ISSN. 0142-7229

electronics today

INTERNATIONAL
OCTOBER 1981 65p

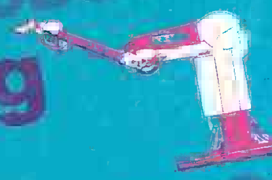
HIGH QUALITY, LOW COST, DIY SPEAKER

Build your own domestic monitor for a fraction of the price!

PLUS

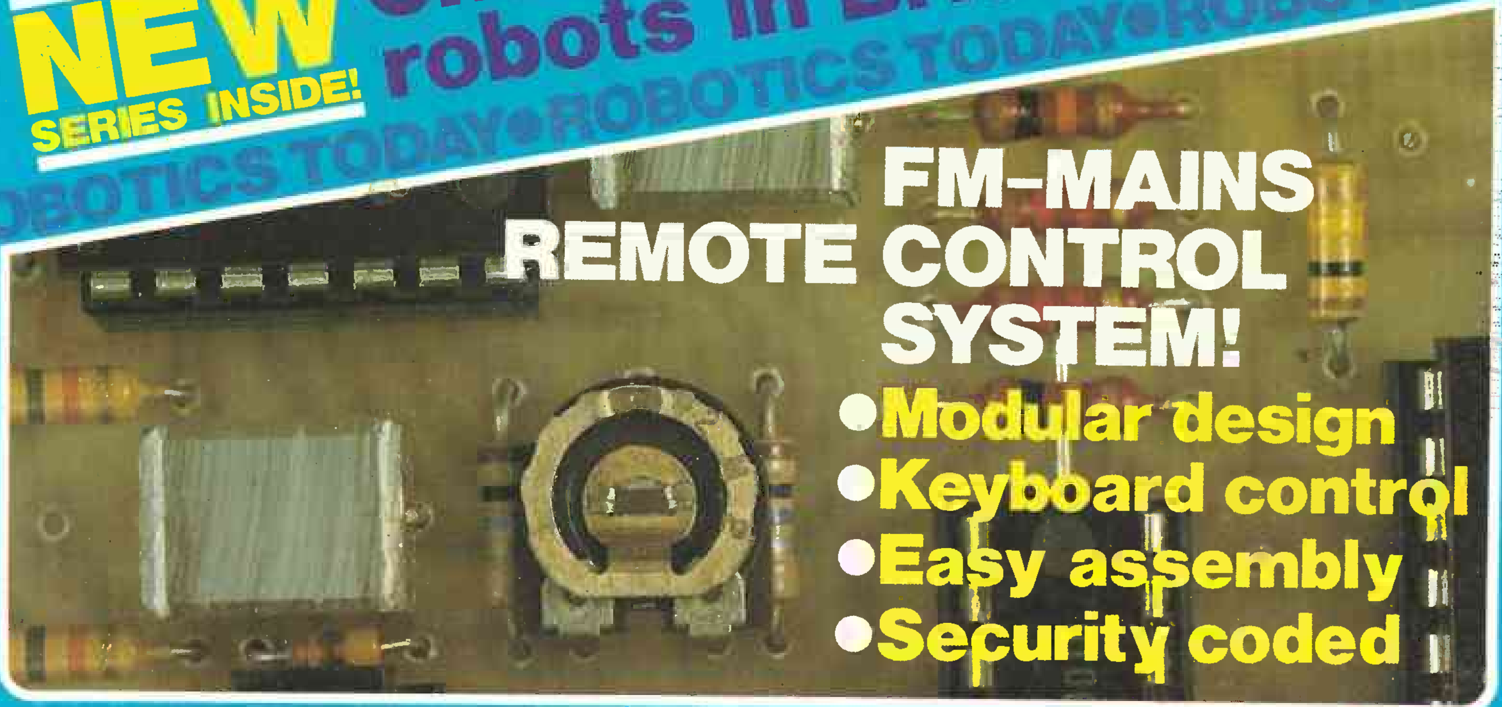
- ★ Engineer's Guide to BASIC
- ★ Laser Testing For Hi-Fi
- ★ Ring Modulator For Voice Effects

ROBOTICS TODAY • ROBOTICS TODAY • ROBOTICS



NEW SERIES INSIDE! Choosing and using robots in Britain

ROBOTICS TODAY • ROBOTICS TODAY • ROBOTICS



FM-MAINS REMOTE CONTROL SYSTEM!

- Modular design
- Keyboard control
- Easy assembly
- Security coded

. . .NEWS. . . .PROJECTS. . . .MICROPROCESSORS. . . .AUDIO.

This results in a plot having the same width from top to bottom (the width of the central slice through the speaker) instead of the circular representation of SCALP. Each separate curve now represents the behaviour of this slice at a different frequency. FRESP gives a complete resonant history of vibration of the cone slice between any two frequency limits, the curves being plotted in 3-D and with added horizontal and vertical perspective to aid visibility.

The Plot Thickens

FRESP may also be plotted in a different manner; instead of each curve being a slice across the middle of the speaker for a single frequency, the axes are both turned through 90°. Each curve is then a complete frequency sweep at a single point on a line across the middle of the speaker; each curve represents the behaviour of the cone at all frequencies, albeit at slightly different points across the width. This change in vision angle can often allow faults to be more clearly seen which could have been hidden behind other features in the normal FRESP.

Furthermore, both FRESP and SCALP can easily be drawn with the phase of the display changed. Peaks in the original display become troughs and vice versa, especially useful where the true depth of very deep 'holes' are masked by the 'foreground' of the plot, as in the 'BAD' example of Fig. 1. The out-of-phase plots along the bottom of Fig. 1 show how this reversal makes holes into peaks and allows their true 'depth' in relation to the rest of the curve to be judged. A powerful tool, then, and one which will keep Wharfedale at the forefront of loudspeaker design.

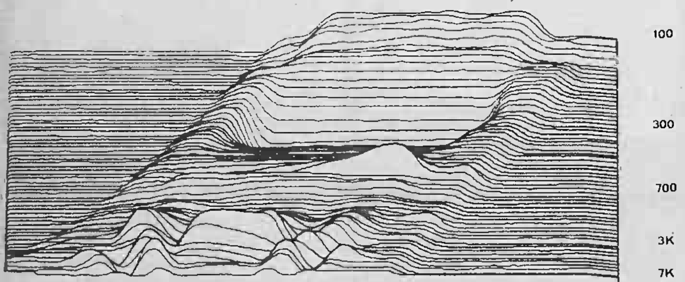


Fig. 2 This FRESP plot pinpoints regions which may benefit from a more detailed SCALP analysis. For example, the odd hump at about 500 Hz is probably worth investigating.

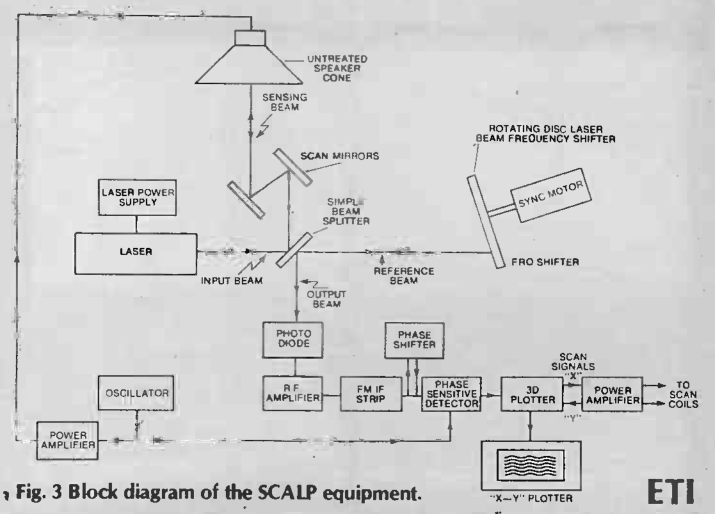
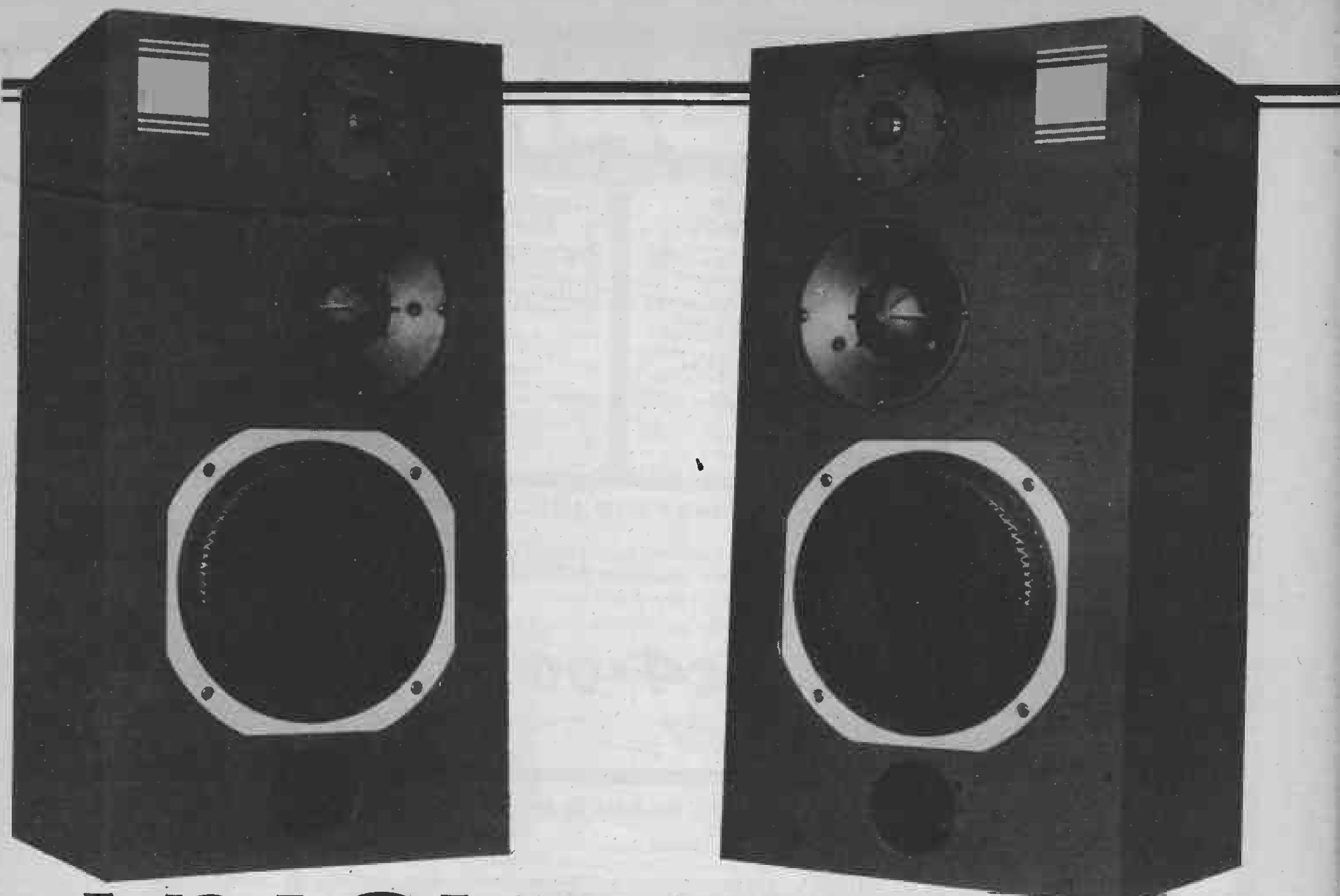


Fig. 3 Block diagram of the SCALP equipment.

ETI



V3 LOUDSPEAKER

As always, ETI delivers the best in DIY hi-fi. These high quality, high power speakers will make your music sound good and your living room look good. Design and development by David Lyth.

The V3 loudspeaker system is a three unit design using a Volt 8" bass driver and a Philips dome midrange and tweeter; crossover points are 700 Hz and 5 kHz. A reflex enclosure is employed, constructed from 19 mm high-density chipboard with the units mounted in a mirror image configuration. A grille baffle is not necessary for other than aesthetic reasons because the driver units incorporate either a grille or similar structure protecting the 'software'. However, extensive research has revealed that small fingers can get at the midrange dome which will result in a recessive sound balance. Beware!

The V3 is a medium efficiency system with a wide frequency response and is capable of high power handling, especially in the bass. Distortion and colouration are very low and the smooth response gives good tolerance of aggressive or edgy material.

The cabinet uses high-density chipboard 19 mm thick and is simple to construct, with panels coming economically from standard sheet sizes. All the drive units are rebated and some care is necessary to get a good fit, although plywood could be used for the front panel to make this task easier.

Reflex Action

Reflex enclosures have been the subject of much controversy in the past because some designs work well and some are appallingly bad. The problem lies in the design itself and the approach taken here is to use tables generated by A. N. Thiele, an Australian. Thiele likened the combination of bass unit and enclosure to an electrical filter and used synthesis techniques from this field to build up tables enabling the designer to choose a cabinet to suit a particular drive unit. Knowledge of various drive unit parameters is necessary — for example, Q_T, V_{AS}, F_S. The system response options are those shown by Butterworth or Chebyshev high pass filters — Fig. 3 shows some characteristics.

However, the Thiele alignments are not the final solution to the design problem. The responses available (with the exception of the QB3) are flat down to the −2 dB point (give or take a ripple) and a correctly aligned system would show this response under free field or anechoic conditions. But who sits around listening to ideal electrical filters hanging 30 m above a field? Your private life is none of my concern, but I have found that when a pair of loudspeakers are listened to in an average sized room the bass response can sound unbalanced. This is because they are not 'looking' into omnidirectional space but seeing rather less than this depending on the wavelength of the sound reproduced and system-room positioning. There is a dramatic difference between the bass response of a system held in the middle of a room and that when placed in a corner. This is similar to the variation when going from true free field conditions to a listening room, and it is necessary to modify the 'correct' response to compensate for the bass

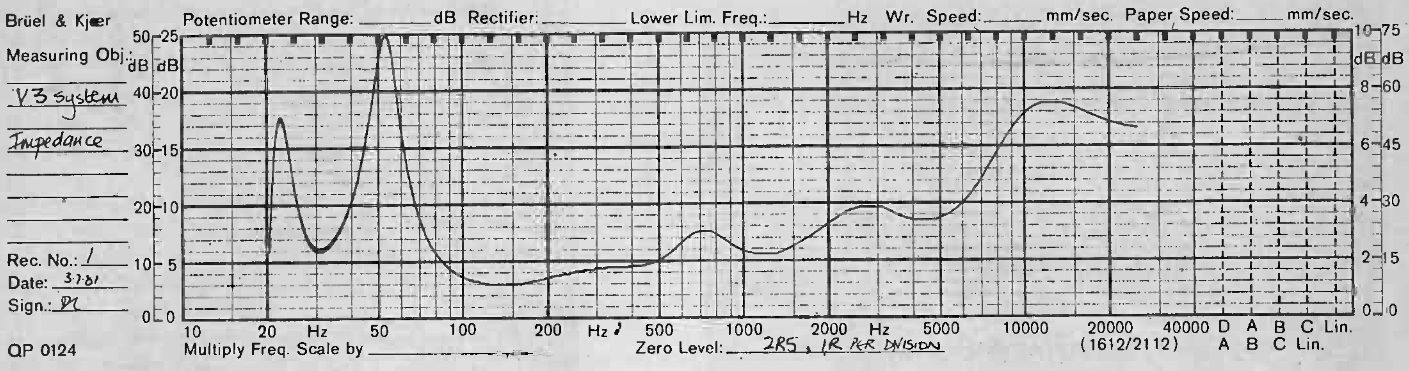


Fig. 1 Impedance curve for the V3 Loudspeaker.

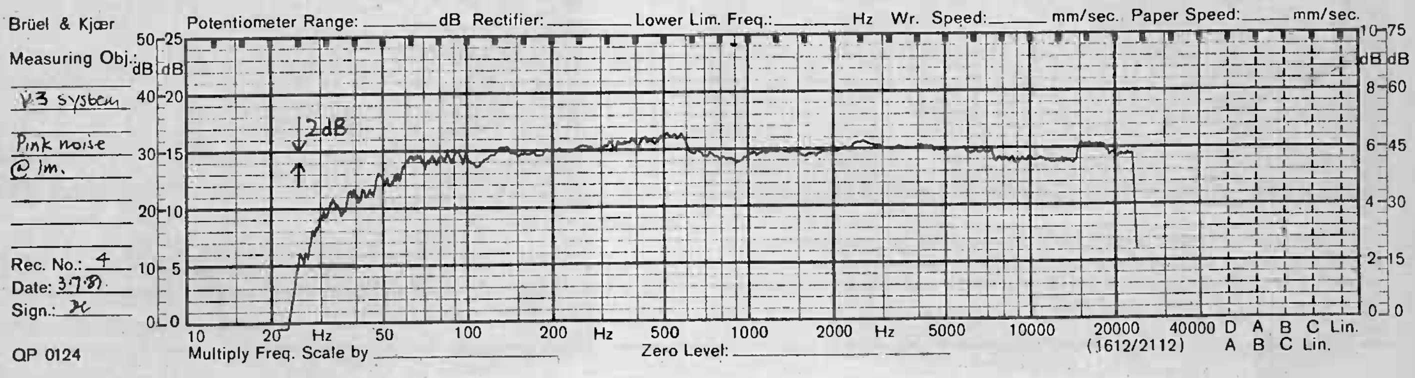


Fig. 2 Frequency response of the V3.

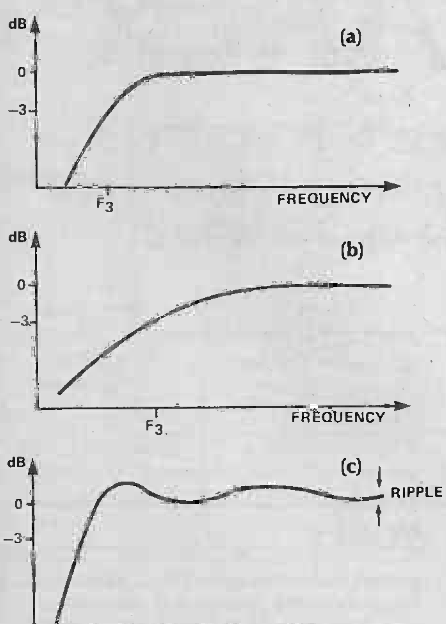


Fig. 3 Butterworth B4 response (a); Quasi-Butterworth response (b); Chebyshev C4 response (c).

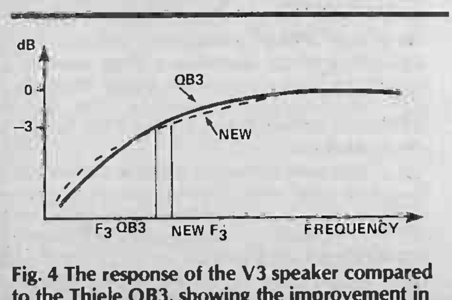


Fig. 4 The response of the V3 speaker compared to the Thiele QB3, showing the improvement in the bass.

boost provided by the room so that very deep bass is maintained but overemphasis of middle and upper bass is avoided.

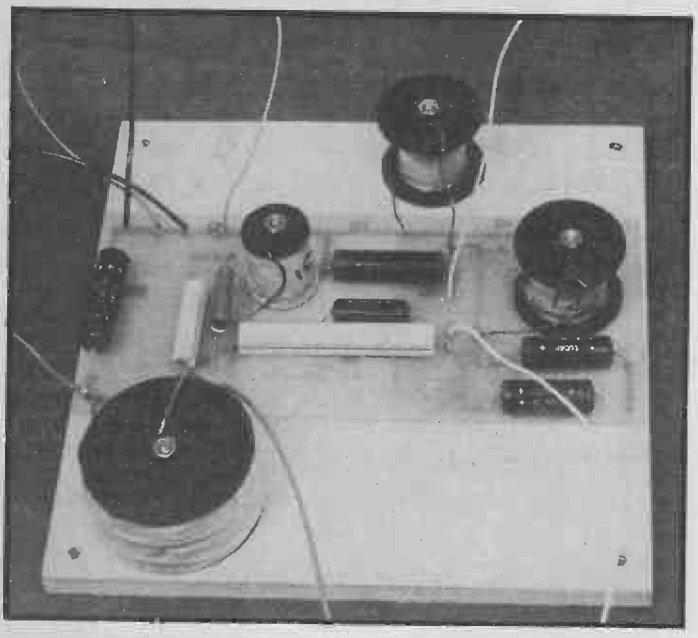
This means that we want a flat response in the room and not in free field conditions. The Thiele alignment that most closely approaches our desired free field response is the QB3. Initial work showed that a fairly small cabinet (volume about 29 litres) produced good results but there was still an overemphasis of middle bass in an average sized room. Enlarging the cabinet by 30% and reducing the reflex tuning frequency to 30 Hz gave a dramatic improvement, the bass output sounding even and with an excellent lower octave. In a way the obvious has occurred ie "a good big 'un will always beat a good little 'un". Excellent transient response is maintained and this is fundamentally due to the large magnet fitted to the B220 bass unit. Nevertheless the Thiele approach was an excellent starting point for the design. Figure 4 shows the effective improvement in the bass response. The system was always used on stands 250 mm high with free space underneath, placed with its back against a wall and kept out of corners.

Middle And Upper Class

A midrange dome was selected because domes have a fundamental advantage over coned units of the same size — their break up modes occur at higher frequencies. As the alternative to a 50 mm dome would have been a 75 mm cone unit, this means that the dome will operate with more diaphragm control to a rather higher frequency. The tweeter has a soft dome as opposed to the midrange's pulp dome, and incorporates a diffuser.

The midrange and tweeter have very smooth responses with low colouration and distortion. These two units are offset from the centre of the cabinet so that the pair are mirror imaged on the two speakers. This improves stereo imaging, mainly by reducing edge diffraction which is a major cause of poor stereo.

The worst case for diffraction is when the tweeter, for example, is mounted equidistant from the three nearest cabinet edges. Re-radiation will then take place at the same frequency for each edge and this will cause a discontinuity in the frequency response. By offsetting the unit the diffraction is smeared and reduced to insignificant levels. Elimination of the grille also helps because there is no grille baffle standing proud of the cabinet to present an obstacle to the surface sound wave, thus worsening diffraction. The only real argument for a grille is aesthetic and then a foam grille is the best solution.



After the components have been soldered to the PCB, the crossover board is secured to a plywood panel using the choke fixing bolts. To get the choke connecting leads the right length, you'll have to cut access holes beneath the PCB pads so you can solder the wires last.

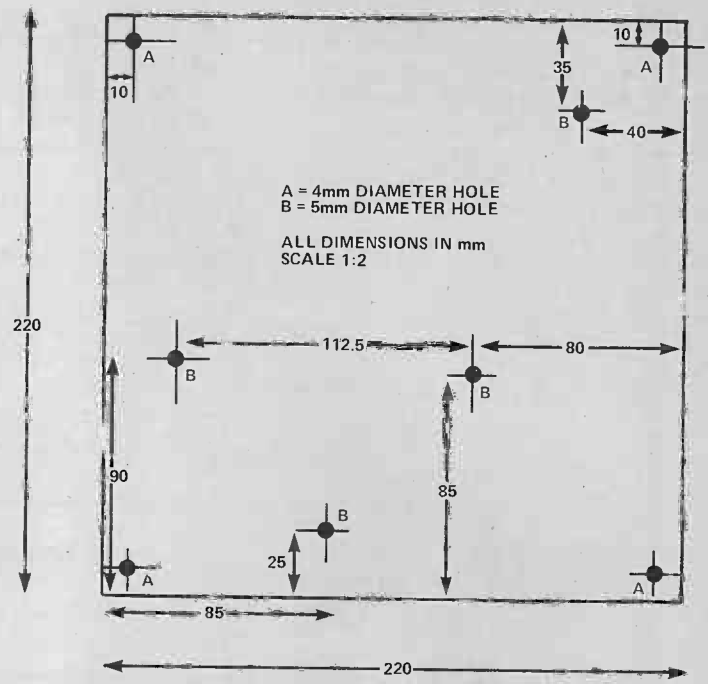


Fig. 5 This diagram shows the drilling positions for the choke and mounting screwholes on the crossover panel.

The Crossover

This uses air cored chokes exclusively because these have a better ability to pass transients than ferrite cored chokes, which can momentarily saturate on high power peaks. The chokes are well spaced to prevent any flux linkage between them. There are two 40uF capacitors feeding the midrange so that their combined voltage rating is great enough to prevent possible failure under high power drive.

The crossover is constructed on a PCB which is attached to a wooden crossover board by clamping it beneath the chokes which are bolted through with brass screws. The wire used should have a 6 A rating.

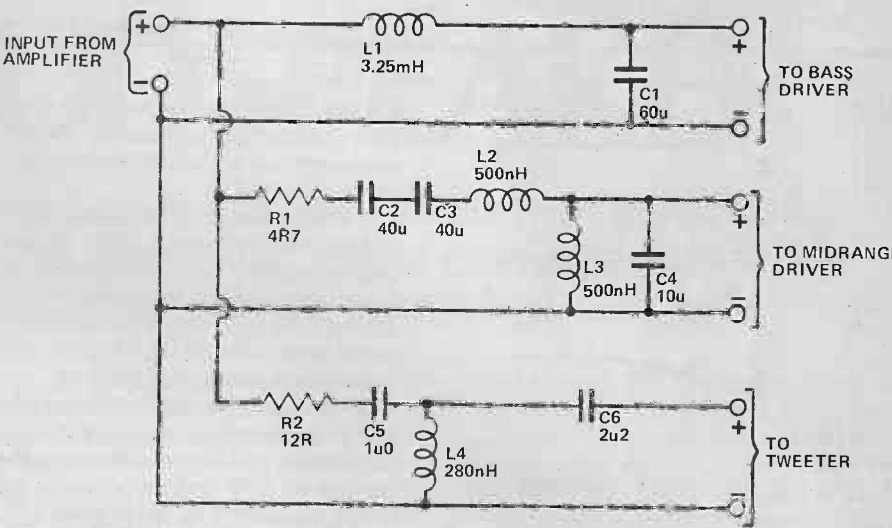


Fig. 6 Circuit diagram of the crossover

Listening Tests

During the design of the V3 there were constant trips made between listening rooms and the test equipment in order to make modifications to the crossover or cabinet. Comparisons were made with the Yamaha NS1000M, Gale GS401A, KEF 105 II and Popular Hi-fi Boxers: each of these systems had particular strong points and it was a design aim to approach the low colouration and discrimination of these designs. Listening was done with material ranging from choral works through to heavy rock. The cabinets were set so that the dome units were on the inside of the pair. A front grille was never used and connection was by screened twin lead with the screen connected to the inner core, thus

HOW IT WORKS

The crossover uses second order filters throughout, except for the high pass tweeter section which is third order. The values diverge from those of the text book because the load presented by the drivers is not a constant resistance. Apart from the impedance rise at resonance for the midrange, all units exhibit a rising impedance characteristic over their possible operational range because of the voice coil inductance. This is compensated for in the low pass section feeding the bass driver by using a larger shunt capacitor than calculations show.

The band pass filter used for the midrange also includes a little response shaping in its function. The midrange unit has an impedance rise at its resonant frequency (which lies one octave below the crossover point) and to control this the shunt choke of 0.5mH is appreciably smaller than calculated. This is because the normally rising impedance characteristic of a high pass filter below the crossover point prevents amplifier damping from controlling a resonance in this area — this is the case with the Philips unit. By using the lowest possible value choke next to the unit that did not upset frequency response or drop overall system impedance it is possible to give the unit a degree of damping by simulating a low impedance drive around resonance. The net result is better control and increased power handling. This consideration dictated the choice of the lower crossover point.

The upper crossover point is chosen to match the radiation characteristics of the units as closely as possible and to provide the best integration. The tweeter is also attenuated to match levels.

making twin flex. If there is a magic in speaker cables, apart from common sense, then the greater surface area of the screen should reduce skin effect, the only thing that would have a deleterious effect on the electrical transmission — 13 A twin cable would probably do just as well, however.

Ancillary equipment tried varied from moving coil cartridges to moving magnets with either valve or a high-powered transistor amplifier. The end result justifies the time and effort and the V3 stands very favourable comparison with systems costing £400 upwards per pair.

Cabinet Making

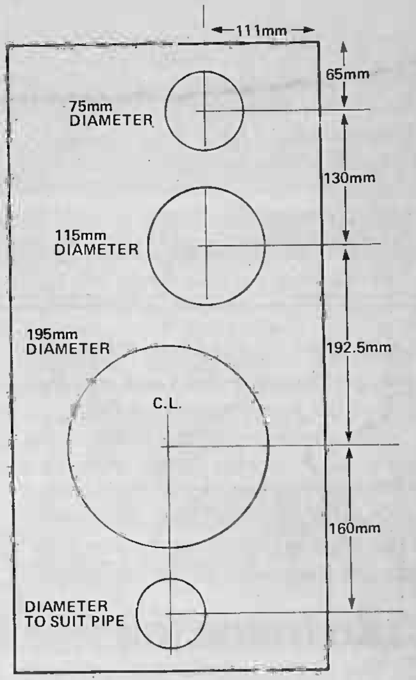
You will need the following: 24 + 1½" x No. 8 self-tapping screws and screw sink No. 8 — 1" long; flexible Plastic Padding, sandpapers, electric drill, jig saw, chisels, 7/32" drill bit, and wood glue. Butt joints are used throughout — providing reasonable care is taken this will provide a satisfactory cabinet. Rebates or internal battens are only necessary where high strength is required, which is not the case with a domestic system.

Internal battens, or a least small blocks, may be useful in helping to locate the side panels.

An important consideration when cutting the panels is to allow the edge of a panel to stand slightly proud (0.5 mm) of the mating panel surface when assembled so that the step produced can be sanded back — at the very least this should be toleranced for.

When it comes to rebating the unit the best plan is to cut the basic mounting hole and rest a unit in this. Draw round the outside edge and rebate to suit the flange thickness — it is not necessary to allow for any gasket thickness. It is more pleasing to the eye if the unit stands slightly proud rather than sub-flush.

The midrange and tweeter are secured by No. 6 x 19 mm pan head self-tapping screws. The bass unit is heavier and requires 2BA x 1" screws



FRONT PANEL (RHS SPEAKER) SHOWING BASIC CUTOUTS FOR UNITS.
PLASTIC PIPE IS 65mm INTERNAL DIAMETER AND 180mm LONG.
CUTOUT ON REAR PANEL FOR TERMINALS IS 30mm x 12mm.
BAF SIZE IS 1 SQUARE METER x 25mm THICK.
SCREWS SHOULD NOT BE MORE THAN 150mm APART.

Fig. 8 Template for the front baffle. The dimensions are important, so cut carefully!

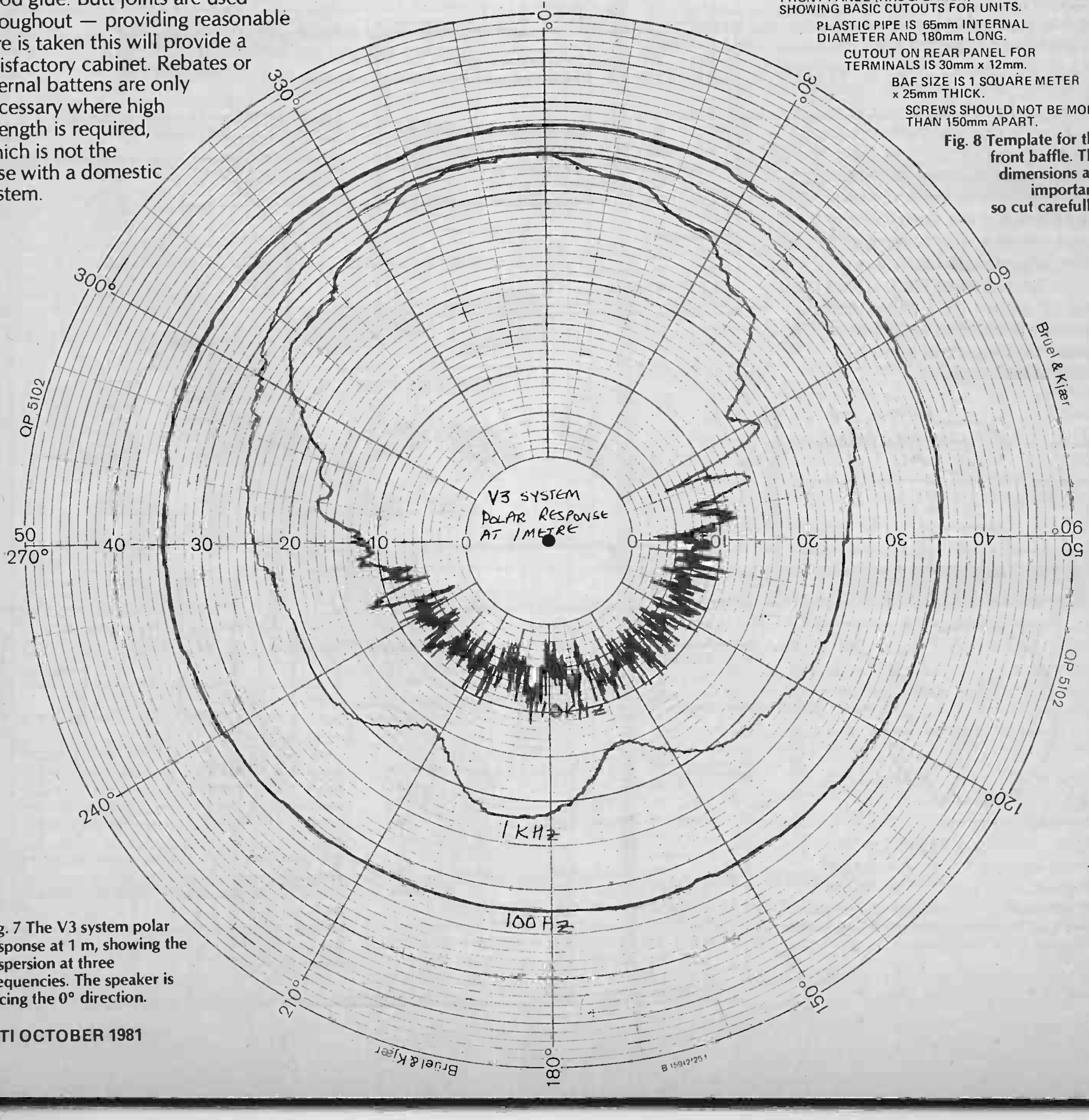


Fig. 7 The V3 system polar response at 1 m, showing the dispersion at three frequencies. The speaker is facing the 0° direction.

TECHNICAL SPECIFICATION

Frequency Range	30 - 20,000 Hz
Frequency Response	60 - 20,000 Hz ± 3 dB
Impedance	8R
Amplifier Requirement	25 W - 150 W
Efficiency	1 W for 82 dB at 1 m
Reflex Tuning	30 Hz
Crossover Frequencies	700 Hz and 5 kHz
Size	600 mm x 300 mm x 300 mm

WOOD CUTTING LIST

2 off 600 mm x 300 mm for front and back
2 off 262 mm x 300 mm for top and bottom
2 off 262 mm x 562 mm for sides
1 off 220 mm x 220 mm for crossover board
All panels are 19 mm high-density chipboard except for the crossover board, which is 12 mm plywood.

with T-nuts — use the 7/32" drill for these and hammer the T-nut into the back of the panel so it seats flat.

The mounting of the plastic tube is easy enough — you simply glue it into the hole at the bottom of the baffle, leaving the inner end free. The length of this pipe is critical, as it tunes the resonant frequency of the enclosure.

An Inside Job

The electrical assembly is straightforward. The completed PCB is bolted to a wooden board which is then glued and screwed onto the back panel of the cabinet — here it will give some extra panel damping. The BAF wadding is distributed about the cabinet such that the vent end is not obstructed and all surfaces other than the front panel are covered. Enough BAF is specified to allow for some to be positioned in the centre of the cabinet where it is at its most effective for stopping standing waves.

Ensure that leads to the drive units do not sit against the cabinet walls or drive units where they might buzz. Air leaks are definitely not allowed.

Good listening!

BUYLINES

A kit of parts comprising all the drive units, all the crossover components including the PCB, BAF wadding, T-nuts and 2BA screws, terminal panel and gaskets is available from Volt Loudspeakers Ltd, 88-90 Grays Inn Road, London WC1X 8AA. The cost of a set of parts for one pair of V3 speakers is £189.75 including VAT and carriage. Note that the woodwork is not included in the kit, although Volt can provide this too for an extra charge. Contact them for details.

PARTS LIST

Resistors

R1	4R7 10%, 17 W wirewound
R2	12R 5%, 7 W wirewound

Capacitors

C1	60u 50 V non-polarised electrolytic
C2,3	40u 50 V non-polarised electrolytic
C4	10u 50 V non-polarised electrolytic
C5	1u0 polyester
C6	2u2 50 V non-polarised electrolytic

Inductors

L1	3.25mH (No. 17)
L2,3	0.5mH (No. 12)
L4	0.28mH (No. 15)

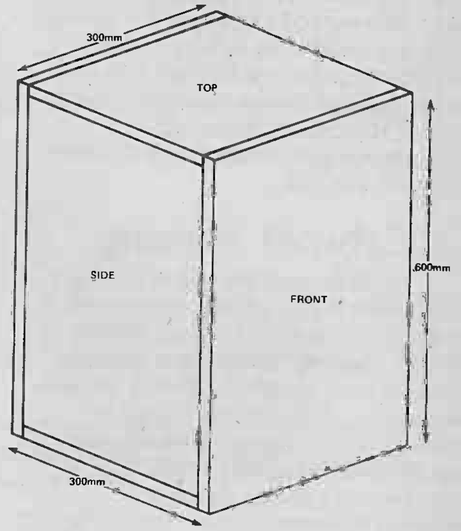


Fig. 10 This is how the panels fit together — if you did your sawing right!

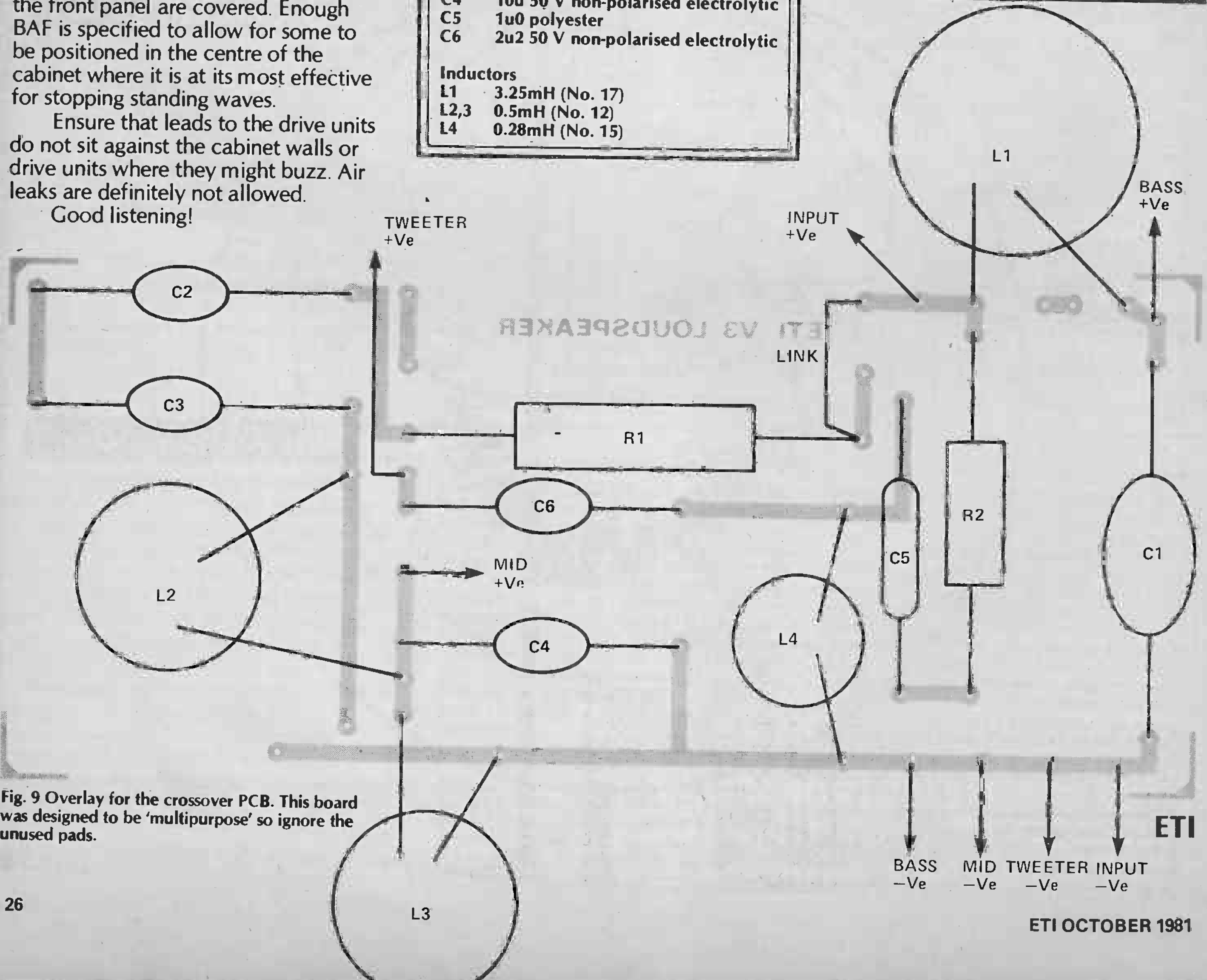


Fig. 9 Overlay for the crossover PCB. This board was designed to be 'multipurpose' so ignore the unused pads.

ETI

DESIGNER'S NOTEBOOK

Ray Marston looks at some unique micropower monitor and oscillator circuits which give years of continuous operation from a battery supply.

Analogue alarm-type monitor circuits have a variety of practical applications in the home and in industry. Such circuits may be used to monitor temperature, light, sound or voltage levels and activate an alarm or relay when preset levels are exceeded. The trouble is, such circuits almost invariably draw fairly high quiescent currents and have to be mains-powered, since they would otherwise flatten a supply battery after only a day or two of continuous operation. This month's Notebook looks at ways of designing micropower versions of such monitors, which will give years of continuous operation from a single supply battery.

Conventional Checking

Figure 1 shows the circuit of a conventional precision temperature monitor, which operates a relay when the temperature of TH1 rises above a value preset by PR1. Here, R1 and R2 are wired as one half of a Wheatstone bridge and apply a fixed reference voltage to the non-inverting terminal of voltage comparator IC1; NTC thermistor TH1 and PR1 are wired as the other half of the bridge and feed a temperature-dependent voltage (which falls with increasing temperature) to the inverting terminal of the comparator. In use, PR1 is adjusted so that the bridge is very slightly unbalanced at the desired alarm temperature, thus driving the output of IC1 high when the temperature reaches or exceeds the preset level and actuating the relay via VFET Q1. Note that the action of this circuit can be reversed, so that it acts as a precision under-temperature switch or monitor, by simply transposing the positions of TH1 and PR1.

An outstanding advantage of the Fig. 1 circuit is that, because TH1-PR1-R1-R2 are bridge-configured, the trip point of the circuit is not influenced by variations in the supply voltage, and the design thus gives true 'precision' operation. A major disadvantage of the circuit is that it draws a quiescent current of about 5 mA and will flatten a PP9 battery after less than two days of continuous operation. In actual fact, however, the circuit does not (logically) need to be *continuously* powered, for the following reason.

Micropower Sampling Techniques

The Fig. 1 circuit monitors the temperature continuously and thus draws continuous power. In reality, however, temperature is a slowly varying parameter and thus does not need to be monitored continuously; instead, it can be efficiently monitored by briefly inspecting or sampling it only once every second or so. If the sample periods are very brief (say 300 us) relative to the sampling interval (1 s) the *mean* current consumption of the monitor can be reduced by a factor equal to the interval/period ratio (eg a factor of 3300) by using the sampling technique; for example, the 5 mA consumption of the Fig. 1 circuit can be reduced to a mean value of a mere 1.6 uA. The sampling technique thus enables micropower monitor designs to be implemented.

Figure 2 shows the basic circuit of a micropower or sampling version of the precision temperature monitor, which operates the relay when the TH1 temperature rises above a preset value but which draws a mean quiescent current of only a few microamps. The TH1-PR1-R1-R2-IC1 monitor network is almost identical to that of Fig.1, but instead of being continuously powered it is powered by a sample pulse generator and Q1. Note that the output of IC1 is fed to temporary memory store R4-C1 via D1, and that the memory store operates the relay via VFET Q2.

Thus, if the TH1 temperature is below the trip level when the sample pulse arrives, IC1 output will remain low and no

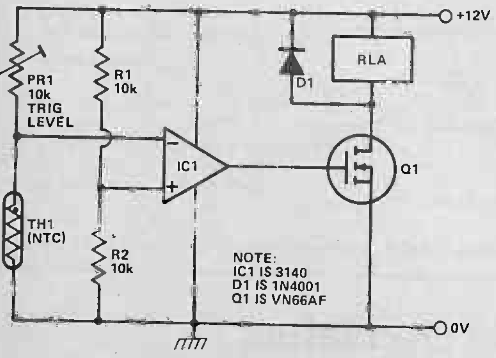


Fig. 1 This over-temperature alarm consumes a quiescent current of about 5 mA and will flatten a PP9 battery in under two days.

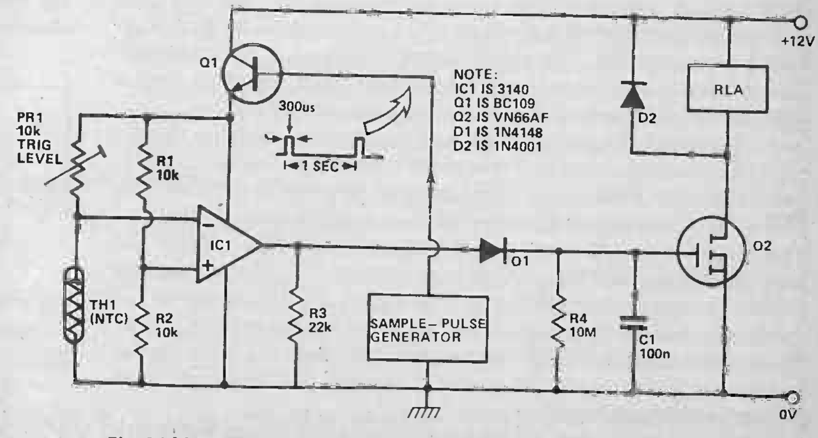


Fig. 2 This micropower or sampling version of the circuit consumes a mean quiescent current of only a few microamps and gives years of operation from a PP9.

charge will be fed to C1, so Q2 and the relay will be off. If the TH1 temperature is above the trip level when the sample pulse arrives the IC1 output will switch high for the duration of the pulse and thus rapidly charge C1 up via D1, driving the relay on via Q2; the C1 charge will then easily hold the relay on until the arrival of the next sample pulse.

The Fig. 2 circuit, then, illustrates the basic principles of the micropower sampling technique. In reality, the sampling interval used (and thus the reduction in mean power consumption) will depend on the specific application. If, for example, you wish to monitor the temperature of a large vat, which has massive thermal inertia, you can happily use sampling intervals of several minutes and thus run the monitor with only nanoamps of current. If, on the other hand, you wish to monitor transient changes in light or sound levels with minimum durations of 100 ms, you may have to use a 50 ms sampling interval and a 1 ms sample pulse, in which case the mean current consumption of your circuit will be reduced by a factor of 'only' 50!

200 us sample period the resulting output pulse will be captured by D1-C1-R7 and use to fully connect the supply to the IC1-IC2 monitor circuitry via OR gate IC3a and Q1: the circuit will then temporarily operate in the conventional mode in which the 5 kHz input tone burst produces a train of square wave output signals from IC2. These signals are then 'conditioned' by D2-R9-R8-C2 and IC3b, which produces a high output only if the signals are continuously present for at least 50 ms. The sampling and conditioning circuitry thus gives very high overall immunity to false triggering by transient signals and other glitches.

Looking again at the Fig. 2 and 3 circuits, it is obvious that if the sampling systems is to be truly efficient, the actual sample-pulse generator must itself consume negligible current, and this immediately makes us think of using a CMOS oscillator in this position. Unfortunately, however, conventional CMOS oscillators are not good enough for the sampling application, so some rather special designs are called for. Let's look at this subject.

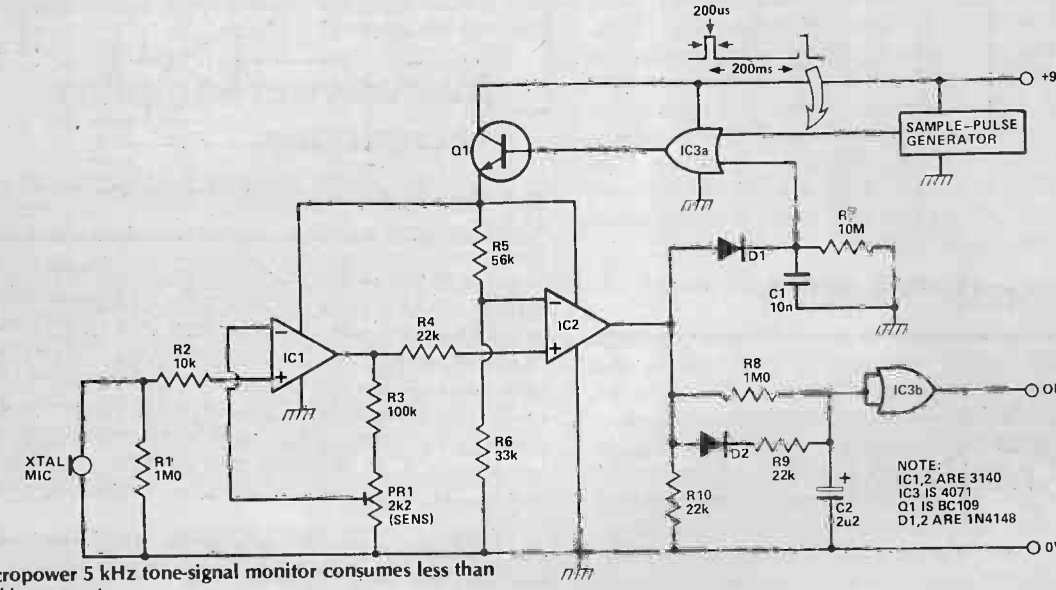


Fig. 3 This micropower 5 kHz tone-signal monitor consumes less than 10 uA of stand-by current.

In some cases you may have to slightly modify the operating principle of the sampling circuitry to obtain the desired micropower operation. Figure 3, for example, shows the basic circuit of a micropower 5 kHz tone-signal monitor which consumes a quiescent current of under 10 uA and in which the monitored tone signals have minimum durations of 250 ms. Thus, the sample pulse generator is designed to produce a minimum pulse width of 200 us so that it can 'capture' at least one full 5 kHz tone cycle, and the sampling interval is set at 200 ms so that part of a tone burst will always be captured. The sampling circuitry thus gives a 1000:1 reduction in monitor current consumption. The Fig. 3 circuit is designed to produce a high output when it receives a tone burst that is greater than a preset amplitude and duration, and operates as follows.

A crystal microphone is used to monitor the tone signals and has its output fed to the input of variable-gain amplifier IC1; this IC is a CA3140 op-amp and its input terminal is grounded by R1-R2, so it produces an output that is equal to an amplified and positively rectified version of the input signal. This is fed to the input of non-inverting voltage comparator IC2, which thus produces a high output when the tone signal amplitude exceeds a value preset by PR1. The IC1-IC2 circuit would normally consume about 6 mA, but in this design is sampled by a 200 us pulse once every 200 ms via OR gate IC3a and Q1 and thus consumes a mean current of only 6 uA.

If no output is produced from the monitor during the 200 us sampling period, the circuit will simply send another sample pulse 200 ms later. If, however, an output is produced during the

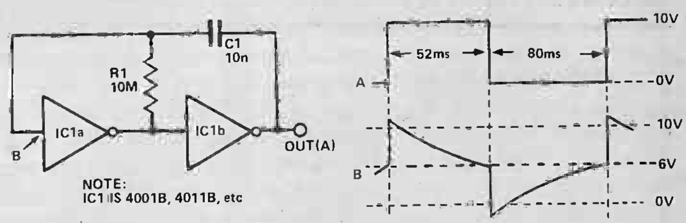


Fig. 4 This standard CMOS astable consumes 12 uA at 6 V, 75 uA at 10 V.

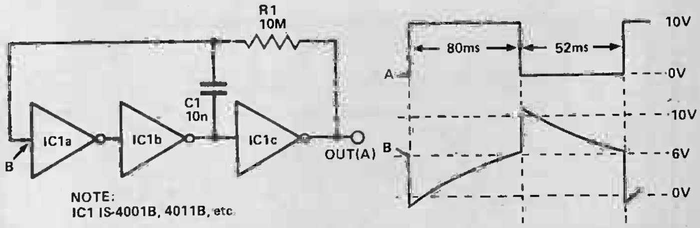


Fig. 5 This ring-of-three CMOS astable consumes 12 uA at 6 V, 75 uA at 10 V.

CMOS Oscillators

Figures 4 and 5 show the circuits and waveforms of a standard and a ring-of-three B-series astable respectively. Note that each of these circuits has a period of 132 ms and consumes a mean current of 12 uA from a 6 V supply or 75 uA from a 10 V supply. Also note that both circuits use a 10M timing resistor, so these relatively high current-consumption levels are clearly attributable to the actual CMOS chips and not to the timing networks.

The Fig. 4 and 5 astable circuits are designed around modern B-series buffered CMOS chips: even higher current-consumption figures are obtained if old-fashioned A-series unbuffered chips are used in the designs. A-series chips are no longer readily available, but you can simulate them by using a 4007UB dual complementary pair plus inverter chip (see Fig. 6). Figure 7 shows how to connect a 4007UB so that it acts like an unbuffered ring-of-three astable; note in this case that the circuit consumes 280 uA from a 6 V supply or 1.6 mA from a 10 V supply.

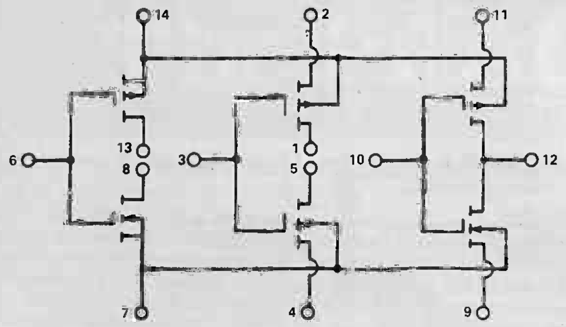


Fig. 6 Functional diagram of the 4007UB dual complementary pair and inverter.

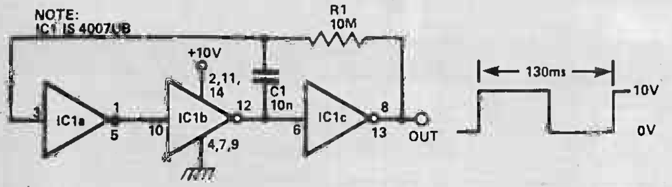


Fig. 7 This 'unbuffered' version of the ring-of-three astable consumes 280 uA at 6 V, 1.6 mA at 10 V.

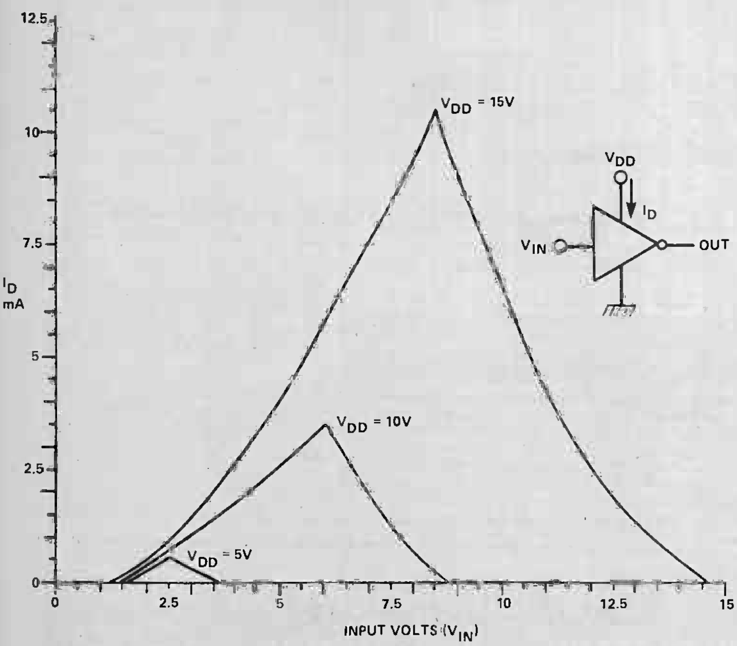


Fig. 8 Typical current and voltage transfer characteristics of a CMOS inverter stage (4001, 4007, 4011 etc).

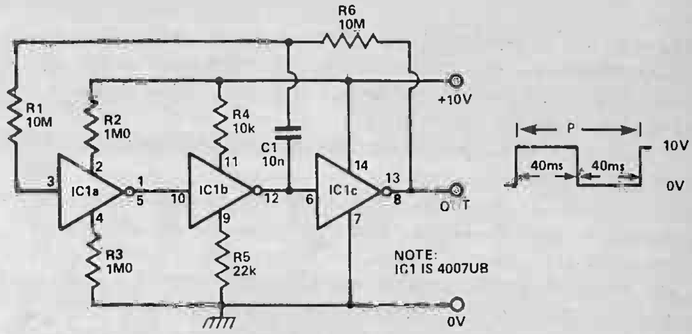


Fig. 9 This micropower ring-of-three symmetrical astable consumes 8 uA at 10 V, or 1.5 uA at 6 V.

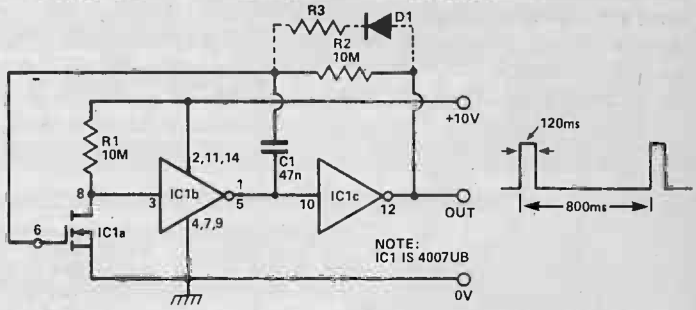


Fig. 10 This asymmetrical ring-of-three astable consumes 5 uA at 10 V, 2 uA at 6 V.

The reason for the high current consumption of the Fig. 4, 5 and 7 circuits can be explained by looking at the typical current/voltage transfer characteristics of a CMOS inverter stage, as shown in Fig. 8. As the inverter is driven into its 'linear' region both halves of its complementary MOS stages are driven on and fairly high currents flow through these stages. Looking back at the basic waveform of the Fig. 4 and 5 astables, you can see that the input of IC1a is almost permanently driven into the linear region, hence the high mean current consumptions of the circuits.

Now that we've discovered the cause of the high current consumption of the conventional CMOS astable, it is a fairly easy matter to solve the problem and come up with a useful micropower CMOS astable design, as shown in Fig. 9. Here, the 4007UB IC is configured as a ring-of-three astable, but current-limiting resistors are wired in series with its IC1a and IC1b stages, to limit its 'linear mode' currents to very low levels. The resulting circuit consumes a mere 1.5 uA at 6 V or 8 uA at 10 V and produces a symmetrical output waveform, although the frequency stability of the circuit is not particularly good, with the period varying from 200 ms at 6 V to 80 ms at 10 V.

Figure 10 shows how to wire the 4007UB a an asymmetrical ring-of-three astable that consumes 2 uA at 6 V or 5 uA at 10 V. The circuit produces a 120 ms pulse once every 800 ms: the pulse width of the circuit can, if desired, be reduced below the 120 ms value by shunting R2 with a diode-resistor series combination, as shown dotted by R3-D1 in the diagram; the R3 value determines the pulse width. Note that this circuit has the desired characteristics of the sample pulse generator that we are looking for.

Figure 11 shows a practical example of the modified version of the Fig. 10 circuit. In this case the circuit produces a 300 us pulse once every 900 ms and consumes 2 uA at 6 V or 4.5 uA at 10 V. In the diagram the output is shown feeding directly to a PB-2720 acoustic transducer, which thus produces a repetitive 'tick-tick' sound: this circuit can usefully be fixed to a lamp or other object, so that the object can easily be sound-located in the dark, or by the blind.

The current consumption of the Fig. 11 circuit can be even further reduced by simply wiring a 22k resistor between pin 2 or the 4007UB and the positive supply line, as shown in Fig. 12. This modification is of value if truly minimal current consumption is essential, or if the circuit is to be used as a sample pulse generator with a brief sample interval. The table shows two typical sets of performance figures obtained using alternative R1 and C1 values.

Note at this point that there is little practical value in spending extra money in reducing the current consumption of a micropower circuit to values that are so low that they are insignificant compared to the leakage current of a conventional battery. The basic Fig. 2 circuit, for example, can 'in theory' operate continuously for 50 years from a single PP9 battery, but in practice the battery itself has a shelf life of only two years, so there is no point in seeking to obtain even further reductions in the current consumption!

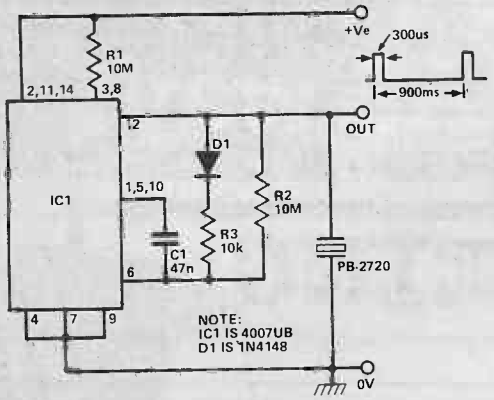
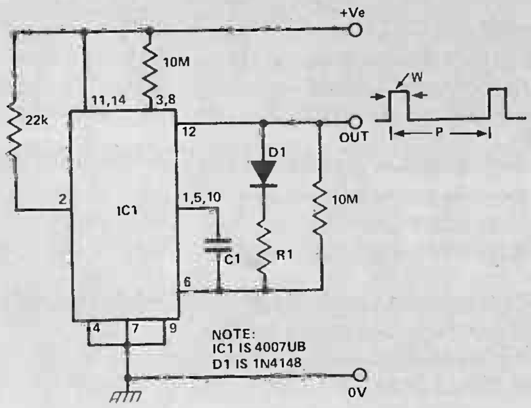


Fig. 11 This transducer-driving version of the Fig. 10 circuit acts as a tick-tick generator or acoustic object-finder. It consumes 2 uA at 6 V, or 4.5 uA at 10 V.



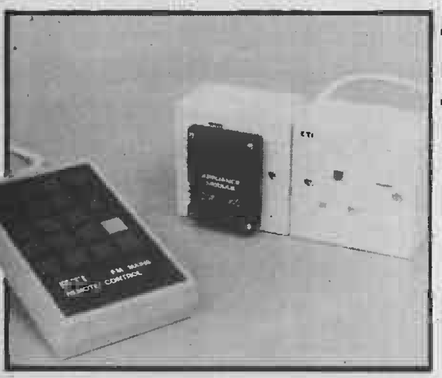
C1/R1 VALUE	I MEAN AT 9V	W	P
47n/10k	1.5uA	300us	900ms
10n/33k	3.5uA	160us	180ms

Fig. 12 This version of the micropower asymmetrical astable consumes absolutely minimal currents.

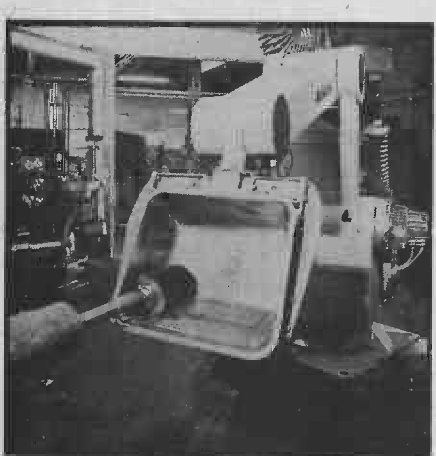
The principles discussed in Notebook this month are so novel that we've included two practical applications of the micropower technique in this month's projects. The Micropower Pendulum on page 37 is a 'tick-tock' sound generator circuit that can be added to virtually any existing electronic clock. On page 68 there is a practical version of the Fig. 2 circuit, incorporating a pulsed-tone alarm generator with a peak audio power of 1 W.

ETI

Home-built hi-fi p.22



Commands by cable p.56



The new workers p.72

Get your prints right p.78

electronics today INTERNATIONAL

OCTOBER 1981 VOL 10 NO 10

FEATURES

PROJECTS

INFORMATION

Due to lack of space, Audiophile has been held over until next month.

EDITORIAL AND ADVERTISEMENT OFFICE
145 Charing Cross Road, London WC2H 0EE. Telephone 01-437 1002/3/4/5.
Telex 8811896.

Ron Harris B.Sc. — Editor
Paul Wilson-Patterson — Group Art Editor
T.J. Connell — Managing Director

Peter Green — Assistant Editor
Tina Boylan, Judith Jacobs — Editorial Assistants
Alison Lilly — Assistant Art Editor
Paul Edwards — Drawing Office Manager
Ray Marston — Project Editor

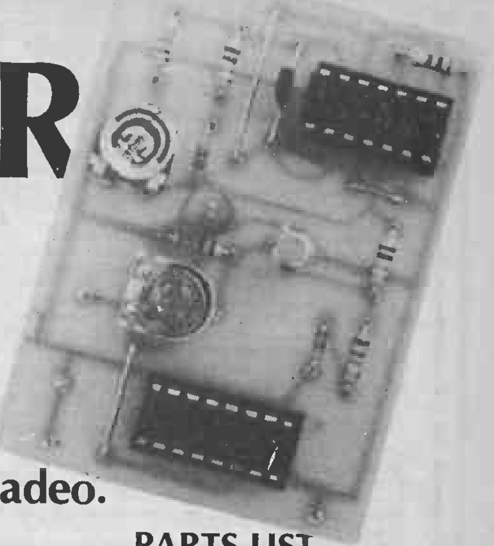
OVERSEAS EDITIONS and their EDITORS
AUSTRALIA — Roger Harrison
CANADA — Halvor Moorshead
GERMANY — Udo Wittig
HOLLAND — Anton Kriegsman

ABC Member of the Audit Bureau of Circulation

PUBLISHED BY Modmags Ltd., 145 Charing Cross Road, London WC2H 0EE
DISTRIBUTED BY Argus Press Sales & Distribution Ltd. 12-18 Paul Street, London EC2A 4JS (British Isles)
PRINTED BY QB Limited, Colchester
COVERS PRINTED BY Alabaster Passmore

MODMAGS LTD

MICROPOWER PENDULUM



Add a 'tick-tock' sound to your electronic clock with this amazing little module. Design by Ray Marston. Project development by Steve Ramsahadeo.

Modern electronic clocks are inexpensive and highly accurate devices, but lack the comforting 'tick-tock' sounds of old-fashioned mechanical timepieces. The 'tick-tock' sound of a clock confers two particular advantages. First, its rhythmic sounds are soothing and tend, at night, to help induce sleep: second, the sounds help the owner to easily locate the clock in a darkened room.

The little module described on this page enables you to add a 'tick-tock' sound to virtually any electronic clock. The unit consists of a low frequency micropower oscillator and divider circuit that has its output fed to a PB-2720 ceramic transducer, which generates the 'tick-tock' sounds. The unit can be operated from any supply in the range 4V5 to 12V; its *total* current consumption varies from 1 uA at 4V5 to 5.5 uA at 12 V. To put it another way, the unit will give a couple of years of continuous operation from a PP3 battery!

Construction

The complete circuit (other than the transducer) is built up on a small PCB and construction should present no problems. Note that three jumper links are used on the board and that C2 is a tantalum component. The use of mounting sockets for IC1 and IC2 is advised.

When construction is complete, fit the PB-2720 transducer in place and simply connect the unit to a battery and check that the tick-tock sound is generated. The tick-tock rate can be varied by PR1 and the volume by PR2: if you can't get the tick-tock rate low enough for your particular application, increase the C1 value to 100n.

The complete module can be powered from the existing clock supply rails (if they are in the 4V5 to 12 V range) or from its own PP3 battery. No on/off switch is needed in the supply line, since the current consumption is so low.

HOW IT WORKS

Circuit operation is quite simple. IC1 is configured as a special micropower oscillator (see this month's edition of Designer's Notebook) and produces a 300 us pulse at pin 12 roughly once every second; the rate can be varied over a limited range by PR1. This pulse is fed to the PB-2720 acoustic transducer via emitter follower Q1 and volume control PR2, and is also fed to the clock terminal of IC2, a 4017B divider chip. The 4017B is configured in the divide-by-two mode and its action is such that pin 2 switches between ground and supply voltage on alternate clock cycles.

Note that pin 2 of IC2 is connected to the base of emitter follower Q1 via R6 and D2. Thus, on the arrival of the 'tick' clock pulse pin 2 is high, so D2 is reverse biased and virtually the full clock pulse is fed to Q1 base (via R5), producing a loud 'tick' sound from the PB-2720. On the arrival of the 'tock' clock pulse, however, pin 2 of IC2 goes low and pulls R6 to ground via D2 so that R5-R6 act as a potential divider, thus causing only two-thirds of the clock pulse to reach Q1 base, and generating a softer 'tock' sound in the PB-2720. This process repeats ad infinitum.

Note that although the *mean* current consumption of the unit is only in the microamp range, the *peak* pulse currents feeding the ultra-efficient PB-2720 acoustic transducer may have amplitudes of several milliamps; the transducer thus produces 'tick-tock' sounds that are (if desired) clearly audible at a considerable range.

BUYLINES

There should be no problems obtaining any of the components used in the Pendulum. The PB-2720 transducer is available from Ambit International. The PCB for this project can be obtained from our PCB service — see page 54.

PARTS LIST

Resistors (all ¼W, 5%)	
R1	10M
R2,5	10k
R3	4M7
R4	100k
R6	22k
Potentiometers	
PR1	4M7 miniature horizontal preset
PR2	22k miniature horizontal preset
Capacitors	
C1	47n ceramic
C2	47u 16 V tantalum
Semiconductors	
IC1	4007UB
IC2	4017B
Q1	BC109
D1,2	1N4148
Miscellaneous	
TX1	PB-2720
PCB (see Buylines); battery (4V5-12 V).	

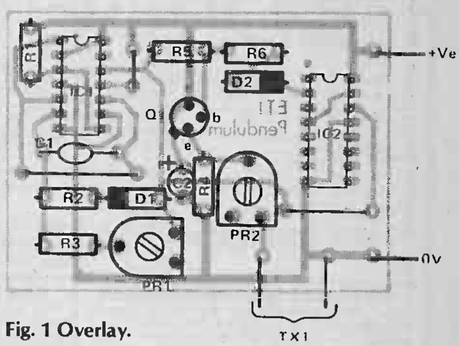


Fig. 1 Overlay.

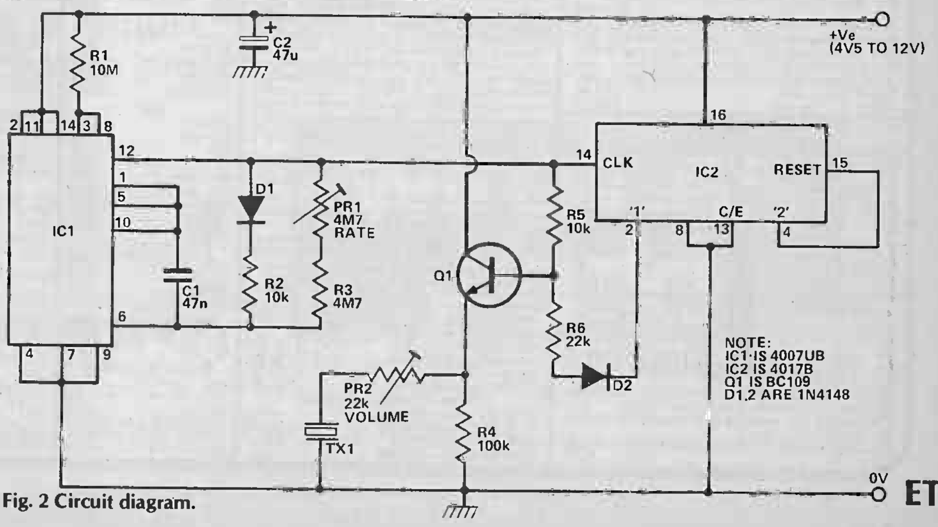


Fig. 2 Circuit diagram.

dbx NOISE REDUCTION

Overshadowed by Dolby despite its theoretical superiority, the dbx noise reduction system now seems poised to take the hi-fi market by storm. Peter Green was at the press launch and this is what he heard.

Until now it has been impossible to listen to music at home with anything like the quality of the original. However much you spend on your hi-fi, however low the distortion figures, however carefully you tend your records and however diligently you clean your tape heads, you cannot get away from the twin evils of surface noise and restricted dynamic range.

Surface noise is caused by the limited quality of the recording medium itself. Imperfections and inhomogeneity in the particles that make up the tape coating generate the familiar hissing we know and hate; the roughness of the vinyl surfaces of record grooves produces its share of hissing and pops. Surface noise also affects dynamic range: During a live performance it is possible for sound pressure levels to momentarily hit 120 dB during music transients; however, background noise levels in the audience can easily range from 30 to 50 dB and so this simplistic treatment indicates that live music has a perceived dynamic range of about 70 to 90 dB. Unfortunately a good cassette recorder has a dynamic range of only about 45 dB, while a conventional vinyl record is not much better at 55 dB. Recording engineers have to compress the signal by a factor of 2:1 so that the loudest passages are below the level that causes tape saturation or distortion, and the quietest passages are above the level of tape hiss or record surface noise (see Fig. 1). This squeezing of the signal into a restricted dynamic range makes the music sound flat, unexciting and unrealistic. You *know* it's a recording.

D Versus d

The noise reduction system that established a virtual monopoly in the world hi-fi market of the seventies was Dolby B, a system that reduced high frequency noise (the most objectionable kind) by boosting high frequencies on recording and attenuating them on playback, thus also reducing the noise added in the recording process.

dbx decided to tackle the other problem — restricted dynamic range. Since sounds have to be compressed to be recorded on tape or disc, a system that allowed 1:2 expansion on playback would recreate the range of the original performance (Fig. 2). This idea is quite old but difficult to apply, because the expander and compressor must track each other (be exactly complementary), especially on transients — this in turn requires accurate detection of the signal. The difficulties in this and the way that dbx overcame them are described later, but the important point is that when the recorded signal is ex-

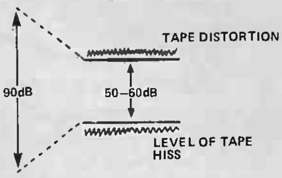


Fig. 1 (left) When recording tapes or discs, engineers monitor the signal and turn the level up or down ('gain riding') to avoid distortion or hiss. This compression greatly reduces the dynamic range to an absolute maximum of about 60 dB.

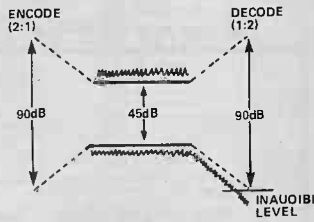


Fig. 2 (right) By introducing 2:1 compression on recording, then accurately and automatically reversing the process on playback, the dbx noise reduction system reclaims the original dynamic range. As a bonus, tape hiss becomes inaudible.

panded *the tape noise drops below the level of audibility*. dbx have killed two birds with one stone, together with an assortment of sacred cows; for example, they recommend that you use chromium dioxide rather than metal tapes, because it's pointless to pay extra money for an improvement of 2 to 3 dB when the system itself is giving you an extra 30 dB across the whole frequency range.

Paths Of Glory

Figure 3 shows the block diagram of a Type II dbx noise reduction system for domestic use (the Type I system has certain differences in the turnover frequencies of the filters to suit professional situations). The encoder and decoder each have two paths — the signal and detection paths.

The music signal to be recorded first goes through a band pass filter to remove unwanted out-of-band components. Type II values are 30 Hz to 100 kHz, Type I are 22 Hz to 27 kHz. The lower limit is there to prevent subsonic noise from underground trains, traffic vibrations and the like from being recorded; the upper limit prevents pick-up of CB and other interference. The Type I value is much lower because studios often have very long leads which are more susceptible to pick-up. The signal passes through a pre-emphasis network that boosts high frequencies and helps to overcome tape modulation noise (which is caused by uneven magnetisation due to tape inconsistency), and into the voltage-controlled amplifier. The VCA is linear in dB with control voltage to make things simpler later on; it compresses the signal by a 2:1 ratio.

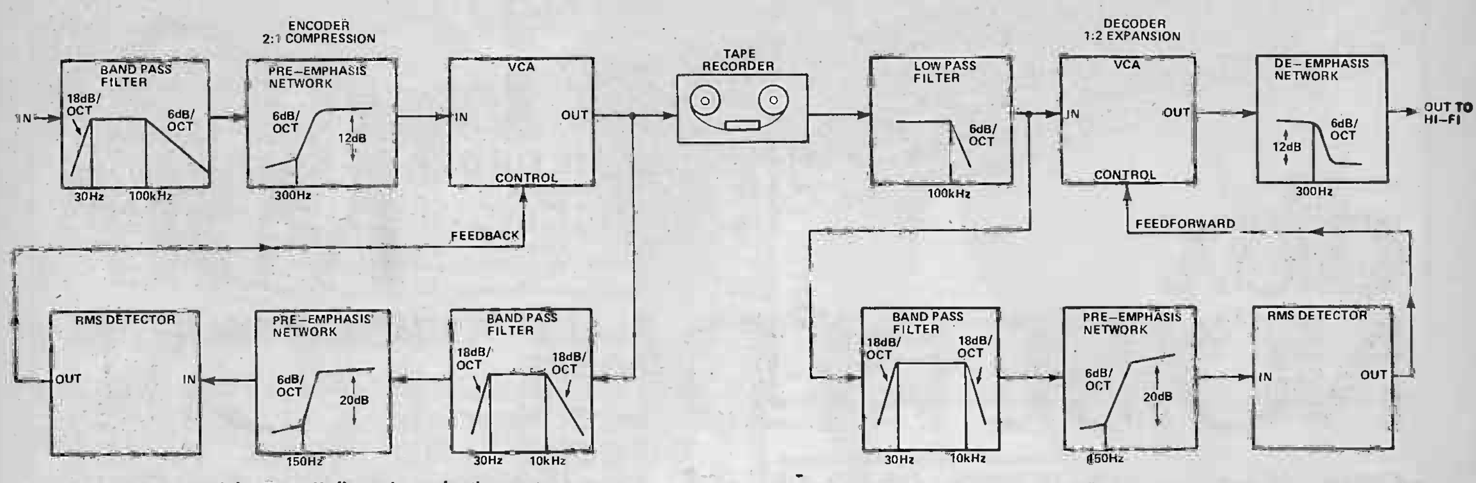


Fig. 3 Block diagram of the Type II dbx noise reduction system.

The output of the VCA is passed to the tape recorder, and also into the detector section. The first stage is a band pass filter which has a slope of 18 dB/octave above 10 kHz, so that the detector 'takes less notice' of high frequencies. Next comes another pre-emphasis network, this time to increase the compression of the signal at high frequencies and avoid the possibility that the pre-emphasis in the signal path will cause high-frequency tape saturation. The RMS detector converts the AC signal into a DC voltage proportional to the level in dB; since the VCA also follows this law the whole system is linear in dB.

Mirror, Mirror

The encoder is a compressor with negative feedback; the higher the signal level the greater the gain reduction. The decoder must be a mirror image to give the correct tracking and recovery of the original performance, so it is configured as a feedforward system acting as a 1:2 expander. The importance of this is that if the tape recorder is considered to be 'transparent', the VCA control voltage in the decoder is being derived from exactly the same signal as that for the encoder VCA. The detector path in the decoder is identical to the one already described — band pass filter, pre-emphasis network, RMS detector — and so the control signals will also be identical (to within component tolerances). The decoder VCA has its control polarity reversed and gives a complementary gain change to that of the encoder; the de-emphasis network reverses the effect of the encoder pre-emphasis to restore a flat overall frequency response. It's interesting to note that this flat system response is due solely to the mirror-image nature of the signal processing — the frequency responses of encoder and decoder are complementary, but *not* flat.

Because a high value of loop gain (40 dB) is employed in the decoder, a low pass filter is needed at the input to prevent high-frequency oscillation caused by capacitive coupling. This keeps the system stable.

RMS detectors have been used because tape recorders aren't perfect, or 'transparent' — they introduce huge amounts of phase shift. This is not noticeable to the ear, but the effect of passing a 1 V peak-to-peak square wave through a 90° phase shift filter is shown in Fig. 4; cheaper and simpler detectors such as peak or averaging types would not give identical outputs for the two waveforms and the mirror-imaging would be lost. An RMS detector is the only one that will give the same output level for both.

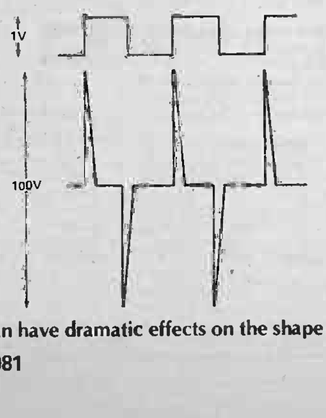


Fig. 4 Phase shift can have dramatic effects on the shape of waveforms!

Silence Is Golden

If anyone feels that the working of the system is hard to understand, rest assured that a practical demonstration isn't. The press showing started with a hiss comparison using blank unencoded tape, first with no noise reduction, then Dolby B, Dolby C and finally dbx. Hiss was still significant with the two Dolby systems, although the improvement was noticeable — but when the dbx cut in, nothing could be heard except the gasps of amazement from hardened journalists. No hiss whatsoever! Listening to extracts from discs and tapes was a revelation; for the first time in my life I could shut my eyes and believe the orchestra was really there. I heard musicians fingering their instruments, I heard someone on the record sniff, and the music appeared out of a silent background — it was *real*!

Naturally the impact dbx has on the market will depend on how many encoded discs and tapes they can release, and how quickly. But several major cassette deck manufacturers (eg Technics, Trio, Teac, Yamaha, Marantz) are fitting dbx alongside Dolby in some of their models, and Dolby must be thinking hard about their next move. (At ETI we're thinking about how nice a review model would be, hint, hint!) With approximate RRPs of £120 for the Model 222 (for two head tape decks) and £170 for the Model 224 (three head decks), a dbx noise reduction system could be the best upgrade you'll ever make.

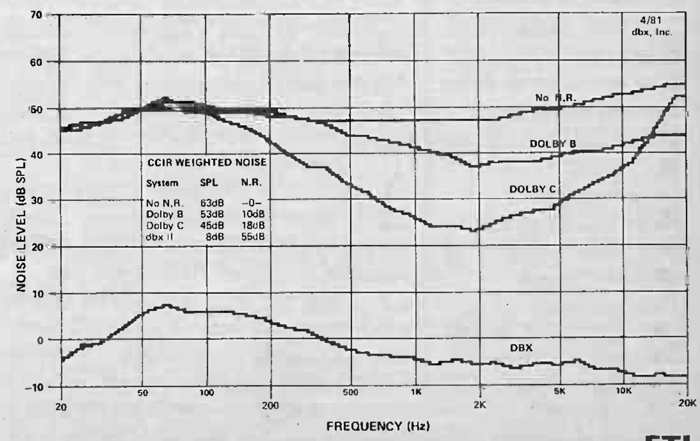


Fig. 5 A comparison graph of noise reduction systems, issued by dbx.

ROBOT ARM

Part 2 of the Armdroid project gives the complete constructional details of the electronics. System concept by Ron Harris. Realisation and development by Ajit Channe, Nick Ouroussoff and Andrew Lennard.

This month we give the Parts Lists and overlays for the Armdroid, plus a few things we have to point out. A large number of supply decoupling capacitors are required on the interface board — for clarity these were not shown on last month's circuit diagram, but they appear as C2-14 in Fig. 3. Figure 3 also includes two extra resistors which experience has shown to be necessary

On the motor driver board, there are four spare pads to the left of each IC4. These may be used to directly connect control signals from the outputs of the latches on the interface board, if direct computer control of the stepper coils is desired as mentioned last month.

Finally, Colne Robotics are continuing development work on the gripper, and invite suggestions for alternative designs. If you think you've got a good idea (some possibilities are mentioned in Robotics Today this month), get in touch with Colne at the address given in Buylines last month. If they like your proposal they're prepared to do the development and engineering work and pay the inventor a royalty. Over to you!

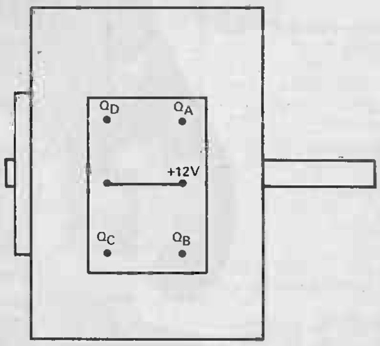


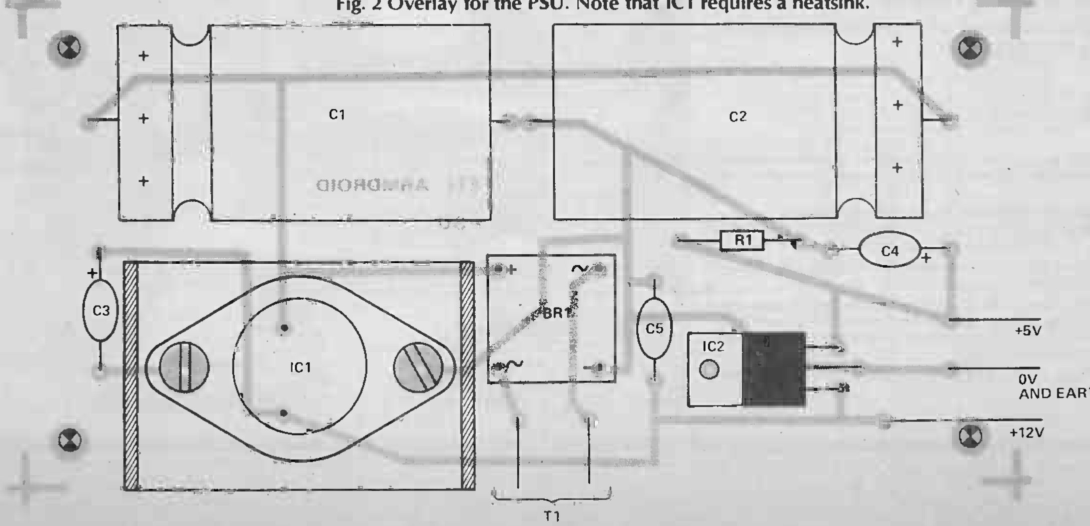
Fig. 1 Motor wiring diagram. Note that both the centre terminals are connected to 12 V.

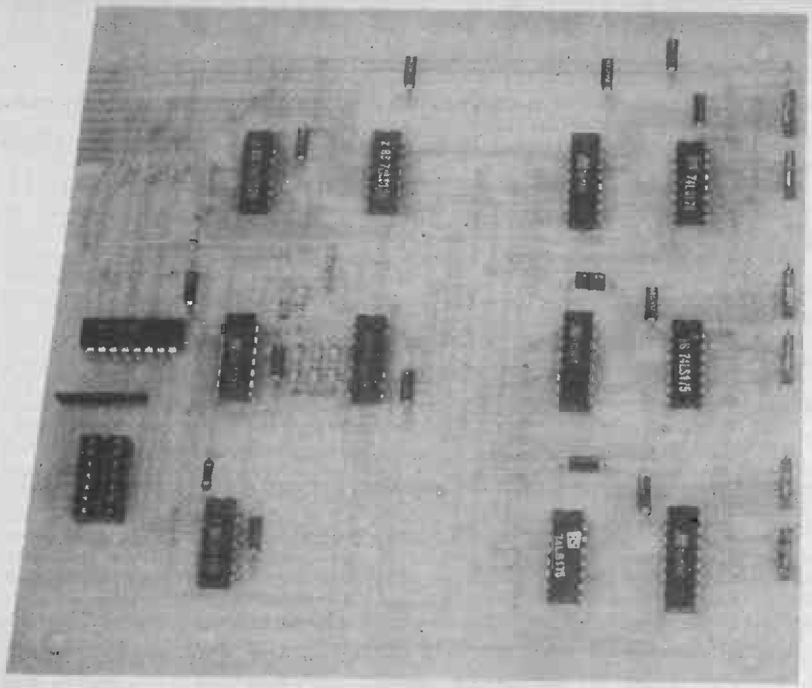
PARTS LIST

POWER SUPPLY

Resistors (all ¼ W, 5%)		BR1	200 V, 6 A bridge rectifier
R1	4k7	TS1	240 V AC transient suppressor
Capacitors			
C1,2	4700u 25 V axial electrolytic	Miscellaneous	
C3,4	1u0 35 V tantalum	SW1	mains switch
C5	220n polyester	T1	12 V, 50 VA
		LP1	12 V, 50 VA
Semiconductors		LP1	neon lamp
IC1	78H12	FS1	1 A fuse
IC2	7805	Heatsink (drilled for T03 case)	

Fig. 2 Overlay for the PSU. Note that IC1 requires a heatsink.





PARTS LIST

INTERFACE BOARD

Resistors (all ¼ W, 5% except where stated)

R1	1k0
R2,13	10k
R3-8	2k2 resistor network
R9-11	1k8
R12	15k

Capacitors

C1	100p polystyrene
C2-14	10n ceramic

Semiconductors

IC1,2	74LS125
IC3	74LS04
IC4	745LS123
IC5	74LS366
IC6	74LS138
IC7-12	74LS175

Miscellaneous

SW1-6 SPST microswitches

0.1" 10-way edge connector (one off); four-way PCB plug and socket connectors (six off).

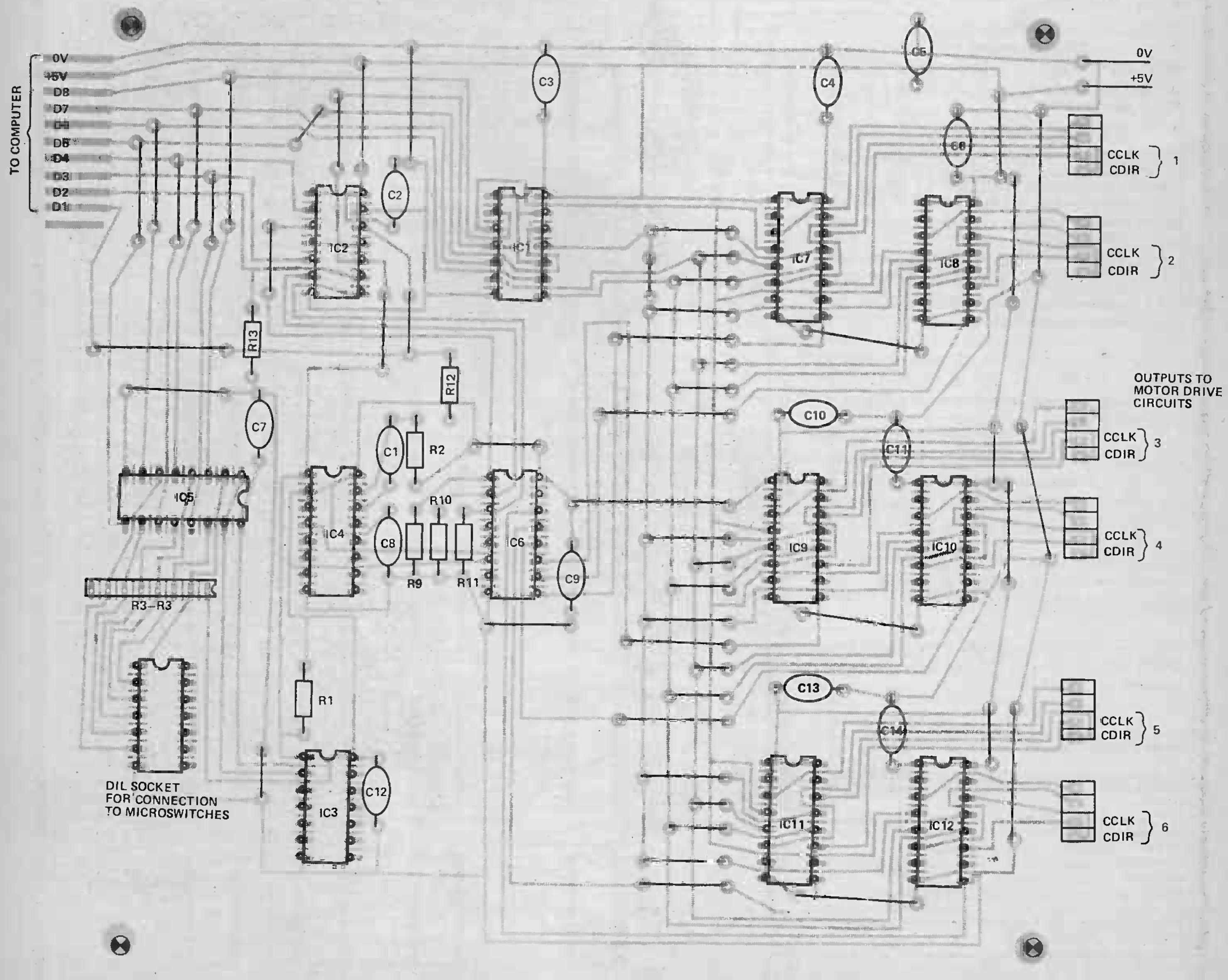
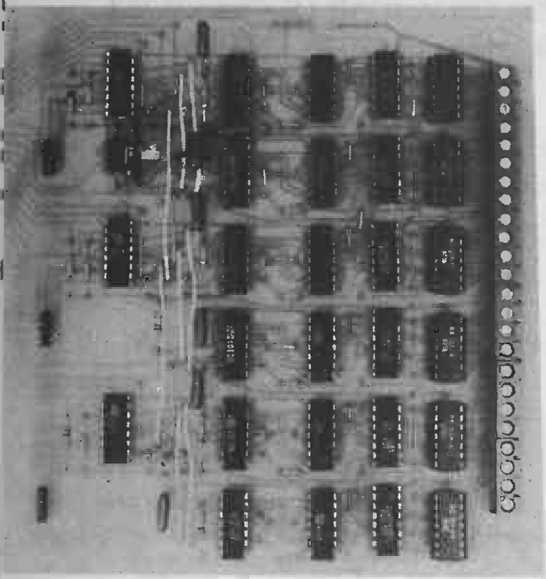


Fig. 3 Interface board overlay. The connection to the computer port will depend on your particular machine.



PARTS LIST

MOTOR DRIVER
(For one channel only — six sets required except where stated)

Resistors (all ¼ W, 5%)

R1	10k (one off)
R2,3	10k
R4	39k (one off)
R5	68k (one off)
R6	100k

Potentiometer

PR1	100k miniature vertical preset (one off)

Capacitors

C1	10n ceramic (one off)
C2	100n ceramic (one off)
C3	10n ceramic

Semiconductors

IC1	CD4551 (three off)
IC2	CD4013
IC3	CD4070
IC4	CD40109
IC5	VQ1000CS
IC6	555 (one off)

Miscellaneous

SW1	SPDT toggle (one off)
SW2,3	SPST push-button
MTR1	12 V stepper motor

0.1" 16-way edge connector (one off); four-way PCB plug and socket connectors (three off); 25-way terminal block (one off).

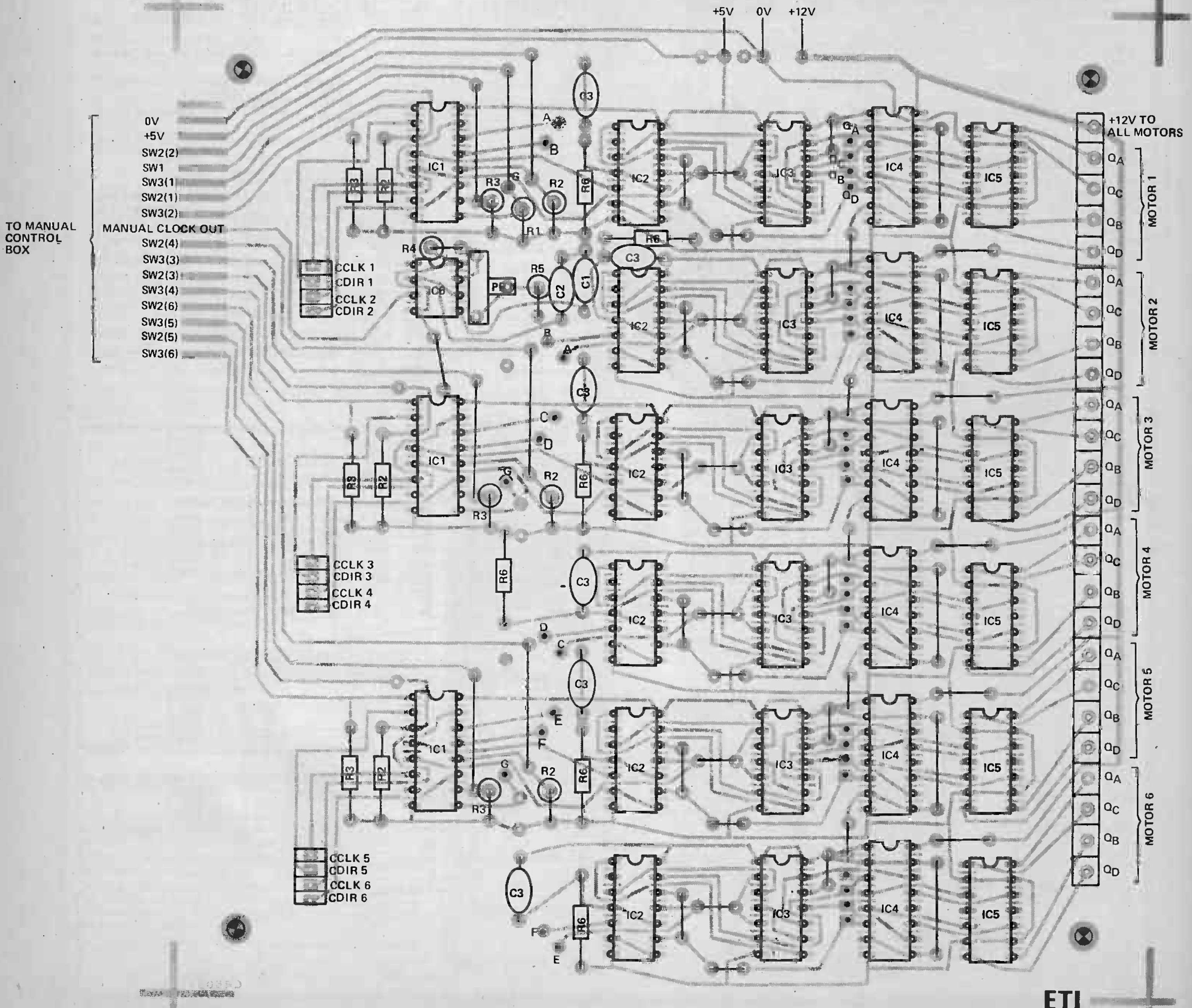
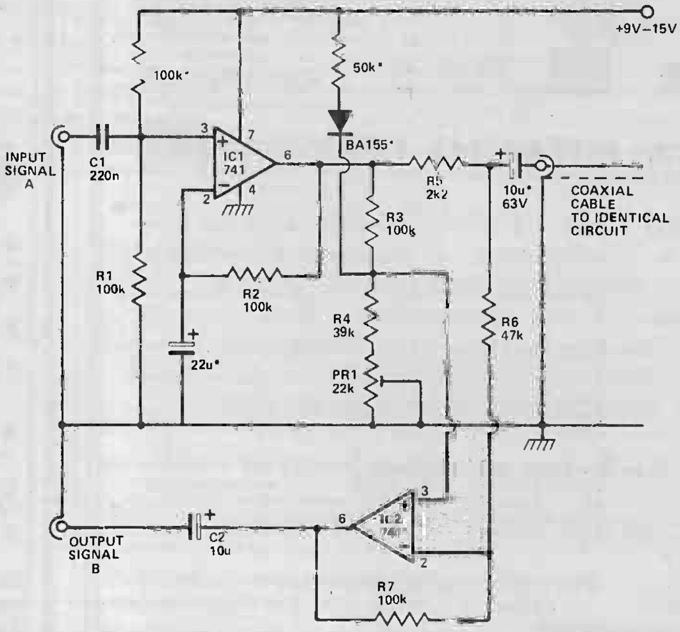


Fig. 4 Overlay for the motor driver board. Points A-A, B-B, ... , F-F are linked by lengths of insulated wire; normally points G-G-G are also linked so that the manual override switch (SW1) controls the CMOS switches in all six channels. However, if it is required to provide a separate override for each pair of channels, pads are provided at pin 9 of each IC1 for the extra pull-down resistors.

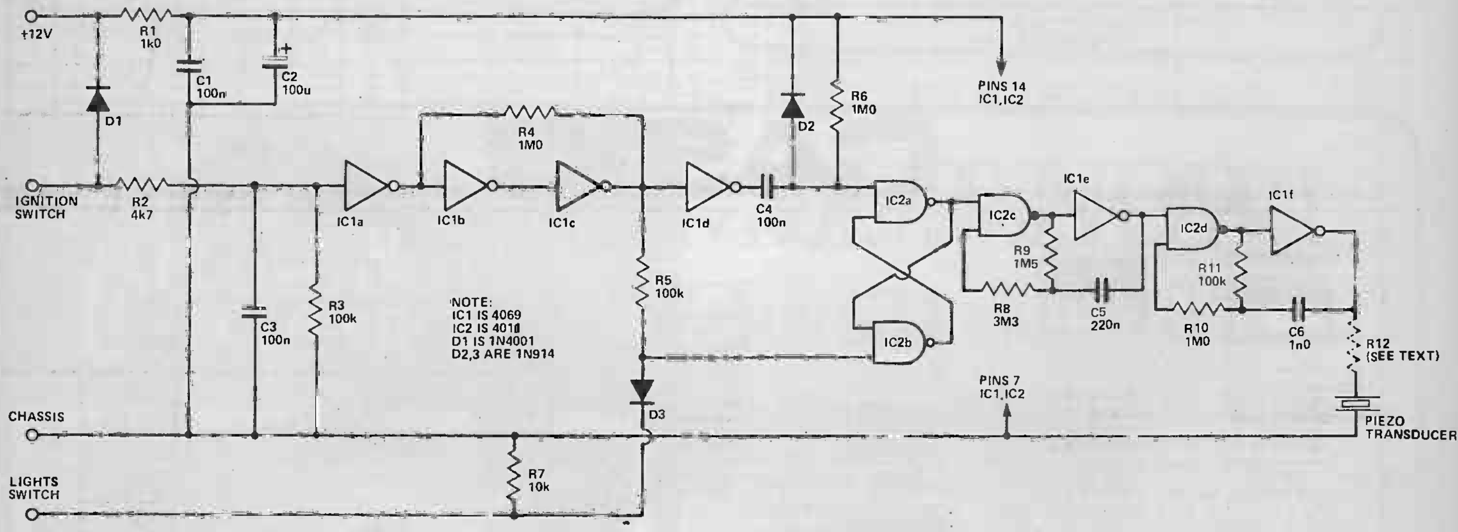
TECH TIPS

Audio Link Modifications

T. Bennett, Hazel Grove



Referring to the circuit information offered by T.P. Hopkins in the June Tech Tips Special for a Bidirectional Audio Link, a closer inspection of the circuit will reveal several omissions, some of which the amateur constructor may find difficult to rectify. There are no biasing components shown (to provide balance); the voltage rails are not shown; and DC blocking capacitors are not shown — it won't work without them. I enclose a drawing of a circuit with these features which I constructed in order to test the rejection — this was measured at 50 dB.



Car Lights Warning

A.M. Tucker, Dorchester

This circuit gives an audible warning if the car lights are left on when the ignition is switched off. If necessary, the lights can be switched off and then on again, and the alarm will be cancelled.

Operation is as follows: the ignition switch is connected to buffer IC1a, Schmitt trigger R4-IC1b-IC1b and inverter IC1d. R1-C1-C2 and R2-C3 are filters. If the lights are on and the ignition is switched off, a negative pulse is applied through C4 to IC2b and the junction of R5 and D3 goes high, causing the flip-flop to change over. This enables the slow oscillator IC2c-IC1e (approximately 1.3 Hz), which pulses the (approximately) 4 kHz oscillator IC2d-IC1f, causing audible bleeps in the piezo-electric transducer. If the lights are off, the input to IC2a is held low via D3 and R7, inhibiting the oscillators. D1 and D2 deal with unwanted transients, while R12 is chosen to give the required warning level.

The circuit can be adapted for positive earth vehicles by reversing the diodes and electrolytic capacitor, reversing the connections to pins 7 and 14 of the ICs, and substituting a 4001 NOR IC for the 4011 NAND IC. With this modification, there may be a short bleep when the ignition is switched off and the lights are not on.

Tech-Tips is an ideas forum and is not aimed at the beginner. We regret we cannot answer queries on these items. ETI is prepared to consider circuits or ideas submitted by readers for this page. All items used will be paid for. Drawings should be as clear as possible and the text should preferably be typed. Circuits must not be subject to copyright. Items for consideration should be sent to ETI TECH-TIPS, Electronics Today International, 145 Charing Cross Road, London WC2H 0EE.

Seven Channel Lightshow

J. McCauley, Dundalk

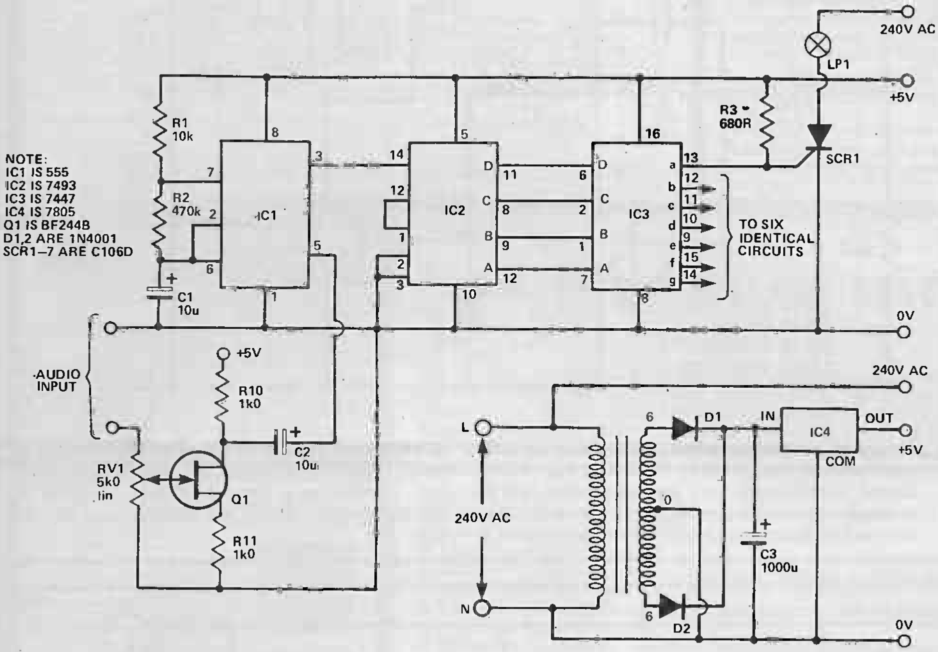
When used with an audio input this circuit gives a very effective display, using seven 75 W coloured spot lamps for disco work or smaller 'pygmy' bulbs when used as an addition to a home audio system. Alternatively the 7447, which is a display driver, can drive seven LEDs directly.

As can be seen from the truth table there are 16 different arrangements for the sequence of switching. This helps give the impression that the bulbs are randomly switched. The operation of the circuit is as follows.

The 555 timer is connected here as a VCO with the control voltage on pin 5 derived from the audio input via the FET input buffer circuit. The variable length pulses from the VCO are then used to clock the 7493 which is connected here as a binary counter.

The outputs from the 7493 are then decoded by the 7447 decoder (BCD to seven-segment). The outputs from this IC are used to trigger the SCRs, thus turning on the appropriate lights.

All that is necessary to operate the circuit is adjustment of the input level control (RV1) to give the best visual display. When switching low power loads ie 75 W, RFI suppression circuitry should not be required; however, with greater loads (absolute max 750 W per channel) such circuitry will be necessary.



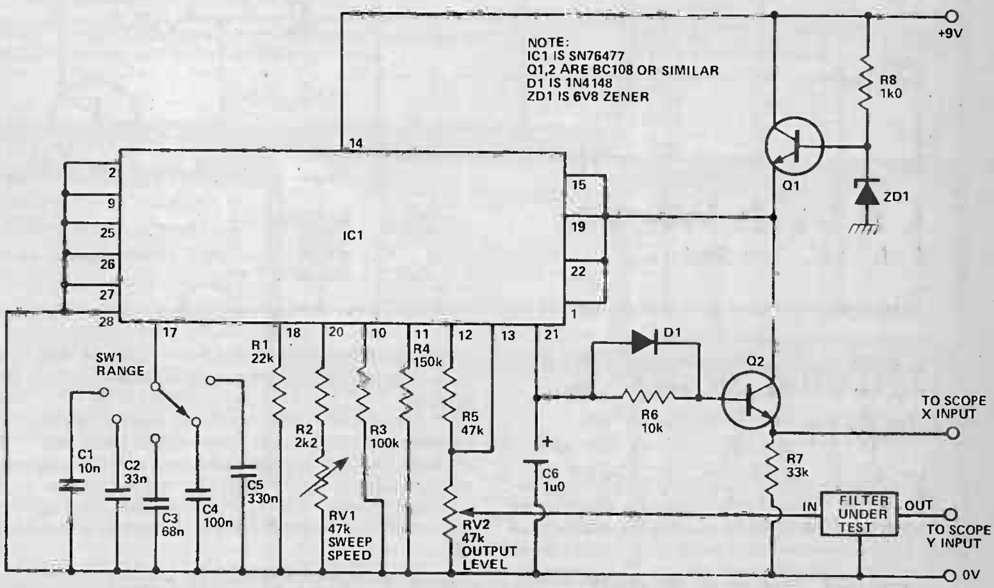
COUNT	LP1	LP2	LP3	LP4	LP5	LP6	LP7
0		X	X	X	X	X	X
1					X	X	
2	X		X	X		X	X
3	X			X	X	X	X
4	X	X			X	X	
5	X	X		X	X		X
6	X	X	X	X	X		
7					X	X	X
8	X	X	X	X	X	X	X
9	X	X			X	X	X
10		X	X	X			X
11				X	X	X	X
12	X	X				X	
13	X	X		X		X	X
14	X	X	X	X	X		
15							

X = LAMP LIT

Simple Frequency Response Display

M. Harrison, London

This circuit was originally designed to test audio filter circuits, but has several other uses such as demonstrating the properties of tuned circuits, or testing graphic equalisers. The circuit consists of a low-frequency oscillator with a triangular wave output which is used to frequency modulate a VCO, while also being fed to the X input of a 'scope (the signal is about 2 V peak-to-peak, so further amplification may be needed for some 'scopes). The VCO output is passed to the Y input through the filter under test. This gives a display of output level against frequency, with the frequency decreasing from left to right. SW1 sets the frequency range of the display, and RV1 sets the scanning speed; it is adjusted to give a good display, and does not affect the actual shape of the display. As well as being simple this circuit is cheap, the 76477 only costing about £2. Q1 and Q2 are any NPN silicon transistors with a reasonable gain, for example BC108.



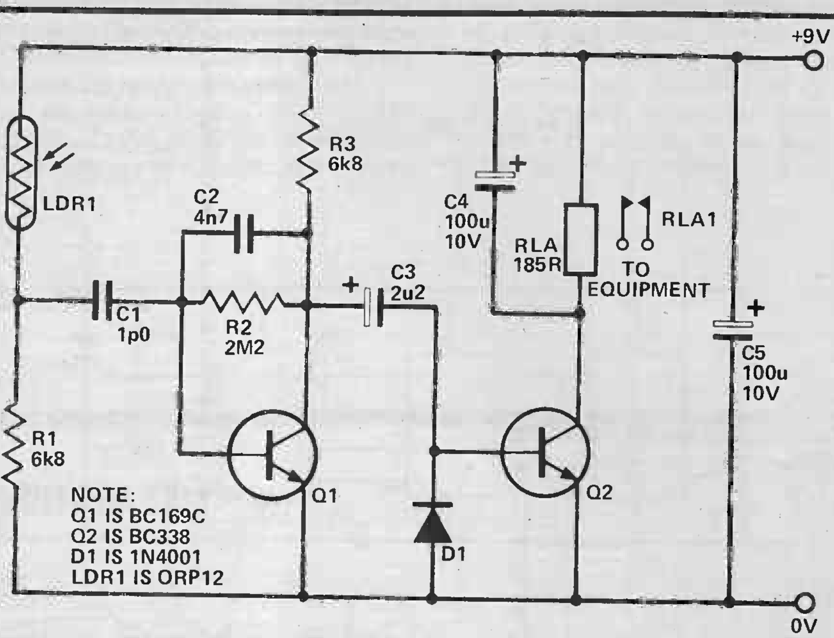
SPOT DESIGNS

Light-activated Switch

Most light-operated switches are designed to respond to the ambient light level so that some item of equipment is switched on or off at a certain light level. This circuit is somewhat different in that it is designed to respond to mains-powered lighting, rather than to some ambient light level. It could, for example, be used with a bedroom TV set, to automatically switch the set off when a bedside lamp was switched off. No doubt there are other applications for a circuit of this type.

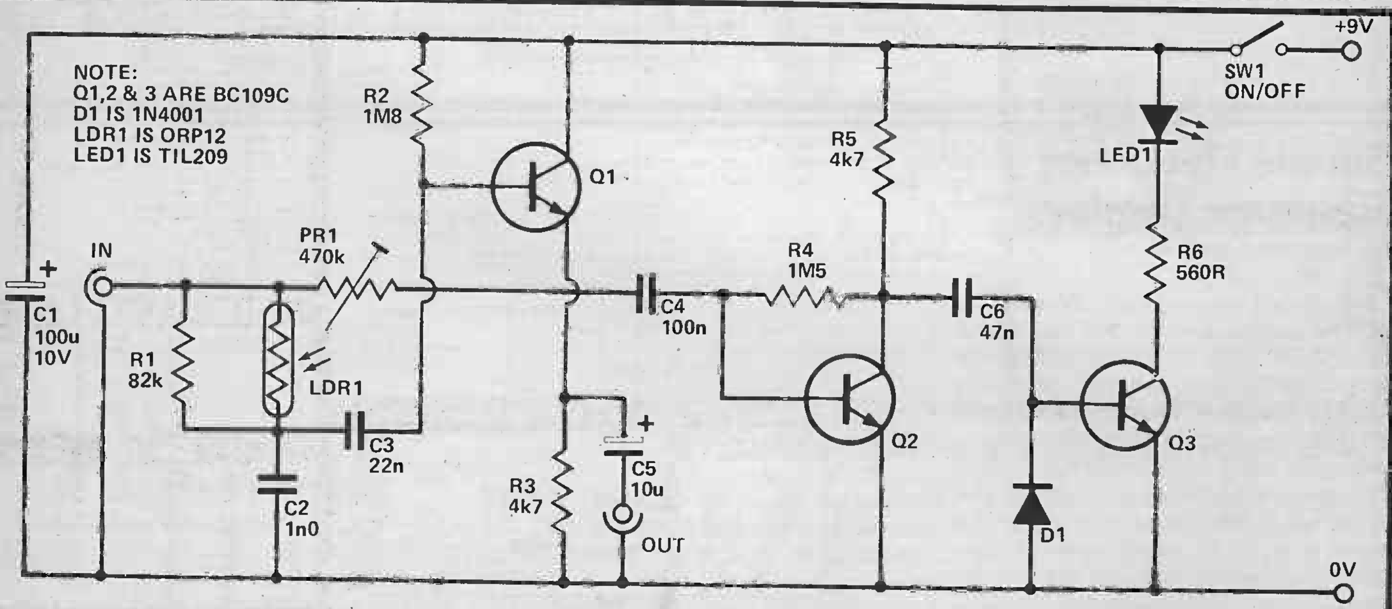
The difference between mains lighting and natural light which is exploited in this circuit is that mains lighting is modulated at the 50 Hz mains frequency whereas natural lighting is fairly stable. LDR1 and R1 are connected as a potential divider across the supply lines, and in the presence of natural lighting only, the output voltage from this network will change only gradually. On the other hand, mains lighting will vary in intensity at 50 Hz, causing the resistance of LDR1 to vary in sympathy and producing a 50 Hz output signal from the potential divider.

This signal is coupled by C1 to the input of a high gain common emitter amplifier which uses Q1 in a standard configuration. C2 reduces high frequency noise that could otherwise upset the operation of the unit. The amplified signal at Q1's collector is coupled by C3 to the base of Q2, and the latter is switched on by positive half-cycles.



This gives a series of pulses across the relay coil, and these are integrated by C4 so that the relay is closed continuously, not pulsed on and off. A normally-open relay contact is used to control the external equipment (or a normally-closed type if it is necessary for the controlled equipment to switch on when the mains lighting is switched off).

Avoid strong natural lighting on LDR1 as this will greatly reduce the sensitivity of the circuit.



Dynamic Noise Limiter

A dynamic noise limiter (DNL) is primarily intended for use with a cassette recorder to process the output when playing a cassette that has not been encoded by a noise reduction unit of some kind, and therefore gives a comparatively poor signal-to-noise ratio. The DNL gives a degree of treble cut at low signal levels, with a subsequent improvement in the signal-to-noise ratio. At higher signal levels the treble cut is gradually lifted, and is practically eliminated at the highest levels. This gives reduced signal-to-noise ratio, but this is not noticeable as the main signal masks the noise.

The parallel impedance of R1 and LDR1 together with C2 forms a low-pass filter. The output from this filter is taken to the output socket via emitter follower buffer stage Q1, and the high input impedance of this stage ensures that loading effects do not impede the performance of the filter.

Some of the input signal is coupled to the base of Q2 via PR1 and C4, and a greatly amplified signal appears at Q2's collector. This is coupled to the base of Q3 by C6, and Q3 will be switched on during positive signal peaks of suitably high amplitude. This causes LED1 to light up, and since it is directed at LDR1 (which should be shielded from the ambient light), the impedance of the latter falls. This reduces the high frequency attenuation of the filter and gives the required lifting of the treble cut at high signal levels. The fast attack and relatively slow decay times of LDR1 ensure that it responds to the average light output of LED1 and not to individual light pulses, so that the required circuit action and low distortion are obtained.

The unit will operate with input signal levels from about 50 mV RMS to over 1 V RMS, and it should therefore match the output signal of any cassette recorder or deck. PR1 is given the highest resistance setting that provides full treble lift at the peak signal level.

FM MAINS REMOTE CONTROL

Control your home without leaving the comfort of your armchair with this cunning system that sends instructions down the mains. Project development by Steven Ramsahadeo.

Remote control on a small scale is fairly simple to implement, these days — ETI has published many circuits on this topic. These have ranged from simple ultrasonic on/off switches, to 'dedicated' hard-wired systems such as the Beast train controller, to general purpose, multifunction infra-red devices. The disadvantages of these systems were that their use was restricted to one room, with the exception of the Beast; but then who wants to control model trains from another room?

Remote control over a reasonable distance needs a rethink about the methods available. Infra-red and ultrasound are both out; light only travels in straight lines, and an ultrasonic system that could operate throughout the house would need an impossibly powerful transmitter — even if you left all your doors open! Radio control is also out of the question, since it may only be lawfully used to operate models, not to mention the interference and bandwidth problems that would occur if everyone started using such a system.

It seems that the only choice left is to run lengths of cable to all the devices that need to be controlled, and use electrical control signals. All that money for expensive copper wire, all the work involved in laying the cable runs beneath floorboards and plaster, all the redecorating; this idea doesn't seem to have much going for it either.

Send A Cable

Fortunately, almost every home in the UK already has a suitable distribution system installed; the mains supply. This network links all the rooms in the house (and probably the shed and garage too), is hidden from sight and yet has access points exactly where you want them — at the appliances you wish to control. A single transmitter can be plugged in to a power socket anywhere in the house and superimpose control data onto the 50 Hz mains using radio frequency FM signals. These signals will be picked up by any receivers that are also connected to the mains, and after suitable decoding the selected appliance can be made to turn on or off.

Such a system was first discussed in our House Wiring feature in the June 80 ETI. At that time we postulated a six bit data word that could address any one of the 16 different devices and convey up to four different instructions; RF filters (with a suitable voltage/current rating) were to be fitted in the feeder lines to the house wiring to prevent interaction with a neighbour's system.

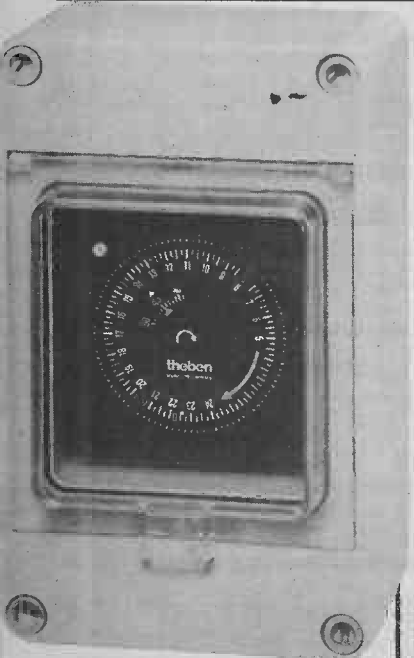
The design presented here takes a somewhat different approach. Suitable inductors for the filter network are not available, so the interference problem has been tackled by using a nine bit data word. Four bits define one of 16 system or house codes, with each house in a street on the same mains phase choosing a different code. Another four bits define one of 16 appliances, with the final bit being the on/off command. Your receiver modules are all set to the same house code, but different appliance codes; thus you can switch appliances individually but not trigger receivers in neighbouring houses.

Pressing Matters

In general, two key closures are required to send an instruction with this system. First press and release the key corresponding to the appliance you wish to control, then press either the on or off key. After a quarter of a second or so (the time taken to transmit the complete data word plus its synchronisation bits), the relay in the chosen unit will change state, operating the microswitch. The system of mains switching has been chosen to provide isolation, and the SW1/RLA assemblies will be made available by the kit supplier (see Buylines). Naturally the number of bits means that data must be transmitted serially, and the system requires information to be latched, combined into a single data word, synchronised to the mains zero-crossing points . . . . a lot of circuitry which results in the use of the ubiquitous chip, in this case two custom-designed ICs which will only be available from the source mentioned in Buylines.

Once latched into one or other state, the receivers will not switch over unless they receive a specific

DIGEST



Cover Up!

Smiths Industries Time Controls, manufacturers of time switches, are introducing a special protective cover for their 'European' range of products. The new cover is made of a resilient waterproof combination of metal and plastic, and is designed to be mounted integrally to the 'European' time switch models without either adhesives or major installation requirements. It has been developed as a protective device, thus making the time switch range equally suitable for both interior and external, home or commercial use. The tough plastic will not only protect the time switch from inadvertent knocks but will also keep it waterproof in situations like exterior walls. The cover also has a sealing arrangement to prevent the setting being tampered with, particularly by children, although it is not difficult to remove when time adjustments need to be made. The European time switches are very popular and feature quartz driven motor and battery reserve which allows for up to 150 hours of supplementary power in the event of power failure. Sixty minute, 24 hour and 7 day versions are available. The cover will fit any of the range and is available from leading electrical appliance outlets and wholesalers throughout the UK. Prices for the timeswitches themselves vary from £11.81 to £35. Smiths Industries Time Controls, Waterloo Road, Cricklewood, London NW2 7UR.

Elementary My Dear Watson

As many education authorities are now allowing and even encouraging the use of calculators, Casio are attempting to help bridge the gap for youngsters between using the simple four-function calculator and its scientific counterpart. They have launched two models which they describe as 'elementary' — the FX5 and the FX7. The FX5 has a 'scientific' layout giving access to fractions, roots, pi, percentages, square, reciprocal, change-sign, parenthesis (three levels) and independent memory. The FX7 also incorporates sine, cos, tan and log functions, while introducing the concept of exponents. There is an LCD display on both models and batteries are the readily available AA size. The recommended prices are: FX5 £10.95, FX7 £12.95 and they should be available from any Casio dealer, but in case of difficulty contact Casio Electronics Co Ltd, 28 Scrutton Street, London EC2A 4TY.

Something In The Air

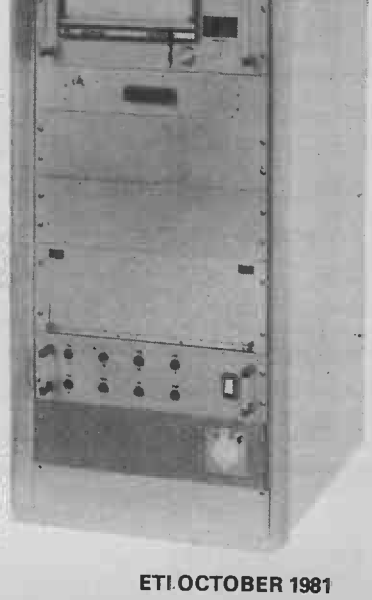
In recent years it has become necessary to monitor precisely the meteorological environment around nuclear power stations, and to this end Frazer-Nash of Hersham, Surrey, has supplied several sets of windspeed and direction monitoring equipment to the Central Electricity Generating Board, including the recent commissioning of a wind monitoring system at the Wylfa Power Station in North Wales. The MK 5B system installed there uses advanced digital and analogue techniques to process the signals from windspeed and direction sensors, mounted at different heights on a remotely sited tower. Signals from the sensors, displayed at the remote site on a meter panel are transmitted to the main electronics cabinet in the Power Station Administrative Building. A second cabinet is for lightning protection and has self-test facilities which allow system testing from the tower site or from the cabinet itself. The wind systems are manufactured to licensed designs of the British Meteorological Office and can be used to upgrade earlier Met Office approved systems. MK 5B systems are designed to use lightweight cables over long distances from the sensors, thus reducing installation and maintenance costs. Telemetry can be supplied to transmit readings via standard PO telephone lines or radio links. For further details of wind monitoring systems contact Frazer-Nash (Electronics) Ltd, The Old Forge, Pleasant Place, Hersham, Walton-on-Thames, Surrey.

TV Game Comeback

TV games are currently having an incredible resurge of popularity in this country after a massive drop in demand over the past few years. Hong Kong's TV games shipments to Britain have risen by 260% in the first quarter of this year, effectively making us their biggest market — even overtaking West Germany, the former largest market. Exports to the third largest market, the USA, also rose by 1,047%, thus giving a total export rise for Hong Kong of 112%.

Disc Shooting

Thorn EMI Video Programmes Ltd has now begun to commission programme material purpose-made for the new VHD Videodisc System. Among the first productions to be launched in June 1982 will be 'Great British Fishing' which features the well-known footballer and amateur angler Jack Charlton. The material is designed to exploit the data retrieval facilities offered by the VHD system. The fishing programme runs for two hours and covers several angling locations including coarse, game and sea fishing, all under the expert guidance of Chris Dawn, Features Editor of 'Angling Times'. The programme will also include a 'data section' — individual frames of information, accessible at the touch of a button, to provide background knowledge of each location featured, details of local accommodation, fishing rights, travel guides and information on other local attractions, tackle suppliers, local angling records and so on.



command or are disconnected from the mains (receivers always assume the off state on power-up). This means you can unplug the transmitter to move it around the house without upsetting any of the slave modules. Using a switched 13 A socket (the switch being wired in parallel with the microswitch) allows manual override of the slave module.

Some RFI may be picked up on radios during operation of the transmitter but this only lasts for the duration of the keypress and will cause no problems.

Construction

Construction of the transmitter should present few problems. The PCBs are specifically designed to fit in a small hand-held enclosure (see Buylines). The case comes apart in two sections; the keypad is fixed in the top half and the control circuit in the other half. These are connected with a short length of ribbon cable and two 14-way header plugs terminated at each end.

We recommend the use of our PCBs, especially for the keypad which is a double-sided board.

Start construction by assembling the 18 push-buttons and LED1 on the top side of the PCB (side A). The 14 pin header socket is mounted on the opposite side and is soldered approximately 2 mm above the surface of the board, allowing just enough space to solder the tracks on this side. Note that wherever corresponding tracks are found above and below a pad, both sides should be soldered to complete the connection. When the keypad is built make a visual check for any solder bridges or dry joints; if all is well you can begin construction of the control circuit. Assemble all components according to the overlay, observing the orientation of the semiconductor devices and electrolytic capacitor. There are two points to note here; C3 is bent at right angles to lie flat on the PCB (as shown by the photographs), and rubber or PVC sleeving should be used to insulate the mains connection on the PCB.

As there is very little height available the best way of securing the control circuit PCB is by double-sided sticky pads. To give a professional appearance a grid can be cut out from a self-adhesive aluminium sheet to match the keypad, which can then be stuck to the front of the case. The keypad is held in place by a few drops of Superglue at each corner. When doing this it is worth checking that there is adequate clearance between the header socket and C3. *This step*

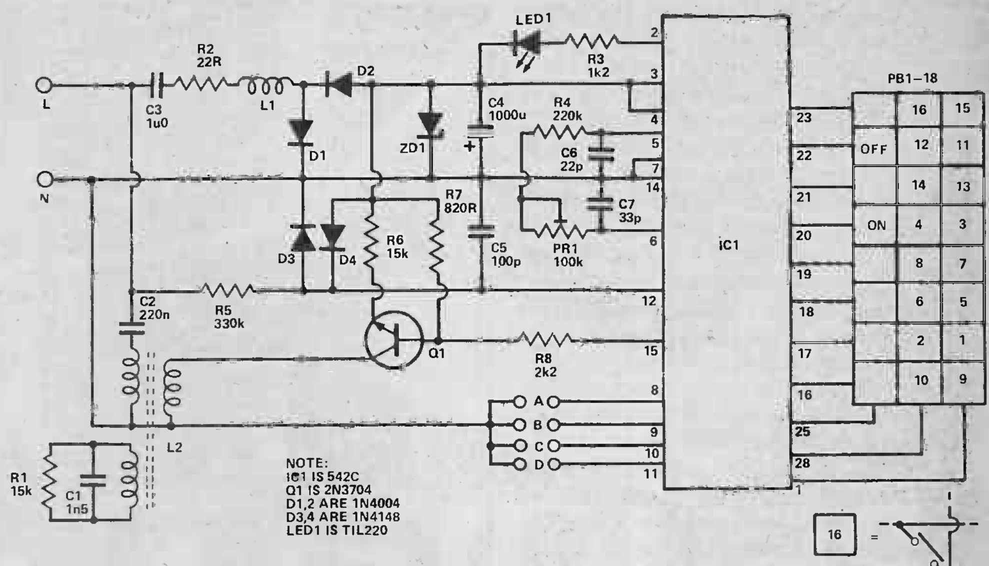


Fig. 1 Circuit diagram of the transmitter.

HOW IT WORKS

TRANSMITTER

The transmitter is built round a customised IC with 16 system codes (selectable by wire links to pins 8-11) and a separate code for addressing up to 16 remote slave modules in your home or office. The system codes are necessary to allow you to switch lights or appliances attached to the slave modules on or off without activating slave modules being operated by neighbours.

The keyboard matrix is scanned at 3.8 kHz; when a key is pressed its code is combined with the system code. Multiple key connection is controlled by the IC. The single digital message is then sent to the transmitter section which generates 120 kHz signals to pulse-position modulate the AC line. The digital code serial output has to be synchronised to the 50 Hz AC signal, so the chip incorporates a zero-crossing detector. The message, now synchronous with the mains waveform, is clocked a bit at a time on the zero crossing of the wave. It contains nine bits of information; a four bit system code and a five bit matrix (keyboard function) code. Each message is transmitted in true and in inverted form on successive half-cycles of the AC waveform. A logic 1 bit consists of three 1 ms bursts of 120 kHz signal at 200 us after the zero crossing of each phase. A logic 0 bit is indicated by no signal for that half-cycle. To synchronise the receivers with the transmitter a trigger code of three successive logic 1 bits followed by a logic 0 bit is used. The complete message takes 11 full AC cycles (220 ms) to complete.

The line attachment is made by a transformer (L2) and capacitive coupler (C2). The transmission can range down the wiring on the domestic side of your electrical system and is bounded by the Electricity Board's transformer. This gives the possibility of controlling slave modules in a number of houses as there can be six or seven on each transformer — hence the system or house code.

The power supply for the circuit comes from C3, R2 and L1 all in series. The mains is rectified negatively by D2, with shunt diode D1 providing DC restoration. The supply voltage, regulated by ZD1, is stored on C4. The timing signal is limited by R5; it is clamped in the positive direction by D4 connected to the common line, and in the negative direction by D3 connected to the negative side of the power supply. This produces an 18 V square wave. C5 is provided to eliminate high frequencies from this section, such as the 120 kHz transmissions.

C2 isolates one side of the transmitter coil from the mains and thereby allows the coil to produce signals across the mains. Q1 provides the drive signals; R7 and R8 set the drive level to the transistor, while emitter resistor R6 provides stabilisation. The oscillator components are R4-C6-C7-PR1, the latter component setting the frequency.

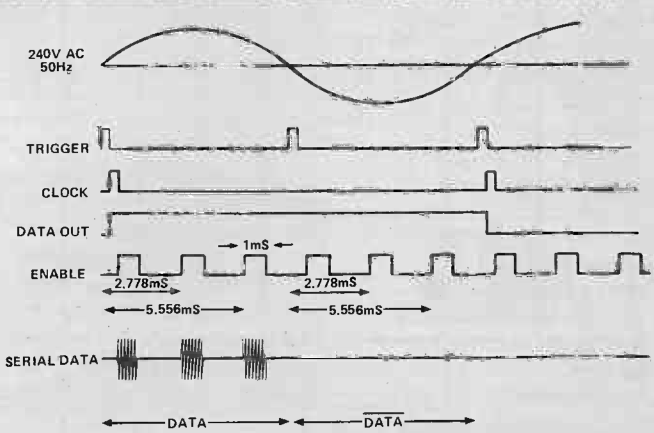


Fig. 2 The timing diagram for the transmitter signals.

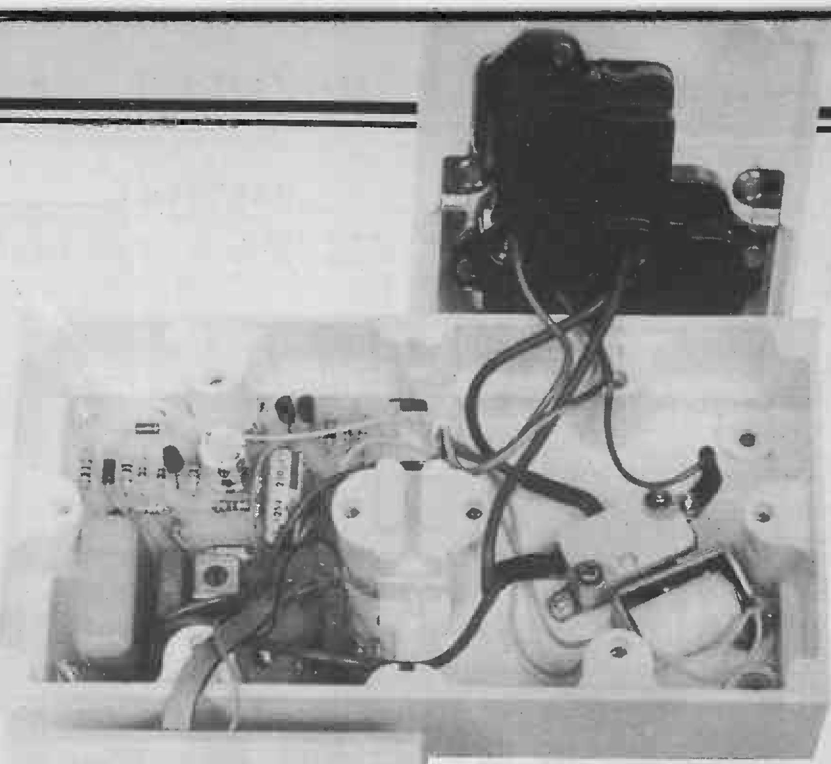
should only be done when the system has been fully tested.

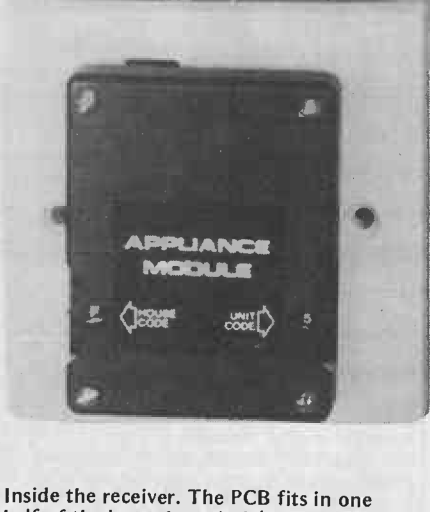
The most practical method of housing the receiver unit is in an MK double surface-mounting box (see Buylines). This particular box accepts two single 13 A sockets (only one used) enabling the PCB to fit in the left side and the switch mechanism on the right beneath the 13 A output socket.

No problems should be encountered in constructing the receiver PCB provided you follow the same precautions as for the transmitter. The board is mounted on three ¼" spacers. The mains lead can be passed through any one of the 'knockouts' located around the edge of the box. Heavy gauge wire (ie 13/0.2) should be used to connect the switch mechanism and the 13 A output socket.

The appliance module, which is supplied as a ready built unit, is fixed on the blanking plate. The connections are passed through a small hole and terminated at the points indicated on the receiver PCB.

Setting up the system is a matter of adjusting the presets in the transmitter and receiver so that the frequency of the clock oscillator is 120 kHz. Range of the system should be good enough for any practical purposes — the prototype unit was able to consistently switch a light on and off when the transmitter was in a bedroom and the receiver was in a shed at the end of a 100' garden.





Inside the receiver. The PCB fits in one half of the box, the switch/relay mechanism in the other.

CODE	A	B	C	D
A	X			X
B	X			
C	X		X	X
D	X		X	
E		X	X	X
F		X	X	
G		X		X
H		X		
I				X
J				
K			X	X
L			X	
M	X	X	X	X
N	X	X	X	
O	X	X		X
P	X	X		

Fig. 3 System code selection table. X means insert a link on the transmitter board (Fig. 6).

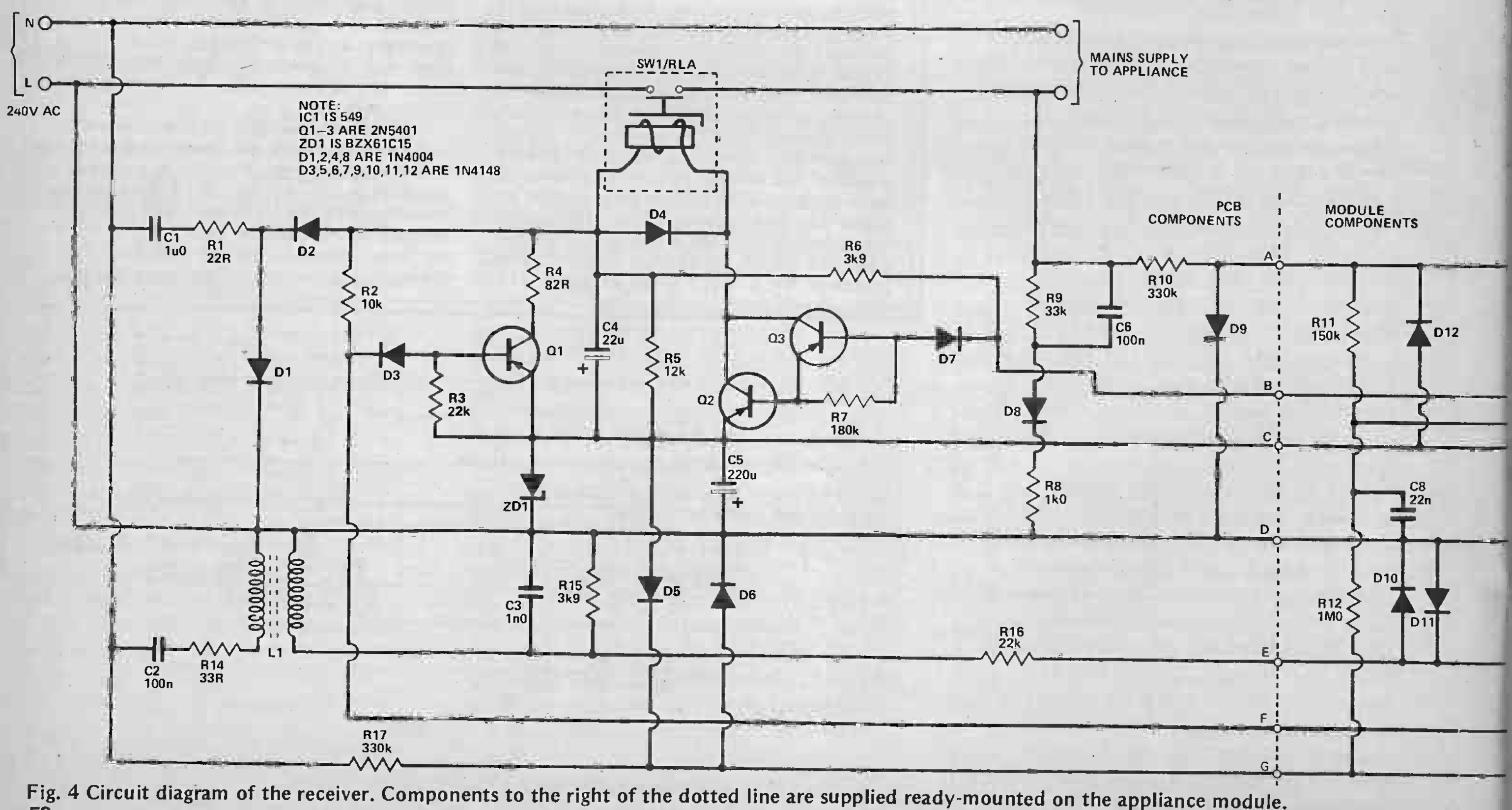
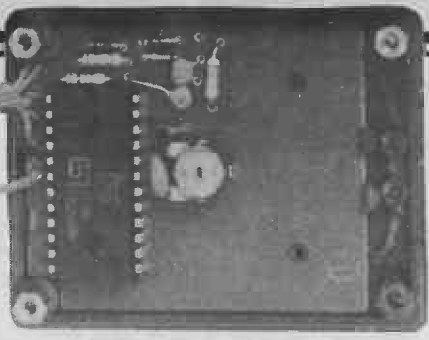


Fig. 4 Circuit diagram of the receiver. Components to the right of the dotted line are supplied ready-mounted on the appliance module.



HOW IT WORKS

RECEIVER

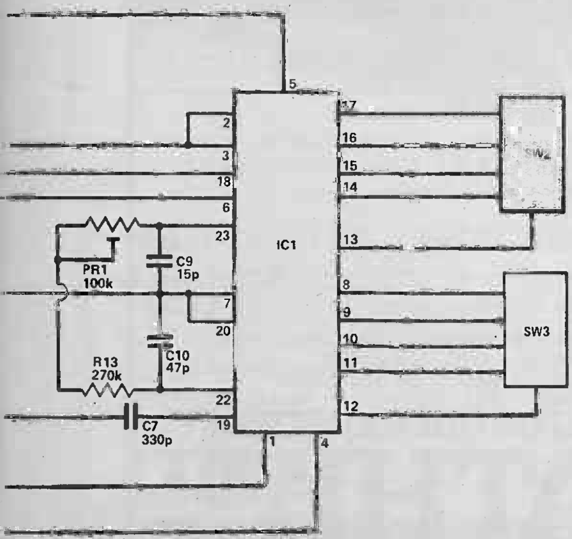
As with the transmitter, a tuned circuit is connected across the mains; signals are picked up by L1 via R14 and mains isolation capacitor C2. The coil is tuned by C3 and R15; its output is clipped by D10,11 and capacitively coupled by C7 into the receiver chip (IC1). Once again synchronisation to the mains is provided by a resistor (R17), the signal being clamped to the 15 V negative supply and the common line by D5 and D6 respectively. The oscillator components are R13-C9-C10-PR1.

Two rotary hexadecimal switches code the receiver in the same way as the transmitter — SW2 selects the channel number and SW3 the device number.

The power supply is similar to that of the transmitter. D2 rectifies the mains with D1 providing the shunt path for R1-C1. Normally Q1 is turned on and connects the very negative supply section (ie D2 anode) to C1 and ZD1, which smooth and regulate the supply to the IC. The Darlington pair Q2-Q3 are turned off, and hence RLA is off and no power is supplied to the appliance via SW1. R5 ensures that C4 is discharged.

When IC1 detects a valid 'turn-on' signal, it momentarily switches the control line to the base of Q1 high, turning the transistor off. This action rapidly charges C4; shortly afterwards IC1 switches on the Q2-Q3 Darlington, so that RLA is connected between the regulated and unregulated supply rails and turns on. C4 discharges rapidly through the relay and the Darlington, giving a switch-on boost that makes sure the relay pulls in. SW1 is now closed and the load is energised. A 'turn-off' signal causes IC1 to switch off the Darlington, cutting the drive to the relay — D4 is connected across the relay to suppress voltage spikes.

R8-R9-C6-D8 provide a low impedance supply to the positive side of C1-ZD1 when SW1 is closed, to help hold the relay in. R10 feeds a clipper circuit that senses when the switch is closed or the socket has a load in it.



PARTS LIST

TRANSMITTER

Resistors (all ¼ W, 5% except where stated)

R1,6	15k
R2	22R ½ W
R3	1k2
R4	220k
R5	330k
R7	820R
R8	2k2

Potentiometer

PR1	100k miniature horizontal preset

Capacitors

C1	1n5 polystyrene
C2	220n 250 V AC polyester
C3	1u0 400 V radial polyester
C4	1000u 25 V axial electrolytic
C5	100p ceramic
C6	22p ceramic
C7	33p ceramic

Semiconductors

IC1	542C
Q1	2N3704
D1,2	1N4004
D3,4	1N4148
LED1	TIL220

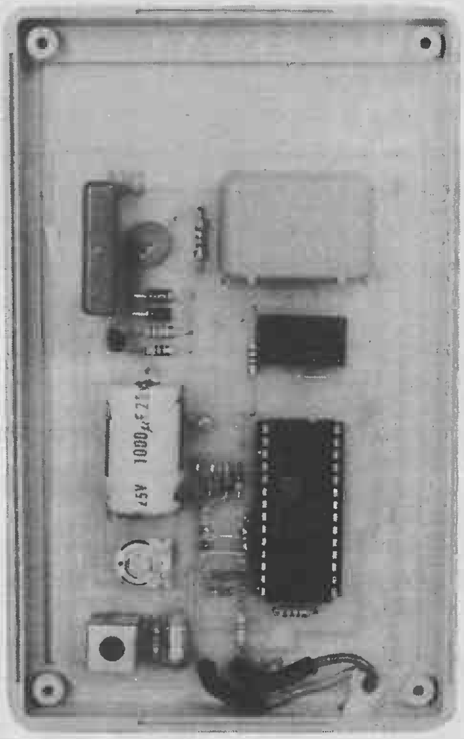
Miscellaneous

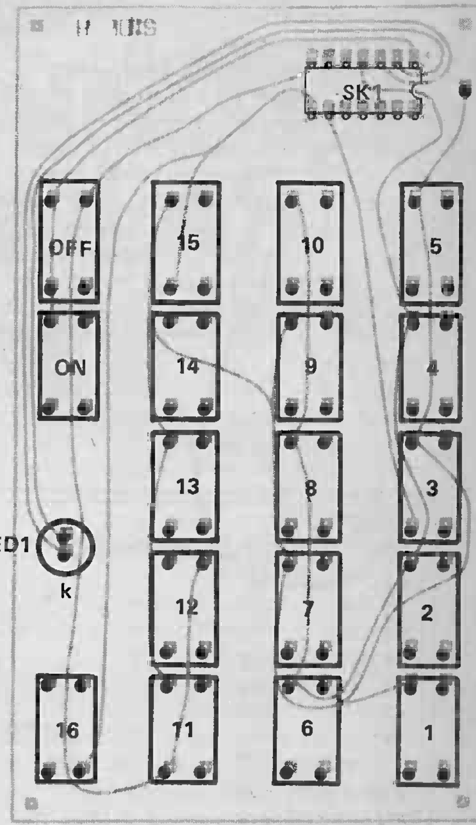
PB1-18	push-button switches
L1	150uH
L2	Toko 1A1011

14 pin DIL plug (one off); ribbon cable; case.

BUYLINES

A kit of parts for the FM Mains Remote Control System is available from Rockway Ltd, 1 Station Road, Twickenham, Middlesex TW1 4LL (telephone 01-892 7044). The kit contains one transmitter unit and two receiver units and costs £99 plus VAT and carriage. The receiver units will also be available separately.





NOTE:
k = CATHODE
● = THROUGH—BOARD LINK

Fig. 5 Overlay for the keypad. Note that SK1 is mounted underneath the board, and that all component pins are soldered on both sides of the double-sided board.

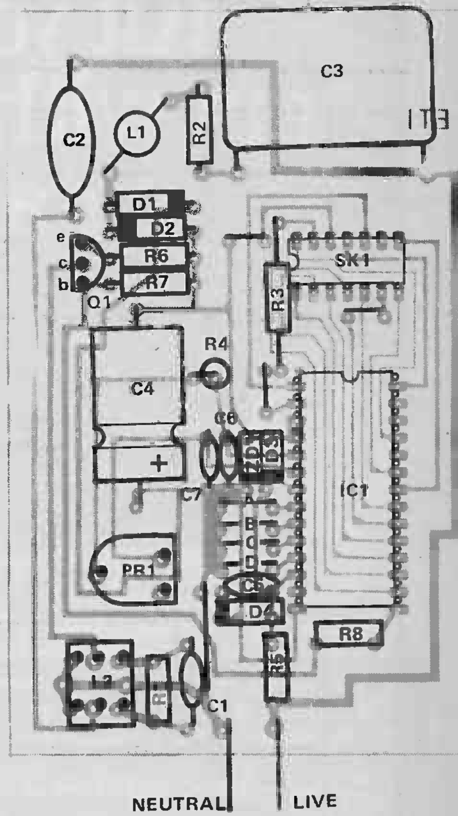


Fig. 6 Overlay for the transmitter board. Make links A,B,C,D as shown in Fig. 3.

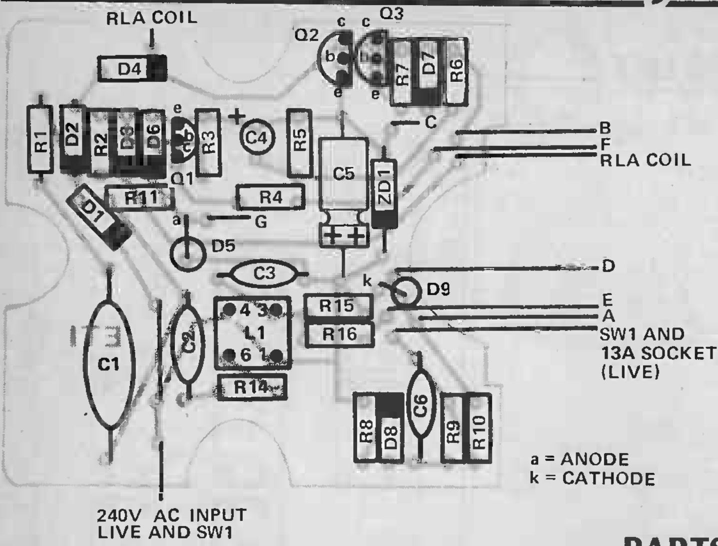


Fig. 7 (Left) Component overlay for the receiver board. The lettered connections are made with ribbon cable to the appliance module – see Fig. 8.

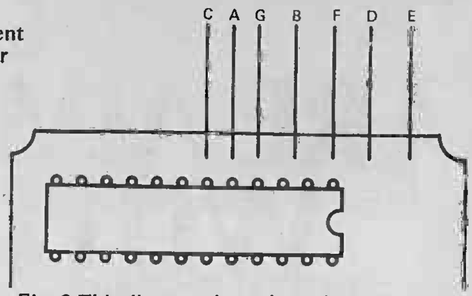


Fig. 8 This diagram shows how the ribbon cable connections are made to the ready-built module.

ETI

PARTS LIST

RECEIVER

Resistors (all ¼ W, 5% except where stated)

R1	22R ½ W
R2	10k
R3,16	22k
R4	82R ½ W
R5	12k
R6,15	3k9
R7	180k
R8	1k0
R9	33k
R10,17	330k
R11*	150k
R12*	1M0
R13*	270k
R14	33R

Potentiometer

PR1*	100k miniature horizontal preset

Capacitors

C1	1u0 400 V radial polyester
C2	100n 250 V AC polyester
C3	1n0 polystyrene
C4	22u 63 V PCB electrolytic
C5	220u 25 V axial electrolytic
C6	100n 250 V AC polyester
C7*	330p ceramic
C8*	22n ceramic
C9*	15p ceramic
C10*	47p ceramic

Semiconductors

IC1*	549
Q1,2,3	2N5401
ZD1	BZX61C15
D1,2,4,8	1N4004
D3,5,6,7,-9,10*,11*,12*	1N4148

Miscellaneous

SW1/RLA	Switch mechanism (see text)
L1	Toko 1A1010
SW2,3*	Hexadecimal coded switches

14 pin DIL plug (one off); MK double surface-mounting plastic box ref. 2025 (one off); single 13 A switched socket (one off); single blanking plate (one off).

*Items marked with an asterisk are supplied ready-mounted on the receiver module supplied in the kit.

ENGINEER'S GUIDE TO BASIC

Despite the various alternatives, BASIC is still the most universally accepted programming language; unfortunately there are almost as many dialects as there are machines. This new series by Stewart Fleming will help you pick your way through the programming jungle.

The purpose of this series of articles is two-fold: to provide the reader with a detailed introduction to the BASIC language (where we will look at the syntax or 'grammar' of the language and illustrate this with lots of interesting applications); and to provide a reference manual of the differences between the versions of BASIC as offered by some of the better-known microcomputer manufacturers together with an indication of the capabilities and limitations of the hardware concerned.

The reader will therefore be able to use this manual:

- to learn BASIC
- to help him decide which BASIC (and possibly which equipment) is most suitable for his proposed application. Thus we hope the articles will be particularly helpful to the first-time microcomputer buyer.
- as an aid in implementing on one machine a BASIC program which has been written for another machine.

Using The Articles

We hope then that this introduction to BASIC will be useful both to the absolute beginner and also to the more advanced programmer. Very little prior knowledge will be assumed of the reader and we will explain any technical terms as we go along.

The articles can be treated as a complete course in BASIC: they will cover all the important features of the language in a simple and concise way. Alternatively they can be used as a reference manual. We have included a section on the general principles of computer operation, and, if you are completely new to computing, it is suggested that you read this first — so that you will understand some of the 'whys' as well as the 'hows' of BASIC programming.

Finally we hope that the applications described will be both interesting and helpful and will be useful to you as models on which to base your own applications. Perhaps you will also be encouraged to come up with your own more elegant and efficient solutions (there will be a short section on programming 'style' and structured programming later on).

The best way to learn BASIC programming is by doing it! If at all possible, get hold of a microcomputer, and work through the illustrations and examples yourself on the computer. By the time you've got to the end of the series you should have a really good grasp of the BASIC language and of its potential applications.

Computer Operation

The way in which microcomputers and most minicomputers are organised (their 'architecture') is different from the organisation of the large computers ('mainframe' computers as they are called). This is partly because of differences in the way the main functional units of the computer (the CPU, memory and the peripherals together with their interface units) are constructed and used and partly because of differences in the way these items are connected together using sets of communicating wires known as 'highways' or 'buses'. The statements which follow concerning microcomputers will therefore not all necessarily be true of the large computers (although the general principles of computer operation will still apply).

Figure 1 is a block diagram showing the main features of a microcomputer. The MPU (Microprocessor Unit) may be further subdivided into functional components as shown in Fig. 2.

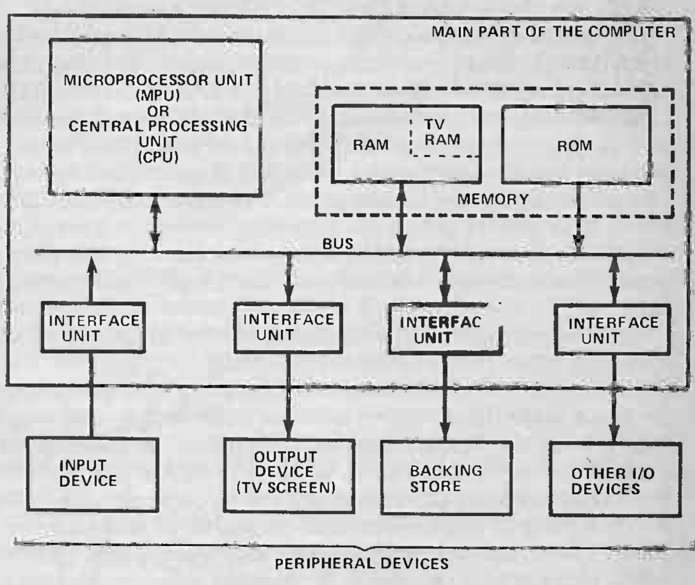


Fig. 1 Block diagram showing the hardware of a microcomputer.

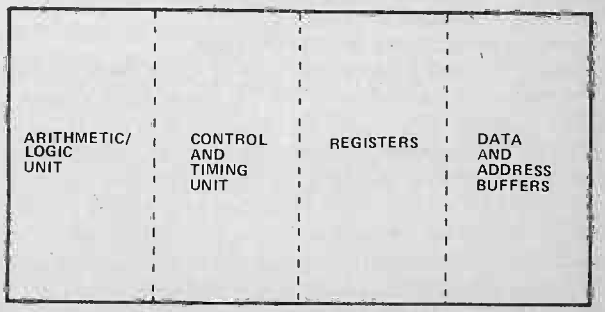


Fig. 2 The functional elements contained in the block marked Microprocessor Unit in Fig. 1.

Programs And Data

The purpose of a computer is to carry out instructions or operations on data that has usually been entered via an input device, and to communicate the results produced to the outside world. A variety of different instructions (the instruction set) will be available and by arranging for a sequence of instructions to be obeyed, or 'executed', one after the other, the computer may be used to perform tasks as diverse as the solution of a complicated mathematical equation and the control of the lighting and heating of a house. A set of instructions to perform a particular task is called a computer program. In all computing, therefore, there are just two types of items that are stored and used within the computer. These are:

- program instructions
- the data which the program instructions are to use.

With this in mind, we can now describe briefly the components of a microcomputer.

Down Memory Lane

Both program instructions and data are stored in the computer's memory. Actually, the very first computers that stored their program instructions internally — EDSAC and EDVAC (1943-1944) kept their instructions and data in separate memory areas — the so-called 'Harvard' architecture — but this was quickly replaced by the idea of a 'shared' memory introduced in 1945 by John von Neumann.

The computer's memory consists of locations, each of which can hold either a program instruction or an item of data (or part of an instruction or item of data). Each of these locations has a unique address — a number used to identify a particular location. Thus, if we have a 32K store ($1K = 2^{10} = 1024$) the addresses may be 0 to 32767. Memory comes in two types: ROM (Read Only Memory) and RAM (Random Access Memory).

We may deposit any valid instruction or data item into a RAM location (this is known as writing to memory), or we may get a copy of the information stored in a RAM location (this is called reading from memory). By contrast, ROM can be used only for the reading operation. ROM is used to hold instructions and data that are a permanent feature of the computer system. This information can be accessed but never altered. ROM holds, among other things, the 'operating system' — a program which is permanently resident within the computer, and which controls the running of the computer and certain fixed items of data.

In the context of microprocessors, the functions of an operating system will include the following:

- control over the selection and operating of input/output devices and file handling (this includes screen editing and interfacing with the screen control electronics and keyboard decoder)
- provision of error correction routines
- the calling of subroutines and programs as and when required. (Note that with some microcomputers, eg the PET, the BASIC interpreter is permanently stored in memory; in others, such as the Research Machines 380Z, the compiler has to be loaded by the operating system under user control)
- sending messages to the user
- obeying instructions sent by the user.

There is often a particular area of RAM dedicated for use by the main output device — the TV screen (also known as the CRT — Cathode Ray Tube). Each location in the TV, or video, RAM is associated with a particular part of the screen. This is an example of memory mapping. By altering the data items stored in the video RAM, different characters or graphics symbols are made to appear on the screen. The actual conversion of data in the video RAM to screen information is accomplished using the TV control electronics (which in some microcomputers works independently of the rest of the microcomputer) and which has been represented as an interface unit in Fig. 1. The control electronics actually accesses an area of ROM containing coded information needed to represent each of the different characters and symbols on the TV screen.

Processor Processes

The Central Processing Unit (CPU) is the part of the computer that takes the program instructions from store and obeys (or 'executes') them. Once an instruction has been obeyed, the CPU fetches the next instruction from store and executes that. Program instructions can be broadly classified as follows:

Load/Store These instructions transfer data from registers within the CPU to the memory and vice versa. (A register is an electronic device capable of storing an item of data — the glossary will give a more precise definition.) This family of instructions will also include those that move data between CPU registers, or put particular items of data into CPU registers.

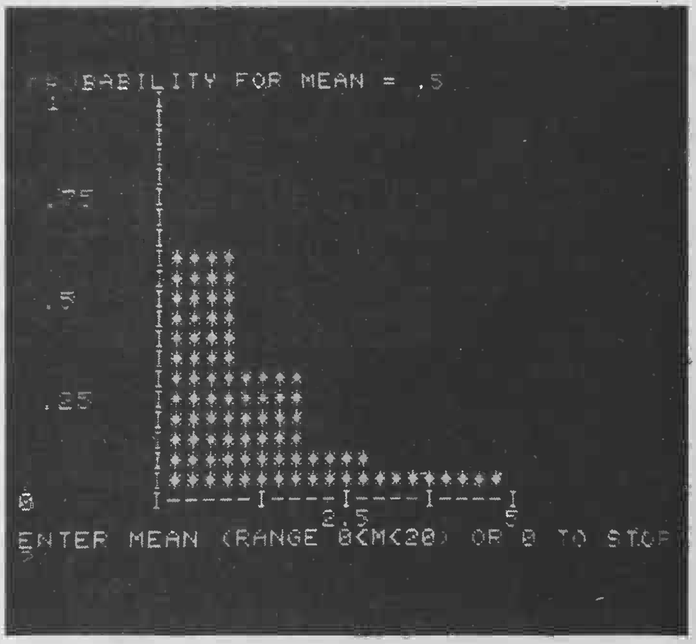
Arithmetic/Logical/Shift These instructions perform operations on data held in registers within the CPU and in memory locations. A typical operation would be the addition of two numbers, one of which is assumed to be in a special CPU register called the Accumulator, the other number being in the memory address specified in the instruction. The result of the addition is put back into the accumulator. The Arithmetic/Logic Unit (ALU) carries out these operations.

Jump/Branch These are instructions to alter the normal sequence in which program instructions are executed.

Input/Output These instructions handle the input of information from peripherals and the output to peripherals.

The CPU, then, actually covers quite a lot of separate items. It includes the Control Unit (the part which actually fetches instructions from memory), decodes the instruction (decides which separate operations have to be carried out in order to obey the instruction), and sends the appropriate signals to the different parts of the computer. (The term 'microprogramming' — a method used by some control units to generate these signals — has absolutely no connection with the subject of this series which is the programming of microcomputers!) The process of fetching and executing program instructions is, in fact, all that computers ever do.

As already mentioned, the CPU also has electronic circuitry known as the Arithmetic Logic Unit where arithmetic and



The program listed in Fig. 5 plots the Poisson distribution and gives this result on the screen of a PET computer. For a mean of 0.5 the graph peaks close to the y-axis at a fairly high value. . .

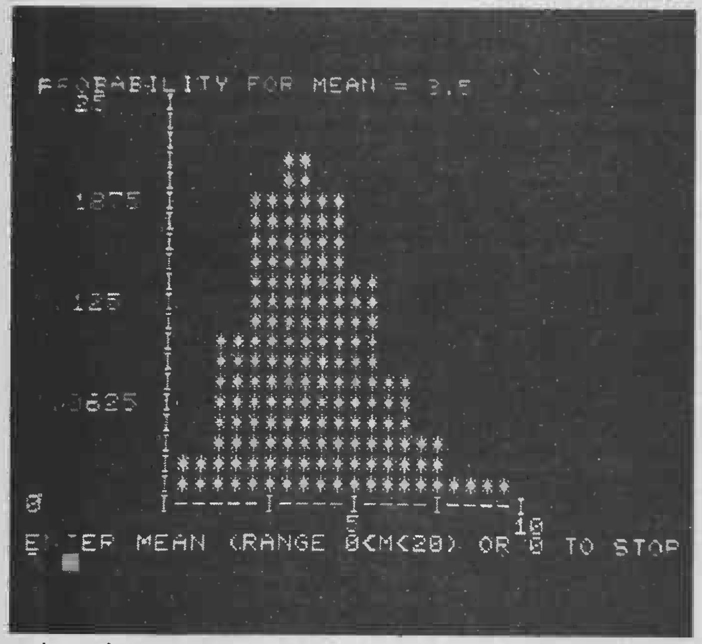
other operations on data are carried out. Another component of the CPU is the series of registers — internal memory locations which may be quickly accessed, and which are used to contain data and addresses which are needed by the CPU. The data and address buffers indicated in Fig. 2 are used to hold data 'in transit' between the CPU and the external memory address stored in the buffer.

Finally, in Fig. 2 the timer has been included as part of the CPU. The function of the timer is to send a steady stream of voltage pulses to the rest of the CPU and to other devices also. These pulses are used for controlling the timing of computer operations.

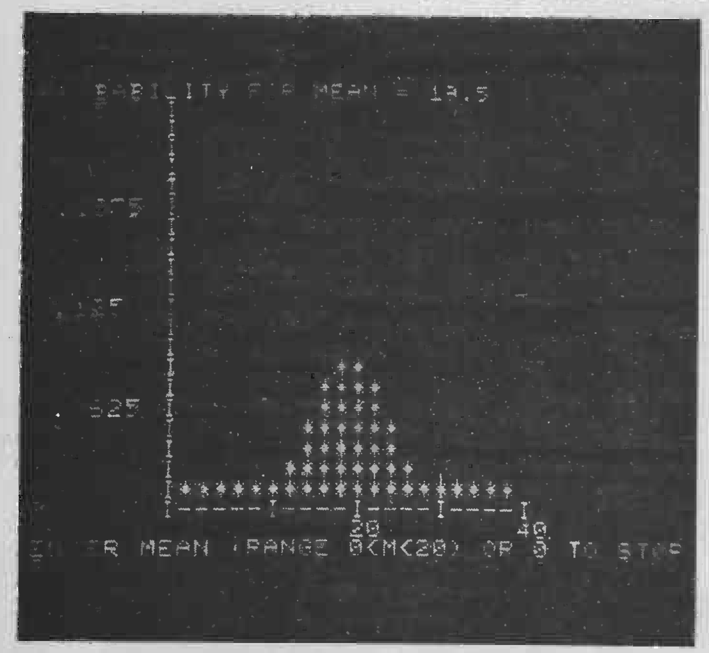
On The Periphery

A peripheral is any external device connected up to the main part of the computer. (The computer here is taken to consist of the CPU, memory and any interface units). Examples are the keyboard, TV screen, floppy disc drive, cassette, graph plotter, strain gauge, light dimmer, robot and so on. The connection between peripheral and computer is normally via an interface unit. The purpose of the interface unit is to act as a 'go-between', thereby ensuring that the voltage levels and the form in which data is represented in the peripheral can be made compatible with those of the computer. Standards for interface units have been set; the RS-232-C, IEEE-488 and the self-styled Centronics interface are some examples.

Fig. 3 BASIC or other high level program instructions cannot be executed until they are compiled or interpreted into a form the MPU can understand — machine code.



. . . but as the mean increases (here it's 3.5), the peak shifts towards the right and its value decreases, the axis scales automatically changing to suit . . .



. . . until at a mean of 19.5 this squat symmetrical shape is obtained. Once again the x and y scales have 'auto-ranged' their values to accommodate the graph in the screen area.

Bus Conductors

The bus is a set of wires connecting all the components of the microcomputer, together with the rules about which wire is to carry which item of information. Some wires carry data, some carry addresses (or locations) and some carry control information (eg indicating whether the CPU is reading or writing the data item).

Storage

The programs that we have been talking about so far are nothing like BASIC or FORTRAN or the other 'English-like' languages. They are in machine code — ie the instructions are stored in locations consisting of eight or 16 electronic 'switches' that are either on or off. This sequence of on or off switches can be represented to us as '1s' and '0s' — a 1 corresponding to on and 0 corresponding to off. Each instruction will have its own unique pattern of 0s and 1s. The individual 0s and 1s are bits and a collection of eight bits is a byte.

Similarly, data is stored as a set of bits — normally one byte per character. Thus the number '3' and the letter 'A' will both have their own code or bit-pattern. Copies of these bit-patterns can be moved from one register or memory location to another under the control of the CPU regardless of whether the pattern represents program instructions or data. When an instruction is to be obeyed, it is read from its location in memory into a register in the Control Unit. The Control Unit then decodes the pattern of 0s and 1s in this register and takes the appropriate actions as already described — thereby executing the instruction.

High-Level Languages

We have seen that there are only two types of item — program instructions and data. A set of program instructions consisting of 0s and 1s is a machine code program. These are the only programs that are ever executed.

A high-level program, such as a BASIC program, will never actually be executed by the computer. It will be used as data by a special machine code program called a compiler or an interpreter which produces, as output, corresponding machine code instructions which will be stored away (in RAM or on an external storage device) and may be subsequently run or executed.

The difference between a compiler and an interpreter is that the compiler converts the high-level language program into machine code all in one go, whereas the interpreter converts high-level language instructions to machine code one at a time as the program is being executed. The versions of BASIC that we will be looking at are all interpreted.

BASIC instructions are stored over several bytes. The details vary from microcomputer to microcomputer, but Fig. 4 is representative. The compressed BASIC text uses 'tokens' to represent keywords, eg "?" means "PRINT". The link contains an address used by the interpreter in the sequencing of program instructions; it indicates where to find the start of the next line of BASIC text.

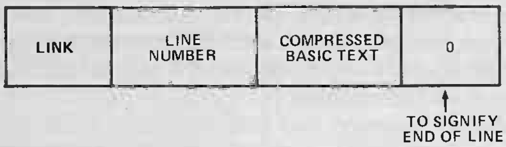


Fig. 4 BASIC programs are generally stored in the microcomputer memory in a form such as this.

For each BASIC instruction, a series of machine-code instructions — known as a subroutine — will be executed. Once these instructions have been obeyed, the next BASIC instruction is interpreted. BASIC, when interpreted rather than compiled, takes longer to execute, but the program can be stored in less memory.

Commands And Statements

Basic instructions are of two types: commands and statements. Commands specify some action which is to be performed on a program; eg the execution of the program or the listing of program statements. Statements specify operations to be performed by the program, or provide information relevant to the program.

Both commands and statements may omit line numbers: normally, commands do not have them, but statements do. (A statement with line numbers is called a program statement; if it doesn't it is called a direct statement). When using direct statements, the computer is rather like a super-calculator — statements are executed as soon as they are keyed-in.

We are now in a position to look briefly at a typical BASIC program.

Program Notes

Figure 5 is an example of a complete BASIC program. It plots a graph of the Poisson distribution, a function used in statistics. Details of this distribution can be found in most statistics books; if you're interested, the formula is

$$Pr(x) = \frac{m^x.e^{-m}}{x!}$$

where m is the mean of the distribution. The program uses a restricted subset of BASIC and should work for most 'floating-point' versions of the language. Ways of implementing such a program in 'integer' BASIC will be discussed in later issues. If your microcomputer supports floating-point BASIC, you should try running this program (it was actually tested using a PET). Note that there may be slight problems with some machines because of different screen formats — for example, the top nine lines will be lost on a TRS-80 because its screen is only 16 lines deep, not 25.

Those of you who are familiar with BASIC and have a detailed knowledge of a particular version would probably write a rather different program to this, but this example nevertheless illustrates how quite attractive results can be obtained using just a few BASIC keywords: DIM, REM, PRINT, INPUT, FOR. . . NEXT, IF. . . THEN, STOP, END and RUN and the functions EXP, INT, LOG and TAB. These will be explained fully in later issues. We will also be discussing the variations that can occur in different versions of BASIC, and looking at BASIC programming structures and techniques, programming style, and the conversion of programs from one version of BASIC to another.

```
100 DIM B$(20,20),A(40)
110 PRINT "POISSON DISTRIBUTION PROGRAM"
120 PRINT "======= ============ ======="
130 PRINT
140 PRINT "ENTER MEAN (RANGE 0<M<20) OR 0
    TO STOP"
150 INPUT M
160 IF M=0 THEN STOP
170 IF M>=20 THEN 140
179 REM **CALCULATE POISSON PROBABILITIES***
180 LET Z=1
190 LET A(1)=20*EXP(-M)
200 LET Y=A(1)
210 FOR X=2 TO 40
220 LET A(X)=(A(X-1)*M)/(X-1)
229 REM **WORK OUT VERTICAL RANGE***********
230 IF A(X)<Y THEN 250
240 LET Y=A(X)
250 NEXT X
260 LET Y=INT(Y)+1
269 REM **WORK OUT HORIZONTAL RANGE*********
270 FOR X=1 TO 40
280 IF A(X)<Y/20 THEN 300
290 LET Z=X
300 NEXT X
309 REM **WORK OUT VERT. AND HORIZ. SCALES**
310 LET V=0.4*(Y+INT(4/Y))-0.2
320 LET V=2↑(2-INT(LOG(V)/LOG(2)))
330 LET H=0.4*(Z+INT(4/Z))-0.2
340 LET H=2↑(2-INT(LOG(H)/LOG(2)))
349 REM **INITIALISE ARRAY******************
350 FOR C=1 TO 20
360 FOR B=1 TO 20
370 LET B$(C,B)=" "
380 NEXT B
390 NEXT C
399 REM **ENTER VALUES TO ARRAY***********
400 FOR X=1 TO 20
410 LET Q=INT(V*A(INT((X-1)/H)+1)+0.5)
420 IF Q=0 THEN 460
430 FOR J=1 TO Q
440 LET B$(J,X)="*"
450 NEXT J
460 NEXT X
469 REM **PRINT GRAPH AND VERTICAL AXIS***
470 PRINT "PROBABILITY FOR MEAN =";M
480 FOR K=20 TO 1 STEP -1
490 IF INT(K/5)<>K/5 GOTO 520
500 PRINT K/(20*V);TAB(7);"I";
510 GOTO 530
520 PRINT TAB(7);"I";
530 FOR J=1 TO 20
540 PRINT B$(K,J);
550 NEXT J
560 PRINT
570 NEXT K
579 REM **PRINT HORIZONTAL AXIS***********
580 PRINT "0      I-----I----I----I----I"
590 PRINT TAB(17-INT(0.99-INT(10/H)+10/H));
    10/H;TAB(27);20/H
600 GOTO 140
610 END
```

Fig. 5 This simple example program should run on most microcomputers. **ETI**

MICROPOWER THERMAL ALARM

This over- or under-temperature alarm consumes a mere 3.5 uA of quiescent current, yet the alarm delivers 1 W of peak audio power. Design by Ray Marston. Development by Steve Ramsahadeo.

Precision temperature alarms have a variety of practical uses in the home: they can be used to indicate ice conditions in the loft, over-temperature conditions in the greenhouse or fire conditions in any part of the building. Trouble is, all conventional systems draw quiescent currents of several milliamps and will flatten a PP9 battery after less than two days of continuous operation. Yuck!

ETI's new Micropower Thermal Alarm system can be used as either an over- or under-temperature alarm; it is specifically designed to overcome the battery flattening problem using the principles described in this month's Designer's Notebook.

Construction

The entire circuit, other than the thermistor, speaker and battery, is mounted on a small PCB and construction should present few problems. Note, however, that the circuit uses some high-value resistors, so take care to keep the board clean during and after assembly; when construction and testing is complete, you can coat the entire circuit with varnish, to exclude the shunting effects of moisture and dirt.

The circuit is designed to work with a negative-temperature-coefficient (NTC) thermistor that has a resistance in the range 1k0 to 10k at the desired alarm temperature; the VA1066S is suitable for use at all 'normal' temperatures. TH1 and PR1 can be configured to give either over or under-temperature alarm operation; with the connections shown in the circuit diagram, the unit acts as an under-temperature (ice warning, etc) alarm; for over-temperature operation, simply transpose the TH1 and PR1 positions using the links provided on the PCB. In

HOW IT WORKS

The circuit comprises three main sections, these being a thermal switch (TH1-PR1-R1-R2 and IC1), a sample pulse generator (IC2 and Q1), and an alarm generator (IC3 and Q2). The thermal switch circuit is quite conventional: TH1-PR1-R1-R2 are wired as a simple bridge across the inputs of voltage comparator IC1. The action is such that the output of IC1 is normally low (at 0 V) but switches high when the TH1 temperature falls below a value preset by PR1 (the circuit can be made to give over-temperature switching by transposing the TH1 and PR1 positions). If this conventional circuit were powered from a continuous DC source, it would draw several milliamps of quiescent current.

The sample pulse generator circuit is designed around IC2, which is configured as a special micropower oscillator (see this month's edition of Designer's Notebook) and produces a 300 us pulse at pin 12 roughly once every second. This pulse is used to connect power to the IC1 thermal switch circuitry via emitter follower Q1, thus reducing its mean current consumption by a factor of 3000 relative to the 'normal' DC value. Thus, if the TH1 temperature is above the preset alarm level on the arrival of the sample pulse, the IC1 output (pin 6) will be low and no charge will be fed to C1 via D1, but if the temperature is below the preset level the output of IC1 will switch high for the duration of the sample pulse, rapidly charging C1: the C1 charge is used to activate the IC3 alarm generator circuitry.

IC3a-IC3b are connected as a gated 6 Hz astable, with the output fed to the input of 1 kHz gated astable IC3c-IC3d; IC3d has its output fed to an external speaker via VFET power amplifier Q2. Thus, when the C1 voltage is zero, the two IC3 astables and Q2 are cut off and the alarm generator circuitry consumes zero quiescent current, but when the C1 voltage is high the 6 Hz astable is gated on and pulses the 1 kHz astable on and off, generating a powerful pulsed-tone alarm signal in the speaker. The supply to the major sections of the circuit is decoupled from LS1/Q2 transients by D3 and C3.

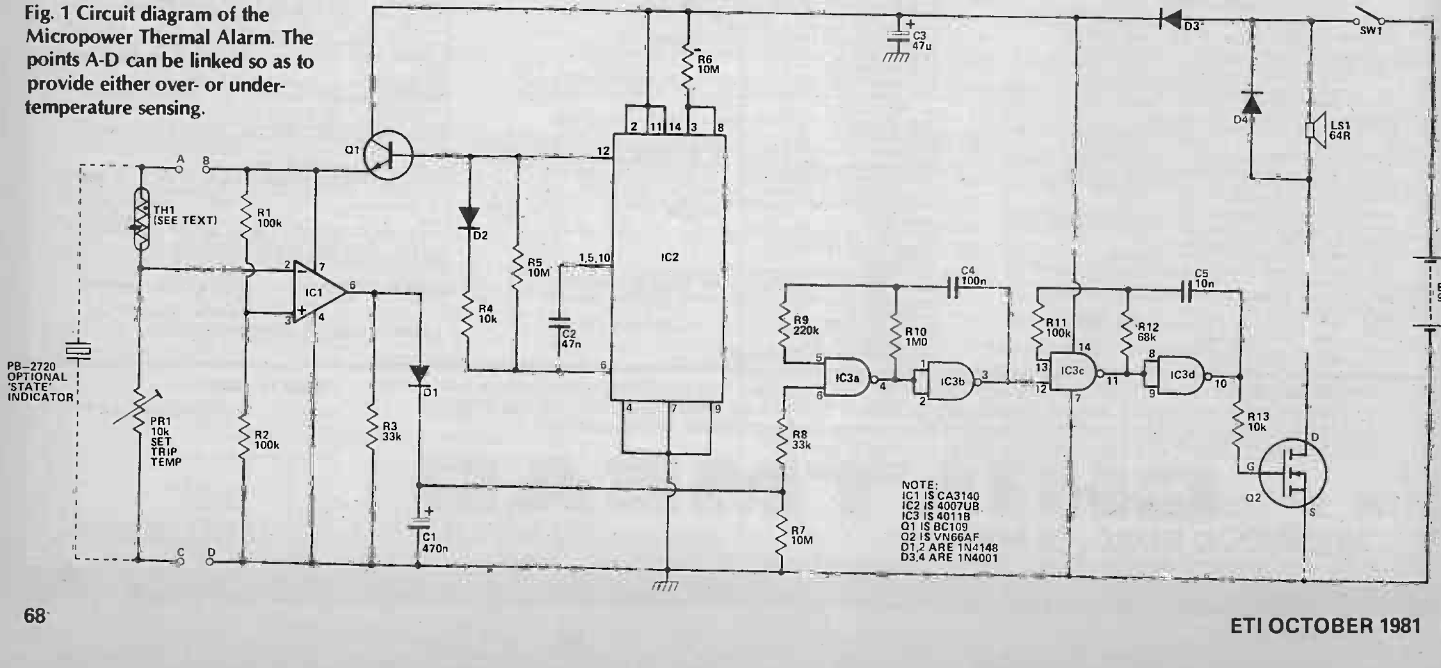


Fig. 1 Circuit diagram of the Micropower Thermal Alarm. The points A-D can be linked so as to provide either over- or under-temperature sensing.

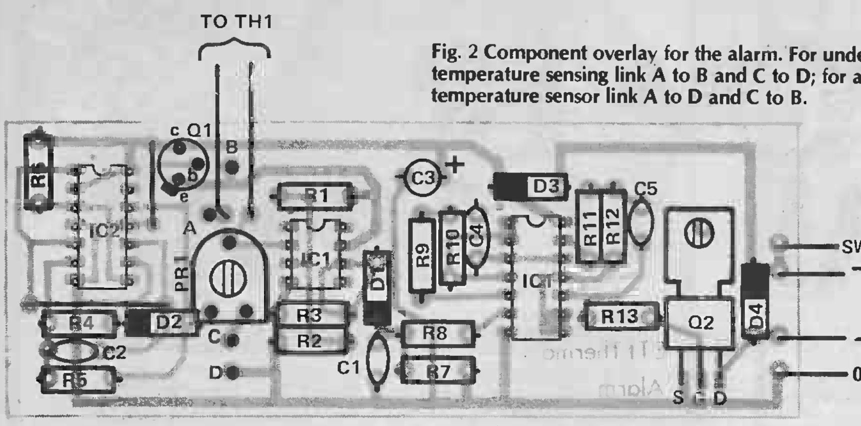


Fig. 2 Component overlay for the alarm. For under-temperature sensing link A to B and C to D; for an over-temperature sensor link A to D and C to B.

practical use, the thermistor is mounted remote from the PCB.

When construction of the unit is complete, fit the speaker and battery in place and give the unit a functional check by adjusting PR1 so that the alarm activates; then back-off PR1 so that the alarm turns off again (after a few seconds delay). Finally, raise (or lower) the TH1 temperature to the desired alarm value and then trim PR1 so that the alarm activates.

If desired, a PB-2720 acoustic transducer can be wired between points A and C of the circuit to act as a state indicator. This transducer will generate an audible click once every second when the circuit is working correctly, and adds only a fraction of a microamp to the total current consumption of the unit.

BUYLINES

TH1 and Q2 are available from Electrovalue. Technomatic stock the 64R loudspeaker. All the other components are readily available from our regular advertisers. See page 54 for details of our PCB service.

PARTS LIST

Resistors (all ¼W, 5%)	
R1,2,11	100k
R3,8	33k
R4,13	10k
R5,6,7	10M
R10	1M0
R12	68k
Potentiometers	
PR1	10k miniature horizontal preset
Capacitors	
C1	470n 16 V tantalum
C2	47n ceramic
C3	47u 16 V tantalum
C4	100n ceramic
C5	10n ceramic
Semiconductors	
IC1	CA3140
IC2	4007UB
IC3	4011B
Q1	BC109
Q2	VN66AF
D1,2	1N4148
D3,4	1N4001
Miscellaneous	
TH1	VA1066S
SW1	SPST miniature toggle
LS1	64R loudspeaker
TX1	PB-2720 (optional)
PCB (see Buylines)	

ETI

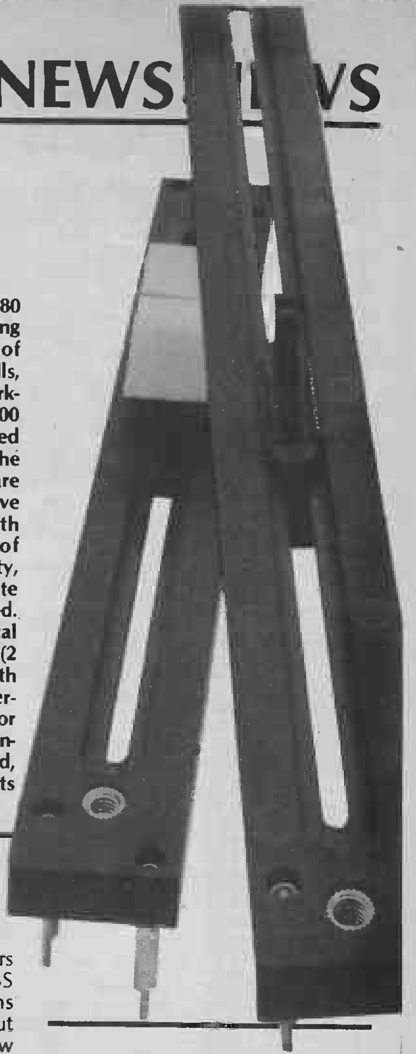
Components

Greater Capacity

Compstock's family of electrolytic capacitors are designed to meet the requirements of power supply circuits in consumer and industrial applications. The Type M series of aluminium electrolytic capacitors, from National Panasonic, is available in values ranging from 220-22,000uF, −10% +50%, and with working voltage ratings up to 500 V DC. Operational temperature ranges vary between −25°C to +85°C according to the working voltage rating, and the series exhibits good DC leakage characteristics. The Type M capacitor is constructed with a vinyl-insulated aluminium can and an annular, chassis mounting clip (for two hole mounting) at the base, which incorporates industry standard solder-slot terminations. Further information from Compstock Electronics Ltd, Compstock House, London Road, Stanford-le-Hope, Essex SS17 0JU.

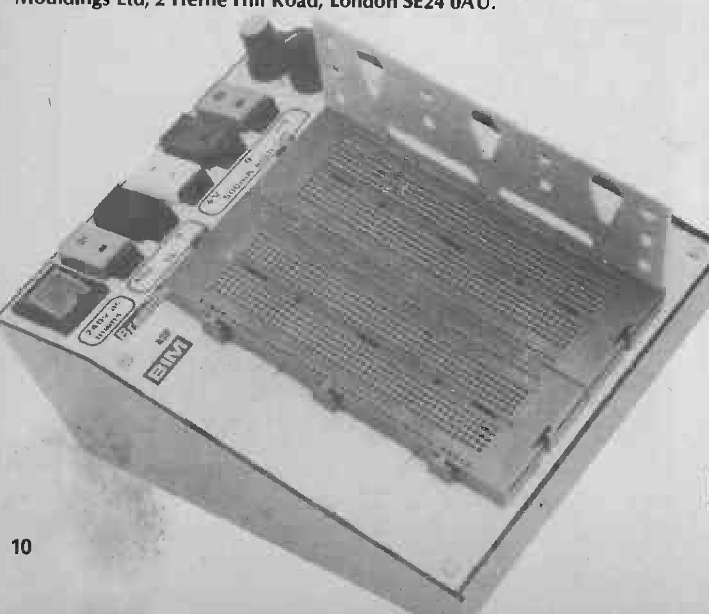
Light Entertainment

From Cetronic Ltd come the RC80 and RC120 Rectilinear Lighting Faders for use in the control of lighting for theatres, concert halls, auditoriums, discos etc. Their working life is greater than 100,000,000 operations and they are designed within a rigid insulated frame; the resistance and collector tracks are made from hard-wearing conductive plastic for long life and smooth operation plus the advantages of very low noise level, good linearity, low residual voltage, almost infinite resolution and high traverse speed. They are available with electrical travel of 8 mm (1 W) and 120 mm (2 W) at 10K nominal resistance. Both models incorporate stand off terminals for easy PCB mounting. For details of suppliers and prices contact Cetronic Ltd, Hoddesdon Road, Stanstead Abbotts, Ware, Herts SG12 8EJ.



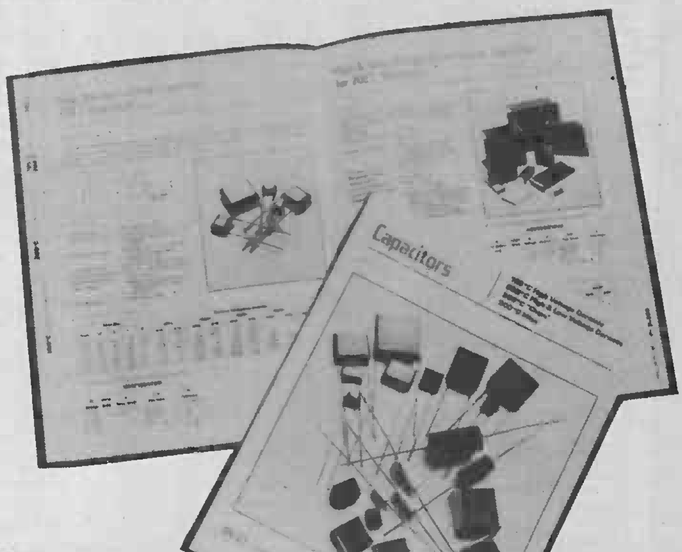
Try It First

For all you eager circuit builders out there BOSS Industrial Mouldings Ltd have launched an upgraded range of their Bimboard Designer Prototyping systems. The new Bimconsole has either one, two or three individual Bimboards mounted on a 15° sloping front panel with a triple rail power supply. Each Bimboard comprises a central breadboarding area in which 47 horizontal rows of 5 interconnected sockets are set either side of a central channel on a 2.54 mm matrix, together with integral bus strips running up each side for power carrying etc. The Bimboard will accept .3" and .6" pitch DIL packages as well as resistors, transistors, diodes, capacitors etc, which can be easily plugged in. It incorporates a fixed 5 V DC at 1 A supply, and independently adjustable positive and negative rails ±5 V to ±15 V DC at 0.5A supplies, all brought out to top panel terminals that simultaneously accept 4 mm plugs and stripped wires. 220-240 V AC, 50-60 Hz mains input is via an IEC plug and socket with a screwdriver-release fuse holder providing 500 mA anti-surge protection. Full details on the Bimboard are available from BOSS Industrial Mouldings Ltd, 2 Herne Hill Road, London SE24 0AU.



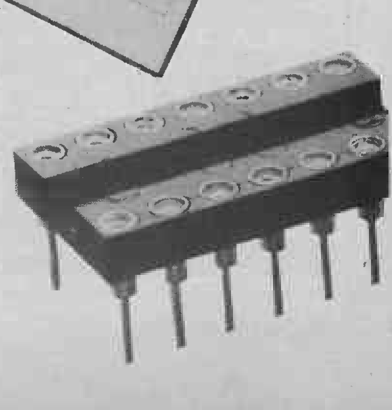
Capacitor Catalogue

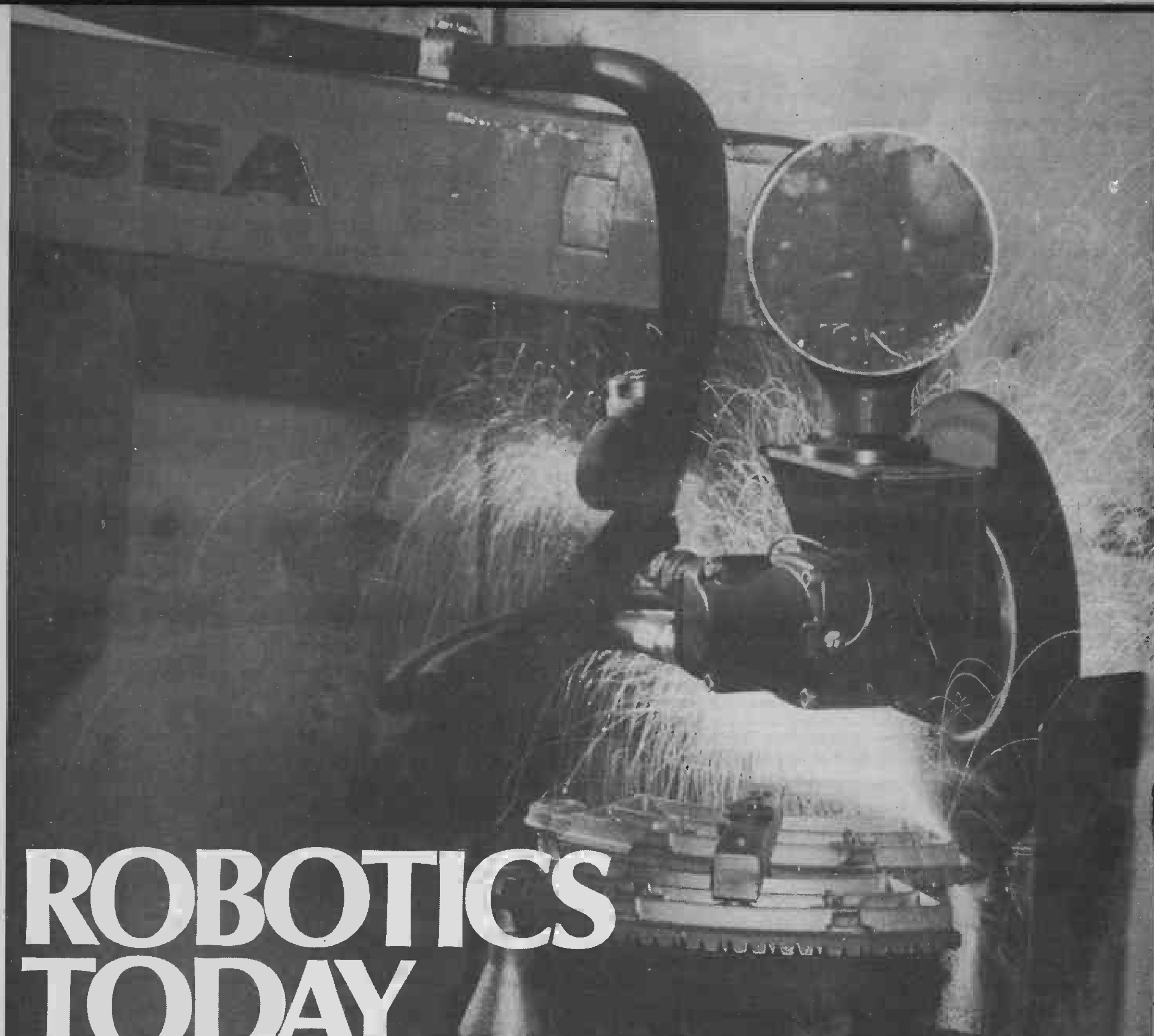
A 10-page catalogue of capacitors has been published by RBS Capacitors Ltd, and it contains everything you need to know about their 125°C to 300°C high and low voltage ceramic, chip and mica capacitors. The booklet is illustrated with photos, diagrams and tables. Methods of installation are described and instructions, theory and parts numbering are explained in clear language. For further details contact RBS Capacitors Ltd, Orchard Works, Vencourt Place, London W6.



IC Sockets

The TI C69 range of screw-machined integrated circuit sockets is now available from BA Electronics. They provide a high level of performance in multiple insertion applications. The low-profile sockets have tin-plated pins for solder-tail assembly, with four-leaf gold-plated beryllium-copper contacts for good electrical performance. Sockets are available with from 6 to 64 pins. Further details are available from BA Electronics Ltd, Millbrook Road, Yate, Bristol BS17 5NX.





ROBOTICS TODAY

As readers must now be aware, we at ETI are convinced that robotics has a major role to play in the industrial development of this country — hence this new series. To start us off, Martyn Paradise of Robotec looks at procedures involved in the application of robots in industry.

Initial contacts between ourselves and companies wishing to use robots are often by direct mailing approach, followed by telephoning. Occasionally, exhibitions such as the recent Automan '81 exhibition at Brighton, where interest was greatly increased over the previous exhibition in 1979, result in contacts.

Generally, customers fall into two categories, those who want to use robots in their production facilities, but don't have a particular area to try first; and those who have decided upon an application and want help to implement a robot system.

The first type of customer requires a visit by us to 'look around' and assess the situation. From this visit, one or more areas where a robot may be feasible are highlighted. Simple quick feasibility studies of each possible application are then carried out in conjunction with the customer. It may be that the feasibility studies show that some other type of automation is required, such as dedicated assembly machines, instead of a flexible robot system.

The second type of customer, who has a definite project in mind, needs careful vetting because often the proposed application may be too arduous for the robot selected, or insufficient funds have been allowed for development costs or the project is only economic, producing a suitable repayment, if the single robot can make a sweeping change to the production processes presently used. For instance, one prospective customer wished to justify one robot project by making it do the work of five manual operators spaced over a distance of 40 ft. The poor robot was expected to whizz back and forth along a track from one work station to the next like a demented yo-yo.

As a general rule, assume that one robot can do the work of one complete human operator, and that one small assembly-type robot can do the work of one human arm and hand.

This new series will provide a stage upon which our readers may display their robotics achievements. It is intended to cover the practical application of robots in Britain today, be it at hobbyist level or in industry.

Readers in either category are invited to write to the editor of ETI, detailing their experiments, projects, application or usage of robotics. Any articles published will be paid for at commercial rates. It is also hoped to run an 'Ideas Forum' wherein readers can exchange views and ideas but that depends upon the response of our readers — you!

Write to: THE EDITOR, ETI MAGAZINE, 145 CHARING CROSS ROAD, LONDON WC2H 0EE and mark your envelope "Robotics Today".

Feasibility Studies

In the initial quick studies above, how did we arrive at a decision as to whether a production process warranted a robot? Basically, a five point approach can be adopted for selection:
1) Types and range of components, and loads to be handled or worked on.
2) The cycle time required (or available) to carry out the work task.
3) The accuracy/repeatability of positioning of the robot to allow it to handle the components correctly.
4) Work envelope — ie, the work area required by the robot to carry out the task; height, length and breadth. This may be constrained by the physical environment of the work situation.
5) Costs and economics. This is an area where an otherwise ideal application falls down; after all, most companies are in business to make a profit, not a loss, and if expensive modern technology does not produce greater efficiency or save costs then there is not much point in using it.

To put some rough figures to each of the five points above, a robot may be viable if the following limits are acceptable.
1) Loads and components vary from a few grammes to 100-150 kg. Often the batch size of individual components is more important than the component size, ie how long does a particular specification of component run on a production line in the proposed application? If it is constantly changing, by how much does it change; is there a family of similar components that can be run one after the other? If the component is constantly changing then the time taken to retool the robot for each new component may be significant and each part may require a separate gripper, making tooling costs very high.
2) Cycle times required should be between 5-8 s minimum and upwards; although shorter times are becoming available, particularly for assembly robots.
3) An accuracy/repeatability of less than 0.004", and generally ± 0.016" - 0.050".
4) A work envelope, as described above, that can vary from the rang of a man's arm and hand, upwards to that of a complete man moving in a 6-8 ft circle.
5) If the project can pay for itself over a 2-3 year period on a first project, then it is usually viable. A typical robot installation may cost £20,000 — £70,000 in total including any other hardware required. Individual project costs and economics can vary from one company to the next, and it is not simply that the robot may save an operator's wages when installed. The robot does not take holidays and always works at a steady pace. The robot may not need any heat or light although when a completely darkened automatic warehouse was tried a few years ago, the few human operators left in the system insisted on lights being put back in, as they were disconcerted by objects being suddenly discharged out of the 'night' from unexpected directions.

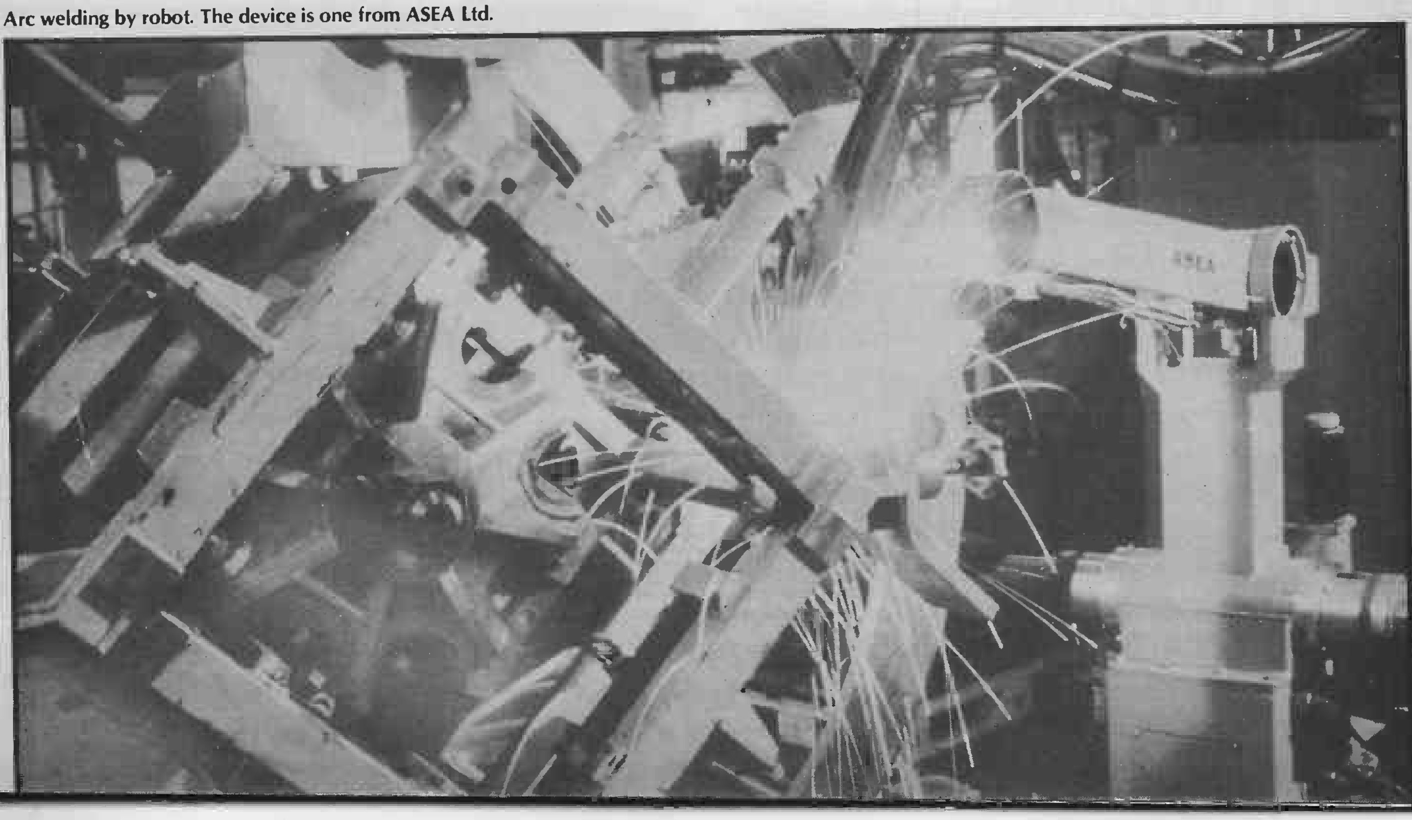
Guarding may be simplified, needing to protect the human operators from the complete system instead of from individual machines. Another cost saving might be shown in the robot's greater consistency; it doesn't have a Monday morning or a Friday night, although problems have occurred with some of the robots that we have worked on that begin to make one wonder.

If from the five points above, a robot system seems feasible, more detailed studies and trials can proceed, to look at the actual operations that the robot needs to carry out and the design of the gripper and the tooling necessary. Some type of modelling of the proposed application is a good idea. We use simple physical 1/10th scale models as well as engineering drawings to aid analysis of the project. Models allow the possible variations and movements of the robot to be quickly understood and observed, something that is not always easy for many people when trying to understand movements in three dimensions.

Selection And Design

Once we know what the robot is expected to do, we can select the 'ideal' robot for the job and design and build the gripper and tooling to suit. The choice of robot may be constrained

Arc welding by robot. The device is one from ASEA Ltd.



by particular preferences towards hydraulic or electric operation; country of manufacture; delivery time; previous track record; and promised after-sales service; as well as the direct costs of installation and running.

The gripper and tooling is the area of a robot project where the most problems occur and often where the smallest amount of money is allocated for development. A robot is no good unless it has a gripper and tooling to allow it to do the job it was bought for; or if its interfaces don't allow it to talk to the outside environment.

The aim of the gripper design is to produce the simplest mechanism to carry out the required tasks. After all, the gripper has to be at least as reliable as the robot to which it is fitted and work day in and day out without attention.

The most common types of grippers use some type of pincer action to hold a component, similar to the action of the human thumb and forefinger. Obviously the mechanical 'thumb' and 'forefinger' may be stronger, wider and thicker than the human counterpart and peculiarly shaped to hold the limited range of components to be handled.

Power to move the gripper (open and close it, for instance) is commonly pneumatic, as compressed air is normally available in factories and a wide range of actuators and valves are available off the shelf. Hydraulic power can also be used, particularly with hydraulic robots.

Magnetic grippers for handling ferrous objects, vacuums for handling glass sheets and cardboard boxes, and electric motors for driving geared jaws are some other types of gripper power that can be tried, although the straight mechanical type is often preferred because of its reliability and simplicity.

The design and development of the gripper may take several months depending on its complexity and any problems that occur with components and hardware used.

Other Interfaces And Hardware

Once the gripper, when mounted on the robot, can carry out the sequence of operations as required by the application, the remaining interfaces need developing. These include electrical interfaces, to connect the solenoid valves of the pneumatic gripper to the robot control system (eg simple relays); also inputs from microswitches and proximity sensors to detect the opening and closing of the gripper jaws and operation of other equipment such as lathes, presses, and conveyors, in order to tell the robot that a component is ready for handling.

Opening of the safety gates also needs monitoring, so that any ingress by human operators into the work area of the robot can be detected and the robot stopped.

Programming

Most industrial robots use a cable-mounted teach box to allow the programmer to instruct the robot. The robot is moved from one position to the next in the required sequence of operations, and each position and operation is stored in the robot's memory. For certain spraying and welding robots, it is possible to teach the robot by holding the spray gun attached to the robot head and leading it through the required cycle.

For complex palletising and handling programs requiring very fine movements, programming can take several days at the initial trial and development stage, followed by further time during installation and commissioning.

All preliminary programming and trials should always be carried out away from the final production area, if only because the problems that always occur during development of a robot system will be spotted and picked on by the sceptics who always seem to abound when new ideas are tried. Everyone has met him — he's the type who doesn't offer help until you've had a go, then says "If I were you I would have done this or that". It is always easier to look backward, than to look forward and anticipate problems.

Final Installation

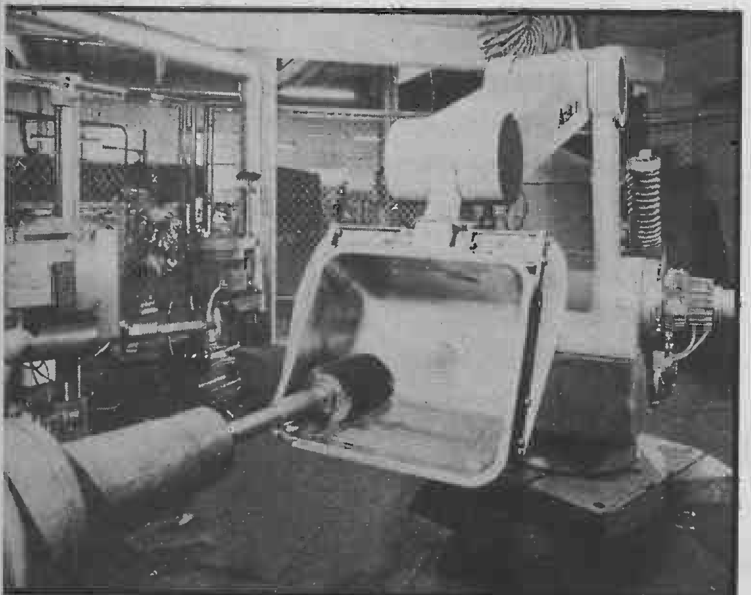
Putting the robot and its associated hardware into the production environment is the final stage, and includes checking all the safety interlocks between the robot and the outside world, final programming and any last minute modifications to the gripper and tooling.

Often a new robot application will be run at half its designed speed to allow it to 'bed-in' and to test the operation of the system over a period of weeks; after this the tooling may be checked for wear and general conditions, and then the speed of the system will be gradually increased up to the designed limit.

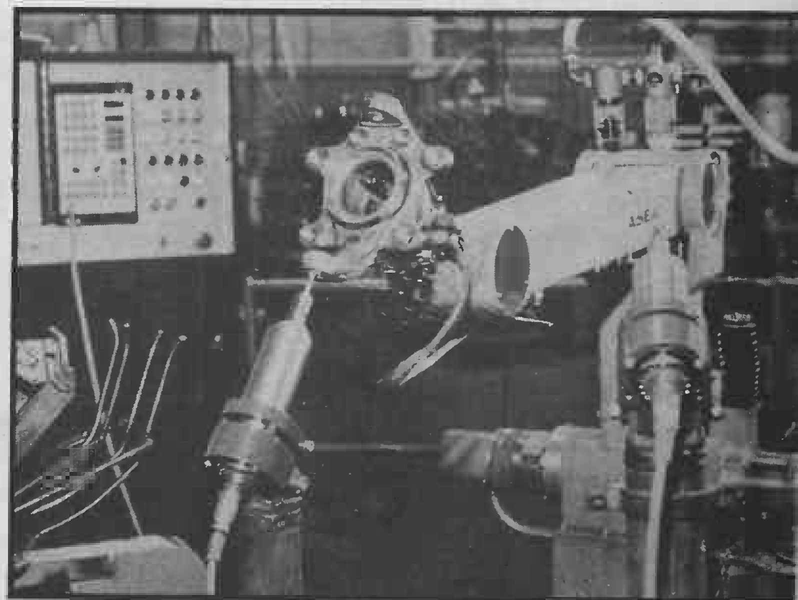
Our thanks to ASEA for providing the photographs.

Suggested Reading

Assembly Automation and The Industrial Robot — both quarterly magazines published by IFS (Publications) Ltd, 35-39 High Street, Kempston, Bedford MK42 7BT.

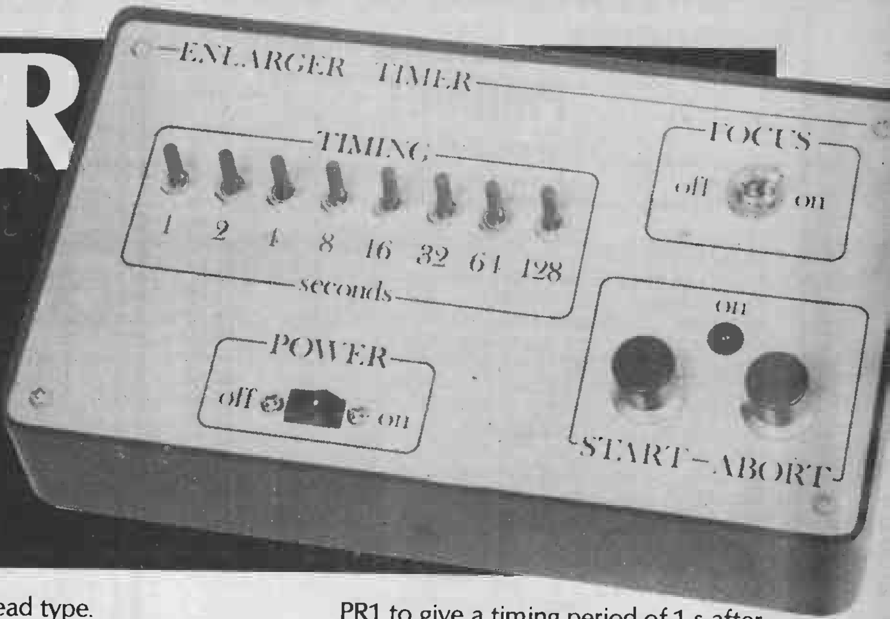


Polishing stainless steel kitchen sinks. The ASEA IRb-60 robot picks up the sinks and guides them against the buffing wheels which are attached to fixed spindles.



De-burring a guide-spindle housing after machining. The IRb-6 robot picks up the items and guides them against rotary files.

ENLARGER TIMER



At last — an enlarger timer designed for the photographer by a photographer. Design and development by Tony Alston.

Most enlarger timers use either potentiometers or rotary switches for time period selection; however, both these methods suffer from some drawbacks. First the potentiometers, although inexpensive, are generally difficult to line up with a timing mark especially under darkroom conditions, and also tend to wear out after long usage. The rotary switch overcomes the alignment problem but the timing period range is normally limited to the number of click stop positions — mostly 12 ways, maximum 18 ways. The ETI Enlarger Timer does not suffer from either of these problems; it uses only eight toggle switches in conjunction with the 2240 programmable timer IC to offer a wide range of accurate and easily selected timing periods ranging from one second to 4 minutes 15 seconds in one-second steps.

This flexibility is due to the programmable eight bit counter, oscillator and control flip/flop featured within the timer IC. Having set the time base to 1 s using PR1, R4 and C2, each single switch (SW1-8) will give the basic timing periods of 1,2,4,8,16,32,64 and 128 s; by switching in more than one switch, any combination of timing periods can be achieved as previously mentioned.

Construction

As can be seen from the photographs, all switches and push-buttons are mounted on the front panel together with the LED indicator. Suitable mains input and output sockets such as Bulgin miniature mains type are mounted on the rear case panel, input nearest the transformer, output (for the enlarger) by the PCB. The PCB design will enable an easier and neater assembly, but make sure to orientate components D1-D5, Q1, IC1, C2, C3 and LED1 as shown in the overlay diagram. Note that C2 must be a tantalum bead type.

Once all the components are mounted on the PCB and the switches, LED1, sockets and transformer are wired to the board, make sure that the panel assembly does not foul the transformer or the relay when fitted to the case.

Setting Up

This couldn't be easier; having checked all connections, connect the timer to the mains and the enlarger to the unit. First put switches SW1-8 and SW10 in the off positions, put SW9 (on/off switch) in the on position, operate focus switch SW10 and the enlarger lamp will light. Switch SW10 to the off position. Adjustment to the timing range can now be made; switch SW1 only (1 s switch) to on and adjust PR1 to give a timing period of 1 s after PB1 (start) is pushed — a stopwatch or digital watch is ideal for this.

Using The Timer

Switch on SW9 (on/off switch) and power will be applied to the circuitry. SW10 can be used for focusing the enlarger; cancel SW10 once this is done. Select the timing period required using a combination of SW1-8, push PB1 and the enlarger lamp timing cycle will commence; after this period the timer will stop/reset. LED1 will be on during timing period as a visual indication. If cancellation of a timing period is needed press PB2 which will abort and reset the timer. If any interference from RLA/2 is experienced, fit a 100n 600 V capacitor as marked on the circuit and overlay diagrams (C4).

HOW IT WORKS

The heart of the ETI Enlarger Timer is the 2240 programmable timer IC which features a time base oscillator, programmable eight bit counter and a control flip-flop that can be used in monostable or astable mode. Here it is used in the monostable mode.

On application of a positive pulse to pin 11 (trigger) via PB1 and R1, the timing cycle is started. The trigger input activates the time base oscillator, enables the counter section and sets the counter outputs low from their normally high state. This switches on Q1 and activates RLA for the time duration as set by the SW1-8 combination. The timing sequence is completed when a positive pulse is applied to pin 10 (reset) via R3 from the output bus, disabling the time base and counter sections and returning the counter outputs to a high state.

The duration of the timing cycle T_o is given as:

$$T_o = nT = nRC \text{ seconds}$$

(R in ohms, C in farads)

where T (= RC) is the time base period as set by the timing components at pin 13 (PR1, R4 and C2) and n is an integer in the range of $1 \leq n \leq 255$ as determined by the combination of counter outputs (pins 1-8) via SW1-8 to the output bus. The time base as set by PR1, R4 and C2 is 1 s.

The binary-counter outputs are the open collector type and can be shorted together to the common pull-up resistor R6. Thus the time delays associated with each counter input can be added together; for example, if pin 6 is connected by SW6 to the output bus the duration of the timing cycle, T_o, is 32T. (T is 1 s as previously stated). Similarly, if pins 1,5, and 6 are all connected to the output bus via their appropriate switches SW1, SW5 and SW6 the total time delay is 49T (1 + 16 + 32). In this manner the timing cycle can be programmed to be from 1 s to 255 s (four minutes 15 s) in 1 s steps by proper choice of switches SW1-8.

The enlarger lamp is powered from the AC outlet socket and receives its current via the RLA/2 contacts for the duration of the selected timing period. An LED is incorporated as a visual indicator; it is switched on by RLA/1 and remains on for the timing period. Manual cancellation is provided for by PB2 which applies a positive pulse to pin 10; this can be used at any point in the timing period. SW10, the focusing switch, overrides the RLA/2 contact regardless the output state of IC1 thus enabling the enlarger to be focused.

The power supply consists of T1, D2-D5 and C3 which provides smoothing.

PARTS LIST

Resistors (all ¼ W, 5%)

R1,2,6	10k
R3	47k
R4	33k
R5	22k
R7	1k5

Potentiometer

PR1	22k miniature horizontal preset

Capacitors

C1	10n disc ceramic
C2	22u 16 V tantalum
C3	1000u 25 V axial electrolytic
C4	100n 600 V mixed dielectric

Semiconductors

IC1	uA2240CP
Q1	2N3702
D1	1N4148
D2-5	1N4001
LED1	0.2" red LED

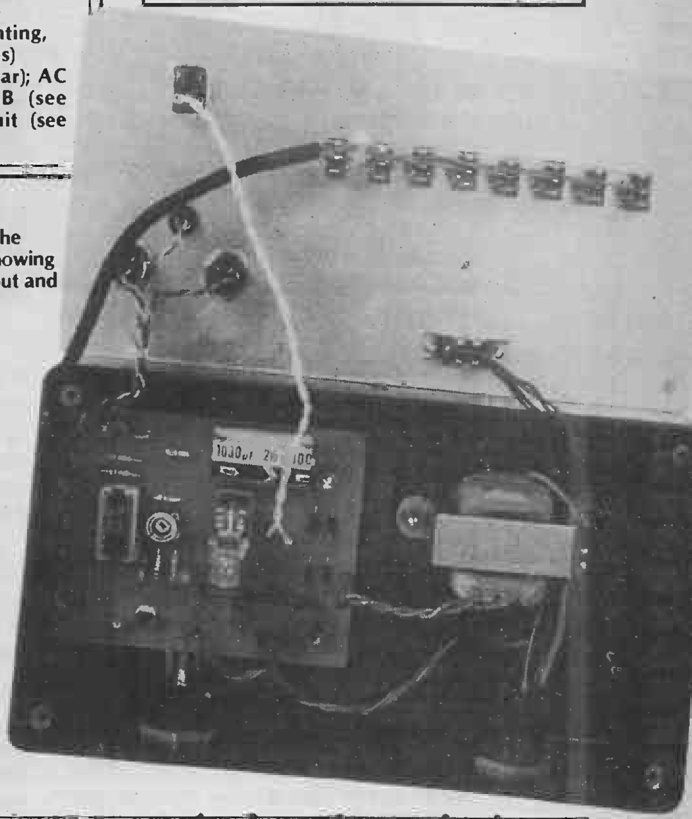
Miscellaneous

PB1,2	momentary action push-button
SW1-8	SPST miniature toggle
SW9	SPST 240 V 3 A miniature rocker
SW10	SPST 240 V 3 A toggle
RLA	12 V DPDT PCB-mounting, 205R coil (see Buylines)

Transformer (12 V, 250 mA or similar); AC outlet socket (Bulgin type); PCB (see Buylines); mains lead; case to suit (see Buylines).

BUYLINES

Most of the components used in this project can be easily obtained for component retailers or mail order firms. IC1 is available from Technomatic and the relay is from Watford Electronics. The case we used is from Tandy, order no. 270-627; and if you don't want to make your own PCB from the foil pattern at the back of the magazine, then take a look at the advert for our PCB Service on page 54.



(Left) Inside the prototype, showing the neat layout and tidy wiring.

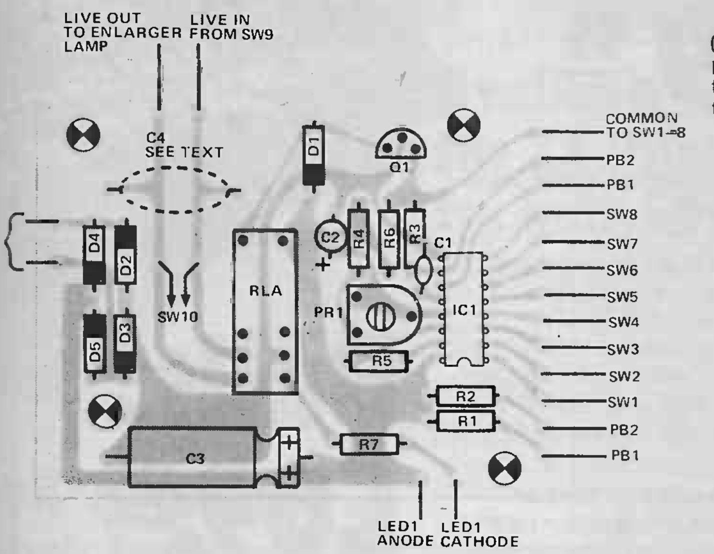


Fig. 1 Component overlay of the ETI Enlarger Timer.

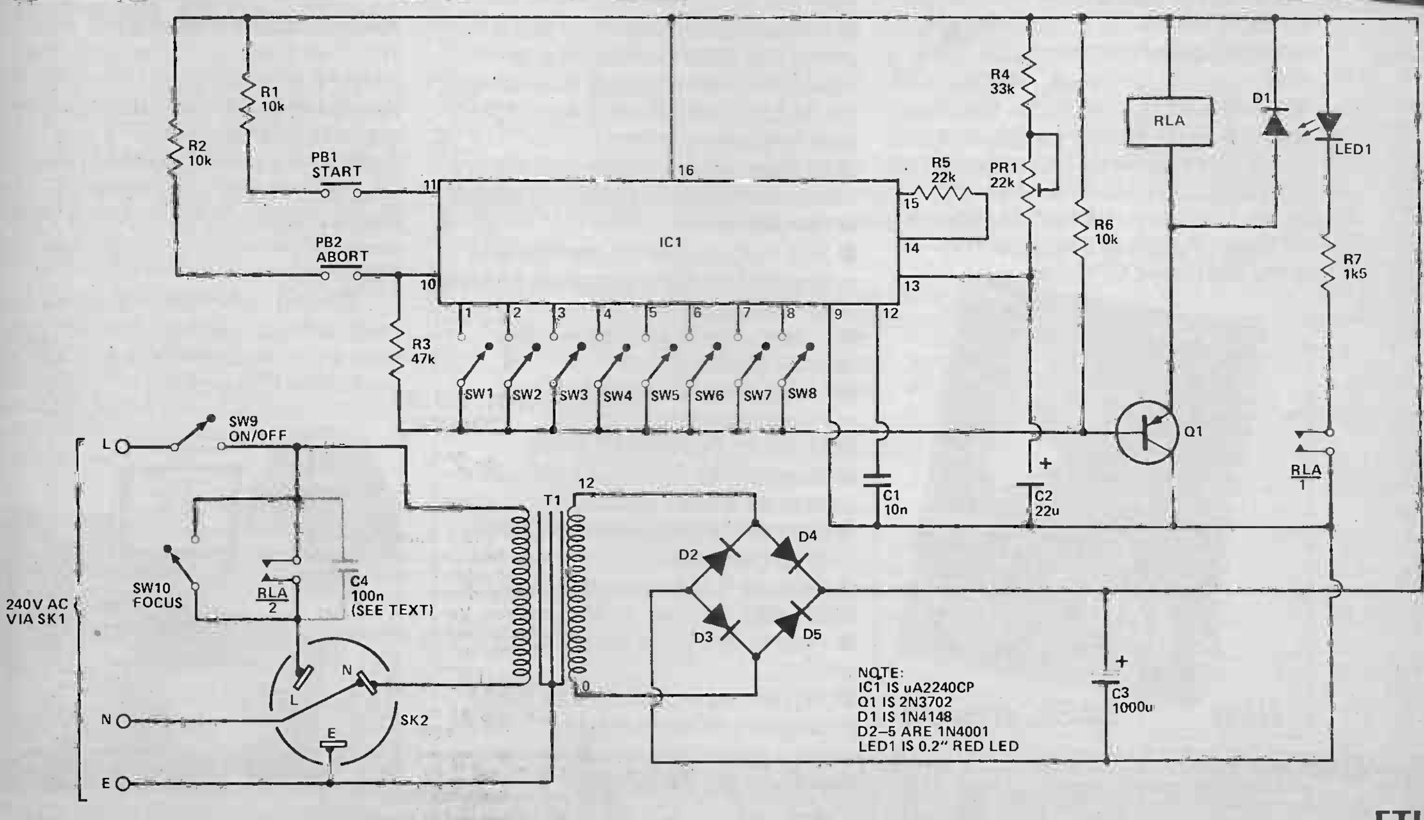


Fig. 2 Complete circuit diagram of the timer. C4 may be necessary to suppress switching noise from the relay contacts.

CASIO FX-602P

Those clever Casio people have done it again. This calculator? — computer? — puts real programming power in your pocket. With Ron Harris on keyboards.

With the advent of the Sharp PC1211 BASIC computer, there are those who have questioned the need to produce programmable calculators at all. With a handheld computer, programmable to do almost anything except make the tea, why bother with a calculator — which has no string handling at all and is necessarily limited in its memory space? The argument rounds off, usually, with the surmise that with the continued plummet in memory cost, it won't be long before 8K handheld machines are available, with all the power of the earlier personal computers.

This may all be true, but somehow I think it will take a little longer than the optimistic programmer fraternity would have us believe.

Even if we all awoke from our slumbers with the dawn tomorrow to find some friendly faerie people had left a handheld TRS-80 under our pillows — with or without stealing our teeth in payment — there will remain a place in the universe for the calculator. After all, working out the electricity bill or last month's overdraft hardly requires an electronic brain the size of a planet, now does it?

Everyday, mundane computations are more readily accomplished at the push of a button, without the need of recourse to an all-singing, all-dancing, all-branching computing marvel. Theirs is a loftier realm.

Casio Diversions

Having gone to all this trouble to justify the existence of the calculator, I must say that this FX-602P from Casio is a brave attempt at totally blurring the distinctions between calculator and computer. It has string handling, of a sort, GOSUB and GOTO commands, a facility to swop memory against program steps, and the option to save programs on tape.

Normally it has 512 program steps and 22 memories. This can be varied up to 32 program steps and 88 memories. As you can see memories cost more than one step apiece. As with its predecessor, the FX-502 (see ETI February 80 issue), the 602 can be hooked up to a tape machine via the FA-1 adaptor.

Rather than me spend large numbers of words explaining what the 602 will do, take a look at the keyboard diagrams given herein, as these show all the keys and their functions more clearly than my prose could illustrate them.

Alpha Modes

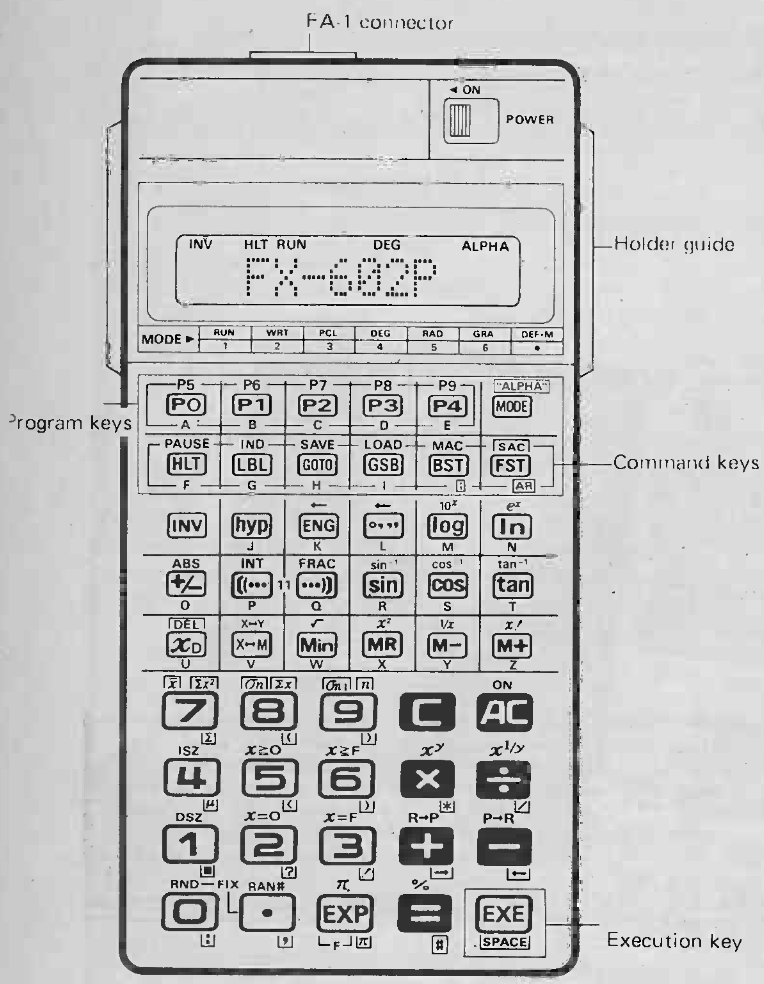
The main difference between the 602 and its predecessors is the ability to input and use alphanumeric strings both in the program — usually as prompts or result indicators — or simply to liven up routine calculations.

Each character is made up on a 7 x 5 dot matrix on the LCD display. Each 'dot' is in fact a small rectangle and imaginative use of this matrix by Casio has given a good clear display with a versatile character set.

As Before . . .

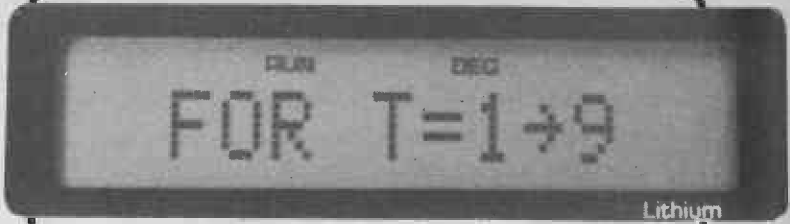
As with the 502, this new machine uses different 'modes' of operation to allow programming and debugging. Mode 1 is the 'RUN' mode and Mode 2 the 'WRITE' mode, which, when selected, lists up the available programs (from a selection of 10) and the number of steps left for use.

It is curious that selecting 'WRITE' mode is in itself con-

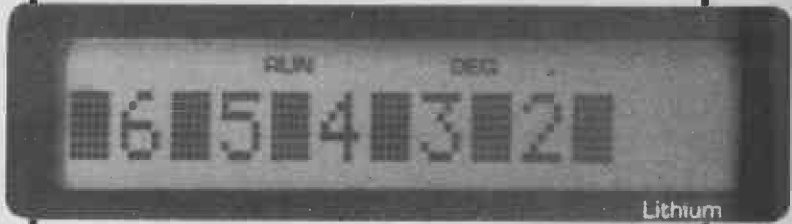


A close-up of the FX602P keyboard when used in the programmable mode. The top two rows of keys control program 'call' and mode selection. Most of the functions of the FX602P can be read off from the keys themselves.

Note that the alpha characters are accessed by mode 'alpha' and then keying in each letter as written under the appropriate keys. The display will automatically scroll across to the left if you exceed the capacity. Under program control this means you could use the 602P to leave messages. "Dinner in the oven" maybe?



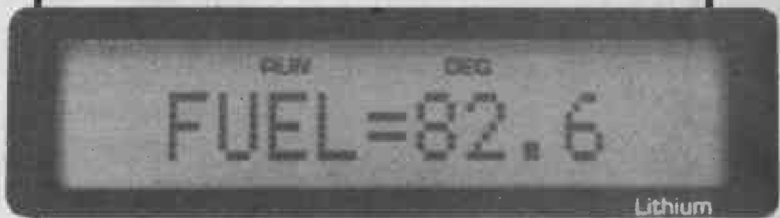
Using the alpha-numeric capabilities of



the display enables both corrective and

informative prompts to be produced on the

display. This gives the FX602P the 'inter-active'



ability more normally associated with computers.

As some 512 program steps are available

sidered a step. Effectively then, since each 'select' uses up a step, 512 are never quite available!

Other 'modes' employ either 'grads' or 'rads' in place of degrees for scientific calculation and will, no doubt, be of inestimable service to someone, somewhere.

Standard deviation is a 'standard' key function, as are 11 levels of parenthesis and a random number generator. It's possible to select (FIX) the number of decimal places in the random number to suit various applications. Percentages too can be obtained from a single keystroke.

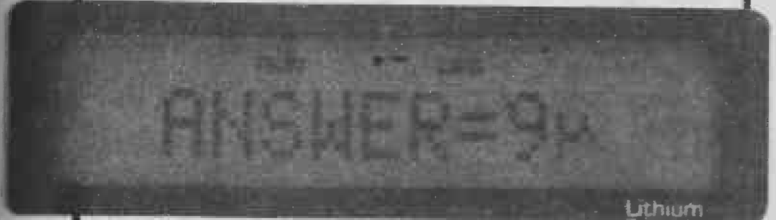
All the information stored in program or data memories is retained, even with the 602 switched off. It takes only a two-key operation to clear the entire store, so care must be exercised here.

Under Program

When running a program, the 602 is capable of conditional branching, ie 'goto line XX if X>0' etc, or a simple GOTO command which is employed in conjunction with sets of 'LABELS'. These the user keys in — they occupy a single program step each. In addition, other programs can be called as subroutines from a main control program. All very versatile.

The 'Alpha' mode allows you to insert strings of letters and/or symbols into the program at any stage desired. This can

for use some very comprehensive software



can be developed. Alpha-strings are permissable

within the program execution at any point.

be used as a prompt, for example
"KEY IN FUEL"

—

"KEY IN DISTANCE"

—

"AVE. MPG = 24.2"

or as indicators to answers or complex key routines requiring the user to keep track of a string of numbers, perhaps in a standard deviation calculation.

Calculated Expense

All this will cost you around £74, which includes a comprehensive program library — although this contains mainly scientific applications and says much about the market in which Casio expect to sell the FX-602P. There can be no doubt at all that the 602P is good value indeed for its price and it duly takes its place at the top of the list of programmable calculators. I could find nothing to criticise in its operation of facilities and can only recommend it to anyone seeking a powerful portable machine, which has comprehensive control over memory and data space.

You can obtain the FX-602P from Tempus, 164-167 East Road, Cambridge CB1 1DB, for the princely sum of £74.95 including VAT and p&p. The FA-1 adaptor to allow storage of programs on tape will cost you £19.95. The basic program library is supplied with the calculator. Our thanks to Tempus for lending us the review machine.

ETI

SOUND BENDER

This neat little ring modulator has a built-in wide-range sine/triangle modulation oscillator and a 'pan pot' output mixer, but can be built (less the case) for under £10. Design by Ray Marston. Development by Steve Ramsahadeo.

One of the most popular types of cheap sound-effects units is the so-called 'ring modulator' or four-quadrant multiplier. These units have two inputs, one being a voice or music audio signal and the other being a simple sine or triangle oscillator waveform: the output of the unit is equal to the product of the two instantaneous signal amplitudes. In other words, the oscillator effectively amplitude-modulates the voice/music signal, to give some very interesting changes in the apparent signal content of the original voice/music material.

The ETI Sound Bender is a fully self-contained version of the popular ring modulator circuit. Naturally, however, our project has few special features. First, it has a built-in modulation oscillator that can span the frequency range 3 Hz to 5 kHz using a single control pot and which can produce either sine or symmetrical-triangle output waveforms. Second, the actual ring modulator is based on a precision four-quadrant multiplier circuit that is integrated into the oscillator chip; the multiplier balance is externally adjustable, enabling the unit to be used either as a 'sound bender' or as a simple sine/triangle audio generator. Finally, the unit incorporates a two-channel audio mixer in its output stage, which enables the original and modulated audio signals to be mixed in any desired ratio (ranging from 'all original' to 'all modulated') by a single pan-pot type control.

Our unit is designed to operate from nominal audio input signal levels of about 100 mV RMS or greater and can simply be interposed between the output of the preamplifier and the input of the main amplifer of an existing audio system. The unit is battery powered by a stack of eight 1V5 cells and typically consumes about 12 mA.

Construction

The ETI Sound Bender is a fairly simple project and construction should present very few problems. Build up the PCB as shown by the overlay, noting the use of 16 Veropins to facilitate the circuit interwiring, then fit the PCB into a suitable case and complete the interwiring to the off-board components, noting that the two halves of RV4 are contra-connected. On our prototype unit the four control pots are fitted on the unit's front panel and the two switches and the input/output terminals are fitted on the

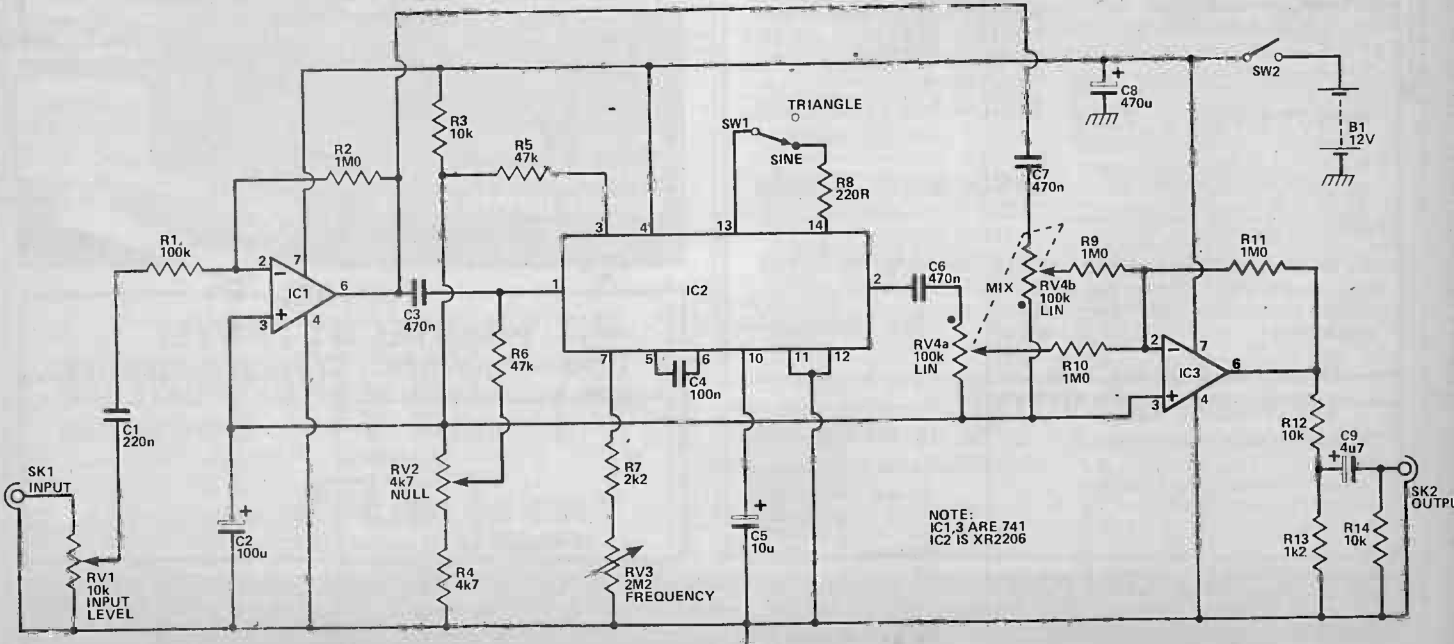


Fig. 1 Complete diagram of the ETI Sound Bender.

rear panel. As you can see from the photographs, the circuitry and battery pack make a fairly tight fit in the specified case.

The unit is very easy to use. Simply connect the output to an audio power amplifier/speaker combination, adjust RV2 (null) for zero output tone, then connect a voice or music input signal and see how the sound can be 'bent' using the frequency and mix controls. Level control RV1 is simply adjusted to give good sensitivity without amplitude limiting (clipping).

To use the unit as a simple audio generator, turn the input level control down and set the mix control (RV4) to give a 'modulation only' output, then adjust null control RV2 to give the desired output signal amplitude. RV3 then acts as the frequency control and SW1 gives selection of either sine or triangle output waveforms.

BUYLINES

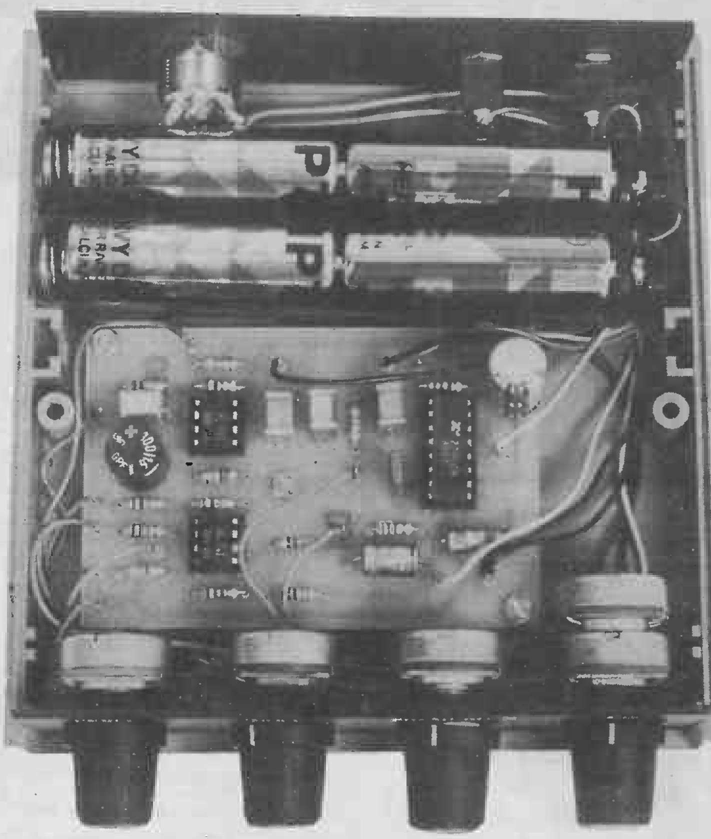
There are no unusual components used in this project — the XR2206 should be available from most major mail order companies advertising in this issue. The case used can be obtained from Watford Electronics or OK Machine and Tool Ltd — order as CM5-125. The PCB is available from our PCB service as advertised on page 54.

HOW IT WORKS

The heart of this unit is IC2, an XR2206 function generator chip that incorporates a wide-range sine/triangle waveform generator and a precision four-quadrant multiplier within a single package. The output of the waveform generator is internally connected to one input of the multiplier, and the other input of the multiplier is accessible at piin 1: the output is available at pin 2.

In our application, the generator can produce either sine or symmetrical-triangle waveforms, depending on the setting of SW1, and its frequency (determined by C4-R7-RV3) can be varied over the range 3 Hz to 5 kHz via RV3. The pin 1 input of the multiplier is biased by RV2, which is normally adjusted to balance the multiplier so that it produces zero output when zero signal input is applied to pin 1.

The audio input signal is applied across RV1 and a fraction of this signal is tapped off and applied to x 10 amplifier IC1. The output of IC1 splits into two paths, with one path passing to one input of two-channel audio mixer IC3 via RV4b, and with the other path passing to the input (pin 1) of IC2, which has its output (pin 2) taken to the other input of the IC3 mixer via RV4a. Note that mix controls RV4a and RV4b are contra-connected, so that they control the mixing action in 'pan pot' fashion, giving a final output from IC3 that ranges from 'all original signal' to 'all modulated signal' in the extreme settings of RV4. The output amplitude of IC3 is divided by 10 (by R12-R13), so that the final output signal has an amplitude roughly equal to that of the input signal feeding IC1, thereby giving the Sound Bender a good overall signal-to-noise ratio.



Everything does fit in the case specified, but only just!

PARTS LIST

Resistors (all ¼W, 5%)		C2	100u 16 V PCB electrolytic
R1	100k	C3,6,7	470n polycarbonate
R2,9,10,11	1M0	C4	100n ceramic
R3,12,14	10k	C5	10u 25 V axial electrolytic
R4	4k7	C8	470u 16 V PCB electrolytic
R5,6	47k	C9	4u7 16 V axial electrolytic
R7	2k2		
R8	220R	**Semiconductors**	
		IC1,3	741
Potentiometers		IC2	XR2206
RV1	10k linear		
RV2	4k7 linear	**Miscellaneous**	
RV3	2M2 linear	SW1,2	SPDT miniature toggle
RV4	100k dual linear	SK1,2	phono sockets
		PCB (see Buylines); four-section HP7 battery holders (two off).	
Capacitors			
C1	220n polycarbonate		

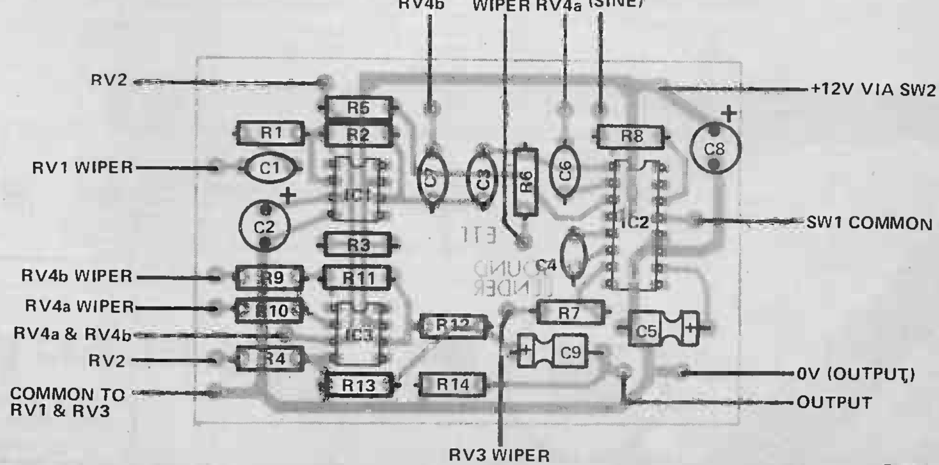


Fig. 2 Component overlay.

System A

Here are a few more cartridges and the recommended input module for the preamplifier. If you have a cartridge that isn't shown here or in the July '81 issue send us an SAE and we'll let you know which module is suitable.

Ortofon VMS 20E	E
Ortofon MC10	C
Stanton 680 EE	E
Entre 1	C
Rega 100	E
Coral MC88	E
Dynavector 10X II	E
Dynavector 20A II	E
NAD 9000	E
Technics EPC 205C	E
Reference Spectre	B
Koetsu	C
Grado FTE + 1	G
Bang & Olufsen MMC20CL	E

ACTing Up!

Hitachi are launching a follow-up to their successful ACT-01 bookcase hi-fi system called (surprise, surprise) the ACT-02. The system comprises of four main separate units — amplifier, tuner, cassette deck and speakers — each miniaturised and with brushed aluminium fascias. The amp and tuner measure only 230 mm wide by 74 mm high and, when placed on top of one another, come to the same height as the cassette deck. The amp has an output of 25 W per channel with no more than 0.3% total harmonic distortion. It has five LED power output meters per channel. The tuner receives FM, medium wave and long wave and has a flywheel coupled tuning knob and LED tuning indicators for spot-on station selection. For good clear, clean FM, the front end features a dual gate MOSFET. The cassette deck accepts metal, normal and C_rO_2 tapes. It has the Hitachi self-programme search system which lets you skip backwards and forwards to find your favourite track. There is also a recording mute function for editing as you record, microphone mixing with volume control, Dolby noise reduction and an air damped ejection system. The speaker enclosures contain a 12 cm woofer and a 5 cm tweeter. The ACT costs £349 complete and further information about it can be obtained from Hitachi dealers.

Happy Answer

Do you get irritated when you make a phone call and the only answer you get is the droning voice of one of those dratted answering machines? Well, GMTC are attempting to lower a lot of blood pressure levels by launching their 'Happy Answer Message Cassettes'. They carry six hilarious (?) singing messages, written, produced and recorded by Mitch Murray who is renowned for hits like 'Bonnie & Clyde', 'You Were Made For Me' and 'I Like It'. The idea of the tape is to put the caller in the right frame of mind for putting his message on the end of the tape. All too often people just mutter expletives and put the phone down — equally irritating for the recipient! The Happy Answer Message Cassettes are £2.50 each from all GMTC stockists including Harrods, Dickins & Jones, Allders and branches of W H Smith and Rymans, or by mail order from their showroom at 15 Newman Street, London W1. Telephone orders on 01-580 3647.

Audio Yearbook

Studio Sound's Pro-Audio Yearbook 1981, edited by Angus Robertson, is the second of a series of reference books for the professional audio and video markets. It's a massive hardbacked effort, running to 624 pages of information for the professional recording and broadcasting industries. The contents are arranged in two parts. The first consists of 71 alphabetically sequenced sections on equipment and services ranging from 'Amplifiers, Power' through 'Engineers, Freelance and Consultant' and 'Links, Radio' to 'Turntables, Pick-up Arms and Cartridges'. The coverage is exhaustive; the only glaring omission seems to be the area of professional sound reinforcement speaker systems. Curiously, synthesisers are included; these are normally considered to be musical instruments rather than sound equipment. Within each section the information is presented in a highly condensed fashion yet with sufficient detail to allow comparison between the makes and models on offer. Prices, in pounds sterling or US dollars, are quoted for most items to permit cost comparison. The first part also contains useful reference material; a list of pro-audio dealers around the world, international power supply standards, and a 'Jargon' chapter (which inexplicably contains many terms from television and even one or two from the print industry). The second, smaller, part consists of a series of indexes to companies and subjects mentioned in the first part, plus a list of international pro-audio manufacturers and distributors giving an address, telephone and telex number and a contact name for each. The Pro-Audio Yearbook will be a useful tool for anyone purchasing professional grade equipment. The inclusion of every aspect of pro-audio — recording, radio, television and film sound — means that much of its content will be irrelevant to any one user; presumably the size of the individual markets did not permit separate publications for each specialisation. In any case it could be argued that there is sufficient overlap in both equipment and services to justify the all-in approach. The retail price of £19.50 should not deter the professional sector but will almost certainly discourage amateur or casual interest. The Pro-Audio Yearbook 1981 is available from specialist bookshops, pro-audio dealers or by mail order from the Special Projects Dept, Link House Magazines (Croydon) Ltd, Link House, Dingwall Avenue, Croydon CR9 2TA. Post and packaging charges are £1.10.

Ron Keeley

Safe Bet

GMTC is a company which has only been operating for a year and has now taken on the sole agency of what they think will be a real winner — a safe with no keys! The GMTC Elsafe has already been featured on Tomorrow's World and Pebble Mill and has full approval from insurance companies like Lloyds of London. The cabinet is fitted with an electronically controlled panel which replaces the conventional keys and it offers one million combinations which can be changed every time the safe is locked. If someone doesn't know the combination and tries to open it, it will automatically cease to function after three attempts. Even if the right combination is then used, it will not open for another 30 minutes. The cabinet can be fastened to the floor with interior bolts and it has emergency batteries in case of power failure. The Elsafe measures 35.6 x 46.5 x 53.6 cm and retails at £450 including VAT. Further information from GMT Company, 15 Newman Street, London W1.

GMTC ELSAFE (SECURITY CABINET)

Defence Digest

This new regular feature is devoted to defence electronics, its equipment techniques and application. Defence remains one of the largest growth areas in UK industry, with much of the real innovation and investment taking place there.

Defence Digest will thus act as a news (and views) section, containing up-to-date information and explanation of some of the happenings in the different sectors of the defence industry.

Companies with information and articles for these columns are invited to submit them direct to Defence Digest at our editorial address. Indeed, anyone with anything to say on the subject, be it information or opinion, is a potential contributor and should not refrain from putting pen to paper.

Sky Flash For Sweden

The British Aerospace Dynamics Group has taken up an option valued at £11 million to supply a further quantity of Sky Flash air-to-air missiles to FMV (Forsvarets Materielverk), Sweden, to arm the Swedish Air Force's Saab Viggen JA37 all-weather fighter. FMV has also identified options for further quantities of missile. Sky Flash has been successfully integrated with Viggen and to date all firings have been effective. British Aerospace is the prime contractor for Sky Flash. Major sub-contractors include Marconi Space and Defence Systems for the advanced monopulse radar seeker and EMI Electronics Ltd for the radar proximity fuse. Sky Flash is the most advanced product of its type in production and affords a highly effective capability against modern air threats. It has a proven performance against both subsonic and supersonic targets flying from high, down to very low altitudes. Sky Flash is in service on Royal Air Force Phantom aircraft and will also arm the Tornado F2 Air defence variant. It has also been successfully fired from the General Dynamics F16 fighter.

New For Jaguar

The Ferranti FIN 1064 inertial navigation system is to re-equip the RAF Jaguar aircraft. The picture shows the program loading unit in position in the inertial navigation control unit. This program loading unit is first programmed by flight planning staff, and includes the flight program, navigation information for the sortie, weapon status and any other relevant tactical information. The PLU, which contains a printed circuit board instead of a tape cassette, is then inserted into the control unit by the pilot or ground crew and the data automatically and quickly transferred to the FIN 1064 computer in the aircraft.

Sunburgh Radar For CAA

After a two-year leasing period, the Civil Aviation Authority have purchased outright the Marconi Radar installation at Sunburgh in the Shetlands. The total cost is estimated to be £1/3 million. Marconi Radar Systems Ltd is a GEC Marconi Electronics company. The radar is one of the S600 series of transportable radars and has provided cover support for helicopters and oil-related air traffic serving the offshore oil industry in the North of Scotland. An S1061 L-band (23 cm) squintless feed antenna together with an S2011 transmitter/receiver provide good range performance against small targets such as helicopters and light aircraft, while circular polarisation and the S7100 Digital Signal Processor ensure a crisp, low 'clutter' display in the adverse weather conditions often experienced in the Shetlands. The company said of this latest order, 'the installation was carried out in record time — just five months from receipt of order the system was designed, assembled, containerised, transported to the Shetlands and commissioned ready for service — and in two years of operation we have been able to provide a quick response specialist back-up service so that a reliable operation has been maintained'.

Marconi Success

A series of trials, sponsored by the Royal Navy, has enabled Marconi Radar Systems Ltd to demonstrate the effective use of millimetric radar to further improve the GWS25/Seawolf anti-missile system's performance against low-level targets. The trials were carried out at one of the Royal Navy's firing ranges, and included seven successful 'live' firings of Seawolf against small and large targets close to the sea surface. Using a derivative of the DN181 Blindfire radar, on the same mount as the Seawolf type 910 tracker radar, the trials showed that the tracking of such targets as sea-skimming anti-ship missiles flying a few feet above the surface is considerably improved, therefore ensuring the probability of successful engagement by the Seawolf missile. At present this low-angle tracking is carried out by a television system. Now the DN181 gives an all-weather, round-the-clock capability. The DN181 was developed by Marconi Radar's sister company, Marconi Space and Defence Systems Ltd, and is used with the successful Rapier missile system. Marconi is the overall ship system contractor for GSW25/Seawolf; British Aerospace for the missile, and Vickers for the launcher.

Surveillance System For The Forces

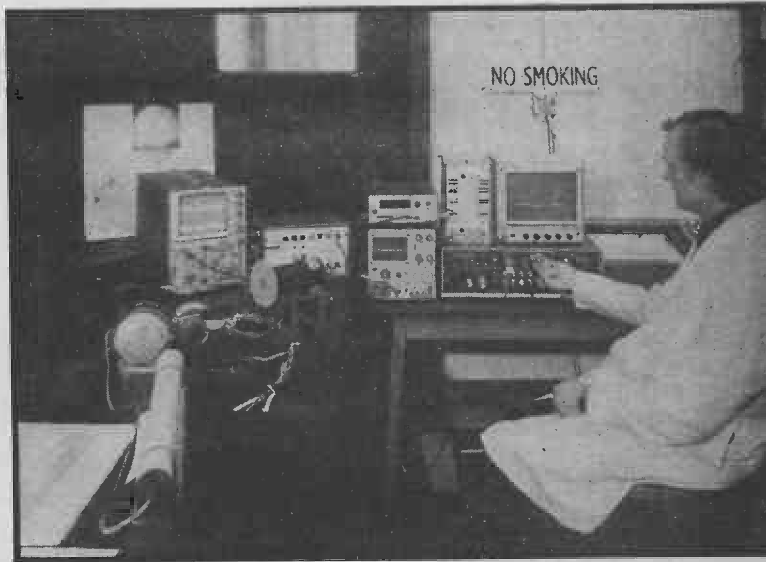
A new range of technically advanced radio surveillance and monitoring equipment is available from MCL (Marlborough Communications Ltd) the British telecommunications equipment company specialising in HF frequency management, electronic warfare surveillance systems, and related communications fields. The new range of equipment called COMINT is for use by all three armed services: Army, Navy and Air Force and can be used in airborne, shipborne, land tactical and in fixed site locations and will be installed as a system by MCL's engineers to suit the user's requirements. The system is designed and developed by SciComm Inc of Garland, Texas, leading specialists in this field, and it will be exclusively supplied by MCL. The Royal Air Force is currently using SciComm ELINT surveillance systems with MCL providing technical support. The picture shows Phil Derry (right), Marketing Director of MCL, discussing customer requirements for COMINT with Ray Urban May, Vice President Marketing of SciComm Inc who designed and developed the range of equipment.

Dart Gyroscope For Texas

The British Aerospace Dynamics Group Dart gyroscope produced at Stevenage has been selected by Texas Instruments for their Paveway III low-level laser guided bomb. The dart will be part of the digital guidance and control system to increase operational flexibility. The Dart is a miniature two-axis rate gyroscope giving high performance for low weight and size. The Paveway program has gained a reputation for one bomb — one target, and Paveway II has been in high volume production for several years, being the principal weapon of its category in the USAF inventory.

LASERS IN HI-FI

Laser technology is making a bid to replace the cartridge in your pickup arm, but it's already been in use for many years at the other end of the hi-fi, helping to develop better speakers. Peter Green takes a look at developments in the Wharfedale labs.



Designing loudspeakers is a complex business. Sound engineers trying to bridge the gap between theory and practice are faced with the tricky problem of investigating exactly how a speaker cone vibrates at frequencies across the audio band and at any point on the surface. Ten years ago the use of laser holography techniques was applied to speaker development by Wharfedale (yes folks, it's British); techniques which provide the design team with a 'contour-line' map of the vibration of a speaker cone.

Typical holograms obtained with this technique are shown in the centre row of Fig. 1. The contours provide a typical guide to the manner and degree of vibration suffered by the cone at the moment the hologram was taken, but although this technique is a good one it has a number of disadvantages. Complicated vibration patterns give intricate contours which require much interpretation; furthermore, there are no helpful little numbers printed on the contours as in an ordinary map so it's not possible to tell whether the vibrations are convex or concave in nature. This makes it difficult to judge what remedy should be applied to counter the resulting sound distortion, so that the analysis becomes an art rather than a science; it also takes time, and in research and development time often means a great deal of money. What is needed is a quick way of producing a three-dimensional view of the actual 'hills' and 'dales' of the terrain, rather than a 2-D map.

To overcome these problems two new laser techniques have been developed by Wharfedale's senior acoustic engineer, Dr Peter Fryer. They are based on the Laser Doppler Velocimeter concept pioneered at the Government's Atomic Energy Research Establishment at Harwell, together with work done at Southampton University. The equipment used was entirely designed and built by Wharfedale for a small fraction of the cost of commercially available (and inferior) sensors, using the excellent engineering rule of never re-inventing the wheel. The sensing circuit uses an ordinary FM radio set, and when you need a scanning mirror system, what else would a loudspeaker company build it from but loudspeaker voice coils?

Take A SCALP

The basic technique uses a Scanned Laser Probe, or SCALP, and in just 15 minutes it can provide an exact 3-D picture of the vibration of the whole surface of the speaker cone when a single frequency is fed into it. The signal from SCALP corresponds to both the amount *and* direction of the cone surface vibration at the point of reflection of the laser light, and thus gives a clearer and more accurate representation than holography requiring a minimum of interpretation. Alternatively a Frequency Slice Plot (FRESP) can be made, which shows on one plot the 3-D behaviour of the speaker cone in one plane over the complete range of audio frequencies. Until now this complete vibration-frequency signature has been impossible to obtain.

The SCALP process is basically quite simple and is shown diagrammatically in Fig. 3. Laser light passes through a beam splitter and emerges as two equally bright beams travelling at right angles to one another. One of these, the reference beam, falls onto a rapidly rotating disc whose speed is such that the frequency of the reflected laser light is Doppler-shifted by 10.7 MHz — the intermediate frequency of the IF strip inside an FM radio. The other beam (the sensing beam) is reflected from two mirrors and then onto the speaker under test. The two reflected beams, reference and sensing, return back along their original paths and meet again at the beam splitter. Half of each of them is sent into a new beam which falls onto a photocell.

This output beam is composed of light-half of which is at the original frequency and half of which has been frequency-shifted by the disc. The two components beat together at the photocell and produce a steady 10.7 MHz electrical signal which is fed into the appropriate part of an FM radio just as if it had been picked up by a radio aerial. With no audio signal being fed to the test speaker the FM radio will output a steady DC level, showing the speaker to be stationary.

Light . . . Music . . . Action

Suppose now that a single frequency is fed to the speaker. During the first part of the vibration cycle the speaker is moving forwards — the reflected laser light is shifted upwards in frequency by an amount that depends on the velocity of the cone. Thus the beat frequency at the photocell is altered and the FM radio output increases by a corresponding amount. When the speaker is moving away from the beam splitter the frequency of the sensing beam is reduced and so the radio output drops. Thus the output of the radio indicates both the amount and the direction of the speaker cone movement — phase information that the hologram would have lost has been preserved.

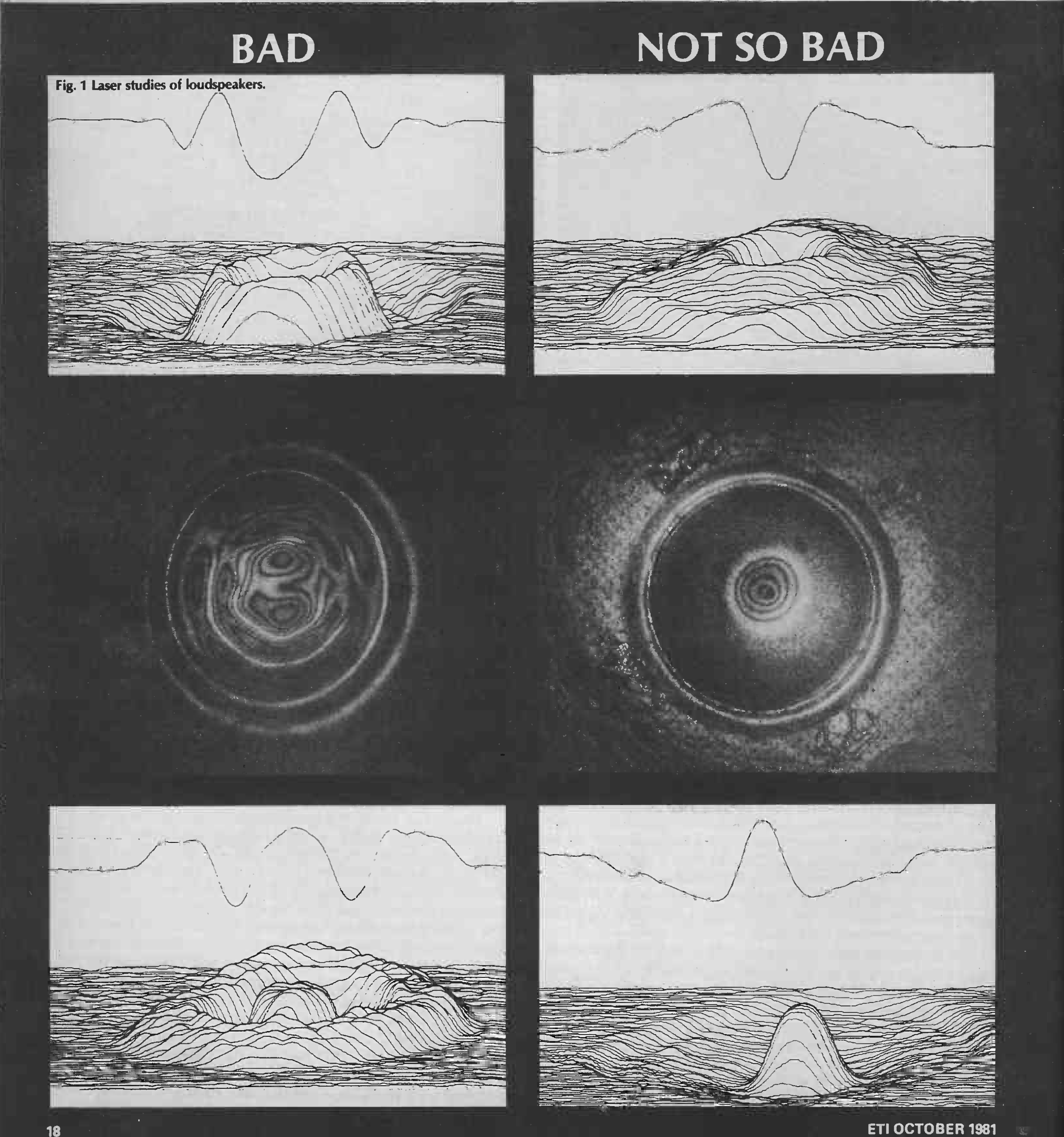


Fig. 1 Laser studies of loudspeakers.

The two mirrors in the path of the sensing beam are attached to loudspeaker voice coils. One of these is connected to the voltage from the 3-D plotter which scans the X-Y plotter across the page, the other to the voltage which scans up the page. Hence the sensing beam is scanned across the cone and at any point on the plot the movement of a corresponding point on the speaker is preserved in the form of a 3-D plot of the speaker vibration. Typical results of laser plotting are shown in the top row of Fig. 1.

FRESP — Son Of SCALP

FRESP is similar to SCALP, but in this case the vertical scanning mechanism is turned off. Thus each curve plotted is of the same horizontal slice across the middle of the loudspeaker. Instead of moving the laser beam by a small amount vertically for each separate trace, the frequency being fed to the speaker is changed between traces starting at the highest frequency and moving down in small steps to the lowest frequency.