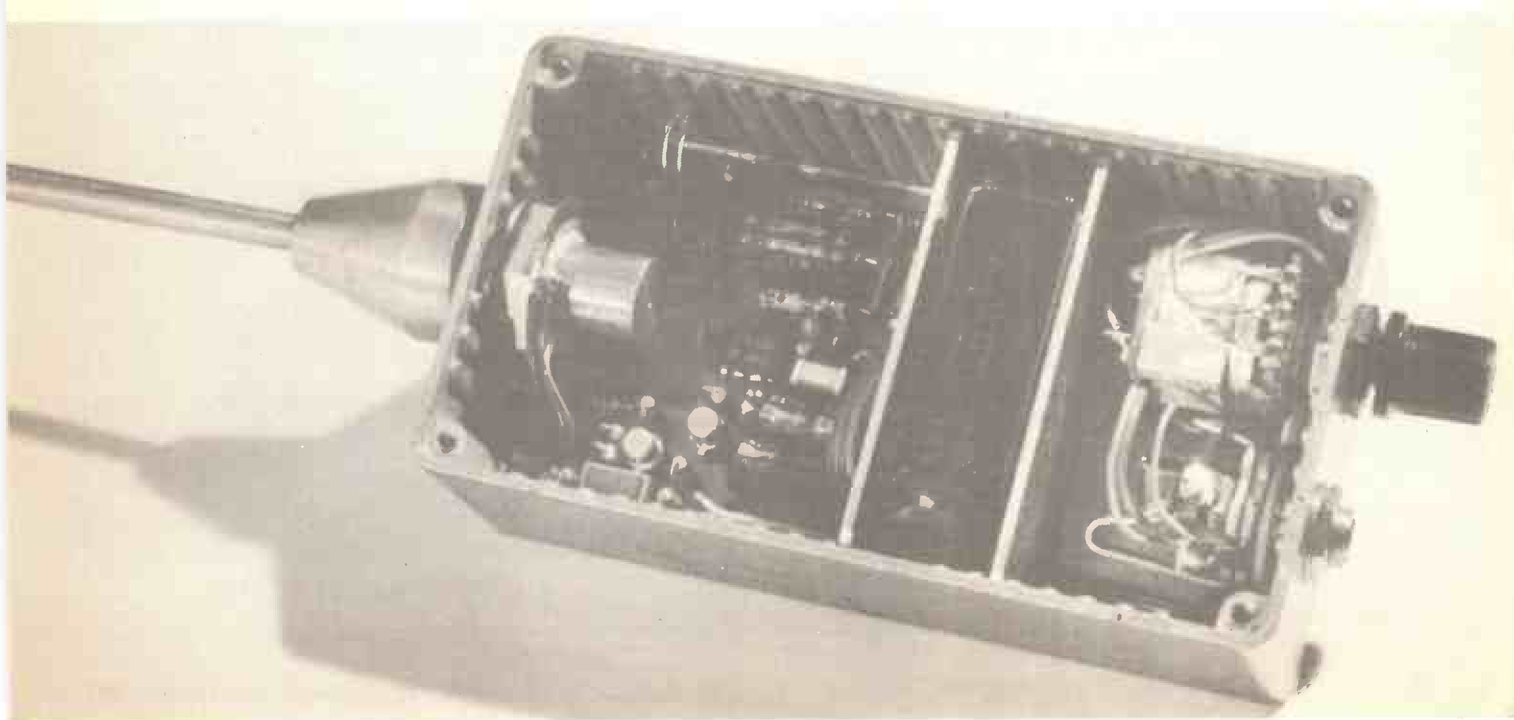
The construction of this project is straightforward, provided a little care is taken to obtain neat results with the upright mounted resistors. The small printed circuit board is available from the *EE* PCB Service, code EE584 (see page 628).

The positioning of all components can be seen in the overlay drawing, Fig. 2. Take care with the orientation of the transistors, D1 and the electrolytics. C2, C4 and C10 are the small, silver coloured polyester layer type.

Capacitors C2 and C10 may present problems in that there appears to be more than one size of this value; an order recently received contained two with different pin spacings. The p.c.b. has been designed to accept either. Though omitted in the prototype, a d.i.l. socket is strongly recommended for IC1. It can be a great help if any trouble-shooting becomes necessary.

TESTING

The board should, of course, be tested before installation. The total current drain should be about 26mA, of which about 18mA will be taken by the l.e.d. If the supply voltage is gradually reduced, this will extinguish fairly rapidly at about 5 to 5.5V. If the initial current



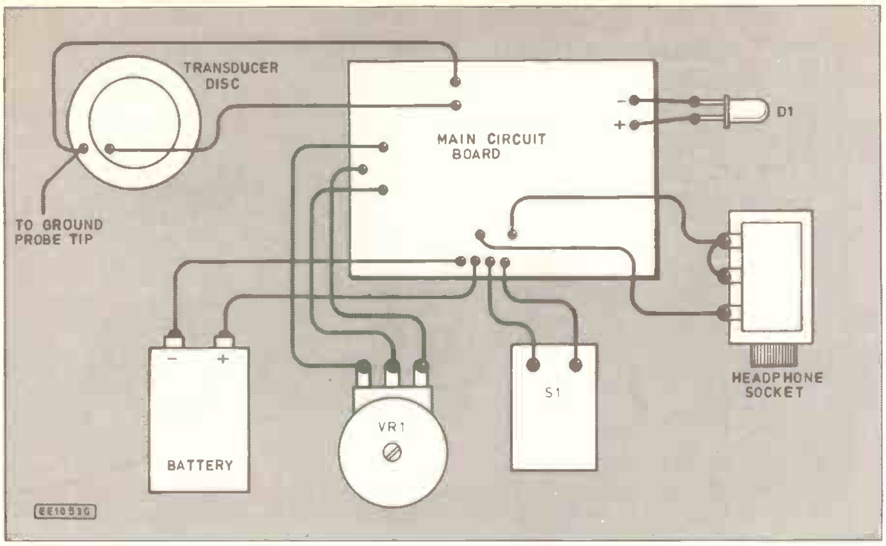


Fig. 3. Interwiring of the case mounted components and the p.c.b. VRI is shown from the front, SI is mounted on the back of VRI.

drain seems about right, the headphones and volume control can be temporarily connected and a quick functional check, if satisfactory, will be enough.

This is also a good time to decide whether the value of R13 needs any alteration to suit the headphones to be used. If there seems to be a problem however, some figures which may be useful are as follows; all were taken with exactly nine volts supply. TR1 source voltage will of course depend on the individual f.e.t. as these have a wide production spread, but it should be between 1 and 5 volts. Try another f.e.t. if it is outside these limits. TR2 emitter will be about 1V, this can be measured across C3, the drop across R6 being very small. TR2 collector (its metal case!) should be at about 4.4V, TR3 emitter about 3.8V. The output of IC5 (pin 5) will be about half supply, nominally 4.5V. The voltage across C1, the positive supply for the preamp stages, should be about 8V. These voltages are all intended purely as a guide for trouble-shooting.

CASE

As the circuit has a high input impedance and gain and may be used in areas where a fair amount of electrical interference may be present, a diecast metal case is specified to provide effective screening. The general layout of components in this can be seen from the photograph.

The l.e.d. is soldered directly to the p.c.b. with leads about 25mm long, allowing it to be bent over and pushed straight into a suitable hole drilled in the side of the case. A drop of "Araldite" will secure it firmly.

The board is sited at one end of the box, secured (and insulated) with double-sided sticky foam pad. The switch/volume control and the headphone socket are fitted at the other end, and between them the battery is held in a compartment formed by two small aluminium plates that fit the case slots. Plastic, such as surplus p.c.b. would do just as well. Some plastic foam prevents the battery from rattling.

The wiring passes beneath the foam and plates; ribbon cable is best as it is neat and lies flat. All the interconnections are shown in Fig. 3.

MICROPHONE

The microphone, as mentioned, is special. Any small microphone insert could be used for the job but would probably prove rather delicate. For vibration sensing something rather more robust is needed, so a vibration transducer was made with a "piezo transducer" element, the sort of thing normally used to provide bleeps in calculators, watches, etc. Being essentially crystal transducers these work just as well in reverse, as microphone elements, if properly mounted. A 27mm bare transducer "disc", readily available at very low cost from most major suppliers, was mounted as shown in the drawing of Fig. 4.

Although the prototype has components that were made in a lathe, early experiments used transducers made from bits of brass bolts with methods available in any reasonably equipped home workshop, so construction should not be too difficult. In essence the bolt is screwed down fairly tightly through a grommet fitted into the end of the case, the piezo element has its larger diameter side glued to the head of the bolt with Araldite, and a small weight is glued to the other side to provide something for the vibration to work against.

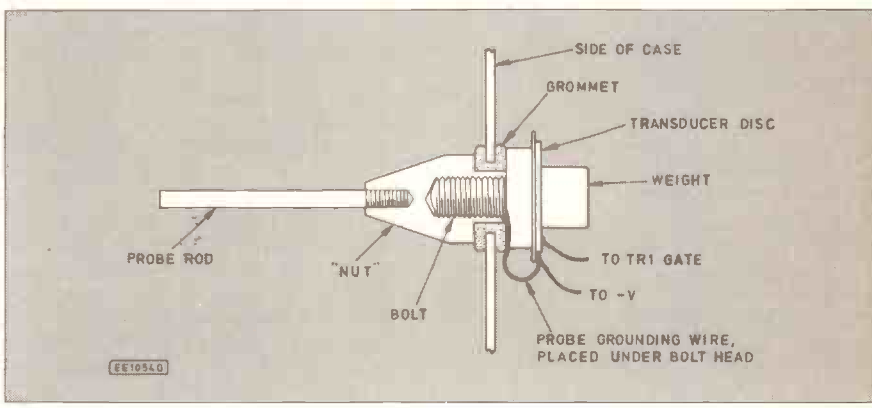
The head of the bolt needs to be flat and smooth; this could be achieved by rubbing it on emery paper placed on a flat surface. The weight is by no means critical and could be the head off another bolt, or a suitable nut, etc. The assembly can be so rigid in the grommet that it seems almost immobile, yet it is amazing how it will transmit sound from the tip whilst attenuating noise from the case. A "probe" can be attached by drilling a blind hole in the bolt, tapping it and fitting a threaded rod. Several rods of various lengths might prove useful.

Note how the connections are made to the element, they are soldered directly to the disc surface. The earthy (negative rail) wire should go to the side glued to the bolt, and an extra wire from here is tucked between the grommet and the bolt to ensure contact. The metal case should also be grounded; in the prototype this was achieved through the metal jack socket. In the case of an all-plastic socket separate earthing to circuit negative should be provided.

The time taken to construct this transducer is well worthwhile. It is very sensitive and more robust than anything that could be achieved with a conventional microphone, and the results are excellent. The frequency response spans the complete audio spectrum; when placed against a loudspeaker surprisingly good sound can be heard. It's certainly more than adequate for the intended purpose.

A commercially produced stethoscope similar to this project is available. Constructors might be interested to know that it is priced around £300 . . . ! In fairness, there is a de-luxe model with an extra feature — an output jack for tape recording! This, the makers claim, can be used to record the sounds of industrial machinery for replay through a telephone, or for comparison at some time later. Perhaps these days it might also be used for computer analysis; at any rate it would be easy to add the facility to this project □

Fig. 4. Construction details for the "microphone".



C&G City and Guilds

INTRODUCING MICROPROCESSORS

MIKE TOOLEY B.A.

Part 1

MICROCOMPUTER SYSTEMS

Last month we briefly outlined the City and Guilds Information Technology scheme and presented the syllabus for Introductory Microprocessors. We also attempted to deal with some of the many questions which readers might have and provided a calendar for the course. In this part we shall be starting in earnest by setting the scene for our nine part course. We begin, however, by stating the learning objectives which relate to this part:

LEARNING OBJECTIVES

The general learning objectives for part one of Introducing Microprocessors is that readers should be able to:

(a) understand the terminology used to describe microcomputer and microprocessor based systems (1.1)

(b) identify the major logic families and scale of integration employed within integrated circuits (1.2)

(c) draw a diagram showing the architecture of a representative microcomputer system and state the function of the principal internal elements (1.3)

(d) understand binary and hexadecimal number systems and convert from/to decimal (7.1)

(Note: City and Guilds module document reference numbers are shown in brackets.)

The specific objectives for this part are as follows:

1.1 TERMINOLOGY

1.1.1 State the meaning of any of the terms listed in the glossary (see note below).

1.1.2 Distinguish between the terms; computer, microprocessor, microcomputer, and single-chip microcomputer.

1.2 INTEGRATED CIRCUIT TERMINOLOGY AND LOGIC FAMILIES

1.2.1 Define the terms SSI, MSI, LSI and VLSI as applied to integrated circuits.

1.2.2 State the characteristics of CMOS and TTL semiconductor technologies.

1.2.3 State the basic properties of CMOS and TTL logic families.

1.3 SYSTEM ARCHITECTURE

1.3.1 Draw a block diagram showing the internal architecture of a representative microcomputer system.

1.3.2 State the function of each of the principal internal elements of a representative microcomputer system.

1.3.3 Explain the bus system used to link the internal elements of a microcomputer system.

1.3.4 Distinguish between the following types of bus; address, data and control.

7. RELATED THEORY

7.1.1 Explain the binary and hexadecimal number systems.

7.1.2 Convert binary, hexadecimal and decimal numbers over the range 0 to 65535 (decimal).

7.1.3 Explain how negative numbers are represented in microprocessor systems.

7.1.4 Perform addition and subtraction of binary and hexadecimal numbers over the range 0 to 255 (decimal).

Note: The complete glossary appears in Appendix A of the City and Guilds module document. Rather than publish a complete glossary of terms, we shall be producing a mini-glossary for each part; introducing new terms as we progress through the series.

INTEGRATED CIRCUITS

The vast majority of today's electronic systems rely on the use of integrated circuits in which hundreds of thousands of components are fabricated on a single chip of silicon. A relative measure of the number of individual semiconductor devices within the chip is given by referring to its "scale of integration", as shown below:

Scale of integration	Abbreviation	Logic gate equivalent
Small	SSI	1 to10
Medium	MSI	10 to 100
Large	LSI	100 to 1000
Very large	VLSI	1000 to 10000
Super large	SLSI	10000 to 100000

The "logic gate equivalent" referred to in the table provides us with a rough measure of the complexity of the integrated circuit and simply gives the equivalent number of standard logic gates. A logic gate is a basic circuit element capable of performing a logical function (such as AND, OR, NAND or NOR). A basic logic gate (e.g. a standard TTL two-input AND) would typically employ the equivalent of six transistors, three diodes and six resistors. At this stage, readers need not worry too much about the function of a logic gate as we shall be returning to this later on. Readers need only be aware that such devices form the basis of circuits which can perform logical decisions.

Integrated circuits are encapsulated in a variety of packages but the most popular type (and that with which most readers will already be familiar) is the plastic dual-

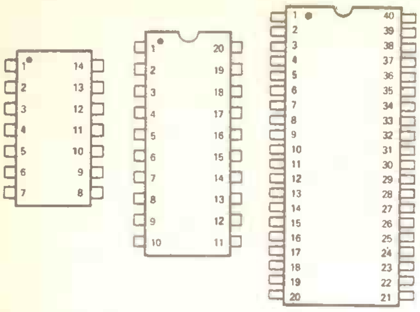


Fig. 1. Some common d.i.l. package outlines (top view).

in-line (d.i.l.) type. These are available with a differing number of pins depending upon the complexity of the integrated circuit in question and, in particular, the need to provide external connections to the device.

Conventional logic gates, for example, are often supplied in 14-pin or 16-pin d.i.l. packages whilst microprocessors (and their more complex support devices) often require 40-pins or more. Fig. 1 shows some common d.i.l. package outlines together with pin numbering. It should be noted that these are TOP views of the devices, i.e. they show how the device appears when viewed from the component side of the p.c.b., NOT from the underside.

In each case, the pins of the i.c. are numbered sequentially (starting at the indentation) moving in an anti-clockwise direction. Thus, in the case of a 14-pin d.i.l. package viewed from the top, pins one and 14 appear respectively on the left- and right-hand side of the identation.

Problem 1.1

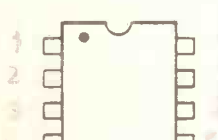
Fig. 2 shows the outline of an 8-pin d.i.l. device viewed from above. Identify the pin numbers for this device.

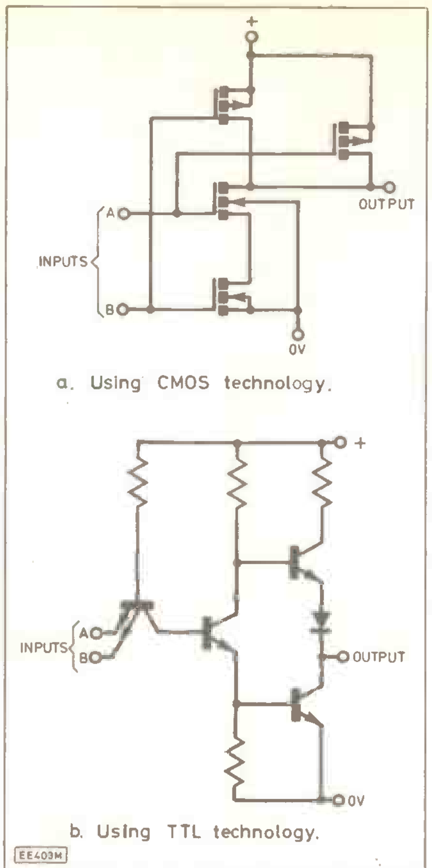
LOGIC FAMILIES

The integrated circuit devices on which modern digital circuitry depends belong to one or the other of several "logic families". Readers should note this term refers to the type of semiconductor technology employed in the fabrication of the integrated circuit. It does not imply that different families employ different logic!

The semiconductor technology employed in the fabrication of an integrated circuit is instrumental in determining its characteristics. This encompasses such important criteria as

Fig. 2. An 8 pin d.i.l. package.





a. Using CMOS technology.

b. Using TTL technology.

Fig. 3. Representative circuitry of two-input AND gates.

supply voltage, power dissipation, switching speed, and immunity to noise.

The most popular logic families, at least as far as the more basic general purpose devices are concerned, are Complementary Metal Oxide Semiconductor (CMOS) and Transistor Transistor Logic (TTL). TTL also has a number of sub-families including the popular Low Power Schottky (LS-TTL) variants.

For the curious we have shown the internal circuitry of representative CMOS and TTL two-input AND gates in Fig. 3. Despite the obvious dissimilarity of these two arrangements, it must be stressed that they have IDENTICAL logical functions.

TTL logic

The most common range of conventional TTL logic devices is known as the "74" series. These devices are, not surprisingly, distinguished by the prefix number 74 in their coding. Thus devices coded with the numbers 7400, 7408, 7432, and 74121 are all members of this family which is often referred to as "Standard TTL". Other versions (or "sub-families") of standard TTL exist and these are distinguished by appropriate letters placed after the "74" coding. Where "Low Power Schottky" technology is used in the manufacture of a TTL logic gate, for example, device codings include the letters "LS". Thus a 74LS00 device is a Low Power Schottky version of a standard 7400 device.

CMOS logic

The most popular CMOS family is the "4000" series and devices have an initial prefix of 4. Thus 4001, 4174, 4501 and 4574 are all CMOS devices. CMOS devices are sometimes also given a suffix letter; A to denote the "original" (now obsolete) unbuffered series, and B to denote the improved (buffered) series. A UB suffix denotes an unbuffered B-series device.

Problem 1.2

To which logic families do each of the following devices belong?

(a) 7407
(b) 74LS74
(c) 4052

Power supplies

Most TTL amd CMOS logic systems are designed to operate from a single supply voltage rail of nominally +5V. With TTL devices, it is important for this voltage to be very closely regulated. Typical TTL i.c. specifications call for regulation of better than ±5% (i.e. the supply voltage should not fall outside the range 4.75V to 5.25V).

CMOS logic devices are fortunately very much more tolerant of their supply voltage than their TTL counterparts. Most CMOS devices will operate from a supply rail of anything between +3V and +15V. This, coupled with a minimal requirement for supply current (a CMOS gate typically requires a supply current of only a few microamps in the quiescent state) makes them eminently suited to portable battery powered equipment.

TTL devices require considerably more supply current than their CMOS equivalents. A typical TTL logic gate requires a supply current of around 8mA; approximately 1000 times that of its CMOS counterpart when operating at a typical switching speed of 10kHz.

Course calendar

October	1987	Course commences in EE
January	1988	Register with your local centre
February	1988	Complete first practical assignment
March	1988	Complete first written assignment
April	1988	Complete second practical assignment
May	1988	Complete third practical assignment
June	1988	Complete fourth practical assessment
July	1988	Complete second written assessment
July	1988	Centre requests issue of certificate

CMOS versus TTL

Having spent some time in discussing the merits of CMOS and TTL devices it is now worth summarising three of the important differences between these logic families in tabular form:

	CMOS	TTL
Speed of operation	Relatively slow (power consumption increases as switching speed increases)	Fast (power consumption substantially constant)
Power consumption	Negligible (but see above)	Appreciable
Supply voltage	Operates over a wide voltage range (typically 3V to 15V)	Must be closely regulated at, or near 5V

Problem 1.3

Which logic family would be most suited for use in a piece of equipment which has to operate over long periods from dry batteries?

MICROPROCESSORS

Having dealt with the basic building blocks of digital circuits we have at last arrived at the point at which we can introduce the microprocessor.

Microprocessors are VLSI and SLSI integrated circuit devices which are capable of accepting, decoding and executing instructions presented to them in binary coded form. Microprocessors thus form the heart of all microcomputer systems in which they act as the central processing unit (CPU). Despite this, the majority of microprocessors are not capable of providing the complete range of facilities expected of a computer (i.e. input, processing, memory and output). Microprocessors require a certain amount of external hardware and other support devices, not the least important of which are those which provide a memory for the sequences of software instructions (i.e. programs) and transient information (i.e. data) used during processing.

Some specialised microprocessors incorporate their own internal memory for data and program storage as well as input/output ports for the connection of external devices such as keyboards and displays. These devices are aptly known as "single-chip microcomputers" and they are ideal for use in low-cost stand-alone control systems.

Microprocessors are often divided into categories depending upon the size of the binary number on which they fundamentally perform operations. Most modern microprocessors perform operations on groups of either eight or 16 binary digits (bits). Whilst 16-bit microprocessors tend to be more powerful than their 8-bit counterparts this is unimportant in many simple applications. Hence, for the purpose of this series and to conform with the City and Guilds programme, we shall concentrate on 8 rather than 16-bit devices.

The first generation of 8-bit microprocessors appeared a little over 14 years ago in the shape of an Intel device, the 8008. At the time, this was something of a minor miracle – a device which could replace countless other chips and which could address a staggering 16K of memory! By modern standards, the 8008 is extremely crude but it was not long before Intel introduced another device, the 8080. This time NMOS technology was employed instead of the PMOS technology which was used in the 8008. The 8080 had 16 address lines (thus being able to address 64K of memory) and 78 software instructions for the programmer to use. The 8080 was an instant success and led the way to enhanced devices such as the 8085 and the "all-singing-all-dancing" Z80.

Other manufacturers were also developing microprocessor chips hard on the heels of Intel. These included Motorola (with the 6800) and MOS Technology (with the 6502). In subsequent years industry has not been content to stand still and much effort has been devoted into huge advances into 16 and 32-bit technology. Despite this, all of these simple 8-bit microprocessors (and their various enhancements and derivatives) are still in common use today.

Costs have fallen very significantly and it is eminently possible to put together a microprocessor system (comprising CPU and a handful of support chips) at a very moderate cost. Hence, if one had the task of designing, for example, a simple control system, one would almost certainly use a microprocessor (or single-chip microcomputer) to form the basis of the controller.

Such a system would not only be capable of fulfilling all of the functions of its conventional counterpart but it would also provide a far more sophisticated means of processing our data coupled with the ability to store it and examine it at a later date or even transmit it to a remote supervisory computer installation. The vast saving in hardware development can usefully be devoted to the software aspects of a project and future modifications can simply involve the substitution of "firmware" (ROM based software).

BITS, BYTES and BUSES

An 8-bit microprocessor fetches and outputs data in groups of 8-bits (known as "bytes"). This data is moved around on eight separate lines (labelled D0 to D7) which collectively form a "data bus". For the curious, the word "bus" is a contraction of the Greek word "omnibus" which simply means "to all", thus aptly describing the concept of a system of wiring which links together all of the components of a microprocessor system using a common set of shared lines.

Microprocessors determine the source of data (when it is being "read") and the destination of data (when it is being "written") by outputing the location of the data in the form of a unique "address". This process involves placing a binary pattern on an "address bus". In the case of 8-bit microprocessors, the address bus invariably comprises 16 separate lines, labelled A0 to A15.

The address at which the data is to be placed or from which it is to be fetched can either constitute part of the "memory" of the system (i.e. RAM or ROM) or can be considered to be "input/output" (I/O). The allocation of the 64K memory address range of an 8-bit microprocessor can usefully be described using a "memory map". We shall discuss this in greater detail in Part Five.

A further bus is used for a variety of general housekeeping functions such as determining the direction of data movement (i.e. whether a "read" or "write" operation is being performed), and placing the machine in an orderly state on power-up. This bus is known as the "control bus" and often has between five and 13 lines depending upon the microprocessor.

SYSTEM ARCHITECTURE

We have already identified the principal elements within a microprocessor system as CPU (i.e. the microprocessor), RAM, ROM, and I/O. Before showing how they are interconnected within a typical microprocessor system, it is worth briefly restating the function of each:

Central processing unit (CPU)

The central processing unit in a microcomputer is a single VLSI device, the microprocessor. This device accepts instructions and data for processing. It also provides control and synchronising information for the rest of the system. We shall look more closely at the function of the microprocessor in Part Two.

Random access memory (RAM)

All microprocessors require access to read/write memory and, whilst single-chip microcomputers contain their own low-capacity area of read/write memory, read/write memory is unvariably provided by a number of semiconductor random access memories (RAM). These will be explained in Part Five.

Read-only memory (ROM)

Microprocessors generally also require more permanent storage for their control programs and, where appropriate, operating systems and high-level language interpreters. This facility is

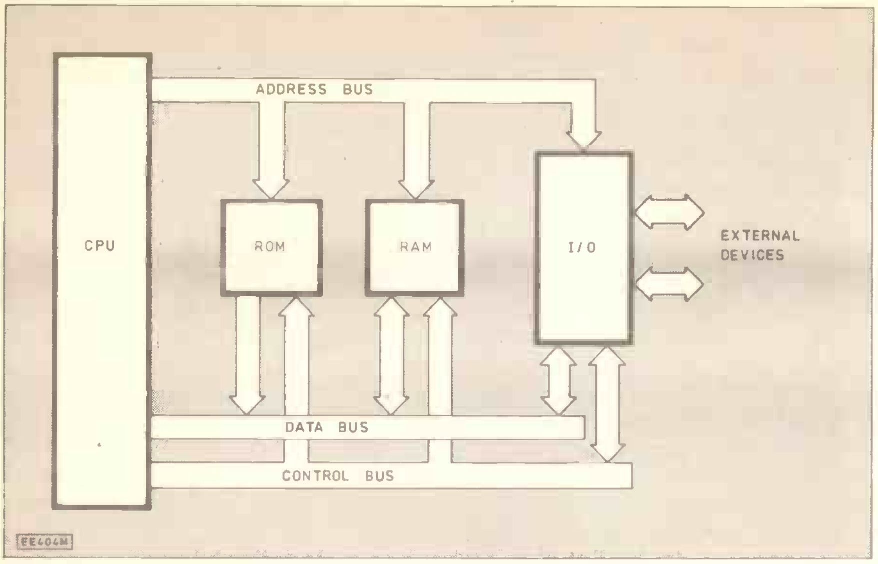


Fig. 4. Principal elements of a microprocessor system.

invariably provided by means of semiconductor read-only memories (ROM). These will also be examined in Part Five.

Input/output devices (I/O)

To fulfill any useful function, the microprocessor needs to have links with the outside world. These are usually supplied by means of one, or more, VLSI devices which may be configured under software control and are thus said to be "programmable". I/O devices fall into two general categories; "parallel" (a byte is transferred at a time) or "serial" (one byte is transferred after another along a single line). I/O devices will be dealt with in Part Six.

The basic configuration of a microprocessor system is shown in Fig. 4, the principal elements; microprocessor, ROM, RAM, and I/O have been shown. Note that the three bus systems; address, data, and control are used to link the elements and thus an essential requirement of a support device is that it should have "tri-state" outputs. It can thus be disconnected from the bus when it is not required.

Support devices (such as ROM, RAM, etc.) are fitted with select or enable inputs. These lines are usually driven by address decoding logic (not shown in Fig. 4). The inputs of the address decoding logic are derived from one, or more, of the address bus lines. The address decoder effectively divides the available memory into blocks which each correspond to a particular support device. Hence, where the processor is reading and writing to RAM, for example, the address decoding logic will ensure that only the RAM is selected and the internal buffers in the ROM and I/O chips are kept in the tri-state output condition.

Problem 1.4

The diagram shown in Fig. 5 represents a microprocessor system. Compare this diagram with that shown in Fig. 4 and hence label the diagram fully.

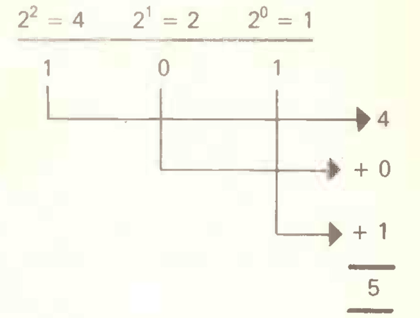
NUMBER SYSTEMS

Unfortunately, the decimal or denary number system with which we are all very familiar, is not at all appropriate to microcomputers. The reason is simply that electronic logic circuits are based on devices which have only two states (variously known as "on/off", "high/low", and "true/false"). The number system most appropriate is therefore binary in which only two digits (0 and 1) are used. Powers of two are shown in Table 1.

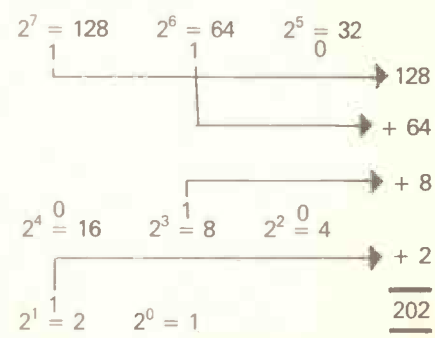
Table 1 Powers of two

n	2^n
0	1
1	2
2	4
3	8
4	16
5	32
6	64
7	128
8	256
9	512
10	1024
11	2048
12	4096
13	8192
14	16384
15	32768

The process of converting binary to decimal and decimal to binary is quite straightforward. The binary number 101, for example, can be converted to denary as follows:



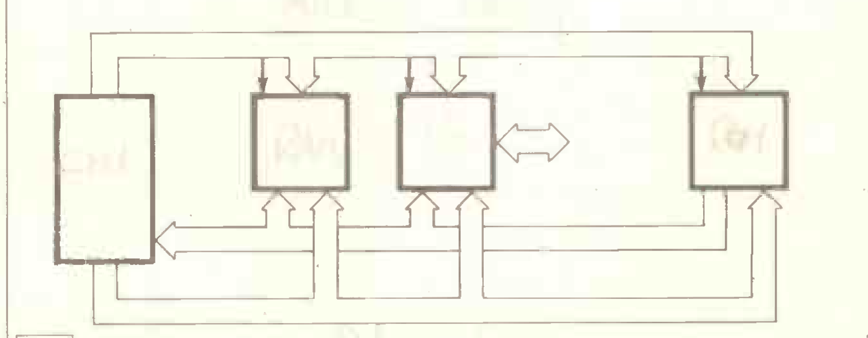
Now, taking a somewhat more difficult example, let's convert the binary number 11001010 to denary. We shall again write the number using column headings but this time we shall simply ignore the zeros in our addition:



There are two basic methods for converting decimal to binary. One involves taking the decimal number and subtracting from it successively smaller numbers which are themselves powers of two. Where a power of two can be subtracted (to leave zero or a remainder), a 1 is placed in the appropriate column of the binary number. This all sounds very much more difficult than it really is, so here is a simple example to illustrate the process.

Suppose that we wish to convert the decimal number 21 to binary. The highest power of two which can be taken away from 21 is 2^4 (=16). This leaves a remainder of $21-16=5$. 2^3 (=8) cannot be subtracted from the remainder but 2^2 can to leave a remainder of $5-4=1$. 2^0

Fig. 5. Microprocessor system (see problem 1.4).



(=1) can now be subtracted from the second remainder to leave zero. Another way of putting this is that;

$$21 = 16 + 4 + 1 = 2^4 + 2^2 + 2^0$$

We can write this as a binary number by placing 1s and 0s in columns, as follows:

2^4	2^3	2^2	2^1	2^0
1	0	1	0	1

The second method involves successively dividing the decimal number by two and noting down the remainder at each stage. The binary number is then formed by reading the remainders as shown in the example below (note that the least significant remainder becomes the most significant bit of the binary number!).

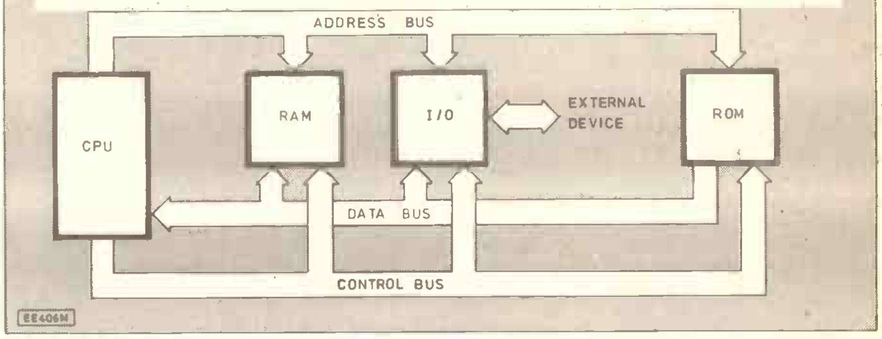
Suppose we wish to convert the decimal number 50 to binary.

2 | 50
25 remainder 0
2 | 25
12 remainder 1
2 | 12
6 remainder 0
2 | 6
3 remainder 0
2 | 3
1 remainder 1
2 | 1
0 remainder 1

1 1 0 0 1 0

Hence 50 decimal is equal to 110010 binary

Fig. 6. Answer to problem 1.4.



Which of the two methods you employ is entirely a matter of preference. If you can easily spot the powers of two present in a decimal number it is probably best to use the first method. If, on the other hand, you are uncertain as to which powers of two make up a number it is best to use the longer method. Remember that, in both cases, you can always convert back to denary in order to check your results!

Problem 1.5

Convert the following binary numbers to decimal:
(a) 1011
(b) 100110
(c) 11100111

Problem 1.6

Convert the following denary numbers to binary:
(a) 33
(b) 100
(c) 213

Hexadecimal

The binary number system is somewhat tedious for human use since numbers of any appreciable size are rather difficult to handle. For this reason we settle on the hexadecimal (base 16) number system. This has the advantage that it is relatively simple to convert from hexadecimal to binary and the hexadecimal numbers which can appear on an 8-bit data bus can be represented using just two digits (rather than the eight binary digits which would otherwise be necessary).

Since the hexadecimal numbering system employs more than 10 digits we have to make use of the first six letters of the alphabet to represent those equivalent to the denary numbers 10 to 15. Hexadecimal digits thus range from 0 to F as shown below left.

Numbers in excess of fifteen will, of course, require more than one hexadecimal digit. Suppose, for example, we wish to convert the hexadecimal number 2A to decimal. Using a similar technique to that which we employed

Table 2 Decimal, binary and hexadecimal numbers

Decimal	Binary	Hexadecimal
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F

Address

Readers requiring their own copy of the module documentation should write to the following address, clearly stating "Everyday Electronics – Introductory Microprocessors" and enclosing a cheque or P.O. for £10 made payable to City and Guilds (do not forget to include your name and address!): Publications Department, City and Guilds, 76 Portland Place, London W1N 4AA.

Comments and queries from readers **should be sent directly to the author** at the following address: Department of Technology, Brooklands Technical College, Heath Road, Weybridge, Surrey KT13 8TT.

Please include a stamped addressed envelope if you require an individual reply. General queries will be dealt with in Readers' Forum which will appear in parts four and nine of the series.

when converting from binary to decimal we would arrive at:

$16^1 = 16$	$16^0 = 1$	
2	A	→ 10
		+ 32
		42

Now, suppose that we wish to convert 2A to binary rather than decimal. This is an easy process (it is NOT necessary to convert to decimal as an intermediate step!) as shown below:

Hexadecimal	2	A
Binary	0010	1010

Thus hexadecimal 2A is equivalent to binary 00101010. Note that the leading zeros are optional (00101010 is exactly the same number as 101010). When dealing with numbers present on an 8-bit bus it is, however, a good idea to get into the habit of showing leading zeros in binary numbers so that all 8-bits are clearly shown.

To convert from decimal (in the range 0 to 255) it is simply necessary to divide the decimal number by 16 to obtain the most significant digit and then take the remainder as the least significant digit. In both cases it will be necessary to convert a digit answer greater than nine to its corresponding hexadecimal digit (i.e. A to F). Suppose, for example, we had the task of converting decimal 75 to hexadecimal:

```
16 | 75
     4   Remainder 11
     |           = B ──┐
     └─────────────────→ 4B
```

Hence decimal 75 is equivalent to 4B hexadecimal.

Taking another example, suppose we had to convert 250 decimal to hexadecimal:

```
16|250
   15   Remainder 10
   = F          = A ──┐
   ───────────────────→ FA
```

Hence 250 decimal is equivalent to FA hexadecimal.

Converting from binary to hexadecimal over the range 0 to 255 is extremely simple. All we need to do is to separate the binary number into two groups of four bits (known as "nibbles") and then convert each of these groups to its corresponding hexadecimal character.

As an example suppose we need to convert the binary number 10001001 to hexadecimal:

1000	1001
8	9

Hence the binary number 10001001 is equivalent to hexadecimal 89.

Taking one further example, suppose we have to find the hexadecimal equivalent of the binary number 101100 (note that this number consists of six rather than eight bits!):

101100 = 00101100 (inserting two leading zeros to form an eight bit binary number)

0010	1100
2	C

Hence the hexadecimal equivalent of 101100 is 2C.

Problem 1.7

Convert the following denary numbers to hexadecimal:

(a) 27
(b) 511
(c) 4100

(Hint: Refer to Table 3 for powers of 16)

Problem 1.8

Convert the following hexadecimal numbers to denary:

(a) BE
(b) 10B
(c) C000

Problem 1.9

Convert the following binary numbers to hexadecimal:

(a) 1011
(b) 10101111
(c) 1010101111001101

Problem 1.10

Convert the following hexadecimal numbers to binary:

(a) 3F
(b) 23A
(c) 812C

Addition

Binary and hexadecimal addition follows the same general rules as employed with denary numbers. The rule for addition of two numbers (which MUST be expressed in the same base) is that digits in the corresponding position in each number are added, starting from the rightmost (least significant) and a carry into the next most significant position occurs if the sum of two digits equals or exceeds the value of the base used.

As an example, suppose we have to add together the binary numbers 10010010 and 01010000.

```
        1 0 0 1 0 0 1 0
      + 0 1 0 1 0 0 0 0
  Carry 0 0 1 0 0 0 0 0
        ---------------
        1 1 1 0 0 0 1 0
```

(Note that a carry is generated when the two 1s are added and the carry is added into the next more significant column.)

To make the process clear it is worth taking another example in which we shall add the binary numbers 10001101 and 01001111:

```
          1 0 0 1 1 1 0 1
  +       0 1 1 0 1 1 1 1
  Carry 1 1 1 1 1 1 1 0
        -----------------
        1 0 0 0 0 1 1 0 0
```

Addition of hexadecimal numbers follows the same pattern. Suppose we have to find the sum of the hexadecimal numbers 14 and 23.

```
        1  4
      + 2  3
  Carry 0  0
        ----
        3  7
```

Hence, the sum of hexadecimal numbers 14 and 23 is (not surprisingly!) equal to 37

Now let's try something a little more difficult by finding the sum of 1F and 2C:

```
        1  F
      + 2  C
  Carry 1  0
        ----
        4  B
```

(Note that adding F to C gives 1B)

Hence, adding 2C to 1F gives 4B hexadecimal.

Problem 1.11

Add:

(a) the binary number 01001111 to the binary number 10000101
(b) the hexadecimal number 5C to the hexadecimal number 71.

Subtraction

Subtraction of binary and hexadecimal numbers also follows the same general rules as employed with denary numbers. The rule for subtraction of two numbers (which again MUST be expressed in the same base) is that digits of the number to be subtracted (the subtrahend) are subtracted from digits in the corresponding position of the minuend. If the difference obtained is less than zero (i.e. negative) a value equal to the base employed is BORROWED FROM the next most significant position. The value of the borrow (i.e. 1) must be ADDED TO the next most significant position of the subtrahend. Again all this sounds much more complicated than it really is so we shall again use several examples to illustrate the techniques.

Consider the problems of subtracting the binary number 0100 from the binary number 1101:

```
         1 1 0 1  (minuend)
       − 0 1 0 0  (subtrahend)
  Borrow 0 0 0 0
         -------
         1 0 0 1
```

(In this simple example we have not needed to borrow!)

Now consider the slightly more difficult problem of subtracting the binary number 0110 from the binary number 1101:

```
         1 1 0 1  (minuend)
       − 0/1/1 0  (subtrahend)
  Borrow 1 1 0 0
         -------
         0 1 1 1
```

(Note that, if you are unsure of an

answer, it is always permissible to convert the numbers to denary in order to check the validity of a result. In the foregoing example we have the equivalent denary calculation; 13 − 6 = 7!)

Subtraction of hexadecimal numbers again follows the same pattern. Suppose we have to find the difference of the hexadecimal numbers 2F and 1A:

	2	F
−	1	A
Borrow	0	0
	1	5

(Note that subtracting A from F leaves 5)

Hence, the result of subtracting 1A hexadecimal from 2F hexadecimal is 15 hexadecimal.

Now let's try something a little more difficult by subtracting hexadecimal 14 from hexadecimal 23:

	2	3
−	1	4
Borrow	1	0
	0	F

Hence, the result of subtracting the hexadecimal number 14 from the hexadecimal number 23 is 0F.

Problem 1.12

Subtract;

(a) the binary number 01001101 from the binary number 11000101

(b) the hexadecimal number 3C from the hexadecimal number F0

NEGATIVE NUMBERS

Thus far we have confined ourselves to positive numbers and many of you will be wondering how we go about representing negative numbers within a computer. One rather obvious method is that of using the first (most significant) bit of a number solely to indicate its sign (i.e. whether it is positive or negative). The convention used is that a 0 in the most significant bit (MSB) position indicates that the number is positive. An MSB of 1, on the other hand, indicates that the number is negative. The magnitude of the number is then given by the remaining bits. We refer to such a number as being "signed".

As an example the signed eight-bit binary number 01111111 represents the decimal number 127 (it is positive as the MSB is 0) whereas the signed binary number 11111111 represents the decimal number −127 (the MSB is 1 and therefore the number is negative).

Problem 1.13

Convert the following signed binary numbers to decimal:

(a) 01000000

(b) 11000000

(c) 10001001

Problem 1.14

Convert the following decimal numbers to signed 8-bit binary:

(a) +5

(b) −99

(c) +99

One's and two's complement

The one's complement of a binary number is found by simply changing all of the 0s present to 1s and changing all of the 1s present to 0s. This process is called "inversion". The one's complement of the binary number 1010 is thus 0101. Note that the result of adding a number to its one's complement will produce a succession of 1s, as shown in the following example:

Binary number	1 0 1 0 1 1 0 0
One's complement	0 1 0 1 0 0 1 1
Sum	1 1 1 1 1 1 1 1

The two's complement of a binary number is found by simply adding 1 to its one's complement. Hence, the two's complement of 1010 is 0110 (i.e. 0101 + 0001).

The result of adding a binary number to its two's complement is not a succession of 1s but a succession of 0s with a leading 1 in the next more significant bit position. This is demonstrated by the following example:

Binary number	1 0 0 0 1 0 1 1
One's complement	0 1 1 1 0 1 0 0
Two's complement	0 1 1 1 0 1 0 1 (added 1)

Original number	1 0 0 0 1 0 1 1
Two's complement	+ 0 1 1 1 0 1 0 1
Sum	1 0 0 0 0 0 0 0 0

Problem 1.15

Find the one's and two's complements of each of the following:

(a) 1001

(b) 10110011

(c) 10001110

Readers can be excused for wondering what all this is leading up to! It actually yields a very neat method for performing subtraction. We simply form the two's complement of the number to be subtracted (the subtrahend) and ADD it to the first number (the minuend). Any leading 1 generated is ignored. To show how this works consider the following example which subtracts the binary number 00110110 from the binary number 10010101:

Subtrahend	0 0 1 1 0 1 1 0
One's complement	1 1 0 0 1 0 0 1
Two's complement	1 1 0 0 1 0 1 0

Minuend	1 0 0 1 0 1 0 1
Two's complement of subtrahend	+ 1 1 0 0 1 0 1 0
	1 0 1 0 1 1 1 1 1

Ingoring the leading 1 gives a result of 01011111.

It is usually much easier to use two's complements to perform subtraction than to use conventional subtraction (using borrow). Readers can easily check the validity of this statement by performing the foregoing example using conventional techniques!

Problem 1.16

Use the two's complement to subtract the binary number 00011001 from the binary number 11010100.

REPRESENTING NUMBER BASES

Thus far we have been quite explicit in stating (rather longwindedly!) the number base which we have been working in. Methods commonly used to indicate the base include:

(a) using a suffix to indicate the base

e.g. 101000_2 is a number having base 2 (i.e. binary)

127_{10} is a number having base 10 (i.e. denary)

76_{16} is a number having base 16 (i.e. Hexadecimal)

(b) adding a trailing H to indicate that a number is hexadecimal

e.g. 9FH, C9H and FFH are all hexadecimal

(c) adding a leading $ to indicate that a number is hexadecimal

e.g. $2A is the same as 2AH which is the same as 2A

Problem 1.17

Determine the denary equivalent of each of the folowing:

(a) 10_2

(b) 10_{10}

(c) $10

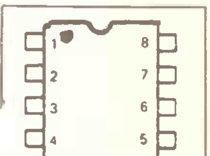


Fig. 6.

ANSWERS TO PROBLEMS

1.1	See Fig. 6.		
1.2	(a) standard TTL	(b) low-power Schottky	(c) CMOS
1.3	CMOS (reasons are wide supply voltage range and very low current requirements)		
1.4	See Fig. 7.		
1.5	(a) 11	(b) 38	(c) 231
1.6	(a) 100001	(b) 1100100	(c) 11010101
1.7	(a) 1B	(b) 1FF	(c) 1004
1.8	(a) 190	(b) 267	(c) 49152
1.9	(a) B	(b) AF	(c) ABCD
1.10	(a) 111111	(b) 1000111010	(c) 1000000100101100
1.11	(a) 11010100	(b) CD	
1.12	(a) 1111000	(b) B4	
1.13	(a) +64	(b) −64	(c) −9
1.14	(a) 10000101 *	(b) 11100011	(c) 01100011
1.15	(a) 0110 and 0111	(b) 01001100 and 01001101	(c) 01110001 and 01110010
1.16	10111011		
1.17	(a) 2	(b) 10	(c) 16

disregard MSB → see Jan. 88 issue.

NEXT MONTH: We shall be taking a look at the internal features and architecture of some common microprocessors.

BACKGROUND READING

The following background reading is suggested for this month:

(a) Chapter Two (The Microcomputer) of **Beginner's guide to Microprocessors** by E.A. Parr (a Newnes Technical Book published by Heinemann-Newnes) ISBN 0 408 00579 3. Available from the *EE Book Service* – see page 626.

(b) Chapter One (Numbering Systems) of **Microelectronic Systems 2 Checkbook** by R. Vears (published by William Heinemann Ltd) ISBN 0 434 92194 7. Available from the *EE Book Service* – see page 626.

CORRESPONDENCE

Comments and queries from readers should be sent directly to the author at the following address:

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Please include a stamped addressed envelope (and be prepared to wait a little!) if you require an individual reply. General queries will be dealt with in "Readers' Forum" which will appear in Parts 4 & 9.

The following companies specialise in the supply of electronics for educational purposes. Many of them can supply microprocessor learning systems or interfaces, etc.

UNILAB Clarendon Road, Blackburn BB1 9TA. (0254) 57643
ECONOMATICS (EDUCATION) LTD. Epic House, 9 Orgreave Road, Sheffield S13 9LQ. (0742) 690801
MICROMON Pont y Cerrig, Pentraeth, Gwynedd LL75 8RZ.
A.M. LOCK & CO. LTD. Neville Street, Oldham OL9 6LF. (061-624) 0333
MAGENTA ELECTRONICS LTD. 135 Hunter Street, Burton on Trent, Staffs DE14 2ST. (0283) 65435
P.K.G. ELECTRONICS Orchard House, Tansley, Derbyshire DE4 5FE. (0629) 3206
RCS MICROSYSTEMS 141 Uxbridge Road, Hampton Hill, Middlesex.
LJ, Francis Way, Bowthorpe Industrial Estate, Norwich NR5 9JA. (0603) 748001
TECHNOLOGY TEACHING SYSTEMS LTD. Penmore House, Hasland Road, Hasland, Chesterfield S41 0SJ. (0246) 78993
FLIGHT ELECTRONICS LTD. Flight House, Ascupart Street, Southampton, Hants SO1 1LU. (0703) 227721
EDUCATIONAL ELECTRONICS LTD. 28 Lake Street, Leighton Buzzard, Beds LU7 8RX. (0525) 373666
OMEGA ELECTRONICS 12 Oxhill road, Middle Tysoe, Warwicks CV35 0SX. (029-588) 455
PILOT ONE Campbell Road, Bedford MK40 3DD (0234) 327688
DATAMAN Lombard House, Cornwall Road, Dorchester, Dorset DT1 1RX.(0305) 68066
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GLOSSARY FOR PART ONE

Address
A number which indicates the position of a word in memory. Addresses typically comprise 16 bits and therefore can range from 0 to 65535_{10}.

Address bus
A set of lines (usually 16) used to transmit addresses, usually from the microprocessor to a memory or I/O device.

Address decoding
The process of selecting a specific address or range of addresses to enable unique support devices.

Binary
A system of numbers using base 2. Binary numbers thus use only two characters; 0 and 1.

Bit
A contraction of binary digit. A single digit in a binary number.

Bus
A path for signals having some common function. Most microprocessor systems have three buses; an address bus, data bus and control bus.

Byte
A group of eight bits.

Central Processing Unit
The part of a computer that decodes instructions and controls the other hardware elements of the system. The CPU comprises a control unit, arithmetic/logic unit and internal storage.

Chip
The term commonly used to describe an integrated circuit.

Complement
The process of changing a 1 to a 0 and vice versa.

Control Bus
The set of control signal lines in a computer system. The control bus provides the synchronisation and control information to operate the system.

CMOS
Complementary metal oxide semiconductor. A family of integrated circuit devices based on unipolar field effect devices.

Data
General term used to describe numbers, letters and symbols present within a computer during processing.

Data Bus
The set of electrical conductors which carries data between the different elements of a computer system.

Digital
A system which only allows discrete states. Most digital logic uses only two states (on/off, low/high or 0/1).

Firmware
A program (software) stored in read-only memory.

Hardware
The physical components of a computer system.

Hexadecimal
A number system with base 16. The first six letters of the alphabet (A to F) are used to represent the hexadecimal equivalents of the denary numbers 10 to 16.

Input/output
Lines or devices used to transfer information outside the computer system.

Input port
A circuit that connects signals from external devices as inputs to a microcomputer system.

Integrated circuit
An electronic circuit fabricated on a single wafer (chip) and packaged as a single component.

Memory
That part of a computer system into which information can be placed and held for future use. Storage and memory are interchangeable terms. Digital memories accept and hold binary numbers only. Common types of memory are magnetic disc, magnetic tape, and semiconductor (which includes RAM and ROM).

Microcomputer
A small computer based upon a microprocessor CPU. Backing storage is usually provided by magnetic disc or tape; input is provided by means of a keyboard and output by a VDU.

Microprocessor
A central processing unit fabricated on one or two chips. The processor contains an arithmetic logic unit (ALU), control block and registers.

One's complement
The inverse of a binary number which is formed by changing all 0s to1s and vice versa.

Output port
A circuit that allows a microprocessor system to output signals to other devices.

Peripheral
Any device that is connected to a computer whose activity is under the control of the central processing unit.

Program
A procedure for solving a problem coded into a form suitable for use by a computer and frequently described as software.

RAM (random access memory)
Usually used to mean semiconductor read/write memory. Strictly speaking, ROM devices are also random access!

Random access
An access method in which each word can be retrieved in the same amount of time (i.e. the storage locations can be accessed in any desired order).

Read
The process of transferring information from memory or I/O into a register in the central processor.

Register
A single word of memory. The CPU contains a number of registers for temporary storage of data.

ROM (read-only memory)
A permanently programmed memory. Mask-programmed ROMs are programmed by the chip manufacturer. PROMs (programmable ROM devices) can be programmed by the user. EPROMs (eraseable PROM devices) can be erased under ultraviolet light before reprogramming.

TTL (transistor transistor logic)
Transistor transistor logic. A family of integrated circuit devices based on conventional bipolar transistors.

Two's complement numbers
A number system used to represent both positive and negative numbers. The positive numbers in two's complement representation are identical to the positive numbers in standard binary, however the two's complement representation of a negative number is the complement of the absolute binary value plus 1. Note that the most significant bit (usually the eighth) indicates the sign; 0 = positive, 1 = negative).

Visual display unit (VDU)
A VDU is an output device (usually based on a cathode ray tube) on which text and/or graphics can be displayed. A VDU is normally used in conjunction with an integral keyboard when it is sometimes referred to as a console.

Word
A set of characters that occupies one storage location in memory and is treated by the computer as a unit. Program instructions and program data both have the same word length (equal to 8-bits or 1-byte in the case of 8-bit microprocessors).

Write
The process of transferring information from a register within the central processor to memory or I/O.

exploring electronics

OWEN BISHOP

This series is designed to explain the workings of electronic components and circuits by involving the reader in experimenting with them. There will not be masses of theory or formulae but straightforward explanations and circuits to build and experiment with.

Part 17 Counting Circuits

THIS month we investigate the J-K flip-flop, another useful circuit that can be obtained ready-built as the 7473 i.c. which contains two such circuits. The J-K flip-flop consists of a number of inter-connected logic gates and has three inputs:

Clock – the flip-flop is triggered to act whenever the input to this terminal changes from high to low (but *not* when it changes from low to high).

J & K – these control what happens when the flip-flop is triggered, as you will find out below. Some J-K flip-flops, including this version, also have a "Clear" input.

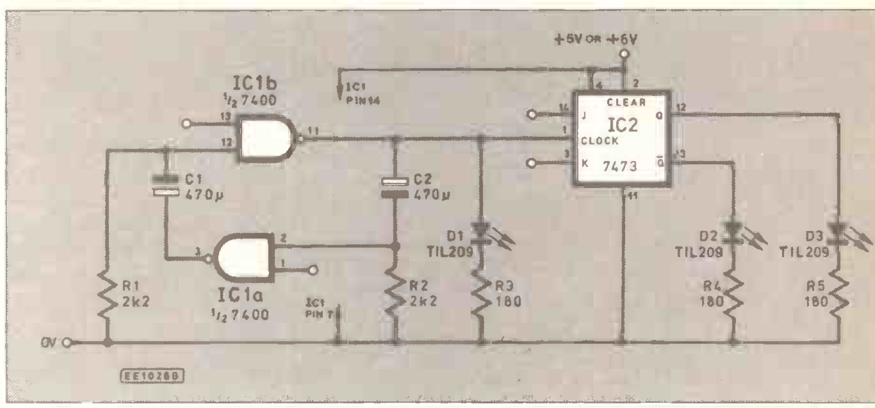


Fig. 17.1. Circuit diagram using a slow oscillator to drive a J-K Flip-Flop.

INVESTIGATION ONE

We start our investigations by using an oscillator to drive our J-K flip-flop i.c. In the circuit diagram Fig. 17.1 we have a slow oscillator made from a 7400 i.c. (see last month's instalment) to provide the input to the "Clock", pin 1.

The demonstration breadboard component layout is shown in Fig. 17.2. Be sure to connect the l.e.d.s and electrolytic capacitors the right way round.

If you prefer, the oscillator can be based on the 555 timer i.c. as described in Part 10, April '87 issue. The circuit

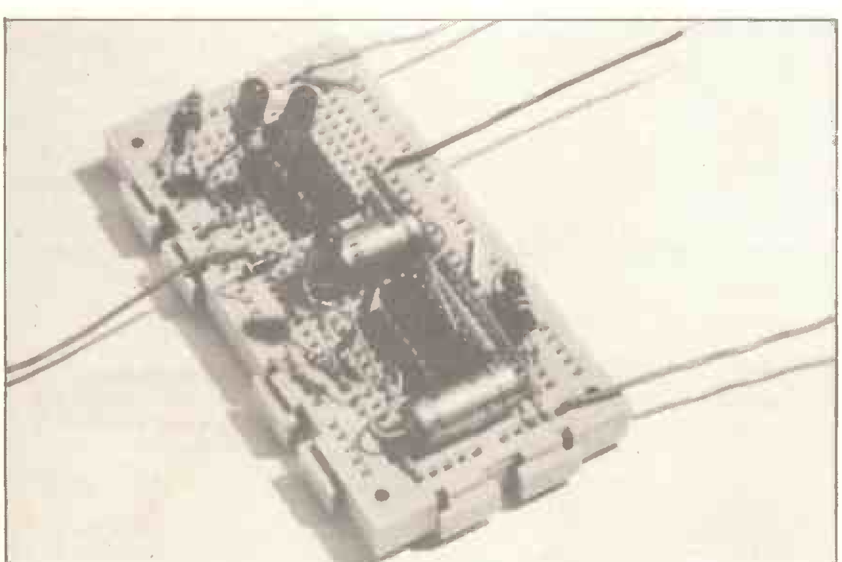
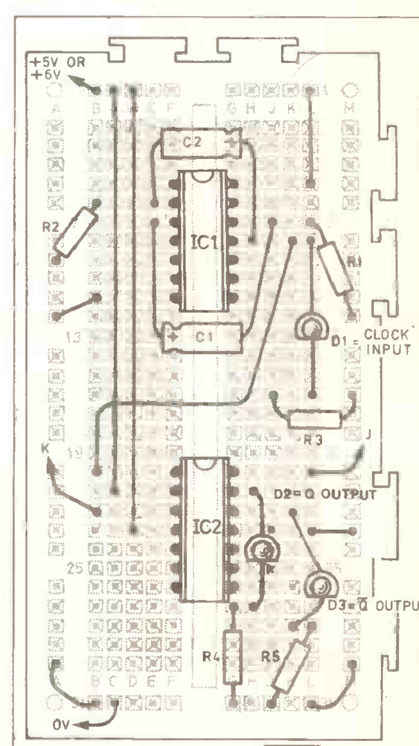
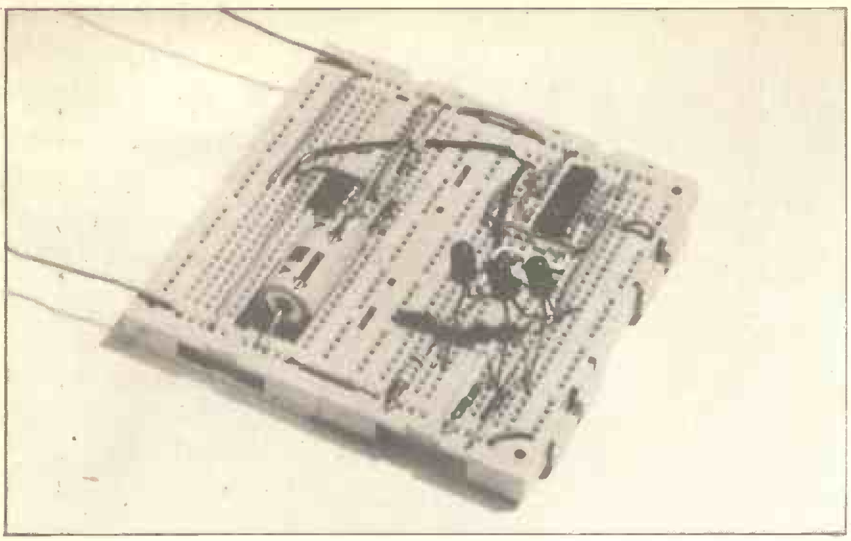


Fig. 17.2. Demonstration component layout for the J-K Flip-Flop.





COMPONENTS

Resistors
R1, R2 — 2k2 (2 off)
R3-R5 — 180 (3 off)
All 0.25W 5% carbon

Capacitors
C1, C2 — 470µ electrolytic (2 off)

Semiconductors
D1-D3 — TIL 209 or similar l.e.d. (3 off)
IC1 — 7400 quad 2-input NAND gate
IC2 — 7473 dual J-K flip-flop

Miscellaneous
Breadboard (e.g. Verobloc); connecting wire and 5V to 6V supply.

OBJECT COUNTER

Shop Talk See page 617

Resistors
R1 — 150k
R2 — 180k
R3-R5 — 180 (3 off)

Capacitor
C1 — 4µ7 electrolytic

Semiconductors
D1-D3 — TIL 209 or similar l.e.d. (3 off)
IC1 — 555 timer
IC2 — 7473 dual J-K flip-flop

Miscellaneous
Breadboards (2 off); connecting wire and 5V to 6V supply.

Approx. cost Guidance only **£5** each

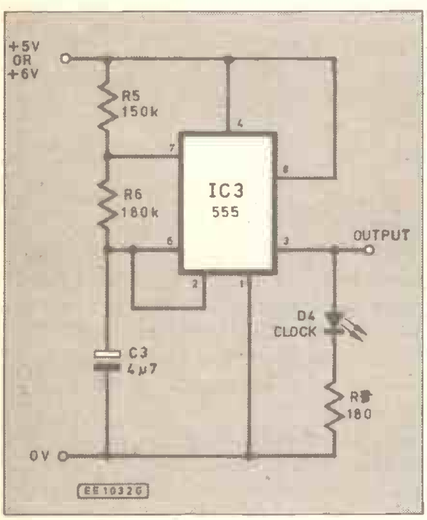


Fig. 17.3. Alternative slow oscillator circuit diagram using the 555 timer i.c.

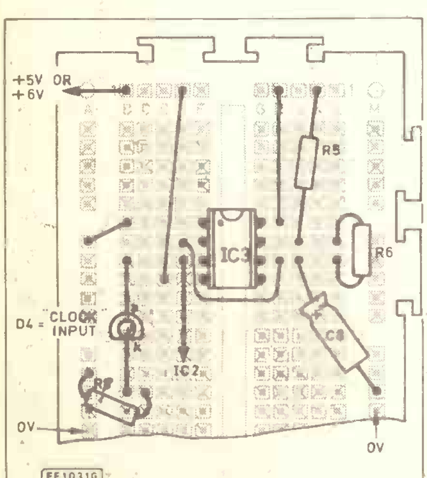


Fig. 17.4. How to connect the 555 i.c. as an oscillator driver for the "flip-flop".

diagram for the alternative 555 timer slow oscillator is shown in Fig. 17.3 and the demonstration breadboard in Fig. 17.4.

The states of the outputs of the oscillator and the flip-flop are indicated by the three l.e.ds. We need investigate only one of the two flip-flops contained in this i.c., for the other behaves in exactly the same way.

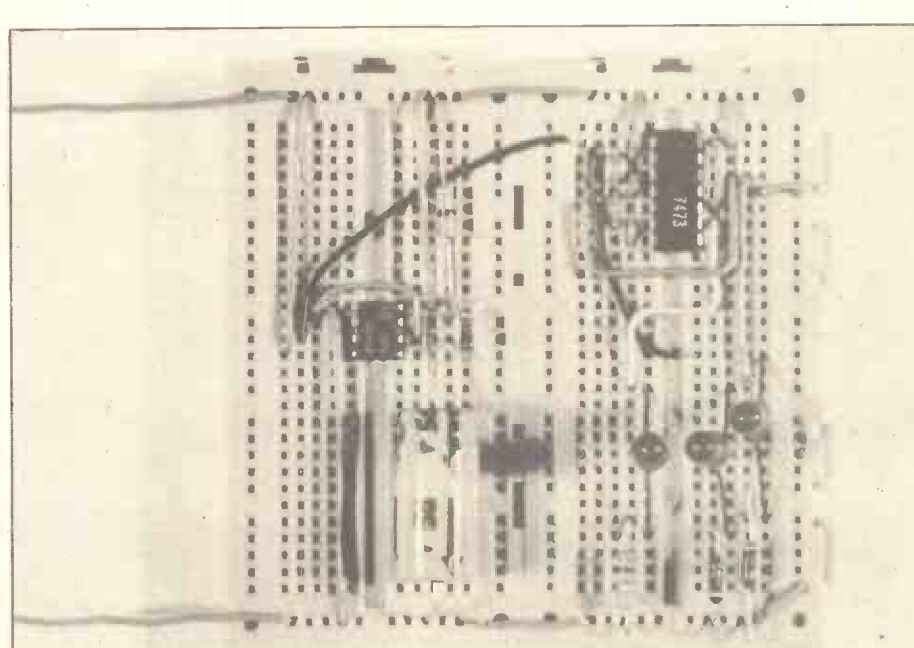
Put both flying leads J and K into sockets on the positive 6V rail (both *high*). What happens to the outputs as the clock goes low? (Answers p. 602.)

Try changing the "clear" input from high to low when Q is high. What happens to Q? Try again when Q is low.

Make the "clear" input high again. Now repeat the above with different J and K inputs. Make J high and K low; make J low and K high; make them both low; make them both high again. Try to work out the logical rules that this flip-flop obeys.

INVESTIGATION TWO – OBJECT COUNTER

The basic counting circuit, Fig 17.5, is made by connecting two or more flip-flops together. It can be used to count all kinds of objects – people, cars (including model cars), even noises.



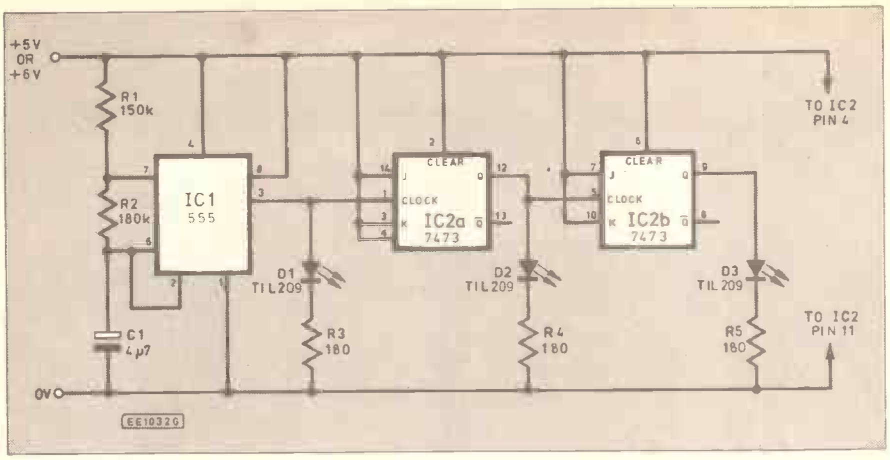


Fig. 17.5. Circuit diagram for the Object Counter.

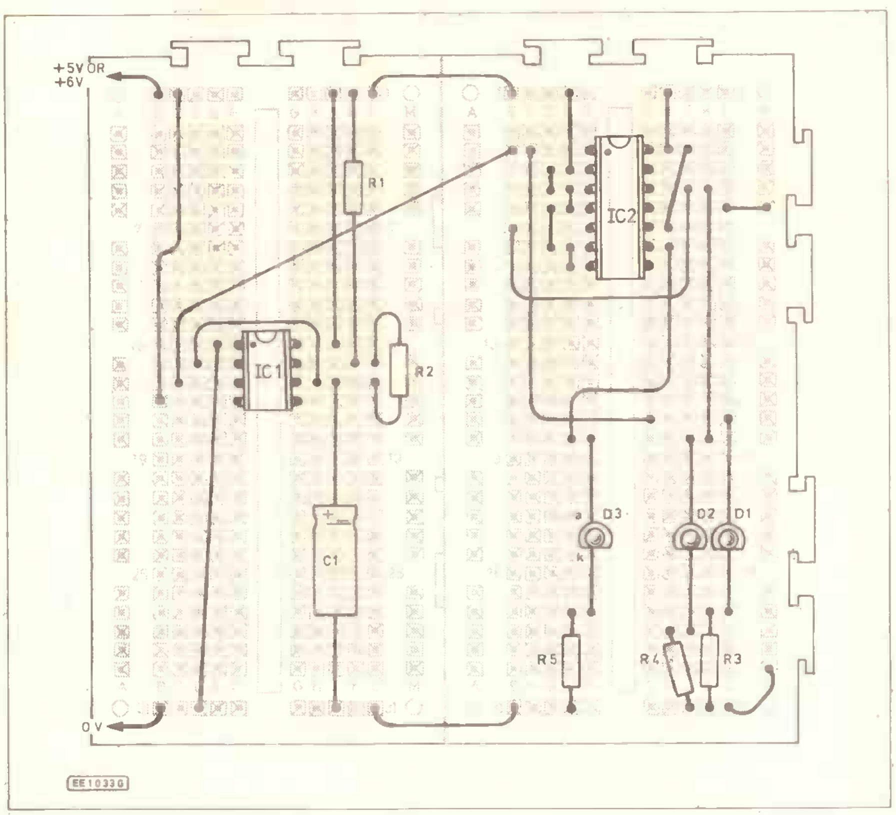
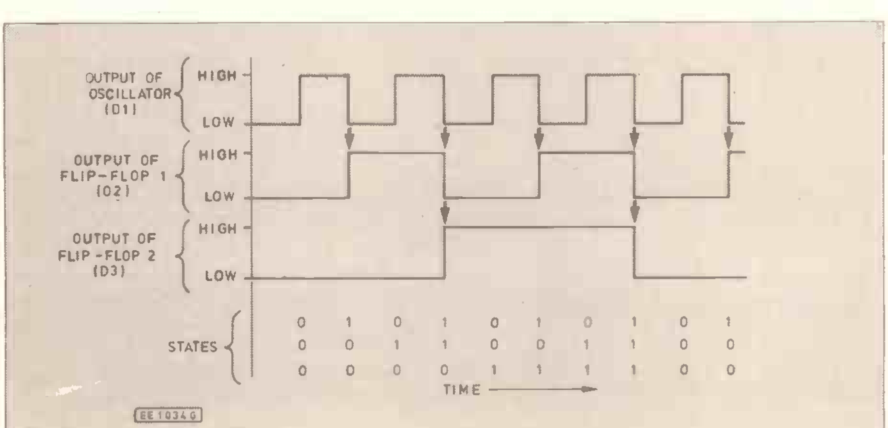


Fig. 17.6. Test-bed component layout for the Object Counter. This project is made up on two inter-linked demonstration breadboards.

Fig. 17.7. The counting sequence. The arrows indicate where an output triggers a flip-flop to change state.



ANSWERS

Output $\overline{Q}$ is awlays the inverse (opposite) of output Q.
Outputs change state only when the clock input changes from high to low.

With J and K both high: both outputs change state at every clock change.
With J and K both low: outputs do not change state ever.
With J high and K low: Q goes high at next clock change.
With J low and K high: Q goes low at next clock change.

Changing clear from high to low makes Q low *immediately*.
Changing clear from low to high has no effect.
The counting sequence of l.e.d.s repeats in this order:

D3	D2	D1	Decimal equivalent
0	0	0	0
0	0	1	1
0	1	0	2
0	1	1	3
1	0	0	4
1	0	1	5
1	1	0	6
1	1	1	7

0 = l.e.d. off 1 = l.e.d. on:
Reading these as binary numbers, they are equivalent to the decimal numbers 0 to 7.

The "test-bed" demonstration component layout for the Object Counter is shown in Fig. 17.6.

HOW IT WORKS

First we feed pulses from the 555 timer or the slow oscillator, to the "clock" input pin 1 of IC2a flip-flop. Then the Q output from IC2a is fed to the clock input pin 5 of the second flip-flop IC2b.

The J and K inputs of both flip-flops are permanently high (+6V), so each flip-flop *changes state* (from high to low, or from low to high) whenever its clock input falls. The effect of this is shown in the counting sequence diagram Fig 17.7.

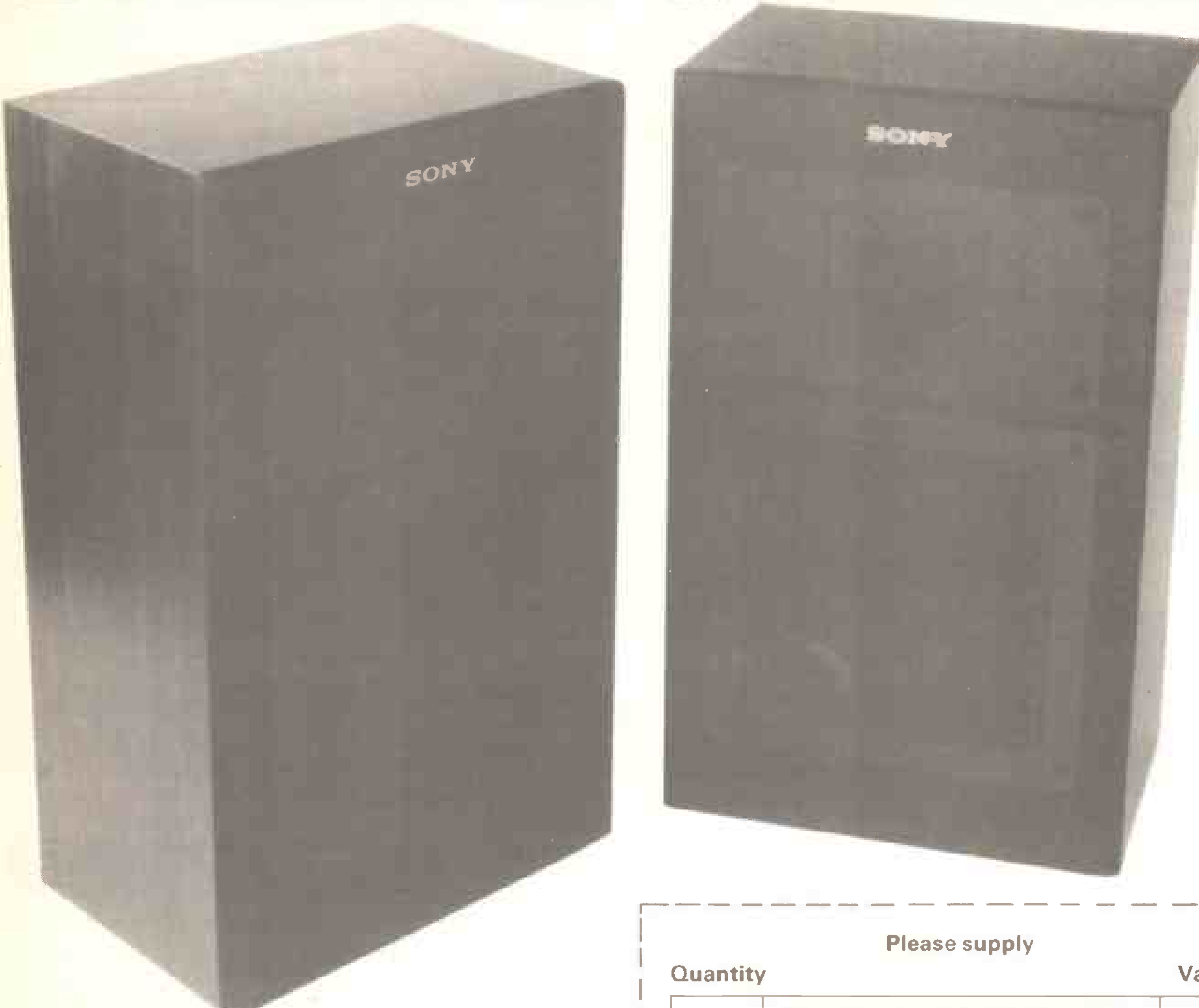
The output of the oscillator (or 555) changes from high to low and back to high again regularly. Whenever it *goes low*, flip-flop IC2a *changes state.* Whenever the output of IC2a *goes low*, IC2b flip-flop *changes state.* The waveform or sequence counting diagram Fig. 17.7 shows the first few steps of this process. Run the circuit to find out what happens next.

Record the complete sequence by writing "0" for low and "1" for high, as has been done below the sequence diagram Fig. 17.7. What do you notice about the sequence in which the lamps light? (Answer above.)

Counting pulses is interesting, but it is more useful to be able to count other things. More on this subject next month.

Next Month. Binary counting.

SPECIAL OFFER...



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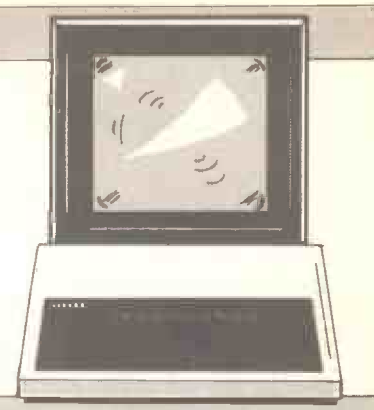


BBC SIDEWAYS RAM/ROM

A.P. GUEST

Provides two blocks of RAM each of 16K. Can also be used as a printer buffer or data store

THIS BBC sideways RAM board will enable ROM based software to be run after being loaded from disc. Many BBC users require ROM based software such as disc, printer, and debugging utilities. Unfortunately, with the BASIC and DFS ROMs fitted there are only two spare ROM sockets left. To have more than two extra ROMs fitted would therefore involve buying a ROM expansion board. The alternative offered by this board is to save the ROMs onto disc and then load in the ones which are needed into extra RAM which can then be used as if it were a ROM.

This board also enables BBC users to write their own ROM software and test it as they go along without having to repeatedly erase and program an EPROM.

A third use for the board is that, though it cannot be used to hold programs which have not been designed for ROMs, it can be used to hold data such as a spreadsheet or a database, or it can be used as a printer buffer.

BBC MICRO

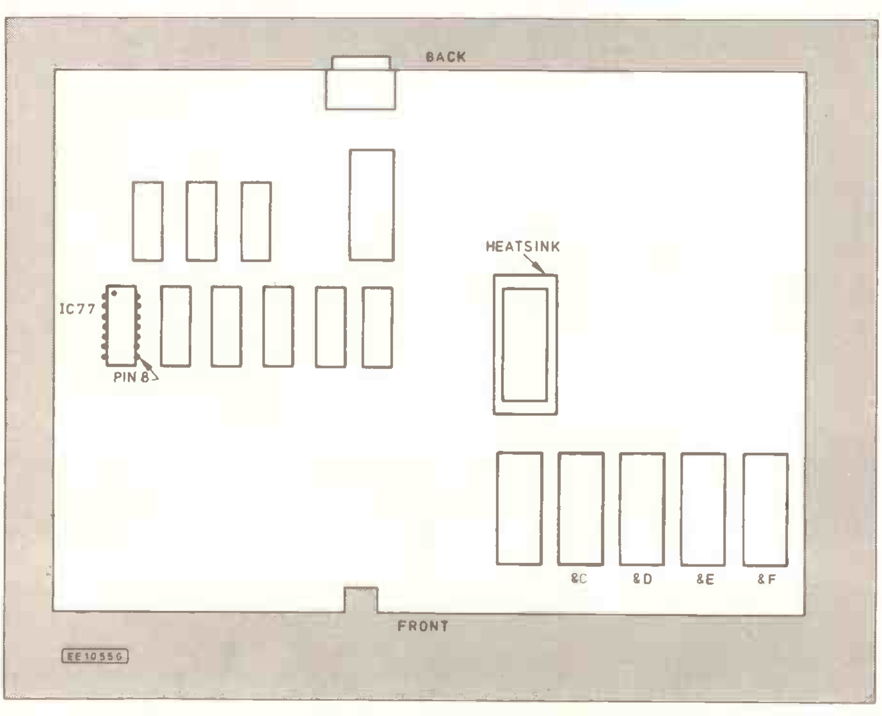
The BBC micro is based on a 6502A microprocessor and can therefore address 64K of memory (&0000 — &FFFF). The lower half of this (&0000 — &7FFF) is RAM, while the upper half (&8000 — &FFFF) is ROM. The upper half of the ROM (&C000 — &FFFF) is the operating system, and the lower half (&8000 — &BFFF) is the paged ROM area. This area of memory may be occupied by the BASIC ROM, the DFS, or any other language or service ROM which has been fitted. Though in theory the BBC can take up to 16 ROMs, only four sockets have been provided on the main circuit board.

To page in a particular ROM, the number of the ROM socket containing it (&0 — &F) should be put in location &FE30 (?&FE30 = n where n is the ROM socket number). The four ROM sockets on the circuit board are, from left to right, &C, &D, &E, &F, (see Fig. 1).

CIRCUIT

The complete circuit diagram of the BBC Sideways RAM/ROM is shown in Fig. 2. This circuit provides two blocks of RAM, each of 16K, thereby enabling two ROMs to be loaded into the BBC. Each block consists of two RAM chips, each of capacity 8K. Each RAM chip has two chip select pins, CS1 and $\overline{CS2}$. The chip is only enabled if CS1 is high and $\overline{CS2}$ is low.

Fig. 1. The main circuit board layout for the BBC Micro.



COMPONENTS

Capacitors
C1 — 100n tantalum

Semiconductors
IC1,IC2, IC3,IC4 — 6264LP15 8Kbyte static RAM (4 off)
IC5 — 74LS04 hex inverters

Miscellaneous
S1,S2 s.p.d.t. toggle switch (2 off)
Single sided p.c.b. 100 × 160mm, available from the *EE* PCB Service, order code EE585; 28 pin i.c. sockets 6 off; 14 pin i.c. socket; miniature probe clip; 14 way ribbon cable; connecting wire; insulation material (see text).

Approx. cost Guidance only **£20**

The computer selects a block by pulling the appropriate $\overline{CS}$ low. This pulls the $\overline{CS2}$ low on both the RAM chips of that block.

Which of the two RAM chips is to be used is decided by address line A13, which is put directly onto the CS1 of one of the RAM chips, and is inverted before being put onto the CS1 of the other chip. This means that if A13 is high then the first RAM chip will be paged in, while if A13 is low then the second chip will be paged in. The second block differs from the first only in that it uses a different $\overline{CS}$ from the main circuit board.

An added facility of this unit is that by switching a switch (the Write Protect switch) a block of RAM can be turned into ROM, thereby making it impossible to accidentally write over the contents of that block. Each block has a separate Write Protect switch.

The read/$\overline{write}$ (high to read, low to write) pins on the RAM chips are switched in pairs by the write protect switches between a read/$\overline{write}$ line from the main circuit board and a +5V line. When a pair of RAM chips are switched to the read/$\overline{write}$ line from the circuit board they will act as normal RAM, but when switched to +5V they are held in the ready mode and therefore cannot be written to, so they imitate a ROM.

The $\overline{OE}$ (output enable) from the circuit board does not attempt to switch off the outputs of the ROMs when the computer wants to write to them because normally writing to them would not work anyway. When RAM is fitted though, we still take the $\overline{OE}$ from the board straight to the $\overline{OE}$ of the RAM chips, because the RAM chips switch off their outputs when they are in write mode, regardless of the $\overline{OE}$ line.

The circuit does not have its own power source, but takes both this, the OV line, all the data lines, address lines AO to A12, the $\overline{OE}$ line, and the first $\overline{CS}$ from one ROM socket. The other $\overline{CS}$ is taken from another ROM socket. The read/$\overline{write}$ line is taken from pin 8 of IC77 on the main circuit board using a miniature probe clip (see Fig.1). The power supply to the board is decoupled with capacitor C1.

CONSTRUCTION

The component layout and full size printed circuit board foil master pattern for the BBC Sideways RAM/ROM is shown in Fig. 3. The circuit board for this project is available from the *EE PCB Service*, code EE585.

If you intend to make the board yourself though, the plan is shown in Fig.3. When the board is being cut to size it must be cut close to the tracks to enable it to fit inside the BBC.

Start the assembly by putting in the one link required. Then fit i.c. sockets for IC1 to IC5 (sockets for IC1 to IC4 have 28 pins, the socket for IC5 has 14 pins). Sockets are used because the RAM chips are of the CMOS type and are therefore sensitive to static and must be handled as little as possible. Now solder in the decoupling capacitor, C1.

Next, make up the ribbon cable to connect the RAM board to the main board. The length of this cable must be measured carefully to ensure that the RAM board does not interfere with any power lines to the main board (see Fig.4). Two 14-way ribbon cables are in fact used, one for each side of the ROM socket (see Fig.3). The ribbon cables are soldered into the RAM board at one end, and at the other end

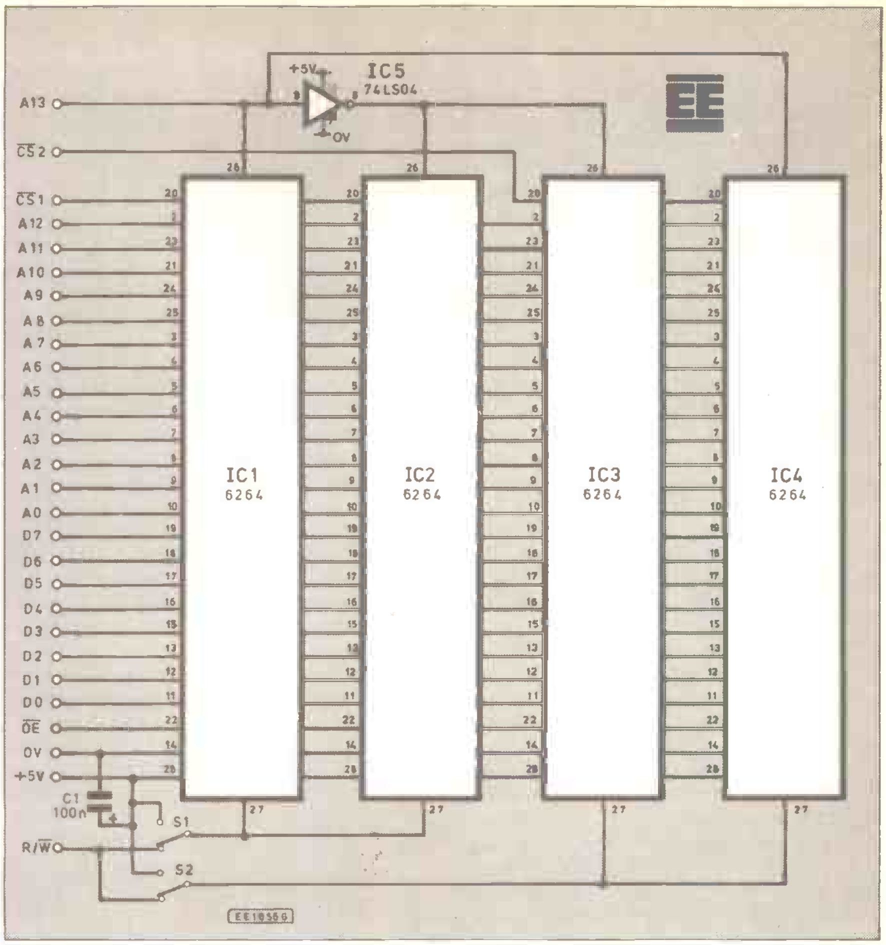


Fig. 2. Complete circuit diagram for the BBC Sideways RAM/ROM.

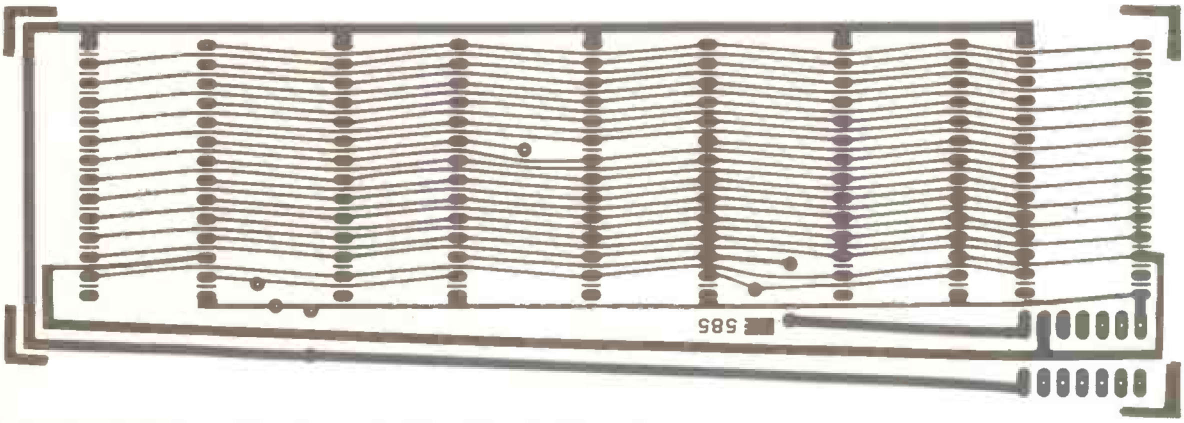
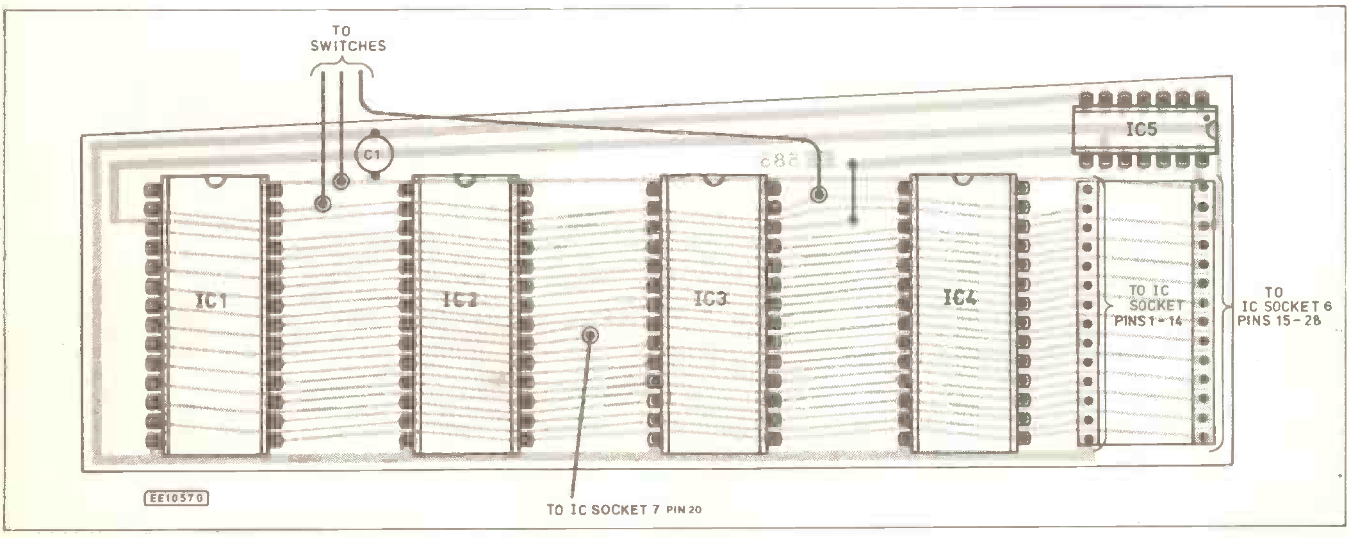


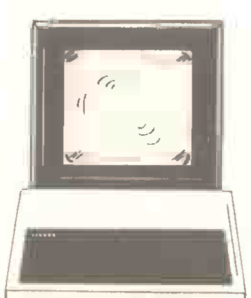
Fig. 3. Full size printed circuit foil master pattern and board component layout.



BBC SIDEWAYS RAM/ROM

SOFTWARE

```
 10 REM PROGRAM 1
 20 REM ---------
 30 REM Sideways RAM tester
 40 FOR C=0 TO 1
 50 READ D
 60 PRINT "Now testing socket number &";~D
 70 count=0
 80 P%=&1100
 90 [.c1 OPT 2:LDA#D:STA&FE30:LDA#0:
.11 STA&A000:LDA&F4:STA&FE30:RTS:]
 100 [.c2 OPT 2:LDA#D:STA&FE30:.12 LDA&A000:
STA&70:LDA&F4:STA&FE30:RTS:]
 110 FOR A=&8000 TO &BFFF
 120 ?(11+1)=(A MOD 256):?(12+1)=(A MOD 256)
 130 ?(11+2)=(A DIV 256):?(12+2)=(A DIV 256)
 140 FOR B=0 TO 255 STEP 255
 150 ?(11+1)=B
 160 CALL c1
 170 CALL c2
 180 IF ?&70 <>B THEN count=count+1:
PRINT~A,~?&70;" not ";~B
 190 NEXT B
 200 IF (A MOD 256)=0 THEN VDU7
 210 NEXT A
 220 PRINT
 230 PRINT count
 240 NEXT C
 250 DATA &D
 260 DATA &E
```



TEST & SAVE PROGRAMS

```
 10 REM PROGRAM 2
 20 REM ---------
 30 REM OFFLOAD source code
 40 osargs=&FFDA
 50 oswrch=&FFEE
 60 osword=&FFF1
 70 oscli =&FFF7
 80 osbyte=&FFF4
 90 inpptr=&80
100 normout=?&20E+256*?&20F
110 FOR I%=0 TO 3 STEP 3
120 P%=&900
130 [ OPT I%
140 LDX #inpptr
150 LDY #0
160 LDA #1
170 JSR osargs
180 LDY #0:LDA (inpptr),Y
190 SEC:SBC #&30:BCC romnumerr
200 CMP #&A:BCC ahok
210 SBC #7:BCC romnumerr
220 CMP #&A:BCC romnumerr
230 CMP #&10:BCC ahok
240.romnumerr BRK
250 EQUB &FF
260 EQUS "Illegal ROM number"
270 EQUB &0D
280.filenameerr BRK
290 EQUB &FF
300 EQUS "Bad filename"
310 EQUB &0D
320 BRK
330.ahok
340 STA &FE30
350.loop1
360 LDX #0
370.loop
380 LDA &8000,X
390 STA &3000,X
400 INX
410 BNE loop
420 INC loop+2
430 INC loop+5
440 LDA loop+2
450 CMP #&C0:BNE loop1
460 LDA &F4:STA &FE30
470 LDY #1:LDA (inpptr),Y:CMP #&20:BNE romnumerr
480 INY:LDA (inpptr),Y:CMP #&0D:BEQ filenameerr
490.loop LDA (inpptr),Y
500 CMP #&0D:BEQ out
510 STA oscliname-2,Y
520 INY
530 CPY #&12:BNE loop
540.out LDX #oscliblock MOD 256
550 LDY #oscliblock DIV 256
560 JMP oscli
570.oscliblock EQUS "SAVE "
580.oscliname EQUS STRING$(19," ")+"3000 7000 8000 8000"
590 EQUB &0D
600 ]:NEXT
```

```
 10 REM PROGRAM 3
 20 REM ---------
 30 REM ONLOAD source code
 40 osargs=&FFDA
 50 oswrch=&FFEE
 60 osword=&FFF1
 70 oscli =&FFF7
 80 osbyte=&FFF4
 90 inpptr=&80
100 normout=?&20E+256*?&20F
110 FOR I%=0 TO 3 STEP 3
120 P%=&900
130 [ OPT I%
140 LDX #inpptr
150 LDY #0
160 LDA #1
170 JSR osargs
180 LDY #0:LDA (inpptr),Y
190 SEC:SBC #&30:BCC romnumerr
200 CMP #&A:BCC ahok
210 SBC #7:BCC romnumerr
220 CMP #&A:BCC romnumerr
230 CMP #&10:BCC ahok
240.romnumerr BRK
250 EQUB &FF
260 EQUS "Illegal ROM number"
270 EQUB &0D
280.filenameerr BRK
290 EQUB &FF
300 EQUS "Bad filename"
310 EQUB &0D
320 BRK
330.ahok
340 STA romnum
350 LDY #1:LDA (inpptr),Y:CMP #&20:BNE romnumerr:
INY:LDA (inpptr),Y:CMP #&0D: BEQ filenameerr
360.loop LDA (inpptr),Y:CMP #&0D:BEQ out:
STA oscliname-2,Y:INY:CPY #&12: BNE loop
370.out LDX #oscliblock MOD 256:
LDY #oscliblock DIV 256:JSR oscli
380 LDA romnum
390 STA &FE30
400.loop1
410 LDX #0
420.loop
430 LDA &3000,X
440 STA &8000,X
450 INX
460 BNE loop
470 INC loop+2
480 INC loop+5
490 LDA loop+5
500 CMP #&C0
510 BNE loop1
520 LDA &F4:STA &FE30
530 RTS
540.oscliblock EQUS "LOAD "
550.oscliname EQUS STRING$(19," ")+"3000"
560 EQUB &0D
570.romnum EQUB 0
580 ]:NEXT
```

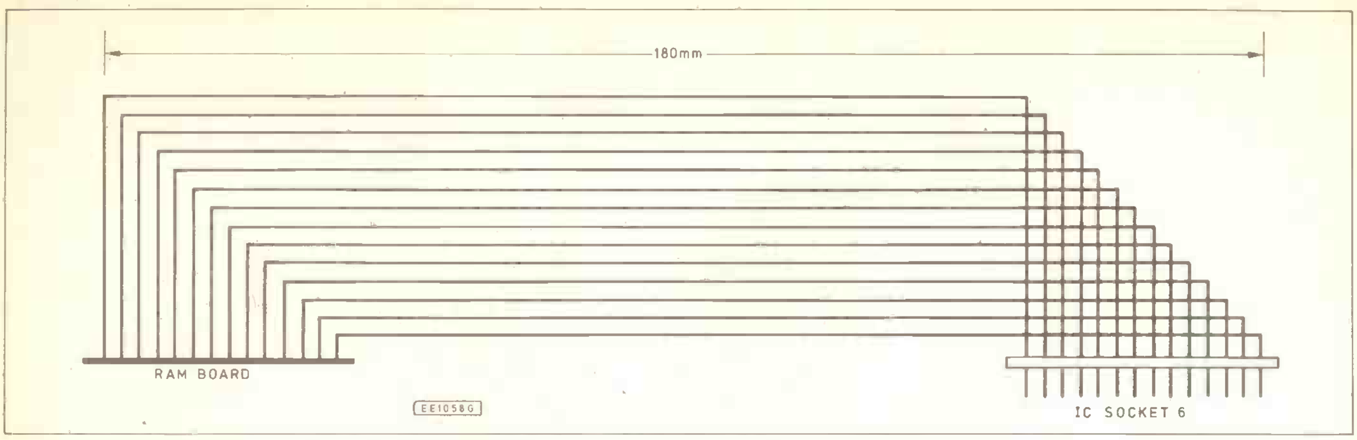


Fig. 4. Dimension and wiring details for the interconnecting ribbon cable (two required) from the RAM board to the 28-pin i.c. connecting socket 6. Note that a single lead is taken from the board to pin 20 of i.c. socket 7 (see photo below).

they are soldered into an i.c. socket (a 28 pin socket), which can then be plugged into a ROM socket on the main board.

If there is a large heatsink near to the ROM sockets then it will only fit easily into ROM socket &D, in which case if you already have a ROM in this socket take it out and put it in another socket. To take out a ROM, use a specially designed extraction tool if you have one, otherwise use a small screwdriver to carefully lever up the four corners in turn, taking care not to bend any of the corner pins.

It is easiest to solder both cables to the i.c. socket first, and then solder both to the RAM board. Now the switches can be wired up as shown in Fig.5. The read/$\overline{write}$ line comes straight from the miniature probe clip to an end terminal of one of the switches. A link goes from here to the equivalent point on the other switch. The +5V line comes from the RAM board onto the terminal at the opposite end of one of the switches and again a link takes it to the equivalent point on the other switch. One wire comes from each of the centre terminals of the switches to the RAM board.

Lastly, solder a wire from the RAM board to pin 20 of the other flying i.c. socket 7 (a 28 pin socket).

Now check the RAM board for dry joints and for any tracks which might have been shorted out. These jobs are best done with a multimeter or continuity tester.

BACKING

If the board were to be fitted now, it could well short out several points on the main circuit board. To prevent this, the back of the RAM board should be covered with some insulating material. Just covering it with sticky tape is not good enough as the ends of the wires can pierce it. The easiest thing to use is a sheet of cardboard cut to the size of the RAM board which can then be stuck onto the back with sticky pads or insulation tape.

FITTING

Since the RAM chips are sensitive to static, it is advisable to earth yourself and the RAM board before handling them. Even so, it is best only to handle them by their ends and not touch the pins. Once all five chips have been fitted, plug the RAM board into a vacant ROM socket (socket &D if you have a heatsink fitted, see Fig.1), clip on the read/$\overline{write}$ line, and plug in the other i.c. socket (with the extra CS wire on) into the last vacant ROM socket. The Write Protect switches can stick out of the slot and be stuck onto the back of the BBC. Check the fitting, reassemble the computer, and switch on. If it does not start up normally, then switch off and check everything again.

TESTING

Before using the RAM board for ROM software, it is best to test it thoroughly. Program 1 tests the board by putting first &O and then &FF into every byte and in each case reading it back and checking for any errors. If an error occurs then the program will print on the screen the location where the error occurred and what was found in the location. If it prints up every location then switch the appropriate write protect switch and try again. The program takes just under 20 minutes to run and bleeps after checking every 256 bytes to show that it has not crashed. When typing in the program, put the numbers of the two ROM sockets used by the RAM board in lines 250 and 260.

SAVING A ROM

Before a ROM can be loaded from disc, it must be saved onto disc. Program 2 does this. Type it in, save it, and run it. Then type:

***SAVE OFFLOAD A00 AB7**

To save a ROM you then just type:

***OFFLOAD n ROMNAME**

where **n** is the ROM socket number from which you want to save, and **ROMNAME** is the name of the ROM you want to save.

e.g. ***OFFLOAD F BASIC**

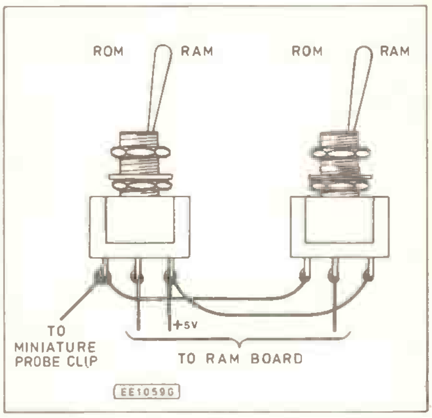


Fig. 5. Wiring details for the Write Protect switches.

SAVING A ROM

Program 3 is used to load a ROM from disc. Type it in, save it, and run it. Then type:

***SAVE ONLOAD A00 AB0**

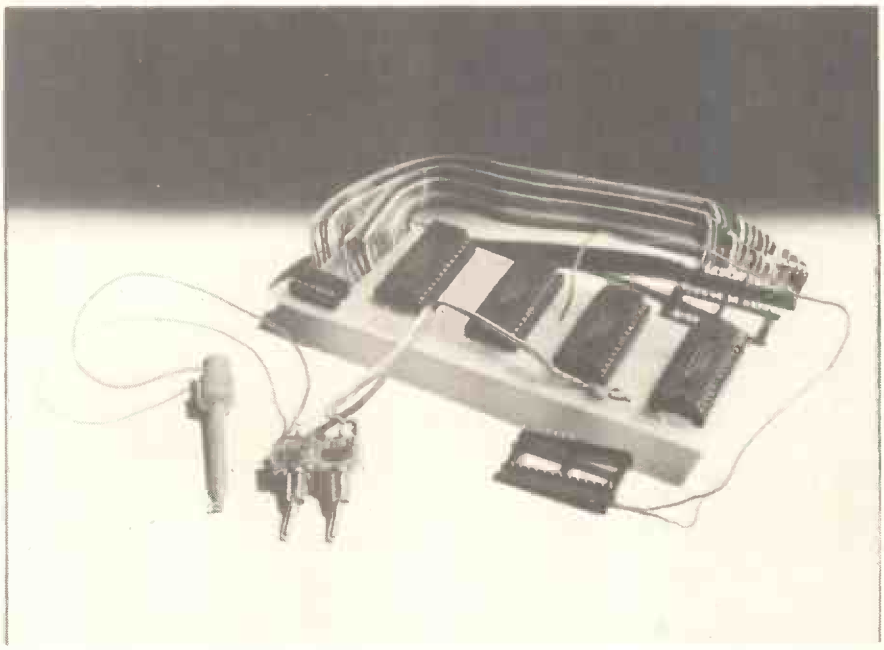
To load a ROM from disc you then just type:

***ONLOAD n ROMNAME**

where **n** is the number of a ROM socket with RAM in it, and **ROMNAME** is the name of the ROM you want to load.

e.g. ***ONLOAD D FORTH** □

The completed board showing the two connecting sockets (6, 7), toggle switches and the read/write probe clip.



N.M.R. IMAGING

X RAY PICTURES WITHOUT X RAYS

SOME years ago the science weekly, *Nature*, printed a picture of a cross-section through a lemon. It wasn't a photograph, or a drawing. It had been made without cutting the lemon. It was a striking illustration of a new kind of picture-making technique with important applications in medicine.

SLICE PICTURES

Tomography, as it's called, means making an image of a slice through something – a picture of a section. One of the earlier ways of doing this without actually cutting the object under investigation used pencil-beams of X-rays (Fig.1).

Suppose the object is a limb with a bone through the middle. The X-ray beam is moved along a circular path round the limb. On the opposite side is an array of X-ray detectors – small semiconductor "photocells".

In some positions the beam will miss the bone, passing only through the flesh. In others it will pass through the bone, to an extent which varies with the angle. If bone is a more efficient absorber of X-rays than flesh then the signal from a detector will be smallest when the beam passes straight through the diameter of the bone.

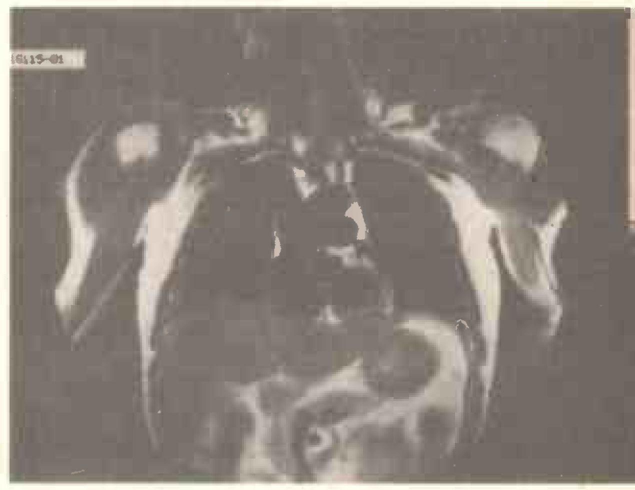


Fig.5 An NMR picture of a slice through the neck and chest. This picture was made at the National Heart and Chest Hospitals using a Picker International NMR scanner.

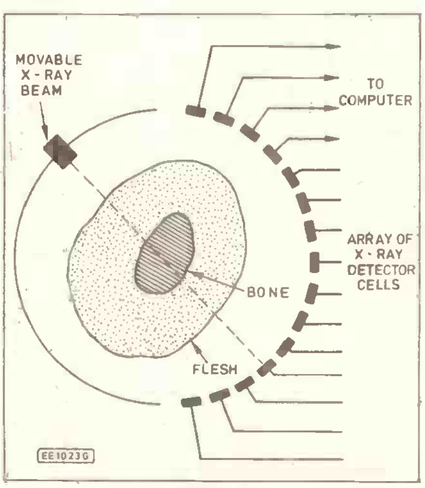


Fig.1 X-ray tomography. A beam of X-rays passing through a limb from different angles yields different detector outputs. Computation on these produces a cross-section of the limb showing the bone inside.

By correlating the detector outputs and the beam angles it is possible to compute the shape of the bone and display a sectional view on a TV screen. This is computerised X-ray tomography and it is now widely used for "scanning" patients in hospitals. In particular it is useful for taking slice-pictures of the skull to look for injuries or disease.

NO RISK SCANNING

By using highly sensitive detectors it is possible to minimise the X-ray dose to the patient. However, any dosage of ionising radiations such as X-rays involves a small risk to the patient, since radiation of this kind can cause cancer. Even though the risk is small it is better to run no risk at all.

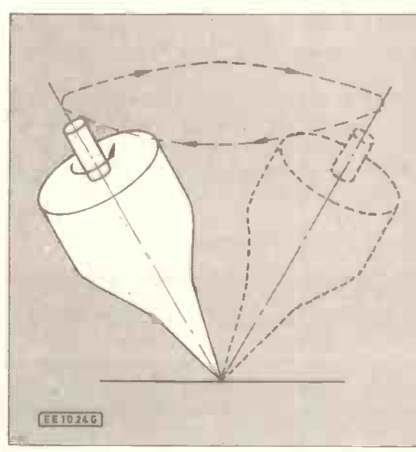


Fig.2 A spinning top given a sharp sideways push wobbles at a steady rate called the precession frequency. Spinning protons and electrons behave in a similar way.

This is one reason why medical researchers have explored ways of making pictures without using X-rays. One possibility is to use sound waves. If the frequency of the "sound" is made very high the wavelength becomes short enough to give fairly detailed images. Many hospitals now have ultrasound imagers which can show babies developing in the womb.

There is another, quite different reason for seeking an alternative to X-rays. This is that X-rays, while very good for imaging bone, are not so good for imaging soft tissues like the organs in the abdomen. It is often possible to get round this problem by giving the patient a dose of some chemical which is opaque to X-rays.

If this X-ray contrast medium can be persuaded to concentrate in the tissue of interest then clear pictures can still be obtained. But if it can't, or if the seat of a disease is just not known, then imaging soft tissues can be a difficult problem.

NUCLEAR RESONANCE

Ideally, what is needed is an imaging technique which poses no risk to the patient and causes no discomfort, but gives clear pictures of any type of tissue.

It was realized years ago that a technique already in use for chemical analysis could in theory be adapted to imaging. This technique is based on a phenomenon called Nuclear Magnetic Resonance (NMR).

Don't be misled by the word "nuclear" into thinking that nuclear magnetic resonance involves radio-activity. It doesn't. "Nuclear" here simply refers to the fact that the technique works by exploiting the behaviour of the nucleus of an atom. Any atom: it doesn't have to be a radio-active atom. In fact, most of the NMR imaging at present being done looks at nothing more sinister than the hydrogen in the water which makes up a great part of the body.

SUB ATOMIC SPINNING TOPS

The protons, neutrons and electrons which make up atoms spin round on their axes, like the Earth. Protons carry a positive charge.

An electric current is just a collection of moving charges. Even one moving charge constitutes a tiny current. So the positive charge on a spinning proton makes a tiny circular current. The current in turn generates a magnetic field. This field is aligned along the spin axis of a proton a bit like the Earth's field.

The proton has a North pole and a South pole. This makes a proton susceptible to the influence of an external magnetic field. The proton's North pole will be attracted to the South pole of an external field, and vice versa.

The effect is to force the axes of the spinning protons to align themselves with the direction of the external field.

NMR is all about what happens when this alignment is disturbed. If the spinning proton is likened to a spinning top or gyroscope (Fig.2) you can get an idea of its behaviour. If the top is spinning strongly and you give it a sideways tap it wobbles in a particular way. Its axis moves round in a small circle. This movement is called precession, and the rate of precession is a fixed quantity: so many circular wobbles per second.

It's not possible to give a tap to a proton. But if the proton "spinning tops" in a substance are aligned with an external field (Fig.3) they can be disturbed by varying the field. This can be done by superimposing a periodic or "a.c." variation on a steady or "d.c." field.

The effect depends on the frequency of the variation. At most frequencies it's small. But if the a.c. variation is at the same frequency as the natural precession of the proton "spinning top" it is very large – perhaps millions of times larger.

TUNING THE PROTONS

The effect of subjecting the aligned protons to a variable frequency field charge is rather like what happens when you loosely couple the output of a radio signal generator to a tuned LC circuit. The voltage across the circuit stays quite low until you hit the resonant frequency, when it increases sharply. The amount of increase depends on the quality factor or Q of the tuned circuit.

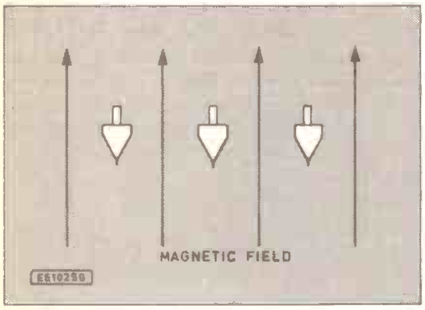


Fig.3 Spinning nuclear particles such as protons align themselves with a magnetic field. The field sets their precession frequencies to calculable values.

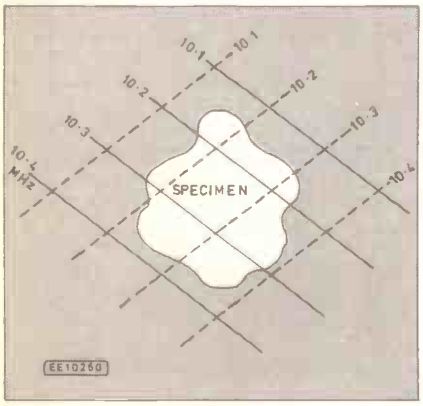


Fig.4 Contours of magnetic field strength are also contours of NMR frequency. By exploring a specimen immersed in the field with the aid of radio-frequency field-variations, the average concentration of protons along a contour can be found. Rotating the field lines gives a second set of readings (dotted). Combining many readings in a computer yields a map of the proton concentrations in the specimen.

The tuned LC frequency depends on the values of inductance and capacitance. But what determines the frequency of the proton resonance? Answer: the strength of the magnetic field. The stronger the d.c. field used to align the spins the higher the frequency. In medical NMR imaging the fields are comparable with those in a loudspeaker magnet and the frequencies are in the short-wave radio band, say 10MHz.

The nuclear resonance frequency is affected by other protons nearby. This is very important when NMR is used for chemical analysis where the effect of nearby protons (or electrons, which also exhibit resonance) indicates the nature of a chemical compound. Potentially, it could be important in NMR imaging. It might be very useful to be able to map the presence of particular compounds or indeed particular elements in the body. But so far, hydrogen and, to a lesser extent, potassium seem to be the only elements accessible to the NMR imager, and no compounds at all.

FIELD GRADIENTS

At first sight it may seem rather pointless to map the hydrogen in a section of the body. Hydrogen – in water – is everywhere in the body, so wouldn't a hydrogen map just be totally featureless, the same all over? Fortunately not. The amount of water, the concentration, varies in different types of body tissue. If the map shows these variations, it shows the different organs, and different parts of the same organ.

But how do you obtain a map from NMR? There's no way of producing sharp pencil-beams of magnetic field, so the X-ray tomography technique is not applicable. What can be produced, very easily, are field gradients. In NMR terms, contours of equal magnetic field strength are also contours of equal resonance frequency. Suppose the field/frequency contour map is a series of slanting lines (Fig.4). if a signal on 10.1MHz is applied, any hydrogen nuclei (protons) which happen to be threaded by the contour marked 10.1 will absorb energy. The response will indicate the average concentration of hydrogen along this contour. Signals at 10.2, 10.3 . . . etc. MHz will give the concentration of hydrogen along these contours. If the field is now rotated to give a new set of contours the specimen or body under examination can be explored in another direction.

By making measurements with field gradients running in different directions and comparing the results in a computer a map of the concentration of hydrogen can be produced. This, for practical purposes, is a map showing water concentration and so it shows the organs of the body, if this is what is being scanned. The photograph shows a vertical slice through the neck and chest, (Fig.5).

IMAGING MOVEMENT

The NMR technique can be refined to yield more information. At the National Heart and Chest Hospitals pictures of blood flow have been obtained. These are produced by exploiting some subtle effects of moving water (in the blood) on the phase of the radio frequency signals used to disturb the d.c. field. Sequences of pictures can be combined to produce "cine film" of the beating heart and reveal irregularities caused by disease.

All the patient has to do is to lie relaxed on a stretcher which is slid into the field of large electromagnet coils. The whole process is painless and doesn't take very long.

In Brief

Microprocessor Fault Test

The Distributive Industry Training Trust (DITT) has awarded a £4,000 grant to the Radio, Television & Electronics Examination Board (RTEEB) to assist in the development of a Practical Fault Location Test for microprocessor-based equipment.

The new test will be available in 1988 to all Colleges running Microprocessor Computer Systems (C&G Course 224) and Microcomputer Technology (C&G Course 223).

The Greater Manchester Exhibitions and Events Centre (G-Mex), formerly a listed railway station, is the venue for the *Northern Amstrad Computer Show*. The show will run from 23 to 25 October 1987.

In its capacity of authorised distributor, Electronic Brokers will be featuring Marconi Instruments' products at the forthcoming COMEX exhibition.

The COMEX exhibition is being held at the Sandown Exhibition Centre, Esher, Surrey from 3 to 5 November 1987.

Action Against Pirates

The destruction of 200,000 pirate music cassettes containing works by over 300 classical, jazz and pop artists was ordered by a Nigerian court recently.

This is the latest in a series of legal moves by the local music industry against importers and manufacturers of illicit tapes and follows a recent pledge by a senior government minister that measures to eradicate piracy will be introduced by the end of the year.

The EEC Commission is to undertake a full scale investigation into music piracy in Indonesia. The Commission announced its decision to open an investigation procedure concerning the unauthorised reproduction of sound recordings as a result of a formal complaint by the International Federation of Phonogram and Videogram Producers.

A new professor of information technology (IT), jointly sponsored by British Telecom and the Fellowship of Engineering, is to be appointed at Salford University.

The professor will direct research activity in the University's recently established Information Technology Institute.

a regular feature for the Spectrum Owner...

by Mike Tooley BA

THIS month, as promised, we shall be describing some software routines for use with our Z80-CTC Counter/Timer Interface. We also review the latest offering from Betasoft in the shape of BETA BASIC 4.0. We start by dealing with a problem which is becoming increasingly worrying for many Spectrum users; that of software support.

Software support

The level of support offered to the serious user of software packages is becoming an increasing cause for concern. Some time ago, I reviewed the excellent Laser Genius package produced by Ocean. Several readers have since written to say that they have had problems with the package and the suppliers have not been able to help. This, unfortunately, is becoming an all too common experience. Many of you will remember the ill-fated BLAST compiler that promised so much and delivered so little. Some of the faults in this package were put right with later versions, but who could recommend a piece of software which was originally supplied with so many faults that it proved impossible to use?

Just who should take the blame for lack of support is open to question. Some software suppliers blame narrow margins — they just can't afford to provide the sort of back-up offered to business users who will happily pay ten times more for a comparable package to run on a PC or PC clone. Others blame those users who knowingly and illegally pirate software by making copies and giving them to friends thereby reducing the income that should be realised by a piece of software. It is an unfortunate fact of life that the more successful an item of software is the more it will be pirated.

Organised software piracy on a large scale is rife in many countries and unauthorised copies of virtually any of the best selling business software can be obtained for prices starting at as little as £1! Illegally copied software is often "bundled" into "package deals" for cheap PC clones in many Far Eastern countries. All of this is doing nothing to raise the level of support we can expect from software houses.

Fortunately, end users are slowly getting wise to the need for effective software support. No longer will they pay for a package which just might perform to expectation. Somebody out there had better sit up and take notice.

Having painted a rather gloomy picture, it is fair to say that some software houses do provide consistently good back-up for their products. Typical of this is the regular Newsletter provided by Betasoft for their BETA BASIC package (more about this later). It takes effort and commitment to produce such an item and those involved should be congratulated — other software suppliers please take note!

Earlier, I made specific mention of Ocean's Laser Genius. As a user of this particular software I am obviously keen that it should stay in existence even if the original authors, Oasis, are no longer in business. If any readers have experienced problems with this package (or, even better, can offer suggestions or solutions) I would be interested to hear from them. If sufficient interest is shown I would be willing to form a "self-help group" which could extend its activities to the entire range of software development packages available for the Spectrum.

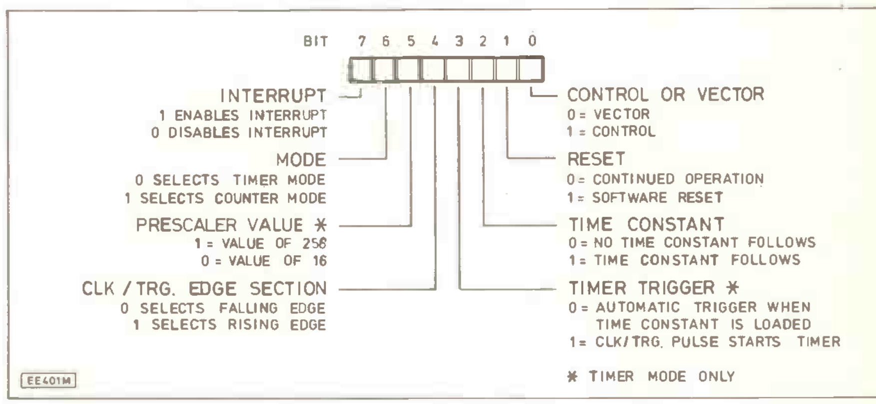


Fig. 1. Channel control word format.

Even better BETA BASIC!

Regular readers of this column will know that I am a fan of Betasoft's BETA BASIC. Some time ago I reviewed version 3.0 of this package and came to the conclusion that it had a tremendous amount to offer anyone who programs in BASIC (I guess that must be just about everybody!).

It was pleasing to note that Betasoft have further enhanced BETA BASIC with release 4.0 which is for Spectrums with 128K memory (i.e. the 128K and Plus Two machines). BETA BASIC 4.0 makes use of the additional facilities offered by the 128K versions of the Spectrum. ALL the commands and functions of BETA BASIC 3.0 are still available and existing BETA BASIC 3.0 programs should run without modification.

BETA BASIC puts the extra 64K of RAM to excellent use by allowing arrays of up to 64K. These arrays can be searched or sorted alphabetically very quickly indeed. RAM disc files can be moved to or from streams, or to the screen. BETA BASIC 4.0 also offers interrupt driven sound facilities; one now has full access to the sound chip without holding the program up every time a sound is generated! Some of the graphics commands have been enhanced, with faster or more flexible versions of CIRCLE, DRAW, PLOT and FILL.

An improved SORT command will sort RAM disc string arrays as well as normal string and numeric arrays. An array of 1000 random 60 character strings will be sorted in approximately 14 seconds – no mean feat for a humble Spectrum!

A CAT$() function returns the entire RAM disc catalogue as a string and can be used, from within a program, for checking the contents of the RAM disc. The use of BETA BASIC's CAT$() and INSTRING functions can be illustrated by the following:

```
10 INPUT "Filename to SAVE under: ";f$
20 IF INSTRING (1,CAT$(),f$)<>0 THEN ERASE !f$
30 SAVE !f$
```

This handy code module checks to see whether the given file exists and, if it does, the old file is erased before saving the new one. This overcomes a rather silly shortcoming in the 128K Spectrum's BASIC RAM disc handling. CAT$() also provides information on the type of file (program, numeric array, string array or code) and its length.

Two manuals are supplied with the BETA BASIC 4.0 package. One of these is the existing BETA BASIC 3.0 manual and the other relates to the 128K extensions in BETA BASIC 4.0. Both manuals are eminently readable and contain a wealth of useful examples. The BETA BASIC 4.0 supplement also provides some useful information for (real!) disc owners and for those using various types of printer interface.

BETA BASIC can be highly recommended; it won't turn your machine into an Atari ST or Commodore Amiga but it will certainly transform your programming and inject new life into your humble Spectrum. Expect to be impressed — this is another superb offering from Betasoft!

Betasoft can be contacted at 92, Oxford Road, Moseley, Birmingham B13 9SQ.

Programming the Z80-CTC Counter/Timer

The Z80-CTC is quite simple to program and operates in two distinct modes; counter mode and timer mode. The channel selection is achieved by means of address lines A5 and A6 which result in the following assignment of the channel control registers:

Channel	Address Lines								Port Address	
No:	A7	A6	A5	A4	A3	A2	A1	A0	Hex.	Decimal
0	0	0	0	1	1	1	1	1	1F	31
1	0	0	1	1	1	1	1	1	3F	63
2	0	1	0	1	1	1	1	1	5F	95
3	0	1	1	1	1	1	1	1	7F	127

A control word is recognised by the CTC whenever bit 0 of the data sent to the relevant channel control register is set. The remaining bits in the channel control register function according to the diagram shown in Fig. 1.

Bit 6 of the control register is particularly important as it determines whether the channel is used in timer mode or counter mode. Counter mode is enabled when bit 6 is set whereas timer mode is enabled when bit 6 is reset.

In counter mode, the CTC counts the edges of the clock/trigger input of the channel in question. In timer mode, the CTC generates timing intervals that are an integer value of the system clock period.

Timer Mode

For the moment, and for the remainder of this instalment of *On Spec*, we shall confine our use of the CTC to timer mode. Next month we shall show how the device can be employed in counter mode.

In timer mode the CTC generates timing intervals that are an integer value of the clock period. The clock is fed through the prescaler and down-counter. Depending upon bit 5 in the control register, the prescaler divides the clock by a factor of either 16 or 256. The output of the prescaler is then used to decrement the down-counter, which may be programmed with any time constant integer between 1 and 256. The time constant is automatically reloaded into the down-counter at each zero-count condition. At zero-count, the channel's time out output (ZC/TO) is pulsed resulting in a uniform pulse train of precise period given by:

$$t_{out} = t_c \times P \times TC$$

where t_c = clock period (0.285714285 μs)
P = prescaler factor (either 16 or 256)
and TC = time constant data word (1 to 255)

Timing may be initiated automatically or with a triggering edge at the channel's timer trigger input (CLK/TRG). This is determined by programming bit 3 of the channel control word. If bit 3 is reset, the timer automatically begins operation at the start of the CPU cycle following the I/O write machine cycle that loads the time constant data word. If bit 3 is set, the timer begins operation on the second succeeding rising edge of the clock after the timing trigger edge following the loading of the time constant data word.

If no time constant is to follow, the timer begins operation on the second succeeding rising edge of the clock after the timer trigger edge and following the control word write cycle. Bit 4 of the channel control word is pre-programmed to select whether the timer trigger will be sensitive to a rising or falling edge. If bit 7 in the channel control word is set, the zero-count condition in the down-counter initiates an interrupt sequence.

The longest output period obtainable using a single channel of the CTC interface (with a prescaler divisor of 256 and time constant data word of 255) is 18.67ms (corresponding to a pulse repetition frequency of approximately 54Hz).

The shortest output period obtainable using a single channel of the CTC interface (with a prescaler divisor of 16 and time constant data word of 1) is 4.576μs (corresponding to a pulse repetition frequency of approximately 218.53kHz).

The desired values to be used in the prescaler and time constant data word can be easily calculated using the formula given earlier. As an example, suppose that we require a pulse repetition frequency of 1kHz (i.e. a period of 1ms of 1000μs). If we employ a prescaler divisor of 16, we can arrange the formula given earlier along the following lines:

$$TC = \frac{t_{out}}{t_c \times P}$$

$$TC = \frac{1000}{0.286 \times 16}$$

(Note that t_{out} and t_c are BOTH in μs)
Hence TC = 218.5

Since we have to use an integer value in the time constant data word a value of 219 should be employed.

Repeated calculations of time constant data words can be a little tedious and, where it is necessary to calculate a succession of values for loading into the down-counter, readers can make use of their trusty Spectrums aided by the following program:

```
5 CLS
10 INPUT "Period of output (us)"; tout
20 LET P = 16
30 LET TC = tout/(0.286*P)
40 IF TC<1 THEN BEEP 0.1,0.1: GO TO 10
45 IF TC>256 THEN GO TO 100
50 LET P = 256
60 LET TC = tout/(0.286*P)
70 IF TC>255 THEN BEEP 0.1, 0.1: GO TO 10
100 PRINT "Frequency of output = ";
      1000000/tout
110 PRINT "Prescaler = ";P
120 PRINT "Time constant = "; INT(TC)
125 PRINT: PRINT "Any key to continue,"
126 PRINT "or press Q to quit . . ."
130 LET r$ = INKEY$
132 IF r$ = "q" OR r$ = "Q" THEN STOP
135 IF r$ = "" THEN GO TO 130
140 GO TO 5
```

Testing the Z80-CTC Interface

The CTC can be tested in counter mode using the following program which generates a signal having a PRF of 218.5kHz on channel 0:

```
10 REM Load code module
20 FOR i = 0 TO 12
30 READ x
40 POKE 32768 + i, x
50 NEXT i
60 DATA 243,217,62,127,219,254,31
70 DATA 218,2,128,217,251,201
100 REM CTC commands
110 OUT 31, BIN 00010101
120 OUT 31,1
130 PRINT "Press SPACE to continue . . ."
140 RANDOMIZE USR 32768
150 STOP
```

The first section of code POKEs a short machine code module into memory starting at 32768 decimal (8000 hex.). This code routine disables interrupts which would otherwise cause discontinuities in the output signal as an interrupt occurs every 20ms with the Spectrum in normal operation. Having disabled interrupts, the code waits for the SPACE (or BREAK) keys to be pressed. If either is pressed, interrupts are re-enabled (restoring keyboard input) and the program terminates. Note that, in this condition, the channel will still be producing an output but this will no longer be "clean" due to the presence of interrupts (which momentarily stop the system clock as it passes through the Spectrum's ULA).

Line 110 send the channel control word to the channel control register associated with channel 0 (port address 31). Note the use of the Spectrum's BIN keyword which makes it very simple to understand the structure of the control word (relate this to Fig. 1). Line 120 contains the time constant (in decimal) which is loaded into the down-counter for channel 0.

Readers having access to an oscilloscope may like to check that the output waveform produced by the CTC Interface looks like that shown in Fig. 2. Readers not having access to an oscilloscope need not despair since the l.e.d. indicator driven by the channel 0 output should illuminate when the program is first run.

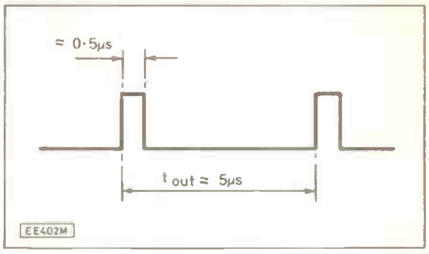


Fig. 2. Waveform produced by the test program.

Readers may wish to further experiment by entering different time constants in line 120. As an example, OUT 31,22 in line 120 will produce an output of 10kHz (actually 9.94kHz) whereas OUT 31, 219 in line 120 will produce 1kHz (actually 998Hz). Note that the l.e.d. indicator will become progressively dimmer as the duty cycle decreases. At 10kHz the l.e.d. will glow dimly, at 1kHz it will be barely illuminated.

If you would like a copy of our *On Spec Update*, please drop me a line enclosing a large (at least 250mm × 300mm!) stamped addressed envelope.

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

Next month: We shall be showing how the Z80-CTC Interface can be used as an event counter.

Robot Roundup

NIGEL CLARK

ROBOTS SIDE-LINED

LAST month's comprehensive list of robots was missing some well-known names, most of which had been around for a number of years, including BBC Buggy, Armdroid and the Memoco Electron. Some have been discontinued and some are in abeyance. And they have been joined by the Alfred arm.

The Buggy and Electron have been stopped but the Armdroid and Alfred are showing signs of continuing, albeit in other guises.

Economatics, which designed the Buggy for the BBC series *Computers in Control* a few years ago, using Fischertechnic parts, said it was being stopped because of problems in obtaining the electronic components. The company added that the add-ons, a gripper and penholder, would still be supplied but the last of the buggies had been sent out.

Production of the Electron, a computer-controlled version of the old Armatron from Tandy, has been stopped because of pressure of work in other parts of the company. Memoco Electron Developments began research and development work some time ago while still planning to upgrade the Electron. However, the R & D work expanded and the Electron was side-lined.

"There is certainly a market for the arm," said Bob French who runs Memoco. "I stopped advertising it last November but I am still getting enquiries." However, the machine is now out of stock.

He added that he had not thought about it in detail but if anyone wanted to take over manufacture he would consider an offer. Some of the company's development plans were well advanced and there was a prototype mobile version controlled via both infra-red and radio links.

ON THE QT

The Colne Armdroid arm appears to have stopped being supplied as well.

When Colne Robotics went into liquidation last year the rights to the five-axis arm were taken over by a company called Qti which traded under the name of Qti Colne Robotics. The Armdroid name was maintained and there were plans for upgrading similar to those of the original Colne.

Nothing has been heard of the company for some time. However, plans by a group of former Colne employees to create a machine based on the Armdroid are going ahead.

Originally it was intended that the employees, as part of a group known as Richmond Logic, would design the machine with the working name of Connect 2 and it would be marketed by Shesto Tech. Richmond has now been disbanded, two of the staff have joined Shesto and the company is bringing out an arm known as Armtech 2000.

The new machine is a five-axis arm with toothed-belt drive and can be used with any computer which has a standard 8-bit parallel port. However, no specific software has been written.

The likely cost to educational establishments of the Armtech 2000 arm is expected to be around £450, plus VAT. There is also the most obligatory workcell to go with the machine.

The workcell includes a linear slide base, a rotary carousel and conveyor belt. Other accessories include pneumatic and relay kits and vacuum gripper. The arm can be controlled through its own keypad.

A larger and more robust version is being developed, but there are no further details at the moment.

FIRST SHOWING

The Armtech 2000 is getting its official launch at the *Craft, Design and Technology Show*. The event, which is aimed at the teaching of CDT subjects in schools, is being held this year over three days from Thursday October 15 to Saturday October 17. Previously it has been staged at the Wembley Conference Centre but this year it has moved to the National Exhibition Centre in Birmingham.

A service to convert existing Armdroids from the string-driven version to what Shesto calls a more efficient silent and trouble-free toothbelt version is under way. Whatever the truth of the claims, Amrdroids have always suffered from a certain lack of precision because of slippage by the driving strings.

Owners who wish to take advantage of the offer should send their machines to Shesto who will carry out the conversion for £160, and £10 for carriage, plus VAT. They promise a turnaround of between two and three weeks.

The company also supplies new software for the converted machines although they will work on the old Colne software.

The story of Alfred is a little less clear at the moment. The low-cost five-axis articulated robot arm, which was featured as a project in *Everyday Electronics* a few years ago, was originally designed and manufactured by Robot City Technology.

The company closed earlier this year and for a time it appeared that production would be taken over by another Milton Keynes company.

Oxbridge Technology had shown an interest but after about three months of talks with Robot City managers, Alan Green and Dave Dowty, and investigations, no agreement could be reached. Green and Dowty decided to go ahead on their own.

The formed a new company, Research Development Associates, and bought the rights and assets of Robot City. Since then they have been selling Alfred, at about £270 + VAT assembled and £200 + VAT in kit form, and its bigger spin-off R-200, at about £2,000.

"There is still a lot of goodwill from the days of Robot City and people remember the Alfred name," said Dowty. He added that talks were being held with two major educational distributors to take Alfred. Whoever won the deal would be launching the machine at CDT.

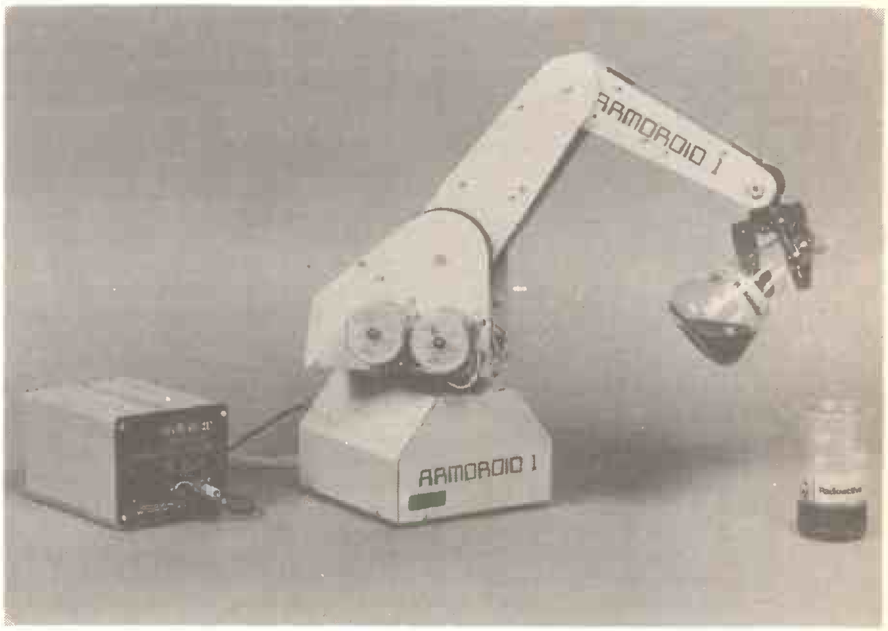
The deal might also include R-2000 but as this machine is aimed more at industry they may continue to sell it direct. They intend to rename it MARS, standing for Modular Automation Robot System, which is a good way to get an acronym.

In the meantime, Oxbridge is pressing ahead with plans for its own arm known as Archie. It has been announced, but the company is not releasing full details until it has sorted out its marketing plans.

Another launch planned for what it seems is going to be a busy CDT show is an addition to the range of technical kits. Joining Lego, Fischertechnik and Meccano is Plawco which, with the usual surfeit of imagination, has named its kit Plawcotech, and is being distributed by Commotion. In addition to the present kit of plastic components for making various models the "tech" package will contain gears, wheels and motors.

The full Plawcotech kit costs about £50 and the technical parts can be obtained separately for about £20. Interfaces are not available but Commotion say that the kit could be used with Beasty servos and interface which will allow the models to be controlled by a variety of small micros.

The Armdroid 1 arm



FOR YOUR ENTERTAINMENT

BY BARRY FOX

Cordless Code

At long last, it is illegal to sell unauthorised cordless telephones. It has always been illegal to *use* them, but a loophole in the law left shops free to sell hardware that could cost the customer a £2,000 fine and three months in jail under the "Wireless Telegraphy Act".

To set the record straight, Britain authorises cordless phones which send and return on the 1.6MHz and 47MHz bands, at a power of 10mW or below. Foreign imports often operate on different frequencies (e.g. 49MHz) and at higher power.

Look for the green approved circle, and steer clear of anything with a red warning triangle — even if it is on sale at ridiculously low prices, often out of the back of a car boot. Last year 16 people were convicted for using unauthorised cordless phones. There will be more this year.

Authorised cordless phones are getting cheaper all the time. From nearly £200 they have now fallen to around £69. But if you are buying, do watch out for the pitfalls.

Unless the handset and base station are electronically paired there is a good chance that someone else with the same make of telephone will be able to make calls on your base station, and so get them charged on *your* line. Fidelity of North London, the only firm actually making cordless telephones in Britain, has a security system based on around 64,000 codes. Each base station and handset is individually paired with one having the same code.

Cross Words

Once Fidelity has made 64,000 systems, the company will start re-using the same codes over again. But even then there will be very little chance of two matching handsets and base stations ending up next door or in the same block of flats. Some cheaper cordless phones use no security codes, or make do with only a few hundred so that cross dialling is much more likely.

Because there are only eight channels in the allocated frequency band, there is always a good chance that two neighbouring phones will interfere with each other to give the equivalent of a crossed line. Fidelity identifies each matched pair with a channel code A, B, C, D, E, F, G or H.

If you buy an A channel pair and find by bad luck that your next door neighbour is already operating on the A channel then — in theory at least — you can go back to the shop and ask to exchange your units for a B pair, and so on. It's not ideal, but at least it's a practical solution to an otherwise insuperable problem.

Not So Smart Imitation

The Hayes Smartmodem for electronic mail and computer communication, has a built-in loudspeaker which gives low-fi monitoring of how a call is progressing. You can hear a call being dialled, listen to the ringing tone and briefly hear the remote modem answering. Then the modem switches off.

Some Hayes-imitation modems cut cost by omitting the loudspeaker. The makers say there isn't room for one. Maybe, maybe not. But a loudspeaker can be very useful.

A friend of mine bought a speaker-less modem and couldn't get it to work with the Telecom Gold electronic mail service. It was only when he borrowed a Hayes modem that he found out why.

Some weird fault on his line was repeatedly misrouting calls from Telecom Gold to the private home of what sounded like a little old lady. Every time the modem dialled Telecom Gold, it reached the little old lady instead. All she heard was a modem whistle at the other end of the line. And she was getting pretty fed up with it. When my friend plugged in the Hayes, he heard the low-fi sound of a frustrated voice saying, "Who is that who keeps calling and whistling?"

■ *Thought for The Day* ■

This Christmas, spare a thought for the Germans. They are only getting one day off this year.

The great British Christmas shut-down starts earlier every year and goes on longer. From mid-December it becomes increasingly harder to find company spokespersons who aren't shopping, partying or lunching.

The official Christmas break now stretches through New Year's Eve to early January. Japanese firms send out business letters dated December 25, but it's a non-Christian country — even though the shops are now full of Christmas cards at this time of year.

West Germany is the surprise. If Christmas falls over a weekend, that's tough luck on the workforce. They get Saturday and Sunday off and start again on Monday with nothing in lieu. It's known in Germany as a "bad year" or a "good year".

A good year for the workforce, when Christmas falls mid-week, is a bad year for the employer. A good year for the employer is a bad year for the workforce.

This year it's half and half. Boxing Day is on a Saturday. So they get Friday off and that's all.

Talking Toys

Each year the world sinks deeper into a new crust. It is made up from discarded gadgetry. There is now a world industry in electronic and mechanical "nick-nacks" which do something clever.

When that something is unashamedly pointless the gadget is labelled a toy. As the saying goes, it is only the price of their toys which now distinguishes the men from the boys.

Adults worry about buying toys. The staff at Hamleys in London, the largest toy shop in the world, soon get used to selling train sets to fathers on their way to the maternity ward to see a three-hour old son for the first time.

Last Christmas I took a trip to Hamleys' London store to find out about new trends in electronic toys. I found that solid state recording is the common factor.

Smarty Bear and Baby Talk dolls both have a microprocessor and memory inside which are triggered by the sound picked up in a hidden microphone. So they churn out stock phrases at random whenever someone talks to them.

At the same time a motor drives a gear to move the mouth and eyes in synchronism with the speech. Pressure sensitive switches trigger a giggle.

Circuit response time is deliberately slow. This way they ignore sharp impulse sounds and respond only to a few seconds of speech. The phrases are cleverly nondescript.

"Who is President of the United States", I asked Smarty Bear. *"Better ask again later"*, he said first time. *"That's a tough question"* was the next answer.

"What's 2 plus 2?" produced the answer "For sure", which sounded uncannily like "Four".

The Teddy Ruxpin bear doll has a tape recorder built in. The audio signal of the tape triggers synchronised mouth and eye movements. Synchronisation is by coded pulses on a custom tape. But some music, like heavy rock, has a similar effect.

Blabber Mouth

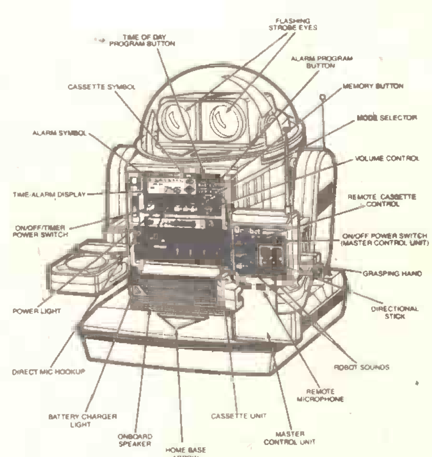
The Talking Friends toy bear works like a spy's bug. The body contains a microphone, loudspeaker and solid state recording device. Any loud sound starts the system loading three seconds of audio into a random access memory chip. When the memory is full the stored sound is automatically replayed. So the bear immediately mimics everything that is said to it.

Blabber Mouse is a radio with a model mouse on top. The mouse has a moving mouth and a signal level sensor in the radio circuitry detects peaks in the audio signal and moves the mouth in sympathy. The effect on serious news broadcasts and political speeches is not to be missed.

This kind of gimmick does not come cheap; it costs between £20 and £60. Although marketed by British toy firms, all the technology is made in the Far East. So too is the Tomy range of robots. Each has a disarming personality all of its own.

Mini robots, like Dustbot and Dingbot walk, run or roll around until called to a halt with a sharp shout or clap. A built-in microphone senses transient peaks and temporarily disconnects the motor drive. The robot then sulks for a few seconds before bustling off again.

The Tomy Omnibot 2000 is almost useful. Costing nearly £400 and larger than many children, it works either under radio control or pre-programmed timer. If you want to be woken in the morning with orange juice, Omnibot will roll across the room with a tray, grab a jug of orange juice with its claw hand, pour the drink into a glass, flash his eyes and say whatever morning greeting the proud owner has recorded on tape the night before.



Omnibot personal robot from Tomy Toys.

DECEMBER FEATURES...

FREE! TWO DATA CARDS

The start of a series of eight Data Cards. Cards 1 and 2 give information on the 6502 microprocessor. The reverse of each card will give more general information, e.g. binary-hex-decimal conversion tables.

16 PAGE RTVC CATALOGUE

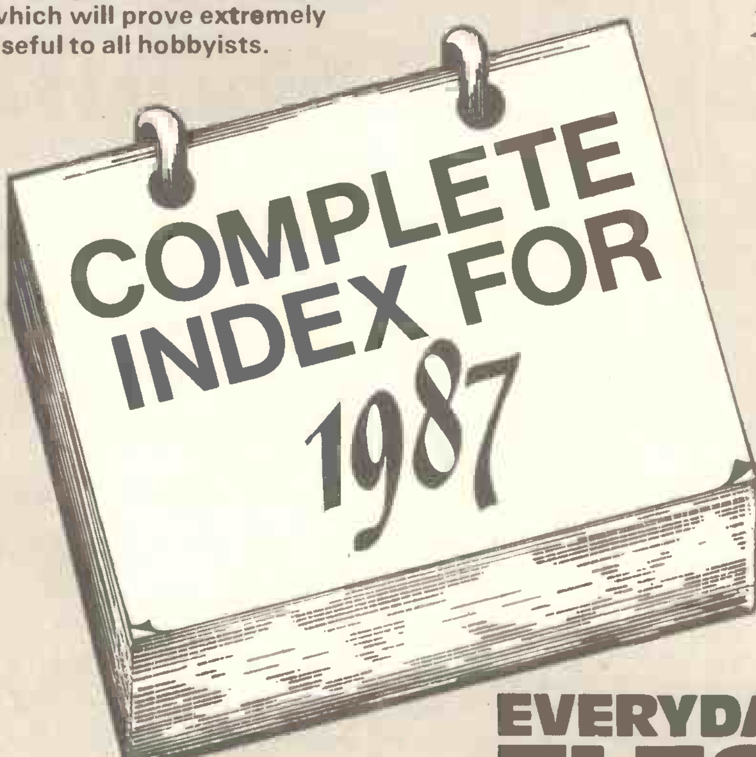
Another free catalogue attached to the centre of every issue. 16 pages mainly featuring loudspeakers and test gear from R.T.V.C.

AUDIO SIGNAL GENERATOR

A straightforward item of test gear which will prove extremely useful to all hobbyists.

Xmas Tree Lights

Two simple lights projects published with Christmas in mind. A control for tree lights and a Twinkling Star.



If you want to know what projects we published in '87 or if you keep your issues in a binder our comprehensive index published in the December issue is a must.

EVERYDAY ELECTRONICS

December issue on sale Friday November 13.

Actually Doing it!!

In last month's *Actually Doing It* we considered various ways of producing a photographic master from which a printed circuit board can be produced. Having reached that far, and by whatever means, there is then the minor matter of actually producing the board! The first stage is to prepare a suitable piece of printed circuit material.

PHOTO-RESIST

You can buy copper laminate board ready-coated with photo-resist, or resist can be added to ordinary copper laminate board. I have produced a number of boards using an ordinary board plus a do-it-yourself layer of photo-resist, and I have used both brush-on and spray-on resists. To be completely honest about it, I have always found it difficult to obtain a reasonably even coating of resist using either method, and on occasions I have struggled to get a usable end result at all. This could be due to a lack of skill on my part rather than something fundamentally wrong with the photo-resists, but initially at any rate, I would strongly recommend the use of ready coated boards. Even these often have a less than perfect coating of resist, but they are generally good enough to enable a sound finished article to be easily produced.

The basic scheme of things is to cut the board to size, expose it to ultra-violet light via the master art-work, and then develop the board. This gives a board having resist left on the areas where copper tracks and pads are needed, but devoid of resist in other places. This is then etched and drilled in the usual way.

The photo-resist boards all seem to have a protective layer of plastic or paper over the etch resist, and this enables them to be handled in normal light without any risk of fogging. It also protects the delicate coating from physical damage. Even with the protective layer, the board should be stored under dark conditions, and preferably somewhere quite cool. Although it can be obtained more cheaply if ten or more boards at a time are purchased, the board has a shelf life of only a few months. It would therefore be unwise to stock up with large amounts unless it will all be used up fairly quickly. You will be in no doubt if the board has passed its "use-by" date, as it will simply fail to develop significantly.

The protective layer provides a useful medium when marking out the cuts in the board. Ballpoint pens seem to readily mark both the plastic and paper varieties. A hacksaw is used to cut the board, and this really needs to be a full-size type rather than a junior hacksaw. Cut the board with the copper/resist side facing upwards. Cutting the board when it is the other way up can tend to damage it by ripping the copper layer away from the fibreglass board material. The cut edges can be very rough, with some quite sharp edges being produced in some cases. A small amount of gentle filing should soon render these completely harmless.

EXPOSURE

Ideally an ultra-violet lightbox should be used when exposing the board, and these are available from some of the larger electronic component retailers. Unfortunately, they are fairly expensive, and are probably not a practical proposition unless you are likely to produce a substantial number of boards over a period of time. If you have access to a suitable lightbox the master art-work is taped to the glass top with the "copper" side facing downwards. In other words, the image you see when the art-work is on the lightbox should be a mirror image of the design copied from the magazine. Be very careful to get this right, as the finished board is unlikely to be usable if you get the art-work upside-down.

The board is taped in place over the art-work, and it is, of course, positioned copper/resist side facing downwards. The board is very insensitive by normal photographic standards, and it is little affected by visible light. Consequently it can be exposed to ordinary (indoor) light levels for periods of a few minutes without risk of fogging. Keep the board out of direct sunlight though, especially once the protective layer has been removed from the resist. Align the board accurately with the corner markings on the art-work. It is important that the lightbox has a pad of foam material in the lid to press the board firmly against the art-work, and a suitable pad must be added if it is not already present.

The optimum exposure time depends on a number of factors, such as the power of the lightbox and the amount of light passed by the clear areas of the art-work. It will range from just a couple of minutes with a powerful lightbox to as much as half an hour with a low power type and a drawing that is what might be termed a poor "conductor" of light. With my 16 watt lightbox I find an exposure time of around 18 minutes is about right. Provided the drawing is a good quality type with good opaque track and pad markings, it is better to have an exposure that errs on the long side than to use one which is too short. A little experimentation should soon reveal an exposure time that will give good results.

If access to an ultra-violet lightbox is not possible, the alternative is to improvise a simple exposure system. Something along the lines of Fig. 1 should suffice, and basically all that is needed is a sheet of glass to which the art-work is fixed, plus some means of pressing the board in place beneath this. As when using a proper lightbox, the board should be taped in place so that there is no risk of it slipping slightly out of position during the course of the exposure.

The obvious problem with an improvised lightbox is that an ultra-violet light source is required, and could prove problematical. An ultra-violet "sunray" lamp probably represents the most practical solution, but it will need to be positioned quite close to the board in order to obtain a reasonably short exposure time. Ultra-violet light is dangerous, and can be particularly harmful to the eyes. If you use a lamp of this type, read the instruction manual and take any necessary safety precautions. It is again a matter of making a few experiments to find the best exposure time. Provided the lamp to board distance is always the same there should be no difficulty in obtaining consistent results using this method (which is one I used successfully for some time before obtaining a lightbox).

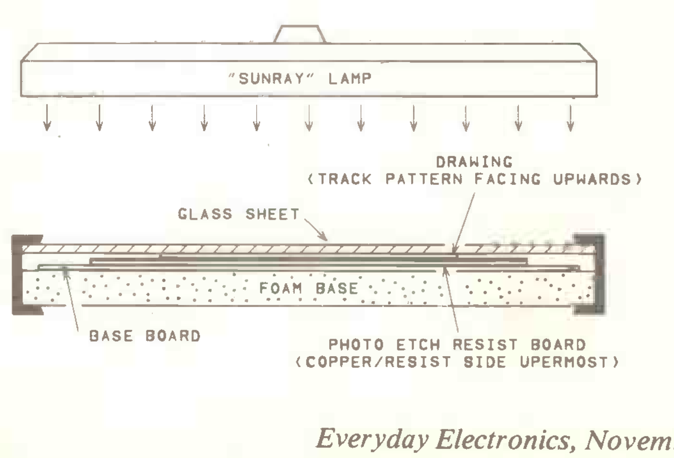
Sunlight is the other option, and although its zero cost makes it seem an attractive method, there are a couple of drawbacks with this method. The obvious one is that in Britain it is often in short supply, and on an overcast day it may well prove to be impossible to obtain a proper exposure. Even if you are prepared to wait for the sun to make an appearance, attempts to get consistent results might prove to be fruitless. The strength of sunlight varies according to the time of day, time of year, and on just how clear the atmosphere happens to be. You may find that after a few experiments you can correctly estimate the required exposure time for the prevailing conditions, or you might end up wasting a lot of expensive photo-resist copper laminate board. It is not a method I could wholeheartedly recommend, but I have managed to successfully produce a few boards using it.

DEVELOPMENT

Having exposed the board, on careful examination the track pattern will probably be visible as a faint image in the resist. The board should be developed as soon as possible after the exposure has been made. The usual developer is a solution of sodium hydroxide, which is perhaps better known as caustic soda. It should be possible to obtain sodium hydroxide crystals from large chemists, photographic suppliers, and some of the larger electronic component suppliers.

Caustic soda lives up to its name, and it should not be manipulated by hand. If the crystals should come accidentally into contact with you, or anything (or anyone) else, thoroughly wash the area of contact at once. The standard developer for spray-on resists is seven grams of caustic soda to one litre of water. For ready-coated boards a stronger solution seems to be needed, with about 15 to 20 grams per litre of water giving good results. The catalogue of the retailer who supplies you with the board or photo-resist may well give details of the recommended developer solution, and may also list suitable developer or crystals. In this case, it would obviously be advisable to follow the retailer's recommendations.

Fig. 1. With a little ingenuity a u.v. lightbox can be improvised.



The developer is not a very strong solution, and as such it is less dangerous than the crystals. However, it still needs to be treated with respect, and contact with your skin should be avoided as far as possible. A flat bottomed dish is needed when developing the board, and proper photographic dishes are ideal. Any dish having a flattish bottom and of adequate size to accommodate the board should suffice though. Place the board in the dish (with its copper side uppermost) and then pour in enough developer to thoroughly cover it.

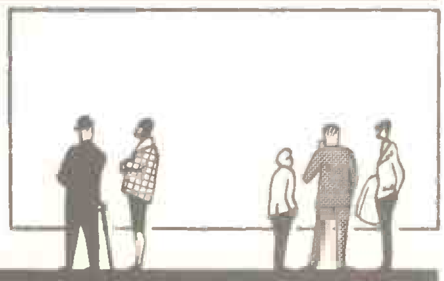
You may find that by gently agitating the dish for a few minutes the unwanted resist is removed, leaving the required pattern on the board. Things rarely go this smoothly though, and in order to get the board to develop reasonably quickly it is usually necessary to swab it with a cotton bud or a piece of kitchen towel. Rapid development is important, as there is a real danger of tracks and pads being seriously eroded if development takes too long. Do not leave the board in the developer any longer than is absolutely necessary in order to remove the unwanted resist. On the other hand, do not be too eager to remove it, or you might end up with large areas of unetched copper on the finished board.

When development has been completed, remove the board from the dish using tweezers, and thoroughly rinse it in water. Sodium hydroxide developer is not reusable, and the contents of the dish should be discarded. The board should now be ready for etching. Where possible, it is advisable to etch the board immediately, as this gives the copper no chance to oxidize in the air (which could hinder the etching process). It is a good idea to carefully examine the board, as there may be slight imperfections in the resist pattern. It is much easier to deal with these now rather than after the board has been etched. Any problems will normally be in the form of cracks in tracks, or thinning of tracks or pads. To repair any imperfections, first dry the board, and then use an etch resist pen or transfers to make the corrections.

Having reached this stage the board is next etched and drilled using the standard techniques, which will be described in next month's *Actually Doing It*.

Robert Penfold

SHOP TALK



BY DAVID BARRINGTON

On Course

The interest in our new C & G Certificate series *Introducing Microprocessors* has been very rewarding with enquiries from students, colleges and industry alike. However, for all those readers who would like the complete series now we regret that for several reasons we are unable to meet their requirements. – Why not take out a subscription or place a regular order with your newsagent now?

Good news for readers in the Manchester area, we have heard from North Trafford College that if they receive sufficient enquiries it may be possible to offer the college facilities for assessment purposes.

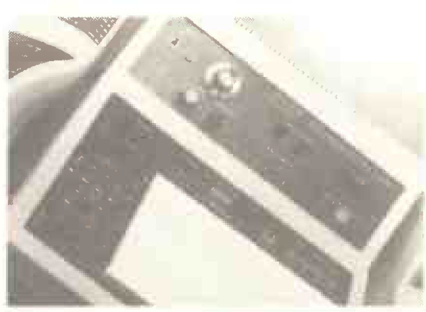
Interested parties should write to **Mr J. Priest, Head of Engineering, North Trafford College, Talbot Road, Stretford, Manchester M32 0XH. ☎ 061-872 3731.**

Digi-Lab

Still on the microprocessor front, we have received news of a comprehensive workstation for those involved in advanced digital electronics. **Flight Electronics** have recently introduced the FLT-102 Digital Training Laboratory.

Built-in features include: a multi-rail variable d.c. supply; four-range digital voltmeter; function generator; seven segment displays; logic switches; function switches; pulse switches and logic indicators. Components with 0.3mm to 0.8mm leads can be plugged into the large 1680 tie-point "test-bed" which accepts all d.i.p.s.

The FLY-102 trainer costs £250 and, for bona fide educational and industrial establishments, a 30-day evaluation period is available. Flight have also just launched their sixth annual 44-page, full colour, catalogue which is available *Free* from: **Flight Electronics, Dept EE, Ascupart Street, Southampton SO1 1LU. ☎ (0703) 227721.**



CONSTRUCTIONAL PROJECTS

Acoustic Probe

The 2W power amplifier i.c., type TBA820M, used in the *Acoustic Probe* is a very popular device and is listed or stocked by practically all of our advertisers.

The "heart" of the probe sensor is made from a piezoelectric buzzer element from the PB2720 range. The ceramic element is available separately from most component stockists.

The element is supplied unhoused and without connecting wires, and soldering to the silvered electrode *must* be carried out with the absolute minimum of heat. The brass rim of the transducer tends to form a heatsink and obviously more heat will be required to attach a connecting wire, but once again it is essential to keep the heat down to a minimum.

When buying the BC184L transistor it is important to purchase a device that carries the suffix **L** as pin connections for this device vary. The printed circuit board for the Acoustic Probe is available through the *EE PCB Service*, order code EE584.

BBC Sideways RAM

The 64K CMOS Static RAM chip, type 6264, called for in the *BBC Sideways RAM* must be in scarce supply in some areas. However, it is still listed by Maplin, Cirkit and Omni Electronics.

The i.c. sockets and interconnecting ribbon cable should not prove difficult to purchase and are usually listed under "computer accessories" sections in component suppliers catalogues. The printed circuit board for this project is available from the *EE PCB Service*, code EE585 (see page 628).

Oil Tank Contents Gauge

The only source we have been able to locate for the dial cord drum, used as part of the tank sensor unit in the *Oil Tank Contents Gauge* project, is Maplin. This is listed as a "Cord Fixing Drum", code RX94C (Cord Drum Large). The 6:1 reduction ball drive appears to be available from both Maplin and Cirkit.

The linear bargraph driver i.c. and 10-segment red bar display are fairly common devices and widely stocked and should not cause buying problems. It may be a cheaper alternative to use 4-core telephone wire (using only 3-cores) in place of the 3-core light duty connecting cable. The 4-core cable is now readily available from most components shops.

Accented Metronome

The LM4017 decade counter i.c. listed in the components list for the *Accented Metronome* is another device that is now a common item and should be available "off-the-shelf" from most suppliers.

The 10-segment bargraph array is also fairly common and should not cause sourcing problems. The anodes of this device are identified by the side which carries the product code mark.

The printed circuit board is available from the *EE PCB Service*, code EE582.

We cannot foresee any component buying problems for the *Object Counter* – this month's *Exploring Electronics* project.

...REPORTING AMATEUR RADIO...

TONY SMITH G4FAI

OLD-TIMERS

There are some radio amateurs on the air today who made their earliest transmissions in the days of spark transmitters. I know one who first went on the air in 1910! Many of them belong to the Radio Amateur Old Timers' Association, membership of which is limited to those who have held an amateur transmitting licence, or have had a continuing interest in amateur radio, for not less than twenty-five years. With the experience of so many going back long before that, however, the journal of the Association, *OT News*, makes fascinating reading, preserving for posterity knowledge, memories and experiences which would otherwise be forgotten.

There's the story of the late Ken Alford, G2DX, who originally obtained an experimental licence with the call TXK in 1912, using a spark transmitter and crystal detector bought at Gamages in Holborn for £5. He took this equipment up in a friend's aeroplane over Lake Windermere, and the reception of his signals on the ground could well have been the first air-to-ground communication.

G2RW recalls how in the 1920s, while serving in the RAF in India he and a friend, using home-made equipment on the then new short wave frequencies, made contact with Gerald Marcuse, G2NM, culminating with Marcuse sending "Congratulations on the very first two-way communication between the UK and India".

REUNION

Some of today's old timers come back to the hobby after a long absence. *OT News* reports the return, after 58 years, of Marcus Samuel, G4FX, described as radio's Rip Van Winkle!

Marcus became interested in radio, listening to broadcasts from 2MT, Writtle, in the early 1920s and received the call-sign G2ACU for experiments using an artificial aerial in 1923. He obtained a full licence, G5HS, in the same year and by the mid-20s was making pioneering transatlantic contacts.

Owing to domestic circumstances he was unable to operate after 1928 and remained "dormant" for ten years. In 1939 he applied for a new licence and was allocated the call-sign G4FX. However, he never used this call as he joined the Civilian Wireless Reserve, being called up soon after.

So it was that in January 1986 at the age of 81, and now blind, he made his first modern amateur radio contact! He soon crossed the Atlantic again, and he describes his first new contact with the USA thus: "It was made in the kneeling position – this was entirely due to my large dog being fast asleep and refusing to get out of the way." A far cry from those pioneering days of the 1920s!

MEMBERS WELCOME

Short wave listeners as well as licensed amateurs can join RAOTA. It costs £6 for the first year and £4 for subsequent years. This includes copies of the *OT News* quarterly, which can be received on tape if required. Nets are held on Thursdays at 11.00 and 19.00 clock time, on 3·765MHz, under the call G20T, when members keep in touch with each other.

Enquiries about RAOTA can be made to: ***The Secretary, Mrs Sylvia Havard, 1 Merricks Lane, Bewdley DY12 2PA,*** enclosing an s.a.e.

CHINA AGAIN

In the August column I described how Chinese amateur stations are getting back on the air again. I said that they were still relatively rare at present, but I didn't realise quite how rare.

According to a report in *Break-In*, journal of the New Zealand Association of Radio Transmitters, July 1987, there are just sixteen amateur stations operating in the People's Republic of China. They may be thin on the ground but they must be pretty busy. Plenty of British amateurs appear to have worked at least one of them, and the Chinese seem to be quite conscientious in sending out their QSL cards.

It's all quite exciting at present if you come across a BY station. But what is it going to be like, I wonder, when there are as many Chinese stations on the bands as there are Japanese!

QUESTION TIME

Q. What is an ATU?

A. An antenna tuning unit is a versatile instrument found in many amateur radio stations, although the one thing it rarely does is tune an antenna! Amateurs experiment endlessly with different types of antenna, trying to find the best one for their particular location and needs, and I will describe some of these in a later column.

All antennas have a *feed point* where a feeder line from the transmitter/receiver connects into the antenna, and it is important to have a suitable impedance at this point. Most radio equipment today requires an impedance of 50-70 ohms but this is only attainable in an antenna with dimensions physically or electrically designed to represent a half-wavelength around a particular frequency.

Such antennas can be *single-band* or *multi-band*, the latter being in effect a number of single-band antennas rolled into one by the use of various techniques. Connecting any of these to the equipment by means of a feeder (e.g. coaxial cable) of the required impedance usually produces a suitable "match" between antenna and transmitter/receiver and an ATU is not required.

If, however, the antenna is not accurately dimensioned for the frequency to be used the impedance at the feed point may be higher or lower than that desired. A mismatch may then occur, resulting in an unsatisfactory transfer of signal, with many modern transceivers automatically reducing their power output in the face of a mismatch.

Enter the ATU. This is a device to ensure that the feeder does not present a mismatch to the equipment in use. When the impedance of the feeder does not match the impedance of the antenna the feeder line itself acts as a transformer. An ATU then placed in the line near the transmitter finds itself faced with varying impedances depending on the frequency in use. The function of the ATU is to transform that impedance to meet the transmitter's needs, at the same time discriminating against the radiation of unwanted frequencies (harmonics) by the transmitter.

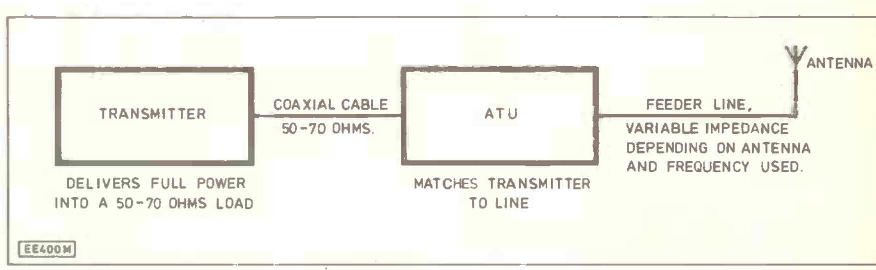


Fig. 1. Block diagram showing the function of an antenna tuning unit (ATU).

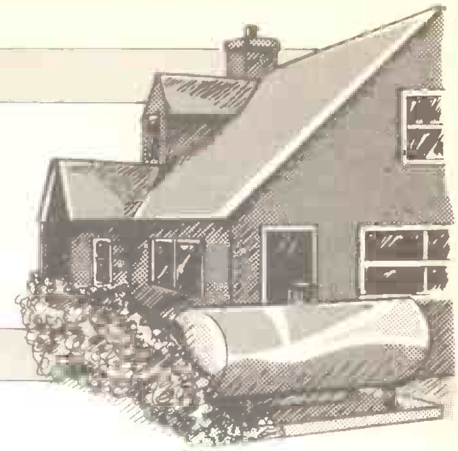
In receiving it ensures the maximum transfer of available signal from the antenna, and provides a high degree of selectivity, helping to reduce "image" interference from stations on other frequencies.

It does actually "tune" one type of antenna, i.e. random length end-fed wire antennas. Then, it functions as described for both transmitting and receiving as well as electrically adjusting the antenna to resonate at the desired frequency.

There are many types of ATU. They can be bought commercially, with de-luxe electric motor powered versions automatically adjusting all controls to achieve a perfect match; or they can be home-constructed from a choice of designs, some requiring only one coil and one tuning capacitor.

They are indispensable for antenna experiments and for day-to-day operation in many stations. Many designs have been published and they represent one of the most popular of all amateur radio construction projects.

OIL TANK GAUGE



T.R. de VAUX-BALBIRNIE

Avoid an empty tank with this in-house indicator

MANY householders use oil-fired central heating either by choice or because they are remote from a mains gas supply. They therefore rely on a storage tank which may be situated some distance from the main building.

It would be convenient to know, from a point inside the house, the quantity of oil in the tank. As well as avoiding an exhausted supply, this can help in budgeting and deciding when to buy the larger quantities which attract a discount.

Our battery-operated circuit indicates the oil level on a 10-point l.e.d. bargraph display. It is suitable for operating depths up to 1.5m (5ft. approximately). The system comprises two sections — a wall mounted unit housed in a plastic box and a tank sensor. The two sections are linked together using light duty wire.

The wall unit houses the circuit panel, l.e.d. display visible through a hole in the lid, push-to-test switch and 9V battery. The circuit draws current only while the switch is pressed so the battery will have a long life. It will be noted that negligible current flows in the tank sensor so eliminating fire risk.

Assuming a 300 gallon (1400L approximately) oil tank is used it may be that "Full" is to be indicated down to 275 gallons and "Empty" at 50 gallons. Each point on the display will then represent 25 gallons. This resolution is adequate for most household purposes.

LEVEL SENSOR

The chief problem with this type of circuit is that heating oil does not conduct electricity. Thus, any device relying on electrical conductivity, although working well with water-based liquids, will fail with oil.

In this device, a float and pulley system rotates a potentiometer to provide the electrical signal. Realising that many readers wish to concentrate on electronic aspects of construction, the mechanical side has been kept straightforward by using easily-obtained radio tuning dial components.

In use, the sensor is hooked over the filling opening of the oil storage tank. It is removed before filling and hand-wound to the start before replacing. Some readers may wish to fit a spring to return the float to the high position automatically. This was not considered worth while in the prototype since it is not done very often.

CIRCUIT DESCRIPTION

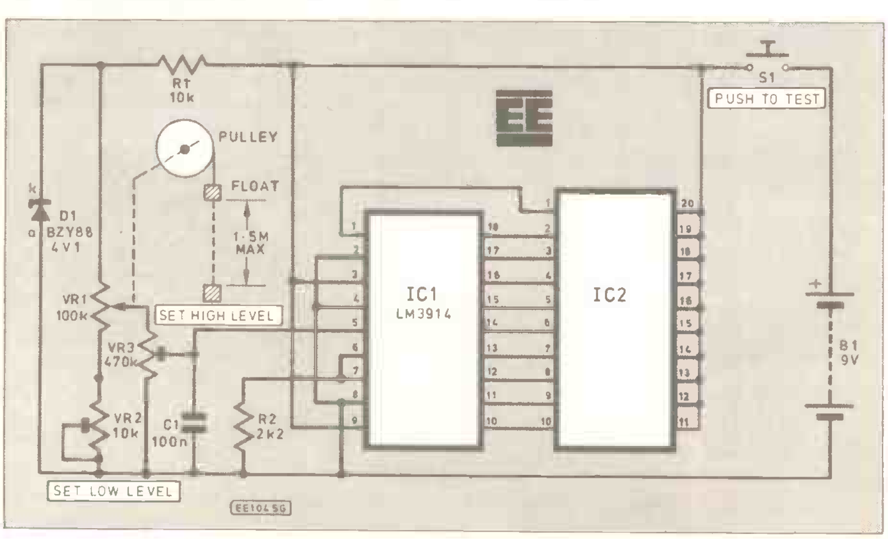
The full circuit diagram for the Oil Tank Contents Gauge is shown in Fig. 1. IC1 is a bargraph driver and IC2 an l.e.d. bar display. IC1 accepts a varying voltage at pin 5 and causes a number of IC2 "bars" to light according to the value of this voltage.

Potentiometer VR1 is part of the tank sensor and is connected through 3-core cable to the main unit. Here, Zener diode, D1, together with resistor R1, provide a reference voltage. VR1 selects a fraction of this voltage between its sliding or wiper contact and supply negative.

When the tank is empty (or at any predetermined low operating level) this voltage will be near-zero — the exact value depending on the adjustment of preset VR2 (Set Low Level). This is adjusted at the end of construction so that the first bar of the display is just on.

Preset potentiometer, VR3, selects a fraction of the voltage at VR1 sliding contact and applies it to IC1 pin 5. This is adjusted so that all IC2 bars light up with a full tank. In this way, the full range of bars are used whatever the range of VR1 rotation – that is, whatever the size of the tank. Resistor R2 sets the l.e.d. bar operating current to the correct working level.

Fig. 1. Complete circuit diagram for the Oil Tank Contents Gauge.



COMPONENTS

Resistors
- R1 10k
- R2 2k2
- All 0.25W 5% carbon

Shop Talk page 617

Potentiometers
- VR1 100k lin. rotary
- VR2 10k sub-min skeleton preset, vert.
- VR3 470k sub-min skeleton preset, vert.

Capacitors
- C1 100n polyester

Semiconductors
- D1 BZY88 4V1 Zener diode
- IC1 LM3914 linear bargraph driver
- IC2 10-segment red bar display

Miscellaneous
- S1 push-to-make switch
- TB1, TB2 3-way 3A terminal block (2 off)

Stripboard, 0.1in matrix size 14 strips × 19 holes; plastic case, approx. 80mm × 61mm × 41mm external; 18-pin d.i.l. socket; 20-pin d.i.l. socket; 3-core light-duty connecting wire; 9V PP3 battery and connector to suit; link wire.

TANK SENSOR

Sheet aluminium, 1mm thick; 10cm diameter dial cord drum; 6:1 reduction ball drive; brass bush; thin cord, approx. 2m; metal spacer; fixings; plastic bottle for float (see text).

Approx. cost Guidance only **£15**

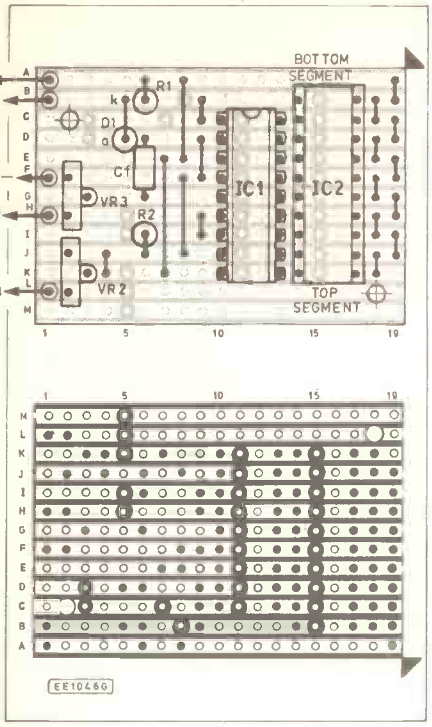
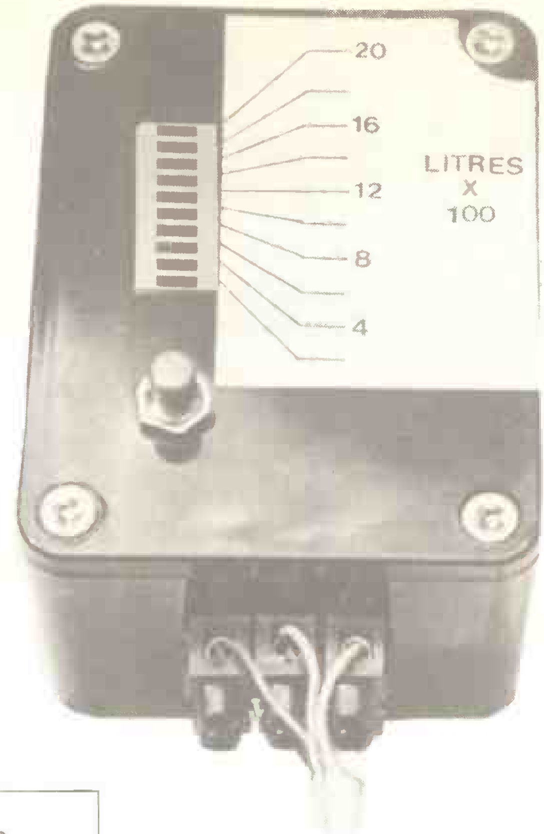


Fig. 2. (left). Circuit board component layout and details of breaks to be made in the underside copper tracks. The integrated circuits IC1 and IC2 should be mounted in i.c. holders.

(right) The completed display unit showing suggested "calibrated" scale, test switch and interconnecting terminal block.



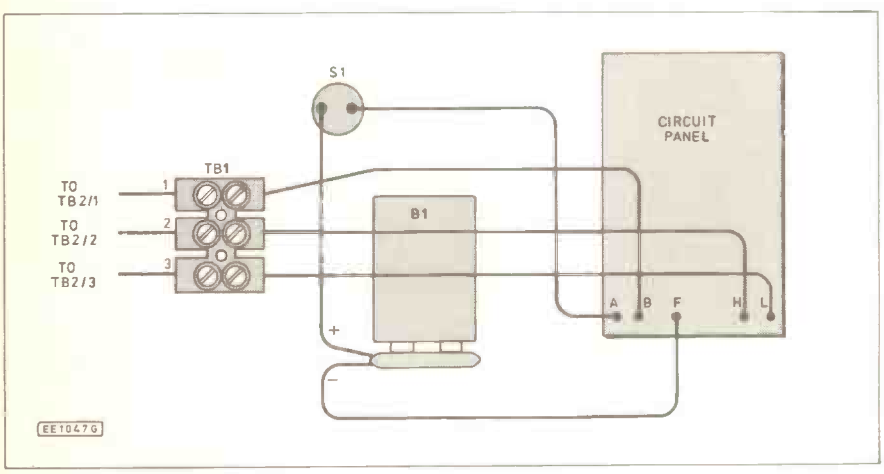


Fig. 3. (left). Interwiring from the circuit board, test switch S1, battery and interconnecting block TB1. The photograph below shows the orientation of the board in the case, i.c. presets on the right.

CONSTRUCTION

The circuit panel is constructed on a piece of 0.1in matrix stripboard, size 13 strips × 19 holes. Refer to Fig 2, cut this to size and drill the fixing holes.

The component layout and underside view showing breaks in the copper strips is shown in Fig 2. Solder the inter-strip link wires and make the track breaks as indicated. Follow with the soldered on-board components then make a careful check for errors — particularly for accidental "bridging" of copper tracks.

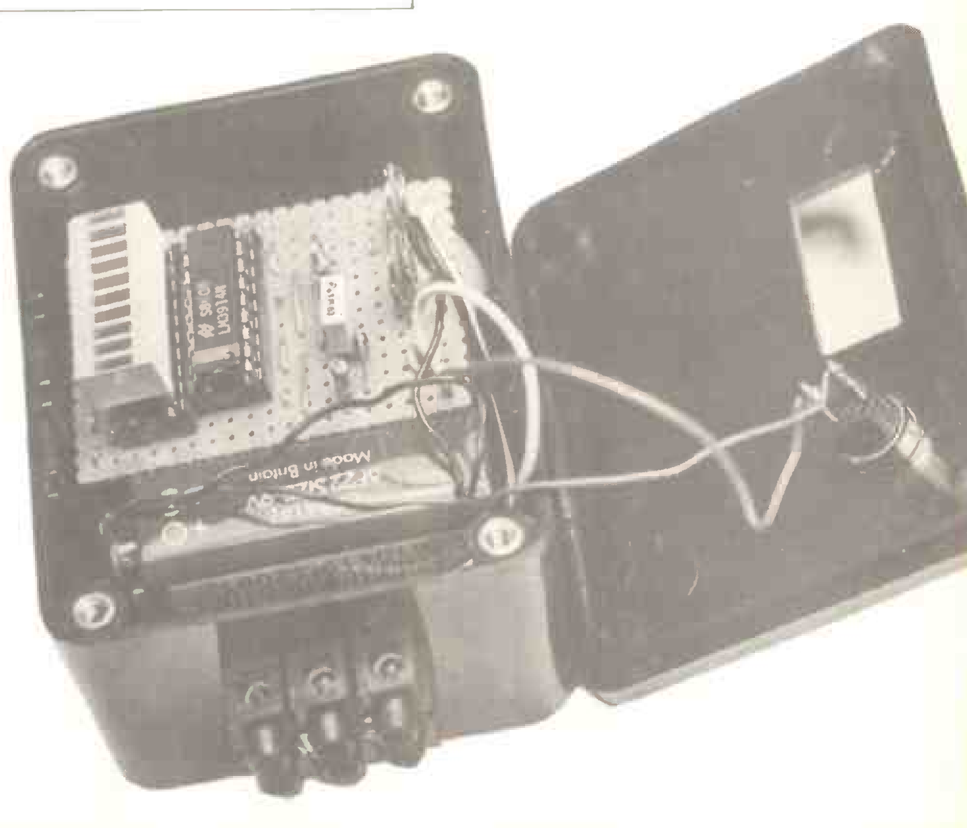
Solder 10cm pieces of light-duty stranded connecting wire to strips *A*, *B*, *H* and *L* as indicated. Solder the negative battery connector lead to Strip *F*.

Adjust presets VR2 and VR3 sliding contacts to approximately mid-track position and insert the i.c.s into their sockets. Note that IC2 has printing on the anode side — this should be placed to the *right* of the panel. Note that as illustrated, the lower bar of IC2 is *uppermost* and the circuit panel will be mounted in the case upside down — that is, with the presets to the right (see photograph).

Prepare the case by making holes for circuit panel, terminal block and push-to-test switch mounting. Drill the hole for internal wires passing to the terminal block.

Measure the position of IC2 and make a hole in the lid to correspond. Mount the circuit board on tall stand-off insulators so that, with the lid on, IC2 stands level with, or slightly higher than, the front face (see photograph).

Next mount the 3-way terminal block TB1 and S1 then, referring to Fig. 3, complete all internal wiring. Connect the battery and secure it with an adhesive fixing pad.



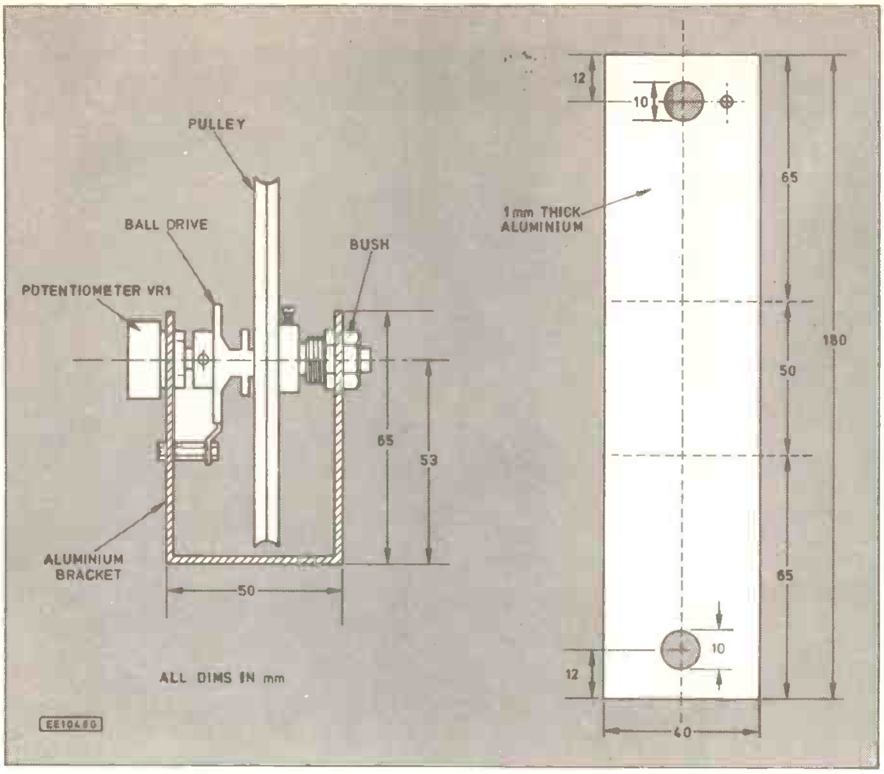


Fig. 4. Drilling details for the pulley U-bracket and mechanical arrangement for the Tank Sensor unit.

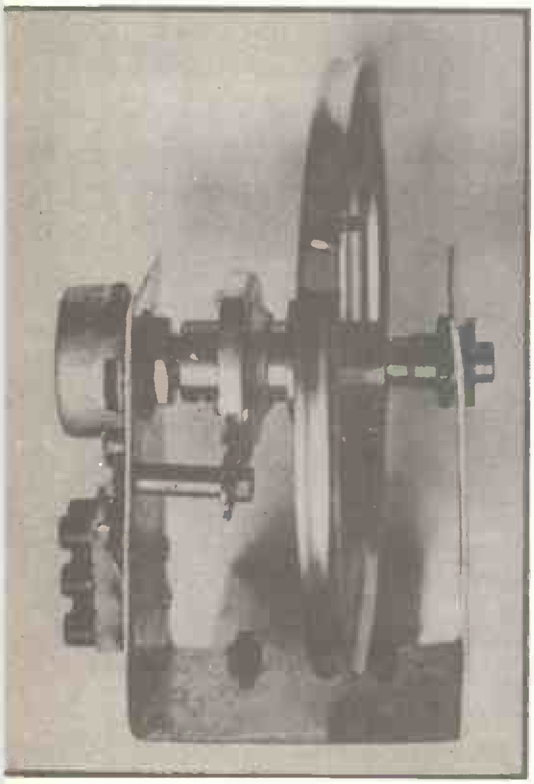
SENSOR

The mechanical arrangement, drilling details and wiring for the sensor unit is shown in Figs. 4 and 5. This uses a piece of 1mm thick sheet aluminium size 180mm × 40mm. Bend it to the form shown and drill two holes 10mm in diameter for the brass bush and VR1 potentiometer mounting.

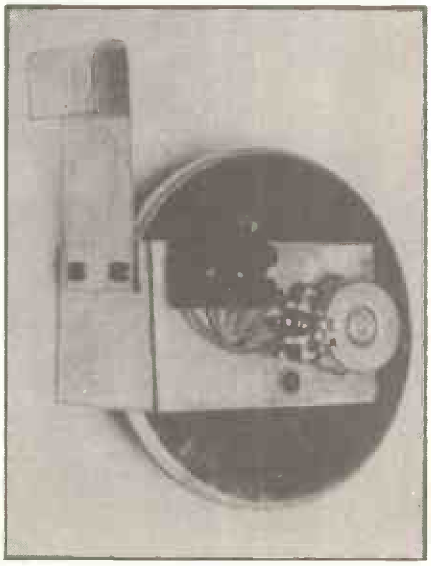
Make the hook from a piece of the same material size 80mm × 35mm. Attach this to the rear panel using two small fixings — see photograph.

Drill a hole 3mm in diameter in the potentiometer side of the U-bracket to accommodate the lug on VR1 (if fitted) which will prevent its body from rotating. Drill a small hole to align with the slotted extension on the ball drive — see photograph. Drill two small holes for terminal block TB2 mounting.

Cut short VR1 spindle and mount the components. Use a long fixing with a metal spacer between the ball drive slotted extension and the metalwork — this prevents body rotation. Connect VR1 to the 3-way terminal block TB2 as shown in Fig. 5.



The completed Tank Sensor unit showing the slotted extension arm on the ball drive held in place by a long spacer.



The Tank Sensor mounting hook bolted on the bottom of the pulley U-bracket.

Check that the pulley rotates smoothly. Decide on the required operating depth and cut a piece of thin, strong cord 20cm longer than this. Tie one end to a pulley fixing screw and attach the float to the other. In the prototype, a small plastic bottle loaded with a few small stones was used as a float. Check that it (a) floats in oil, (b) is heavy enough to rotate the pulley as the level falls and (c) that it is completely liquid proof.

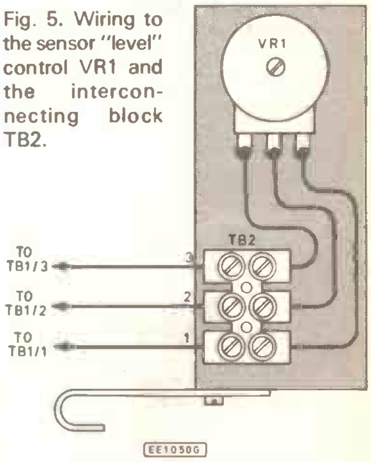
TESTING AND ADJUSTMENT

Adjustment is carried out with the sensor unit outside the oil tank. This is easier than adjusting it under true operating conditions. Attach it temporarily to a high shelf so that the full operating height is available. Interconnect the two terminal blocks, TB2 and TB1, using light duty 3-core wire. Make sure that this is done in the correct sense — TB1/1 to TB2/1 and so on.

When the float is at maximum travel (low operating point), VR1 spindle should be turned fully clockwise. Adjust the position of the pulley on the spindle so that the cord hangs vertically through the opening on the rim.

Press switch S1 and note that some segments light. Adjust preset VR2 so that only the *first* one is on. Rotate the pulley anticlockwise (the cord passing between the pulley and hook) until the float reaches its high operating point — VR1 sliding contact should not now reach its fully anticlockwise position. Adjust preset VR3 so that *all* segments are now on.

Fig. 5. Wiring to the sensor "level" control VR1 and the interconnecting block TB2.



Re-check low and high operating levels re-adjusting VR2, VR3 and the cord length as necessary. Each l.e.d. segment should operate in sequence as the float is allowed to fall gently between upper and lower levels.

Connect the sensor to the main unit using light-duty wire and hook it over the oil tank filling hole. Four-core telephone wire with one conductor ignored was used to make the connections in the prototype. Allow the float to fall gently to the existing oil level and check that the l.e.d. segments indicate this correctly. Check that the cover for the filler opening may be closed and does not interfere with correct operation of the pulley.

To reset the device after the oil tank has been filled, allow the float to fall to maximum travel and check that VR1 is rotated fully clockwise. Carefully turn the pulley until the float reaches the top. Hook the unit over the filler hole and allow the float to fall gently to the oil level. The Oil Tank Contents Gauge is now ready for use.

If desired, a calibrated scale may be made and attached to the lid of the case to show the actual contents of the tank in litres or gallons. □

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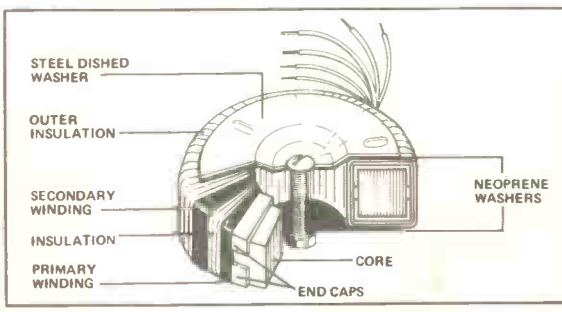

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. . . Logic Tester . . . Logic Tester . . .

I WAS hoping to give details of a battery backed clock/calendar circuit in this month's article, but problems with the multiplexed address/data bus of the 146818 chip have resulted in a rather inefficient circuit that will need some tidying up before it is suitable for publication. However, in the mean time we will consider use of the BBC computer as a logic tester. There are actually a variety of ways in which the BBC computer can be used for logic testing, ranging from a basic logic probe function through to automatic chip testing and analysis. In earlier articles we have touched on this subject when considering the 6522 VIA in its pulse and frequency generation modes. Here we will look at ways of utilizing the machine for logic probe style checks.

State Indication

The most basic of logic probes just provide an indication of whether the test point is at logic 0 or logic 1. This is something that can easily be achieved with the BBC computer using one line of the user port as an input. For example, after first connecting one of the user port's earth lines to the earth rail of the equipment under test, PB0 could then be connected to the test points. This simple three line program is all that would then be needed to display the detected logic level on the screen.

```
10 CLS
20 PRINTTAB (10,10) ?&FE60 AND 1
30 GOTO 10
```

All this program does is to clear the screen, and then print the value returned from PB0 at approximately the middle of the screen. The logic AND function is used to mask PB1 to PB7, so that the returned value can only be 0 or 1, depending on whether the test point is low or high (respectively). Line 30 loops the program indefinitely so that the display is regularly and frequently updated. The update frequency is probably limited by the number of frames per second generated by the display driver circuit.

This method is perhaps a little risky in that there is no isolation between the test circuit and the BBC computer, and under some circumstances this could result in damage to the computer. It would certainly be unwise to use this method with anything other than a test circuit having ordinary five volt logic levels (a few CMOS logic circuits use higher supply voltages of up to 18 volts). I have only experienced difficulties when connecting other items of equipment to a computer when both pieces of equipment are mains powered, but neither of them uses a mains earth connection. This can result in a large voltage difference between the two chassis. Although this voltage is at a high impedance, it can easily result in damage to one or both items of equipment.

The BBC computers have an earthed chassis, and this seems to largely remove the possibility of problems of this sort. However, you may prefer to play safe and use opto-isolators at the inputs when using the machine for this type of testing. An alternative is to add a buffer ahead of the input. If any damage should then occur, it will be to the buffer device costing a few pence, rather than to the 6522 VIA.

There should be no real risk if the test circuit is a five volt type which is powered from batteries. Neither should there be any risk if the five volt output of the computer is used to power the test circuit. If you use this method though, remember to keep within the output current limit of your computer.

Transitions

A logic probe which provides no more than simple high/low level indication is of limited practical value. A valid logic level will always be indicated, even if the voltage at the test point is an invalid one. In other words, a high state will be indicated if the test point is above a certain level, or a low state will be indicated if it is below this level. To be completely accurate the system should indicate a low level if the test point is below a certain voltage, a high state if it is above a different and higher voltage, and an illegal state if it is between these two voltages.

Perhaps a more major problem with a basic high/low logic indicator is that it is unlikely to handle medium or high frequency pulse signals very well, and many logic test points fall into these categories. With a low frequency pulse signal having something approximating to a 1:1 mark-space ratio the on-screen indication will fluctuate rapidly between 0 and 1, showing that the input is pulsing. In fact with high frequency signals having a mark-space ratio of about 1:1 the on-screen indication seems to vary in much the same way. Presumably it is a matter of chance as to which logic state the input line happens to be at during the instant when the line is read, and the on-screen indication is purely random.

Matters are less satisfactory with signals that have very low or very high mark-space ratios, as it is then quite likely that the brief pulses will be missed. A change in the on-screen indication will only occur if the input line happens to be read at the instant one of these pulses occurs, and the chances of each pulse being read could literally be a million to one.

The BBC computer has the facilities to overcome both these shortcomings with the aid of a little discrete circuitry. The analogue port enables the voltage at the test point to be accurately measured, and warning to be provided if it is not a valid voltage for the logic devices used in the circuit. The user port has edge sensitive inputs, and these can be used to detect whether or not the input signal is pulsing.

Fig. 1 shows the simple way in which this can all be achieved in hardware, and the software provided in Listing 1 provides this set-up with high/low, pulsing, and voltage warning indicators.

If we take the pulse detection first, this is provided by line CB1 of the user port. As explained in an earlier article (see the November 1986 issue of *Everyday Electronics*),

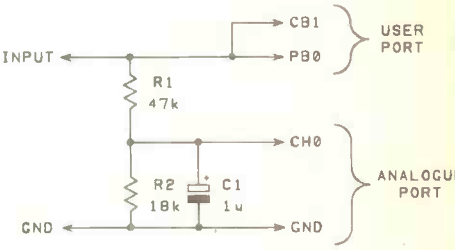

Fig. 1. A simple arrangement that enables the BBC Micro to function as a logic checker.

both CB1 and CB2 can be used as edge triggered inputs. Either line could be used here, but as CB1 can only be operated as an input and has no output modes, CB1 is the better choice as it leaves the more versatile CB2 line free for other purposes. CB1 has two operating modes, and it can set its interrupt flag bit on either a high to low transition, or a low to high type. In this case it does not matter which mode is used, since a brief pulse will provide both types of transition in rapid succession. CB1 can therefore be left in whatever operating mode it happens to be set in at switch-on.

The CB1 flag is bit 4 of the interrupt flag register at address &FE6D. It can be reset by writing a 1 to this bit (i.e. ?&FE6D = 16).

Voltage measurement via the analogue port has also been covered in a previous article in this series (see the June 1986 issue of *Everyday Electronics*). In this circuit channel 0 of the analogue port (read from BASIC as ADVAL1) is fed from the test point via a potential divider comprised of R1 and R2. These reduce the sensitivity from 1.8 volts full scale to about 6.3 volts full scale. The resistance through the potential divider has been kept quite high so that no significant additional loading is placed on the test circuit. C1 provides smoothing so that the signal fed to the analogue input is a reasonably stable d.c. voltage.

Some simple division is all that is needed in order to convert the values returned by the ADVAL1 function to a voltage value that can be displayed on the screen. The on screen indication could be in the form of an "illegal voltage" message when appropriate, with a

LISTING 1

```
10 CLS
20 PRINTTAB (10,10) ?&FE60 AND 1

30 FLAG = ?&FE6D AND 16
40 IF FLAG = 16 THEN PRINTTAB
(17,12)"PULSE"
50 VOLTS = ADVAL(1) DIV 1024
60 PRINTTAB (8,14) VOLTS/10; "VOLTS"
70 ?&FE6D = 16
80 FOR DELAY = 1 TO 100:NEXT
90 PRINTTAB (17,12) "          "
100 GOTO 20
```

program line being used to detect whether or not the detected voltage was a valid one for the device under test. The problem with this system is that what constitutes a valid voltage depends on the device being checked, and to some extent on how heavily its output(s) are being loaded. It is probably more practical to have a voltage readout so that the user can make a subjective judgement as to what does and what does not qualify as a legitimate voltage.

An essential point to keep in mind is that with a pulsing input signal the displayed voltage is an average level. This renders it largely meaningless with this type of input signal, and it will often show an illegal voltage even though the signal is switching between two valid potentials. When the input signal is indicated as a pulsing type, the voltage reading can still provide some useful information. It provides a rough indication of the mark space ratio of the input signal.

If the indicated voltage is very low, this shows that the input signal is at the low state for most of the time, with only brief or very infrequent positive pulses. Conversely, if a high voltage is indicated, the signal is high for the majority of the time with only very short or infrequent pulses. A 1:1 mark-space ratio would produce a voltage reading half way between the logic 0 and logic 1 voltage levels.

This arrangement is quite versatile, and is much more informative than most logic probes. Its only major shortcoming is that it cannot detect very short pulses of less than about one microsecond in duration. These are too fast for the 6522 VIA to handle, and will pass totally undetected. In practice this does not render the system unusable with many circuits, as few have the entire circuit operating at high frequencies with short pulses, or even have a substantial amount of the circuitry handling such signals. However, this is something that should obviously be kept in mind when using this equipment.

There is actually a simple solution to the problem, which is to add a monostable pulse stretcher circuit ahead of CB1. This will detect very short input pulses, but gives an output of a few milliseconds in duration that will reliably trigger CB1. A suitable circuit is shown in Fig. 2.

Software

The program in Listing 1 is very simple, and does not merit a detailed description. Note that the voltage readings are only given with a resolution of 0.1 volts. The 12 bit analogue to digital converter of the BBC machines can give much better resolution than this, but in the present application higher resolution is not really needed, and could make the display less clear. Note also that a "PULSE" indication may briefly flash on the screen when the unit is initially connected to a test point which is at a static level, or when it is disconnected from one. This can happen with any logic checker, and it occurs simply because the input is normally at logic 1, and if it is connected to logic 0 this results in transitions as it is connected to and disconnected from the test point.

The ability of the BBC computer to provide a number of logic outputs while simultaneously monitoring several logic and (or) analogue inputs enables it to operate as a very versatile linear/logic integrated circuit tester. In fact it can also be used for checking other devices such as transistors, and these are subjects which will be explored in future articles.

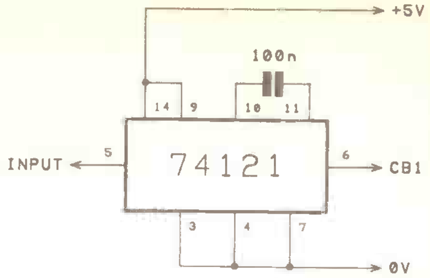

Fig. 2. Positive edge triggered pulse stretcher.

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Please note that when ordering it is important to give project title as well as order code. Please print name and address in Block Caps. **Do not send any other correspondence with your order.**

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10/87

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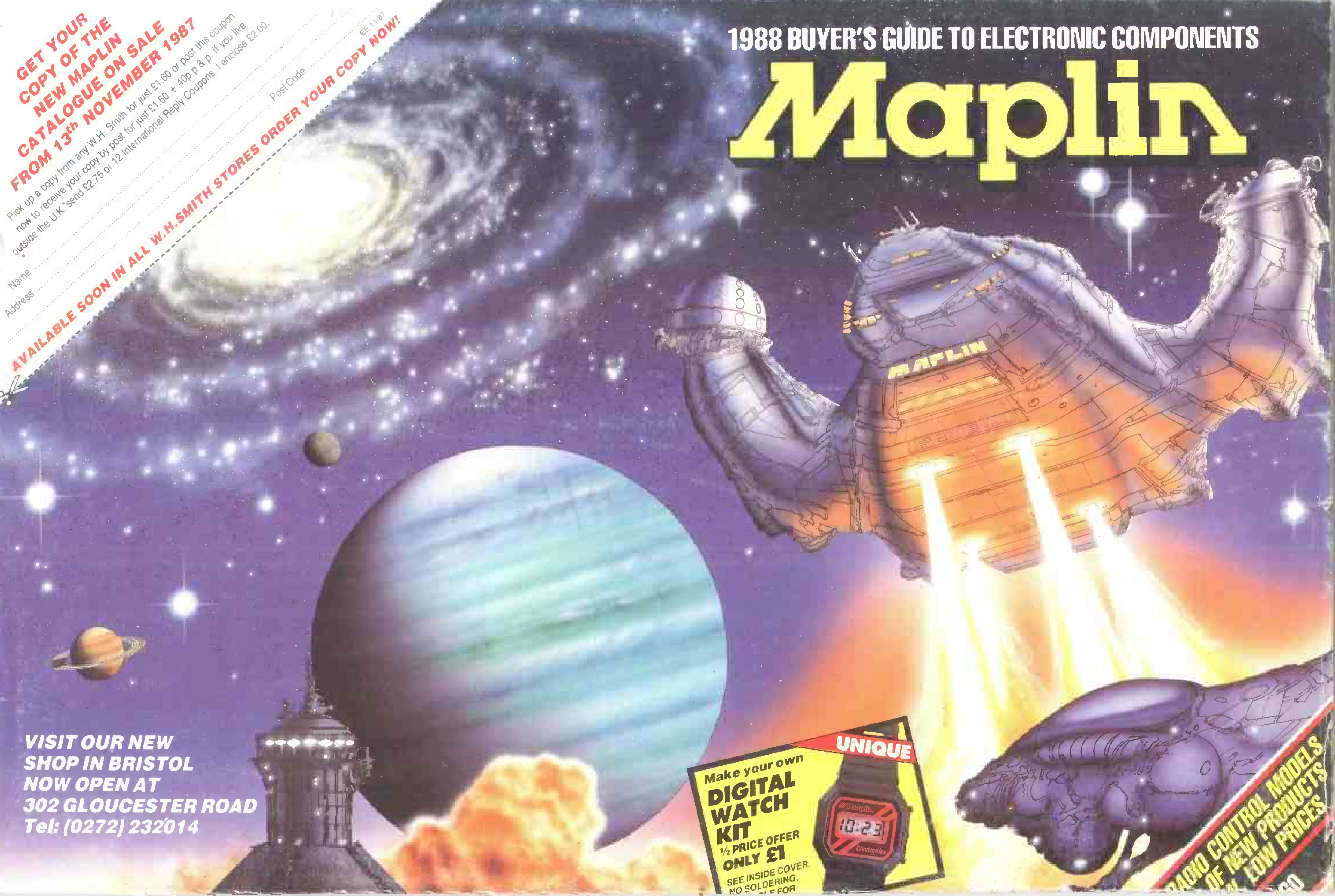

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