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PROJECTS . . . THEORY . . . NEWS . . .
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VOL. 26 No. 6 JUNE 1997

EVERYDAY PRACTICAL ELECTRONICS

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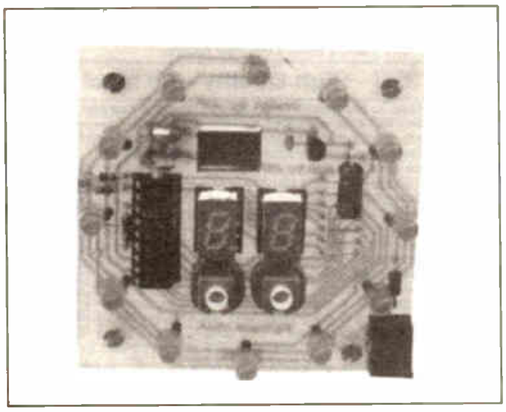
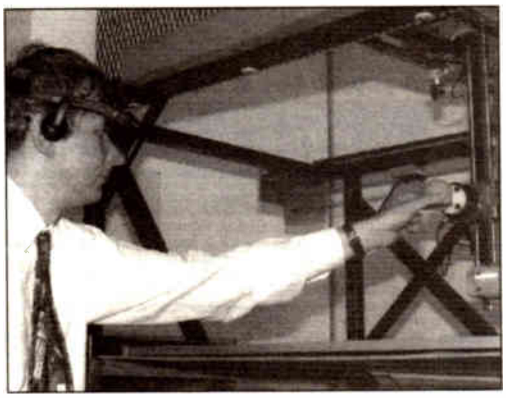
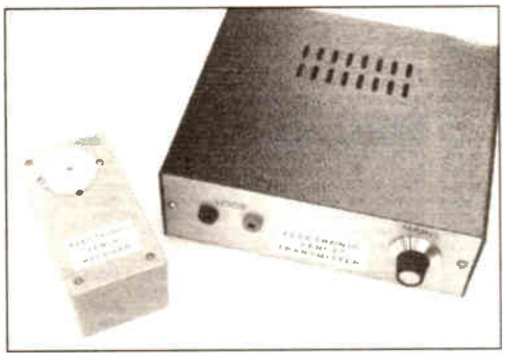
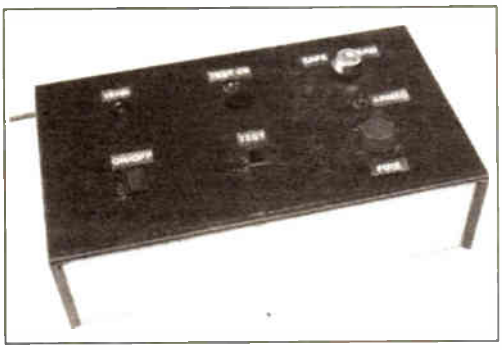
The No. 1 Magazine for Electronics, Technology and Computer Projects









Projects and Circuits

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Our July '97 issue will be published on Friday, 6 June 1997. See page 415 for details.

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THE *ORIGINAL* SURPLUS WONDERLAND!

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LOW COST PC's -

SPECIAL BUY
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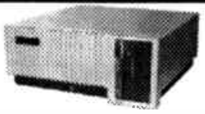
40Mb HD + 3Mb Ram



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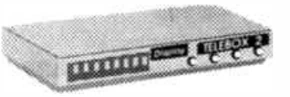
Converts your colour monitor into a QUALITY COLOUR TV!!



TV SOUND & VIDEO TUNER
CABLE COMPATIBLE

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

TELEBOX ST for composite video input type monitors	£36.95
TELEBOX STL as ST but fitted with integral speaker	£39.50
TELEBOX MB Multiband VHF/UHF/Cable/Hyperband tuner	£69.95

For overseas PAL versions state 5.5 or 6 mHz sound specification.
*For cable / hyperband reception Telebox MB should be connected to a cable type service. Shipping code on all Teleboxe's is (B)

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One of the highest specification monitors you will *ever* see - At this price - Don't miss it!!

Mitsubishi FA3415ETKL 14" SVGA **Multisync** colour monitor with fine 0.28 dot pitch tube and resolution of 1024 x 768. A variety of inputs allows connection to a host of computers including **IBM PC's** in CGA, EGA, VGA & SVGA modes, **BBC, COMMODORE** (including Amiga 1200), **ARCHIMEDES** and **APPLE**. Many features: Etched faceplate, text switching and **LOW RADIATION MPR** specification. Fully guaranteed, supplied in EXCELLENT little used condition.

Tilt & Swivel Base £4.75 **Only £119** (E) Order as MITS-SVGA
VGA cable for IBM PC included.
External cables for other types of computers CALL

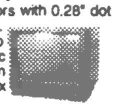
As New - Used on film set for 1 week only!! 15" 0.28 SVGA 1024 x 768 res. colour monitors. Swivel & tilt etc. Full 90 day guarantee. £145.00 (E)

Just In - Microvitec 20" VGA (800 x 600 res.) colour monitors. Good SH condition - from £299 - CALL for info

PHILIPS HCS35 (same style as CM8833) attractively styled 14" colour monitor with __both__ **RGB and standard composite 15.625 Khz video inputs** via **SCART socket** and separate phono jacks. Integral audio **power amp and speaker for all audio visual uses.** Will connect direct to **Amiga** and **Atari** BBC computers. Ideal for all **video monitoring / security applications** with **direct connection to most colour cameras.** High quality with many features such as front concealed flap controls, VCR correction button etc. Good used condition - fully tested - guaranteed
Dimensions: W14" x H12¾" x 15½" D. **Only £95** (E)

PHILIPS HCS31 Ultra compact 9" colour video monitor with standard **composite 15.625 Khz** video input via SCART socket. Ideal for all monitoring / security applications. High quality, ex-equipment fully tested & guaranteed (possible minor screen burns). In attractive square black plastic case measuring W10" x H10" x 13½" D. 240 V AC mains powered. **Only £79.00** (D)

KME 10" 15M10009 high definition colour monitors with 0.28" dot pitch. Superb clarity and modern styling. Operates from any 15.625 khz sync RGB video source, with RGB analog and composite sync such as Atari, Commodore Amiga, Acorn Archimedes & BBC. Measures only 13½" x 12" x 11". Good used condition. **Only £125** (E)



20" 22" and 26" AV SPECIALS

Superbly made UK manufacture. PIL all solid state colour monitors, complete with composite video & *optional* sound input. Attractive teak style case. Perfect for Schools, Shops, Disco, Clubs, etc.In EXCELLENT little used condition with full 90 day guarantee.

20"....£135 22"....£155 26"....£185 (F)

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MITS. FA3445ETKL 14" Industrial spec SVGA monitors	£245
2kW to 400 kW - 400 Hz 3 phase power sources - ex stock	£POA
IBM 8230 Type 1, Token ring base unit driver	£950
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Trend DSA 274 Data Analyser with G703(2M) 64 i/o	£POA
Marconi 6310 Programmable 2 to 22 GHz sweep generator	£6500
HP1650B Logic Analyser	£3750
HP3781A Pattern generator & **HP3782A** Error Detector	£POA
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HP6621A Dual Programmable GPIB PSU 0-7 V 160 watts	£1800
HP3081A Industrial workstation c/w Barcode swipe reader	£175
HP6264 Rack mount variable 0-20V @ 20A metered PSU	£675
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EG+G Brookdeal 95035C Precision lock in amp	£650
View Eng. Mod 1200 computerised inspection system	£POA
Ling Dynamics 2kW programmable vibration test system	£POA
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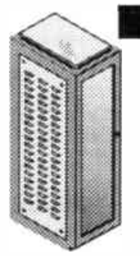
Fiskers 45KVA 3 ph On Line UPS - New batts Dec.1995	£9500
ICI R5030UV34 Cleanline ultrasonic cleaning system	£POA
Mann Tally MT645 High speed line printer	£2200
Intel SBC 486/133SE Multibus 486 system. 8Mb Ram	£1200
Zeta 3220-05 A0 4 pen HPGL *fast* drum plotters	£1150
Nikon HFX-11 (Ephiphot) exposure control unit	£1450
Motorola VME Bus Boards & Components List. SAE / CALL	£POA
Trio 0-18 vdc linear, metered 30 amp bench PSU. New	£550
Fujitsu M3041R 600 LPM band printer	£1950
Fujitsu M3041D 600 LPM printer with network interface	£1250
Perkin Elmer 2998 Infrared spectrophotometer	£POA
VG Electronics 1035 TELETEXT Decoding Margin Meter	£3750
Andrews LARGE 3.1 m Satellite Dish + mount (For Voyager!)	£950
Sekonic SD 150H 18 channel digital Hybrid chart recorder	£1995
TAYLOR HOBSON Tallysurf amplifier / recorder	£750
System Video 1152 PAL waveform monitor	£485
Test Lab - 2 mtr square quietised acoustic test cabinets	£300
Kenwood 9601 PAL Vectorscope - NEW	£650

Please call for further details on the above items

19" RACK CABINETS

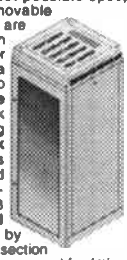


Superb quality 6 foot 40U
Virtually New, Ultra-Smart
Less than Half Price!

Top quality 19" rack cabinets made in UK by **Optima Enclosures Ltd.** Units feature designer, smoked acrylic lockable front door, full height lockable half louvered back door and louvered removable side panels. Fully adjustable internal fixing struts, ready punched for any configuration of equipment mounting plus ready mounted integral 12 way 13 amp socket switched mains distribution strip make these racks some of the **most versatile we have ever sold.** Racks may be stacked side by side and therefore require only two side panels to stand singly or in multiple bays. Overall dimensions are: 77½" H x 32½" D x 22" W. **Order as:**

OPT Rack 1 Complete with removable side panels.	£335.00 (G)
OPT Rack 2 Rack, Less side panels	£225.00 (G)

32U - High Quality - All steel RakCab



Made by **Eurocraft Enclosures** Ltd to the **highest possible spec,** rack features **all steel construction** with removable side, front and back doors. Front and back doors are **hinged for easy access** and all are lockable with **five secure 5 lever barrel locks.** The front door is constructed of double walled steel with a **'designer style'** smoked acrylic front panel to enable status indicators to be seen through the panel, yet remain unobtrusive. Internally the rack features fully slotted reinforced vertical fixing **members to take the heaviest of 19" rack equipment.** The two movable vertical fixing struts (extras available) are pre punched for standard 'cage nuts'. A **mains distribution panel** internally mounted to the bottom rear, provides 8 x IEC 3 pin Euro sockets and 1 x 13 amp 3 pin **switched utility socket.** Overall ventilation is provided by fully louvered back door and double skinned top section with top and side louvres. The top panel may be removed for fitting of **integral fans** to the sub plate etc. Other features include: fitted castors and floor levelers, prepunched utility panel at lower rear for **cable / connector access etc.** Supplied in **excellent, slightly used** condition with keys. Colour Royal blue. External dimensions mm=1625H x 635D x 603 W. (64" H x 25" D x 23¾" W)

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Half length 8 bit memory upgrade cards for PC AT XT expands memory either 256k or 512k in 64k steps. May also be used to fill in RAM above 640k DOS limit. Complete with data.
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1 MB x 9 SIMM 9 chip 80 ns **£21.50**	or 70ns	**£23.75** (A1)
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Shipping on all fans (A). Blowers (B). ***50,000 Fans Ex Stock CALL***

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Hardware and software are supplied together as a package - no more worries about incompatibility and no programming required.

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- Supplied with PicoLog data logging software for advanced temperature processing, min/max detection and alarm.
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- 50 MSPS Dual Channel Digital Storage Scope
- 25 MHz Spectrum Analyser
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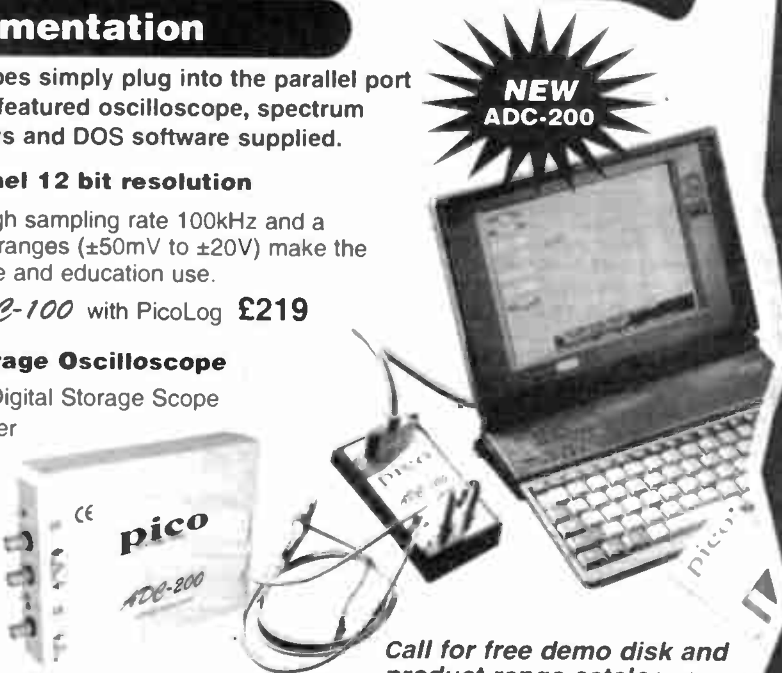
- ±50mV to ±20V
- Multimeter
- 20 MSPS also available



ADC 200-20 **£359.00**
ADC 200-50 **£499.00**

Both units are supplied with cables, power supply and manuals.

Call for free demo disk and product range catalogue

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EVERYDAY
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TOO COMPLEX?

Is it all necessary? The increasing complexity of modern devices has to be marvelled at in terms of advancing technology, but I sometimes wonder if it is all necessary and always desirable. What triggered the thought was the cost of repairs to a colleague's car when the cam-belt broke. Over £1000's of parts and work including a new cylinder head. When I first started driving about 30 years ago most cars used a chain, not a belt, to drive the camshaft, it rarely broke but "slapped" to let you know it needed adjusting or replacing. Even if it did break the valves cleared the pistons and the chain could be replaced without major repairs or renewals. It makes you wonder if the complexity of modern, multivalve, overhead camshaft engines with highly developed computerised management systems is really worthwhile, simply to provide improved performance.

True, emission reduction is also an essential factor, but this can be achieved without such highly complex systems.

The same can sometimes be said of modern electronic equipment. For instance, I'm sure that few users ever employ all the programs available on washing machines or video recorders. When we investigate projects for publication one of the key elements in decision making is the complexity of the design in relation to its usefulness and performance.

2TR or 1IC?

We have been accused of using an i.c. when a couple of transistors will do, but since an op.amp i.c. represents a single component to the constructor and is now available for the same price as those two transistors, surely this makes sense. What we must try to avoid is using six i.c.s when one will do virtually the same job – unless of course the complexity is justified in the quest for the best possible performance – but then that defeats the "car" argument.

I should say that I regularly drive two very different cars, one with a "mangle" type low tech. engine designed in the '60s and the other with more valves, revs and technology than I care to think about. They are both great fun and very different and both have their place and their devotees. And so it is with our projects, you pay your money and take your choice!

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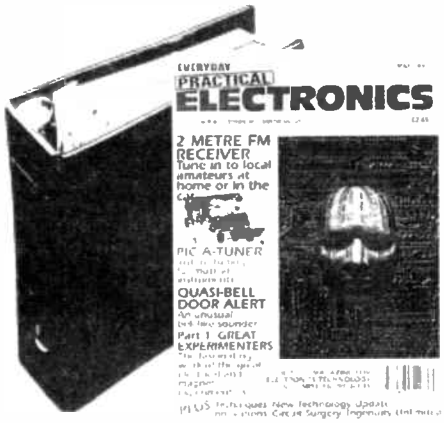

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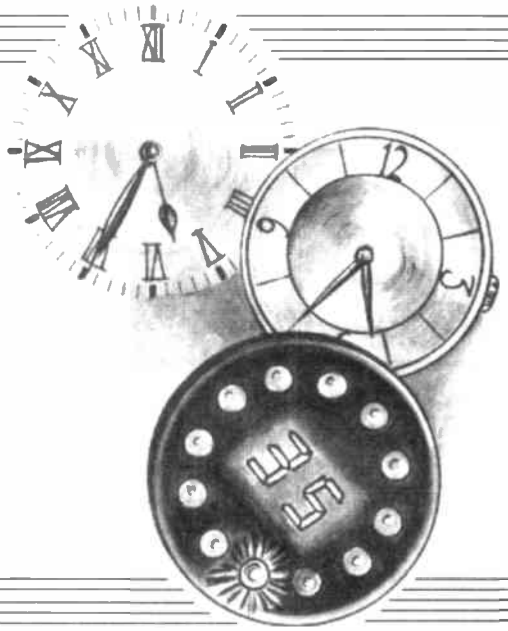


PIC DIGILOGUE CLOCK

JOHN SCOTT PATERSON

Space and time both benefit when PICs are programmed into an updated circuit design.

THIS project is a redesign of the *Digilogue Clock* published in *EPE* October 1994. The original was designed around several CMOS counters and a large number of other components which took the parts count to around 90, with the printed circuit board having to be fairly large to accommodate them.

Since then, the author has purchased a PIC programmer and learned how to program PIC microcontroller chips. Consequently, it became possible for him to produce a design in which all of the functions of the original clock are handled by a single PIC and a mere handful of other components, thus greatly reducing the physical complexity.

The resulting clock is approximately 7cm square and is suitable for use as a desk clock, although the circuit is so simple that almost any size of clock could be built, with only minor modifications.

As with the original design, the display is part analogue and part digital, hence the *Digilogue* name. Hours are displayed on twelve 5mm light emitting diodes (l.e.d.s) set in a circle, mimicking the hours on a conventional analogue clock. Minutes are displayed on two seven-segment displays in the centre.

The "face" of the clock is always visible as those l.e.d.s which are not "on the hour" are dimly lit, making readability easy even in the dark.

CONTROL CIRCUIT

The full circuit diagram for the PIC Digilogue Clock is shown in Fig. 1. A PIC16C54 microcontroller, IC2, is at its heart, controlling all the time-keeping, display and switch-setting functions.

The master clock control frequency required by the microcontroller in this

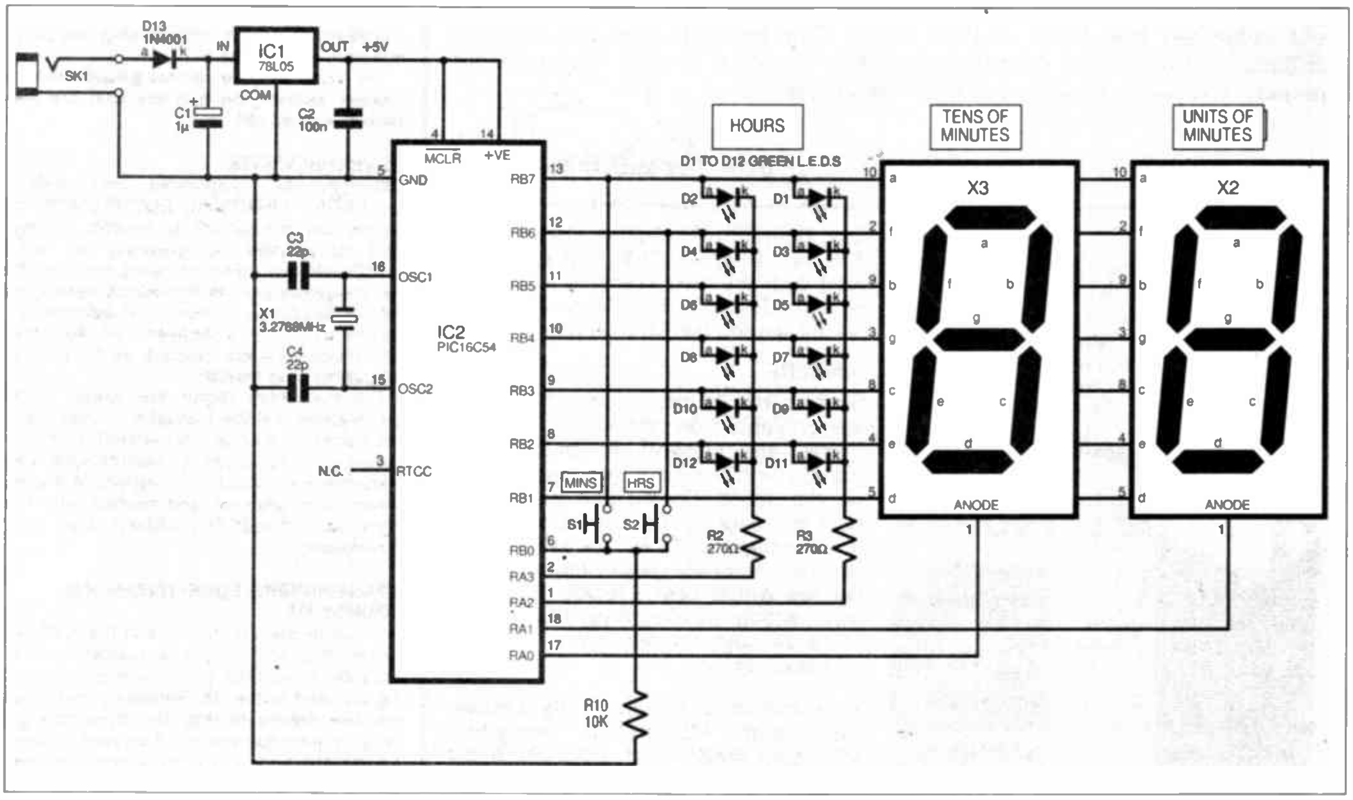


Fig.1. Complete circuit diagram for the PIC Digilogue Clock.

application is 3·2768MHz. This is generated using crystal X1, in conjunction with capacitors C3 and C4.

Two bi-directional ports are available on the 16C54 and these are used to drive both the hours display and the minutes display, as well as scanning the two time-setting switches.

Because the seven-segment displays are common-anode low current types and are only required to be on for 2ms in every 20ms, current limiting resistors are not used in series with their segments.

The l.e.d.s, D1 to D12, which display the hours, are driven by Port B lines RB1 to RB7. Resistors R2 and R3 have been included to limit the current drawn by them.

Switches S1 and S2, respectively, are used to adjust the setting of the hours and minutes. They are controlled by Port B lines RB6 and RB7, and read via line RB0, resistor R1 providing a 0V bias.

POWER SUPPLY

The PIC has to be powered at 5V d.c., but voltage regulator IC1 allows power supply sources of between about 7V to 12V d.c. to be used, regulating them down to the required voltage. Current consumption is around 20mA. It is suggested that a 9V d.c. mains adapter (battery eliminator) is used as the power source, plugging it in via socket SK1. Diode D13 prevents power of the wrong polarity being fed in.

TIME KEEPING

The processor has a built-in 8-bit Real Time Clock Counter (RTCC) which can be used to count pulses, either externally via pin 3, or internally under clock control, to produce accurate time intervals. Within the PIC, the crystal frequency is divided by four, resulting in an internal clock frequency of 819·2kHz, giving an instruction cycle of around 1·22µs.

It may seem as though this could be used to increment the RTCC directly, advancing it on every instruction cycle. However, the RTCC register is only 256 bytes long, which would not allow many instructions to be performed before the counter rolled over to zero.

To slow down the incremental rate of the RTCC, there is a prescaler or divider which can be assigned to it, which greatly increases the number of instructions which can be handled before the roll-over. Once the prescaler is set, the RTCC can be loaded with a preset value and the register will increment at the rate of the internal clock divided by the prescaler value.

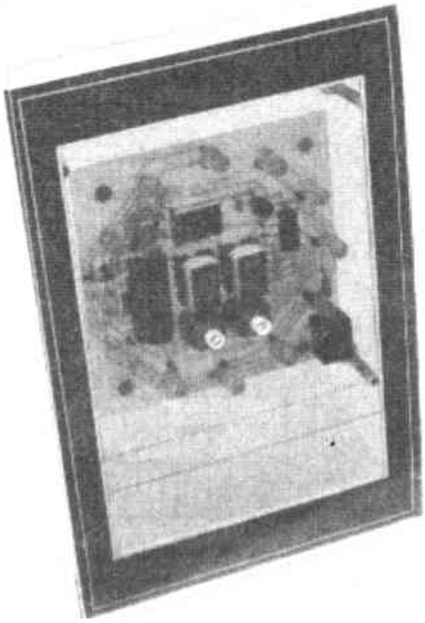
When it reaches hexadecimal &FF (decimal 255) it will roll over to &00 (zero). This happens regularly at a precise rate and is used as the timing reference from which the seconds, minutes and hours counts are derived.

In this design the prescaler is set to 64 and the RTCC initially contains zero. The time taken for the RTCC to increment from zero through all its 256 bytes and back to zero is 1/(3.2768MHz/4) × 64 × 256, which gives a basic timing interval of 20ms.

If 25 of these 20ms intervals are counted, half-second increments are available, and counting 120 half-seconds gives the increment rate for the minutes, which in turn are counted to derive the hours increment rate.

You may wonder why 50 of the 20ms intervals should not be counted to produce one-second intervals, and just count 60 of these to produce the minutes. This could be done, but it would make adjustment of the time setting via switches S1 and S2 seem slow, only incrementing the hours or minutes by one per second. Using half-second increments is faster!

Twenty milliseconds is quite a long time in relation to the number of instruction cycles that can be executed. In fact, there are 16394 instruction cycles performed in every 20ms. The main program takes nothing like this amount of time to execute, so there is time in hand to jump back to the RTCC timing loop to wait until the counter overflows again. This simplifies the code and does away with the need for interrupts to generate the timing reference.



Ingeniously, the Digilogue Clock is mounted in a photograph frame.

BASIC FLOW CHART

Illustrated in Fig. 2 is the flow chart for the basic time-keeping program used in the clock. The RTCC is constantly checked to see if it has overflowed to &00, if it has, the TBCTR register, which counts the 20ms intervals, is decremented from a starting value of 25, and checked for a zero result.

If TBCTR is not zero, the program jumps to RUNEND, displays the time and rejoins the RTCC loop in time for it to overflow again. If TBCTR is zero, then half a second has elapsed (25 × 20ms). The register is reloaded with its original value (25).

Next the keyboard scan routine is called and, because of the half-second timing, the hours or minutes counts can be incremented at a rate of two units per second when pressing switches S1 or S2.

Register HSCTR, which is used to count 120 half-seconds is decremented from its starting value of 120, and also checked for zero. If HSCTR is not equal to zero, the time is displayed and program flow directed back to the RTCC loop.

If HSCTR equals zero, one minute (120 half-seconds) has elapsed. HSCTR is then reloaded with its original value (120) and

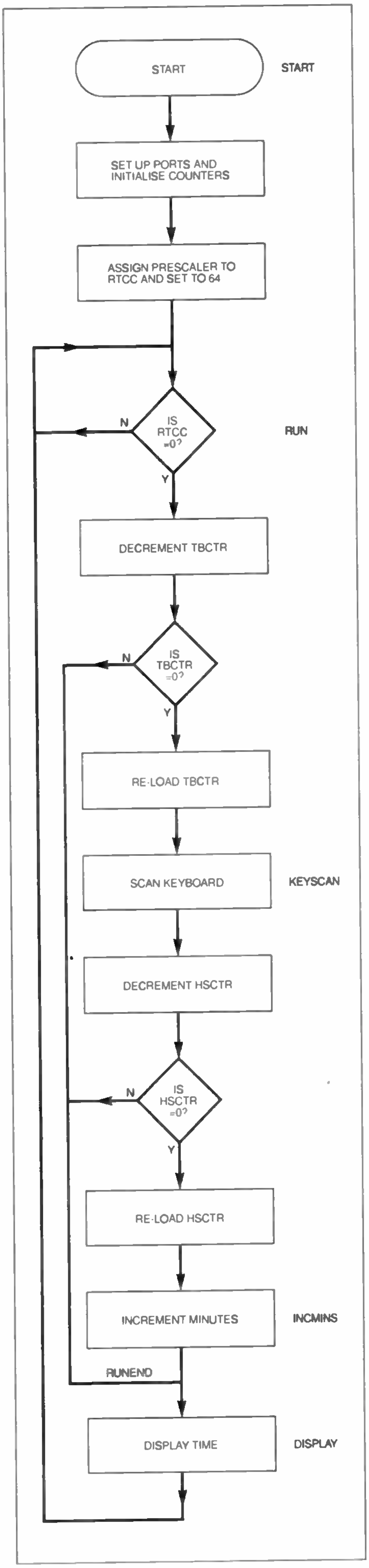


Fig.2. Basic timing flow chart.

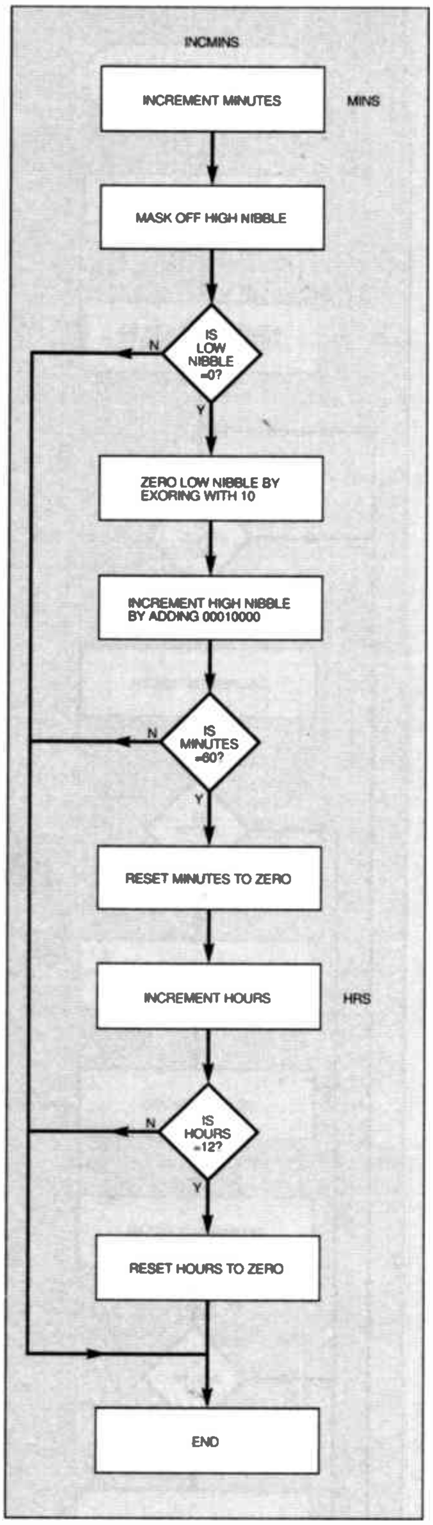


Fig.3. Flow chart for the INCMINS routine.

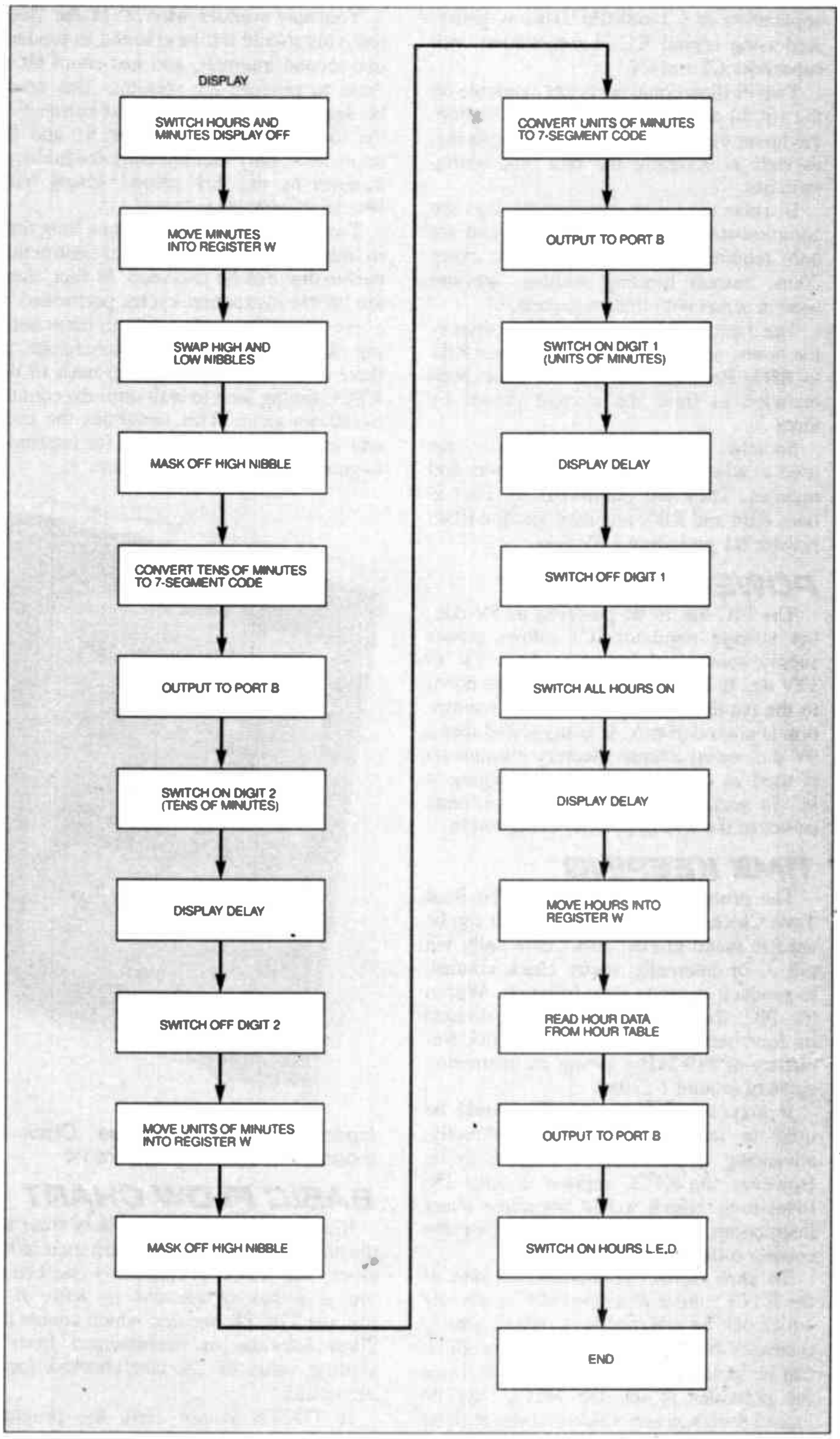


Fig.4. Flow chart for the display routine.

the minutes and, if appropriate, the hours are incremented. The time is then displayed and the program jumps back to the main RTCC timing loop.

DETAILED TIME FLOW

Flow chart details for the increment time (INCMINS) routine are shown in Fig.3. First the register MINS is incremented and the high nibble, (bits 4 to 7) masked off to give the units of minutes in the low nibble (bits 0 to 3). If this value is less than 10, no action is taken and the routine ends.

If the value is equal to 10, the units are reset back to zero by EX-ORing the register with 10, and the tens of units (high nibble) are incremented by adding 16 (binary 00010000) to it. Next, the value of MINS is checked; if it equals 60, the minutes are reset to zero and the hours are incremented.

Lastly, the value of the HRS register is compared with 12; if it equals 12, the hours are reset to zero.

DISPLAYING THE TIME

To display the time, Port lines RA0 to RA3 and RB1 to RB7 are configured as outputs. and Port line RB0 is configured as an input.

Each of the different functions are dealt with in turn. To display the minutes, a 7-bit value is output on Port B and the corresponding anode of one or other of the seven-segment displays is taken high (by RA0 or RA1) to turn on the digit.

Hours are displayed by single l.e.d.s. requiring only one of Port B's lines RB1 to RB7 to be taken high, plus either of the two common cathode lines which are controlled by Port A lines RA2 and RA3, taking the appropriate one low to turn on the l.e.d.

To suit night-time viewing, all the l.e.d.s are constantly seen to be dimly turned on. This is achieved by taking RB1-RB7 high and RA2. RA3 low for a short period.

DISPLAY FLOW

The flow chart for the display routine is shown in Fig. 4.

At the start of each display routine, both seven-segment displays are first blanked by setting Port A lines RA0 and RA1 low, and the l.e.d.s turned off by setting lines RA2 and RA3 high.

To display the minutes, the high and low nibbles of the MINS register are temporarily swapped and the upper nibble masked off. The result is then converted to the corresponding seven-segment display code using a standard look-up table routine called HourTable.

Tables are accessed in PIC microcontrollers by moving the value whose tabulated equivalent is required into the W (Working) register. This is the equivalent to the Accumulator in some microprocessors.

On jumping to the table, the value in W is added to the processor's Program Counter, causing it to jump by the same number of places to the instruction at the new location. In the case of tables, the instruction is to load the value stated at that location into the W register. The program then returns to the main routine with the acquired value still in W.

In this design, the first table call of the display sequence acquires the code value which is output via Port B to the tens of minutes digit (display X3). The digit is immediately turned on by setting Port A line RA0 high. After a short delay, digit 2 is turned off by taking this line low again.

The minutes register is again read and the upper nibble masked off to get the units of minutes value. This value is converted to the corresponding seven-segment display code via the look-up table and output via Port B to the units of minutes digit (X2). This display is now briefly turned on by setting Port A line RA1 high and then low again.

All the hour l.e.d.s are now turned on briefly by first setting Port B lines RB2 to RB7 high, after which Port A lines RA2 and RA3 are set low and then high again. This action causes the clock face l.e.d.s to appear dimly illuminated for viewing in the dark.

COMPONENTS

See SHOP TALK Page

Resistors

R1	10k
R2, R3	270Ω (2 off)

Capacitors

C1	1µ tantalum, 16V
C2	100n polyester
C3, C4	22p polystyrene (2 off) (see text)

Semiconductors

D1 to D12	green l.e.d., 5mm (12 off)
D13	1N4001 rectifier diode
IC1	78L05 5V 100mA voltage regulator
IC2	pre-programmed PIC16C54 (see text)

Miscellaneous

X1	3·2768MHz crystal
X2, X3	7-segment display, common anode, micro-bright, low current, green (2 off)
S1, S2	min. push-to-make switch, p.c.b. mounting (2 off)
SK1	2·1mm power jack socket, p.c.b. mounting

Printed circuit board, available from the *EPE PCB Service*, code 156; 14-pin i.c. socket (2 off) (see text); 18-pin i.c. socket; plastic photo frame (see text); green celluloid; small plastic sheet (see text); nuts and bolts; solder, etc.

Approx Cost Guidance Only £23 Excl. mount

Next, the hour display is dealt with, selecting the l.e.d. which has to appear to be brightly illuminated. The HRS register is read and another look-up table is used to obtain a corresponding code which is output to Port B. If the hours are odd, Port A line RA2 is set low and RA3 is set high. If the hours are even, RA2 is set high and RA3 is set low.

SWITCH SCANNING

The last function, scanning the two time-setting switches, is controlled by first setting Port B line RB7 high and checking the status of Port B line RB0. When switch S1 is pressed this line goes high and accordingly the software increments the minutes counter.

Port B line RB7 is then cleared and RB6 is taken high. Again line RB0 is checked and if this is high, as it is when switch S2 is pressed, the hours are incremented. Pressing both switches together will have an indeterminate effect.

CONSTRUCTION

Details of the printed circuit board (p.c.b.) are shown in Fig. 5. This board is available from the *EPE PCB Service*, code 156.

Start off assembly by fitting the wire links, resistors, diode D13, then the capacitors (C1 is mounted flat). Next solder in IC1, plus the sockets for the displays and IC2 (do not solder in the latter). Cut down the 14-pin sockets to suit the 10 pins of the displays.

The twelve l.e.d.s, D1 to D12, should be fitted next, mounting them so that they are flush with the top of the two seven-segment displays. This is best done by cutting short equal lengths of p.v.c. insulation (taken from a spare piece of mains cable, for example) and threading them onto the legs of the l.e.d.s before insertion into the p.c.b. This ensures that all l.e.d.s will be at the same height.

Fit the crystal, flat with the board, and the two push-button switches S1 and S2 and the power jack socket, SK1.

TIMELY CHECKS

Thoroughly check all your connections and component positions and orientations. Before plugging in the displays and IC2, connect power and check that +5V and 0V are where they should be, according to the circuit diagram.

When satisfied, switch off, plug in the displays and IC2 (assuming the latter has already been programmed – see later).

When switched on again, the clock should immediately start working, requiring you only to set the correct time.

Setting the time is easy! Just increment the hours first, pushing the hours switch, S1, and then similarly adjust the minutes

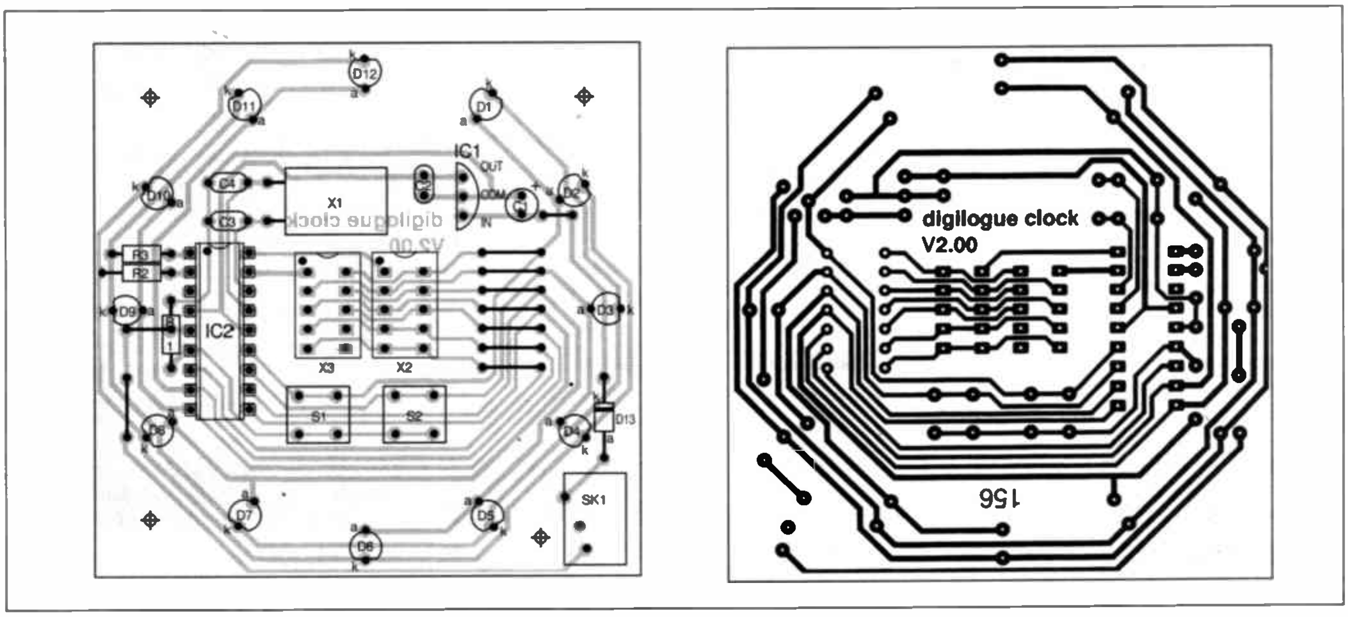
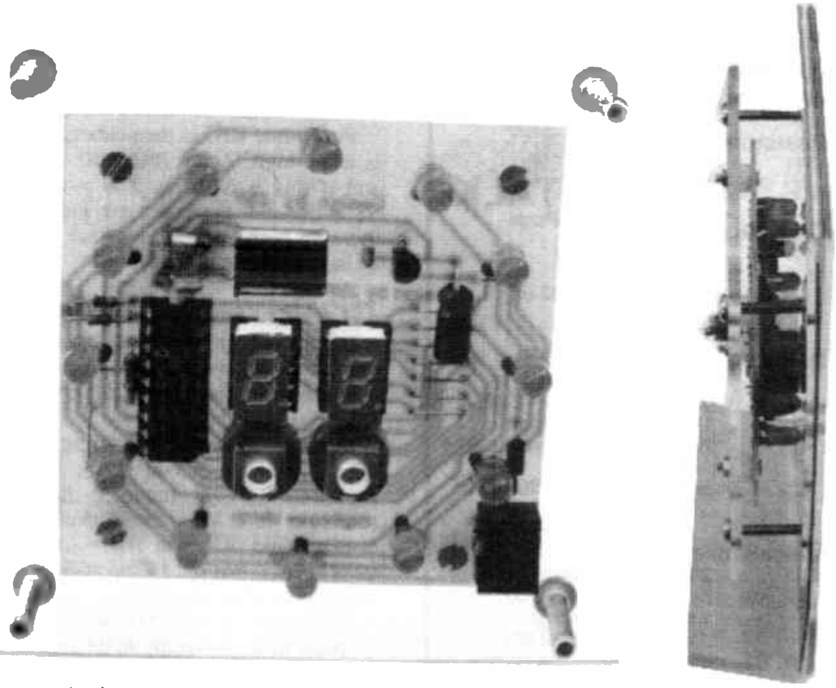


Fig.5. Details of the printed circuit board component layout and full-size copper foil track pattern.



The p.c.b. is mounted on a small piece of Perspex which is then bolted to the photo frame. Green celluloid is placed above to enhanced the image.

using switch S2. Note that the seconds are reset to zero just as the minutes change, which makes accurate setting possible. Also note that the hours will increment if the minutes are incremented past 59.

CLOCK CASE

An appropriate case did not seem to be readily available, so the author opted to use a small Perspex photograph' stand on which to mount the clock – the kind where you insert the photo between two sheets of Perspex.

The clock was first mounted on a small piece of Perspex using spacers, then this was fixed to the photo stand, again using spacers. Two small holes, just large enough to allow a ball-point pen to be pushed through, were drilled in front of the switch positions.

An advantage of using this kind of mounting is that a small sheet of clear green plastic film, the type used in theatre and television lighting, for example, can be inserted to act as a filter, giving a pleasing overall effect.

IN RETROSPECT

The author has built several of these clocks and has found that there may be very slight differences between the frequencies generated by different crystal oscillators.

Should you find that the crystal you use is not quite in tune, a change to its frequency can be achieved by reducing the value of capacitor C4 to 12pF, and adding a trimmer capacitor of nominally 22pF in parallel with it. The trimmer can be soldered directly to the tracks on the back of the p.c.b., as seen in the photographs.

Adjustment of the crystal's frequency can then be done by making very small changes to the setting of the trimmer capacitor. Obviously, it is likely to take several days before the effects of these changes are likely to be observed.

SOFTWARE DETAILS

Pre-programmed PIC16C54 microcontrollers for the Digilogue clock are available from Magenta, see Dave Barrington's *Shoptalk* column (thank you Magenta).

Readers who wish to program their own PICs can obtain the software either on disk from the *EPE* editorial office or download it from our Web site (there is a nominal charge for the former, but the latter is free – again see *Shoptalk* for details). The Web site files are in sub-directory PIC-DIGILOG.

There are two versions of the source code available. Files CLOCK54.ASM and CLOCK54.HEX are for use with the PIC16C54. Files CLOCK84.ASM and CLOCK84.HEX are for use with the electrically erasable (EEPROM) PIC16C84, and make use of the interrupts available on the chip.

The .HEX files can be downloaded directly to the PICs, via a suitable programmer. The .ASM files are for those who wish to translate or otherwise change the source coding to suit their own needs.

The software has been written for the industry-standard MPASM assembler, but should be fairly readily translatable by experienced programmers for other assemblers, such as the shareware TASM, for instance. The latter is included on the same disk as the Digilogue software, and also available free via our Web site.

Readers who wish to know more about PIC programming should refer to the *Back Issues* page where previous *EPE* PIC-based project articles are listed and available as stated.

You should also obtain the PIC data books from Arizona Microchip, Unit 6, The Courtyard, Meadowbank, Furlong Road, Bourne End, Bucks. Tel: 01628 851077. Fax: 01628 850259. Web: **http://www.microchip.com.** □

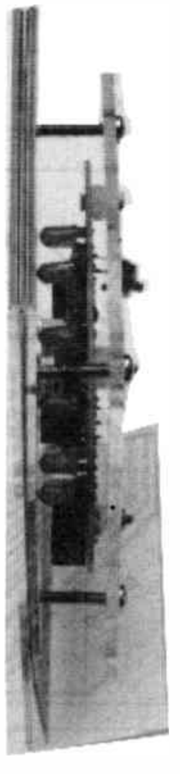
TIME WARP

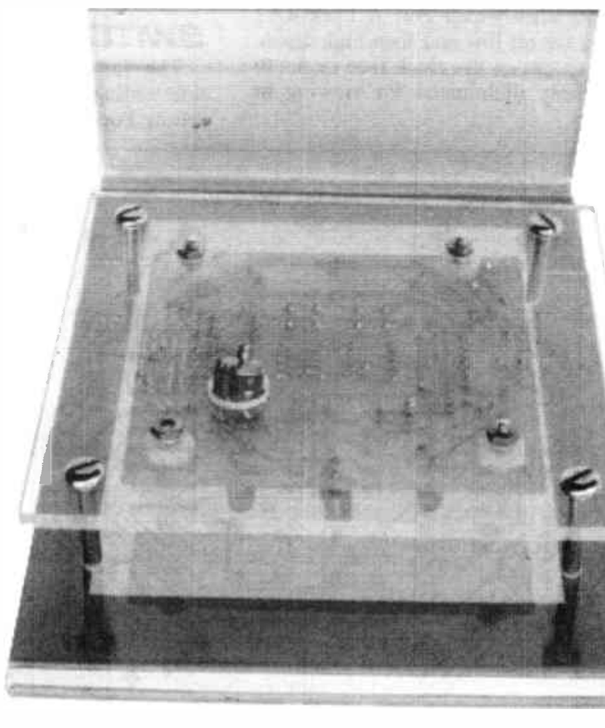
We continue to be inundated by information from the DTI concerning the need to ensure that computers and their software will cope with the date change at the year 2000 and beyond.

Although research shows that most companies know that a problem may exist, few have yet to take active measures to ensure that Y2K does not affect their business detrimentally.

Be aware, Y2K is a *real* problem that could induce a world-wide recession, and your company's demise, if not met with proper preparation.

For further information about Y2K updating contact Taskforce 2000 (a non-profit making organisation) on 01582 832110.





Another view of the p.c.b. mounting, also showing the optional preset variable capacitor on the rear of the board.

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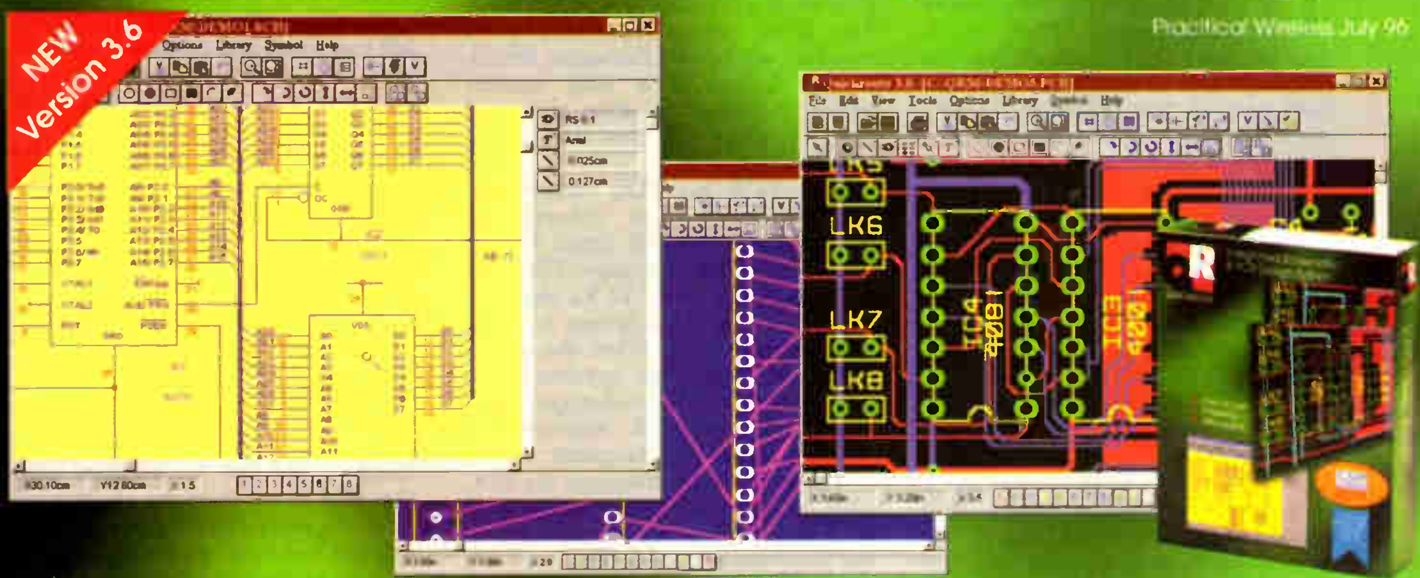

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PDC NEEDS FIXING – PDQ!

The technology exists to help all VCR users who battle with broadcast program timing accuracy, why isn't it implemented?

Barry Fox investigates

THE BBC has now finished a year of trials on PDC, or Programme Delivery Control. There is no date yet for a "full service", but the BBC expects it to start in the summer. Until then an "experimental service" continues. This means that the BBC will be transmitting PDC on both BBC1 and BBC2, but will not advertise the fact. Why?

The official reason is that there are still some fine details to be sorted out on regional opt-outs, where local stations drop their own news and current affairs into the national schedules. The BBC knows that once the service is advertised there will be a flood of calls from viewers whose VCRs are not taping programmes. Every time PDC is mentioned on a phone-in radio programme, callers tell of mind-bending problems.

PDC has been around so long, but never fully implemented or exploited, that many dealers will have forgotten the basics.

POLITICALLY INSENSITIVE

PDC lets a VCR ignore its timer and start taping only when a programme actually begins. So it spares viewers the frustration of setting a VCR to tape a movie and then finding the recording starts with a Party Political Broadcast, which has been slipped into the schedule at short notice. The tape then ends before the movie finishes.

This is another reason why the BBC is waiting until the summer to announce a full PDC service. It would have been politically insensitive to publicise PDC as a way of avoiding PPBs, just before the General Election.

PDC also protects programmes which are delayed when a football match runs into extra time. Because a PDC VCR is ignoring the timer, it does not matter whether the VCR's clock is wrongly set, e.g. by an hour during summertime. PDC also compensates for the natural slippage that can occur during an evening's TV programmes, with later programmes tending to start late.

When broadcasters compile their programme schedules, up to eight weeks ahead of transmission, they give each programme a PDC label. The label, which conforms to a standard set by the European Broadcasting Union, is a long number which combines the date, time and channel. Once set, this label never changes.

If a VCR has PDC circuitry, it can be switched to convert any data entered into the timer by the owner, into PDC language. The same thing happens with VCRs that use Gemstar's VideoPlus system to make timer-setting easier. When the owner enters the VideoPlus number for a programme, as listed in a magazine or newspaper, the VCR automatically converts it into PDC language.

The broadcaster transmits the PDC label, as an invisible part of the conventional teletext signal, as soon as the programme begins. Ordinary TV sets and VCRs ignore the label, but VCRs with activated PDC circuitry are looking for it. Instead of starting to record at the appointed time, they start only when the label arrives over the air. If the programme starts late, so does the VCR.

MOST VCRs HAVE PDC

All but the cheapest VCRs now have PDC circuitry, but only *Channel 4* has been broadcasting PDC labels with its programmes. *Channel 5* will use PDC. The ITV network is experimenting but has special difficulties because its programmes are regional and vary widely across the country. Broadcasters in Holland, Germany and some Scandinavian countries are at a similar stage.

Broadcasters and viewers share a practical problem with PDC. The published time and VideoPlus code for a programme should exactly translate to the PDC label allocated to that programme. If there is mismatch, the VCR will not start at all. Sometimes a broadcaster changes the scheduled time for a programme a few days before transmission. Because the PDC label is set in stone, the new times and codes do not match the PDC label.

DUAL LISTINGS?

Gemstar wants newspapers to publish two times and codes where necessary, one for people who are using PDC and thus over-riding their timer, and another for people whose VCRs are relying on the timer clock. But Broadcast Data Services, the independent company which handles the programme listings for the BBC and ITV, does not supply the media with double times and codes.

BDS says the problem is Gemstar's. Broadcasters say the computer system used by BDS cannot cope with double numbering. So don't expect any change for the better until the BBC publicises its service, the complaints flood in and the broadcasters insist that BDS does something about it.

In the meantime, there is a simple stopgap solution which dealers can pass on to confused customers. Those with VCRs that are using PDC and thus over-riding their timers, should take their programme times and VideoPlus codes from weekly magazines, because they will be the originals that match the PDC label; those whose VCRs are relying on their timers, should take their times and VideoPlus codes from a daily newspaper because these will incorporate any scheduling changes.

SEQUENTIAL PROBLEM

Another complaint is that some PDC VCRs refuse to tape two different programmes, if they follow too closely one after the other. The PDC standard requires the broadcaster to transmit a label 30 seconds ahead of the programme start time, and cease at the end. But different VCR manufacturers implement the PDC standard differently, just as they implement the VideoPlus standard differently; they may play safe and make the VCR start early and stop late. Or the broadcaster may spread the programme labels by more than 30 seconds so that VCRs tape commercials. Either way, the VCR may miss the start of one programme that follows immediately after another.

There is no simple fix for this.

YEDA PRIZES

WE ARE always pleased to publicise awards that encourage interest in electronics by all age groups, but especially so by those who are still in full-time education. The *Young Electronic Designer Awards* (YEDA) for 1997, announced at the end of March, showed particularly high talent amongst those who entered their designs for consideration.

Once again, we notice the re-occurrence of several schools in the list of finalists. One in particular we must highlight, Radley College, who had four finalists. Electronics is taught at Radley by Max Horsey who, many of you will recall, was the author of our 10-part *Teach-In* '96 series.

One of Max's students, Edward Brocklebank, received first prize in the Junior Category (under 15 years) for his "safety device for a bicycle providing enhanced visibility at night and including left/right turn indicators".

Three more of Max's students received "Highly Commended" recognition in the Intermediate (15-17 years) Category: Andrew Buckmaster for his "device for measuring and displaying the quantity of water used by showers and hose pipes", and jointly John Morton and Max Kendall for their "bath temperature warning device in the form of toy".

The finalists from all the schools named show a remarkable sense of creativity and imagination in the subjects tackled. Congratulations to all.

Andrew Buckmaster and his water monitor.

For more information about YEDA contact: The YEDA Trust, 60 Lower Street, Pulborough, West Sussex, RH20 2BW. Tel: 01798 874767. Fax: 01798 873550. E-mail: **yeda@cix.compulink.co.uk.**

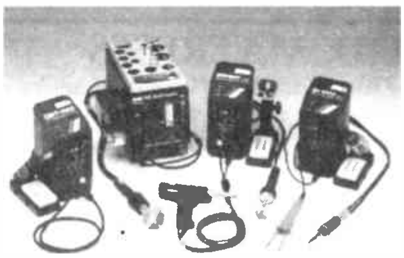
BETTER SOLDERING

QUALITY of soldering is a prime determinant of how well your circuits function over the years; a fact we never tire of stressing. For the really ultimate in joint perfection, SEME Ltd. have the equipment that is designed to and for a fine art.

Their OK Industries equipment is naturally not as pocket-money priced as your budget use-a-few-months-then-replace pointed heat source, but then you don't get high quality for peanuts. And if you are doing electronics on a regular basis you need high quality and price takes on a lesser priority.

Nonetheless, SEME-stocked soldering products give you the best of both worlds rolled into one: good value for money, a point which will be obvious when you examine their latest catalogue with its enhanced range of products. The range comprises not just soldering equipment, but all the other related products as well, including: desoldering tools, replacement tips and nozzles, fume extractors and a host of other accessories.

Take our hot tip and contact: SEME Ltd., Dept EPE, Unit 2, Saxby Road Industrial Estate, Melton Mowbray, Leics, LE13 1BS. Tel: 01664 65392. Fax: 01664 63976.



BULL AND THE TABLOID

BULL ELECTRICAL'S *Newsletter* has basically followed the same format for the past 50 years (50 years? It seems like only yesterday!) so they thought it was a good idea to change the format. *Newsletter 214* is the result, an 8-page tabloid format · with sizeable headlines and even more sizeable photographs of the newsworthy products.

One eyecatching headline highlights Bull's new colour mini catalogue – a first for them – already winging its way to customers. It's available on request to non-customers (you shouldn't be – they've got products to suit everyone, find out for yourself).

Of the other products newscast, some that stand out are: handheld laser pointers for only £29; 5.25in floppy disks at £5.99 per 100; 12-inch square solar panels for £18; l.c.d. screens for laptops at £15; solar energy plans for your home at £7; National Lottery predictors at £2 (could rapidly multiply the returns from a meagre investment); most astonishing is a real hot-spot offer of a Chieftain tank laser for £199 – we don't recommend it for home security, though – more suited to that are the ceiling mounted PIR detectors at £15!

We're urging you to be press-ganged into getting all Bull's info and becoming one their many addicted customers; you never know what you might be offered but you'll always know that interesting bargains will keep coming up for your enticement.

For your own info pack, contact: Bull Electrical, Dept EPE, 250 Portland Road, Hove, Sussex, BN3 5QT. Tel: 01273 203500. Fax 01273 323077. E-mail: **bull@pavilion.co.uk.** Web site: **http://www.pavilion.co.uk.bull-electrical.**

SAFER MOBILES

THE Department of Trade and Industry tell us that the police now have new powers to crack down on mobile phone fraud following the Telecommunications (Fraud) Bill which received Royal Assent on 27 February.

The Act makes it an offence to possess or supply equipment for use in the course of, or in connection with, the dishonest obtaining of telecommunications services. The Act will be widely welcomed as a powerful measure to protect mobile phone users from fraud.

POWERFUL HOBBY KIT

MINICRAFT, the "household name for precision tools for the perfectionist", have regarded the MB1000 Hobby Kit as their best selling kit in the range. Now the kit has *twice the power* at the *same price*!

It's a perfect starter kit and is ideal for all kinds of hobby, craft and DIY uses. With emphasis on continued quality and value for money, the MB1000 drill now contains a more powerful motor, and the transformer is upgraded as well, giving it twice the power of the original hobby kit.

At £44.99, the kit represents excellent value, containing a lightweight pencil-grip drill, plug-in transformer, plus a selection of versatile accessories, all packed in a tough carrying case.

We frequently emphasis the need to have a mini-drill amongst your workshop tools. If you haven't got one yet, here's one to ideally fill the gap. If you do have one, is it up to performance compared to this one?

Either way, contact Minicraft for more details, their catalogue and list of stockists: Minicraft, Dept EPE, Units 1 & 2, Enterprise City, Meadowfield Avenue, Spennymoor, Co Durham, DL16 6JF. Tel: 01388 420535.

YOUNG RADIO AMATEURS

WE HAVE received information from the RSGB (Radio Society of Great Britain) about their *Young Amateur of the Year Award 1997*. The award, which is for the most outstanding achievement by a young amateur radio enthusiast, is open to anyone under 18 who has an interest in radio. Candidates do not have to be licence holders to apply, but the following areas of activity will be taken into account when applications are assessed:

DIY radio construction; operation of radio; community service (e.g. helping the disabled or assisting in emergency communications); encouraging others (e.g. through the novice licence scheme); school projects.

The prize will be awarded for the most outstanding achievement between 1 August 1996 and 31 July 1997. The winner will receive a £300 cash prize, and the runner-up a £50 cash prize plus amateur radio equipment from the RSGB. All entrants will receive a copy of the RSGB's amateur radio log book.

Applications should be sent to: Young Amateur of the Year Award, Radio Society of Great Britain, Dept EPE, Llambda House, Cranbourne Road, Potters Bar, Herts. EN6 3JE. Tel: 01707 659015. The closing date is 31 July 1997.

ELECTROMAIL CD-ROM

ELECTROMAIL, the company that supplies RS Component's products to the largely non-trade users of electronic components, i.e. hobbyists like most of you, have released their massive 3-part catalogue on CD-ROM.

RS themselves have had a CD-ROM cat for some months, and highly useful we've found it to be (although the paper edition is still periodically referred to). Electromail now offer the same CD-ROM at £5 per edition. Updates are published every four months, to keep you informed of new products and any price changes. It also contains the *full* RS Data Sheet Library of Technical Information.

If you don't already have a CD-ROM on your PC-compatible computer, Electromail have three super value CD-ROM drives available, starting at only £59.

You will not find a larger catalogue of high quality mail order components than that from RS/Electromail and *all* electronics constructors should possess or have access to one.

For more information, contact: Electromail, Dept EPE, PO Box 33, Corby, Northants, NN17 9EL. Tel: 01536 204555. Fax: 01536 405555. Web: **http://www.rs-components.com/rs/.**

BATTERY NEWS

ALLIED Battery Technologies Ltd. have announced what they describe as "a major breakthrough in the field of battery technology". They have introduced the first ever mercury-free, rechargeable alkaline manganese cells.

Apparently, by using these batteries, the average family could save about £100 a year in battery purchases. Whilst some of you may contend that you don't spend *that* much, it's seems likely that you could make some sort of significant saving.

Known as RAM™ (Rechargeable Alkaline Manganese) cells, they have recharge characteristics such that their lifetimes are increased over conventional alkaline batteries by at least 10 and up to 50 times or more.

For more information contact: Allied Battery Technologies, Dept EPE, 14 Bates Industrial estate, Wycombe Road, Stokenchurch, Bucks, HP14 3RJ. Tel: 01494 484050. Fax: 01494 482161.

CROCS, RATS AND PCBS

YOU'RE all familiar with Quickroute Systems and their commendable PCB CAD software products regularly advertised in our pages, aren't you? Naturally, then, you will be interested to know of their new Croc2QR software, which allows Crocodile*clips* circuit files to be converted into Quickroute PCB files.

Croc2QR works by reading a Crocodile*clips* circuit files (.CKT) and replacing the circuit symbols with appropriate Quickroute PCB symbols. You can then save the circuit as a Quickroute binary netlist and import the netlist into Quickroute 3.6 to produce a PCB rats-nest. Symbols can then be repositioned and autorouted.

Not only that, Croc2QR automatically adds power supply rails to logic and op.amp i.c.s, and groups individual logic gates, e.g. NAND, NOR, and the rest, into the minimum number of integrated circuit packages. That's handy!

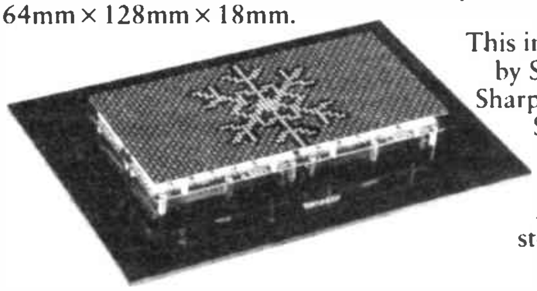
Says Managing Director Dr Ian Frost, "We are sure that Croc2QR will prove of great benefit to the many teachers and enthusiasts who use Crocodile*clips* and who would like to produce a PCB from their circuit diagrams". Technical support for Croc2QR is *free*.

For more information contact: Quickroute Systems Ltd., Dept EPE, Regent house, Heaton Lane, Stockport, Cheshire, SK4 1BS. Tel: 0161 476 0202. Fax: 0161 476 0505. E-mail: **info@quicksys.demon.co.uk** Web: **http://www.quickroute.co.uk**

FULL COLOUR L.E.D. MATRICES

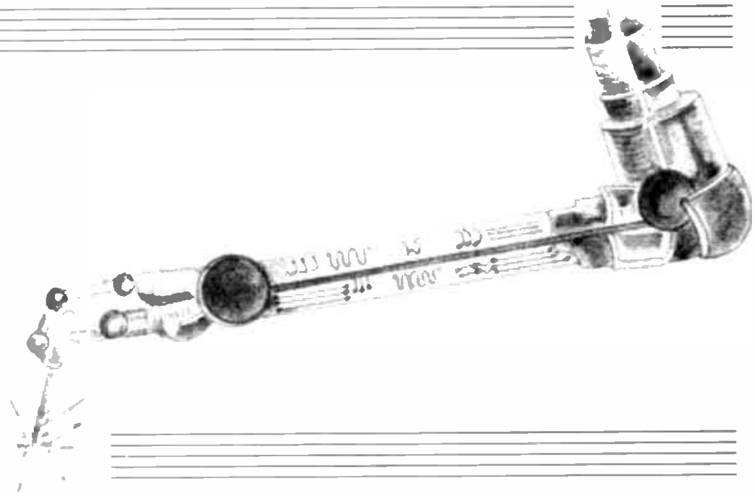
SHARP Electronics have announced the introduction of a whole series of full colour dot matrix l.e.d. units. These devices are stackable and provide dot pitches of 2·5mm, 4mm and 6mm at extremely good brightness levels.

They are suitable for use as indoor full colour information display panels and incorporate a 16 × 32 pixel array. The devices are driven with four serial lines. The 4mm dot pitch version (illustrated) measures 64mm × 128mm × 18mm.



This information was supplied to us by Sharp's German headquarters: Sharp Electronics (Europe) GmbH, Sonninstr.3, 20097 Hamburg. Tel: 040 2376 2215. Fax: 040 2376 2991. Ask your favourite electronics stockist to add these interesting devices to his range.

CIRCUIT SURGERY



ALAN WINSTANLEY

Our monthly "surgeon" puts together an ear-blowing siren using a custom siren driver chip, along with a simple burglar alarm module. Also, why does the letter "I" actually mean "current"? Getting live supplies "down to earth" – literally – and a way of putting old batteries in the can.

Power Siren

EVERY so often, I take the lid off an interesting chip, and following on from the May 1997 *Circuit Surgery*, which described piezo sounders and buzzer technology, I've been experimenting with a dedicated siren integrated circuit which is manufactured by Zetex. Indeed my ears are still ringing from testing the ZSD100, which can be configured to produce a variety of siren wails!

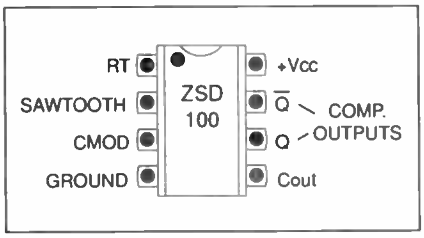


Fig. 1. ZSD100 pin-outs.

The pin-outs for this 8-pin d.i.l. device are shown in Fig. 1. The Zetex ZSD100 will operate from +4V to +18V d.c. and requires very few external parts indeed to produce a fully-fledged, and deafening, siren. The device consists of an internal audio frequency generator which provides a basic tone, and this is modulated by another low frequency oscillator to generate the characteristic siren "whoop" or wail.

In standby mode, this chip consumes less than 1µA which makes the device ideal for battery-powered applications. An internal 61·5k timing resistor is available at pin 1 (RT): in many applications this default value can be used by grounding pin 1, but an external resistor up to 1M can be interposed between pin 1 and ground to provide improved frequency control (see later). Pin 1 has a further use in that it can be utilised to disable the chip – leaving it either open circuit or connected to the positive rail inhibits the siren. Connect to ground to enable the siren operation.

Two external capacitors are required to control the siren effect. Pin 3 (Cmod) is the low frequency modulator waveform which controls the sweep rate, and tests showed that the value of the capacitor can be between 2µ2 to 220µF or so. Pin 5 (Cout) is the base audio oscillator timing capacitor and a value of between 10nF and 100nF proved satisfactory.

Timing Caps

By combining the two capacitor values, the following siren effects can be obtained:

Cmod	Cout	Effect
2µ2	10nF	high pitch whistle, rapid "chirp"
4µ7	22nF	police-style siren
22µF	47nF	slow "whoop"
100µF+	100nF	slow siren

Intermediate values for the timing capacitor can be selected and a little trial and error will soon produce the desired effect. Pin 2 is a "sawtooth" selection pin and linking this to pin 3 will create a rising ramp sound (sawtooth) instead of the rising and falling modulated tone of a classical siren when pin 2 is left open circuit. The output audio tone is available at pins 6 and 7, which are complementary outputs (5mA source).

The circuit shown in Fig. 2 is mostly based on manufacturer's application notes, using transistors which were available at the time, and it forms a highly effective Power Siren. The ZSD100 is configured to directly drive a transistor bridge arrangement as shown. TR1 and TR2 are *npn* drivers for the four main bridge transistors: when pin 6 is high, then TR1 switches on and drives TR3 and TR6. This is reversed when pin 7 goes high, this turns TR2 on instead, and powers TR4 and TR5. Thus, only one pair of "diagonally opposed" transistors is switched on at any one time, and this directly drives the loudspeaker. A piercing alarm siren can be constructed using a moving-coil loudspeaker as the sound element and in fact the Power Siren

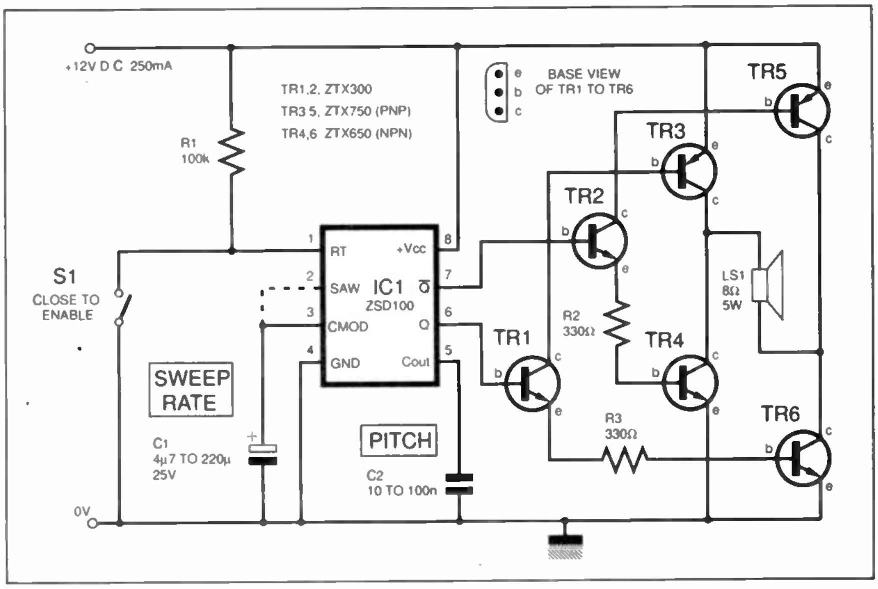


Fig. 2. Power Siren circuit using the ZSD100.

was tested in conjunction with an 8Ω five watt type taken from an old stereo system. You can also use it with a basic piezo disc element for low power applications.

Zetex say that the integrated circuit is designed to prevent cross-conduction (when both driver transistors are turned on slightly) and I used ZTX650 and ZTX750 complementary pairs which are rated at 1A; any equivalent will be fine. In tests, the sound proved virtually unbearable at close range and generated a strident and piercing alarm siren – I also noted that the siren has a start-up "ramp" – a one-off rising tone before the main "whooping" effect takes over, just like real police sirens. In fact it was necessary to insert a couple of 47Ω wirewound resistors in series with the loudspeaker, or face premature deafness!

It's also worth relating that although the ZTX650/750 transistors were generally effective in this arrangement, one half of the bridge (TR5 and TR6) did fail when I tested the circuit on-load by substituting the loudspeaker for a 4·7Ω 10W wirewound resistor. Hence it is probably worth ensuring that the impedance of your selected speaker is at least 8Ω, or perhaps uprate the H-bridge transistors accordingly. (Since all six transistors look identical, in order to trace the faulty transistors, all I did was to spray them with freezer aerosol, and then switch on: the faulty transistors thawed out instantly!)

The makers also recommend that an external timing resistor is not used when a bridge driver circuit is employed on the output, because this can lead to problems with cross-conduction between the two complementary pairs. All in all, the ZSD100 is a simple and highly effective way of producing a powerful warning device. Simply select the two capacitors to produce the required tone: perhaps consider using a DIP-switch network to select various values – but consider other people when testing it!

Burglar Alarm module

A simple burglar alarm add-on circuit is shown in Fig. 3. This takes advantage of the fact that by grounding pin 1 of the siren chip, it will be enabled, but if the pin is biased to the positive rail then it is inhibited. I found that the forward voltage (between anode – cathode) of a conducting thyristor was low enough to enable the chip when connected as shown. Fig. 3 is actually based on a very old burglar alarm design which I produced back in the late 1970's, and has been updated slightly. I was prompted by some interest expressed by the British Amateur Electronics Club (BAEC – see their advertisement in our classified section) who wish to use this and other simple designs in their newsletter.

In Fig. 3, TR1 is an *npn* MPSA14 Darlington with its base biased midway to 6V by R1/ R2. A voltage of 6V-1·2V (because the Darlington has two base-emitter junctions, each losing about 0·6V) therefore appears at its emitter, and so roughly 4·8V is developed across R3. This is further dropped by D1 and R4 to provide a triggering signal to CSR1. However, if the normally-closed (n.c.) loop is intact, then TR1 base is grounded and no voltage appears across R3, so no triggering signal is present. Opening the n.c. loop temporarily will "fire" the thyristor: even if the n.c. loop is closed again, the thyristor remains in conduction until you reset it.

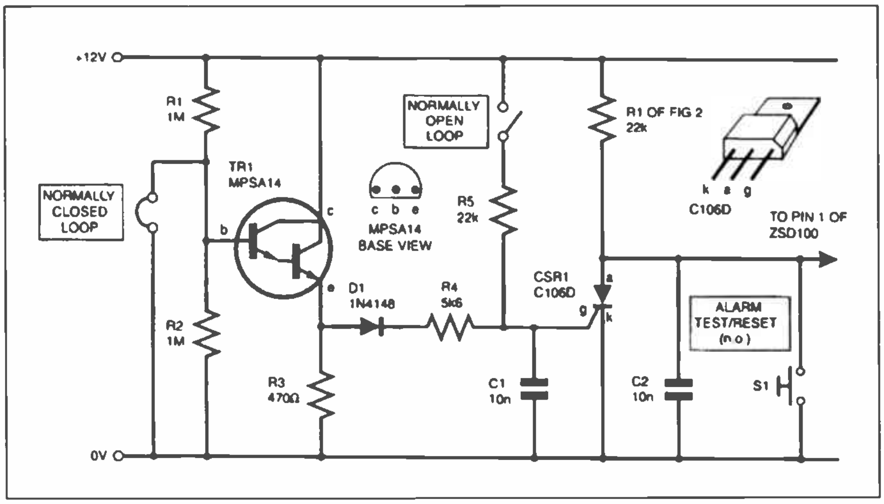


Fig. 3. Burglar Alarm add-on circuit.

A simple normally-open loop can also be added as shown, which, when closed, will directly trigger the thyristor and sound the siren. A C106D thyristor was chosen as this was to hand: it has a 1V 0·5mA gate and will easily handle the siren load. It was found that in order to provide a reasonable holding current for the thyristor, the pull-up resistor on pin 1 of the siren chip needed to be reduced to approximately 22k.

Notice the apparently unnecessary capacitors surrounding the thyristor. These are included to prevent false triggering of the device but will not have any noticeable effect on performance. Sometimes, a thyristor will trigger when the main power rails are applied, due to an excessively steep rate of voltage turn-on (dV/dt) and the capacitor will slow this down. It's worth doing this on most d.c. thyristor alarm applications, especially battery-operated projects where the power rail can be applied almost instantaneously.

A favourite trick of mine in some thyristor applications is to use a switch (S1) directly across the anode and cathode of the thyristor. It serves two purposes – it will reset a conducting thyristor and will also double as an "alarm test" switch.

Pinouts for all the semiconductors are included in the circuit diagrams. The ZSD100 is available from Zetex distributors including Farnell Components of Leeds, tel. 01132 636311, part ref ZSD100D8, price 0·65p + VAT, delivery free. However, please note that Farnell impose a £10.00 minimum order charge for payment by credit card, and their 2,000 page catalogue is only shipped to bona fide trade sources. Perhaps try contacting your nearest retailer or distributor to see if they can obtain the part.

On the subject of piezo devices, ***Harri Suomalainen*** in Finland recounts via the Internet how he needed an oscillator running at approximately 1Hz to 2Hz to drive a piezo buzzer, so he placed a flashing l.e.d. in series with a d.c. piezo sounder and got a flashing beacon into the bargain! The piezo sounded when the l.e.d. chip was alight.

SI Units rule OK

Elsewhere in this issue is the second part of a fascinating series describing the historical work of key electrical and magnetic experimenters. It is incredible to think that much pioneering work was performed over 150 years ago! One of the most fundamental rules of electronics is that a voltage (or "potential difference") exists *between two points* in a circuit, whilst a current flows *through* a conductor or component. Current is of course measured in Amperes (A), or say milliamperes (1mA = 0·001A) if the Ampere is too large a unit to be applied. Voltages are measured in, erm, Volts! This gives rise to an excellent question from ***Gareth Taylor*** of Rhymney, Gwent, who asked:

I'm a second year student in systems control, and one problem has cropped up to which no-one seems to know the answer. I've asked many electronics and maths tutors, and electronic companies, who just reply 'I can't answer you'! This problem comes from a test paper, and reads: 'Why is the symbol "I" used to represent current in both Ohm's Law and circuit schematics, when A is used as the international symbol for Amperes?' Perhaps you could include this letter in your column, as it seems to catch everyone out.

Why is current actually depicted as "I" and not "A"? After all, Voltages are both measured and depicted as "V"! The internationally-adopted SI "base unit" for measuring current is the Ampere (after André Ampère, its 1820's "inventor"), and has the symbol A. The answer to the question is that the SI System *(Système International d'Unités)* of metric units has primary definitions which were phrased in the French language, and these were subsequently translated into English.

The letter "I" comes from *"Intensité"* which is the French word for "force" or "magnitude" (I'm not sure it translates too well in this context – any offers?) and is utilised in the original French definition for the Ampere SI unit:

L'ampère est l'intensité d'un courant constant qui, maintenu dans deux conducteurs parallèles, rectilignes, de longueur infinie, de section circulaire négligeable, et placés à une distance de un mètre l'un de l'autre dans le vide, produirait *entre ces conducteurs une force égale à 2×10^{-7} newton par mètre de longueur.*

(The ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed one metre apart in vacuum, would produce between these conductors a force equal to 2×10^{-7} newton per metre of length.)

The remaining six base units of the SI System are: length (metre, m), mass (kilogram, kg.), time (second, s), thermodynamic temperature (kelvin, K), amount of substance (moles, symbol mol.) and luminous intensity (candela, cd.). You will often see the candela used to describe the output level of light-emitting diodes. The National Physical Laboratory has an excellent World Wide Web resource at **http://www.npl.co.uk,** if you're on the Internet, where you can check out the SI System in more depth.

Down to earth

Spyros Bonatsos of Limassol, Cyprus posed the following question concerning the need to earth electrical appliances.

My knowledge of power electrical engineering is limited, and I wondered why it's necessary to ground the neutral point (at the "power station end"). If the neutral was not connected to earth then there would be no danger for someone touching the live wire, since they would not complete a circuit to the earth itself. It would only be the same as touching one pole of a 240V battery. The only danger would be by touching the neutral and the live wires at the same time, it seems to me.

In a UK domestic supply, the live voltage alternates at +230V to −230V with respect to neutral, 50 times per second (50Hz). The neutral wire is grounded and effectively at the same voltage as earth, though it is *very dangerous* to touch a neutral pin to test this in case your wiring is faulty. The metal housings of electrical appliances are connected to earth too, unless they are "double insulated", indicated by a symbol of two concentric squares, in which case no earthing is required. American readers should note that "earth" is our term for "ground".

If a live wire comes adrift internally and the cabinet of the equipment becomes "live", then since the cabinet is earthed and in effect connected to neutral, a massive short-circuit current flows from live to neutral/earth, which will melt a fuse or trip a circuit breaker and immediately disconnect the supply. If the cabinet became live but it wasn't earthed properly, then if a human touched the case, a potentially lethal current would flow through the body en route to earth.

Hence it's critical that the earth of an appliance is connected correctly to avoid a lethal shock being delivered in the event of a fault or insulation failure; it is also vital that the correctly-rated fuse is fitted to the mains plug, so that the fuse blows as soon as possible. Follow the maker's instructions closely, to prevent a fire or shock hazard.

Batteries in the can

Finally this month, further to my item in March 97 on the "KCA" wheelie-bin logo appearing on batteries – indicating that when exhausted they should be treated as small chemical waste and not simply sent to land-fill sites – ***Robert Brodie*** comments that when on holiday in Majorca, he noticed that a tin box was placed on the wall in the supermarket, for the disposal of all small batteries. An excellent idea – Tesco, Sainsbury's and all the others, take note! (All UK chain stores are in the process of implementing the recently introduced Packaging Waste regulations, so things are starting to move in the UK at last.) I really do feel that consumers are quite happy to play their part in helping to recycle and dispose of waste properly when the facilities are there to permit this.

If you have any questions or comments, please write to Alan Winstanley, Circuit Surgery, Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset, BH21 1PF, United Kingdom. E-mail **alan@epemag.demon.co.uk.** We cannot guarantee a personal reply but will endeavour to offer help wherever possible.

READOUT

John Becker addresses some of the general points readers have raised. Have you anything interesting to say? Drop us a line!

PINNING DOWN THE NET

Dear EPE

Any ideas if or where data sheets, or at least pinouts, of chips might be available on the net? If not, might it be another service that could be added to *EPE On Fax*? There was a time when pinouts were published as part of major component catalogues, Maplin, Electromail, RS, etc. Unhappily, such helpful information has been deleted from their recent cats. This becomes very frustrating, whether designing around current chips, or when "recycling" now-obsolete components.

Bryan Buckby, via the Internet

No doubt Alan Winstanley will be answering the Internet side of this in due course through his monthly Net Work *column. I can answer from another point of view, though.*

We thoroughly agree that the deletion of pinouts from catalogues is a highly regrettable action. We, too, for all our multi-volume data books miss the convenience of a single up-to-date source of common pinouts. Naturally, we sympathise with suppliers' needs to keep page counts down in their catalogues; they do, after all, make their money out of selling products and not from the peripheral information. However, it could be argued that a cat which is being kept as a general reference work is much more likely to be turned to when the need to buy components arises (we still keep, and refer to, old copies of Maplin and RS which have pinout info). Additionally, in some instances, a constructor might not know which of a selection of similar products would best suit his needs if the pinout functions are not shown and consequently decide not to buy any of the selection, choosing instead to reuse known, but possibly less ideal, items from his "spares box". Not an ideal situation to encourage experimentation in the latest technology.

The offer of some companies to fax or post data sheets is helpful, but not the best answer for someone who wishes to compare device parameters right NOW *before making a design decision. (We will consider your suggestion about them being available from us by fax, but suspect that the logistics of the situation, considering the sheer quantity of data, would be a signifant problem.) Nor is it realistic for many constructors to have full ranges of data books on their shelves. The cost would prohibitive to most non-professional designers. Even professional designers might be inhibited from using this option by their company's Accounts Dept! However, some manufacturers can sometimes be persuaded to part with their previous year's data books at low cost; an option worth investigating if you are heavily into designing.*

Here at the office, and in my own workshop, we have two other sources of information which you might consider obtaining. The first is the Semicon Index *volumes. Different volumes, which are in ring-binders, cover different semiconductor groupings, i.e. transistors in one, i.c.s in another, diodes and SCRs in a third. The volumes possibly comprise the most comprehensive source of basic s/c data to be found. An updating service is available, as is on-line phone advice and a data-sheet fax service. To find out more, contact Semicon Indexes, PO Box 470, London SE12 8AF. Tel: 0181 852 2309.*

The other very useful source of semiconductor data is in the Electronics Service Manual *which has recently started to include extensive pinout diagrams for a wide range of semiconductors, and will be continuing to do so through its future supplements. Adverts for ESM are frequently included as "inserts" with* EPE *and other electronics monthly publications, professional and hobbyist. It is published by* EPE*'s parent company, Wimborne Publishing, and you can phone us at* EPE *if you would like to be sent more information about it.*

Also obtainable is the IC Master, *a massive work covering i.c. data for chips that go back yonks, right up to present day. It's expensive, though, and our (rather old) copy is not good on pinouts, though it is otherwise useful for general i.c. data and such things as manufacturer's and distributor's addresses worldwide. Companies such as RS and Electromail sell it.*

JB

ENGINEERING RECOGNITION

Probably originating on the Net, but now doing the rounds as photocopies of photocopies, is a document that shows a remarkable degree of perception with regard to what makes an engineer tick. Its origin is unknown, but it appears to have some connection with graduates at Bath University.

It recognises, for example that "people who work in the fields of science and technology are not like other people. This can be frustrating to non-technical people who have to deal with them. The secret to coping with technology-orientated people is to understand their motivations.

"Engineers", it states, "can be distinguished by their reactions to everyday life". What would be *your* reaction in this next situation that it quotes?

"You walk into a room and notice that a picture is hanging crooked. Would you:

A. Straighten it?

B. Ignore it?

C. Buy a CAD system and spend the next six months designing a solar-powered, self-adjusting picture frame while often stating aloud your belief that the inventor of the nail was a total moron?

"As any sane person knows, the answer is "C" but partial credit can be given to anybody who says *It depends*, or simply blames the whole stupid think on *Marketing*."

There's more, but I'll save it for a future occasion! (What do you think constitutes an "engineer"?)

JB

New Technology Update

Putting the right package together is set to further improve the performance of communications equipment – reports Ian Poole.

RADIO technology has increased in its importance over the last few years. At the beginning of the 1980s few people could have predicted the popularity of cellular phones.

When they were first introduced they were restricted mainly to business users because of the cost. Now they are freely available to anyone who wants to use them. New shops are appearing, selling the phones and there are many introductory offers and deals to be taken for anyone looking for one of these phones.

As a result of the rapidly expanding markets for these products, there has been a new impetus given to new developments in the field of radio technology. It is now one of the areas of electronics receiving large amounts of development, along with the computer section of the industry.

The results of this development are easy to see. When cellular phones were first introduced they were large and cumbersome. Most were fitted into cars because of their size and battery requirements. Those portable phones which were available were almost the size of a small brief case.

Today small phones which slip into a top pocket are standard, showing an enormous reduction in size. Battery requirements have also been greatly reduced. They can now operate for considerable periods of time between charges.

Package Developments

One of the reasons for the reduction in size has been the increased level of integration which is now possible, and the almost exclusive use of surface mount components (SMDs). When the first cell phones were manufactured, the range of surface mount components which were available was relatively limited. In addition to this the components were larger.

Early designs would have used 1206 type (industry code) resistors measuring 3·2mm × 1·6mm, whereas most of the phones being produced today use 0402 type resistors which measure 1·0mm × 0.5mm. Other components have seen similar reductions is size, as well as the fact that far higher levels of integration are now possible and many r.f. circuits are contained within i.c.s.

For those r.f. components which are now contained within an i.c. there are many advantages in terms of performance, resulting especially from the smaller packages and lack of leads. Older r.f. circuits operating at v.h.f. and above were very prone to oscillation. Much of this resulted in the stray capacitance between leads and, more importantly, the stray inductance in the leads. By using surface mount devices, these stray effects can be almost eliminated.

It is quite easy to use standard surface mount resistors and capacitors in circuits operating at frequencies up to 1GHz and slightly more. There are almost no stray effects which degrade the performance of the circuit to any significant degree.

Short Fall

Whilst this is true for most cases, when frequencies rise above about 1GHz losses start to become significant. Components like diodes are often mounted in plastic SOT-23 packages. However, the packages themselves have a significant effect on losses. Above about 1GHz, where many of the emerging radio or wireless applications are being used, diodes in the standard packages start to fall short of the required performance.

A variety of types of diode are required in r.f. circuits and, as their performance is critical, they are rarely integrated into the many r.f. i.c.s. These include PIN diodes for r.f. switching where losses must be kept to a minimum, or Schottky barrier diodes which find uses in high performance double-balanced mixers. Varactor diodes for use in the tuning of oscillators are another example.

Other types of component could also benefit from better packaging. Items like voltage controlled oscillators (v.c.o.) and voltage controlled crystal oscillators (v.c.x.o.) are also widely used, and have to be enclosed in expensive packages.

The ordinary plastic packages are the cheapest to produce but, at these frequencies, they introduce unacceptable levels of parasitic capacitance and inductance. This is due mainly to the package's frame and lead connections and these can be the limiting factor of the performance of a device. On its own the device may be capable of operating to frequencies of several GHz, but the package may limit its performance to only one GHz.

Enhanced Performance

To overcome this, superior packages are required. In the past these have been relatively expensive, often being the major cost driver for the whole component. Sometimes a component encapsulated in a high performance package may cost several times that of the same component in a plastic package.

For consumer applications cost is of major importance and, as a result, a company called Lockheed Martin Microwave have devised an Enhanced Performance Surface Mount (e.p.s.m.) package. This uses an alumina material to keep the parasitic elements to a minimum whilst still retaining a sufficiently low cost.

The package consists of an alumina substrate which has gold pads printed onto the top surface. These pads extend through to the bottom surface and provide the means of connection to the external circuit. The device die itself is attached to a gold pad on the top surface and bonded to the opposite terminal with a gold wire which is very short.

Diehard

When the die has been placed, connected and secured, the package is encapsulated in a material which has a low dielectric constant to reduce losses. This protects the wire and the die from mechanical damage as well as preventing moisture ingress.

The assembly method produces a package which has low levels of stray capacitance and inductance. Typically the capacitance is 0·09pF and the inductance is only 0·5nH, making it suitable for applications up to about 4GHz.

The underside of the package has been designed so that it has the same p.c.b. footprint as an SOT-23 package. This means that to upgrade existing designs it only requires the package to be exchanged, with no changes to the remainder of the p.c.b. This is a great advantage because small changes to a board can alter the performance of the circuit, especially when components are packed as tightly as possible to minimise the board area required.

Future

With personal communications expanding, ever increasing frequencies will need to be used. As this sector of the market requires very high volumes and it is very price sensitive, it is likely that many more packages like these will start to be seen.

Until recently high frequency packages for diodes have been expensive. As a result they have only been viable for equipment where cost is not the prime mover. Often these packages have been used in military equipment, but with the way this market is moving, price will become a major issue here as well.

Apart from a wider variety of packages for these frequencies, it is likely that similar developments will be seen for even higher frequencies. This will open the door to the use of a greater portion of the radio spectrum, and may even help to reduce the congestion on the frequencies which are already being used.

PYROTECHNIC CONTROLLER

KEITH RIGBY

FLASH ★ BANG ★ WALLOP ★

Stage fright becomes a reality with this special effect generator!

THE USE of stage flashes for effect has increased in recent years. Once, it was strictly the domain of professional theatre companies. Now, it is not unusual for stage pyrotechnics to be used in the local pantomime or even by the group performing at the local youth club.

Commercial flash cartridges are readily available as are the controllers required to initiate them. The controllers are expensive and are often designed to give a large amount of flexibility. This project describes a relatively simple pyrotechnic controller that can be built for approximately £35.

The most common pyrotechnic devices are electrically initiated. The idea is simple: Supply enough energy into a resistance wire to heat the surrounding material to its flash point. The material ignites and burns in a fraction of a second, causing the flash. Simple, but very effective when the "Genie Of The Lamp" appears on stage.

SAFETY AND RELIABILITY

The use of pyrotechnics does require very careful consideration of safety. Once connected there must be no risk that the device can be initiated accidentally or when not intended as this could cause damage to surrounding scenery or even serious personal injury.

Equally, when it is intended, the cartridge must fire every time. This gives two important design requirements; safety and reliability.

SAFETY

All pyrotechnics can be extremely dangerous if not treated with the utmost care. Always follow the manufacturers' instructions and ensure that when a cartridge is to be detonated, that there is absolutely no risk of injury to persons or damage to surroundings.

If used with care, flash cartridges can add a new dimension to any stage production. Be sensible and enjoy the effect.

CIRCUIT DESCRIPTION

The full circuit diagram for the Pyrotechnic Controller is shown in Fig. 1. A typical flash cartridge requires about 200 to 300 millijoules of energy to fire. In this unit, the energy is supplied by a pulsed discharge of a high value capacitor (C6) through the flash cartridge.

To ensure that the unit is always ready for operation, the power is derived from the mains supply by a fairly standard power supply circuit formed by mains transformer T1, bridge diodes D1 to D4 and regulator IC1 and its associated components. The mains on/off switch S1 is a neon type so that in darkened backstage conditions the fact that the unit is powered is obvious to the operator.

Transformer T1 is a step-down type with a secondary output of 12V at nominally 1A. Any transformer of this approximate rating will work; the prototype used a transformer from an old project.

Full wave rectification is provided by diodes D1 to D4 with the circuit protected by fuse FS1. The 1,000µF capacitor C1 acts as a reservoir feeding IC1, a standard voltage regulator.

Additional smoothing and high frequency de-coupling is performed by capacitors C2 and C3. The integrity of the power supply is indicated by light emitting diode D5, an orange l.e.d. whose current is limited by resistor R1.

ENERGY STORE

Capacitor C6 is the main energy storage component in the unit. The capacitor is charged through resistor R7 and D7, a blocking diode. The value of C6 (22,000µF) and R7 (18 ohms) are critical components.

The value of C6 is chosen to store significantly more energy than is required to fire a typical flash cartridge. Using the equation for energy stored in a capacitor, namely $E = 1/2CV^2$, C6 stores about 1·5 Joules of energy.

The value of R7 is chosen to minimise the time taken to charge C6 whilst limiting the maximum current drawn from the power supply. With R7 equal to 18 ohms, C6 will charge in about two seconds with the initial charging current limited to 628mA.

Depending on the actual rating of the transformer, R7 can be changed to suit. The charged state of C6 is indicated by D10, a red l.e.d. whose current is limited by resistor R9. Zener diode D9 acts as a voltage detector, ensuring that l.e.d. D10 does not illuminate until the capacitor has charged up to about 10·5V.

RELAY DISCHARGE

The main capacitor (C6) is discharged through the load (the flash cartridge connected to output socket SK1) when the relay contact RLA1 changes over. As the design is a pulsed discharge circuit, RLA1 only needs to be switched for a short duration to allow C6 to discharge. The minimum duration that RLA is energised is controlled by the monostable circuit built around IC2, a standard 555 timer i.c.

Trigger pin 2 of IC2 is held high by resistor R2. The output pin 3 is normally low so transistor TR1 is turned off. On operating the Fire pushbutton switch S3, the monostable is triggered, sending pin 3 high and turning on TR1 and therefore relay RLA on.

The duration of the pulse at pin 3 is set by the values of resistor R3 and capacitor C4. These have been chosen to generate an 80 millisecond pulse. This is more than sufficient time to fire the cartridge.

When key-operated switch S2 is operated it allows capacitor C6 to charge from the supply. The key operation is important as this acts as a "security measure" to prevent premature arming of the unit and inadvertent firing of the flash cartridge.

Once the cartridge has fired and RLA is released, C6 will recharge. When S2 is switched to the safe position, contact S2b will close, providing a discharge path for C6 through resistor R8. The chosen value of R8 will cause C6 to discharge in about five seconds.

TEST CIRCUIT

As noted above, when it is intended to "fire" the cartridge it is essential that it does. The most common cause of cartridges not firing is through poor connections.

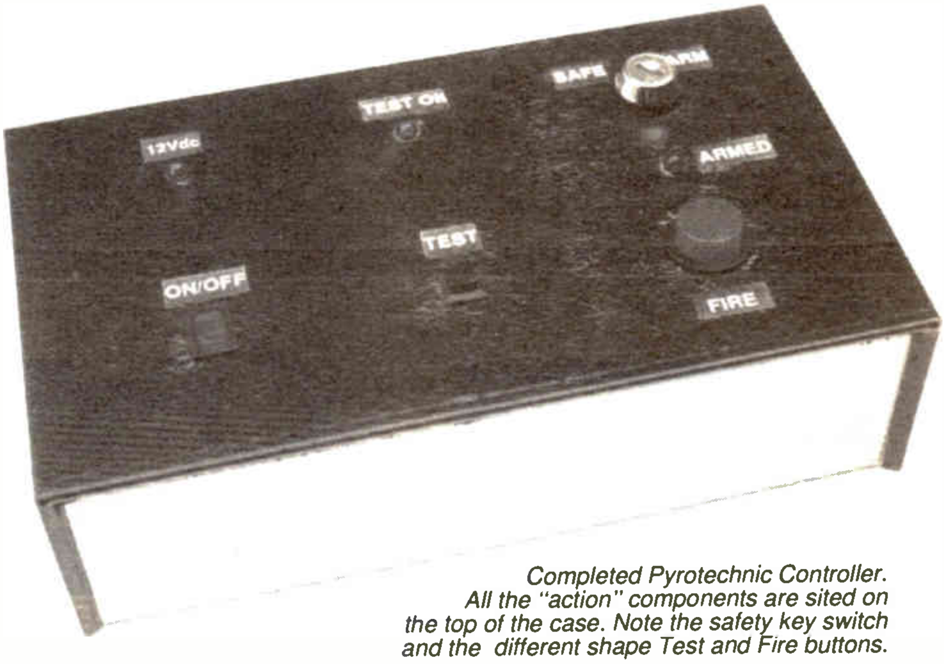
This unit incorporates a simple but effective "test" circuit to ensure continuity through the connecting wires and the flash cartridge. Light emitting diode D8 is a low current (for safety) green l.e.d. with its current limited by the series combination of resistors R5 and R6.

Two resistors are used in series so that any single failure in the test circuit does not cause a significant current to flow through the flash cartridge, causing premature initiation. S4 is the push-to-make Test switch.

The switches chosen for S3 and S4, although being push-to-make types are physically different switches. The significant difference lies in the type of button fitted. S3 has a round bezel and S4 is square. The reason for this is that often the timing of a flash is critical.

Using different styles of button for these switches means that in darkened stage conditions, the operator can differentiate between the two by touch and does not accidentally push the Test button instead of the Fire button, thereby missing an important cue.

The Pyrotechnic Controller circuit is housed in a metal box that is earthed by the mains Earth lead. The output socket SK1 is a metal 4-pin DIN type. The output cable used is a twin cable with an overall screen, with the screen being connected to the case through pin 2 of SK1. To ensure a reliable and long-life connection, a screened cable with a conductor area of 0·5mm^2 should be used.



Completed Pyrotechnic Controller. All the "action" components are sited on the top of the case. Note the safety key switch and the different shape Test and Fire buttons.

CONSTRUCTION

Construction of the Pyrotechnic Controller is straightforward even though many components are mounted on the box. A printed circuit board (p.c.b.) is used for the smaller components. This board is available the *EPE PCB Service*, code 155.

The full size underside copper track master and topside component layout are shown in Fig. 2. Note that three wire links are fitted to the circuit board.

The usual care should be taken when soldering the semiconductors in position. A socket could be used for IC2 but this is not essential as direct soldering gives a more reliable connection. The large resistor R7 should be mounted so that its body is just above the board.

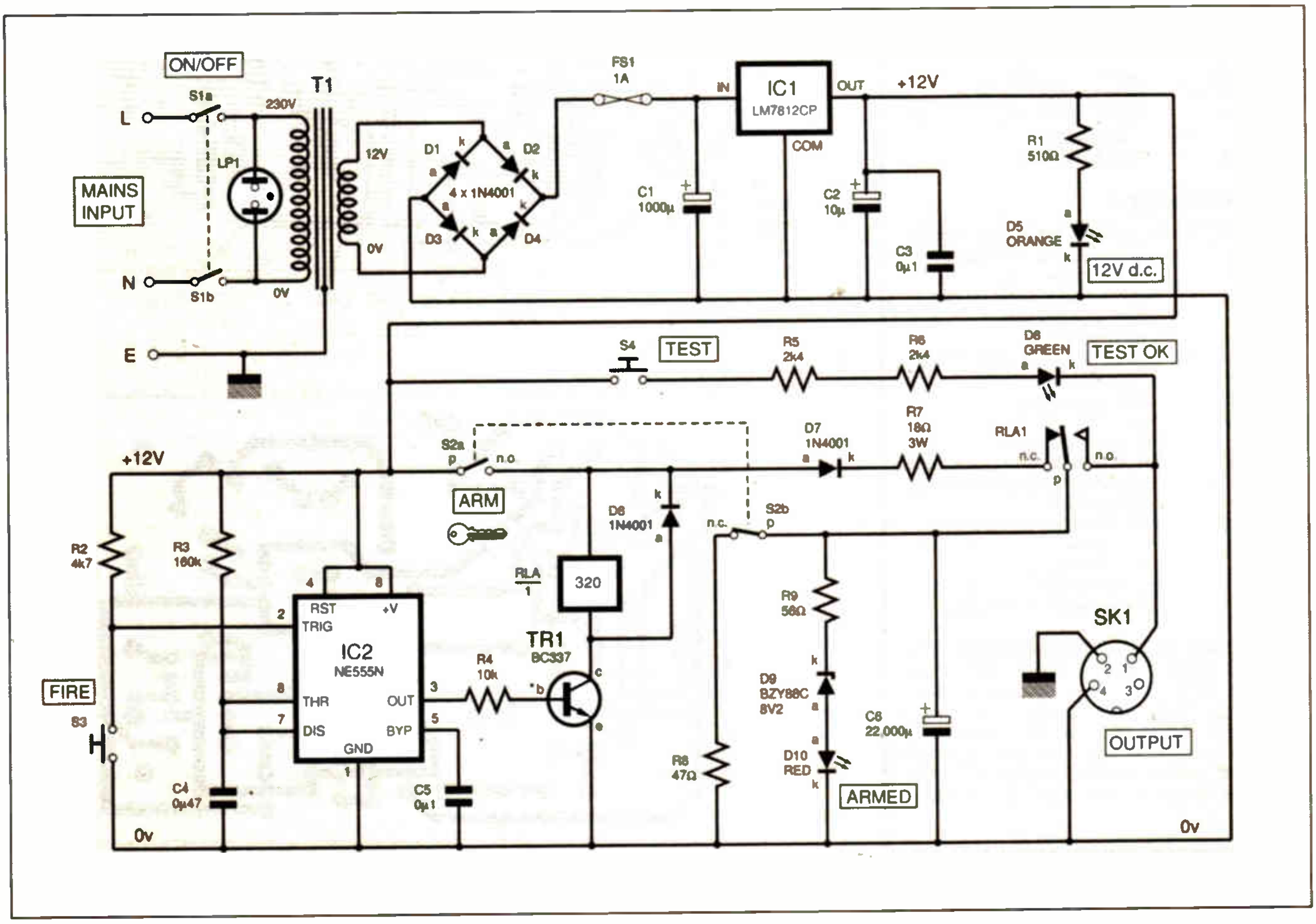


Fig.1. Complete circuit diagram for the Pyrotechnic Controller.

FINAL ASSEMBLY

Any suitable *metal* box can be used to house the controller. The choice is left to the individual but it is important that the box chosen is deep enough to accommodate the keyswitch and the mains transformer. The voltage regulator IC1 is also mounted directly on the box as this acts as a more than adequate heatsink.

All flying leads should be sleeved to reduce the risk of inadvertent short-circuits. The interconnections are shown in

COMPONENTS

Resistors

R1	510Ω
R2	4k7
R3	160k
R4	10k
R5, R6	2k4 (2 off)
R7	18Ω 3W
R8	47Ω
R9	56Ω

See SHOP TALK Page

All 0·6W 1% metal film, except R7

Capacitors

C1	1,000μ axial elect. 16V
C2	10μ axial elect. 50V
C3	0μ1 disc ceramic
C4	0μ47 polyester
C5	0μ1 polyester
C6	22,000μ radial elect. 25V

Semiconductors

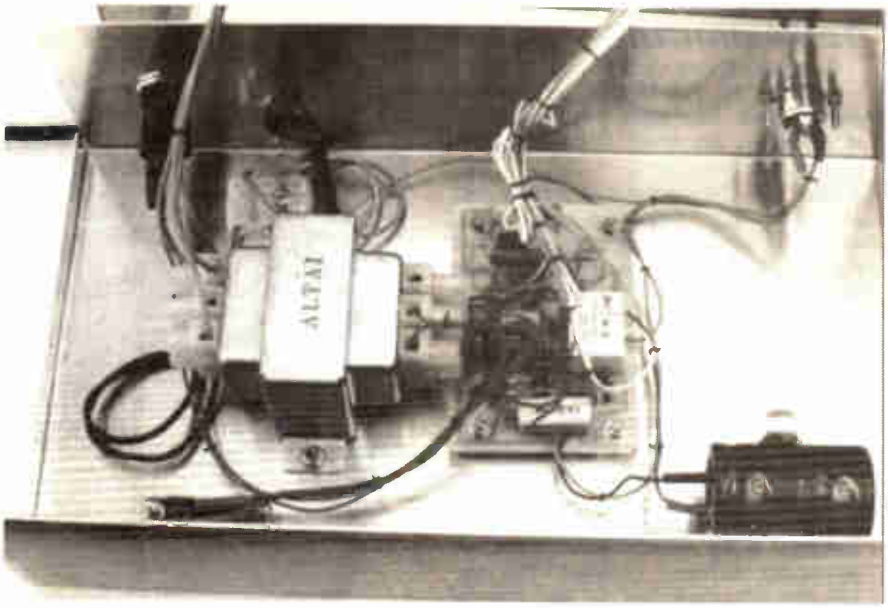
D1 to D4, D6, D7	1N4001 rec. diode (6 off)
D5	5mm l.e.d., orange
D8	5mm low current l.e.d., green
D9	BZY88C 8·2V 500mW Zener diode
D10	5mm l.e.d., red
TR1	BC337 *npn* transistor
IC1	LM7812CP +12V voltage regulator
IC2	NE555N timer

Miscellaneous

S1	d.p.d.t. mains rocker switch, with integral red neon
S2	key-operated d.p.d.t. switch
S3	pushbutton (round bezel) non-locking switch, push-to-make
S4	pushbutton (square bezel) non-locking switch, push-to-make
SK1	4-pin DIN metal chassis socket, with plug
FS1	1A 31mm (1¼in.) quick-blow fuse, with panel mounting fuseholder
RLA	12V 320 ohm coil ultra min. high power relay, with 10A d.c. contacts
T1	mains transformer, with 12V 1A secondary winding

Printed circuit board available from *EPE PCB Service*, code 155; metal case, size 280mm x 160mm x 76mm approx; 8-pin d.i.l. socket; l.e.d. clips (3 off); Terry clip for C6; multistrand coloured connecting wire; 3m 3-core 3A mains cable; 2-core screened output cable, length to suit; solder pins; solder etc.

Approx Cost Guidance Only £35 *excluding case*



Layout of components on the base of the case. The metal floor of the case acts as a heatsink for voltage regulator IC1.

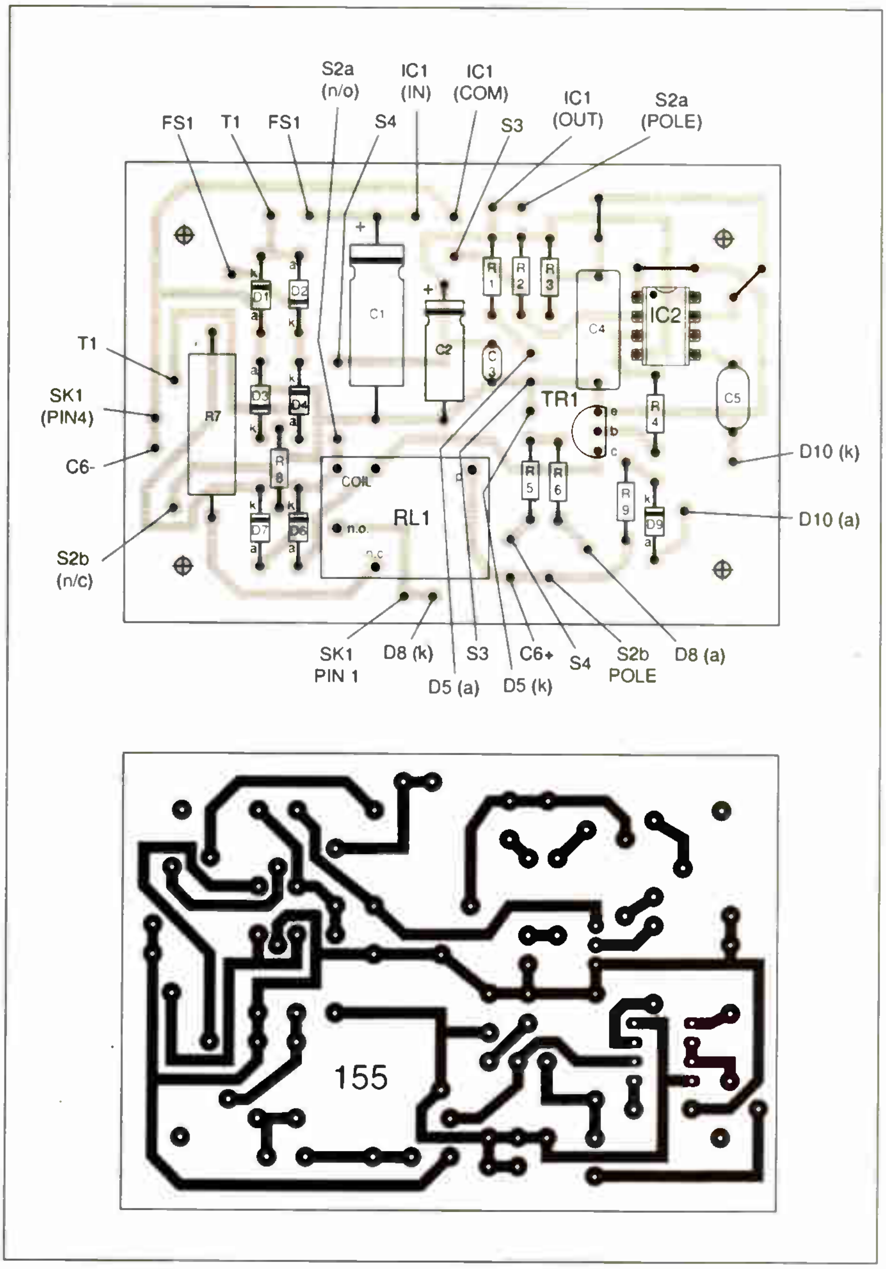


Fig.2. Printed circuit board component layout, interwiring details and full size copper foil master pattern.

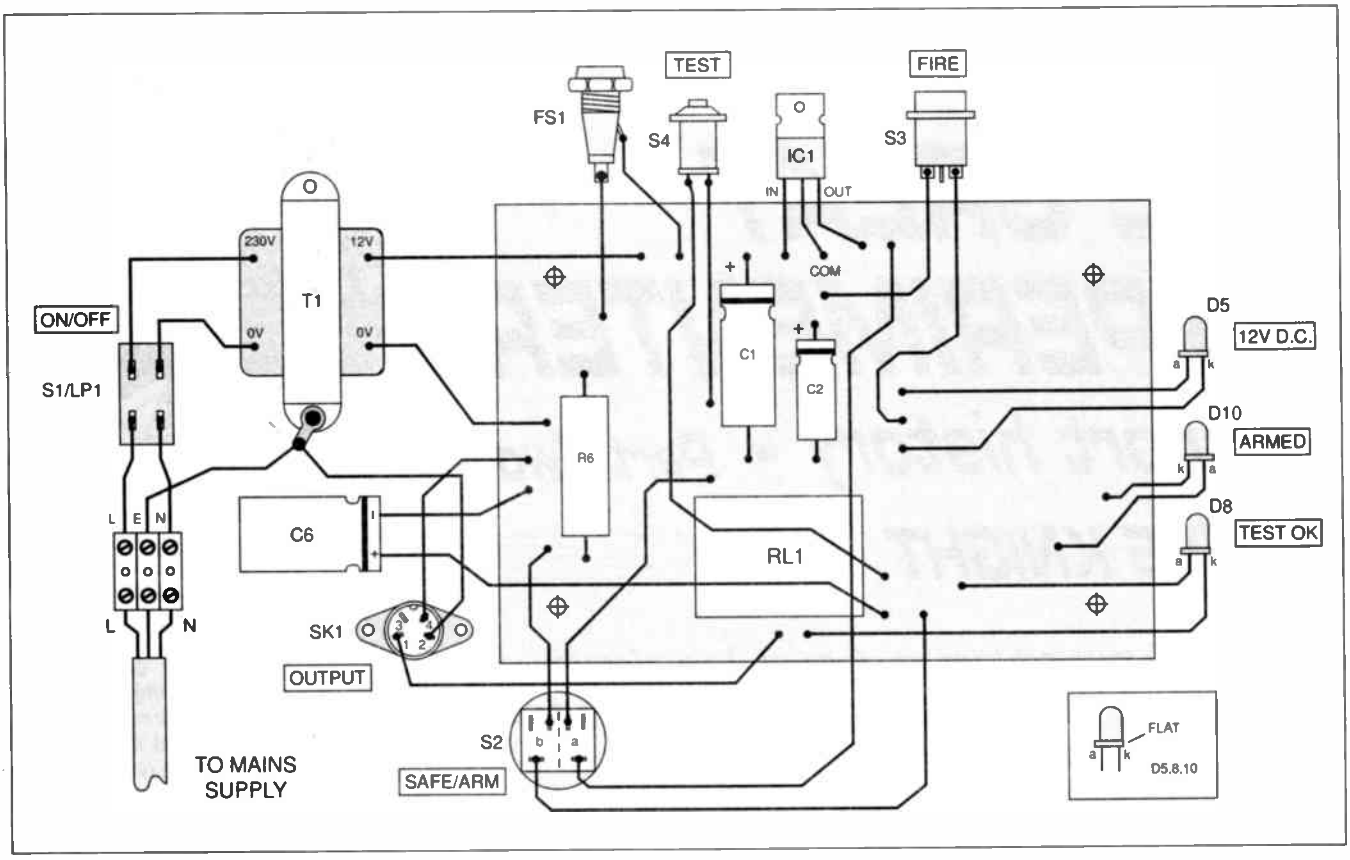


Fig.3. Interwiring to all the off-board components. The general layout inside the case can be seen in the photographs.

Fig. 3. The general layout of components inside the case can be seen in the photographs.

Once construction is complete a careful double-check should be made of the p.c.b. to ensure there are no solder splashes causing shorts between copper tracks. A final check of the wiring to the off-board components is also essential. The unit can now be tested.

TESTING AND OPERATION

For safety reasons, the initial testing of the unit should NOT use a live flash cartridge.

The initial testing is simply a matter of checking for unwanted short circuits in the power supply. The remainder of the test is identical to using the unit operationally with the exception that a low value resistor is substituted for the flash cartridge.

With the 1A fuse removed from the fuseholder, use a multimeter set to a × 10 resistance range to check for short circuits between the 12V supply rails. This should be done across both capacitors C1 and C2.

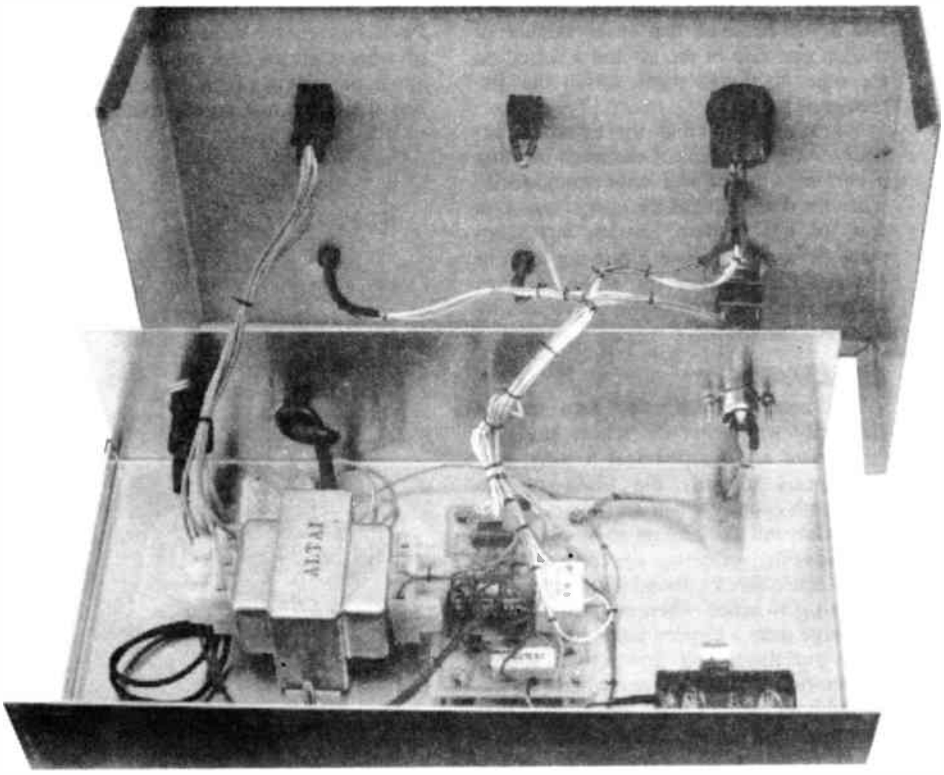
The next step is to fit a 1A quick-blow fuse in its holder and wire a low value resistor (around 4·7 ohms should be sufficient) between pins 1 and 4 of Output socket SK1. With the meter now set to a d.c. volts range, connect it across capacitor C6. ***Make sure that the keyswitch (S2) is in the Safe (off) position*** and then plug the unit in and switch on S1.

The neon within switch S1 and l.e.d. D5 should illuminate. Now press S4 (the square Test switch), D8 should now illuminate.

The Controller can now be "armed" by setting S2 to Arm (on). Capacitor C6 should quickly charge to about 12V and D10 should illuminate.

If this is OK then press and release S3 (the round Fire button). The voltage on the meter should initially fall and then increase as capacitor C6 is first discharged and then recharged. D10 will extinguish and then illuminate once the voltage across C6 returns towards 12V.

If these tests are successful then the unit is now ready for a live firing.

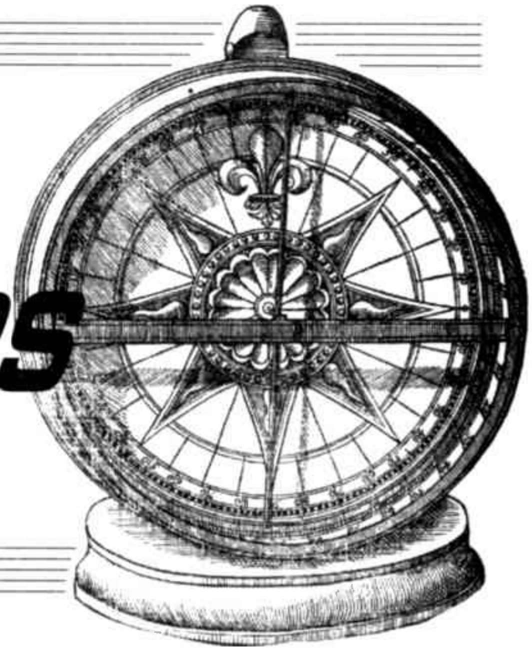


Using "cable looms" to tidy-up the interwiring. All flying leads should be sleeved at their solder connections to avoid the risk of short circuits.

SAFETY

All pyrotechnics can be extremely dangerous if not treated with the utmost care. Always follow the manufacturers' instructions and ensure that when a cartridge is to be detonated, that there is absolutely no risk of injury to persons or damage to surroundings.

If used with care, flash cartridges can add a new dimension to any stage production. Be sensible and enjoy the effect. □



THE GREAT EXPERIMENTERS

A short history - Part Two

STEVE KNIGHT

With Aristotle's hold broken, by the late 18th century research into electrical forces had gathered pace and definition.

As we saw in the previous part of this series, electrostatics held the attention of the scientific fraternity up until about the time of Benjamin Franklin. During that time a number of electrostatic generating machines made their appearance; readers of mature years might well remember the Wimshurst generator which would generate many tens of thousands of volts by cranking a handle and produce some very impressive sparks.

We turn now to the subject of current electricity which had inevitably to emerge out of the many experiments that had been conducted into the nature of electrostatics. The famous Leyden jar, which was simply a particular example of what we now call a capacitor, when charged had a separation of negative and positive charges across its dielectric.

Luigi Galvani (1735-1798).

The nature of what these charges were was not understood at the time, but it was realised that the discharge of the jar must be some kind of neutralisation of these charges and that therefore something had moved along the connecting wire (or through the experimenter's body!) when the discharge took place.

Benjamin Franklin had already introduced his "one fluid" theory of electricity and it was believed that an abundance of this on one side of the jar and a deficit on the other exhibited itself during the discharge of the jar.

We know now that the effect is actually a *displacement* of electrons forming a current which flows only momentarily when the discharge (or the charge, come to that) of our modern Leyden jars takes place. It is, nonetheless, a moving form of electricity as against the static state of charge produced on various substances by frictional means.

GALVANI

The actual investigation into current electricity which put the whole study of the subject on to a practical footing, saw its genesis towards the close of the eighteenth century when an Italian doctor, Luigi Galvani, working on an investigation into the ability of certain species of fish to give electric shocks, found that the leg of a dead frog twitched when subjected to the discharge from a Leyden jar.

He put this effect down to a source of electricity residing somewhere in the leg, without perhaps fully appreciating that scientists (and public exhibitionists) themselves twitched in a like manner when connected, accidentally or otherwise, to the famous jar.

Galvani did, however, declare that the observed convulsions could not be due to sources of electricity *outside* the leg because when he suspended the leg by copper hooks on the balcony of his home, each time the wind blew and moved the leg into contact with the iron railings of the balcony, the twitching occurred although there was no external source of electric charge present.

Personally, I have always taken this story of the balcony and the wind with a pinch of salt – it all sounds a bit contrived, like Newton and his apple. But, whatever the truth may be, the contact of the leg with two *dissimilar* metals produced the effect that Galvani reported.

VOLTA

Galvani's conclusions, however, were challenged by another Italian, Alessandro Volta, who was a professor of biology at Pavia University. Volta suspected, in spite of what Galvani had apparently deduced about the origin of the twitch in the leg, that the nerve had no electrical source of

Alessandro Volta (1745-1827).

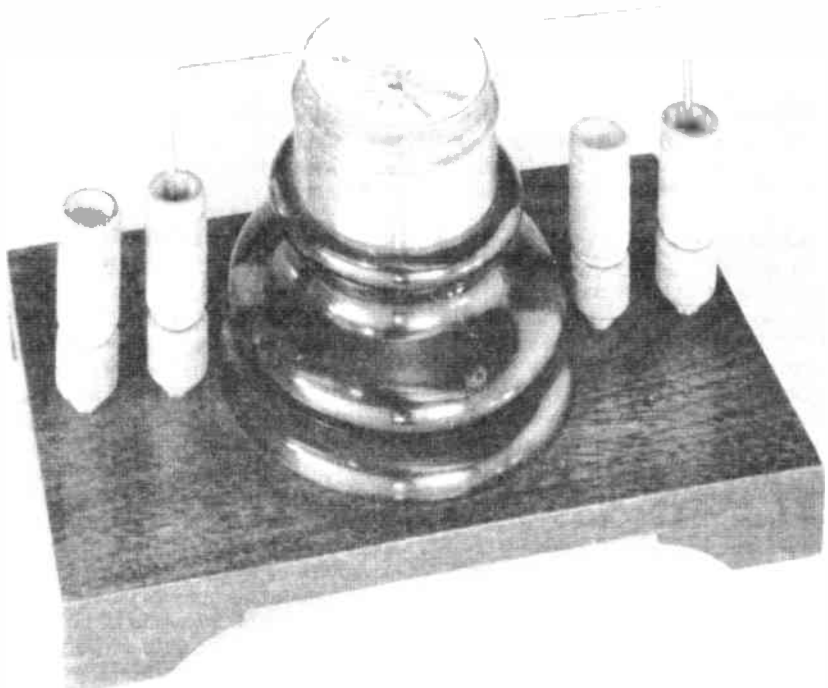
its own and that the presence of dissimilar metals, on the balcony or wherever, was the vital factor in the generation of the effect.

He instanced such phenomena as the metallic taste experienced when holding two different metals against the tongue, the metals being in contact at one end or connected by a wire.

It is a simple matter to perform Volta's experiment by placing a strip of copper or brass above the tongue and a strip of some other metal, such as zinc, below, and then bringing the ends of the strips together. Connect the strips to a digital voltmeter and see what you get. Now eat an orange and try again!

It was not long before Volta found that the tongue was not the most convenient thing to use for his experiments. By supporting his metal strips in acidulated water, much better results (and presumably metallic tastes) were obtained, and the evolution of the electric cell quickly followed.

In a letter to the Royal Society in 1800, he described his "voltaic pile" consisting of a number of alternating copper and zinc discs separated by suitably moistened discs of cloth, as illustrated in Fig. 1.



Replica of Oersted's compass.

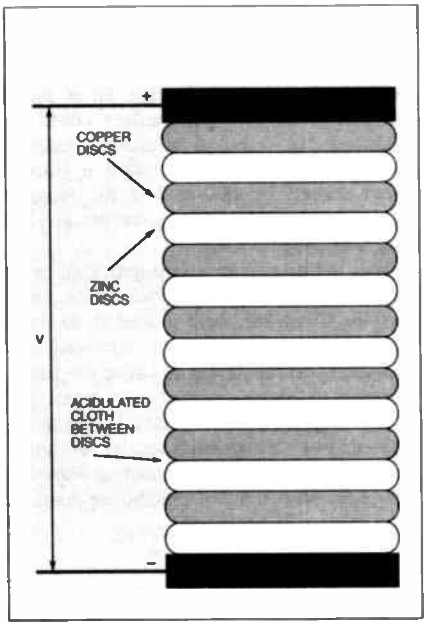


Fig. 1. The voltaic pile, a number of elementary cells joined in series.

This amounted to a large number of basic cells joined in series to provide the first practical battery; and apart from the ingredients (and the price), not a lot different from the cells and batteries we use today.

OERSTED

Up to about 1820, there appears to have been no suspicions that there was a relationship between electricity and magnetism. In that year, however, a Danish physicist, Hans Christian Oersted, accidentally discovered such a relationship.

The story goes that he was experimenting with a galvanic battery (as Volta's discovery was then known) on the same bench top as there happened to be a magnetic or compass needle supported horizontally. A length of wire which was carrying a current from the battery came into a position parallel to the needle and Oersted was surprised to see that the needle, which up to then had been resting in its usual compass position, north and south, swing around so that it pointed approximately to the east and west.

By reversing the direction of the current in the wire, Oersted observed that the needle again deflected, this time in the opposite direction; the effect is shown in Fig. 2.

Although Oersted himself did little more in extending his observations, it was soon realised that the effect on the compass could be intensified by a simple rearrangement of things; all that was necessary was to wrap the wire into a coil and place the compass at its centre, rather as Fig. 3 illustrates.

The man who thought of this was, outside of scientific circles, a little-known German experimenter, Johanne Schweigger. Schweigger saw that if instead of a single wire he had many turns of wire, the current now acting above the needle being

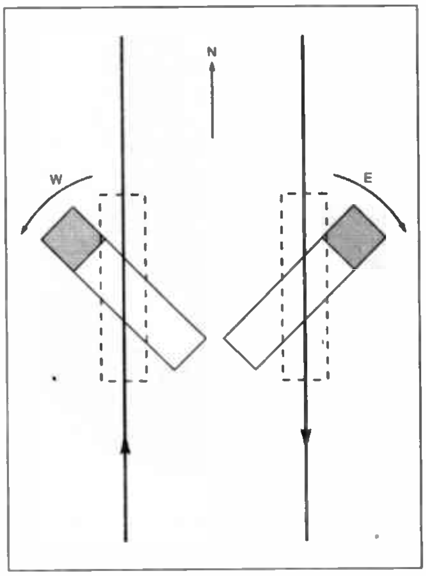


Fig. 2. Oersted's discovery. Reversing the current reverses the direction of movement of a magnetic needle.

Hans Christian Oersted (1777-1851).

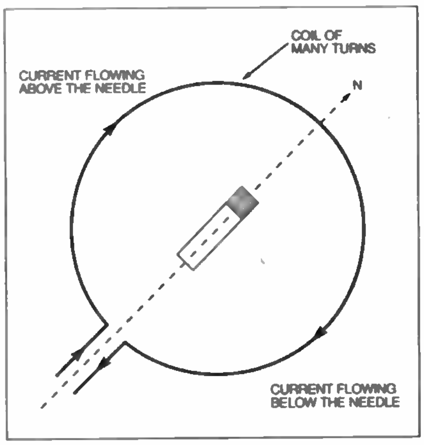


Fig. 3. The principle of the galvanometer.

in an opposite direction to the current acting below the needle, then the magnetic effect on the compass would be correspondingly multiplied. This meant that an appreciable movement of the needle could now be obtained even for a very small current in the wire, each turn of the coil making its own contribution.

So was the galvanometer invented, an instrument by means of which the relative strengths of electric currents could be measured. This type of galvanometer, known as the tangent galvanometer, can still be found in college laboratories.

AMPERE

Another great investigator now took up the reins into this new branch of electrical science, the famous French physicist after whom the unit of current is named: Andre Marie Ampere.

Andre Ampere was born at Lyons early in the year 1775. He had little formal education but showed early promise as a self-taught mathematician, reading most of the available scientific literature of his time while he was still a young man.

Andre Marie Ampere (1775-1836).

His marriage in 1799 brought with it the question of a reliable income, something that previously had not particularly bothered him; a not completely unique experience to a lot of men, then and since. He was urged by his parents-in-law to become a dealer in fabrics, but this suggestion did not appeal to his taste for things scientific and he decided to take to teaching, giving private lessons at Lyons.

This gave him a modest income and in 1802 he produced a book dealing with the mathematical theory behind gambling games. This brought Ampere some much needed publicity and through the influence of Jean Delambre, a well-known mathematician and astronomer who at that time was highly impressed by the talent displayed in the book, Ampere was offered an appointment as professor of physics in a newly developed school in his own area of Lyons.

Three years later, however, after the early death of his wife, Ampere left Lyons and took up an appointment at the Polytechnic school in Paris, though for a time he regretted leaving his home town. Nonetheless, in 1806 he remarried and two years later became Inspector General to the University, eventually reaching the position of Professor of mathematics and mechanics, a post which he held for the rest of his life. It was here that his famous experiments into electro-magnetism were carried out.

OERSTED UPDATED

In September 1820 there arrived at the Institute of France an account of Oersted's discovery of a relationship between electricity and magnetism. Ampere was a member of the audience when this news was announced; he was greatly excited by what he heard and his immediate reaction was to get back to his laboratory and repeat the experiment. This he did, not only in Oersted's original form, but with every possible combination of the bits and pieces employed.

A week or so later, he turned up before the assembled members of the Institute and gave a lecture on the results of his labours, demonstrating how he had verified and extended Oersted's original work.

He showed that if a current flowed along a wire from south to north and a magnetic needle was placed under the wire, as Fig. 4 depicts, then the north seeking end of the magnet was deflected to the west: but if the wire was placed under the magnet, then the deflection took place towards the east.

AMPERE'S SWIMMING RULE

He then proceeded to state a simple rule, which became known as Ampere's Swimming Rule, which demonstrated in what way a magnetic needle was deflected by an electric current, no matter what the direction of the current may be.

He imagined a tiny swimmer going along the wire in the same direction as the current, at all times *looking at the needle*. Then the north seeking pole of the needle is, in every case, deflected towards the swimmer's left hand.

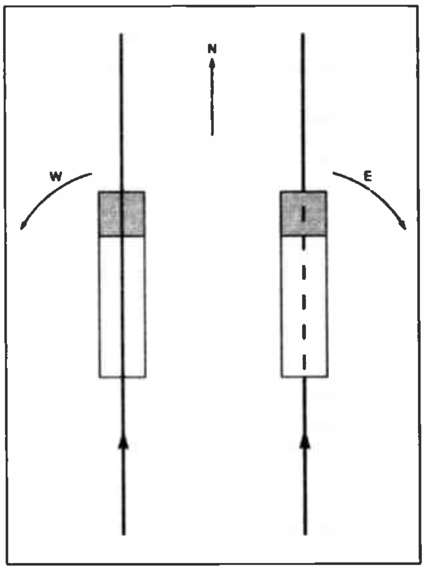
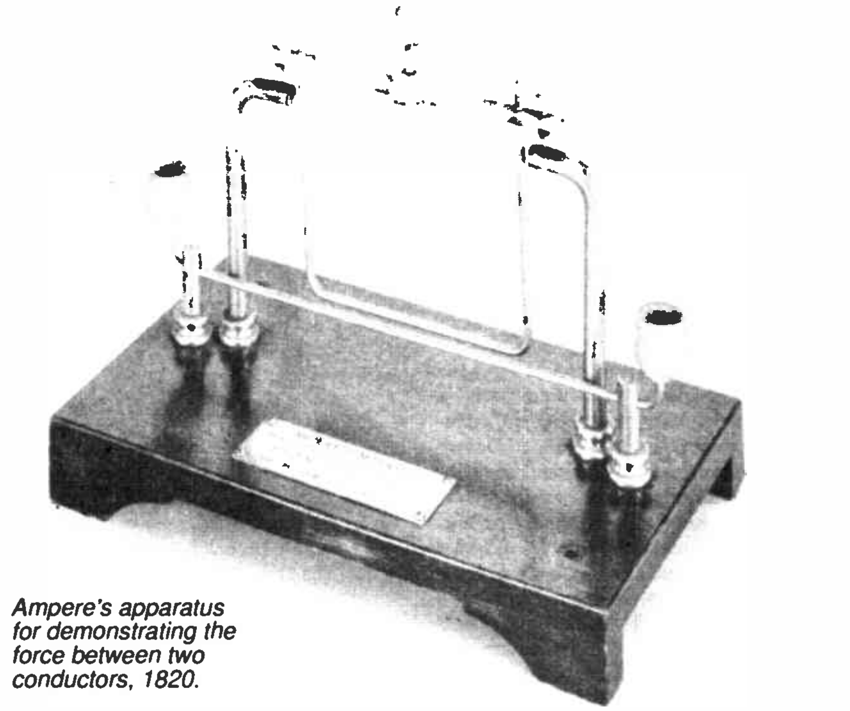


Fig. 4. Ampere's Swimming Rule: magnet under the current, deflection is to the west; magnet over the current, deflection is to the east.

Ampere's next step was of the greatest influence upon what was to come in his later years. He argued that since an electric current exerted an influence on a magnet, and since this same effect could be produced by bringing a second magnet close to the first magnet, then a similar effect should be obtained if the magnet was removed and another current-carrying wire was used instead.

This led him to an investigation of what happened when two parallel wires, each carrying a current, were placed in the near vicinity of each other. He surmised that two such currents ought to cause the parallel wires to attract or repel each other, just as two magnetic poles behaved. He put his argument to experimental test by arranging two wires side by side in such a way that they were free to move together or apart.



Ampere's apparatus for demonstrating the force between two conductors, 1820.

When he sent an electric current in the same direction through each of the wires they were at once attracted to each other. He then reversed one of the currents and the wires were seen to move away from each other. Ampere concluded that some sort of magnetic "field" surrounded each of the wires, and that this field was established by the passage of electric current.

When he wrote a paper for the Institute describing his experiments, he found that his arguments were ridiculed by a number of other physicists. Every man has his detractors and Ampere was no exception.

What his critics asserted was that Ampere was simply demonstrating to them not a *magnetic* effect at all, but a purely electrical phenomenon illustrating nothing more than a case of simple electrical attractions and repulsions such as were observed when static charges were established on certain materials by friction.

Ampere answered this charge by pointing out that like charges repelled and unlike charges attracted each other, whereas in his case of parallel currents, like currents (currents going in the same direction) attracted each other, whilst unlike currents (or opposite currents) repelled. But his critics persisted to the last, even when the correctness of Ampere's conclusion became generally assured.

There is a story that one of his detractors, in the company of the famous scientist and statesman Dominique Arago, declared that since it was known that two currents acted upon one and the same magnet, it was obvious that they would act upon one another – what nonsense Ampere was speaking!

Hearing this, Arago pulled two iron keys out of his pocket and said: "Each of these keys attracts a magnet. Do you believe, therefore, that they also attract one another?" It is to be hoped that this rejoinder put the malcontent in his proper place.

GALVANOMETER PRINCIPLES

Working on his conclusions that there was a "field" surrounding his current-carrying wires, Ampere pressed on with his research. He soon succeeded in showing that if the current strengths in the two wires were I_1 and I_2 respectively (to use our modern symbolism and keeping in mind that current strengths were simply relative values), and *d* was the distance between them, then the force of attraction (or repulsion) between them was proportional to I_1I_2/d^2, the inverse square law similar to that which Newton had discovered for gravity and as Coulomb had deduced for electrostatic charges.

We use this relationship today to establish the S.I. unit of current: the ampere (amp). One ampere is that current which, flowing in a long straight conductor at one metre distant from a similar parallel conductor carrying an equal current, produce between them a force of 2×10^{-7} newtons per metre length.

Ampere next looked into the working principles of the galvanometer, which, as we have seen earlier, had already been developed by Schweigger. This instrument was based on the observed fact that in the centre of a circular coil, the resultant magnetic force acted at right-angles to the plane of the coil. If, therefore, the coil is positioned in the plane of the magnetic meridian, and a magnetic needle is placed at the centre, then, when a current is set up in the coil, the resulting magnetic force at the centre is at an angle to the meridian.

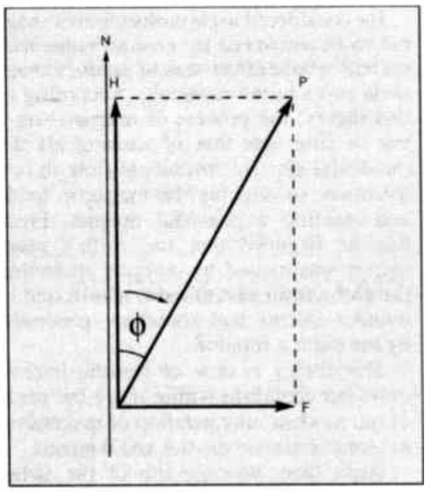


Fig. 5. The theory of the tangent galvanometer: force F *due to coil current acts at right angles to the earth's field* H.

Two forces are acting on the needle: the force *H* due to the earth's magnetic field, which causes the needle to align itself with the north and south magnetic poles, and a force *F* at right-angles to this, which is due to the magnetic effect of the coil current. This is illustrated in Fig. 5.

The position taken by the needle is thus the resultant *P* of these two components; and since *H* is constant for a particular location, the angle ϕ through which the needle swings depends upon the strength of the current developing the value of force *F*.

Notice that the deflection is not directly proportional to the strength of the current; doubling the current, for instance, does not double ϕ but *tan* ϕ. Consequently, because tan 90° is infinite, the needle can never be made to point exactly east to west whatever the strength of the coil current may be.

So the tangent galvanometer (as it is known) is a non-linear instrument, but it provided the early experimenters with a reliable means of measuring and comparing electric currents. Our modern galvanometers (analogue voltmeters and ammeters) are linear in most instances, but they are based on the same fundamental principle as the tangent galvanometers, though not being dependent upon the earth's magnetic field. We use instead a radial field established across a shaped system of pole pieces and the coil moves within this magnetic field.

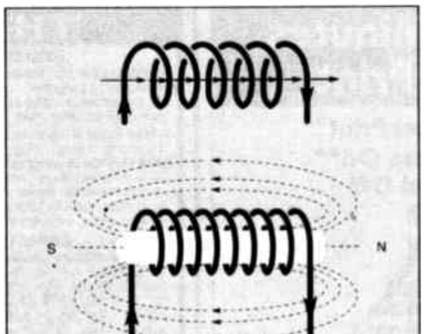


Fig. 6. The solenoid: the magnetic field due to each turn of the coil combining produces the equivalent field of a bar magnet.

THE SOLENOID

Thinking about the operating principle of the tangent galvanometer, Ampere reasoned that the magnetic effect at the centre of a current carrying coil could also be produced by arranging the turns of the coil into an extended form, or solenoid. At the centre of each turn there would be a magnetic force acting at right-angles to the turn and therefore along the axis of the solenoid. So these individual forces should assist each other and collectively establish a very strong magnetic field right along the length of the solenoid, as shown in Fig. 6.

Ampere constructed such a coil and found that the field set up by the coil current did indeed behave in the same form as a bar magnet, and when freely suspended set itself along the earth's magnetic meridian. By winding the solenoid so that the turns were closely together, Ampere found that the magnetic force was increased. He argued that since a bar of iron or steel always became magnetized when placed in a magnetic field, it should be feasible to magnetize such materials by placing them along the core of the solenoid.

He tried this out and found that a steel bar became very retentive of its acquired magnetism (what we now call the *remanance*) after being removed from the solenoid, but that soft iron showed negligible remanance and lost practically all of its magnetism under the same condition. Hence, a soft iron bar placed in a solenoid becomes more strongly magnetized for a given current flow than does a steel bar, but on switching the current off the iron bar demagnetizes while the steel bar does not.

Ampere called his device an *electro-magnet*, and this became a major component in many practical inventions which followed it. It is, perhaps, a little surprising that a man of Ampere's talents did not anticipate the work of Michael Faraday not many years later and discover electromagnetic induction and the principle of the transformer.

ELECTRICAL COMMUNICATION

From his researches into electromagnetism, Ampere suggested the possibility of electrical communication, although he did not put his ideas into practical fruition for reasons which are apparent when his proposed system is examined.

His idea was to have twenty-six wires, one for each letter of the alphabet, and presumably others for numerals and punctuation marks. Under each wire at the receiving end of the line was to be placed a magnetic needle which would deflect on reception of a current from the sending end, so indicating the particular letter for that wire. Thus, assuming that the receptionist was quick in hand and eye, the message would be spelled out by the swing of the corresponding needles.

The suggestion was very crude and unmanageable in practice, as a calculator would be that used ten decimal symbols instead of the binary two. But the seeds were sown by Ampere for the later work of Charles Wheatstone and William Cooke who developed a five-needle telegraph working system in 1837, using the same basic theory.

LATER YEARS

In his later years, Ampere turned his thoughts more to theoretical speculation of his work than to experimentation. One of his most famous theories concerned the relationship between magnetism and electricity which had doubtless intrigued him throughout his experimental years. In this he attempted to explain the phenomenon of magnetic effects in terms of electrical current.

He considered each molecule in a magnet to be encircled by a small equatorial current whose effect was to produce magnetic poles in the molecule. According to this theory, the process of magnetizing a bar of iron was that of causing all the molecular electric currents to flow in one direction, so aligning the magnetic fields and creating a powerful magnet. From this he deduced that the earth's magnetism was caused by currents encircling the globe from east to west, manifested in thunder storms and somehow generated by the earth's rotation.

This theory is now of historic interest only, but contained within it are the seeds of our modern interpretation of magnetism in terms of atomic dipoles and domains.

Such, then, was the life of the father figure of electromagnetism. In 1881, forty-five years after Ampere's death, there was an International Congress of Electricians in Paris for the purpose of the adoption of universal units for the fundamental quantities of magnetism and electricity; Ampere received his reward – along with Volta, Faraday and Ohm – by having his name given to the practical unit of current: the ampere.

PART THREE

Next month we will have a look at Georg Simon Ohm and his famous law.

AKNOWLEDGEMENT

The illustrations used in this article have been kindly supplied by the Science Museum, London.

SHOP TALK
with David Barrington

PIC Digilogue Clock

Most components required for the *PIC Digilogue Clock* should be found at most of our component advertisers. If you elect a similar construction technique as outlined, the Perspex photograph stand will, of course, be available at most photographic shops.

The neat, miniature pushbutton switches used in the model are the "click-effect" types and were obtained from **Maplin** (☎ ***01702 554000***), code FF87U.

Although not a "special" product, the two green seven-segment, micro-bright displays have 0·2in pin spacing and may prove difficult to find locally. These must be *common anode*, low current devices and the ones in our model are Hewlett-Packard type HDSP-7801 and came from the above source, code CZ55K. Incidentally, the 10-pin d.il. display socket was cut down from a 14-pin d.i.l. socket.

For those readers who do not have the facilities to program their own microcontrollers, a ready-programmed PIC16C54 can be purchased from **Magenta Electronics** (☎ ***01283 565435*** or E-mail: **Magenta_Electronics@compuserve.com**) for the sum of £15, including post and packing.

However, if you wish to do your own programming, the software listing is available on a 3·5in disk from the Editorial Offices – see Printed Circuit Board Service pages for details. If you are an Internet user, it is available *Free* from our FTP site: **ftp://ftp.epemag.wimborne.co.uk**. (Subdirectory PIC-DIGILOG).

The Clock printed circuit board is available from the *EPE PCB Service*, code 156.

Pyrotechnic Controller

Key components called for in the *Pyrotechnic Controller* project are the flash cartridges and the high current relay which, for differing reasons, may take some tracking down locally.

The contact arrangement for the ultra miniature 12V 10A relay appears at odds from most relays and, as the p.c.b. has been designed around this device, alternatives may he hard to find. This means that you may need to mount a substitute relay off-board and "hardwire" the contacts to the p.c.b. using heavy-duty wire. The "ultra miniature" 12V relay, with 10A 240V a.c. contacts, used in the prototype is the **Maplin** High Power Mains type, code YX97F.

Still on components, you may find suppliers offering alternatives to the high wattage resistor and a different "working voltage" for the high value electrolytic capacitor. This is OK, provided they have *higher* ratings than specified.

Not being into stage management, we suggest you phone or write to the following company for details of nearest stockists of the flash cartridges: **Le Maitre Fireworks, Dept EPE, 6 Forval Close, Wandle, Way, Mitcham, Surrey, CR4 4NE. Phone: *0181 646 2222*.**

The printed circuit board is obtainable from the *EPE PCB Service*, code 155.

Child Minder Protection Zone

Only a couple of pointers need to be made concerning the *Transmitter* and *Receiver* units that make up the *Child Minder Protection Zone* project.

As the Transmitter is mains driven it ***must*** be housed in a metal case, with screw fittings, and be properly "Earthed." The model used a fairly expensive steel **Maplin** 1605 case, code XJ27E.

The Transmitter ***must*** be sited indoors for *safety*. Also, if the inductive loop-wire is to be run outdoors, in the garden play area for instance, it ***must*** be double-insulated cable. Ordinary two-core 3A mains cable seems to be the cheapest option here.

Looking at the Receiver, most component advertisers still stock "germanium" diodes. However, as far as we can tell, the Toko (187LY-222) 2·2mH inductor is only available from **Cirkit** (☎ ***01992 448899*** or E-mail: *mailorder@cirkit.co.uk*). This can be found under their 8RB series, code 34-22201.

The two printed circuit boards are available from the *EPE PCB Service*, codes 153 (Trans.) and 154 (Rec.) – see page 435.

Narrow Range Thermometer

Not too much to report on parts for the *Narrow Range Thermometer*. The 25-turn "top" adjust preset potentiometer should be generally available, the only differences being the number of turns. The model carries the **Electromail** (☎ ***01536 204555***) version, code 160-124.

If difficulties arise finding the disc thermometer, it can be ordered from **Electrovalue** (☎ ***01784 433604***), Siemens K164 series, stock code K16410K. They also supplied the handheld case, code HH270.

The small printed circuit board is available from the *EPE PCB Service*, code 158.

Please Note

Since we published the *2M F.M. Receiver* project last month, and highlighted the problems finding the MC3359P i.c. we have received further news. Thanks to our readers, we can report that **Nottingham Radio Com. Services** (☎ ***0115 960 8222***) have stocks.

Note that the **Marco Group** phone number is: 01628 604383, not as previously printed.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CHILD MINDER PROTECTION ZONE

ROBERT PENFOLD

Give your children the freedom to play knowing that they cannot stray outside your "invisible" protection zone without sounding an alert.

ELECTRONICS seems to be used in an ever increasing array of electronic security devices, and this sphere of electronics now covers a lot more than simple intruder alarms. The system featured here is an example of what is sometimes termed an electronic "fence."

This name is not a strictly accurate one, since equipment of this type does not provide any sort of barrier. It simply activates an alarm if someone or something goes outside the area encompassed by the fence "force field".

The system featured here consists of a Transmitter and a portable Receiver. The receiver produces an audio alarm if it goes outside the area covered by the transmitter.

No doubt there are many potential uses for equipment of this type, but the system was primarily designed to give warning if a toddler starts to wander too far away from the designated play area. If the youngster should start to wander off, the alarm alerts you to this fact, and also enables you to quickly home in on the adventurous youngster!

HOW IT WORKS

An inductive loop transmitter is very simple, and is basically just an audio power amplifier driving a large loop of wire. The loop of wire can have several turns, but a single loop is often sufficient.

The receiver is equally simple, and it is a high gain audio amplifier fed from a pickup coil. The latter normally has a large number of turns. The transmission loop and pickup coil effectively form a very large and inefficient transformer.

LOOP SENSITIVITY

When using an inductive loop system it has to be borne in mind that the relative orientation of the pickup coil and loop is important. Maximum pick up is obtained with the windings as shown in Fig. 1a, and quite a strong signal is still obtained with the pickup coil raised, as in Fig. 1b. In the current application it is therefore acceptable to have the transmission loop at ground level with the pickup coil up to a metre or so above ground level.

No significant pick up is obtained with the relative orientations shown in Fig. 1c. This does give the slight possibility of the system producing the occasional false alarm, but the directional properties of the pickup coil cannot result in the alarm failing to sound when it should.

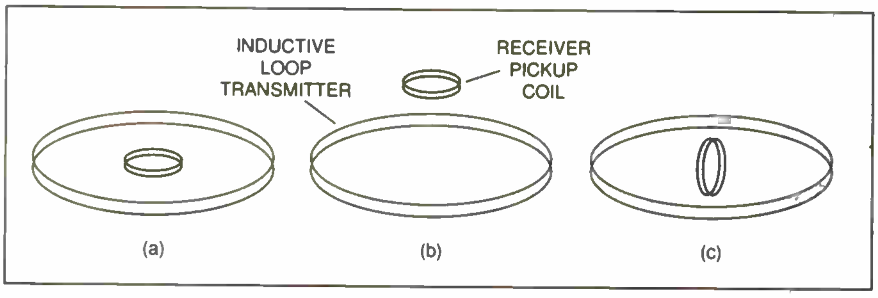


Fig. 1. The loop/pickup coil orientations of (a) and (b) produce strong coupling. The orientation of (c) gives poor coupling.

LOOP THE LOOP

There are several potential methods of implementing a system of this type, most of which are quite hi-tec and potentially expensive. At the Editor's suggestion the lo-tec alternative of an "induction loop" system was tried. This low cost method was found to work perfectly well, and was therefore adopted in the final design.

Inductive loop systems have been around for many years, but there seems to have been relatively little published on this subject. They are not used a great deal in "real world" applications, but apparently some halls, cinemas, etc. have inductive loop transmitters, and many modern hearing aids can be switched to pick up this transmission instead of sounds.

One might reasonably expect that the receiver would pick up a strong signal when near the transmission loop, and a weak signal when well away from it. In practice things do not quite operate in this way. A strong signal is received with the pickup coil close to the loop, and the signal level does rapidly decay as the receiver is moved away outside the loop.

However, with the receiver inside the loop, even with the pickup coil a few metres away from the loop, a strong signal is still received. The prototype system has only been tried with a rectangular loop measuring about seven metres by 10 metres, but it would probably work reliably with a somewhat larger loop.

SYSTEM OPERATION

The block diagram of Fig. 2 shows the general arrangement used for the Child Minder Protection Zone. The Transmitter generates a (more or less) sinewave signal at a middle audio frequency, and the Receiver produces an audio alarm signal if this tone is not detected at a high enough level.

The transmitter is quite simple, and is basically just an audio oscillator which drives the loop via an audio power amplifier. A triangular signal is generated by the oscillator stage, and this waveform has quite a low harmonic content.

It is important that harmonics (multiples of the fundamental frequency) are kept to a very low, level, as the transmitter might otherwise radiate illegal interference at radio frequencies (r.f.). Provided there is no significant output at frequencies outside the audio range, the unit should not cause interference with other electronic equipment, and being an audio frequency device it does not require any form of operating licence.

In order to make sure that any r.f. output is kept to a very low level, a lowpass filter is used between the oscillator and amplifier stages. This gives an output signal that is not a pure sinewave, but it is pure enough to provide interference-free results. A LW/MW transistor radio operating within the loop of the prototype system showed no trace of interference.

PICKUP LEVEL

The output from the pickup coil of the receiver will normally be at a very low level, and is unlikely to be more than a few millivolts r.m.s. Also, the coil will pick up all manner of signals, such as radio signals and 50Hz mains "hum."

The output of the pickup coil is therefore fed to a high gain amplifier and a bandpass filter. The filter has a response which peaks at the transmission frequency, but falls away rapidly to either side of it. This gives good sensitivity to the signal from the transmitter, but makes the unit insensitive to mains "hum" and radio frequency signals, which are well removed from the transmission frequency.

The output from the bandpass filter is rectified and smoothed to produce a positive d.c. signal that is roughly proportional to the strength of the received signal. This d.c. signal is fed to a voltage comparator where it is compared to a reference potential.

If the output voltage from the smoothing circuit is higher than the reference potential, the output of the comparator goes low. If the reference voltage is the higher of the two, the output of the comparator goes high.

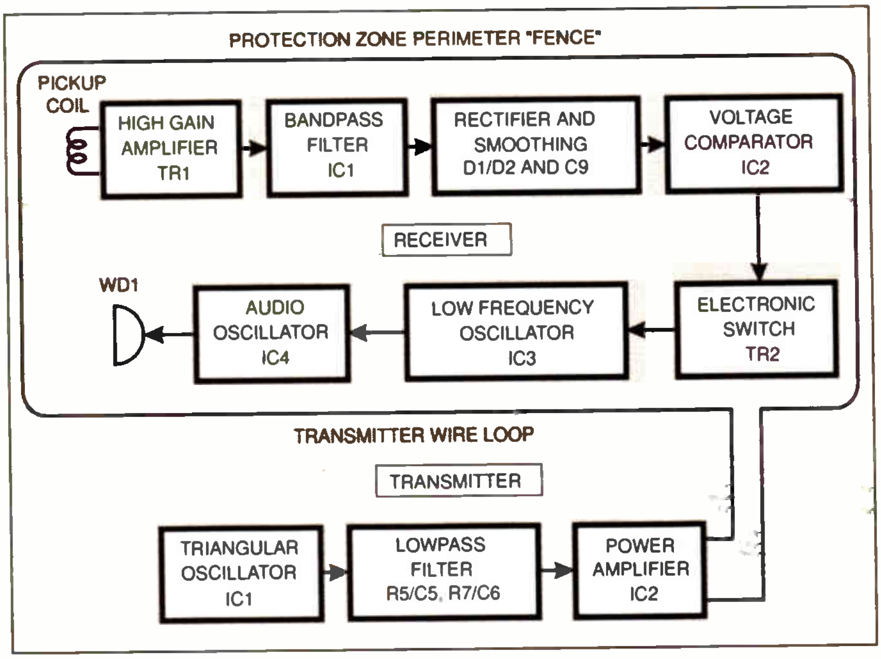


Fig. 2. System block diagram for the Child Minder Protection Zone Transmitter and Receiver circuits.

ALARM GENERATOR

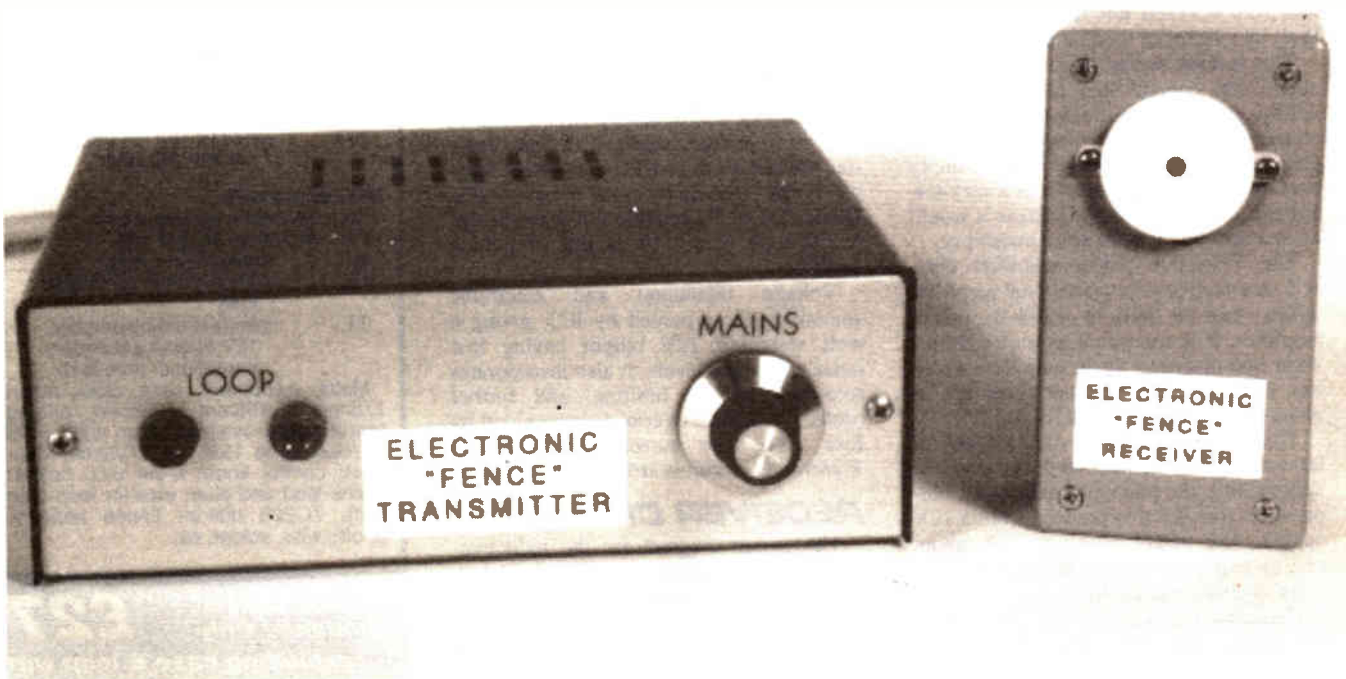
A simple audio alarm generator is controlled by the comparator via an electronic switch. If the pickup coil receives a strong signal, the output of the comparator goes low, turning off both the electronic switch and the alarm generator. If the pickup coil receives only a weak signal, the output of the comparator goes high, the electronic switch is turned on, and the alarm generator is activated.

The alarm generator consists of an audio oscillator which is gated by a low frequency oscillator. This gives a simple "beep-beep-beep . . ." alarm sound, which is perfectly adequate for the present application.

TRANSMITTER CIRCUIT

The main circuit diagram for the Inductive-Loop Transmitter and the mains power supply circuit are shown in Fig. 3. IC1 is used in a conventional triangular/squarewave oscillator, with IC1a acting as the integrator and IC1b operating as the trigger circuit. In this case it is only the triangular output signal from IC1a that is required.

Preset potentiometer VR1 enables the output frequency of the transmitter to be matched or "trimmed" to the frequency at which the receiver has peak sensitivity. The output frequency is typically about 1·4kHz to 1·5kHz.



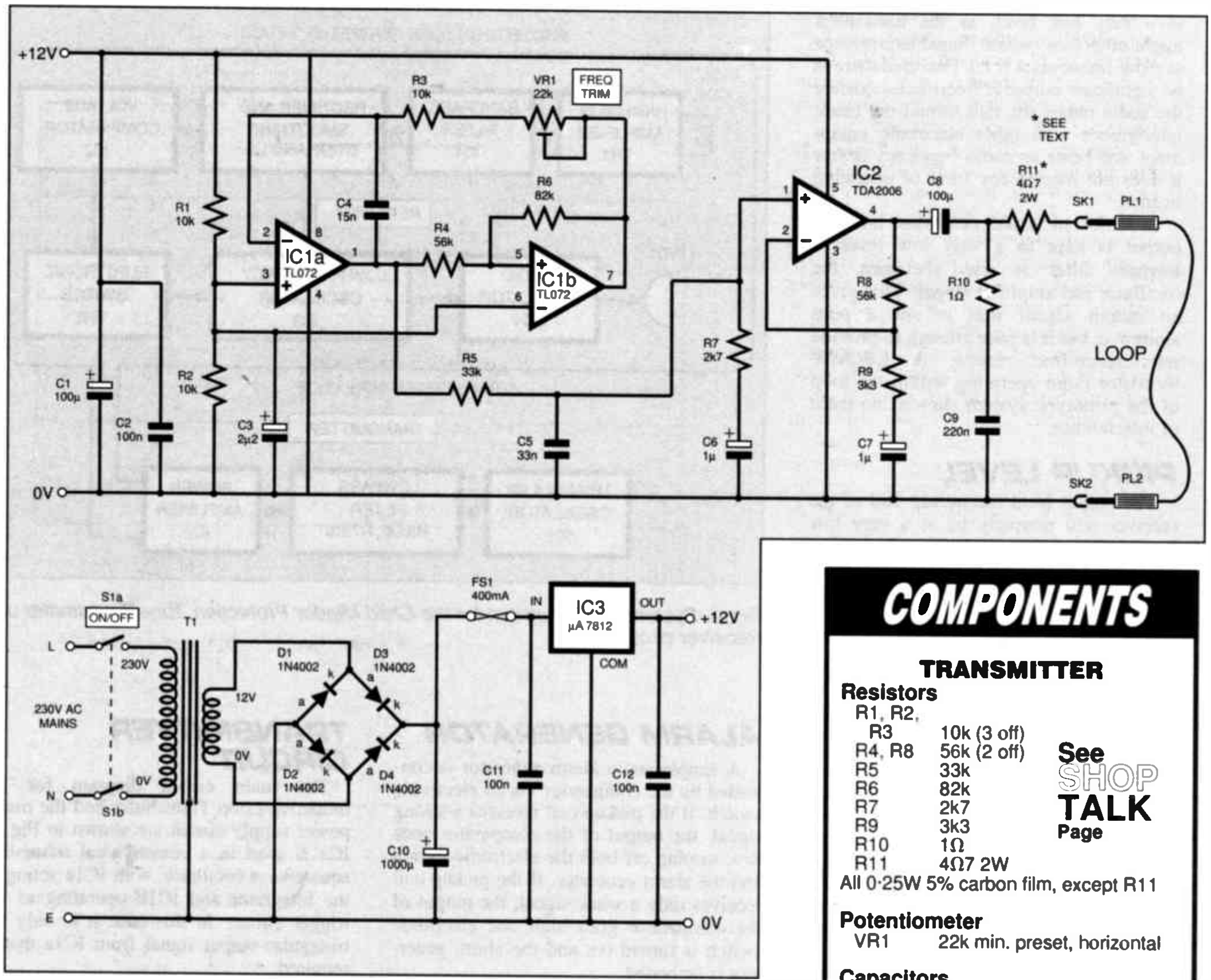


Fig. 3. Circuit diagram for the Inductive-Loop Transmitter together with the mains power supply circuit.

The triangular output signal from IC1a pin 1 is taken to a simple passive lowpass filter which is comprised of resistor R5 and capacitor C5. R7 and C6 provide a substantial amount of attenuation in conjunction with R5, and this reduces the signal level by a factor of more than ten.

This is done so that the power amplifier circuit can operate at a reasonably high voltage gain without the output signal becoming clipped (which would result in the generation of strong harmonics). Simply operating the power amplifier at a very low voltage gain is not a good idea as it would almost certainly lead to gross instability.

The TDA2006 power amplifier chip, IC2, is effectively an operational amplifier which has a built-in class-B power amplifier. It is used here as a straightforward non-inverting mode amplifier which has its closed-loop voltage gain set at about 18 times by resistors R8 and R9.

This gives a typical output signal of around seven volts peak-to-peak, which is approaching the maximum unclipped output level that IC2 can produce from a 12V supply. The output power is only about one to two watts r.m.s., but this is sufficient to give good results.

Capacitor C8 provides d.c. blocking at the output, and R10 plus C9 aid good stability. Resistor R11 is not needed if the Transmitter is used with a reasonably large loop, and it can then be replaced with a shorting-link. If the unit is used with a small loop consisting of less than about 10 metres of wire, R11 is needed to ensure that the amplifier drives a suitably high load impedance.

POWER SUPPLY

The mains power supply circuit (Fig. 3) is a conventional regulated design, using transformer T1 to provide the voltage step-down and isolation from the mains supply. Diodes D1 to D4 provide full-wave bridge rectification, and C10 is the smoothing capacitor.

Voltage regulation and electronic smoothing are provided by IC3, giving a well stabilised 12V output having low noise and ripple levels. It also incorporates fold-back current limiting, and further protection against overloads is provided by fuse FS1. The current drain of the Transmitter circuit is around 300mA or so.

RECEIVER CIRCUIT

The circuit diagram for the Inductive-Loop Receiver appears in Fig. 4. Pickup coil L1 is just a simple inductor. A telephone pickup coil was used in the original design, and this gave excellent results with a high level of pickup.

COMPONENTS

TRANSMITTER

Resistors

R1, R2, R3	10k (3 off)
R4, R8	56k (2 off)
R5	33k
R6	82k
R7	2k7
R9	3k3
R10	1Ω
R11	4Ω7 2W

See SHOP TALK Page

All 0·25W 5% carbon film, except R11

Potentiometer

VR1	22k min. preset, horizontal

Capacitors

C1, C8	100µ radial elect. 16V (2 off)
C2, C11, C12	100n ceramic (3 off)
C3	2µ2 radial elect. 50V
C4	15n polyester
C5	33n polyester
C6, C7	1µ radial elect. 50V (2 off)
C9	220n polyester
C10	1000µ radial elect. 25V

All polyester types should have 7·5mm lead spacing

Semiconductors

D1 to D4	1N4002 100V 1A rect. diode (4 off)
IC1	TL072CP dual bifet op.amp
IC2	TDA2006 audio power amp
IC3	µA7812 12V 1A positive voltage regulator

Miscellaneous

SK1, SK2	4mm socket (2 off)
PL1, PL2	4mm plug (2 off)
S1	rotary mains switch
FS1	400mA 20mm quick-blow fuse
T1	standard mains primary, 12V 500mA secondary transformer (see text)

Metal instrument case, size about 175mm x 155mm x 58mm; printed circuit board available from *EPE PCB Service*, code 153; pair of 20mm fuse-clips; control knob; 8-pin d.i.l. holder; mains lead and plug; wire for loop (see text), TO220 bolt-on finned heatsink (2 off), wire, solder, etc.

Approx Cost Guidance Only £27 excluding case & loop wire

Unfortunately, a telephone pickup coil is relatively expensive, and modern types seem to be physically quite large. Using a small and inexpensive inductor together with higher gain in the receiver is a more practical solution to the problem.

Transistor TR1 is used in the preamplifier stage, and this is a common emitter amplifier. Input coupling capacitor C3 has a low value, which gives a certain amount of highpass filtering to combat possible mains "hum" pickup. Capacitor C4 provides lowpass filtering which reduces the sensitivity of the circuit to radio frequency signals.

The main filtering for the Receiver is provided by IC1. IC1a simply provides buffering between the output of transistor TR1, and the relatively low input impedance of the bandpass filter based on IC1b. This filter provides a substantial amount of voltage gain at its centre frequency, and its gain is actually about the same as that of the preamplifier stage.

Diodes D1 and D2 half-wave rectify the output from IC1b, and capacitor C9 provides smoothing. IC2 is an operational amplifier, but in this circuit it is used open-loop as a voltage comparator. Resistor R9 and R10 provide a reference potential of about one volt to the non-inverting input of IC2 pin 3, and the output of the smoothing circuit is coupled to the inverting input pin 2. The output of IC2 (pin 6) goes high if the output from the smoothing circuit drops below the one volt reference potential.

ALARM OSCILLATORS

When this happens, transistor TR2 is biased into conduction, and it provides power to the alarm generator circuit. This has IC3 and IC4 as standard 555 oscillators. IC3 operates as the low frequency oscillator, and it operates at about 3·7Hz. Its output, at pin 3, drives the reset input (pin 4) of IC4, which in this case operates as a simple gate input.

The tone generator, IC4, is pulsed on during the periods when IC3's output is high. IC4 operates at about 3kHz.

This relatively high operating frequency is needed to give good efficiency from WD1, which is a cased ceramic resonator. These provide high volume levels from modest drive powers, but only at fairly high audio frequencies of around two to four kilohertz.

This circuit *should not* be used with a conventional moving coil loudspeaker because this could overload the output stage of IC4.

RECEIVER POWER

It is likely that in normal use the Receiver will have to operate for long periods, but mains power is not practical since the unit must be portable. Large batteries are undesirable, since the unit should ideally be very small and light. The circuit has therefore been designed to operate at a low standby current so that a long battery life can be obtained from a humble PP3 size battery.

Transistor TR1 is operated at a typical collector current of under 100µA, which gives acceptable performance in an application of this type which does not require a wide bandwidth. IC1 and IC2

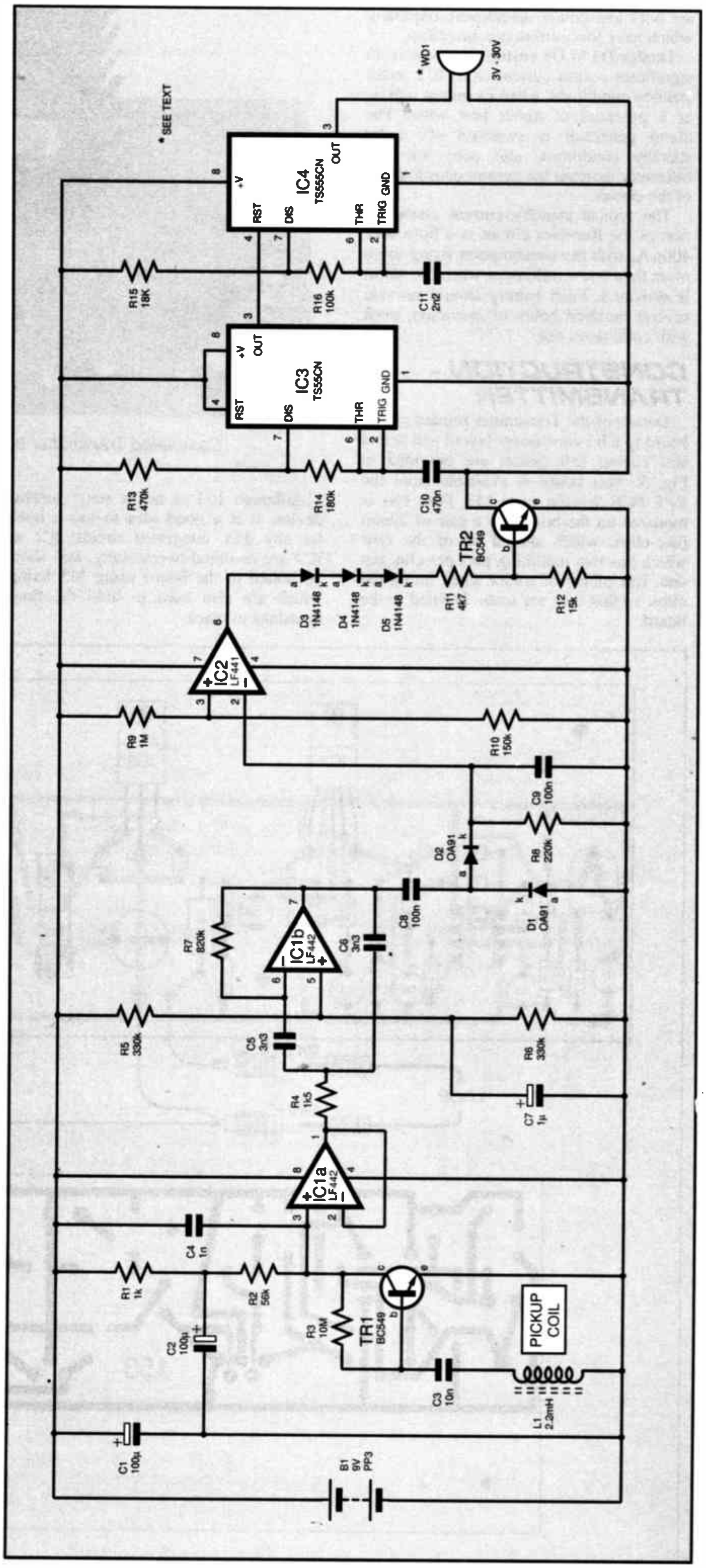


Fig. 4. Complete circuit diagram for the self-contained Receiver.

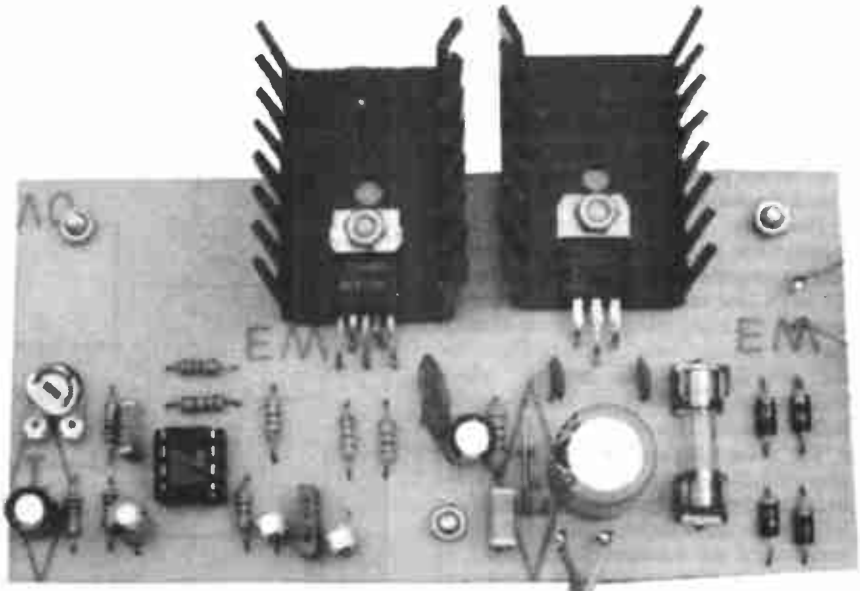
are both low power operational amplifiers which have low current consumptions.

Diodes D3 to D5 ensure that there is no significant output current from IC2 under standby conditions, when its output will be at a potential of about two volts. The alarm generator is switched off under standby conditions, and does not significantly increase the current consumption of the circuit.

The typical standby current consumption of the Receiver circuit is a little over 400µA, with the consumption rising to no more than a few milliamps when the alarm is activated. Each battery should provide several hundred hours of operation, even with continuous use.

CONSTRUCTION - TRANSMITTER

Details of the Transmitter printed circuit board (p.c.b.) component layout and actual size copper foil master are provided in Fig. 5. This board is available from the *EPE PCB Service*, code 153. Fuse FS1 is mounted on the board via a pair of 20mm fuse-clips, which should be of the type which has two mounting pins per clip, not one. Use plenty of solder when fitting the clips, so that they are securely fitted to the board.



Completed Transmitter board with finned heatsinks bolted to i.c.s.

Although IC1 is not a static sensitive device, it is a good idea to use a holder for any d.i.l. integrated circuit. IC2 and IC3 are mounted horizontally, and should be bolted to the board using M3 fixings, which are also used to hold the finned heatsinks in place.

Neither of these components dissipate particularly high power levels, but they still require small bolt-on heatsinks in order to prevent overheating. The type used on the prototype are rated at 9·9 degrees per watt, but smaller types rated at around 14 degrees per watt should be perfectly adequate.

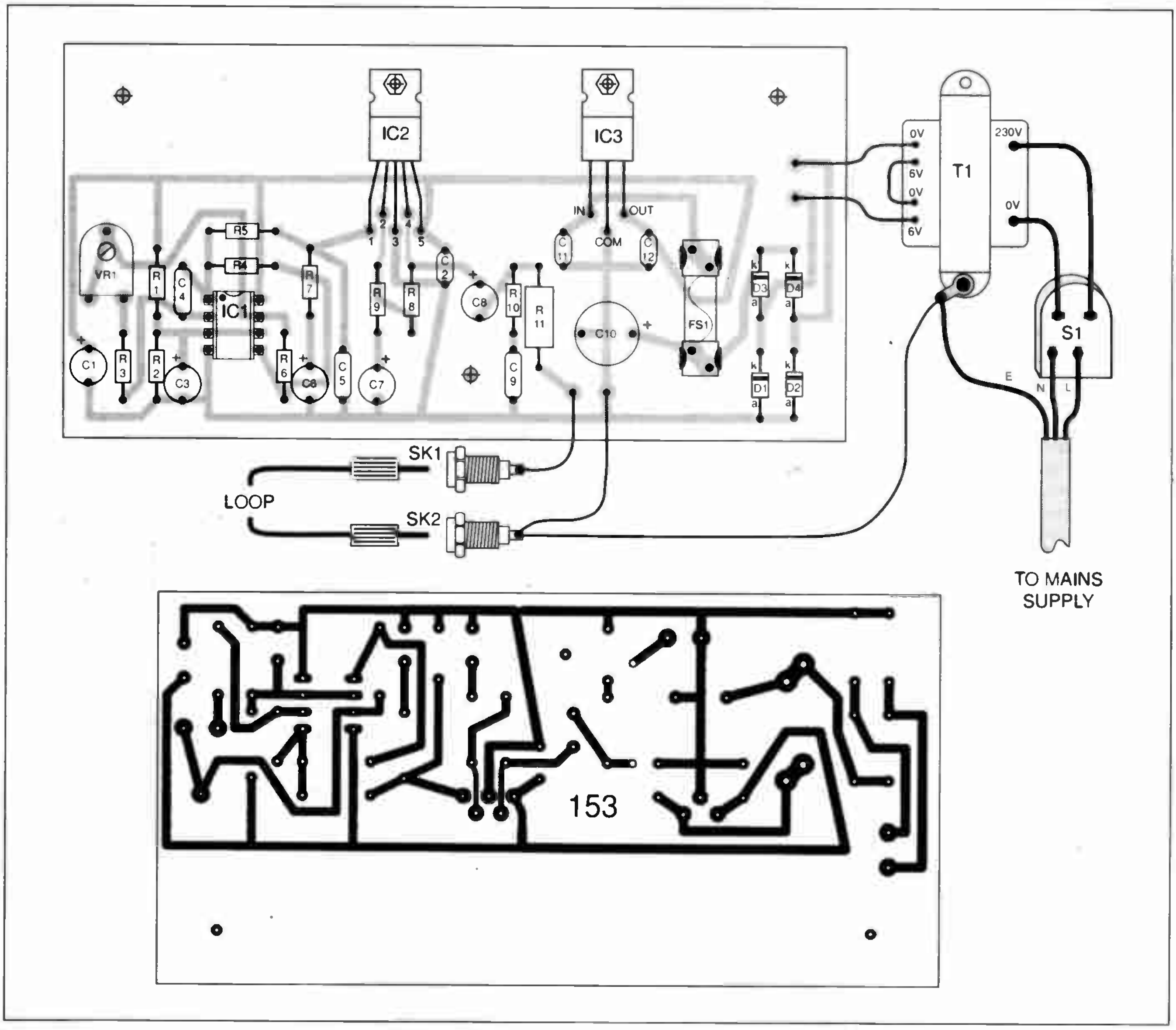


Fig. 5. Transmitter printed circuit board component layout, including mains power supply, and full size underside copper foil master.

Be very careful to fit capacitors C1, C10, and diodes D1 to D4 the right way round. Mistakes here could result in damage to some of the components, and could even be dangerous.

Fit single-sided solder pins to the board at the four points where connections to the output sockets and mains transformer secondary winding T1 will eventually be made. "Tin" the tops of the pins with a generous amount of solder.

CASE FOR CARE

As the Transmitter is mains powered it ***must*** be housed in a ***metal*** case, and reliably earthed to the mains Earth lead. The case must also be a type that has a screw fitting lid, and not one which has a clip-on lid that would give easy access to the dangerous mains wiring. A metal instrument case is probably the best choice, and one having a width of about 170mm or more should comfortably accommodate everything.

Output sockets SK1 and SK2 are fitted on the left hand section of the front panel, with on/off switch S1 at the other end of the panel. A hole for the mains lead is made in the rear panel, roughly opposite S1. This hole must be fitted with a strain-relief grommet to protect the cable.

Mains transformer T1 is bolted to the base panel of the case just to the rear of S1, making sure that there is sufficient space left for the circuit board to the left of T1. The transformer and p.c.b. can be used as templates to aid accurate marking of the mounting holes' positions. A solder tag is fitted on one of T1's mounting bolts, and this provides a chassis connection point for the mains Earth lead.

The circuit board is mounted using plastic stand-offs, 6BA screws, or metric M3 screws. If screws are used, spacers at least six millimetres long must be used to ensure that the underside of the board is kept well clear of the metal base panel.

INTERWIRING

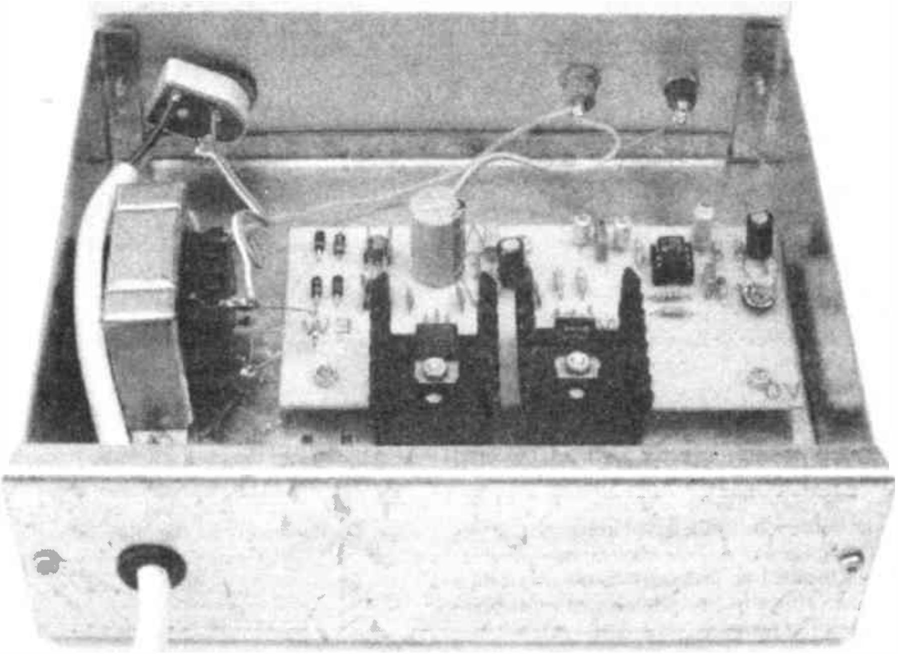
To complete the unit the small amount of hard wiring is added. The appropriate two pins on the board are connected to sockets SK1 and SK2, and the power supply wiring "Loop" is then completed, see Fig. 6. The power supply wiring is perfectly straightforward, ***but as the mains supply is involved it is essential to take extra care here, and to double-check the finished job.***

A transformer having a 12V 500mA secondary winding is needed for T1, but modern mains transformers mostly have twin secondary windings. A twin six volt 500 milliamp type is suitable if the two windings are wired in *series*, as shown in Fig. 5.

CONSTRUCTION RECEIVER

The component layout for the receiver printed circuit board, and the actual size underside copper foil master appears in Fig. 6. This board is also available from the *EPE PCB Service*, code 154.

In most respects the board is straightforward to construct, but the component density is quite high in many parts of the board. This makes it essential to use modern miniature components. The polyester capacitors must be a printed circuit mounting type having a lead spacing of 7·5mm (0·3 inches) if they are to fit neatly into this layout.



Finished Transmitter with lid removed to show wiring to the mains on/off switch and loop sockets SK1 and SK2 on rear of the front panel.

Once again, although the integrated circuits are not static-sensitive they should still be mounted in holders. D1 and D2 are germanium diodes, and are more easily damaged by heat than silicon devices.

It is not essential to use a heatshunt on each lead as it is soldered into place, but the joints must be completed reasonably quickly. Diodes D1 and D2 should be the last components fitted to the board.

PICKUP COIL

Pickup coil L1 is mounted on the board, but it might be necessary to mount it on solder pins in order to give it a suitable orientation. For example, if the unit is to be used with the case in a vertical position, L1 must be mounted on the board horizontally, with its top end towards IC1.

The circuit might work well with other 2·2mH chokes, but it has only been tried with the specified choke, see *Shoptalk* page. The system cannot be guaranteed to operate properly using other inductors, and it will not work at all using an inductor

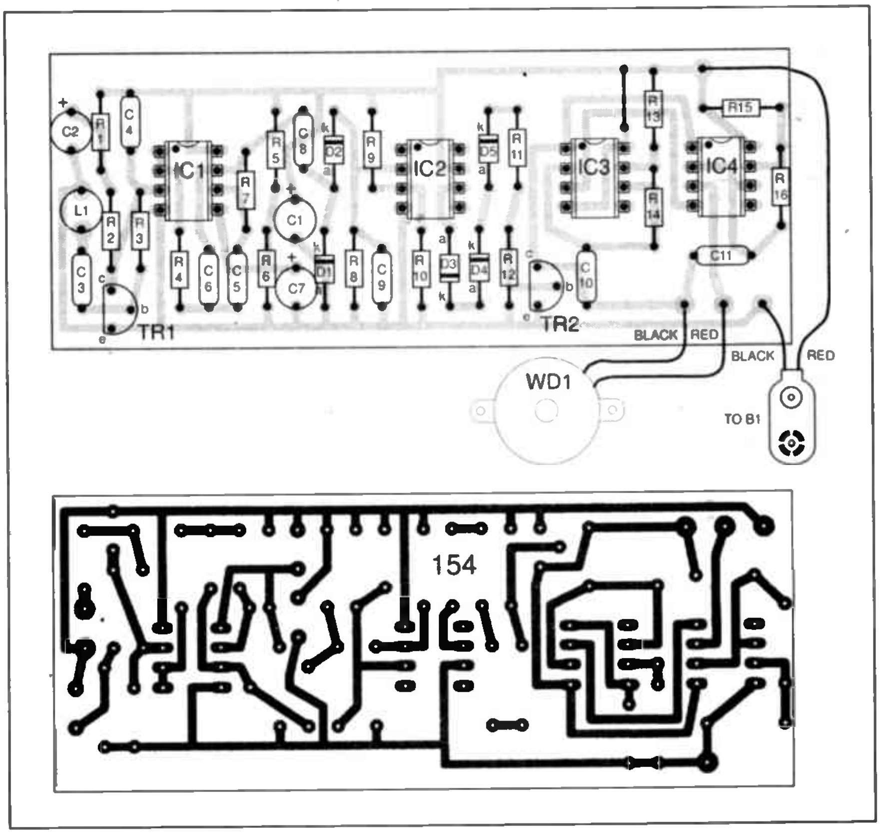
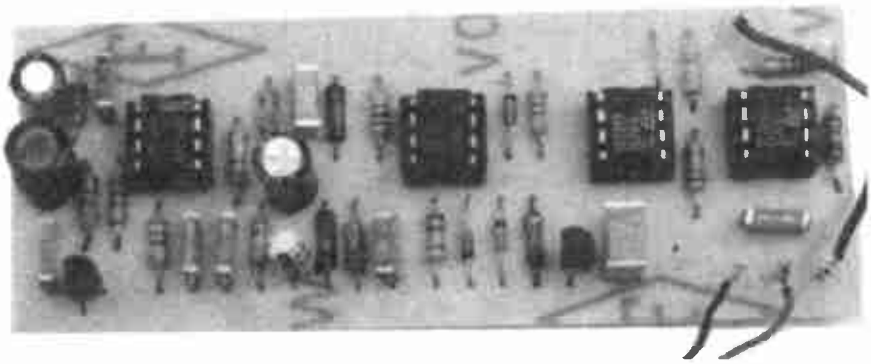


Fig. 6. Printed circuit board component layout, wiring and full size copper foil master pattern for the Receiver.



Layout of components on the completed Receiver printed circuit board.

that is wound on some form of potcore (which tends to screen the winding).

The p.c.b. has been designed to fit into the guide rails of the specified plastic case. This case has a somewhat tapered shape, and it might be necessary to file down the sides of the p.c.b. slightly, towards the bottom of the board, in order to get it to fit right down into the case. The board should be positioned as far as possible to one side of the case, which should leave ample space for the battery on the other side.

COMPONENTS

RECEIVER

Resistors

R1	1k
R2	56k
R3	10M
R4	1k5
R5, R6	330k (2 off)
R7	820k
R8	220k
R9	1M
R10	150k
R11	4k7
R12	15k
R13	470k
R14	180k
R15	18k
R16	100k

All 0·25W 5% carbon film

Capacitors

C1, C2	100µ radial elect. 10V (2 off)
C3	10n polyester
C4	1n polyester
C5, C6	3n3 polyester (2 off)
C7	1µ radial elect. 50V
C8, C9	100n polyester (2 off)
C10	470n polyester
C11	2n2 polyester (2 off)

Semiconductors

D1, D2	OA91 germanium signal diode (2 off)
D3, D4, D5	1N4148 silicon signal diode (3 off)
TR1, TR2	BC549 *npn* silicon (2 off)
IC1	LF442CN dual low power op.amp
IC2	LF441CN low power op.amp
IC3, IC4	TS555CN low power timer (2 off)

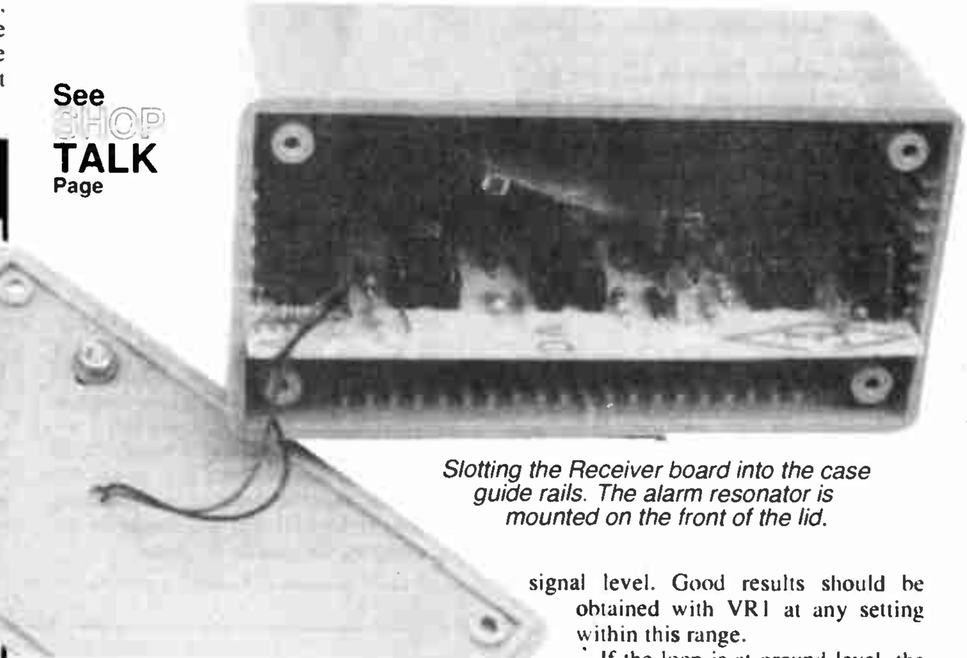
Miscellaneus

B1	9V (PP3 size)
L1	2·2mH inductor (8RB)
WD1	Cased ceramic resonator

Plastic case about 104mm x 54mm x 42mm, printed circuit board availabe from *EPE PCB Service*, code 154; 8-pin d.i.l. holder (4 off); battery connector (PP3); wire; solder; etc.

Approx Cost Guidance Only £18

See SHOP TALK Page



Slotting the Receiver board into the case guide rails. The alarm resonator is mounted on the front of the lid.

It should be possible to use other small plastic cases, but fixing the board in the case could be a problem if a different type is used. Double-sided self-adhesive pads offer a possible solution. It is not advisable to use a metal case as this could tend to screen the pickup coil, giving inadequate sensitivity.

INTERWIRING

Apart from the battery, the only off-board component is the cased ceramic resonator. This is fixed to the lid of the case using a couple of small (usually 8BA or metric M2) nuts and screws.

A third hole of about 2·5mm in diameter is needed to enable the two leads of the resonator to pass through to the interior of the case. The leads may be red and black, but a ceramic resonator is not a polarised component, and it can be connected to the circuit board either way round.

TESTING

The transmission loop should be made from fairly heavy gauge double insulated wire, and ordinary two core 3A mains cable seems to be the cheapest double insulated cable available. The loop can be at ground level if desired, but whether it is a few feet up or on the ground, make sure it does not represent a hazard. There is no point in a safety system which keeps tripping people up!

The loop does not have to be a perfect circle, rectangle, or other neat shape. On the other hand, if the shape is made highly intricate, results might be a bit unpredictable.

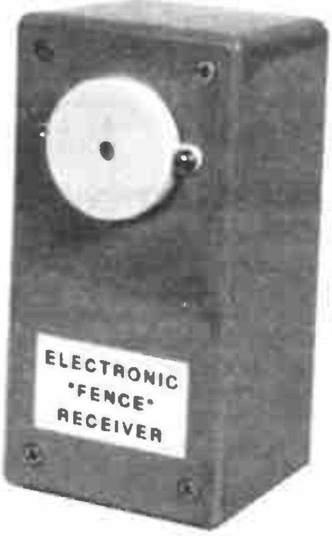
The Transmitter *must* be kept inside and not used in an exposed position. Preset VR1 in the Transmitter must be given a suitable setting before the system will work properly. With the Receiver placed within the loop the alarm will almost certainly sound.

By adjusting VR1 it should be possible to find a small range of settings that silence the alarm. If the receiver is placed just outside the loop, where a weaker signal is received, it should still be possible to adjust VR1 to switch off the alarm.

However, there will be only a restricted range of settings that give an adequate signal level. Good results should be obtained with VR1 at any setting within this range.

If the loop is at ground level, the Receiver will work at a height of about two or three metres towards the middle of the loop. Close to the loop the maximum operating height is reduced, but should still be about one metre.

It is not necessary for the pickup coil to have perfect orientation in order to produce an adequate signal level. It is only with the pickup coil almost perpendicular to the transmission loop that the received signal becomes very weak. □



INTERFACE

Robert Penfold

AUDIO MILLIVOLTMETER INTERFACE

IN RECENT *Interface* articles we have covered several types of test equipment. We continue in the same vein this month with a simple Audio Millivoltmeter Interface project.

This is based on an analogue-to-digital converter which interfaces to the PC's printer port. The analogue-to-digital converter is preceded by a precision rectifier circuit which converts the incoming audio signal to a proportional d.c. voltage.

Combining any sensitive audio equipment with computer equipment tends to be problematic due to the large amount of electrical noise generated by the digital circuits in the computer. Ideally the Millivoltmeter Interface would be totally isolated from the computer via an opto-isolator. The problem with an opto-isolator is that it tends to compromise linearity, which is clearly undesirable in a situation where accurate measurements are required.

Therefore, this interface connects direct to the analogue-to-digital converter, and a certain amount of noise pickup has to be tolerated. In practice, the amount of noise picked up will be very low provided the circuit is properly screened.

At maximum sensitivity the interface has a full scale value of 25·5mV r.m.s. with a resolution of 100µV (0·1mV). This is sufficient for most purposes, such as gain measurement and frequency response testing, but the system is unsuitable for certain applications such as the measurement of signal-to-noise ratios. There are two additional ranges which have full scale values of 255mV and 2550mV (2·55 volts) r.m.s.

How It Works

As explained previously, the Audio Millivoltmeter Interface connects to the computer via an analogue-to-digital converter. The basic function of the interface is to convert the a.c. input signal into a corresponding d.c. voltage that can be read by the analogue-to-digital converter.

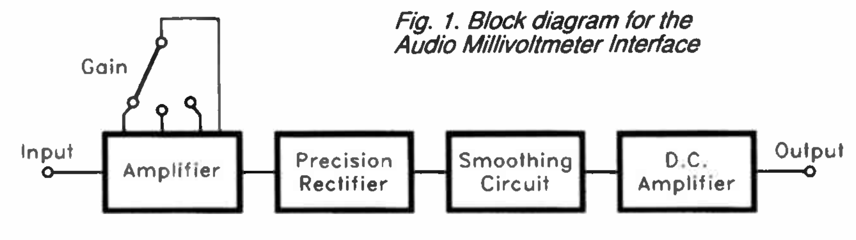


Fig. 1. Block diagram for the Audio Millivoltmeter Interface

The block diagram of Fig. 1 helps to explain how the Millivoltmeter Interface functions. A two-stage amplifier at the input of the interface provides a boost in sensitivity as well as providing the unit with a high input impedance so that there is minimal loading on the circuit under test. The amplifier has three switched levels of gain, which give the interface its three measuring ranges.

A precision rectifier provides the conversion from a.c. to d.c., and in this circuit a full-wave rectifier is used. A simple passive rectifier is not suitable in this application due to the extreme non-linearity through such a circuit.

An active rectifier uses negative feedback to counteract the non-linearity of the semiconductor diodes, and provides almost perfect linearity at audio frequencies. It is not strictly necessary to use a full-wave rectifier, but this does help to give better accuracy with asymmetric signals.

The raw d.c. output of the precision rectifier is converted to a steady d.c. signal by a simple smoothing circuit. The output of the smoothing circuit is slightly insufficient to drive the analogue-to-digital converter properly, so a simple low gain d.c. amplifier is used to boost the output signal.

Circuit Description

The main circuit diagram for the Audio Millivoltmeter Interface is shown in Fig. 2. The input amplifier is based on IC1, which operates as a standard non-inverting amplifier. It operates with voltage gains of 214, 21·4, and 2·14, depending on which feedback resistor or resistors are selected using switch S1. This provides the unit with its three measuring ranges.

The input impedance of the circuit is set at one megohm by resistor R1, and this is high enough to ensure minimal loading

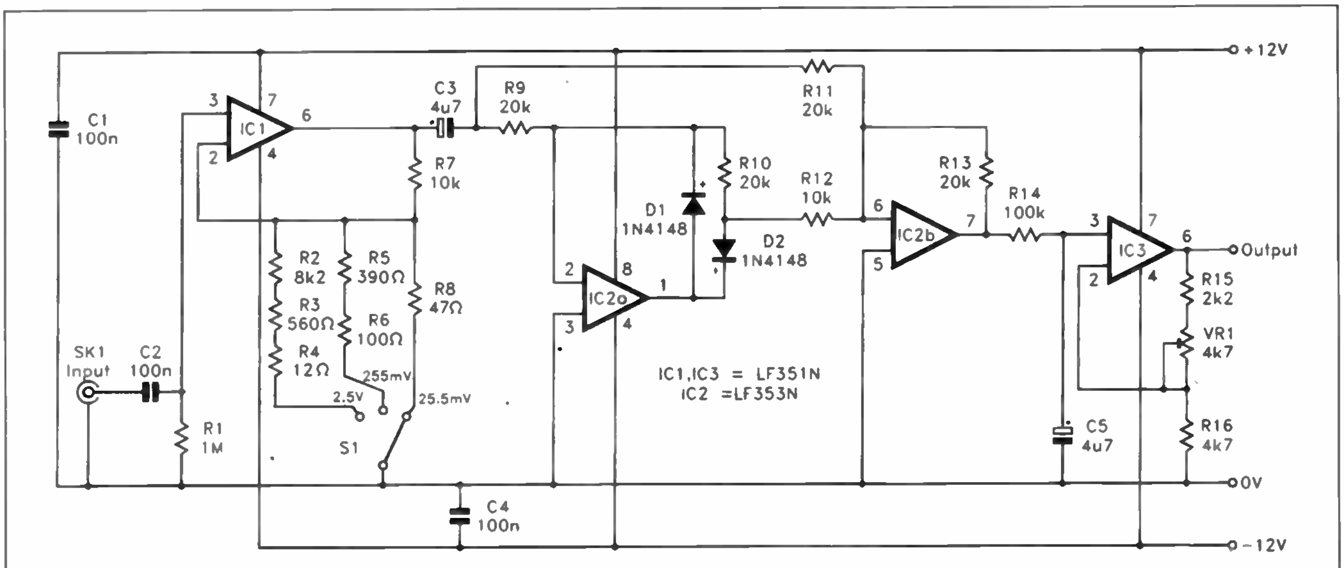


Fig. 2. Main circuit diagram for the Audio Millivoltmeter Interface.

on the test circuit. Capacitor C2 provides d.c. blocking at the input of the interface. In theory it is not necessary to have d.c. blocking capacitor C3 at the output of IC1, but in practice there can be problems with strong d.c. offsets if it is not included.

Dual j.f.e.t. op.amp IC2 forms the basis of the precision rectifier, which uses a conventional full-wave precision rectifier configuration. Ideally resistors R9 to R13 should all have close tolerances of two per cent or better, so that the gain of the circuit is precisely the same for positive and negative half cycles.

Smoothing is provided by resistor R14 and capacitor C5, which have a fairly long time constant so that good smoothing is attained even at low frequencies. This inevitably means that the unit takes a second or two to adjust to large changes in the signal level.

Op.amp IC3 forms the basis of the d.c. amplifier, and this is a standard non-inverting mode circuit. The amplifier has a closed loop voltage gain of approximately two, but preset potentiometer VR1 provides some variation in gain so that the unit can be accurately calibrated. There is clearly no point in building this interface unless you have some means of calibrating it.

Great Dictator

Until quite recently, anyone who talked to their computer was quite likely to be taken away by two men in white coats. Things have changed recently with the introduction of low cost voice recognition systems for PCs. I have mentioned in the past that voice recognition systems are forever just about to reach full development, but never actually seem to arrive in the shops. The current systems are something less than fully developed as they cannot be used with normal speech, and require the user to pause very briefly between each word, but they *are* actually available in the shops. Prices start at under £100.

Even for a reasonably proficient one finger typist, one word at a time dictation is still much easier and less tiring than typing large amounts of text. Inevitably a few mistakes are made at first, but you soon get the hang of talking in this fashion, and quite high dictation speeds can be attained.

Speeds of around one hundred words a minute can be achieved, although not necessarily with a high degree of accuracy. With most systems it is now possible to achieve a level of accuracy in excess of 95 per cent, and it is possible to train the systems to achieve an accuracy of more like 99 per cent.

This piece was dictated into IBM Voice Type "Simply Speaking", and although a fair amount of manual correction was required, it was still quicker than typing the text. Possibly, in the not too distant future, voice recognition systems will be a standard part of computer operating systems.

Systems that can handle ordinary speech without pauses between words might be a practical possibility in the next few years. In the meantime, the current systems represent a practical alternative to using a keyboard.

Unfortunately, a fairly up-market PC is needed in order to run most of these systems. In the case of IBM's Voice Type the minimum requirement is a 100MHz Pentium PC with a CD ROM drive, Soundblaster 16 compatible sound card, and 16 megabytes of memory.

A/D Converter

The circuit diagram for the analogue-to-digital converter appears in Fig.3. This is basically the same converter that has been used in several previous *Interface* projects, and it will not be described in detail here.

It is a form of serial analogue-to-digital converter, and as such it can be interfaced to the computer using very few lines. In fact, it needs only three lines (two outputs and one input), which in this case are provided by the PC's printer port. Of course, the circuit can interface to any other computer port that provides sufficient input and output lines at standard TTL logic levels.

Diode D3 and resistor R17 provide over-voltage protection at the input of the converter. This is necessary because the main interface circuit is powered from dual 12V supplies, and could otherwise provide input voltages substantially higher than the maximum safe levels for IC4.

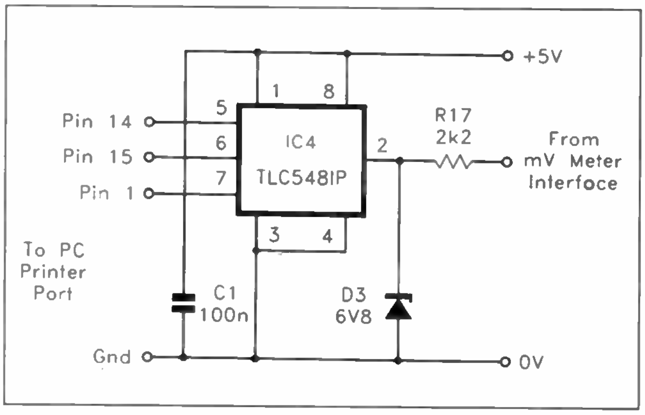


Fig. 3. Circuit diagram for the analogue-to-digital converter. This is an 8-bit serial type.

Software

The GW BASIC software program provided in Listing 1 is based on the analogue-to-digital converter software provided in the November 1995 issue of *EPE*. The method of reading the converter is fairly convoluted, since bytes must be read in one bit at a time. The majority of the listing is therefore concerned with reading the analogue-to-digital converter.

Initially the programme operates on range 2, but it can be switched to any desired range by pressing key "1", "2" or "3". The subroutines print the range number on the screen and manipulate the value read from the converter so that the correct figure is displayed on the screen (e.g. 23·2 instead of the raw value of 232 read from the converter).

A returned value of 255 might be valid, but it is assumed to be an overload and a suitable warning is displayed on the screen. There is no built-in means of exiting the programme, but the usual Control-Break key combination will bring the programme to a halt.

The system obviously has scope for improvement, and it would probably be possible to provide auto-ranging by controlling the gain of the input amplifier via MOSFETs controlled from three outputs of the PC's printer port. It should also be possible to obtain logarithmic readings in decibels by utilizing the mathematical capabilities of GW BASIC. There is obviously plenty of scope for the experimenter to tweak the system.

Listing 1: Audio Millivoltmeter Program (GW Basic)

```
10 REM Audio Millivolt Meter Program
   (TLC548 A/D)
20 CLS
30 LOCATE 7,38
40 PRINT "RANGE 2"
45 Z = 1
50 OUT &H37A,1
60 OUT &H37A,3
70 OUT &H37A,2
80 X = INP(&H379) AND 8
90 X = X*16
100 OUT &H37A,3
110 OUT &H37A,2
120 Y = INP(&H379) AND 8
130 Y = Y*8
140 X = X + Y
150 OUT &H37A,3
160 OUT &H37A,2
170 Y = INP(&H379) AND 8
180 Y = Y * 4
190 X = X + Y
200 OUT &H37A,3
210 OUT &H37A,2
220 Y = INP(&H379) AND 8
230 Y = Y * 2
240 X = X + Y
250 OUT &H37A,3
260 OUT &H37A,2
270 Y = INP(&H379) AND 8
280 X = X + Y
290 OUT &H37A,3
300 OUT &H37A,2
310 Y = INP(&H379) AND 8
320 Y = Y/2
330 X = X + Y
340 OUT &H37A,3
350 OUT &H37A,2
360 Y = INP(&H379) AND 8
370 Y = Y/4
380 X = X + Y
390 OUT &H37A,3
400 OUT &H37A,2
410 Y = INP(&H379) AND 8
420 Y = Y/8
430 X = X + Y
440 OUT &H37A,3
445 A$ = INKEY$
450 IF A$ = "1" THEN GOSUB 520
460 IF A$ = "2" THEN GOSUB 560
470 IF A$ = "3" THEN GOSUB 600
480 LOCATE 10,30
490 IF X = 255 THEN PRINT "
    Overload   " ELSE PRINT
    X*Z"Millivolts R.M.S. "
500 OUT &H37A,1
510 GOTO 50
520 Z = .1
530 LOCATE 7,38
540 PRINT "RANGE 1"
550 RETURN
560 Z = 1
570 LOCATE 7,38
580 PRINT "RANGE 2"
590 RETURN
600 Z = 10
610 LOCATE 7,38
620 PRINT "RANGE 3"
630 RETURN
```

EVERYDAY PRACTICAL ELECTRONICS

BACK ISSUES

We can supply back issues of *EPE* by post, many issues from the past five years are available. An index for each year is also available – see order form. Alternatively, indexes are published in the December issue for that year. Where we are unable to provide a back issue a photostat of any *one article* (or *one part* of a series) can be purchased for the same price.

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FEATURES ● Teach-In '96 Part 7 ● Ingenuity Unlimited ● Thermionic Valves Part 2 – The C.R.T.

JUNE '96

PROJECTS ● Sarah's Light ● Ultra-Fast Frequency Generator and Counter Part 1 ● VU Display and Alarm ● Pulstar ● Home Telephone Link.
FEATURES ● Teach-In '96 Part 8 ● More Scope for Good Measurements Part 1 ● Circuit Surgery ● Miniscope Review.

JULY '96 Photostats Only (see below)

PROJECTS ● Advanced NiCad Chargers ● Single-Station Radio 4 Tuner ● Games Compendium ● Twin-Beam Infra-Red Alarm ● Ultra-Fast Frequency Generator and Counter – 2.
FEATURES ● Teach-In '96 Part 9 ● More Scope for Good Measurements Part 2 ● Circuit Surgery ● The Internet ● Ingenuity Unlimited.

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PROJECTS ● Component Analyser ● Garden Mole-Ester ● Mono "Cordless" Headphones ● Bike-Speedo ● Mobile Miser.
FEATURES ● Teach-In '96 Part 10 ● Circuit Surgery ● Ingenuity Unlimited ● Spies, Lies and Electronics ● EPT 3.0 Review.

SEPT '96

PROJECTS ● Analogue Delay and Flanger ● Simple Exposure Timer ● PIC-Tock Pendulum Clock ● Draught Detector ● Power Check.
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FEATURES ● Build Your Own Projects, Part 1 ● Ingenuity Unlimited ● Circuit Surgery ● Net Work ● Interface.

DEC '96

PROJECTS ● Vari-Colour Christmas Tree Lights ● PIC Digital/Analogue Tachometer ● Stereo Cassette Recorder ● EPE Elysian Theremin, Part 2.
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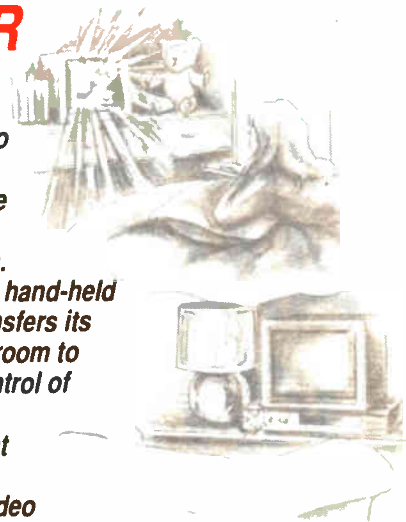
NEXT MONTH

IR REMOTE CONTROL REPEATER



Simple, inexpensive and easy to build, this project will allow you to remotely control your video recorder, satellite tuner or audio system etc. from another room.

It employs the existing hand-held remote control but transfers its instructions from one room to another to give full control of equipment.

Just right if you want to watch a TV set in a bedroom showing a video playing on the machine in the lounge – you can fast forward, rewind or simply switch off the video as required.

MICROPOWER PIR DETECTOR

The µPIR is the first of three projects designed to form an integrated intruder alarm system. This can be used to protect any property but is intended especially for premises where battery power is an essential requirement.

The PIR Sensor project may be used on its own, but the article also shows it as part of a complete system, the rest of which will be described in the following two issues.

The Controller Unit (Aug. issue) provides adjustable sensitivity and timed alarm periods. It incorporates a power output stage for the direct operation of sirens, beacons and similar deterrent devices.

The final part of the series will describe the provision of a neat, weatherproof "secret" disarming switch featuring a "delay on reset" to allow the user to leave the protected area.

KARAOKE ECHO UNIT

"Karaoke", according to the Oxford dictionary, is Japanese for "empty orchestra" (no doubt our Japanese readers will correct us if this is not so!). To others it means a lot of lager-louts having a cacophonous booze-up. To the initiated, though, it means the chance to prove to the world that you are in totally the wrong job, your musical talents being unjustifiably ignored and that you should, of course, be performing nightly with Madonna, or Jose Carreras (depending on your inclination and vociferous tonality), in full glare of the TV lights and cameras.

But why is it that the obviousness of your talents is less pronounced outside of a spirited pub atmosphere? The proof of the alcohol has nothing to do with it – it's the echoing resonance of your vocalising that inspires calls for repeat performances, and that's thanks to the landlord's audio gear...

So what can you do to discard your ill-befitting anonymity that prevails outside of opening hours? Build this Karaoke Echo Unit and let your tenorial talents resound and reverberate with repetitive proclamation! It's simple to build, easy to use, won't cost more than a couple of rounds amongst mates, and could get you on the road to the stardom you deserve. TOTP and La Scala Milan await you!

EVERYDAY PRACTICAL ELECTRONICS

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JULY ISSUE ON SALE FRIDAY, JUNE 6

Special Feature

REACTOBOT™ AND VIRTUAL REALITY

ROB MILES

Rob Miles describes some of the research into Virtual Reality in the Department of Electronic Engineering at the University of Hull, in an attempt to make an artificial world more "real".

WHAT is Virtual Reality? Computers run programs: the programs tell the computer what to do. Anything which we can understand ourselves, we can tell the computer about. If we know how to *do something*, such as fly a plane or bake a cake, we can program a computer to do it at least as well as, if not better than, we can! We human beings know how the outside world looks and, at some levels, how it behaves. This means that we can create programs which produce worlds that look as real as the one in which we live. As computers become more powerful, the complexity of these worlds will increase until we can't distinguish them from reality.

The interesting thing is that those bits of human life which we don't understand, such as what makes a good joke in the best traditions of dry English humour (a horse walks into a bar and the barman says "Why the long face?"), are beyond the most powerful computers!

What do we mean by Virtual?

I first came across the word "virtual" when studying Physics at school. A "virtual image" was something to do with mirrors and lenses. You could "see" it but you were actually looking at *nothing*! The *real* object was somewhere else and the mirrors and lenses were making it *appear to be* where you were looking. Virtual Reality is an image of something which exists, well, nowhere! The computer forms the image, based on what you tell it about the universe you are creating, and you look at it.

What do we mean by Reality?

One of the wonderful things about the human brain is that it is very good at making sense of what it sees. A huge number of optical illusions work because as soon as the brain sees something, it starts making it into a picture of a three-dimensional scene, see. Fig. 1.

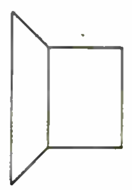


Fig. 1. 3D scene?

You will probably say, "Aha!, a loudspeaker". Mathematicians might say "Aha!, a rhomboid and a rectangle". On the other hand, your brain will probably say "Aha!, an open door". If I added some "depth cueing", a cute way of describing methods such as making the near parts brighter and the distant parts darker, I could fool the brain and produce a passable imitation of a doorway. Artists have known about this for centuries and have all kinds of tricks for making the brain take a two dimensional picture and come up with the "Taj Mahal by moonlight".

The Computer as an Artist

We can now use computers to perform all manner of artistic tricks to generate images which look as real as photographs. Most of the work is based on simple geometry. You can specify the position of any part of a picture in terms of numbers: for example, the light in a room is two metres from the floor, one metre from one wall and 1·2 metres from another. If you offer the computer this information describing everything in the room, you can use geometry to draw a picture of all the items within it.

The fun starts when you add more complex information: "if the chair is behind the desk, we can't see all of the chair" and "the chair is covered with shiny leather but the desk is matt finish pine". This gives the poor computer a lot to think about, and explains why high quality computer generated pictures take a long time to create . . .

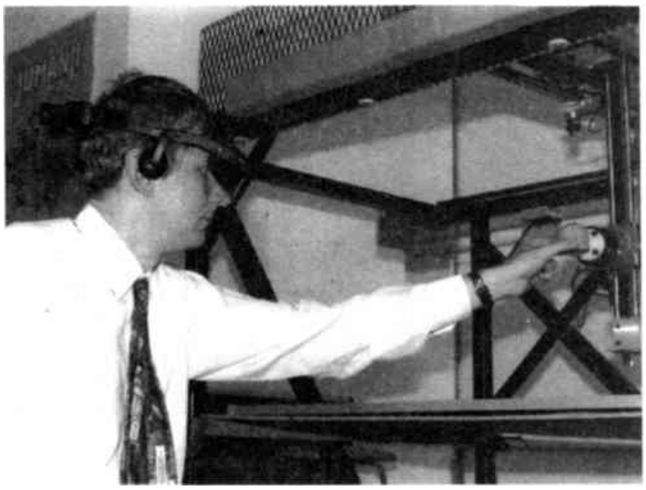
With Virtual Reality the aim is to draw the pictures in *Real Time*, i.e. create a world in which you can interact and move around. We can now do this with simple scenes, and the increasing power of computers means that the images will become more complex in the future.

Virtual Reality in Action

Virtual Reality (VR) systems feed the brain information via the eyes and the ears in order to describe this artificial environment. It receives data from sensors which identifies your whereabouts in the artificial world, and then VR creates what you would *see* and *hear* in that position. As you move your position, the new view that is created changes accordingly. One of the big problems at the moment is "reality lag", where the environment doesn't quite keep up with you due to the time lapse in the computing process. This gives you a queasy feeling not unlike sea-sickness!

Reactobot and Virtual Reality

Once you have created your virtual world on a computer, you can "enter" it and wander around: then, you are going to want to *do* things in there! The first VR hardware which came along was the "data glove". This told the computer the position of your



Rob Miles, with VR headset, using Reactobot.

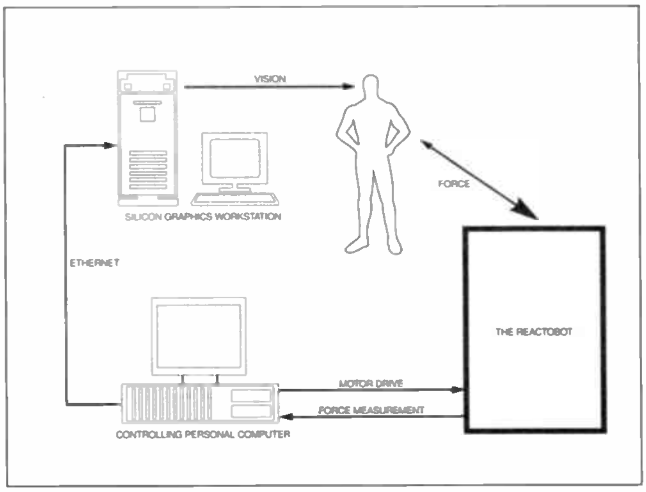


Fig. 3. Control and feedback for Reactobot.

hand in the virtual world, and what it is doing. By "reading" the hand position and actions using sensors on the VR glove, we could now create systems which enabled us to "pick things up" and "play" with or manipulate them. However, as far as you, the human being, are concerned, you are not physically holding anything. Everything weighs the same, i.e. *nothing*! This means that the experience is still very artificial indeed.

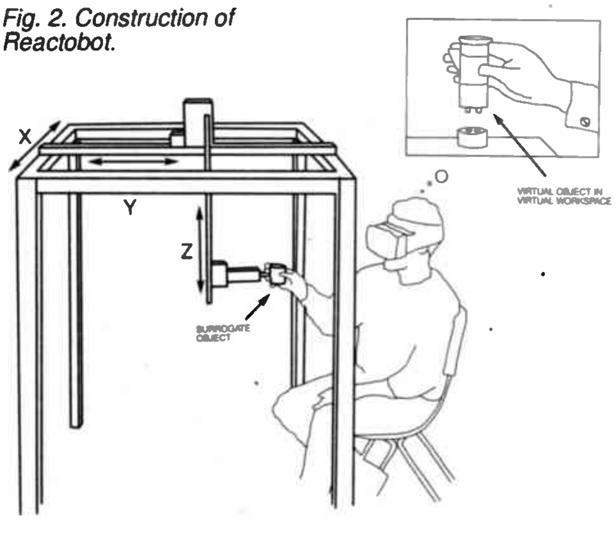
Your brain has been making sense of the world via your arms and legs for at least as long as it has via your eyes. It knows that, generally, big things weigh a lot and little things don't weigh so much. It also knows that to move objects around, you have to put in some effort in the direction they are supposed to go. A vast amount of growing up involves finding these things out and building a universe around them. You might think that a child is just playing with building blocks, piling them up and knocking them down, but really the child is assembling a model of how the world around him behaves. So, for a virtual experience to become more real it has to behave like the outside world.

The Reactobot is a so-called "reacting robot" which has been created to give you something *real* to hold on to within your virtual world, but it also has other potential uses, as we shall see later. Reactobot is built within a steel frame which accurately guides the movement of an object in all three dimensions (*X, Y and Z*) as shown in Fig. 2.

Surrogate Object

When you use the Reactobot you take hold of an artificial object (called a "surrogate object") whilst a vision system shows you a picture of the "virtual environment". The Reactobot's computer-controlled DC motors drive the load and the actual surrogate object, whilst a force sensor provides the computers with feedback information. Professor Paul Taylor, the chief researcher in the Reactobot project says that the Reactobot provides "force feedback to the user, and is programmed to

Fig. 2. Construction of Reactobot.



Newton and the Reactobot

The principles governing the Reactobot date back to Sir Isaac Newton and his laws of motion. If **force = mass × acceleration,** then the harder you push something, the faster you can change its speed. (A 2 litre car will accelerate faster if we use the engine, rather than if I push it.)

Hence, **acceleration = force/mass.** This makes sense too: the greater mass an object has, the less its speed will change when we push it with a given force – a 2 litre car will accelerate more slowly with four people aboard and a sackful of cement in the boot!

The Reactobot computer "knows" how hard we are pushing the object, and the direction as well. It has also been programmed with the mass of the object it is pretending to be. By putting these values into the above formula, it can calculate the acceleration that the "pretend" object should have. Newton also said: **the speed now = old speed + (acceleration × time).**

If we know the speed of the object at any time in the past, this new formula will tell us the speed the object should have now. The Reactobot software is constantly working out the force on the object, doing these sums and working out the speed. It can then feed the speed value into the viscosity sums, and work out how hard our motion is being resisted.

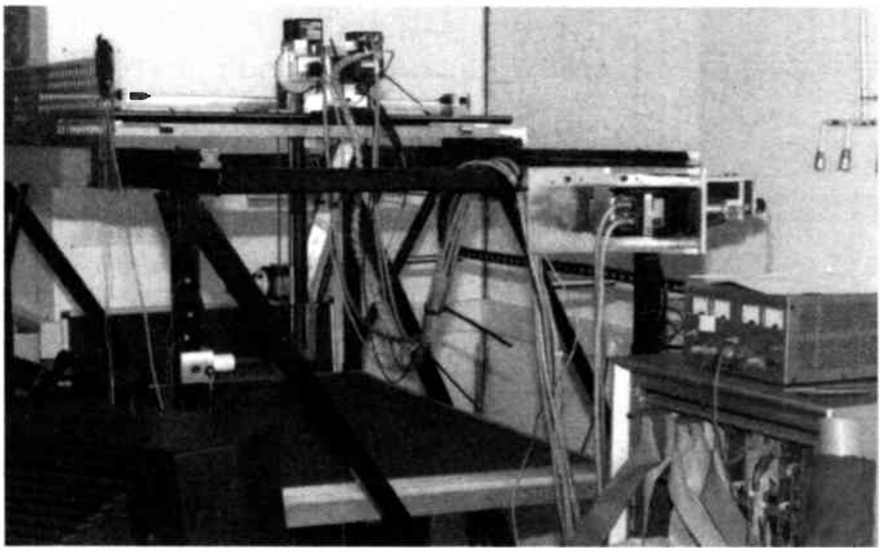
How Reactobot Works

The user pushes against a force sensor which measures in all three axes. The amount of "push" being applied to the object is fed into the PC which uses a model of the world it is simulating, to provide drive signals to a set of brushless d.c. motors. The motions are transferred to the object using drive belts. The force sensor samples at a rate of 1kHz, with motor feedback generated at 200Hz. This means that the user finds the action very smooth and realistic.

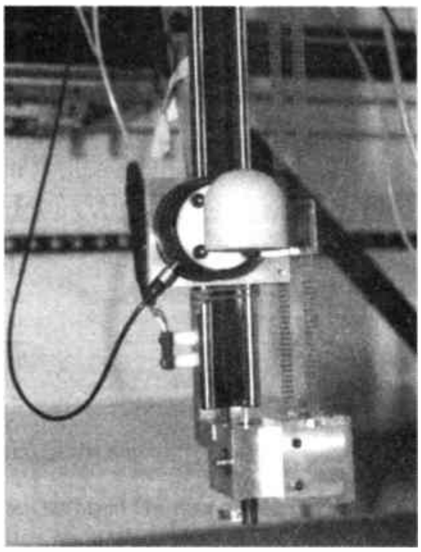
By changing the software configuration files, objects with a mass between 0·5 to 3 kilograms can be simulated. The Reactobot considers three forces; the force applied by the user, the force of gravity (if any), and the viscosity of the medium we are moving through.

If the user pushes up harder than gravity pulls down, the object will rise. There is then a subsequent force acting against the movement – the viscosity or "thickness" of the medium surrounding the object. Treacle or water? The faster I try to move the object, the greater the opposing force, making it harder to increase the speed of the object. This is why it's harder to swim quickly in treacle, not that I've tried.

The computer is constantly working out the size and direction of these forces, summing them and driving the motors appropriately. Because Newton's Laws really work, the object behaves just like a "real" one.



Reactobot and its controlling PC system.



Reactobot's "surrogate object."

mimic the dynamic characteristics of the virtual object and its interaction both with the virtual environment and the operator".

Because of the way that the brain values visual information above all else, the object that you *see* completely overrules what the hand *thinks it is holding*. In the Department of Electronic Engineering, a surrogate object has been created using a small piece of lightweight foam plastic. If the *picture* you see is of a pint of Hull's finest beer, or anything else, then your brain will decide that *that* is what you are holding.

Driving the Reactobot

The object you hold on to is connected to a system of strain gauges which provide inputs to the computer system, to drive the motors which control how the surrogate object moves. The computer also knows whereabouts in space the object actually is, and passes this on to the system providing the pictures.

Put plainly, when you press on the object, the computer thinks "Aha!, he is lifting the object, I know that the object weights 1kg and so I will wait until he is pushing hard enough and then allow the object to rise." By using Newtons' Laws the computer can make the object behave just as it should, you can even throw it up in the air and catch it!

Juggling in Treacle?

Once we have the system working, one of the really fun things we can do is to change the universe in which the object exists. Want to work under water? No problem! We can change the computer program and give the object buoyancy, so that you have to *work to hold it down*. Prefer to work in treacle? Just add an appropriate amount of "drag" and you can practice juggling in a tin of Tate and Lyle's finest Golden Syrup!

We can even take away gravity completely to give the object mass, so that once you give it a push, it moves in that direction for ever (or until the Reactobot hits the end stops!). The Reactobot can be programmed to simulate the mass, gravitational constant, drag, and static friction of an object or medium, amongst other things.

Other Uses

There are many other useful party tricks which Reactobot can be called upon to perform. Imagine controlling a robot which is doing some construction work. Most robots operate in what is called "open loop". This means that there is no feedback: they don't know, or care, about the effects of their actions. In the Department there once resided a robot which was aptly named "Little Giant". Using this robot, students, being students, came up with the following joke: "What time is it when you tell Little Giant to put his hand three feet into the bench?" "Time to buy a new bench!"

If the universe which is driving the Reactobot has been configured with the constraints of the robot environment, or we have a strain gauge on the end of the robot to tell us how hard the robot is working, we can give the user of the big, powerful, almost *dangerous*, robot some feedback so that they can *feel* when the robot hits something. Hence the robot knows not to damage things. This is especially valuable if the robot is working in a distant, possibly hazardous, place and we want to control what it is doing. The user can see a computer generated picture of the environment, and interact remotely, receiving appropriate feedback.

Right Now

At present, the thrust of the work is directed at using an IBM PC to generate the graphics using the "blue screen" (chroma-key) technique beloved of TV weather forecasters. This makes it easier to create the pictures more economically. Professor Paul Taylor has moved to the Department of Mechanical Engineering, Newcastle University and Reactobot has gone with him to its new home; we trust that glasses of Newcastle Brown Ale will be as easy to "simulate" with the Reactobot as the products of Hull Brewery!

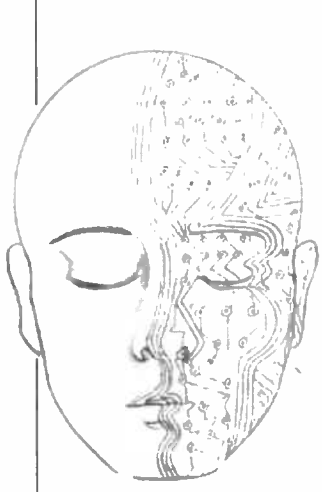
Teaching work centres on the "Robot Pick and Place" Laboratory, where Third Year students are involved in making a robot pick up a component and drop it onto a target which the robot can "see" via a camera. Research continues on other areas too, including Flexible Manufacturing Techniques and Garment Making, amongst other things!

Some material for this article was taken from the research paper *Tactile and Kinaesthetic Feedback in Virtual Environments* published by Prof. Paul Taylor, PhD, CEng, FIEE, MIEEE in the journal *Transactions of the Institute of Measurement & Control* Vol. 17 No 5, 1995.

Rob Miles is the Computer Manager at the Department of Electronic Engineering, University of Hull, England. E-mail: **r.s.miles@e-eng.hull.ac.uk**. *Reactobot* is a Registered Trade Mark of the University of Hull, England.

Photographs courtesy of Alan Winstanley.

D.C. gear motor drive on Reactobot.



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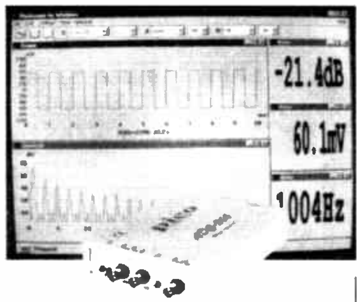

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Multiple Retry Watchdog -

A "WATCHDOG" system which, although originally designed for a radio repeater station, could be adapted for other uses is illustrated in Fig. 1. The purpose of the Watchdog was to monitor an Amateur Radio repeater station that should send identification signals at intervals of not more than twelve minutes.

Every time the system sends an "Ident" it also sends a trigger pulse to the Watchdog. If the Watchdog has not received a trigger after approximately 13 minutes then it tries to reset the system twice. If it still fails to "Ident" then the Watchdog sends an inhibit signal to stop it transmitting further.

The circuit comprises a 4060 counter (IC2) coupled to a flip-flop (IC1c and IC1d) which sends a disable signal if the system fails to re-start. The 4060 has an internal oscillator which is used to provide a clock signal for its counter. It runs at approximately 10·5Hz. The counter outputs change state as follows:-

Output	Division By	Changes State Every
Q8	256	12·8 seconds
Q10	1024	51·2 seconds
Q14	16,384	780 secs. (13 mins.)

The counter has a switch-on reset formed by IC1a and R1/C1, which also in turn resets the flip-flop. The $\overline{Q}$ output (pin 6) is hooked to the third input of a diode AND gate (D2 to D4), and the output will be high when the f/f is in its reset state. Normally, the counter resets every time the system being monitored sends a trigger signal via IC1a. This should have an interval of no more than 12 minutes.

If a fault occurs and the systems fails to send a trigger after 13 minutes, then the Q14 output of IC2 goes high. As Q8 is changing state every 12 seconds, then every time Q8 goes high, all the inputs to the diode AND gate will go high, which drives the open-collector transistor TR1 on. This can be utilised to send a reset signal to, say, a CPU which will be pulled low for 12 seconds.

After 12s Q8 output will go low and the CPU will reset, and hopefully send a trigger signal. Otherwise, after 12 seconds Q8 will go high again, all inputs to the diode AND gate will remain high and the CPU will again be reset.

If the system has failed to start up and transmit a trigger after 51.2 seconds then Q10 goes high, which is "NANDed" with the Q14 (13 minute) output to generate a SET signal to the flip-flop. Any further reset attempts are then inhibited because one of the diode AND inputs is sent low. The Q output of the flip-flop can be used to send a disable signal to the system.

J.J. Trinder,
Johnstone,
Renfrewshire.

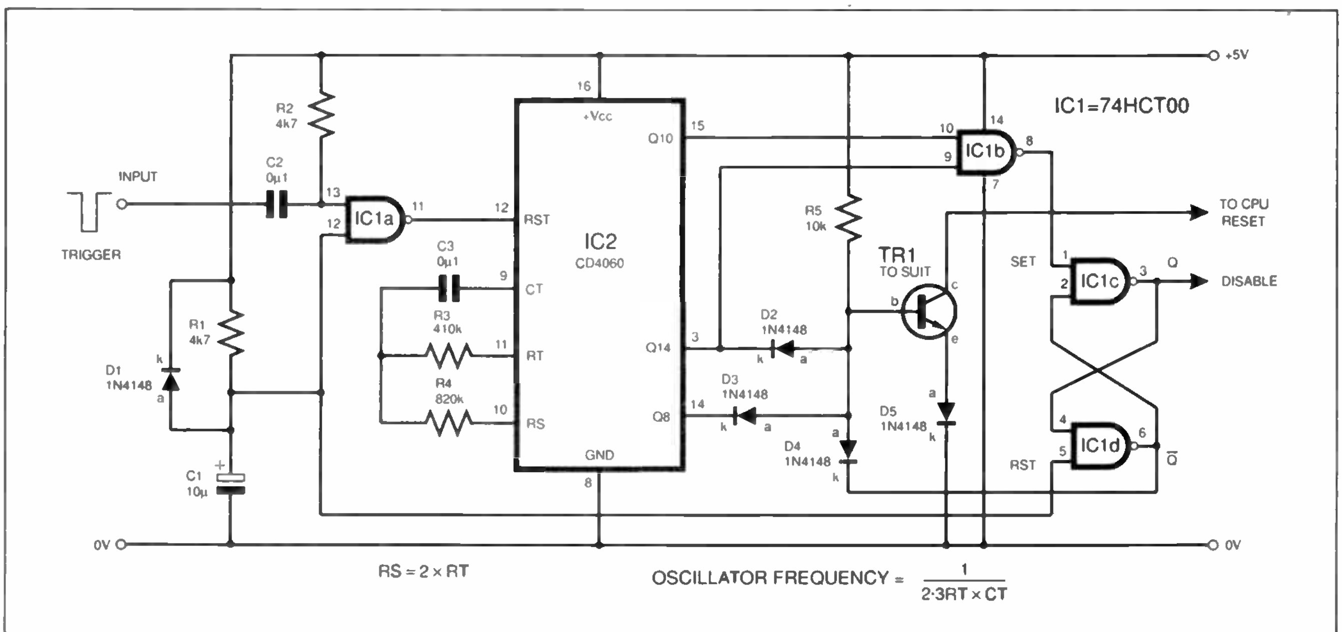

Fig. 1. Circuit diagram for a Multiple Retry Watchdog.

THE power amplifier circuit diagram of Fig. 2 was designed from a collection of ideas using generally-available components. It is a high-quality, low noise Class-B design which delivers 50 watts r.m.s. into 8 ohms, and I constructed a stereo version which now forms part of my stereo system. The design has a wide frequency response (10Hz-100kHz) so a tone control was not incorporated, and distortion was estimated at 0·005 per cent.

The input is centred around a "long-tailed pair" ultra-low noise matched dual transistor SSM2210P TR1/2 *(Maplin code UL79L – A.W.)*. Transistor TR5 is a current source and diode-biasing is used. Resistor R8, R9 and Capacitor C4 filter the bias network which improves noise to less than –100dB.

Resistor R11 sets the gain of the amplifier to 350mV r.m.s. sensitivity rendering a preamplifier unnecessary, although the use of a magnetic phono cartridge would require a suitably equalised preamplifier. Capacitor C6 (150pF) guards against high frequency instability.

Transistors TR9 and TR10 are a BD131 and BD132 complementary pair which are drivers for the main power output transistors TR11 and TR12 (2N3773 and 2N6609). For thermal stability TR8 must be in thermal contact with the output transistors, bolted to their heatsink.

Components R22, C9 and L1 form a Zobel network which ensures good stability at high frequencies. L1 was formed by winding 15 turns of 0·56mm enamelled copper wire around a 1k 2W resistor (R21).

Power Supply

A suitable Power Supply circuit is shown in Fig. 3. This was formed with a 120VA toroidal mains transformer *(Maplin DH65V)* and a 3A bridge rectifier (e.g. *4 × 1N5401 – A.W.*), followed by smoothing, to produce a 30V d.c. supply. Note the colour coding of the leads.

For testing and setting up the amplifier, proceed as follows. Fit 1A fuses in both the positive and negative supply rails, and connect a 2A d.c. ammeter in series with the positive supply lead. Adjust preset VR1 to give a quiescent current of 20mA. Switch off and uprate the fuses to 3A. Switch on again and allow the amplifier to warm up for fifteen minutes, then re-adjust VR1 if necessary.

Also, check the d.c. offset at the output using VR2 (a 25-turn potentiometer), measuring the output voltage with a 200mV voltmeter. The offset voltage should be a few microvolts only.

B. Reeves,
Romford,
Essex.

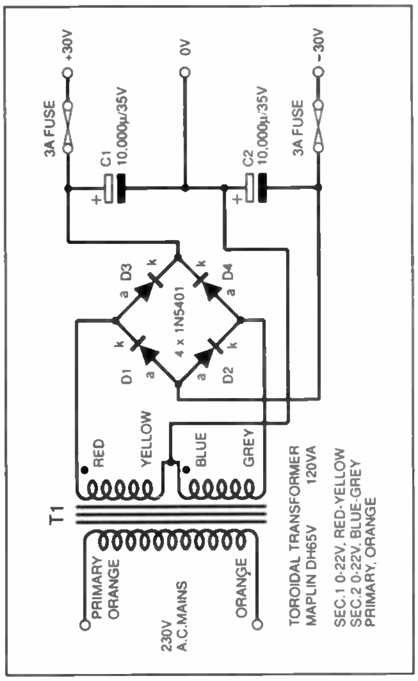

Fig. 3. Suggested Power Supply circuit for the 50W Amplifier.

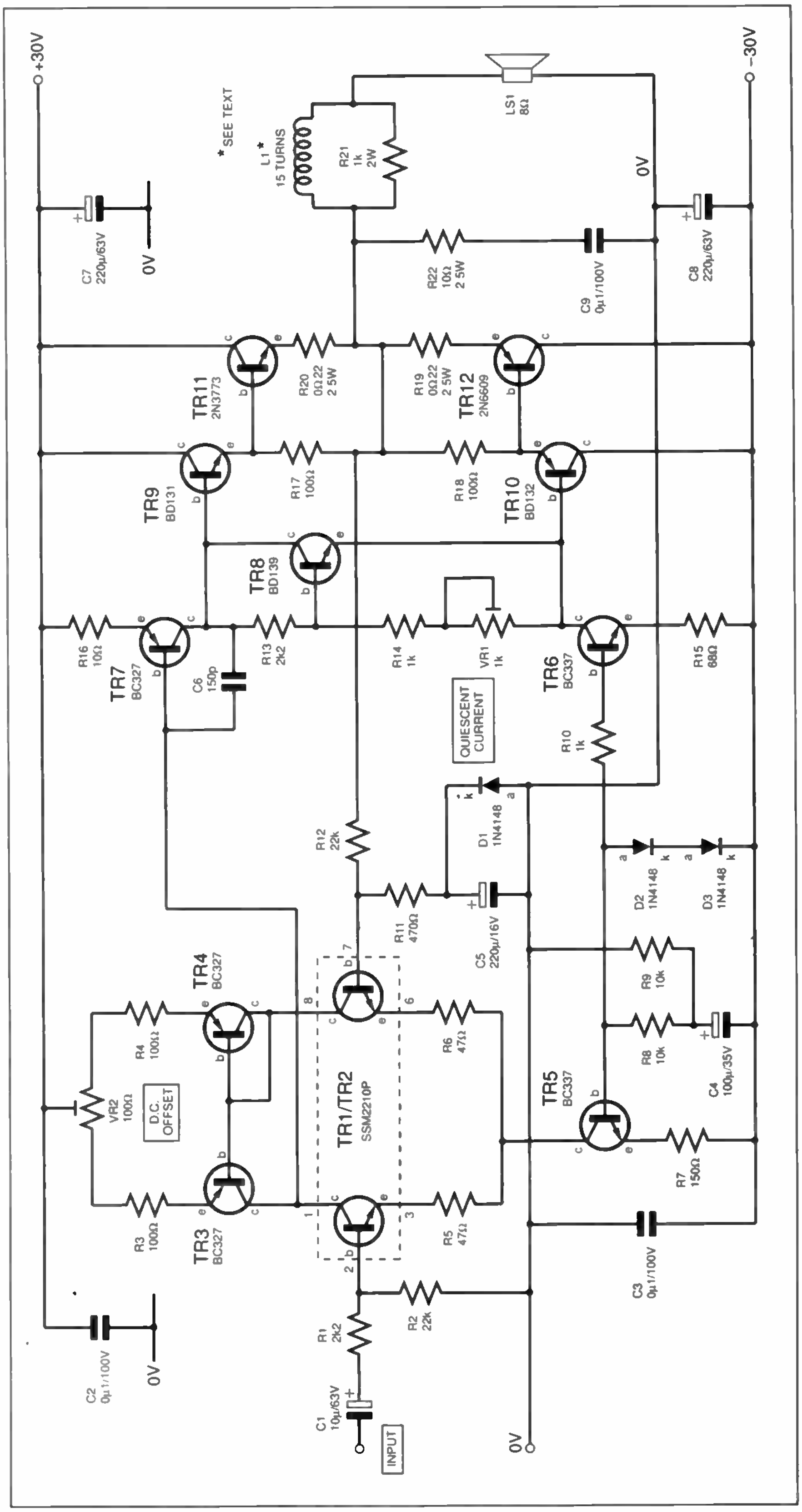

Fig. 2. Circuit diagram for the 50W Analogue Power Amplifier.

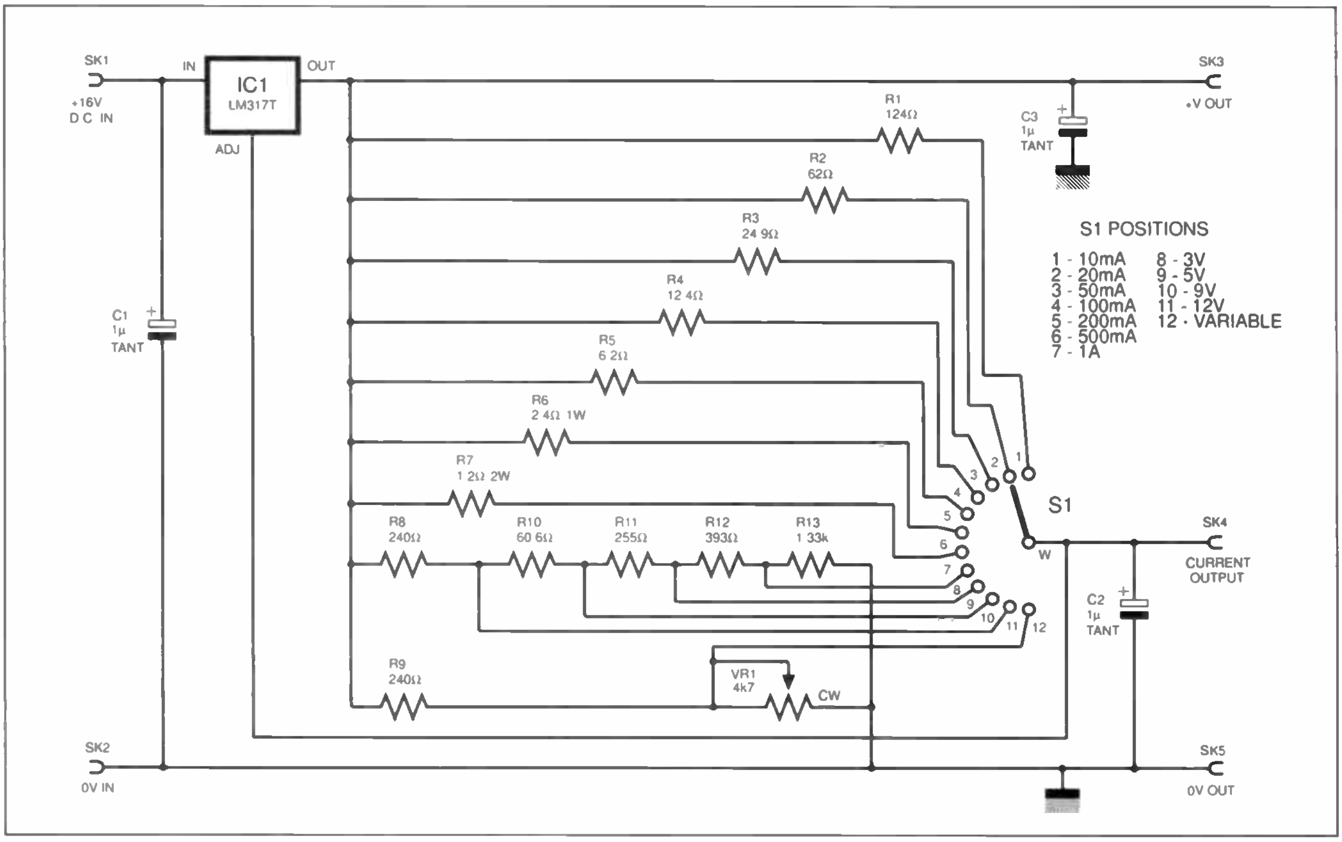

Fig. 4. Circuit diagram for the Mini Power Supply Unit. Switch S1 is a 12-way single-pole rotary type and the capacitors are tantalum types.

Mini PSU –

A VERY simple LM317T-based voltage/current source, which may be used for charging Nickel-Cadmium cells or whenever a handy power supply is needed, is shown in Fig. 4. It is an easy project for the beginner to build, and is intended to be used with a plug-in mains adaptor offering an unregulated d.c. output.

IC1 is a variable regulator type LM317T. The rotary switch S1 selects the mode (constant current or constant voltage) as well as the current or voltage value. The regulated voltage is available at SK3 and the current is at SK4. Note a variable setting (position 12) is included which permits an adjustable voltage to be trimmed using potentiometer VR1.

The resistor values should be made from the nearest available fixed values, placed in series as required. Resistor R6 is rated at 1W and R7 at 2W but the rest can be 0·25W. Voltage regulator IC1 should be fitted to a heatsink the size of which depends on the input and output voltages and currents required.

Martin G. Gulbrandsen,
Heer,
Norway.

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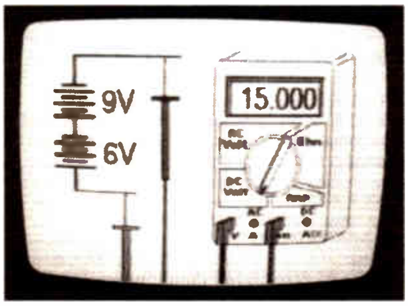

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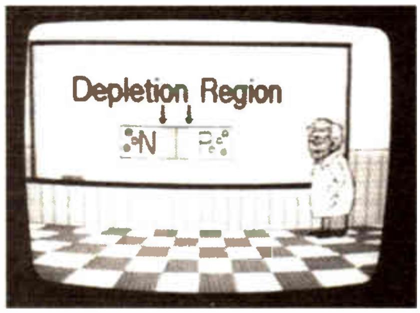

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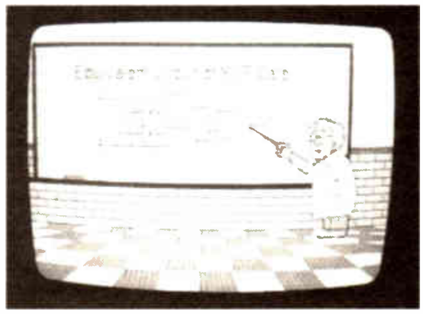

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NARROW RANGE THERMOMETER

STEVE KNIGHT

Check out baby's bath water with this low cost electronic thermometer – No need to scald mother's elbow!

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This project started off as the design and construction of a handheld device for the measurement of the "safe" temperature range of a baby's bath water. The idea being to indicate the small range of water temperature between that which is considered *too cool* and that considered *too hot*. A matter on which a considerable difference of opinion and in some cases a diplomatic silence was found.

This situation often arises in other areas where a restricted temperature range (perhaps less contentiously) is necessary for some operation or other and where an indication is given if the temperature falls below, or rises above, the limits desired.

The first thing, of course, was to find a temperature sensor which would discriminate easily between two relatively near-by temperatures; the electronic circuit to follow would then have to operate some form of alarm when the measured temperature moved beyond either of the selected limits. So, a few words on possible sensors will not be out of place.

TEMPERATURE SENSORS

There are a number of temperature sensors: thermocouples, specially prepared transistors, thermistors and diodes to name the most common. For a simple design such as this is, a thermocouple would involve a relatively expensive device and a rather complicated circuit system.

The humble silicon diode has the advantage of cheapness in comparison with the thermocouple but it was found that for the restricted temperature range envisaged for this present project, its forward voltage variation was insufficient for a non-critical design. After a number of bench experiments, a thermistor sensor was selected.

Thermistors are semiconductor devices with either a negative temperature coefficient (n.t.c.), the usual kind used for temperature measurement, or positive temperature coefficient (p.t.c.) which are generally used for over-current protection purposes and will have no further interest for us here.

The resistance of the n.t.c. thermistor, which is available in rod, disc or bead types, decreases with a rise in temperature in a non-linear but predictable manner, and has a high sensitivity to temperature change. It is well suited, therefore, to the detection of small fluctuations in temperatures covering a restricted range such as we require than in covering a large span, such as 0°C to 150°C where heatsink temperatures are possibly under investigation.

DISC THERMISTOR

A disc type thermistor is most suitable for this application as it is small and can be easily fitted into a probe which is held in the water being measured. There are two forms of interest: those in which there is a 10 per cent tolerance in the resistance of the disc at an ambient temperature of 25°C, and those so-called matched-curve types in which the characteristic of resistance against temperature is held within tight limits, so enabling one to be interchanged with another without the necessity of recalibrating a particular system.

These latter types are, however, as might be expected, rather more expensive but not prohibitively so. The design of this project will incorporate the cheaper model, but if you wish to use the matched type, some notes will be given about the initial calibration later on.

CHARACTERISTICS

The average form of the temperature/resistance characteristic of the thermistor used in this project is shown in Fig. 1, where the nominal resistance at 25°C is 10kΩ (10 kilohms). The curve is exponential (though this in not significant for our purposes) and covers the range 25°C to 40°C.

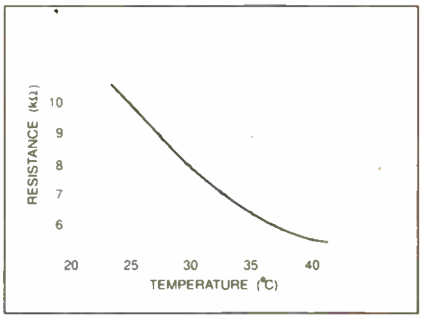


Fig. 1. Plotting the resistance of the thermistor against temperature.

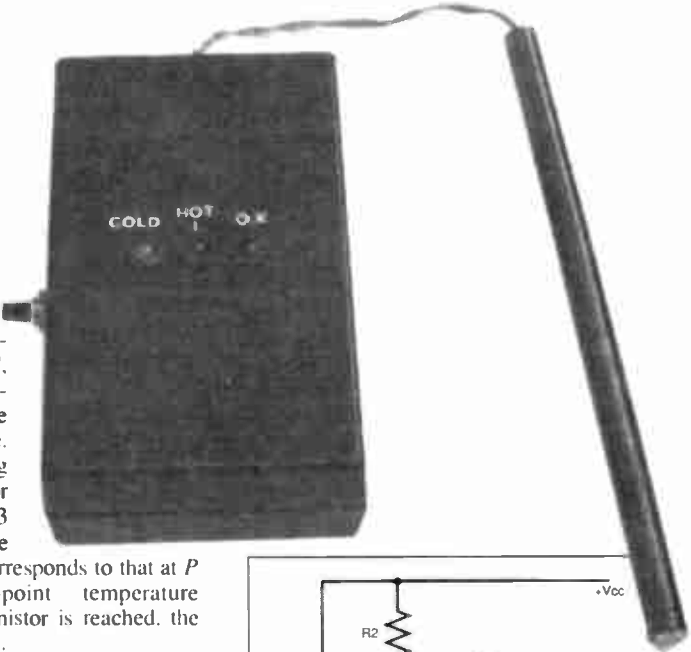
It is easy enough to draw this curve for your own thermistor (though you don't have to!); just connect the thermistor to a digital ohmmeter set on the appropriate range, and dip the thermistor into a cup of water which is at 40°C as measured against a good mercury-in-glass thermometer, holding it in close proximity to the thermistor. Give the water a gentle occasional stir and note the resistance at the stated temperature.

Now add cold water in small quantities to reduce the water temperature, noting the resistance at 35°C, 30°C and 25°C. This last measurement should correspond with the manufacturer's stated value within his stated tolerance, that is, 10kΩ ± 10%.

The figures for the thermistor used are given in Table 1 and the curve of Fig. 1 is drawn from this. Your own example may differ sightly from this (much depends upon the care of your measurements) but provided no extreme variations are obtained there will be no problems in setting up the thermometer.

Table 1: Temperature/resistance

Temp°C	Resistance (kΩ)
25	9·97
30	7·93
35	6·38
40	5·44



PRINCIPLE OF OPERATION

The purpose of this Thermometer project is that a required *temperature range* may be immediately distinguished from end limits which indicate either *too hot* (above the range) or *too cold* (below the range). It is suggested, on good authority, that the range for bathing the baby is from 32°C to 36°C, though other opinions reckon 28°C to 32°C is adequate.

The whole thing is, of course, highly subjective (as is mother's old "elbow" test), but we will take the first mentioned range as a design objective, and anyone making up a thermometer of this sort can adjust the range to suit his or her own preference. This may well include photographic buffs and others who require narrow temperature limits for their various activities.

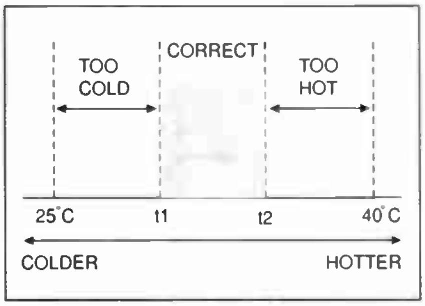


Fig. 2. Setting the limits for the thermometer.

So we can now establish a design principle. The obvious thing that comes to mind is a comparator system; we need to compare the actual bath temperature against the two selected limits and obtain an indication, preferably optical, when the bath temperature goes to either side of the set limits. So three indications are needed: too hot; too cold and correct, as Fig. 2 illustrates for temperatures in the range t1 to t2.

When an op.amp is used as a comparator of potentials at its input terminals the conditions shown in Fig. 3 will exist, as many of you will no doubt know. When the non-inverting input (+) exceeds that on the inverting input (−), the output switches high, approximately to Vcc level. When the reverse applies, that is, when the + input is less than the − input, the output switches to low, approximately the zero line level. The transition from one state to the other is very abrupt.

A basic set up is shown in Fig. 4. Here the thermistor Rt forms a potential divider with resistor R1 across the supply. Now at 25°C the resistance of the specified thermistor is nominally 10 kilohms (10k); if therefore R1 has a value of 10k also, the potential at point *Q* will be half the supply voltage.

As the temperature rises above 25°C, the thermistor resistance will fall and the potential at *Q* will rise. Hence, by selecting appropriate values for the resistors R2, R3 and R4 so that the potential at point *Q* corresponds to that at *P* when the highest-point temperature resistance of the thermistor is reached, the output of IC1 goes low.

Similarly, when the potential at point *Q* corresponds to that at *S* when the lowest-point resistance of the thermistor is reached, the output of IC2 will go low. For values between these limits neither i.c. output will be low; this condition must then trigger an indication telling us that we are in the permissible temperature range.

OPERATING POINTS

If we use the set up of Fig. 4 we must find values for resistors R2, R3 and R4 such that the voltage present at points *P* and *S* correspond to the voltage across R1 when the thermistor resistance is at the high and low temperature values respectively. This is no problem in itself, requiring only a bit of work with Ohm's law to calculate the resistor values; but for this it is necessary to know pretty accurately the values adopted by the thermistor at the temperature points concerned.

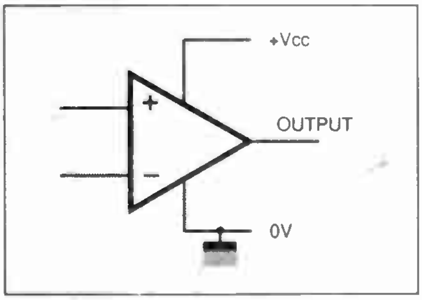


Fig. 3. Comparator set-up.

This does not follow from a simple resistance measurement when the thermistor is immersed in a water bath in the manner described earlier. Since a current is then passing through the thermistor, there is a small self-heating effect which can shift the true resistance from what it is at the measured water temperature.

Further, very odd values turn up for R2, R3 and R4 and this makes for a lot of work (and expense) either by having to buy precision components or make up series/parallel combinations of preferred values. In one particular experiment, using this method, the respective values worked out to be 34·83kΩ, 4·24kΩ and 52·5kΩ.

What's to do? Using the nearest preferred values directly, that is, 33kΩ, 4·3kΩ and 51kΩ respectively did not lead to a successful outcome, so it was

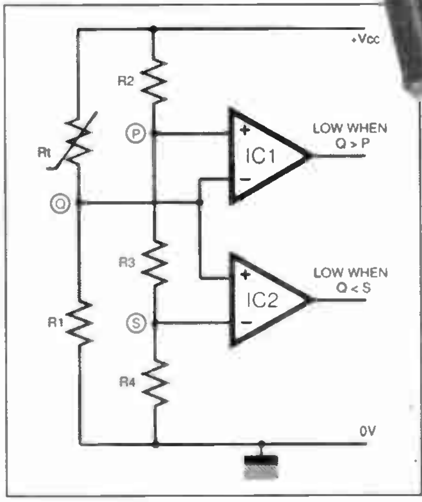


Fig. 4. Basic comparator circuit set-up using fixed resistors and a thermistor.

precision resistors (at a cost) or a selection from among 10 per cent and 20 per cent types to get nearer what was wanted – and these tolerances are not so readily available these days either. A tedious process altogether. Not only that, an error in one of the values will affect the voltage distribution of the other two.

It seems logical, therefore, to use preset potentiometers, replacing the three-resistor chain with two parallel adjustables as shown in Fig. 5; there is then no problem with the setting points and neither adjustment has an effect on the other. Most useful of all, of course, is the ability to easily alter the temperature end ranges if you wish to do so.

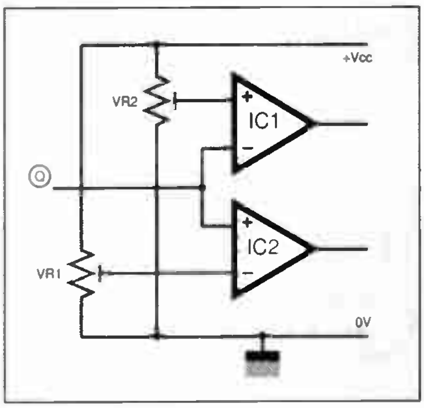


Fig. 5. Replacing the three resistors R2, R3 and R4 in Fig. 4 with preset potentiometers.

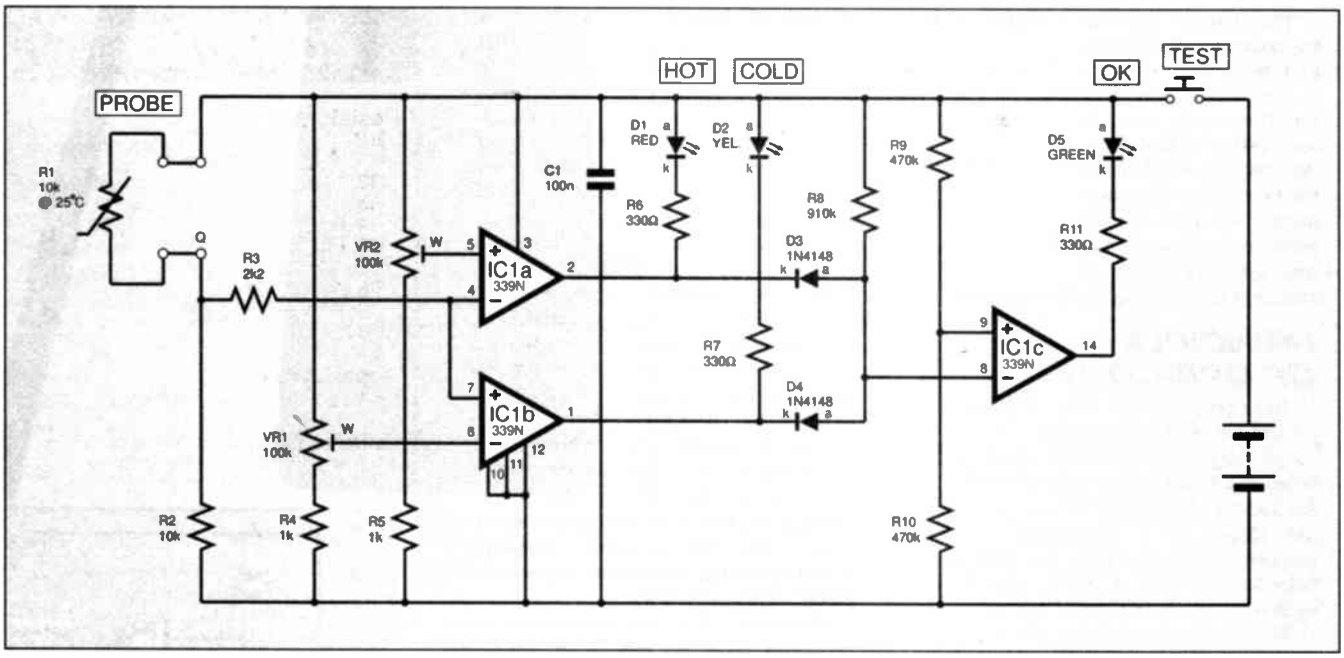


Fig. 6. Complete circuit diagram for the Narrow Range Thermometer.

The presets used are small top-adjusting multiturn types, about 25 turns of the adjusting screw being necessary to shift the slider (w) contact from one end of the resistance track to the other. When either end stop is reached, an indication is given by a faint clicking sound as the wiper idles at the end of its travel. No damage will accrue from moderate over-turning.

CIRCUIT DESCRIPTION

We can now set about the final form of the complete Narrow Range Thermometer circuit. This is shown in Fig. 6, which is based in part on an erstwhile ITT application note.

The input arrangement of thermistor R1 and the associated preset potentiometers, VR1 and VR2, has already been discussed. Three op.amps are used; these may be separate i.c.s but the printed circuit board layout is simplified by using three sections of a quad integrated package IC1.

If the voltage at point *Q* goes lower than that present at the slider (w) of VR1, the output of IC1b goes low and light emitting diode (l.e.d.) D2 (yellow) indicator lights, indicating a bath that is too cold. If the voltage at *Q* goes above that present at the slider of VR2, the output of IC1a goes low and l.e.d. D1 (red) lights, indicating a bath that is too hot.

For input voltages between these limits, both IC1a and IC1b outputs will be high. Diodes D3 and D4 will then switch off and the inverting input (pin 8) to IC1c will be pulled above the 4·5V present on the non-inverting input (pin 9), so lighting l.e.d. D5 (green) to indicate the correct range of bath temperature.

CONSTRUCTION

The Narrow Range Thermometer is assembled on a small printed board which suits the specified quad op.amp i.c. and also the ABS plastic box which can contain a 9V PP3 battery as well. There is no objection, of course, to you designing your own board or using an alternative box.

The topside printed circuit board (p.c.b.) component layout and full size underside copper foil master are shown in Fig. 7. Apart from the l.e.d.s, it is suggested that construction should follow the usual trend, starting with the smallest working up to the largest components. This p.c.b. is available from the *EPE PCB Service*, code 158.

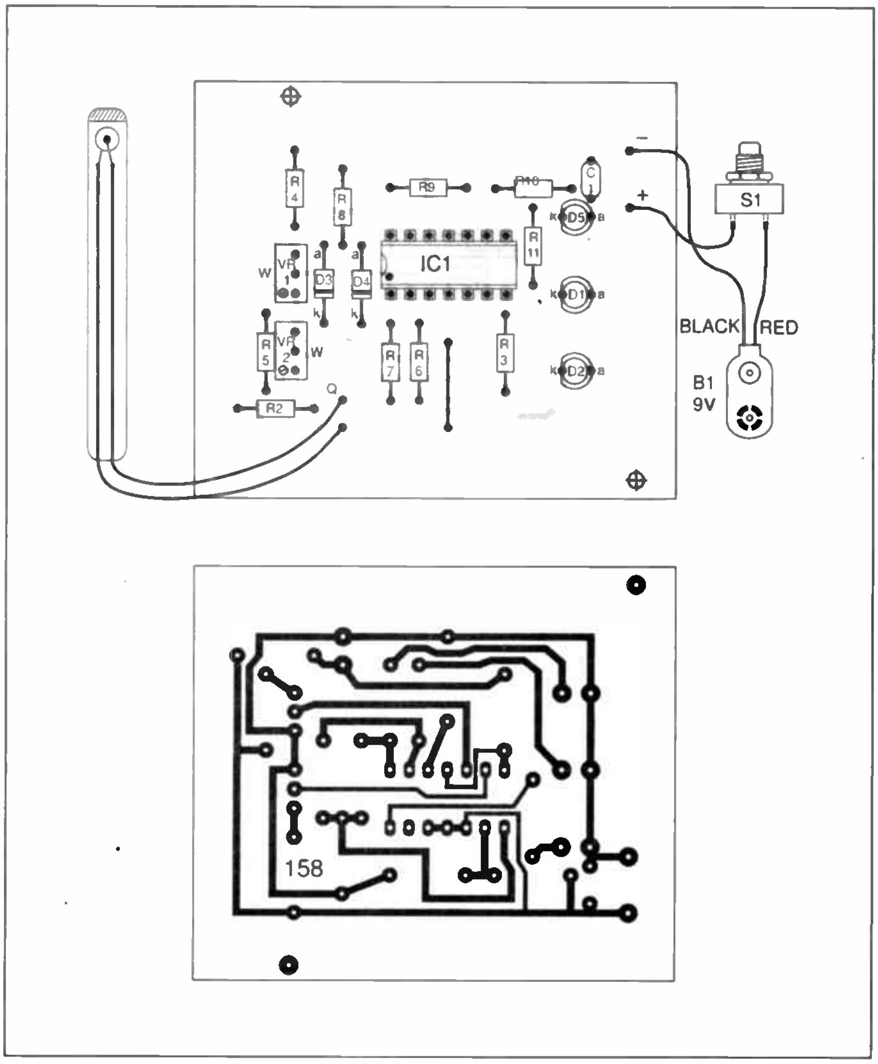


Fig. 7. Thermometer printed circuit board component layout, interwiring and full size copper foil master pattern.

There is little that requires explanation about assembly except possibly the mounting of the three indicator l.e.d.s which (if you use the specified box) have to be positioned at a precise distance above the board surface so that they just stand proud of the box lid when this is fitted. For this reason it is as well to leave the soldering of the l.e.d.s to last.

When you do come to the mounting of these, the lead length above the board surface should be 12mm. If you cut six pieces of 1mm sleeving to the 12mm lengths, they will provide an easy and simple guide to getting the l.e.d. height correct. Fig. 8 shows the arrangement.

The p.c.b will fit snugly into the base of the case and can be secured by four screws (although only two need be used) which self-tap into holes provided. It is best to drill these two fixing holes in the board, as indicated in Fig. 7 and check their positions against the box holes before any of the components are soldered in place.

Take the usual care in soldering and preferably fit small (1mm) solder pins to the battery input points and the thermistor copper pads.

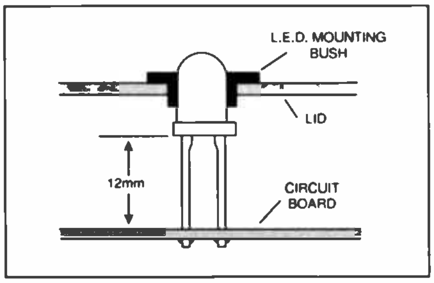


Fig. 8. Method adopted for mounting display l.e.d.s.

CALIBRATION

It is as well to do the calibration of the Thermometer at this stage, rather than wait until the board is fitted into the box. There are several methods by which the calibration may be made and two of these will be covered. The first involves making a good graph (similar to that shown in Fig. 1) by plotting the thermistor resistance against temperature. The method was described under "Characteristics" earlier and need not be repeated here.

The temperature range and spot values given in Table 1 need not be followed; provided the resistance of the thermistor is noted for whatever the particular temperature happens to be, and provided there are about half a dozen such readings, a graph can be drawn, using the largest scale you can to help in its accuracy. Draw the best balanced smooth curve through your points – do not "wobble" from one point to the next or draw straight lines between the points.

This graph then enables you to read off the value of thermistor resistance Rt for *any* given temperature within the overall range.

Method One

The first method of calibration uses the graph and is probably the easiest way of doing things since no further messing about with water baths is necessary. Select first of all the lower and upper temperature limits you require; for illustration we will take these to be 32°C and 36°C.

Read from your graph the thermistor resistance values corresponding to these temperatures; by way of an example, the model values were 7·2kΩ at 32°C and 6·1kΩ at 36°C. Now take either a resistance box (if you have one) or a 10kΩ potentiometer and set it as precisely as you can to the higher of these values i.e. 7·2kΩ in our example.

Before applying power to the board, set VR1 and VR2 fully *clockwise*. Now solder (temporarily) the 7·2kΩ resistor to the thermistor pins on the p.c.b. Connect up the battery and, ignoring the fact that the green l.e.d. will light up at this stage (since both op.amp outputs will be high), adjust VR1 *anticlockwise* until the yellow l.e.d. just lights as the green extinguishes. This determines the lowest temperature point.

With the high temperature resistor (6·1kΩ in our example) now connected to the thermistor pins, adjust VR2 *anticlockwise* until the red l.e.d. just lights. This determines the highest range point and completes the calibration. Remember, the actual limit temperatures are your own choice; after finding their equivalent thermistor resistance value from your graph, proceed in the manner described.

For the stickler after truth, of course, you need not use a graph; for each of your chosen limits immerse the thermistor itself in water at the appropriate temperatures and do the adjustments at each of these as described above.

Method Two

In the second method of calibration the voltage across resistor R2 is measured when the thermistor is in water at a temperature corresponding to the lowest limit, say 32°C. Whatever this voltage happens to be, preset VR1 is adjusted anticlockwise until the voltage measured at pin 6 of the op.amp IC1b has the same value.

When the thermistor water bath temperature is raised to the upper required limit, say 36°C, the voltage across R2 is again noted and this value is established on pin 5 of op.amp IC1a by adjustment anticlockwise of VR2. These measurements must be made with a high impedance digital voltmeter; an analogue instrument will almost certainly be unsuitable.

COMPONENTS

See SHOP TALK Page

Resistors

R1	10k @ 25°C min. disc n.t.c. thermistor
R2	10k
R3	2k2
R4, R5	1k (2 off)
R6, R7, R11	330Ω (3 off)
R8	910k
R9, R10	470k (2 off)

All 0·25W 5% metal film or better

Capacitors

C1	100n polyester, 63V

Potentiometers

VR1, VR2	100k multiturn top-adjust preset (2 off)

Semiconductors

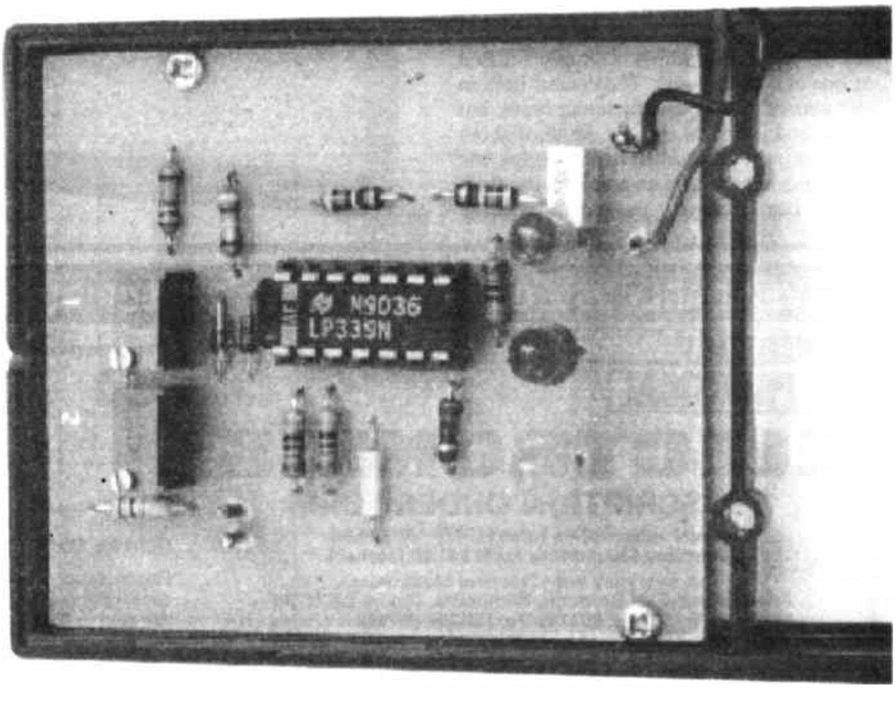
D1, D2, D3	5mm l.e.d.s, red, yellow, green respectively
D3, D4	1N4148 signal diode (2 off)
IC1	LP339N or LM339N quad op.amp voltage comparator (14-pin d.i.l.)

Miscellaneous

S1	miniature s.p. push-to-make switch

Printed circuit board available from *EPE PCB Service*, code 158; handheld plastic case (with battery compartment), size 105mm x 61mm x 28mm; PP3 battery snaps; 14-pin d.i.l socket; l.e.d mounting holder (3 off); 1mm solder pins (4 off); old ball-point pen case for probe; flexible connecting wire; solder, etc.

Approx Cost Guidance Only £14



Layout of components on the prototype p.c.b. The "grey" resistor-like component in the foreground has been replaced with a link in the final version.

Arrangement of the display l.e.d.s in the lid.

CASE PREPERATION

Back to construction. The box comes in two parts, base and lid. The base contains the p.c.b and battery, the lid acting as the display part for the l.e.d. indicators.

The lid has to be drilled for the display l.e.d.s and a pushbutton on-off switch, and the general layout is shown in the photographs. The l.e.d. holes are 6·4mm (¼in) diameter and are about 10mm apart (starting 20mm from one lid edge), each adorned with part of the mounting bush supplied for l.e.d.s; this keeps things tidy looking in the event of any of the drilled holes being a bit ragged. You may wish to leave the drilling until the board is in position in the box, taking your own measurements from that.

Only two pairs of interwiring leads are required; one for the battery and one for the thermistor probe, see Fig. 7.

THERMISTOR PROBE

So far for testing and calibration purposes we have simply used the thermistor disc on the end of a short length of flexible wire. This is a bit basic for the finished job, but nothing particularly sophisticated is required if the liquid being measured is water.

A short length, say, 150mm (6in.) of insulating tube, which may be the barrel of an old ball point pen, will do as a holder for the thermistor which is simply situated at one end of the tube. The central hole in this sort of tube is usually about 6mm, but if one end is drilled out to a depth of about 6mm or so with a ¼in. drill, leaving the wall thickness as thin as possible, the thermistor can be snugly pushed in, with its leads (extended as necessary) brought out through the original end bung of the pen as Fig. 9 shows.

For liquids other than water it is best to insulate the thermistor disc from contact, not only from the point of view of possible corrosion, but the liquid itself may be a good enough conductor to upset the resistance characteristic of the thermistor. It is therefore necessary to block off the thermistor end of the tube in some way; the bung from the tube of a second pen will do if it is carefully glued to the open end.

Before doing something of this kind, fill the enlarged end with heatsink compound to improve the heat conduction. A relatively simple method is to close the tube end with a small amount of mixed epoxy resin; if the tube is held upright, a small dome-shaped end-piece can be formed over the thermistor, which, when allowed to dry and set, gives a suitable protection.

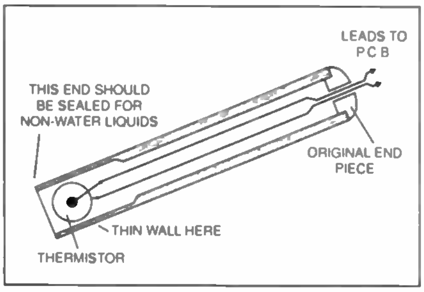
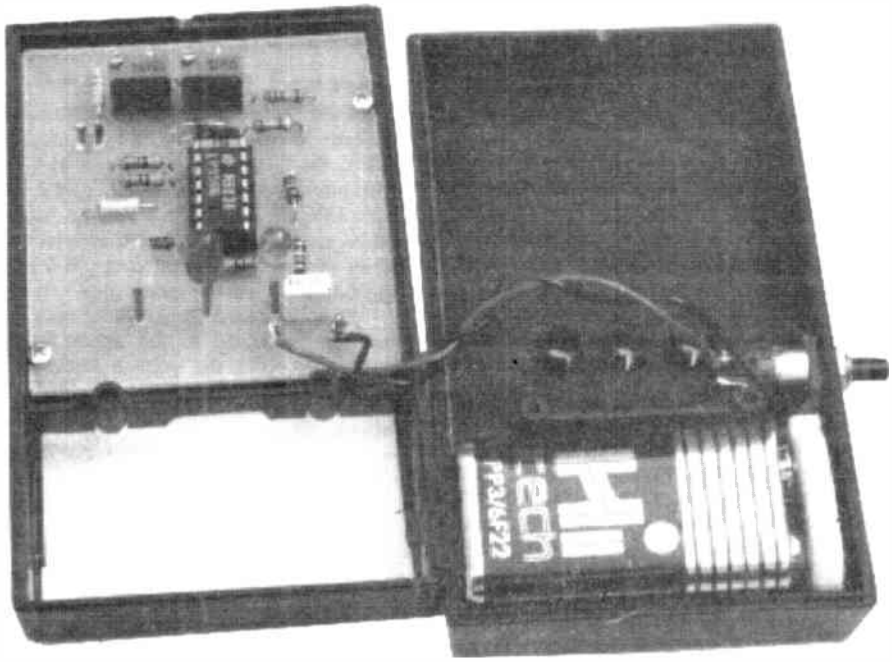


Fig. 9. Construction details for the probe.

Whenever the thermistor is closed-up in this way, the response to temperature change will be retarded, so the necessity of a thin walled tube at the thermistor end must be emphasised. The only problem with old pen tubes is the brittleness of the plastic used and care is needed in the drilling. For this reason it is better if you can get hold of a short length of polystyrene tube (or rod) and design yourself a suitable probe.

The probe may be permanently connected to the box or it may be pluggable. For the first option, a small nick made with a round file in the lid, as seen in the photographs, is used as the exit point for the probe leads. The cutout should be small enough to clamp the wires firmly when the lid and base of the box are brought together.

For a pluggable probe a couple of 1mm sockets in the end wall of the lid can connect to 1mm plugs on the ends of the probe wires. The position of these sockets is best left to the constructor, but make sure that they do not foul the p.c.b. or any of the components on the board at that end of the box.



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3a

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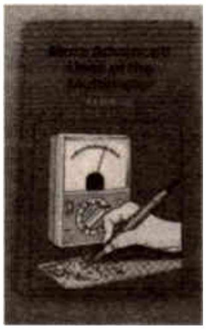

This book is primarily intended as a follow-up to BP239, (see below), and should also be of value to anyone who already understands the basics of voltage testing and simple component testing. By using the techniques described in Chapter 1 you can test and analyse the performance of a range of components with just a multimeter (plus a very few inexpensive components in some cases). Some useful quick check methods are also covered.

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IF NO PRICE IS SHOWN THE BOOK IS OUT OF PRINT (O.O.P.)

SEE PREVIOUS PAGE FOR FULL ORDERING DETAILS

PCB SERVICE

Printed circuit boards for certain EPE constructional projects are available from the PCB Service, see list. These are fabricated in glass fibre, and are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £1 per board for airmail outside of Europe. Remittances should be sent to **The PCB Service, *Everyday Practical Electronics*, Allen House, East Borough, Wimborne, Dorset BH21 1PF. Tel: 01202 881749; Fax 01202 841692 (NOTE, we cannot reply to orders or queries by Fax); E-mail: editorial@epemag.wimborne.co.uk**. Cheques should be crossed and made payable to *Everyday Practical Electronics* **(Payment in £ sterling only).**

NOTE: While 95% of our boards are held in stock and are dispatched within seven days of receipt of order, please allow a maximum of 28 days for delivery – overseas readers allow extra if ordered by surface mail.

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Mains Signalling Unit, Transmitter and Receiver		970/971 (pr)	£9.09
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– Main Board		118	£7.33
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– Step-Up Regulator		124	£6.12
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(double-sided p.t.h.)		121	£22.00
* PIC Digital/Analogue Tachometer		127	£7.23
Stereo Cassette Recorder			
Playback/PSU		128	£7.94
Record/Erase		129	£9.04
* Earth Resistivity Meter	JAN'97		
Current Gen. – Amp/Rect.		131/132 (pr)	£12.70
Theremin MIDI/CV Interface (double-sided p.t.h.)		130 (set)	£40.00
Mains Failure Warning		126	£6.77
Theremin MIDI/CV Interface	FEB'97		
(double-sided p.t.h.)		130 (set)	£40.00
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* PIC-Agoras	APRIL'97	141	£6.90
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EPE SOFTWARE

Software programs for the *EPE* projects marked above with an asterisk (*) are available altogether on a *single* 3.5 inch PC-compatible disk, or as needed via our Internet site. The same disk also contains the following additional software: Simple PIC16C84 Programmer (Feb '96), PIC Disassembler (unpublished).
The disk (order as "PIC-disk") is available from the *EPE PCB Service* at £2.75 (UK) to cover our admin costs (the software itself is *free*). Overseas £3.35 surface mail, £4.35 airmail. Alternatively, the files can be downloaded *free* from our Internet FTP site: **ftp://ftp.epemag.wimborne.co.uk.**

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SURFING THE INTERNET

NET WORK

ALAN WINSTANLEY

Building

EPE Net Work is our monthly column specially written for electronics enthusiasts with Internet access. Regular web users who visit our site – **http://www.epemag. wimborne.co.uk** – will know that we are gradually building up a series of on-line resources to help *EPE* readers and electronics enthusiasts generally. The *EPE* Basic Soldering Guide now has a colour photo gallery on-line, showing you step by step, how to make a solder joint. Look forward to more on-line resources on a variety of topics and FAQs (Frequently Asked Questions).

Fans of Andy Flind's *Simple Dual Output TENS Unit* (March '97 issue) will know of our specially-written page offering guidance for TENS users, available on our web site (**../aecctens.htm**) prepared in conjunction with the Anglo-European College of Chiropractic in Bournemouth, England. The College has now opened its own web site (**http://www. aecclib.demon.co.uk**) to which – as promised – you can now link from our TENS Page.

New EPE PIC Mirror Site

As soon as a new PIC project is launched, the code is there on our FTP site, ready for free download (**ftp:// ftp.epemag.wimborne.co.uk/pub/PICS**) where it will stay in a subdirectory for the foreseeable future. We've now improved access even more, by announcing a new *EPE* PIC Project UK Mirror Site which is maintained by Gareth Downes-Powell of MEC Systems, a company supplying PIC16C84 chips and PIC development boards. The URL of the new PIC Mirror site is **http://ds.dial.pipex.com/mecsystems/epe/epemain.htm** – drop in at Gareth's enthusiastic PIC Infosite!

Web by E-Mail

Generally much hyped and talked about, the World Wide Web (WWW) is a way in which graphical information is conveyed over the Internet and displayed on your screen in an appealing and attractive way. The language of the "web" – HTML (Hypertext Mark-Up Language) was originally created at CERN – the European Particle Physics Laboratory based in Switzerland, intended just to enable complex technical information to be readily shared amongst colleagues using a computer network. However, HTML and the web has exploded in popularity and versatility in the past two years.

In order to view a web page on your computer, a browser program such as Netscape Navigator or Microsoft Internet Explorer is needed on your machine; simply enter the address (URL) of the web site you'd like to visit with your browser. It will then fetch the page, translate the HTML mark-up "tags" and format the page on your screen.

This is great if you have reasonable bandwidth available. If, however, you only have limited E-mail access rather than a fully-fledged Internet account, it is still possible to retrieve web documents in a limited form using just your E-mail account. Then either read the page in straight ASCII mode or view it in a local browser – off-line, without being connected to the Internet. Thanks to reader Michael Clarke who offers us the following pointer.

WebMail is a mail-based server machine in Ireland specifically set up to provide E-mail users with access to HTML documents. To request a web document in this way, you should send a one-line E-mail message (with no subject) to the following address: **webmail@www.ucc.ie.** In the body of the text, write the following:

GO url

where **url** is the full URL (**http:// etc.**) of the target document you wish to retrieve.

The WebMail server will mail you back with the raw HTML file: cut and paste, then view the file in a web browser on your machine, if available (though graphics will not be displayed). Additionally, you will receive a UUencoded plain-text version of the web page, stripped of the mark-up and viewable as a plain text document once you have UUdecoded it. Thus you can obtain a textual, human-readable version of a web page. If you want a help file on WebMail, simply type HELP in the message of your E-mail instead.

It's very important to note that this is a free service which should not be routinely used if you already have access to the WWW via your browser: you swallow resources which are badly needed by those who depend on the service for fetching web pages by E-mail. So if you don't need it, don't hog it for others. If you wish to try it, send a message **GO http://www.epemag.wimborne.co.uk/whatsahd.htm** and you will receive our Web Home Page information of "What's Ahead on the *EPE* Web Site". I chose this page because it's quite small (in length, not ideas.).

Hot Links

Onwards to this month's selection of hot links for electronics enthusiasts. Remember that these are already enabled on the Net Work page of the *EPE* web site. Last month I described a cure for a security flaw in MS Explorer: a cunning scam in which cash can be transferred to a third party if you happen to have a certain accounts package installed on your hard disk.

Navigator 2.0 and 3.0 users should note that if you access a Shockwave-enabled site using an MS Windows-based version of Navigator, Shockwave can be utilised adversely to upload your Netscape Mail directory to another party, without your knowledge. Try **http://www.webcomics.com/shockwave/ mail.html** for a "safe" demonstration. Upgrading to Netscape version 4.0 is said to be a cure, if you're worried.

Sagebrush Systems produce a great Theremin Simulator for Windows, where your PC mouse can control pitch and volume, so you can play in a Theremin-like way, including vibrato! A 30-day demo shareware (American) version of Sagebrush MouSing V2 is at **http://www.sagebrush.com/~sells/** (205K). Also they have demos for a Wind Chimes program, Wave Sounds and Applaud – which lets you launch programs by clapping. Needs a microphone and sound card, and might be of interest to disabled users. A super little site with some fascinating programs on sale.

Cybercircuit is an encyclopaedia of electronic circuits and formulae, in the form of an archive of published data sheets and US magazine articles. Fetch a demo from **http://members. aol.com/cybercir/index.html**. Ahmet Onat has a Home Page of electronics, robotics, R/C servo drivers and circuits, desoldering advice and more besides, at Kyoto University, Japan: **http://turbine.kuee.kyoto-u.ac.jp/staff/onat.html**.

A new kind of microcontroller simulator (it says here) for the PIC, HC11, HC705, 8031 or ST62XX for Windows users has arrived in the form of *UMPS*, which can also simulate I^2C, peripherals, l.c.d. panels etc., as described on **http://idls.izarbel.tm.fr/entp/techer/P01.HTM** from where a demo is available (note the upper case filename). Finally, a US firm called EIO has some technical forums available for exchanging information on a variety of advanced topics, including lasers and CCDs. Have a look at **http://www.eio.com/frumindx.htm.**

More *Net Work* information for electronics users next month. My E-mail address is **alan@epemag.demon.co.uk.** My Home Page is (still!) **http://ourworld.compuserve.com/homepages/ alan_winstanley.**

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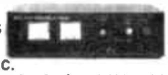

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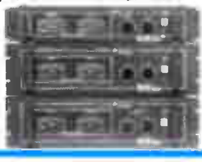

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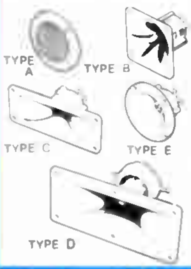

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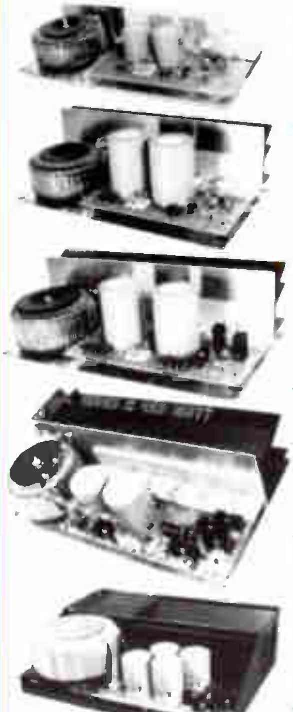

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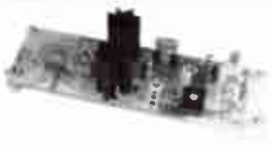

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