Easy to build projects for everyone

Everyday ELECTRONICS

SEPT. 82

70p

SOUND SPLITTER

FOR MUSICAL INSTRUMENTS

SCHOOLS
Electronic Design Award
COMPETITION
Full Report inside

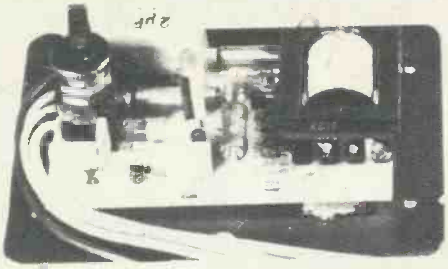
MONTHLY PLANNER

CB BATTERY CHARGER

SCREEN WASHER DELAY

Australia $1·35 Malaysia $4·95 IR £1·06 (inc. V.A.T.)

ELECTRONIC IGNITION KIT



TOTAL ENERGY DISCHARGE electronic ignition gives all the well known advantages of the best capacitive discharge systems.

PEAK PERFORMANCE —— higher output voltage under all conditions.

IMPROVED ECONOMY —— no loss of ignition performance between services.

FIRES FOULED SPARK PLUGS no other system can better the capacitive discharge system's ability to fire fouled plugs.

ACCURATE TIMING —— prevents contact wear and arcing by reducing load to a few volts and a fraction of an amp.

SMOOTH PERFORMANCE —— immune to contact bounce and similar effects which can cause loss of power and roughness.

PLUS

SUPER POWER SPARK —— 3½ times the energy of ordinary capacitive systems – 3½ times the power of inductive systems.

OPTIMUM SPARK DURATION 3 times the duration of ordinary capacitive systems – essential for use on modern cars with weak fuel mixtures.

BETTER STARTING —— full spark power even with low battery.

CORRECT SPARK POLARITY unlike most ordinary C.D. systems the correct output polarity is maintained to avoid increased stress on the H.T. system and operate all voltage triggered tachometers.

L.E.D. STATIC TIMING LIGHT for accurate setting of the engine's most important adjustment.

LOW RADIO INTERFERENCE fully suppressed supply and absence of inverter 'spikes' on the output reduces interference to a minimal level.

DESIGNED IN RELIABILITY an inherently more reliable circuit combined with top quality components – plus the 'ultimate insurance' of a changeover switch to revert instantly back to standard ignition.

IN KIT FORM

it provides a top performance electronic ignition system at less than half the price of competing ready-built systems. The kit includes everything needed, even a length of solder and a tiny tube of heatsink compound. Detailed easy-to-follow instructions, complete with circuit diagram, are provided – all you need is a small soldering iron and a few basic tools.

AS REVIEWED IN
ELECTRONICS TODAY INTERNATIONAL JUNE '81 ISSUE
and EVERYDAY ELECTRONICS DECEMBER '81 ISSUE

FITS ALL NEGATIVE EARTH VEHICLES,
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BARCLAYCARD VISA

DIMENSIONS:

Length	12.5 cm
Width	8.9 cm
Height	4.3 cm
Lead length	100.0 cm

TECHNICAL DETAILS

The basic function of a spark ignition system is often lost among claims for longer 'burn times' and other marketing fantasies. It is only necessary to consider that, even in a small engine, the burning fuel releases over 5000 times the energy of the spark, to realise that the spark is only a trigger for the combustion. Once the fuel is ignited the spark is insignificant and has no effect on the rate of combustion. The essential function of the spark is to start that combustion as quickly as possible and that requires a high power spark.

The traditional capacitive discharge system has this high power spark but, due to it's very short spark duration and consequential low spark energy, is incompatible with the weak air/fuel mixtures used in modern cars. Because of this most manufacturers have abandoned capacitive discharge in favour of the cheaper inductive system with it's low power but very long duration spark which guarantees that sooner or later the fuel will ignite. However, a spark lasting 2000µS at 2000 rev/min. spans 24 degrees and 'later' could mean the actual fuel ignition point is retarded by this amount.

The solution is a very high power, medium duration, spark generated by the TOTAL ENERGY DISCHARGE system. This gives ignition of the weakest mixtures with the minimum of timing delay and variation for a smooth efficient engine.

SUPER POWER DISCHARGE CIRCUIT A brand new technique prevents energy being reflected back to the storage capacitor, giving 3½ times the spark energy and 3 times the spark duration of ordinary C.D. systems, generating a spark powerful enough to cause rapid ignition of even the weakest fuel mixtures without the ignition delay associated with lower power 'long burn' inductive systems.

HIGH EFFICIENCY INVERTER A high power, regulated inverter provides a 370 volt energy source – powerful enough to store twice the energy of other designs and regulated to provide sufficient output even with a battery down to 4 volts.

PRECISION SPARK TIMING CIRCUIT This circuit removes all unwanted signals caused by contact volt drop, contact shuffle, contact bounce, and external transients which, in many designs, can cause timing errors or damaging un-timed sparks. Only at the correct and precise contact opening is a spark produced. Contact wear is almost eliminated by reducing the contact breaker current to a low level – just sufficient to keep the contacts clean.

TYPICAL SPECIFICATION

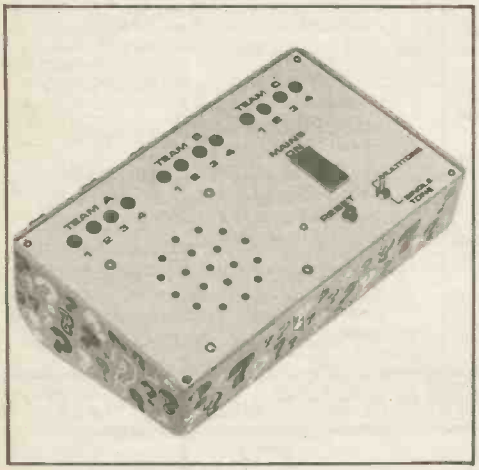
	TOTAL ENERGY DISCHARGE	ORDINARY CAPACITIVE DISCHARGE
SPARK POWER (PEAK)	140 W	90 W
SPARK ENERGY	36 mJ	10 mJ
(STORED ENERGY)	135 mJ	65 mJ
SPARK DURATION	500 µS	160 µS
OUTPUT VOLTAGE (LOAD 50pF EQUIVALENT TO CLEAN PLUGS)	38 KV	26 KV
OUTPUT VOLTAGE (LOAD 50pF + 500 KΩ EQUIVALENT TO DIRTY PLUGS)	26 KV	17 KV
VOLTAGE RISE TIME TO 20 KV (Load 50pF)	25 µS	30 µS

TOTAL ENERGY DISCHARGE should not be confused with low power inductive systems or hybrid so called reactive systems.

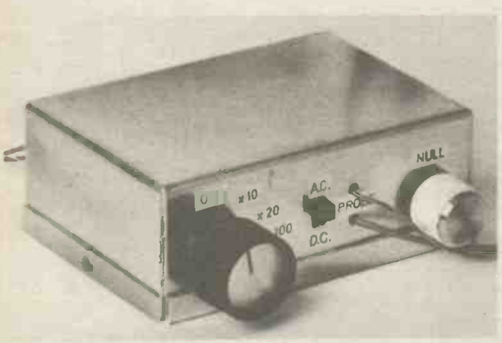
VOL. 11 NO. 9 SEPTEMBER 1982

Everyday ELECTRONICS

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



SCHOOLS Electronic Design Award COMPETITION



A full report appears on page 590.

PROJECTS

SERIES

FEATURES

Our October issue will be published on Friday, September 17. See page 587 for details.

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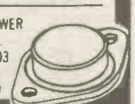

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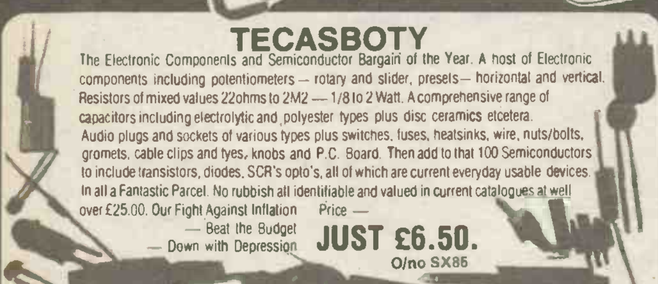

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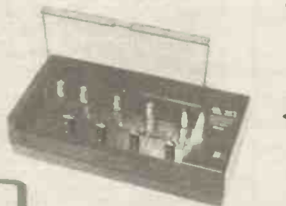

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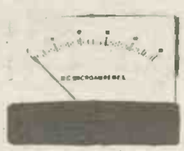

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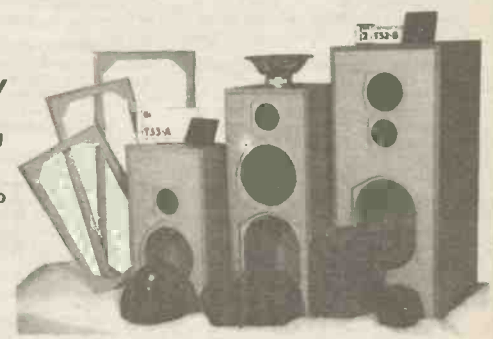

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THE YOUNG GENERATION

Electronics casts its spell at an early age and younger members of our society are readily attracted to this technology. Whilst at school many children become actively involved in experimenting and building projects to meet actual needs or perhaps just to satisfy inquisitive minds.

If given but a modicum of encouragement by members of teaching staff, this youthful enthusiasm is likely to be self-sustained throughout the final and formative years at school. Even more fortunate are those children who have a teacher with a similar interest in electronics. With such a mentor to guide and advise them in these (usually extra-curricular) activities, young minds will develop their appetite for electronics in the best and most logical manner.

Schools, themselves, can gain materially from the practical work of their electronically inclined pupils, a fact most clearly demonstrated by the Schools Electronic Design Award Competition (SEDAC), sponsored by Mullard Ltd and this magazine. The culmination of this competition was the presentation of prizes by the Parliamentary Under-Secretary of State, Department of Education and Science. The Minister praised the endeavours and inventiveness of the young entrants and the excellence of their working models: he was particularly pleased by the practical aspect of the competition and welcomed this encouragement of interest in electronics and computers amongst the young. The Minister voiced one regret: that was concerning the absence of girls amongst the finalists. We agree with him that this cannot be because of lack of interest in electronics among schoolgirls—our own evidence points to the contrary. So come on girls, don't let the fellows get away with it at next year's SEDAC.

The success of our first national schools competition has been well noted. We are delighted to announce that Mullard Ltd have agreed to join us in sponsorship of a second Schools Competition, to be launched this autumn. Full details will appear in next months EVERYDAY ELECTRONICS.

NEW SEASON IS A'COMING

October is always a notable month on account of the renewed activity amongst constructors after a summer lull. It is also the optimum time for newcomers to make a start in this stimulating and useful leisure pursuit.

Next month we will give a pair of transistors with every copy and inside will be suitable designs for their use. For those hovering on the edge there's encouragement to take the plunge in the first of a six-part series, *Introducing Electronics*.

Finally, to something over which we have little control. Economic facts of life make it necessary for the price of EVERYDAY ELECTRONICS to be increased to 80p as from next month. But it will be well worth every penny.

Fred Bennett.

Back Issues
Certain back issues of EVERYDAY ELECTRONICS are available worldwide price 80p inclusive of postage and packing per copy. Enquiries with remittance should be sent to Post Sales Department, IPC Magazines Ltd., Lavington House, 25 Lavington Street, London SE1 0PF. In the event of non-availability remittances will be returned.

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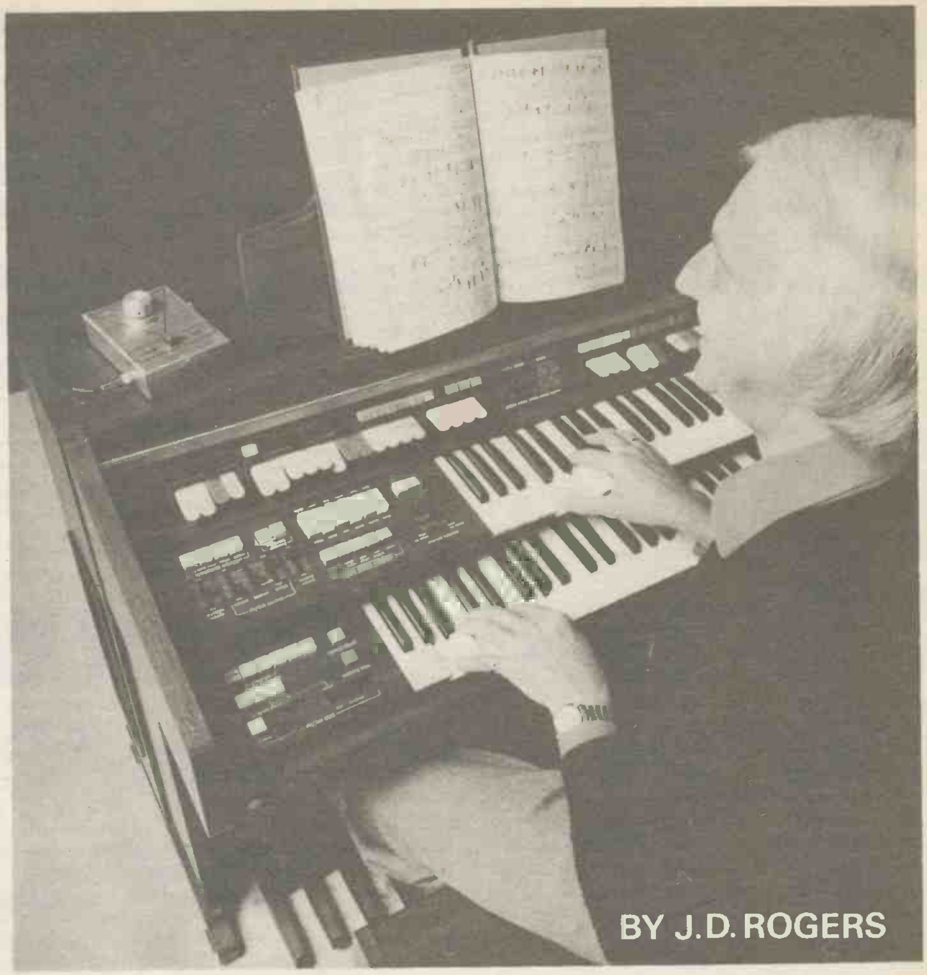
SOUND SPLITTER



BY J.D. ROGERS

CIRCUITS to give a stereo simulation from a mono input have been published before but these are normally for hi fi use and are not suitable for the musician. It might also be said that a "stereo" splitter would be of little value to the average musician with only one amplifier. In this unit however, the stereo splitter circuitry is modified so as to be useful with even a small, single input amplifier.

The unit combines an improved pseudo-stereo effect with two other useful functions, described later, to give a device which has a wide range of applications.

The unit is simple to use and easy to construct, no test equipment is needed and no setting up or adjustments are required. The circuit contains only two i.c.s, both common types, there are no unusual components and it uses a standard size Veroboard and ready made case.

To describe the unit itself and describe its applications it is best to consider both of these together, and this is done later, under a separate heading for each of the three modes of operation. These modes are selected by a small toggle switch on the side of the unit and are: SWITCHER MODE, FREQUENCY SPLIT MODE and CROSSMIX MODE. Regardless of which of these modes is set, selecting NORMAL on the footswitch will always give a "straight" signal at the main output.

All effect/normal signal routing is performed by electronic (f.e.t.) switches, as this is superior to normal switching and does away with the need to use a d.p.d.t. footswitch. A wider choice of footswitch is made available since a s.p.s.t. or indeed any type of footswitch can be used, and yet always give smooth and reliable switching. This is because the footswitch itself only has to carry a d.c. command voltage while the actual audio signal switching takes place on the circuit board.

CIRCUIT OPERATION

The circuit diagram for the Sound Splitter is shown in Fig. 1.

Although the circuit uses six op-amps, these are contained in just two packages, IC1 and IC2 one dual and one quad. IC1a acts as a input buffer and a preamplifier. At its input is a network which adds a treble pre-emphasis.

When footswitch S1 is set to NORMAL (contacts open) a negative voltage is fed to the gates of the two f.e.t.s. (TR1, TR2) and this switches them both off. IC1b therefore has only R11 in its negative feedback loop and so it acts simply as a unity gain inverting amplifier stage.

Its signal passes via R17 to the output (TR2 has no effect as it is off) where C9 and R19 form a treble cut (de-emphasis) filter to cancel out the effect of the pre-emphasis that was added at the input. This restores a virtually flat response overall and the net result is noise (hiss) reduction, since any noise arising from any source within the unit is reduced by being attenuated at the last possible point, the output. The circuitry is low noise anyway, but this gives a further improvement.

EFFECT SWITCHING

Now consider the same parts of the circuit when EFFECT is selected. Now S1 is closed so the voltage sent to the f.e.t. gates is positive, which switches them both on. IC1c and d form two bandpass filters and so will only pass certain sections of the audio spectrum, in this case centred at

Front cover: courtesy Bert Kempster, Riverside Organ Studios Ltd, Crawley.

approximately 300Hz and 3kHz. These bands are now added (via TR1, now on) to IC1b where, being in antiphase to the main signal (via R10), they cancel out parts of the response. The output of IC1b therefore becomes notched.

C7 is also brought into circuit when TR1 comes on, increasing the negative feedback around IC1b so reducing the gain, but only at high frequencies. The result is that frequency response above 7kHz is removed. Fig. 3a shows the final response.

COMPENSATION

Since three bands have now been removed from the response, a noticeable drop in overall sound level would be heard upon switching between NORMAL and EFFECT, so TR2 has been included to compensate for this by bringing R16 into circuit whenever EFFECT is selected. This gives a general level boost and also reduces the treble de-emphasis at the output, so even though response around 3kHz and above 7kHz has been removed, the overall "brightness" is preserved. The final result is a unique change of timbre without any volume loss.

The other, more important, reason for including TR2 is to ensure that when NORMAL is selected the main output is isolated from the other channel crossmix network (C10, C11, R26).

So much for the main signal path, now consider the secondary channel, which consists of IC2a and b and associated components. Normally the signal from the preamp (via R20) plus an identical but inverted signal from IC1b (via R21) are fed to IC2b and these cancel to give zero output.

When EFFECT is selected however, parts of the main signal are removed, as described earlier, and where this takes place the two inputs to IC2b can no longer cancel out and so there is now an output at these frequencies, that is around 300Hz, 3kHz and above 7kHz. See Fig. 2b.

This can be summarised as "whatever is removed from the main channel appears in the secondary channel".

The secondary path continues to IC2a, which, with VR1 forms a centre zero volume and phase control. When VR1 is at zero resistance IC2a is an inverting amp; when VR1 is at full resistance IC2a is a non-inverting amp; when VR1 is at 10kΩ resistance then there is no output at all since IC2a is equally inverting and non-inverting.

Finally, the signal is fed via C10, C11, R26, R27 to the secondary output jack SK3. R26, C10, C11 only have effect when CROSSMIX mode is selected. C11 is included so as not to lose, in crossmixing mode, the feature whereby a second amp does not have to handle low frequencies. It forms a highpass filter with R26 whenever

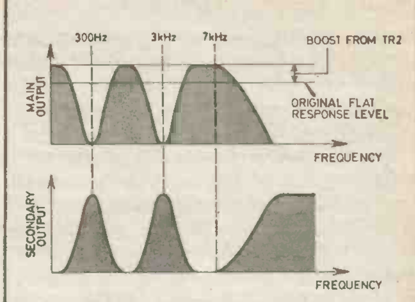
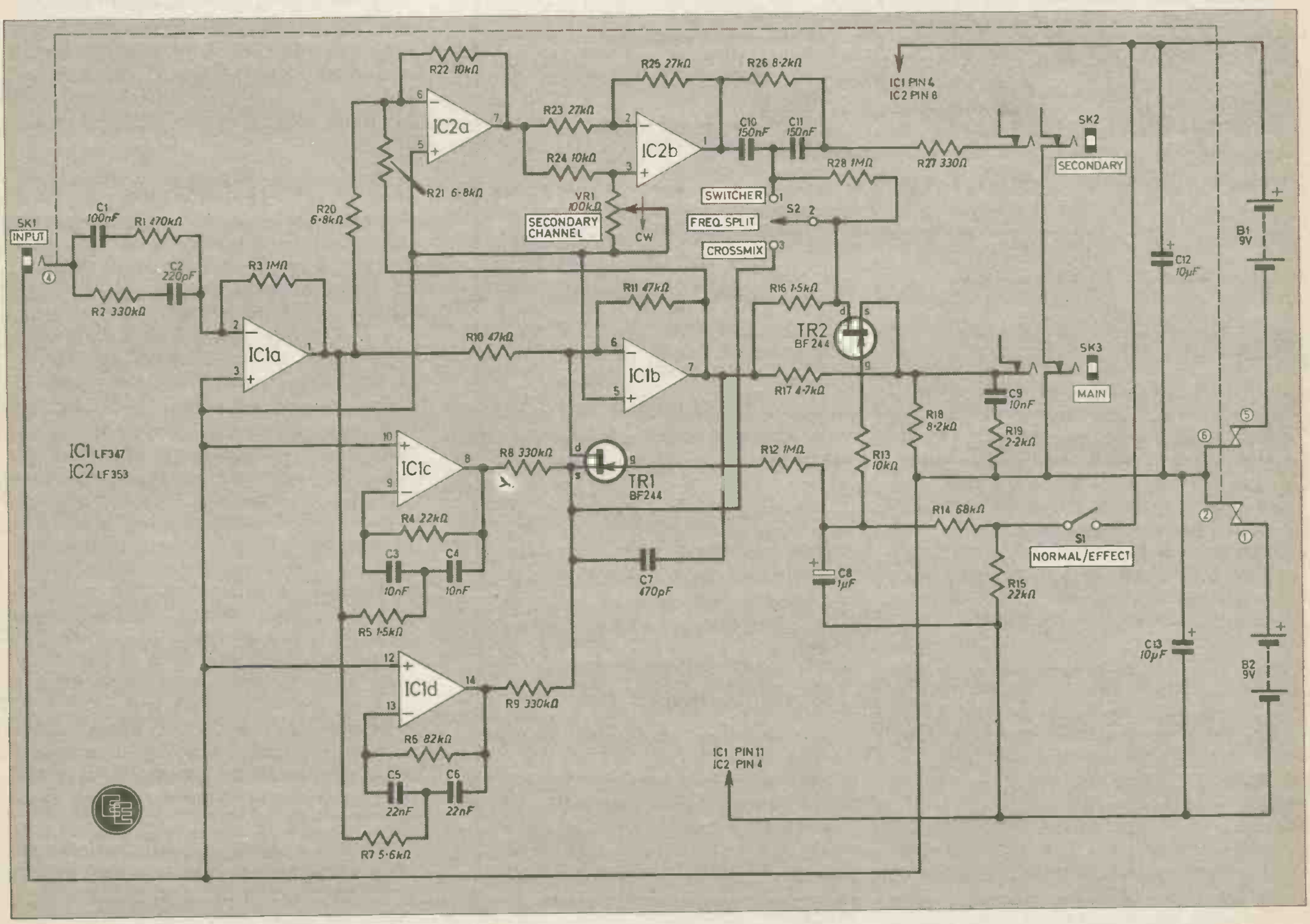


Fig. 2. Frequency response in the FREQUENCY SPLIT mode.

Fig. 1. The complete circuit diagram of the Sound Splitter.



CROSSMIX mode is selected thus preventing bass signals from the main output getting into the secondary output. R27 is included to isolate the output of the op-amp from cable capacitance which could otherwise cause instability.

R28 is placed across S2 to prevent switch clicks by equalising any small d.c. offsets that could otherwise accumulate, but it is of sufficiently large value as to have negligible effect on the actual audio signals.

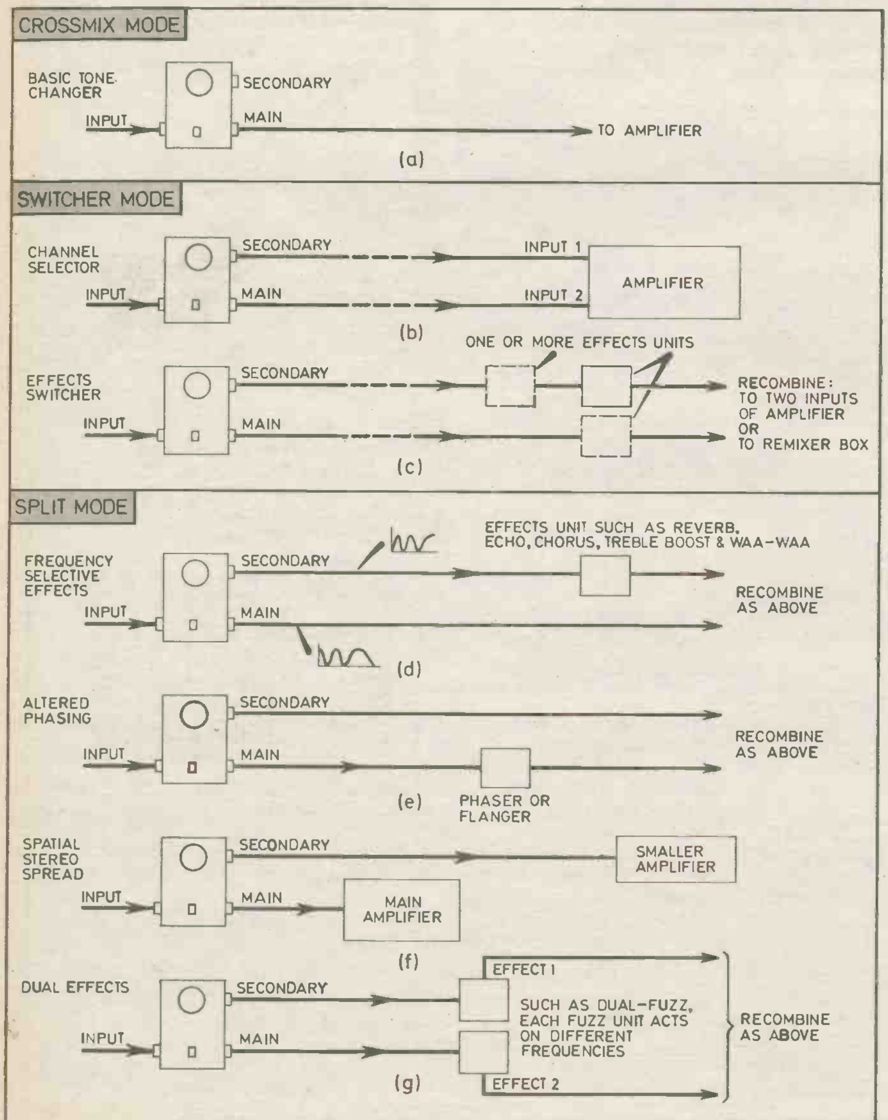
SWITCHER MODE

In SWITCHER mode pressing the footswitch routes the signal alternately to the two outputs (MAIN and SECONDARY). SWITCHER mode allows better use to be made of any amp with two or more inputs or channels, that is most amps. Each channel can be set up for a different sound and then selected remotely and instantly by the footswitch. It also allows any other effects unit (or combinations of effects units), placed in either the main or the secondary path(s) to be switched, see Fig. 3b and c.

So as to allow improvement of other effects units, the level of the secondary output has been made variable, by means of VR1. Designers of effects circuits can only have an average input level in mind, so it is likely that any real instrument output is either too low (so you don't get the best signal-to-noise ratio from the effect) or too high (so it overloads). This control allows the "drive level" to any effect unit to be boosted (up to ×3) or reduced compared to the instruments original level. To find the best level, turn the control until maximum output is obtained without distortion occurring.

If you do not have two inputs on your amp, then the simple and inexpensive "Two-way Remixer" box (described later) can be used instead.

Fig. 3. A few applications of the Sound Splitter from the simple to the more complex. Set the footswitch to EFFECT for the stated effect in each case.



This accepts any two inputs and combines them into one output.

SPLIT MODE

When set to NORMAL, there is a "straight" signal from the MAIN output, but upon pressing the footswitch certain bands of frequencies are removed from it, thus altering the response.

To keep the overall volume constant a general boost is automatically applied, enough to make up for the removed bands. So, just by using the MAIN output on its own, this mode provides a footswitchable tonal change effect, from normal to a lighter, coloured, sound not possible using normal tone controls. See Fig. 3a.

The missing bands of frequencies are not lost, but are transferred to the previously "dead" SECONDARY output. All of the audio frequency spectrum is therefore still passed but is split into two complementary outputs, whatever is absent from one will be present in the other, see Fig. 2.

Having generated these two outputs, what to do with them is up to the user, but some tried suggestions are:

(1) To a simple passive remixer (see Fig. 7). This then allows you pan between two entirely opposite tonal responses. The relative volumes of these can be balanced by using VR1 to preset the level of the secondary output.

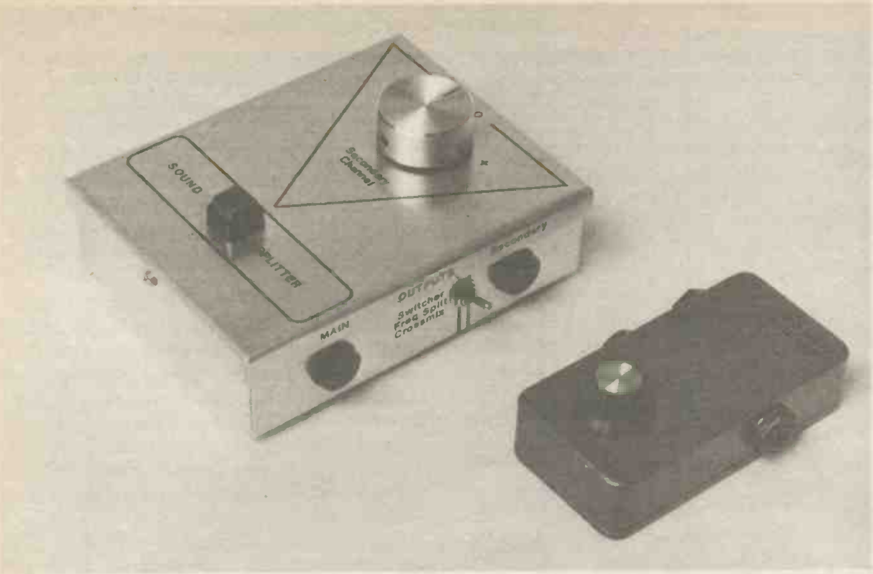
(2) To two channels of the same amp. Each channel now handles different parts of the signal, so tone controls and any built-in effects (such as reverb or tremolo) can be applied to some frequencies and not to others, with some unusual results. The footswitch can be used to return to normal single channel operation of the amp at any time.

(3) To two separate amps (or to two sides of a P.A. system). This produces a pseudo-stereo effect which gives a spatial enhancement or "spread" of the sound.

Two useful features are that (i) it is possible to use a much smaller amp/speaker for the secondary channel since its output signal consists only of certain bands of the audio spectrum, the lowest of which is centred around 300Hz, so there is no deep bass present which would require a more substantial amp/speaker to handle it. And (ii) the second amp can be positioned any distance away and its volume conveniently "remote controlled" by VR1 on this unit. See Fig. 3f.

(4) One output via effects unit(s), the other straight. Then as in (1), (2) or (3) above.

(5) Both outputs via effects unit(s). Then as (1), (2) or (3) above.



Prototype Sound Splitter and Two-Way Remixer.

With the latter two methods, novel variations on existing effects are possible by feeding the effect with certain frequencies only and allowing the others to bypass it or even to go via another effects unit. Here then are hundreds of possibilities to be explored, just a few examples are given in Figs. 3d, e and g.

All of the effects using the frequency split mode have been found to sound better or worse depending on the relative phases of the final signals appearing at the speaker(s). There is no way of predicting whether a signal via any particular route will end up being inverted as this depends on many stages in the circuits within the amp(s) and any effects unit(s) used, as well as on which way the speakers are wired.

To take all possible situations into account, the Sound Splitter SECONDARY output has been given the facility whereby it can be of either phase relative to the other output. It is controlled by VR1, which has a centre zero arrangement. Volume increases towards either side of centre but the phase of the output is different depending on whether it is in the +ve or the −ve half of its rotation, as marked on the panel.

CROSSMIX MODE

In the CROSSMIX mode there is normally "straight" signal from the main output and upon pressing the footswitch the frequency splitting as described above occurs, but in this mode the two channels are internally cross-mixed in such a way as to produce new tonal colours.

These are available from either one of the outputs and can be varied by using VR1 to alter the percentage of the mix coming from the secondary channel. In this mode then, VR1 effectively becomes an unusual tone control.

CONSTRUCTION starts here

COMPONENT ASSEMBLY

Construction is straightforward, but is most convenient if carried out in a certain order. If you follow the stage-by-stage instructions given here, and tick off each part as you proceed it will ensure that everything gets done with the least possible effort and that nothing is forgotten.

The majority of the components are mounted on a piece of 0·1 inch

COMPONENTS

Resistors

R1	470kΩ	R15	22kΩ
R2	380kΩ	R16	1·5kΩ
R3	1MΩ	R17	4·7kΩ
R4	22kΩ	R18	8·2kΩ
R5	1·5kΩ	R19	2·2kΩ
R6	82kΩ	R20	6·8kΩ
R7	5·6kΩ	R21	6·8kΩ
R8	330kΩ	R22	10kΩ
R9	330kΩ	R23	27kΩ
R10	47kΩ	R24	10kΩ
R11	47kΩ	R25	27kΩ
R12	1MΩ	R26	8·2kΩ
R13	10kΩ	R27	330Ω
R14	68kΩ	R28	1MΩ

All ¼ watt carbon film ±5%

See Shop Talk page 567

Capacitors

C1	100nF polyester type C280	C8	1μF 25V elect.
C2	220pF polystyrene	C9	10nF polyester type C280
C3	10nF polyester type C280	C10	150nF polyester type C280
C4	10nF polyester type C280	C11	150nF polyester type C280
C5	22nF polyester type C280	C12	10μF 10V tantalum
C6	22nF polyester type C280	C13	10μF 10V tantalum
C7	470pF polystyrene		

Semiconductors

TR1, 2	BF244 *n*-channel f.e.t. (2-off)
IC1	LF347 quad j.f.e.t. op-amp
IC2	LF353 dual j.f.e.t. op-amp

COMPONENTS approximate cost £12
Remixer £3.50

Miscellaneous

VR1	100kΩ carbon log. potentiometer
S1	s.p.s.t. footswitch
S2	s.p.d.t. centre-off miniature toggle
SK1	stereo jack socket with d.p.d.t. switched contacts (Tandy 274-277)
SK2, SK3	standard jack socket with break contacts (2 off)
B1, B2	PP3 9V battery (2 off)

Stripboard: 0·1 inch matrix size 24 strips × 37 holes; aluminium case with lid size 125 × 100 × 40mm; control knob with index marker; PP3 battery clips (2 pairs); Veromounts.

Two-Way Remixer

R1, R2	150kΩ ¼W carbon (2-off)
VR1	47kΩ carbon linear potentiometer
SK1, 3	standard jack socket (2-off)
SK2	standard jack socket with break contacts

Case: 100 × 50 × 25mm enamel finish aluminium diecast box (Maplin DCM5002).

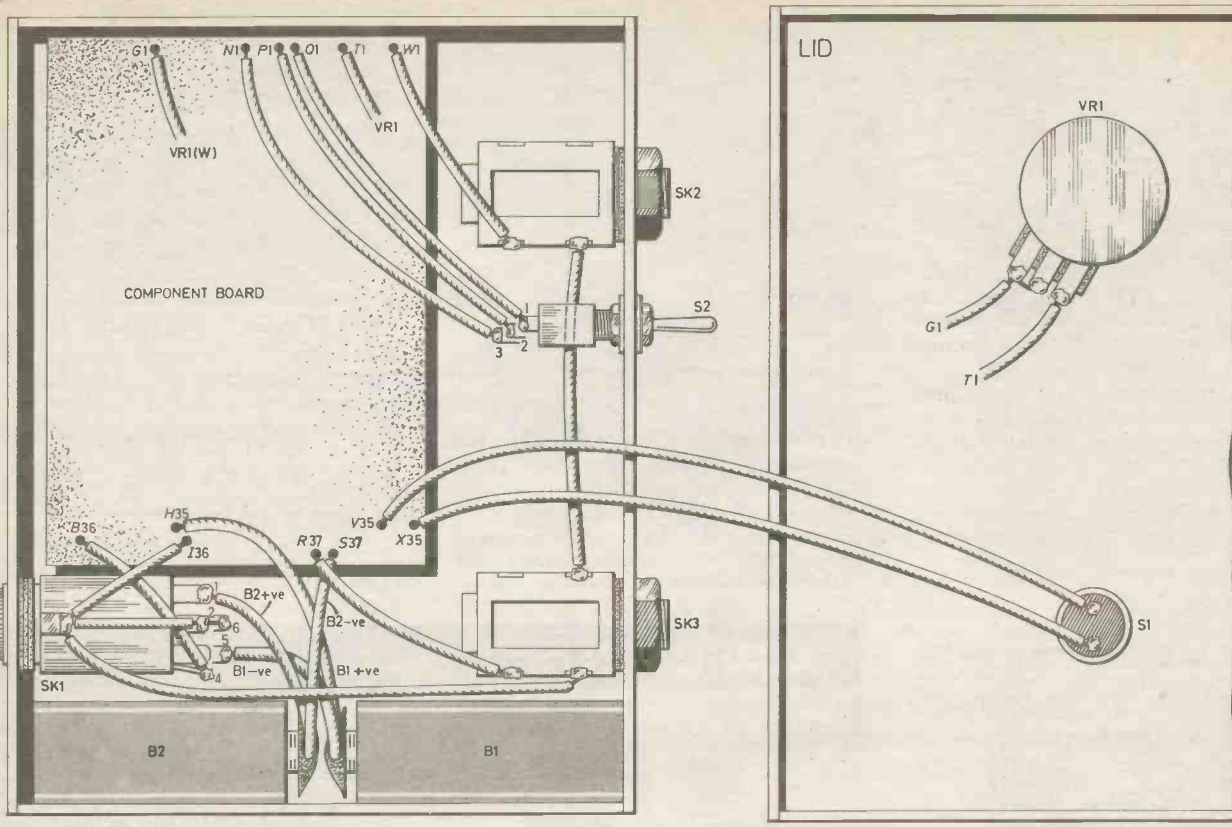
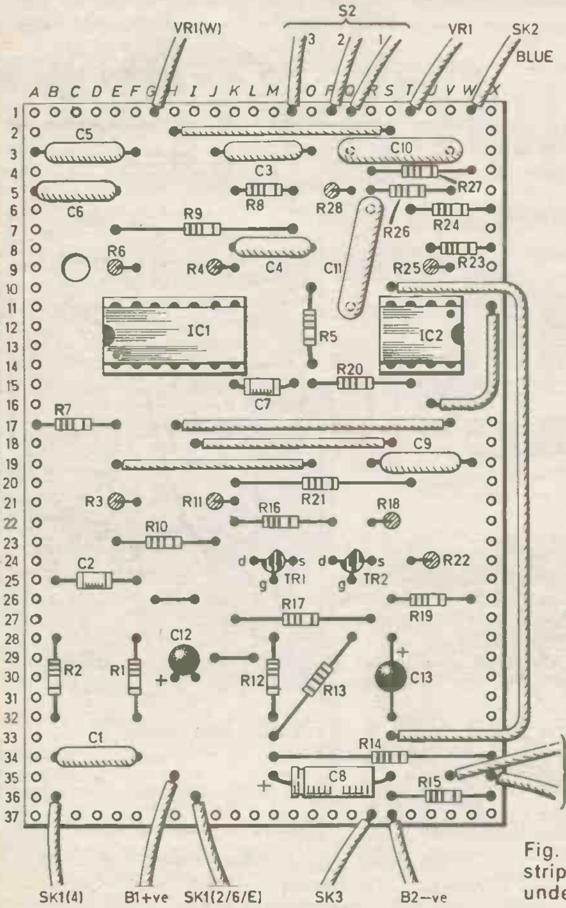


Fig. 5. Complete interwiring details.



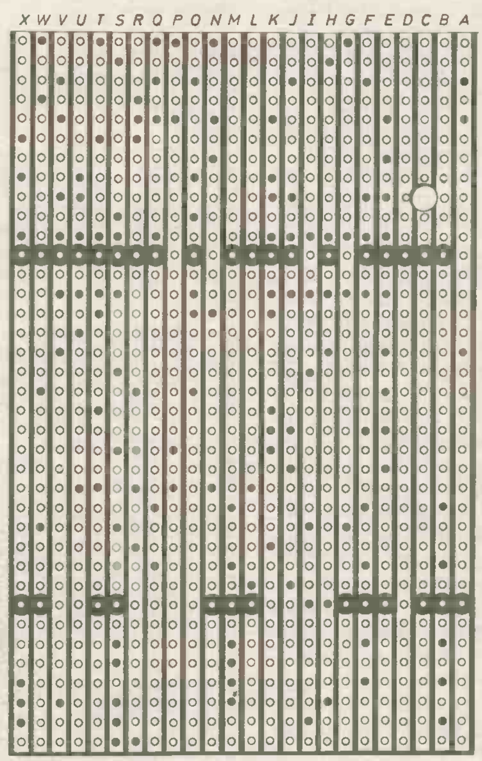


Fig. 4. Layout of the components on the topside of the stripboard and the breaks to be made in the tracks on the underside.

Veroboard size 24 strips × 37 holes as shown in Fig. 4. Cut the board to size and then make all the necessary breaks in the copper tracks using a spot face cutter or a small drill bit (about 3mm diameter). Drill the board fixing hole where shown in Fig. 4. The other three corners of the board should be supported by pieces of plastic foam stuck to the bottom of the case. In fact, separated Vero-mounts are ideal for this, just stick squares of either type of the velcro material where the three other corners of the board will rest.

By having just one bolt point and three resilient mounts the board is well anchored and is insulated from the metal case but is not held too rigidly, so accidental knocks to the case are less likely to be transmitted through and damage the board.

CIRCUIT BOARD

Begin board construction by soldering in all of the flat-lying resistors, then the 220pF and 470pF capacitors.

Solder in the six larger of the links. Use insulated wire for these so as to prevent any shorts should the links flex and touch other components.

Solder in the two smaller links, using bare wire.

Insert and solder in the two i.c. sockets, then the eight vertically mounted resistors and finally the rest of the capacitors. Next solder sufficient lengths of insulated stranded wire to the board to reach the appropriate case mounted components.

Position and solder in place the two transistors and then insert the i.c.s into their sockets, carefully checking their orientation.

CASE DETAILS

Drill out holes in the case, for the footswitch, the potentiometer, the toggle switch and the three jack sockets, following the dimensions given in Fig. 6 (unless of course a different case is used). A small hole is also required in the bottom of the case to put a small bolt through to hold the circuit board in place. The two jack sockets at the lower end have been placed so as to act as battery retainers. A strip of plastic foam across the bottom can be added to keep the batteries firmly in place.

Clean the case before proceeding to letter it. Letraset or similar rub-down transfers will give a professional finish. Either the panel design shown on the prototype can be followed or the constructor can make up a design to suit himself.

Fix the lettering for protection with a clear varnish. Letraset 101 aerosol is most convenient and gives a tough enough finish. When the varnish has

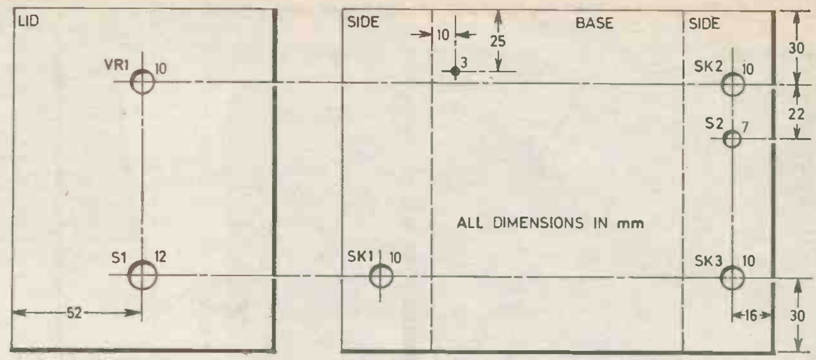


Fig. 6. Case drilling details.

dried, mount the sockets, potentiometer and two switches. Put four stick-on rubber feet on the case underside. See Fig. 5.

Interwire just the case mounted components, as shown, using the usual multi-strand hook-up wire, neatly routing all leads around the bottom of the case out of the way. Next interwire the circuit board to the case mounted components, keeping the wiring neat as before. After checking all connections, bolt the board into the case.

REMIXER BOX

Apart from its intended use with the Sound Splitter, the remixer box is a generally useful unit to have around, and being purely passive it needs no batteries.

The circuit for the Two-Way Remixer is shown in Fig. 7. The two input signals to *A* and *B* are "mixed" across VR2, the amount of each appearing at the output depending on the resistance between VR2 wiper and the input socket. With the wiper in its mid-position, the output contains equal amounts of signals at *A* and *B*.

The two 150kΩ resistors R1 and R2 ensure that there is always a d.c. reference path for any connection to the box, these resistors are placed prior to the potentiometer VR2 where they do not cause unnecessary reduction of the signals.

Construction is very simple, any metal box can be used as long as it is big enough to contain three plastic jack sockets and a potentiometer, see Fig. 8.

A Maplin type DCM5002 diecast box was used for the prototype. The jack sockets had to have their con-

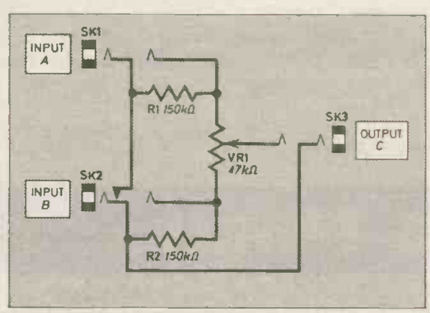


Fig. 7. Circuit diagram for the Two-Way Remixer.

Interior view of the completed prototype Remixer.

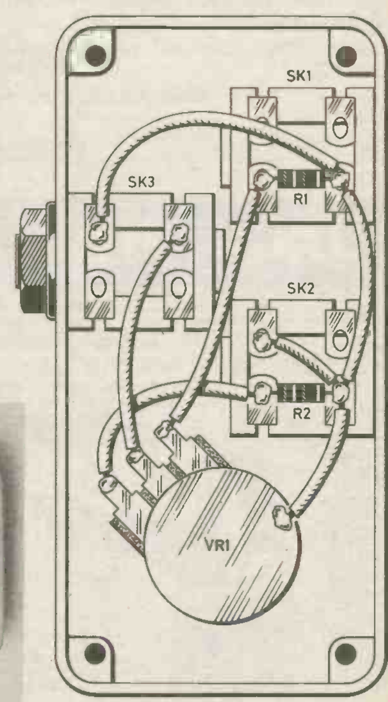
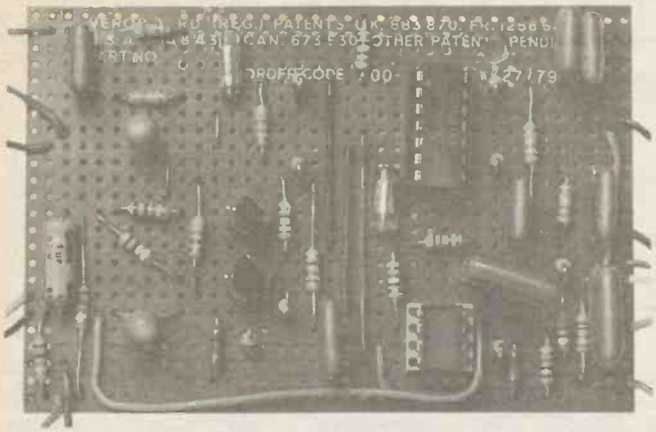
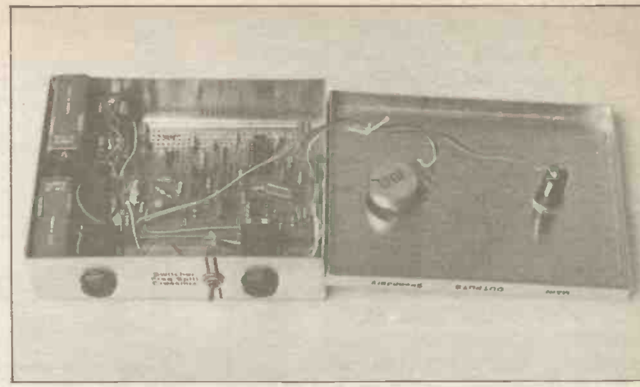


Fig. 8. Layout and wiring of the Remixer components in the diecast aluminium box.





The completed Sound Splitter unit with lid removed showing batteries in position.

Left. Close-up view of the Sound Splitter component board.

tacts folded down flat to fit into this particular box and a few strips of insulation tape were stuck on the inside of the case lid to prevent the contacts shorting to the metal case.

The earth contacts of the three sockets are wired together and, since they are all plastic types, the metal case must be earthed via the potentiometer, by soldering an "earth lead" to the back of its case.

When there is no jack inserted in *B* then the unit is still usable simply as a volume control for the *A* input, because the *B* input is automatically earthed by the normally closed contact on the socket itself.

EARTHING CONSIDERATIONS

Problems can occur whenever two separate signal paths are in use from a common source, because of the formation of earth loops, which invariably give rise to unacceptable mains hum.

However, these situations are automatically prevented in the Splitter by means of a break contact on the main output jack SK2 which, when a plug is inserted, disconnects the earth to the secondary output jack. So, whenever *both* outputs are in use, only the lead from the main output will be directly earthed (the other lead will still be earthed, but from the "other end" via the amp.).

If only the secondary output is being used, then its earth will remain connected, thus all situations are catered for.

CONCLUSION

The unit will accept an input from any instrument or other audio source, and the input jack switches on the batteries when a plug is inserted. Battery drain is low (about 10mA) so two PP3 batteries should last a long time.

The Sound Splitter is an effects unit in its own right, and of course can be used as such, however, its real versatility lies in the many interesting ways in which it can be used in conjunction with any other effects unit and the Two-Way Remixer. Used in this way it can help in the musicians constant search for different sounds by squeezing a few more variations out of existing types of effects.

As mentioned earlier there are so many combinations possible, simple and complex, that it is pointless to try and list them here, it is really up to the user to discover uses to suit his own equipment, taste and style of playing.

Finally, for anyone who wishes to experiment with further effects, a useful control to add is a 47kΩ log. potentiometer connected between the "capacitor ends" of R5 and R7. This allows the peaks of both the band pass filters in the unit to be swept to different frequencies, eventually forming into a single peak when the potentiometer is at zero ohms. ⌑

JACK PLUG & FAMILY...

BY DOUG BAKER

By Dave Barrington

Mastering PCBs

Making printed circuit boards is a highly skilled profession and an art. So any news of a product that makes it easier for the non-professional to produce boards of a high quality is most welcome.

One such system is the new CM100 Circuit Maker kit from Electrolube. Due to space considerations, it is not possible to evaluate the kit from a "hands-on" viewpoint but the problems of making p.c.b.s will be the subject that we will return to at a later date.

The kit provides all the necessary hardware and chemicals to produce positive photographic film masters from published layout diagrams and a final definitive circuit board.

The kit can be broken down into two groups or packs consisting of equipment and chemicals for making the film positive masters and one for making the final printed circuit board. Amongst the film processing equipment is a photoflood bulb used for activating the sensitised film when placed over the published master diagram.

We like the idea of a special "jig" which can be used as an exposure frame for the photographic part of the process, as well as a component assembly frame. A foam-backed plate, which forms part of the frame, is ideal for holding components in place whilst any excess leads protruding on the underside of the board can be trimmed prior to soldering. It is also claimed that the foam backing is heat-resistant which allows the components to be held firmly during the soldering operation.

It is obvious that a great deal of thought and attention to detail has gone into making the CM100 kit as extensive as possible. As well as containing six double-sided copper-clad fibreglass circuit boards (no single-sidedl), plus such items as rubber gloves, retouching pen, photographic dishes, thermometer, etchant and drills, there are workbench charts and an instruction manual.

Selling for about £70, first impressions would seem to indicate that the kit is rather an expensive outlay, but when weighed against the cost of purchasing finished boards it appears to be a reasonable investment.

For more details of prices and local stockists of the CM100 Circuit Marker contact Electrolube Ltd., at Dept EE, Blakes Road, Wargrave, Berks, RG10 8AW.

Catalogues Received

A new 21-page components catalogue has just been received from Rapid Electronics. The Autumn '82 Catalogue includes a wider range of Linear devices, plus data sheets, an extended range of capacitors and p.c.b. mounting transformers.

Copies of the Rapid Components Catalogue can be obtained by sending 45p to Rapid Electronics, Hill Farm Industrial Estate, Boxted, Colchester, Essex, CO4 5RD. The catalogue will be sent free to customers who place orders for goods totalling over £10.

A Shortform catalogue just published by Keyswitch Varley contains abbreviated data on their range of relays, solenoids, controllers, timers and switches.

New products described in the 12-page catalogue include a range of 1-, 2-, 3- and 4-pole reed relays, 30A power relays and a solid state relay. Recent additions are a range of DIP slide switches and a double wound solenoid with integral solid state switch.

Copies of the Shortform catalogue are available from Keyswitch Varley Ltd., Dept EE, Tom Cribb Road, Thamesmead, London SE28 0BH.

The CM100 Circuit Maker from Electrolube

Booklet

A 20-page pocket guide entitled "The 100 Most Asked Questions and Answers" has just been released by the Ferguson Video Advisory Service to show the capability of the Videostar range.

Aimed at both the customer and trade staff, the booklet covers all aspects of their video equipment and accessory range, plus a section devoted to cross compatibility with other makes. It also contains some general information on lighting, sound recording and connecting leads.

Copies of the booklet are available *free* from Thorn EMI Ferguson Ltd., Dept EE, Cambridge House, Great Cambridge Road, Enfield, Middlesex, EN1 1UL. A stamped addressed envelope would be appreciated.

Public Address Amplifier

We have been informed that all semiconductors used in the P.A. amplifier (May/Aug) can be supplied by Hart Electronic Kits, Pennyland Mill, Oswestry, Shropshire.

CONSTRUCTIONAL PROJECTS

Monthly Planner

A source of supply for the 1-bit clock timer, IC1, which forms the heart of the *Monthly Planner* project has proved the most difficult item to locate.

The E 050-16 clock chip is not normally available in the UK but the author, Mr Donleavy has made special arrangements with the Swiss manufacturers to supply them to E.E. readers.

The E 050-16 costs £6·50 and the crystal 90p from A. P. Donleavy, 13 Wasdale Road, Liverpool 9. Add 20p postage and packing for all orders.

The clock chip is available separately, but the crystal can only be supplied together with the E 050-16 device. However, other crystals can be used in the circuit.

The rest of the semiconductor devices should be available from Ambit, Enfield, Electrovalue, Magenta and Watford Electronics.

The miniature keyboard push switches are now generally available and is left to individual choice on the type of switch used here.

Continuity Tester

Practically any of the low-voltage piezoelectic transducers, available from most of our advertisers, should be suitable for the *Continuity Tester*. The device used in our model was the PB2720 (with case) obtainable from Ambit.

The size of plastics case is not critical and any type may be used.

Screen Washer Delay

The relay used in the *Screen Washer Delay* is a low-profile encapsulated type with a 1000 ohm coil. This is a RS encapsulated reed relay and is coded Blue, stock number 348-986. Any RS component supplier will be able to obtain this item.

Note that the casing of capacitor C1 must be completely isolated from any metal when installed in a vehicle. This can be accomplished by wrapping in insulating tape or rolled in a strip of polythene sheet.

Temperature Interface for TRS-80

A couple of special i.c.s are required for the *TRS-80 Interface* project. The LM334Z, adjustable current source used as a remcte temperature sensor, is available from Maplin Electronic Supplies; order No. WQ32K. The TL507C, single slope analogue to digital converter, may be obtained from most Tandy shops; stock No. 276-1789.

The printed circuit board has been designed to accommodate a specific RS transformer, stock No. 207-829. This transformer is available through any RS component dealer. Other suitably rated transformers may be fitted to the case and wired to the appropriate p.c.b. locations.

The double-sided (20 + 20 way) wire-wrap edge connector may prove difficult to locate and may need to be cut from a larger version. One such item is the 2 × 22-way strip from Watford Electronics which will allow alignment guides to be fitted.

Sound Splitter

There should be no component buying problems for the *Sound Splitter* or the add-on mixer unit.

A suitable jack socket for SK1 is the "stereo phone jack" from Tandy stores, stock number 274-277.

On its own, a useful application for the Two-Way Remixer box is to couple two instruments to a single input amplifier.

CB BATTERY CHARGER

BY A. FLIND

SINCE the long-awaited advent of legal CB radio, several types of 40-Channel hand-held portable rigs have become available and are growing increasingly popular. Most of these use HP7 type batteries, but with a current drain of 0·5A or more when transmitting, the cost of ordinary dry batteries quickly leads most users to invest in a set of rechargeable ni-cads.

The problem of supplying a suitable charger for these arises. Commercial chargers often cost as much as the batteries themselves and few incorporate any kind of automatic "full-charge" sensing feature. The charger described here is the author's answer to this problem, at around half the cost of most units.

It provides fully automatic, trouble-free performance and is simple to construct. It was designed to charge the complement of ten AA sized (HP7) ni-cads in the Harvard 410T rig, however, the Dixons' Harrier WT2 40-channel handheld appears to be identical to the Harvard, and the Tandy Realistic 1001 also uses the same battery complement. Possibly other portables such as the DNT and Alba are similarly powered, so this charger design may prove useful to many readers.

RECHARGEABLE NI-CADS

A few facts about the ni-cad cells themselves may be of interest before continuing. Most readers will probably be aware that these are available as direct replacements for the common sizes of 1·5V dry cell, and that they can be recharged up to 1,000 times.

In general they should be charged by a constant current, the value of which is normally quoted as being about a tenth of the cell's capacity in ampere-hours (Ah). The AA size has a capacity of 0·5 Ah so the charge rate should be around 50mA. It is also stated that they cannot be damaged by long term continuous overcharging at this rate, however, it cannot be seen to do them much good either.

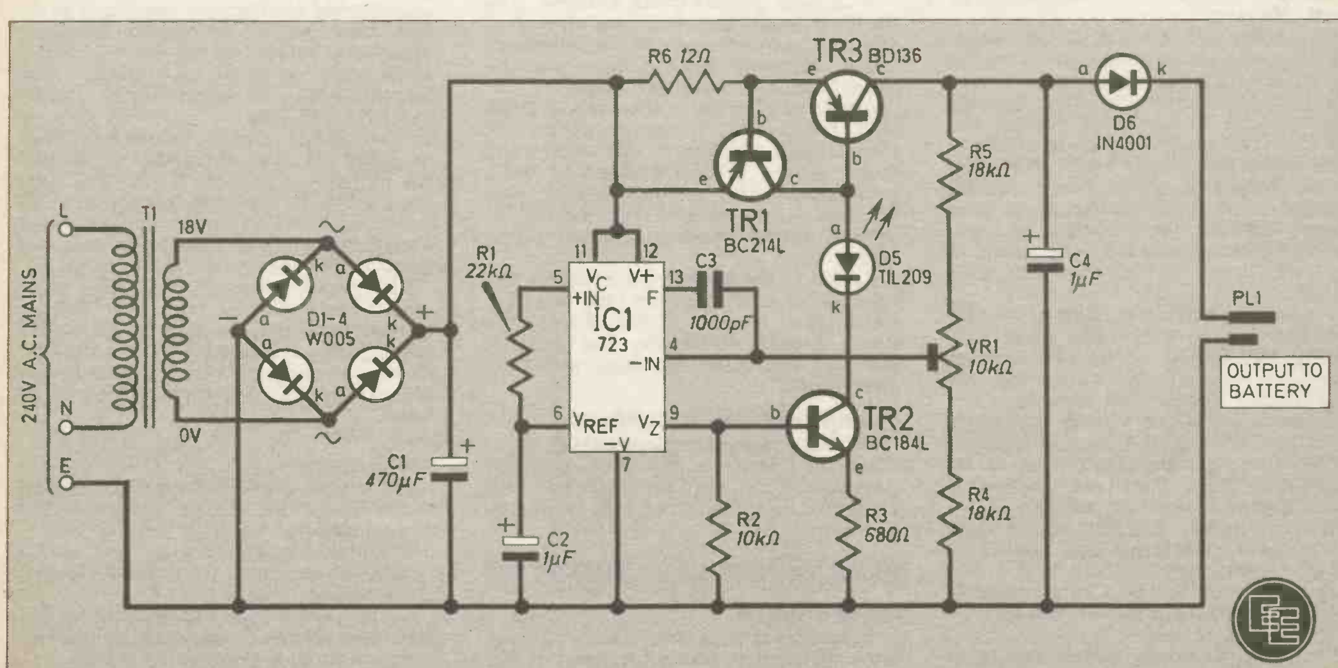
Since the cell voltage rises quite steeply when the fully charged condition is reached, it is a fairly simple matter to detect this and reduce the charge rate accordingly. An advantage of this type of charger is that the battery can be connected at any time for "topping-up", regardless of it's initial state of charge.

It is unwise to let batteries of ni-cad cells become completely exhausted as one cell will inevitably run down before the others, which then "reverse-charge" the flat cell and cause permanent damage to it. So topping-up whenever the equipment is not in use will greatly reduce the risk of this occurring.

CIRCUIT DESCRIPTION

Fig. 1 shows the complete circuit of the CB Battery Charger. Transformer T1, bridge rectifier D1 to D4

Fig. 1. Circuit diagram of the CB Battery Charger.



and capacitor C1 provide a smoothed d.c. supply of about 20V. The circuit has to charge the battery on a fixed current until a pre-set full-charge voltage is reached and then maintain this voltage by reducing the current.

The LM723 regulator i.c. was chosen for the circuit as it contains a stable reference voltage source and an amplifier for comparing this reference with the battery voltage. The reference voltage of about 7V appears at pin 6 and any noise present is decoupled by C2 before it is connected to the non-inverting amplifier input on pin 5. The inverting amplifier input, pin 4, is connected to the potential divider R4, R5 and VR1 placed across the circuit's output.

The chip also has provision for current limiting, but the operation of this is not really sharp enough for the present purpose so a constant current generator circuit based on TR1 and TR3 has been incorporated.

The action of this configuration is quite simple. A silicon transistor begins to conduct when it's base-to-emitter voltage exceeds about 0·6V. The bias current supplied by TR2 to TR3 causes TR3 to conduct until the voltage across R6 reaches 0·6V, at which point TR1 starts to conduct away surplus bias current to progressively limit the conduction of TR3. Thus the current through TR3 can be calculated from Ohm's law as being 0·6V/R6, and it will remain virtually constant regardless of load and voltage conditions.

So provided the voltage fed back from the output potential divider is lower than the reference voltage, the output of IC1 will be fully positive, causing TR2 to supply about 10mA of bias to the constant current generator. This bias passes through the l.e.d. D2 which indicates that charging is in progress.

Once the feedback voltage reaches the reference value however, the drive to TR2, and hence the bias is rapidly reduced, so the output current drops to a value just sufficient to maintain the output voltage at the desired level and the l.e.d. virtually extinguishes, indicating that charging is complete.

CONSTRUCTION starts here

CIRCUIT BOARD

Construction, using the simple p.c.b. shown in Fig. 2 is quite straightforward. This diagram also shows the layout of all components. It's a sensible precaution to mount the transformer T1, D1-D4 and C1 first, and then to carefully apply power and check that the voltage across C1 is around 20 to 25V d.c. Remember that

COMPONENTS

See Shop Talk page 567

Resistors

R1	22kΩ
R2	10kΩ
R3	680Ω
R4, 5	18kΩ (2 off)
R6	12Ω

All ¼W carbon ±5%

Capacitors

C1	470μF 63V elect.
C2	1μF 35V tantalum
C3	1000pF ceramic
C4	1μF 63V elect.

Semiconductors

D1-4	W005 50V, 1A rectifier
D5	TIL209 miniature red l.e.d.
D6	1N4001 silicon
TR1	BC214L silicon *pnp*
TR2	BC184L silicon *npn*
TR3	BD136 silicon *pnp*
IC1	LM723 adjustable voltage regulator

Miscellaneous

T1	Miniature mains transformer, 9V-0-9V secondary
VR1	10kΩ miniature horizontal preset
PL1	Plug to suit host CB equipment (the prototype uses a 2·5mm jack plug)

Single sided glass fibre p.c.b., 116 × 36mm; plastic case, 120 × 65 × 40mm (type BIM 2004); mains lead; twin cored lead; 7/0·2mm wire; l.e.d. mounting clip; mounting hardware for T1 (4 BA).

Approx. cost Guidance only **£13·00**

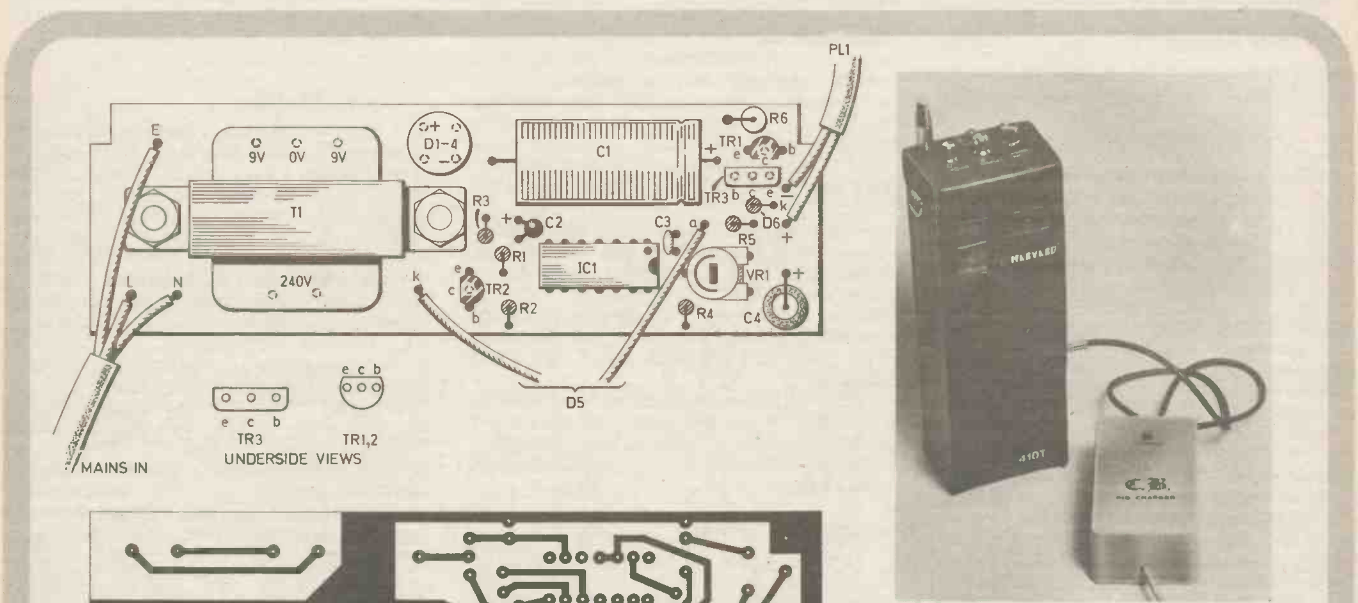


Fig. 2. Actual size p.c.b. artwork and component layout. T1 mounting holes may require slight adjustment to suit individual transformers. The photograph shows the authors hand-held CB rig being charged by the prototype unit.

some parts of the p.c.b. will be live at 240V mains whilst testing, so take adequate precautions when doing this.

The transformer is an inexpensive 9-0-9V miniature type, the centre-tap of which is unused so that it provides an 18V output. It is fastened to the board with a couple of 4BA screws.

After assembling the rest of the circuit, check with an ammeter that the output of the unit into a resistance of 100 ohms is around 50 to 60mA. Setting the output voltage requires a little more care.

The voltage of a ni-cad cell when approaching the fully charged condition is about 1·45V, so the unit should be set to supply this value multiplied by the number of cells in the battery. The author's CB rig is the Harvard model 410T, which contains ten cells but also incorporates an internal silicon diode in series with the batteries in it's charging circuit, so an extra 0·6V has to be added to compensate for this, bringing the total to 14·5V+0·6V=15·2V.

A check of the circuit diagram of your rig will show whether it contains a similar internal diode. Note that the voltage setting must be made with the charger supplying some current, so a resistance of 1kilohm should be placed across the output before carefully adjusting VR1 for the correct output voltage.

The finished board is designed to slip into the moulded mounting slots provided in the specified case, and on the author's prototype, the cable strain relief clamps are simply a few turns of insulating tape around the input and output leads. A small hole is drilled for the l.e.d. which is then secured by means of a mounting clip.

FAST CHARGER

Experimenters might like to note that this circuit can be adapted quite simply for other output voltages and currents. A further interesting application would lie in the construction of a "fast" charger. The ten-hour charge rate usually quoted for ni-cads is the maximum at which they will withstand indefinite overcharging; if provision is made to reduce the supply current when the charge is complete they can be charged in far shorter times, down in fact to as little as fifteen minutes.

A charge rate of 1A, completing the charge in 30 minutes is apparently quite feasible for the AA size. Note that if they are overcharged at these higher currents gas will form and they will vent, thereby losing electrolyte. The "button" types of cell have no provision for pressure venting and under similar conditions may explode, so don't try it with these!

However, with an up-rated transformer and some heatsinking for TR3 this design could be modified into an efficient high speed charging system.

Out and About

Recently it occurred to me that it might be of interest to look in on component and equipment suppliers, giving a short history and other points concerning their businesses.

There can be few if any of our readers who are not acquainted with the firm of J. Bull. I have no doubt, that many readers have in the past called at his shop in Croydon to purchase goods. Unfortunately, a large increase in rent forced him to move to Haywards Heath and store the greater part of his stock on his farm a few miles away. It was with expectation and excitement that I drove down to his home near Brighton to learn his story, which is an interesting one.

Jesse Bull served with the Fleet Air Arm during World War II and started up his business in 1946 with his gratuity. The bulk of his business was and still is Mail Order, and originally he specialised mainly in "Kits". His first Kit was a television set made mainly from ex-RAF radar parts and used a 5-inch green tube. It proved to be very popular because commercially made sets were in short supply.

The advent of the transistor gave a real boost to the sales and the company sold over 50,000 transistor radio kits. Older readers may remember, "The Good Companion" "The Pocket Four" and the "Solderless Three".

The importation of cheap Japanese sets gradually put paid to this market. Although Jesse still sells the more popular Kits, the emphasis has shifted more to bargain lines which are regularly displayed in his adverts. In addition he issues a monthly bargain list. I was particularly taken with his offer of 10 kilo (22 lb) of components for £14·50 including postage and packing, this seemed to be an offer that cannot be refused.

When we had finished our discussion, Jesse took me around the sheds that house his stock. Each shed is 100 yards long and about 15 yards wide, and is packed with every conceivable piece of electronic equipment you can imagine. You name it, I am sure Jesse Bull must have it.

After we had examined two of the sheds, he smiled at me and said, "Do you want to see any more?" I had to reply honestly, "As interesting as they are, I will take the rest as read!"

Computer Doctor

Turning again to computers, in this country we don't seem to use them as frequently in diagnostic medicine as they do in Russia. Over there, due to the shortage of Doctors, 85 per cent of whom are women, the computer is often substituted for the G.P. and hard as it is to believe they claim a better success rate than the real G.P.s.

While I was trying to evaluate how this would work out in practice, my resident Imp, who can never be entirely suppressed, paints the picture for me. "Can't you Imagine it?" he says, "This poor chap goes into the surgery with an ingrowing toenail, sits down at the computer and presses all the relevant buttons.

"Unfortunately unknown to him, this machine is malfunctioning due to a couple of dry joints on one of the circuits and having put him out cold with a smart tap on his 'noggin' with a Black Jack, proceeds to operate. When the poor man regains consciousness he finds either he has had a vasectomy or is minus an ear!!"

While reluctantly agreeing with my Imp, I have an answer, which is this, that even real flesh and blood doctors make similar mistakes, usually by getting their patients mixed up!

Ship's Doctor

I must confess this method of treating patients, is rather like the method used in small ships. On a ship of less than 5,000 tons, a Doctor need not be carried. This chore being carried out by the Captain or Mate.

To assist them they have a Board of Trade Medicine Chest, which contains all the medicants likely to be required on the voyage. These are numbered and there is a book of instructions.

If, for example, a sick sailor complains of headaches, the book would instruct the Locum to give him one tablet number 6. On returning to port, the skipper would report to the port Medical Officer, who would question him about any sickness on the voyage.

I must conclude with the story of the skipper reporting to the Medical Officer, which goes as follows: M.O. "Well Captain, did you have a good voyage?" Captain. "Splendid, thank you." M.O. "Any medical problems?" Captain, "Not really, I did have one of the crew who had stomach pains and I had run out of pill number 12."

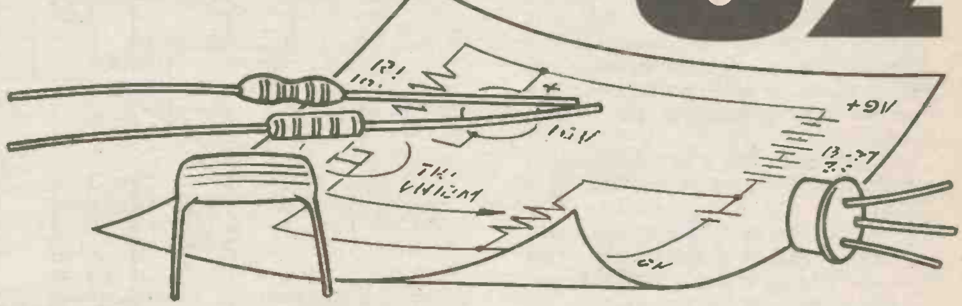
M.O. "Oh! What did you do?" Captain, "Oh! it was quite simple really, I gave him one number 7 and one number 5!!"

I am confident that computerised medicine will do better than that.

EE TEACH-IN 82

PART 12

BY O.N. BISHOP



BASIC ELECTRONIC THEORY WITH EXPERIMENTS

COMPUTING CIRCUITS

IN THIS final instalment of the series we bring our study of electronics up to date. We see how some of the simple circuits we have already studied can be put together to make more elaborate systems capable of performing calculations and logic.

The term "computer" is taken to refer to the *digital* computer nowadays, since most of the computers we use are of this type. *Analogue* computers operate in a different way and, although they have been replaced by the digital computer as a calculating or logical tool, they still have important applications.

They are usually based on the operational amplifier (see Part 7, EE April 1982). Indeed it was the need for high-performance amplifiers for use in analogue computers which gave rise to the 741 and other op-amps which are still so widely used today. Before we see how op-amps are used for calculating, we must study one more amplifying circuit.

INVERTING AMPLIFIER

The circuit configuration in Fig. 12.1 is different from the other op-amp circuits we have studied in that the input voltage is fed to the inverting input (−) of the amplifier. Consequently, an *increase* of V_{IN} produces a *decrease* of V_{OUT}, and the other way about.

Since the output signal is fed back through R24 to the negative input, this amplifier has negative feedback. The amplifier is stable only when both of its inputs are at the same voltage. Since the non-inverting input is at 0V, the amplifier can be stable only when the inverting input too is at 0V.

We can think of R23 and R24 as a potential divider (Fig. 12.2). For any given value of V_{IN}, the amplifier adjusts V_{OUT} until the voltage at the inverting input (−) is exactly 0V. In effect, if V_{IN} is a positive voltage, a current flows from the input of VR1, through R23, R24, and into the output of IC1. If this current is I, and knowing that the p.d.s. are as shown in Fig. 12.2, we can calculate that:

$$I = \frac{V_{IN}}{R23} = \frac{-V_{OUT}}{R24}$$

The negative sign is needed because V_{IN} and V_{OUT} have opposite signs. Rearranging this equation we get:

$$\text{Amplification} = \frac{V_{OUT}}{V_{IN}} = \frac{-\ R24}{R23}$$

With the values given in Fig. 12.1, the amplification is $\times(-10)$. Note that the amplification depends only on the ratio between R23 and R24. It does not depend upon the gain of the op-amp circuit, or variations in the manufacture of the op-amp, or the temperature in which it is operating.

If we use two high-precision resistors with high temperature stability, amplification is precisely determined and is stable. This is essential if we are to use the circuit for computing.

Note that the calculation above does not include any current flowing into or out of the inputs of the op-amps. A small current (about 100nA for the 741) flows to the base of each of the input transistors. These currents should be equal, otherwise an offset p.d. will appear between the inputs, causing errors in operation.

In Fig. 12.3, R26 is roughly equal to R23, R24 and, R25 in parallel. These are effectively in parallel since one end of each is at 0V under stable conditions. Since the current through R26 is only 100nA, the p.d. across it is only 0·0034V. We can consider the input voltage to be almost 0V, and the description above still holds good.

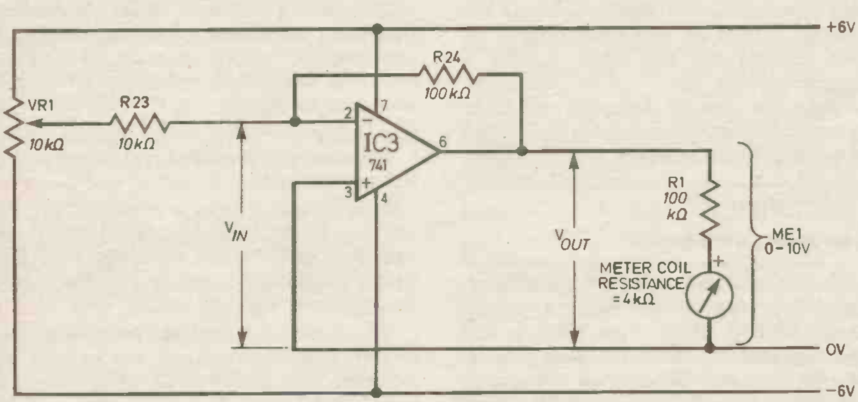


Fig. 12.1. Using an op-amp as an inverting amplifier. Offset null compensation is not essential and is omitted. You could connect up this circuit on *Minilab* and test its action. For positive input voltages from VR1, reverse the connections to the meter.

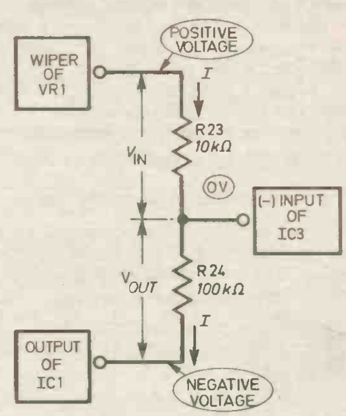


Fig. 12.2. The resistors of the inverting amplifier re-drawn as a potential divider. The current flowing to the (−) input can be ignored as it is very small.

EXPERIMENT 12.1
Op-amp adder

The circuit in Fig. 12.3 is recognisable as an inverting amplifier, but it has two inputs, via R23 and R25. Since R23, R24 and R25 all have the same value, the gain of the amplifier is 1. We will be using only positive inputs, so outputs will be negative and the meter connections are reversed accordingly.

R27/R28 and R29/R30 are potential dividers used for providing known input voltage:

$V_A = (12 \times 270/(150 + 270) - 6)\text{V} = 1{\cdot}7\text{V}$

$V_B = (12 \times 270/(180 + 270) - 6)\text{V} = 1{\cdot}2\text{V}$

The exact voltages at *A* and *B* depend upon the actual values of the resistors; use the meter to check that they are near to the expected values. Then reconnect the meter to the output of the op-amp.

Connect flying lead *X* to point *A*. With a gain of 1 the output should be $-V_{IN}$, so the meter should read 1·7V. Connect *X* to *B*; the meter should read 1·2V. Input *Y* is identical to input *X*, so you should obtain the same pair of results by using lead *Y* instead and connecting it to *A* and *B* in turn.

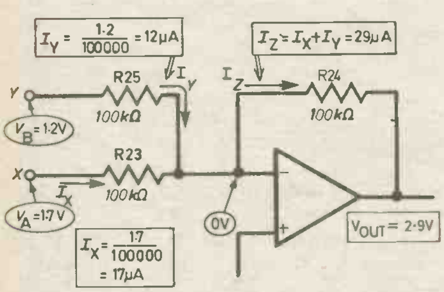


Fig. 12.5. Potentials and currents in the adder when inputs are 1·2V and 1·7V.

EXPERIMENT 12.1

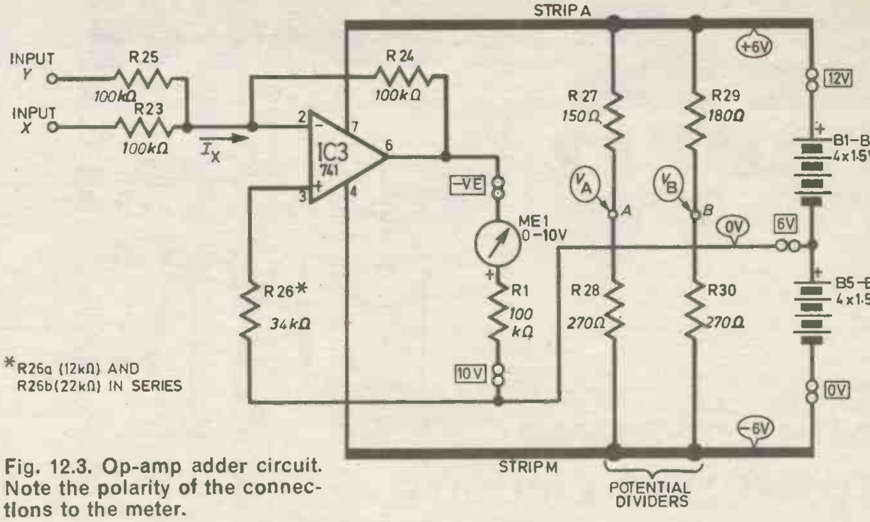


Fig. 12.3. Op-amp adder circuit. Note the polarity of the connections to the meter.

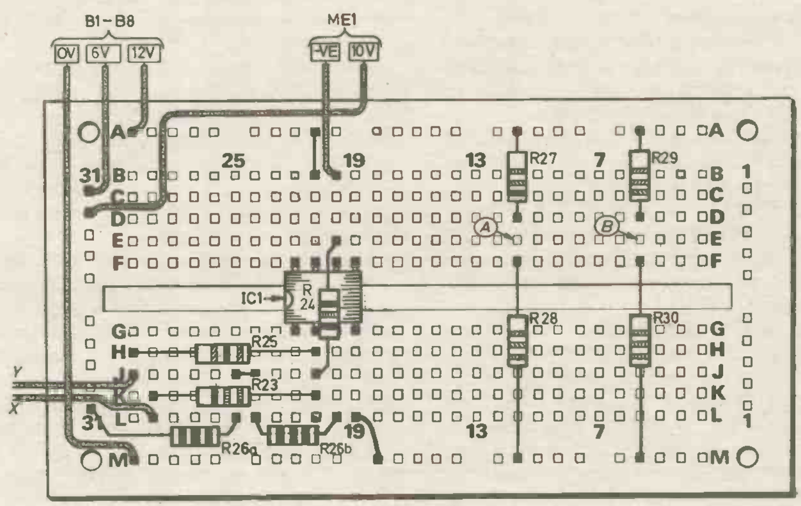


Fig. 12.4. The layout of the components on the Verobloc for the circuit in Fig. 12.3.

Now connect lead *X* to *A and* lead *Y* to *B*. Does the meter read 2·9V? The op-amp acts to bring its inverting input to 0V. The currents which are flowing through R24 and R25 (Fig. 12.5) combine and flow through R26. Thus the output voltage must be $-100000 \times 29 \times 10^{-6} = -2{\cdot}9\text{V}$, which appears on the meter as 2·9V. The currents are added, so the output voltage is the sum of the two input voltages.

Answers to Part II

11.1. Its voltage is easily transformed.
11.2. So that current is relatively small and little power is lost from heating the cables.
11.3. 0V.
11.4. +339V.
11.5. 114V.
11.6. 6·25mA.
11.7. 1.11A, r.m.s.
11.8. 8·4V.
11.9. 10·6V.
11.10. It increases in amplitude.

Make the connections needed to find the sum of 1·2 and 1·2, and read the result. Now find the sum of 1·7 and 1·7. You could experiment with other resistors in the potential divider to get different sets of input voltages and add them. If R29 is changed to 330Ω, V_{IN} is −0·6V. Now you can find the sum of 1·7 and −0·6, in other words, subtract 0·6 from 1·7. Read the meter to find the answer to (1·7 − 0·6).

EXPERIMENT 12.2
An op-amp differentiator

The mathematical operation of differentiation is a way of calculating a *rate of change*. In Part 9 (EE June 1982) it was explained that the current flowing into or out of a capacitor depends on the *rate of change* of voltage. In this circuit (Fig. 12.6) we change the voltage on one side of a capacitor. The current flowing out of the other side goes to an op-amp.

The layout for this Experiment is shown in Fig. 12.7. To begin with, the capacitor is charged to +6V. Now press and hold S1 to discharge C9 through R23. Note the maximum value reached by the needle of the meter. It kicks up, showing that voltage is falling, but quickly returns to 0V as the capacitor discharges and the rate of fall of V_{IN} decreases to zero (see Fig. 9.5).

Release S1: the meter kicks *down*, as the voltage *increases*.

Now replace R23 by a wire link, so that C9 may be discharged more rapidly. Press and hold S1. The rate of change of V_{IN} is much greater now, and the needle moves much further up the scale.

This is only a simple demonstration, but it shows how an op-amp can be used to calculate *rate of change of voltage*. Such a circuit could be used in real-time computing, for example, when we want to measure a rate of change of a quantity such as velocity, to calculate acceleration.

EXPERIMENT 12.2

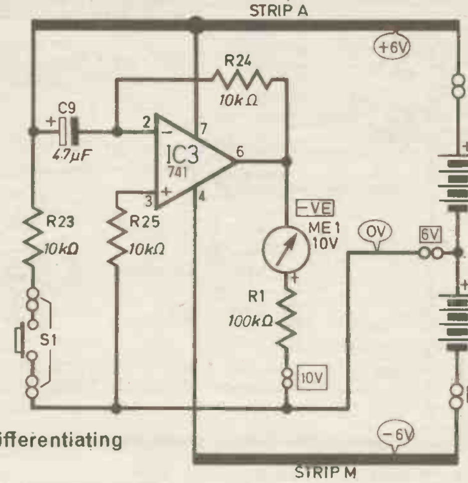


Fig. 12.6. Op-amp differentiating circuit.

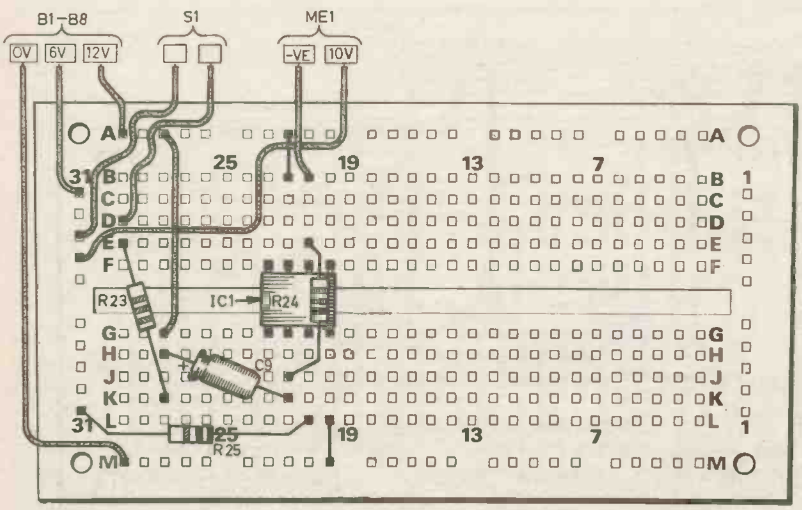


Fig. 12.7. The layout of the components on the Verobloc for the circuit in Fig. 12.6.

QUESTION TIME

12.1. Which of the quantities in this list is *not* an analogue quantity: velocity of a car, engine temperature, the number of wheels on the car, the amount of fuel in the tank.

12.2. If R24 in Fig. 12.1 is replaced by a 1·2MΩ resistor, what will be the gain of the circuit?

12.3. If the circuit of Fig. 12.1 has $V_{IN} = -20$mV, what is its output?

12.4. If a circuit is set up as in Fig. 12.2, but with three inputs, and the input voltages are 1·2V, 0·4V and −1·1V, what is the output voltage?

12.5. If in Fig. 12.6, C9 was connected to +3V instead of +6V, and S1 was NOT pressed, what would be the reading on the meter?

Suppose that the counter has 8 flip-flops in series (Part 4, EE January 1982), then the greatest binary number the counter can register is 1111 1111, or 255 in decimal. The velocity may range smoothly from 0 to 100 metres per second, but the count can take only 256 distinct values in the range 0000 0000 to 1111 1111. We can have a count of 134, or one of 135, but we can not have anything in between. Instead of having a *single* meter to indicate the quantity, we need several lamps or other devices, one to indicate the state of each digit.

The great advantage of representing values in digital form is that it is so much easier to deal with them at high speed with relatively simple and reliable circuits. We have already seen in Part 4, how the two kinds of binary digit are represented by 0V and +5V respectively, and how gates can be built which will perform logical operations. Now we will see how these gates can be used for performing calculations.

ANALOGUE AND DIGITAL

It is implied in the previous sentence that we can represent velocity by a voltage. Both are analogue quantities in that they can vary smoothly over a given range and be represented by the position of a pointer on a scale.

The velocity of a vehicle over the range 0 to 100 metres per second can be represented in an electronic speedometer by voltages in the range 0V to +5V (Fig. 12.8a). Then a voltage of 3·524V, represents a velocity of 70·48 metres per second. For each possible value in the range of velocities there is a corresponding voltage. As the velocity changes and hence the voltage changes, an op-amp differentiator could compute acceleration in metres per second per second.

We can also represent velocity as a binary digital number, as in Fig. 12.8b. The voltage is fed to a voltage-controlled oscillator, and the number of pulses per second is counted.

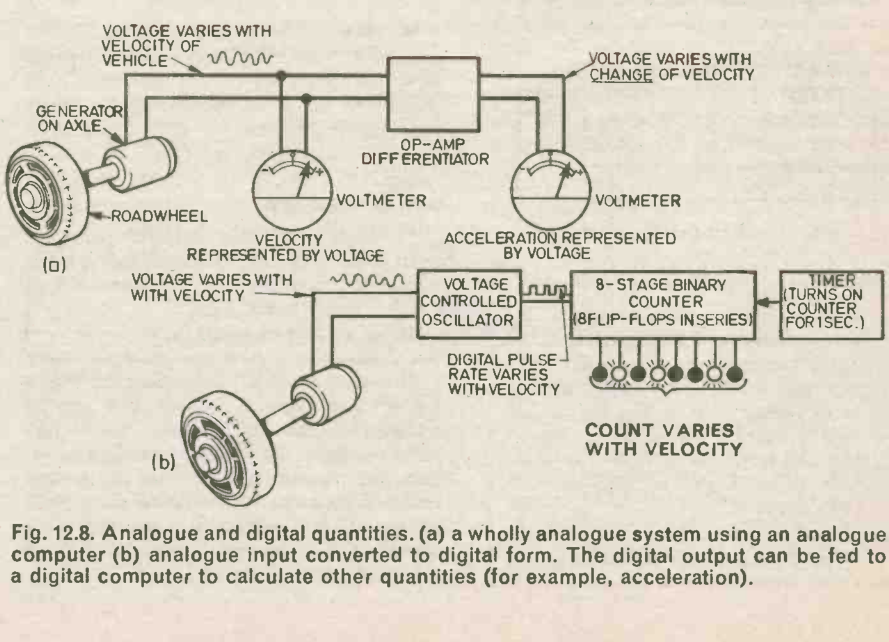


Fig. 12.8. Analogue and digital quantities. (a) a wholly analogue system using an analogue computer (b) analogue input converted to digital form. The digital output can be fed to a digital computer to calculate other quantities (for example, acceleration).

EXPERIMENT 12.3
A Half-Adder

The circuit in Fig. 12.9 (Verobloc layout in Fig. 12.10) includes a logic gate which we have not used before, an EXCLUSIVE-OR gate. The arrangement of the four gates within the 4070 i.c. is just the same as that of the 4011 (see Fig. 4.10), but their action is different. The EXCLUSIVE-OR gate has two inputs. Its output is high when either one input OR the other input, (*but not both*), inputs is high. Table 12.1 is its truth table, and Table 12.2 reminds us of the truth table for NAND gates.

The half-adder circuit has two inputs, which are normally held low by R23 and R24. When the buttons are pressed, the corresponding inputs are made high. The state of the outputs is shown by the l.e.d.s; a "0" is represented by the l.e.d. being off, a "1" by it being on.

Try the combinations of inputs listed in Table 12.3, by pressing the corresponding buttons and note the state of the outputs. Use the truth tables to work out how the circuit operates.

We think of this circuit as having two inputs, representing two numbers which are to be added together. Each number has only 1 digit, so the numbers to be added can be either 0 or 1. If you press neither button, this is equivalent to adding 0 + 0. Their sum is indicated by the state of D3 (column *ZS* in the table). You will have found that 0 + 0 = 0, 0 + 1 = 1, and 1 + 0 = 1.

When we sum 1 and 1 in binary arithmetic, the result is 10 (= 2 in decimal). In effect we say "1 plus 1 gives 0, carry 1". The 1 is carried over into the next column on the left, and we write down the answer, 10. In this circuit the carry digit is represented by D2 (column *ZC*).

Table 12.1: EXCLUSIVE-OR.

Inputs A	Inputs B	Output Z
0	0	0
0	1	1
1	0	1
1	1	0

Table 12.2: NAND.

Inputs A	Inputs B	Output Z
0	0	1
0	1	1
1	0	1
1	1	0

Table 3: Results of testing Half-Adder.

Inputs *A*(S1)	Inputs *B*(S1)	Outputs *ZC*(D2)	Outputs *ZS*(D3)
0	0		
0	1		
1	0		
1	1		

EXPERIMENT 12.3

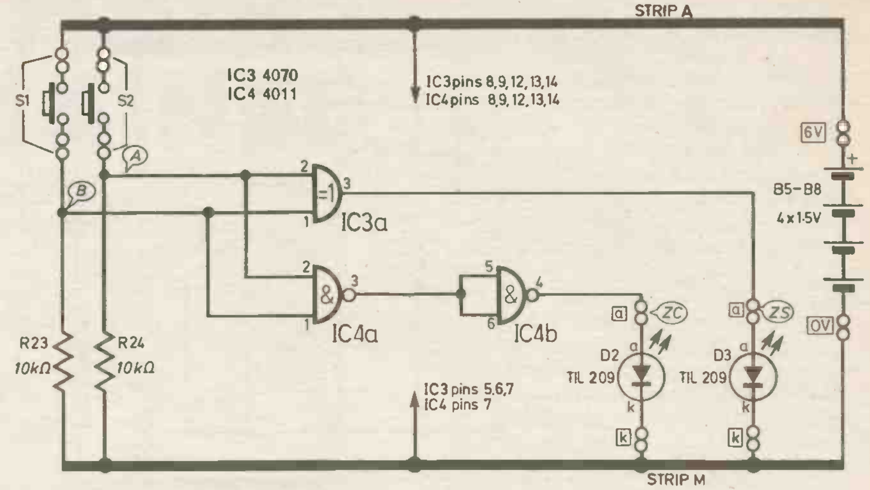


Fig. 12.9. Circuit of a half-adder.

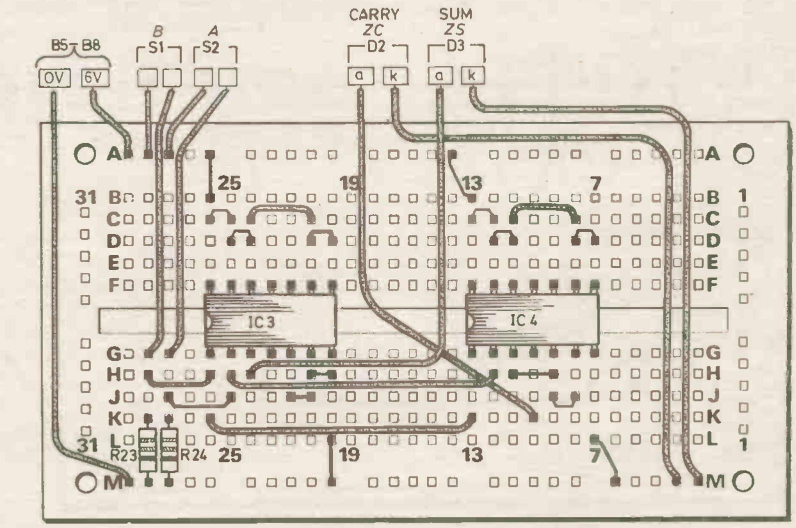


Fig. 12.10. The layout of the components on the Verobloc for the circuit in Fig. 12.9. Unused inputs are connected to 0V or +6V so that the i.c.s operate correctly.

FULL ADDER

The half-adder can perform only the most basic of summing operations. It sums two 1-digit numbers and produces a 1-digit answer, with a carry digit.

When we add numbers on paper we sum one column at a time and take the carry digit over to be added in the next column to the left. Similarly, we could have several half-adders, each dealing with the corresponding digits from two multi-digit numbers, and passing the carry digit to the next half-adder to the left. This gives a full-adder, which can consist of enough half-adders to allow it to sum two numbers of any given number of digits.

EXPERIMENT 12.4
Full Adder

Fig. 12.11 shows a 2-digit full adder. It can add a number A^1A (where A is the least significant digit), to a number B^1B, giving the sum as a 2-digit number Z^1Z, with a third carry digit, ZC.

It is clear from Fig. 12.11 that this circuit consists of two half-adders. Digits A and B go to the first half-adder (IC3a, IC4a and IC4b), and digits A^1 and B^1 go to the second (IC3b, IC4c and IC4d). The carry digit from the first half-adder is added to the sum digit of the second half-adder by the EXCLUSIVE-OR gate (IC3c), just as we add in the carry digit in ordinary arithmetic.

The suggested Verobloc layout for Expt. 12.4 is shown in Fig. 12.12.

The A^1 and B^1 digits are given the value "1" by pushing the flying leads A^1 and B^1 into sockets *A20* and *A22*.

EXPERIMENT 12.4

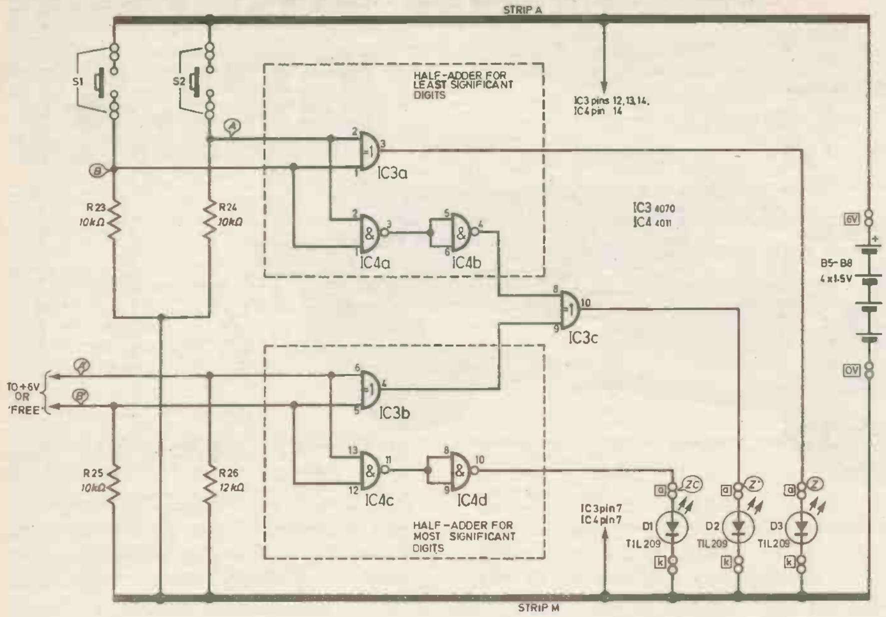


Fig. 12.11. Logic diagram of a 2-digit full adder.

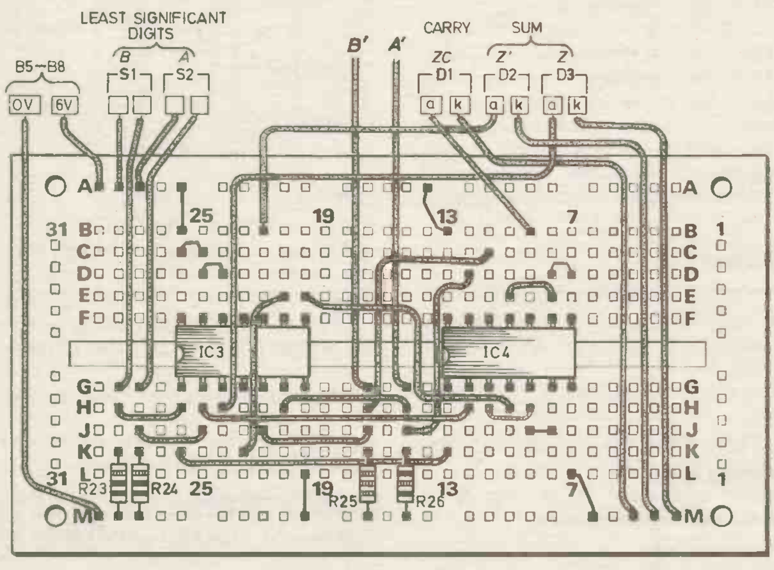


Fig. 12.12. The layout of the components on the Verobloc for the circuit of Fig. 12.11.

As an example of how to use the circuit, try the addition, 1 + 3. A^1A is 01, B^1B is 11 (the binary equivalent of decimal 3). A^1 is to be 0 so lead A^1 can be left loose; B^1 is to be 1, so push lead B^1 into socket *A22*. Then press S1 and S2 to make both *A* and *B* represent 1. You should find that D3 and D2 do not light, but D1 does. This indicates the sum 100 (equivalent to decimal 4).

Answers to Part 12

12.1. Number of wheels.
12.2. 120 times.
12.3. +2·4V.
12.4. $(1{\cdot}2 + 0{\cdot}4 - 1{\cdot}1)\text{V} = 0{\cdot}5\text{V}$.
12.5. C9 is charged to +3V so V_{IN} is not changing. Its rate of change is zero, so V_{OUT} is zero.

Try adding other pairs of numbers, such as 1 + 2, 2 + 2, 2 + 3, and 3 + 3.

The readout can be made much clearer by using the *Minilab* DISPLAY MODULE. Remove the connections to D1, D2 and D3. Now make these connections to the DISPLAY MODULE:

Digit *Z*—from *J24* to display *a*
Digit Z^1—from *B22* to display *b*
Digit *ZC*—from *B9* to display *c*

Connect display *d* and *L* inputs to the 0V rail (strip *M* of the Verobloc). Switch on the module (S8), and you can now read the answers directly in decimal; the DISPLAY MODULE does the binary-to decimal decoding for you. Run through all the sixteen different sums that the adder can do, from 0 + 0 to 3 + 3, and check that it gives the right answers.

OTHER CALCULATIONS

Readers who are proficient in binary arithmetic will know that binary subtraction can be performed by a routine which essentially consists of addition. We can multiply two numbers together by a series of additions.

For example, to find 3 × 5, we add three fives together. First we add 5 + 5 = 10, then we add a third 5 to that sum to get 15. All we need is a full adder, and a way of counting how many times the addition has been performed. This is just what happens in a microprocessor when it has been programmed to multiply.

Division can be done by repeated subtraction. To divide 15 by 5 we subtract 5 from 15, leaving 10. We continue subtracting 5 from the remainder until the result is zero. Zero is reached on the third subtraction, so (15 ÷ 5) = 3. This is how logic circuits are able to perform the four basic operations of arthmetic.

MICROPROCESSOR

To perform other mathematical operations we simply have to arrange for a sequence of such operations to be performed. A microprocessor, the heart of the microcomputer, can be programmed to perform such sequences and thus can be made to carry out all kinds of mathematical operation.

The circuits which are used in a computer are basically very simple ones, concerned with elementary logical operations such as NAND and NOR, and the simple addition of two binary digits. The reason that computers seem to have almost human powers is that they can be programmed to perform a sequence of tens of thousands of such simple operations in a single second without making mistakes.

It is hoped that readers who have followed this series will have gained some insight into the inner workings of many of the electrical appliances such as thermostats, radio sets, and amplifiers, which are so common in our homes today. It is also hoped that this final part of the series will have helped take some of the mystery out of the mighty microcomputer. ⌘

SCREEN WASHER DELAY

BY G. L. STONEMAN

WITH all the rain, sleet and snow that seems to deluge our cars every year, windscreens tend to become soiled very quickly, leading to a reduction in the driver's visibility.

To overcome this problem, the driver must regularly operate the windscreen washers. This results in the driver removing his hand from the steering wheel and interrupting concentration on the road ahead.

This article describes the construction of a simple but effective device that operates the electric screen washers for a period up to about 10 seconds or so after a single press of a switch, thereby ensuring that one hand does not have to leave the steering wheel for more than a second or two allowing the driver to concentrate more on driving.

The circuit is designed for operation in cars with a negative earth but details are also provided for modifications to allow it to be fitted and used on positive earth vehicles.

CIRCUIT DESCRIPTION

The complete circuit diagram of the Screen Washer Delay is shown in Fig. 1. It can be seen that only a few components are required.

When the washer switch is pressed, C1 is immediately charged up to 12V and the relay contacts close. When S1 is released, C1 slowly discharges through the coil of RLA. During this time, the relay contacts RLA1 stay closed and supply power to the windscreen washer motor, resulting in a stream of water to the screen.

As C1 discharges through the relay coil, the current through the relay decreases and eventually a point is reached where this current is insufficient to operate the relay. The contacts then open resulting in the pump motor turning off. VR1 is used to set the operating time of the pump motor.

COMPONENTS

The relay used on the prototype was a low-profile p.c.b. encapsulated reed type with a 1,000 ohm 9-12V coil. This is colour coded blue. If a different type of relay is used, one that has two pairs of contacts, combined wash and wipe with one-shot operation could be achieved.

Capacitor C1 should be one with axial leads (one from each end) rated 16V or more. The can should be completely insulated before mounting using p.v.c. tape or tubing.

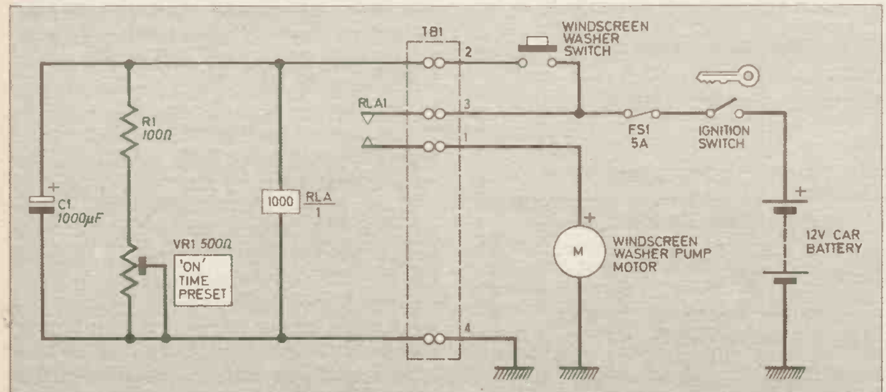
CONSTRUCTION starts here

CIRCUIT BOARD

Construction is straightforward with the components being mounted on a piece of 0·1 inch pitch stripboard measuring 13 strips by 24 holes.

Begin by drilling the two 6BA clearance holes in the board for mounting purposes. Use the 4-way terminal block as a template for this using the two outermost holes. The board is to be secured using the terminal block fixings through the case.

Fig. 1. The complete circuit diagram of the Screen Washer Delay



COMPONENTS

R1	100Ω ½W carbon ±5%
C1	1,000μF 16V elect. axial leads
VR1	470 ohm miniature horizontal preset
RLA	encapsulated reed type relay, 1,000 ohm coil, 9 to 12V operating voltage
FS1	5A with in-line fuseholder

Stripboard: 0·1 inch matrix, 13 strips × 24 holes; 5A screw terminal block, 4-way; 6BA fixings: 25mm long screw, nuts (2 off), 5mm long spacer; plastics case, Vero 202-21025K; rubber grommet; 5A auto connecting wire.

Approx. cost Guidance only £3·20

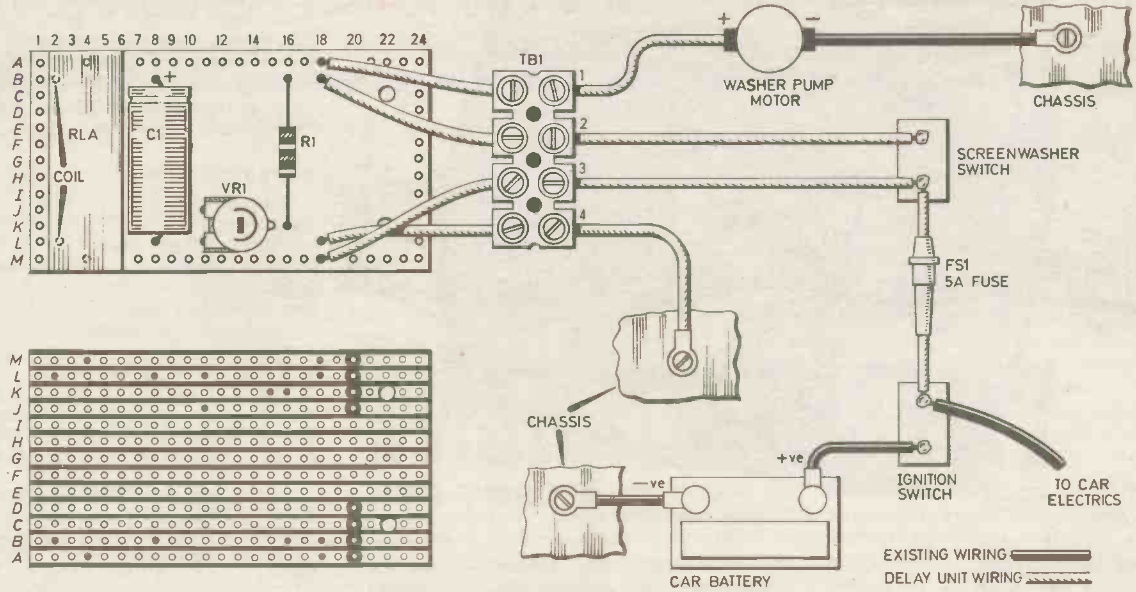


Fig. 2. Layout of the components on the stripboard, breaks to be made on the underside and wiring details to the existing car electrics.

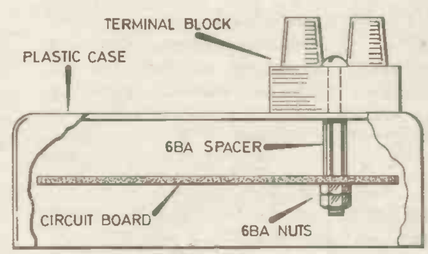


Fig. 3. A suggested method of mounting the component board in the case.

Also use the terminal block as a template for drilling the holes in the case.

Make the necessary breaks in the copper tracks using a spot-face cutter or small drill bit. These are necessary to isolate the fixings from the components soldered to the tracks.

Position and solder the components and flying leads to the board according to the layout in Fig. 2. A suitable case for this project is the General Purpose Plastic Box from Vero, size 72×50×25mm. Drill a hole of size suitable for a grommet to be fitted to carry the wires from the board to the terminal block fitted to the case top.

Fit the board and terminal block to the case and wire the flying leads to TB1. Fig. 3 shows the suggested way of mounting the board using a lock-nut arrangement. This is necessary as the unit will be subjected to vibration in the car.

INSTALLATION

Wiring to the existing car electrics is also shown in Fig. 2. Do not use single-core wiring for this. Use 5A wire intended for use on a car, readily available from car spares shops. Fig. 2 shows wiring for a negative earth system. For positive earth cars, simply reverse the capacitor, C1, and the connections to the pump motor. In either case make sure that a 5A fuse is fitted, connected to the "live when on" terminal on the ignition switch, (or a suitable terminal in the fuse box).

The unit should be mounted in a dry place away from exhaust fumes and extreme temperatures. It could be fitted to a suitable position inside the car, on the parcel shelf perhaps using self adhesive foam pads. ⌘

NEWS

GIRL GRANTS

Only two per cent of engineering technicians in British industry are female. To encourage more girls into technician employment the Engineering Industry Training Board is offering 250 grants to firms willing to recruit girls over and above their normal planned technician intake.

Each grant is worth £6,000 and the scheme starts in September 1982.

Fibrevision

Eighteen lucky families in Milton Keynes are having a free trial of British Telecom's Fibrevision, the "wired city" of the future. Through optical cable they get five TV channels, pay-TV, Prestel and FM radio selected by hand-held infra-red control.

Sir Michael Edwardes, of British Leyland fame, is to be a part-time director of Project Mercury, private industries answer to British Telecom.

SPEAKING BOOK

Following on from TI's educational "Speak and Spell" for children, the company has developed a logical follow-on in the form of a talking book. The text has a bar-code which is scanned manually with a lightpen by the child to produce the spoken sound.

It will be available in the USA by Christmas and in the UK next year.

Intelpost, the Royal Mail's high-speed public facsimile transmission service, is now extended to cover the whole of Holland.

PLEASE TAKE NOTE

CIRCUIT EXCHANGE— INVADER LANDING GAME

(August 1982)

The circuit diagram incorrectly shows the cathodes (k) of the l.e.d.s D3 to D12 connected to the positive supply rail (B1+). This link must be removed, leaving these l.e.d.s connected to the negative supply via the 470 ohm resistor, R8 (as shown).

For your ENTERTAINMENT

By BARRY FOX

Resistance to Space

Everything electronic and mechanical goes wrong in the end. And it isn't just domestic equipment that fails. This is why satellites, which are beyond the reach of a repair engineer, must be made to the highest possible standard of reliability. But *Meteosat-1*, the European weather satellite which was launched in November 1977, failed almost exactly two years later. The power supply just shut down. So a replacement, *Meteosat-2* had to be built and launched in June 1981. So what went wrong with *Meteosat-1*?

The answer is to be found in the April 1982 issue of the journal of the Institution of Electronic and Radio Engineers, albeit in very obscure wording. After the failure a team of aerospace experts met at the European Space Agency Research Centre in Darmstadt, West Germany, and built a breadboard replica of the circuit that had failed in space. With this circuit they then tried to simulate the fault.

To quote the IERE journal "It appeared that a digital circuit, which was designed to be triggered only in the case of overcurrent, was able to oscillate depending on the value of a resistor. Technological studies showed in fact that a degradation mode specific to this resistor caused its resistance value to be equal to this critical value".

When you translate this technical "gobbledegook" into plain words, it means that a single resistor in the power supply changed value as it aged. This tripped a safety circuit breaker like a fuse, in the satellite power supply.

Thankfully *Meteosat-2* has different resistors. It also has relays which can bypass the protection devices if they go haywire.

So far *Meteosat-2* has been working without problems. But when you get down to the nitty gritty, the stark truth is that a meteorological satellite which costs tens of millions of pounds to put into orbit failed because a single resistor developed a fault.

Domestic Facsimiles

There's a lot of talk these days about document transmission systems, for use in homes and small offices. Already of course large offices have facsimile equipment which can transmit pictures over the telephone line.

This is possible, despite the small bandwidth of a phone line, because the transmitting machine scans the source picture slowly, to produce a slow or low frequency stream of information. This is sent down the phone line to control a receiver which prints out a copy picture at equally slow rate, for instance onto heat sensitive paper.

There are obvious advantages in having a facsimile machine in the home, hooked up to a telephone. Where it's impossible to describe something by spoken word, you can send pictures or graphs down the line. Where there are strings of facts and numbers to be communicated, it's safer to send them as a written page.

Domestic facsimile reception could eventually replace the postman. Transmission and delivery take only as long as the machines take to scan a page. You don't even have to be at home to receive the transmission. If a message comes in while you are out, it's there waiting for you on your return, like a spoken message on an answering machine.

Japanese Line

Needless to say the Japanese are already excited about domestic facsimile systems. The Japanese Post Office, Nippon Telegraph and Telephone (NTT) is hard selling Minifax. Even by the end of last year NTT had installed nearly 4,000 Minifax units in Japanese homes, for a connection fee of around £12 and a monthly rental of £8.

The NTT sales campaign was based on the idea of using Minifax instead of telephone answering machines. But now the practical problems have started to emerge.

Junk Mail

The Minifax receiver cannot distinguish between messages which the subscriber wants to receive, and those which are unwelcome. So obscene callers can send lewd pictures and text down the phone line to unsuspecting victims.

Perhaps even worse, advertising firms can deluge subscribers with unwanted material. This isn't just inconvenient to the recipient, it is also very expensive. The subscriber has to pay for all the paper used by his Minifax machine to receive whatever comes down the line.

At the moment junk mail sent through the post doesn't cost the recipient anything. You can even get your own back on anyone who sends you too much junk mail, by simply returning it to sender without a postage stamp. The originator of the junk mail then has to pay twice the normal postage and very soon strikes your name off their mailing list. But the owner of a Minifax has no choice but to pay for all junk mail.

Car Statics

A tip on static. Modern cars have nylon or similar man-made fibre upholstery. This wears well but can generate very high voltages of static electricity when rubbed, for instance when the driver or passenger slides across a seat. Then when you get out of the car and put a key in the door to lock it, you get a very unpleasant jolt as a spark jumps across.

Car owners try all kinds of cures. Often you'll see a length of chain or conductive fibre trailing from the rear bumper. This is intended to keep the car at earth potential. But static is an unpredictable beast and you'll often still get just the same belt from an earthed car.

The reason is that your body picks up the high voltage charge as you get out of the car and separate yourself from the nylon upholstery. This leaves two oppositely charged objects, the car and your body or your highly charged body and an earthed car. Either way you'll get a shock when you touch the car again—unless the weather is damp so that the charge leaks away naturally, very quickly.

The trick

The trick for dry weather, which took me an infuriatingly long time to learn, is to get out of the car in a special way. As you lift off the car seat you make sure you are holding the car metal work with a wide firm grip. So as you leave the car seat any static equalises or discharges through the wide contact area of your hand.

Usually you won't feel a thing. And you won't get a shock when you touch the car door with a key because there's no longer any charge to jump across.

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RADIO WORLD

By Pat Hawker, G3VA

A Better Picture?

NEW and developing technology makes interesting reading and journalists not unnaturally tend to play up the importance of each and every advance. On the other hand, a considerable number of last year's "exciting new breakthroughs" gradually sink unsung out of sight. "In five years time everybody will be . . ." is an attractive cliche since the writer is usually well aware that in five years time nobody, except possibly himself, will remember that over-confident forecast and hold it against him.

The number of financially successful inventors (or nowadays the more usual research and development teams) is relatively small: "Pioneerin' don't pay" was a classic belief of Andrew Carnegie. But the consumer electronics industry keeps on hoping: video discs, digital audio, large-screen projection television, direct-broadcast satellites, the electronically wired city, high definition television and of course home computers are all seen as growth areas.

However, the industry does display some worries about all-digital audio that has to compete with high-quality analogue audio, a branch of the industry that is currently feeling the effects of the long industrial recession. Similarly with video discs that have arrived on the scene rather later than expected and without the record as well as playback facility of the video cassette recorders which have proved one of the few really popular new products of recent years.

Surprisingly VCRs have been in greater demand in Europe than in either the USA or Japan.

Cinema Quality

What about high-definition television (HDTV)? Japanese, American and Irish broadcasting organisations (NHK, CBS and RTE) recently co-operated in demonstrating the remarkable NHK 1125-line system with wide-screen (1·85 : 1 aspect ratio) and separation of the chrominance and luminance components.

All who saw the demonstration agree that the system provides a superb picture, virtually the equivalent of good cinema film. You can sit very close to the screen without being worried by the line structure. Several forms of display device, including a widescreen picture tube and high-resolution projection systems, have been successfully developed.

But there are problems. The 27MHz of basic video bandwidth cannot be accommodated in our broadcast bands, not even the European 12GHz satellite band although CBS wants to try using two adjacent DBS channels in the United States, when that country begins direct-broadcast satellite services.

To obtain real benefit it needs a large screen. We still seem some way off from a high-resolution, large-screen display system within reach of many viewers.

HDTV does offer the possibility of all-video cinema presentations or for the dubbing of electronic video on to film. The idea of using 1000 line television to make cinema films is an old one.

In 1951-52 a British company, High Definition Films, had a black-and-white 1000-plus line system and showed that with such a system the very high cost of film making could be reduced. But I do not think they ever overcame the problem that film-makers, particularly the production teams, much prefer the techniques used in film (short sequences, single camera, post-production editing) to those of the large multi-camera electronic studio. Paradoxically, electronic production can today closely resemble that of film—though this then tends to put the cost of video up because of the high cost of machine-time for intensive editing.

The old question "how good is good enough?" may well be asked, and certainly I suspect it will be some time before many viewers in their own homes will be watching pictures of the quality shown in Killarney. Though all credit to the Japanese engineers who began work on the system in 1970 and have since made remarkable progress.

Solar Storms

The month of June witnessed some severe solar flares and other disturbances that had the effect of upsetting h.f. propagation conditions. These included at least one almost total "blackout" during which it is possible to spin the dials of a powerful shortwave receiver and yet hear no signals except those within ground-wave distances.

It is a strange experience to find usually crowded frequencies devoid of all activity. Total blackouts occur only during daylight and often seem most severe between about 5 and 10MHz.

More complaints

The Home Office report on the investigation by British Telecom engineers of complaints about interference to television and radio reception for 1981 shows very substantial increases both in complaints received (70,452, up 96·85 per cent) and completed investigations (60,571 up 47·42 per cent). Much (but not all) of the increase is due to interference from the 27MHz amplitude-modulated CB rigs before the issue of licences for 27MHz f.m.

It is also clear that much of this interference was *not* due to spurious or harmonic radiation from the CB transmitters but reflects the vulnerability of so much domestic electronic equipment to strong local signals, in other words poor "electromagnetic compatibility" (emc). Domestic equipment is much less affected by f.m. signals but the report does further dent the original Home Office case for advocating 934MHz for CB on the grounds that lower frequencies would cause interference due to harmonics.

The investigators found 14,359 cases where complaints were due to CB rigs, considerably more than the usual worst offender—the thermostats in central heating systems etc. which accounted in 1981 for 8,318 complaints. A large proportion of the CB interference was found to be due to direct breakthrough into the audio stages of solidstate domestic equipment and a lot could be prevented if manufacturers added some bypass capacitors and ferrite-bead chokes.

The Sting

Did they fall or were they pushed? That seems to be the question that can be resolved only in the American courts.

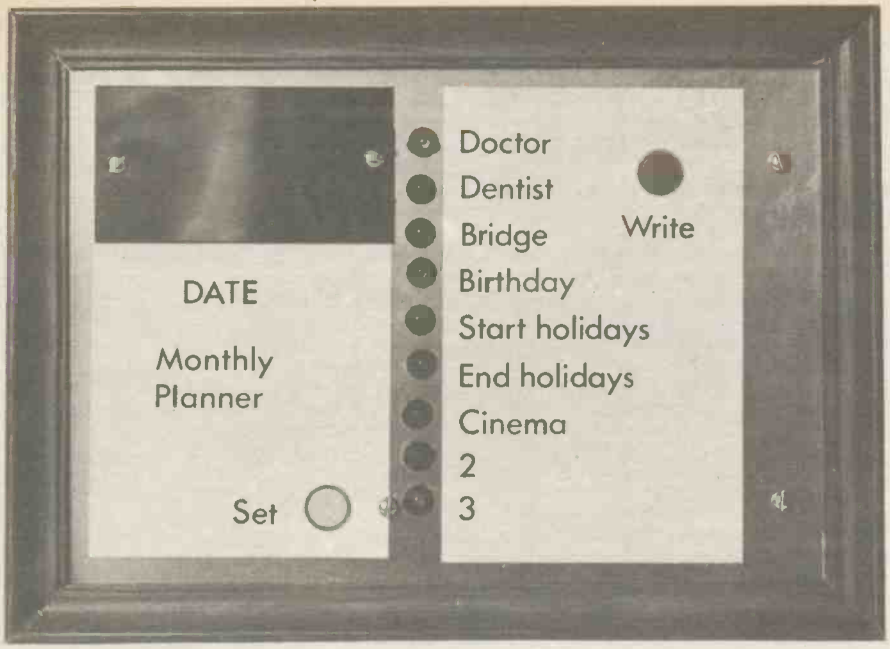
I refer to the astonishing "Japscam" operation in which major Japanese electronics firms admit they parted with $648,000 for secret information that they thought would allow them to market computers plug-compatible to those of the giant IBM firm. The money was paid to a Silicon Valley consultancy firm Glenmar. But Glenmar happened to be a "front" for an FBI operation "Pengem" (Penetrating the Grey Electronics Market).

The Japanese firms claim they had no knowledge that the secret data was "stolen". Indeed, since it was material fed by IBM to the FBI for this operation it was arguably *not* "unlawfully" obtained by Glenmar—and indeed this type of sting operation does appear to have more than an element of "agent provocateur" about it.

The Americans are clearly worried about the continued flow of information and high-technology to East Europe, and competitive "know how" also to Japan. FBI have recently been briefing American elecronics firms about techniques of industrial espionage that are far more sophisticated than the usual stories of bugging the boardroom.

In the UK, one gains the impression that inter-firm competition does include a certain amount of trickery. For example there appear to be firms that advertise non-existent jobs and then pump applicants about what their present firms are up to. But in-depth acquisition of design data is probably a good deal less common—partly I suspect because so many British firms and engineers are firmly convinced that if an idea is "not invented here" (NIH) it *must* be worthless!

Perhaps the most surprising feature of the incident is the lavish amount that the Japanese firms admit paying. By any standard, £350,000 is a fantastic sum to pay for information received, whether acquired legally or illegally, and shows the scale on which the computer industry now operates.



MONTHLY PLANNER

BY A. P. DONLEAVY

THIS project describes the construction of a calendar, which displays the date and a particular event which is to occur on that day, for example, a visit to the dentist or perhaps a birthday. There are nine possible events, one of which can be selected for a particular day.

The design uses two simple 64-bit RAM memories to store the events for the month. These memories are easily programmed using d.i.l. switches and the information for any particular day can be changed at any time.

SYSTEM OPERATION

Fig. 1 gives a block diagram of the system illustrating the various functions. The crystal controlled clock produces one negative going pulse every 24 hours. This is fed to a decimal counter which displays the date information and also to a binary counter.

The outputs from the binary counter are connected to the address inputs of the memory. Each binary number from the counter represents a day of the month. The information in the memory store for that day is then displayed in the EVENT DISPLAY.

Thus there are then two counters which operate in parallel, the decimal counter for the date and the binary for the memory address. The binary counter resets itself *and* the decimal counter on the 32nd pulse.

CIRCUIT DESCRIPTION

The circuit is shown in Fig. 2. IC1 an EO50-16, provides the clock pulses. A brief description of the function of this i.c. may be of interest. It is made by MEM, part of a Swiss watch making concern, and is primarily intended for industrial timekeeping uses. The chip uses 32,768Hz crystal and an internal dividing circuit to provide negative going pulses at intervals of seconds, minutes, hours and days at pins 12, 11, 10 and 7 respectively.

The crystal XTAL1 acts as the time base for IC1. For correct functioning there should be a 1·5V difference between pins 16 and 1 of IC1 and this is provided by D1 and R1, using the forward volt drop of the l.e.d.

The daily output pulses from pin 7, IC1, are fed via R2 to input pins 9 of IC3 and 2 of IC4a. IC2 and 3 are both CMOS 40110 counter/latch and drivers for a seven segment display.

These two i.c.s count the daily pulses and display the date. When the count of IC2 goes from 9 to 0, a pulse appears at the CARRY output, pin 10, which is connected to the CLOCK UP input of IC3. The CLOCK DOWN facility of these i.c.s is not used, nor the LATCH and TOGGLE facilities. Hence, pins 7, 6 and 4 are tied to earth.

The two MAN3740 displays are common cathode types with their cathodes connected to the collector of TR1 for a reason which will be explained later.

BINARY COUNTERS

IC4, is a 4520 CMOS dual four-bit binary counter. The two counters are connected together to form an eight-bit binary counter and this is done by connecting the Q4 output (most significant bit) of one counter, pin 6, to the ENABLE input of the other counter. The ENABLE and CLOCK inputs of this i.c. can be reversed causing it to increment on a different polarity pulse transition.

Since one count is required for each day of the month, a maximum of 31 counts are required, so that the counter is arranged to reset itself at a count of 32. This represents a binary output of 00100000, the 1 being on pin 12. The RESET inputs of IC4 are 7, 15, and for the decimal counters, IC2, IC3 it is pin 5.

IC7 and IC6 are two CMOS 64-bit random access memories (RAM) with a 16 x 4 arrangement. That is 16 locations with a 4-bit word. The two memories together provide 32 locations, of which a maximum of 31 will be used for the days of the month.

The information stored in a location is essentially a number from 0 to 9 written in b.c.d. (binary coded decimal). The outputs from the memories are from pins 5, 7, 9, 11, and are fed to the inputs of IC8, a CMOS b.c.d. to decimal decoder, the 74C42. Thus the four-bit word written in the selected memory location is displayed directly as a

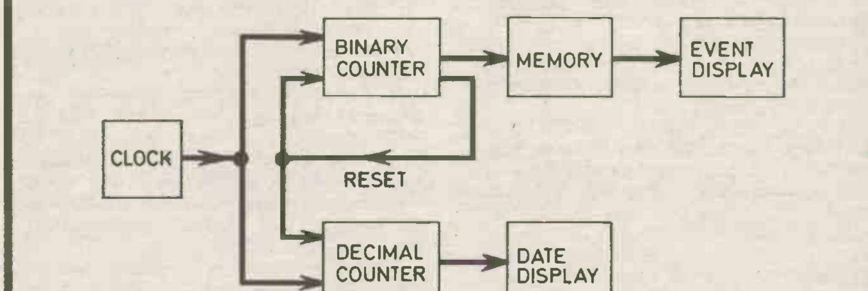


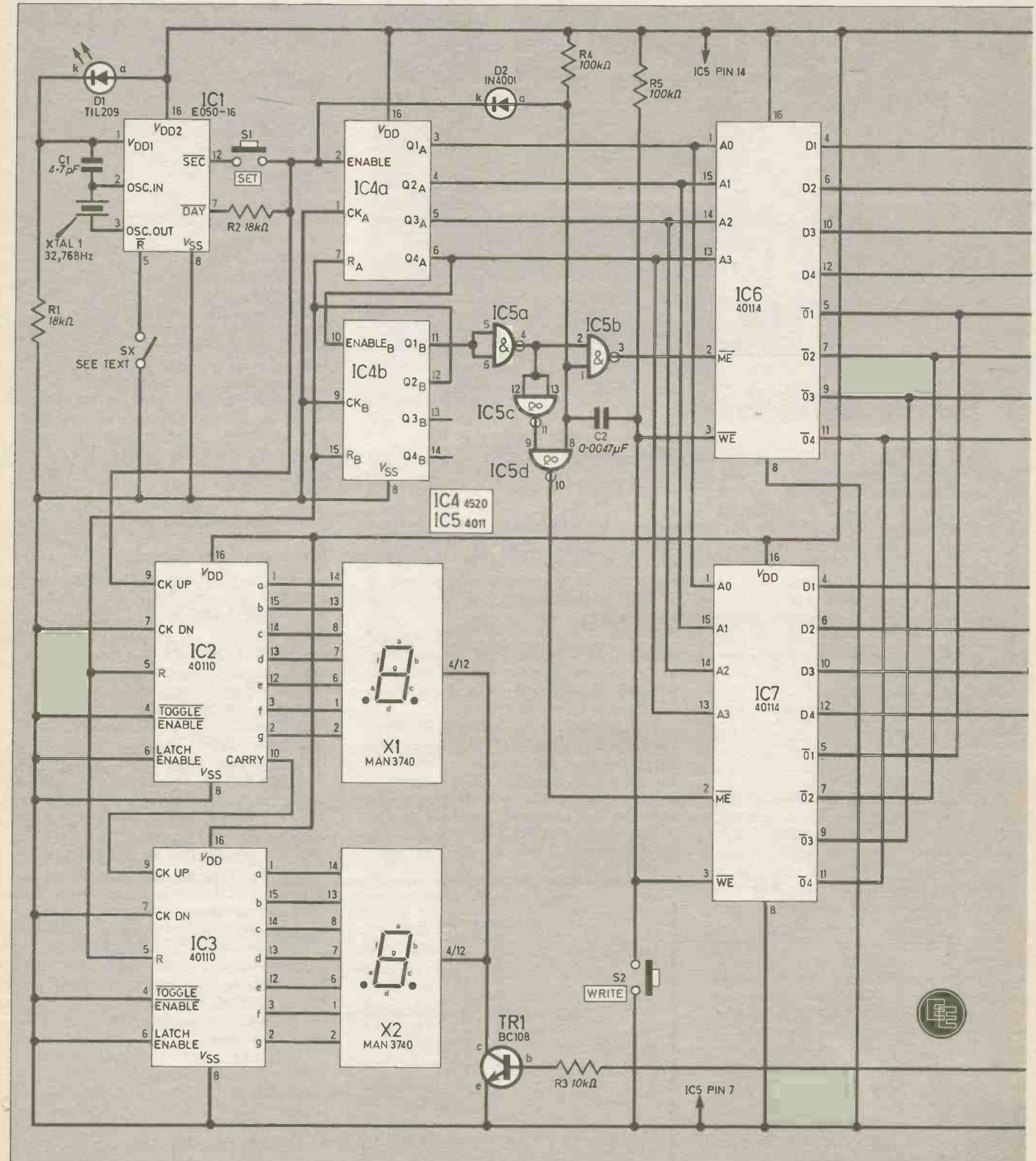
Fig. 1. Block diagram of the Monthly Planner.

number 0 to 9 by the l.e.d.'s connected to the outputs of IC8. The outputs of IC8 are normally high, and go low when selected.

As previously stated, each memory has 16 locations numbered from !0000 to 1111. So for example, on the third day of the month the binary counter will be at 0010 since the first location is at zero (0000) and not at 1 (0001). The corresponding ADDRESS (location) inputs (pins 13, 14, 15 and 1) of the two memories are connected to each other, as are the DATA inputs (pins 4, 6, 10 and 12) and outputs (5, 7, 9 and 11).

Memory enable, ME, inputs are arranged so that if IC6, for example, is at logic 1, then IC7 is at logic zero and vice versa. This is achieved with the arrangement of the four NAND gates of IC5. When the ME pin is at 1, the outputs of the i.c. have a high impedence; and give out no informa-

Fig. 2. Monthly Planner circuit diagram. Note that SX need not be an actual switch as this is only required to ground pin 5 of IC1 at midnight



tion (having tri-state or three-state outputs). Also the inputs will not accept new information. Hence the i.c. is ineffective in the circuit.

Between the counts of 0 and 15, pin 11 of IC4 is at 0, so IC6 WE is at 0 and IC7 ME is at 1. Thus IC6 is the active memory. Between the counts

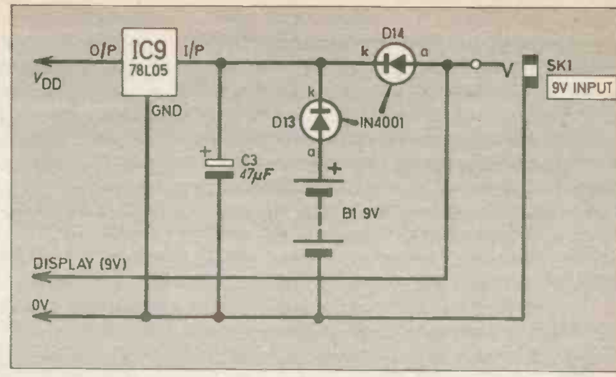
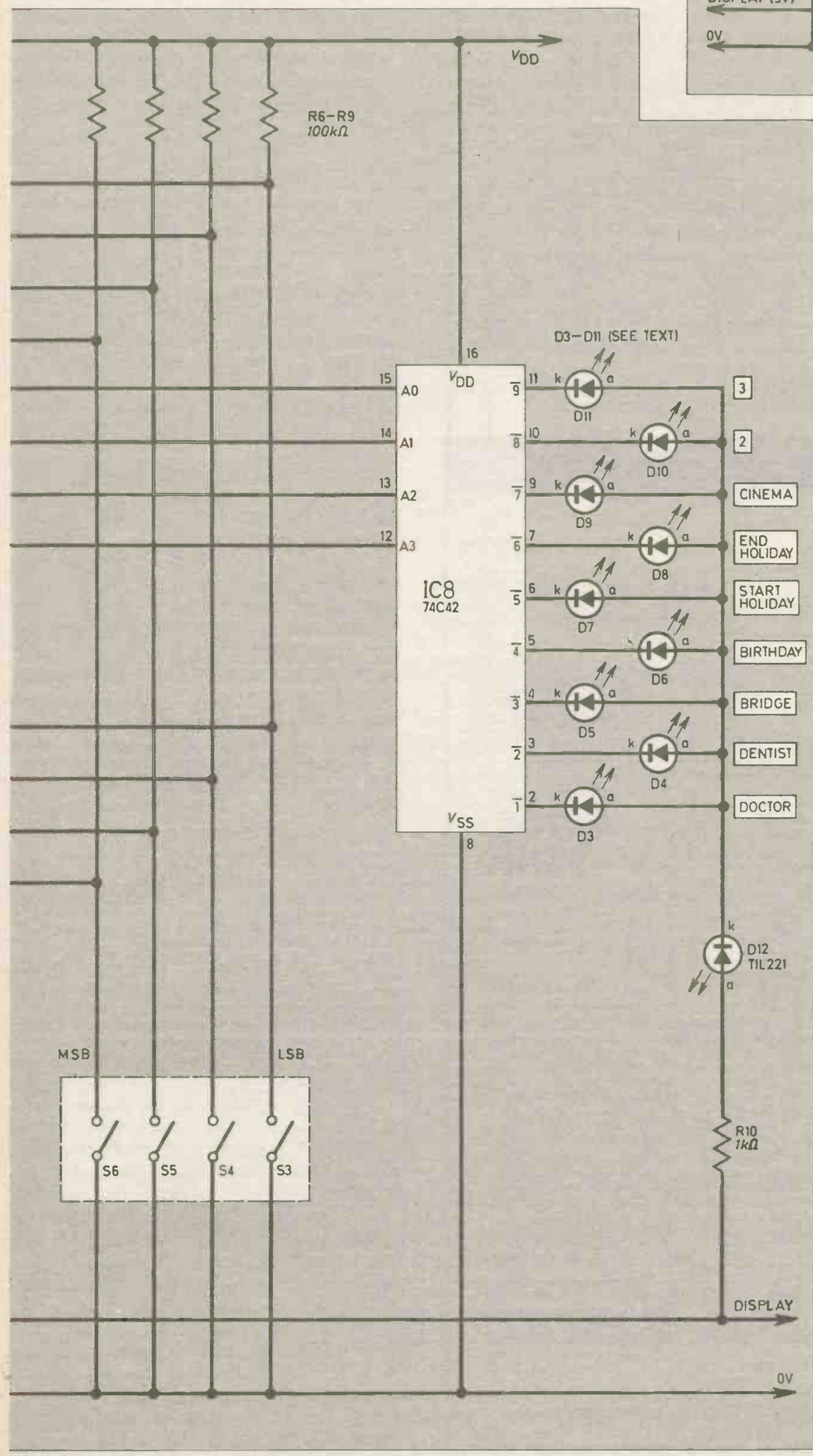


Fig. 3. Power supply circuit. Note that some 9V adaptors drop below 9V under load so an extra diode in series with D13 may be necessary to prevent B1 discharging.

on the first day of the month. S3 to S6 input data to the memory.



of 16 and 31, pin 11 of IC4 is at 1, thus IC6 ME is at 1 and the IC7 ME is at 0. IC7 is now the active memory.

To read information from the memory, the write enable WE input must be at 1. A READ cycle is accomplished by causing a 1 to 0 transition of the ME pin while the WE remains high. This happens as follows. The output of IC1 is a negative pulse of about 32µs. The falling edge of this pulse increments the binary counter (IC4), thus establishing the address. This pulse is also applied to pins 8 and 1 of IC5 via D2, causing the ME pin of whichever memory i.c. is active to go high.

The rising edge of the time pulse will then cause the ME of the active chip to go low again, thus fulfilling the requirements for the information in the memory to be transferred to the outputs. This sequence of events happens automatically as the timing pulses arrive from IC1, since the WE (pin 3) are held high by R5, as S2 is normally open.

MEMORY INPUT

To write information into the chip the WE input must be low, and the ME input must see a 1 to 0 transition. To do this, when S1 is pressed the counters will increment one count every second until the required date is reached. On pressing S2, the WE input goes low, and the ME input also sees a 1 to 0 transition from the negative pulse transmitted via C2 and R5. D2 is included to stop this WRITE pulse from being transmitted to the inputs of IC3 and IC4 and incrementing the counters.

On receiving this 1 to 0 transition, the data at the inputs of the i.c. is written into the memory at the selected location. The DATA inputs are pins 4, 6, 10 and 12, and in this design represent the range from the LSB (least significant bit) to the MSB (most significant bit) in that order. Pins 4, 6, 10 and 12 are tied to V_{DD} by R9 R8 R7 and R6 respectively.

By switching in any of S3 to S6, the information can be set. For example, if S3 and S4 are closed, the information presented to the DATA inputs is 0011 (3). However, the information at the outputs is the complement of the inputs. So if 0011 is set at the input, the outputs would give 1100.

This difficulty is easily overcome merely by relabelling the switch positions 1 instead of 0, and 0 instead of 1. Having set the switches to the desired information, pressing S2 will write the information into the memory.

POWER SUPPLY

Almost all the current in the circuit is consumed by the displays and the l.e.d.s. The unit is therefore intended to be powered by a 9v calculator adaptor, which allows a permanent display of the date and event. However IC1 is only specified to a maximum of 5·5V. So a 5V regulator, IC9, is used to provide the V_{DD} voltage.

However, should for any reason the power supply be cut off, then all the stored information will be lost. To avoid this, a back up battery is used. The circuit in Fig. 3 shows the arrangement. When the power is coming from the adaptor and is cut, the base current supply to TR1, and also the supply to D3 to D12, is cut. Hence, the displays are disconnected, but the back up battery supplies current to the i.c.s and the information is retained.

The current supply in this case is about 2mA so a PP3 battery can supply enough current for many hours. Diodes D13 and D14 stop one supply feeding current into another.

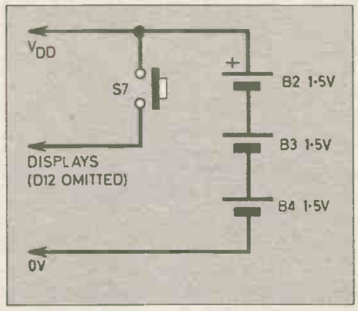


Fig. 4. Optional battery only power supply. The display is enabled with S7.

If the 9V adaptor voltage drops below 9V on load, a 1N4001 diode must be added in series with D13, effectively reducing the voltage at which the back-up battery is brought in.

Therefore, the output of the adaptor must be measured, on load, to determine if this diode is required.

For flexibility in positioning, the supply circuit shown in Fig. 4 can be used. Using 3 1·5V cells, the display will only light when the additional switch, S7, is pressed. With the low consumption the battery life should be over a year.

COMPONENTS

Resistors

R1, 2	18kΩ (2 off)	R4-9	100kΩ (6 off)
R3	10kΩ	R10	1kΩ

All ¼W carbon ±5%

Capacitors

C1	4·7pF sub-miniature ceramic plate
C2	0·0047μF polyester, axial lead
C3	47μF 16V tantalum bead

Semiconductors

D1	Miniature (3mm) red l.e.d.
D2, 13, 14	1N4001 silicon rectifier (3 off)
D3-11	Miniature (3mm) l.e.d. colours to suit (9 off)
D12	TIL221 0·2in green l.e.d.
TR1	BC108 silicon *npn*
IC1	E050-16 1-bit clock timer
IC2, 3	40110B CMOS decade up/down counter/driver (2 off)
IC4	4520B CMOS dual binary up/down counter
IC5	4011B CMOS quad 2-input NAND gate
IC6, 7	40114B (74C89) 64-bit random access memory (2 off)
IC8	74C42 CMOS b.c.d. to decimal decoder
IC9	78L05 5V, 100mA regulator
XTAL1	32,768Hz miniature tubular quartz crystal
X1, 2	MAN3740 (TIL313, DL304 or HP5082) 0·3in high, 7-segment, common cathode display (2 off)

Miscellaneous

S1, 2	Push-to-make miniature keyboard switch (2 off)
S3-6	4-s.p.s.t. 8-pin d.i.l. switch
S7*	Push-to-make miniature push button
SK1	P.C.B. mounting power socket to suit plug on 9V mains adaptor
B1	9V PP3 battery
B2-4*	1·5V size AA batteries (3 off)

0·1in stripboard, 62 holes by 39 strips; single sided copper clad Paxolin or s.r.b.p. sheet, 175 × 125mm (front piece); wooden picture frame, internal dimensions 175 × 125mm; red plastic display filter, 65 × 35mm; 9V mains adaptor; PP3 battery clip; 3mm l.e.d. mounting clip (9 off); 16 pin d.i.l. holder (7 off); 14 pin d.i.l. holder (3 off); 1/0·6mm sleeved wire for board links; 7/0·2mm wire for interconnections; 6BA or M2·5 spacers, 13mm long (4 off); 6BA or M2·5 screws, 6mm long (8 off); 6BA or M2·5 nuts (3 off); 6BA or M2·5 nylon screw, 6mm long.

* Components marked thus are only required for battery only operation.

COMPONENTS approximate cost £34·00 excluding 9V P.S.U.

See Shop Talk page 567

COMPONENTS

D1 may be any red l.e.d. but a 3mm is advised for size consideration. Use good quality l.e.d.s for D8 to D11 since the current drive from the output of IC8 is not high. Any colour or size may be chosen, the prototype used a 3mm with a mixture of colours. D12 should be a green l.e.d. since the circuit is employing the forward voltage drop to prevent the diodes from passing current into the outputs, which are off.

The seven segment displays may be any one of the following: TIL313, DL304, HP5082 as they are pin for pin equivalents of the MAN3740.

The two 40114 memories given in the components list are pin for pin equivalents for 74C89 i.c.s. It would be possible to use a 74LS42 (TTL) for IC8, but the overall current would increase by about 8mA which would slightly reduce the back-up battery life in the situation where the mains adaptor is frequently disconnected.

Switches S1 and S2 are push-to-make circuit board mounted types, designed for making up keyboards.

CIRCUIT BOARD

All components except for D3 to D11 are mounted on a piece of 0·1 inch matrix stripboard, 62 holes x 39 strips. Fig. 5 shows the layout. This diagram also shows the breaks made in the copper tracks.

Use of i.c. sockets is recommended since the removal of i.c.s is often necessary when debugging circuits.

There are many wiring connections to be made, and many breaks to be made in the tracks, so some constructional errors may occur, so take care.

The 8-pin d.i.l. switch is mounted on the copper side of the board, using small pieces of wire soldered to the tracks and soldered to the d.i.l. tags on the other side of the board. Discarded leads are useful for this.

Solder the capacitors, transistors, and diodes as close to the board as possible so that they do not stand proud of the mounted ICs. Use veropins for making the connections from the board to l.e.d.s D3 to D11.

MONTHLY PLANNER

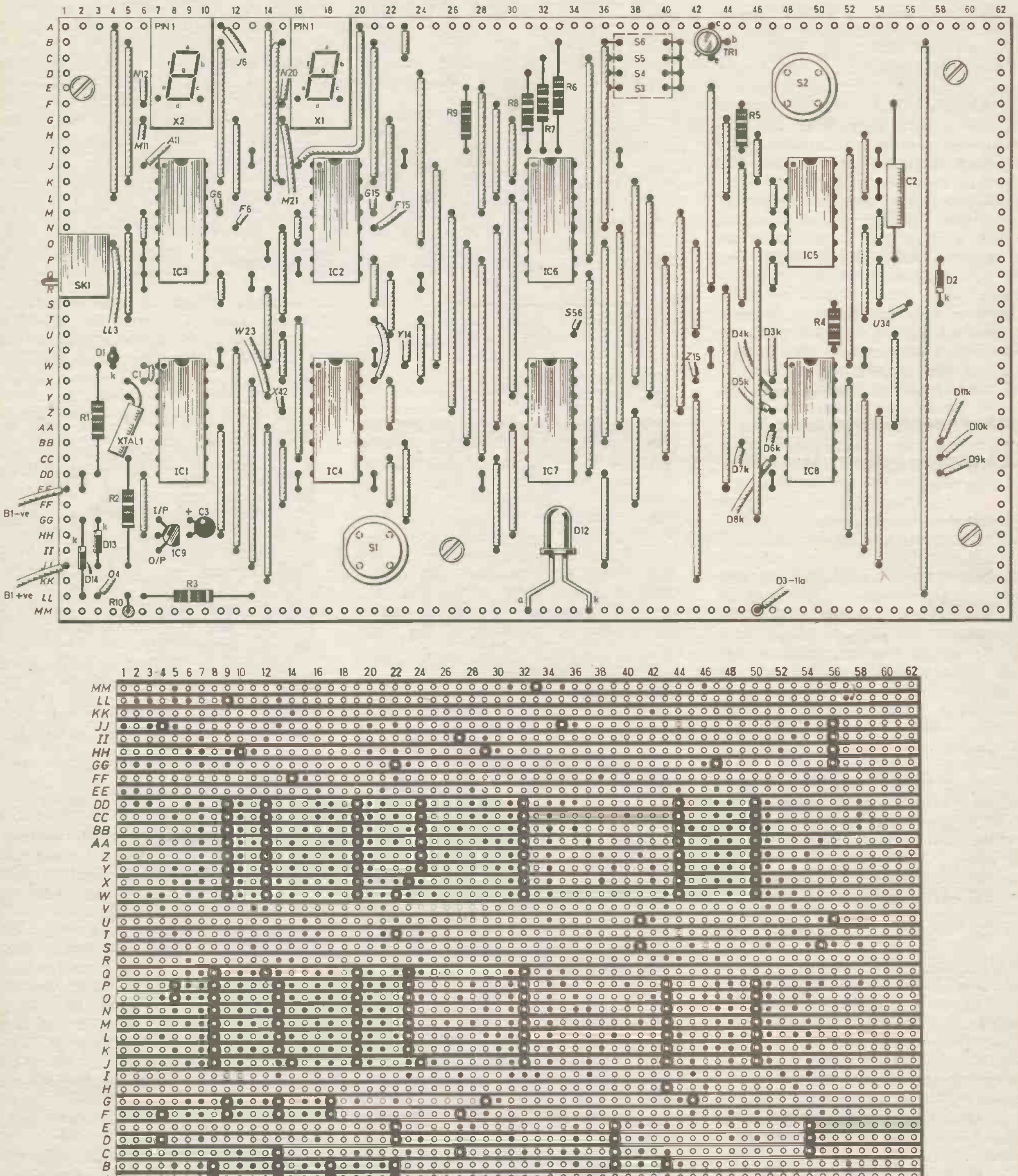


Fig. 5. Stripboard component layout. Note that the 8-pin d.i.l. switch (S3 to S6) is mounted on the copper track side of the board. The underside view shows the positions of the track breaks but omits the d.i.l. switch for clarity.

FRAME

Owing to the nature of the project, the unit should ideally be housed in something more attractive than the usual plastic box. To this end, the prototype was housed in a commercially available photograph frame of internal dimensions 125 x 175mm, the glass is replaced by a piece of p.c.b. of the same size. Use metal polish to polish the copper to a bright finish. Copper board with a paxolin base, besides being much cheaper, is also better than glass fibre for this purpose, since the woven texture of glass fibre tends to come through the copper.

Drill the holes for the diodes D3 to D11, the holes for S1 and S2, and cut out a rectangle 43 x 25mm for the display window. Repolish the board if necessary. Also drill the pillar support holes using the p.c.b. as a template and finally spray a clear varnish on the board to stop the copper from tarnishing. The use of copper board as a frontpiece can be made to look very effective.

On the prototype model, two white panels of self-adhesive p.v.c. sheet were stuck in the position shown in the accompanying photographs. On this, the functions of each event l.e.d. can be written in felt pen (although we used Letraset on the model) and wiped off should the event change.

Another possibility, if the picture frame system is used, is to use a card over the frontpiece with suitable cutouts for the displays and l.e.d.s, and to replace this every month with a fresh set of events written in.

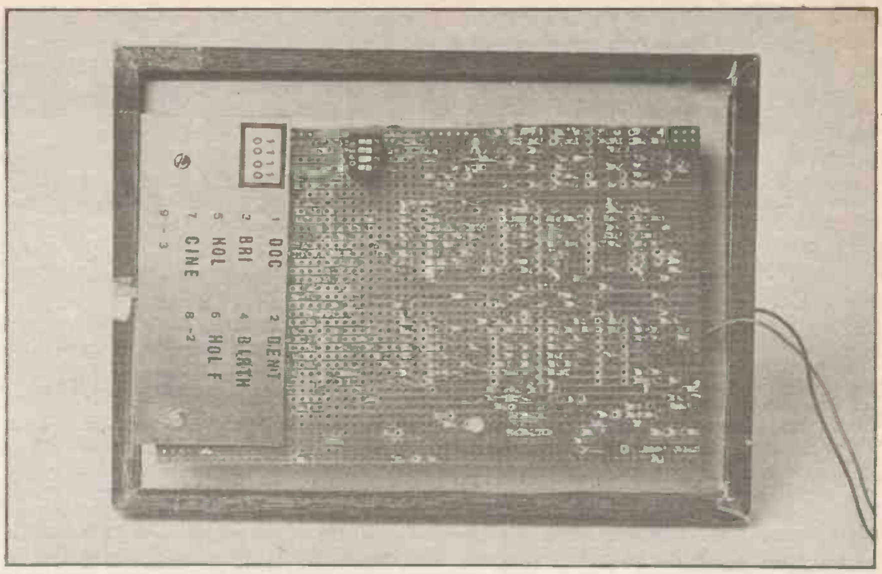
The strip board is held to the frontpiece using four 0·5in long 6BA spacers. The switches S1 and S2 should just protrude through the holes drilled in the frontpiece. Use a red plastic filter to cover the window for the display The l.e.d.s are held in place on the frontpiece using bezel clips.

The back up battery can be tied to the stripboard using wire threaded through the holes.

SETTING UP

No calibration is required since the timing depends on the crystal frequency and any minor trimming of this crystal would be beyond the means of most constructors.

So assuming the unit is debugged and working, the first thing to be done is to synchronise the binary and decimal counters. Do this by pressing S1 (SET) and waiting until the date display resets to 1. This may take a long time depending on the random number in the binary counter when first switched on. A quicker way is to momentarily short pin 5 of IC2 or IC3 to V_{DD}. The display will zero.



Rear view of the framed Monthly Planner showing the position of d.i.l. switches S3 to S6. An additional board was fixed to the rear of the prototype unit to show the codes for each event (given here as a decimal number). Note the use of the nylon screw in hole //26.

Note the date, when automatically reset by the binary counter, will reset itself to 01 and not 00, for the following reason. The binary counter increments on the leading edge of the pulse so on the 32nd pulse both counters are reset by the leading edge, a process which takes less than 1µs, and 32µs later the trailing edge of the timing pulse increments the date (decimal) counter. The difference in count will always be the same and therefore is of no consequence for the working of the unit.

Table 1. Event input codes. Note switch open = 0 and switch closed = 1.

EVENT		BINARY CODE			
		S6	S5	S4	S3
No event		0	0	0	0
Doctor	(D3)	0	0	0	1
Dentist	(D4)	0	0	1	0
Bridge	(D5)	0	0	1	1
Birthday	(D6)	0	1	0	0
Start holiday	(D7)	0	1	0	1
End holiday	(D8)	0	1	1	0
Cinema	(D9)	0	1	1	1
Aux. 2	(D10)	1	0	0	0
Aux. 3	(D11)	1	0	0	1

The unit can now be programmed. When the programming switches S3 to S6 are open then the information at the programming inputs are 1111, and 0000 when all these switches are closed. However, because the information of the output is the complement of that of the input, it will be necessary to label the open position as an "0" and closed position as "1" S3, S4, S5 and S6 represent the LSB to the MSB respectively.

To aid the setting up procedure, a small plate was screwed to the back of the stripboard and labelled with the event codes and the "1" and "0" positions of switches S3 to S6.

EVENT INPUT

To write the events for each day of the month into the memory, the procedure is as follows:

Suppose that, for example, the bridge club meet on the first day of the month, then ensure that the date reads 01 and set up the code for BRIDGE on switches S3 to S6. From Table 1, that code is 0011 (switches S3 and S4 closed and S5 and S6 open) and when set, press S2 (WRITE) and the information is put into the memory.

Proceed to day 02 by pressing S1 (SET) and enter the code for the event planned for this day. If nothing is planned, the memory must be told by writing in the NO EVENT code, 0000 (all switches open) and pressing S2 (WRITE).

Continue through all the days in the month, inserting the relevant event code for each with S3 to S6.

Remember that NO EVENT must be entered on all days on which nothing is scheduled. It is not necessary to use all nine event codes and events can be duplicated on different days should, for example, the dentist need be visited twice in the same month.

To make the timer send out its daily pulse at midnight to change the date, it will be necessary to stay up once until midnight and momentarily short pin 5 of IC1 to 0V ("sx" on fig. 2). This resets all the internal conters. This operation will need to be performed again if the power from both the supplies it cut.

The information written into the memory can be read non destructively any amount of times merely by pressing S1 until the required date is reached. Finally, when the monthly information has been written, the correct date is set with S1. ⌑

Barry Fox reports from Chicago

Consumer Electronics Show

In America, interest in hi fi and audio is still declining; the video cassette market is stabilising; videodiscs are not selling as well as expected and the video games market is booming so fast it could soon produce a glut of outmoded games cartridges on the market and commercial casualties among firms selling them. These are the clear signs which emerge from the 1982 Summer Consumer Electronics Show, held in Chicago, in June.

CES is now acknowledged as the largest, and most important, exhibition of its kind in the world. It is also the most influential. Around 70,000 wholesalers, retailers and journalists from all round the world congregate for four days to look at new products from over a thousand companies. What they see, think, order for their shops and write about in print can have a decisive effect on what the public buys over the next year.

HI-FI AND COMPUTERS

In America, as in Europe, the audio and hi fi trade is suffering badly both from the recession and widespread interest in video. The large manufacturers hope that things will pick up again when the Compact digital audio disc is launched. But lack of interest amongst American record companies has put back the digital disc launch until at least this time next year, or six months after the launch scheduled for Europe and Japan.

Home computer sales are clearly on the rise and it was good to see Britain's own Sinclair system attracting much attention on the Timex stand. It sells in the USA for just under one hundred dollars.

VIDEO MARKET

The video cassette market in America has now stabilised, with a split of around two-to-one between VHS and Beta formats. Plans to launch the European V2000 format have now been shelved.

JVC has now shown a miniature VHS portable recorder, called VHS-C. This is smaller and lighter than any other portable recorder using half inch tape, because it uses a scaled down version of the standard VHS cassette. The tape can be replayed either in the portable, or in a standard domestic VHS recorder using a dummy VHS cassette in which the mini cassette is temporarily housed.

Stereo VHS recorders, with Dolby B noise reduction, are now available, along with pre-recorded stereo VHS software. So far there has not been a stereo Beta machine on sale in the USA, although they are available in Japan. Sound quality is always a problem with stereo on a domestic video format, because the slow running tape has only a narrow audio track, and splitting it in half for stereo degrades the already poor signal-to-noise ratio.

Sony has now developed a system for encoding stereo sound inside the video waveform. Although the company refuses to explain how this is done, it seems that the waveform coding is in addition to a conventional linear track in mono or stereo. This preserves compatibility with existing Beta machines and tapes.

LASERS AND DISCS

Laservision players and videodiscs have been on sale in the USA since December 1978 and the cheaper RCA Selectavision disc system has been sold since March 1981. Both formats were on show at Chicago, with much puff and publicity. But the retail sales of both formats have been disappointing. This has caused JVC and

Thorn-EMI to pull the plug on VHD, the third videodisc system which was scheduled for launch around the world this summer. No firm date for a VHD launch has been set.

The US trade breathed an audible sigh of relief at the delay on VHD because shop keepers already have difficulty in explaining to customers the difference between the two incompatible disc formats. They do not welcome the added confusion of a third, and again, incompatible format.

VIDEO GAMES

The video games market is booming, largely because several companies are now making games cartridges for consoles sold by other companies. It is, for instance, now possible to buy a games cartridge for an Atari video game from nearly a dozen different software companies.

Even Mattel, makers of the rival Intellivision system, now offer Atari cartridges. But to confuse the issue even further Atari has now announced the launch of another games console which is incompatible with the Atari units and cartridges already on the market.

As most of the games available are either banal, boring or pander to our baser violent instincts, the video games explosion is not altogether welcome. Also, because of competition, ever-more complex games appear every day. So some manufacturers may soon go out of business and suffer the same fate as the video graphic blips which their game players must strive to eliminate.

TELEVISION

The USA has not yet agreed on a standard for the transmission of stereo sound with TV. Three different multiplex systems have been proposed, none the same as that being recommended as the European standard. There is also no agreement on a.m. stereo, with six competitive systems trying to win support on the open marketplace. There is no agreement yet on direct broadcasting by satellite. But many video buffs now own three metre wide dishes which enable them to tap into the satellite links between cable stations. In this way they can watch pay TV programmes free of charge—at least until the stations start electronic scrambling. ⌑

LETTERS

Everyone needs a Woolies

Dear Mr. Fox,

I am writing to you to defend the vicious attack you made on Woolworth's employees in your article *For Your Entertainment* on MFP (Music for Pleasure) records in the July Issue of EVERYDAY ELECTRONICS.

First of all I don't understand what you mean by "shops like Woolworths". Firstly you should have written "shops like Woolworth", and secondly there is no other shop like Woolworth. The reason for this is that Woolworth is a general store stocking a lot of different items, and not specialising in any fields whatsoever.

When you say "shops like Woolworths" I suppose you mean shops such as Boots and Tesco whose names are mentioned at the end of many adverts with Woolworth in the "and other leading stores" category. Well these stores specialise in toiletries and food respectively. Other "general stores" are usually very big, for example, Bentalls, Chiesmans, like their prices! So you see there is no other shop like Woolworth. Anyway I digress.

As for the "assistants often know next to nothing about what's available", firstly it's very difficult to keep track of what albums are sold as the stock is very large, and there is usually more than one helper in the record department, so that one rarely knows what has and has not been sold, and thus what is and what is not in stock. After all the assistants are only human and not computers as most customers would want them to be.

Secondly, with regard to actual MFP records, do you know how difficult it is to stock them? Obviously not if what you write is anything to go by. I can tell you that Woolworth only sells them as a service and not as a profit making item. This must be true for all the stores that sell MFP records. This therefore is bound to get the albums neglected and put to the back "out of the way". Also the suppliers of these albums don't go out of their way to help the retailers. All they do is give the retailer an MFP turnstile rack and a batch of records to fill it up with and that's it.

Only when one particular album has sold an obvious greater amount than the others can a retailer order a set of that particular record. That is a very rare occurrence and more often than not what happens is that when the stocks in the MFP rack have become low, the suppliers are informed and another batch of *assorted* records is sent up. You'd be very lucky to get one of the more popular albums!

So you see it's very difficult for a retailer to keep track of what's in the rack. This explains both the knowing "next to nothing" and why other specialist shops do not stock MFP records: they're just too much bother!

I have worked on and off for Woolworth for two and a half years now, and am fed up with people "slanging them off" at every opportunity. It is a good general store with the items sold being of good quality. Any item which is not will automatically be exchanged since the after-sales service is on the whole very efficient. Most important is the fact that the prices are kept as low as possible.

I hope you publish this letter so that the readers of your article will be able to hear both sides of the story. It's rotten to take the poor service of the suppliers of MFP records out on Woolworth, it's not Woolworth's fault!

Martin Gosling,
Chessington,
Surrey.

I am quite happy for the editor to publish your letter in its entirety.

I am sorry you think I made a vicious attack on Woolworth. I can only say I have watched what I regard to be the decline of British Woolworth with disappointment.

Two stores near my home in North London have recently closed and I can't say I am surprised. Prices were high compared to other shops. The range of goods was very poor.

In America the story is very different. Frankly I would not be surprised if Woolworth finally go out of business in Britain, although I would be sorry because we need a general store of this type.

I note your comments on MFP with interest.

Barry Fox.

Everyday News

TOP MARKS FOR SCHOOLS

Minister applauds budding engineers at SEDAC prizegiving ceremony

THE first Schools Electronic Design Award Competition (SEDAC), sponsored jointly by Mullard Ltd, and EVERYDAY ELECTRONICS, reached a splendid and exciting climax on June 29 when the final judging and presentation of prizes took place in Mullard House, London.

The finalists—12 in all—came from schools all over the country. From Durham, Middlesex, Dorset, Surrey, Leicester, West Midlands, Lancashire, Cornwall and Yorkshire. **It said something for the determination of the contestants that, in spite of a crippling rail strike, there was a 100 per cent turn out.**

Opening the prizegiving ceremony, Ivor Cohen, managing director of Mullard Ltd., stressed the importance of technology to the future of the country and praised the enthusiasm and hard work that schools had obviously put into their projects.

Pat Barnes, managing director of the Youth & Practical Group, IPC Magazines Ltd., endorsing Mr. Cohen's remarks, said: "If SEDAC has helped concentrate attention on the importance of encouraging an interest in technology among our youngsters—all of whom are growing up in an age of increasing technological development—the efforts of all those concerned with organising the competition have been amply rewarded."

The prizewinners, who received their awards from William Shelton, MP, Parliamentary Under-Secretary of State, Department of Education & Science, were as follows:

1st: Peel Sixth Form College, Bury, Lancs. £150 The SEDAC Trophy and components to the value of £100.

2nd: Burscough Priory High School, Burscough, Lancs. £100 and components to the value of £100.

3rd: Mellow Lane Comprehensive School, Hayes, Middlesex. £50 and components to the value of £100.

The runners-up were Belmont Comprehensive School, Durham; Queen Elizabeth's School, Wimborne, Dorset; St. Peter's & Merrow Grange Comprehensive School, Guildford, Surrey; Lutterworth Grammar School, Leics; High Park School, Stourbridge, W. Midlands; Richard Lander School, Truro, Cornwall; Aireborough Grammar School, Leeds, Yorks; Tettenhall College, Wolverhampton, W. Midlands; and Hollins High School, Accrington, Lancs. All received components to the value of £50.

The proud winners of the 1982 SEDAC Trophy, Anthony Hudson and Martin Lysejko of Peel Sixth Form College show off the trophy to the Minister William Shelton, MP, Ivor Cohen of Mullard and Pat Barnes of IPC Magazines Ltd.

The top prizewinners' project was a ZX81 Microcomputer Expansion System. Burscough Priory High School's entry was an Oscilloscope Companion. And a Velocity Measurer won third prize for Mellow Lane Comprehensive.

In his address the Minister congratulated all concerned and said he was impressed especially by the practical aspect of the competition—for in addition to preparing a written paper the contestants had to produce a working model for final assessment. Mr Shelton emphasised the government concern that involvement in technical subjects such as electronics be fully encouraged amongst our school children.

Registering some surprise that there were no girls amongst the finalists, Mr. Shelton hoped the fair sex would demonstrate their interest in technology by coming forth in strength in next year's competition.

Winding up the ceremony, Mr aBrnes made the announcement that the competition would be run again in 1983.

SEDAC TROPHY

A specially designed trophy was awarded to the winner of the Schools Electronic Design Award Competition.

As a fitting symbol of contemporary electronics this trophy is in the form of a high grade glass fibre printed circuit board. The copper tracks are gold plated.

The p.c.b. is mounted on a polished wooden base and this carries a small brass plate engraved with the name of the school and title of the winning project.

JUDGING PANEL

Scrutiny of Papers (Stage 1) and evaluation of working models (Stage 2) was performed by a panel of four judges representing the two sponsoring parties. The panel members were:

Gerald Crowther	Head of Application Laboratory, Mullard Limited.
John Warren	Technical Manager, Consumer Electronics Division, Mullard Ltd.
Fred Bennett	Editor, EVERYDAY ELECTRONICS.
Brian Terrell	Assistant Editor, EVERYDAY ELECTRONICS.

The judges' task was difficult and exacting. After long and careful deliberation—with the objects of the Competition always in mind—the declared results were agreed unanimously.

The judges wish to record their admiration for the generally high standard throughout, both in the presentation of written work and in the practical realisation of the designs. All students participating deserve the highest commendation. Those who, in several instances, worked entirely alone merit additional praise. All did honour to their schools, a fact that will surely be recognised by these establishments. Their efforts provide a model for members of other schools to emulate in future contests.

(far left) Simon Rainey of Burscough High describes the merits of his Oscilloscope Companion project to the Minister. This won Simon second prize in the competition.

(centre) Balijinder Dhanda, Michael Finnemore and Michael Stallery, from Mellow Lane Comprehensive, look anxiously as judges inspect their Velocity Measurer. This project was eventually placed third.

(below) Putting the Minister to the test on his Digital Readout Ergometer is Mark Vaughan of Richard Lander School.

A VISITOR'S VIEW

On June 29, the 12 finalists for the 1982 Schools Electronic Design Award Competition all gathered together at Mullard House in London to meet the judges and the press to demonstrate and discuss the end result of the past few months labours. As the final decision as to who was the overall winner of SEDAC 82 was not to be made until the judging panel had seen all the finalists involved and chatted to the pupils, the atmosphere was one of tense excitement.

And indeed it was a close run event, for the quality of the entries was very high.

It is interesting to note that out of the 12 finalists, no fewer than five had utilised computers in their entries (four of these the ubiquitous Sinclair ZX81!) thus illustrating the mating of these two branches of technology—electronics and computing.

But perhaps the most important factor to emerge was the sheer usefulness of all the entries; all had been designed with a specific application in mind. Ranging from the Bee Hive Temperature Meter from Aireborough Grammar School which evolved from a liaison between the school's beekeeping club and electronics club, to the sophisticated ZX81 Microcomputer Expansion System from Peel Sixthform College.

This was the eventual winner and consists of an ingenious system to extend the application of the ZX81 to enable it to be used as a teaching aid. By means of a motherboard plugged into the back of the Sinclair unit, additional daughterboards are incorporated into the system, each with a specific function or task. The example on show at the judging ceremony analysed the classic physics experiment of determining the acceleration due to gravity and displayed the result graphically on the screen.

This project was developed by two sixthformers, in what proved to be a most successful team of one hardware man and one software man.

The second prize, a solo effort from Burscough High School, went to the Oscilloscope Companion. This equipment will also perform a very valuable function within the school, for it is, as its name suggests, a unit to expand the facilities available on a simple single beam oscilloscope.

The third prize winner also has its application rooted in the school's physics laboratory, for Mellow Lane Comprehensive School's Velocity Measurer supersedes the old "ticker tape timer" in performing velocity measurements even on objects as diverse as parachutes and rolling footballs!

However, it was not necessary to be at "the state of the art" to be considered as a winner. Provided that the idea was good and the execution of that idea practical, the entries did not have to be too sophisticated circuitwise. This was illustrated by some of the runners up and in particular St Peters and Merrow Grange Comprehensive School with their Logic Demonstrator, a console type unit to teach the principles of Boolean algebra.

Although the complete list of all the other runners up is too long to describe in detail, another one does deserve a mention as it proved quite popular with those attending the prizegiving, and that is The Electronic Pressure Gauge from The Hollins County High School.

This project measures lung pressure and displays the result on a graph of pressure vs. time and also calculates and records maximum level attained. Quite entertaining when invited to blow into a piece of plastic pipe and have the results appear before your eyes!

The overall impression was one of competence and confidence amongst the pupils in an event thoroughly enjoyed by all those who took part. Which brings us back to the purpose of SEDAC; if these are the electronics engineers of tomorrow then the future certainly looks good. Congratulations to students and staff alike.

SCHOOLS
Electronic Design Award
COMPETITION

THE TWELVE WINNING DESIGNS

Bee Hive Temperature Meter

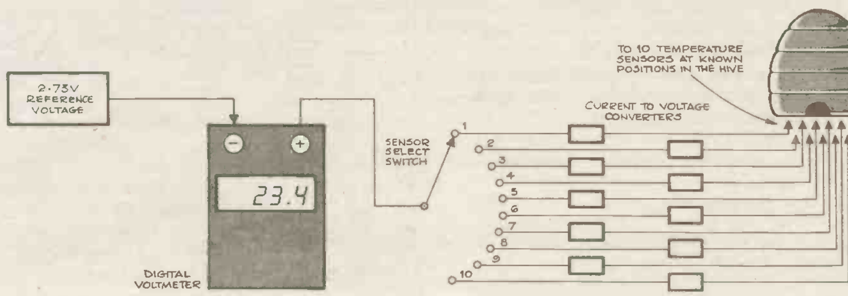
Aireborough Grammar

Mr. B. Thorp (teacher), Andrew Smith (12), Jonathan Green (12), David Allewell (13), Andrew Green (13)

THE beekeeping club at the school wanted to follow movement of the bee cluster in a hive during the winter months, and analyse the movement with respect to external factors and conditions. It was decided to use a temperature sensor to determine the cluster position from the body heat of the bees. The information was gathered from ten sensors at known positions in the hive.

A digital voltmeter was used in the project in a novel way to allow the display reading to be interpreted directly as degrees Celsius.

Ten precision temperature sensors are used to monitor the temperature at the top of each frame in the hive. These sensors operate in a similar manner to a Zener diode, and have a breakdown voltage directly proportional to the absolute temperature (°K). The output voltage obeys a linear relationship with temperature and is equal to 10mV/°K. On board calibration circuitry provides an accuracy of 1°K.



The sensor voltage feeds one input of the digital voltmeter. The other input is maintained as 2·73V by means of a precision voltage reference i.c. Thus the reading on the display is in degrees Celsius (0°C=273°K).

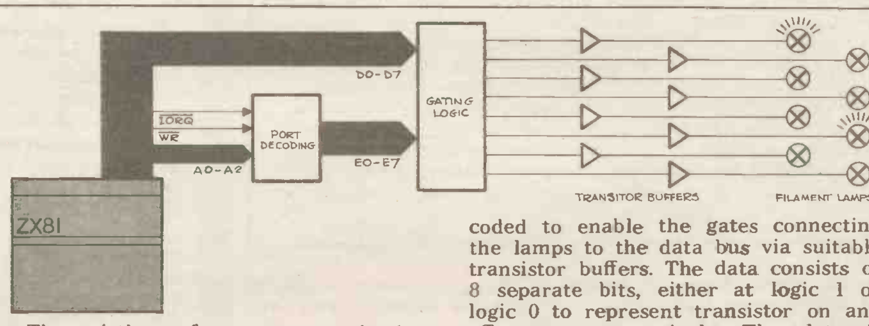
Computer Control Interface

Belmont Comprehensive

Mr. S. Duncan (teacher), David Morton (14), David Williamson (14)

A COMPUTER interface unit allows a computer access to the "real world". This project has been designed to provide such access for the very popular ZX81 Personal Computer. It plugs into the ZX81 bus and is constructed to show how software may be used to control external devices, in this case two filament lamps. The lamps may be replaced by other electronic devices such as relays, thyristors, motors, electric valves to control complex circuitry and machinery.

The control information reaches the various extrnal devices along the computer data bus (8-bits wide) and is routed to the appropriate device by decoding the information appearing on the address lines at this time.



The existing software commands the computer to repeatedly send data to a particular port number, OC. The port number appears on the lower half of the address bus at this time and is decoded to enable the gates connecting the lamps to the data bus via suitable transistor buffers. The data consists of 8 separate bits, either at logic 1 or logic 0 to represent transistor on and off states respectively. The data is modified for each successive "out" command so the transistors are constantly being turned on and off which results in the lamps flashing on and off.

Oscilloscope Companion

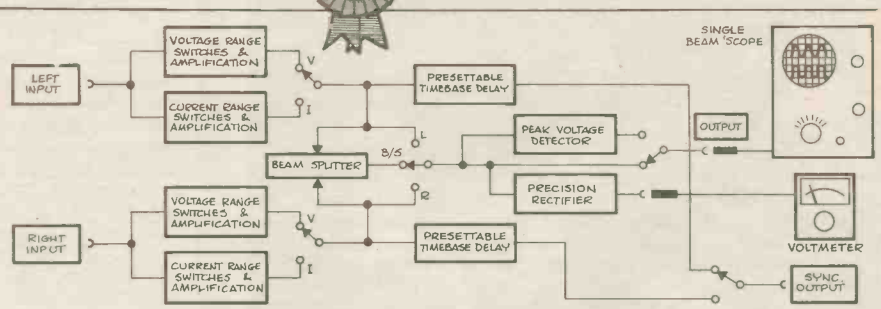
Burscough Priory High

2nd

Mr. M. Earnshaw (teacher), Simon Rainey (16)

THIS inexpensive unit will convert a single beam 'scope with ext. sync. input to a dual beam version, expand the Y-amp volts/cm in both directions, allow current measurements to be taken from the screen display, display peak levels for easy reading from screen and has a time base delay. A precision rectifier/buffer is incorporated to allow a voltmeter to be connected for more accurate measurements of voltage and current.

The unit plugs directly into the oscilloscope Y-amp input set to 1V/cm and signals to be investigated fed to left and/or right channel inputs on the unit. By means of a number of switches, the input signals may be routed through to any of the Companion's function blocks.



Input impedance is in the order of 10,000 megohms which makes special measurements possible such as those associated with bio-activity and pH values. Input voltages from 1mV to 50V in 15 ranges may be measured.

The Beam Splitter facility permits two waveforms to be displayed simultaneously, one above the other readily allowing frequency and phase shift comparisons to be made. Either waveform may be used for synchronisation.

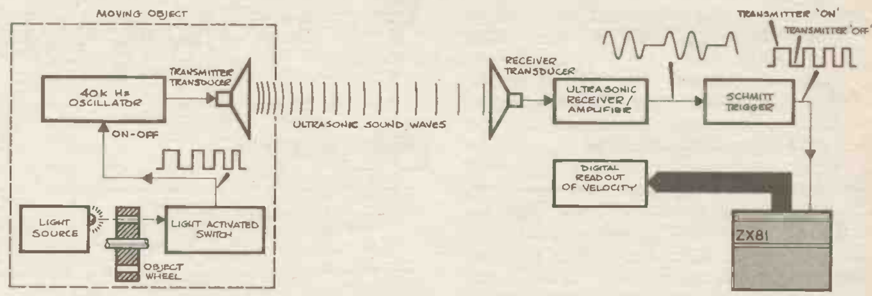
The Peak Voltage Detector detects the highest positive input voltage and remembers it for about 10 seconds.

G.E.M.N.I.F. — High Park — Mr. A. J. Merrett (teacher), David Wilkes (16), Andrew Williams (16)

THIS project was devised to overcome the inaccuracies associated with the ticker tape method of determining the velocity and equations of motion of a moving object using a ZX81 computer for data processing.

Velocity measurement experiments conducted in the school laboratory usually employ a "standard" three-wheel trolley and this has been retained in this project with no external connections. Ultrasonic soundwaves are used to transmit the data obtained on the moving trolley to an u/s receiver on the mains unit. This data is fed to the ZX81, processed and returned to the main unit display circuitry after completion of the experimental "run".

One of the trolley wheels is drilled with two small holes diametrically opposite. These act as windows to open or close an optical link, an l.e.d. light



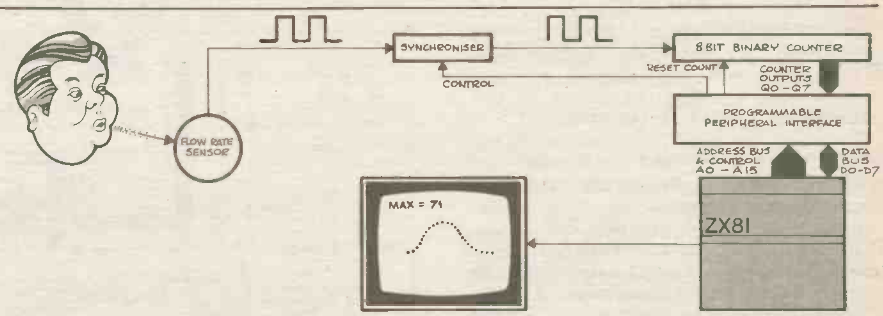
source on one side of the wheel and a light activated switch on the other. As the trolley moves, the light activated switch operates and turns the ultrasonic oscillator on. The on-to-off rate of the ultrasonic transmitter is therefore proportional to the velocity of the trolley. The transmitter on and off periods are converted to logic 1's and 0's respectively. The software instructs the ZX81 to periodically read in this data to compute and store the trolley velocity. At the end of the "run" after a set number of readings, the ZX81 outputs the calculated velocity to the display and TV screen in chronological order.

Electronic Pressure Gauge — Hollins County High — Mr. J. S. Hagan (teacher), Darryl Grimshaw (16), Michael Howarth (16)

THIS project was designed and developed for use in the school science laboratories where lung pressure was required to be measured. It replaces the previous difficult to control water manometer method. It also has other applications in the laboratory where pressure measurements are to be taken, and with suitable software could be employed as a fluid flowmeter with results displayed on a TV screen.

A ZX81 Microcomputer is interfaced to the Gauge hardware which reads in data processed by the on-board circuitry to plot a graph of pressure vs time, and calculate and display the maximum pressure level attained.

The pressure produced by a person blowing down the plastic tube feeding the flowmeter sensor causes a paddle in the sensor to rotate at a speed pro-



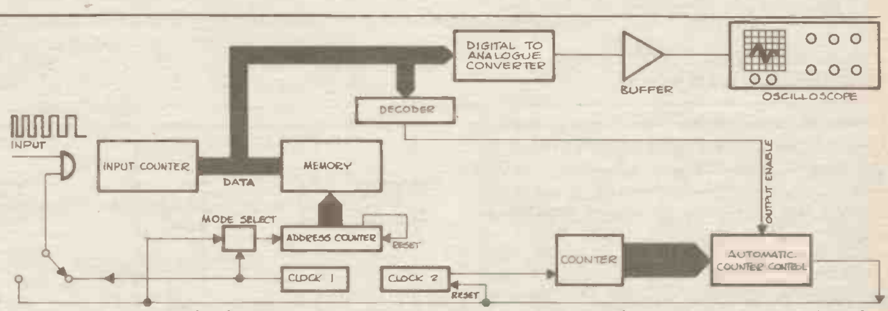
portional to the applied pressure. Internal Hall effect switches in the sensor produce a train of pulses at its output. The pulse rate is thus proportional to the applied pressure.

These pulses are fed to a synchroniser circuit and then reach an eight-bit counter. The software previously loaded into the ZX81 from cassette tape periodically reads the data in the counters, and then causes them to be reset for the next count sample while using the read information to plot the graph and compute maximum value.

Digital Results Storage System — Lutterworth Grammar — Mr. H. Rigby (teacher), Richard Moulds (18)

THIS system has been designed to automatically collect and store the results obtained from experiments, into a solid state memory device. After the experiment, the memory may be repeatedly scanned and the retrieved data processed to make it suitable for inputting to an oscilloscope or X-Y plotter, to obtain a quick graphical representation of the results. It is suited to those experiments where the results are in the form of a varying frequency (a train of pulses) or can be converted to this form.

The system can therefore condense the results of long duration experiments—possibly taking days to complete and display them over any time period (a few seconds for example) which is determined by the memory scanning rate. Also, very short duration experiments, say in the order of a few hundreths of a second, may be expanded by suitable setting of the memory scan rate control.



The system works by counting pulses over a preset period or over a period automatically determined by the time taken to fill the data input counter. The counting can take place continuously or at a predetermined count rate.

Basic operation is as follows: pulses arriving from the experimental output being monitored are gated to a counter. The counter outputs form the data to be written to memory. Internal address coding selects memory location and a control signal is generated to write the data into the location. The address is caused to advance by one, ready for the next data word. In this way the memory is filled with the experimental result in digital form.

To output this data to a 'scope, internal circuitry repeatedly scans all relevant memory locations in sequence. The information is fed to an 8-bit D to A converter and its output scaled before reaching the 'scope for display.

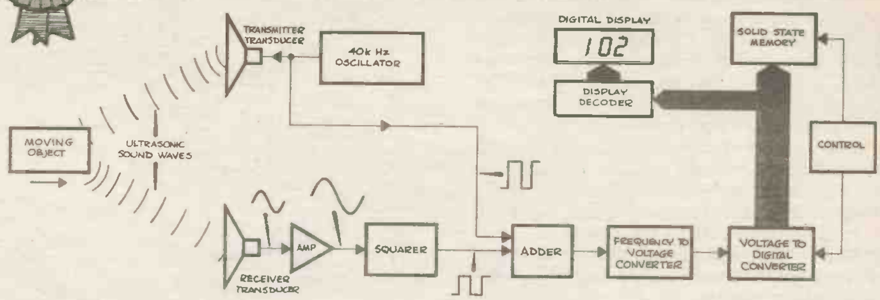
Velocity Measurer

Mellow Lane Comprehensive

Mr. S. Webster (teacher), Michael Stollery (14)
Michael Finnemore (15), Baljinder Dhanda (15)

THE Velocity Measurer can be used in the laboratory with greater ease and accuracy than with conventional methods of taking velocity measurements, such as with the electromechanical ticker timer. It is capable of measuring small changes in velocity at selectable sampling rates, and to store this data in a semiconductor memory. After the experiment, the data may be read out in single steps to allow a velocity-time graph for any moving object to be plotted.

The project uses ultrasonics for determining velocity of the object based on the Doppler effect. The unit emits a constant frequency 40kHz sound wave. This reaches the object and is reflected back to an ultrasonic transducer mounted on the unit. The moving object causes the reflected sound waves to apparently increase in frequency in proportion to its velocity.



The circuitry computes the difference in transmitted and reflected frequencies to calculate the speed of the object.

Sixteen spot velocity measurements are made during the motion of the object on release of the START switch, 5 per second, 10 per second or 50 per second depending on the setting of the Speed Selector Control Switch.

Outputs exist on the unit (1) to allow connection to a proprietary memory bank to store the results of many experiments which is able to feed a chart reader to automatically produce velocity-time graphs; (2) for connection to an oscilloscope to display velocity directly.

ZX81 Expansion System

Peel Sixth Form College

Mr. H. Meredith (teacher), Martin Lysejko (18),
Anthony Hudson (18)

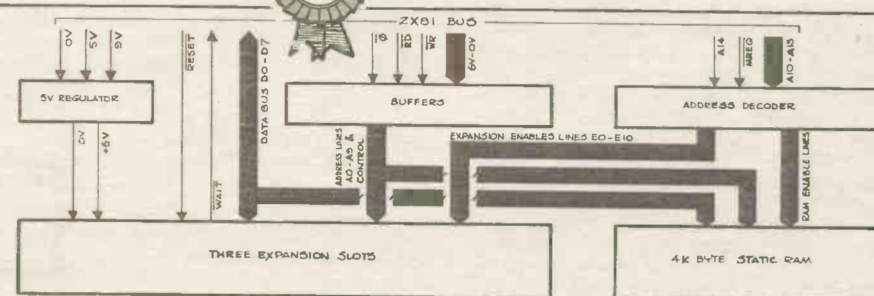
PLUGGING this expansion system into the back of a ZX81 computer immediately adds another 4K bytes to the existing 1K bytes of RAM on board.

The system has its own regulator which helps share the load with the ZX81 resident regulator, and three 37 pin expansion sockets.

Signal lines A0 to A9, $\overline{RD}$ $\overline{WR}$ and ø from the ZX81 bus are buffered. High order address decoding generates 16 enable lines, with the lower 5 lines enabling RAM and the upper 11 lines reaching the expansion sockets.

RAM consists of 8 × 2,114 static RAMS (each 4 bits × 1,024) configured to realise 8 bits × 4,096. It is kept low in the memory map to ensure continuous RAM for Basic.

The expansion socket bus reaches the 3 sockets wired in parallel and consists of the following. 0V, +5V, AØ-A9 (buffered), DØ-D7, ø $\overline{WR}$, $\overline{RD}$, $\overline{RESET}$, $\overline{WAIT}$ and 11 enable lines labelled E0-E10. The latter are active low and enable blocks of 1,024 memory locations. These can be used to enable RAM, EPROM, I/O and any other device which is capable of supporting a bus.



The particular value of this piece of equipment (Motherboard) is its ability to allow inexpensive ZX81 computers to be used for acquiring data from in-progress experiments and display the processed results on a t.v. screen. Additional hardware (daughter boards plugged into the sockets) and software are needed to accomplish this.

Some ideas in mind for daughter boards and software are: measurement and graphical display of radioactive decoy; a spectrum analyser; an I/O board for digital control applications; a serial I/O port for communication to RS232 devices such as printers/terminals.

Coulomb Meter

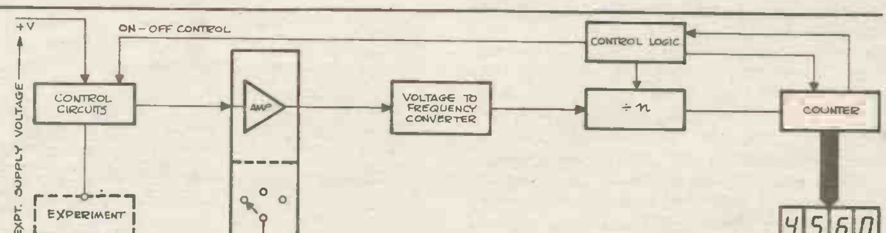
Queen Elizabeth

Mr. C. E. Saunders (teacher), G. Rafferty (17),
M. Shillabeer (16), S. Melhuish (15)

IN the school science laboratory, experiments are often carried out which require the calculation of the electric charge which has flowed in the circuit during the experiment. If the current is constant, this is easily done using an ammeter and a timepiece. In some electrolysis experiments the current can change considerably during the process. This makes continuous monitoring necessary with regular adjustments to maintain constant current.

A more accurate, reliable and easier to use system was sought and resulted in the design and development of the Coulomb Meter.

The meter is able to read up to 1,000 coulombs and has a sensitivity from 1µ C/sec to 10^{-4}C/sec in five switched ranges. The large l.e.d. display which indicates charge flow is capable of being set in a count-up or count-down mode to/from a preset value. When the preset value is reached, the unit switches off power to the experimental apparatus.



0V

RANGE SELECT & AMPLIFICATION

Experimental current flow passes through the range select/amplifier circuitry to produce a potential difference which is applied to the control inputs of a voltage-to-frequency stage (v.c.o.).

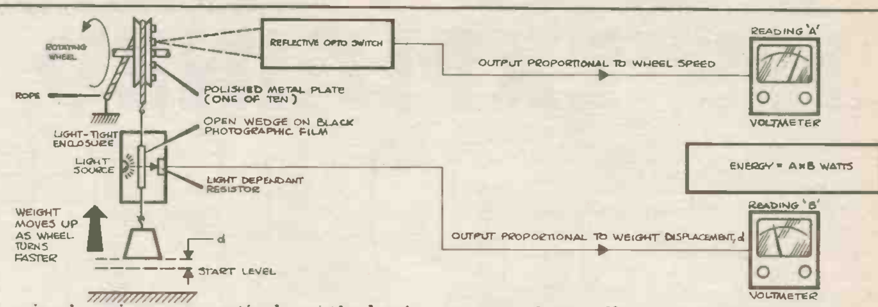
The output frequency is thus proportional to the current flowing.

The high frequency oscillator output reaches divider circuitry to produce a 10Hz display counter input for 1A experimental current to 0·1C.

Presettable inputs to the counter are set by means of b.c.d. thumbwheel switches. When the set value is reached, a control signal is produced that switches off experimental current flow.

Digital Ergometer Readout

Richard Lander — Mr. B. Thomas (teacher), Mark Vaughan (16)



An ergometer is a piece of machinery designed to allow the work input for a particular task to be determined. The machine to be used with this project consists of a wheel attached to a set of pedals by means of a chain. A piece of rope is hung over the wheel rim held taught by mass at one end. As the wheel is turned via the pedals, a force due to friction is transferred to the rope to lift the mass.

This force multiplied by the revs/sec of the wheel enables the applied work to be determined.

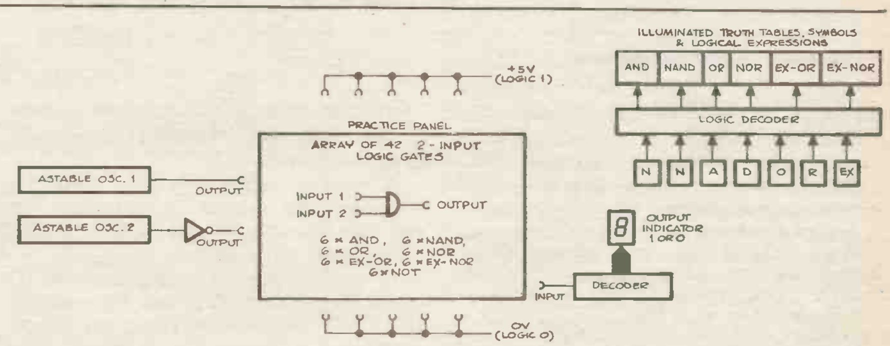
It was originally intended that the work done would be displayed on a 7-segment read-out. However, difficulties were encountered in the realisation of this and the circuitry modified to produce two analogue signal read-outs on scaled meters.

The force due to friction was determined using an optical method. An l.e.d. was situated on one side of a photographically produced and calibrated clear wedge on black film. On the other side of the film was a light dependent resistor. The assembly was mounted in a light-tight box. The film was attached to the rope. As the rope was made to lift the mass, the film moved to allow more light from the l.e.d. to reach the l.d.r. and provide a reading proportional to the force.

The rotational speed of the wheel was measured using a reflective optical switch. An analogue signal was produced from this to appear on a second voltmeter. Multiplying the two readings gives the applied work.

Logic Demonstrator

St Peters and Merrow Grange — Sister M. Clement (teacher), Jonathan Page (14)



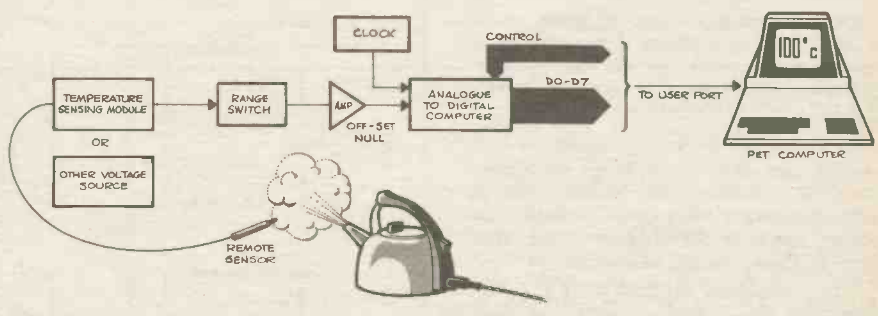
The Logic Demonstrator is intended for the student and others wishing to gain hands-on experience in investigating the functions of various logic gates and to assist one in understanding the basic concepts of Boolean algebra. It will also provide a useful "breadboard" for checking out project designs using NAND, AND, NOR, OR, EXNOR, EXOR and NOT gates. Logic circuits may be quickly "assembled" using only linked-plugs (wire with a plug at each end) before committing the design to permanent form.

A useful feature is the logical expression, circuit symbols and truth table displays for the six basic gates.

An array of 42 logic gates (six of each of the seven types mentioned above) is available to the user. Each input and output is accessible to the user via sockets on the top panel. A set of jumper leads allow these to be easily interconnected as required. Two pulse generator outputs are provided in the design at similar sockets for feeding clock driven logic circuits, as are banks of logic 1's (+5V) and logic 0's (0V). The generators may be switched to be in phase or in antiphase. Outputs are monitored on a seven-segment display arranged to read 1 for logic high and 0 for logic low.

Analogue to Digital Converter

Tettenhall College — Mr. G. M. Feather (teacher), Lee Chapman (16) Simon Monk (16), John Adlington (16)

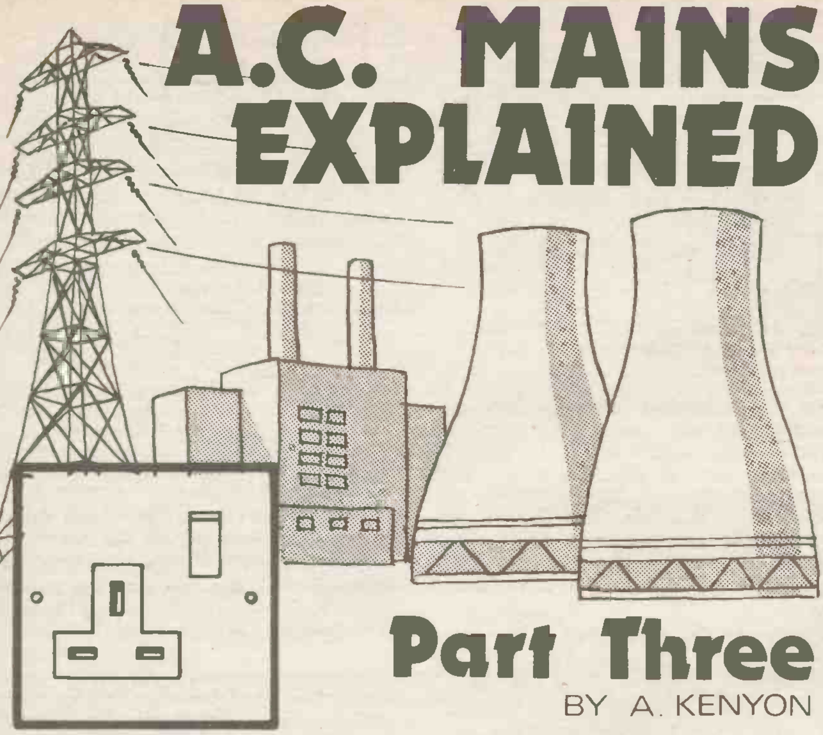


This project illustrates how a microcomputer may, with suitable interface techniques, access, process and display analogue data from measurement transducers obtained during the course of experiments. Many existing laboratory experiments and equipment for measuring physical parameters provide an analogue output such as electronic thermometers, pH meters, sound level meters, radiation detectors and so on.

This piece of equipment will process *analogue* signals and convert them into *digital* data (8-bits wide) which can be recognised and used by the microcomputer. Although designed for use through the PET User Port, it could be easily adapted for use with other computers with suitable software.

Most of the electronics is contained in a single integrated circuit package known as an analogue-to-digital converter. An analogue signal (within a specific voltage range) is inputted to the converter i.c. analogue input and is clocked into the chip to provide a digital representation of the input voltage level in the form of an 8-bit word (eight binary bits). The number of samples taken is dependent on the clock rate which has been selected to give a conversion rate of 28,000/sec. The 8-bit wide information reaches the microcomputer data bus when enabled by a command from the software.

On board scaling circuitry is included in the design to allow input voltage signals of up to 10V peak to be processed. Two input modules were provided for demonstration: (1) a direct input module with 100 ohm switchable shunt. This simulates a load provided by a 1mA, 100 ohm meter and (2) a temperature module for displaying the temperature of the remote probe.



A.C. MAINS EXPLAINED

Part Three

BY A. KENYON

In order to explain the differences between true power and apparent power in the examples discussed last month, it is necessary to examine the relationship between the alternating current waveform and the alternating voltage waveform in a reactive circuit.

PHASE SHIFT

In a purely resistive a.c. system, the current through a resistor rises and falls together with the voltage across it and as such, is said to be **in phase** with it.

However, in a capacitive a.c. system, the current through a capacitor "leads" the voltage across it by a quarter of a cycle. That is, when the voltage waveform is at zero, the current waveform is at its peak, so it is said to have a **phase difference** of a quarter of a cycle (or 90 degrees, as one complete cycle is equal to 360 degrees).

In the third case, the inductive a.c. system, the current through an inductor "lags" behind the voltage across it by a quarter of a cycle. Again, the **phase shift** is 90 degrees but this time in the opposite direction.

The waveform diagrams in Fig. 3.1 illustrate these three cases and also show the conventional method of representing the phase relationship by means of a **phasor diagram.** The phasor diagram shows both the voltage and current as vector quantities (a line with both magnitude and direction), which are imagined to revolve anticlockwise about a fixed point. *0*.

By convention, the current phasor is taken as the reference phase and is drawn horizontally.

A useful mnemonic to help remember the phase relationship in reactive circuits is the word *CIVIL*, to be read as follows:

In a capacitor (*C*), the current (*I*) leads the voltage (*V*), but the voltage (*V*) leads the current (*I*) in an inductor (*L*).

POWER IN A.C. CIRCUITS

If a 24 ohm resistor is connected across the 240V, 50Hz supply, the current through it would be 10A. Now, as the voltage and current are in phase in a purely resistive system, the power consumed by the resistor is equal to $V \times I$, that is, 240V × 10A = 2,400W. It follows that if the circuit was left on for one hour, the electricity meter would register 2·4 units used (as one unit equals on kilowatt-hour).

If the 76mH inductor is connected in parallel with this resistor, the current through each branch of the circuit would be measured as 10A (remember that the inductor also has an impedance of 24 ohms at 50Hz) but the current drawn from the supply would be 14·14A. This is shown in Fig. 3.2.

Furthermore, if the circuit was again left on for one hour, the electricity meter would still only register 2·4 units, indicating that 2,400W (the true power) was being used. The apparent power is 14·14A × 240V = 3,394W.

The phasor diagram in Fig 3.2 shows why the current flowing from the supply is 14·14A. Note that I_R is in phase with V_S (the supply voltage) whereas I_L is lagging by 90 degrees, so that the resultant current (I_Z) is the vector sum of these two, that is 14·14A.

This resultant current can also be calculated by the application of **Pythagoras' theorem,** which states that for a right angled triangle, the square of the hypotenuse equals the

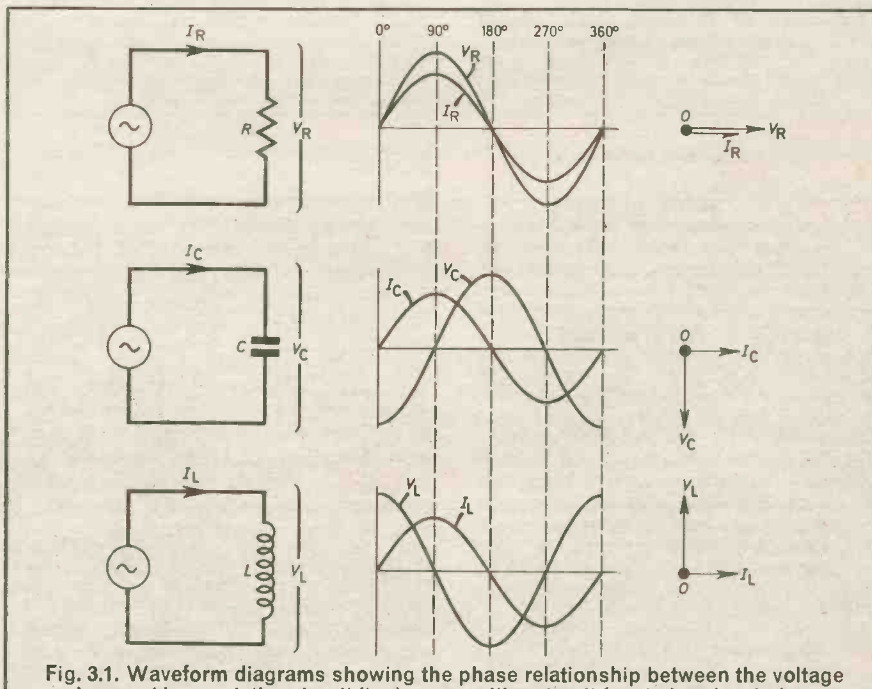


Fig. 3.1. Waveform diagrams showing the phase relationship between the voltage and current in a resistive circuit (top), a capacitive circuit (centre) and an inductive circuit (bottom). The phasor diagrams (right) illustrate this phase relationship.

sum of the squares of the other two sides. So the resultant current, $(I_Z)=\sqrt{I_R^2+I_L^2}=\sqrt{200}=14\cdot14$A.

POWER FACTOR

So far, it has been established that the product of the supply voltage and the measured current is the apparent power (equal to 3,394W) and that registered on the electricity meter is the true power (equal to 2,400W). The ratio of true power to apparent power is known as the **power factor**.

So for the circuit shown in Fig. 3.2, the power factor is 2,400/3,394 = 0·707 (note that the power factor cannot exceed one).

From the phasor diagram in Fig. 3.2, it can be seen that the angle ϕ (greek symbol *phi*) is the angle at which the resultant current lags behind the applied voltage, and in this case it is 45 degrees. The cosine (abbreviated to *cos*) of this angle is equal to the ratio of the in phase current to the resultant current which equals 10/14·14 = 0·707.

This shows that the cosine of the phase angle (cos ϕ) equals the power factor.

The lagging (out of phase) current component in a reactive system does no work and therefore does not register on the elecricity meter. For this reason it is known as the wattless component of the current. It is the in phase current which actually does the work in registering the true power.

Therefore, in order to calculate the in phase current, multiply the resultant current (I_Z) by the power factor (cos ϕ), remembering that, in a practical circuit, the resultant current is the easiest to measure with an ammeter. In our example, $I_R=I_Z\times\cos\phi=14\cdot14\text{A}\times\cos 45°=14\cdot14\times0\cdot707=10$A.

Similarly, the true power is the product of the apparent power and the power factor $=240\text{V}\times14\cdot14\text{A}\times0\cdot707=2{,}400$W. This is the figure originally registered on the kWh service meter.

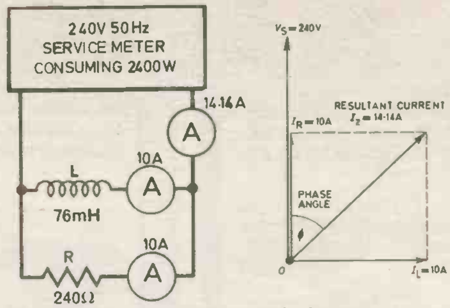
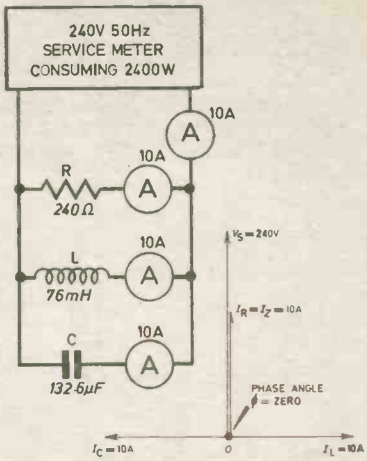


Fig. 3.2. (above) Circuit and phasor diagram of an inductive loaded a.c. mains circuit.

Fig. 3.3. (right) The effect of adding capacitance in parallel with the circuit in Fig. 3.2.



QUESTION TIME

3.1. The information plate on a piece of electrical equipment reads as follows: 240V—1 ph—15A—cos Ø=0·8.
How many units will the equipment use per hour?

3.2. What are the *in phase* and *wattless* components of the equipment in 3·1?

PART 2 ANSWERS

2.1. (a) $X_C=\dfrac{1}{2\times3\cdot142\times2{,}000\times0\cdot00004}=2\Omega$

(b) $X_C=\dfrac{1}{2\times3{,}142\times50\times0\cdot00004}=80\Omega$

therefore current, $I=V/X_C=240\text{V}/80\Omega=3$A

2.2. An inductive reactance is causing the current to flow giving rise to apparent power. However, as no true power is being consumed, the disc on the electricity meter would be stationary.

POWER FACTOR CORRECTION

Industrial electrical equipment and transformers contain coils and windings and will therefore have inductance properties and lagging, out of phase current components. This type of equipment will also carry wattless current, sometimes called **reactive volt-amperes**.

Take for example, a 500kVA transformer supplying a works having many electric motors to drive production machinery, the total power factor of which adds up to 0·76. This transformer on full load at unity power factor could supply 500kW, but because the power factor is 0·76, the true power on full load is only 500×0·76=380kW.

If the power factor could be improved to say, 0·92 at 380kW, the transformer loading would be reduced to only 413kVA, which would leave an additional 87kVA to supply an extra load.

In order to improve the power factor, it is necessary to reduce the phase angle, (ϕ), the net result of this being that cos ϕ (the power factor) will increase. This is achieved by adding a capacitor in parallel with the inductive load. Fig. 3.3 shows this done to the original example.

As the 132·6μF capacitor has an impedance of 24 ohms at 50Hz, the current through it (I_C) will also be 10A. However, the current drawn from the supply is reduced to 10A from the 14·14A in the example shown in Fig. 3.2.

So the capacitive current has cancelled the effect of the inductive current and this can be illustrated by removing the resistive element from the circuit. The supply current will drop to zero but the current through both the reactive branches remains at 10A each.

PARALLEL RESONANCE

This effect is known as **parallel resonance** and occurs when the inductive reactance equals the capacitive reactance. The impedance of a parallel resonant circuit is infinity at its resonant frequency. The formula for calculating the frequency at which a parallel *LC* circuit resonates (the same formula, incidently, as used in radio transmission and reception) is:

$$\text{frequency }(f)=\frac{1}{2\pi\sqrt{LC}}$$

where L = inductance in henries
C = capacitance in farads
π = 3·142 (pi)

The phasor diagram shown in Fig. 3.3 gives the phase relationship between the respective current components in the circuit. Note that I_C leads the supply voltage (V_S) by 90 degrees and is therefore acting in the opposite direction to I_L meaning the resultant current will be equal in magnetude and direction to I_R.

So the true power and the apparent power are equal in this case giving a power factor of one. This is verified by observing that the resultant current is neither leading nor lagging, therefore angle ϕ=zero and cos ϕ=1.

The power factor can therefore be improved by adding capacitance in parallel with the inductive load. In reality it is not practical to increase the power factor to more than 0·92 since when the equipment is switched off (assuming a unity power factor), the high voltages induced upon the change from parallel to series resonance could damage the windings of the electrical equipment.

To be continued

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4017	0.40	4528	0.65	74LS26	0.14	74LS157	0.30
4019	0.38	4529	0.70	74LS27	0.12	74LS158	0.30
4020	0.55	4531	0.65	74LS28	0.15	74LS160	0.37
4021	0.56	4532	0.80	74LS30	0.12	74LS161	0.37
4022	0.55	4534	4.00	74LS32	0.12	74LS162	0.37
4023	0.15	4536	2.50	74LS33	0.15	74LS163	0.37
4024	0.33	4538	0.85	74LS38	0.14	74LS164	0.40
4025	0.15	4539	0.80	74LS40	0.13	74LS165	0.60
4027	0.26	4543	0.80	74LS42	0.30	74LS168	0.70
4030	0.35	4549	3.50	74LS47	0.35	74LS169	0.85
4043	0.50	4553	2.70	74LS48	0.45	74LS170	0.90
4044	0.60	4554	1.20	74LS49	0.55	74LS173	0.60
4046	0.60	4555	0.35	74LS51	0.13	74LS174	0.40
4049UB	0.24	4556	0.40	74LS54	0.14	74LS175	0.40
4050	0.24	4557	2.30	74LS55	0.14	74LS181	1.05
4051	0.55	4558	0.80	74LS73	0.21	74LS190	0.60
4060	0.75	4559	3.50	74LS74	0.16	74LS191	0.60
4066	0.30	4560	2.50	74LS75	0.22	74LS192	0.45
4068	0.16	4561	1.00	74LS76	0.20	74LS193	0.42
4069UB	0.14	4562	2.50	74LS78	0.19	74LS194	0.35
4070	0.16	4566	1.20	74LS83	0.40	74LS195	0.35
4071	0.16	4568	1.45	74LS85	0.60	74LS196	0.55
4072	0.16	4569	1.70	74LS86	0.14	74LS221	0.50
4073	0.16	4581	0.18	74LS90	0.28	74LS240	0.80
4075	0.16	4572UB	0.22	74LS92	0.31	74LS241	0.80
4076	0.55	4580	3.25	74LS93	0.31	74LS242	0.70
4077	0.18	4581	1.40	74LS95	0.40	74LS243	0.70
4078	0.18	4582	0.70	74LS96	1.20	74LS244	0.60
4081	0.12	4583	0.80	74LS107	0.25	74LS245	0.80
4093	0.30	4584	0.27	74LS109	0.20	74LS257	0.40
4175	0.80	4585	0.45	74LS112	0.20	74LS258	0.37
4502	0.60	40174	1.05	74LS113	0.20	74LS260	0.50
4503	0.50	40195	1.08	74LS114	0.19	74LS266	0.22
4506	0.70	74LS00	0.10	74LS122	0.35	74LS273	0.70
4507	0.37	74LS01	0.10	74LS124	1.80	74LS279	0.35
4508	1.50	74LS02	0.11	74LS123	0.35	74LS365	0.32
4510	0.55	74LS03	0.11	74LS125	0.24	74LS366	0.34
4511	0.45	74LS04	0.12	74LS126	0.24	74LS367	0.32
4512	0.55	74LS05	0.13	74LS132	0.42	74LS368	0.35
4514	1.25	74LS08	0.12	74LS133	0.24	74LS373	0.70

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NE567	1.30	MC3357	2.85	ICL8038CC	4.50	Z80A S10/2	11.00
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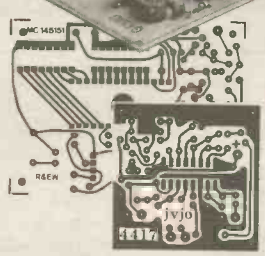

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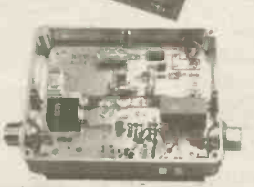

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TEMPERATURE INTERFACE FOR THE TANDY TRS-80

BY O. N. BISHOP

LAST month dealt with the circuit for this Interface describing in detail how it works. In this second and final part, details are given for the assembly and testing, together with the necessary software to run the system.

PRINTED CIRCUIT BOARD

The components are to be assembled on a single-sided p.c.b. The full size pattern to be etched is shown in Fig. 5.

The layout of the components on the board, and wiring to case mounted components are shown in Fig. 6. First of all drill the four fixing holes in each corner. The specified plastic snap-fixing stand-off pillars used in the prototype require a hole diameter in the board of 3·2mm. The hole size to fit these to the case needs to be 5mm diameter. Use the p.c.b. as a template when drilling the case and then enlarge case holes to 5mm.

Begin assembly by soldering in all the link wires, 22 s.w.g. tinned copper wire was used on the prototype. Next fit and solder the i.c. sockets and resistors and voltage regulator followed by the capacitors and bridge rectifier. Do not fit T1 or insert the i.c.s. yet.

The reason for the suggested order of assembly will become apparent as you proceed.

Attach sufficient lengths of stranded insulated wire to reach the case mounted components, including a suitable length of 3-core mains cable.

20-way ribbon cable fitted with an edge connector attached is required to connect to the TRS-80. Separate one end of the 30cm long ribbon cable into 20 separate wires, each about 4cm long. Strip about 5mm from each end and tin. Solder these ends into the board in a regular order, see photographs. T1 may now be soldered in place.

If you contemplate expanding the interface sometime, it may be a good idea to carry out the preliminary wiring for this now. The remaining seven decoded address lines, Q1 to Q7 from IC9, data lines D1 to D7, $\overline{RD}$, $\overline{WR}$, +5V and 0V may be picked up from the underside of the p.c.b. and connected to an 18-pin d.i.l. socket for example mounted on the case. This allows connection to other interfaces using similar circuitry to IC3a/IC4a in the main unit.

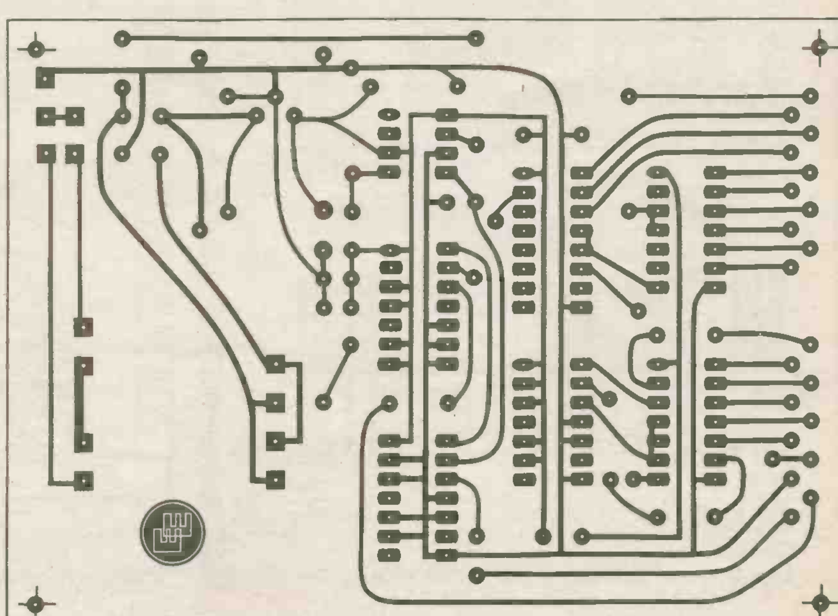
Prepare the case to suit the case mounted components, D1, S1, SK1 and a 13mm diameter hole for mains cable bush and fit these, with exception of the bush, in place.

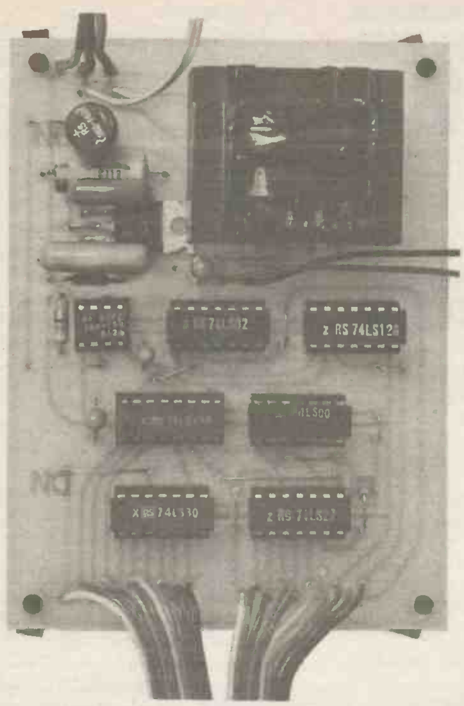
With the plastic stand-off pillars in position in the case, the board can then be aligned with these pillars and firmly pushed onto them to hold the board secure. Feed the mains cable through its entry hole in the case (do not fit the strain relief bush yet). Wire the board to the case mounted components, with sleeving fitted over D1 leads and S1 tags.

EDGE CONNECTOR

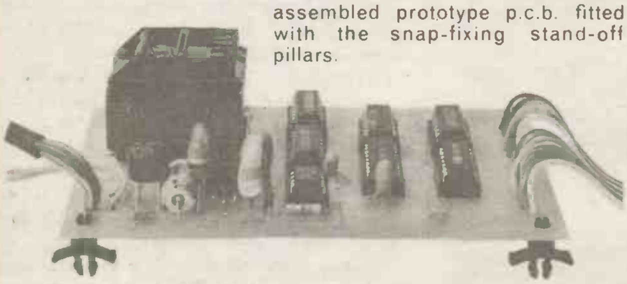
The connections to the computer are by way of a 20-way ribbon cable

Fig. 5. P.C.B. pattern viewed from the copper track side.





Above and below. Shows the assembled prototype p.c.b. fitted with the snap-fixing stand-off pillars.



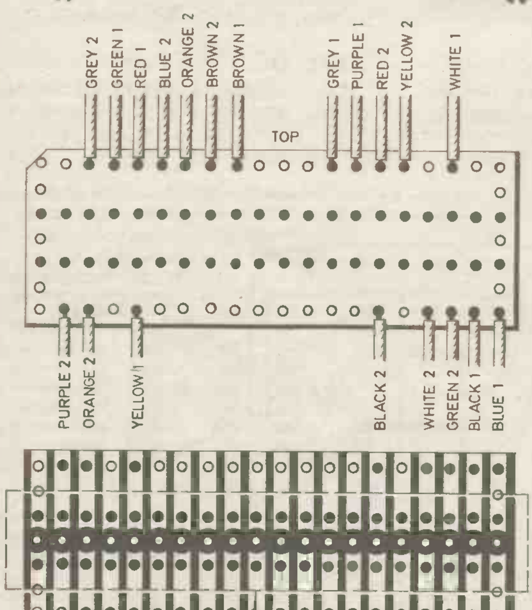


Fig. 8. Wiring and connection details to the stripboard holding the 22 + 22 way edge connector. The labelling of the wires assumes that two 10-way ribbon cables have been used, called 1 and 2.

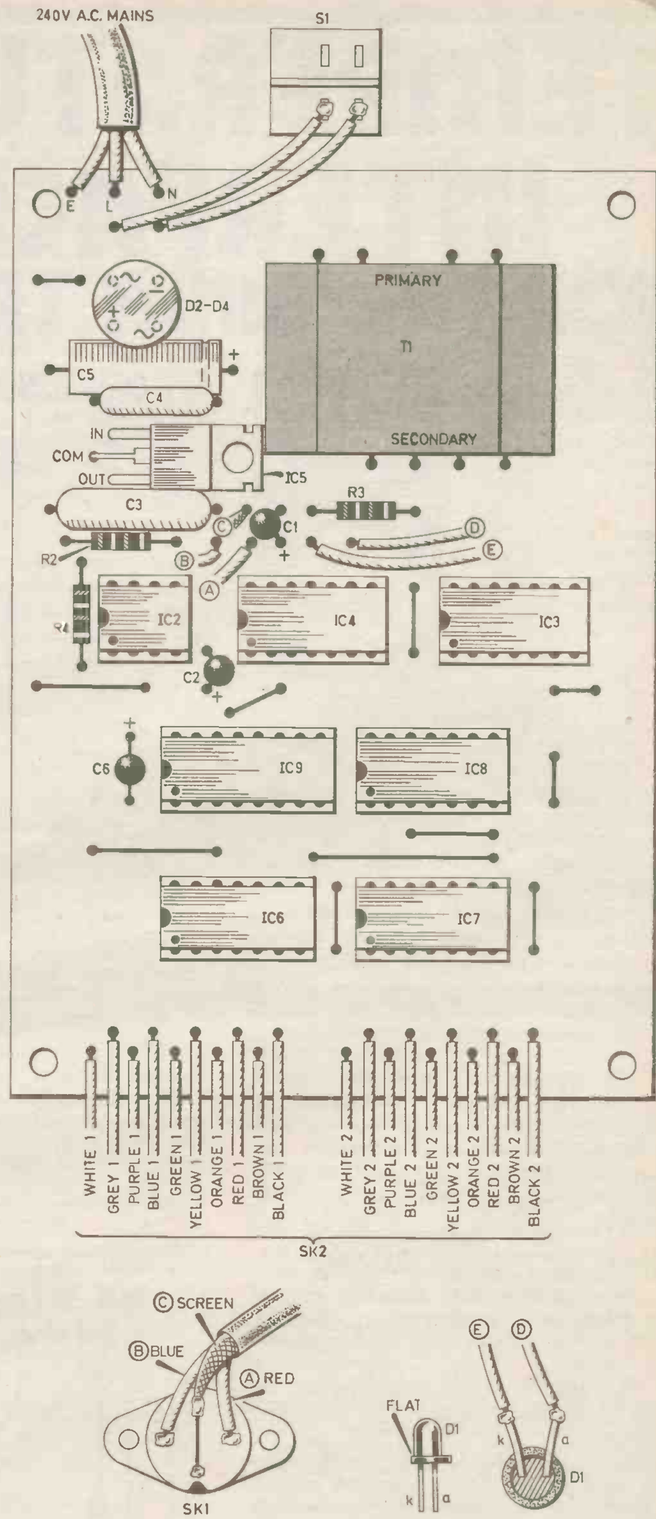


Fig. 6. Layout of the components on the p.c.b. topside with complete interwiring information.

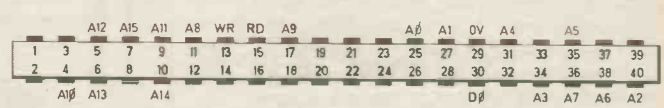


Fig. 7. The TRS-80 expansion outlet viewed from the rear. Only the relevant tracks have been labelled.

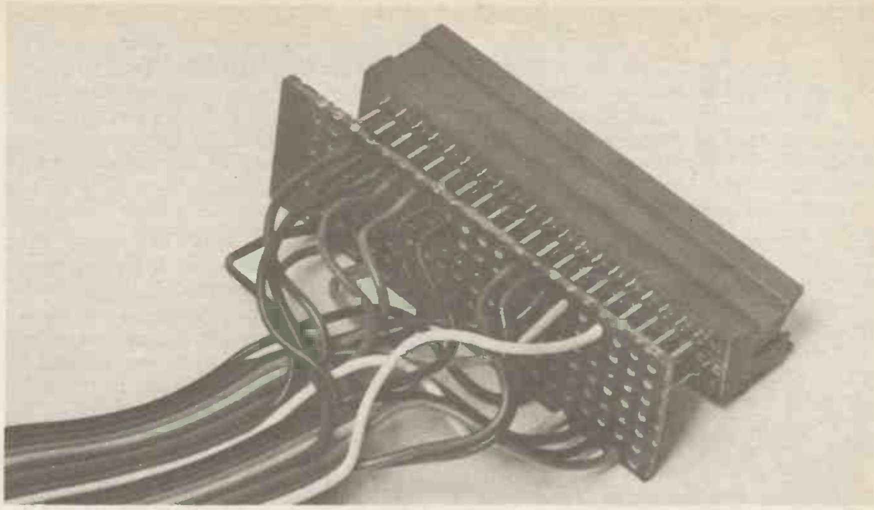
(or two 10-way ribbons). The cable is already connected at the p.c.b. end and now requires a 20 + 20 way edge connector to be fitted to the other. Fig. 7 shows the arrangement of the signals viewed from the rear of the TRS-80 Level I and Level II. The top set of "fingers" are labelled as odd numbers, 1 to 39, with 1 at top left. The lower finger set is labelled using the even numbers between 2 and 40, 2 being immediately below 1. The circuit diagram has been labelled accordingly.

The TRS-80 needs a 20 + 20 way socket but this is not easy to obtain. You can use a more readily available 22 + 22 type and not use the positions at either end. The end pins should be removed and small pieces of s.r.b.p. slotted in their place. These will act as position guides since the TRS-80 does not have a polarising slot. This arrangement was adopted on the prototype. Mark the top of the socket with a label or paint to avoid the risk of plugging it on the TRS-80 board upside down. (If you are using a different computer, you will need to obtain a diagram of the edge connector, plug or socket and make connections accordingly.)

The colours shown in Figs. 6 and 8 are those found on most kinds of ribbon cable. If you keep to this system of colours, it will help to reduce wiring errors. For convenience in wiring up, the edge connector and ribbon cable are joined on a short length of stripboard. The socket is mounted on the copper track side and the wires brought in from the plain side to the appropriate track. This can be seen in Fig. 8 and the photographs. Take special care that the connections are made to the correct locations. The wires ends should be stripped and tinned before soldering to the stripboard. Check out each connection thoroughly after you have finished soldering the wires in place, using a magnifying glass to discover any solder bridges that may have occurred.

It is worth while to use a multimeter to test for short circuits between each line and adjacent lines, and eliminate these before going any further.

The $\overline{WR}$ line is not used in this project, but since there is one spare wire in the cable and $\overline{WR}$ could be used for any user designed interface projects, it might as well be wired in now.



The stripboard/edge connector fully wired. The two outermost connector positions should be fitted with inserts to act as alignment guides.

THERMOMETER PROBE

The construction of the probe is shown in Fig 9. A twin screened cable terminated in a 3-pin DIN plug connect the probe to the rest of the circuit via SK1. The cable can be several metres or even tens of metres long. In the prototype, the lead was about 1 metre long. There was evidence that unshielded lead picked up electromagnetic interference which, by causing short voltage spikes across R3, resulted in spurious triggering of the converter, IC2. It was found that this could be reduced by wiring C6 to the output of IC2. For this reason it is strongly recommended that shielded cable is used for the probe. However, do not run the lead close to sources of electromagnetic interference. The magnetic field from the coil of the tube of a video monitor can give rise to serious interference. For the same reason, keep the leads and the probe well away from TV sets, loudspeakers, and electric bells or buzzers.

Slip a short length of sleeving over one wire before soldering it to the V+ wire of the i.c. An overlap joint is sufficient. It is advisable to use a heat shunt while soldering. Slide the sleeving over the joint. Next twist the wires of a 270Ω resistor to the R and V− wires of the i.c. Make sure that the resistor wires are not short-circuiting the wires of the i.c. Solder the resistor in place. Although a 0·25W resistor can be used, a smaller (0·125W) resistor is to be preferred. Now slip a short length of sleeving on to the lead. Solder the wire to the V− lead, and slide the sleeving over the joint. Finally, slide a piece of wide-bore sleeving or 5mm plastic tube over the whole assembly except for the body of the i.c. Note that the screen is not connected at the sensor end of the cable.

Strip the free end of the cable and separate and trim the three conductors. Make sure that these do not touch each other when soldered to PL1 as shown in Fig. 9. Sleeving may be required over the connections.

TESTING

Before plugging the i.c.s. into their sockets, the power supply section should be checked. First check for

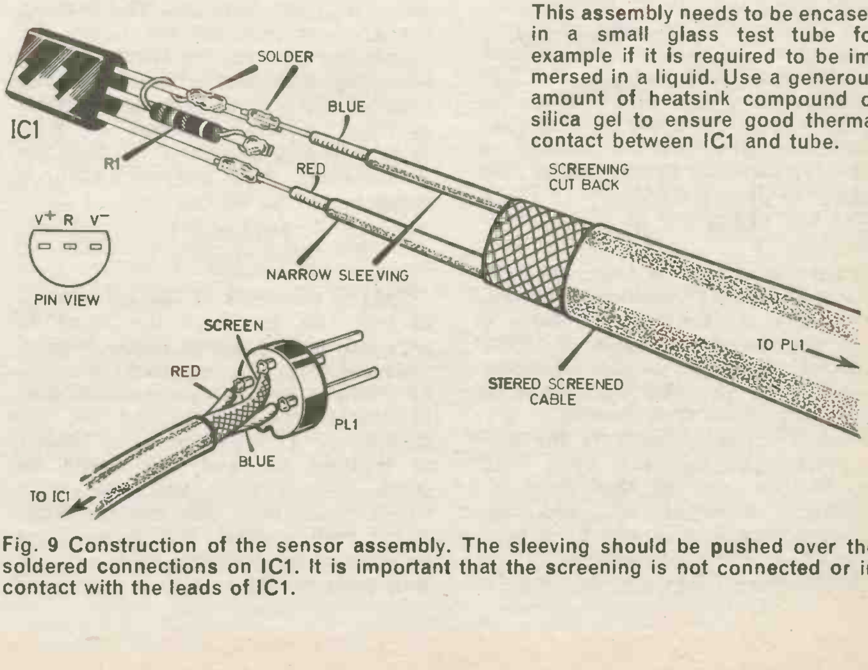


Fig. 9 Construction of the sensor assembly. The sleeving should be pushed over the soldered connections on IC1. It is important that the screening is not connected or in contact with the leads of IC1.

continuity between all the 0V line connections.

With one lead from an ohmeter connected to the mains earth lead, work through the board using the circuit diagram to check that all the connections to the 0V rail are made. Check the +5V likewise with one ohmeter lead connected to the +ve end of R4.

If these checks prove satisfactory, the unit may be plugged into the mains and switched on. A spot check across the power supply rails using a voltmeter set to 10V or more should give a reading of 5V. If so, switch off and insert the i.c.s.

The decoding may now be tested by connecting the appropriate inputs of IC7 and IC9 to the 0V line. This is easier done at the edge connector using short lengths of wire temporarily soldered to the appropriate wire-wrap pins.

Unconnected inputs of TTL i.c.s. act as if they were high, so this in effect provides the address 60,000. The output *A* from pin 15 of IC9 should be low. If you make any one or more of the inputs to IC6 low, or disconnect any one or more of the inputs to IC3 or IC5, *A* should go high. Switch off.

Plug the edge-connector on to the computer board, taking care that the contacts on the connector are exactly aligned with the contacts on the board. Switch on the computer. If you fail to obtain the usual display (MEMORY SIZE?, on TRS-80) switch off. It is likely that one or more of the cable connections is wrong, or that there is still a short circuit between lines. If all is in order, switch on the power to the interface. Again, if the display changes, switch off both the interface and the computer and check for wiring errors.

The simplest test is to read the state of the output of IC2, using the PEEK command, as in **Program A.** With TRS-80, high memory addresses are differently coded, so that, instead of PEEK(60000), we use PEEK (−5536). The result of PEEKing depends on the computer. With the TRS-80, an *open* data line is read as high (1), so when the output of IC2 is high, all lines are high (1111 1111) giving the equivalent of 255 in decimal.

When the output is low, the data lines hold 1111 1110, which is equivalent to 254. As the program runs, a rapid succession of 255's or 254's should scroll up the screen, changing from 255 to 254 and back to 255, about once every 2·5 seconds.

Other computers, such as the ZX-81, return "0" for each open data line. The display will thus show alternating series of 0's and 1's, changing from 0 to 1 and back to 0 about once every 2·5 seconds.

Should the program produce nothing but 255 or 0, switch off and check the circuit for wiring errors. It may be that you have two address-lines crossed, giving an address outside the range of the decoder. Another possible fault is a dry joint on one or more of the lines of the ribbon cable.

CALIBRATING

The simplest way of using the thermometer is to use a BASIC program such as **Program B.** This reads the output from IC2 over and over again, waiting for it to go low (line 40). As soon as it goes low it begins to count how many times it reads a low output (line 50). It continues to do this until it goes high again. The number N is proportional to the time spent in the low condition. All that is then needed is to multiply N by a constant factor to convert it to a temperature expressed in degrees.

It was found in trials that when the probe was immersed in water containing melting ice (0 degrees C), the count N was 111. The count increased to 119 when the probe was allowed to warm up to room temperature (20 degrees C). This is as expected, since the count is proportional to absolute temperature and 20 degrees C is 293 K degrees.

The effect of an increase of temperature of 20 degrees is an increase of only 8 counts. There can be only eight different readings between 0 and 20 degrees C, giving a resolution of less than 2 degrees. This may be sufficient precision for triggering alarm systems, but is not good enough when temperature is to be precisely known. To obtain maximum counts the program has been written so as to run as fast as possible.

Variables A to Y are defined as integers and it uses variables instead of constants (line 20). Even so, resolution needs to be improved.

The simplest way to do this is that adopted in the program. The reading operation is repeated six times, the first being ignored, for it might have been begun during a low pulse. The total of the five remaining counts is M (line 70). Tests showed this total to be 555 at 0 degrees C, so that the temperature, ×, in degrees Celsius is given by:

$$\times = \left(\frac{273 \times M}{555}\right) - 273$$

This is the basis of the calculation in line 100, in which the result is rounded to the nearest whole degree.

To calibrate the Interface, a means of taking a spot temperature reading of the sensor is required. In the absence of a thermometer, a beaker of melting ice and salt could be used. This is at a temperature of 273°K (0°C). With this and any other liquid bath method, the sensor must be isolated from the liquid, see Fig. 9. Run program B.

The total count will be displayed with the calculated temperature. Allow the sensor temperature to stabilise. This will be evident from the display. Mentally note the constant total count and run program B from line 200. After typing in new value for Z, run the program to read the sensor temperature in degrees C. Line 95 may be deleted if not required.

HIGHER RESOLUTION

To achieve even higher resolution we need read the output of IC2 many more times during each low pulse. This can readily be done by using the machine-code routine of **Program C.** The program waits until output goes low, then reads and counts until it goes high again. This routine is extremely fast, giving a count in the region of 44000 at 0 degrees C. The program is written in Z80 machine code and can be accessed by the USR(0) command in the TRS-80. **Program D** shows how this may be done. A count of 44000 at 0 degrees C increases to 47223 at 20 degrees C, an increase of 161 counts per degree. Thus it is possible to resolve temperatures to the nearest 0.01 degrees. At this speed it becomes possible to detect occasional spikes on the output, which give rise to very low counts. Such counts are excluded by line 80 of program D.

A complication arises because the value returned from the routine is treated as a "signed number". Being greater than 32767 (0111 1111 1111 1111), its most significant digit is '1', and it is taken to be a negative number. The remaining 15 digits are evaluated as if it were positive, and a negative sign is placed in front of the result. To obtain its true value as a 16-digit number, we subtract it from 65536 (line 90). The calculation of temperature, rounded to the nearest hundredth of a degree, is done on the same line. The equation on which this is based is:

$$\text{Temp.} = \frac{273 \times X}{44000} - 273$$
$$= (0{\cdot}06245 \times -273) \text{ degrees K}$$

Derive and insert the calibration factor as described in the previous section. The routine from line 200 calculates Z.

With this established, other temperatures are obtained by the calculation in the program. It is important to allow the sensor several minutes to come to a steady temperature before attempting to calibrate it. The output of the i.c. is upset by sudden changes of temperature, presumably because some parts of the i.c. acquire the new temperature before other parts and the balance of the circuit is disturbed. □

TEMPERATURE INTERFACE SOFTWARE

Program A: Testing

```
10   PRINT PEEK (−5536)
20   GOTO 10
```

Program B: Reading Temperature

```
1    CLS
5    Z = 1
10   DEFINT A − Y
20   X = −5536: Y = 255
30   FOR K = 1 TO 6
40   IF PEEK (X) = Y THEN 40
50   IF PEEK (X) < > Y THEN N = N + 1: GOTO 50
60   IF K = 1 THEN 80
70   M = M + N
80   N = 0
90   NEXT K
95   PRINT M; "    ";
100  PRINT "TEMPERATURE = "; INT (Z*M −272·5)
110  M = 0
120  GOTO 30
200  CLS
210  PRINT "TO CALCULATE CALIBRATION FACTOR, Z"
220  PRINT "TEMP. IN DEGREES K = ";
230  INPUT A
240  PRINT "COUNT =";
250  INPUT B
260  PRINT "Z = "; A/B
270  PRINT "ENTER THIS VALUE FOR Z IN LINE 5"
```

Program C

```
                   00100  ; PROGRAM TO READ THERMOMETER
7D00               00110           ORG   7D00H
7D00    210000     00120           LD    HL, 00H       ; CLEAR HL REGISTER
7D03    3A60EA     00130  WAIT     LD    A, (0EA60H)            ; READ OUTPUT
7D06    FEFF       00140           CP    0FFH          ; IS OUTPUT HIGH?
7D08    CA037D     00150           JP    Z, WAIT       ; STILL HIGH, SO WAIT
7D0B    3A60EA     00160  COUNT    LD    A, (0EA60H)            ; READ OUTPUT
7D0E    FEFE       00170           CP    0FEH          ; IS OUTPUT LOW?
7D10    C29A0A     00180           JP    NZ, 0A9AH              ; HIGH AGAIN, RETURN TO BASIC
7D13    23         00190           INC   HL            ; COUNTING NO. OF LOW READS
7D14    C30B7D     00200           JP    COUNT         ; FOR NEXT READ
0000               00210           END
00000   TOTAL ERRORS
Count   7D0B
Wait    7D03
```

Program D: Reading Temperatures to 0·01 degrees

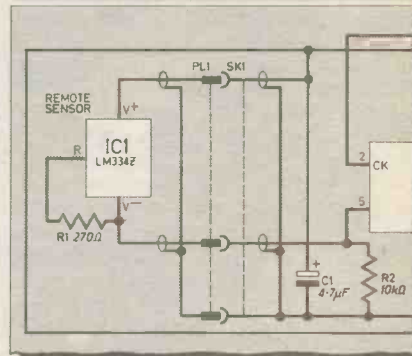
```
1    CLS
5    Z = 1
10   DATA 33, 0, 0, 58, 96, 234, 254, 255, 202, 3, 125, 58, 96, 234, 254, 254, 194, 154, 10, 35, 195, 11, 125: ' Program in decimal
20   FOR J = 0 to 22: ' Putting program into memory
30   READ D
40   POKE 32000 + J, D
50   NEXT J
60   POKE 16526, 0: POKE 16527, 125: ' Starting address of program
70   X = USR(0): ' Go to program
80   IF X <50 AND X> 0 THEN 70: ' Reject small counts
85   PRINT (65536 + X); " ";
90   PRINT "TEMPERATURE = "; INT( Z*(65536 + X) — 27299·5)/100
100  GOTO 70: ' To take next reading

200  CLS
210  PRINT "TO CALCULATE CALIBRATION FACTOR, Z"
220  PRINT "TEMP. IN DEGREES K = ";
230  INPUT A
240  PRINT "COUNT = ";
250  INPUT B
260  PRINT "Z = "; (100*A)/B
270  PRINT "ENTER THIS VALUE FOR Z IN LINE 5"
```

MODIFICATIONS

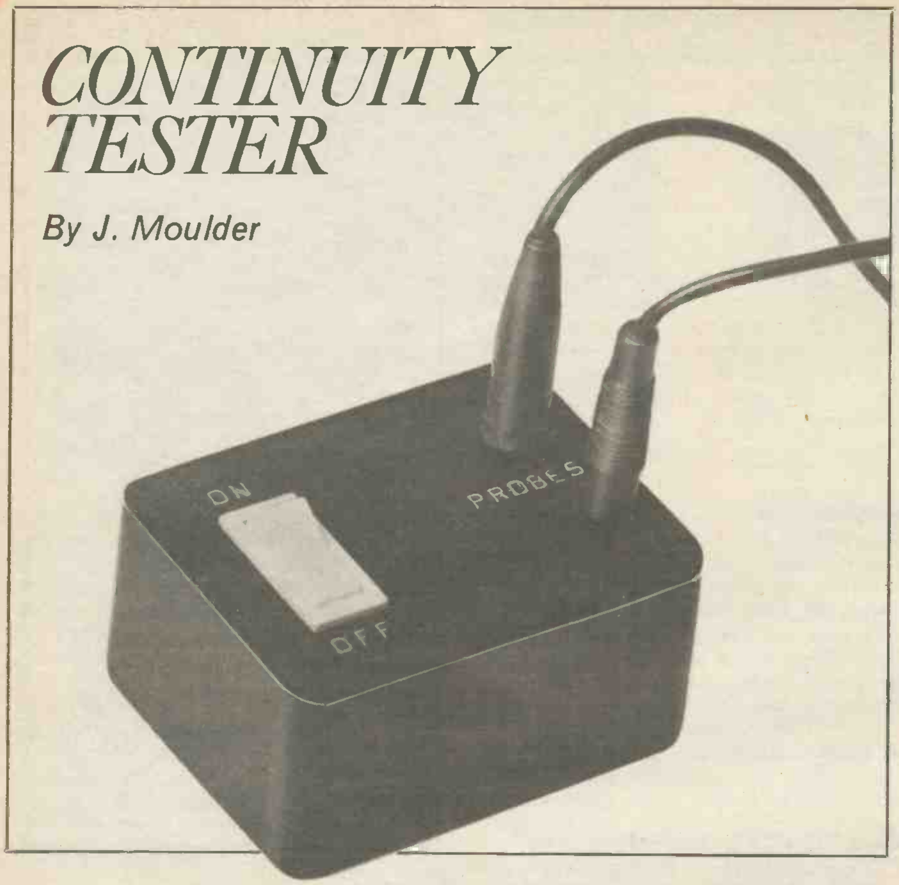
There is an error on the circuit diagram, Fig. 2 published last month. The "short" across R2 should of course not be there.

It was found necessary to use screened cable to connect the sensor to the unit in order to minimize the effect of e/m noise pick-up giving rise to false triggering of IC2 and thus "odd" calculations. Consequently, PL1 and SK1 have been re-specified as 3-pin DIN plug and socket respectively. Twin screened cable should be added to the Component List. The circuit diagram front end should be modified as shown below. The likelihood of false triggering may be further reduced with C2 2·2μF.



CONTINUITY TESTER

By J. Moulder



A CONTINUITY tester is a valuable piece of equipment used to determine whether a component or circuit has a broken connection. That is, it tests for the continuity of current flowing.

It can also be used to check fuses, bulbs, wires and certain semiconductors, including diodes and transistors.

DESIGN CONSIDERATIONS

This circuit has been designed to overcome difficulties often associated with basic continuity testers. These are:

1. Difficulty in establishing if continuity has been made.
2. High probe current damaging semiconductor junctions.
3. Inability to pre-determine the maximum resistance that the tester "sees" as continuity.
4. Variation in the tone produced by the tester according to the resistance being checked.
5. High stand-by current.

The first problem was simply overcome by giving the Continuity Tester an audio output, not a visual indication, thus allowing the user to concentrate on the component under test, and with a probe current of less than 1mA, the second problem was also removed.

Provision of a potentiometer in the tester input circuit permits the user to programme the resistance at which the unit registers continuity and by incorporating an oscillator with a tone frequency independent of test resistance, difficulties 3 and 4 were erased.

The stand-by current was reduced to an almost negligible level by using ultra-low power CMOS circuitry thus overcoming the last problem.

CIRCUIT DESCRIPTION

The tester employs a CMOS 4011 i.c, consisting of four NAND gates, three of which form an oscillator, the remaining gate acts as an inverter to enable the oscillator. See Fig 1.

IC1b, c and d form the "ring of three" oscillator, the frequency of which can be calculated with the formula:

$$\text{frequency } (f) = \frac{1}{R2 \times C1} \text{ Hz}$$

where R2 = resistance in ohms
C1 = capacitance in farads

With the components used in this circuit, the frequency will be approximately 1kHz.

The last NAND gate, IC1a, is made into an inverter by wiring its two inputs together. Its output is connected to the oscillator which will only oscillate when the output of IC1a is high (logic 1). This will only occur when a low resistance path is connected between SK1 and SK2, thus forming a potential divider along with R1 and VR1.

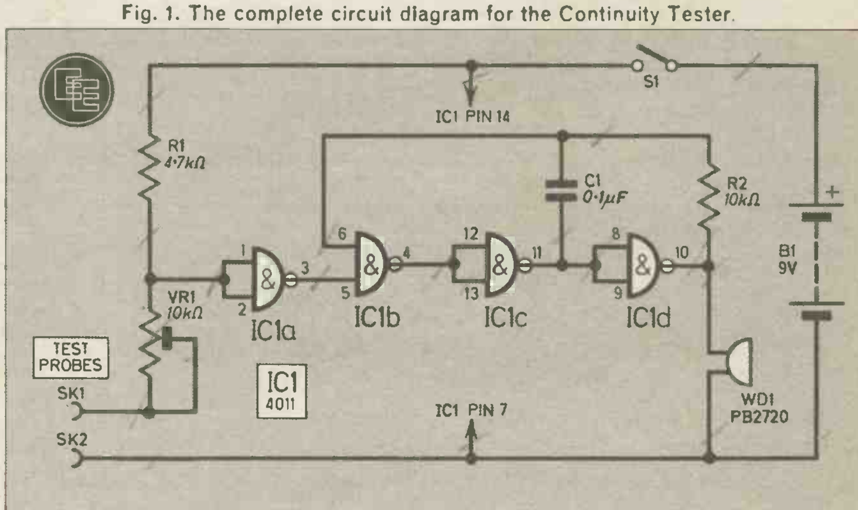
TRANSDUCER

The oscillator drives WD1, a piezo ceramic transducer. This type of device consists of a piece of ceramic material deposited on a circular brass "resonator" and it produces a very high output when energised. This makes it more efficient for this application than a traditional speaker, particularly considering its low power consumption and diminutive size.

CIRCUIT BOARD

Fig. 2 shows the construction of the circuit board on 0·1 inch stripboard, 12 strips by 19 holes. It is best to start with the i.c. holder for IC1 and then solder in the wire links (9 in all), VR1, the resistors and the capacitor.

Fig. 1. The complete circuit diagram for the Continuity Tester.



Next, the flying leads of 7/0·2mm equipment wire should be added, and these should be about 100mm long. Finally solder the leads from the piezo ceramic transducer into position, taking great care as these tend to be a little fragile, and to complete this stage of construction, add the battery clip (remember that the red lead goes to switch S1).

THE CASE

The tester is now ready to go into its case, and the prototype was fitted into a plastic box, 75×55×35mm. The red and black banana sockets and the rocker switch are mounted on the outside of this case as shown.

The piezo ceramic transducer (WD1) is glued onto the inside of the case with a contact adhesive (such as "Evostick") and the battery B1 is taped to the inside of the lid. When all the flying leads have been soldered in place, the unit can be completed by slotting the board into the space between the battery and the plastic body of the rocker switch.

SETTING UP

To set up the Continuity Tester, a small screwdriver and 1·5 kilohm resistor are required.

With the unit open so as to give access to VR1, switch on and connect the 1·5 kilohm resistor between the two probes. A 1kHz tone may be heard but don't worry if it is not at this stage.

Adjust VR1 until the tone just ceases and if the unit was not initially making the tone, VR1 must be rotated until it does and then adjusted to the point where it ceases. It is important that this adjustment is exact so that the tester is sensitive to this resistance.

The value 1·5 kilohm was chosen as the maximum resistance at which the Continuity Tester "sees" as continuity for the prototype as it is a practical value. However, the constructor may wish to substitute a different value here.

The unit is now ready to test components and circuits, and Fig. 3 and 4 show how it can be used to check diodes and transistors ⌑

COMPONENTS

Resistors
R1 4·7kΩ R2 10kΩ
All ¼W carbon ±5%

Capacitors
C1 0·1μF polycarbonate

Semiconductors
IC1 4011B CMOS quad 2-input NAND gate

Miscellaneous
RV1 10kΩ miniature horizontal preset
S1 on/off rocker switch
B1 9V PP3 battery
SK1 4mm banana socket, red
SK2 4mm banana socket, black
WD1 PB2720 piezo ceramic transducer
Stripboard, 0·1 inch matrix, 12 strips by 19 holes; plastic case 75 × 55 × 35mm; 14 pin d.i.l. holder; battery clip; 7/0·2mm equipment wire; probes (2 off, one red, one black) on 4mm banana plugs.

Approx. cost Guidance only £6·20

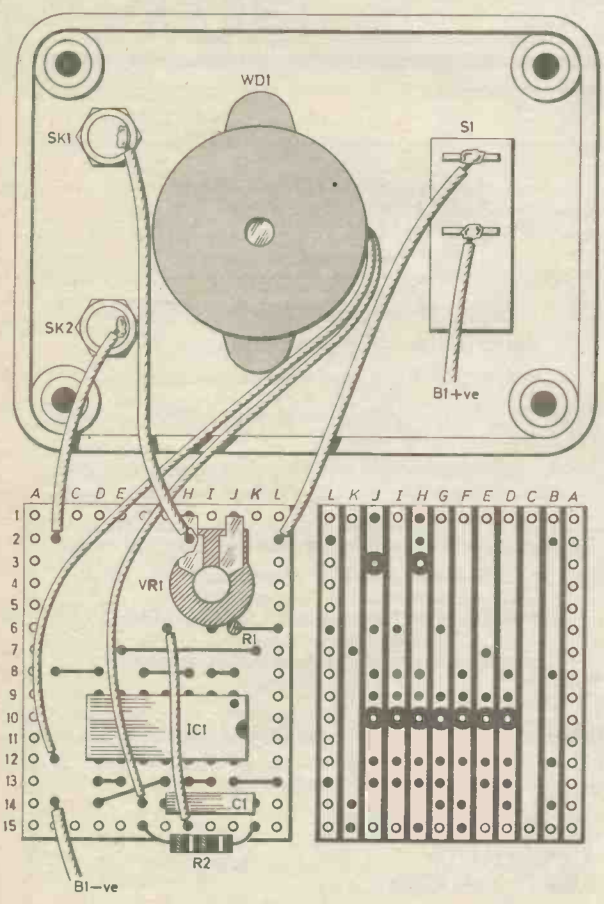


Fig. 2. Stripboard layout and inter-wiring diagram.

SEMICONDUCTOR TESTING

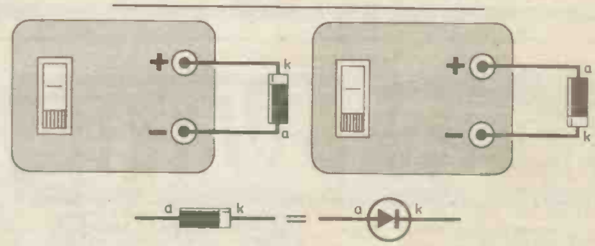


Fig. 3. Method of testing a diode with the Continuity Tester unit. If the cathode (k) is first connected to the positive (red) terminal as shown, the diode should not conduct. By reversing the diode across the terminals as shown in the right hand diagram, the tone should sound, indicating conduction. If the tone sounds for both tests or does not sound at all, then the diode is defective.

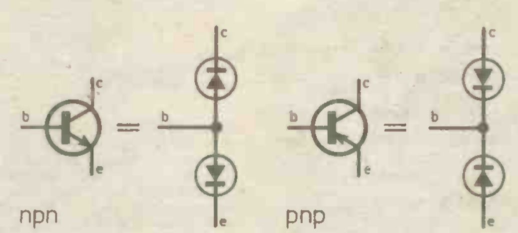


Fig. 4. When testing a transistor with the Continuity Tester, the device must be thought of in terms of the equivalent circuits shown. For example, an *npn* transistor is equivalent to two diodes, connected in series by their anodes (a), the base (b) being at this junction. Then by testing each "diode" in turn using the procedure given in Fig. 3, that is the base-collector junction and then the base-emitter junction, thus checking the function of the transistor. The *pnp* transistor is tested in a similar manner, remembering that the diodes in the equivalent circuit are reversed.

LOOK

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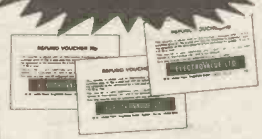

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SQUARE one FOR BEGINNERS

So what is this mysterious form of energy called electricity?

It's not mysterious at all, and the voltage and current of an electricity supply can be explained quite simply if we use the example of water flowing in a pipe, for instance in a basic central heating system.

In our central heating system, three points must be remembered. Firstly, if water is to flow in the pipes, they must be connected into a complete loop or "circuit". Secondly, the water must be pumped around the system to maintain the flow, and lastly, the same water must be moving round all the time; no water is added or removed.

VOLTAGE AND CURRENT

The voltage in an electric circuit can be thought of as the pressure at which the water is pumped around the system and the current is the amount of water actually flowing through it.

Note that if you were to cut the water pipe and block off the two exposed ends (in effect, break the circuit), no water could flow. Similarly, in an electric circuit, if the circuit is broken, no current would flow.

However, in the water system, the pump could still be operating at the same pressure even though no water is actually moving. Again, in our electric circuit, the voltage can still be present even if the current flow is interrupted.

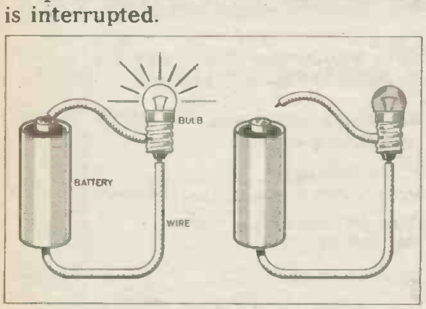

Fig. 1. Demonstration of current flow.

This is illustrated in a simple circuit consisting of a battery (a voltage source), a small light bulb (to indicate the flow of a current) and two wires to make the "circuit".

When these components are connected as shown in Fig. 1a, a current flows and lights the bulb. It is the battery that provides the voltage (or pressure) for this current to flow.

If one wire is now removed from the battery as shown in Fig. 1b, no current can flow and the bulb goes "out". However, the voltage is still present on the battery.

UNITS OF ELECTRICITY

The voltage (V) is measured in volts (V). As a voltage is a "pressure" or force, it is also referred to as an **electro-motive force** (e.m.f.).

To give an idea of various voltages, the cylindrical torch light battery (say an SP11) produces $1\frac{1}{2}$V, the PP3 transistor radio type battery can supply 9V and the mains voltage is 240V.

These high voltages are potentially **very dangerous** and must be treated with great care.

The current (I) flowing in a circuit is measured in **amperes** (A). The abbreviation for amperes is not *amps* as this could cause confusion with the abbreviation for an amplifier.

Again to give some idea of practical current values, a torch bulb may require as little as one twentieth of an ampere (0·05A), whereas a two bar electric fire uses as much as 12A!

RESISTANCE

Having established the basic concepts of voltage and current, we can look at another property affecting the electric circuit; that of **resistance** (R). Resistance in a circuit literally "resists" the flow of current through the circuit and if we return to the central heating system comparison, resistance can be thought of as the bore (the inside diameter) of the pipes.

So a small bore pipe restricts the flow of water, meaning it has a high resistance, and a large bore pipe permits a lot of water to flow as it has a low resistance. Similarly in the electric circuit, a high resistance limits the current flow and a low resistance allows more current to flow.

The unit of resistance is the **ohm** (given the greek symbol omega, Ω) and a **resistor** is a component that has a definite known value of resistance. It is the most widely-used type of component and is commonly available in resistance values ranging from one ohm to ten million ohms.

OHM'S LAW

The most important fundamental law governing all electric and electronic circuit theory is **Ohm's law.** This concerns the relationship between voltage, current and resistance in a circuit and states that the current flowing through a circuit is proportional to the voltage applied to that circuit and inversely proportional to the resistance in that circuit.

What this means in real terms is that voltage, current and resistance are governed by the formula:

voltage(V) = current(I) × resistance(R)

It also follows that:

$$I = V \div R \text{ and } R = V \div I$$

These three formulae derived from Ohm's law allow us to calculate an unknown quantity in a circuit if we know the other two quantities. For example, if a 10 ohm resistor is connected across a 12V car battery, the current through it can be calculated from $I = V/R$. Therefore $I = 12/10 = 1\cdot2$A.

A simple way to remember this relationship between V, I and R is to draw a triangle as shown in Fig. 2.

Then by covering the unknown quantity with a finger, the relationship between the other two quantities will be exposed in the triangle.

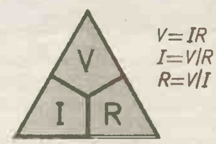

Fig. 2. Ohm's law triangle.

POWER

The **power** (P) developed in a circuit is the product of the voltage and the current and is measured in watts (W). So in our previous example, the power developed in the 10 ohm resistor is equal to 12V × 1·2A = 14·4W.

A similar triangle can be constructed to remember the relationship between P, V and I and this is shown in Fig. 3.

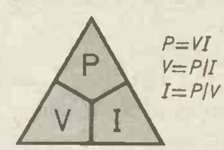

Fig. 3. Power equation triangle.

MULTIPLES AND SUB-MULTIPLES

When dealing with voltages, currents, wattages and resistances, sometimes the values are very large or very small numbers and to make these numbers a little easier to understand they are expressed as multiples and sub-multiples.

The following are the most commonly used:

micro (μ) = one millionth of ($\times 0\cdot000001$ or $\times 10^{-6}$)

milli (m) = one thousandth of ($\times 0\cdot001$ or 10^{-3})

kilo (k) = one thousand times ($\times 1{,}000$ or $\times 10^{3}$)

mega (M) = one million times ($\times 1{,}000{,}000$ or $\times 10^{6}$)

For example:

one microvolt (1μV) = 0·000001V
four milliamperes (4mA) = 0·004A
six kilowatts (6kW) = 6,000W
two megohms (2MΩ) = 2,000,000Ω

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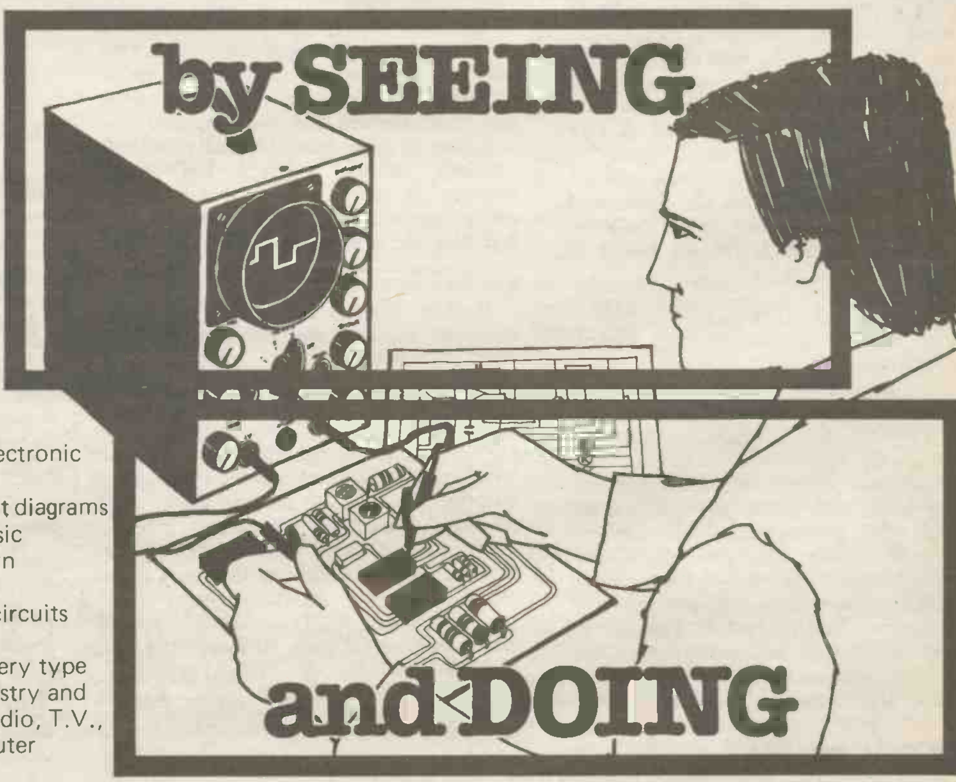

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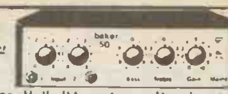

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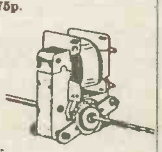

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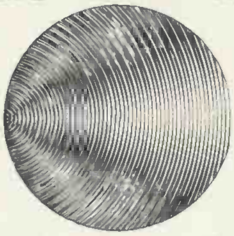

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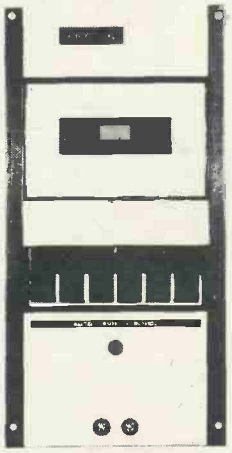

6 piano type keys

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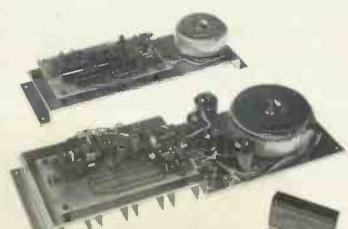

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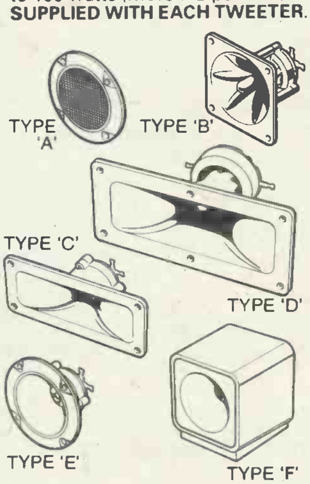

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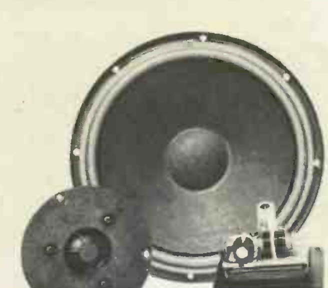

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**Projects for book 4 were in an advanced state at the time of writing, but contents may change prior to publication (due 14th Aug 1982).*

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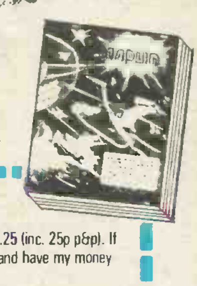

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