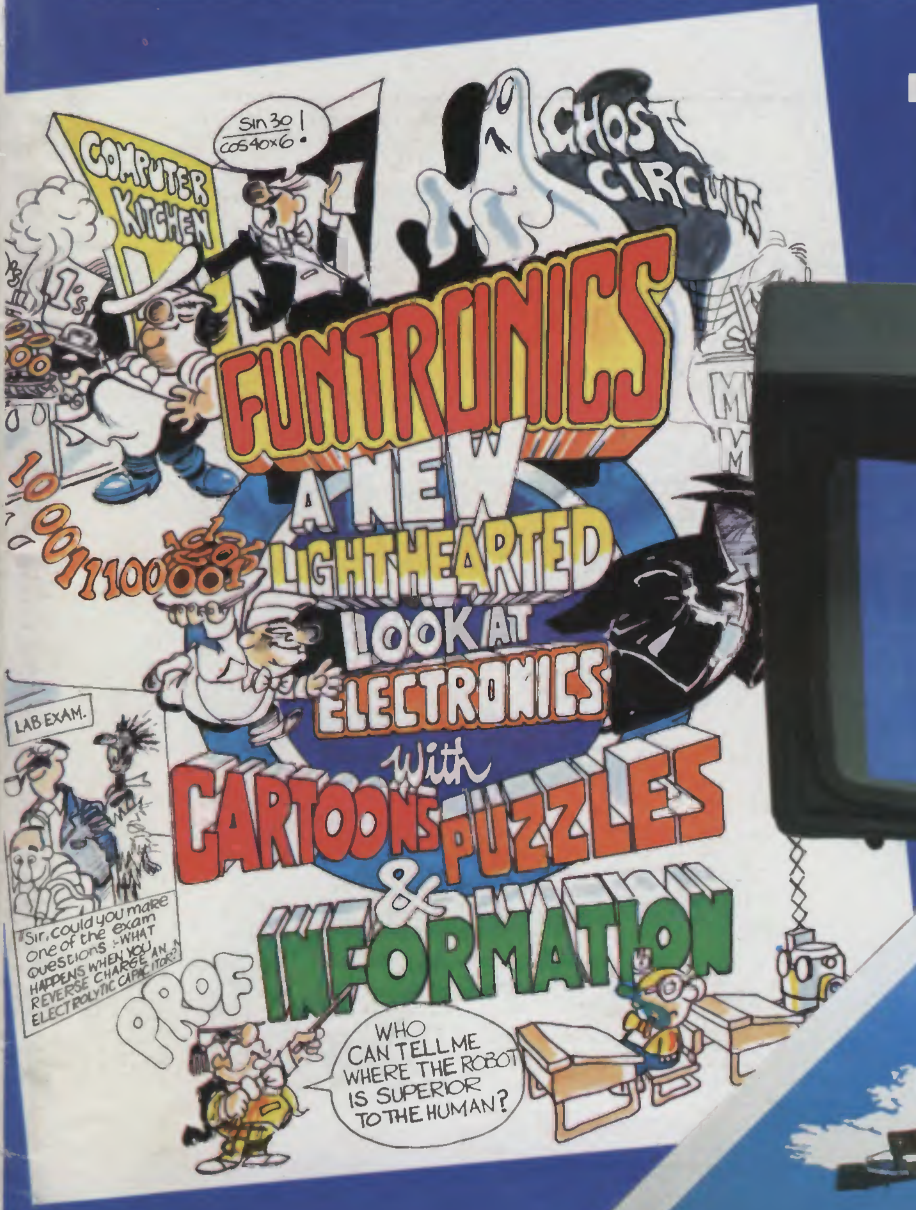
EVERYDAY ELECTRONICS and computer PROJECTS

SEPTEMBER 1984 90p



MICROCOMPUTER DIGITISER

GUITAR HEADPHONE AMPLIFIER

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EVERYDAY ELECTRONICS and computer PROJECTS

VOL. 13 NO. 9 SEPTEMBER 1984

PROJECTS . . . THEORY . . . NEWS . . .
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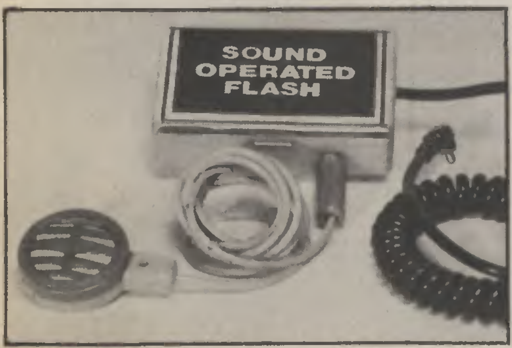

Our October 1984 issue will be published on Friday, September 21. See page 581 for details.

PROJECTS

SERIES

FEATURES

EVERYDAY ELECTRONICS and computer PROJECTS

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LEARNING

ANOTHER new course in EE? Yes, the October issue is the starting point for a series on digital electronics. For those readers who have been following *Teach In '84*, the new series will strengthen and expand your knowledge of digital electronics. With so much electronic technology now relying on digital techniques, including of course the microprocessor, a basic understanding of this area is essential to the constructor or engineer.

The new series is suitable for those with a basic understanding of general electronics as well as providing an excellent refresher for the more advanced reader. For those readers who have followed *Teach In '84* there will be further interesting features and series coming up in EE (including one on fault finding) and some may find that items in our sister publication *Practical Electronics* may provide an expansion of their knowledge and more challenging constructional projects.

CHECK IT OUT

One of the frustrations suffered by readers is the problem of obtaining components for projects. While we take every care to make sure all items we use in EE projects are readily available, we cannot guarantee their availability in the future. Fortunately many of our past and present projects are now supplied in kit form from advertisers, as we are sure observant readers will notice. In such cases the advertiser has solved your problems by making all the items very easy to buy. However, readers often decide to build projects that were published many years ago. If it is your intention to do this, wait before you start buying bits. If there is no kit available from an advertiser please check that you can still obtain all the parts you require *before* you start spending money.

We get many letters from readers who have started to build a project that was published up to ten years ago, only to find that one vital part is no longer available. The speed of development in electronics does mean that items are discontinued by manufacturers at an alarming rate and very often there is no way a replacement can be found.

The editorial staff of EE do check out unusual items and keep abreast of the general component supply situation but we cannot foretell the future and a component we specify now could be unobtainable in a year or two. So please make sure you can get every part before committing yourself to a project.

SEDAC

To all the schools and pupils that took part in our *Schools Electronic Design Award Competition*, jointly sponsored by Mullard and EE, we would like to extend our thanks for your time and interest. Unfortunately you cannot all be winners but we are sure you will be interested to see the finalists and the prizewinners featured in this issue.

The knowledge and enthusiasm of those taking part is very encouraging for the future of electronics in the UK.

Mike Kenward

Readers' Enquiries
We cannot undertake to answer readers' letters requesting modifications, designs or information on commercial equipment or subjects not published by us. All letters requiring a personal reply should be accompanied by a stamped self-addressed envelope or international reply coupons.
We cannot undertake to engage in lengthy discussions on the telephone.

Component Supplies
Readers should note that we do not supply electronic components for building the projects featured in EVERYDAY ELECTRONICS, but these requirements can be met by our advertisers.

All reasonable precautions are taken to ensure that the advice and data given to readers are reliable. We cannot, however, guarantee it and we cannot accept legal responsibility for it. Prices quoted are those current as we go to press.

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MICROCOMPUTER DIGITISER

J. HOWDEN Ph D

WHEN I got my BBC micro I looked forward to seeing lots of complex images such as maps of the British Isles on the screen. After all, most high resolution graphics computers are advertised with this sort of picture to show off their capabilities. Alas, it soon occurred to me that getting the required data into the computer was not going to be easy.

There were several possible methods. I could copy the map from my atlas onto squared paper using straight line approximation and then number each break point with screen co-ordinates. Alternatively, I could use a light pen or joystick and copy the map by eye. Apart from not having a light pen, I did not like any of these. The correct tool for the job was obviously a digitiser; a pad with a stylus or cross-hair device which can be moved over an existing drawing and pass its co-ordinates to the computer.

DO IT YOURSELF

Professional digitisers are expensive and complex but if you do not need top performance a digitiser can be based on a simple hinged arm with a couple of ordinary potentiometers.

At this point I had an idea of how the software might be handled, so I set to work on the hardware. If you too have a few simple tools and a few odds and ends of wood and metal lying around, you may care to have a go at a digitiser yourself. The cost will range from zero (in my case), to a few pounds, depending on what you have available. You may wish to modify my design to suit the parts you have to hand. There are very few critical dimensions or components in this design so feel free. The only really vital factors are to avoid slop in the joints and to get the two potentiometer shafts vertical.

The digitiser described here is, of course, only directly usable with computers such as the BBC and the Dragon which have an analogue-to-digital interface with at least two channels. It is not too difficult to add such an interface if you have a parallel port but if you do so ensure that the conversion is linear.

THE TUBE??

My first thought was to make the arms of the device (Fig. 1) from wood as this would be light and easily worked, but then I found a length of copper water pipe left over from the last plumbing job and decided that this would be satisfactory. One advantage of tubular construction is that wires can be passed through it.

Fig. 1 shows the construction with some suggested dimensions, none of these is critical. The first step was to decide upon the largest drawing size that I would wish to use and to find a base for the digitiser. I was lucky in finding an offcut of veneered chipboard of just the right size.

Next step was to get a length of pipe roughly equal to the diagonal of the baseboard and cut it in half. Actually the two lengths do not have to be exactly equal but they should be roughly the same. If I were building the digitiser again I would consider allowing extra length for the pipe which is fixed to the base. The hinge point could than be set in from one end sufficiently to allow a counter-balance weight to be added. This would take some of the side load off the pot spindle; not that I have had any trouble so far, but it may be as well to look ahead.

One end of each pipe must be flattened, in one case to take a pot and in the other for some form of pointer.

CONSTRUCTION

Next comes the only really tricky part. The quarter-inch holes for the pot shafts must be marked and drilled on the other end of the tubes. The precise position of the holes is not important but they must be exactly at right angles to the flattened sections and exactly vertical. This is where a drilling stand comes in handy, although in fact I drilled mine with a hand drill; so it can be done! If your holes are very slightly out of true it may be possible to correct by twisting the flattened sections of the tubes slightly, but do not count too much on this. The holes for the pot shank, wires, etc. can now be drilled.

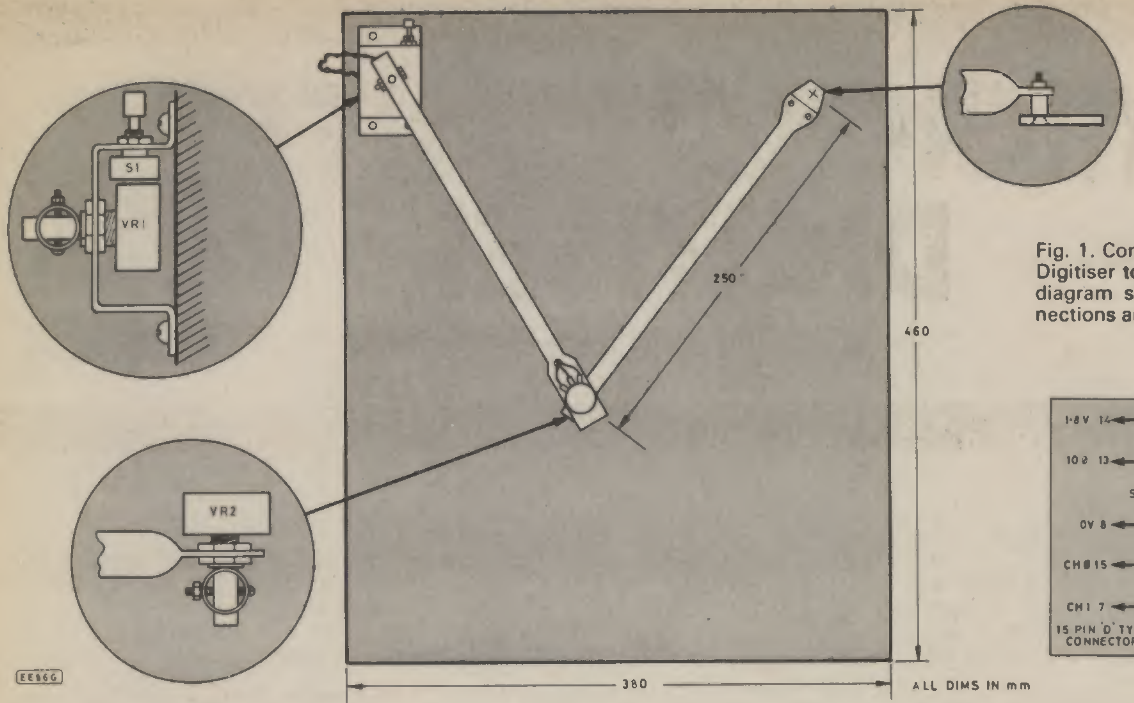
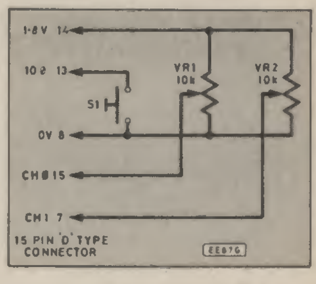


Fig. 1. Construction details of the Digitiser together with the wiring diagram shown below (pin connections are for BBC computer).



By this time you should have found or purchased a couple of pots. Again there is nothing critical about these although they must be linear types (as opposed to log.). I suggest 10 kilohms as nominal but they could range from perhaps 5kΩ to 100kΩ in value and the two pots need not be the same. I used Colvern wirewound pots about an inch in diameter. The support for the baseboard mounted pot consists of a strip of 18 gauge aluminium which is easily bent to shape in a vice (Fig. 1). Adjust the dimensions for your pot and push switch (if you intend to mount it on this bracket). The aim should be to support the pot just clear of the base. Mark out the bracket and bend it with care or the pot shaft will not be vertical. I chose to mount my push switch on the bracket to avoid having to run wires all round the base but you may mount it in any convenient place. Indeed two push switches could be fitted if you feel you may need them. The switches are intended to tell the computer when to input the current arm positions. If you can, choose one with a light, silent, action.

When the metal bracket has been made, drill it for the pot, switch and fixing screws and mount the pot loosely with the connection tags toward the top edge of the board. On the main tube arm mark and drill one of the holes for the spindle fixing bolt with a slightly undersized drill. Turn the pot spindle fully clockwise and push the appropriate section of tube over it. Turn this to its fully clockwise position which should be with the arm in a "North-East" or roughly "Two o'clock" position. It is not necessary to be exact but it IS essential that the pot should be off its end stop when the arm is later turned to its "North" or "12 o'clock" position (Fig. 2a). Now for the only other tricky bit. Mark out the position of the hole for the pot shaft fixing bolts on the pot shaft and drill the shaft with a slightly undersized drill. It is absolutely essential that there should be no slop at all between the fixing bolt (6BA) and the shaft, so ideally the bolt should have to cut itself a very slight thread. It might be a good idea in fact to thread the shaft with a 6BA tap if you can keep it tight. Use a smaller drill through the shaft to mark the fixing hole on the other side of the tube and drill it out.

Fix the second pot to the end of the main arm and turn the tags toward the tube. Rotate the shaft fully anti-clockwise (as seen from underneath) and repeat the operation as for the first pot. In this case the fully clockwise (as seen from on top) arm position should be about 45 degrees more clockwise than the in-line position (Fig. 2c).

ODD JOBS

That completes the difficult operations and leaves a few odd jobs to do before wiring up. Shape a small thin piece of perspex to act as the cursor on the end of the "moving" arm and inscribe a cross on it. Mount the cursor on spacers as shown in Fig. 1 so that it just skims the baseboard when everything is assembled. Fix a small strip of insulating material to the back edge of the metal bracket, or to the baseboard, to act as a grip for the main interconnecting cable. Now is the time to finish the baseboard and tubes to your usual standards if you wish.

Wiring is very straightforward as shown in Fig. 1. Any reversal of polarity can be compensated for in the software. I would suggest that multicore, overall screened wire is used for the main cable since electronic noise pick-up can be a problem. Since this is not so easy to get hold of, especially in the scrap box, I have included a function in the software which takes the average of a number of readings in order to reduce noise problems. If screened wire is used, the screen should be connected to 0V at the D-type connector.

SOFTWARE

Fig. 3 shows the principle of the essential routine, PROCarm which indicates the position of the cursor relative to the

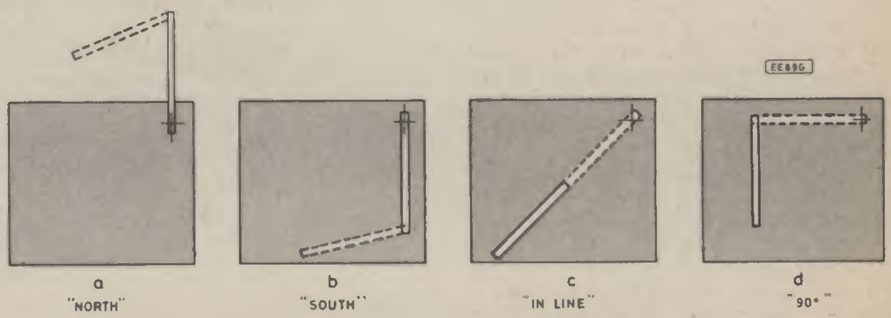


Fig. 2. Arm positions for the calibration program.

LISTING 1

```
>LIST
  100 REM - DIGITISER CALIBRATION PROGRAM
  110 REM - J.W.Howden.   -  1983
  120 MODE7
  130 CLS
  140 PRINT'''"Set main arm 'North' and press button"
  150 REPEAT UNTIL ADVAL(0)=1
  160  A1=FNAVG(30,1)
  170 PRINT A1
  180 VDU7:REM - BEEP
  190  REPEAT UNTIL ADVAL(0)=0
  200 PRINT'"Set main arm 'South' and press button"
  210 REPEAT UNTIL ADVAL(0)=1
  220 A2=FNAVG(30;1)
  230 PRINT A2
  240  VDU7
  250  REPEAT UNTIL ADVAL(0)=0
  260 PRINT'"Set second arm 'in line' and press"'"button"
  270 REPEAT UNTIL ADVAL(0)=1
  280 A3=FNAVG(30,2)
  290 PRINT A3
  300 VDU7
  310 REPEAT UNTIL ADVAL(0)=0
  320 PRINT'"Set second arm '90 deg.' and press"'"button"
  330 REPEAT UNTIL ADVAL(0)=1
  340 A4=FNAVG(30,2)
  350 PRINT A4
  360 VDU7
  370 REPEAT UNTIL ADVAL(0)=0
  380 KT1=A1-A2
  390  KT2=2*(A4-A3)
  400 PRINT'"VALUES FOR DIGITISER PROGRAM DATA"'"STATEMENT ARE:"
  410 PRINTINT(A1);",";INT(KT1);",";INT(A3);",";INT(KT2)
  420 END
  425
  430 REM - AVERAGE N% READINGS FROM PORT   SPECIFIED
  440 DEFFNAVG(N%,PORT%)
  450  LOCAL TL,C%
  460 TL=0:C%=0
  470 REPEAT
  480 TL=TL+ADVAL(PORT%)
  490 C%=C%+1
  500 UNTIL C%=N%
  510 TL=TL/N%
  520 =TL
```

MICROCOMPUTER DIGITISER

LISTING 2

```
>LIST
   10 REM - DIGITISER PLOTTER PROGRAM
   20 REM - J.W.Howden.  -  1983
   30 REM~~~~~~~~~~~~~~~~~~~~~~~~
   40 DATA64424,43761,8977,43879:REM - Parameters from calibration program
   50 DATA 25.8,28.1:REM -  Rod lengths L1,L2 in any units.
   70 REM~~~~~~~~~~~~~~~~~~~~~~~~
   80 REM - SET UP
   90 REM~~~~~~~~~~~~~~~~~~~~~~~~
  100 MODE7
  110 READ A1,KT1,A3,KT2,L1,L2
  120 K1=PI/KT1
  130 K2=PI/KT2
  132 REM - Activate next two lines if you have printer and screen dump program.
  135 REM - PRINT TAB(16,3);"PLOTTER"'
  140 REM - *LOAD"SCR-DUMP"
  150 ON ERROR GOTO 1780
  160 CLS
  170 PROCscaleset
  180 INPUT'''"WHICH MODE",mode
  190 IF mode>5 OR mode=3 GOTO 180
  200 PRINT'"About to begin plotting..."
  210 Z=INKEY(200):REM - 2 sec. delay
  220 VDU7:REM - BEEP
  230 MODE mode:PROCinit
  240 REM~~~~~~~~~~~~~~~~~~~~~~~~
  250 REM - Main loop
  260 REM~~~~~~~~~~~~~~~~~~~~~~~~
  270 REPEAT
  280 PROCarm
  290 PROCscale
  300 PROCkey
  310 IF (ADVAL(0) AND 3)=1 THEN PROCplot
  320 UNTIL FALSE
  330 END
  340 REM~~~~~~~~~~~~~~~~~~~~~~~~
  350 REM - PROCEDURES
  360 REM~~~~~~~~~~~~~~~~~~~~~~~~
  370 DEFPROCarm
  380 THETA=(A1-FNAVG(5,1))*K1
  390 x1=L1*SIN(THETA)
  400 y1=L1*COS(THETA)
  410 PSI=(FNAVG(5,2)-A3)*K2
  420 PSITOT=PSI+THETA
  430 x2=L2*SIN(PSITOT)
  440 y2=L2*COS(PSITOT)
  450 X=x1+x2
  460 Y=y1+y2
  470 ENDPROC
  480
  490 DEFPROCscaleset
  500 PRINTTAB(0,5);"Move pointer to required bottom left"'"corner position and
press button."
  510 REPEAT UNTIL ADVAL(0)=1
  520 PROCarm
  530 BLX=X:BLY=Y
  540 VDU7
  550 REPEAT UNTIL ADVAL(0)=0
  560 PRINT'"Move pointer to required top right"'"corner position and press butt
on."
  570 REPEAT UNTIL ADVAL(0)=1
  580 PROCarm
  590 TRX=X:TRY=Y
  600 VDU7
  610 XSCAL=1280/(TRX-BLX)
  620 YSCAL=1024/(TRY-BLY)
  630 REPEAT UNTIL ADVAL(0)=0
  640 ENDPROC
  650 REM~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
  660 DEF FNAVG(N%,PORT%)
  670 LOCAL TL,C%
  680 TL=0:C%=0
  690 REPEAT
  700 TL=TL+ADVAL(PORT%)
  710 C%=C%+1
  720 UNTIL C%=N%
  730 TL=TL/N%
  740 =TL
  750 REM~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
  760 DEFPROCscale
  770 X=(X-BLX)*XSCAL
  780 Y=(Y-BLY)*YSCAL
  790 ENDPROC
  800 REM~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
  810 DEFPROCkey
  820 KEY$=INKEY$(0)
  830 IF KEY$="" ENDPROC
  840 IF KEY$="M" STATE=4:ENDPROC
  850 IF KEY$="L" STATE=5:ENDPROC
  860 IF KEY$="P" STATE=69:ENDPROC
  870 IF KEY$="D" STATE=21:ENDPROC
  880 IF KEY$="T" STATE=85:ENDPROC
  890 IF KEY$=CHR$(34) INPUT""K$:ENDPROC
  900 IF KEY$=CHR$(&87) PROCscrdump:ENDPROC
  910 IF KEY$="S" PROCscrsave:ENDPROC
  920 IF KEY$="O" PROCloadscr:ENDPROC
  930 IF KEY$="G" PROCgcol:ENDPROC
  940 IF KEY$="C" PROCcls:ENDPROC
  950 IF KEY$=CHR$(&7F) PROCdel
  960 ENDPROC
  970 REM~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
  980 DEFPROCplot
  990 PLOT STATE,X,Y
 1000 IF STATE=4 THEN STATE=5
 1010 FOR N=9 TO 0 STEP-1
 1020 OLDX(N+1)=OLDX(N):OLDY(N+1)=OLDY(N):OLDSTATE(N+1)=OLDSTATE(N)
 1030 NEXT
 1040 OLDX(0)=X:OLDY(0)=Y:OLDSTATE(0)=STATE
 1050 ENDPROC
 1060 REM~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 1070 DEFPROCinit
 1080 STATE=4
 1090 VDU5:REM - Print text as graphics.
 1095 REM - Disable copy key edit function.
 1100 *FX4,1
 1110 DIM OLDX(10),OLDY(10),OLDSTATE(10)
 1120 ENDPROC
 1130 REM~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 1140 DEFPROCcls
 1150 PROCgetstr
 1160 IF LEFT$(K$,2)="LS" OR LEFT$(K$,2)="LG" THEN CLG:STATE=4
 1170 VDU7
 1180 ENDPROC
 1190 REM~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 1200 DEFPROCscrdump
 1210 VDU26,2
 1220 CALL &D00
 1230 VDU3,7
 1240 ENDPROC
 1250 REM~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 1260 DEFPROCscrsave
 1270 PROCgetstr
 1280 IF LEFT$(K$,1)<>"S" VDU7:ENDPROC
 1290 *OPT1,0
 1300 ON mode+1 GOTO 1310,1310,1310,1330,1330,1330
 1310 *SAVE"SCREEN"3000 7FFF
 1320 GOTO1340
 1330 *SAVE"SCREEN"4000 7E7F
 1340 VDU7
 1350 ENDPROC
 1360 REM~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 1370 DEFPROCloadscr
 1380 PROCgetstr
 1390 IF LEFT$(K$,1)<>"S" VDU7:ENDPROC
 1395 *OPT1,0
 1400 *LOAD"SCREEN"
 1405 VDU7
 1410 ENDPROC
 1420 REM~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 1430 DEFPROCgcol
 1440 PROCgetstr
 1450 LOCAL N1,N2
 1460 N1=VAL(MID$(K$,4,1))
 1470 N2=VAL(MID$(K$,6,LEN(K$)-5))
 1480 GCOL N1,N2
 1490 ENDPROC
 1500 REM~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 1510 DEFPROCgetstr
 1520 K$=""
 1530 REPEAT
 1540 C$=INKEY$(0)
 1550 IF C$="" GOTO 1570
 1560 K$=K$+C$
 1570 UNTIL C$=CHR$(13)
 1580 ENDPROC
 1590 REM~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 1600 DEFPROCdel
 1610 IF OLDSTATE(0)=4 GOTO 1660
 1620 IF OLDSTATE(0)=85 MOVE OLDX(0),OLDY(0):MOVE OLDX(1),OLDY(1):PLOT 87,OLDX(2
),OLDY(2):GOTO1660
 1630 IF OLDSTATE(0)=69 PLOT 71,OLDX(0),OLDY(0):GOTO1660
 1640 MOVE OLDX(0),OLDY(0)
 1650 PLOT OLDSTATE(0)+2,OLDX(1),OLDY(1)
 1660 PROCpop
 1670 ENDPROC
 1680 REM~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
 1690 DEFPROCpop
 1700 FOR N=0 TO 9
 1710 OLDX(N)=OLDX(N+1)
 1720 OLDY(N)=OLDY(N+1)
 1730 OLDSTATE(N)=OLDSTATE(N+1)
 1740 NEXT N
 1750 ENDPROC
 1770 REM~~~~~~~~~~~~~~~~~~~~~
 1780 REM - ERROR HANDLER
 1790 REM~~~~~~~~~~~~~~~~~~~~~
 1800 IF ERR=17 VDU7:GOTO 270
 1810 MODE7:PRINT''"Error in line ";ERL
 1820 REPORT
 1830 PRINT
 1840 *FX4,0
 1850 END
```

Table 1

KEY(S)	OPERATION	NOTES
M	Move graphic cursor	Resets to "L" after one move
L	Draw lines	
P	Plot points	
D	Draw dotted lines	
T	Draw triangles	
(Delete)	Reverse last plot	Can repeat several times
(Copy)	Dump screen to printer	
CLS	Clear screen	All this group
CLG	Clear screen	of instructions
SS	Save screen to tape	should be followed
OS	Load screen from tape	by RETURN key
GCOLn,m	Change plotting colour	As usual GCOL command
"<text>	Write text	Everything between quote mark and RETURN is printed

main arm fixing point. Once calibration (see later) has established the A to D (ADVAL) readings at two known angles of the "fixed" arm, its angular position at any time is readily calculated by ratio, assuming linear pots. This angle (theta) can then be used, with the length of the rod, to calculate the X and Y displacement of the far end of the rod using SIN and COS. Knowing the position of the end of the "fixed" rod, the process can be repeated for the "moving" rod to find the cursor position. This position will be in the same units as the rod lengths and relative to the main hinge point.

Digitiser units may be related to graphic display units by adding another, very simple calibration. In this, two diagonally opposed corners of the required working area are read into the computer and related to the equivalent corners of the screen. This means that any reasonable size of drawing can be made to fill the screen or even stretched in one direction or the other. The latter is quite useful when dumping the screen to a dot matrix printer as some printers can distort the image.

CALIBRATION

Now that we have seen the general idea we can look at a couple of practical programs. There is no need to feel limited to these as there are countless ways in which the digitiser can be used. As an example I have chosen to use the main keyboard as a means of changing the drawing technique. Another method is to have a set of symbols drawn on your paper (or baseboard) such that a change of state occurs if you press the digitiser button when the cursor is over one.

The programs are written for the BBC micro but it should not be difficult to work out the principles involved and rewrite for other machines. Listing 1 is the main calibration program which I hinted at previously. It is only necessary to run this when first commissioning the unit or after repairs or adjustments. The four numbers produced by the program are then written into the main program (Listing 2) in the first DATA statement, in place of those I have given. It is also necessary to enter the lengths of your two rods (the length is taken between pot shafts or from cursor cross to pot shaft). It does not matter what units you use provided that they are the same units for both rods.

The calibration positions for the arms are shown in Fig. 2. The terms "North" etc. are not to be taken literally of course. If you find that the program returns negative numbers just reverse A1, A2, etc. or simply ignore it.

THE MAIN PROGRAM

When the program in Listing 2 is run (after changing the DATA statements as above), there is provision for loading up your favourite "dump screen to printer" routine, at lines 230 and 240. Simply omit these lines if you do not want this facility. The next stage is the calibration of the active working area of the digitiser as discussed previously. This calibration is carried out each time that you use the digitiser, but takes only a couple of seconds.

After a pause the screen is cleared for you to begin plotting. I have not included a cursor on the screen because you would not usually need one, but the main loop is structured such that a cursor procedure could readily be added. The first press of the digitiser button is arranged to give a "MOVE" so nothing is plotted. After that the line plotting mode is entered; in fact this reversion to line plot will occur after every MOVE command.

In the line plotting mode a line is drawn from the previous position logged to the current arm position, whenever the button is pressed. If you hold the button down a continuous trace will be plotted, but it is very difficult to move the digitiser smoothly and this technique is not recommended.

Other forms of plotting and various commands are selected by pressing a key or keys on the computer keyboard. Thus "P" will cause subsequent button presses to plot points rather than lines. Table 1 lists the commands provided. Commands involving more than one key must be terminated by "RETURN" and are NOT echoed on the screen (except for the text printing operation). This does not present too much of a problem in practice.

A delete function, operated from the delete key, is provided to allow up to the last ten operations to be reversed. A rather simple approach to this has been taken whereby a line, triangle or whatever, is redrawn in the background colour. This could have the result of leaving holes in some drawings but works fine for maps.

The most direct method of screen loading and saving has been used. Be warned that this is rather slow and uses a lot of tape. For many drawings it would be better to keep a log of all operations for the purposes of the delete function. The appropriate arrays could then be saved and reloaded instead of up to 20K of screen memory. When loading and saving no messages are printed so be ready with the "RECORD" or "PLAY" keys and watch the keyboard lights for your cue.

To clear the screen just type CLS or CLG followed by RETURN. The GCOL command can also be used in order to change the plotting colour.

Well, there we are! It is only a couple of days work so why not root through the old junk box and get building? By the way, in case you were wondering about the map, I did plot it in the end as shown below. □

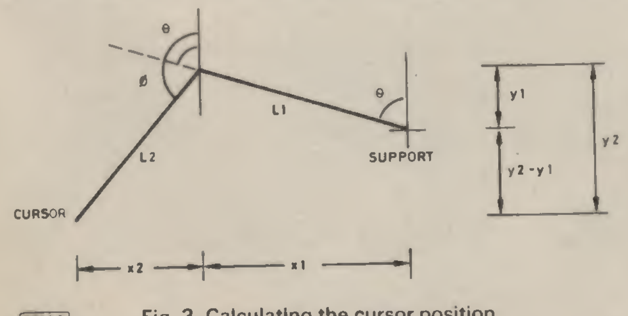


Fig. 3. Calculating the cursor position.

GUITAR HEADPHONE AMPLIFIER

M.G. ARGENT

THIS useful little unit is a simple amplifier which has been adapted for use as a guitar practice amplifier, for use with headphones. The electronic circuit is very straightforward and could be built by anyone. None of the components are critical and most of them should be in your "junk box". The amplifier is invaluable for tuning up in noisy environments such as dressing rooms, or back stage, and is great for keeping the neighbours happy. It has been tested using several different types of headphones including the modern lightweight variety, all with satisfactory results.

THE CIRCUIT

As can be seen from Fig. 1 the circuit is very simple, consisting of only one i.c. (LM380) and a few discrete components. The LM380 is a low cost amplifier which will deliver 2 watts at 20V. However, in this circuit the power supply is only 9V (PP3 battery) and the power output is much lower, even so, it is more than enough to drive a pair of headphones.

The guitar output is applied to pin 2 of IC1 and the volume control (gain) pot, VR1, is connected between pins 2 and 6. This may seem a little odd, but is quite normal when using the "380". A lot of pins are connected to 0V for two reasons; pin 7 is the 0V supply and the other pins are used to transmit heat when working at full power. The positive supply is connected to pin 14 and the amplifier output, pin 8, is connected to the headphones via C2. The value of C2 is not critical and was chosen as a compromise between bass response and physical size.

Connected across the output is a Zobel network, R1 and C1. If these components are omitted, the unit will still work but the quality may suffer, as they are used to counter the effects of the inductive element in headphones and speakers. If stereo headphones are used the two speakers must be connected in parallel, as this is only a mono amplifier. The other capacitor, C3, is provided to aid stability, and once again is not critical providing a suitable working voltage is selected.

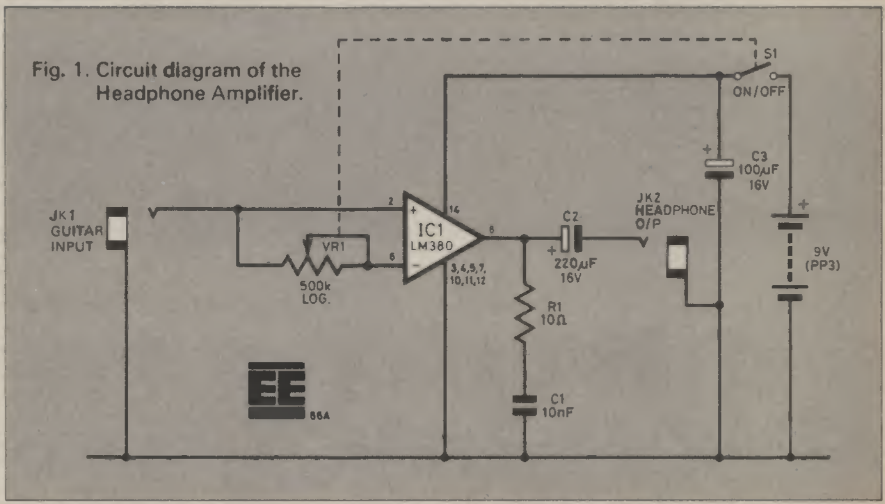
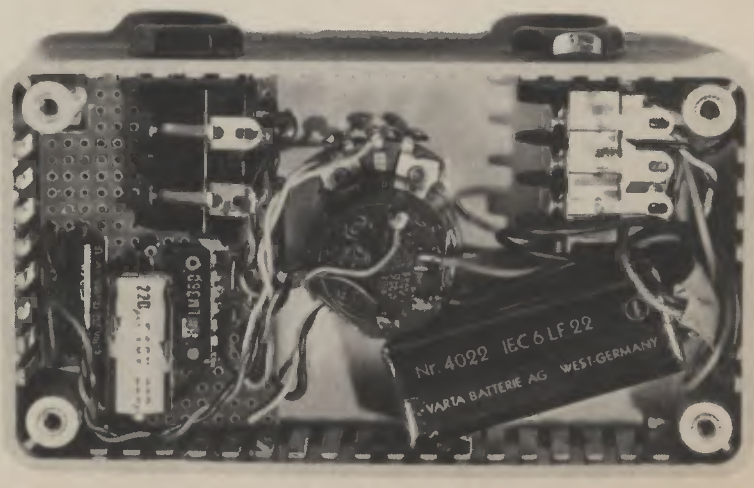


Fig. 1. Circuit diagram of the Headphone Amplifier.

CONSTRUCTION

All the components were housed in a small plastic box, which can be any size as long as it is large enough to hold all the components comfortably. The stripboard only requires four tracks to be cut and the component layout is very straightforward. Once the stripboard has been assembled, as shown in Fig. 2, it should be mounted in the box and the switch and gain control connected. The connecting wires should be kept as short as possible to prevent any pick-up problems. After checking all the solder joints and components the battery can be connected and switched on. The unit should only draw about 7mA under quiescent conditions (no signal) and will rise in relation to the volume set. □



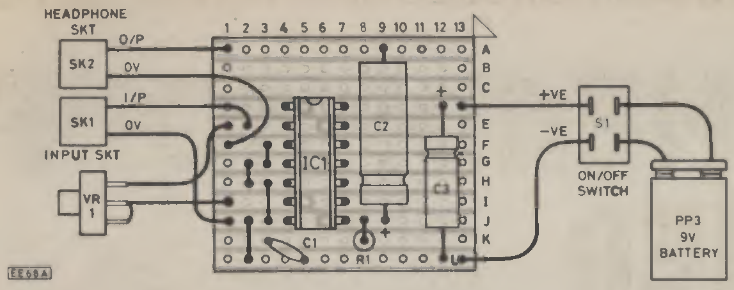
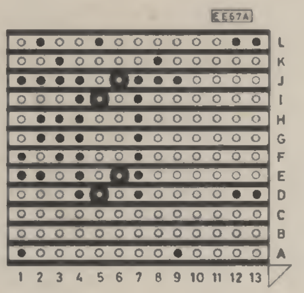


Fig. 2. Stripboard layout and wiring diagram of the Headphone Amplifier.



See
Shop Talk
page 560

Approx. cost
Guidance only **£6**

COMPONENTS

Resistors
R1 10Ω ± 5% ¼W
VR1 500kΩ log, switched

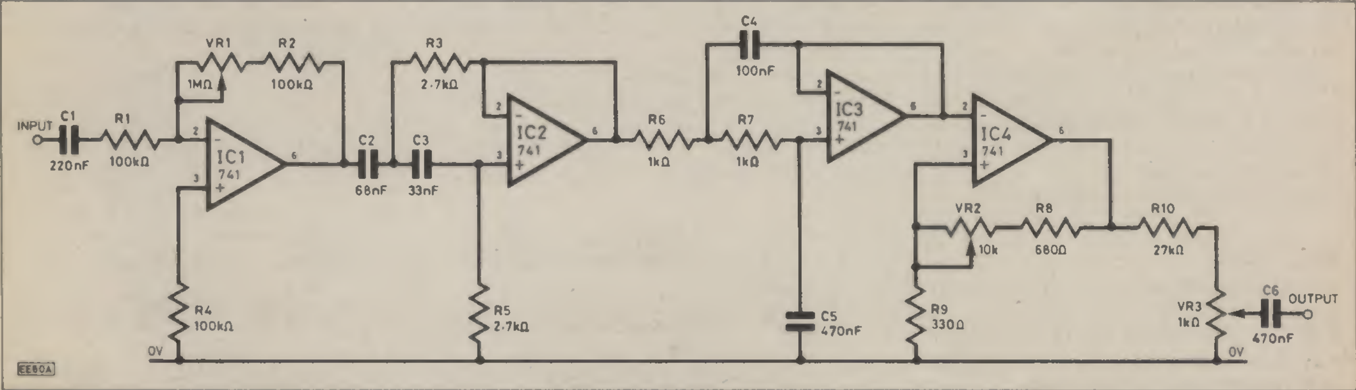
Capacitors
C1 10nF disc ceramic
C2 220µF 16V electrolytic axial
C3 100µF 16V electrolytic axial

Semiconductors
IC1 LM380 audio amplifier

Miscellaneous
S1 (see VR1 n/o contacts).
JK1 mono ¼in jack socket.
JK2 stereo ¼in jack socket (or miniature to suit headphones).
Knob for gain control.
0·1in matrix stripboard 12 strips x 13 holes.
PP3 9V battery.
Plastic box as available.

CIRCUIT EXCHANGE

This is the spot where readers pass on to fellow enthusiasts useful and interesting circuits they have themselves devised. Payment is made for all circuits published in this feature. Contributions should be accompanied by a letter stating that the circuit idea offered is wholly or in significant part the original work of the sender and that it has not been offered for publication elsewhere.



SOFTWARE SALVAGE

This circuit is for use in retrieving cassette based software, which will not run on a computer. A cassette may not load for a variety of reasons. These include: a lack of high frequency response, due to azimuth differences in the recording and playback machines, a low or varying output, caused by worn or dirty heads, and noise on the tape itself induced by stray magnetic fields.

The circuit was designed to overcome these problems. It connects between two cassette recorders, and cleans up the signal, enabling a better quality copy to be made. The input stage consists of a variable gain amplifier, which allows adjustment for a range of input signals. This is followed by a band-pass filter, made up of two sections. The first is a high-pass filter with a roll off of 9dB per octave below 1200Hz. The second is a low-pass filter with a roll off of 9dB per octave above 2400Hz. The output from this feeds a Schmitt trigger, with a variable threshold. This may be adjusted between 0·2V and 2·4V to secure triggering on the data tones, while discriminating against noise. The Schmitt also restores "attack" to the signal, and provides a constant output volume, which is stepped down, through a potential divider, to suitable audio levels.

P. Thompson,
Lennoxton,
Glasgow.

TEACH-IN '84

12

A TWELVE-PART HOME STUDY COURSE IN THE PRINCIPLES AND PRACTICE OF ELECTRONIC CIRCUITS. ESSENTIALLY PRACTICAL, EACH PART INCLUDES EXPERIMENTS TO DEMONSTRATE AND PROVE THE THEORY.
USE OF A PROPRIETARY BREADBOARD ELIMINATES NEED FOR SOLDERING AND MAKES ASSEMBLY OF CIRCUITS SIMPLE.
THE IDEAL INTRODUCTION TO THE SUBJECT FOR NEWCOMERS. ALSO A USEFUL REFRESHER COURSE FOR OTHERS.

By GEORGE HYLTON

AIDS TO DESIGN

WELL, here we are at the end of Teach-In '84. Congratulations for getting this far. You are now, I'd say, likely to want to go ahead and design your own circuits—and having designed them to build them in a permanent form. So, before we part company, here are some hints for design and construction.

TEMPORARY BREADBOARDS

This Teach-In has been based on solderless methods of construction. Plug-in breadboards like EBBO and its many rivals are ideal for experiment and for refining designs by selecting components by trial and error.

Commercial designers usually try to produce circuits which will accept the rather wide tolerances of transistors and integrated circuits. This is a good principle because a circuit which accepts variations among nominally identical devices will also accept small changes which result from ageing.

You, however, as an individual designer, can improve on this. You can start off with tolerant circuits, but go on to select the best possible component values to suit your particular devices.

AUTO BIAS

To give a simple example, in the "auto bias" circuit (Fig. 12.1) the "rule of thumb" is that if Rb is h_{FE} times Rc then V_{CE} is half V_{CC}. In other words, the collector sits at half the supply voltage. The rule falls down rather badly at low supply voltages because it ignores the effect of V_{BE}. And in practice h_{FE} is known only very approximately.

For a given transistor type h_{FE} might vary over a three to one range such as 100–300. But if you start off with an average value then adjust Rb by trial and error while measuring V_{CE} you can get it just right. In fact you can set up to obtain not just $V_{CE}=V_{CC}/2$ but virtually any value of V_{CE} you want, right up to nearly V_{CC} itself or down to nearly zero.

With a good meter, a breadboard and a selection of resistors, the job can be done in minutes. You then use the actual transistor and resistors in your permanent circuit.

PERMANENT BASEBOARDS

Eventually you are ready to build the circuit in a permanent form. So far, the only solderless means of doing this which we've used is the screw terminal block. This is bulky and won't accept integrated circuits.

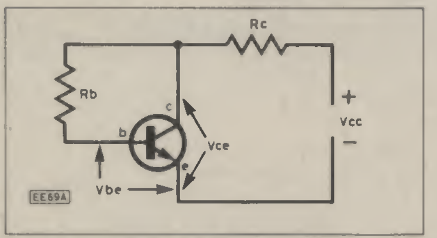


Fig.12.1. Auto-bias circuit.

Recently, permanent but solderless breadboards compatible with i.c.s have come on the market. They are based on precision engineering.

Imagine a terminal in the form of a tiny two-pronged fork. The prongs are just far enough apart to grip firmly a wire of a particular diameter. By shaping the prongs so that they cut into the wire slightly when it's pushed between them, a good firm connection is made.

When suitably insulated wire is pushed in, the prongs cut through the insulation and grip the wire inside. So circuits can be wired up using insulated wire, but without soldering.

These "insulation displacement" systems are simpler and faster to use than their older rival, the solderless "wire-wrap" system, in which a special tool wraps wire round a rectangular post whose corners bite into the wire.

Insulation-displacement boards are about the present limit of refinement in solderless wiring. But even they can't do everything and some soldering is almost inevitable. To connect off-the-board, control-panel-mounted items such as potentiometers reliably and permanently calls for soldering to the potentiometer connecting tags, if not to the board itself.

An essential job, then, is to learn how to make good soldered joints. The way is then open to using many forms of permanent baseboard. If you can't yet solder, get someone to show you or follow the explanations which appear in EE from time to time.

SOLDERED BASEBOARDS

As you know, the commonest form of permanent baseboard is the printed circuit board (p.c.b.). This is a subject in itself and I'm not going to discuss it here, except to note that a purpose-designed printed circuit is almost totally unadaptable. It is designed to do one job very well, that is, to hold the parts and supply the interconnections of one particular circuit. It's an end-of-the-line item.

More versatile are "half-way" adaptions of printed circuits such as Veroboard or stripboard, where the user is given a board with printed-circuit strip connections with component lead holes at convenient intervals. A simple hand cutting tool enables the strips to be broken into convenient segments to suit individual designs. Boards with a hole spacing of 1/10 inch (2·54mm) accept most i.c.s, transistors and passive components.

Now that the design of plug-in experimental boards is becoming standardised, manufacturers are making "half-way" boards whose conductor patterns match the terminal arrangements of the plug-in boards exactly. A design worked out on a plug-in board can then be easily transferred to its permanent board.

PIN BOARDS

A crude but simple and versatile bread-board for discrete (not integrated) circuit components can be made by driving pins into plywood to form anchorage points for components and wiring connections. The ends of leads are wrapped round the pins then soldered. Domestic pins, if new and bright, do the job well and cheaply.

The great advantage of pinboard construction is that the components and wiring are both on the same side of the board, which makes checking and fault tracing easy. Also, the positions of the pins are entirely under the constructor's control.

The component layout can be made to follow the circuit diagram so closely that with a little ingenuity an actual circuit diagram, laid over the plywood, can be used as a wiring plan. Short-lead components salvaged from printed circuit boards can be accommodated, and if the component layout is kept fairly open modifications can be made later.

ENCLOSURES

Most finished circuits require a housing. Often this must incorporate a panel on which switches, volume controls, jack sockets, meters, and the like can be mounted. Neat plastic or metal boxes can be bought from advertisers in EE. Boxes made for other purposes (such as the switch boxes used by electricians for mounting switches in walls) can sometimes be adapted; for example, by adding a panel cut from sheet aluminium.

Most enclosures are expensive. An economic alternative is to make your own from easily-obtained materials. This is much easier than it sounds. For all-metal enclosures the most suitable material is sheet aluminium. For insulated enclosures the choice includes plywood, hardboard and laminated materials such as Formica.

Hardboard and plywood are easy to cut and can be joined by pinning and/or gluing with wood glue. Formica is less easy to work, but is by far the most attractive in appearance and being thin is most suitable for panels, where the thickness of the other materials is often an embarrassment. Here are some tips on working with Formica and similar laminated materials—which, by the way, can often be bought cheaply from DIY shops as offcuts.

CUTTING LAMINATED MATERIALS

Although it can be cut with a hacksaw, Formica and the like is best cut by a method known as "score and snap". This needs some skill and practice but once mastered is quick and easy. In "score and snap" the line of cut is first scratched deeply into the decorative side of the laminate (which is the harder side). When bent upwards, "into" the scratch, the board snaps along the score line.

It's essential to score right across a piece of Formica, from one edge to another. Stopping halfway isn't possible. Use a special tool for the scoring. The easiest to obtain is a purpose-made scoring blade designed to fit into the holders of handyman's "trimming knives". (I use a Stanley blade No. 5194 in a Stanley 199 holder.)

When drilling holes in Formica always drill from the decorative side. Small loudspeakers can be glued to the back of a panel, after first drilling a pattern of holes to let the sound out.

A form of enclosure which is often convenient has both a removable panel and a removable back. To make it, cut the top, bottom, and sides from hardboard or plywood and assemble them into a rectangular tube by using square-section wooden moulding for corner braces (Fig. 12.2). The panel and back can be fixed with screws driven into these corner braces.

FREE COMPONENTS

The average discarded radio or TV set contains large numbers of components which potentially are re-usable. Unfortunately, an old TV also contains a picture tube, which can be dangerous! Inside the tube is a vacuum. Outside is the atmosphere, pressing down on the tube at 14 pounds per square inch (1kg/sq.cm). The total pressure on a large tube is several tons. If the tube is broken this pressure makes it implode violently and although an implosion is less spectacular than an explosion, chunks of sharp-edged glass are still thrown about.

In order not to be around when it happens, either remove components from a TV set without touching the tube or, if you know how, first remove the tube and dispose of it safely.

Goggles or a visor should be worn when working on a TV set with a tube or handling the tube. Better still, avoid TV tubes altogether. Some TV repair shops will sell you old sets with the tube removed. Many give them away after removing what parts they need; there are still plenty left for you.

Resistors, unless special in some way, are hardly worth the trouble of unsoldering from their circuit boards. Capacitors are a better bet. So are discrete transistors. I.C.s are so difficult to unsolder that they usually get ruined in the attempt. Inductors of various sorts can be useful, including those inside metal "screening cans"; these often have re-windable coil formers (tubes) with dust-iron or ferrite "slugs" for tuning adjustment.

Colour TVs may contain a quartz crystal which (in Europe) resonates at about 4·3MHz, and a glass delay line complete with input and output couplers.

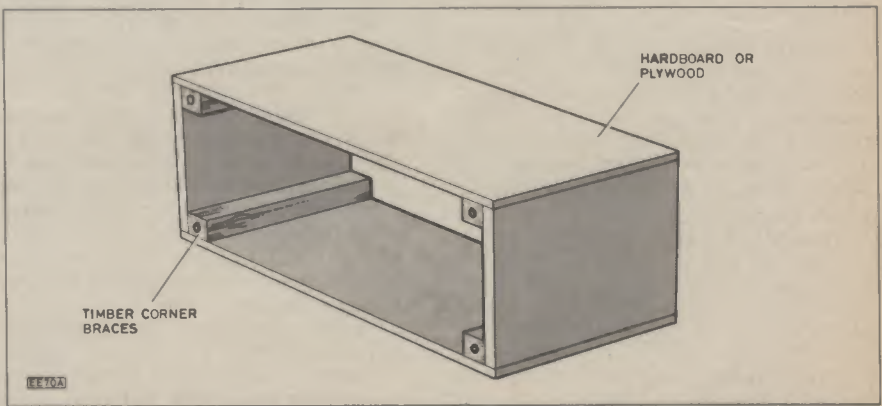
COMPONENT CHECKING

Before trying to use salvaged components check them. For bipolar transistors a simple two-diode test will sort out most of the duds. A bipolar transistor has two junctions, base-emitter and base-collector. Each junction by itself is a diode. An ohmmeter applied to an intact junction will register a resistance with the test leads one way and an open circuit (infinite resistance) the other, as the meter's internal battery forward-biases or reverse-biases the junction.

If your meter has a 1·5V cell for ohms measurements and the transistor is a silicon type then in the forward direction the meter needle will probably move to a position between third-scale and half-scale. (For an old-fashioned germanium transistor the deflection is less.) Readings of zero ohms (short-circuits) indicate duds.

The larger values of capacitor can be given an ohmmeter check. When the

Fig. 12.2. Open-ended box construction for an equipment enclosure. The back and the front panel are screwed to the corner braces.



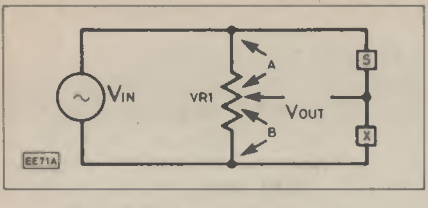


Fig. 12.3. A measuring bridge.

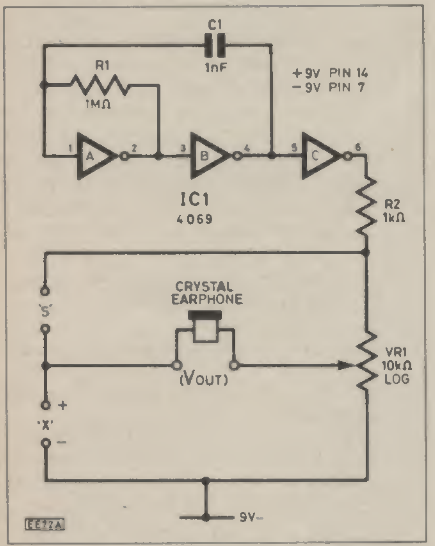


Fig. 12.4. Simple experimental a.c. bridge. Numbers refer to the CMOS 4069 i.c. pinning. Polarity markings at the X terminals refer to electrolytic capacitors.

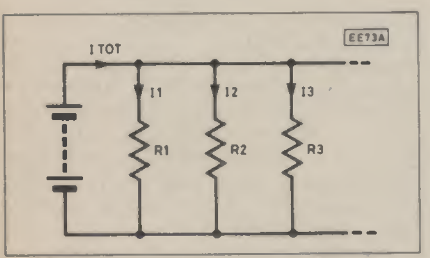


Fig. 12.5. Resistances in parallel.

leads are first applied the internal battery charges the capacitor, causing a momentary inrush of current which shows as a kick of the needle. When checking electrolytics, apply the negative terminal of the meter to the positive plate of the capacitor. This charges the capacitor with the correct polarity.

A small permanent deflection may be seen with electrolytics after the initial kick. This is leakage and doesn't necessarily mean that the capacitor is a dud. But non-electrolytics should show no leakage.

BRIDGE MEASUREMENT

For more accurate checks, build a "bridge". Designs for bridges to measure capacitance, resistance and sometimes inductance are published occasionally. Here's an experiment to get you used to the bridge principle.

EXPERIMENT 12.1

EXPERIMENTAL A.C. BRIDGE

In Fig. 12.3 an alternating voltage Vin is applied to two voltage dividers. One is the potentiometer, VR1. The other is the "network" formed by S and X. (Engineers tend to call any assembly of circuit elements a network whether or not it is net-like in form.)

Let's assume that S and X are resistances. There must be a certain voltage across X. The wiper of VR1 can be moved to a position where the voltage across B (the lower part of VR1) exactly equals the voltage across X. In this condition, Vout is zero, because the two voltages being the same there is no voltage difference to drive current from one output terminal to the other.

This condition is called the balanced condition. It occurs when the proportion or ratio of B to A is the same as the ratio of X to S. If B, A and S are all known then X can easily be calculated:

$$X = S \text{ times } (A/B)$$

Thus if S = 1kΩ and A is five times B, X must be 5kΩ.

By adjusting VR1, the ratio A/B can be given a wide range of values, say from 0·1 to 10, so a single "standard" component S can be matched against widely differing "unknown" components X. This arrangement is called a bridge and works for capacitance and (less well) inductance as well as resistance. In the form shown here S and X must be in the same class; for example both capacitances.

OSCILLATOR

Almost any form of audio oscillator can in principle be used to energise the bridge. The one shown in Fig. 12.4 is simple and convenient. Your crystal earpiece, connected to the Vout terminals, provides the means of telling when the output falls to zero. As an exercise, work out your own EBBO layout for this.

If you connect two resistors as X and S, or two non-electrolytic capacitors, you should be able to set VR1 to give a "null", or at least a very small output. Electrolytics and inductors may not yield a sharp null, and very small inductances and resistances and very large capacitances cannot be measured because their impedance is so low that it short-circuits the oscillation.

Real-life component-checking bridges generally use a "linear-law" potentiometer for VR1. This is fitted with a knob with a pointer which moves over a scale. To calibrate (mark out) the scale you connect known-value close tolerance resistances to both X and S, balance the bridge with VR1 then mark the appropriate ratio on the scale. Thus when X and S are both 1kΩ the ratio is 1; when S = 1kΩ, X = 100 ohms, the ratio is 10, and reversing S and X then gives 0·1.

Bridges like this actually measure impedance. Since the impedance of a capacitor goes down as its capacitance goes up, the ratio scale for a capacitance bridge is a mirror image of the scale for resistance (and inductance). So "10" for R and L is "0·1" for C. By providing a selection of S values such as 1kΩ, 10kΩ, 100kΩ, or 1nF, 10nF, 100nF the bridge can be multi-range, within reason.

COMPONENT BOXES

Another invaluable aid to the experimeter is the component selection box. This contains a number of resistors, capacitors or inductors any of which can be selected by a switch. You can buy selection boxes but it's easy to make your own, once you've learned to solder.

A 1-pole, 12-way wafer switch permits up to 12 selections.

For capacitors, a sequence such as: 100pF, 330pF, 1nF, 3·3nF, 10nF, 33nF, 100nF, 330nF, 1μF, 3·3μF, 10μF, 100μF gives a handy choice of values. If you use electrolytics for the higher values, you can get components small enough to allow the use of a tobacco tin as an enclosure. (Get components with as high a voltage rating as you are likely to need.)

For resistance, where a wide range is more important than precision it's cheaper to use a calibrated log-law potentiometer than a wafer switch and individual resistors. Two such potentiometers one 10kΩ log and the other 1MΩ log will provide most of the values you need.

For more exact work, a 12-way switched selection can cover nearly one decade (10 to 1 range) of resistance in steps increasing by 20 per cent:
100, 120, 150, 180, 220, 270, 330, 470, 560, 680, 820 ohms.

The next box starts at 1kΩ and ends at 8·2kΩ and so on. Ranges of values which follow this numerical pattern are called E12 series. To cover a wider range in coarser steps you can use the alternate values only:
100, 150, 220, 330, 560, 820, 1·2k, 1·8k, 2·7k, 4·7k, 6·8k, 10k ohms.

POCKET CALCULATOR

Another handy aid to circuit design is the pocket calculator. It needn't be very elaborate. Mine cost £3 at Woolworth's but that was some years ago. The calculators made for students are best. They have, in addition to ordinary arithmetic facilities, buttons for "pi" (π), "square root", and "reciprocal" (1/X), and a memory to which you can add (or subtract) numbers.

The number "pi" comes into most a.c. calculations. The reactance of an inductance, for example, is $2\pi f L$ ohms, where f is in hertz and L in henries. (For kHz you multiply by 1,000, for MHz by 1 million. For mH you divide by 1,000, for µH by 1 million.) Don't buy a very elaborate calculator with all sorts of facilities you may never need.

PARALLEL RESISTANCES

A student's calculator is excellent for doing a job which constantly crops up: finding resistances in parallel. The key to the calculation (Fig. 12.5) is the fact that each resistance feels the full voltage V. The total current (I_{TOT}) is therefore the sum of all the individual currents ($I1 + I2 + I3$ . . . and so on), one current for each resistance. The equivalent single resistance is then $R = V/I_{TOT}$.

A useful way of simplifying the problem is to think of each resistance not in terms of its power to resist current flow but in terms of the extent to which it permits current to flow.

A low resistance permits more current to flow than a high one. If a resistance is reduced to zero then it becomes a simple conductor; it conducts with absolute freedom. A real resistance conducts with less than absolute freedom, but it still conducts, a bit. This ability to conduct partially is called, quite simply, conductance. A low resistance has a high conductance. A high resistance has a low conductance.

CONDUCTANCE CALCULATIONS

Now, conductance, though it doesn't often appear in the pages of EE, is an exact numerical quantity, just like resistance. It is in fact a sort of mirror image of resistance.

Conductance is a useful quantity for our present need because conductances in parallel simply add together. If, in Fig. 12.5, R1 has a conductance of 1 unit, R2 and 2 units and R3 of 3 units then the total conductance is $1 + 2 + 3 = 6$ units.

The unit of conductance has a name, the siemens, after a German scientist called Siemens. (In older books it was called the "mho", which is "ohm" written backwards to suggest the mirror-image quality.)

How do you find the conductance if all you know is the resistance? Easy, with a calculator. You key in the resistance then press "1/X". The answer is the conductance. For typical electronics-circuit values of resistance the conductance often comes out as a messy-looking decimal fraction. My calculator tells me that the conductance of a 3·3kΩ resistance is 0·000303. But you don't have to worry about that. The calculator doesn't mind how messy it looks!

ACCUMULATING MEMORY

Given a calculator with an accumulating memory (M+) button, it's easy to find the total conductance of any number of resistances in parallel.

Key in the first resistance, R1, press "1/X" to turn it into its conductance, store the answer in the accumulating memory by pressing "M+". Then key in R2, press "1/X" and add the answer to what's in the memory. Do the same for R3 and so on until you've put in all the resistances in your parallel network. The memory now contains the total conductance.

Press the "memory recall" button (usually marked "MR" or "R") and the calculator will display it. It's still a messy fraction. To convert it into the equivalent resistance, press "1/X". That's the answer, the equivalent single resistance of all those separate resistances in parallel.

In practice it takes a good deal less time to do the calculation than it has taken you to read my rather laboured description of the process. But you must have a calculator with an accumulative memory. Some calculators only have memories that hold the last figure you key in. They wipe out what has been put in before. No good for this job.

COMMON SENSE

Use your common sense in dealing with the answers. I've just calculated the equivalent of 330Ω and 3·3kΩ in parallel. Answer: 300·0003Ω. But clearly the last bit is of no practical significance. The answer for practical purposes is simply 300Ω. (As a matter of fact 300Ω is the correct answer. The extra fraction of my calculator is the result of its not being able to make the calculation to enough figures to get it absolutely right.)

This calculation shows that if you need 300Ω but haven't got a 300Ω resistor you can make one up from 330Ω and 3·3kΩ in parallel.

ADJUSTING RESISTANCES

Quite often, the problem is to find some combination of parallel resistances of standard values which will make up some non-standard value which you need. Suppose, for instance, that you have a stock of "E12" resistors but need 700Ω, which is not in the E12 series. The nearest value, 680Ω, will do for everyday purposes, but not for more precise jobs where the extra error of about 3 per cent (over and above the tolerance) would be unacceptable.

Suppose we start with a standard value which is too high, then connect another across it, can we get close enough to 700Ω? Let's try 820Ω. If we work out the conductance of 700Ω then subtract the conductance of 820Ω we are left with the extra conductance we need. By inverting this into its equivalent resistance (with the 1/X key) we get the required parallel second resistance.

My calculator says 4,785Ω. The nearest E12 value is 4,700Ω. Will this do? Try it. My calculator says that 4,700Ω and 820Ω in parallel come to 698Ω. This is well within 1 per cent of 700Ω so unless very great precision is needed it should do. (If very great precision *is* needed we'll have to use very close tolerance resistors, in which case we may as well buy a 700Ω precision resistor and forget about parallel combinations.)

ALIGNMENT CHARTS

Useful though calculators are, for some jobs using them is tedious. For example, the resonant frequency of an LC tuned circuit is $1/[2\pi\sqrt{(LC)}]$. This may be calculable but it's quicker to use an alignment chart. Such charts appear in books about electronics and in magazines from time to time. The same chart which gives the resonant frequency can be made to give the reactances of inductance and capacitance as well, so you get three for the price of one.

GOOD LUCK!

That's positively the last bit of theory in this Teach-In! I hope you've enjoyed the series and will now move on to greater things. Good luck, and thanks for coming along. □

ANSWERS TO PART II

Q11.1 (a) 0·5Hz. (The f to V converter gives a change of 1mV per hertz and this is amplified 1,000 times.)

(b) 5 parts per million.

(c) At least every 3 seconds. (A drift of 0·5Hz gives 500mV output change and upsets the system. Time between retunings must be less than time taken to drift 0·5Hz, which is equivalent to 5 ppm. If the oscillator drifts 100ppm in 60 seconds it drifts 5ppm in 3 sec. This shows how vulnerable the system is to changes of temperature.)

SHOP TALK

BY DAVE BARRINGTON

Repair Job

Although, thanks to new techniques and materials, the reliability of printed circuit boards has improved beyond recognition, even now it is still possible to cause damage and/or "curling" of the copper tracks through excessive heat.

The repair to such damage can be rather messy and not always successful. However, a repair kit from **OK Industries UK** promises to take some of the "trial-and-error" out of the repair to p.c.b.s.

They also claim that the salvage of just one printed circuit board assembly and the new track repair kit is paid for.

The kit is available in de-luxe, standard and economy form, includes master frames with tracks, fingers, pads, elbows and flat-pack pads, eyelets and funnelets plus the setting tools. Standard and de-luxe kits also have consumables such as epoxy, flux, cleaner, spatulas, abrasive sticks and other items, as well as tweezers, clamps and knives.

The addition of a temperature controlled soldering iron and five high quality pliers makes up the de-luxe kit.

The copper master frames are not pre-tinned because the epoxy bond between the new circuit and the printed circuit board is destroyed later by re-soldering which melts the tin coat and epoxy.

All items can be purchased separately. For more details and prices write to: **OK Industries UK Ltd., Dept EE, Dutton Lane, Eastleigh, Hants SO5 4AA.**

Blowing A Fuse

The safety of equipment should always be one of the main criterion when designing projects and so the inclusion of a fuse is always to be recommended. This is strongly advisable where mains voltages are present.

Two types of cartridge fuses are usually used in equipment and consists of the anti-surge or "slow-blow" and the ordinary "quick-blow" types.

The choice of the "slow-blow" type is used where a high current or "surge" is present on switch-on. Circuits which are particularly vulnerable to this effect are those containing motors, filament lamps and charging capacitors.

The filament of a cold lamp has a low resistance so, on first switching on, there will be a high current until temperature rises. Electric motors pass an unusually high current until they reach operating speeds.

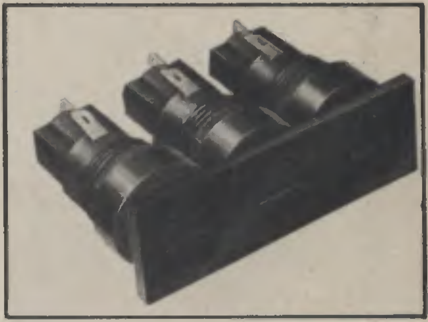
Another closely linked safety factor is in making fuseholders touch- or tamper-proof. To this end, a range of "fully touch-proof" fuseholders accepting 5 × 20mm fuse cartridges, with bayonet and screw release cap/fuse carrier, are available from **A. F. Bulgin**.

The bayonet release types have a new moulded design and robust metal contacts. They claim that the fuse cannot become open circuit when pushing cap/fuse carrier after insertion. They also claim that it is impossible for the "standard" finger to touch the inner contacts, even if the fuse is inserted with cap/carrier removed.

For added safety, moulded insulation covers to shroud the fuse body and contacts are available as extras.

The bayonet versions are produced with either a round or square bezel, both being low profile. The screw styles are available with round bezels with a choice of high or low profile.

For details of local stockists contact: **A. F. Bulgin & Co. PLC, Dept EE, Bypass Road, Barking, Essex IG11 0AZ.**



CONSTRUCTIONAL PROJECTS

Sound Operated Flash

The operational amplifier i.c. used in the *Sound Operated Flash* project is the equivalent of two "popular" 741 devices. Therefore, if any readers have difficulty in obtaining the MC1458 i.c. then, by adapting the wiring and board layout, the circuit could be built using two 741s.

However, the MC1458 dual op-amp is also listed as the LM1458 and is currently stocked by: Electrovalue; Greenweld (MC1458); Magenta (MC1458); Rapid and TK Electronics. All the above mentioned suppliers also stock the C106D thyristor.

Guitar Headphone Amplifier

The LM380 audio amplifier i.c. called for in the *Guitar Headphone Amplifier* is available from: Magenta; Maplin; Rapid and TK Electronics.

Op-Amp Power Supply

There should be no problems in obtaining components for the *Op-Amp Power Supply*. The dual-tracking regulator may prove a little difficult to locate, but is available from Maplin. Order code XX02C (4195).

The transformer is specified as 15-0-15V at 100mA. If a type of this rating cannot be obtained then a similar type can be used. Note, however, that the secondary voltage must not be any more than that specified.

The current rating of any other transformer can be higher as desired, but note that no more than 50mA can be drawn from the circuit whatever the secondary current rating the alternative transformer has. For example, a transformer of 12-0-12V at 300mA could be used without damage.

A transformer of 15-0-15V at 50mA could be used but, of course, the current available would then only be 25mA per rail.

Caravan Dipstick

The dual operational amplifier type μA747 used in the *Caravan Dipstick* is available from Maplin Electronic Supplies.

Microcomputer Digitiser

We cannot foresee any component buying problems for the *Microcomputer Digitiser*.

BI-PAK BARGAINS

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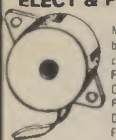
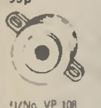
PIEZO



Miniature round piezo-electronic buzzer White plastic Low consumption
Frequency 4kHz approx
Output: 70dB (A) @ 1. typ
Power. 12Vd.c. 4mA
Dims. 22 (dia.) × 11.5mm
Fixing Centres. 26.5mm

O/No VP 107
95p

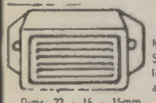
PIEZO



Piezo buzzer. White plastic 90mm leads For use on a.c mains
Frequency: 3.5kHz approx
Output: 85dB (A) @ 1m typ
Power 240Va.c. 5mA
Dims: 32 (dia.) × 14mm
Fixing centres. 38mm

O/No. VP 108
£1.15

ELECTRONIC



Miniature electronic buzzers Solid state. Ivory plastic 150 leads. Frequency: 500 Hz approx.

Dims 22 · 16 · 15mm
Output: 82dB (A) @ 1m typ
Fixing centres 26mm
3V 25mA: O/No VP 82 — 6V 25mA. VP 83
9V 25mA: O/No VP 84 — 12V 25mA: VP 86

80p each

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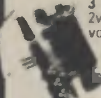

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FB4	2	14 × 4"	110	£2.00

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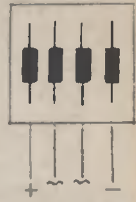

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IFM – 1.5 Amps

Size: 1 inch square
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ORDER NO: 4R1 B Rect.

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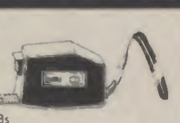

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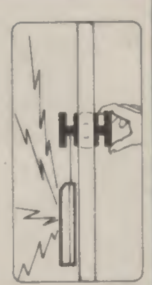

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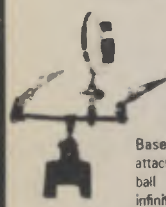

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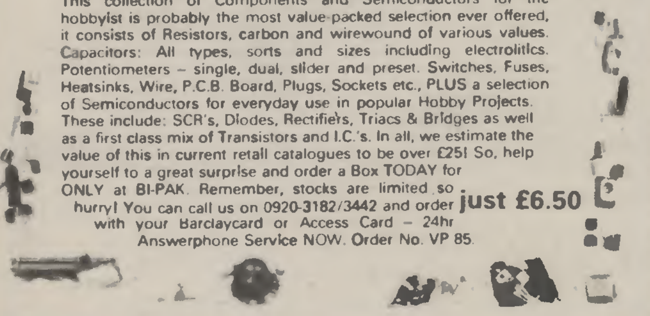

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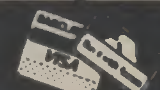

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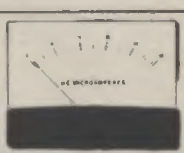

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OP–AMP POWER SUPPLY

BY T. J. JOHNSON

THE power supply described here was designed primarily to be used on circuits which require both positive and negative voltages of the same value, for example, operational amplifiers. The power supply uses a single i.c. to produce both positive and negative voltages of 15V. The maximum current which can be supplied is 50mA per rail, and although this seems low it is quite sufficient for most circuits which may be encountered.

The supply is fully protected within the i.c. and shuts down if the currrent drawn exceeds the safe limit.

CIRCUIT DESCRIPTION

The complete circuit for the Op-Amp Power Supply appears in Fig. 1. It can be seen that the circuit is very simple, and comprises IC1 and a few associated components. The mains transformer T1 steps the mains voltage down to approximately 30V a.c. With the centre tap earthed, essentially two a.c. voltages are applied to the bridge rectifier D1 to D4. After rectification two d.c. voltages appear at the respective pins of the i.c.

An explanation of how the bridge rectifier can produce both negative and positive voltages from a single transformer secondary can be found in many text books and thus will not be given here. Suffice to say that the two top diodes (D1 and D3) as shown, produce a full-wave rectified positive output, and the two lower diodes (D2 and D4) produce a full-wave negative output.

Each d.c voltage (approximately 22V) appears across one of the two smoothing capacitors C1 and C2, and hence to the inputs of the i.c. Pin 8 on the i.c. is for positive inputs and Pin 4 is for negative inputs. The internal circuitry of the i.c. is quite complex but can be considered as two independent conventional regulator circuits, such as the 78XX series, but of course having the refinement of automatic shut-down in the event of a large current being drawn.

FREQUENCY COMPENSATION

The two capacitors, C3 and C4, provide a degree of frequency compensation and hum rejection. After regulation by the i.c., each output, pin 7 (positive) and pin 5 (negative), are passed direct to the output sockets SK1 and SK2. The two capacitors, C5 and C6, provide final smoothing for the outputs. A balance control, VR1, enables the outputs to be adjusted to precisely the same voltage. It may be found that the outputs are not exactly 15V each when adjusted, this is perfectly satisfactory and indicates no fault in the circuit.

Finally, indication that the unit is on, is given by LP1 which illuminates when the a.c. mains voltage is on. Note here, that the d.c. outputs have no on/off switch of their own, on/off switching being done purely by the mains switch.

PRINTED CIRCUIT BOARD

The prototype unit was constructed on a single-sided printed circuit board, size 76 × 76mm and the p.c.b. master pattern to be etched is shown actual size in Fig. 2. This board is available through the *EE PCB Service*, Order code 8409–01.

The layout of the components on the topside of the board are also shown in Fig. 2. Note the two large electrolytic capacitors are mounted with their positive leads opposite each other, likewise with the two smaller electrolytics.

The orientation of the bridge rectifier must, for obvious reasons be correct, the positive lead is usually the longer of the four and is nearly always marked on the top of the device.

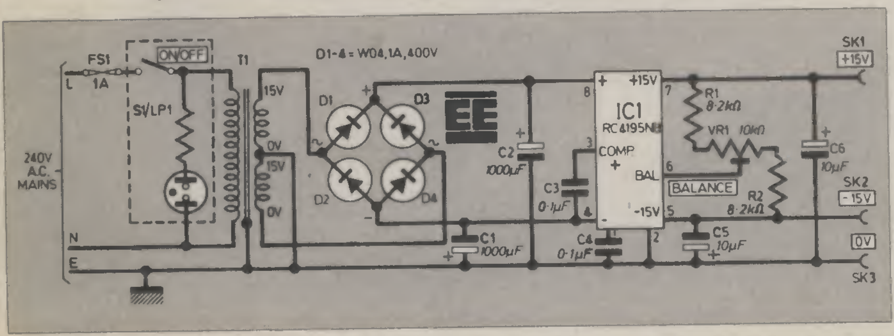
CASE

A small metal box of dimensions 153 × 114 × 38mm is used for the power supply. Relative positions for the terminals, transformer and switch can be seen along with the final wiring details in Fig. 3.

Note, the p.c.b. is connected to the metal case via its copper tracks and mounting hardware. This means that the common (0V) terminal is effectively connected to the mains earth. Obviously this is correct procedure, to earth any exposed metal, but in a few instances earthing the common rail can be a disadvantage. The answer is to remove the earth lead completely. However, this is not advised for safety reasons. The complete answer then, is to isolate the p.c.b., either by using insulated spacers and nylon nuts and bolts, or to remove the copper from around the fixing points.

If a combined neon/switch cannot be obtained then it is quite in order to employ a separate switch and small neon indicator. A standard toggle switch is possibly the best type to use as this will give a little more room on the front panel to mount the neon.

Fig. 1. Complete circuit diagram for the Op-Amp Power Supply.



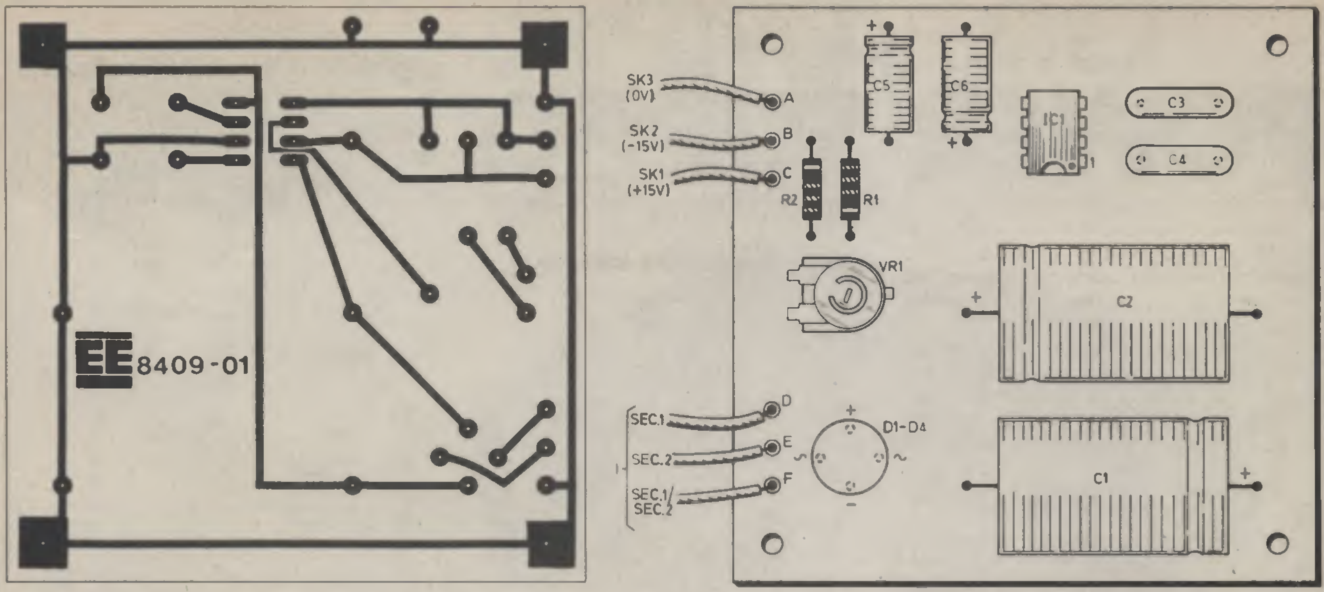


Fig. 2. The printed circuit board master (and component layout), which is available from the *EE PCB Service*, Order code 8409-01. The layout of the components on the topside of the board are also shown, note the orientation of the electrolytic capacitors.

COMPONENTS

See **Shop Talk** page 560

Resistors
R1,2 8·2kΩ (2 off)
Both ¼W carbon ±5%

Capacitors
C1,2 1000μF 25V elect. (2 off)
C3,4 0·1μF polyester (2 off)
C5,6 10μF 25V elect. (2 off)

Semiconductors
D1–4 WO4 1A, 400V bridge rectifier
IC1 4195 ±15V dual-tracking regulator

Miscellaneous
VR1 10kΩ lin. horizontal skeleton preset
T1 mains transformer, 0–15V, 0–15V, 100mA secondaries
S1/LP1 single-pole rocker switch with neon
SK1 4mm insulated terminal post, red
SK2 4mm insulated terminal post, black
SK3 4mm insulated terminal post, green
FS1 1A fuse and panel mounting holder

Printed circuit board: single-sided size, 76 x 76mm, *EE PCB Service*, Order code 8409-01; case 153 x 114 x 38mm (Maplin Order code WB2 vinyl); connecting wire.

Approx. cost Guidance only **£16**

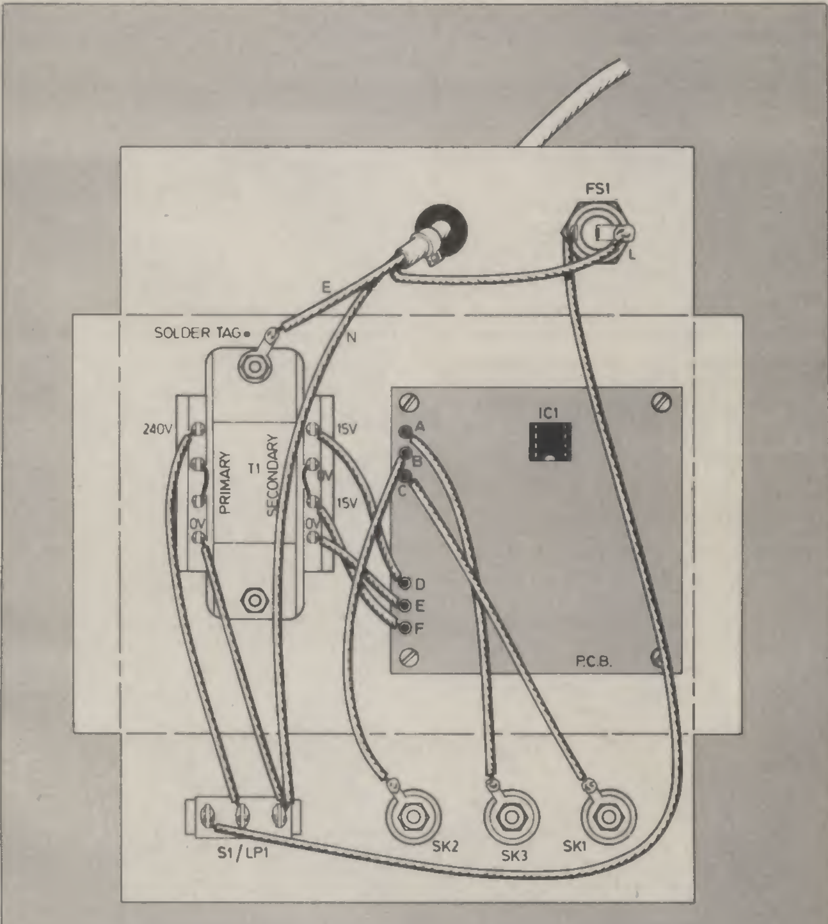


Fig. 3. Off board interwiring details for the Op-Amp Power Supply.

TESTING

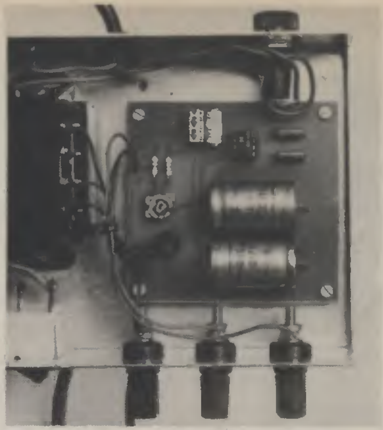
Initially set the wiper of VR1 to about mid-position and connect a d.c. voltmeter between the common terminal and the positive terminal. Set the voltmeter to 25V full-scale deflection. Plug the unit into the mains and observe almost immediately that the voltmeter shows a voltage. If no reading is observed, switch off the unit and re-check for errors.

Assuming all is well the voltmeter should show a reading of about 15V. Transfer the meter leads to measure the negative voltage of the power supply. This reading should be very nearly the same as before, if it is not, simply adjust VR1 until the two readings are the same.

As was mentioned earlier the two voltages may not be exactly 15V, a reading of 14·9V being typical. Once this adjustment has been made, there is nothing further to do and the power supply is then ready for use.

Remember, when using the power supply, the absolute maximum current which can be drawn from each rail is 50mA. It is wise in fact to assume that the current maximum is 45mA, this will give the circuit a 10 per cent operational safety margin.

Some constructors may find the voltage of 15V slightly high on some circuits. For example, an op-amp may be being used with t.t.l. i.c.s, which require only 5V. Providing the current requirement of the t.t.l. circuit is not too large, then the power supply may be effectively put to use by using two Zener diodes of 5V connected across each terminal. Other lower voltages, either of the same value or different values can thus be derived from the two 15V supplies of the power supply. □



(Left). Interwiring details inside the case.

Details of the front panel, showing the positioning of the switch and sockets.

CIRCUIT EXCHANGE

VIC-20 LIGHT PEN

Don't let the simplicity or low cost of this unit fool you, it works very well on any black and white, or colour, TV. It uses the VIC 20's built-in light pen facility to produce coordinates of its position on the screen. The pen is constructed using a photodiode (TIL 78), a couple of pieces of wire and an old pen, and is connected via a 9-pin D-type connector to the VIC's user port.

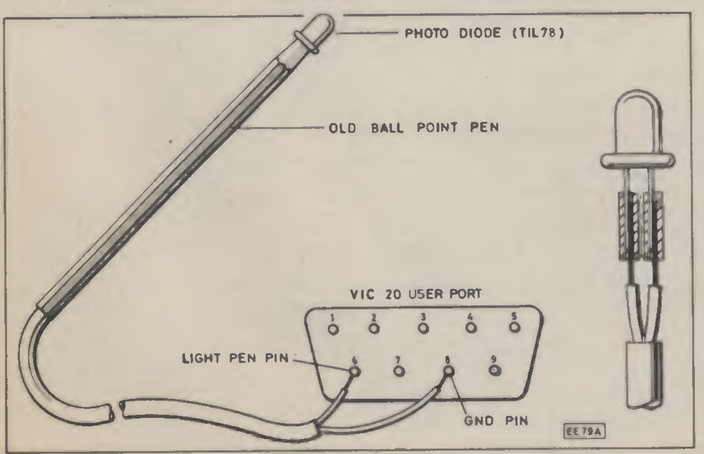
Construction could not be simpler, with just a couple of wires to solder to the photodiode and the socket. The positive connection is made to pin 6 and the negative to pin 8 of the D-type connector. When the unit is assembled it is important to ensure that there is as much of the photodiode showing as possible, to ensure correct operation.

Testing and operation is very straightforward. Simply plug in the pen and turn the screen up to full brightness, then type in the following program:

```
10 Y=INT((PEEK(36871)—32)/4)
20 PRINT
30 GOTO 10
```

When you run the program and touch the screen with the pen, the number printed is the Y coordinates and should decrease as you move the pen up the screen. A similar program is used for the X coordinates and if all is satisfactory the brightness and contrast can be adjusted for optimum efficiency.

The applications of the pen are only limited by your imagination and software. A starter program to return coordinates of the pen is listed below.




```
10 X=INT((PEEK(36870)—49)/4):Y=/NT((PEEK(36871)—32)/4)
20 PRINT "X COORDINATE =";X; "Y COORDINATE ="; Y
30 FOR T=1 to 20 ; NEXT T
40 GOTO 10
```

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ANATOMY OF YOUR MICRO

PART THREE

OWEN BISHOP

IN THE FINAL part of this series, the computer "peripheral" equipment is examined. The essentials are a keyboard and some kind of VDU, of course, but disk storage and cassette recorders, sound generation and "joysticks" are also considered.

KEYBOARD

The keyboard is the main way in which we control the micro. In the cheaper machines the keyboard is just a set of key-switches. The switch is closed when the key is pressed. The keys connect two sets of lines, one of which is connected to the data bus through buffers (Fig. 3.1). These buffers are quite different from the buffer areas of memory referred to earlier. They are integrated circuits with one input and one output. The output may take the same logic level as the input (a non-inverting buffer) or it may take the opposite level (an inverting buffer). The function of a buffer is to pass logic levels from one part of a circuit to another when required. Some types of buffer are designed to provide extra power; many other devices can be connected to the output terminal of such a buffer. Often the function of a buffer is to isolate one part of the circuit from another except at certain times.

This is the case with the keyboard circuit. Although the output of the buffer may take the same logic level ("high" or "low") as its input, this only happens when the buffer circuit is enabled. At other times the output terminal is in its third state, which we call *high impedance*. In this state, it is virtually disconnected so that it is incapable of giving output of either kind. The three-state output is particularly important for devices which are putting data onto the data bus. If more than one device tried to put data onto the bus at the same time, the situation would be utterly confusing. So buffers and other devices (such as the MPU, and the RAM and ROM chips) which put data on the bus all have three-state outputs. Only when a device is enabled is its output active and able to transfer data to the bus.

The MPU goes through a repeated routine of enabling the buffers when it is waiting for input from the keyboard. At the same time it scans the keyboard by addressing the i.c. (which could be a 74LS138) which makes each of the lines 0 to 7 go low in turn. If a key is pressed, and the line is made "low", this "low" appears on the data bus. The MPU knows which line has just been made "low", and which data line has shown this "low", so it can then work out which key has been pressed.

Such a system is cheap but gives the MPU a lot of work to do. The higher priced micros have a special i.c. to read the keyboard. This is able to detect when a key is pressed by automatically scanning the board. It uses a method similar to that described above, to find out which key it is. It contains an encoder circuit which puts this information into the form of an ASCII code. The ASCII code (American Standard Code for Information Interchange) for any given letter, numeral, symbol or control key consists of a byte with a definite value. When the micro wants to find out which key has been pressed, it simply has to read from the keyboard decoder i.c. and instantly is told the ASCII code of the key. This saves the MPU a lot of time, giving it more time to spend on operations more important than routine keyboard-scanning.

VIDEO SCREEN

Most micros provide visual display by means of a video screen, either a TV set or a monitor (not to be confused with the monitor program mentioned last month!). At present, only a few portable computers, such as the Sharp PC-1251, and the Casio FX-702P have other methods of display (liquid crystal displays, limited to a few characters at a time). The Grundy NewBrain has a built-in l.e.d. display, but can readily be attached to a TV

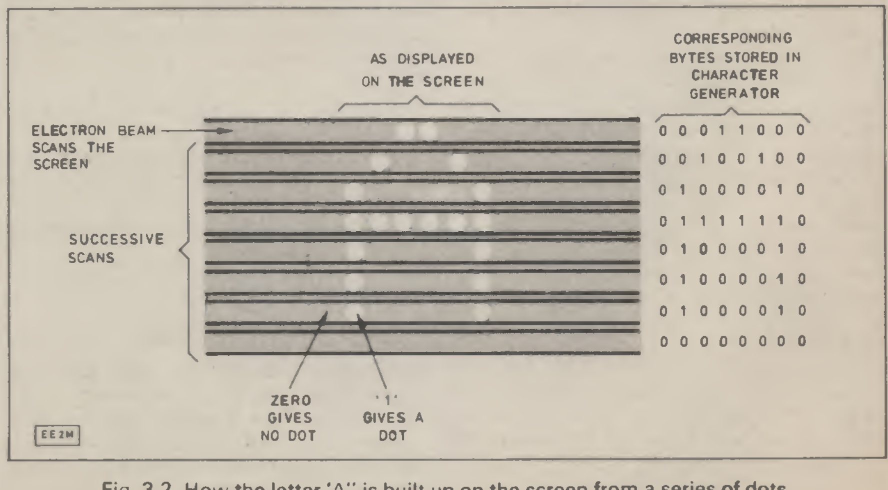


Fig. 3.2. How the letter 'A' is built up on the screen from a series of dots.

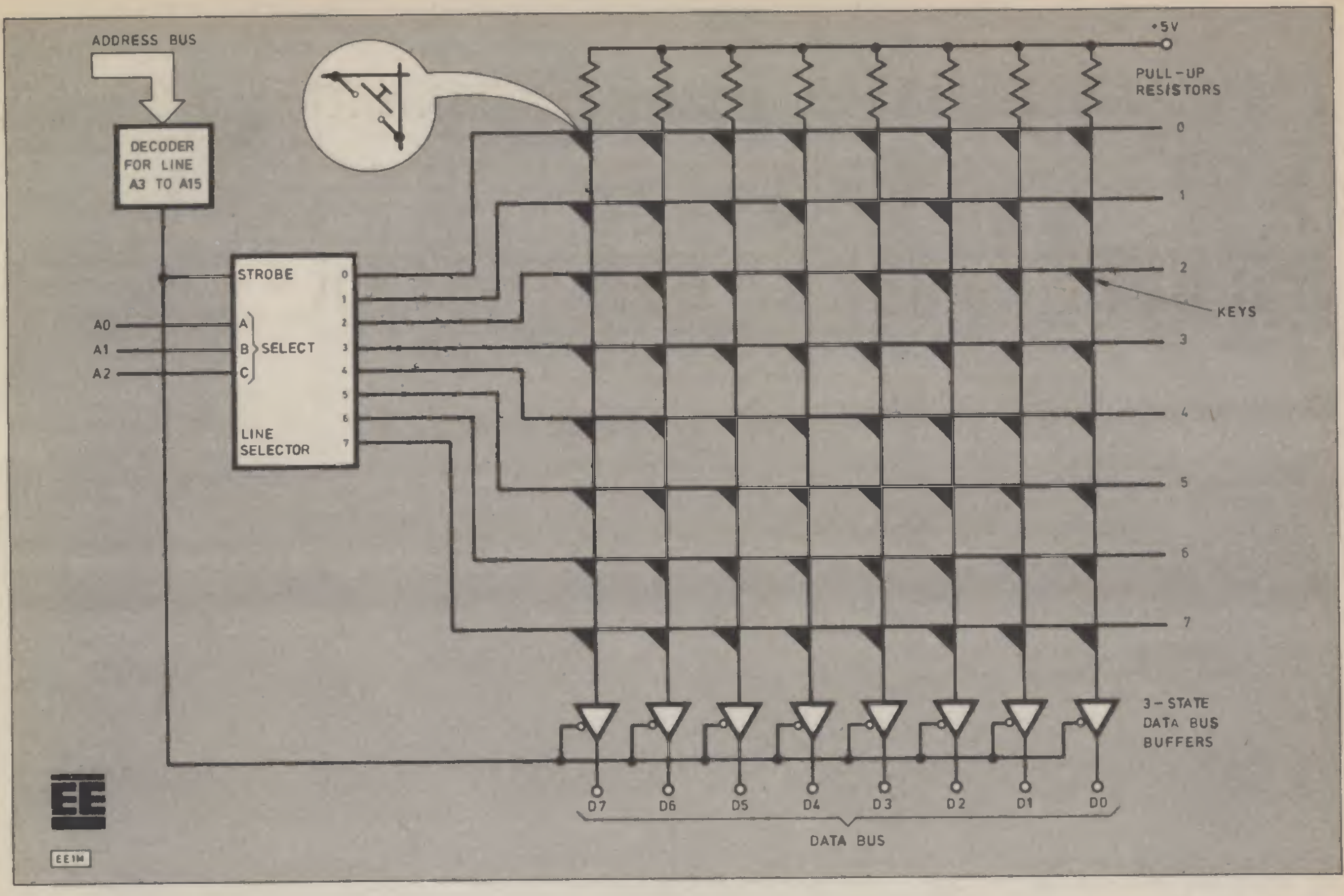


Fig. 3.1. Simplified keyboard circuit. Lines to data buffers are held "high" by pull-up resistors, but go "low" if a key is pressed *and* the wire to that key from the line selector is made "low".

or monitor when it is not being used as a portable.

To display characters and graphics designs on the screen, the computer must be able to produce signals which cause a pattern of dots to be displayed. The signals must be synchronised with the scanning of the screen by the electron beam. Fig. 3.2 shows the patterns needed to produce the letter "A". It is obvious that this pattern must be read from memory, either directly from a character generator or from RAM. Special i.c.s are available to deal with the production of a suitable signal.

A TV set is designed to receive carrier-wave radio signals and to demodulate these in order to extract the information required to produce the sounds and pictures of the TV programme.

Unfortunately, they cannot respond directly to the signals produced by the video circuits of the computer. These signals have to be modulated, that is, combined with a UHF carrier signal, before they can be of use to the TV set. For this reason the computer incorporates a modulator, with connections to the aerial socket of the TV set.

There are two unnecessary stages, modulation and demodulation, between the originating of a display by the MPU and its appearance on the TV screen. There is the inevitable introduction of noise and other forms of distortion at both stages, so that the picture appearing on the screen loses quality, both in definition and in colour rendering.

These two stages can be cut out by using a monitor, which is able to work directly with the signals from the video logic circuits of the computer. There is usually a marked improvement in the quality of the picture when a monitor is used. With TV sets and with many kinds of monitor, the signals for colour are mixed with the signals for brightness before being sent from the computer and have to be separated before the picture can be displayed. Separation of signals is another potential source of degradation. With an RGB monitor, the three primary colour signals are fed separately to the colour tube and a picture of the highest quality results. Many micros now have a special RGB output socket, as well as a socket for an ordinary monitor and one for a TV set, so that you can connect any kind of video display.

CASSETTE INTERFACE

Several methods are used for communicating with a cassette recorder but all have one feature in common. The data is transmitted serially, a bit at a time. Bits are usually transmitted in groups of eight, thus each group corresponds to a byte. In one method, bits are transmitted as a series of tone bursts. The burst may be of one of two distinct frequencies, one frequency corresponding to a "1" and the other to a "0". The TRS-80 marks the beginning and end of each bit with a "blip" and, if the bit is a "1", there is another "blip" at the half-way point. The monitor program of the micro generates the required signals and feeds them to the cassette interface. This is often an operational amplifier which gives a "low" or "high" output according to what input it is receiving along the data line. The cassette input also has an amplifier and its output is fed to a line of the data bus when the MPU is in the "cassette read" program. Naturally, the micro is only able to interpret signals which it or another micro of the same make has generated, so it is virtually impossible for programs taped by one computer to be loaded into a computer of a different make.

DISKS

These are the other main method of large-scale data storage for micros. They have many advantages over cassette tapes, but the considerable cost of the disk drive means that they are the exception rather than the rule in home computer systems. The floppy disk used most often with personal computers is the mini-floppy, which is about $5\frac{1}{4}$ inches in diameter.

It is contained in a protective cover, with a slot through which the magnetic surface may be read from or written to by the head of the disk drive. See Fig. 3.3. There is another hole in the cover to allow the disk to be spun on a spindle. The disk spins at high speed (about 300 r.p.m.) so that data may be read or written at a very rapid rate (a hundred or more *kilo*bits per second).

Compare this with the usual rate of data transfer with a cassette recorder, which may be as low as 300 bits (not kilobits) per second and is rarely as high as 1500 bits per second. Added to this, the cassette recorder stores the bits as a single string running from one end of the tape to the other. It is not easy to find any particular part of the tape, yet to run the tape through the recorder from beginning to end at its usual speed takes several minutes.

Moreover, cassette recorders have no means of automatically finding any required section of track. The disk, with its concentric tracks and a head that can slide from one track to another in an average of 300ms, can rapidly pick out any segment of a disk. There is no need to run all the way through the disk to find the part that is required. In addition, the disk operating system keeps a directory of all programs and other material stored on the disk, and the location of each program, so that any item of data can be called up within a few seconds.

SOUND

Even the cheaper of the more recent micros include a loudspeaker in their anatomy. Often this occupies a single address in memory. A write operation to this address toggles the speaker on, while a second write operation toggles it off again. A series of write's repeated at a suitable frequency cause the speaker to emit an audible note of the required pitch.

The latest refinement is to have a special-purpose sound generator chip. Toggling loudspeakers on and off is rather menial work for the MPU and occupies it when it would be better employed in other activities. In a game, for example, it has plenty to do with moving graphics characters around the screen, receiving input from the keyboard and keeping the score. If it can simply instruct a sound generator to produce a note of a given frequency for a given length of time and then leave it to get on with this task, it is able to give better attention to the game in progress.

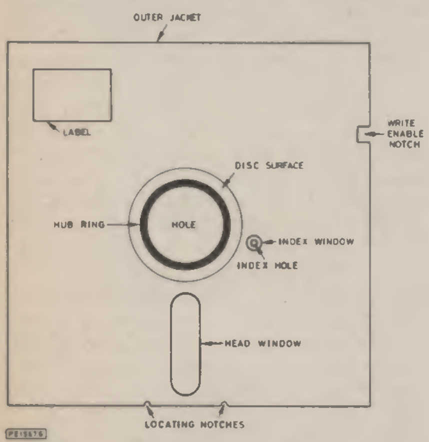


Fig. 3.3. A typical floppy disk, showing the "window" in the protective cover which allows the disk-head to read or write data.

Most sound generator chips are able to make more than one musical note at a time, so allowing chords to be played. Some also include a "white noise" generator, which is a very useful addition for sound effects. The more sophisticated chips allow you even greater control over the sounds they make. The sound generator of the Commodore 64 not only has three tone generators, each with a range of nine octaves, but their waveform can be a sinewave, a triangle wave, a sawtooth or a squarewave.

The period of attack and decay and other parameters are all under the control of the MPU. There are also variable filters to further modify the sound which has been produced, and resonance too is variable. A small loudspeaker buried among the micro's i.c.s would do little justice to such sounds so, in this computer (as in the VIC-20, which has a similar though less comprehensive sound generator) the sound signals are fed to the TV set. This brings better quality sound and allows the overall volume to be set by adjusting the control on the TV set.

INPUT/OUTPUT PORTS

Most manufacturers of microprocessors also provide compatible i.c.s for performing other functions of importance in the activities of the computer. Among these are the input and output devices. They come with a variety of names but do roughly the same things. Examples are: the 6522 Versatile Interface Adapter designed to be used with the 6502, and the Z80-PIO, or Parallel Input/Output controller. Devices of this kind usually comprise two or more 8-bit *ports*. Each port consists of eight latches, through which data can be transferred between the data bus of the computer and peripheral devices such as printers, the keyboard (in certain micros), robots, chart plotters, graphics tablets or anything else that we may wish to link to the computer. The ports can act as inputs, receiving data from the external device (e.g., from a graphics tablet) or as outputs, passing data from the MPU to, for example, a printer or robot. See Fig. 3.4. It is, of course, possible to connect such devices *directly* to the address and data buses, in effect making them an integral part of the computer system, but this leads to certain complications. For one thing, the device would then have to have its action more closely synchronised with the MPU. When instructed to receive data in a write operation, it would have to be able to take in the data immediately. The data would be on the bus only for as long as the write operation lasted—a matter of a few hundred milliseconds. How could a robot follow the instruction "move forward two metres" in such a short time? If the data is held in the latches of an I/O device, it remains on the output lines indefinitely until a new instruction is issued by the MPU. In the meantime the instruction remains in force and the robot can continue to obey it.

Similarly, data coming from sensors on the robot can be fed continuously to the input ports of the I/O device. The inputs to the latches may be connected permanently and directly to these sensors. When the MPU wants to read the sensors, it simply directs a read operation to the I/O device and there is the data it wants. As before, there is no need to syn-

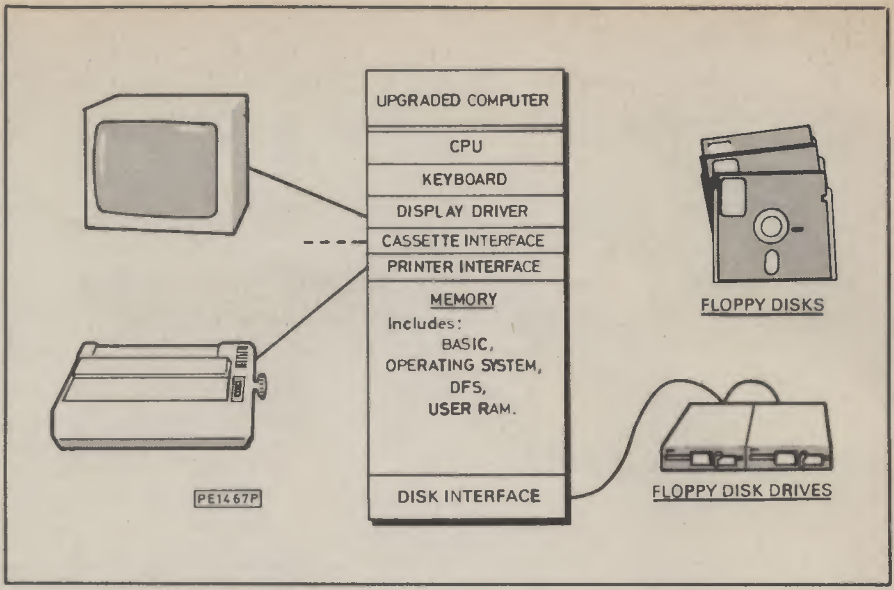
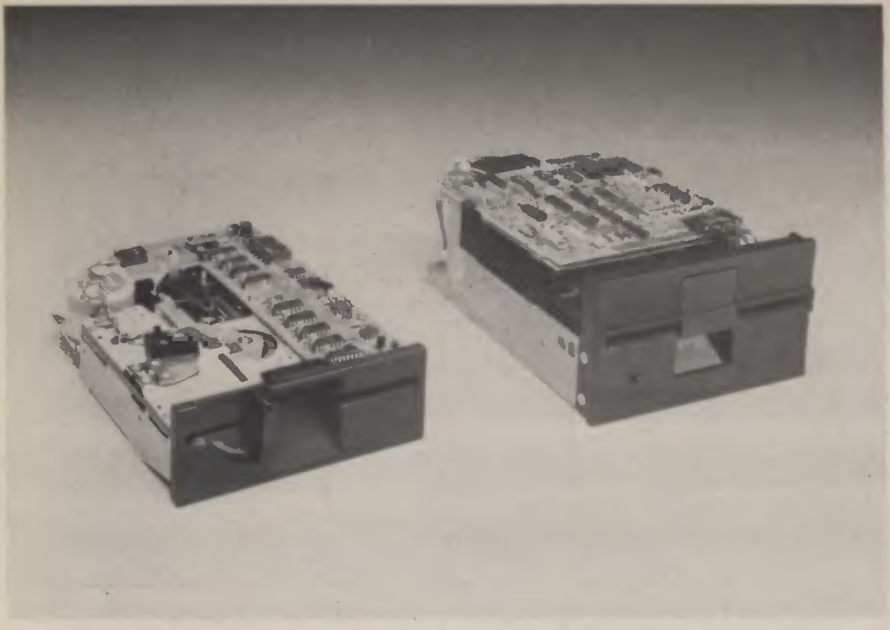


Fig. 3.4. A computer interfaced to a VDU, a printer, and dual disk drives.



Floppy disk drives, showing the electronics.

chronise the action of the robot with that of the MPU, for the I/O device acts as an intermediary.

Another advantage is that the I/O device is allocated its own fixed addresses in memory. Standard routines which do not depend on which external device is plugged into it, can be used for part of the program. This programming allows the ports to be used either as inputs or as outputs, or some lines of a single port can be used as inputs while others are used as outputs. All of this can be changed by a few simple commands made during the running of a program.

The two devices described above are both parallel I/Os. They transfer data eight bits (one byte) at a time. The connection between the computer and the external device is usually by means of a ribbon cable. Printers are usually connected in this way, the advantages being that the eight bits of the ASCII code for each character or printer command may be sent simultaneously. This means quicker response.

I/O devices usually have control lines to assist the MPU and external device to keep in step. It is no good the computer sending masses of text to the printer when the printer is not able to keep up with it. Micros work so much quicker than printers! The printer usually has a small RAM of its own to store a few lines of text. It also has its own character generator ROM and may have its own microprocessor to manage its complicated operations. But its speed is limited by mechanical considerations and it must be able to tell the MPU when it is lagging behind. A control line from the printer to the I/O device (or alternatively a special printer interface circuit) carries a "high" signal when the printer is "busy" and cannot receive any further text. The I/O device relays this information to the micro.

There is a wide range of printers available, from miniature ones which often use thermal paper, to expensive colour printers such as the one above.

When the printer has completed its current task, another line (Acknowledge) goes "low" indicating this fact to the MPU. In some systems there is another line to indicate that the supply of paper is exhausted and that no more data should be sent until it is renewed. The MPU is also able to send messages to the printer. The data strobe line goes low, instructing the printer to accept the new data.

CHIPS GALORE

There seems to be no end to the variety of i.c.s that may be found inside a micro. Here is yet another example. It might almost be said that the VIC-20 computer was designed around its video interface chip instead of its 6502 MPU. At any rate the computer's full name, the Video Interface Computer, suggests that this is what happened. This chip, the 6560 (or 6561) controls both sound and vision. Some of its sound capabilities have been mentioned earlier. As far as the user is concerned, it has 16 registers, each capable of holding one byte. You POKE values into one or more of these in order to produce the sound and colour effects you require. Four registers are concerned with the three tone generators and the noise generator already described. A fifth register controls the volume of sound. There are three registers used in conjunction with a light pen and the games paddles. These registers are PEEKed to find out the positions of the pen or paddles.

The remaining registers are concerned with the picture on the TV screen. This may be controlled in a number of ways by POKEing values to these registers. Like the ZX-Spectrum, the VIC-20 has a coloured border around the main display area. The number of rows and columns in the display area can be controlled. The colour of the border (chosen from eight) and the colour of the display area (chosen from 16) is set by POKEing to a single register. The colour in which characters are displayed is set by another POKE. It is also possible to choose between characters displayed in a single colour, and multicolour characters, which can have up to four colours at once. Given that two of these can be chosen from eight colours and two from 16 colours, this gives 16384 possible colour combinations! It is surprising what can be done with a versatile chip and a little ingenuity on the part of the programmer. It is also surprising that neither the user-definable graphics capability nor the existence of multicolour characters are mentioned in the VIC-20 manual.

ANALOGUE-TO-DIGITAL

Mention of games paddles reminds us that a computer works with digital signals ("highs" and "lows"), whereas many devices which may be attached to it produce *analogue* signals. Their output voltage may vary smoothly over the whole of a given range. The games paddle, or joystick, is a common example. Fig. 3.5 shows how this works in the Apple II. The games paddle is an ordinary potentiometer and, when it is plugged into the micro, forms part of a timer circuit, usually based on the well-known 555 i.c. When the MPU wants to know the setting of the paddle, it triggers the timer. Then it repeatedly reads the output from the timer. The length of time this output stays "high" depends on the setting of the potentiometer. The MPU can measure this period and so work out the position of the paddle.

This is an inexpensive but rather crude method of analogue-to-digital conversion. Except for the most costly variety (which are certainly *not* used in games paddles) the track of a potentiometer is never perfectly linear, and soon suffers from wear. But, since the user is able to receive visual feedback from the screen, these irregularities are unimportant in practice. If you want to interface your micro to a thermometer or a laboratory instrument, such as a balance, you will need not only accuracy but precision. There are several i.c.s designed to convert an analogue signal into a digital one. An example is the ZN427E. This incorporates a voltage reference against which all input voltages are compared. This gives the device its accuracy. The i.c. has eight output terminals, which are three-state (see above) so, if these outputs are wired to the data bus, the data coming from this converter may be "read" by the MPU as a single byte. Provided that the input voltage varies over the whole range, its value may be determined to the nearest "bit". This gives a precision of 1 in 256 or 0·4 per cent, which is close enough for most purposes.

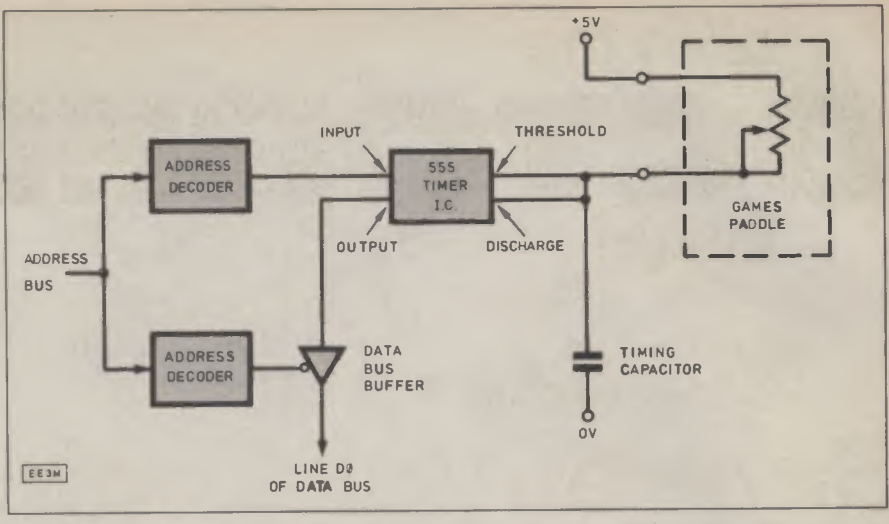


Fig. 3.5. Using a 555 timer i.c. as an analogue-to-digital converter in conjunction with a games paddle.

THE ULTIMATE I.C.?

We are nearly at the end of the array of electronic wonders that you might expect to find inside your micro. Of course, it must have a power supply, regulated to the standard +5V on which TTL i.c.s and most other microcomputer i.c.s work. If it is a portable micro, it may also have a battery. These and "power-on" l.e.d.s, and edge connectors which allow you to plug other devices on to the buses are very straightforward in their construction. But one might wonder how it is that, with such a wide range of possibilities, some computers manage with so few i.c.s inside them.

A notable example is the ZX-81. Those who have built their own from a kit will know that this contains only four i.c.s. These comprise the Z80 MPU, a ROM (holding the ZX-81 monitor program and the Sinclair BASIC interpreter program), and two 2114 RAM i.c.s to provide the one kilobyte of user memory. The 2114s can be replaced by a single RAM i.c., the 4118, which provides 1K, or the 4816, which provides 2K. The fourth i.c. is the Sinclair Computer Logic i.c. This undertakes all the functions of address decoding, video interfacing and many other routine operations which in other computers would be done by a dozen or more separate i.c.s. Mass production has made it feasible to design and manufacture a special-purpose chip solely for running the ZX-81, instead of using the commonly available i.c.s.

There is a growing trend to adopt this approach in other micros, in order to reduce size, simplify the p.c.b., and to cut costs in general. The usual procedure is to make use of an *uncommitted logic array* chip. A ULA has a very large number of logic gates on the chip but these are not connected at first. The connections can be added during the final stages of manufacture but, since the major part of the work has already been done in designing the initial array, the costs of a ULA are much less than that of designing and manufacturing a special-purpose logic system from scratch. The only trouble is that it is normally fairly easy to get hold of the circuit diagram of a micro and puzzle out how it works. But manufacturers are usually unwilling to publish the details of what goes on inside their ULAs. With increasing use of these devices, it may in future be less easy to write an informative article on *The Anatomy Of Your Micro.*

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Part One of a new series which will be of importance to anyone interested in home computers, titled "Digital Electronics", will be published next month.

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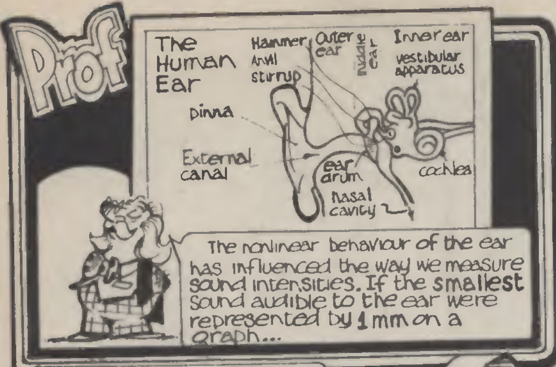
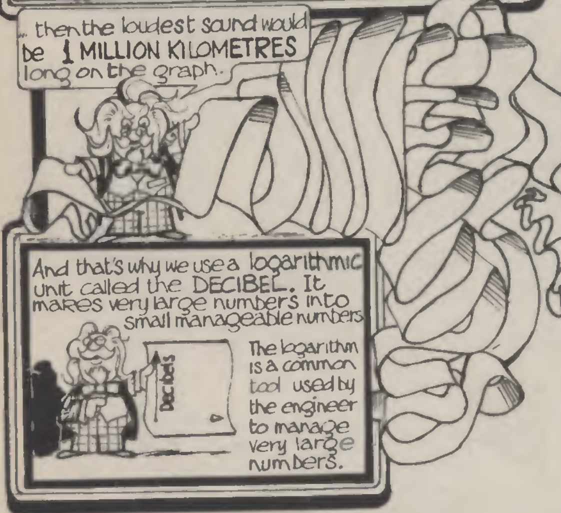
...With the 'DECIBEL'

A NEW LIGHTHEARTED LOOK AT ELECTRONICS





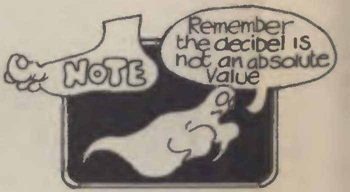
WHAT IS A LOGARITHM?

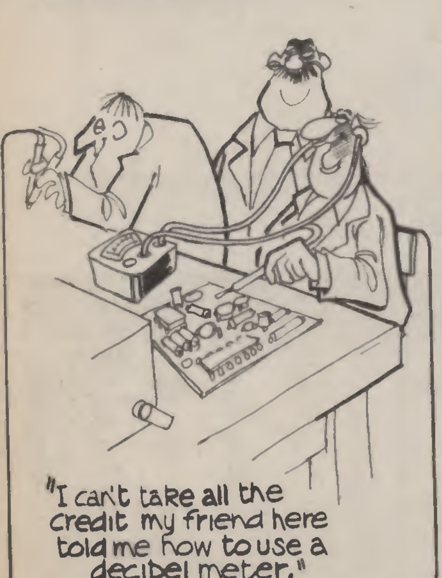
The logarithm of a number is equal to the power to which 10 has to be raised to equal that number e.g.
$10 = 10^1$ ∴ log of 10 = 1
$100 = 10^2$ ∴ log of 100 = 2 this applies to any number.

The 'decibel' is one tenth of a Bel (after Alexander Graham Bell) and is a logarithmic unit used to measure ratios of SOUND INTENSITIES

There is a range of sound intensities called the DYNAMIC RANGE. The range begins with the Threshold of hearing and increases to the loudest sound the ear can withstand without damage called the THRESHOLD of PAIN.

The Threshold of pain is 1,000,000,000,000 times greater than the Threshold of hearing. Find the logarithm of this huge number (12) and times by 10 for power and you have the decibel i.e. 120, a much easier number to use!



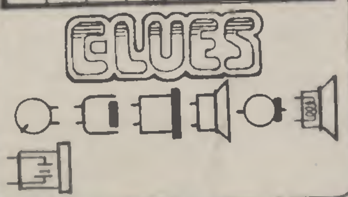


LINK-UP

Link-up the letters to form a continous chain of component names.

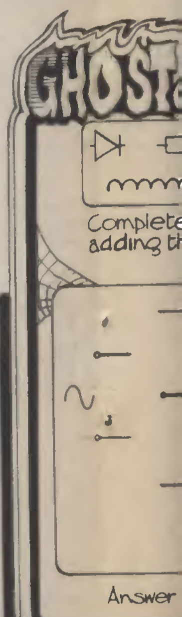
N	I	V	O	M	R	E	K
G	E	C	E	I	V	E	A
C	R	D	N	U	O	R	E
O	R	E	O	N	S	L	P
I	M	I	H	E	O	O	S
L		C	P	P	H	U	D
P		R	O	I	C	E	P
I	E	Z	O	C	K	-	U

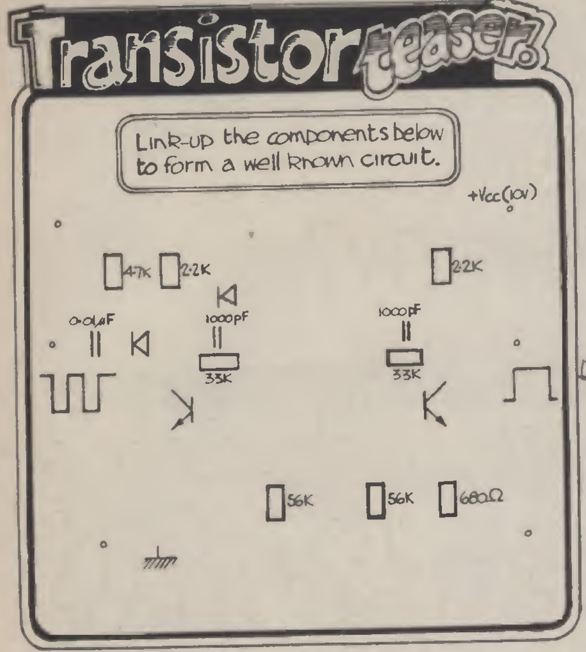
CLUES

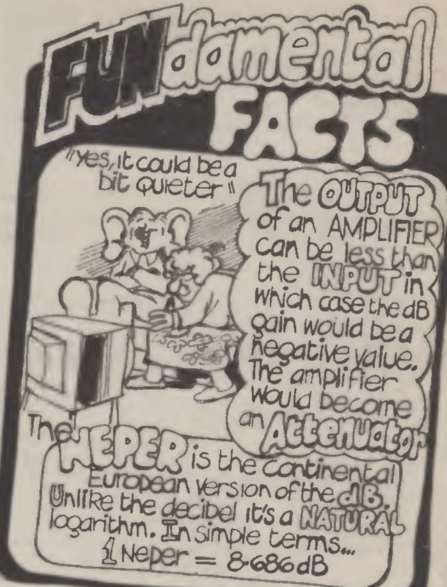


DYNAMIC RANGE.

Decibels	SOUNDS LIKE...
120	YOU!
110	DISCOTHEQUE
100	NOISY FACTORY
90	CITY STREET
80	LARGE OCHESTRA
70	NOISY FACTORY
60	HI-FI IN ROOM
50	RESTAURANT
40	LIBRARY
30	QUIET CONVERSATION
20	WHISPER
10	SOUNDPROOF ROOM
0	THRESHOLD OF HEARING.

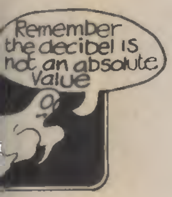


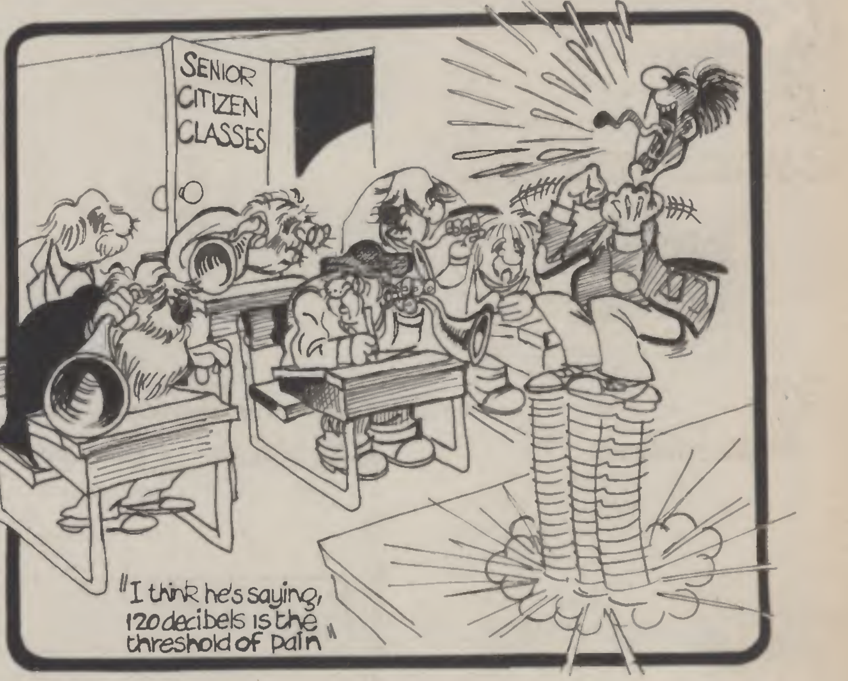


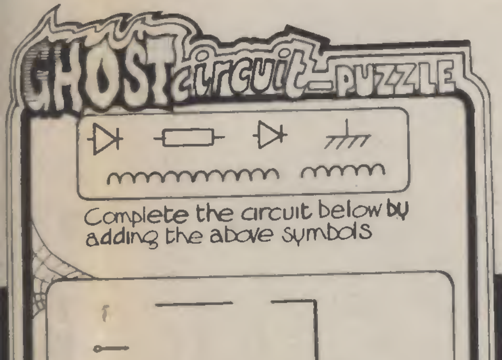


with

Thakery







Solutions page 584

SOUND OPERATED FLASH

M.G. ARGENT

THE purpose of this unit is to trigger an electronic camera flash on receipt of an audible signal. What on earth for? You may well ask. Well as can be seen from the accompanying photographs, some very spectacular impact-triggered shots can be made. This low cost sound operated flash should provide hours of entertainment limited only by the imagination of the user.

CIRCUIT OPERATION

As can be seen the unit is quite simple, consisting of a "pick up" (microphone), an amplifier and a triggering device. In this case a CSR is used as the triggering device.

The complete circuit diagram is shown in Fig. 1. An amplifier is constructed using two 741 type op-amps, which are both contained in a single d.i.l. package (MC1458). IC1a is wired to have a voltage gain of 10, set by R4/R1 and its output is fed to IC1b which has a gain of 100, R6/R5. This gives a total gain of 1000, which is sufficient for most purposes.

The output of IC1b is coupled to the gate of the triggering device CSR1, via the d.c. blocking capacitor C2. When a signal of sufficient amplitude is applied to the gate of a CSR, then the CSR will conduct if forward biased. This is a similar condition to the short circuit required to operate the flash. The CSR chosen for this unit is the C106D, which requires only 800mV applied to the gate to operate. It will also handle the flash current easily.

Any low cost crystal insert microphone will work with this unit, the one in the prototype being a crystal lapel microphone.

CONSTRUCTION

No problems should be encountered when constructing the sound operated flash as none of the components are CMOS and they are all assembled on a small piece of stripboard as shown in Fig. 3. When the stripboard has been assembled it should be checked for shorts and dry joints. All the polarity sensitive components such as the capacitors and the CSR should be checked for correct orientation.

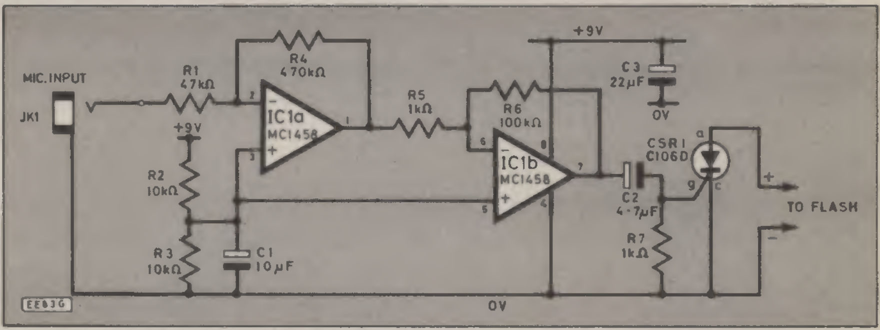


Fig. 1. Complete circuit diagram of the Sound Operated Flash unit.

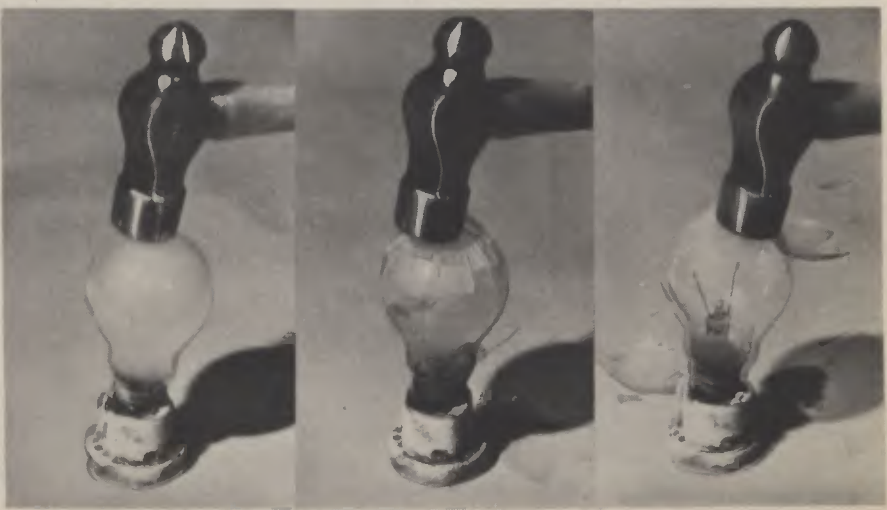
The long microphone lead should, of course be screened, and all the leads within the box should be kept as short as possible to avoid pick-up problems. The board and battery holder were housed in a suitable plastic box which could be used to mount an on-off switch if required.

TESTING

After checking all connections, plug in the battery and microphone, and if a small earpiece is available connect it across R7, whereby background noise should be heard if the amplifier section is working correctly. If all is well, plug in the electronic flash and switch on. When it is ready, click your fingers a few feet away from the microphone and the flash should operate. If this does not happen then reverse the flash leads and try again.

RESULTS

The photographs shown were all taken using a Halina camera and a National PE-182 flash unit, neither of which are specialist items. The only specification being that the camera has the facility to



hold the shutter open (normally shown as a β symbol on the shutter speed adjustment).

To take shots using this unit the room should be darkened and the shutter held open. When a sufficient noise level is apparent the flash will operate. The shutter should then be closed, and that is about it. Notice that positioning the microphone further away from the noise source will cause a delay in the triggering due to the sound having to travel a greater distance. As a guide it should be noted that placing the microphone one foot away will cause a delay of approximately 1ms.

If it is necessary to increase the sensitivity of the amplifier, then R1 should be decreased to 22kΩ. This will lower the input impedance which should not matter as we are not interested in the sound quality. □

COMPONENTS

See Shop Talk page 560

Resistors

R1	47kΩ
R2,3	10kΩ
R4	470kΩ
R5,7	1kΩ
R6	100kΩ

All resistors $\frac{1}{4}$W ±5%

Capacitors

C1	10μF 10V tant.
C2	4·7μF 10V tant.
C3	22μF 10V tant.

Semiconductors

IC1	MC1458 dual op-amp
CSR1	C106D

Miscellaneous

Miniature jack socket for microphone; crystal microphone insert and screened cable; stripboard 20 strips x 19 holes; plastic box, battery clip, PP3 battery; on-off switch if required.

Approx. cost Guidance only **£6.00**

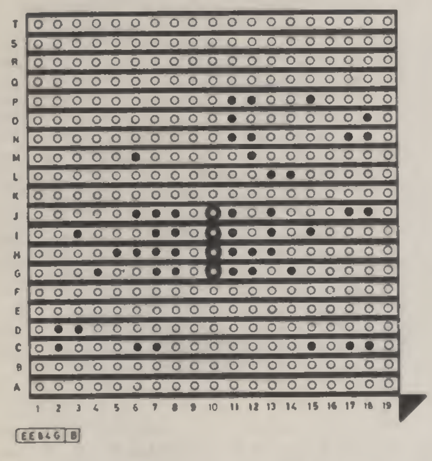
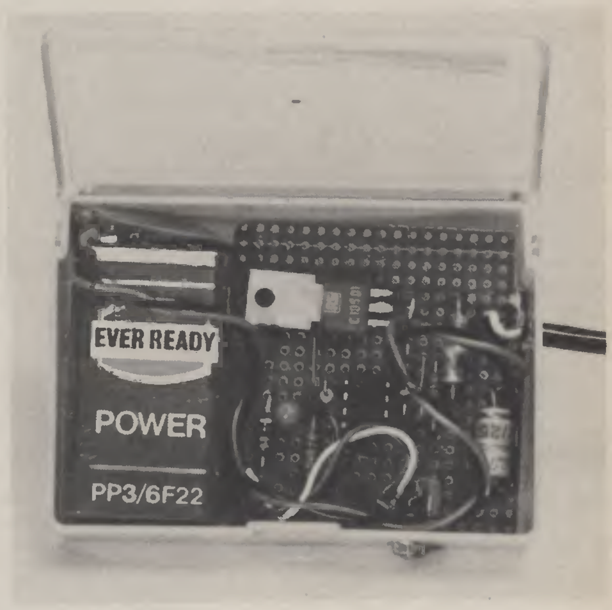


Fig. 2. Underside of the circuit board showing breaks in the copper strips (4 off).

Pin out connections of the CSR.



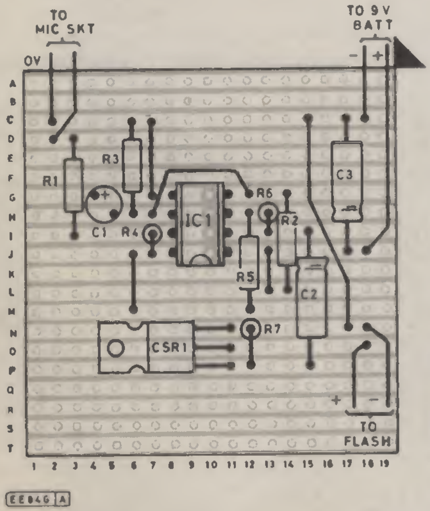


Fig. 3. Stripboard component layout of the Sound Operated Flash unit.

Photographs showing internal and external view of the Sound Operated Flash unit.

RADIO WORLD

BY PAT HAWKER G3VA

Operation Overkill

Even those of us who were involved in the Normandy campaign of 1944—admittedly in my case not arriving at the Mulberry harbour at Arromanches until July—must have felt that the media, particularly television, overdid the commemoration of D-Day plus 40 years.

The battle was not won in a day and for the British Army, particularly the tank crews, the costly battle for Caen lasted several weeks. Nor did I notice any mention of the heavy casualties sustained during several mass bomber raids when the bombs fell short on to the Allied lines, emphasising the need for better air liaison communications.

Nor did the media or politicians see the need to mark the 40th anniversary of the liberation of Rome on June 5, 1944 after the long struggle following the "Husky" invasion of Sicily. Operation "Husky" not "Overlord" was the *first* sea-borne invasion of "Fortress Europe" though marked by the disaster to the glider troops released too soon and lost in the sea. Again, it was on the Eastern Front that the German Army suffered its major defeats.

Wartime radio communications equipment was far from reliable and sometimes failed at the most critical times. It could be argued in view of the successful interception and decoding of so much German, Italian and Japanese top-secret transmissions that the enemy might have done better if his radio had been restricted to short-range tactical networks.

The mechanical construction of many of the German communications equipment was superb. They were also proficient at developing equipment for detecting centimetric radar transmissions, such as H2S from Allied aircraft—a fact that contributed to the heavy losses in the later stages of the RAF's strategic bombing offensive.

Lilli Marlene in Rome

The D-Day nostalgia made much of the wartime entertainers such as Dame Vera Lynn, yet the tune of the period that sticks most firmly in my memory was an anglicized version of "Lilli Marlene" used as a tuning signal on the Special Communications 7050kHz transmitter at Crowborough that broadcast messages to the Jedburgh, SAS and similar groups in Normandy. One of the announcers was the late David Niven who spoke from a temporary studio in a golf club in the Home Counties.

Other words to the tune of "Lilli Marlene" were popular in Italy following some uncomplimentary remarks by a British woman politician, whose name escapes me:

"We're the D-Day Dodgers, out in Italy
Always on the vino, always on the spree.
Eighth Army scroungers, and their tanks
We live in Rome, among the Yanks,
We are the D-Day Dodgers in sunny Italy."

Words that even then reflected the bitter feeling that their hard-fought Italian campaign had been forgotten in the excitement of Normandy.

Resistance in Europe

Until April 21, 1985 there is a special exhibition at the Imperial War Museum in London: "European Resistance to Nazi Germany 1939-45" (£1.50 entrance) that brings together some fascinating, if sad, memorabilia of the Resistance. Included amongst the exhibits are a number of the suitcase radios used on the clandestine links with France, Belgium, Denmark and Holland—though with the notable exception of the equipment provided by British Intelligence and manufactured by its Special Communication Unit at Whaddon near Bletchley.

The radios include the well-known B2 suitcase set designed by Major John Brown (later G3EUR) for SOE; the miniature MCR–1 battery communications receiver made by Philco (GB); two of the excellent Anglo-Polish designs AP4 and BP3; and SOE's S-phone 460MHz radiotelephone set used to guide aircraft to dropping zones.

A home-made Belgian transmitter used on an Intelligence link for "Clarence", and a compact transmitter-receiver built by a Danish engineer who felt the equipment supplied from the UK was too bulky. He proved his point but his equipment did not have to survive a parachute drop!

Also to be seen is one of the all-too-effective German D/F receivers with the loop mounted inside a truck to avoid revealing its presence. There are also bits and pieces, including a Morse key, used by Yvonne Cormeau one of the more successful SOE radio operators credited with more than 400 messages from the same location and who unlike many others survived.

A notebook of Yeo-Thomas, who as "White Rabbit" was one of the most successful British agents working for de Gaulle's BCRA (SOE "RF Section"), contains some valuable advice on coping with interrogations. "Beware of microphones, stool pigeons, bluff, repetition, reconstruction and bullying, sympathetic or "stupid" interrogators."

Japanese DBS woes

Japan planned to begin the world's first fully-operational, high-power direct broadcasting from satellite (DBS) on May 12, 1984, with NHK, the Japanese non-commercial broadcasting system, providing two of its programme channels on the *Yuri 2A* satellite. This satellite was successfully launched during January but in May the Japanese announced that faults had developed in two out of the three 100-watt 12GHz transponders.

The vital travelling-wave tubes for these had been manufactured in France and assembled in the USA. The Japanese have made plain, at a political level, their displeasure at these costly component failures.

It is a serious setback to their ambitions to establish Japanese industry in the forefront of DBS receiver production. The necessary parabolic reflector aerials and converters are already widely on sale in Japan at a cost of around 200,000 yen (roughly £620). The NHK educational channel has been abandoned, and the whole project re-classified as "experimental" rather than "operational".

The world is thus still waiting for the first fully-operational DBS service, and becoming increasingly uneasy about the reliability of high-power transponders in space. This is not the first time that high-power units have failed in a matter of months.

Cellular Radio and Safety

Early next year the first 900MHz computer-controlled "cellular" mobile/portable radiotelephone system in the UK, the Racal Vodafone, is expected to open in the major urban centres in the south of England and Midlands, extending shortly afterwards to other main urban centres.

The Vodafone system links a driver with the public national and international telephone network in a more flexible manner and with much greater potential capacity than the v.h.f. Radiophone services established almost 20 years ago. In the London area BT's Radiophone has usually had a long list of people waiting to become suscribers and there are often appreciable delays in obtaining a connection during peak periods.

The much more sophisticated Vodafone looks set to smooth out many of the operational problems of having a telephone in a car. The basic costs at around £63.50 per month are claimed to be cheaper.

There is, however, one feature that could give cause for concern. Vodafones will be fitted with one of those modern telephone handsets with in-built push-button dialling.

Convenient to use, but surely raising once again the question of whether a driver on the move using a telephone handset linked to the public telephone system (possibly receiving an important or emotionally distracting call) represents a safety hazard.

As I have noted before, in 1965 the Ministry of Transport was convinced that the answer was yes, but was persuaded to change its mind. Hand-held microphones and handsets are less safe than the boom and similar hands-free arrangements used by taxi-drivers.

Is it not time that there was an in-depth investigation into this question before the roads are filled with drivers using cellular radio networks? Use of a handset by a passenger does not pose this problem.

FOR YOUR ENTERTAINMENT

BY BARRY FOX

In The Swim

You may have read in the popular press about a new water purifier for swimming pools. It was on show, tucked away in a corner, at the Ideal Home Exhibition held at Earl's Court earlier this year.

The system, called Tarn Pure, is the brain-child of a firm best known for its hi fi loudspeakers, IMF Electronics of High Wycombe. The purification technique used is derived from the technology built into the *Apollo* spacecraft to provide the astronaut's drinking water. Although Tarn Pure is initially being marketed for use with swimming pools, the same system can be adapted to purify water in hotels, schools and hospitals in remote areas, for instance, the tropics where there is no reliable tap water system.

The purifier works on the well-known principle that silver kills bacteria and copper kills algae. These are the two types of micro organisms you have to remove from water to make it safe for swimming and drinking.

The difficulty is in finding a way of releasing a constant, controlled stream of metal ions into the water. The incentive is to avoid the need to use chlorine gas.

As anyone who has swum in a heavily chlorinated pool will know, it causes red stinging eyes, by damaging the very sensitive transparent layer over the eye-ball. I once swam in an hotel pool in Hong Kong that was so rich in chlorine that I could hardly see for two days afterwards.

A less obvious problem with chlorine is that it is degraded by heat and ultra-violet light. So a swimming pool in hot sunny weather needs a great deal of chlorine to keep it clean. Exactly how much is basically a rule of thumb. Hence the risk of overdosing.

The answer from IMF is to use an electrode which is a mix of pure copper metal with a few per cent of pure silver metal. The exact percentage is a closely guarded secret.

A d.c. amplifier pushes low voltage (under 30 volts) through a pair of these electrodes into the water, with the positive-negative polarity changed every half minute or so. This releases copper and silver ions into the water. As long as the water is circulated, bacteria and algae in a 30,000-gallon tank can be killed by a power drain of around 40 watts. That is equivalent to a small light bulb.

Cost of the system is only around £550 so it is likely that IMF will have hit the jackpot. Already some public swimming pools are trying to phase out the use of chlorine because it is such a horrid chemical to work with.

Normally I would be suspicious of any firm claiming to clean water so efficiently with such a cheap system. But IMF have a good track record for electronics. They are involved in the Ambisonics surround-sound project as well as loudspeakers.

Also, I have seen reports from a public analysts laboratory in Reading, which confirms that water at 30°C heavily polluted with sewage containing 21,500 living organisms per millilitre was purified within half an hour, and the bacterial population reduced to 60 per millilitre. This is safe for swimming.

A happy bonus is that as the bacteria and algae are killed, they are electrostatically charged. This causes them to stick together in lumps, and are easily filtered off.

When the system is used to purify a drinking water supply, two separate tanks are used. One is circulated to speed purification while the other is left still after purification. The drinking water supply is switched so that it is always drawn from the still tank.

Censorship

If the video software companies think they have problems over censorship, they should count themselves lucky they weren't in business back in the 30s. Earlier this year, the British Film Institute staged some readings from the archive files of the British Board of Film Censors.

The President T. P. O'Connor drew up a list of 43 forbidden topics. Sex appeal, violence, the reality of war, mistresses, mutiny, mocking the crown, nudity, and naughty words like "twerp, belly, bloody, sex, nappies and piddling"; all were censored.

One film with an all-negro heaven was banned. So was the word Satan.

The Film, "Follow the Fleet", had a song about Satan. So they just chopped the word out, entirely destroying the music rhythm.

Actors often appeared to hiccup, where words like "bloody" had been excised. Incidentally, British TV stations have in the past excised four-letter words from the film versions of "Mash" and "Butch Cassidy".

At least they did it by muting or distorting the audio. In the 30s they quite literally used a pair of scissors to make the cuts so that the action jumped like a frog.

Until the outbreak of war Hitler and the Nazis couldn't be criticised. In the 40s they *had* to be ridiculed.

On one art-film script the censor wrote: "This seems almost meaningless. If there is a meaning it is doubtless objectionable".

Global Village

Satellites in the sky have made the world truly a global village. We now see things when they happen, as they happen.

There is only a delay when a satellite link breaks down or the censors step in. Pictures from the Falklands war zone were held back by the censors for the obvious reason that agents in Britain could have talked on the telephone to the Argentine forces while watching live coverage of the battle on TV.

In the early days of satellite transmission, the links often broke down. Now this usually only happens in Third World countries.

Recently ITN spent £25,000 on sending a news crew to Africa for an important political press conference. But the only available satellite dish aerial transmitted such poor pictures that they could not be used on British TV.

The last remaining barrier to global communications is language. There is no point in watching a live speech from across the world if it is not in an understandable tongue.

This is why the electronics companies, especially Japanese, are beavering away on machines to give an instant translation from one language to another. The technology is relatively straightforward. Voice recognition circuits register the words used, and pull equivalent foreign language codes out of a memory. These codes then control a speech synthesis circuit.

Cognitive Psychology

There are, of course, daunting technical problems. The speech recognition circuits have to cope with different dialects and pronunciations. But the real sticking point is in what is known as "cognitive psychology".

Electronics enthusiasts will be hearing a lot more of this in future years. I can't do better than to quote the gist of a letter recently published in a scientific journal.

Consider the phrase "Time flies like an arrow". You know what I mean by this phrase. So do I. But when a computer pulls equivalent words out of a memory bank it may well translate the phrase as meaning a stopwatch used to time flies in the same way as an arrow. Or it could mean a species of fly known as the time fly which likes nibbling arrows.

It isn't only machines that get this kind of thing wrong. Classically trained human translators get into terrible muddles with technical documents. I once saw a German description of electronic valves in screening cans translated as "bottles wearing overcoats".

There is a special problem where the same person translates both questions and answers. I have been at press conferences in Japan where questions asked through an interpreter produce answers which bear no relation to the questions.

To take a simple example, if a Western journalist asks an Eastern electronics manufacturer "how many lasers a year the company makes?", the interpreter (falling into the traditional Eastern language trap of confusing "Ls" with "Rs") may translate the question as "razors".

The manufacturer says the company makes a million razors a year and the interpreter, making the same translation mistake again, announces that the company makes a million lasers a year.

"Are you sure you mean a million lasers?" asks the journalist. The Japanese manufacturer nods confirmation at the question which is translated as "Are you sure you mean a million razors a year?".

What is RADIATION?

fission & fusion

A.J.Bentley

WE'VE all seen them, sinister looking things, perched on the landscape, hundreds of feet across and needing only a spluttering fuse on top to complete the picture. A nuclear reactor looks more like a bomb than anything else on earth, and what are the public told about the reactor core inside that ball? "It works something like an atom bomb." Great! That raises more questions than it answers. Like, "How come it doesn't explode?" and furthermore "What would happen if it did?"

THE NUCLEAR FORCE

Most of us have an idea of what a chain reaction is, how an atom splitting up sprays off bits of itself, that split other atoms nearby and so on. That description is OK so far as it goes, but to really understand this nuclear reaction in detail it is necessary to discuss the make-up of atoms and the forces that hold them together.

Atoms can be broken up into three main ingredients—electrons, protons and neutrons. The electrons pass their time in orbit around the atomic "nucleus", which consists of a tight cluster of protons and neutrons. The protons are charged electrically positive and they hold the negatively-charged electrons in orbit by electrostatic attraction.

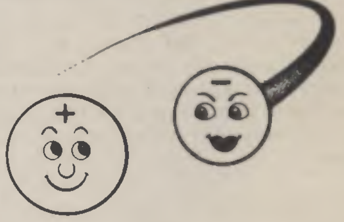
Neutrons are not charged but it is their influence that holds the positive protons together, despite the electric charge trying to force them apart. This is what we call the "nuclear force". Nobody as yet fully understands how this force works. It seems to be very powerful but only over a very short range. A fairly good model is to compare it with a sort of glue.

Another odd thing about neutrons is that when they are separated from the protons they disintegrate—apparently from sheer loneliness! In fact, a neutron has only a 50:50 chance of surviving more than eleven minutes on its own. (That's what we call a half life of eleven minutes.)

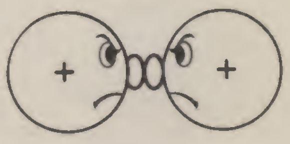
ATOMS, ELEMENTS AND ISOTOPES

What makes an atom of say, lead different from another atom, oxygen for instance, is the number of protons and neutrons in its nucleus. The electrons are fairly free to move from atom to atom (that's electricity) so they tend to cluster around the nucleus in just sufficient numbers to neutralise the positive charges of the protons involved: one electron per proton.

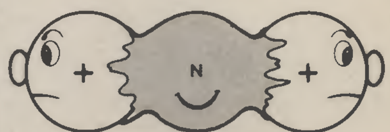
If we could have just any combination of protons and neutrons in a nucleus there would be an infinite number of dif-



Protons attract electrons . . .



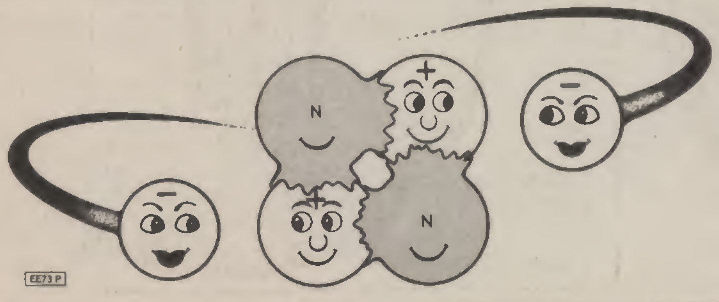
but repel each other.



Neutrons use the nuclear force to hold protons together . . .

but disintegrate when alone.

The Helium atom—a very happy family.



ferent elements. This is not the case. It's a question of stability. If there are too many protons in a nucleus, the electric charges push them apart until the nucleus splits up. On the other hand, if there are too many neutrons, they begin to disintegrate.

When atoms combine chemically to make molecules, like water (hydrogen and oxygen) or salt (sodium and chlorine), it is because their orbiting electrons get tangled with one another, locking the atoms together. This means that the chemical name given to an atom depends on the number of electrons in orbit. Since this is the same as the number of protons in the nucleus, the name is connected with the number of protons, but not the number of neutrons. Within the limits of nuclear stability, the number of neutrons can vary slightly from atom to atom without any effect on the chemical properties. We call these different atoms "Isotopes" of the particular chemical element named, and to distinguish them from each other we quote the total number of protons and neutrons involved.

For instance, oxygen atoms all have eight protons, but there are three naturally occurring isotopes of oxygen containing eight, nine or ten neutrons. We write this as O^{16}; O^{17}; and O^{18}. It is possible to tell these isotopes apart by their weight.

FISSION REACTION

Now we've got to the point where it's possible to make a full technical description of the nuclear fission reaction. It goes like this: natural uranium has three isotopes—U^{234}; U^{235}; U^{238}. Each of these isotopes has ninety-two protons. (Therefore, 142, 143 and 146 neutrons respectively.) Most of the uranium is U^{238} with about 1% of U^{235} and just a trace of U^{234}, but it is the 1% of U^{235} that is of interest. If a U^{235} nucleus comes across a passing neutron that hasn't yet disintegrated, it swallows it. The result is indigestion. The U^{235} has now become U^{236}, which doesn't exist, so it splits violently in half, shooting off two or three spare neutrons as it does so. These ejected neutrons zip off to start another fission reaction each, and we have a chain reaction *or do we?*

Actually there is still one problem. The neutrons from the initial fission reaction are moving so fast that the other U^{235} nuclei just don't have a chance to grab them as they go past. Because of this, it isn't possible for a chain reaction to start in a sample of ordinary uranium under normal circumstances. There are two ways of getting round this difficulty:

i) crowd the U^{235} atoms round like slip fielders.

ii) slow down the neutrons somehow.

The first method gives us the atomic bomb, but the second produces a nuclear reactor. We'd better take them in turn.

THE BOMB!

As we have seen, ordinary uranium as dug out of the ground only contains about 1% of U^{235}, but it can be separated from the slightly heavier U^{238} by a process similar to distillation of whisky. Once the required quantity of U^{235} has been collected, all you have to do is to squeeze it together into a tight lump and off it goes! Of course you have to have a big enough lump to make sure that one of the "fielders" catches each neutron. A piece about the size of a grapefruit will do, and it has to be squeezed pretty tight so that it all goes off together. If it isn't held together until the chain reaction is well under way, the bomb will just break up without a proper explosion. A carefully shaped charge of conventional explosive is used to do this job.

Apart from U^{235}, there is another atom that can be used for a fission bomb, Plutonium 239. (94 protons; 145 neutrons). This isotope isn't found on the earth, it is too unstable and all our natural Pu^{239} disintegrated long ago. We can make it though, in a nuclear reactor at great expense.

On the whole, it is fairly easy to make an atom bomb once you have the virtually priceless U^{235} or Pu^{239}. Ordinary uranium is just not good enough.

MODERATION

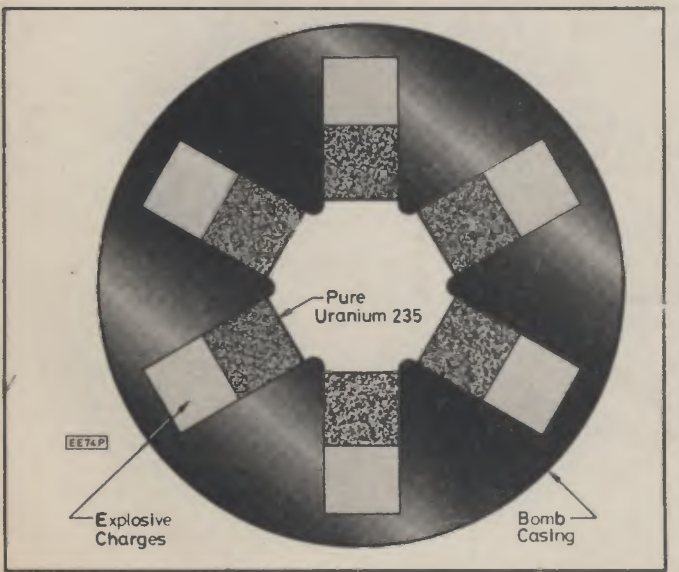
A nuclear reactor uses ordinary uranium, perhaps slightly spiced with extra U^{235} (up to 3%). To slow down the fast moving neutrons a material known as a moderator is used in the reactor. This moderator is a substance like water or graphite that has fairly light atoms in it. Water contains oxygen and hydrogen, graphite is just pure carbon. If you look at Table 1 (overleaf) you can see that these atoms are much smaller than uranium. The idea is that bouncing a ball off feathers tends to slow it down a lot more than bouncing it off bricks.

Fission reactors are usually built so that the uranium can be slid into holes in the moderator. The uranium is contained in tubes known as fuel rods which are replaced as the U^{235} gets used up. As well as the fuel rods there are also control rods containing cadmium or boron. These materials soak up free neutrons without producing a fission reaction and so act as a brake on the reactor. When they are pulled out, the chain reaction gets enough neutrons to keep it going. When they are pushed in the reaction dies of neutron starvation.

The fragments of the disintegrating U^{235} atoms are stopped in the reactor by friction and this heats up the reactor. This heat is taken away by special liquids and used to drive steam turbines.

It is very important to realise how different an atom bomb and a reactor really

The nuclear bomb.



The fission reactor.

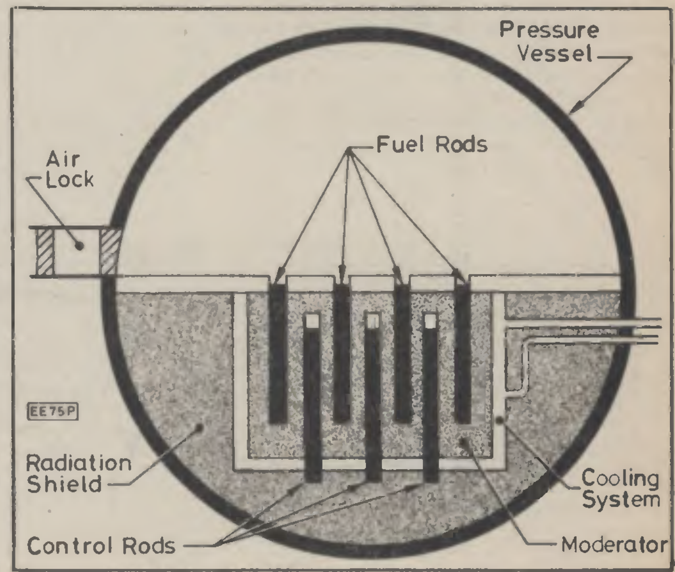


Table 1. Some chemical elements and their atomic structures

Element	Number of Protons	Usual No of Neutrons
Hydrogen	1	0
Helium	2	2
Boron	5	6
Carbon	6	6
Oxygen	8	8
Cadmium	48	66
Lead	82	126
Uranium	92	146

are—both in principle and construction. To say that a nuclear reactor works like an atom bomb is worse than saying that a car engine works like a Molotov Cocktail. A nuclear reactor cannot be used to make a nuclear explosion because its construction is all wrong.

FUSION—THE HEAVY STUFF

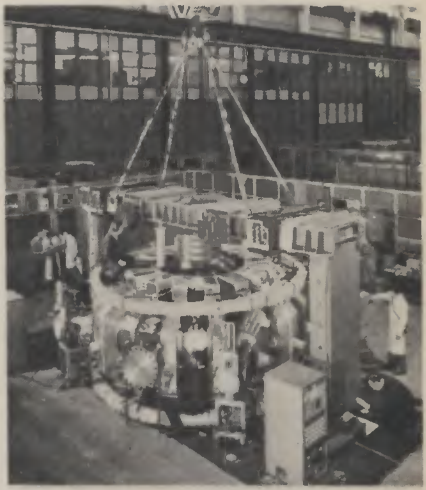
There is another way that we can get power from nuclear reactions, that is by fusion. Fusion involves an isotope of hydrogen. Ordinary hydrogen has the simplest possible nucleus—one proton, this single proton nucleus has one solitary electron orbiting around it. Apart from this usual arrangement, hydrogen atoms exist which also have a neutron joined to the proton. This is the isotope that makes the fusion reaction possible, and it is so important that we give it a special name. Instead of calling it hydrogen 2, we call it deuterium, or sometimes "heavy" hydrogen. (Heavy water is a deuterium/oxygen molecule instead of hydrogen/oxygen.)

What makes deuterium so important is that if two deuterium nuclei are forced together against the electrostatic repulsion of the protons, they suddenly "recognise" each other and instead of pushing apart, they rush together. We don't know why this is so, one clue is the fact that when they join they form a helium nucleus. If you read last month's article *What is Radiation?* you will remember that the helium nucleus is sort of ultra-stable and is almost impossible to split open. The resounding smack as the deuterium nuclei meet gives off tremendous energy in the form of heat and gamma radiation. If there are plenty of other deuterium atoms about, this heat smashes them together hard enough to start another sort of chain reaction.

This fusion reaction produces a lot more energy than the fission reaction and this is what makes the hydrogen bomb so destructive. (Really it ought to be called a deuterium bomb). The only trouble is that to start the reaction off you have to push the deuterium atoms together very hard indeed. The only way that we have been able to produce the temperature and pressure required so far is to use an atom bomb as a detonator. A hydrogen bomb is simply an atom bomb containing a lot of deuterium in the middle.

Obviously we can't use an atom bomb to start up a power station. It would be a bit like using a stick of dynamite instead of sparking plugs in a car. Anyway we don't want the deuterium to go off all together. Scientists are working now to trigger a fusion reaction using lasers instead, but it hasn't been done yet and we are still a long way from a practical fusion reactor. □

An experimental nuclear fusion reactor under construction.



COUNTER INTELLIGENCE

BY PAUL YOUNG

Computer Nasties

I have never thought of it as part of my brief to pass comment on the social evils of the present day, but when unpleasant things transgress in our particular domain, I think it is time to stand up and be counted.

I am not referring to "Video Nasties", as there is already sufficient outcry about these to ensure that some corrective legislation will be passed. I am referring to "Computer Nasties" which really do intrude on our patch.

It has recently been brought to my notice that there is now a new version of "Killer Gorilla" called "Killer Priscilla". Without going into all the lurid details, it seems that poor Priscilla is either carried off by the man-eating gorilla or suffers a fate worse than death countless number of times. This may be an isolated example, but at the risk of being labelled a puritan, I would say that this is not suitable for young children.

This game by the way, has been designed for the BBC machine. Poor Sir John Reith would never forgive them.

How do you legislate against these things? The difficulties the legislators face are immense. How do you cover all the various systems without leaving loopholes, bearing in mind that computer programs can be on tape disc, or even solid-state memories (ROMs)?

It needs someone with a fine command of English to define the terms with precise wording. A combination of Sir Ernest Gowers, who wrote the famous "Plain Words", and Mr. Bowden. Mr. Bowden worded the patent for his world renowned cable as follows: "It consists of two members, the outer being flexible and incompressible and the inner being flexible and inextensible". In spite of its brevity, no one ever got round it.

In a recent statement, Sir Clive Sinclair said that he estimated that in a few years it would be possible to make a computer as "complex" as the human brain. I have the feeling that Sir Clive chose the word "complex" after careful deliberation. There is after all a subtle difference between this, and saying it would be possible to produce one capable of intelligence and reasoning, which I touched on in my last article.

I have just received an interesting letter from Mr. Murray Eagle, who works in the Fighting Bay Cable Station at Blenheim Sound, New Zealand. He kindly sent me a circuit for a 28-day clock for keeping your spare car battery on top line (see February issue of EVERYDAY ELECTRONICS).

More about that later, but he concluded his letter by saying that he was disenchanted with computers and automation. He has been a lighthouse keeper for over 13 years and now he has been replaced by a chip!!

Luckily he still has a job, looking after the Cook Strait power cables to the North Island, but it has meant learning a whole lot of new skills. Unfortunately it will be Christmas before Mr. Eagle reads this, as he says it takes almost forever for EE to reach him. How lucky are our UK readers.

Matter of Opinion

I read recently of a man bringing back from Japan an electronic gadget that would instantly translate words and phrases into several different languages at the touch of a button. From this, he concludes, erroneously in my opinion, that we are way behind in technology.

This is certainly not my impression, which is why the Japanese are so anxious to get hold of INMOS, probably one of the most advanced silicon chip manufacturers in the world. He goes on to say that British manufacturers cannot even supply equipment for the proposed multi-million pound Cellnet Radio Network.

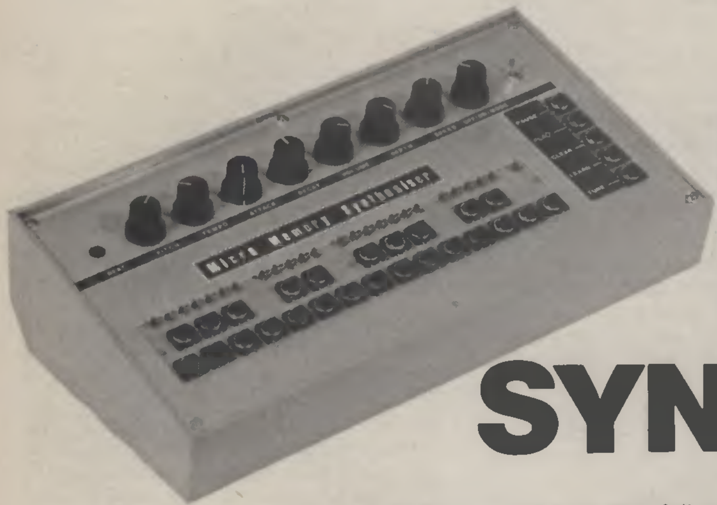
While this accusation is serious enough, it is not necessarily a technological problem.

Attraction of CB

To end on a lighter note, regular readers may remember my stern warning that certain unprincipled young ladies were using CB Radio to lure unsuspecting men to their doom (or was it room?). I would like to imagine that it sparked off a CB boom, but I don't know.

In America this particular use of CB by sweethearts and others has grown to such proportions, that they have had to allocate a special channel (dubbed the "Mating Channel") for this purpose. Could romance by radio be what is needed to empty the shelves of all those surplus CB sets??

OCTOBER FEATURES...



MICRO MEMORY SYNTHESISER

A musical instrument covering two full octaves (*F* to *F*) and featuring attack/decay, tremolo and variable pitch controls. A memory is provided to store a played tune (up to 28 notes) and there are ten pre-programmed tunes which can be learnt by pressing the learn key; each key in turn is then lit by an l.e.d. and remains on until it is pressed.

NEW COURSE... DIGITAL ELECTRONICS

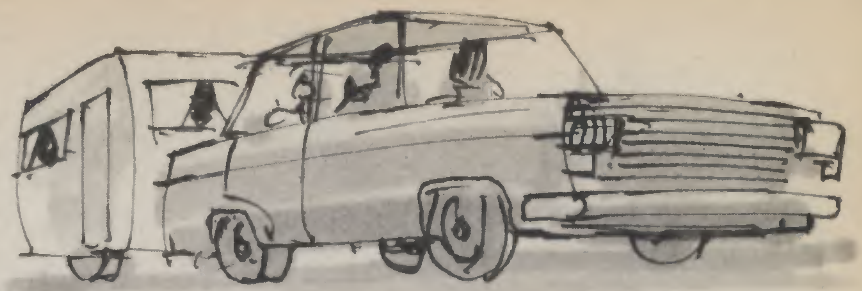
A series of articles explaining the principles of digital electronics, from component descriptions through logic families and circuit design to microprocessors. An insight into the digital circuit "building brick" for those with a basic understanding of analogue electronics.

MAINS CABLE DETECTOR

EVERYDAY ELECTRONICS and computer PROJECTS

OCTOBER 1984 ISSUE ON SALE FRIDAY, SEPTEMBER 21

Caravan Dipstick



T. R. de Vaux-Balbirnie

EVEN the most enthusiastic caravanner shrinks from the thought of carrying water late at night. If the level in the fresh water storage container is known, then the family can regulate their requirements and refilling can be avoided at inconvenient times.

Unfortunately, the traditional method of checking the level—peering into the container with a torch—is itself very inconvenient. This project indicates the level at any time, simply by pressing a button on a unit inside the caravan. A large (0·5in) 7-segment l.e.d. display lights up with an appropriate letter—"L" for Low, "I" for Intermediate or "F" for Full. Although 7-segment displays are normally used for *numbers*, letters such as these are readily produced.

There could be other uses for this project but remember that it works by current passing through the liquid—in this case water—so it would be useless for non-conducting liquids such as heating oil.

GENERAL DESCRIPTION

The Logic Dipstick comprises two components. Firstly, the dipstick itself which is placed in the water container outside. The dipstick has a 3-way terminal block on top which connects through a cable to the unit inside the caravan. This main unit carries the display, a push-button switch and a terminal block for the dipstick connections. The box houses the electronic circuit and a PP3 battery. Excellent service is provided by a small battery since it is only used while the switch is operated.

The letters L, I and F were chosen not only because they are appropriate but because they can be produced by simple logic. This obviates the need for logic gates.

In the prototype, the top quarter of the water container was used to signal "F". The middle half for "I" and the last quarter for "L". This was found to be a good arrangement in practice but some readers might wish to change the levels to suit their own requirements.

CIRCUIT DESCRIPTION

The dipstick has three conducting probes—two (A and B) are at a low level and one (C) near the top (see Fig. 1). Probe A is at battery positive voltage. When the water level is low, then Probe A will be connected to neither of the other two probes. At a higher level, Probe A will be connected to Probe B through the water. When the water reaches the high level, then Probe A will be connected to both Probes B and C.

The information from Probes B and C is passed to the inputs of the operational amplifiers IC1a and IC1b. Both op-amps are in a single i.c. package. These will switch on and off through very high resistances such as water. They also provide the logic for the system to operate.

Referring to Fig. 1, it will be seen that the two op-amps are connected slightly differently. IC1a has its non-inverting input held at one-half battery voltage by means of the potential divider R3 and R4. IC1b shares this potential divider but this time the voltage is applied to the *inverting* input. R1 and R2 connect the remaining inputs of the op-amps to battery negative. In this way, when S1 is pressed, IC1a will be *on* and IC1b *off*. The output from IC1a is connected to segment d while the output from IC1b is connected to segments a and g of the display, X1. Whenever S1 is pressed, segments e and f will light up since they are connected through R7 to the battery positive line. With IC1b on, segments a, e, f and g will therefore light signalling "F". With both op-amps off, only segments e and f will be lit giving "I". With IC1a on, segments e, f, and d will be lit producing "L". As the water level in the container falls, this sequence will be followed.

The current for each segment of the display is limited to about 20mA by means of R5, R6 and R7. Note that R6 and R7 have only approximately one-half the value of R5 since these resistors carry the current for *two* display segments rather than just one. The display is of the *common cathode* type where all segments have a common connection (pin 8) to the battery negative line.

CONSTRUCTION

Refer to Fig. 3 and construct the dipstick itself. The details refer to the prototype and some readers may wish to use their own ideas. If the water is for drinking then choose materials which are normally used for winemaking and cookery purposes. The prototype dipstick was made from narrow plastic tubing, 20 s.w.g. bare copper wire and rubber bands. It is thought that the rubber bands will only give one season's use but they are cheap, effective and easily replaced. Avoid any material which absorbs water or remains wet when the water level falls since these will effectively short-circuit the probes and cause faulty operation. Note that the dipstick does not need to reach the bottom of the water container but only down to the "Low" level. A wire hook is used to attach the dipstick to the filler neck.

I found that the plastic tubing was stiff enough for the purpose but suitable plastic rod could be used for stiffening if required. If the tubing has been coiled it may be straightened by heating it in steam from a kettle spout and pulling it straight a few times. Some curling of the dipstick is permissible.

The 3-way terminal block at the top of the dipstick is self supporting. It must be kept well clear of the water since, otherwise, short circuits may occur.

When the dipstick is complete, construct the circuit panel. Refer to Fig. 2 and build the circuit using a piece of 0·1in matrix stripboard 24 strips by 18 holes in size. Start by carefully removing the corner to give clearance for S1. A 14-pin d.i.l. socket is used for IC1 but the display, X1, is soldered direct to the panel using minimum heat from the soldering iron. Do not insert IC1 into its holder until construction work is complete.

Make the breaks between the rows of pins of IC1 also at X1 and near the fixing holes. Note that eight links are required between copper strips. Complete construction by soldering 10cm connecting wires to strips B, H, M and T.

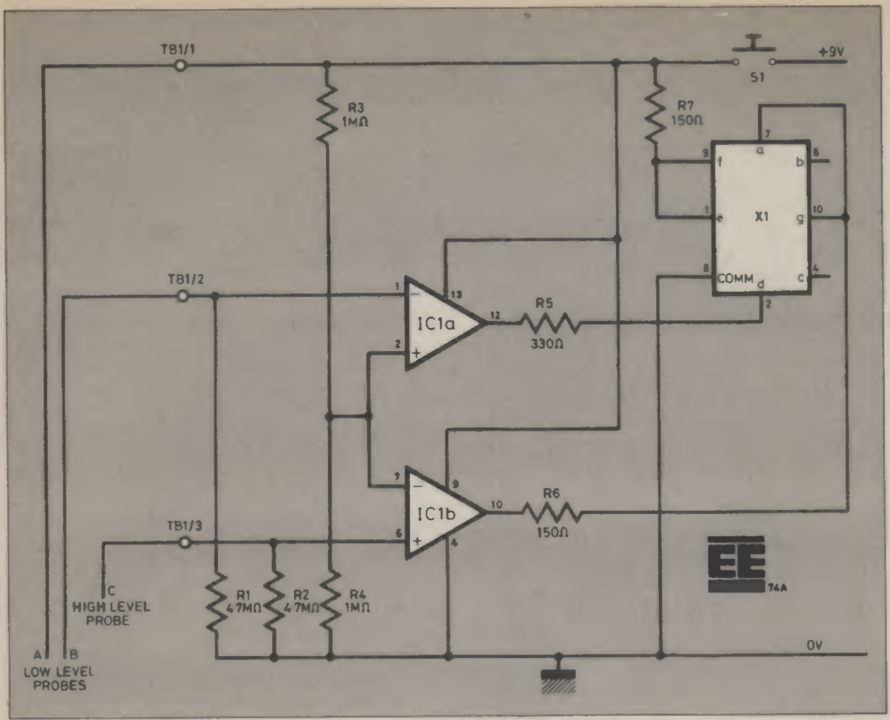


Fig. 1. Circuit diagram of Caravan Dipstick.

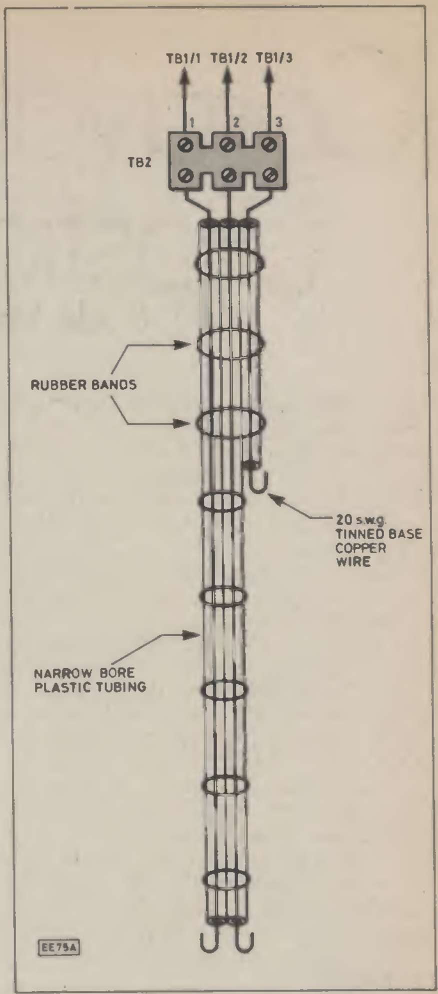


Fig. 3. Construction of the dipstick itself.

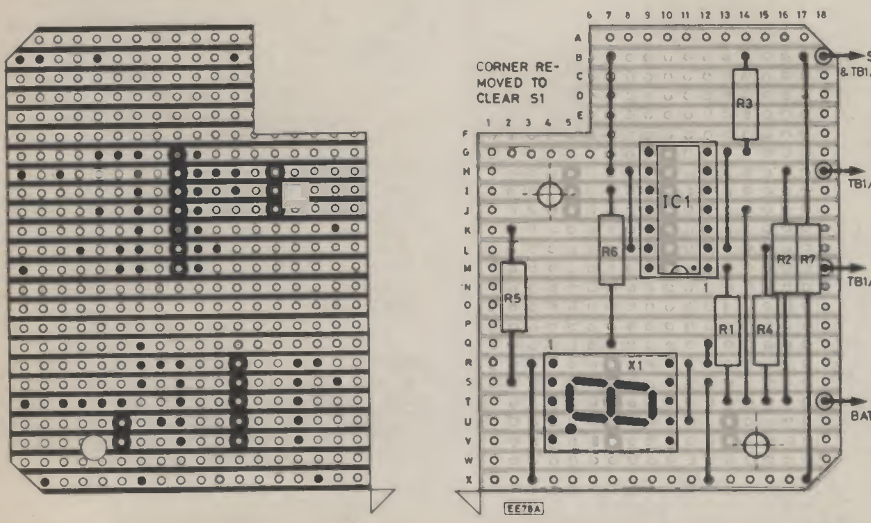
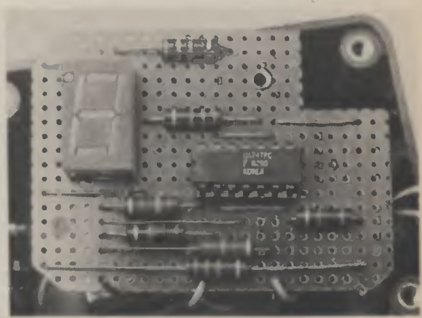


Fig. 2. Stripboard layout (actual size).



COMPONENTS

Resistors

R1,2	4·7MΩ (see text) (2 off)
R3,4	1MΩ (2 off)
R5	330Ω
R6,7	150Ω (2 off)

All $\frac{1}{2}$W carbon ±5%

Semiconductors

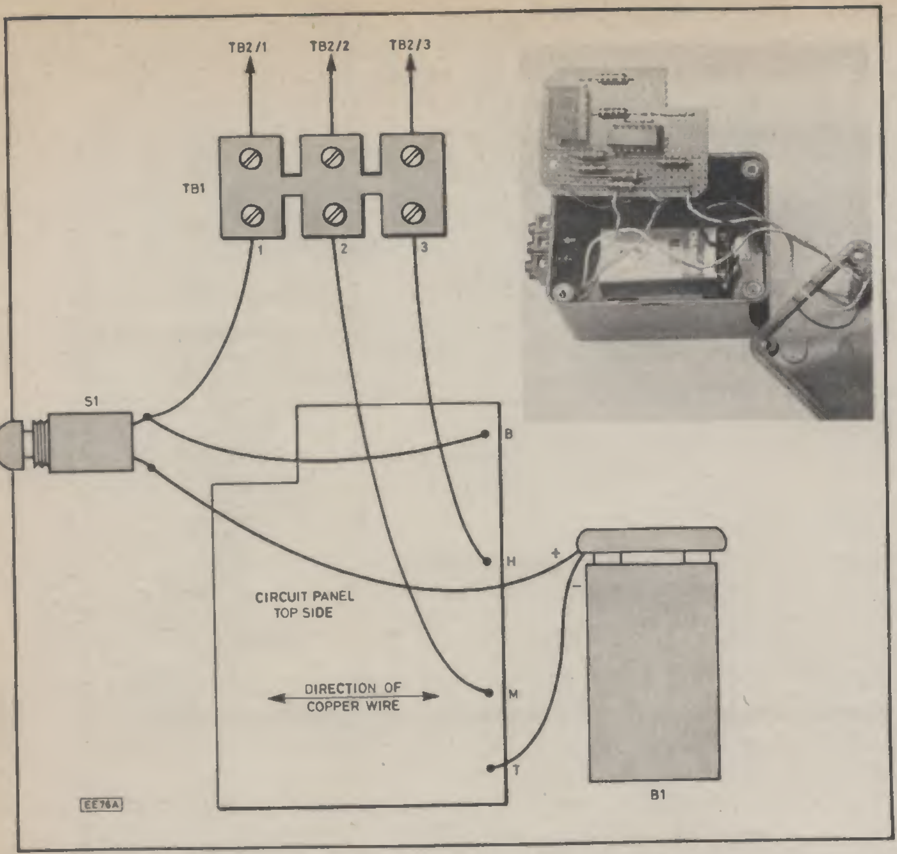
IC1	μA747PC or μA747CN dual operational amplifier
X1	0·5in 7-segment common cathode l.e.d. display

Miscellaneous

MB1 plastic box internal dimensions 76 x 56 x 35mm; 0·1in matrix stripboard 24 strips by 18 holes in size; 14-pin d.i.l. i.c. holder; 3-amp terminal block—6 sections required; PP3 battery and battery connector; stand off insulators (see text) (2 off); 3-core light duty connecting wire; adhesive pad; materials for dipstick—plastic tubing, 12 s.w.g. bare copper wire, elastic bands—see text.

COMPONENTS approximate cost £5.00

See Shop Talk page 560



Make a rectangular hole in the lid for the display. Drill a hole for S1 and mount this component in position. Attach the terminal block to the side of the box and drill a small hole nearby for the wires to pass through from the circuit panel. Complete all wiring (see Fig. 4). Check that when the circuit panel is in position, there is clearance for the bushes used to secure the lid of the box. File off any corners if necessary.

Attach the circuit panel to the lid using small nuts, bolts and washers. Place short stand-off insulators between the panel and lid. The display should then be just below the level of the lid.

TESTING

Secure the battery to the back of the box with an adhesive fixing pad. Connect the battery and replace the lid of the case. When S1 is pressed, "L" should light up. Using a short length of connecting wire, link TB1/1 to TB1/2. Press S1 and "I" should be produced. Finally, link all three terminals on the block and "F" should light.

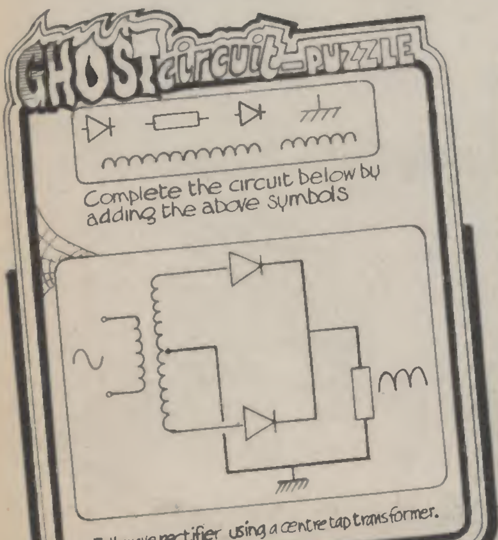
If all is well, TB1 and TB2 may be connected together—light-duty 3-core mains wire is ideal for the purpose. The system may then be tested under actual operating conditions. Site the unit in a shaded part of the caravan for best visibility of the display. Try to avoid a place subject to excessive condensation since this may find its way to the circuit panel and cause faulty operation. In severe cases this could be cured by using a silicone aerosol spray on both sides of the panel but avoiding the display. Reducing the values of R1 and R2 would also help.

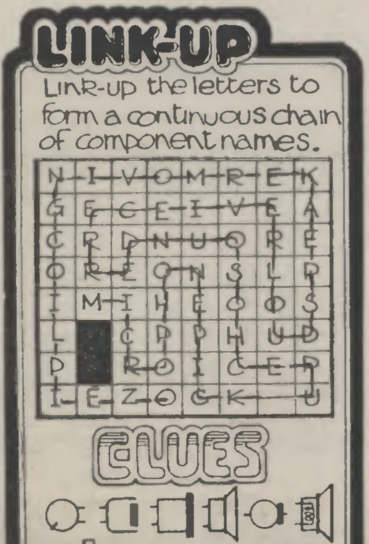
CHOICE OF R1 AND R2

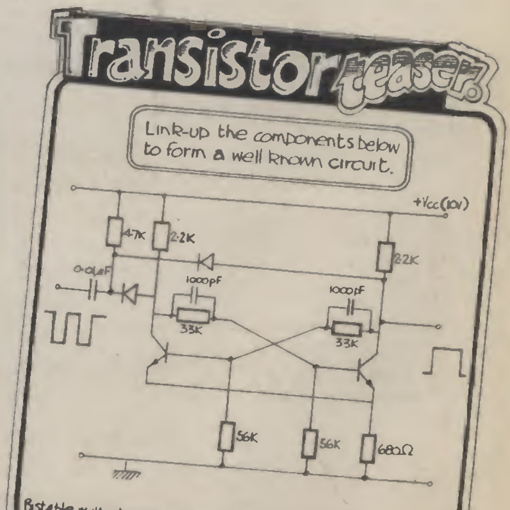
The values of R1 and R2 determine the sensitivity of the project. Using high values such as 4·7MΩ as in the prototype, the circuit will work even using distilled water. If readers find that excessive condensation, either on the dipstick or the circuit panel, causes erratic operation then lower values may be used. Always keep the values of R1 and R2 *equal*.

If the value of these resistors is too low, then the circuit will fail to respond in pure water. The electrical conductivity of water varies greatly from one place to another. □

FUNTRONICS Solutions...



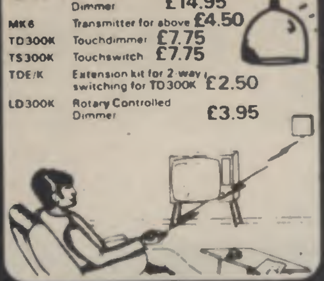




HOME LIGHTING KITS

These kits contain all necessary components and full instructions & are designed to replace a standard wall switch and control up to 300w of lighting.

TDR300K	Remote Control Dimmer	£14.95
MK6	Transmitter for above	£4.50
TD300K	Touchdimmer	£7.75
TS300K	Touchswitch	£7.75
TDE/K	Extension kit for 2 way switching for TD300K	£2.50
LD300K	Rotary Controlled Dimmer	£3.95



MINI KITS

MK1 ELECTRONIC THERMOSTAT
Uses LM3911 IC to sense temperature (80°C max) and triac to switch heater (1KW). Mains powered. £4.60

MK2 SOLID STATE RELAY
Switches 240V ac motors, lights, heaters from logic/computer circuits. Zero voltage switching, opto isolated. Supplied without triac £2.00

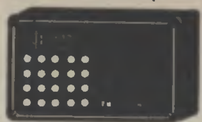
MK4 PROPORTIONAL TEMPERATURE CONTROLLER
Uses "burst fire" technique to maintain temperature to within 0.5°C. Ideal for photography, incubators, wine making, etc. Max. load 3KW (240V ac). Temp. range up to 90°C. £8.50

MK5 MAINS TIMER
Mains powered timer enabling a load up to 1KW at 240V ac to be switched on (or off) for a variable time from 20 mins. to 35 hrs. Longer or shorter periods possible with minor component changes £6.50

MK15 DUAL LATCHED SOLID STATE RELAY
Comprises two MK2s with latch circuit enabling the MK12 kit to control two mains loads independently. Two output triacs not supplied. (See remote control kits.) £4.50

NEW! MK19 DC CONTROLLED AUDIO AMPLIFIER
May be used with virtually any stereo audio amplifier to control bass, volume, treble and balance remotely either using a wire link or the MK11 infra red receiver. A 1 of 10 decoder with LEDS is also included for remote input selection/display. (See remote control kits.) £10.70

MICROPROCESSOR CONTROLLED MULTI-PURPOSE TIMER



Now you can run your central heating, lighting, hi-fi system and lots more with just one programmable timer. At your selection it is designed to control four mains outputs independently, switching on and off at pre-set times over a 7 day cycle, e.g. to control your central heating (including different switching times for weekends), just connect it to your system programme and set it and forget it — the clock will do the rest.

- 7mm LED 12 hour display
- Day of week, am/pm and output status indicators
- 4 open collector outputs for driving relays, triacs, etc
- 50/60Hz mains operation
- Battery backup saves stored programmes and continues time-keeping during power failures. (Battery not supplied)
- Display blanking during power failure to conserve battery power
- 18 programme time sets
- Powerful 'Everyday' function enabling output to switch every day but use only one time set
- Useful 'sleep' function — turns on output for one hour
- Direct switch control enabling output to be turned on immediately or after a specified time interval
- 20 function keypad for programme entry

NOW ONLY £39.00

- Programme verification at the touch of a button
- Plastic box with attractive screen printed front panel 15 × 10 × 5.5cm

(Kit includes all components, PCB, box, assembly and programming instructions)
Order as CT6000

XK114 OPTIONAL RELAY KIT
Kit includes one relay, PCB to accommodate up to 4 relays, terminal blocks, etc., to fit inside CT6000 box. Provides up to 4 3amp 240V AC changeover contacts. £3.90

Additional relays £1.85 each

DISCO LIGHTING KITS

DL 1000K
This value for money kit features a bi-directional sequence, speed of sequence and frequency of direction change being variable by means of potentiometers and incorporates a master dimming control. £15.95

DLZ 1000K
A lower cost version of the above, featuring unidirectional channel sequence with speed variable by means of a pre-set pot. Outputs switched only at mains zero crossing points to reduce radio interference to a minimum. £8.95

Optional opto input DLA1
Allowing audio ("beat") — light response 60p

DL 3000K
This 3 channel sound to light kit features zero voltage switching, automatic level control and built-in mic. No connections to speaker or amp required. No knobs to adjust — simply connect to mains supply and lamps (1Kw channel) Only £12.95

DVM/ULTRA SENSITIVE THERMOMETER KIT

This new design is based on the ICL 7126 (a lower power version of the ICL 7106 chip) and a 3½ digit liquid crystal display. This kit will form the basis of a digital multimeter (only a few additional resistors and switches are required — details supplied), or a sensitive digital thermometer (−50°C to +150°C) reading to 0.1°C. The basic kit has a sensitivity of 200mV for a full scale reading, automatic polarity indication and an ultra low power requirement giving a 2 year typical battery life from a standard 9V PP3 when used 8 hours a day, 7 days a week. **Price £15.50**

24 HOUR CLOCK/ APPLIANCE TIMER KIT

Switches any appliance up to 1kW on and off at preset times once per day. Kit contains: AY-5-1230 IC, 0.5" LED display, mains supply, display drivers, switches, LEDs, triacs, PCBs and full instructions.

CT1000K Basic Kit £14.90
CT1000K with white box (56/131 × 71mm) £17.40
(Ready Built) £22.50

XK113 MW RADIO KIT

Based on ZN414 IC, kit includes PCB, wound aerial and crystal earpiece and all components to make a sensitive miniature radio. Size: 5.5 × 2.7 × 2cms. Requires PP3 9V battery. IDEAL FOR BEGINNERS. £5.50

3-NOTE DOOR CHIME

Based on the SAB0600 IC the kit is supplied with all components, including loudspeaker, printed circuit board, a pre-drilled box (95 × 71 × 35mm) and full instructions. Requires only a PP3 9V battery and push-switch to complete. AN IDEAL PROJECT FOR BEGINNERS. Order as XK 102. £5.50

COMPONENT PACKS

PACK 1	650 Resistors 47 ohm to 10 Mohm — 10 per value £4.00
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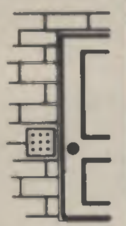
19 ranges including DC voltage (200 mv-1000 v) and AC voltage, DC current (200 mA-10 A) and resistence (0 — 2M) + NPN & PNP transistor gain and diode check. Input impedence 10M. Size 180 × 140 × 50mm. Complete with battery, test leads and carrying case **ONLY £32.00**

ELECTRONIC LOCK KIT



With hundreds of uses in doors, garages, car anti-theft devices, electronic equipment etc. Only the correct easily changed four digit code will open it! Requires a 5 to 15V dc supply. Output 750mA. Fits into standard electrical wall box. Complete kit (excl. front panel) XK101 £11.50

Electronic lock mechanism for use with the above kit. 70 150 £14.95

INFRA RED GARAGE DOOR CONTROLLER KIT

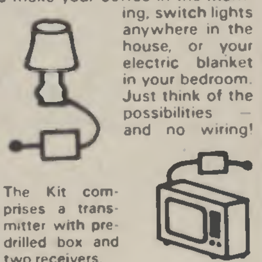
For opening and closing motorised garage doors plus switching garage and drive lights on and off up to a range of 40ft and numerous other applications like controlling lights and TV's etc. in the home. Ideal for aged or disabled persons, this coded kit comprises of a mains powered infra red remote control receiver with a normally open relay output plus two latched transistor outputs; battery-powered four button transmitter and an opto isolated solid state mains switch. As with all our kits, full instructions are supplied.

XK103 £25

Extra transmitters XK105 £10.00

HOME CONTROL CENTRE

This kit enables you to control up to 16 different appliances by means of coded pulses in the mains wiring which may be decoded by special receivers anywhere in the house. The transmitter may be controlled manually or by the computer interface enabling your favourite micro to make your coffee in the morning, switch lights anywhere in the house, or your electric blanket in your bedroom. Just think of the possibilities — and no wiring!



The Kit comprises a transmitter with pre-drilled box and two receivers.

XK112 £42.00

ADDITIONAL RECEIVERS XK111 £10.00

REMOTE CONTROL KITS

These kits have been designed to enable infra red remote control to be incorporated into virtually any application from switching car locks or alarms to controlling Hi-Fi or TV. The exact application will determine the interface circuitry (not supplied) between the receiver and the device to be controlled. In many cases this could by a relay or triac. General instructions and applications are supplied with the kits. The kits are coded and provide a high degree of noise immunity and security.

MK18 Transmitter Kit For use with MK11 MK12 Receivers and MK9 10 13 keyboards. Requires PP3 battery. Size 8 × 2 × 1.3 cms. Range approximately 60ft £6.80

MK11 Receiver Kit Mains powered. Provides 10 latched plus 3 analogue outputs. Ideal for controlling audio amplifiers, TV or lighting circuits where control of lamp brightness is required £13.50

MK13 Transmitter Keyboard £4.35

MK19 DC Controlled Stereo Amplifier Kit If control of stereo amplifier is required the MK19 may be used providing for remote control of base, treble and volume (or balance). This kit also includes a one of 10 decoder with LEDs for remote selection of programme or channel. May be connected between the pre amp and power amp sections of almost any audio amplifier £10.70

MK12 Receiver Kit Mains powered. Provides up to 16 latched or momentary on off outputs. The latched version is suitable for applications where only one of the 16 outputs is to be on at any one time, e.g. TV channel selection. The momentary version provides an output only during transmission. Lines may be latched separately if required (circuit supplied). This may be used in conjunction with the MK15 Dual latched Solid State Relay to switch mains loads, e.g. radio, lights, TV.

MK12 (state latched or momentary)	£13.50
MK9 4-way Transmitter Keyboard	£1.90
MK10 16 way Transmitter Keyboard	£5.40
MK15 Dual Latched Solid State Relay	£4.50

SINGLE CHANNEL UNCODED INFRA RED KITS

MK6 Transmitter — supplied with hand held plastic box. Requires a 9V PP3 battery. Range approximately 20ft £4.50

MK7 Receiver Mains powered with triac output to switch up to 500W at 240V ac. On off or momentary output available £10.50

MK16 Mains Powered Transmitter For continuous operation such as burglar alarms, automatic door operators, etc. Range approximately 6 ft. May also be powered from 9v dc £3.50

MK17 12V d.c. Receiver For use with MK6 or MK16. Relay output with DP 3A change over contacts. May be used as latched, momentary or break beam receiver. Operates from 6-13V dc £10.50

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EVERYDAY news ... from the world of

HIGH STANDARD OF INNOVATION MAINTAINED IN THIS YEAR'S SCHOOLS COMPETITION

SEDAC '84 AWARDS

★ WINTERBOURNE WINS BIG PRIZE ★

★ SCARBOROUGH SECOND ★
★ NORWICH THIRD ★

A NETWORK SYSTEM to link a school's computer for greater power and flexibility, designed and built by sixth-year students David Omar and Zee Bunker, both aged 17, won the first prize in this year's Schools Electronic Design Award Competition (SEDAC). Their school The Ridings High School, Winterbourne, Bristol now becomes the proud possessor of the SEDAC 84 trophy, as well as £300 cash and a selection of components valued at £200.

The second prize of £200 plus components valued at £200 was awarded to Malcolm McKie, aged 14, of Scarborough College, North Yorkshire, for his Multi-Purpose Laboratory Timer. Several striking and novel features are incorporated in this instrument, which should prove an admirable asset to any schools physics lab.

The third prize of £100 plus components valued at £200 was awarded to a team of three: Rosemary Erskine, 15, Nicola Hargreaves, 15, and Juliet Wright, 16, of Norwich High School for Girls, Norwich. This local trio collaborated to produce a Digital Anemometer and Wind Direction Indicator, suitable for use in a geography or physics department. It can be used either as a "stand alone" device, or with a BBC micro so that readings can be taken, stored and plotted automatically.

The eight remaining finalists received components to the value of £100.

All eleven finalists received a certificate and one year's subscription to EVERYDAY ELECTRONICS.

PRESENTATION OF AWARDS

Results of the third Schools Electronic Design Award Competition were declared and prizes presented to the successful participants on July 11 at Mullard House, London.

Throughout that day eleven finalists' projects were on display with their young designers in attendance to describe and demonstrate their purpose and operation. Visitors who toured the exhibition were obviously impressed by the wide range of subjects covered and by the enterprise of the individual students who had won through to this final stage in this competition sponsored by Mullard and EE.

SEDAC '84 winners David Omar and Lee Bunker of The Ridings High School, Winterbourne, with Michael Paton of IPC Magazines (left) and Ivor Cohen of Mullard.

Runner-up Malcolm McKie of Scarborough College receives his prizes from the Managing Directors of the competition sponsors.

Rosemary Erskine, Juliet Wright and Nicola Hargreaves of Norwich High School for Girls, winners of the 3rd Prize.

Around noon as the formal part of the proceedings commenced, an air of excitement developed. Hopes ran high amongst all the contestants—and justifiably too.

NEED FOR YOUNG ENGINEERS

Immediately before the announcement of the results, Mr. Ivor Cohen, Managing Director of Mullard, welcomed all present and expressed his delight—and, frankly, amazement—at the continuing high standard of the electronic designs submitted by students.

The injection of fresh young blood into the mainstream of the electronics industry was a constant requirement and of paramount importance to the future of this country. That was why his company was very pleased to be associated with this Schools Competition, which played a part in encouraging the study of electronics in our teaching establishments and in directing young people's attention towards a future career in design or research in industry.

Mr. Cohen finally expressed his particular pleasure at the inclusion of a girl's school among this year's finalists, and hoped this would encourage more girls to become involved in this technology.

ASTONISHING VARIETY

Then Mr. Michael Paton, Managing Director of the SEAL Group, IPC Magazines, publishers of EVERYDAY ELECTRONICS, thanked Mr. Cohen for Mullard's enthusiastic and generous support of SEDAC.

Commenting on the astonishing variety of subjects covered by this year's finalists, Mr. Paton picked out for mention the interest in subjects such as astrology and meteorology as evidenced by some entries. He also remarked on the effect of widening the rules this year to embrace projects having a useful function *anywhere* within a school's environment, and not limited exclusively to the teaching area, as hitherto. Thus we have an Automatic Schools Bells System, while of the six computer based projects included in the final eleven, four of these are capable of universal application and will thus be as useful in the administrative part of a school as in a classroom.

THE BIG MOMENT

At last, the big moment when the judges' decisions were revealed. **First prize** was awarded to The Ridings High School of Winterbourne, Avon, for a Network System for BBC/RML micros. **Second prize** was awarded to Scarborough College for a Multi-Purpose Laboratory Timer. **Third prize** was awarded to Norwich High School for Girls for a Digital Anemometer and Wind Direction Indicator. (A brief description of these and the other finalists' projects appears in the following pages.)

TEAM OR SOLO

(Some thoughts arising from SEDAC 84)

Examining the eleven finalists in SEDAC 84 we find student participants make up five solo performers, five duos and one trio.

What conclusions can one draw from this? One thing immediately apparent is that the strictly individualistic approach to electronic system design is balanced by the team approach. What are the advantages or disadvantages of either—or is it of any consequence at all?

The lone operator is obviously totally immersed in his brain child and takes the utmost pride in his task.

The team approach on the other hand is sometimes essential because of the sheer size or complexity of the project; also perhaps because of its nature, involving maybe different disciplines or techniques, it calls for shared effort.

THE TEACHER'S ROLE

The teacher concerned with electronic and computer studies should be able to determine those students who are likely to give of their best by working alone, and those who would do best by working in concert with other like-minded fellows. In this latter case the teacher would most likely be the one to propose a project to suit the different talents and/or interests of the team. The teacher might have to play the role of co-ordinator as the work proceeds.

COURSES...

Hendon College will be offering a course for the "Radio Amateurs Exam," starting in September 1984. They have been running the courses for the past three years with, they claim, excellent results.

The course is to be held from 7.15 to 9.15pm at the Williams Building, Hendon College of Further Education, The Burroughs, London, NW4 4BT.

Enrolment is on 12 September, from 2 to 8pm.

The Basildon Adult Education Centre is to run a series of one-year courses entitled "Electronics for Beginners" and "Preparation for The RAE." They are also holding a six weeks' course entitled "Maths for The RAE."

The courses are to commence in September at the Basildon Adult Education Centre, Fryerns School, Crayland, Basildon, Essex.

The North Trafford College are starting a new course for the City & Guilds Electronics Servicing Course which includes Radio, Television and Robotics. This is a full-time course spread over two years, and is designed to help the school-leaver or the unemployed to gain experience and qualifications in electronics.

City & Guilds Certificates for Electronics Servicing Parts I and II; Radio and Television; and Industrial Robot Technology will be awarded to successful students.

Details from: J. T. Beaumont, North Trafford College of F.E., Talbot Road, Stretford, Manchester, M32 OXH.

The results from recent BMRB surveys, carried out during February–May, shows, in contrast with the general trend, that the Radio Luxembourg audience is growing. The total audience growth since 1982 is claimed to be 7 per cent.

Queues for Sugar

The first supplies of the Amstrad CPC 464 went on sale on 21 June. This is in keeping with Managing Director Alan Sugar's promise made when he launched the home computer product range in mid-April.

The Rumbelow's chain, one of the nominated stockists, has received its first consignment and further supplies to Rumbelows and the other retailers—W.H.Smiths, Dixons, Boots, Comet and the major mail order houses—have been taking delivery of their supplies on a weekly basis.

Sales Director Dickie Mould has been overwhelmed by the intensity of the retailer demand:

"The initial interest, at the time of the launch, was perhaps predictable, but this level has been maintained and I am called every day by retailers who want to be supplied. Our initial run of 200,000 units for 1984 is already underwritten by our nominated stockists and we are urgently reassessing our budgets for 1985, when we anticipate bringing in 600,000 units."

SCHOOLS Electronic Design Award COMPETITION

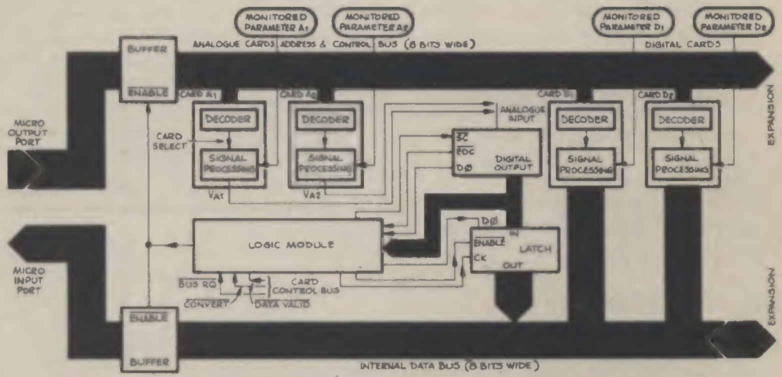
1984 WINNING DESIGNS

Data Collection System

Michael Cowperthwaite (17)

Barrow Sixth Form College,
Barrow-in-Furness, Cumbria.

Mr. R. Nodroum (teacher)



014

THE AIM of this project is to ease the collection of data produced from experiments in the science laboratories. It is capable of collecting the data from several different sources in rapid succession, manipulating this data and displaying the information on the computer VDU in a form specified by the software. The data is stored in the memory of the RML 380Z or 480Z microcomputer.

This is achieved by constructing an internal data bus which receives information from the outputs of "cards". Each card receives information from suitable transducers in the experiment to produce, after signal processing, an analogue or digital output to reach the internal bus.

The analogue outputs feed an A-to-D converter which produces an 8-bit wide digital translation of the input voltage. The digital outputs go direct to the internal bus.

The system is under control of the computer which through its Output Port selects the card to be read, and collects the information presented by this card to the internal bus, at its Input Port.

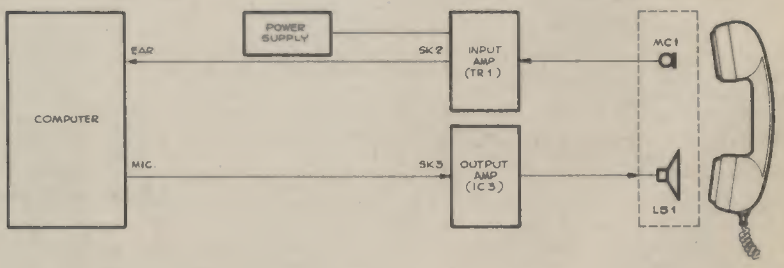
Information may also be exchanged between cards under management of the logic module. Cards being considered are for measurement of: a.c./d.c. voltage and current, temperature, light levels, pH values, GM count, magnetic flux density, resistance and capacitance.

Computer/Telephone Adaptor

Stephen Plumridge (14)

Dartford West Secondary School (Boys),
Dartford, Kent.

Mr. A. J. Barned (teacher)



016

THIS PROJECT has been designed to allow a microcomputer to transfer information or programs to another computer of the same kind. It could be used to link the computer in the science laboratory to the main computer in the computer room. This would also expand the scope of the school's computer.

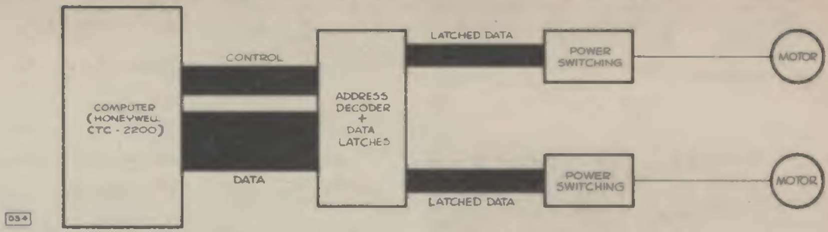
It was primarily designed for use with the ZX Spectrum but could be used with a ZX81 or a Jupiter Ace. With some modifications it can be used with most other computers such as the Oric I or Dragon 32.

The project in essence comprises a simple acoustic coupler and amplifier as shown in the block diagram. The signal from the telephone receiver (earpiece) is picked up by microphone MC1 and amplified by a single transistor before being passed on to the computer. The outgoing signal from computer "mic" socket is boosted to a sufficient level by an audio amplifier i.c. before being fed to the loudspeaker LS1 which provides acoustical coupling to the telephone transmitter (mouth-piece).

Computer Controlled Telescope

King George V Sixth Form College, Southport.

Ian K. Piumarta (17)
Gary M. Williams (18)
Mr. F. E. Large (teacher)



THIS PROJECT was developed to allow a small desk-top computer to control the College's 13½-inch reflector telescope, but other machinery or robot arms may easily be controlled using this system.

The computer used is an old Honeywell CTC.2000 8-bit microcomputer. Any computer with an 8-bit output port could control the system by simulating the required simple control lines.

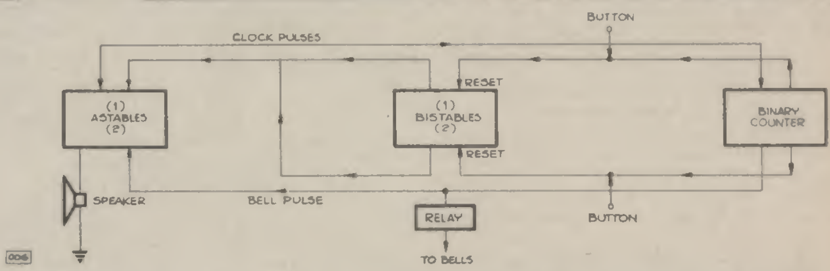
A small interface has been designed to provide latching of transient output data and to facilitate individual addressing of the drive units. To eliminate the need for any form of feedback it was decided to employ stepper motors to manipulate (via appropriate gearing) the telescope. Two such motors are used: one for right-ascension and the other for declination.

Each motor is connected to the interface via a drive unit which performs the high-current switching for each coil. A bipolar drive method was chosen to provide the highest torque-per-watt available.

School Bells Project

Manor Farm School, Walsall.

John R. Corfield (17)
Mr. I. S. Creaser (teacher)



THIS CIRCUIT is designed to improve the school bells signal system. It automates a few simple signals used in the school: three bells are used to signify wet break and four bells to signify the caretaker is needed at the school office. Instead of repeatedly pressing the one button three or four times, it is only necessary to press once one of the two buttons incorporated in this project, and then the correct number of bells will be sounded, evenly spaced and automatically.

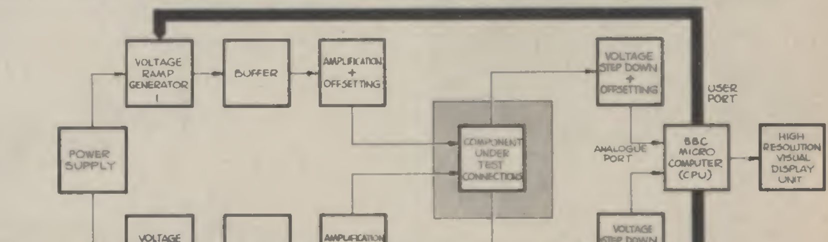
When one of the buttons is operated a bistable chip decides whether three or four bells are needed. An astable feeds a binary counter which counts to produce the bell pulses and resets after three or four bells. The binary counter turns on the second astable which produces a tone in the monitor loudspeaker and also triggers a relay to turn on the bells.

The circuit could easily be extended to allow for more codes or numbers of bells.

Transistor/Diode Curve Tracer For BBC Micro

Mill Hill School, London.

M. L. Melconian (16)
Dr. W. D. Phillips (teacher)



THIS UNIT is operated via the user and analogue ports of the BBC Micro. Appropriate ramp voltages are fed to the component under test. The resulting currents are measured via the analogue port.

A full range of characteristic curves can be drawn on the computer VDU including I–V curves for diodes, l.e.d.s and Zener diodes, for both positive and negative voltages, as well as $I_b - V_{be}$ and $I_c - V_{ce}$ curves for both *npn* and *pnp* transistors.

It can also detect the type of device being used, as well as calculating other properties of a given component, for example, current gain.

The voltage ramp generator is centred around the ZN425E digital-to-analogue converter i.c. By connection to the user port of the BBC Micro, the chip's clock can be pulsed to form a voltage staircase of up to 256 steps. The ramp generator can also be reset at any time, by the computer program.

The two ramp voltages are fed to the component under test. The ramp voltage from ramp one is applied across V_{be} and ramp two across V_{ce}. The diode is connected across the collector and emitter.

Thus a voltage proportional to I_c can be taken straight from this circuit.

To obtain I_b, a differential amplifier is used to amplify the difference between the input voltages. The output is thus a voltage proportional to I_b.

The voltages are fed via voltage step-down and off-setting stages to the analogue port of the BBC Micro and the programming takes care of the rest.

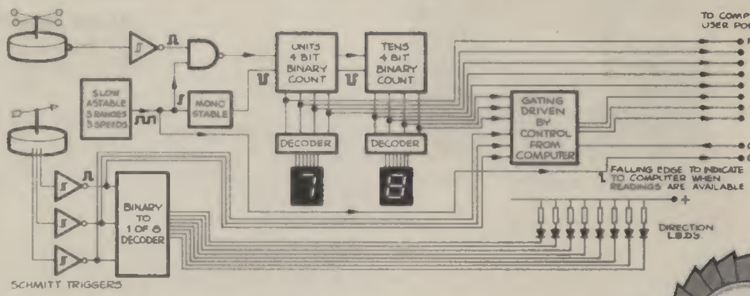
Suitable software has been developed for use with the unit.

Digital Anemometer And Wind Direction Indicator

Norwich High School For Girls, Norwich.

Rosemary Erskine (15)
Nicola Hargreaves (15)
Juliet Wright (16)

Mr. P. W. Stevenson (teacher)



002

THIS DEVICE has been designed to give continuous readings of wind speed and direction for use in a geography or physics department at school. It is battery driven and can be used as a "stand alone" device read directly by users from digital displays or, optionally, it can be used with a BBC/Acorn computer so that readings can be taken, stored and plotted automatically.

A typical application of this last type would be to monitor wind speed and direction every minute or so during the night with the results available next morning for display and analysis. A high resolution graph could then be displayed from which details of such things as strength of gusts and directional changes could be monitored.

Since the time between readings in this method of working is fixed by the computer software, a wide range of time intervals between readings is possible (from seconds to tens of minutes).

The wind-speed sensor is a conventional anemometer head. A single reed switch is closed once per revolution by a rotating magnet fixed to the rotor axis. Pulse rate is thus proportional to wind speed.

The wind-speed readings will be displayed in two 7-segment l.e.d. displays and there will be three switchable sets of units in which data can be collected (km/hr, miles/hr, metres/sec).

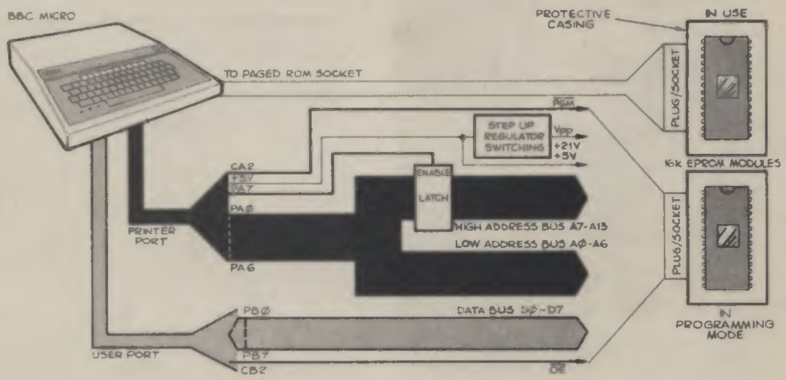
The wind-direction sensor consists of a rotating vane. The shaft carries a coded printed circuit disc at its lower end. Three infra-red transmitters/receivers pick up a 3-bit binary code by reflection from this disc. The wind direction will thus be coded into one of eight possible compass directions. The direction will be indicated by lighting an l.e.d. against the appropriate point of a compass card on the instrument front panel.

Eprom Filing System For The BBC Micro

Princess Margaret Royal Free School, Windsor, Berks.

Graham Ford (16)
Michael Hayward (17

Mr. G. Mort (teacher)



010

THIS SYSTEM was designed to meet the need for an inexpensive quick and reliable means of loading BASIC programs into the BBC Micro memory. It easily out-performs the cassette based loading and provides a cheaper alternative to disc drives. The program is stored in Eprom.

The Eproms containing the program are encased in a strong plastics case fitted with a robust multi-pin connector. This affords considerable protection to the device, since the 28 legs on the device are fragile and can be damaged when plugging into and removing from a socket as is frequently done with the Eproms sited in the sideways ROM sockets on the BBC Micro. This is known as the Eprom Module.

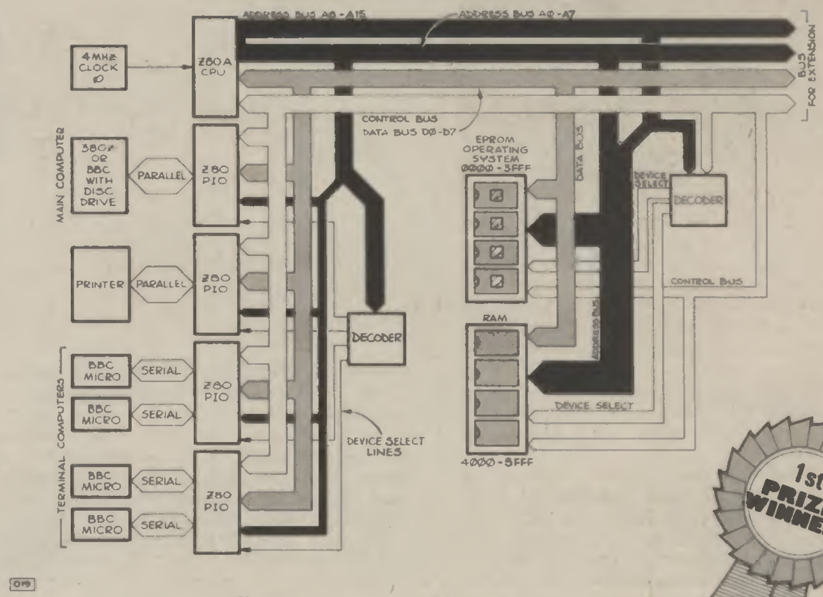
It resides in a spare sideways ROM socket on the main board but connects to it by a suitably terminated connector. Different programs will be contained in different Eprom Modules. The Eproms are specially programmed with a file name, so when called by its name, the program data is loaded into RAM and run automatically.

To put the data into the Eprom in the first instance, an Eprom blower is required. The Eprom module containing a "clean" Eprom is simply plugged into the blower which is connected to the Printer and User Ports on the Micro. The Printer Port is used to drive the 14-bit wide address bus and other control lines. Program data is sent to the Eprom along the User Port; CB2 controls the $\overline{OE}$ line.

The required +21V programming voltage is derived from the BBC Micro +5V through a switching regulator.

Network System For BBC/RML Micros

Lee Bunker (17)
David Omar (17)
The Ridings High School, Winterbourne.
Dr. V. Coveney (teacher)



THIS PROJECT provides a network system which will link a main computer (BBC or RML micro) with its disc drive, to four other terminal computers and a parallel printer. With such a set-up, the printer and disc drive are shared by all the computers in the system and any computer can communicate with any of the others. Files can be stored and retrieved on CP/M or BBC discs through the network.

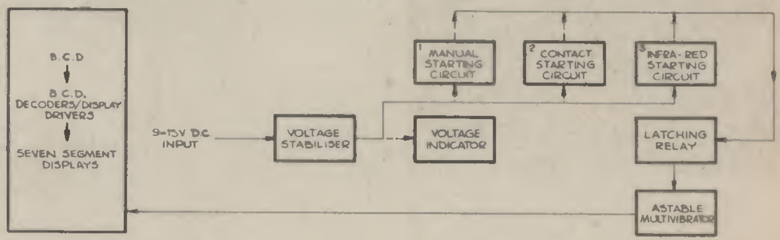
The system uses a Z80A CPU running at a clock frequency of 4MHz which controls *all* communications. The operating system software resides in Eprom. This is made up from four 4K × 8-bit Eproms type 2532. This occupies memory from 0000 to 3FFF.

There is also temporary storage available on board amounting to 8K bytes. This is made up from four 2K × 8-bit CMOS static RAM which may be expanded up to 48K via the extension bus. On board RAM occupies locations 4000 to 5FFF.

Interfacing between the computers and peripherals is via the Z80 PIO (Parallel Input/Output). These are daisy-chained to allow priority interrupts to be easily implemented and rapidly executed. The terminal computers communicate in an asynchronous serial mode employing handshaking techniques.

Multi-Purpose Laboratory Timer

Malcolm McKie (14)
Scarborough College, Scarborough, N. Yorks.
Mr. T. E. Drake (teacher)



THIS TIMER has the accuracy, capacity and price tag to replace many of the timers used in school laboratories. It is simple yet versatile due to its three starting systems: (1) manual push-button; (2) contact starting and (3) infra-red starting. Several circuitry-saving ideas reduce the cost of the timer. A voltage stabiliser enables many low-quality supplies to be used safely and the display and other parts are selected to withstand the hard use experienced in the school laboratory.

The timer may be successfully employed in experiments from timing the decay of radio-activity to the uptake of water by a leafy shoot to calculating the force of gravity.

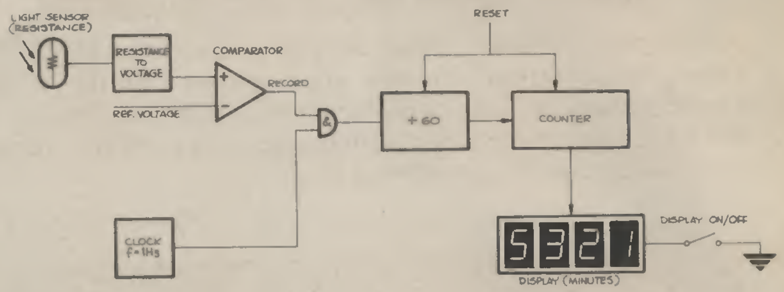
Timing is achieved by means of an astable multivibrator calibrated using an oscilloscope to give 1/100 of a second accuracy. This sends pulses at 100Hz to a series of binary coded decimal counters, dividers and display drivers. The display consists of six 7-segment l.e.d. displays, giving a timing capacity of 99 minutes 59·99 seconds.

A particularly novel feature is infra-red starting. This gives the ability to time all or part of the movement of an object, even though it may move very quickly and in a random pattern, and may be already in motion. Two infra-red beams and sensors are used, when the first beam is broken the timing starts, and it stops when the second beam is broken.

Digital Sunshine Recorder

Skegness Grammar School, Skegness.

Paul Thorlby (16)
Paul Rock (16)
Mr. G. W. Payne (teacher)



020

The Sunshine Recorder has its place amongst other weather recording equipment—recording the number of hours of sunshine each day. Our unit was designed to provide a cost effective, easy to use alternative to the expensive commercial unit.

The light sensing circuitry consists of an l.d.r. coupled to one input of a comparator, a reference voltage (which is adjustable to calibrate) being fed to the other input. The output from the comparator forms a logic pulse 1 = record 0 = no sunshine, this is anded with a 1Hz clock. The resultant signal is divided by 60 and fed to a 4-digit counter which gives a readout in minutes of sunshine. The range being 0–9999 minutes or 0–166 hours, 39 minutes, allowing the unit to operate and provide a reading for the whole week as opposed to one day.

The display is only switched on as needed, to conserve battery power. CMOS circuitry minimises other power requirements.

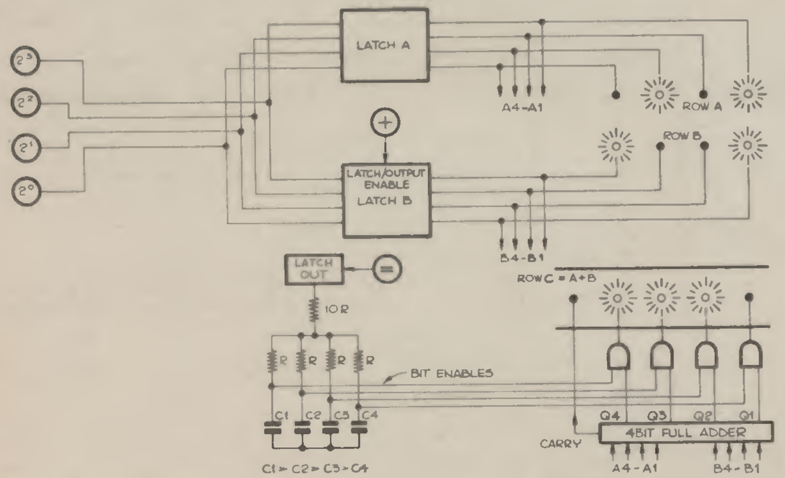
The unit is free standing and independent of everything, except the sensor, if a remote housing is chosen. Provision can be made for more than one sensor to be applied if a single ideal situation cannot be found.

Calibration of the clock is achieved by means of VR2, and of the light level necessary to trigger the unit by VR1.

Slow Motion Binary Adder

Warren Wood Boys School, Rochester, Kent.

Peter Wellard (16)
John Blaker (12)
Mr. M. Horsey (teacher)



025

STILL GOOD FRIENDS!
The SEDAC '84 finalists on the steps of Mullard House, London.

This project was designed for use in the mathematics department to be a teaching aid to explain the stages of binary addition. It allows two 4-bit numbers to be added together, but does it "slowly" so that the students may easily follow the operations.

The two numbers are entered at the keyboard using the 2^0, 2^1, 2^2 and 2^3 keys to give any number from zero to decimal 15. The first number entered is stored in latch A and is displayed in row A. An illuminated l.e.d. represents a "1", an unlit l.e.d. represents a "0". The "+" key is then operated. This enables latch B whilst enabling latch A. When the second number is entered it appears on the l.e.d.s in row B.

The two numbers reach the inputs on the 4-bit full adder but the gates on its output prevent the answer being displayed in row C. The latch connected to the "=" button gives a low output until operated, whereby it flips to a logic 1 and the bank of capacitors start to charge up towards a logic 1 level. The *CR* networks are calculated to enable the AND gates in ascending order of bit significance at a slow rate, the actual time depending on the values of C1 to C4.

OSCILLATORS

A variety of different types of resistance capacitance feedback oscillators, all having wide use, are described in this short series. Some of the circuits are based on discrete semiconductors, others on familiar i.c.s. In addition to theory of operation, design pointers for particular needs and applications are given. Each part in the series also includes a detailed circuit for a practical project.

Part Four: HYSTERESIS OSCILLATORS

By J. R. DAVIES

THIS concluding article in the current series is devoted to oscillator circuits which exploit the voltage hysteresis effect.

BASIC SCHMITT

The classic Schmitt trigger circuit, employing transistors, is shown in Fig. 4.1. If the base of TR1 is at the same potential as the negative rail this transistor is turned off, allowing current to flow through R1 and R3 to the base of TR2, which turns on. The collector-to-emitter current of TR2 causes voltages to be dropped across R5 and R2. If the base of TR1 is taken slowly positive a level will be reached at which TR1 commences to pass collector current. The base current to TR2 is reduced and its emitter goes negative, thereby taking TR1 emitter negative and causing TR1 to pass a higher current. A regenerative effect is set up which results in TR1 turning hard on with TR2 being cut off.

If TR1 base is now taken negative a voltage level will be reached at which its collector current will fall and the voltage at its collector will rise. Only a fraction of the collector voltage is applied to TR2 base, and the base of TR1 has to be taken negative to a lower voltage than the previous triggering level if TR1 is to cut off and TR2 be turned on again.

VOLTAGE HYSTERESIS

This effect is referred to as voltage hysteresis, and can be produced in circuits other than that shown in Fig. 4.1. Such circuits are also described as Schmitt triggers and can be made to function as RC oscillators.

Hysteresis oscillators are not new in this series because the 555 and ICM7555, which were dealt with in Part Two, function by reason of voltage hysteresis. When pins 2 and 6 of either of these i.c.'s are joined together to provide an input, the output goes negative when this input rises to two-thirds of supply potential, and goes positive when the input falls to one-third of the supply potential.

We shall now consider other hysteresis oscillators.

SCHMITT NAND GATE

The CMOS i.c. type 4093 is a quad 2-input NAND Schmitt trigger, and has the internal circuitry shown in Fig. 4.2. There are four NAND gates, each having Schmitt trigger characteristics.

The performance of the NAND gates can be checked by the circuit of Fig. 4.3. The two inputs of a NAND gate are joined together, causing the gate to function as an inverter, and are coupled to the slider of a potentiometer connected across the supply rails. Voltmeter ME1 monitors the input voltage whilst voltmeter ME2 indicates whether the output is high or low. If, with a 9-volt supply, the potentiometer slider is advanced from the negative end of the track the output

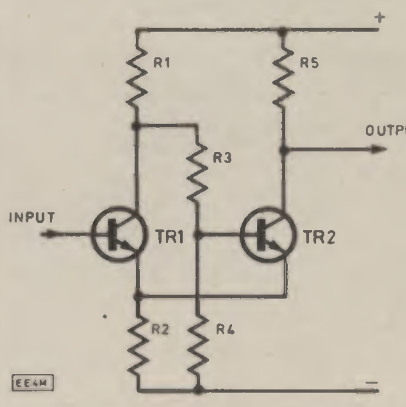


Fig. 4.1. The basic Schmitt trigger.

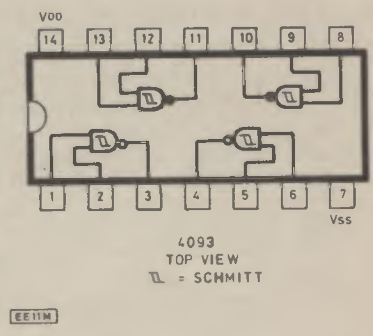


Fig. 4.2. The CMOS 4093 incorporates four 2-input NAND Schmitt triggers.

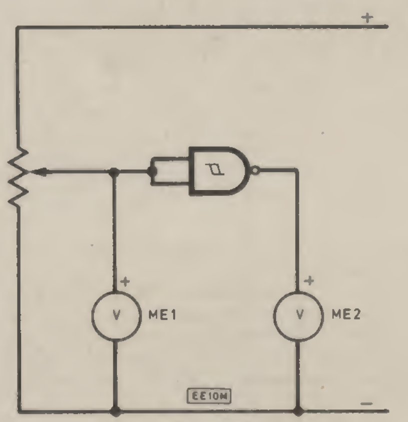


Fig. 4.3. The performance of a NAND Schmitt trigger can be evaluated with this test circuit.

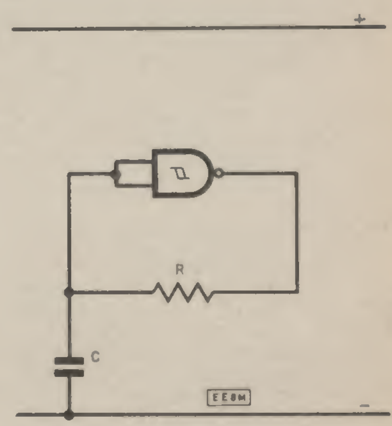


Fig. 4.4. Adding a resistor and a capacitor causes the Schmitt trigger to function as an oscillator.

will be high until the input voltage reaches around 6 volts, whereupon the output will abruptly go low. If the input voltage is next reduced the output will abruptly go high again when the input voltage is around 4·7 volts.

The Schmitt NAND gate may be made to oscillate by adding a resistor and capacitor, as in Fig. 4.4. At switch-on the capacitor is discharged and the gate output is high. The capacitor charges through R and the input voltage increases until the positive-going trigger level is reached, whereupon the gate output goes low. The capacitor next discharges through the resistor until the input voltage reaches the negative-going trigger level and the output then goes high again. Oscillation proceeds with the capacitor alternately charging and discharging. A near squarewave is given at the gate output, with the positive pulses being a little longer than the negative pulses.

OSCILLATOR FREQUENCY

Oscillator frequency is governed by the values of R and C, and will vary somewhat with different gates due to spread in gate characteristics. In very approximate terms, the cycle length with a 9-volt supply is of the order of 0·8 times the time constant of the resistor and capacitor. If R is equal to 1MΩ and C to 0·0047µF, the time constant is 0·0047 second. Cycle length is around 0·00376 second, which corresponds with a frequency of 266Hz.

The supply current drawn by the oscillator is largely dependent on the value of R. The current drawn from a 9-volt supply is around 0·2mA for resistances in R between 100kΩ and 10MΩ, rises to about 0·35mA with a resistance of 10kΩ, and increases to approximately 2mA with a resistance of 1kΩ. Suitable resistance values which do not cause excessive current drain lie, therefore, between 10kΩ and 10MΩ. The oscillator functions satisfactorily with a value in C as low as 100pF, and the maximum capacitance which can be used is governed by the reliability of the oscillator at very low frequencies.

At frequencies of the order of 0·2Hz or less there is an occasional tendency for the oscillator to "stick". What happens here is that the gate input voltage is rising or falling very slowly and the limited linear voltage gain in the gate results in a relatively slow change in output potential at one of the input triggering levels. The oscillator then latches, with the gate output and input taking up a steady voltage at some level between the supply rails. Because of the effect it is preferable not to employ the circuit for oscillation below some 0·5Hz and this, in company with the value chosen for R, limits the maximum value for C.

HALF-SECOND BLEEPER

Fig. 4.5 shows a practical working circuit which demonstrates Schmitt NAND gate operation. Three of the gates in a 4093 are employed to form a bleeper which produces audible pulses at a repetition frequency of about 2Hz.

Gate G1 is in a standard hysteresis oscillator circuit with its frequency controlled by R1 and C1. These two components have a calculated time constant of 0·594 second, whereupon the oscillator has a frequency of the order of 2Hz. A second hysteresis oscillator is given by gate G2 whose timing components, R2 and C2, have a time constant of 0·001 second. Frequency is therefore in the region of 1·25kHz.

Only one of the gate inputs, pin 9, connects to R2 and C2, and the other gate input at pin 8 connects to the output of G1. Since G2 is a NAND gate the output at pin 10 is always high when pin 8 is low, and the oscillator cannot then function. When pin 8 is high, inversion takes place between pin 9 and pin 10, and the oscillator is able to run. Thus, G2 oscillates only when the G1 output is high.

Gate G3 functions as a buffer amplifier and drives TR1 which, in turn, drives the loud speaker LS1. Note that when gate G2 is disabled its output is high, and the output of gate G3 is then low. In consequence, TR1 is turned off between bleeps with a saving in supply current.

The loudspeaker can have any impedance between 15Ω and 80Ω, and R4 is given a value which causes the sum of its resistance and the speaker impedance to be approximately equal to 100Ω.

Bypass capacitor C3 ensures that the relatively heavy speaker currents do not upset CMOS operations if the 9-volt battery has a high internal resistance. The capacitor is quickly discharged, to prevent irregular oscillation, when the circuit is switched off. The total current drawn from the battery averages at approximately 20mA.

The fourth gate in the 4093 is not used and its two inputs, at pins 5 and 6, are connected to the negative rail. No connection is made to the fourth gate output.

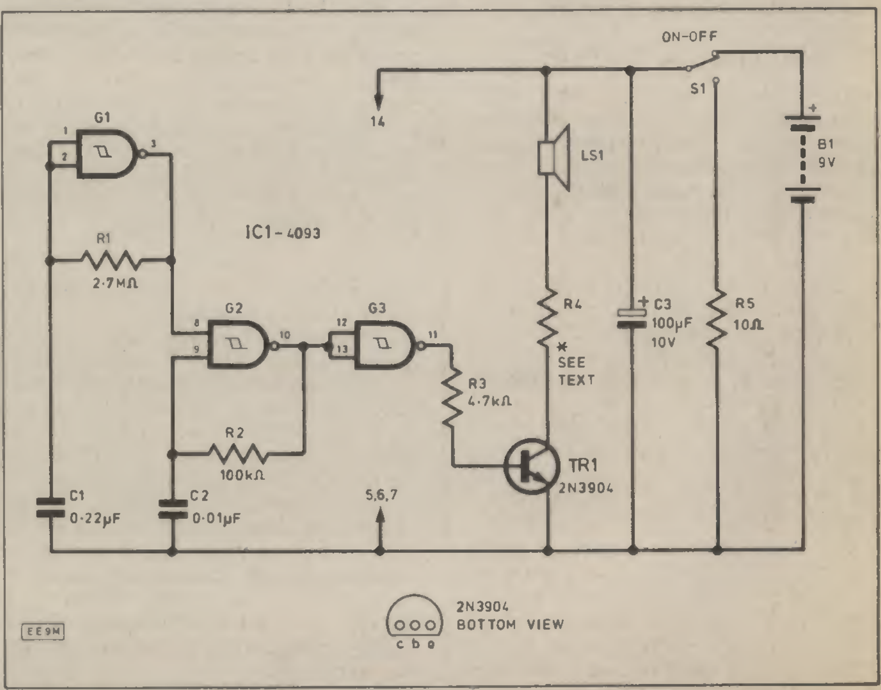
TTL NAND OSCILLATOR

A TTL Schmitt NAND gate can also function as an oscillator employing the CMOS gate circuit of Fig. 4.4. However, the very much higher input currents required by a TTL gate cause the values of the frequency control components, R and C, to be considerably different for a given frequency of oscillation. Also, the TTL oscillator should be followed by a second NAND gate which functions as a buffer amplifier. The output of the second gate is then used to drive other TTL circuitry.

A typical TTL oscillator and amplifier can incorporate two gates of a quad 2-input NAND Schmitt trigger type 74132. This has the internal circuitry shown in Fig. 4.6. To give an idea of TTL input current magnitudes an ordinary NAND gate, such as appears in the 7400, requires a current of the order of 1mA to take an input low to logic 0. Input current at logic 1 is much lower, being usually in the region of tens of microamps. With the 74132 the input current at the positive-going Schmitt threshold is typically 0·43mA, and the input current at the negative-going threshold is typically 0·56mA.

These high currents necessitate a relatively very low value in R, and the resistance specified by the i.c. manufac-

Fig. 4.5. A practical working circuit. This produces audio bleeps at a repetition frequency of approximately 2Hz.



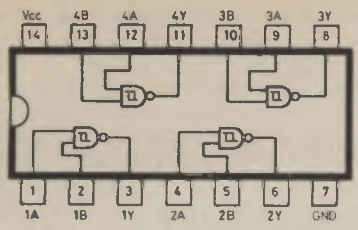


Fig. 4.6. The internal circuitry of the TTL 74132 quad NAND Schmitt trigger.

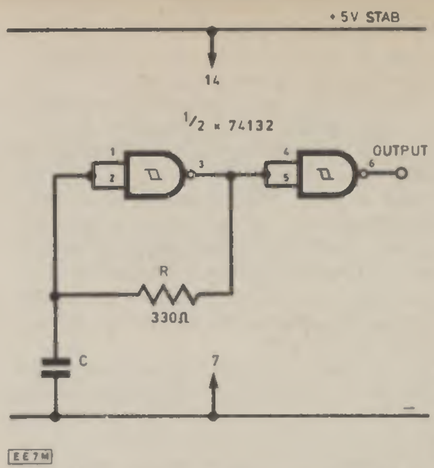


Fig. 4.7 (right). In the TTL version of the Schmitt oscillator the feedback resistor is 330Ω at all frequencies.

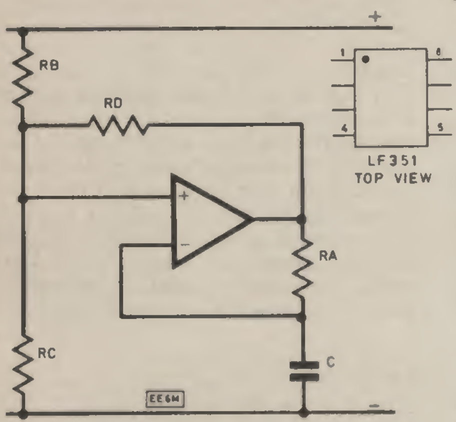


Fig. 4.8. A hysteresis oscillator incorporating an operational amplifier. RB, RC and RD all have the same value and frequency is controlled by RA and C.

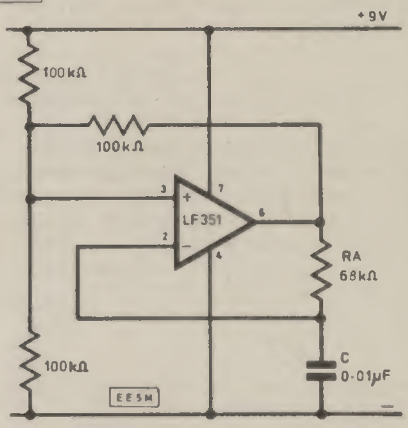


Fig. 4.9. A practical op-amp hysteresis oscillator. Frequency is slightly less than 1·07kHz.

turer for the oscillator function is 330Ω. In consequence the only variable for frequency control is C. The manufacturer quotes a frequency range for the oscillator circuit of 0·1Hz to 10MHz.

TTL OSCILLATOR CIRCUIT

Fig. 4.7 shows two gates of the 74132 connected to function as an oscillator and buffer amplifier. For lower frequency oscillation the capacitor can be electrolytic, with the negative plate connected to the negative rail. At higher frequencies it may be a non-polarised component.

Due to the wide spread in characteristics involved, a precise frequency of oscillation cannot be calculated. Experiment shows that the length of a cycle in seconds is roughly equal to the capacitance in microfarads divided by 2500. So, a value in C of 2500μF will give a cycle length in the region of one second, and a frequency of 1Hz. Corresponding values of C and frequency are given by 250μF and 10Hz, 25μF and 100Hz, 2·5μF and 1kHz, and so on.

The duty ratio of the output signal from the buffer amplifier gate is some 60 to 65 per cent. This refers to the percentage of time in the cycle when the output is at logic 1. The current drawn by the 74132 i.c. from the stabilised 5-volt supply with no connections made to the two unused gates is some 25mA to 30mA at all frequencies.

A feature of the TTL Schmitt oscillator is that if the frequency controlling capacitor is connected into circuit after power has been applied the oscillator may not start. Because of this effect, the temporary disconnection and reconnection of the capacitor due to a fault condition can cause the oscillator to stop and stay stopped.

OP-AMP OSCILLATOR

Fig. 4.8 illustrates a hysteresis oscillator employing an operational amplifier. The three resistors, RB, RC and RD all have the same value and frequency is controlled by RA and C.

Assuming that the op-amp output goes fully to the positive rail voltage when it is high, and fully to the negative rail voltage when it is low, oscillator functioning can be described in the following manner.

When power is applied C is discharged, with the result that the inverting input (—) is negative of the non-inverting input (+). The op-amp output is therefore high, causing RD to be effectively in parallel with RB and two-thirds of the supply voltage to be present at the non-inverting input.

Capacitor C charges via RA until the voltage across it reaches two-thirds of the supply voltage, whereupon the op-amp output starts to go negative. The non-inverting input goes negative also, causing the op-amp output to go fully negative very rapidly and bringing RD effectively in parallel with RC. The voltage at the non-inverting input becomes equal to one-third of the supply voltage.

Since the op-amp output is now low, C discharges through RA. When the voltage across the capacitor falls to one-third of the supply voltage the reverse effect to that just described takes place and causes the op-amp output to swing very rapidly positive. The capacitor charges once more through RA until the voltage across it reaches two-thirds of the supply voltage and the op-amp output then goes negative again. Oscillation continues in this manner, with capacitor C charging to two-thirds of supply voltage and discharging to one-third of supply voltage.

The discharge period from two-thirds to one-third of the supply voltage is the same as occurs with the 555 or ICM7555, as described in Part Two, and is theoretically equal to 0·685.RA.C. Because of the circuit symmetry the charge time from one-third to two-thirds of supply voltage is the same as the discharge time and so the length of the total cycle is theoretically equal to twice 0·685.RA.C or 1·37.RA.C.

The reciprocal, at

$$\frac{0{\cdot}73}{RA.C}$$

gives the corresponding frequency.

In practice, apart from devices such as the CA3130, most op-amp output voltages do not go fully to the positive rail or fully to the negative rail, whereupon the charge and discharge currents for C are slightly less than would be given with our initial assumption. The result is that cycle lengths in practice are a little longer and frequency is slightly lower.

WORKING CIRCUIT

Any op-amp with high impedance inputs can be used in the oscillator circuit, and Fig. 4.9 shows a working circuit employing an LF351. This has a frequency of oscillation, determined by RA and C, which is a little lower than the calculated figure of

$$\frac{0{\cdot}73}{0{\cdot}068 \times 0{\cdot}01}$$

or 1·07kHz. Reasonable values for RA are in the range of 10kΩ to 1MΩ, and the LF351 draws approximately 2mA from the 9-volt supply with all resistor values within this range. C can be electrolytic for very low frequencies.

Because the linear voltage gain in an operational amplifier is very much higher than is that in the CMOS Schmitt NAND gate discussed earlier in this chapter there is little risk of latching at very low oscillator frequencies.

The oscillator output is available at the op-amp output pin. There is also an approximate triangular wave at the upper plate of the frequency control capacitor.

HAND CAPACITANCE SWITCH

The project which concludes this Part incorporates a hysteresis oscillator in a switching circuit which turns on an electrical circuit when a hand is placed lightly on a sheet of insulating material which bears no electrical contacts. Behind this insulating material are two metal plates and placing a hand on the material increases the capacitance between them.

CIRCUIT DESCRIPTION

The circuit of the hand capacitance switch is given in Fig. 4.10. IC1 is an LF351 hysteresis oscillator running at a frequency of slightly less than 4·8kHz. Its output connects to one of the metal plates.

The other metal plate connects to the inverting input of IC2, another LF351. This input is biased to a mid-supply voltage by the two equal-value resistors, R5 and R6. The voltage on the non-inverting input is set up by adjusting VR1. R7 is inserted in series with VR1 because the LF351 does not function correctly with input voltages which are close to the negative supply rail.

VR1 is adjusted to make the non-inverting input slightly negative of the inverting input, whereupon the output of the LF351 is fully negative and is, in practice, about one volt positive of the negative rail. This output is applied via D1 and the potential divider consisting of R8 and R9 to the base of TR1 and causes this transistor to be fully cut off. Connected in the collector circuit of TR1 is the coil of a relay whose contacts control the external circuit to be switched.

When a hand is placed on the insulating material above the metal plates the output of IC1 is coupled to the inverting input of IC2 by the added capacitance between the plates. Although this capacitance is low it is sufficient to produce, at IC2 output, a signal which has the full peak-to-peak voltage swing for the i.c. The output signal is rectified by D1, causing a positive voltage to appear on the upper plate of the reservoir capacitor C4 which is applied to R8. TR1 turns on and energises the relay. The relay releases as soon as the hand is removed from the insulating material.

METAL PLATES

The size and spacing of the metal plates is not critical and they can be around $3\frac{1}{2}$in square with $\frac{1}{2}$in spacing, as shown in Fig. 4.11. Two pieces of metal foil glued to the underside of the insulating material could be used instead of the plates, if desired.

To keep stray capacitances between the two sections of the circuit to a minimum, all the components around IC1 are assembled as a module on one side of the plates and all the components around IC2 in a second module on the other side of the plates. The second module includes the bypass capacitor, C3. The on-off switch and the 9-volt battery can be positioned at any convenient points.

The relay should be capable of energising reliably at less than 9 volts and have a coil resistance of 300Ω or more. The current drawn from the battery is approximately 3·5mA when the relay is de-energised. To this is added the relay coil current when the relay is energised.

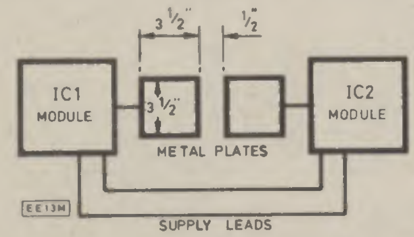


Fig. 4.11. Approximate metal touch-plate dimensions.

SETTING-UP

The circuit is set up by adjusting VR1. The slider of this potentiometer is initially set near the positive end of its track, whereupon the output of IC2 goes high and TR1 is turned on by way of the forward biased diode, D1. VR1 slider is slowly moved towards the negative end of the track until the relay suddenly releases. The potentiometer slider is then taken slightly further towards the negative end of the track. A little experience with the circuit soon shows what is required here.

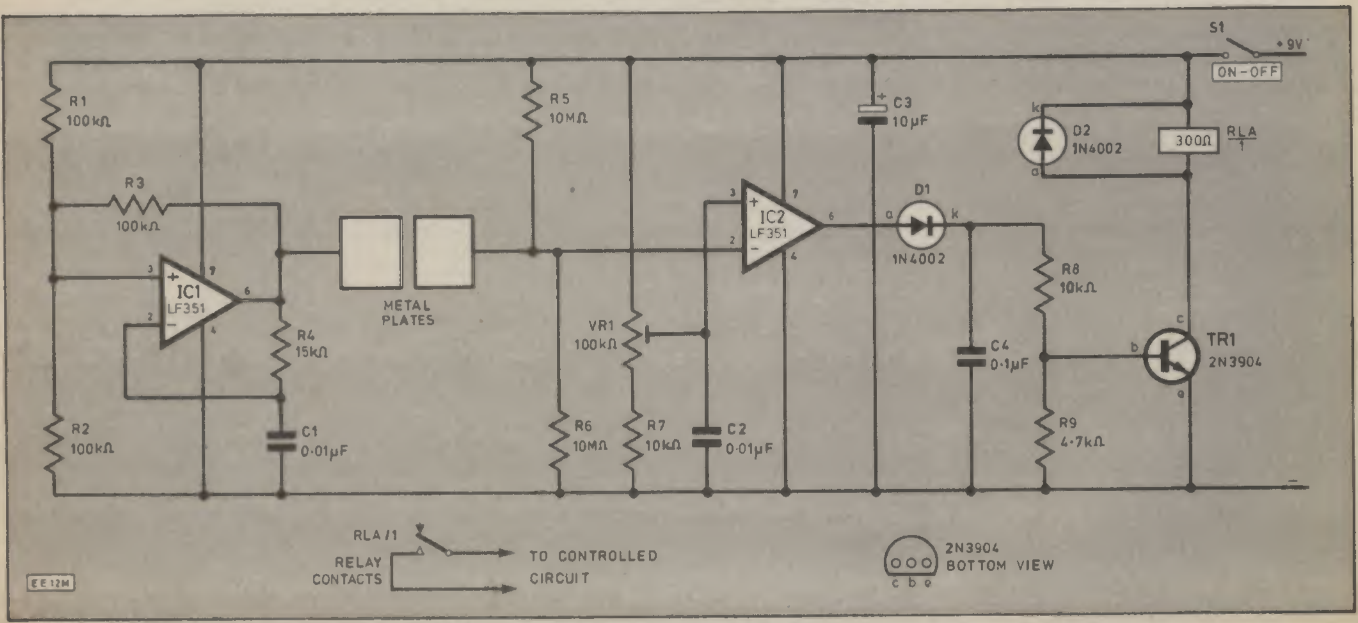
When a hand is placed on the insulating material the relay will then energise. If the relay has a very light armature with a weak return spring it may "chatter" slightly as VR1 slider reaches the point at which the relay just releases. This is not due to a circuit malfunction and the effect may be ignored.

The insulating material can be plastic, card or any other material. For best results it should not have a thickness greater than one-sixteenth of an inch.

APPLICATIONS

The hand capacitance switch can be used as a novelty device in stores, with customers being invited to place a hand on the insulating material. The relay could then cause an advertising sound and/or vision display to be activated. An attractive touch would be given by painting the outline of a hand over the area where the customer's hand should be placed. Many other novelty applications can also be envisaged. □

Fig. 4.10. Hand capacitance switch. Placing a hand on a piece of insulating material covering the metal plates causes the relay to energise.



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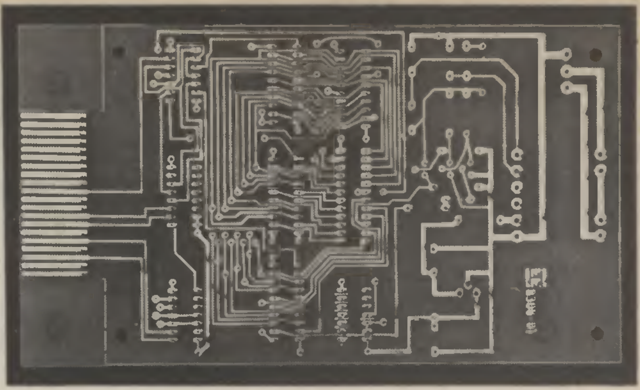

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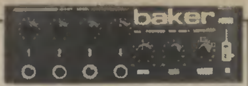

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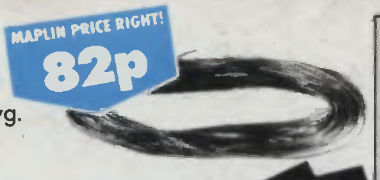

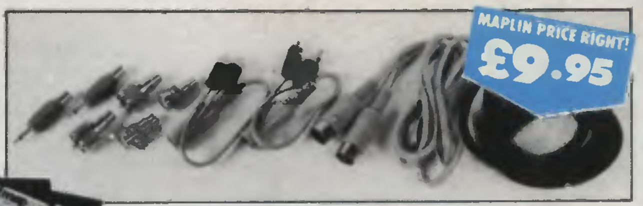

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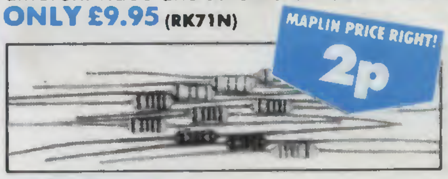

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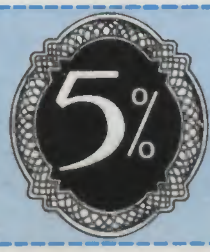

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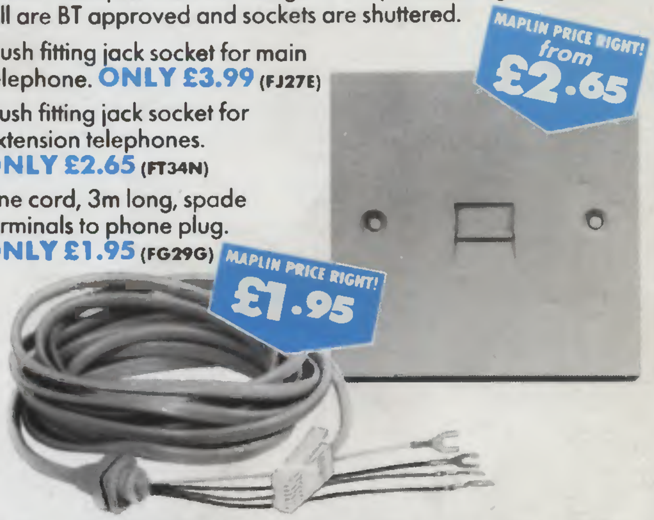

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