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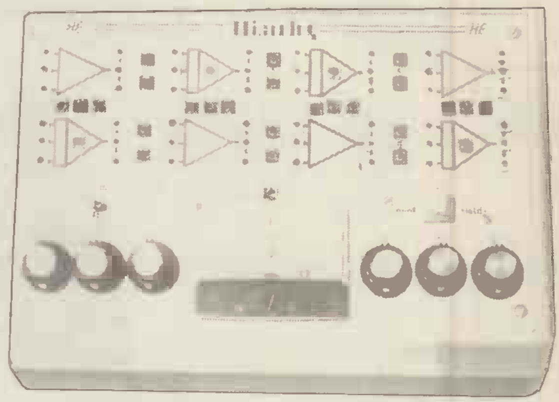

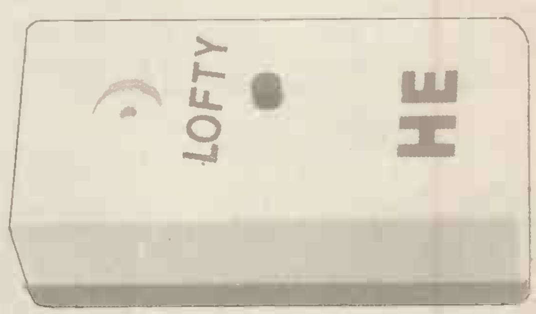

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MONITOR

Directory Update

The response to our *Directory Of Electronic Component and Hardware Suppliers* has been tremendous, from both readers and the suppliers themselves. The reaction has been particularly strong from those suppliers who, for one reason or another, were either not included in our listings — or those whose address/telephone number got scrambled.

Naturally, they will all be listed (correctly) in our next Directory, here are some more companies operating on the supply side of our hobby . . .

A.P.T. Radar Systems Limited, Cybervox Language Laboratory Division,
Unit B, Sprint Industrial Estate, Chertsey Road, Byfleet, Surrey KT14 7LA. Tel. 09323 41331.
Specialists in the manufacture of tape recorders and related components together with headsets and spares.

Candis Electronics Ltd.
Highdown Works, Highdown Avenue, Worthing, West Sussex BN13 1PU. Tel. 0903 690750.
Specialists in temperature sensing components of all kinds.

Electronic Hobbies Ltd.,
17 Roxwell Road, Chelmsford, Essex CM1 2LY.
The correct telephone number is 0245 62149.

Garland Bros. Ltd.,
Chesham House, Deptford Broadway, London SE8 4QN. Tel. 01 692 4412.
"We are an established retail firm (20 years) dealing in electronic components, audio equipment, in-car entertainment, and we also do a very large range of CB equipment. A repair service for audio and CB is also available".

Garland Bros. carry all the lines mentioned in the charts, but do not operate a mail order service.

Roadrunner Electronic Products,
116 Blackdown Rural Industries, Haste Hill, Haslemere, Surrey GU27 3AY. Tel. 0428 53850.
"Developed and manufactured in Hazlemere, our most well-known product is the Roadrunner prototype wiring system. This British product is already used extensively in industry and educational establishments, and is also ideal for the 'home engineer'.

Our hardware products range from packs of terminal pins to 19" subracks. We also handle computer and word-processing products, from typewriter ribbons through to microcomputer systems.

With a combination of the right product, a competitive pricing structure and excellent service, we make customer satisfaction our priority".

Roadrunner are moving to new, larger premises in Haslemere, with the intention of improving overall service to the professional and hobby markets. Orders using Access or Barclaycard are welcomed, either by phone or letter. There is no minimum order level, although a 50p handling charge is made on orders under £5. Carriage and packing charges are 5% of the total order before VAT is added.

TK Electronics,
11 Boston Road, London W7 3SJ.
The middle two numbers of TK's "easy to remember" telephone number were inadvertently transposed, rendering it 'not so easy'. The number should be, of course, 5-6-7-8-9-10.

The Vintage Wireless Company,
64 Broad Street, Staple Hill, Bristol BS16 5NL. Tel. 0272 565472.
"We are major stockists of obsolete electronic components, especially valves, and operate on a mail order business as well as personal calls to our premises. We try and offer a personal service, and also have a huge library of service data".

The range of services offered include:
Sale of radio and television receivers, 1914 to 1954.
Sale of spare parts for the above.
Sale of radio, television and industrial valves.
Sale of service data, technical information, sales data, historical and other items of interest in vintage radio and TV.
Restoration and overhaul (but not basic repairs of vintage equipment) of valve domestic and automobile radio of all types.
Sale of new and used books on the subject, plus second hand magazines, often dating back to the First World War!
Hire of radios and related props for theatrical purposes.
Sale of restored radios, with guarantee.
Sale of restored vintage car radios.

The full range of stock and vintage radio news can be found in The Antique Wireless Newsheet, published by the company from the above address — contact them directly for subscription rates.

Credit card sales are offered via Access and Barclaycard, and credit card orders are accepted by 'phone.

Flash Point Alarm

As if by magic, we have had replies to our request for suppliers of the difficult bits for this project.

First, the ICL7611 CMOS IC is readily available from **Rapid Electronics**, Hill Farm Industrial Estate, Boxted, Colchester, Essex CO4 5RD. The telephone number is 0206 36412.

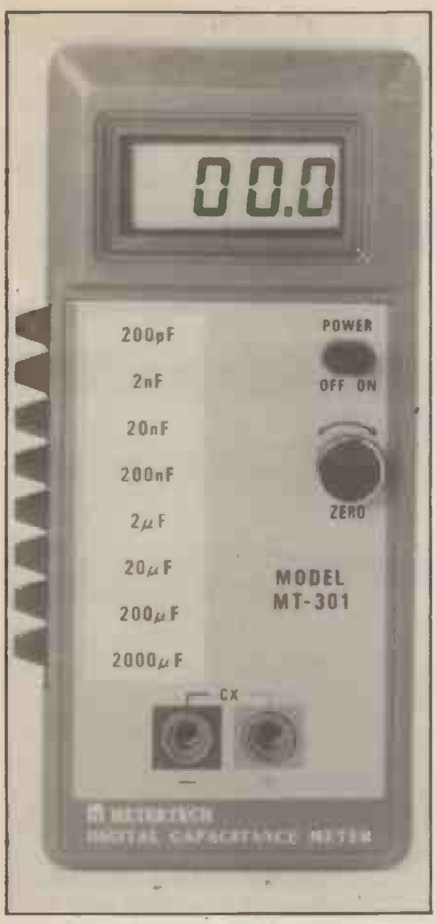
The other tricky item was the thermocouple, without which the project had very little point; the exact thermocouple required is stocked in vast lengths by **Candis Electronics Ltd.**, Highdown Works, Highdown Avenue, Worthing, West Sussex BN13 1PU. Tel. 0903 690750. Candis are specialists in the design and manufacture of temperature sensing equipment, and they carry a large stock of all kinds of thermal devices.

Add-Ons For The ZX Computers

Thurnall Electronics have produced a range of accessories for Sinclair's ZX 80 and 81 computers, with an adaptor system to fit the ZX Spectrum.

The range is based on a 16-line I/O port, and the modular system allows different add-ons to be used simultaneously via an inexpensive motherboard.

Thurnall recommend their system as ". . . an ideal way of learning about inputting and outputting information . . ." from the computers. An analogue-to-digital converter and an RS232 interface are also promised. For details contact **Thurnall Electronics**, 95 Liverpool Rd., Cadishead, Manchester M30 5BG. A catalogue is available — but send an SAE with your enquiry.



A Little Luxury

More advance builders, especially of radio equipment, may find **Centemp Instrument's** hand-held digital capacitance meter useful, provided they can spare £69. The little MT-301 is small and robust and designed to travel. It comes complete with battery, alligator test clips, spare fuse and instructions — all ready to go. A bold ½-inch, 3½ digit liquid crystal reads out from 0p1 to 200u across eight separate ranges; the controls are all push buttons for easy one-hand operation.

This is a slightly unusual piece of equipment, so anybody who feels the need of a digital capacitance meter could do worse than to start enquiring here. Incidentally, for the really rough rider, there's an optional "deluxe protective case" (fur-lined??) for an extra £6.00. Details from **Centemp Instrument Co.**, 62 Curtis Rd., Hounslow, Middx. Tel. (01) 894 2723.

Hiding His Lights

Our apologies to **Dr. D.L.H. Blomfield**, who designed the *Three-Aspect Signal Lights Controller* project which appeared in our September '82 issue.

Dr. Blomfield has certainly earned our collective congratulations for his exceptional design, which has attracted high praise from several model rail enthusiasts.

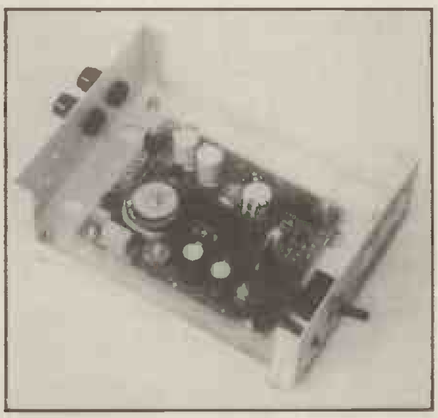
We generally credit our designers — where would we be without them — but due to an oversight in this case, Dr. Blomfield's name was omitted from the article.

Full Protection, But No Racket

Radio buffs going mobile should take a look at a low-noise 24 to 12 volt switched-mode voltage converter gives an output of 13.6V (, 0.2V) at 6A continuous current, has a low noise rating of 2 mV RMS below 1 MHz and 1 mV RMS above 1 MHZ, and is fully protected and operable up to 50°C.

The 6A version is priced at £39.95 and is supplied with M4 bolts for bulkhead mounting if required. The unit is also available in a 10A version. For further information contact **Davtrend Ltd.**, 89 Kimbolton Rd., Portsmouth, Hants PO3 6DA.

And we'd better add that the unit is sold in a proper case, and not open to the air as our picture shows it!



Little Boxes

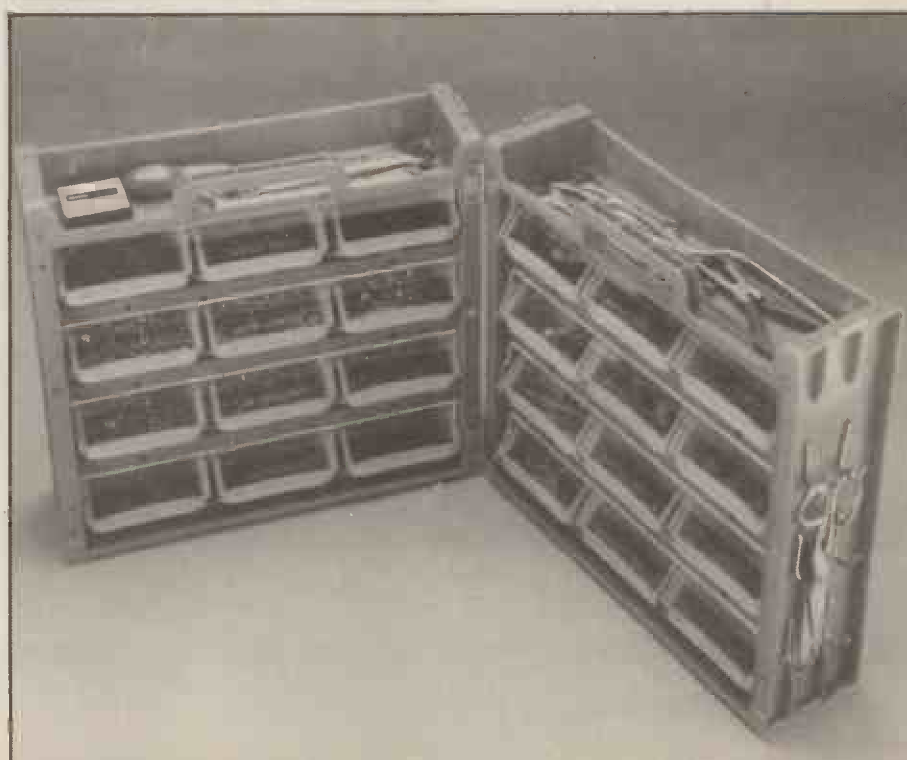
Things for putting other things in may not provide the total answer to how to run an orderly workshop, but they certainly do help, so **SSI Fix Equipment** have come up with a new system of component storage modules known as **Portafix 6**.

Each Portafix unit (sounds like something out of Asterix the Gaul, doesn't it?) has 12 bin-shaped drawers, each 2 x 4 x 3" deep. The overall size is 14 x 14 x 4", with a tray area on top, integral carrying handle and (an unusual feature) optional hooks, for carrying tools, at either end of the unit.

The whole thing seems to be designed for absolute minimum spillability and, for travelling, this principle can be taken even further — any two units can be hinged together face to face and securely locked shut — no more drawers sliding out every time the car tilts! Each little bin has a transparent dust-cover which opens upwards and the modules themselves can be stacked.

A very handy bit of storage equipment for any kind of craft which uses small components, from cake-decorating to woodworking to . . . well, electronics. At £7.40 for a single unit and £14.80 for a double (hinged) unit, this could knock a few of your Christmas present problems on the head!

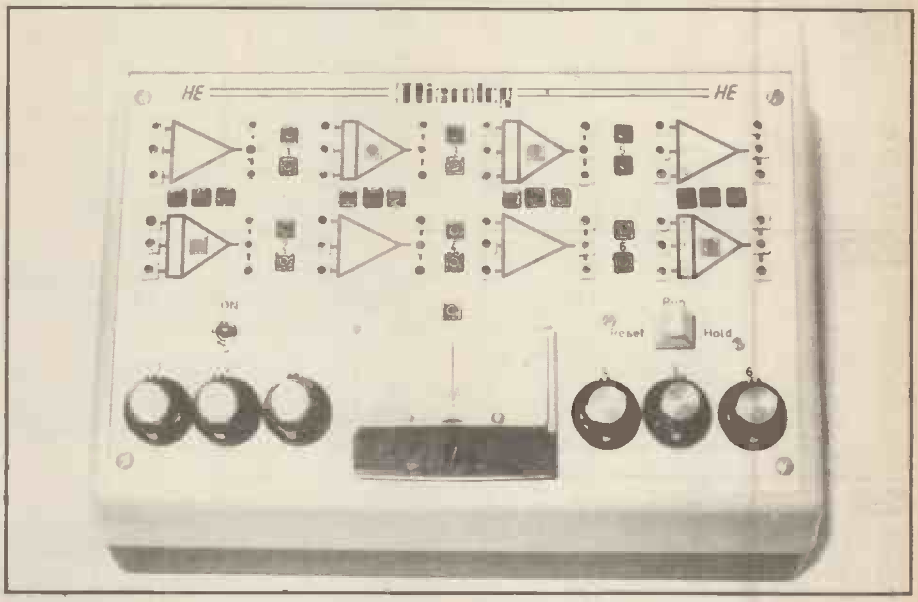
At the moment Portafix 6 is only available from **SSI Fix Equipment Ltd.**, Kingsclere Rd., Basingstoke, Hants RG21 2UJ, and prices don't include postage and packing, so you will have to enquire about that: telephone 0256 26511.



HE Microlog

The return of the Analog Computer.

K. Manison



WITHOUT DOUBT we are living in a rapidly expanding digital world; *everything* is going digital. Clocks and watches, once precise mechanical instruments with analogue dials, now consist of tiny electronic circuits displaying the time in digits accurate to a tenth of a second. The acceptance of digital technology can be seen in the rapid increase in the availability of women's digital watches; it is no longer a symbol of male technology!

Digits are also appearing in other areas, long the exclusive domain of analogue indicators, but display methods are not the only field to fall to digital techniques. Our telephone conversations are digitised and transmitted as serial bit streams and who, today, hasn't heard of digital hi-fi? And with the recent release of video disc systems, digital video has finally arrived.

One of the reasons for the digital revolution, of course, is cost. With the rapid advances of digital integrated circuits — and that superstar the microprocessor — it has become much cheaper to produce a silicon circuit with an LED or LCD display, than to make a complicated mechanical indicator.

In many cases, the increased accuracy and resolution is definitely required and digital systems may be used to excellent effect. In other cases, however, the older analogue systems have many advantages, and that is true also of the analogue computer.

The Analogue Computer

Remarkable though it may seem, the analogue computer, which need not have a single TTL or CMOS logic chip in the whole of its circuit, manges to perform calculations that many digital machines would find difficult. Analogue computers have been around for decades in one form or another. In fact, many of us have used a slide rule without even being aware that it is an analogue computer.

Whereas a digital computer performs its calculations directly, using numbers, an analogue computer will use some physical parameter to represent the values it is to manipulate. The slide rule, for example, uses length; the length is considered to represent the log of a number so that adding two lengths together is *analogous* to adding logarithms which, of course, is a method of performing multiplication.

Until the cheap digital calculator became available, the slide rule was dexterously manipulated by generations of engineers and scientists, and it has in no way hindered the advance of technology! In fact, entering experimental results accurate to two decimal places into a calculator and getting out a result with eight places of decimals can be meaningless. If the data is limited to two place accuracy so is the result, and we have to round off the answer anyway. The slide rule, being accurate to two places, can in many cases produce answers that are just as valid as a calculator, and it is not much slower either!
To further illustrate the difference between analogue and digital computation, let us look at a common problem. When changing a note for coins, the bank teller can count the money in one of two ways. The most obvious way is to empty a heap of 10ps on to the table and count the required number. For small sums this is adequate, accurate and, for the experienced teller, remarkably fast. However, if a large sum has to be changed, the digital computing method becomes too slow and also increases the chance of error. So, the teller will weigh the coins and, the weight of a single 10p piece being known, the scale can be graduated in pounds and pence. This is an analogue method in which weight is the analogue of value. In this case, the analogue method will be faster than physically counting each coin and, with an accurate scale, just as precise.

It is obvious that different applications are better suited to either digital or to analogue computation. For example, analogue computers have long been used for solving differential equations of the type frequently encountered in control theory and servo systems. While these equations can be solved by digital means, it is a time consuming process and often expensive as well. However, an electronic analogue of the system can be constructed on an analogue computer, the stimulus then fed in and the output viewed in real time on an oscilloscope or chart recorder. Variables of the system can be changed independantly and the process run again and again.

It is the speed of computation, and the graphical output, that give the analogue computer the edge on this type of problem. So now let's look into an analogue computer and see what it consists of and how it can be used. For those that are interested in experimenting with these machine, the Microlog is a simple and cheap analogue computer that can be used to try out some of these concepts.

Analogue Computing

An analogue computer performs the functions of summation (adding), multiplication, integration and differentiation. While a digital computer can perform all these functions, it can only do them one at a time. So, even though it works very fast it has to perform a series of calculations. Particularly where integration is concerned, many simple calculations have to be made to solve one integral, and, if the step size is kept small to increase accuracy or resolution, then more calculations are required and the time taken is increased.

Say, for example, the solution to the problem $X = Y + (V + U)/2$ is required. A digital computer would tackle the problem like this: first, V and U would be added together and stored as a variable; second, that variable would be divided by 2; last, it would be added to Y to give the required answer. A program, written in BASIC, to handle the problem may look like this:

```
10   INPUT U
20   INPUT V
30   LET X = ( U + V ) / 2
40   INPUT Y
50   LET X = X + Y
60   PRINT X
70   END
```

For a simple problem like this these steps take very little time, but if a large complicated formula were being calculated you can see that this sequential type of process may take a very long time indeed.

The analogue computer, however, uses separate modules to simultaneously perform each function required in the calculation, and the manner in which the modules are interconnected determines the formula being calculated. If two additions have to be performed then two summers will be used, one for each.

For the problem $X = Y + (V + U)/2$, an electronic analogue computer would have modules connected together as shown in **Figure 1**. The triangle symbols are summers and produce the algebraic sum of the input voltages. The circle symbol is a coefficient multiplier, used to divide the sum of V + U by 2 (multiplication by 0.5). You can see that as soon as the input voltages corresponding to Y,V and U are presented to the modules, X will be instantly available. Notice that the analogue computer is effectively performing all of its calculations in parallel, not one after the other. It is also performing an 'on-line' calculation in that the output X will continually follow the inputs. A digital machine would have to prompt for updated values, or interrogate I/O ports for them. This is what gives the analogue computer a speed advantage, in many cases. To find out how an analogue computer works, let us examine each of the building blocks; then we will determine how to put them together!

Computing Units

An analogue computer uses voltage and time to represent numeric values. For example, a voltage rising from 0 volts to 3 volts over a period of a minute could be used to represent the filling of a 300 gallon tank in the same time. In this case, 1 volt represents 100 gallons, and its variation with time shows the changing level in the tank. So, a plot of voltage against time will show the physical movement of the system we are simulating with the analogue computer. The analogue computer, therefor, needs devices that will sum, integrate and multiply electronic voltages. If we think of these devices as circuit elements, then we can connect them together as a circuit to produce the function we require.

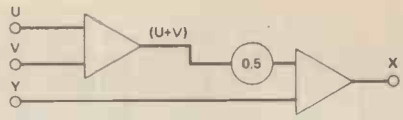


Figure 1. The analogue solution to the equation.

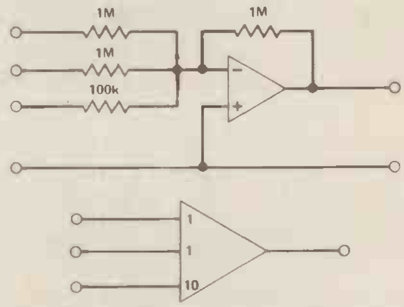


Figure 2(a). An analogue summing circuit (above); 2(b) the graphic symbol used for a summer (below).

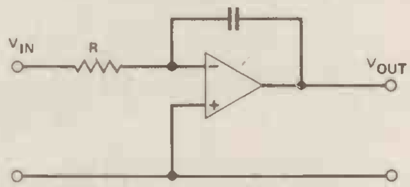


Figure 3. The circuit of an op-amp integrator.

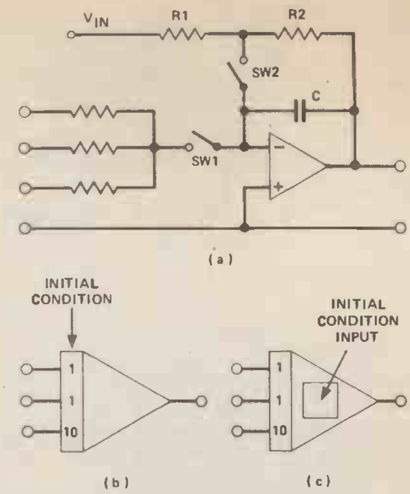


Figure 4. Above (a), the integrator circuit modified for initial condition input; (b) the usual graphic symbol; (c) the representation used on Microlog's panel.

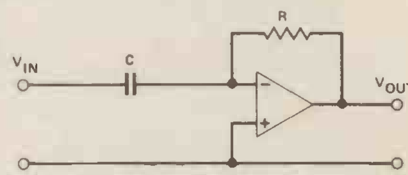


Figure 5. An op-amp differentiator.

Summers

If our computer is to use voltages to represent physical values then we need an electronic device to add two voltages together; it must produce a voltage which is the algebraic sum of two or more instantaneous voltages.

The simplest method is to use an op-amp; if we add several inputs through resistors, we get an output proportional to the sum of the input voltages. A typical circuit is shown in **Figure 2a**. The summer circuit module is usually shown by the symbol of **Figure 2b**. The gains, normally 1 and 10, are shown for each input.

Integrators

We stated at the beginning that analogue computers are used to produce solutions to differential equations, and this means that integration and differentiation are involved. Integration is essentially the sum of all the instantaneous values of a function. Normally it is performed between definite limits, say between the times $t = 0$ and $t = 100$. Some initial condition must also be specified if the integration is to be valid. For example, when integrating a voltage signal V, the starting condition may be $V = 2$ when $t = 0$. Therefore, the integrator must also have an '''initial condition'' input.

We can use an op-amp to integrate a voltage; consider the circuit shown in **Figure 3**. The output is given as:

$$Vo = -\frac{1}{RC}\int Vi\,dt$$

Of course, we can integrate multiple inputs in exactly the same waythat we summed several inputs, and it should also be clear that by changing the input resistors the integrator gains, expressed as 1/CR, can be independently set for each input.

Now to set the initial conditions: we must be able to set the output (by setting the charge on the capacitor) to a desired value. In effect, the circuit must behave as a summer up to time $t = 0$, but operate as an integrator after that time. We achieve this by means of two switches, as shown in the circuit **Figure 4a**.

If switch SW2 is closed, you can see that you have a summer with only one input, VI x R1/R2. The capacitor will also have this voltage across it and will be charged to the desired initial condition.

If switch SW2 is opened and SW1 closed, we have an integrator with three inputs. When both switches are open, the circuit acts as a 'hold' circuit — the output will remain at whatever the voltage was when SW2 was opened. This is dependent, of course, on the capacitor remaining charged, but as the input impedance of the op-amp is very high, it can hold the voltage for an appreciable time.

In a large analogue computer, these switches are replaced by relays, which allows the machine to be switched from Reset to Compute repeatedly, and the response can be displayed on an oscilloscope. This mode of operation is called Rep-Op, short for Repetitive Operation.

Differentiators

We learn at school that integration is the opposite procedure to differentiation, so that the opposite

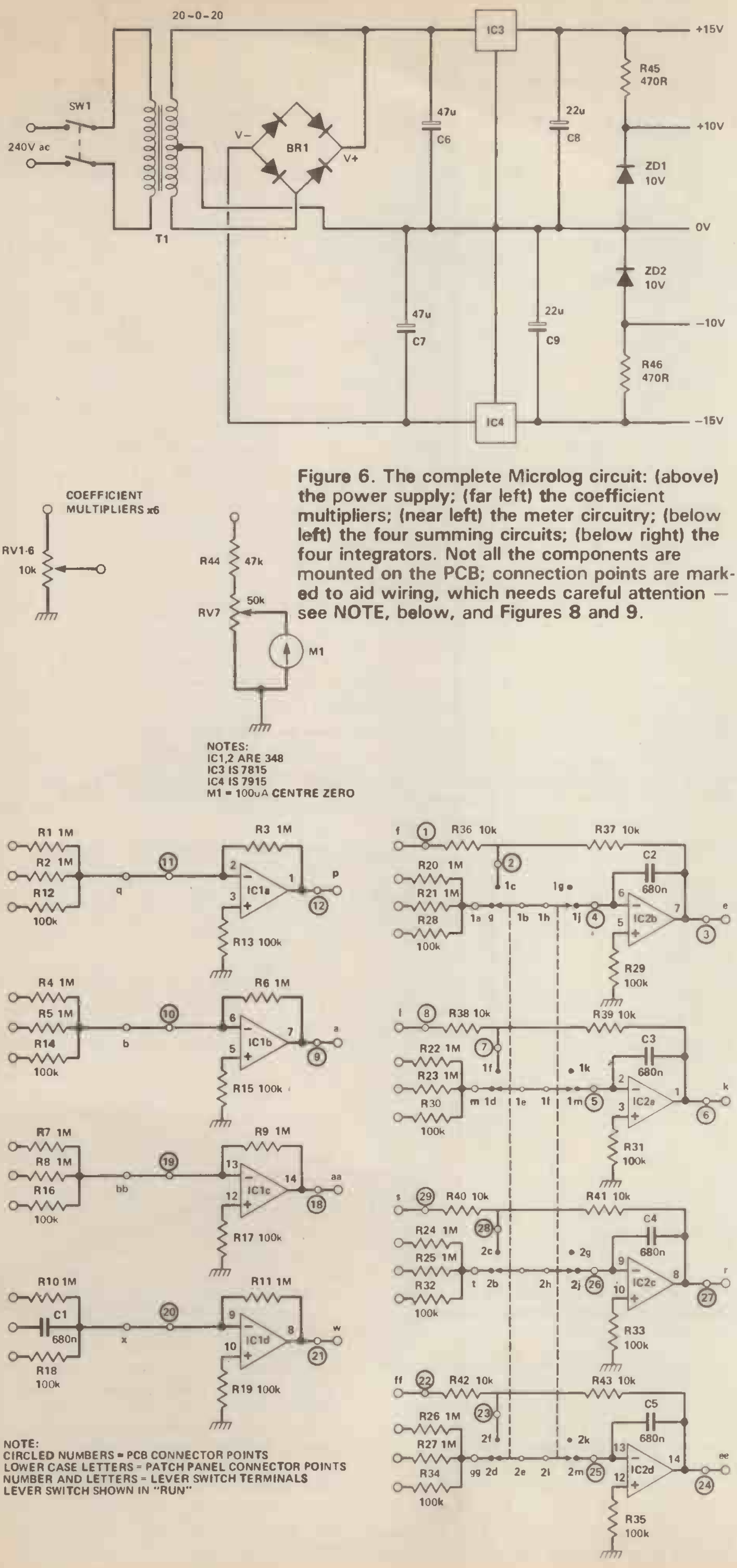


Figure 6. The complete Microlog circuit: (above) the power supply; (far left) the coefficient multipliers; (near left) the meter circuitry; (below left) the four summing circuits; (below right) the four integrators. Not all the components are mounted on the PCB; connection points are marked to aid wiring, which needs careful attention — see NOTE, below, and Figures 8 and 9.

configuration, in the op-amp circuit, will produce a differentiator. The circuit in **Figure 5** produces the differential of the input voltage, and once again we can have several inputs with independent gains.

Coefficient Multipliers

So far we have shown our summers, integrators and differentiators with fixed gains of, eg., 1, 10, or 100. We could, of course, set them to any value required — 2.375 for example — but we lose flexibility if the gains are set to such 'strange' values, as they will only be useful for a calculation that needs that particular number! However, if we have a device that will divide a voltage by 1/.2375 (ie. *multiply* by the coefficient, 0.2357) and then follow that by a summer with a gain of 10, we have achieved our required gain of 2.375. So we need a voltage, or potential, divider — which is nothing else but a potentiometer!

For analogue computers, the potentiometers have to be precise and stable. Also, there must be some means of setting them to the required value. The way this is achieved is to connect them across an accurate, known voltage and measure the output while adjusting the pot until the desired coefficient is reached. In large machines, this may be done automatically by small servo motors connected to the wiper mechanism. For small machines, such as the one described in this article, the pot has to be set manually. In the example above, the potentiometer could be connected across 10 volts and adjusted until the output at the wiper measured exactly 2.375 volts.

The HE Microlog

Microlog stands for Micro-Analogue Computer (we can't have digital machines claiming sole rights to the term 'Micro'!). It has been designed as a conceptual trainer to give you a feel for analogue computing and, therefore, accuracy has been traded for low cost and simplicity.

Microlog's patch panel shown in **Figure 7** and from it you can see that it has four integrators, four summers and six pots (coefficient multipliers). The Initialise-Integrate-Hold selection is performed by the keyswitch labelled Reset-Run-Hold; no rep-op mode is available as that would entail the use of relays, increasing the cost. The complete circuit is built on one PCB and fits in a type 104 Verobox, with 2 mm plugs used for the patch connectors. The most expensive item in the Microlog is the meter!

To keep everything simple, single chip voltage regulators are used for the 15 V power supplies and the reference supplies are simple zener diode regulators. Two 348 quad op-amps are used, one chip providing the four integrators and the other the four summers. One of the summers has a capacitor on one input to provide a differentiator function. The complete circuitry is shown in **Figure 6**.

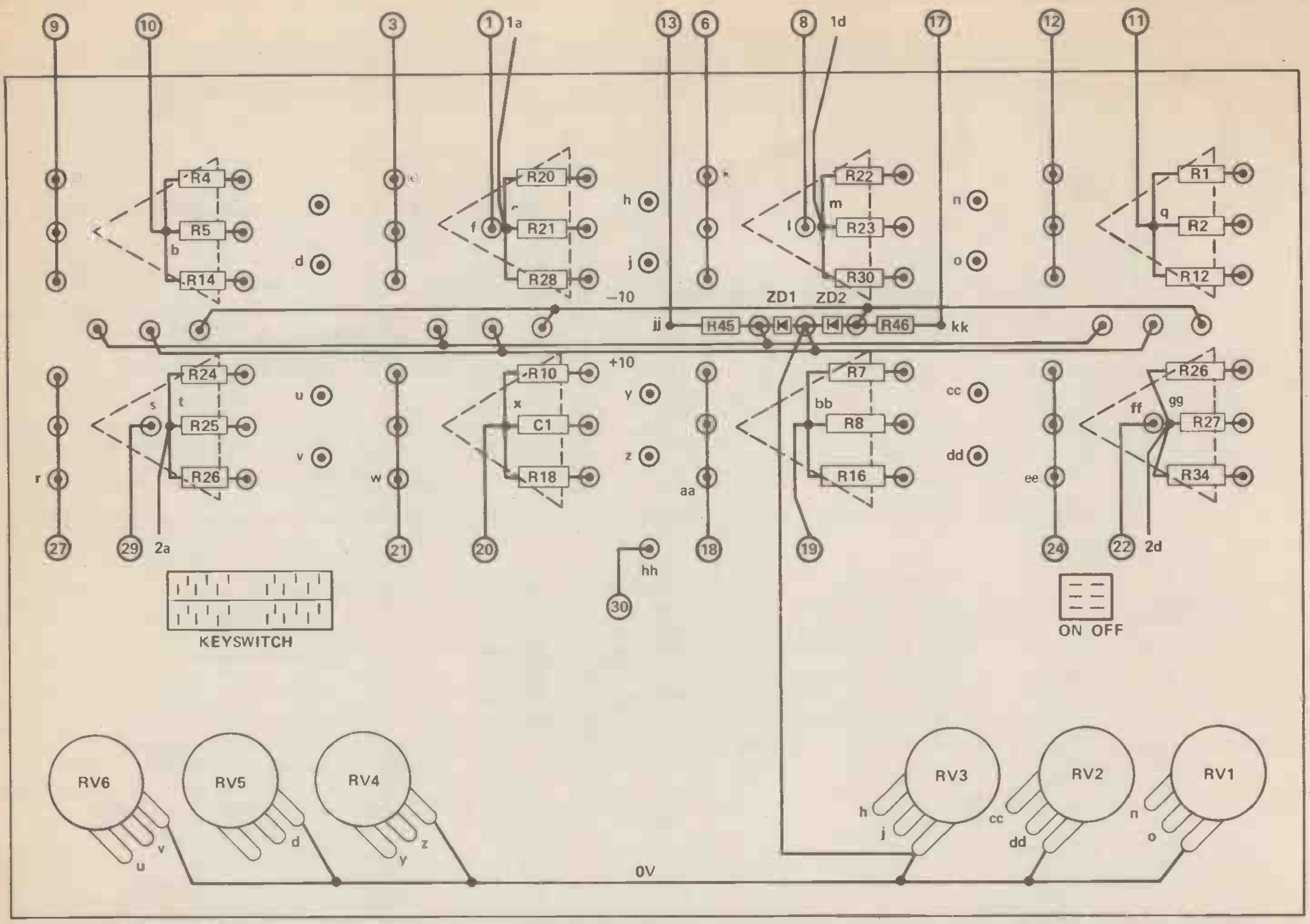


Figure 8. The front panel wiring diagram, showing the mounting positions of the components and the wiring points (eg, point 'f' goes to PCB point '1'; point 'g' goes to the leverswitch terminal '1a'). The switch terminal connections are shown in Figure 9.

The Patch Panel

Having designed the various computing elements that go to make up an analogue computer, we now require a method to interconnect them in order to solve problems. This is usually done by means of a patch panel. The inputs and outputs of each computing unit are brought out to sockets and jumper wires may then be used to connect the desired units to simulate a system or solve an equation.

Construction

The first thing is to drill the front panel of the Verobox for the 2mm sockets, pots, switches and the meter. Then, using Letraset or similar rub-down lettering, mark out the patch panel and spray with a clear polyurethane lacquer so that the markings will not rub off after a little use. The full-sized patch panel is reproduced on page xx for use as a template in this operation.

Next, mount all the sockets and pots. When tightening the nuts on the 2 mm sockets, take care not to overdo it or you may strip the thread. Using the wiring diagram, **Figure 8**, as a guide, connect up the pots to their respective sockets. Again, be very careful when soldering to the 2 mm sockets, as the plastic body melts very easily!

The next step is to mount the input resistors on the correct sockets for the summers and integrators (mounting them here, instead of on the PCB, reduces the amount of wiring from the patch panel to the PCB). Use the circuit diagram and the wiring diagram to determine the correct place for each resistor. Then mount the 10 volt Zener diodes, ensuring that you have put them in the right way round, and the 470R resistors.

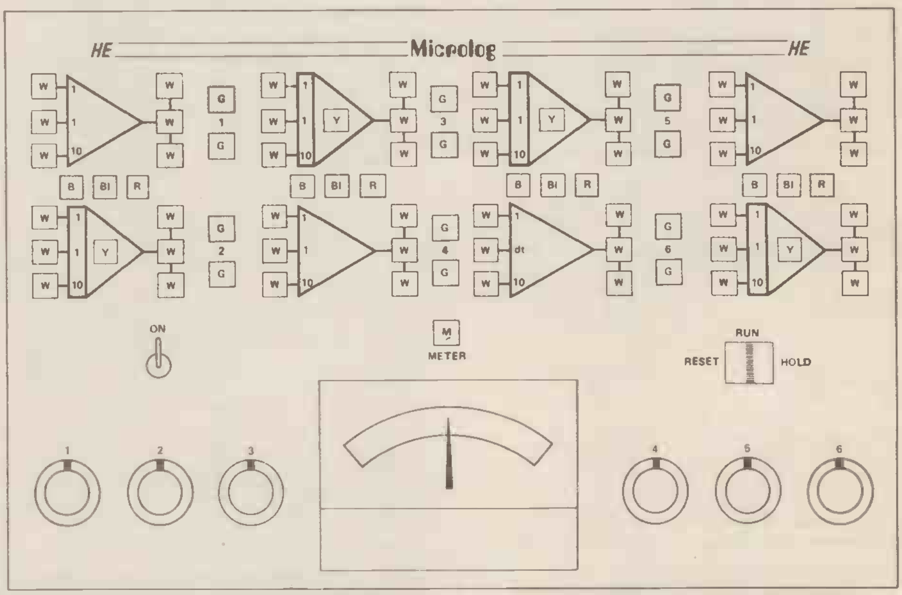


Figure 7. The front panel of Microlog.

□ 2mm SOCKETS
B BLUE = –10V
Bl BLACK = 0V
R RED = +10V
G GREEN = POTENTIOMETERS
Y YELLOW = INITIAL CONDITION INPUTS
W WHITE = OP-AMP INPUTS AND OUTPUTS
M = METER INPUT (BLUE)

The final front panel wiring is that from the keyswitch to the sockets. Take *special* care that this wiring is correct, as it is easy to get confused with the connections on the keyswitch. Use the circuit diagram and **Figure 9** and double check it when you've finished. It is easier to change incorrect wires then, than at a later stage in the

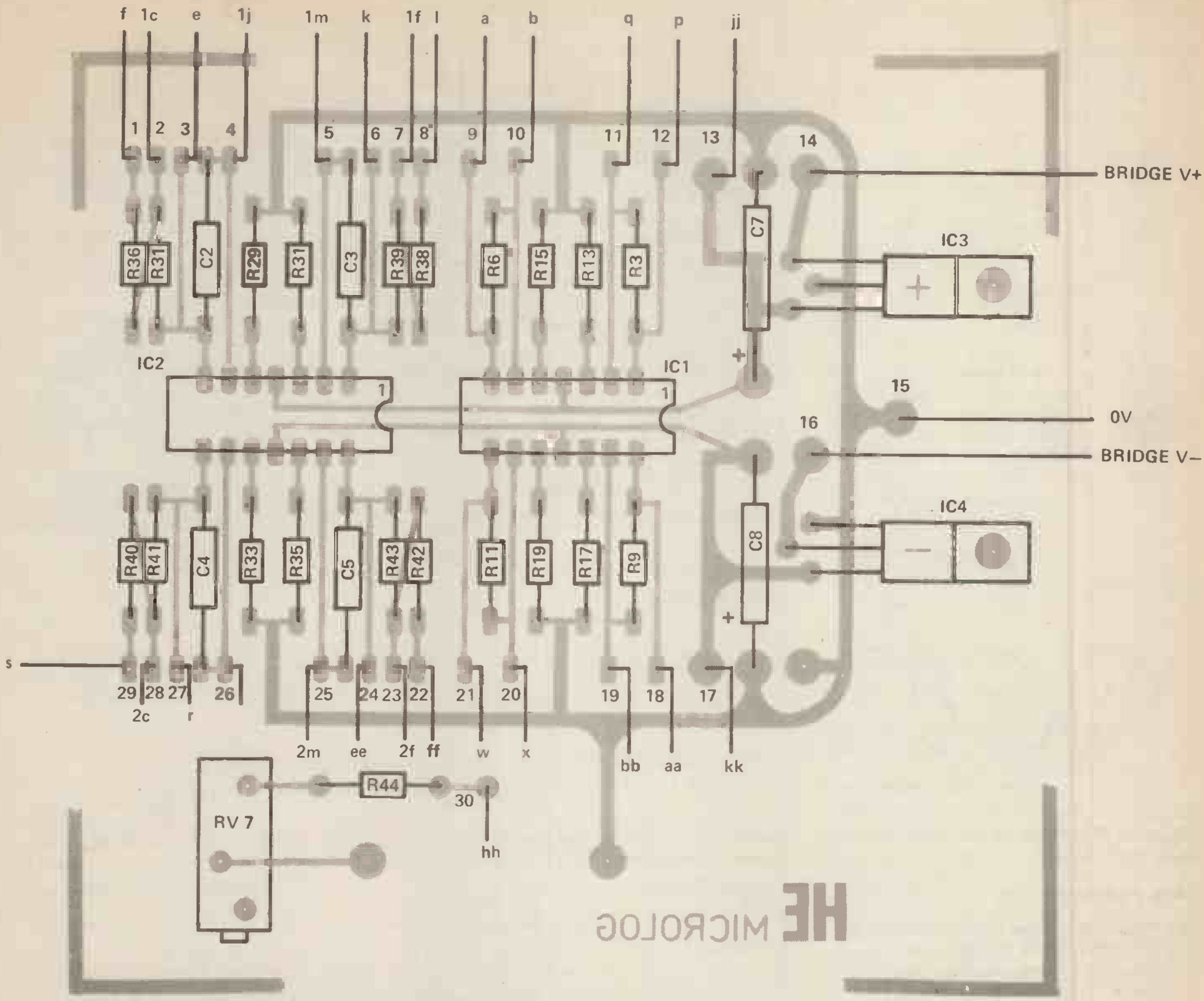
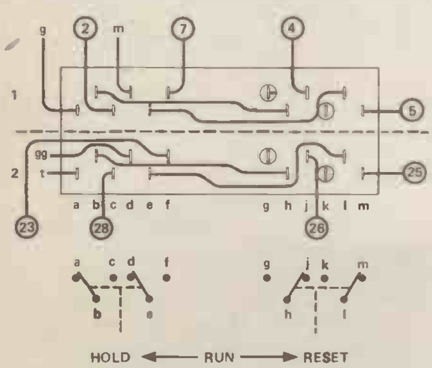


Figure 10. The PCB component overlay diagram; note the connection points.



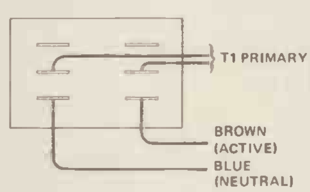


Figure 9. The leverswitch (Keyswitch) wiring connections (left) and the on/off switch connections (above). Note that flipping from RUN to HOLD connects 'h' to 'g' etc, and in RESET, 'b' is switched to 'c' and 'e' to 'd'.

construction.

Before the panel can be put back on the Verobox, you will have to remove the central plastic strip that crosses the panel aperture. Don't worry — it doesn't weaken the box in any way. Some time before the testing stage, too, you will have to make up about 20 patch leads with 2 mm plugs on each end; it is best to make assorted lengths, say 3,6 and 9 inches long.

Now you can start to mount the components on the PCB, using the Parts List and component layout **Figure 10** to locate each part. First check the tracks, to ensure there are no breaks or bridges, and then install the IC sockets and solder them in. Do not plug in the op-amps until the check-out procedure, later. Next, install the resistors on the board and once they are soldered, mount the capacitors. Ensure that the orientation of the electrolytic capacitors is correct; the layout diagram shows the way. Finally, install the two voltage regulator ICs; these are mounted with the metal face against the PCB and held in position with a small screw lockwasher and nut, and be sure the regulators are in the right places. One is a positive voltage regulator and the other negative and if you accidentally swap them around, they won't last a second when you switch on! Bend the leads down into their respective holes and solder them in. Go over the board, then, checking for any solder bridges or dry joints, touching up where necessary.

Once the board is complete you can start wiring from the patch panel to the PCB connection points, using the wiring diagrams, **Figures 8** and **9**. This is where great care must be taken, as it is all too easy to get wires crossed. Give yourself enough length on the wires to be able to route them neatly, and to allow the panel or top of the box to be taken off without pulling the wires!

The wiring from the PCB to the keyswitch can be done next, again taking care that the correct connections are made. The PCB is then mounted to the panel, using the screw terminals of the panel meter, which also provides the electrical connections to the meter.

The last part of the construction is the power supply unit (PSU). This is extremely simple, consisting of the small transformer, a bridge rectifier and two capacitors. They can all be mounted on the transformer as shown in the internal photograph. The final stage is the wiring from the PSU to the PCB, and to the ON/OFF switch. After that, you are ready for testing.

Testing

First make sure you have NOT inserted the ICs and that the ON/OFF switch is OFF. Plug Microlog into the mains, switch on and inhale strongly. No burning smell? So far so good! With a multimeter, check that you get plus and minus 15 volts at the correct pins of the IC sockets, and plus and minus 10 volts at the correct pins of the IC sockets, and plus and minus 10 volts at the patch panel red and blue sockets, respectively. None of these voltages are critical, and the 10 volt supplies may be a little out due to the tolerance of the Zener diodes. If any of these supplies are not present check the AC voltage out of the transformer. If this is present and you are getting good unregulated DC from the diodes, then check the IC regulators. Hope you didn't swap them!

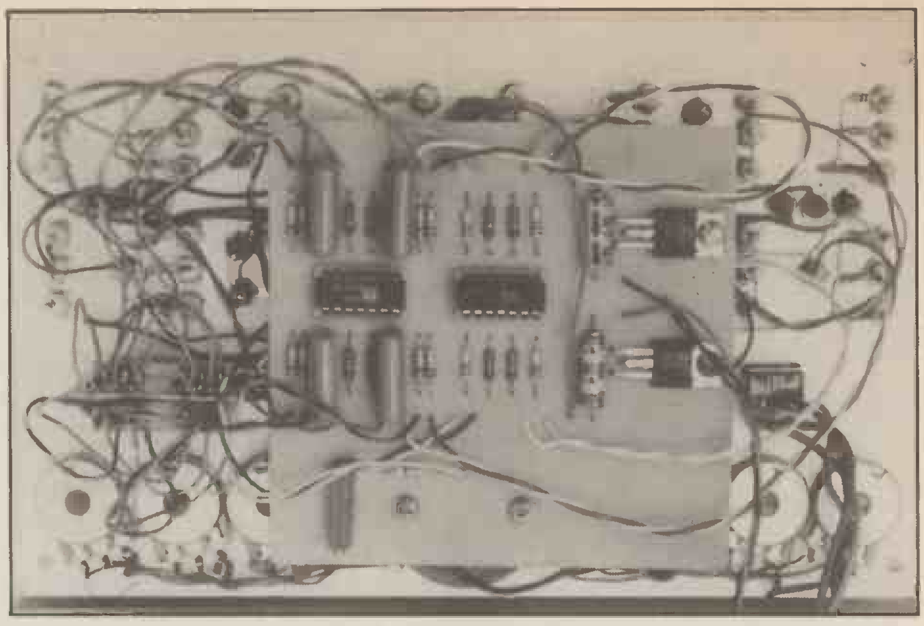
When all is well, patch from any red socket into the meter socket and adjust the trimpot on the PCB for a positive full scale deflection. This sets the meter to whatever voltage you get from the Zeners, and so eliminates the need for an absolute 10 volt reference. For completeness, you can then patch into a blue socket and see that you get negative full scale deflection.

Switch off, then, and plug in the op-amp (ICI) that is used for the summer circuits. Patch up the circuit shown in **Figure 11**, set RV1 fully anticlockwise and switch on. You should see an increasing negative meter deflection as you rotate the pot clockwise, showing that the op-amp is inverting correctly. A mid-range setting on the pot should give a −5 reading on the meter. Now patch into the x10 input; the same thing should happen, except that you can only move the pot about a tenth of its travel before you get a full-scale reading. Test the other summers in the same way.

Now for the integrators. Switch off and plug in the second op-amp, IC2. Patch up the circuit shown in **Figure 12**, and make sure the keyswitch is set to Reset.
Switch on and check that operating RV1 gives you a varying output on the meter; it should, in fact, behave just like the summers. Re-turn the pot to zero and switch to Run. If RV2 is also at zero, nothing should happen but if you turn RV2 up a little, the voltage output will slowly move towards negative full scale. Turn RV2 to zero and the ramp will stop. Now patch the input of RV2 into the negative reference (blue socket) and repeat the test; the voltage output should slowly ramp the other way. Switching the keyswitch to Hold should stop the ramp and hold the present value, while switching back to Run resumes the ramp. This test should be repeated for the other integrators and be performed on each input. The speed of the ramp will be faster when you patch into the x10 inputs.

The last thing to check is the differentiator input on summer 3. Set up according to the patch diagram of **Figure 13**. The output should be zero until you move RV4. Any movement in the pot, ie. change in the input voltage, will cause a change in output, but as soon as you stop moving the pot, the output will return to zero. A positive change in input will give a negative swing and a negative change will produce a positive swing.

If all of the above tests work out as described, you now have a working Microlog. If they don't work, check your wiring very carefully, especially the wiring to the keyswitch. If that is OK, then check that the op-amps are firmly inserted in their sockets. There is not much else that can be wrong!



Parts List

RESISTORS
(All ¼ watt 5% carbon)

R1−11, 20−27	1M
R12−15, 28−39	100k
R16−19, 40−43	10k
R44	47k
R45,46	470R

POTENTIOMETERS

RV1−6	10k linear carbon
RV7	50k linear carbon trimpot

CAPACITORS

C1−4	680n C352* polyester
C5,6	47u 25V axial electrolytic
C7,8	22u 25V axial electrolytic

*C352 series replaces C280

SEMICONDUCTORS

IC1,2	348 quad op-amp
IC3	7815 +15V regulator
IC4	7915 −15V regulator
BR1	W01 bridge rectifier

MISCELLANEOUS

SW1	DPDT 240V min. toggle
SW2	lever switch (see Buylines)
T1	20−0−20 240V/3VA transformer
M1	meter 50−0−50uA

Case (Vero type 104 or similar); 6 x knobs; 2mm sockets (48 x white, 4 x red, 5 x blue, 4 x black, 12 x green, 4 x yellow); 2 mm plugs (approx. 30); PCB, wire, solder etc.

BUYLINES . . . . page 34

Using Microlog

All being well, you are now the proud owner of an HE Microlog, the smallest analogue computer in the west! So what do you do with it? Well, the best way to describe its capabilities is to show some examples of problem solving using it.

Earlier in this discussion we mentioned using voltage as the analogue of water level in a tank, so lets use Microlog to solve that well known school problem: "How long will it take to fill a bath if water is flowing in at X gallons per minute and flowing out at Y gallons per minute." Working this out at school, you assumed a constant inflow, (reasonable) and a constant outflow. However, with the wisdom of advancing years, you now know that outflow will actually depend on the head (or level) of the water, so the problem is not quite as simple as it

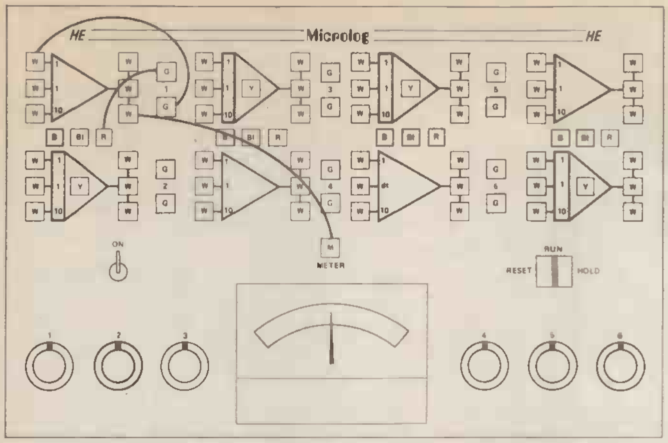


Figure 11. Patch diagram for testing the summing amps.

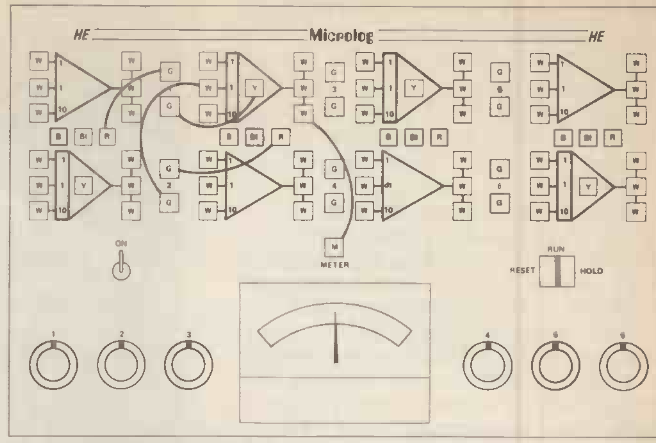


Figure 12. The patch for testing the integrators.

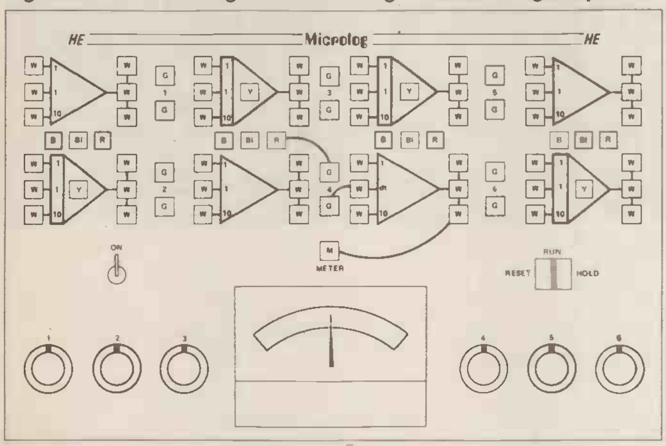


Figure 13. Testing the differentiator.

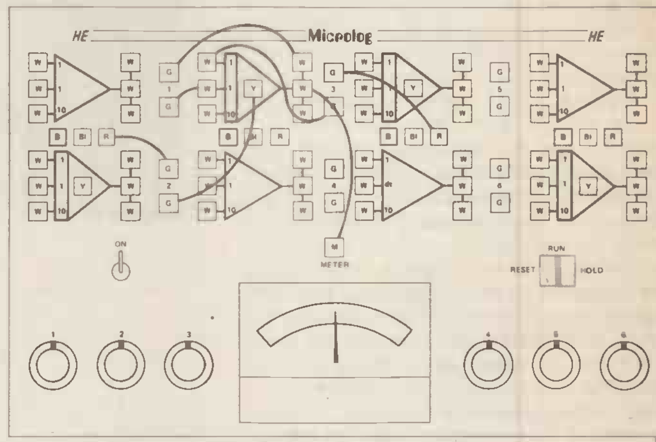


Figure 16. Patching the bathtub.

first seemed. First, then, we shall look at the filling problem with no outflow all all.

If we fill the bath from the tap the inflow will be a constant, 'K', determined by the setting of the tap and the water pressure. The quantity poured in, 'di', during time interval 'dt' is:

$di = K.dt$

Now the rise in level 'dh' for quantity 'di' is:

$dh = 1/A.di$

where 'A' is the area of the bath. Rearranging to make 'di' the subject we get:

$di = A.dh$

Substituting this for 'di' and rearranging we get:

$$\frac{dh}{dt} = \frac{K}{A}$$

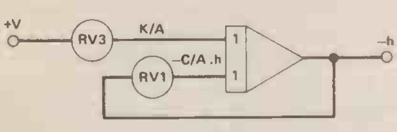


Figure 14. Developing the bathtub circuit.

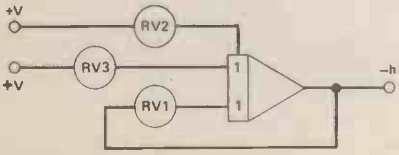


Figure 15. The bathtub completed.

So now we have a differential equation expressing the rise in level with time. The value 'K' represents the amount by which the tap is turned on and the main water supply pressure.

Now about the emptying part; the amount of water that will flow out in time interval 'dt' we shall call 'do'. Therefore, 'do' will be equal to the head 'h', multiplied by some constant 'C', where 'C' takes into account the size of the plug hole! Mathematically then:

$do = C.h.dt$

If the bath has a cross-sectional area of 'A' then the fall in head will be equal to:

$$dh = -\frac{1}{A}do$$

The sign is minus because the level is dropping. Rearranging we get:

$do = -A.dh$

Substituting we get:

$A.dh = -C.h.dt$

or:

$$\frac{dh}{dt} = \frac{-C.\,h}{A}$$

This, too, is a differential equation showing the change of head with time, but this time it is due to the bath emptying. Therefore, the change in level at any instant in time will be the sum of the filling and emptying. So, finally, we can write:

$$\frac{dh}{dt} = \frac{K}{A} - \frac{C.}{A}h$$

This is a differential equation of the type that Micrlog can solve with ease; let's set up the circuit. First we will need an integrator, so that if we put 'dh/dt' in we will get '−h' out (which is what we want). So, we have to put voltage signals corresponding to the right hand side of our equation into the integrator, and we will then get out a voltage that will be the analogue of the water level at any instant in time. The circuit, then, will look like **Figure 14**. Notice that each input does in fact represent a term on the right of our equation and that, as the inputs are summed, the terms are added, just as in the equation.

To complete the picture we have to set the initial conditions of the system; in this case the initial condition is the level of the bath water *before* we start the filling and emptying process. We can set it to zero (an empty bath) or at any level up to full. The complete circuit is shown in **Figure 15** and the Micrlog patch diagram is shown in **Figure 16**.

Now to run the program: first set Micrlog to Reset and adjust RV2 to set the water level to full. That will be minus full scale deflection of the meter. Ensure that RV1 and 3 are turned fully off, anticlockwise, and switch to Run; the water level should remain constant. Now pull out the plug! You do that by turning up RV1; the value determines the size of the plug hole and thence the rate of outflow. Notice that the water level is dropping, as shown by the meter movement, and that the rate slows down as the bath empties. If we turn on the tap, RV3, you can fill the bath. Of course, the filling rate will have to be greater than the emptying rate or the level will slowly drop. It is interesting to start with an empty bath and start pouring water in. If the plug is open, the level will start to rise until the increased head causes the outflow to equal the inflow. At this point the level will remain constant. Turn down the inflow rate a little and after a while a new equilibrium level will be found. The time taken is the 'response time' of the system that we have just modeled on our analogue computer!

So instead of doing lengthy calculations, or getting wet running an experiment, Microlog has allowed you to set up an analogue of the system under test. You can try various settings for all the pots to see how the result changes.

Let's look at another application. You may remember that integrating SIN(X) gives −COS(X), and integrating COS(X) gives −SIN(X).

Again, this is a differential equation of the type easily set up on Microlog. Look at the circuit and patch diagram in **Figures 17** and **20**. If you patch this on Microlog, set the initial condition of integrator 1 to 10 volts and then switch to Run you will get out a sinewave or a 90 degree phase shifted sine wave (COS). Using pots RV1 and 2, you can slow down the frequency of oscillation (or by patching into the x10 inputs of the integrators you can speed it up). This makes quite a neat and simple very low frequency sinewave oscillator. Due to the tiny leakage of the capacitors and the small input currents of the op-amps the amplitude will decay eventually, but it will continue to oscillate for many minutes.

Loops and Bumps

Two areas in which analogue computers are often used are those of modeling dynamic systems and servo loops. These two problems require the solution of second order differential equations of the type:

$$A\frac{d^2x}{dt^2} + B\frac{dx}{dt} + Cx = 0$$

Let's take the front suspension of a car: what will happen if you hit a large pothole in the road and your shock absorbers are bad? **Figure 19** is a simple representation of the type of system we are going to model, and the equation that describes the response of the system to a disturbance (a pothole) is:

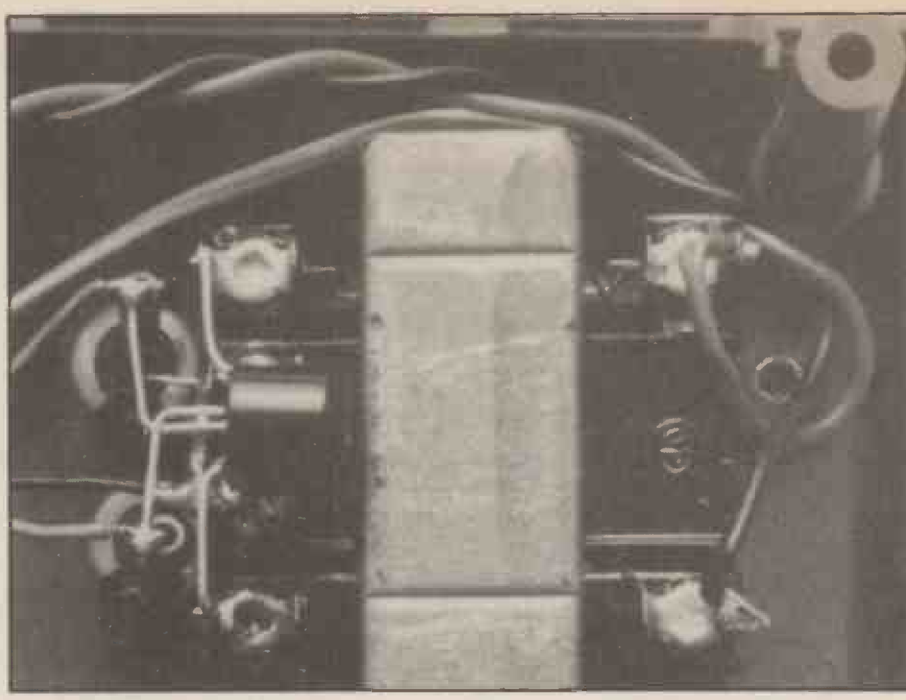
$$M\ddot{X} + D\dot{X} + SX = 0$$

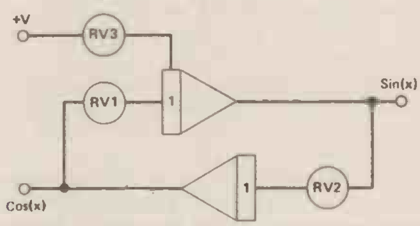
where $\ddot{X} = \frac{d^2x}{dt^2}$ and $\dot{X} = \frac{dx}{dt}$

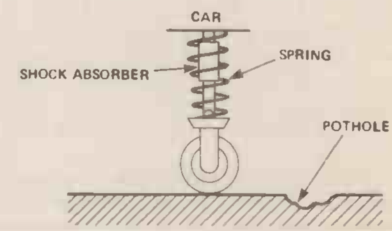
$M\ddot{X}$ is the inertial force due to the mass of the car, DX is the viscous damping force produced by the shock absorber, and SX is the restoring force of your front spring. X, of course, is the displacement of the suspension system, and we want to see how quickly this will be restored to the original value.

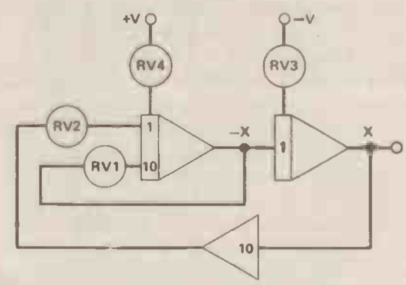
To patch this on Microlog we first rearrange the equation so the $\ddot{X}$ is the subject:

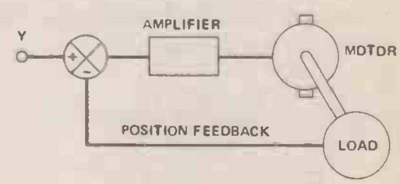
$$\ddot{X} = -\frac{D\dot{X}}{M} - \frac{SX}{M}$$











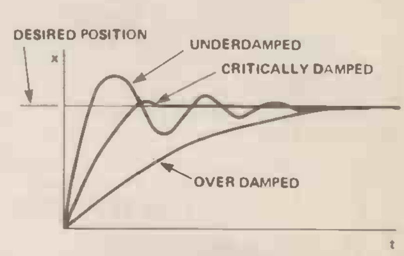


Figure 17 (top left). The Sin X/Cos X generator circuit.

Figure 18 (top right). A model suspension.

Figure 19 (middle left). Suspension circuitry.

Figure 22 (middle right). Model of a closed-loop servo system.

Figure 23 (right). Response curves of a closed-loop servo.

Integrating $\ddot{X}$ gives $\dot{X}$, and integrating $\dot{X}$ gives X. These can then be summed according to the formula to give $\ddot{X}$. The circuit and patch are shown in **Figures 19** and **21**. Pot RV1 is used to set the D/X term and RV2 determines S/X: Set them both to about mid range. But if we drive along a perfectly flat road the suspension will not move, so we have to simulate the bump. This is done by setting an initial condition into the integrators, to show that the suspension has been displaced.

Turn Microlog to Reset and set RV4 to about mid value and RV3 to give −50 on the meter — this is a medium sized pothole! Now switch to Run and watch the meter. It will return to zero (the original position) and then overshoot, then reverse direction but overshoot zero again, though not by so much this time. Eventually, it will settle down to a smooth ride again. Try playing around with RV1 and RV2; reducing RV2 reduces the effectiveness of the shock absorber and you will find the front end of your car bouncing up and down for the next few miles. Increase it, and it takes a

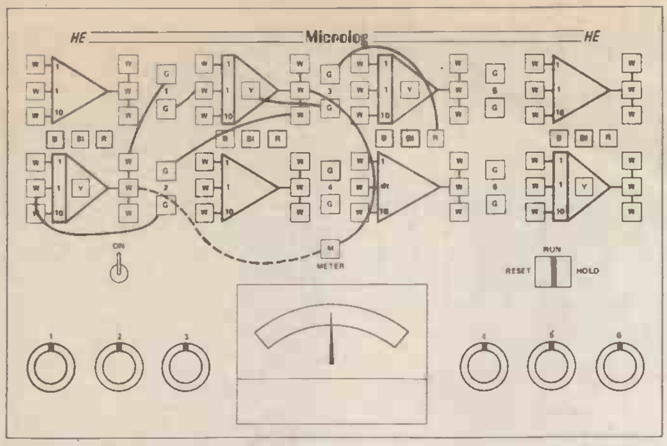


Figure 20. Sin X/Cos X patch.

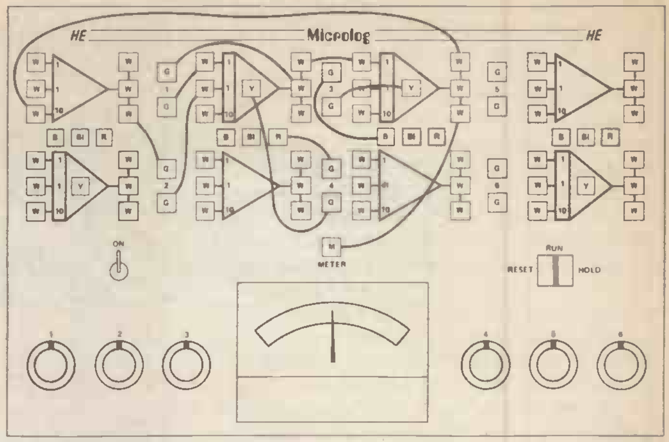


Figure 21. Pothole patch.

long time to return to the level condition again. If you increase RV1 you stiffen the spring. A high RV1 and RV2 setting simulates the rock hard suspension of a sports car, while a low setting for both (especially P1) gives you the ride of a big American Cadillac!

A closed loop servo system, of the type shown in **Figure 22**, also has a second order differential equation to describe its performance. In this case, instead of turning to the zero displacement position, the system must move to the position corresponding to the input signal Y.

Microlog can model this system too, and in fact it is very similar to the car suspension problem. To change the patch to model the system shown in **Figure 22**, all you have to do is take the output of RV3 from the initial condition input of the integrator and plug it into the free summing input; this pot is now your position control. RV1 now sets the gain of the feedback loop and RV2 the inertia of the system. Switch Microlog from Reset to Run and then move RV3 to a new position; the meter output will follow but overshoot, and then come back. You can determine the best response by playing with the gain and inertia of the system, and if you have an oscilloscope you can plot the response and should be able to see the sort of curves shown in **Figure 23**.

These are just a few of the possible systems and problems that can be solved with an analogue computer. Microlog is not designed to produce accurate numerical results; however, it can give a good idea of how a system will function, and give you a feel for analogue computing.

It can also be used to add signals, or the integrators can be set up to give you a very slow ramp. The differentiator input can be used to measure the slope of a ramp and it can also be used to detect drift in a circuit, so Microlog can be quite a useful lab instrument as well!

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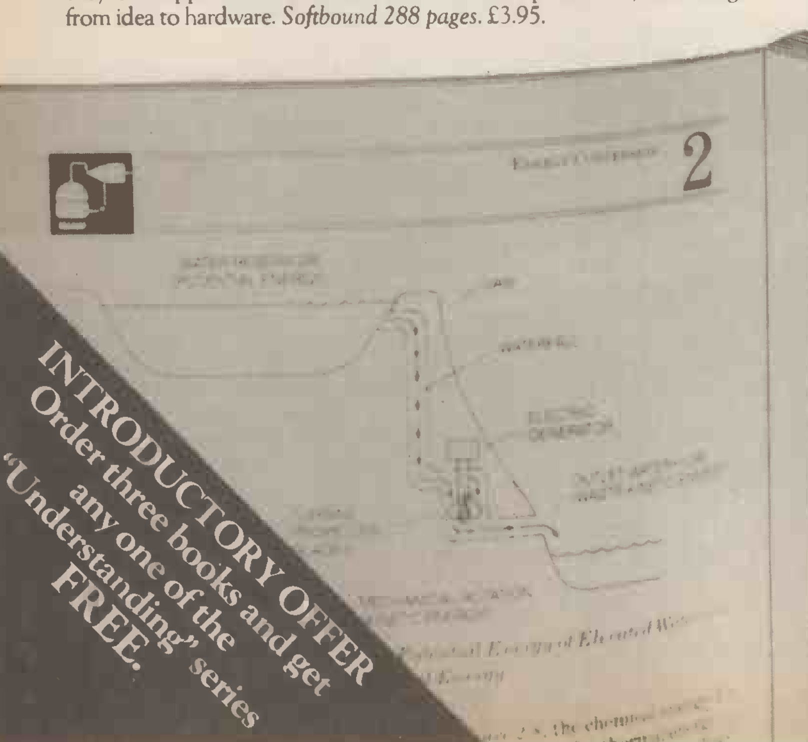

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Remove hiss and noise from your recordings! Mono or stereo, our noise gate deals with both.

Stereo Noise Gate

NOISE is present in every electronic circuit, and in audio circuits it results in the all too familiar background "hiss". Although modern electronics components have provided great improvements in noise performance in recent years, noise in audio circuits can still be very troublesome at times, and there can sometimes be a build-up of noise which results in a poor signal-to-noise ratio when using certain combinations of equipment. Re-recording material can also lead to a build-up of noise.

Two useful ways of combatting audio noise are to use either a noise gate or an expander. These two devices are very similar, but there is a very important distinction between them. A noise gate is rather like an automatic switch which normally allows the input signal to pass straight through, but cuts off the output when noise *only* is present at the input. Noise is most obtrusive during pauses in the main signal, and a noise gate can therefore give a large subjective improvement in performance.

An expander permits low level signals to pass normally but at medium and high signal levels, it gives a progressive boost to the processed signal. Thus the noise level remains the same but the maximum volume level is increased; or, the noise level can be reduced with the maximum volume level remaining the same; or, a combination of the two, as desired. A simple volume expander was described in the January 1982 issue of Hobby Electronics.

Whether a noise gate or an expander is the best choice depends upon the particular circumstances in which the equipment will be used and, to some extent, on personal preferences. A disadvantage of an expander is that it alters the dynamic levels of the processed signal, whereas a noise gate simply cuts off the noise during breaks in the signal. A noise gate is therefore normally preferable for use where changes in dynamic level are undesirable. However, a gate is likely to be less satisfactory when the wanted signal may, at times, be almost lost in the noise, since it is then possible that the gate might cut off the signal. A noise gate is of most use when there is a fairly strong noise level, but the wanted signal is usually significantly above this level.

The unit described here is a stereo noise gate, although by using only one channel it can obviously be used in mono. Although expanders normally process each stereo channel separately it is preferable for a stereo gate circuit to switch the two channels in unison, as it can be rather disturbing if one channel cuts out while the other is still present! This circuit therefore switches the two channels on and off simultaneously — see **How It Works** for an over-view of the system.

The Circuit

The full circuit diagram of the Stereo Noise Gate is shown in **Figure 1**. It is based on an LM13600N integrated circuit, which is a dual operational transconductance amplifier. An operational transconductance amplifier has features common with an ordinary operational amplifier, but there are also a number of important differences — a transconductance amplifier provides an output current (rather than an output voltage), governed by the differential input voltage, and it also has an additional input which enables the gain of the amplifier to be controlled over a wide range, from zero up to about 20 dB. Note that a gain of less than one is equivalent to attenuation!

In order to make a transconductance amplifier operate as a voltage amplifier, it is merely necessary to add a load resistor at the output; R20 is the load resistor for IC3a while R24 is the load for IC3b. The current flow into the

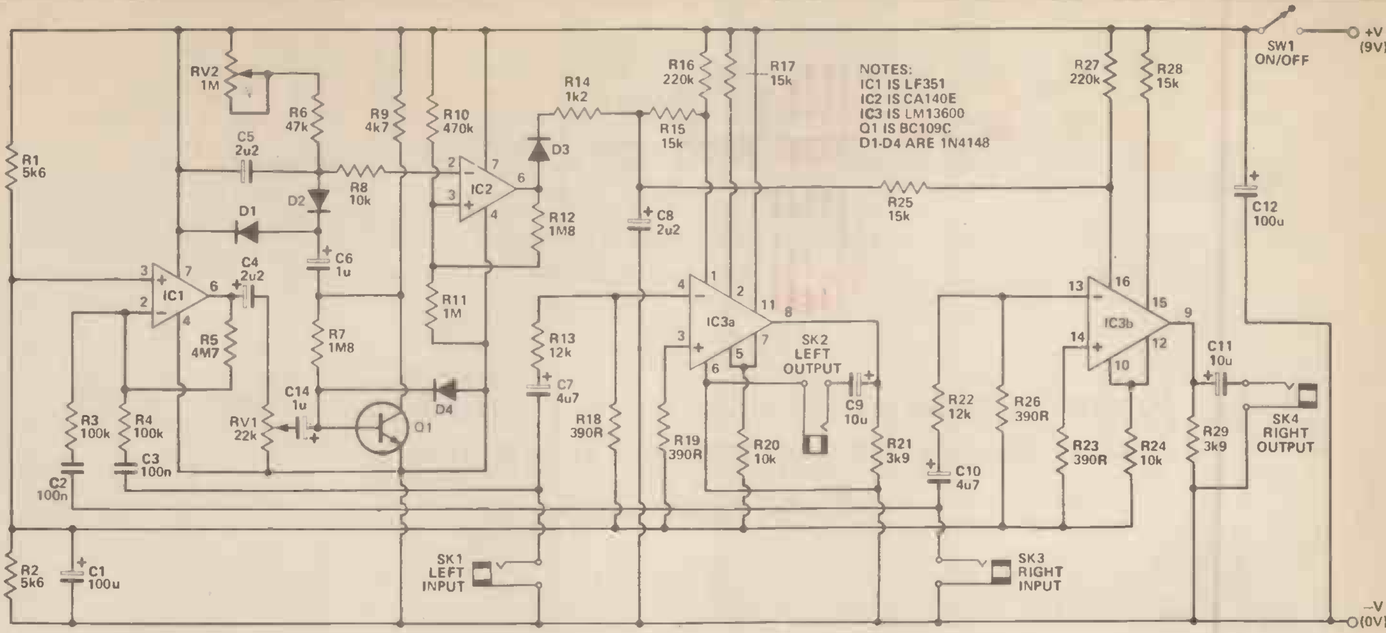


Figure 1. Circuit diagram of the Stereo Noise Gate. Note that both channels are included.

control input, rather than voltage, determines the gain of the amplifier. This is achieved by simply adding resistors (R15 and R25) in series with each control input so that the current flow is proportional to the applied voltage. Resistors R16 and R27 apply a small bias current to the control inputs; this gives the circuit about -20 dB of gain (ie, 20 dB attenuation) in the high attenuation mode, rather than completely cutting off the output signal, which usually gives more satisfactory results. The circuit can be made to operate as a true gate, if preferred, by simply omitting R16 and R27.

The LM13600N incorporates two Darlington Pair output stages which are used as emitter follower buffer stages, to give the VCAs a low output

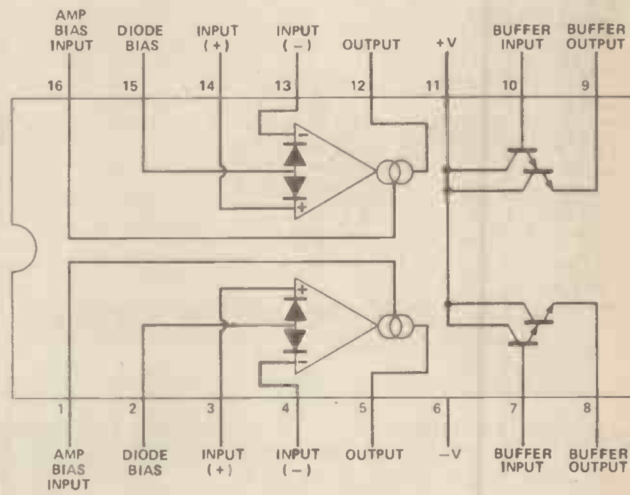


Figure 2. Pin configuration for the LM13600 dual transconductance op-amp.

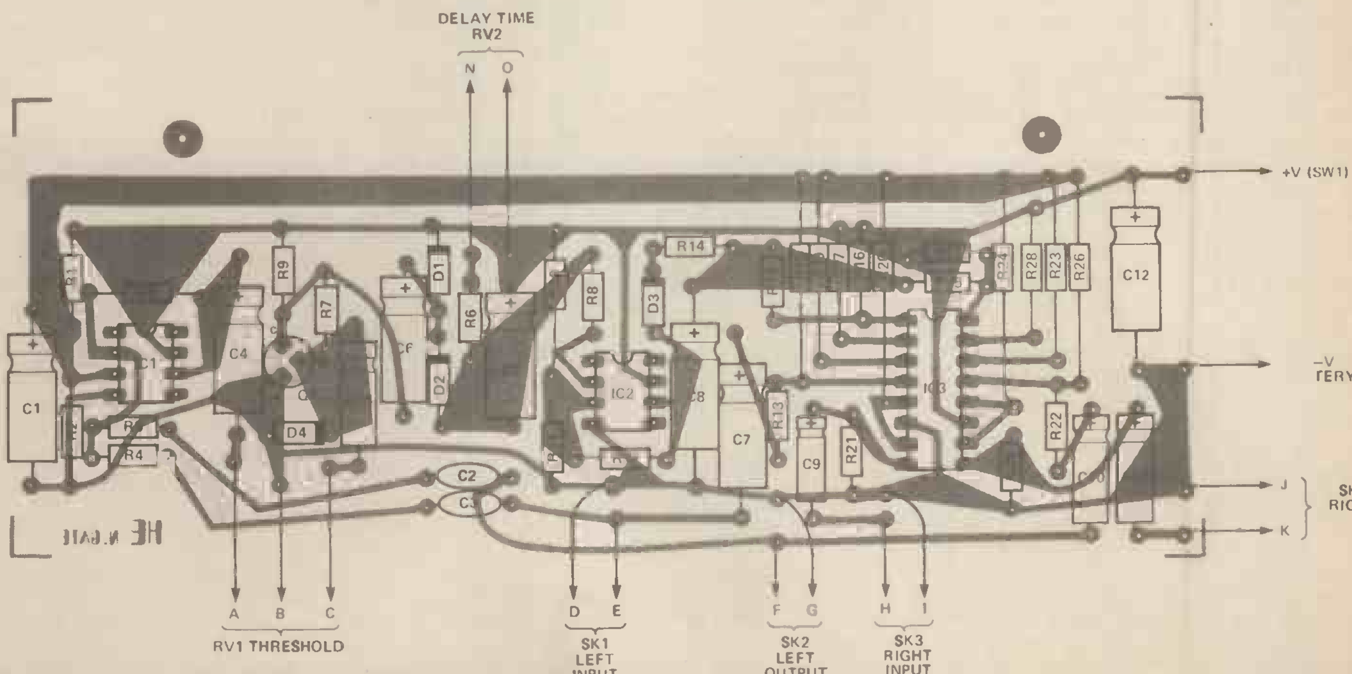


Figure 3. Overlay diagram for the Noise Gate.

impedance. R21 and R29 are the iscrete load resistors for these stages. The LM13600N has 'linearizing diodes', which enable a higher input signal level to be handled for a given distortion level, and these diodes are given the appropriate bias by R17 and R28.

In order to operate as a voltage controlled amplifier, a transconductance amplifier must be used open loop (ie, without any negative feedback). R1, R2, and C1 form a centre tap on the supply rails and the inputs of the two transconductance amplifiers IC3a, b, biased to this voltage by R18,19,23 and 26. R13 and R22 are used to reduce the voltage gain through each section of the unit to about unity (with a high control voltage), and also to boost the input impedance to a little over 12k.
The mixer stage is a conventional operational amplifier, IC1, and gives a voltage gain of about 47. Threshold control RV1 is a volume control type attenuator, and the output from this is coupled to a high gain common emitter amplifier based on Q1; the combined gain of Q1 and IC1 is needed in order to boost weak input signals to a high enough level to drive the subsequent circuitry.

The output of Q1 is coupled by C6 to a simple rectifier and smoothing circuit (D1, D2, C5 and R8) and RV2 controls the decay time of this circuit. Op-amp IC2 is used as a simple inverting trigger circuit, with positive feedback and hysteresis provided by R12; 'hysteresis' simply means that the input voltage at which the output triggers to the high state is lower than that at which it triggers back to the low state. This prevents instability when the input voltage is close to the switching threshold levels. D3 and R14 are used at the output of the trigger to very slightly slow the rise-time of the control voltage, and to provide a slightly larger slowing of the fall-time. This prevents "clicks" from being introduced at the output as the gate changes state.

Construction

An aluminium and steel instrument case measuring about 152 x 114 x 44 mm is used to house this project — it is about

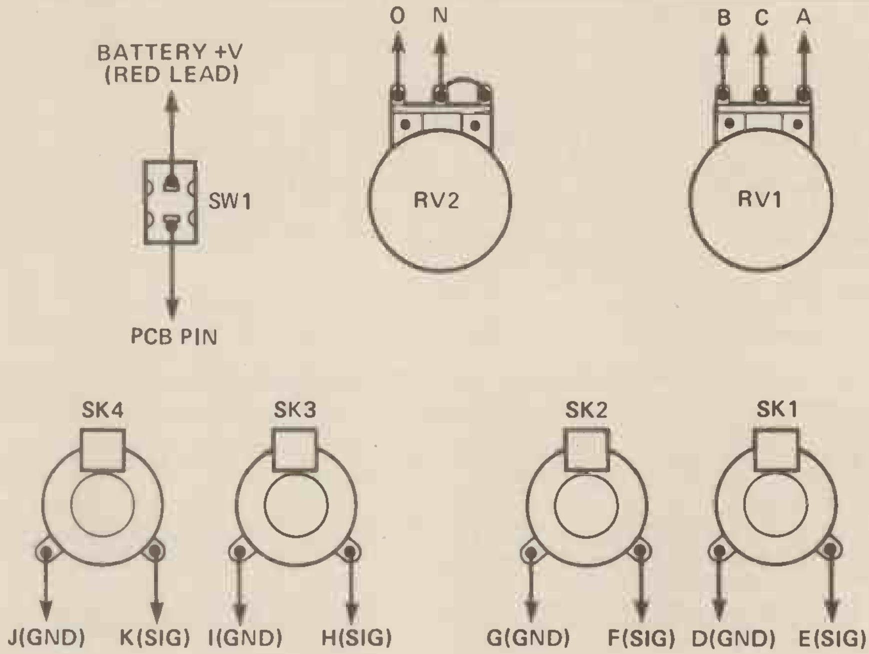
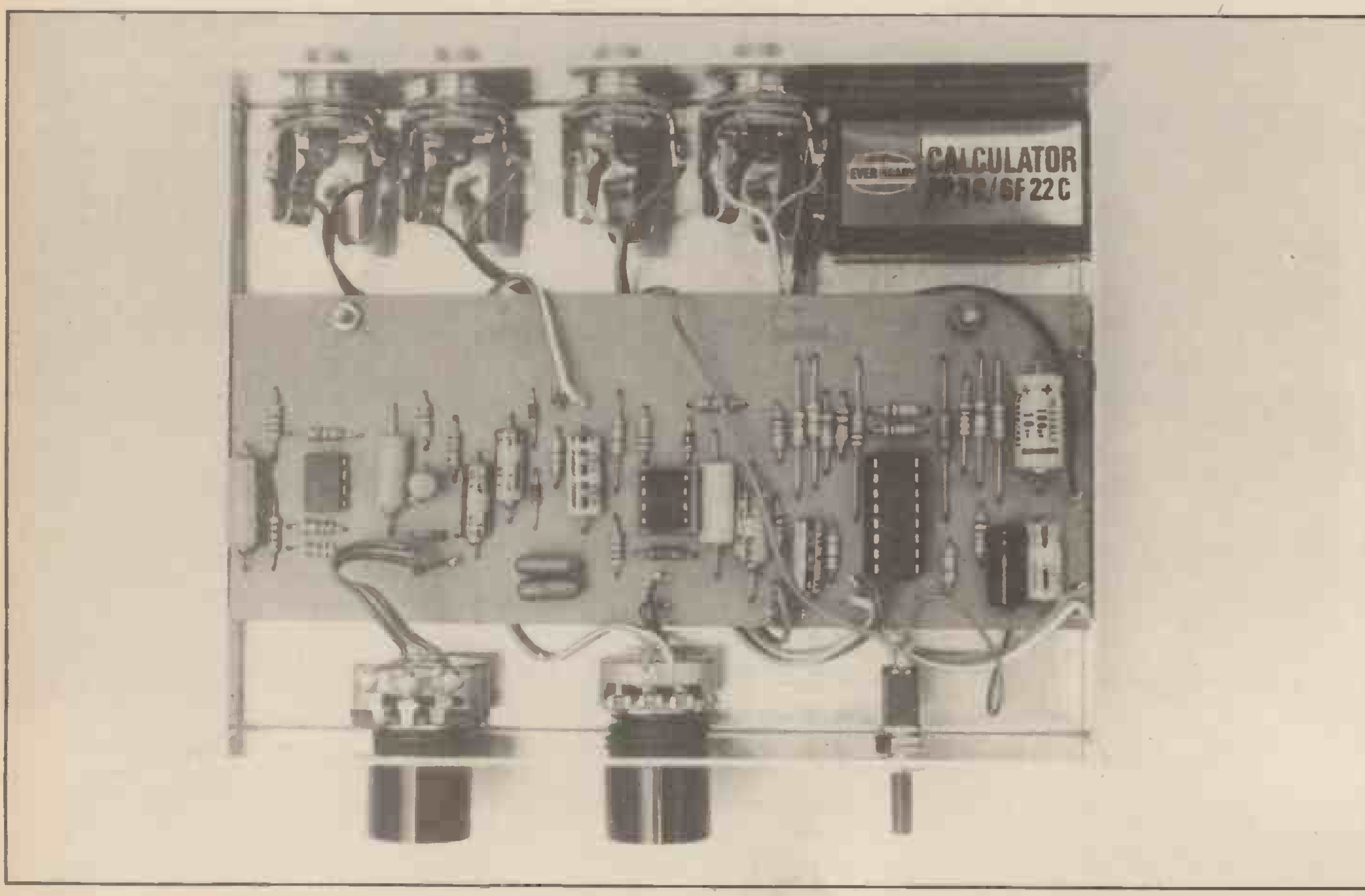


Figure 4. The internal wiring and connections inside the case of the Noise Gate.



the smallest case that could be used to accommodate all the parts. The three controls are mounted on the front panel and four sockets are fitted on the rear panel of the case.

Apart from the battery, all the other components are mounted on the printed circuit board, and this is detailed in **Figure 3**. As IC2 is a MOS device, it should be fitted in an 8 pin DIL IC socket and the normal MOS handling precautions should be observed. Use Veropins where connections to off-board components will eventually be made.

The completed board is mounted on the base panel of the case using 6BA fixings, including 6.3 mm spacers to hold the connections on the underside of the board clear of the metal case. The unit is then completed by adding the point-to-point wiring, illustrated in **Figure 4**. Ordinary PVC covered multistrand connecting wire is used here; it is not necessary to use screened leads.

In Use

The unit is intended for use with a high level signal and can take inputs of 2 volts RMS or so without serious distortion occuring. The threshold voltage at which the gate switches to the unity gain (zero attenuation) state can be varied from about 1 mV RMS (with RV1 set fully clockwise) to about 70 mV RMS. The best setting is likely to be such that the noise signal alone is not quite sufficient to trigger the circuit to the zero attenuation state, but it is worthwhile experimenting a little to find the setting which gives the best subjective results.

The circuit will respond very rapidly to an input signal (fast attack), but the decay — the delay between the cessation of the main signal and the gate switching to the high attenuation state — can be varied from less than a tenth of a second to more than two seconds. A fast decay time will often give best results, but it might sometimes be found that the gate tends to switch back and forth between the two states fairly rapidly; a slightly longer decay time should eliminate this problem.

Parts List

RESISTORS
(All ¼ watt 5% carbon)
R1,2 . . . . 5k6
R3,4 . . . . 100k
R5 . . . . 4M7
R6 . . . . 47k
R7,12 . . . . 1M8
R8,20,24 . . . . 10k
R9 . . . . 4k7
R10 . . . . 470k
R11 . . . . 1M
R13,22 . . . . 12k
R14 . . . . 1k2
R15,17,25,28 . . . . 15k
R16,27 . . . . 220k
R18,19,23,26 . . . . 390R
R21,29 . . . . 3k9

POTENTIOMETERS
RV1 . . . . 22k log carbon
RV2 . . . . 1M linear carbon

CAPACITORS (All axial electrolytics unless noted)
C1,12 . . . . 100u 10V
C2,3 . . . . 100n C280 polyester
C4,5,8 . . . . 2u2 63V
C6 . . . . 1u 63V
C7,10 . . . . 4u7 63V
C9,11 . . . . 10u 25V

SEMICONDUCTORS
IC1 . . . . LF351 JFET op-amp
IC2 . . . . 3140E MOSFET op-amp
IC3 . . . . LM13600N dual transconductance amp
Q1 . . . . BC109C silicon NPN transistor
D1-4 . . . . 1N4148 silicon signal diode

MISCELLANEOUS
SK1-4 . . . . ¼" jack socket standard metal chassis type
SW1 . . . . SPST miniature toggle switch
Case (see Buylines); PCB; 6BA nuts and bolts; Veropins; IC sockets; knobs (2); PP3 battery, clip, wire, solder etc.

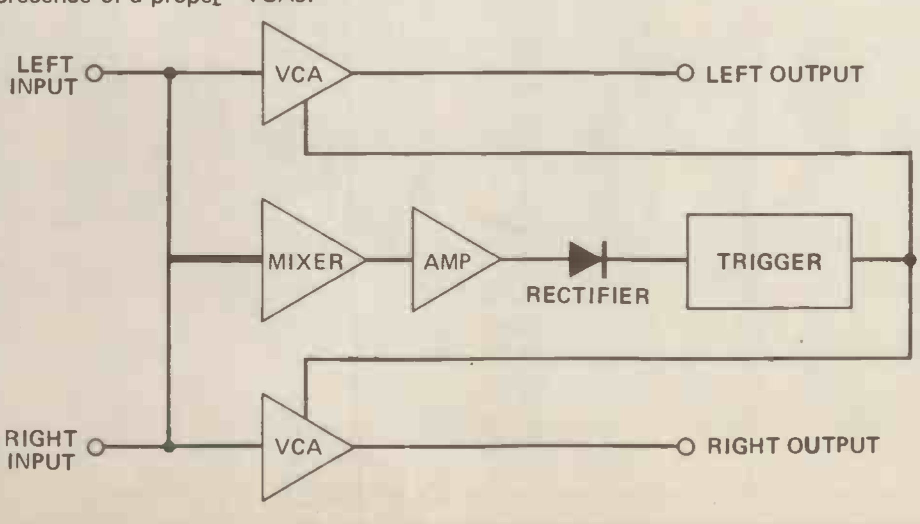
BUYLINES . . . . **page 34**

How It Works

THIS Noise Gate design is a stereo type which uses a separate VCA (voltage controlled amplifier) to process each channel. With a low control voltage, each VCA gives a substantial amount of attenuation (about 20 dB — a 90% reduction in the signal voltage, in other words). A high control voltage gives unity gain (zero attenuation) through each VCA and the input signal is effectively allowed to pass straight through.

Automatic switching — to zero attenuation in the presence of a proper input signal but high attenuation with only noise applied to the input — is achieved by first mixing the two input signals and then amplifying them. The amplified signal is then applied to a rectifier and smoothing circuit to produce a DC output level proportional to the strength of the combined input signals. this voltage is fed to a trigger circuit which has a high output voltage if the input voltage is above a certain threshold level, and a low voltage if it is not; this is the control voltage for the VCAs.

The circuit is adjusted so that with only background noise present at the input, the voltage fed to the trigger circuit is below the threshold voltage and the VCAs give a high attenuation level. With a high input signal, in addition to noise, the input voltage to the trigger circuit goes above the threshold level and the VCAs 'open' producing zero attenuation. Thus the required automatic attenuation of the noise-only input signal is obtained.



HE

HE TV Amp

N.D.N. Belham

Specially designed to let Grandad hear the telly clearly without annoying the rest of the household, it will also double-up as a general-purpose bench amplifier.

ALTHOUGH we loved the old man and owed him a lot, Grandad was becoming a pest with his complaints that he couldn't hear the TV sound. For a while we did our best, though the volume was painful, but something obviously had to be done about it — if not for ourselves, then certainly for the sake of the neighbours! Fortunately our TV set is a modern one, with two headphone sockets built in, so when we bought him a pair of 'phones, we thought the problem had been solved — but it wasn't long before he refused to wear them because he didn't like the voices ''inside his head'' when they should have been coming from the screen. Anyway they became too

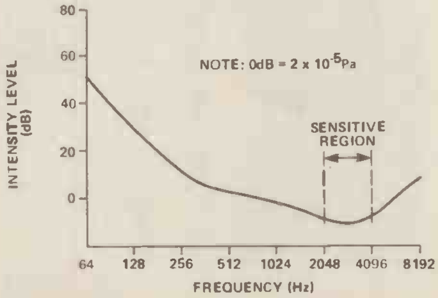


Figure 1. The response curve for the average person's sense of hearing (after Fletcher and Muson).

uncomfortable for him, after an hour or two. Another solution had to be found.

Grandad wasn't really deaf; he did not need a hearing aid, as he could carry on a normal conversation, but he did find it difficult to follow conversations on the telly. Strangely, it seemed to us, he preferred the sound from a small portable set to the one with full range hi-fi reproduction. Indeed, several factors seemed to be involved, some of a general nature and some peculiar to the elderly.

The diagram of **Figure 1** shows the average frequency vs intensity response for an average person's hearing. Clearly, the energy required for a sound to be just audible varies greatly

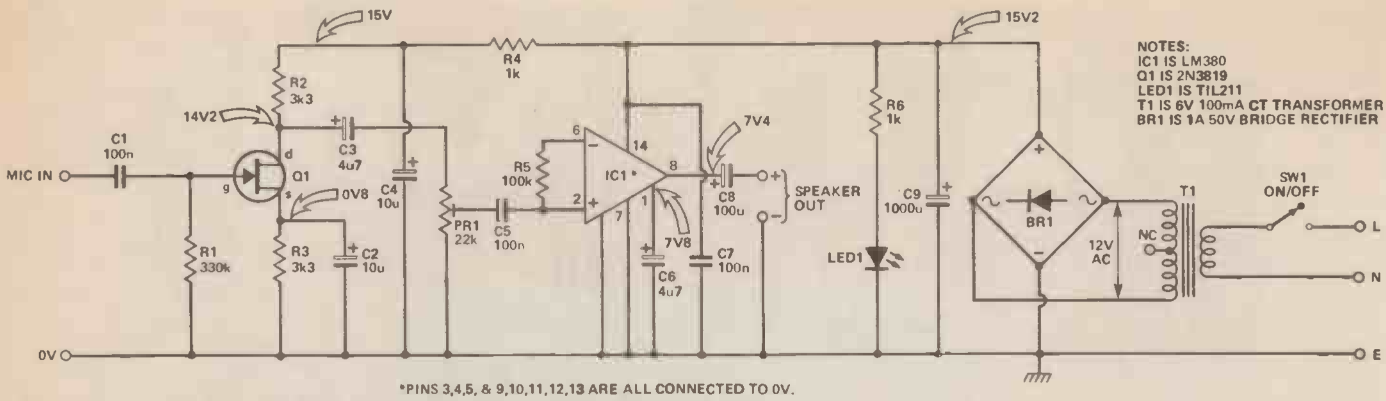


Figure 2. The circuit; the input is high impedance adn will accept any audio input of around 10 to 50 mV.

Parts List

RESISTORS
(All ¼ watt 5% carbon)
R1 .... 330k
R2,3 .... 3k3
R4,6 .... 1k
R5 .... 100k

POTENTIOMETERS
PR1 .... 22k
miniature cermet preset

CAPACITORS
(All radial electrolytic unless stated)
C1,5,7 .... 100n
disc ceramic
C2,4 .... 10u 16V
C3,6 .... 4u7 35V
C8 .... 100u 16V
C9 .... 1000u 25V
axial electrolytic

SEMICONDUCTORS
IC1 .... LM380
power amplifier
Q1 .... 2N3819
FET transistor
BR1 .... 50V 1A
bridge rectifier
LED1 .... TIL211
0.2" green LED

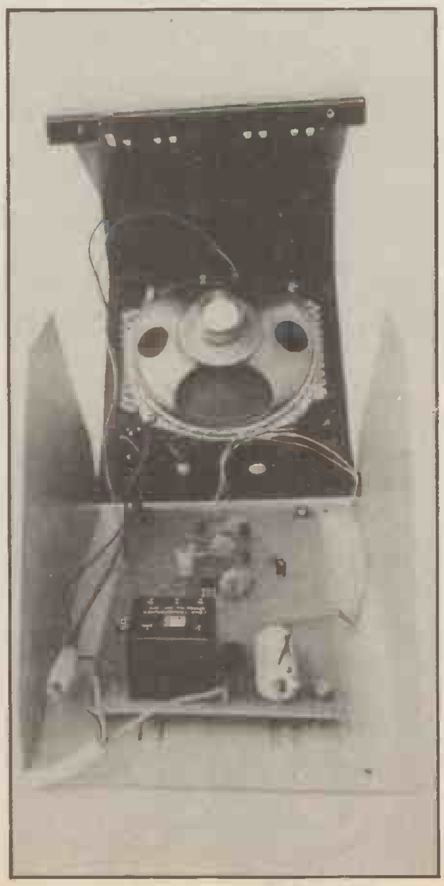
MISCELLANEOUS
SW1 .... SPST
mains toggle switch
T1 .... 6-0-6 1.2VA
Crystal microphone; centre-tapped transformer; speaker (see Buylines); Mains 'P' clip; mains lead and plug (2A fuse); case (see Buylines); ¼" jack socket (plastic); LED bezel; PCB, wire, solder etc.

BUYLINES .... page 34

with frequency; very little sound energy is needed if it is at the right pitch, and the frequency range 2000 Hz to 4000 Hz is where the average ear is most sensitive.

Anyone who has worked in long range radio communication will know that restricting the audio bandwidth to between 500 Hz and 4000 Hz greatly improves the clarity of the transmission (especially in adverse atmospheric conditions), and this seems to indicate that, for speech, most of the essential information is contained in that frequency range.

Another factor, it seemed, was that the elderly find it difficult to concentrate on more than one sound at a time. They are easily put off by unwanted 'noise' — this is as much to do with the way in which sound is interpreted (psychoacoustics) as with



the sense of hearing. Hi-fi-quality sound, with its extended frequency range, produces too much 'noise' at the upper and lower limits of hearing which, for the elderly, masks the information in the mid-range frequencies. So, simply turning up the TV sound was not the solution because the unwanted frequencies are also boosted (this, also is why deaf aids are personally tailored to an individual's frequency response curve).

Grandad's Specifications

So, with these points in mind, we were able to write a specification for Grandad's TV amplifier:

- The output frequency must be tailored to peak at about 2000 Hz, with little response below 500 Hz or above 4000 Hz.
- The output should be directional, so that it could be directed at Grandad, not at us!
- The output level to be sufficient to allow it to be placed near the TV screen, to give it realistic 'TV sound'.

The first step was to select a small loudspeaker, which automatically restricted the frequency response to the specified limits and also produced a degree of directivity. Unfortunately, the power available from a headphone socket is not sufficient to drive a loudspeaker, so an amplifier had to be designed and constructed. A single integrated amplifier, the LM380, proved adequate for the job, especially as it needs very few external components.

The price of batteries being what it is (expensive!), a simple mains power supply was built into the unit, together with an on/off switch and a LED power-on indicator. Since most TV sets do not have a headphone output, the circuit was adapted for general use by incorporating a microphone input. A crystal mic (use a short lead, because of its high impedance) is quite adequate, or a more expensive electret type can be used with a longer lead, if necessary. Dynamic microphones contain a coil which will respond to the varying magnetic field produced by the video scan, so they cannot be used here.

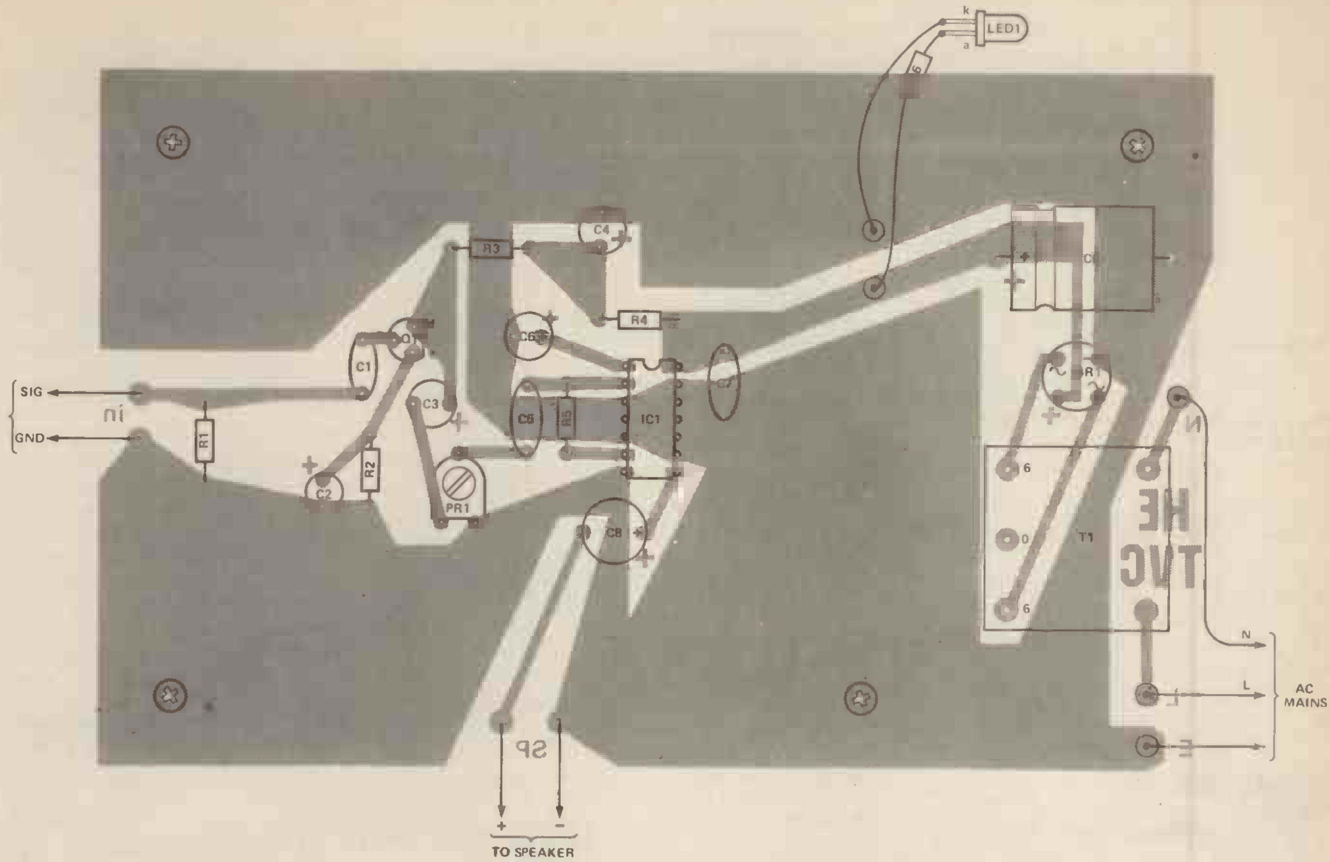


Figure 3. The PCB layout, viewed from the component side. Large areas of copper have been left to serve as a heatsink for the LM380 amplifier.

Grandad's Circuit

The microphone will give an output of a few tens of millivolts when placed fairly close to the loudspeaker with the volume control set for normal listening, and this is fed via coupling capacitor C1 to a FET amplifier, Q1. This provides the high impedance input required for the microphone and a voltage gain of between five and six.

A 4u7 capacitor, C3, couples the output of the FET stage to the preset volume control PR1, and C5 couples the signal to the inputs of IC1, the LM380 amplifier. This has an internally fixed gain of 34 dB (50Vout/Vin), but it is reduced to 20Vout/Vin by using a 'common mode' input, where part of the input voltage is coupled to the inverting input of the amplifier via the 100k resistor, R5.

Capacitor C6, connected to the bypass pin (pin 1) of IC1 de-couples the internal bias of the amp, preventing AC ripple on the output, while C7 performs the same function on the supply line.

The output is fed to the speaker via C8; together, C8 and the speaker voice coil impedance form a high pass filter, rolling off the response below 200 Hz when an 8R speaker is used. The speaker itself is the main factor in shaping the frequency response; by choosing a small 4" diameter unit and monting it in an unsealed box, most of the lower frequencies are attenuated, while the mechanical properties of the cone ensure that frequencies above about 4 kHz are also 'lost'.

Finally, the amp is powered from a simple DC supply derived from a 6V/100mA centre-tapped transformer and a diode bridge; the ripple voltage is filtered out by C9. LED 1 is included to provide 'power-on' indication, with R6 to limit the current through the LED.

Construction

In order to improve the stability of the amplifier (reducing the chance of it becoming an oscillator), it is mounted on a PCB which has a very large area of copper. The unused pins of the IC are soldered directly to these areas — do not use an IC socket in this project! This method also provides an effective heat sink.

The layout shown in **Figure 3** is designed for a preset volume control to be mounted on the PCB; should a full-sized pot be required as a front panel volume control, leads must be taken from the PCB to the potentiometer solder tags. The choice of preset or variable volume control is left to the constructor — perhaps the solution depends on how many "knob-twiddlers" there are in the house!

Grandad's TV Amp can be built into any enclosure large enough to hold the components, including the speaker. Our prototype was cased in a rather classy custom-built box from Newrad Instrument Cases Ltd (see Buylines for the ordering details); this also has a pre-drilled hole for a panel-mounted volume control.

Operation

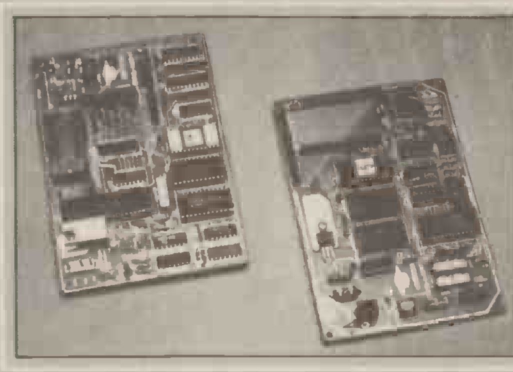
The problem with any microphone-amplifying system is the risk of acoustic feedback, which will occur whenever the mic is picking up sound from the loudspeaker. Steps must be taken to prevent this from happening!

First, the best position for the TV Amp is on the floor, or on a low table in front of the TV set, so that the sound is coming from the same direction. Second, the mic should be placed as close to the TV speaker as possible, but without actually touching it. Then, the preset or volume control must be adjusted so that, at normal listening levels, there is no trace of whistling or "howl round" from the TV Amp.

In most cases, this arrangement will be quite satisfactory though for very deaf people, it may be necessary to place the Amp closer to the listener and to use a longer mic lead. If such is the case, a crystal microphone should not be used with a lead longer than about three feet.

HE


MICRO-PROFESSOR



POINTS OF VIEW

Feel like sounding off?
Then write to the Editor stating your Point Of View!

New Devices for Old Effects

Dear Sir,
*With regard to your **Fuzz-Box** project in the February '82 HE, please could you inform me where I can obtain the BC650 transistors, as I have been unable to find them listed in any catalogue.*
Graham Walsh,
Pudsey.

When the Noiseless Fuzz-box was designed, the BC650 transisitor had only recently come on to the constructors' market. Consequently it was difficult to obtain (one source was, and still is, Magenta) and we had to do a lot of leg-work to seek out suitable suppliers. Now, however, it has proved to be quite popular and should be available from the larger semiconductor stockists. Incidentally, it does no harm to ask about a component that doesn't appear in a given advertiser's list. Once the enquiries start flooding in, most companies will obtain stocks from the distributors.

Echoes On The Line

Dear Sir,
*I tried to 'phone you for clarification of the **HE Echo-Reverb** (May '82, pages 33-37) but apparently you are no longer on the phone (why not pay the bill?). Two points: the circuit and layout differ for the diodes, and the circuit and Parts List differ on the value of R15. Are there any other discrepancies?*
Do pay the phone bill — it's such a long wait by Post Office Non Communications system.
H. W. Fletcher,
Marlow Bottom,
Bucks.

The HE Gremlins chose our Echo-Reverb unit for their *pièce de résistance* — and they really did a job on it. The full list of errors are given in the reply to the following letter. Our apologies to all concerned; the Gremlins have been dealt with!

Our phone bill has been paid, but it won't help you — we cannot take enquiries *and* produce a magazine every month, and if we didn't produce the magazine, you'd have nothing to enquire about, would you?

Designer on the Dole

Dear Sir,
*For an eight month old dole freak like myself, the **HE Echo-Reverb** met a very real need.*
Some months ago I had scraped up the pennies and lashed out on two TDA1022 ICs with a view to designing my own phaser/flanger/chorus/echo/reverb. Needless to say I found myself hopelessly out of my depth (even with the Mullard spec sheet to hand)! To cut a long story short, my courage has been rewarded by the appearance of your design (heaven-sent!).
Thanks! I now hope to proceed with: switchable clock timing capacitors for phase/flange/chorus/echo and possibly a sine-wave modulator for the VCO input of the 4046 clock. (I fear a saw-tooth oscillator would be prone to spikes and hence 'clicks' in the output.
Please keep up the cost pruning!
Thanks again.
D.P. Allen,
Wembley,
Middlesex.

The **Echo-Reverb** (HE May '82) has been one of our more popular projects. For a modest outlay and with careful setting-up, the unit will produce varying degrees of reverberation and echo. However, as with some other projects of this standard, a few errors crept into the printed article. So, to all readers who've had a few problems, here's the list — exhausative, we hope!

p. 34	Figure 1.	RV2 wiper comes from pin 9 of IC 1. D2 is shown inverted (ie. cathode goes to OV).
p. 36	Figure 2.	The end tags of RV2 are connected to +15 and OV supply rails. Transformer should be 9-0-9 V.
p. 37	Parts List	RV1 should be 47K log. RV4 should be 22K log. The transformer should be 9-0-9 V. R15 should be 27K.

A Better Building Block

Dear Sir,
*I enjoyed the series of articles **Into Electronic Components**. As a now regular reader of your magazine, however, I must say the most interesting and informative articles to date are the "Building Blocks" — I would appreciate more of the same. Detailed information on ICs, etc. is of great value, too.*
A. Easom (G4OPI),
Scarborough,
N. Yorkshire.

We are pleased that you appreciate the Building Blocks series. A great deal of work goes into researching the information and presenting it in a form that is easy to understand. However, details of applications for ICs and general constructional info can also be found in our How It Works sections, and Breadboard pages. And in this issue we start a special Building Blocks series on ICs used in mirocomputers, called Components for Computing.

A Better Class of Meter

Dear Sir,
Having read copies of various electronic magazines, may I say that yours is very enjoyable and you can be sure that I will buy HE every month in future.
Is it possible to construct a voltmeter of range 0-16 V DC with a digital LED seven segment display, calibrated to read to a tenth of a volt?
If so I would be grateful if you could supply me with any relevant information including circuit diagrams, etc.
Paul Humphries,
Newcastle upon Tyne,
Co. Durham.

Thanks for the compliment, although we'll answer your questions (usually) even if you're rude about us! It's not only possible to build this voltmeter, but we have just done one in the August '82 issue, and with a better specification, at that.

A Little Ingenuity

Dear Sir,
*In the **Three-Aspect Signal Lights** project (September '82) you suggest fitting microswitches to the points to obtain the required switching. Those modellers who have PECO points can use the PECO "accessory switch". This clips to the point motor (if fitted). I see no reason why this neat unit cannot be fitted to other makes of points, with a little ingenuity. I think this project has been one of your best yet. It would be ideal for large club layouts where there is more than one operator.*
Yours in electronics.
M. Wilkins,
Ipswich,
Suffolk.

A double thanks to Mr. Wilkins; first for the comments and second for the information on accessory switches. We are always happy to pass on tips from readers who can provide extra info about any of our projects! Thanks too, to Dr. D.L.H. Bloomfield, who designed that model project, but who was not properly credited in the article. **HE**

ELECTRONIC IGNITION

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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

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Some older current impulse types (Smiths pre '74) require an adaptor – PRICE £2.95

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Assembled and Tested	**£26.70**	
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Access 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.

Jean Baudot

A name to ring bells with.

Ian Sinclair

BAUDOT — the name might ring a few bells if you are into computing: drop the last two letters and you get baud, which is a unit for the speed of transfer of information. The old-fashioned teleprinter, for example, operates at a rate of 110 baud, but a modern cathode-ray terminal may work at 2400 baud or higher. Having established the connection, let's look at the story of J. M. E. Baudot.

Jean Baudot was born in 1845 at Magneaux in France, and you will search in vain for details of his early life, unless you are prepared to look through a fairly large library. You won't find his name mentioned, often; it's the usual problem — a brilliant engineer whose name has entered our language hardly gets a mention, even in his own country.

He seems to have had the conventional schooling of the French middle classes at the time, which was, incidentally, one of considerable social unrest, with minor revolutions breaking out all over Europe. His firm interest, from the time that he left school, was the growing technology of the electric telegraph, and it was to this that he turned his attention when the time came to earn his own living.

Dots and Dashes

In these early days, the universal code for telegraph use was Morse code, which relies on the use of two types of electric impulse, a long (dash) and a short (dot) — the form of the code is shown in Figure 1. Now there is nothing wrong with this as a code, and it is used, to a limited extent, to this day, but it was devised in 1832, long before electrical communications began to evolve into the systems that were beginning to be commonly used in the 1870s. Baudot, in particular, thought that the use of Morse code was very restricting. In 1874, he was working on the development of what we now call time-multiplex telegraphy, which allowed one telegraph line to carry several sets of messages between different sets of transmitters and receivers, with no interference between the signals. The system that he was working with was a completely mechanical one; each signal source was connected to a separate contact of a group arranged in a circle, over which a revolving contact, like the brush of a dynamo, revolved at high speed, connecting each contact in turn to the single telegraph line. The current return was through the earth, which is why we use the term "earth" to mean current return path to this day. At the receiving end, a similar arrangement was used to connect the signals from the telegraph line to the different receivers but obviously, the sytem could operate correctly only if the motors driving the rotating contacts were synchronised.

Another of the problems of using this system with Morse code was that each dash was liable to be broken up, by the action of the rotating brush, into a series of dots, on different channels; unless the speed of the brush was varied, so that it spent more time on a contact transmitting a dash than on one transmitting a dot, it inevitably scrambled the message. Many other people, at the time, were trying to synchronise the movement of the rotating brushes to the varying dots and dashes of Morse code, but Baudot came up with a completely different answer.

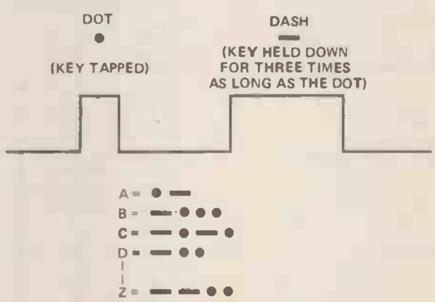

Figure 1. International Morse Code. The length of the pulse determines the meaning — dot or dash.

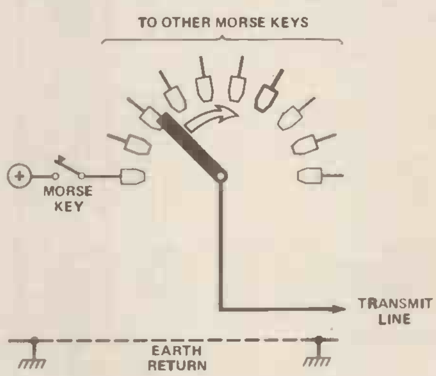

Figure 2. Early multiplex telegraphy.

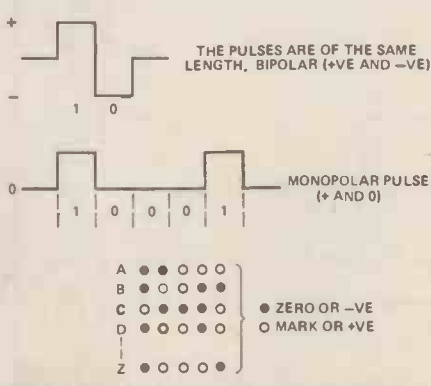

Figure 3. The modern 5-bit code. The bipolar version (top) is preferred because the difference between signal levels is easier to detect. This signal later became standardised as RS232.

Digital Codes

His approach was to use an entirely different code, one which used what we would now call digital signals — on and off — as distinct from the Morse code signals of 'long' and 'short'. The impor tant point about Baudot's signals was that they were separated by *equal* time intervals. For example, if we take the two Morse signals, R (. — .) and S (. . .), the time between the first and last dots of each letter is not the same, because the middle dash of the R takes about three times as long as the middle dot of the S. Baudot devised a new 5-digit code, using pulses and spaces of equal length, so that the time needed to transmit a five-character message was always the same. This was the breakthrough that multiplex systems needed because the speed of the rotating contact (commutator) could now be synchronised to the pulse rate of the code.

Baudot patented his five-unit code in 1874. Five digits gave a choice of 32 characters, so that the early Baudot codes allowed the transmission of the letters of the alphabet (upper case) plus a few punctuation marks and operator signals (eg, BELL), but no digits. A later version of the code used seven digits and it is this version which has evolved into the ASCII seven-bit code that is used almost universally in computers.

The Baudot code was a major step forward in telegraphy because, as well as permitting more efficient multiplexing, it also permitted the faster development of the logical accompaniment to multiplexing — mechanical methods of sending and receiving telegraph signals.

The transmitter was primitive — if the operator released the key too soon, the wrong character would be sent — but it was a step forward from manual transmission. It was soon superseded by other methods.

Baudot's equally ingenious receiver used a method that was to remain current right up to the time when fully electronic printers were developed. It can still be seen, with some modern improvements, in some Telex terminals. It all looks like a mechanical nightmare — and anyone who has tried to get an old-style teleprinter going will agree that it *is*. Baudot's work vastly improved the rate at which data could be transmitted, and the principles which he established are in use to this day, although the methods have changed — for the better! Baudot code was not entirely logical and it was improved by Don Murray in 1903, so that the modern 5-bit code and its 7-bit successor are often known as Murray-codes rather than Baudot codes. The principles, nevertheless, are those of Baudot, and a good reason for immortalising his name in the term "baud rate". HE

BUY LINE

HE Microlog

Our prototype was built into a standard Verocase, code 65-2523E, however because of the amount of drilling and marking involved, we had a chat with **Newrad Instrument Cases**, who have designed a suitable case for the Microlog. It is available from them (their address is printed elsewhere in this column) for £7.90 including VAT, p&p, complete with screen printed front panel and all holes drilled and punched. The lever switch is a Post Office type 1000.

Tape/Slide Synchronizer

There should be no problem obtaining the parts for this project; just remember that the relay is a 12V, 2-pole subminiature (ie PCB mounting) type, and choose the jack sockets to fit your sound system.

Phase Four

If your local supplier does not stock the TL064, it is always available from **Technomatic**, who also stock the 2N5457 FETs; a TL084 can be substituted for the TL064, if you are willing to accept increased battery usage. Once again, the custom case for our prototype was made by **Newrad Instruments** (see elsewhere in this column for their address).

Intruder Alarm

All the components contained on the PCB should be easy to obtain. The remainder will vary in availability according to the sort of system you envisage. However as a guide, suitable sirens can be bought from **Greenweld**.

A source for most of the other switches, mats and foils etc is Maplin.

Stereo Noise Gate

Most of the components are readily available and you should be able to get the thing working within a few hours.

The low voltage electrolytic is sold by **Greenweld**, who also stock a range of suitable cases. Other sources for a case are **Lightning** and **West Hyde**.

Big Ear

A complete list of parts for this project is available from **Bewbush Audio**, 26 Hastings Road, Pound Hill, Crawley, Sussex. The cost of the kit is £15.00, including VAT, post and packaging.

TV Amp

Newrad Instrument Cases have produced a case for our prototype, as shown in the photograph; this is available for £5.00, plus posage. **Newrad Instrument Cases** are at **Tiptoe Rd.**, Wootton, New Milton, Hants BH25 5SJ.

Hobby Electronics

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PART	CODE	UNITS	PRICE	COST

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LESS CREDIT VOUCHERS ETC.	
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VAT (15% if applicable)	
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**Delete as necessary*

Debit my *Access/*Barclaycard

My Cheque*/Postal Order*/International Money Order* for £ __________ is enclosed.

Phase Four

Paul Coster

A Four-stage audio phaser unit, based on last month's Breadboards design.

AN AUDIO PHASER is simply a circuit designed to produce a 'comb filter' (**Figure 1**). When the notches of the 'comb' are swept up and down the audio spectrum, the musical effect known as 'phasing' occurrs. One of the first times this trick was used on a recording was in 1968; the song was "Pictures of Matchstick Men" by a group called Status Quo. Another was "Itchycoo Park", by the Small Faces.

As a slightly more interesting (and relevant) diversion, it is worth mentioning that 'phasing' is not the same as a similar musical effect called 'flanging'. Flanging depends on a reasonably long time delay — as much as, oh, a millisecond or so; mixing the delayed signal with an undelayed signal also results in a comb filter, but now the notch frequencies are spaced at musical intervals — thirds, fifths, flattened ninths and so on — and the effect so produced has a more "musical" quality, so it is said. Flanging was discovered by the American record producer, Phil Spector...but that's another story!

Shifting Circuits

The HE Phase Four, however, is a phaser. It is based on the circuit of **Figure 2**, a single stage phase shifter producing 90° of phase shift from input to output.

At zero frequency (DC), the input to the non-inverting pin of the op-amp is blocked by the capacitor, C1, so the circuit acts as an inverter with a gain of one; this, of course, is equivalent to a phase shift of 180°. At very high frequencies, though, the capacitor becomes a short circuit and so the op-amp becomes a non-inverting amplifier, still with a gain of one; the phase shift now is 0°.

But at some intermediate frequency, set by the time constant (RC) of the high-pass filter network on the non-inverting input, the phase shift will be exactly 90°; the gain is still one! Essentially, the op-amp is buffering the phase-shift produced by the high-pass network of C1 and R3, maintaining a constant gain of one.

If two of these units are cascaded — the input signal passing through one, then the other — the total phase shift will be 180° at the frequency set by the RC time constant, and if the phase-shifted signal is then added to an un-

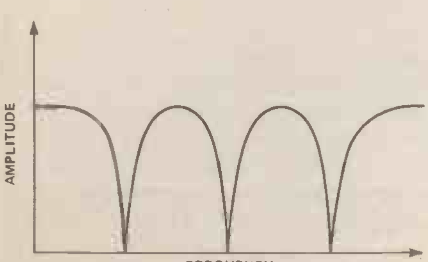


Figure 1. A comb filter forms a series of notches in the frequency response curve.

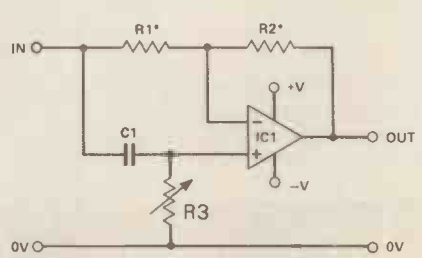


Figure 2. The basic phase shifting circuit.

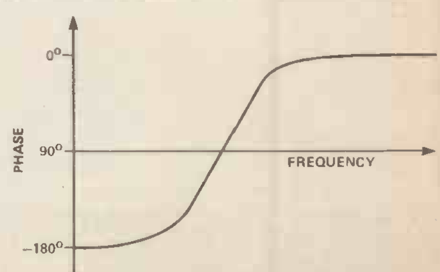


Figure 3. The frequency-phase response of the circuit in Figure 2. The crossover point is set by the values of R3 and C1.

shifted signal, the result will be a notch in the response, at the specified frequency.

In fact, there are easier ways to produce a notch filter. The reason why this circuit is used so often for phasing units is because it is quite easy to change the position of the notch. At its simplest, this is done by varying R3, thus changing the time constant which determines the corner frequency (the two are really equivalent). In a manually operated phaser, this would be achieved by using a potentiometer in place of R3 and varying it, by means of a foot pedal or something similar, to produce a manual sweep (ie, movement of the notch, up and down the response band).

It is just as easy to produce an automatic sweep; Figure 4 also shows a FET transistor connected across R3; by varying the voltage to the gate of the FET, its resistance can be changed from a few hundred ohms to around a few hundred megohms. All we need now is a way of producing a varying voltage to control the resistance of the FET, and a summing amplifier to combine the phase-shifted and unshifted outputs.

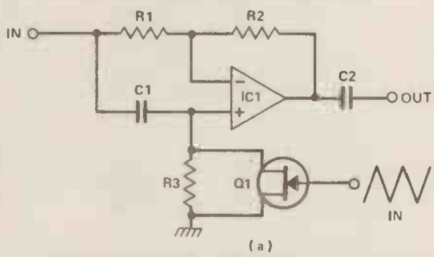


Figure 4. By putting an FET in parallel with R3, the effective resistance can be varied over a wide range.

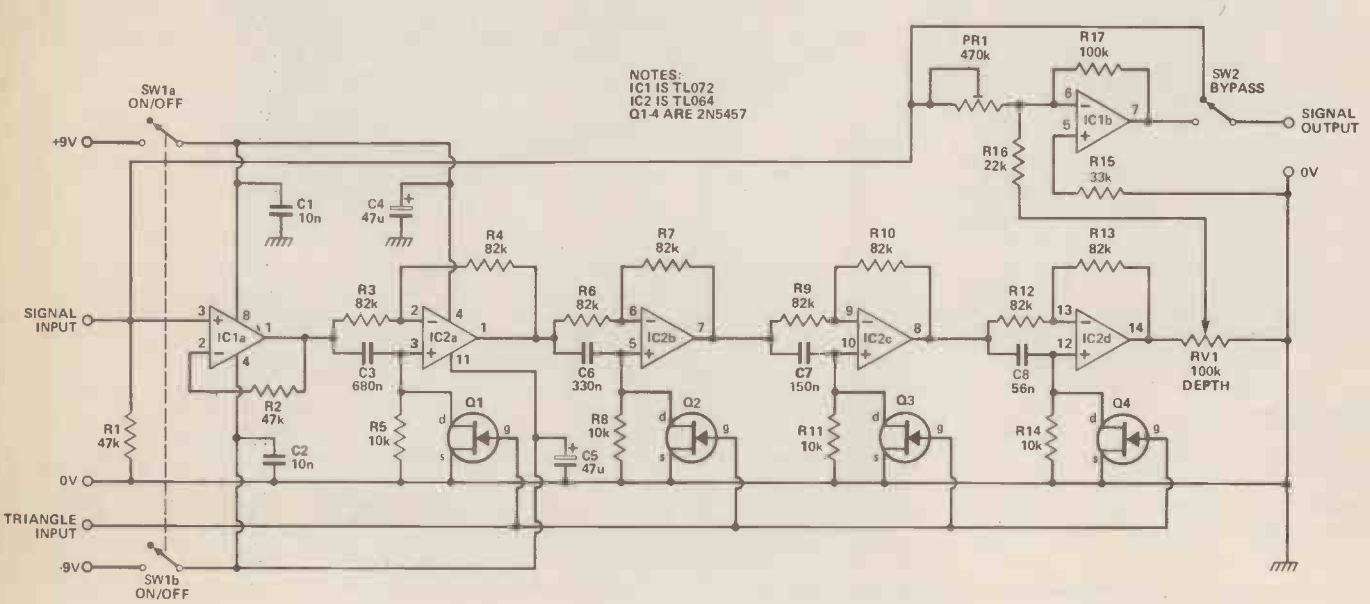
Phase Four

All these elements are brought together in the HE Phase Four circuit, shown in Figure 5. It uses four stages to produce a total phase difference of 360° between input and output, producing two notchs in the response.

The input to the unit is buffered by a unity gain stage, IC1a; the IC used in this position was chosen for its low noise specification. The phase shifters use all sections of a quad op-amp package, IC2 (elected for low power consumption).

The values of C3,6,7,8 are chosen somewhat arbitrarily, but they will affect the total quality of the output. Capacitors C1,2,4 and 5 are to decouple the supply rails, eliminating high frequency spikes from the output.

The phase shifted signal is fed to a standard virtual earth mixer. The amount of shifted signal added to the output is set by the depth control, RV1, which determines depth of the notches. A switch is also included which allows the effect to be bypassed; PR1 is used to adjust the output so that the gain is



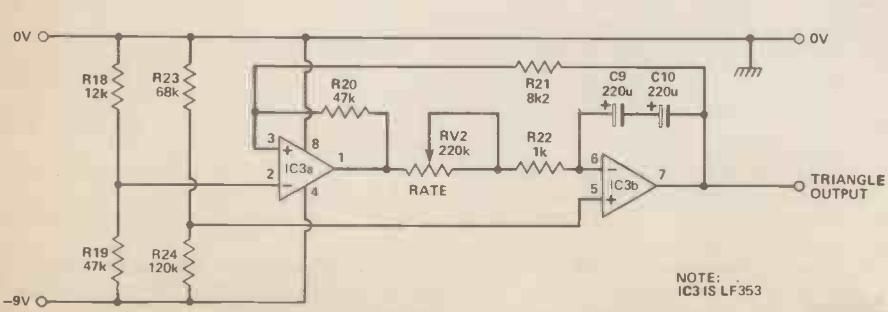


Figure 5. The Phase Four circuit consists of an input buffer (IC1a), four stages of phase shift (IC2), and an output buffer (IC1b). The triangle wave generator (left) drives the FET gates and consists of a square wave generator (IC3a) and an integrator (IC3b).

Parts List

RESISTORS
(All ¼ watt, 5% carbon)
R1,2,19,20 . . . . 47k
R3,4,6,7,9,10,11,12 . . . . . . 82k
R5,8,11,14 . . . . 10k
R15 . . . . 33k
R16 . . . . 22k
R17 . . . . 100k
R18 . . . . 12k
R21 . . . . 8k2
R22 . . . . 1k
R23 . . . . 68k
R24 . . . . 120k

POTENTIOMETERS
PR1 . . . . 470k
horiz. carbon preset
RV1 . . . . 100k
log carbon
RV2 . . . . 220k
log carbon

CAPACITORS
(All metallised polycarbonate, unless noted)
C1,2 . . . . 10n
ceramic disc
C3 . . . . 680n
C4,5 . . . . 47u
16V radio electro
C6 . . . . 330n
C7 . . . . 150n
C8 . . . . 56n
C9,10 . . . . 220u
16V radio electro

SEMICONDUCTORS
IC1 . . . . TL072
dual BIFET op-amp
IC2 . . . . TL064
quad BIFET op-amp
IC3 . . . . LF353
dual J-FET op-amp
Q1-4 . . . . 2N5457
N-Channel FET

MISCELLANEOUS
SW1 . . . . DPDT
min. toggle
SW2 . . . . SPST
footswitch
2 × ¼" jack sockets; 2 × PP3 battery clips; 2 × 8 pin, 1 × 14 pin DIL sockets; 2 × knobs; case (see Buylines); PCB; solder, wire etc.

BUYLINES . . . . **page 34**

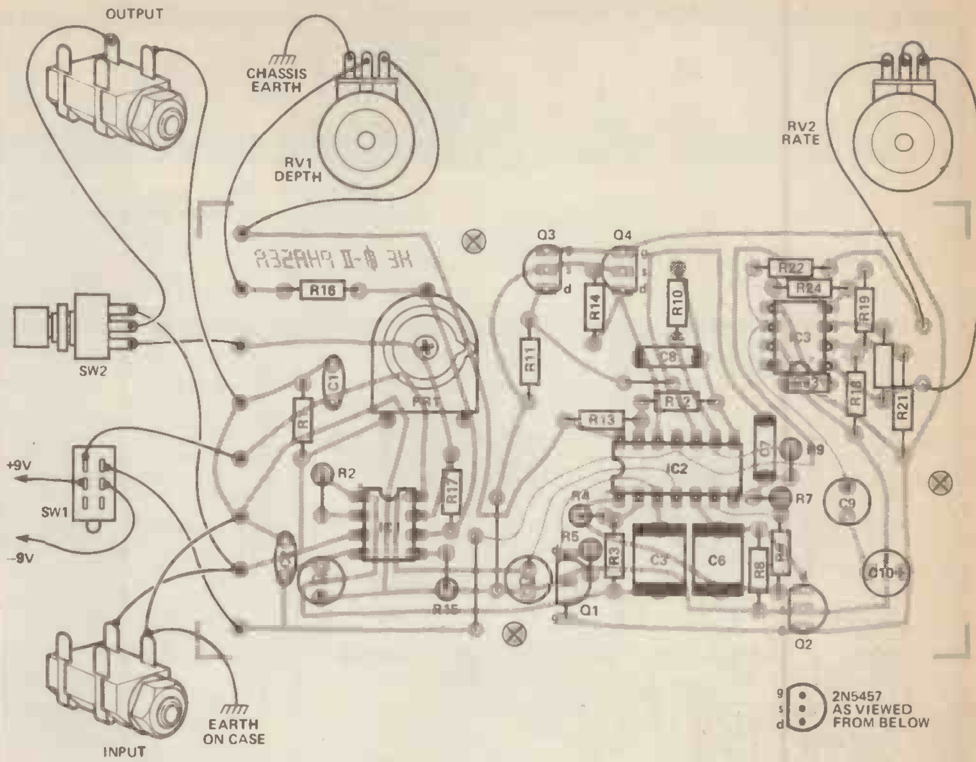
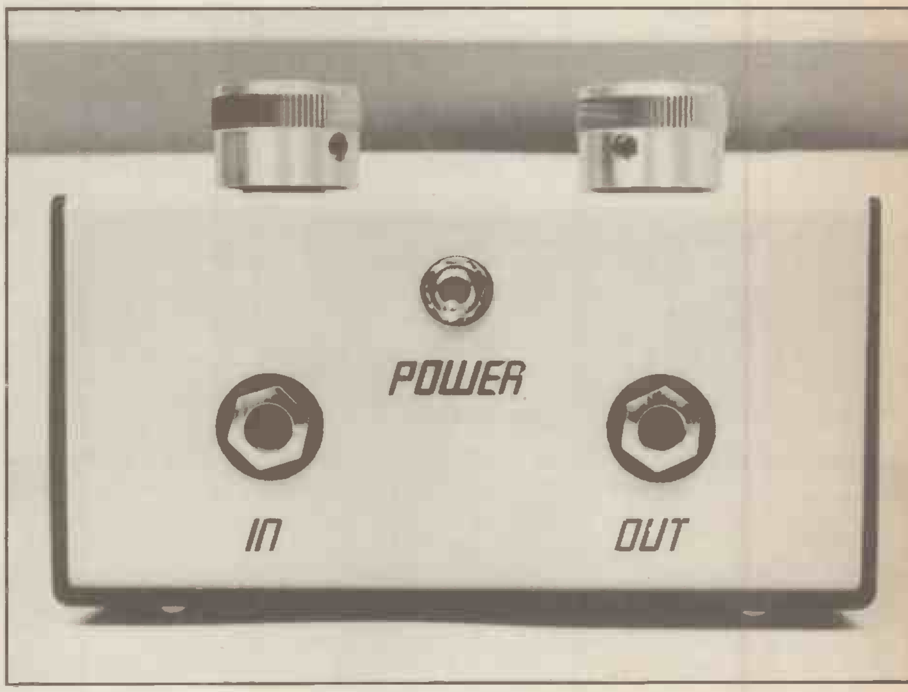


Figure 6. The PCB component overlay.



the same in either case.

The voltage sweep for the FETs is produced by ICs 3a,b, and LF353. The two op-amps are configured as a triangle-wave generator; in fact the sweep could be controlled by any slowly varying cyclic waveform, such as a sine wave or sawtooth, but the triangle shape works best in this application.

The circuit works in two stages: IC3a produces a square wave output and this is integrated by 3b to give the triangle shape. RV2 controls the frequency, ie the sweep rate, between the limits of about 0.1 and 10 Hz, with the values chosen. The values of C9 and C10 are not critical, but they must be connected as shown, to form a simulated bi-polar capacitor.

Construction

Assembly of this project is not particularly difficult; simply follow the component overlay (Figure 6), taking care that the ICs and electrolytic capacitors are correctly positioned. One point to note is that RV2, a potentiometer with a logarithmic characteristic, must be connected the right way round; otherwise, the variation in sweep speed will all come at one end of the rotation.

The ideal case for the Phase Four is the custom built job supplied by Newrad Instruments (see Buylines for details), though any case large enough to contain the PCB and batteries would do; it depends on how heavy-footed you are!

The only adjustment required is to set PR1 so that the gain through the phaser is the same as in the 'bypassed' condition. Simply set the depth control for minimum and adjust PR1, switching between effect and bypass, until the levels sound equal. **HE**

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AL30A 7-10 watt Audio Amp. Module 22-32v supply

£4.16.

AUDIO AMPLIFIERS

15-25-35 watts (RMS)

AL60 15-25 watt Audio Amp Module 30-50v supply £5.15.

AL80 35 watt Audio Amp Module £8.07

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Audio Amplifier, 50W R.M.S., with integral heat sink and short circuit protection.

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125 watts (RMS), AL250.

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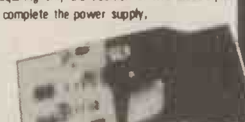
SPM120 is a fixed voltage stabiliser with an output voltage of either 45v, 55v, or 65v. Designed for use in audio applications, the stabiliser which provides output currents up to 2.5A operates direct from a mains transformer requiring only the addition of two Electrolytic capacitors to complete the power supply.



STEREO PRE-AMPLIFIERS

PA12 Supply voltage 22-32v input sensitivity 300mv Suit: AL10/AL20/AL30 £8.55. PA100 Supply voltage 30-55v inputs. Tape Tuner Mag P.U. Suit: AL60/AL80 £17.65. PA200 Supply voltage 35-70v inputs. Tape Tuner Mag P.U. Suit: AL80/AL120/AL250 £18.24.

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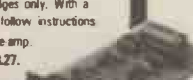
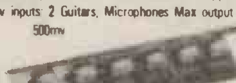


MONO PRE-AMPLIFIERS

MM100 suitable for disco mixer. MM100G suitable for guitar pre-amp mixer.

The MM100 and MM100G mono pre-amplifiers are compatible with the AL60, AL80 AL120 and AL250 power amplifiers and their associated power supplies. MM100 Supply voltage 40-65v inputs. Tape Mag P.U. Microphone Max output 500mv £12.43. MM100G Supply voltage 40-65v inputs. 2 Guitars, Microphones Max output 500mv



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10 Channel, Monographic Equaliser.

Only 155mm x 65mm x 50mm including the 10 x 10K 45mm slider potentiometers and knobs which are mounted on a board above the circuitry. In the range of 31Hz to 16KHz you can cut and boost ±12dB with the 10 sliders each with frequency marked on the circuit board. The GE100 uses include mixers, P.A. systems and discos. It will also improve the sound reproduction of your existing audio equipment. Power supply for GE100 old SG30. Together with Transformer no: 2043.

GE100 MKII 10 Channel mono-graphic Equaliser with sliders & Knobs £20.00.

PUSH BUTTON STEREO FM TUNER

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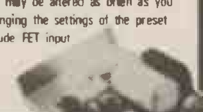
S453 Provides instant programme selection at the touch of a button ensuring accurate tuning of 4 pre-selected stations, any of which may be altered as often as you choose, simply by changing the settings of the preset controls. Features include FET input stage, Vari-cap diode tuning.

£19.00.



Transformers are not included with power supplies. SPM120 Range also require reservoir and output capacitors

TRANSFORMERS

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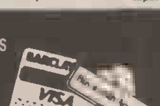

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Single Sideband

IF you think back to amplitude modulation again, you may remember that business of sidebands. When a carrier is amplitude modulated, the output signal contains the carrier frequency and both sets of sidebands (sum and difference), all requiring power at the PA stage to transmit. All the information of the audio signal is carried in one sideband, however (either one), and none by the carrier, so that this well-worn double-sideband scheme is very wasteful of transmitter power. The solution is to use only one sideband, eliminating the other sideband and most of the carrier. This system is called single-sideband-suppressed-carrier, usually abbreviated to SSB, though this could also refer to systems that eliminate one sideband but retain most of the carrier.

Starting with transmitters this time, how do we achieve these two aims of removing one sideband and most of the carrier? Once again, there are several methods, but the most popular one consists of using a balanced modulator to remove the carrier, and filtering to remove the unwanted sideband. A balanced modulator is a circuit to which both carrier and audio signal can be applied. If there is no audio signal, then there is no output from the circuit, but adding an audio signal spoils the balance of the circuit and the sidebands of the modulated carrier form the output. There is very little trace of the carrier frequency in the output.

A simple type of balanced modulator is illustrated in Figure 1. This is a bridge or ring modulator and its action depends on the use of the audio signal to bias a set of diodes into conduction. Imagine that there is no audio signal, so that the audio input to the diode bridge at A is at earth voltage as far as signals are concerned. The carrier signal is injected at a point where the voltage lies exactly between the bridge outputs, so that the carrier signals to the transformer primary ends are in phase. In this condition, there is no output.

Now imagine that an audio signal is applied and that the audio voltage has reached its positive peak. Diodes D1, D2 will conduct when the carrier voltage is zero, putting a bias voltage onto the output line, at X. Now the carriér signal is no longer balanced because, when the carrier has its negative peak at X and its positive peak at Y, the diodes D1, D4 will conduct *carrier* signal, and D2, D3 will not conduct. This will cause some out-of-phase carrier signal to reach the transformer. The situation reverses when the audio signal at A goes to its negative peak. Now diodes D4,D3 conduct when the carrier voltage is zero, but when the carrier wave is positive at Y, negative at X, then D1, D4 don't conduct but D1, D2, D3 do, producing a signal to the transformer again. These signals to the transformer are of sidebands only because no carrier can pass, by itself.

The circuit works well, but needs carefull setting up. An alternative is to use a balanced-modulator IC – the Motorola MC1496G is an old favourite for this task. Even so, these methods can never totally remove all traces of carrier, but suppression of 30 to 50 db can be easily achieved.

The next part of single sideband modulation is the filtering system which removes one sideband. Unless you can test and adjust crystal filters, the filter units just have to be bought — these can be quartz crystal types or surface wave types. The filter characteristic can be arranged so that it contributes to the suppression of the carrier, as well as removing the unwanted sideband.

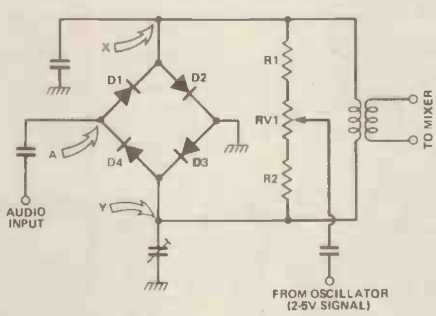


Figure 1. A bridge or Ring Modulator, which eliminates the carrier frequency from the output, is the first and most important stage in SSB transmission.

The combination of balanced modulator and filter is the complete single-sideband generator. The whole system can be designed around a low carrier frequency — 455 kHz is a favourite — or at high frequencies such as 9 MHz — the choice is fixed by the availability of commercially-built filters. You don't, of course, transmit at either of these frequencies. To reach the actual transmitting frequency, you would normally think of using multiplier stages, but this step is taboo with SSB transmitter circuits because multiplying up the carrier frequency means multiplying up the bandwidth of the sidebands. The alternative is 'frequency mixing', using another mixer stage to obtain a signal which is the sum of the modulated frequency and another crystal-controlled frequency.

Once the correct frequency has been reached (and several mixings may be needed, particularly if the original modulation was at 455 kHz and the final frequency is VHF), power amplification must use Class A or Class B circuits rather than Class C, to avoid distortion. This will make the efficiency of the output stage lower, but the effective power of the modulated signal, as compared to a double-sideband signal with full carrier is so much greater that the loss is acceptable. As a guide, if we assume that the output stage is 66.7% efficient (meaning that 2/3 of the DC power fed to the output stage causes useful output), then the maximum allowed DC power of 150 W will cause an RF power of 100 W. This is all useful power however, so that the way in which we measure SSB power is in terms of what is called "peak envelope power", which is four times the actual output power (100 W in this example). This is an approximation, but it implies that the SSB signal is equivalent in transmitted power to a conventional AM signal of four times its output power.

Problems, problems

Problems start when we want to receive a SSB signal. To start with, the demodulator must be a balanced type, operating like the modulator in reverse, and it has to be fed with a carrier signal of the correct frequency and phase. This is most easily arranged if transmitter and receiver share the same oscillator in the form of a transceiver, as the oscillator section of the transmitter can then provide a signal of exactly the correct frequency and phase to the demodulator. However, all of this makes a single-sideband rig a very complicated piece of goods, particularly if it is to be used at several frequencies, because there is a convention that the lower sideband is used at frequencies below 10 MHz while the upper sideband is used at frequencies above 10 MHz. Not many readers are likely to get involved in SSB as a do-it-yourself project! It's advantages, however, make impressive reading, and even more impressive listening. To start with, the bandwidth of the SSB signal is the same as that of the audio signal, no more. This means that a lot more SSB rigs can use a band than conventional AM rigs. There is also a gain in range, because all of the output power of the SSB transmitter is concentrated on the one sideband which the receiver uses. In addition, SSB is much less liable to atmospheric disturbance effects, such as fading and blasting, than conventional AM or even FM. The advantages of SSB can be increased by using speech-processing units which ensure that the modulation is always near the upper limit while you are speaking. SSB rigs of good quality are never cheap, but they represent just about the optimum in modern radio communications and a dream for every amateur licence holder to aspire to.

Due to space limitations in the November issue, this portion of Radio Rules was held over till December.

Next month we will back-track to examine AM Receivers.

HE

COMPONENTS FOR COMPUTING

This is the first of a series of articles in which the components of microcomputer systems will be discussed. We will investigate the many aspects of each type of component, including general functions and areas of application, internal circuit operation, external circuits and the range of products on the market.

WE WILL START by describing Input/Output (I/O) port components. This may not seem entirely logical, but it follows from our Micro-Trainer series of earlier this year. Consequently, in this issue alone, there will be specific references to the Micro-Trainer when the programming of I/O ports is considered.

What Is An I/O Port?

A port, whether input or output, is a device that interfaces between the 'raw' hardware of a computer's central processing unit (CPU) and the external machinery of a control system. In its simplest form , a port consists of a data latch or register connected to the three busses (address, data and control) of the CPU. The diagram of **Figure 1** shows an eight bit output port and an eight bit input port connected to a simple microprocessor system. The ports have an eight bit capacity simply because the microprocessor has an eight bit data bus, and can therefore transfer data eight bits at a time!

The output port has eight inputs connected to the data bus and eight separate outputs for connection to external circuits, and a strobe. The outputs follow the logic states of the inputs for as long as the strobe input is high; however when the strobe is taken low, the data at the outputs is frozen or 'latched' indefinitely. An IC of this sort is called an 'Octal Transparent Latch'', and a 74LS373 is a typical example using TTL Technology in the microprocessor system of **Figure 1**, the strobe is derived from the $\overline{WR}$ signal of the control bus and the decoded address bus. Data will be latched into the port only when the MPU attempts to write to a specific address, as determined by the address-decode logic. This configuration is called "Memory-Mapped I/O" because the port appears to the MPU as a single byte of memory, in this case a write-only memory location. Using simple 'store' instructions, the MPU is able to control the state of eight logical outputs, each of which can be interfaced to anything from a LED to a large industrial machine, using no more than a few transistors and relays.

The input port, as shown in **Figure 1**, is also an octal latch but this time the outputs are wired to the data bus and the inputs are taken from the external circuit. For an input port, the latch must have (like the 74LS373) a control which can 'tri-state' the outputs to the data bus; this means that the outputs can go to a high impedance state, and thus have no effect upon the data bus when it is being used by other devices, such as RAM or ROM. The output control signal is decoded from the address bus and the $\overline{RD}$ signal so as to 'map' the port to the desired memory location. The strobe to an input latch is not synchronised with the MPU as with the output port; it has to be provided by the external circuit to synchronise with incoming data. In certain applications (A/D conversion being the best example) the data presented to the MPU's input port may not be valid (true) at all times, which explains the reason for an external synchronising pulse.

However, the MPU is often required

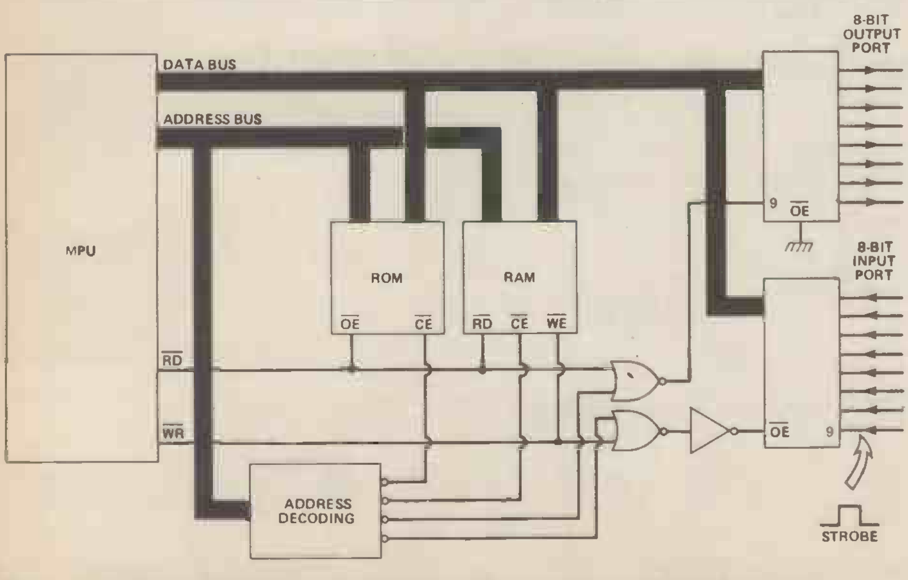


Figure 1. A simple microprocessor system with one output and one input port.

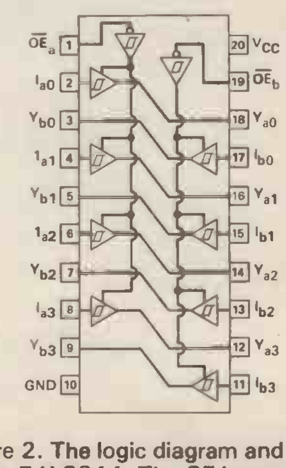


Figure 2. The logic diagram and pin outs of the 74LS244. The OE inputs latch the outputs to the high impedence (off) state.

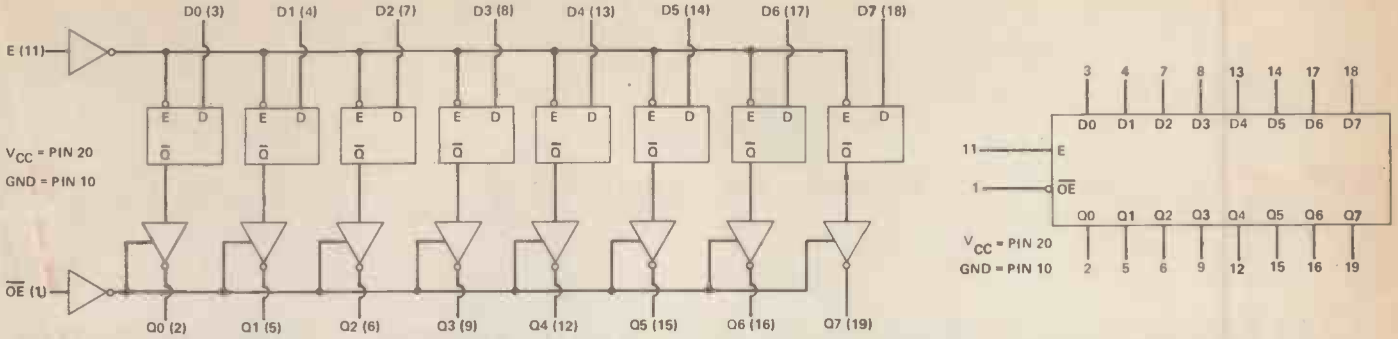


Figure 3. The logic diagram (above) and pin-outs (right) of the 74LS373. Data is latched by taking the E input low; a high on the OE input forces the outputs to the high impedance state.

only to sample the inputs periodically (if, for example, they connect to a set of logically independent switches) and in this case, latching of data is unnecessary; an "Octal Tri-State Buffer" (such as a 74LS244) will then be sufficient as an input port.

Memory mapped I/O is a system which can be readily applied to any microprocessor; yet there is a common alternative which is worth mentioning. "I/O Mapping" is a system which is unique for each type of microprocessor (some simply do not have the facility, eg. the 6800 and the 6502) because it requires specific sets of hardware and instructions. The 1802 has a three-bit address bus, separate from the normal address bus, which can be decoded to provide 'enables' for up to seven I/O devices; these addresses are generated only in response to special instructions (INP1 - INP7, OUT1 - OUT7).

Other processors (eg. the Z80 and many other Intel products) place I/O addresses (0-255) on the usual address bus and have a separate control line to indicate whether the instruction is to be executed on memory or on I/O.

I/O ports can easily be constructed from a few TTL chips, however the manufacturers of all microprocessor types offer more 'clever' devices designed for flexibility in applications, in a single low cost package, with each device type intended for a particular microprocessor. Most of these contain several ports within a chip, and can be programmed to behave either as input or output devices; many have other interesting facilities, as we shall see.

The 8255

It is impossible, in these few pages, to describe every I/O device on the market so we shall concentrate on just one — the 8255. This device is intended to interface with the Intel 8080 and 8085 family of microprocessors; however, it can be used readily with the Z80 and, of course, the 1802, as in the Micro-Trainer. It is one of the most versatile PPIs (Programmable Peripheral Interface) available and has recently become very inexpensive.

Referring to the block diagram of Figure 4 and the pin diagram of Figure 5, you will see that the 8255 has three eight-bit ports within a 40 pin package. Port A (PA0-PA7) and Port B (PB0-PB7) can be separately programmed as either input or output, while Port C is logically divided into individually programmed upper (PC4-PC7) and lower (PC0-PC3) portions.

The 8255 possesses all the necessary signal inputs to interface directly to the CPU. Signals D0-D7 connect directly onto the data bus, for bi-directional transfer of data between CPU and the ports and, likewise, the signals $\overline{RD}$ and $\overline{WR}$ connect directly to the corresponding signal lines of the CPU. The control signal $\overline{CS}$ (Chip Select) is used to allow the CPU to use the 8255. For example, if $\overline{CS}$ is provided with a logic low, decoded from the address bus (the Micro-Trainer uses an address in the range 2000H to 2003H) the device will be 'enabled'.

The signals A0 and A1, the two least significant bits (LSBs) of the address bus, will select one of the four internal registers, according to the address; three of these registers are, obviously, the ports A, B and C, while the fourth is a control register used for programming the device. These addresses (summaris-

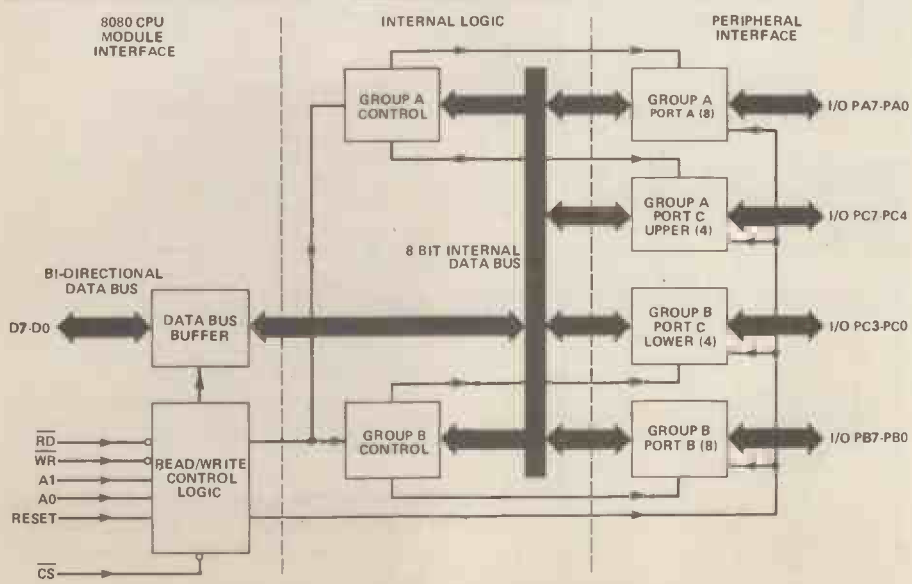
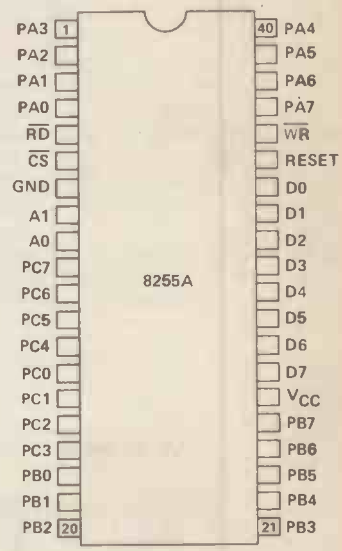


Figure 4. The logic diagram of the 8255 PPI; the ports are split into two groups for control purposes.



PIN NAMES

D7-D0	DATA BUS (BI-DIRECTIONAL)
RESET	RESET INPUT
$\overline{CS}$	CHIP SELECT
$\overline{RD}$	READ INPUT
$\overline{WR}$	WRITE INPUT
A0,A1	PORT ADDRESS
PA7-PA0	PORT A (BIT)
PB7-PB0	PORT B (BIT)
PC7-PC0	PORT C (BIT)
V_{CC}	+5 VOLTS
GND	0 VOLTS

Figure 5. The pin-outs of the 8255 (top) and their meaning (bottom).

A		B		GROUP A			GROUP B	
D4	D3	D1	D0	PORT A	PORT C (UPPER)	#	PORT B	PORT C (LOWER)
0	0	0	0	OUTPUT	OUTPUT	0	OUTPUT	OUTPUT
0	0	0	1	OUTPUT	OUTPUT	1	OUTPUT	INPUT
0	0	1	0	OUTPUT	OUTPUT	2	INPUT	OUTPUT
0	0	1	1	OUTPUT	OUTPUT	3	INPUT	INPUT
0	1	0	0	OUTPUT	INPUT	4	OUTPUT	OUTPUT
0	1	0	1	OUTPUT	INPUT	5	OUTPUT	INPUT
0	1	1	0	OUTPUT	INPUT	6	INPUT	OUTPUT
0	1	1	1	OUTPUT	INPUT	7	INPUT	INPUT
1	0	0	0	INPUT	OUTPUT	8	OUTPUT	OUTPUT
1	0	0	1	INPUT	OUTPUT	9	OUTPUT	INPUT
1	0	1	0	INPUT	OUTPUT	10	INPUT	OUTPUT
1	0	1	1	INPUT	OUTPUT	11	INPUT	INPUT
1	1	0	0	INPUT	INPUT	12	OUTPUT	OUTPUT
1	1	0	1	INPUT	INPUT	13	OUTPUT	INPUT
1	1	1	0	INPUT	INPUT	14	INPUT	OUTPUT
1	1	1	1	INPUT	INPUT	15	INPUT	INPUT

A1	A0	$\overline{RD}$	$\overline{WR}$	$\overline{CS}$	INPUT OPERATION (READ)
0	0	0	1	0	PORT A = DATA BUS
0	1	0	1	0	PORT B = DATA BUS
1	0	0	1	0	PORT C = DATA BUS
					OUTPUT OPERATION (WRITE)
0	0	1	0	0	DATA BUS = PORT A
0	1	1	0	0	DATA BUS = PORT B
1	0	1	0	0	DATA BUS = PORT C
1	1	1	0	0	DATA BUS = CONTROL
					DISABLE FUNCTION
X	X	X	X	1	DATA BUS = 3–STATE
1	1	0	1	0	ILLEGAL CONDITION
X	X	1	1	0	DATA BUS = 3–STATE

X = DON'T CARE

Table 1 (right). The ports can be set up in any of 16 different ways.

Table 2 (above). Ports are addressed, as appropriate under program control. A WRite instruction to a port set up for Input will be ignored.

ed in Table 3) are used in the Micro-Trainer to access the 8255.

In order to write data to a port, it is simply a matter of executing an 'STR' instruction to the appropriate address, eg:

```
LDI $20   PHI R3
LDI $01   PLO R3; R3 is pointer to
          Port B
LDI $0F   STR (R3); data $0F ap-
          pears on PB0-PB7
```

Data which has previously been written to an output port can also be read back from the same address — a feature which is not possible with the system of **Figure 1**.

We have not, so far, discussed how the ports are programmed — but there are no prizes for guessing that the control register is used for this. All the programming information is illustrated in **Figures 7 and 8**, but some explanation is also required.

A1	A0	MICROTRAINER ADDRESS	REGISTER ENABLE
0	0	2000H	PORT A
0	1	2001H	PORT B
1	0	2002H	PORT C
1	1	2003H	CONTROL

Table 3. The Micro-Trainer I/O addresses.

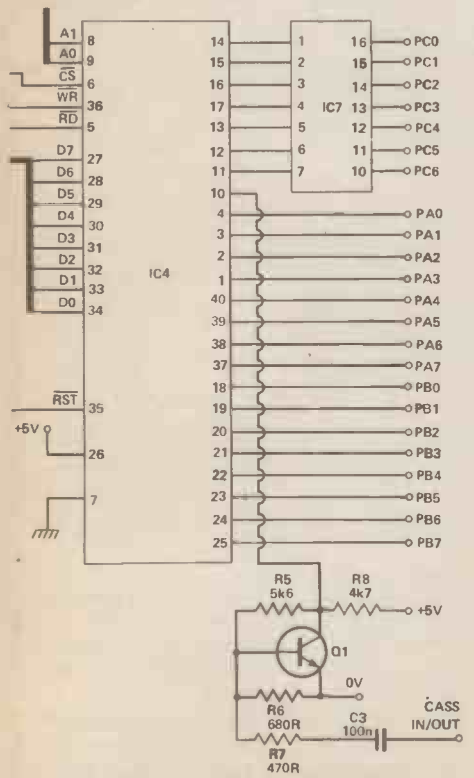


Figure 6. The I/O Port circuits of the Micro-Trainer; IC4 is an 8255.

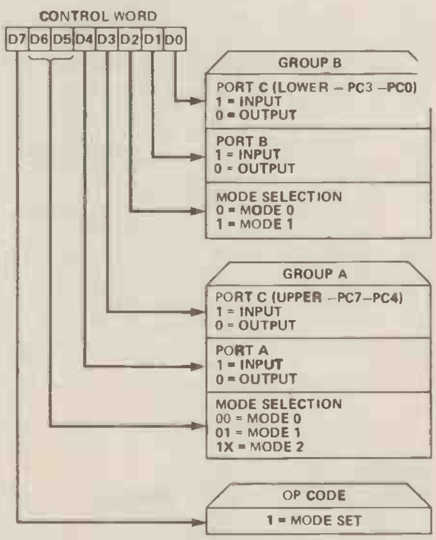


Figure 7. The mode control word can be constructed from this diagram.

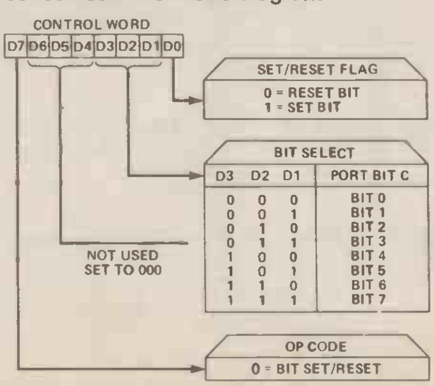


Figure 8. Deriving the control word to set or reset bits of Port C.

The first step is to decide how the ports are to be configured (output or input) then, using the two diagrams, work aout a control word on a bit by bit basis. You may be confused by the references to Modes 0, 1 and 2; just assume these bits are set to zeroes. Our description of the 8255's operation are all in Mode 0; the other modes configure certain bits of Port C as 'handshake' lines and as this facility is little used we will not discuss it here!

As an example, suppose we require PA0-PA7 as outputs, PC0-PC3 as outputs and PB0-7, PC4-PC7 all as inputs. **Figure 7** tells us that the required data is 10001010 = 8AH so, simply by storing 8AH in the control register, our ports are set up as required. The contents of the control register may not be read back by the CPU. It is also well worth noting that each time a port is configured as an output, the contents are reset to zero.

During power-up, or reset of the MPU, it is normal to reset the 8255 also, using the hardware line RESET (pin 35). When this happens, all ports are configured as inputs in Mode 0, so that the machine's software must initialise the control register, as required, after reset. **Figure 8**, shows how Port C an be conveniently operated on bit by bit, when programmed as an output. Here, by storing the appopriate data in the control register, a single line of Port C may be set or reset. As an example, again, PC7 has been interfaced to a transistor (**Figure 6**).

This forms the cassette interface for the Micro-Trainer. It is controlled by a routine in ROM which recognises a LOAD or SAVE instruction, configures Port C (upper) as required, and then toggles bit 7 to transfer the data.

The other seven bits of Port C are all configured as outputs, buffered by a ULN2003 (IC7 in **Figure 6**), which provides open collector outputs suitable for driving LEDs, relays etc. Each output can sink up to 500mA.

Next month's installment will investigate the hidden depths of memory — RAMs, ROMs, and the multivariate degrees of PROMs.

HE

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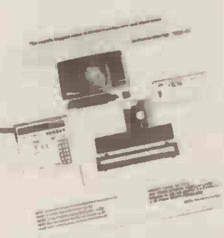

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CPS 80	Power Supply	22.82	3.42	26.24	2.10
CPS 80D	Dual Power Supply	27.63	4.14	31.77	2.25
CPS 150	Power Supply	25.86	3.88	29.74	2.50
CPS 150D	Dual Power Supply	31.65	4.75	36.40	2.60
CPS 250	Power Supply	32.03	4.80	36.83	3.50
CPS 250D	Dual Power Supply	39.43	5.91	45.34	3.65
TS 70	Thermal Switch 70°C	1.92	0.29	2.21	0.02
HS 50	50mm Heatsink	1.60	0.24	1.84	0.15
HS 100	100mm Heatsink	2.60	0.39	2.99	0.30
HS 150	150mm Heatsink	3.65	0.55	4.20	0.45
FM 1	Fan Mounted on 2 × HS 100	32.13	4.82	36.95	1.20
FM 2	Fan Mounted on 2 × HS 150	36.10	5.42	41.52	1.50
CPR 1X	Pre-Amplifier Module	31.30	4.70	36.00	0.15
MC 2	Moving Coil Pre-Pre-Amplifier Module	20.00	3.00	23.00	0.07
REG 1	Regulated Power Supply	8.09	1.21	9.30	0.07
TR 6	6VA Mains Transformer	2.87	0.43	3.30	0.21
XO 2	2 Way Crossover Module	17.39	2.61	20.00	0.07
XO 3	3 Way Crossover Module	26.09	3.91	30.00	0.07
MU 1	Muting Circuit for XO 2 or XO 3	8.35	1.25	9.60	0.04
CK 1010	Complete Pre-Amplifier Kit	78.26	11.74	90.00	2.50
CK 1040	Complete 40 Watt Power Amplifier Kit	103.48	15.52	119.00	7.30
CK 1100	Complete 100 Watt Power Amplifier Kit	129.56	19.44	149.00	7.30
MC 2K	Add On Moving Coil Kit	21.74	3.26	25.00	0.12
PSK	Pre-Amplifier Power Supply Kit	17.39	2.61	20.00	0.75

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Clever Dick

A blast from the past . . . .

This seems to be a year for revivals — musicals in the West End, old pop songs from the 50s and 60s reappearing in the Charts, and now . . .

Dear Clever Dick,
I have "Experimenter" and "S-Dec" boards and I am wondering if you could devise projects for these for future editions of HE. I find it very difficult to get anything suitable.
P. Siddi,
Porthcawl,
Mid-Glam.

. . . . "Short Circuits" have been brought back, in the shape of a new page called "Breadboards". Although these experimenter's circuits have been laid out and tested using Vero's Verobloc system, they can easily be adapted to any other breadboarding system.

Dear CD,
I have one short question; is there any errors in the shortwave Receivers veroboard diagram etc?
T Chapman
Fareham
Hants

'Is there any errors' . . . it's enough to make you ask : is good grammar a thing of the past? Another question, which might be pertinent; which short wave receiver do you mean—we have published at least three?

However, passing over such minor considerations (it only took four times longer to sort things out), the receiver in question is probably that featured in September '81 issue. There were three errors discovered at the time; missing track cuts at F17 and G17, a missing link (not the . . . no it couldn't be) between F12 and G12 and no markings on D1—the cathode should go to F7.

Dear CD,
I am eleven years old, and have been alarmed to find a mistake on the "Intruder Confuser". Capacitor (Cl) has been connected (not across) but in the same direction as the copper strips and there is no break between the two terminals. Also (according to the schemetic diagram) the integrated circuit has been connected the wrong way round, there is also another problem . . . . I have, nowhere to store my Hobby Electronics magazine Yours Faithfully,
R Einstein
Ipswich
Suffolk

(hint, hint). Life isn't all problems though, because I think your magazine's great

Correct on both points—though the issue was raised in a previous HE (June '82, I think). As for the mag, I also think it's great too (especially this page), but then I am a little biased!

Dear CD,
I DO NOT WANT A BINDER!!!
I would, however, like to pick your amazingly intelligent brain. Way back in January '79, HE published a Touch Switch project. I find it works fine if the OV level is connected to the mains earth, but if I try to run it off batteries (as you recommended, all those years ago) the operation becomes sporadic and unreliable.

So far as I can make out, the signal input level drops dramatically under certain conditions, depending on my posture (keep your remarks to yourself!).

Please could you suggest a circuit mod or, failing this, are there any ICs which I could use, preferably with several switches on one chip?

I am designing a piece of equipment for use by small children so that a single touch-control switch is important, as, of course is the electrical safety.
Guy Inchbald,
Burnage,
Manchester.

The circuit is intended to be triggered by the 50 Hz hum voltage which we all carry around with us — effectively, the body acts as an antenna. Touching the contact transfers the voltage to the input of IC1, which amplifies it enormously. This is rectified by a diode and the resultant DC is used to switch another op-amp from low to high, thus turning on a LED, relay or whatever. Note, too, that this circuit does not latch up; it will turn off shortly after the finger is removed.

The unreliable operation is probably because the 50 Hz signal is being coupled to all parts of the circuit, (remember that a battery is a short circuit for AC, even at 50 Hz), so that the input op-amp is seeing similar 50 Hz voltages on both its inverting and non-inverting inputs. The easiest way to solve the problem is to physically isolate the touch plate from the circuitry; metal shielding may even be necessary. Alternatively, you could try increasing the sensitivity by increasing the gain of IC1; reduce R2 by stages until you find a value where the operation becomes reliable. However, you may find that the circuit becomes unstable if R2 is taken too low.

Dear Richard,
I have had the HE watch dog intruder Alarm (Oct 80) working on a test basis for some months. But have found that it is triggered by an external source/s.

A 3 foot instant start fluorescent fitting and a portable TV that I know of, have, when switched off, bought on LED2 showing a short.

I don't know what electrical appliances my neighbours have but it has happened when I have only had a fridge working. Its only occasionally this happens, and after 2200 hrs, or the early hours of the morning.

The PB1 doesn't cancell LED2 and RV1 has to be re-adjusted to cancel it then adjusted back to its normal position, which may take five minutes or more of adjusting. The circuit board (its not a printed circuit, they were not available) is mounted in a metal box and the box is bonded to earth. The only alteration to the circuit is in the window, where the 22k resistor has been changed to 56k. resister, to give a bigger window. But I find there is still only a small amount of movement of RV1, when adjusting, to equal door and window switches LED1 before LED2 comes on.

The value of my switch resistors are 470k. I have changed the ICs at different times but trouble always reappear's.

Have you had or heard of anyone having had this happen with the Intuder Alarm and how did you or they overcome it? My knowledge at the moment of electronics is limited so I'm hoping you can throw some light on to it for me.
N. Kilbey
Ilford
Essex

What can be deduced from this tale of woe? Gremlins in the alarm system . . . not likely . . . well, how about spikes in the mains . . . ah, that sounds more like it—mains borne interference.

What can be done about it? Well, first of all try putting the unit on a PCB—it's amazing the increased stability you'll get. There are also some other steps you can take. One is to wire a 100u capacitor across the supply rails; and try a 100n in parallel to cut out HF spikes. Another filter can be made by wiring a 10k resistor in series with the line from point X, followed by 4u7 capacitor down to earth (try different positions around the board). If you want to make RV1 more sensitive, change it to 1M and replace R2 with the original 22k value . . . and if all that fails, I hear Alsatians are also pretty effective!

HE

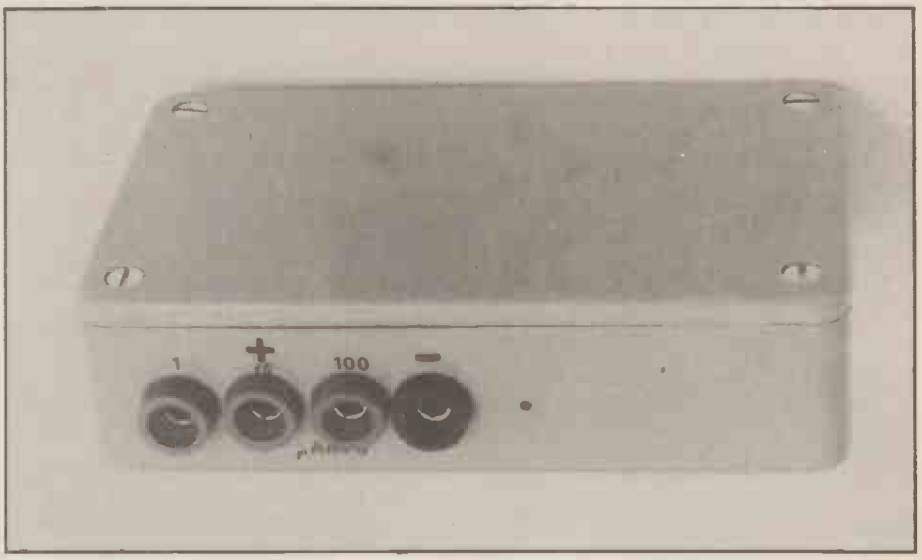
POP-AMPS

Owen Bishop

Simple measuring circuits based on operational amplifiers.

No. 1: Microammeter

THIS circuit adapts any ordinary voltmeter to measure currents in the microamp range. You can also use it with a multimeter, switched to a voltage-measuring range. The lowest current range on a typical multimeter is 0 - 250 uA, but with this circuit the range can be as small as 0 - 1 uA. Of course, if you have an FET multimeter, you will probably not need this circuit, as it is likely to be built in to your meter already.



Measuring Currents

An ammeter is always connected in series with the circuit which is to be tested, and the current to be measured flows from the test circuit, through the meter and back to the test circuit. For this reason, the ammeter must have as low a resistance as possible, so that the flow of current in the test circuit is not reduced by the resistance of the meter. A typical microammeter has a coil resistance of around 750R, though some microammeters have coils of considerably higher resistance. However in this circuit, when it is used on its 100uA range, the resistance encountered by the current is only 100R, resulting in much greater accuracy. The improvement can be seen by taking a numerical example.

In **Figure 1a**, the current flowing through the 2k7 resistor is 0.2/2700 = 74uA. If we try to measure this using an ordinary microammeter **(Figure 1b)**, with a coil resistance of 750R, the total resistance becomes 3450R and the current is reduced to 58 uA. This is a 23% error!

Using the op-amp circuit **(Figure 1c)**, the total resistance is much less affected. It becomes 2800R, reducing the current to 71 uA, and the error is now only 4%.

Some reduction of current is inevitable, for we can not avoid using power to drive the measuring instrument. The advantage of using the op-amp microammeter then, is that it needs very little power and so has a relatively small effect on the current you are trying to measure.

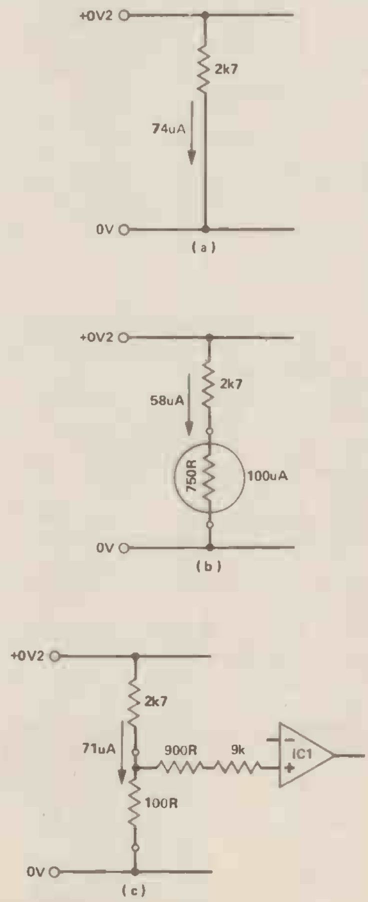
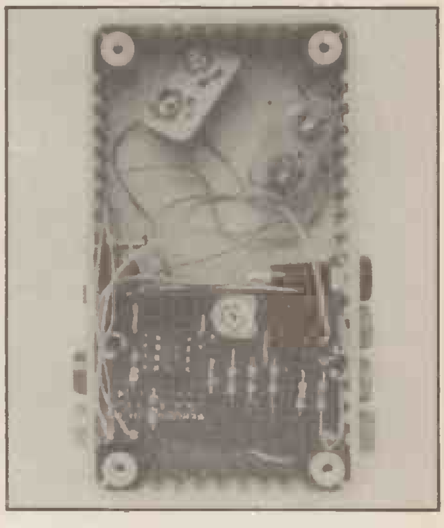


Figure 1. Measuring current (a) using a meter alone (b) results in a large error. The op-amp circuit (c) increases the accuracy of the measurement.



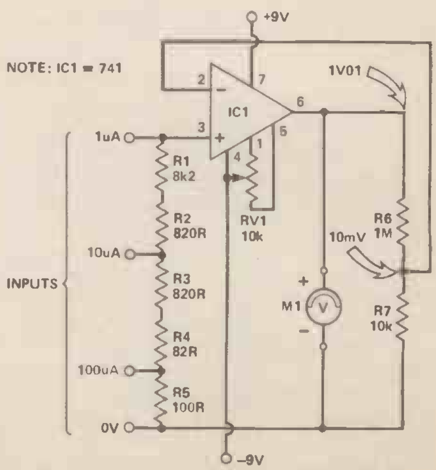


Figure 2. The Microammeter circuit.

The Circuit

We will assume that the circuit is being used on its 100 uA range, when a current of 100 uA flows through R5, the potential difference between its two ends is [V = IR = $100 \times 10^{-6} \times$

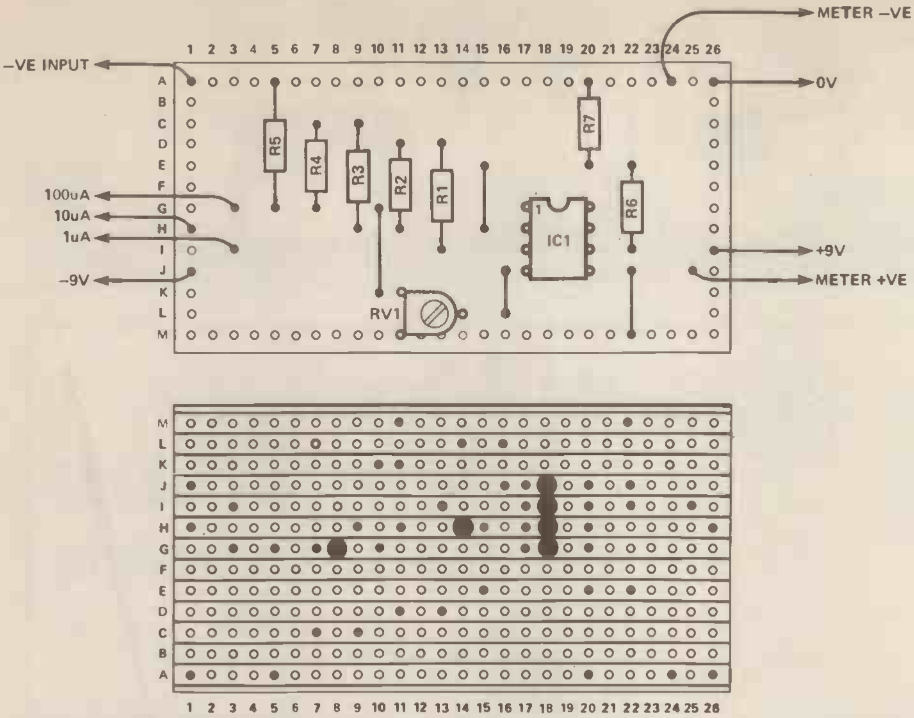


Figure 3. Veroboard component overlay and track-side view.

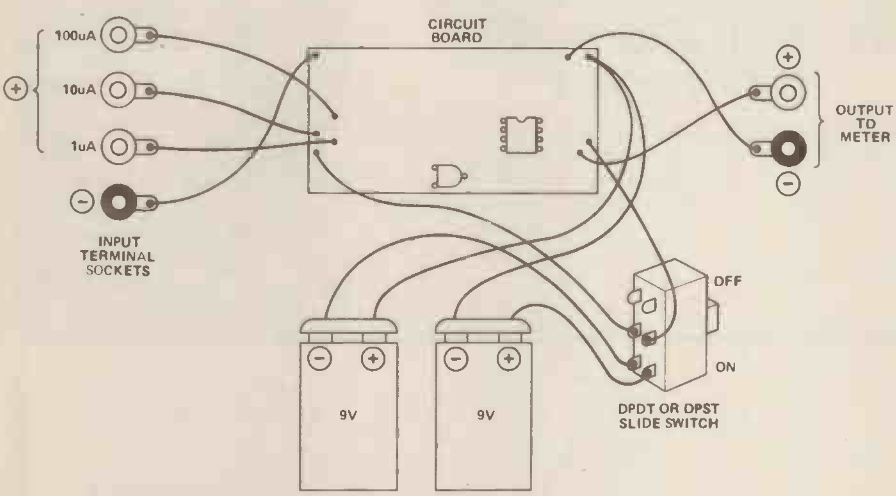


Figure 4. Wiring up the off-board components.

100 = 0.01 V [or 10 mV.] Thus, at full scale deflection (FSD), the non-inverting input (+ve) of the op-amp is at 10 mV compared with the 0 V line. We can ignore the effects of R1/R2 and R3/R4, since these are relatively small resistances compared with the input impedance of the op-amp (the input impedance of a 741 is typically 2M, so these resistors merely increase it to 2.0099M!). If the non-inverting input is at +10 mV, the amplifier adjusts its output to try to bring the inverting input (–ve) to the same potential. This is a special feature of op-amps, and one that is made use of in several other of the circuits we shall be describing.

If the inverting input is to be at +10 mV, the junction of R6 and R7 must be brought to +10 mV. Since R6 and R7 form a potential-divider network, the output voltage if the op-amp has to rise to +1.01 V to achieve this, and this is the voltage which is measured by the voltmeter. When measuring a current of 100 uA, the voltage reading is 1.01 V; we can ignore the odd fraction of a volt and say that 1 V is equivalent to 100 uA. The currents equivalent to lower voltages are easy to calculate — 0V5 means 50 uA, 0V73 means 73 uA and so on, in proportion.

We work with a maximum potential difference of 10 mV on the other two ranges as well, so the reading obtained on the voltmeter is always between zero and 1 V. If the test circuit is connected to the 10 uA socket, the total resistance is 1k. With 10 uA flowing through this, the potential difference across R3/R4/R5 is 10 mV, as before. Now, a reading of 0V73 means a current of 7.3 uA. The 1 uA socket gives a total resistance of 10k, with a PD of 10 mV when 1uA flows. A reading of 0.73 V means a current of 0.73 uA.

Parts List

RESISTORS
(All ¼ watt 1% carbon)

R1	8k2
R2,3	820R
R4	82R
R5	100R
R6	1M
R7	10k

POTENTIOMETERS

RV1	10k min. horiz. preset

SEMICONDUCTORS

IC1	741 op-amp

MISCELLANEOUS
2.5 mm stripboard, 66 x 33 mm; 9 x 1 mm terminal pins; 2 x 4 mm red sockets, 2 x black; DPDT switch; 2 x PP3 battery clips; optional case; wire; solder etc.

BUYLINES .... page 34

Construction

Like all the circuits in this series, this one is built up on a single, small piece of stripboard (**Figure 3**). Whether you mount it in a case or not is a matter of preference. The circuit is powered by two PP3 batteries, giving the ±9 V supply required, though it is possible to operate on other balanced supplies, such as ±6 V or ±15 V.

Construction presents no problems but be sure to make the track cuts, and check the position of all components. Note that two pairs of resistors are wired in series (R1/R2 and R3/R4) to obtain the values 900R and 9kR, as nearly as possible.

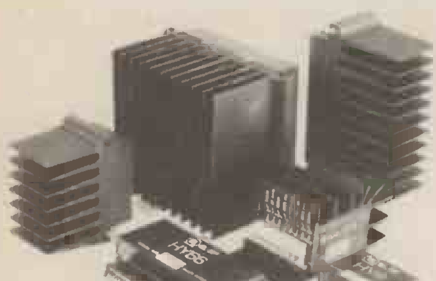
Setting Up

To set up the circuit, connect the voltmeter as shown in **Figure 4**. This should, preferably, be a 1 V FSD panel meter or a multimeter switched to the 1 V DC range, but a 2 V or 3 V meter will do almost as well.

It does not matter if it is a cheap meter, with low coil resistance, since the op-amp is capable of supplying all the current required. If you can afford a meter for the purpose, there is no reason why you should not wire it to this circuit and mount it permanently in a case.

Now switch on the power; the meter will show a reading of some kind. Join the 1 uA input socket to the junction of R6 and R7, using a test-lead; this connects the two inputs of the op-amp together. The reading on the meter should be 0 V, but if not, adjust the offset null potentiometer (RV1) until the needle of the meter comes to rest at zero. The temporary lead may now be removed, and the circuit is ready for use. This is a simple circuit, with no provision for adjusting full-scale deflection or range; it is assumed that the use of 1% tolerance resistors will have ensured all the accuracy required. **HE**

GET BIG POWER



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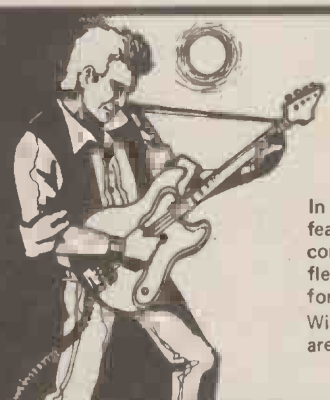

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HY30	15	4-8	0.015%	<0.006%	± 18	76 x 68 x 40	240	£8.40
HY60	30	4-8	0.015%	<0.006%	± 25	76 x 68 x 40	240	£9.55
HY6060	30 + 30	4-8	0.015%	<0.006%	± 25	120 x 78 x 40	420	£18.69
HY124	60	4	0.01%	<0.006%	± 26	120 x 78 x 40	410	£20.75
HY128	60	8	0.01%	<0.006%	± 35	120 x 78 x 40	410	£20.75
HY244	120	4	0.01%	<0.006%	± 35	120 x 78 x 50	520	£25.47
HY248	120	8	0.01%	<0.006%	± 50	120 x 78 x 50	520	£25.47
HY364	180	4	0.01%	<0.006%	± 45	120 x 78 x 100	1030	£38.41
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Protection: Full load line. Slew Rate: 15v/μs. Risetime: 5μs. S/N ratio: 100db.
Frequency response (−3dB) 15Hz – 50KHz. Input sensitivity: 500mV rms.
Input Impedance: 100K Ω. Damping factor: 100Hz >400.

PRE-AMP SYSTEMS

Module Number	Module	Functions	Current Required	Price inc. VAT
HY6	Mono pre amp	Mic/Mag. Cartridge/Tuner/Tape/ Aux + Vol/Bass/Treble	10mA	£7.60
HY66	Stereo pre amp	Mic/Mag. Cartridge/Tuner/Tape/ Aux + Vol/Bass/Treble/Balance	20mA	£14.32
HY73	Guitar pre amp	Two Guitar (Bass Lead) and Mic + separate Volume Bass Treble + Mix	20mA	£15.36
HY78	Stereo pre amp	As HY66 less tone controls	20mA	£14.20

Most pre-amp modules can be driven by the PSU driving the main power amp.
A separate PSU 30 is available purely for pre amp modules if required for £5.47 (inc. VAT). Pre-amp and mixing modules in 18 different variations.
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Mounting Boards
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MOSFET MODULES

Module Number	Output Power Watts rms	Load Impedence Ω	DISTORTION T.H.D. Typ at 1KHz	I.M.D. 60Hz/ 7KHz 4:1	Supply Voltage Typ	Size mm	WT gms	Price inc. VAT
MOS 128	60	4-8	<0.005%	<0.006%	± 45	120 x 78 x 40	420	£30.41
MOS 248	120	4-8	<0.005%	<0.006%	± 55	120 x 78 x 80	850	£39.86
MOS 364	180	4	<0.005%	<0.006%	± 55	120 x 78 x 100	1025	£45.54

Protection: Able to cope with complex loads without the need for very special protection circuitry (fuses will suffice).
Slew rate: 20v/μs. Rise time: 3μs. S/N ratio: 100db
Frequency response (−3dB): 15Hz – 100KHz. Input sensitivity: 500mV rms
Input impedance: 100K Ω. Damping factor: 100Hz > 400.

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PSU 43X	1 x MOS128	£16.70
PSU 51X	2 x HY128, 1 x HY244	£17.07

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PSU 54X	1 x HY248	£17.86
PSU 55X	1 x MOS248	£19.52
PSU 71X	2 x HY244	£21.75

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PSU 73X	1 x HY364	£22.54
PSU 74X	1 x HY368	£24.20
PSU 75X	2 x MOS248, 1 x MOS368	£24.20

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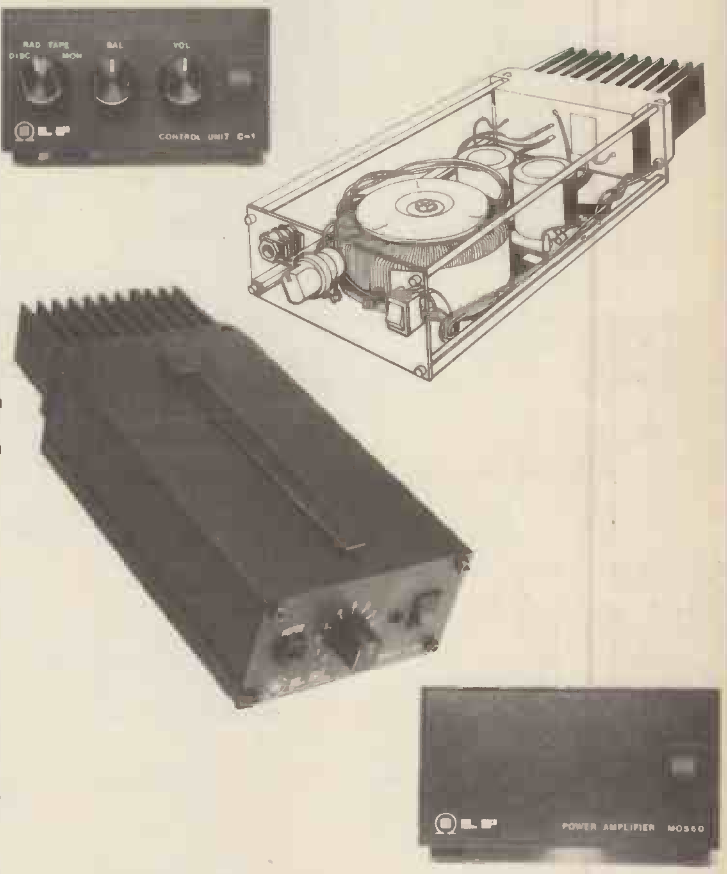

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UP4X	120W/4Ω	Bipolar	Mono	HiFi	£74.95
UP5X	120W/8Ω	Bipolar	Mono	HiFi	£74.95
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TAPE/SLIDE SYNCHRONIZER

R. A. Penfold

Keep your audio in sync with your visuals!

THERE ARE several different types of slide/tape synchroniser, but the function they all perform is to record short "bleeps" of tone, on a cassette or tape recorder, and then use these tones on playback to automatically operate the slide-change mechanism of the projector. In its most basic form, a unit of this type is simply used with a monophonic cassette or tape-recorder as a programmable slide timer, or in conjunction with stereo tape equipment the "bleeps" can be recorded on one channel while the other carries background music and (or) a commentary.

More sophisticated units enable the tone to be mixed with the music or commentary during records. Then, during playback, circuits in the unit operate the projector only when the "bleeps" of tone are detected and ignore other signals on the tape, so that spurious operations of the projector are avoided. This system has the advantage of enabling the slide show to have a monophonic accompaniment using a monophonic recorder, or a stereo accompaniment using a stereo recorder, but is not very satisfactory in practice since the "bleeps" are clearly audible to the audience, and are something of a distraction.

This problem can be overcome using the arrangement described above *plus* an additional stage which operates during playback to filter the "bleep" signals from the output. The HE Slide/Tape Synchroniser is of this type, but it is reasonably simple and inexpensive and does not require any test equipment to enable it to be set up correctly for use. It would not be true to say that there is no loss of quality introduced by adding in the "bleeps" to one channel and then filtering them out again, but the loss of quality is not likely to be noticed, even if your slide shows are not quite as riveting as they might be!

The bursts of tone are at quite a high frequency (about 5kHz) and when these are filtered out, any signals at around this frequency in the music or commentary are also removed. This obviously gives a certain loss of audio quality but, as only a very narrow band of frequencies are seriously affected and the fundamental frequencies in music are usually below 5kHz (so that only harmonics are attenuated by the

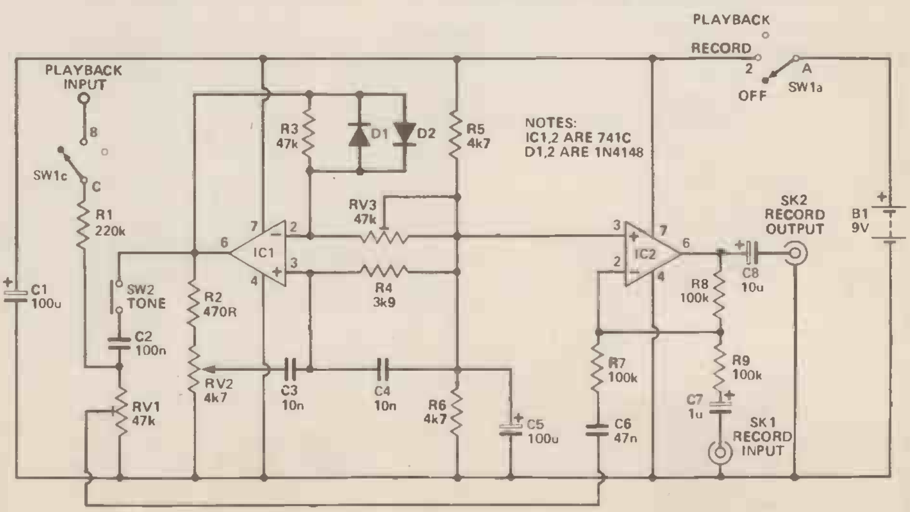


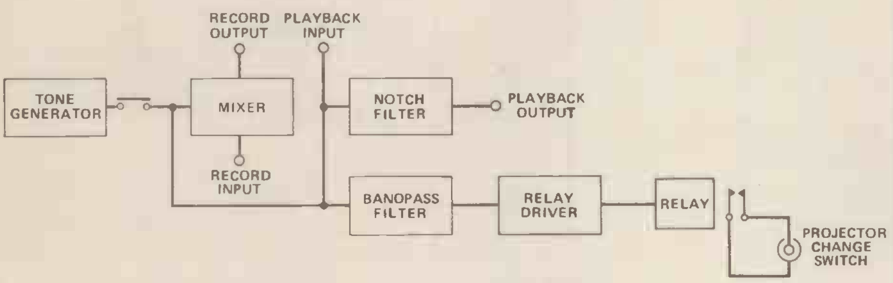
Figure 1. The Record section circuit.

How It Works

A MIXER and a tone generator are used to add bursts of high frequency tone to the input signal when a push button switch is briefly operated; the output is fed to the input of one channel of a tape recorder. Another circuit is used to process the signal when the tape is played back; the purpose of this circuit is to separate the bursts of tone and the main signal. The tone bursts are used to automatically operate the projector at the appropriate times, and this signal is filtered from the main signal using a bandpass filter tuned tio the frequency of the tone signal. The output of the filter is fed to a driver circuit which pulses a relay when the tone bursts are detected; a pair of relay contacts are used to operate the slide change mechanism of the projector.

On playback the output from the tape recorder is also fed to a notch filter which gives very high attenuation at the frequency of tone bursts, and thus eliminates them, but enables other frequencies to pass unhindered. In practice, the notch filter will actually remove some of the wanted signal, while the bandpass filter permits some of the main signal to pass through to the relay driver. However, the loss of quality is not serious, and breakthrough to the relay driver should not cause spurious operation of the unit.

The "bleeps" of tone are also fed to the bandpass filter and the Record Output so that the projector is operated when the push button is operated, so that the tone burst is added to the sound track as the projector is operated.



filtering) there is no drastic loss of quality. There is also, inevitably, a reduction in the signal-to-noise ratio, but this is marginal and is of no practical consequence.

The unit is powered from an ordinary 9 volt (PP6 size) battery, and it should be compatible with any normal cassette or reel-to-reel tape deck or recorder. It has unity voltage gain in both the recording and playback modes and should not introduce any problems of incompatibility between the tape machine used and other items of equipment such as the amplifier used during playback.

The Circuit

If we consider the recording circuit first, (shown in **Figure 1**), IC1 is used as the tone generator. The oscillator configuration is a form of the Wien Bridge which is capable of giving a good quality sinewave output. The operating frequency is determined by R2, RV2, C3, C4 and R4; adjusting RV2 permits the operating frequency to be varied from around 2kHZ to 10kHZ. In use, RV2 is adjusted to adjust the output frequency to give maximum attenuation from the notch filter in the playback circuit; this is nominally at 5kHZ.

R3, D1 and D2 form a negative feedback network, RV3 can be set to give gentle oscillation with a reasonably pure output. D1 and D2 help to stabilise the feedback at the correct level and make the adjustment of RV3 a little less critical.

IC2 is used as a standard operational amplifier mixed circuit having unity voltage gain. RV1 controls the volume of the tone signal fed through to the output socket, so that it can be set at a suitable level relative to the main signal; however the tone signal is only coupled through to RV1 when SW2 is operated.

The circuit diagram of the playback section of the unit is shown in **Figure 2**. C17 couples the input signal (from the recorder) to a notch filter, which is basically a twin-T type using C18, 19, 20, R17, 18, 19, and RV5. RV5 enables the attenuation of the filter to be peaked at a very high level (about 80 dB or more).

A problem with a simple, twin-T filter is that it tends, also, to significantly attenuate signals at frequencies well away from the centre frequency, and in this application the audio quality would be adversely affected. Typically, a twin-T filter gives about 10 dB attenuation at half and double the operating frequency. In this circuit, the response of the filter is improved by the negative feedback loop around IC4. The circuit may look a little confusing, due to the use of two negative feedback loops, but the effect of this is to stabilise the gain of the circuit at unity. This can only be achieved at frequencies where the losses through the twin-T network are fairly low, however, and at the operating frequency of the filter its losses are far too high to be significantly reduced by the negative

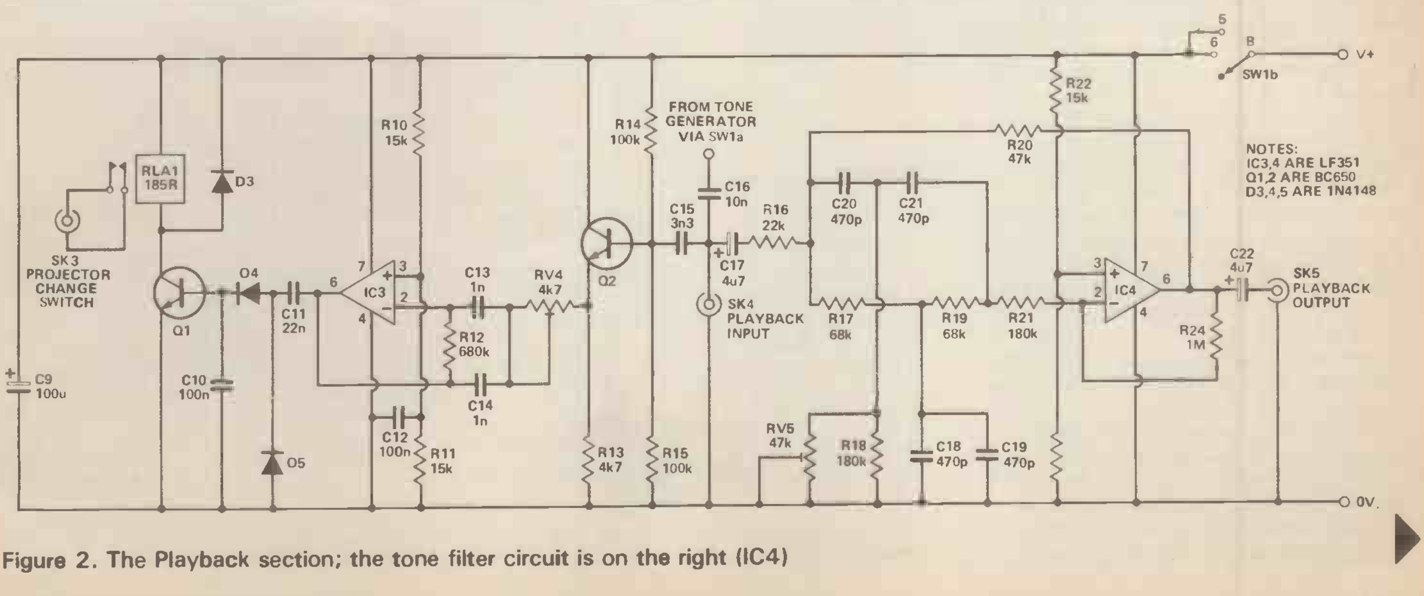


Figure 2. The Playback section; the tone filter circuit is on the right (IC4)

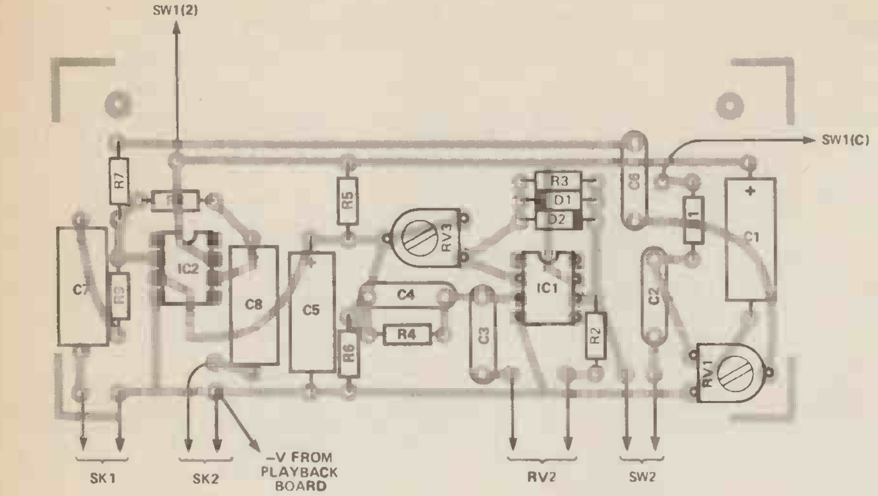
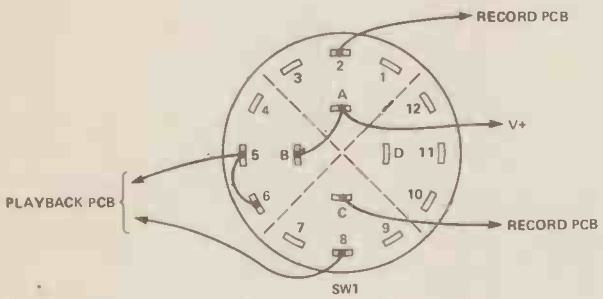


Figure 3. PCB overlay for the Record section circuit.



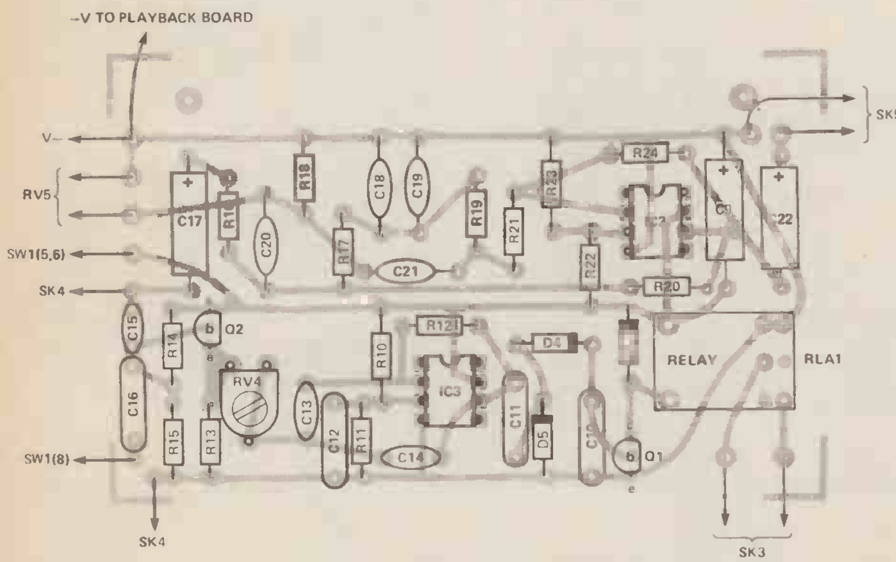


Figure 4. The PCB and component overlay of the Playback section.

Parts List

RESISTORS
(All ¼ W 5% Carbon)
R1 . . . . 220k
R2 . . . . 470R
R3,20 . . . . 47k
R4 . . . . 3k9
R5,6,13 . . . . 4k7
R7,8,9,14,14 . . . . 100k
R10,11,22,23 . . . . 15k
R12 . . . . 680k
R16 . . . . 22k
R17,19 . . . . 68k
R18,21 . . . . 180k
R24 . . . . 1M

POTENTIOMETERS
RV1,3 . . . . 47k
0.1W horizontal preset
RV2 . . . . 4k7
linear carbon
RV4 . . . . 4k7
0.1W horizontal preset
RV5 . . . . 47k
linear carbon

CAPACITORS
(All C280 polyester unless noted)
C1,5,9 . . . . 100u 10V
axial electrolytic
C2,10,12 . . . . 100n
C3,4,16 . . . . 10n
C6 . . . . 47n
C8 . . . . 10u
25V axial electrolytic
C11 . . . . 22n
C13,14 . . . . 1n
polycarbonate
C15 . . . . 3n3
ceramic
C17,22 . . . . 4u7
63V axial electrolytic
C18,19,20,21 . . . . 470p
polystyrene

SEMICONDUCTORS
IC1,2 . . . . 741C
op-amp
IC3,4 . . . . LF351
bifet op-amp
Q1,2 . . . . BC650
D1,2,3,4,5 . . . . IN4148

MISCELLANEOUS
RLA1 . . . . 12V 185n coil
2 pole changeover contacts
SW1 . . . . 3 way 4 pole rotary
SW2 Push to make non-locking type
B1 . . . . PP6, 9 volt
Case, about 203 x 127 x 51 mm; battery clip (PP3 type); PCBs; three control knobs, wire, solder, etc.

BUYLINES . . . . page 34

feedback. Thus the response of the filter is improved, with reduced losses away from the operating frequency but with the deep attenuation notch being retained.

C15 couples the tape input signal to an emitter follower buffer stage which uses Q2, and this simply ensures that the next stage is fed from a suitably low source impedance. The next stage of the circuit is actually a standard operational amplifier bandpass filter using IC3, tuned by RV4 to peak the response of the circuit at the correct frequency.

The output of IC3 is coupled to a smoothing and rectifier circuit which drives Q1 which, in turn, drives the relay coil. When the bursts of tone are present on the input signal, these produce a strong positive bias at the base of Q1, which is then switched on, activating the relay and the projector's slide change mechanism via a set of normally open relay contacts.

SW1 is the mode switch; this couples the output of the tone generator through to the playback circuit when the unit is in the record mode (it also provides on/off switching for both circuits). Note that power is applied to the playback circuit when the unit is in the recording mode, so that the relay activates the projector to synchronise the slide-change with the sound track.

Construction

An aluminium case measuring about 203 x 127 x 51 mm will comfortably accommodate all the components, including the battery. The four controls

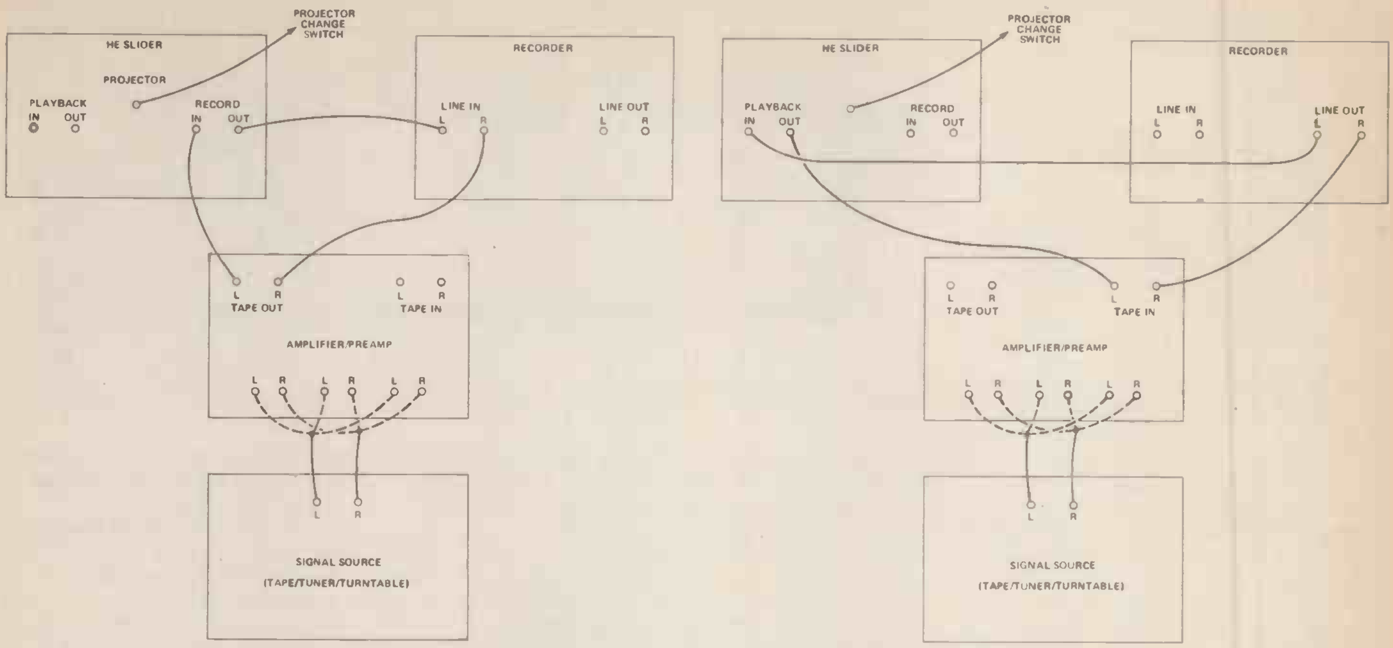
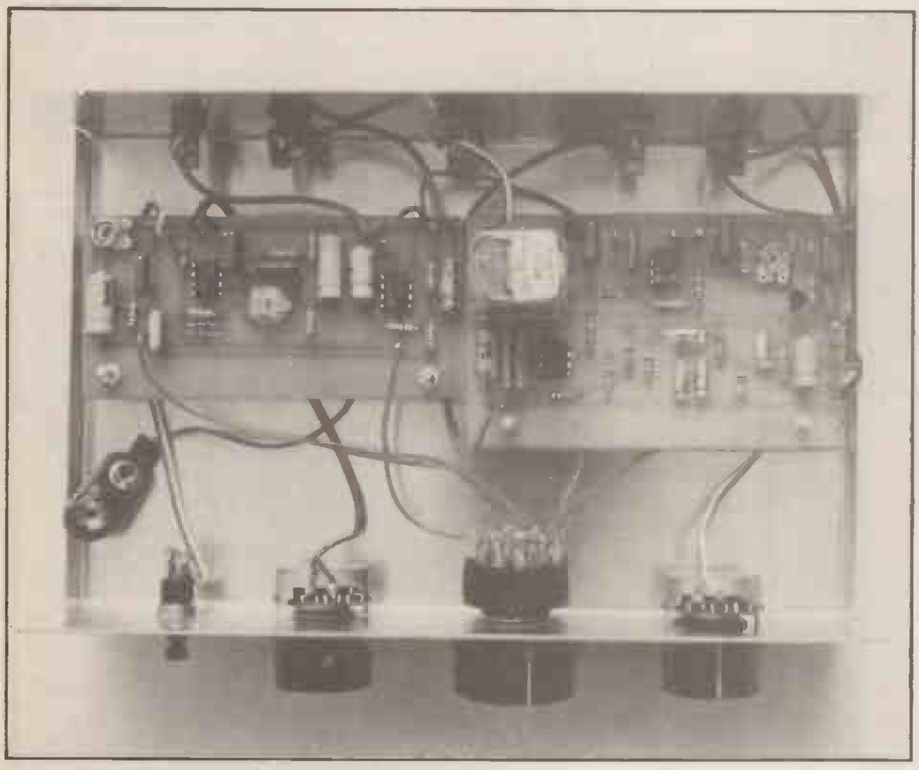


Figure 5. Connecting the unit for Record (left) or Playback (right).



are mounted on the front panel, although SW2 can be mounted in a separate small (hand held) case and connected to the main unit via a lead several feet long, if this will be more convenient in use. The lead would need to be terminated in a two way plug and SW2 would be replaced (on the front panel of the case) by a matching two way socket. Note that this socket should be a type which is insulated from the case, such as a plastic jack type or a two way DIN socket. SK1 to SK5 are mounted along the rear panel of the case; these are all 3.5 mm jacks on the prototype, but can be changed to any other type of socket, if this will be more convenient in use.

The other components are mounted on two printed circuit boards, one for the recording circuit and the other for playback. The component layouts and wiring are shown in **Figures 3** and **4** respectively; use Veropins at points where off-board connections will be made. The specified relay will fit directly onto the printed circuit board, but other types will work provided they have a coil resistance of about 185 ohms or more, will operate from about 6 volts, and have at least one set of normally open contacts rated at about 2 amps (AC) or more. However, if an alternative relay is used it will be necessary to alter the PCB to suit, or mount the relay off-board. Incidentally, the specified relay has two sets of changeover contacts, with four of its pins unused.

Setting Up

A quick initial check of the unit can be made by switching the unit to the recording mode and operating SW2. If the output of SK2 is monitored using an amplifier and loudspeaker (or even just a crystal earphone), a tone should be produced when SW2 is operated, provided that RV3 is set well into the anticlockwise position. RV1 should control the volume of the tone, with RV2 giving pitch control.

The next stage is to set RV5 at about half way and monitor the output from SK5. By adjusting RV2, it should be found that the tone is greatly attenuated at some setting that gives a fairly high pitch and, by repeatedly adjusting RV2 and RV5, it should be possible to eliminate the fundamental frequency of the tone. With the tone generator oscillating strongly there will be quite strong harmonics (multiples of the fundamental frequency) at the output although, due to the high frequency of the tone, probably only two harmonics will be audible. Setting RV3 further in a clockwise direction will produce more gentle oscillation but will alter the pitch of the tone slightly, and RV2 will need to be readjusted. A little experimentation with the settings of RV1 to RV3 should produce a reasonably pure tone, with the filter attenuating this to an insignificant level.

By adjusting RV4, it should be possible to get the relay to operate whenever SW2 is operated; at this stage RV4 should be set in the middle of the range. If suitable test equipment is available, this can be used to help peak RV4 at the correct frequency. In the absence of test gear, the best procedure is to make a recording of the tone signal (taking the output from SK2) at a recording level of about −12 dB to −18 dB and then play this back into SK4; adjust RV4 to give reliable operation of the relay.

It is just possible that the output of the recorder may be inadequate to operate the unit reliably, and in this case it is better to boost the sensitivity of the circuit by using a higher value for C15 than to use a higher recording level. Similarly if your recorder has an abnormally high output and the unit operates with a wide range of settings of RUG, it would be advisable to reduce the sensitivity of the circuit by making C15 lower in value. Otherwise the bandpass filter might be overloaded and give spurious operations of the projector.

Before using the unit it is a good idea to check that RV2 and RV5 are set for optimum attenuation of the tone signal (RV3 should need no further adjustment, once set correctly). RV1 is set to give a recording level of about −15 dB from the tone signal source, having a substantially different signal source. Once set, RV1 should not need any readjustment unless a different signal source, having a substantially different output level, is used.

The normal way of making a tape using a synchroniser is to connect the unit to the projector and load the slides. The commentary and (or) music are fed through the synchroniser (which should be set to recording mode, of course) and into the tape recorder. SW2 is operated at the points where slide changes are required and this will operate the projector via the relay, as well as recording the tone bursts. To give maximum reliability, SW2 should be depressed as long as necessary, but without causing a double slide change to occur, and a good quality tape should be used. This minimises the risk of tape 'drop-outs' causing a slide change to be missed and the tape having to be re-recorded.

If the unit is used with stereo equipment, the convention is that it is used in the left hand channel. Input and output sockets for the right hand channel could be added to the unit, but in practice this channel can simply be coupled direct from the program source of the recorder during record, and from the recorder to the amplifier during playback.

HE

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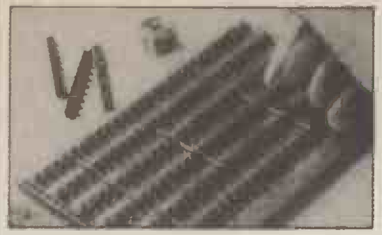

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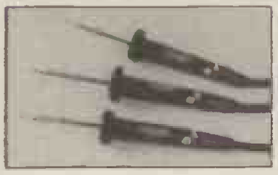

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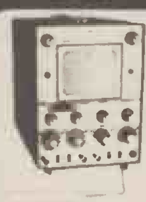

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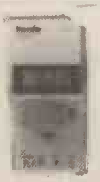

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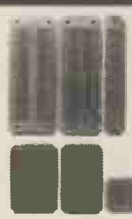

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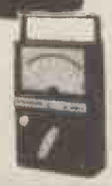

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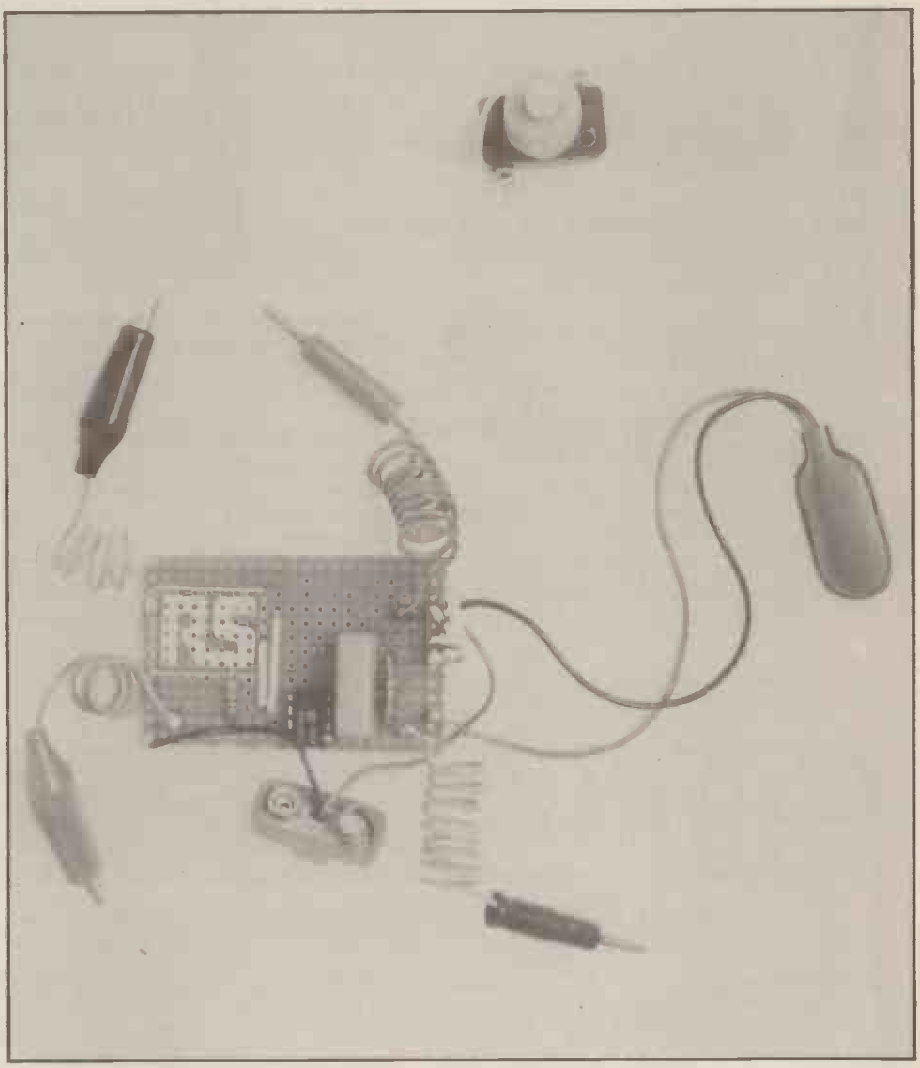


ONCE in a while, and probably more often, it is necessary to measure a voltage which is changing rapidly — but trying to follow the needle of the voltmeter by eye and read it at *just* the right instant is tension-generating, to say the least! And, if your eye cannot follow the needle, it is likely that the needle cannot follow the rapidly changing input voltage, either, so whatever reading you have struggled to obtain will be doubly in error. This circuit, however, gives your eye *and* the needle a breathing-space in which to catch up with the changing voltage. Pressing the button, it takes a sample of the input voltage at any instant; the circuit then holds the sampled voltage while the needle of the meter comes to rest, and your eye has time to take the scale reading with all the accuracy you need.

The Circuit

The output of the circuit (Figure 1) follows the input voltage as long as the button is held pressed. When the button is released, the output remains constant at whatever value it had at the instant of release. When the button is pressed again, the output immediately becomes the same as the input voltage. The operation of the circuit is diagrammed in Figure 2.

The op-amp is connected as an inverting amplifier with unity gain and with the button pressed, output follows input except that it is inverted.

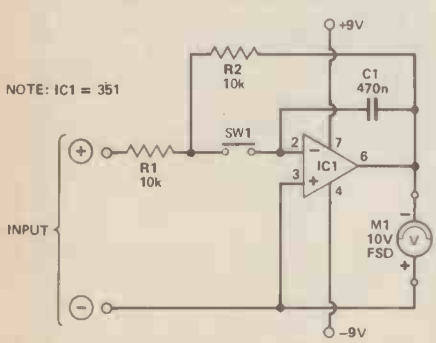
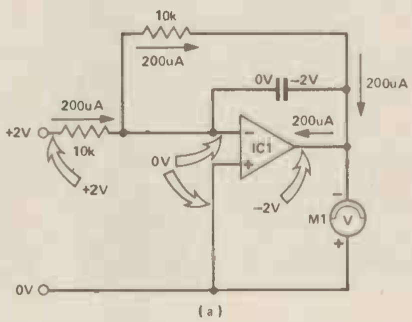


Figure 1. The Follow and Hold circuit.



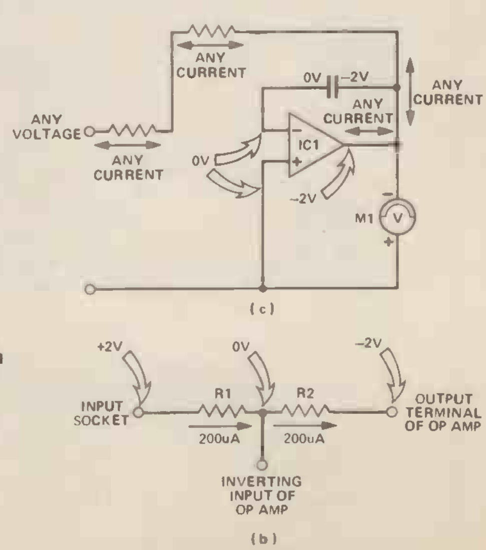


Figure 2 (above). How it works; (a) with + 2V on the input, a current of 200 uA flows into the op-amp output pin; (b) this causes voltage drops of 2V across each resistor, so that the inverting input is at 0V, the output at – 2V and the op-amp is stable; (c) in " hold", changes at the input cannot effect the op-amp output.

Now an op-amp is stable when there is no potential difference between its two input terminals. But since the non-inverting (+ve) input is wired to 0 V, the inverting input must also be at 0 V if the circuit is to be stable. So given an input of, say, +2 V, a current of 200 uA flows toward the inverting input, by way of the input resistor R1. The amplifier input has extremely high resistance, so almost no current enters it, but, instead, flows on through R2 and *into* pin 6 of the op-amp. Since R1 has the same value as R2, and the same current flows through each; the voltage difference across each resistor is the same (**Figure 2b**). Therefore, with a drop of 2 V across each resistor, the output potential is −2 V, the potential at the inverting output is 0 V and the op-amp is stable. In this state, one side of capacitor C1 is at 0 V and the other is at −2 V; there is 2 V across it.

When the button is released, the circuit becomes as shown in **Figure 2c**. The input to the circuit may change, either increasing or decreasing in voltage, and a varying current may flow in either direction through R1, R2 and into or out of the output terminal of the op-amp — but the output of the op-amp is entirely unaffected by this! The potential at its inverting input is held at 0 V because of C1 and, since this is still the same as the potential at its non-inverting terminal, the amplifier is stable; it maintains an output potential of −2 V.

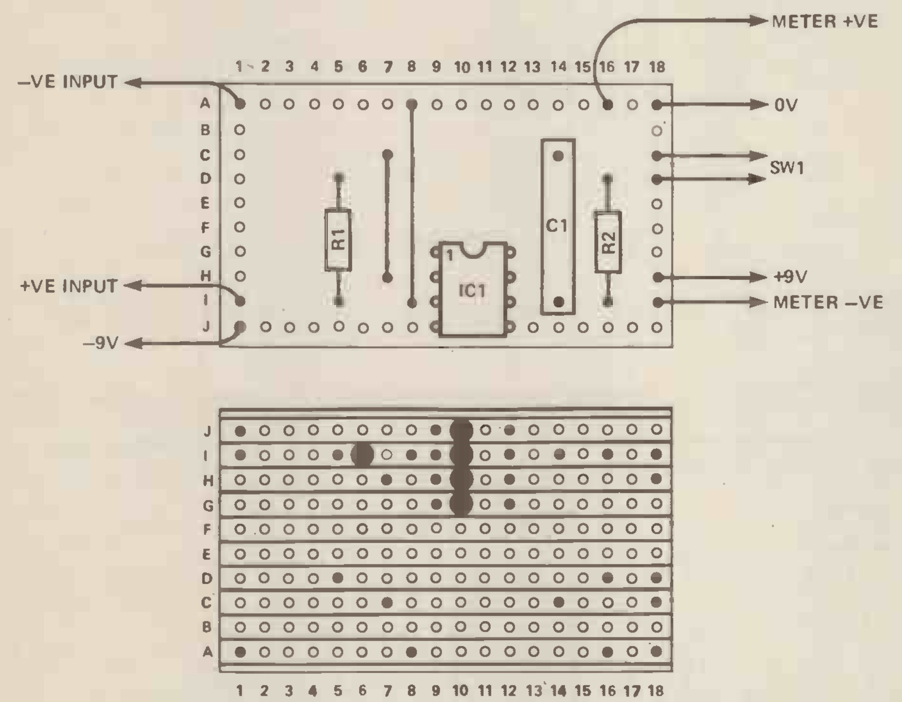


Figure 3. The Veroboard component overlay (top) and the track-side view (bottom), showing the positions where the strips are cut.

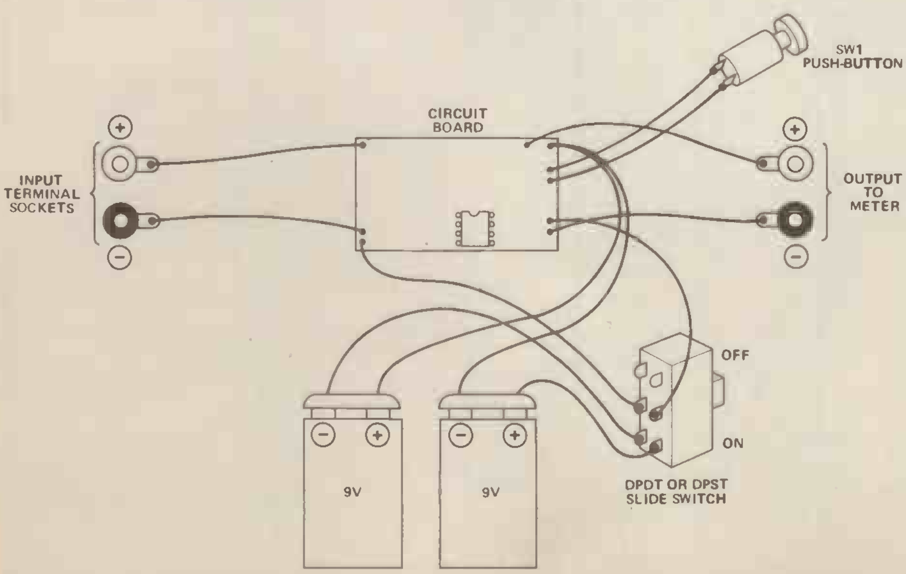


Figure 4. Wiring the external components to the Veroboard.

The capacitor retains its charge for a long time, since there is no way in which a large current can flow from one side of the capacitor to the other. The plates of C1 are effectively insulated from each other by the dielectric, which has a resistance of 20,000M or more, while leakage into the amplifier is very small too, since the input impedance is 10^{12}R — a million megohms! — and this high input impedance is the reason for choosing a JFET op-amp for the circuit. With such high resistances, a charge of 2 V on C1 takes 47 seconds to drop just a hundredth of a volt. This should give you (and the meter) plenty of time to cope!

The circuit described has unity gain, so meter readings are equal to input voltages, though increasing the value of R2, you can make the circuit amplify the voltages as well as hold them. The amplification is set by the ratio R2/R1; for example, if you replace R2 with 100k, the op-amp amplifies ten times.

The reason for choosing the 531 in preference to other JFET op-amps is that it has a very high slew rate (rate of change of output voltage) of 13V/us, which compared with the rate of 0V5/us for the 741, makes it a good device for sampling rapidly changing voltages.

Operating the multimeter on the 10 V range means that offset null adjustments (see *Pop Amps No. 1* in this issue) are less important and an offset potentiometer is not needed.

Construction

There are so few components that construction of the circuit takes only a few minutes. The component layout is shown in **Figure 3**. Whether you decide to mount it in a case is a matter of preference. If you have a 10 V meter to spare, you can mount this on the case; it does not need to have a high coil resistance, so a cheap one will do. Otherwise, plug your multimeter into the circuit, using the two sockets indicated. This circuit, like No. 1, can also be used with the *LED Millivoltmeter* featured in HE August 1982.

HE

Parts List

RESISTORS
(All ¼ Watt 1% carbon)
R1,2 . . . . 10k

CAPACITORS
C1 . . . . 470n polycarbonate

SEMICONDUCTORS
IC1 . . . . 7611 CMOS op-amp

MISCELLANEOUS
2.5 mm stripboard, 48 x 25 mm; 6 x 1 mm terminal pins; 2 x 4 mm red sockets, 2 x black; push-to-make switch; DPDT switch; 2 x PP3 battery connectors; optional case; wire, solder etc.

BUYLINES . . . . page 34

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8251	300p
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8259	450p
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741S	55p
747	65p
748	35p
CA3080E	70p
CA3130E	75p
LA4422	295p
LF355	80p
LF356	90p
LF357	100p
LM301A	26p
LM307	50p
LM308A	95p
LM311N	66p
LM324	35p
LM339	50p
LM348	75p
LM358	60p
LM380	95p
LM381	150p
LM393	90p
LM3909	85p
MC1310P	210p
MC1455	66p
MC1456	135p
MC1458	35p
MC3242A	630p
MC3302	95p
MC3340	120p
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MC3403	70p
MC3456	107p
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500mA	
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78M06	55p
78M08	55p
78M12	50p
78M15	50p
78M18	55p
78M24	55p
1A	
7805	45p
7806	65p
7808	65p
7812	45p
7815	45p
7818	65p
7824	65p
−Ve 100mA	
79L05	35p
79L12	35p
79L15	35p
1A	
7905	60p
7906	70p
7908	70p
7912	60p
7915	60p
7918	60p
7924	60p

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BC157	9p
BC158	9p
BC177	25p
BC178	25p
BC179	25p
BC182	10p
BC182A	10p
BC182B	10p
BC183A	10p
BC183C	10p
BC184	10p
BC184C	10p
BC212	10p
BC212A	10p
BC212B	10p
BC213A	10p
BC213C	10p
BC214	10p
BC214C	10p
BC237A	12p
BC237C	12p
BC238	12p
BC238A	12p
BC238B	12p
BC238C	12p
BC239	12p
BC307A	15p
BC307C	15p
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BC308B	15p
BC308C	15p
BC309	15p
BC309C	15p
BC327	15p
BC328	15p
BC337	15p
BC338	15p
BC477	28p
BCY70	18p
BCY71	20p
BCY72	20p
BD135	42p
BD136	46p
BD139	40p
BD140	40p
BD165	45p
BD166	45p
BD169	45p
BD170	45p
BD538	95p
BD677	60p
BD678	60p
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MPSA92	30p
TIP29	35p
TIP29A	35p
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2N4919	120p
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2N4921	105p
2N4922	95p
2N4923	96p
2N5190	75p
2N5191	75p
2N5192	75p
2N5193	90p
2N5194	90p
2N5195	90p
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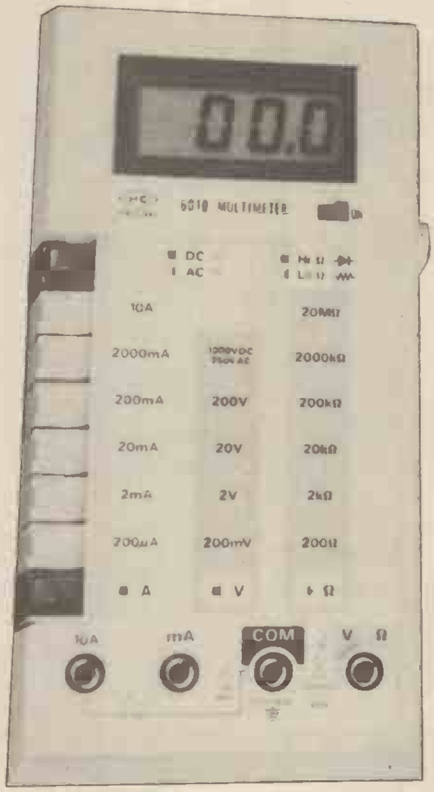

WHEN I unpacked the HC6010 from its mustard coloured box, I could tell I was in for a few surprises. Described by the manufacturers as accurate and reliable, it is a digital multimeter with all the usual AC/DC current and voltage ranges *and* some extra ones not common to meters in this price range — for example, a basic DC accuracy of 0.5%. In use it was very robust — of the highest electronic standards of construction — and well thought out. In fact, my only real criticism was of an aesthetic nature rather than due to any great failing of the meter.

The 6010 multimeter is made by Hung Chang Products and distributed by Armon Products Ltd. The basic ranges are AC/DC current and voltage (extending up to 1000 V and 10 A DC, and 750 V and 10 A DC) and two resistance — low and high output voltages. The display is 3½ digit LCD with auto-zero, auto-polarity and 'lo-bat' indicators. Range and scale selection is made via a series of push-buttons along the left-handside of the instrument. There are eight buttons in all, two for selecting AC/DC (or hi/lo resistance) and voltage/current/resistance and six for setting up the correct full scale deflection (FSD). For instance, to measure up to 20 mA AC you would press the top button (conveniently coded dark grey) for AC and the fifth button to read up to 19.99 mA. However, there's no need to worry if the value is over range, since the meter is protected against overloads by sparkgap (voltage), inrush current limiter (current) and a 2A fuse (current). Also protected are the battery eliminator input and resistance ranges *and* as if that isn't enough, the test lead sockets are recessed — not to make plugging and unplugging the leads as difficult as possible as I first thought, but to ensure there is no bare metal to give you any nasty shocks — as part of an overall philosophy of 'safety first'.

Clearly A Better Meter

The voltage ranges are chosen by pressing the lowest of the (dark grey) buttons. Both AC and DC voltage scales have the same ranges (apart from maximum values of 750 V AC and 1000 V DC) and so AC or DC can be switched by a single button. Accuracy is quoted at ±0.5% (reading + 1 digit) DC and ±1% (reading + 5 digits) AC, which despite being a strange way of expressing the tolerances, is pretty good for a meter of this price range.

Sinusoidal voltages are measured with an averaging response, but the meter is calibrated to read RMS (though this is not as good as direct reading RMS) and resolution for both AC and DC is a very good 100 uV.

To measure current, you have to plug the red test lead into a different socket (slightly tedious with the safety measures mentioned earlier), and the two dark grey buttons operate in a similar manner as when reading voltage — upper for AC/DC, lower remains 'out'. In addition to this, if you want to take readings up to 10 A you must plug the red lead into a third socket. This was again a chore, but when you consider that most other meters need a shunt to measure such large currents, perhaps it's forgivable.

Accuracy on the current ranges is not as high as on the voltage, but since the worst case (2 A and 10 A AC) is still fairly good at ±3% (reading + 5 digits), I do not feel the 6010 is any poorer than the competition (I was particularly impressed by the clear manner in which *all* the technical specifications were presented). Resolution on both AC and DC current is adequate at 100 nA; but this meter, like others I have reviewed, would have benefitted from a lower limit of 10 nA, say — after all, isn't everyone interested in the current consumption of their LCD calculator!

Resistance measurements are made by pressing the lowest button and then selecting either the 'hi' or 'lo' ohms scale. These two scales are present, as with other meters, to allow in-circuit readings to be made. However, unlike some other similar instruments, the lo output is low enough (280mV) to facilitate testing around *most* semiconductors. Both outputs (hi and lo) have six ranges from 200 ohms up to 20 megohms, with resolution down to 100 milli-ohms on the 200R. Accuracy is very good on the four lower ranges (0.5% nominal) and creditable on the 2M and 20M settings (better than 2% nominal). The high range (up to 20M) is quite rare for a unit of this type and I was pleased to see it included.

Specs And The Rest

The HC6010 DMM comes complete with an instruction leaflet, which is very clear but (sadly) not that well laid out — whatever happened to those neat pocket-sized manuals that used to accompany most of the better meters! Even so, operation is easy to grasp and the leaflet is only necessary as a source of reference information. What I do commend Hung Chang for, is the inclusion of a circuit diagram *and* parts list — it is always a good sign if a manufacturer is proud enough of his design work to want to make it public. However, it's a pity this pride doesn't extend to the fascia panel, on the front of the case, which has the lettering printed on it. Not only does this have a tendency to peel off, but it gives the meter a gimmicky appearance. A bit of time spent here (and on improving the shape of the case and buttons) would pay in the long run — designers of the 'Mark II' take note.

So, for those of you who are after a robust and accurate digital multimeter, that is easy to use and out-performs most others at the price, I can recommend the 6010. However, if you're after something to show off to your friends, then keep looking . . . and one final surprise, a price tag of £34.44. For further information contact **Armon Products Ltd**, 53-63 Wembley Hill Road, Wembley, Middlesex HA9 8BH. **HE**

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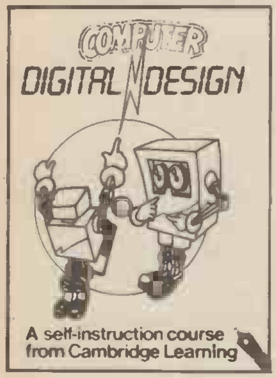

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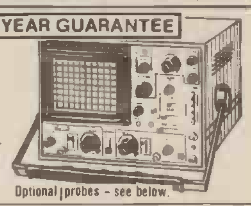

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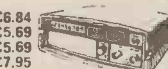

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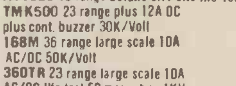

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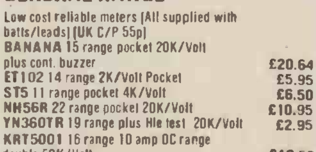

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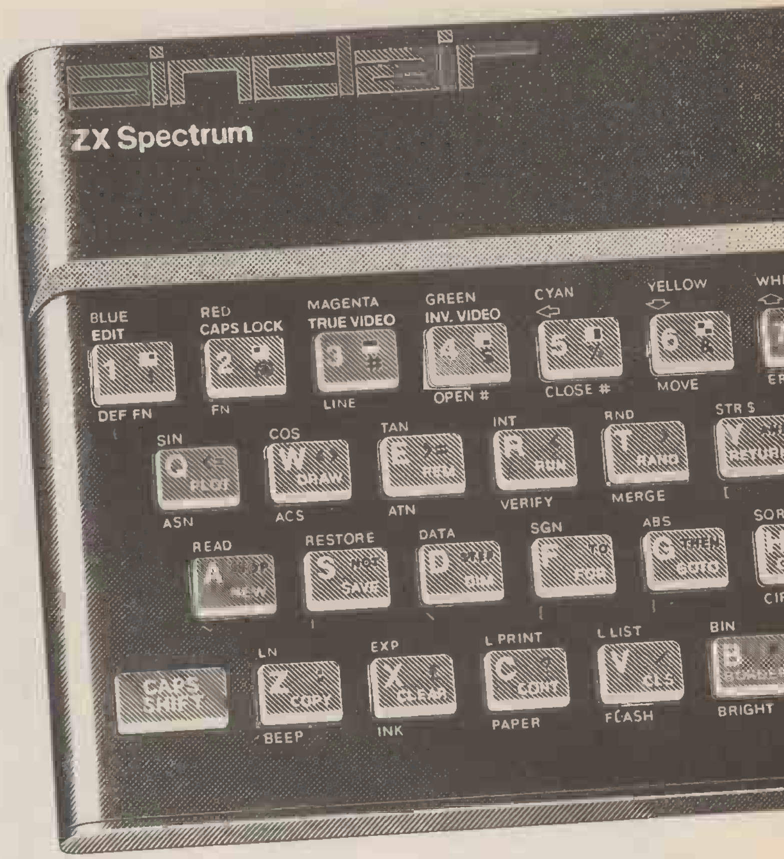

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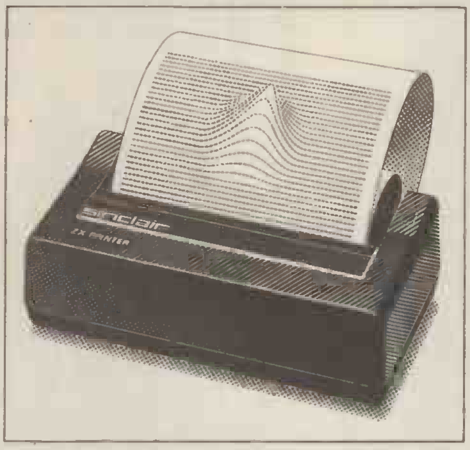

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The noise generated by the solid state audible alarm is more than enough to wake the household or to rouse the attentions of neighbours. The alarm draws only 25mA, yet emits a piercing warbling tone with a power of 95 dB at 1m. Since its current requirements are low, it is feasible to wire two or more AWDs in parallel and site them in various parts of the house. But try using just one to begin with, for it is more than likley that you will find it does all that is needed.

The system has two kinds of detection circuit, the peripheral loop and the pressure mat system.

Peripheral Loop

This consists of normally closed switches mounted on all doors and windows, forming a loop which surrounds the area to be protected. The switches are in series so that, if any one switch is opened, the loop is broken and the alarm is sounded. It may be sufficient to protect ground-floor entry-points only, but upstairs windows should be protected too, if they are readily accessible from outside. Do not forget the less obvious points, such as coal-shed doors, hatches and skylights.

It is best to use a magnetic switch specially made for the job. The switch consists of two parts (Figure 1). The reed switch itself is mounted on the frame of the door or window or may be concealed in a hole drilled in the frame. The other part contains a permanent magnet. This is mounted on or concealed in the door or window itself. When the door is shut, the magnet holds the reed switch closed. When the door is opened, even by only a centimetre or so, the switch opens and the loop is broken.

The use of a normally-closed loop of this kind makes it difficult for an intruder to de-activate the system by cutting wires. A cut at any point on the loop sounds the alarm immediately. However, it is worth remembering that intruders do not always open doors or windows in the conventional way, in order to gain entry, especially if the door or window is securely locked or bolted. It may be easier for the intruder to quickly cut away the glass of a french door or picture

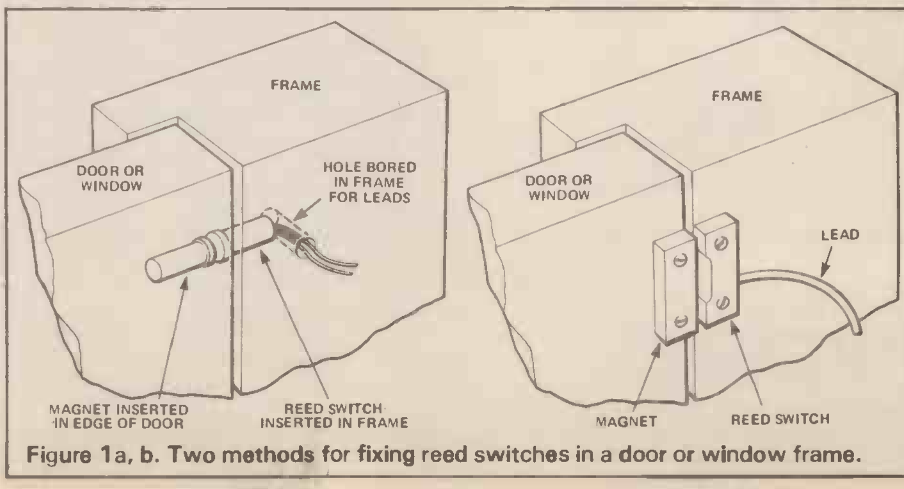


Figure 1a, b. Two methods for fixing reed switches in a door or window frame.

window, and enter through the hole. Another ploy is to cut an entry hole in the panel of a lightly-constructed door, or in the thin panelling which is often to be found alongside front-door units. Glass panes and thin panels may be protected by fixing strips of thin metal foil across them. Special window foil is sold for this purpose, together with terminal blocks for making connections to the end of the strip. These strips can be included as part of the peripheral loop.

Where the devices mentioned above are not suitable, it is usually easy to rig up a normally-closed microswitch which will be opened by an attempted break-in.

Pressure Mats

These are specially made mats which are placed beneath carpets or other floor coverings. They act as normally open switches, closing when stood on. If you have large pets loose in the house at night, or if any member of the family is a habitual sleep-walker, take care where you place them! Otherwise, they may be placed in strategic positions around the house, especially in areas such as the living room, where expensive equipment is likely to attract the intruder. The mats are wired in parallel, so that the circuit is completed when any one mat is stood on. This section of the system may also contain other normally-open switches. A valuable safety feature is to have a few push-buttons situated in the house where they can be used for sounding the alarm manually. This provides a quick and effective way of alerting the household in case of fire, for example. The wiring of this part of the system needs to be as carefully concealed as possible, for the system can easily be de-activated by cutting the wires, but since much of the wiring is beneath the carpets, this presents little difficulty. The wire used for the pressure mat system and the peripheral loop can be light-duty PVC covered wire (7/0.2 mm wire is cheap and perfectly satisfactory).

Circuit Details

The peripheral loop runs from the 12 V line, around the premises and back to the loop input terminal. If the loop is broken, the pull-down resistor, R2, causes the input voltage to IC1a to drop to 0V. The other input to IC1a is held high (at 12 V) by R1. If any one mat is stood on, the input voltage falls to 0 V (low). With two high inputs, the output of the NAND gate is low; this is the quiescent state. If the loop is broken, or if a mat is stood on, the output goes high.

A high output causes a current to flow through D1 and R3, charging C1. If the output remains high for long enough (about 0.5 seconds) the voltage rises above 6 V, which is effectively a high input to IC1b. The output then changes from high to low. If the output of IC1a is high for only a short time, as when a transient pusle appears on one of the inputs, C1 discharges through D2. Since there is no resistor in the return path, C1 discharges rather more rapidly than it charges, quickly eliminating the effect of the transient voltage. It would take an incredibly severe series of transients to break through this filter.

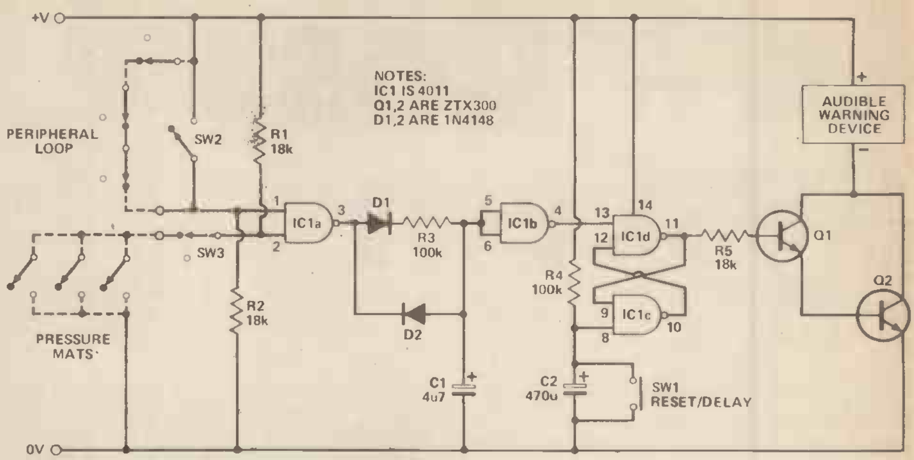


Figure 2. Circuit diagram of the alarm system.

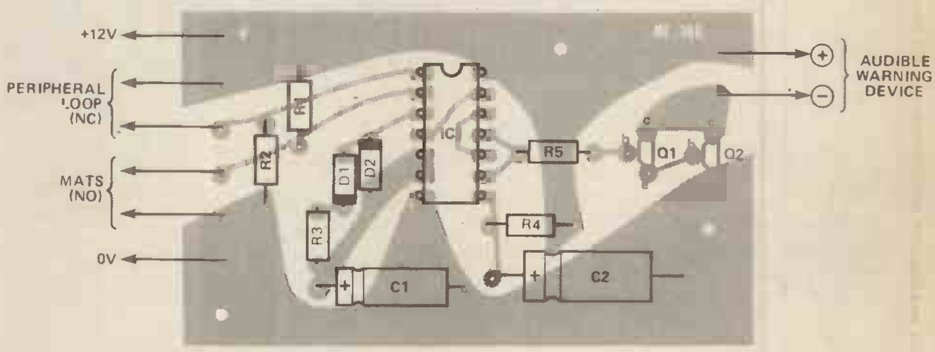


Figure 3. The component overlay.

Gates IC1c and d form a Set-Reset flip-flop. Its inputs are normally high and it is triggered to change state by a low pulse on one of the inputs. The Set input comes from IC1b. When this goes low, the flip-flop changes state, the output of IC1c changes from low to high and current flows to Q1, which is connected with Q2 as a Darlington pair to give sufficient current gain to operate the AWD.

The Reset input to the flip-flop comes from the junction of R4 and C2; it is held high by the pull-up action of R4, but when SW1 is pressed, the input falls immediately to low, thus resetting the flip-flop. While this input is low, a break in the loop or pressure on a mat can cause the input of the IC1c to go high and sound the alarm, but only for as long as the condition lasts, because the flip-flop does not change state permanently. The input to IC1c rises very slowly from 0 V as C2 charges through R4; it take about 30 seconds to reach 6 V, providing the delay which allows the alarm to be set when the house is to be left unoccupied. After that, the flip-flop is ready to be triggered permanently by a low pulse from IC1b.

SW2 switches out the peripheral loop, by connecting the loop input directly to the 12 V line. This switch is not an essential part of the system, but it may be useful to de-activate the loop if, for example, a member of the household plans to return home late at night when the other members are in bed. This allows the mats to provide some kind of protection in the meantime. SW3 disconnects the mat system, and this too is useful but not essential. During the evening, when all doors and windows are shut and the family is engrossed in the TV, the mat system is probably best kept inactivated. The peripheral loop gives adequate protection against intruders, many of whom prefer to break in when everyone is settled in one room with the sound from the TV to mask the noise of breaking glass or splintering timber.

Construction

There should be no problems in assembling the board and getting it to work straight away. As already mentioned, this circuit is ideally powered by a battery of 8 dry cells, or Ni-Cad cells. These may be contained in two 4-cell battery holders. Whether or not the circuit needs a case is a matter of opinion. It is preferable that the intruder should not be able to locate the circuit and cut off the power supply, so there is much to be said for hiding it away in a cupboard or drawer, eliminating the expense of a case.

The dead space below a table (**Figure 5**) is a good place to hide the circuit and batteries, though almost any other odd space will do; accessibility is not important, as you need renew the batteries so infrequently, provided that the switches can be reached easily. Concealed wiring should lead to the Reset/Delay button, hidden away in a convenient location fairly close to the door by which you normally enter the house. The AWD should be in some relatively inaccessible location, *not* beside the circuit itself. The wiring to it should be concealed as much as possible. The

Parts List

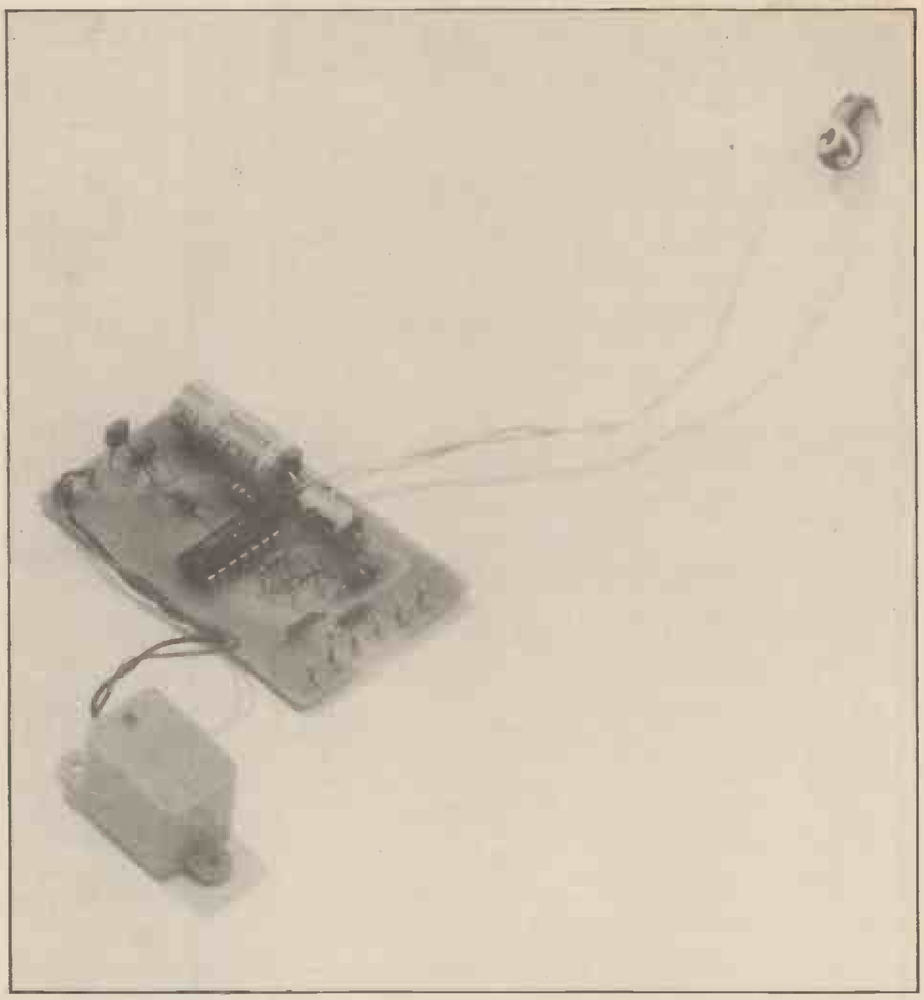
RESISTORS
(All ¼ watt 5% carbon)
R1, 2, 5 . . . . 18k
R3, 4 . . . . 100k

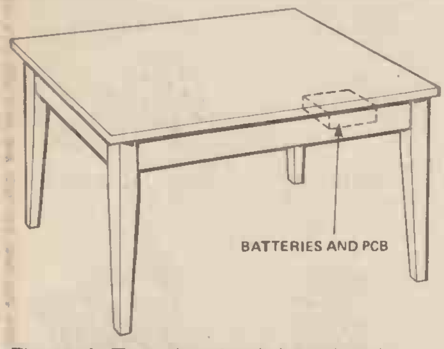
CAPACITORS
(All electrolytic)
C1 . . . . 4u7 16V
C2 . . . . 470u 16V

SEMICONDUCTORS
Q1, 2 . . . . ZTX300 silicon NPN transistor
IC1 . . . . 4011 CMOS quad 2-input NAND
D1, 2 . . . . 1N4148 signal diode

MISCELLANEOUS
SW1 . . . . Push-to-make push-button switch
SW2, 3, 4 . . . . SPST standard toggle switches
Siren (AWD), 12 V with optional multitone; battery holder (2); door and window switches; window foil and terminals; pressure mats; wire; solder etc.

BUYLINES . . . . page 34





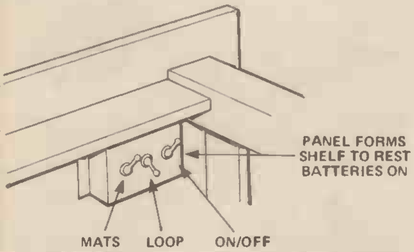


Figure 4. Top, the circuit board and power supply can be conveniently hidden underneath a table top — but make sure the switches are easily accessible (bottom) as well as being hidden.

AWD could be mounted in the loft, where its sounds will readily be heard both inside and outside the house.

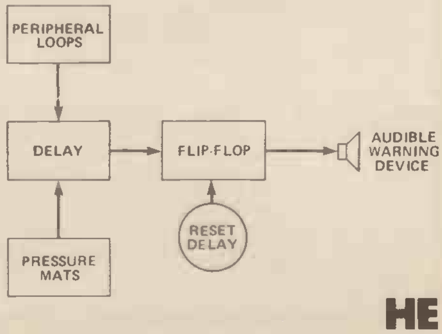
Maintainance

A power-on lamp is not provided, since this would consume 25 times as much current as the quiescent circuit, so check the batteries regularly; remember that flat batteries will run the quiescent circuit well enough but may fail to provide enough power for the AWD. The check should include sounding the alarm; check each window and door switch every few months, and also each pressure-mat.

How It Works

THE TWO detecting systems, peripheral loop and pressure mats, provide inputs to the system which are normally high (12 V) but go low (0 V) when an intruder is detected. Since the wiring is many metres long and surrounds a houseful of electrical and electronic appliances, it frequently picks up transient electromagnetic signals. The switching on and off of equipment such as TV sets and refrigerators causes pulses to appear in the wires of detector systems, and these are often strong enough to trigger a flip-flop. The delay circuit filters out all these transients so that the alarm does not sound unless the detector circuit shows a low voltage for about half a second. It is not likely that an intruder could make an entry during so short a time, yet this is long enough for any transient to subside.

The action of the intruder triggers a flip-flop which sets off the alarm. This sounds continuously until the power supply is disconnected or the Reset/Delay button is pressed. Once the button is pressed, the flip-flop is inactive for a period of about 30 seconds. If the peripheral loop is broken during this period, the alarm sounds, but only for as long as the loop is broken. This delay is essential if you are leaving the house empty, allowing the last person to remain in the house to press the Reset button and quickly leave by the front door. The alarm sounds very briefly as the door is opened and closed, but is silent after that. A few moments later the system becomes activated. On return to the house the alarm sounds but, if the first person in is prepared to act quickly and if the reset button is concealed not too far away from the door (on the inside, of course), it takes less than a second to silence the alarm. The delay operates similarly on the pressure-mat system, so there is no need to jump over the doormat on the way out.



HE

Lofty

A handy loft-light alarm to build

CAUTION

The 'Lofty' uses a transformerless power supply and, as a result, all parts of the circuit are at mains potential and are possibly lethal to touch. No metallic parts must be accessible when the unit is operational.

RETURNING from a weekend away, not so long ago when the weather was still warm, we happened to meet our neighbours from across the street. The evening was balmy, though the light was fading fast as we exchanged pleasantries about the weather and Botham's batting while we unloaded the car; then our neighbour dropped his bombshell. "By the way", he said innocently, "did you know you left a light on in your loft? We can see it from our upstairs window". In fact, we could see it from across the street, shining brightly through narrow chinks between some of the tiles.

That rapidly put an end to the conversation as, feeling foolish, I hurried into the house thinking, as I climbed the ladder, of the electricity bill we were about to receive (without thanks, oh lord); those lights (two 150 watt bulbs) had been burning continuously for at least three weeks!

From that incident, Lofty was born — a simple device that could be connected across the light switch and which would sound an alarm after a preset period, unless the light had been turned off. As finally constructed, Lofty actually has two alarms; a winking LED for visual warning and a two-tone beeper which, although not particularly loud, generates a penetrating tone that will be audible throughout a quiet house.

Another aim, when we designed Lofty, was to keep the size of the unit as small as possible, and to keep the cost low.

For these reasons, we used a novel transformerless power supply. As a result of this design, though, *all parts of the circuit are at mains potential with respect to earth and are therefore possibly lethal to touch. No metallic parts must be exposed when the unit is operational, and particular attention must be taken in the construction to ensure that the unit is effectively insulated.*

As an added precaution, it should be mounted in an inaccessable position, well out of the way of prying fingers! The method is perfectly safe provided these precautions are taken.

The Circuit

The transformerless power supply is based on C1; this has an impedance of 6k7 ohms at 50 Hz mains frequency. Therefore, the current through it at 240 VAC is 36 mA. Although it is acting as a 'dropping resistor' and is passing a fairly high current, C1 does not dissipate any power; that is, it does not get hot.

The AC current through C1 is then rectified by the diode bridge, BR1, and charges C2 to a maximum of 15V, determined by ZD1; this is the power rail for most of the circuit. Resistor R1 drops the supply voltage further before it is fed to the internal shunt regulator in IC1, and C3 provides some additional filtering.

IC1 is a ZN1034 precision timer IC made by Ferranti. It contains an oscillator, a 12-bit counter and a regulator circuit. When power is applied to the chip, the counter is reset; 4095 oscillator cycles later, the output at pin 2 goes high.

The time period is determined by the oscillator frequency; the higher the frequency, the longer the time period. The frequency is set by just two components — R2 and C4. The values used here give a period of around 45 minutes, but this can easily be altered, as described later.

While IC1 is still counting, the two sections of IC2, a dual 555 timer, are prevented from operating by the low output from pin 2 of IC1 on their reset inputs, pins 4 and 10. Then, when IC1 times out, its pin 2 goes high and enables both sections of IC2. It is now possible for LED1 to light, since its anode is no longer at 0V.

IC2b will oscillate at a frequency of a few kilohertz, but the tone will be modulated from the output from IC1a, which is generating a asymmetrical waveform at 1 or 2 Hz. As well as modulating the output from IC2b, this waveform also causes LED1 to flash on and off. The output from IC2b is fed to the piezo-electric sounder, X1, which generates the audio tone.

Construction

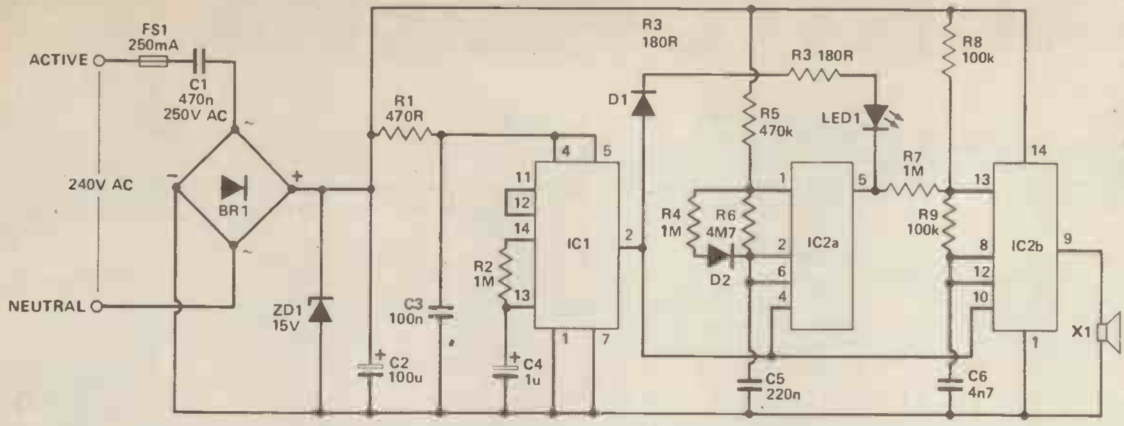
Start by assembling the timer and tone generator components on the PCB; points to watch here are that the ICs and the tantalum capacitor (C4) are correctly oriented. At this stage, the time period can be changed by altering the values of R2 and C4. The delay, in seconds, is equal to 0.7 x 4095 x R2 x C4, with R in megohms and C in microfarads; R2 should not be reduced below 10k and C4 must be between 10n and 100u.

Before proceeding with the power supply section (BR1, ZD1 and C2), test the timer and audio beeper by connecting a temporary 12-15 volt supply to the unit. Naturally, you will have to wait 45 minutes (or whatever period you have set) to find out if all is well! If the unit does fail to work for some reason, first carry out the usual checks for solder bridges, dry joints and so on. The operation of IC2 can be checked by first removing IC1, then applying about 3V to the IC1 pin 2 connection. This will enable both sections of IC2 and it should immediately burst into life unless there is a fault present. Testing IC1 will be more difficult, although there is very little that can go wrong here. If you do need to check the IC, it would be best to change R2 and C4 to give a short time delay — 39k and 10n give a one second delay — otherwise fault-finding could take a very long time!

When the timer and audio generator are working, the power supply can be wired up. Before proceeding with this, however, check that the LED is bright enough to be seen. If not, reduce the value of R3, but not below 100R.

Power Supplied

The vital component in the transformerless power supply is C1; this *must* be rated for 240V/50Hz operation ie, at least 250 VAC, 600 VDC working. When it has been soldered in place, make sure C1 cannot vibrate by tying it down with two cable ties passed



NOTES:
IC1 IS ZN1034
IC2 IS 556
D1,2 ARE 1N4148 OR SIMILAR
ZD1 IS 15V 1W3 ZENER
BR1 IS 1A 800V (W08)
LED1 IS LARGE RED LED (PLASTIC) FOR PANEL MOUNTING
X1 IS PB2720 PIEZO BUZZER

Figure 1. The complete Lofty circuit — note that the mains earth lead is not connected.

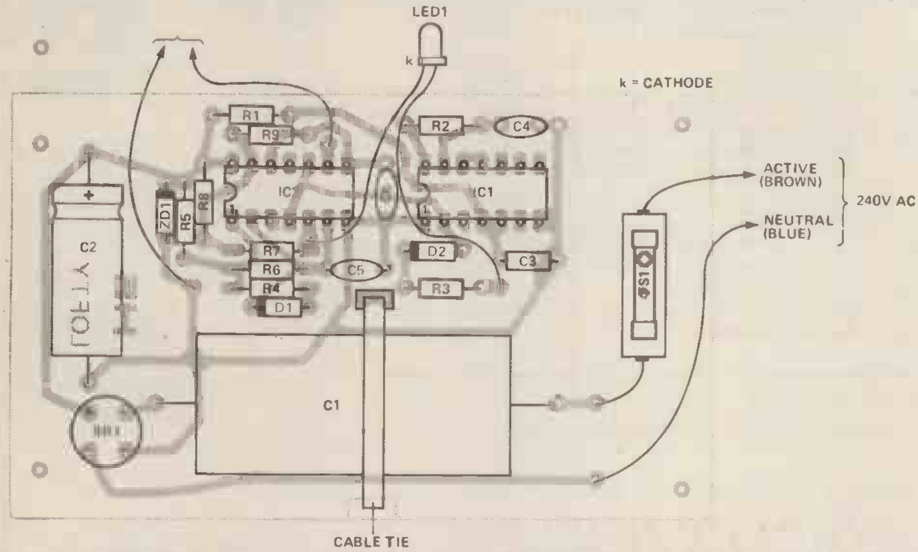


Figure 2. The PCB component overlay. Capacitor C1 takes up most of the board space!

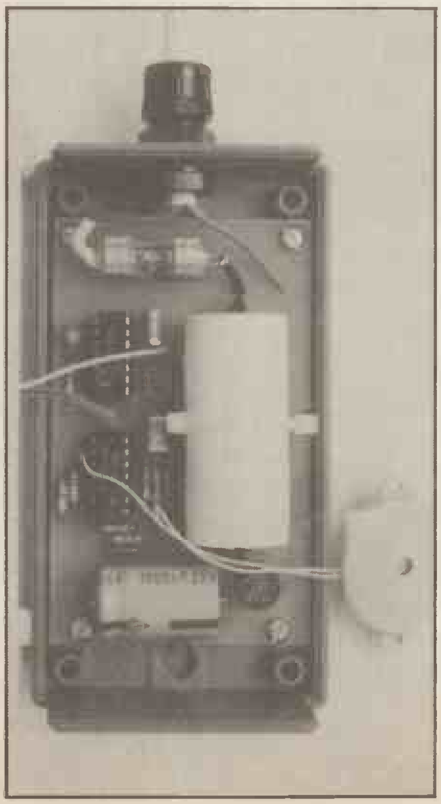
through the holes in the PCB. Next, mount the diode bridge, C2 and the Zener diode, then the fuse, FS1. This is included to protect against the possible failure of C1; if it ever needs to be replaced, remember to *totally disconnect* the 'Lofty' before doing so!

Insulation

The last stage is to mount the piezo transducer and connect it to the appropriate points on the PCB. Use a stout piece of plastic film between X1 and the underside of the case to insulate the diaphragm of the transducer because, as explained earlier, this could be 'live' and thus potentially lethal to touch. Finally, mount the PCB in the case using M3 screws. It is now ready to be wired into the loft light circuit.

Wired Up

The unit should be placed near the loft opening, where it can easily be seen and the sound of the alarm will not be muffled. A length of ordinary two-core lighting flex is connected from the Lofty's mains input to the loft light, so that the unit is turned on with the lights. Forty five minutes later, the alarm will sound. If you are still working in the loft, reset the unit by briefly turning off the lights, initiating another timing period.



Parts List

RESISTORS

(All ¼ watt 5% carbon)

R1 . . . . 470R
R2,4,7 . . . . 1M0
R3 . . . . 180R
R6 . . . . 4M7
R8,9 . . . . 100k

CAPACITORS

(All polycarbonate unless noted)

C1 . . . . 470n
250 VAC/600 VDC minimum
C2 . . . . 1000u
25 V electrolytic
C3 . . . . 100n
C4 . . . . 1u
35V tantalum
C5 . . . . 220n
C6 . . . . 4n7

SEMICONDUCTORS

IC1 . . . . ZN1034
precision timer
IC2 556
BR1 . . . . W08
800V, 1A bridge rectifier
ZD1 . . . . BZX61C15
15V, 1.3W Zener diode
D2,3 . . . . 1N4148
LED1 . . . . panel mounting LED
with plastic (not metal) bezel

MISCELLANEOUS

FS1 . . . . 250mA
20 mm fuse
X1 . . . . PB2720
piezo-electric buzzer

Chassis-type fuse holder; small cable gland; plastic LED bezel; Verobox enclosure (see Buylines); PCB; IC sockets; stout plastic film, 1" x 1"; M3 bolts; cable ties; wire, solder etc.

BUYLINES . . . . **page 34**

HE

BACKNUMBERS

February 1980
Passion Meter, Win Indicator, Short Circuit Special, Kit Review Special, Into Electronics Construction Part 1.

May 1980
MiniClocks, 5080 Preamp, Model Railway Track Cleaner, 5080 Loudspeakers, Loudspeaker Crossover Design, Radio Controlled Model Survey.

June 1980
Microbe Radio Control System, Egg Timer, Two Watt Amplifier, Fog Horn, Short Circuits, LEDs and LED Displays.

July 1980
Sound-Operated Flash Trigger, 18 + 18 Car Stereo Booster, Hazard Flasher, Electronics in Photography, Electronic Espionage, Piezo Electricity.

August 1980
EquiTone Car Equaliser, Pass-The-Loop Game, Gaztec Gas Detector, OP-Amp Checker, In-Car Entertainment Survey, Introducing Microprocessors.

September 1980
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Kitchen Timer, Tug 'o' War Game, Light Dimmer, Freezer Alarm, Intruder Alarm, Temperature-Controlled Soldering Iron.

January 1981
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February 1981
Heartbeat Monitor, High-Impedance Voltmeter, Medium Wave Radio, Two-Tone Train Horn, Audio Signal Generator.

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Public Address Amplifier, Windscreen Wiper Controller, Bicycle Speedometer, Photographic Timer, Microcassettes.

April 1981
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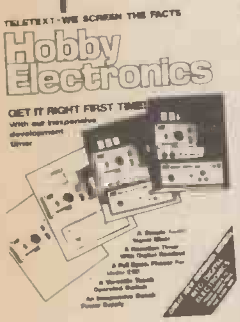
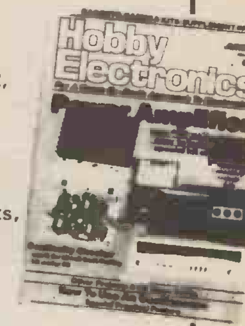
May 1981
Electronic Organ, Voice-Operated Switch, Infra-Red Controller, Pre-Amplifier Part 2, Audio Millivoltmeter.

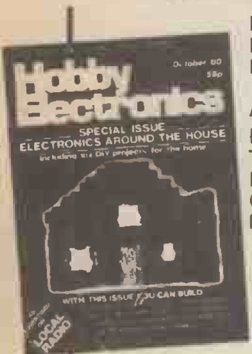
June 1981
Power Amplifier Part 1, Continuity Checker, Envelope Generator, Early Radio, Gadgets, Games and Kits Supplement.

July 1981
Burglar Alarm, Doorbuzzer, Treble Booster, Electronic Aids for the Disabled, Power Amplifier Part 2.

August 1981
Electronic Ignition, Thermometer, Electronic Organ (final part), RPM Meter, Bench Power Supply, Radio Control Survey, Into Electronic Components Part 1.







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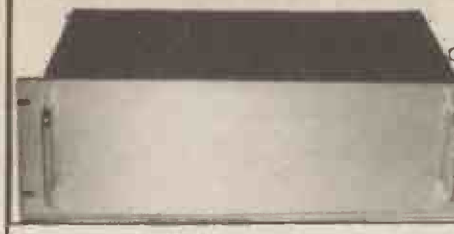

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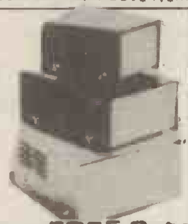

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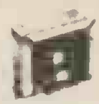

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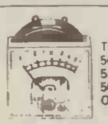

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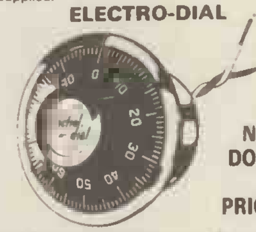

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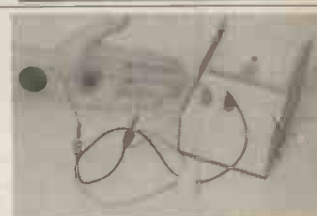

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Big Ear

A high gain, directional microphone, ideal for nature studies.

THIS is one project where the mechanical work is greater than the electronic! The Big Ear consists of an omnidirectional microphone insert mounted in a length of common, garden variety 2½'' PVC pipe, and a simple two-stage amplifier circuit. It was originally designed for recording or listening to the sounds of wildlife; however, the prototype has also proved useful as a stethoscope, and for listening in to distant conversations (be warned — the listener may not always like what he hears!)

The length of pipe serves two purposes; first, it acts as a resonant cavity with many resonant frequencies extending from a few hundred Hertz right up to the top of the audio band. Any pipe or tube has a fundamental resonant frequency which is a function of its length, and it is also resonant at overtones (harmonics) of the fundamental frequency. In general, the fundamental frequency, f, of a pipe which is closed at one end is approximately equal to c/4l, where l is the length of the pipe and c is the velocity of sound (330 metres per second, for most purposes). Thus the fundamental frequency of a pipe 0.25m long will be at 330 Hz; the overtones produced by a closed pipe occur only at odd harmonics, therefore resonant peaks will also occur at 990 Hz (3f), 1650 Hz (5f), 2310 Hz (7f) and so on. The effect of these resonances is to accentuate any sound at those frequencies, increasing the gain of the system at specific points in the audio spectrum. The length of the

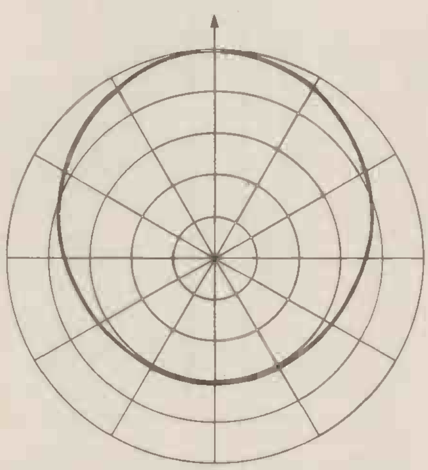


Figure 1. The directional response of the Big Ear.

pipe specified for this project has been arrived at after considerable experiment, and provides good results with minimum undesirable side-effects.

Second, the pipe provides a useful measure of directivity, due to diffraction effects. Diffraction is simply the change in direction of sound when it passes around an obstacle. The degree of bending depends on the ratio of the wavelength of the sound to the size of the obstacle and is greatest when the size of the object approaches the wavelength of the sound. In general, long wavelengths (bass frequencies) bend more easily because few everyday obstacles are more than about one metre long (the wavelength of a 100 Hz note, for example, is about 3.3m). The higher frequencies

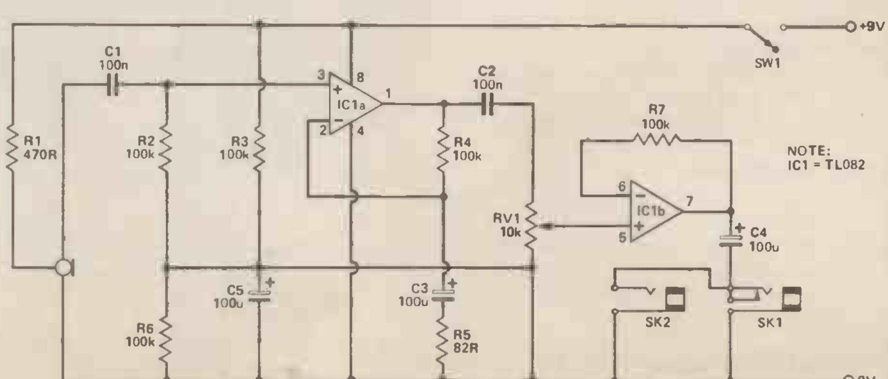


Figure 2. The internal circuitry of the Big Ear.

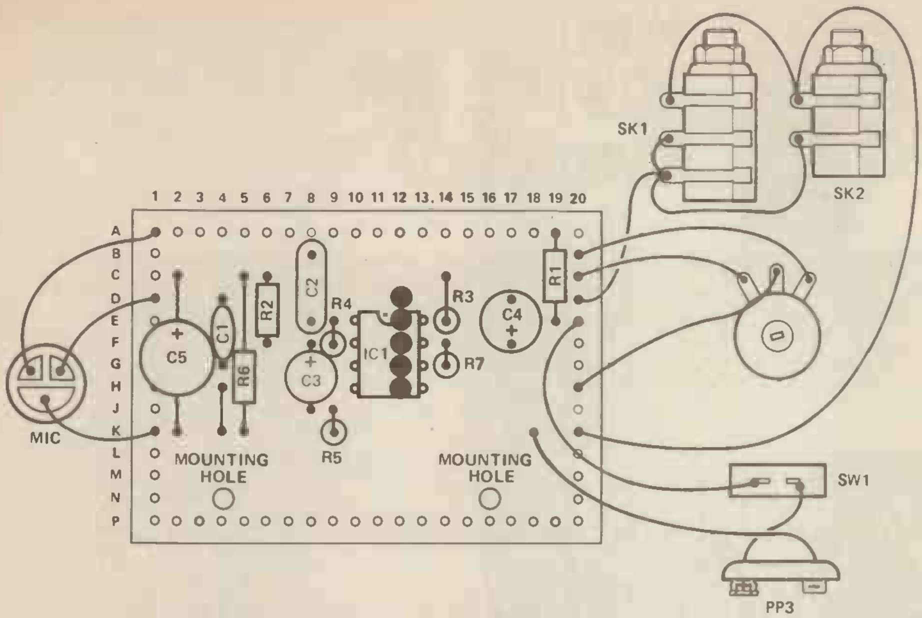
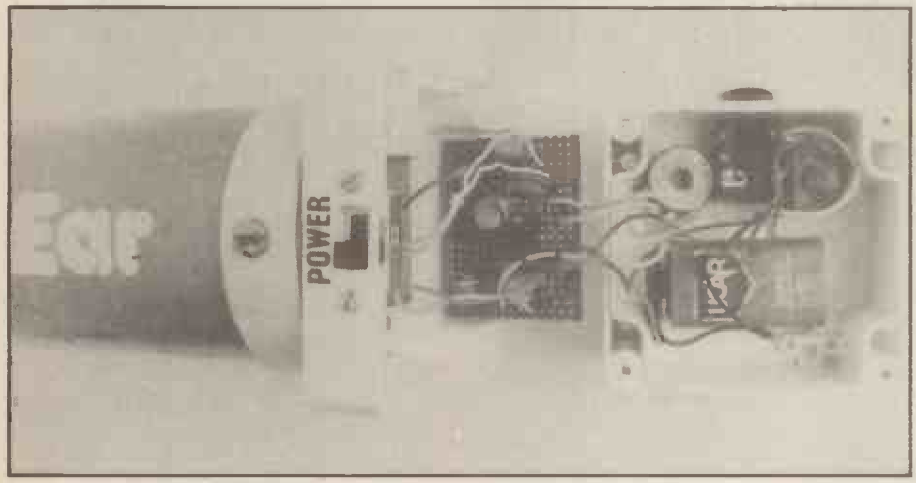


Figure 3. The project is simple enough to build on Veroboard. The diagram shows the component layout and the track cuts *viewed from the top.*



Parts List

RESISTORS
(All ¼ watt 5% carbon)
R1 . . . . 47OR
R2,3,4,6,7 . . . . 100K
R5 . . . . 82R

POTENTIOMETERS
RV1 . . . . 10K log carbon

CAPACITORS
C1,2 . . . . 100n C352* polyester
C3,4,5 . . . . 100u 16V electrolytic
*Replaces C280 Series

SEMICONDUCTORS
IC1 . . . . TL082 dual op-amp

MISCELLANEOUS
SK1 . . . . ¾'' stereo socket
SK2 . . . . ¼'' mono socket
Small ABS case, approx. 80 × 60 × 40 mm; omnidirectional electret microphone insert; 0.1'' Veroboard, 50 x 38 mm (20 holes x 15 strips); slide switch; PP3 battery clip; PVC pipe, 254 x 63 mm (10'' x 2½''); wire, solder etc.

BUYLINES . . . . page 34

bend less easily and therefore are more directional, since they are reflected by common-sized obstacles rather than bending around them.

In the Big Ear, the pipe tends to 'hear' only those mid-range and high frequency sounds coming from directly in front, whereas sounds from the sides or rear will be rejected because they cannot bend around the edges of the opening. At low frequencies, however, the tube has no effect and so the response of the system reverts to that of the microphone insert, ie omnidirectional. To prevent these frequencies from being transmitted through to the output, the response of the amplifier is rolled off at the bass end. Overall, this combination of techniques gives a back-to-front ratio of 2:1 (see **Figure 1**).

The Big Ear is designed to be hand-held, and for this purpose, a standard 2½'' pipe clip serves quite well as a handle in normal use; it will also do as a tripod mount, should that be required.

The amplifier section has two outputs: a headphone socket for monitoring purposes and a ¼ jack socket for connection to the line input of a tape recorder.

The Circuit.

The circuit (**Figure 2**) consists of two op-amps contained in a single TL082 IC package. The circuit can be split into two sections: a voltage amplifier and an output buffer.

Starting at the input (where else?), notice that the microphone has three connections to it. This is because it is an electret insert which contains a FET preamplifier to provide a low impedance drive from the high impedance microphone source. Thus, it must be connected to the supply rail via R1.

The input from the mic is fed to the non-inverting (−ve) input of IC1a. The value of the coupling capacitor, C1, is chosen to filter out the very low frequencies generated by handling the unit. Otherwise, these would create low rumbling sounds which would seriously interfere with the performance, especially at high gain settings! The voltage gain of this stage, set by the ratio of the values of R4 and R5, is x1000.

The Big Ear was intended to be portable, and therefore a dual supply system, positive and negative rails, was not suitable because of the extra battery requirements. Instead, a half-supply voltage reference is created by the resistive divider network R3 and R6. The junction of the two resistors is bypassed to OV by C3 to remove any noise from the signal.

The full gain of the first stage is not always required (the results could be ear-splitting), so the output from IC1a is coupled to the buffer stage, IC1b, via a volume control, RV1; coupling capacitor C2 is chosen to roll-off the bass response. IC1b is set-up as a unity gain amplifier; its output is at a low impedance and is sufficient to drive an ordinary set of headphones or the input circuit of a tape recorder, via socket SK1. Blocking capacitor C4 is included to prevent the DC level at the output of IC1b from reaching the load.

Construction

As the circuit is so simple, it was decided to build it on Veroboard; the usual precautions concerning layout, track cuts and solder bridges apply! Pay particular attention to the correct orientation of the electrolytic capacitors and the IC.

When the board is assembled, attach flying leads about 9'' long to each of the off-board connection points. Next comes the mechanical assembly.

Mark out and drill the mounting holes as shown in **Figure 4**. These are easily made — but the slot for the slide-switch will cause greater problems! Carefully drill ¼'' holes at each

end of the slot, then file it to shape. A small flat file will be useful for finishing the task. Although the box cut-out for the microphone is shown as a square, this can be drilled out to 3/8" clearance, the size of the microphone insert.

Lastly, the wooden disc which holds the mic insert, and to which the length of 2½" pipe attaches, must be cut out; the dimensions are shown in **Figure 4**. Preferably, the disc should be cut from a solid piece of wood; the pipe is held by screws into the sides of the disc, and chipboard has a tendancy to fall apart if used in this fashion.

After the parts have been made, the Big Ear can be assembled. Mount the sockets, poteniometer and Veroboard; the mic insert should be a tight fit in the 3/8" hole through the centre of the wooden disc; glue it if you must, but the arrangement then becomes somewhat permanent! The disc itself is attached to the box by two small self-tapping screws, and the pipe can then be screwed onto the disc with three or four self-tappers. Finally, the flying leads should be connected as shown in **Figure 3**; the battery should be fixed to the base of the box with a piece of double-sided tape or Blu Tack, to prevent it rattling around inside.

At this point, the Big Ear is ready to use. Switch on and try it. There will be silence for a couple of seconds, then it should burst into life.

Why Not Experiment?

Although the final form of the Big Ear was arrived at after a considerable period of trial-and-error experiment, there are several other methods which could be used to improve the directional response.

The most effective would be to replace the omnidirectional mic insert with a directional type; however, these do not seem to be readily available and can probably only be had by dismantling a cheap directional electret mic of the type usually sold with cassette recorders.

The next most important factor determining the directivity is the aperture of the pipe; decreasing the diameter will increase the directional response to high frequencies, at the expense of less directivity at lower frequencies. Another trick is to form many small resonant cavities, rather than one large one, by filling the pipe with ordinary plastic drinking straws; the overall response can be 'tuned' by cutting the straws to different lengths. The directional response can also be improved by isolating the mic insert from the case and pipe, as some of the sound from the sides and rear will otherwise be conducted through the solid material to the microphone.

Finally, there are alternatives to the resonant tube system; one method worth trying is to use a parabolic or dish reflector; a simple plastic bowl would be adequate! **HE**

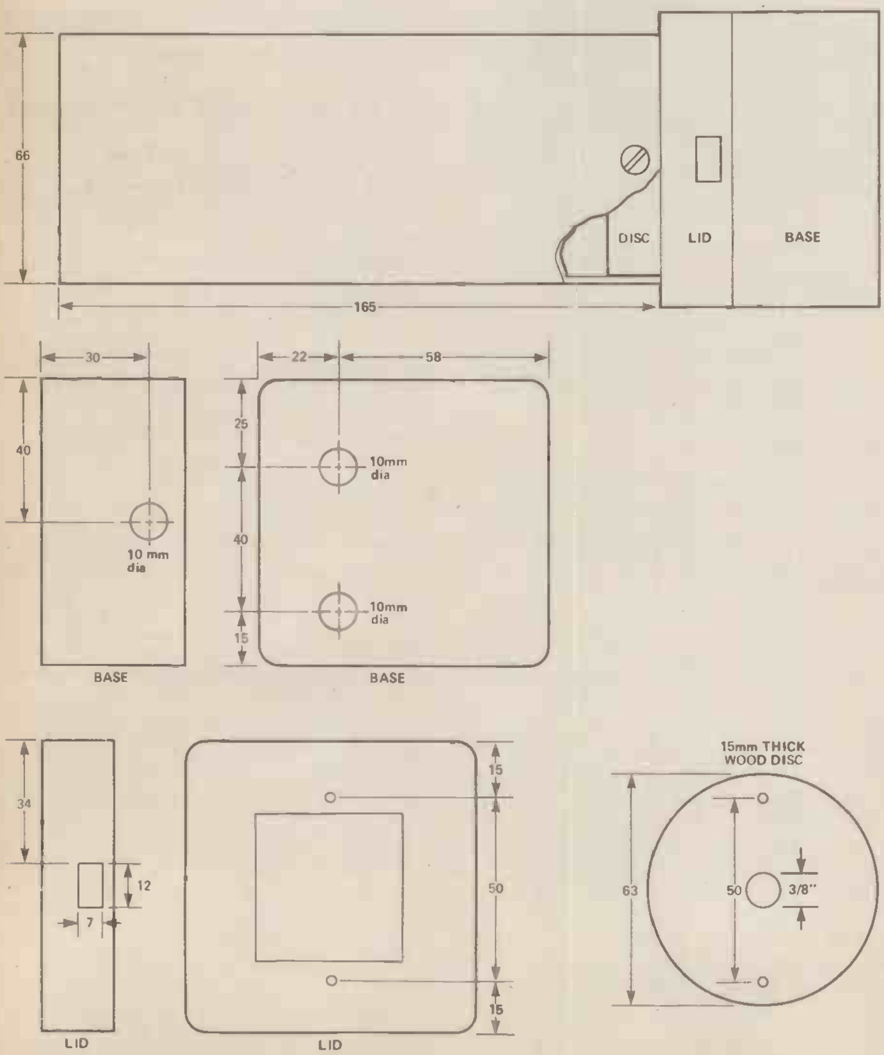


Figure 4. The mechanical details.

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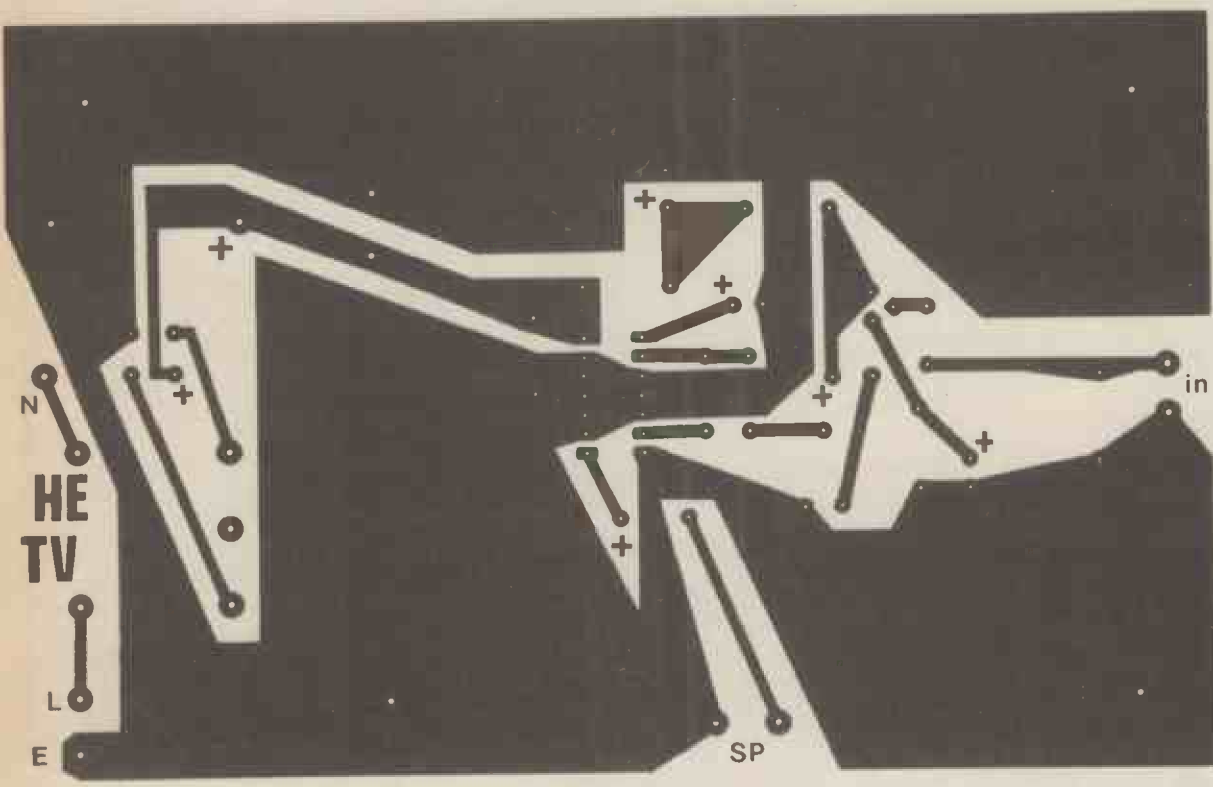
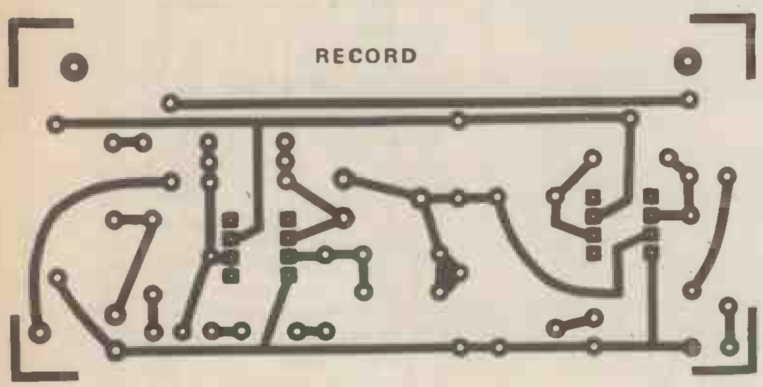
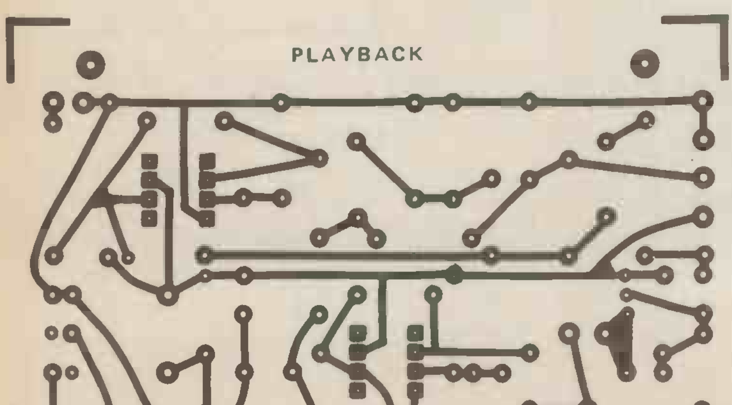
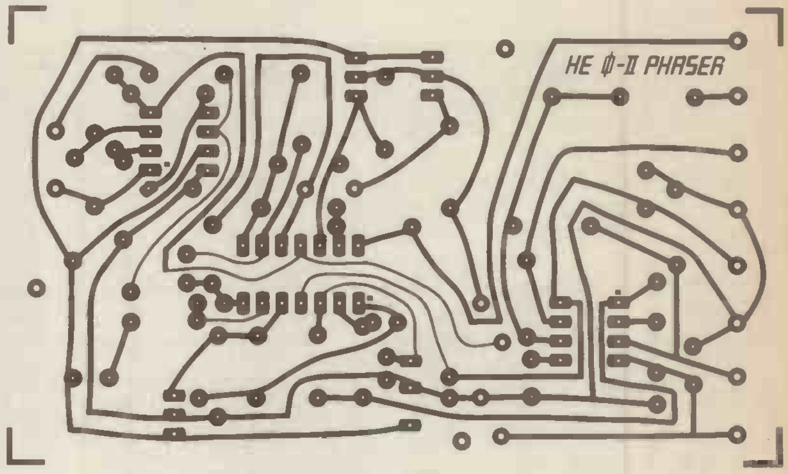




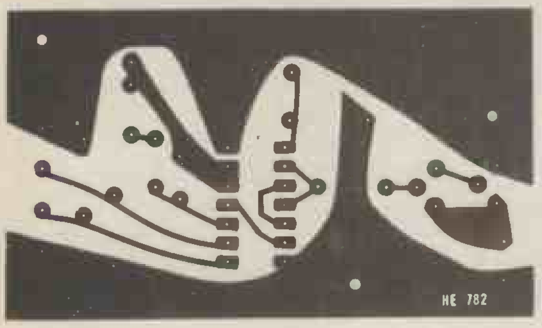


Left: Both PCB patterns for the Tape/Slide Synchroniser; top, the Recording board; bottom, the Playback board.

PCBs

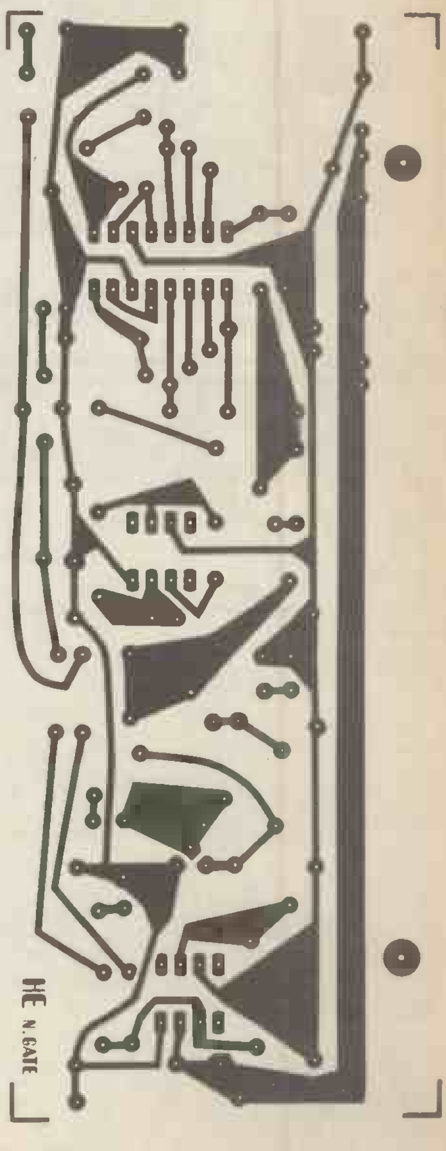


Right: The HE Phase Four PCB



The Stereo Noise Gate PCB pattern (right). Note that there are only two mounting holes.

Left: The PCB foil pattern for the Low Cost Alarm. The three large holes are for mounting bolts.



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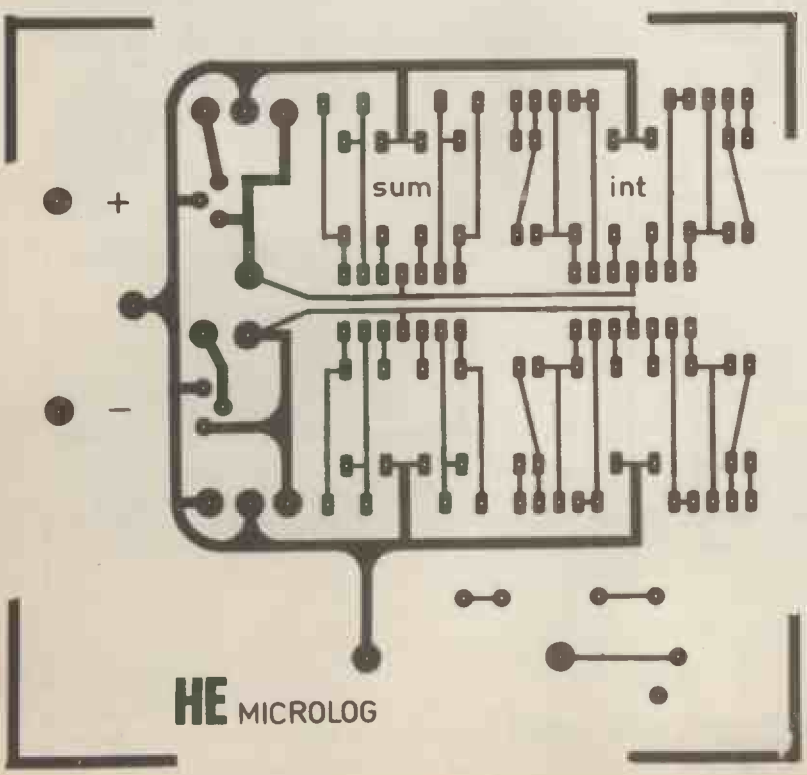

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