20 SIMPLE ELECTRONIC PROJECTS FOR THE ZX81

and other computers



by Stephen Adams

20 Simple Electronic Projects 20 for the ZX81 and other computers

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The Projects

1. Mains operated + 5 volt/ + 12 volt power supply
2. A monitor
3. A universal gate
4. Tape recorder control
5. Minitone
6. Numeric keypad for the ZX81
7. Giant seven segment display
8. Score board
9. Wheel of fortune
10. Analogue to digital converter (A/D)
11. Light pen
12. Shift lock for keyboards
13. A cheap thermometer
14. Graphics — Function — Edit — Rubout keys for the ZX81
15. The moveable "occupant"
16. A computerised voltmeter
17. Unbeatable burglar alarm
18. Standby power supply
19. Mains supply filter
20. A logic probe.

What the components look like
Resistor and capacitor colour codes
Useful addresses

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INTRODUCTION

This book was written for people who feel that they would like to get more out of their computers than games and writing large business programs. The computer should be used as a TOOL for the job in hand, as it makes a helpful companion which does not tire and will carry on quite happily twenty four hours a day.

This book shows how this tool can be used in various applications and how the computer can turn itself into many things: a thermometer, voltmeter, burglar alarm, all costing a lot less than many specialised units. The computer is a programmable device that can be altered to suit any home, business or pleasure application, tailored to your own needs by YOU.

This book is based on a 1K ZX81, but most of the projects in this book can also apply to TANDY TRS80's, PET's, TANGERINE's, SHARP MZ80K's etc. This means of course that the humble ZX80 even with a 4K ROM should not be left out. This is because most of the projects listed in this book are based on one thing all computers have in common; a means of getting in and out of the computer called a PORT. This is used as a doorway, to get information in and out of the computer quickly and easily in eight bit 'lumps' called BYTES.

The projects in this book are NOT designed to be the best, or most elegant, but the cheapest and easiest solution to the question: "YES, BUT WHAT DOES IT DO?".

It is possible, using this book, to just make up the projects and use them. Hints are given on SOLDERING, COMPONENT IDENTIFICATION and understanding CIRCUIT DIAGRAMS. Programs are only given where absolutely necessary to use the project, sprinkled, I hope, with enough notes to make it easily convertible to any BASIC. Only one project requires diving into machine code and the code given is very short. The book is self-contained, in that all the essentials to run a project, from a +5 volt/+12 volt mains operated power supply to an explanation on how the various ports work are included.

A full explanation is given for each project, avoiding as many technical terms as possible. It will, I hope, give insight into how integrated circuits (I.C.'s) work and how they can be controlled to do what you want.

Constructional notes are given to help you through the difficult bits in the construction of a project, explaining why it is done that

way. Most of the construction, however, will depend on how YOU want to do it, hand wiring, veroboard, mounting on to a printed circuit board (P.C.B.), it is up to you. It will still work!

ALL the projects have been built by the author, AFTER they were designed, and the book is made up of ONLY the successful ones! So this is not another designers daydream, as all the projects will work first time, if they are constructed correctly from the circuit diagrams and constructional notes given.

I would like to thank MIKE JOHNSTON for suggesting the idea and the readers of INTERFACE, the magazine of the NATIONAL ZX80 AND ZX81 USERS CLUB for their suggestions as to what was needed.

I hope that you will not stop at just building the projects in this book, but will expand them with your own ideas and applications. Any suggestions for more projects would be welcome.

STEPHEN ADAMS

The only projects that are exclusively for the ZX81 are projects that concern the ZX81's keyboard, i.e. the numeric pad, SHIFT lock and GRAPHIC's keys etc. The others are based on the PARALLEL or USER port available for both the ZX81 and other computers. They will work with the following computers:

1. ABC 24
2. ACT 800
3. ACT sirius 1
4. ADLER alphatronic
5. Altos ACS 800-2
6. Altos ACS 8000-10
7. ATOM
8. BASF 7120
9. Canon BX3
10. Comart communicator
11. Compucorp 625
12. Computermart 2000 DS
13. Cromenco system zero, system 2, system 3, system Z2H2627
14. Digital Microsystems DSC-4
15. Dynabyte
16. Equinox 200
17. Exidy sorcerer
18. Gemini 801
19. Haywood 3000
20. HP85
21. IMS 5000
22. IMS 8000
23. Ithaca DPS1
24. Mega micro
25. Microtan 65
26. Millbank sys 10
27. MSI 6816
28. MSI system 12
29. NEC PC 8001
30. Northstar Horizon
31. Onyx C8000
32. Oscar
33. Pascal micro engine
34. Pasca
35. Periflex 1024/64

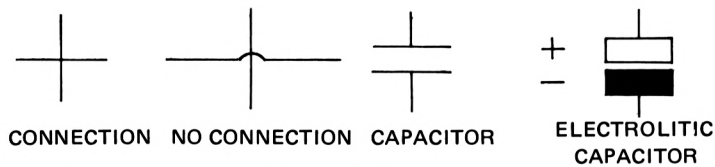
36. Periflex 630z564
37. PET
38. 380Z
39. S/09
40. SEED system 1
41. SHARP MZ-80B
42. Sinclair ZX80
43. Sinclair ZX81
44. Tandberg TG 8450
45. TANDY TRS80 Model 1
46. TANDY TRS80 Model II
47. TANDY TRS80 Model 3
48. TANDY TRS80 Colour Computer
49. Terodec CPC-1000
50. Terodec DPS 64/2M
51. TI99/4
52. Tuscan CP/M starter
53. Vector MZ
54. Vector system
55. Vic 20
56. VIP
57. VIDEO genie
58. Zebith WH-11A
59. Zilog MCZ
60. Z-PLUS
61. Acorn system 1
62. AEX-09
63. Cromeco SC
64. Hewart 6800S
65. Microaxis 1
66. MPC 09
67. Nascom 1
68. 77/68
69. 79/09
70. SBC100
71. Windrush 6801
72. ZCB
73. SGS Nanocomputer
74. Cifer 2684
75. Micron
76. APPLE
77. Quasar QDP-100
78. Olympia BOSS
79. Onyx Sundance
80. Powerhouse 2
81. Powerhouse 3
82. B.B.C. Microcomputer

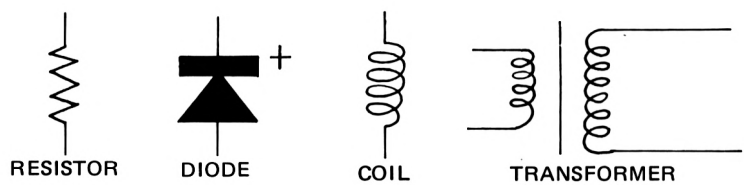
\+ ALL S100 based computers

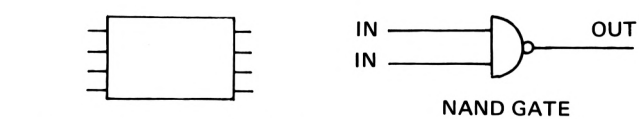
83. DAI personal computer
84. UK 101
85. Superboard

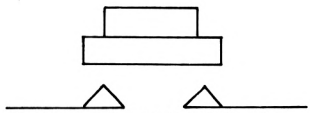
CIRCUIT DIAGRAMS

Circuit diagrams show the components and how they are connected. A circuit is any electrical arrangement. In order to understand what each component's symbol is, the diagrams below will give the symbol and its name. What it actually looks like is given in the back of the book. This covers only the components used in this book. There are thousands of different ones available to use with computers.





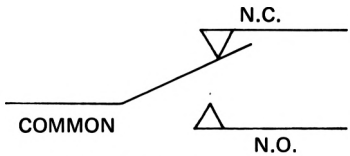




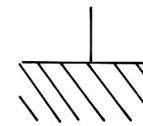
PUSH-TO-MAKE SWITCH



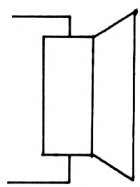
LOCKING SWITCH



CHANGEOVER SWITCH



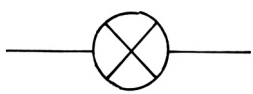
CHASSIS EARTH (METAL CASE)



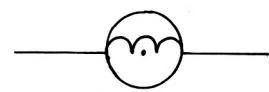
LOUDSPEAKER



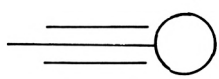
BATTERY



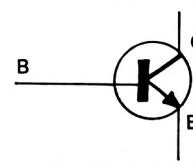
!NDICATOR LAMP (TORCH BULB)



MAINS LAMP



JACK PLUG



N.P.N. TRANSISTOR

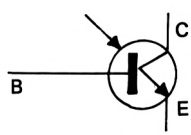
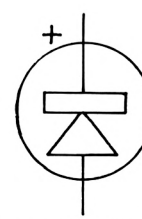
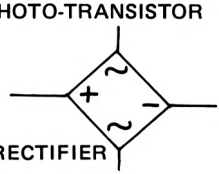


PHOTO-TRANSISTOR



LIGHT EMITTING DIODE (L.E.D.)



BRIDGE RECTIFIER

SOLDERING

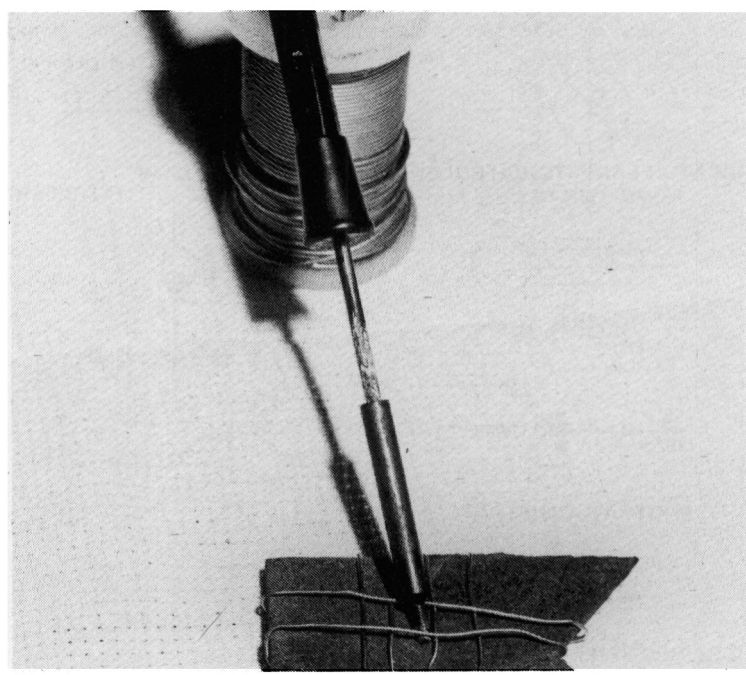
At sometime or other during this book you will have solder a connection between two components, so if you start practising now you will make fewer mistakes.

Firstly, NEVER have the power on anything which you are soldering, (MAINS or 5 volts) as even if it does not hurt you, it will definitely damage the equipment.

Use a low wattage soldering iron (15 watts is usual), selecting one that is earthed and has a small soldering bit. This makes it a lot easier not to overheat the components and ruin them. Always keep the tip of the iron clean by wiping it after using. If necessary, file off the black copper oxide which collects on the tip and tin the iron afterwards.

Tinning the iron consists of making a film of solder run over the tip of the iron, so that it is nice and bright. This makes sure that the iron has a good heat conduction to the joint and that the solder flows quickly.

Keep the hot iron in some sort of metal holder and switch it off if you are not using it, even for a few minutes. This saves wear on the iron and possibly burns to both clothing and yourself.



The solder should be of the resin cored type and if you can get the fine sort, all the better. Fine solder makes it easier to solder without connecting up adjacent tracks of copper or pins accidentally (shorting). Always have a container handy into which you can drop surplus solder, a small tin will do.

Clean both components with sandpaper and tin both surfaces, Connecting wire is usually tinned during manufacture.

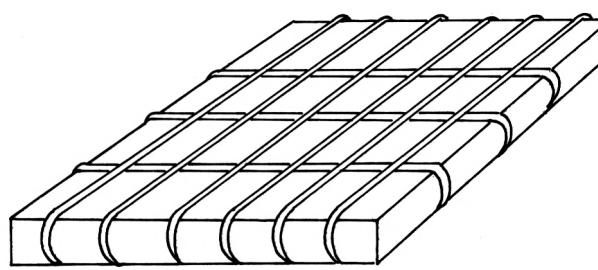
Apply the soldering iron to BOTH surfaces of the joint at once and then apply the solder. The solder should flow immediately over the joint and leave it bright when cold. Dull, grey joints are called dry joints and do not make good connections. If you get a dry joint, clean it up and do it again.

Remove the iron and the solder together as soon as the joint has been covered. Use a heat sink to protect the components and sockets, and to prevent the I.C.'s (Integrated Circuits) from cooking. A pair of metal tweezers can be used as a heat sink between the joint and the component. They can also be used for straightening out the I.C.s' pins before putting them in the socket.

After soldering the joint, cut off the surplus wire as close to the board as possible, a pair of short nosed side cutters is useful, but not essential.

To practise your soldering without using any components, wind some wire round a piece of wood in a criss-cross pattern as shown and try to solder up the places where the wires cross using the minimum of solder.

SOLDERING TEST BED



GETTING IN AND OUT OF THE COMPUTER

In order to make the ZX81 more useful, and allowing it to control things, we must first be able to send signals to and from the ZX81. A device to do this is called an INTERFACE.

Interfacing

An INPUT/OUTPUT port.

A common interface is an INPUT/OUTPUT port, this consists of one or several chips which will store any data sent to it and keep it available for an external device. It will also allow you to "see" through it to an external device. The maximum amount of data that it can store is eight Binary (TWO STATE) BITS, which consist of eight wires which have either +5 volts (binary 1) or 0 volts on them. The INPUT and OUTPUT ports are usually separate, so the data emitted by the output port is not affected by "reading" the input port. To tell if it is a READing operation or a WRITEing (OUTPUT) operation the ZX81 puts out two signals NOT WRITE ($\overline{WR}$) and NOT READ ($\overline{RD}$). The fact that either of these signals is at 0 volts (Binary 0), enables the operation to be done.

The device also requires a place where you know that you can collect and send your data. It is called an ADDRESS. The address applies only to this port and no other piece of equipment connected to the computer. The ADDRESS wires AO-A15 contain this number when the ZX81 wants to talk to your port.

There are several companies which produce INPUT/OUTPUT ports for the ZX81, but their ports fall into one of two categories.

One of these requires a special machine code routine to be written in order to get the data to and from the port. This is because they are treated differently to a normal memory location. They are in a separate memory map to the RAM (Random access memory), controlled by a signal called NOT INPUT/OUTPUT REQUEST ($\overline{IOREQ}$). When this line is at 0 volts ALL memory is switched off the memory map and replaced by locations numbered 0-255. Thus on INPUT/OUTPUT signals only ADDRESS lines A0-A7 need to be used. BUT because this is not available through B.A.S.I.C., a special machine code routine needs to be written.

The other type of port is a MEMORY MAPPED port, which is treated like a piece of RAM. It may be PEEK'd (transferred from the port into the program) or POKE'd (transferred to the port from the program).

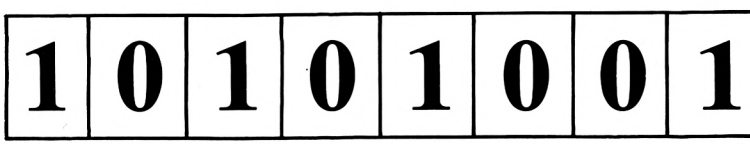
The ZX81 is not supplied with a users port, so one must be externally attached.

The PEEK and POKE are BASIC commands and can be included into a program in the following form:

PEEK 16396

POKE 16396,255

PEEK returns the number between 0 and 255 (the maximum number of combinations available from 8 bits). POKE puts a number between 0 and 255, which is after the comma, into the location in memory which is before the comma. No matter what method you use, you can only put in a number between 0 and 255. This is because we only have 8 bits (1's or 0's) at each location. These are numbered Bit 0 (B0) to Bit 7 (B7) as below.



Each bit represents a number in the multiplication table. The bit number gives the number of times 2 must be multiplied by itself, if it contains a BINARY 1 (1), i.e. if Bit 3 is Binary 1 then it represents $2 \times 2 \times 2$ or 8. If it is Binary 0 (0), then it represents exactly that Ø. One thing to watch out for is Bit 0, when it is Binary 1, represents an odd number e.g. 1. An example is that, if Bit 7 and Bit 0 are Binary 1 and the rest are Binary 0, it equals 128 + 1 (129). Try this for yourself with different numbers from bits to numbers and back again.

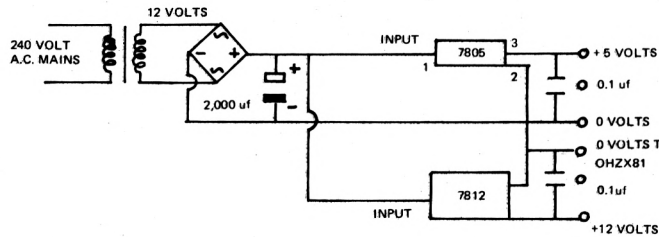
If you have trouble with converting numbers into bits then try this. Subtract the highest number below yours scoring a Binary 1 in this bit. Then do it again until you reach 0. (See example).

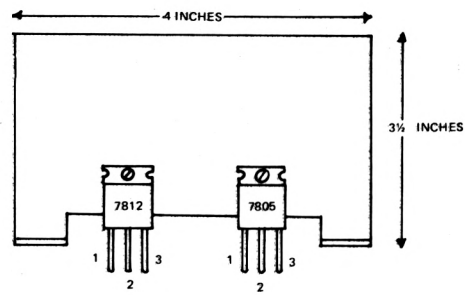
EXAMPLE

Number 28		4	
− 16	Bit 5 = 1	− 4	Bit 2 = 1
12		0	
− 8	Bit 3 = 1	Number 28 = 0 0 1 0 1 1 0 0	

All the rest of the eight bits must therefore be 0's.

Figure for Mains Operated D.C. Power Supply





QUANTITY	COMPONENT
1	TRANSFORMER 240/12 VOLTS 2 AMPS MINIMUM
1	BRIDGE RECTIFIER 6 AMPS
1	2,000 uf ELECTROLITIC CAPACITOR 35 VOLTS
1	7805 + 5 VOLTS VOLTAGE REGULATOR
1	7812 + 12 VOLTS VOLTAGE REGULATOR
2	0.1 uf 35 VOLT CERAMIC CAPACITORS
1	4 x 4 INCHES 18 SWG ALUMINIUM
SCREWS AND NUTS FOR VOLTAGE REGULATORS	

MAINS OPERATED D.C. POWER SUPPLY

To use most of the projects in this book an extra source of power is required as the + 5 volt internal regulator has enough to cope with in running the 16K RAM, printer etc. The first project in this book therefore is to build a power supply which gives us not only + 5 volts to run the integrated circuits, but + 12 volts to run lamps etc.

Construction

The design is based on two voltage regulator I.C.'s. These devices contain both current and voltage within certain limits and so must get rid of extra energy somewhere. It therefore gives off the energy in the form of heat through the metal tag on the back of the plastic block. It cannot however get rid of ALL this heat directly, so it must be connected to a large metal surface which will transfer the heat from the voltage regulator to the surrounding air. This metal surface is called a HEATSINK. The heatsink for this project needs to be at least four inches by four inches, and because it also needs to be light, is made of aluminium. The voltage regulator must transfer the heat at maximum efficiency because any surplus heat will "cook" the I.C., and one thing that ruins I.C.'s is heat. Therefore the metal tag must be screwed to the heatsink.

The metal tag is also one of the electrical connections of the voltage regulators (0 volts) and therefore MUST be kept away from any wires not connected to 0 volts. There is a gap between the two legs of the heatsink, to allow the other connections to be wired up safely. The heatsink legs are made of $\frac{1}{2}$ inch aluminium bent out by90° so that it stands up on its own. The legs should be fixed to a non metallic base, even the inside of a box as long as it has ventilation holes.

The transformer is the largest and heaviest component. It also carries mains voltage and should therefore be treated with care. The fully enclosed types have a metal casing, which not only means that enquiring fingers are kept away from the 240 volt mains, but also stops the transformer sending out magnetic waves, which could upset the I.C.'s. If you buy another type, make sure that all the 240 volt wiring is covered up before switching on the power.

NEVER WORK ON ANY EQUIPMENT CONNECTED TO 240 VOLTS A.C. MAINS, WITHOUT FIRST REMOVING THE PLUG FROM THE WALL SOCKET.

The rest of the construction of the power supply is a matter of choice, as long as you wire it up to the circuit diagram given. Don't forget to check that all the components that have a + connection are connected the right way round. The positive is usually identified by a red spot or in the case of the ELECTROLITIC capacitor, the centre connection, the metal case usually being the negative connection.

HOW IT WORKS

First of all the voltage in the house wiring is 240 volts A.C. (Alternating Current). This simply means that it changes direction fifty times a second. The LIVE (L) is first POSITIVE and the NEUTRAL (N) is NEGATIVE, then 1/50th of a second later, the NEUTRAL is POSITIVE and the LIVE is NEGATIVE. CURRENT (which is what provides the energy to do the work in an electrical circuit) flows from POSITIVE to NEGATIVE, so the current first flows one way and then the other (A.C.).

What we need is + 12 volts D.C. (DIRECT CURRENT) to feed into the voltage regulator integrated circuits. This is current that always flows from one terminal (POSITIVE) to another terminal (NEGATIVE), it never changes.

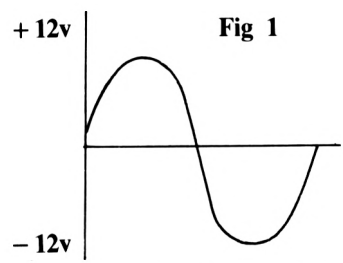
The first thing then is to get the 240 volts A.C. down to 12 volts A.C. and we can do this by a transformer. Transformers do not work on D.C. The transformer does this by using a different number of turns of wire for each coil, the voltage being dropped by the RATIO of the turns. Thus the 240 volt side has 20 times more turns of wire than the 12 volt side (240/12 = 20). This 12 volts A.C. is fed into a BRIDGE RECTIFIER which will only allow current to appear out of it when it is in the correct direction POSITIVE out of the POSITIVE terminal and NEGATIVE out of the NEGATIVE terminal).

Thus we have + 12 volts A.C. input (fig 1) and + 12 volts maximum D.C. output (fig 2). Notice that the two halves of the A.C. voltage are diverted by the rectifier bridge to the correct terminal. All the voltages are measured in respect of the 0 volt line in this book.

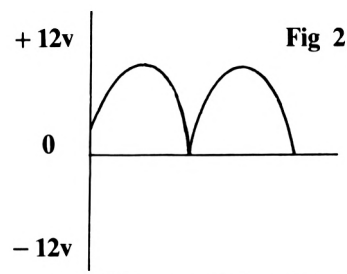
But the voltage coming out of the bridge rectifier varies from 0 to + 12 and back to 0 volts again, which is no good for what we want, we need a CONSTANT + 12 volts. So we insert an ELECTROLITIC capacitor which holds up the voltage when the output from the bridge rectifier drops to 0 volts, see fig 3. The voltage still varies slightly, but not as badly as in fig 2. The voltage regulators used are I.C.'s which will do two jobs for us. The most important one is, of course, that

each will further smooth out the voltage variations to either + 5 volts or + 12 volts (to within a few millivolts). The other is that it also prevents 'shorts' from damaging the power supply components. This prevents you causing any damage, if you accidentally solder the + 5 volts to the 0 volts.

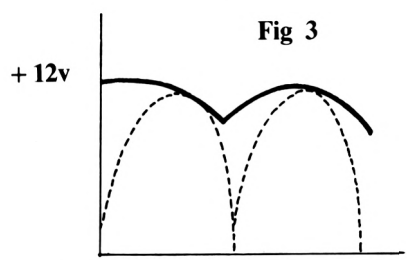
The last component is a 0.1μf capacitor which prevents the voltage regulators being affected by a sudden surge in voltage, from any circuit to which it is connected. This might damage the voltage regulator as it uses the output as a reference to see if any adjustment needs to be made. Voltage regulators use up spare voltage and current by creating heat, they must be kept cool by the use of a heatsink. The 240 volt supply should not be connected until this has been done, otherwise some damage might occur. The two voltage regulators are rated at 1 amp each of current and it means that they will NOT be able to supply any more than this. This also means that the transformer should be able to supply two amps in order to give one amp to each one. The voltage regulators may be changed at a later date to a higher current as long as the total current does not exceed the transformer or bridge rectifier rating. Voltage regulators of this type are only available up to a current rating of 5 amps.



A.C. with a transformer to 12v.

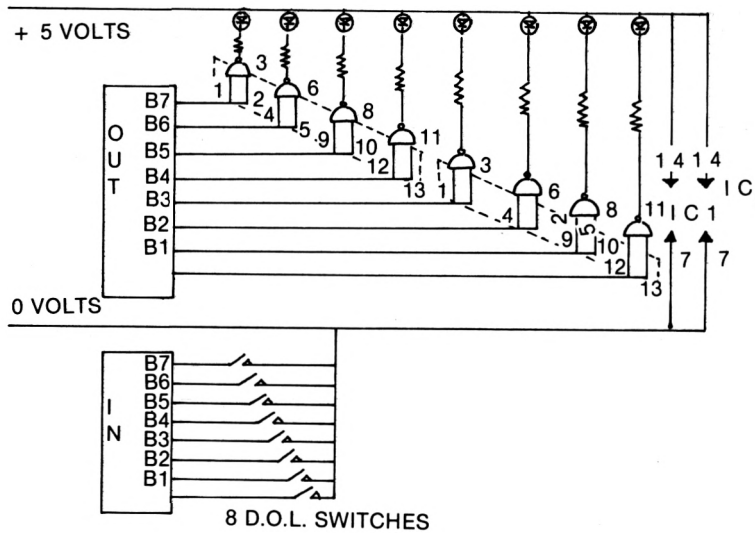


12v D.C. with Bridge Rectifier.

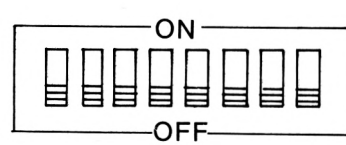


12v D.C. with Bridge Rectifier and Electrolitic capacitor.

Figure for A Monitor for an Input/Output Port



QUANTITY	COMPONENT
2	7400 I.C.
8	1.2K ohm RESISTORS, ¼ WATT
8	L.E.D.s (ANY COLOUR, ANY SHAPE)
8	D.I.L. SWITCHES SINGLE POLE
2	14 PIN I.C. SOCKETS
1	OUTPUT PORT
1	INPUT PORT
1	+ 5 VOLT SUPPLY (100 MA)



D.I.L.
8-WAY SWITCH

A MONITOR FOR AN INPUT/OUTPUT PORT

Now we have sixteen wires, eight wires for input and eight wires for output. These data lines are NOT connected to the computer data bus and are unaffected unless the ZX81 talks to the port. Therefore we can leave wires switched ON or OFF and watch the reaction from the equipment on the INPUT port. To test this, you can build a MONITOR which will tell you the state of the OUTPUT wires and allow you to set the state of the INPUT port.

The monitor consists of L.E.D.'s driven via a 7400 integrated circuit from the OUTPUT port and switches connected to the INPUT PORT, which when closed, connect their wires to 0 volts (Binary 0).

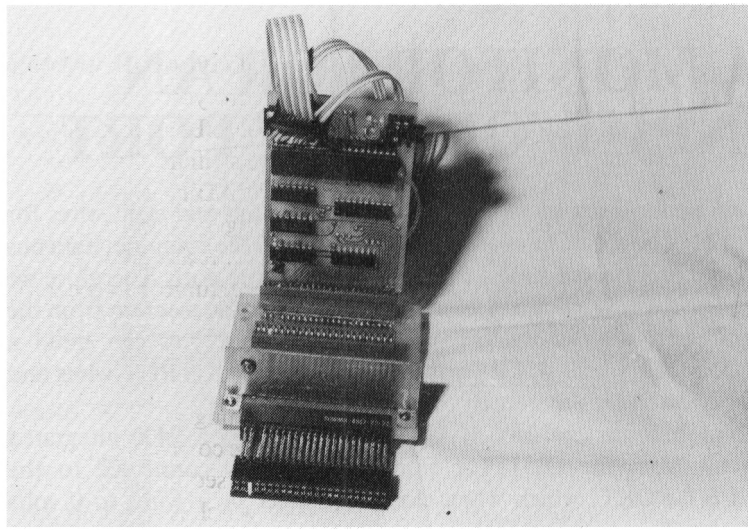
HOW IT WORKS: OUTPUT

The LOGIC GATES shown in the I.C. are NAND gates. There are four of them in one I.C. and they can only drive (operate) one L.E.D.per gate. Do not use other lamps such as torch bulbs as they will cause the I.C. to burn out. Also do not use more than one L.E.D. per gate. The L.E.D.'s can be any colour, but must be connected the right way round (see Appendix A). The resistors are used to stop the L.E.D.'s putting too much power through the I.C. and must not be lowered in value.

The Logic gates are only used as INVERTERS, so the two inputs to the NAND gate are connected together. This means that if the OUTPUT port wire is Binary 1 then the output from the NAND gate is Binary 0. If the OUTPUT port is Binary 0, then the output from the gate is Binary 1. The output is therefore the opposite of the input to the gate (INVERTED).

Remember that Binary 1 is + 5 volts and Binary 0 is 0 volts. Thus the L.E.D. has + 5 volts on both ends, when the input is Binary 0. When the voltage is the same at both ends of any circuit, NO CURRENT FLOWS. This is because it needs a voltage DIFFERENCE, and will then travel in that direction. If no current flows, no work is done by the electrical circuit and the L.E.D. will not light.

When the input of the gate is Binary 1, the output is 0 volts and current will flow in the direction of the arrow symbol making up the L.E.D. i.e. from positive + 5 volts through the resistor, through the



L.E.D. and down to 0 volts through the gate. Therefore the L.E.D. lights up when Binary 1 is input from the OUTPUT port.

The number of gates that the port will drive is usually given by the manufacturer but most will drive at least one more than it says, so we can leave the monitor on the port and be able to check what is happening all the time by looking at all the L.E.D.'s.

INPUT

The INPUT port is connected to very tiny switches which come in blocks specially made for printed circuit boards and an eight switch arrangement only takes up about an inch of space. That is the reason for using it here. If you have some switches available which will LOCK into the closed position then you can use those if you prefer.

If you have no connections to the input port, try PEEKing or READing from the port (the method depending on which type of port you have) and you should get 255. This is because the port contains resistors attached to each INPUT bit, which are connected to the + 5 volt supply at the other end. This means that each bit has + 5 volts on it (Binary 1), and all the bits produce the number 255 or 11111111 in Binary.

When one of the switches is turned to 'ON' or closed, this brings the INPUT bit down to 0 volts as the other end of the switch is connected to 0 volts. The port recognises this as Binary 0. Thus if all the switches were closed, the INPUT would be Ø or 00000000 in Binary. Try different combinations of switches, there are 256 in total, and see what numbers you get.

If you go back to the chapter about GETTING IN AND OUT OF THE COMPUTER, you can check the answers you gave against those of the L.E.D. for conversion from decimal to Binary and set up problems in Binary on the INPUT, by using the switches. the answer will be shown in decimal by PEEKing or READing the number received from the port. The ZX81 always changes Binary numbers received into decimal when you are using BASIC. It also changes the decimal number into Binary when OUTPUTing a number to the port automatically.

Construction

As has been said before, the most important thing about the construction of the monitor is getting the port bits the correct way round, otherwise you could end up with some very out of sequence numbers. Check the instructions for the port to find out which is which. If you are not sure, INPUT or OUTPUT multiples of 2 to make sure you have it the right way round. It is better to leave this bit on wires that can be changed if necessary. All the ports shown throughout the book are marked only with IN or OUT and with the bits that are being used (BO-B7), BO being the lowest bit.

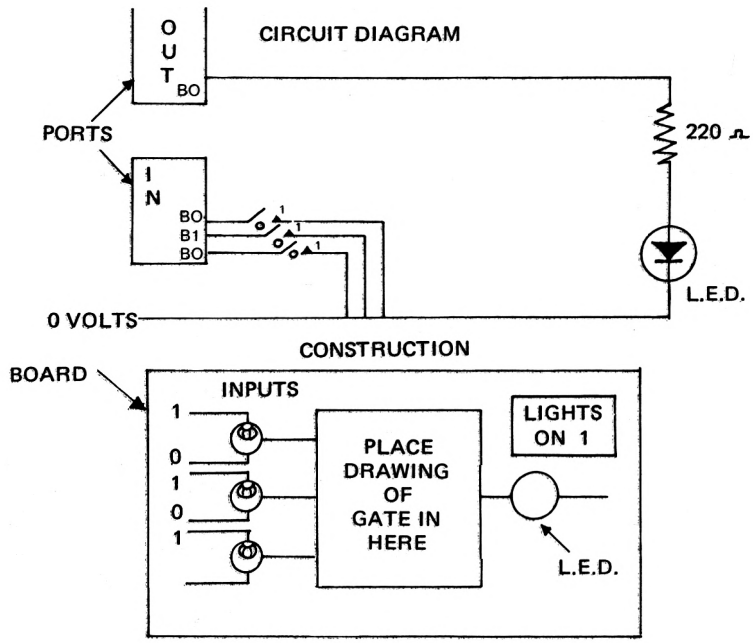
It is usually best to lay out the L.E.D.s in a line with B0 on the left and B7 on the right. The switches should be arranged in the same way underneath the L.E.D.'s.

The NAND gates are contained in two I.C.'s, therefore you must be sure that you connect up the I.C. pins the right way round. Check the physical numbering in the back of the book. Also remember that the L.E.D.'s have to be connected the right way round with the CATHODE connected to the I.C. gate, otherwise it will not light, but this will not cause any damage. The CATHODE of an L.E.D. is usually identified by the fact that it is always the biggest one (near the plastic casing). The I.C.'s should be inserted into the socket ONLY after you have checked that the socked is wired correctly. The resistors are identified by the three coloured bands on one end and you can check that they are the right value by checking against the chart in the back of this book. It does not matter which way round you connect the resistors or the switches as they will operate both ways.

How you wire it up I leave to you, as it does not matter, and as long as only the connections shown are made, it should work perfectly. You can buy tag boards to hold all the components or make up a printed circuit board or just use insulated wire going from one com-

ponent to another. Double check before you attach any power supply that there are no "shorts" and that the connections are correct. The 0 volts of the ZX81 should also, of course, be connected to the 0 volts of the power supply otherwise nothing will work.

Figure for A Universal Gate



QUANTITY	COMPONENT
1	INPUT/OUTPUT PORT
1	LIGHT EMITTING DIODE (L.E.D.)
1	220Ω RESISTOR (¼ WATT)
3	LOCKING SWITCHES
1	WOODEN BOARD

A UNIVERSAL GATE

The purpose of this project is to make a demonstration model of a LOGIC gate, the ZX81 can use the gate for anything you wish. There are three inputs (B0-B2) to the INPUT port, but there could be as many as eight, each one using one bit. Each INPUT bit can be set to Binary 1 or Binary 0 using the switch provided. Internal resistors in the INPUT port chip mean that if nothing is connected to that bit, it is set to Binary 1 (+ 5 volts). By closing the switch, connected to 0 volts, this INPUT can be changed to Binary 0. The switch position is marked on the board as an INPUT to the gate (which is drawn on a piece of paper).

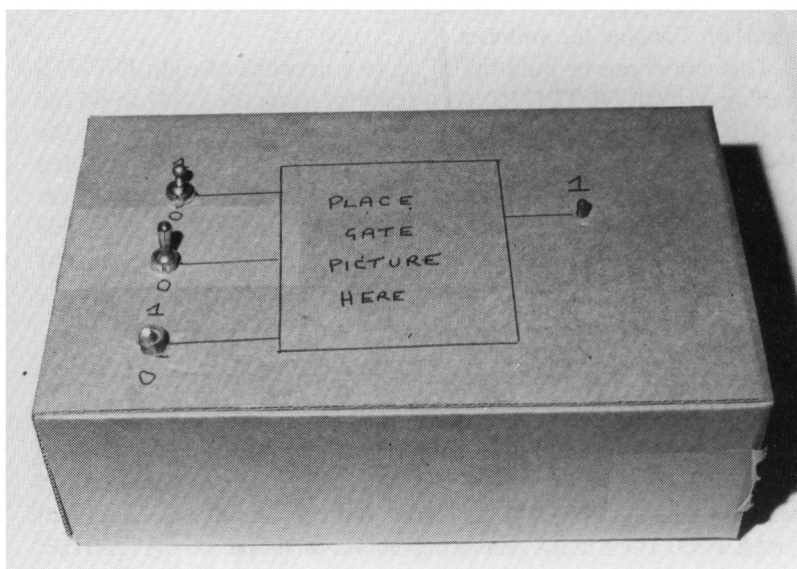
The ZX81, having computed what the output should be, lights the LIGHT EMITTING DIODE (L.E.D.) if the OUTPUT is Binary 1. The LOGIC of the gate can be changed by calling a different subroutine within the program given, and changing the piece of paper with the gate drawn on it. The gate could be selected by a random number and a pupil asked to fill in the gate by looking at the result of changing the switches.

This model can be built upon, up to a network of eight INPUTS and up to eight OUTPUTS. As a result of using the ZX81 to do the LOGIC of the gate, quite a complex network can exist between the INPUTS and the OUTPUTS. If you intend to use more than one L.E.D. as an OUTPUT, then it is best that you do not attach them direct to the OUTPUT port or it may cause damage. You can safely drive up to four L.E.D.'s from a 7400 I.C. as shown in the MONITOR project. The 7400 and 74LSOO are exactly the same except that the 74LSOO draws less power to work the chip.

Construction

The resistor is a 200 ohm (Ω) resistor, and limits the current flowing through the L.E.D. and the OUTPUT port. It is required to stop any damage to the port or the L.E.D. by excessive current from the + 5 volt line, through the OUTPUT chip to the 0 volt line via the resistor and L.E.D. The L.E.D. can be any colour or shape. Its CATHODE, which is connected to the 0 volt line, can be identified by the fact that it is larger, and nearer the plastic encapsulation, than the ANODE. All diodes have one cathode and one anode, so it is best to make a note of these words.

The circuit uses 'locking' switches which stay in whatever position they have been put. Another word for 'locking' switches is 'toggle' switches. They are the same as those used to switch electric lights on and off at home. The wiring to the computer INPUT port should be kept short (about 18 inches to 2 feet), as longer wires would pick up noises from radios and other equipment. These noises could cause a wrong reading of the switches if they were left in the Binary 1 position. As long as there is a current flowing (i.e. when the switches are connected to 0 volts) this will not affect the input, but when an INPUT port is just connected to a long piece of wire, it can act like a radio aerial picking up all sorts of electromagnetic interference.



The Program

```
 1Ø    DIM N(8)
 2Ø    LET IN = PEEK PORT
 3Ø    REM USE USR IF NECESSARY
 4Ø    REM GET BITS
 5Ø    FOR X = 7 TO Ø STEP – 1
 6Ø    IF 2 **X> IN THEN GOTO 9Ø
 7Ø    LET N(X + 1) = 1
 8Ø    LET IN = IN – (2 ** X)
 9Ø    NEXT X
1ØØ    PRINT ''2.AND 3.OR 4.NAND 5.NOR''
11Ø    INPUT IN
12Ø    IF IN> 5 OR IN< 2 THEN GOTO 11Ø
13Ø    GOSUB IN * 1ØØ
14Ø    POKE PORT,X
15Ø    REM USE USR IF NECESSARY
16Ø    INPUT A$
17Ø    CLS
18Ø    GOTO 1Ø
2ØØ    LET X = N(1) AND N(2) AND N(3)
21Ø    RETURN
3ØØ    LET X = N(1) OR N(2) OR N(3)
31Ø    RETURN
5ØØ    REM INVERTED COMES HERE
51Ø    GOSUB (Y – 2) * 1ØØ
52Ø    LET X = NOT X
53Ø    RETURN
```

Lines 50 - 90 allocate a '1' to the appropriate N(X + 1) where X is the bit being tested. The test consists of finding out if the number being tested is equal to, or greater than, the value in decimal for that bit. 'Decimal' is the numbers we normally use when we count on our fingers and is called the BASE 10. In other words when the count reaches 10 we have two digits instead of one as in 1 - 9. Binary is to the BASE 2 and adds another digit when the count reaches 2. Since DIM N(8) sets all eight numbers to zero, any number which comes through the jump to line 90 willk be a 0. If N(X + 1) = 1 then the equivalent decimal number for that bit is subtracted from total before testing the next bit.

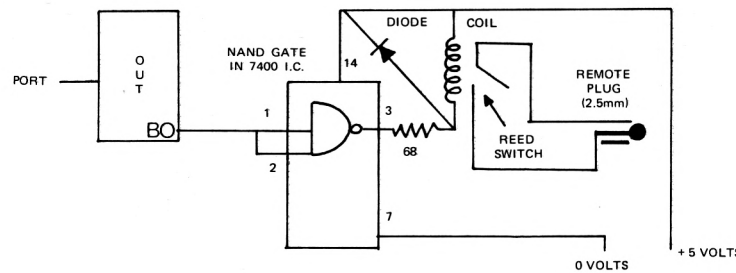
Lines 100 - 130 gives the operator a choice of gates, and selects by calculating the subroutine from the INPUT IN. If the INPUT is 4 or 5 subroutine 500 is called. The Sinclair BASIC assumes that if it cannot find line 400 then the next line is the correct one. In this case line 500.

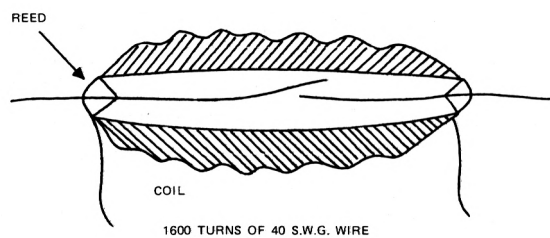
Line 140 lights the L.E.D. by setting bit 0 to Binary 1 if X = 1.

Subroutine 500 calls the appropriate routine then INVERTS the result, i.e. if X = 1 then X = Ø and if X = Ø then X = 1.

ALL OF THE PROGRAM WILL FIT INTO A 1K ZX81.

Figure for Tape Recorder Control





QUANTITY	COMPONENT
1	OUTPUT PORT
1	7400 (OR 74LS00) I.C.
1	68 RESISTOR, ¼ WATT
1	NORMALLY OPEN REED SWITCH
70	FEET OF 40 S.W.G. WIRE
1	2.5 MILLIMETRE JACK PLUG
1	SIGNAL DIODE (ANY TYPE)
1	+ 5 VOLT POWER SUPPLY

TAPE RECORDER CONTROL

The tape recorder control shows how the ZX81 can control reed relays and how useful they can be. A reed relay can isolate the controlling equipment from the equipment to be controlled and the supply voltages can be totally different. The current-carrying capacity is also only limited by the capacity of the switch. The reed we are using can carry up to 125 volts, D.C. or A.C., up to a current of 1 amp. An example of how useful they can be, is that most electronic telephone exchanges use reed relays.

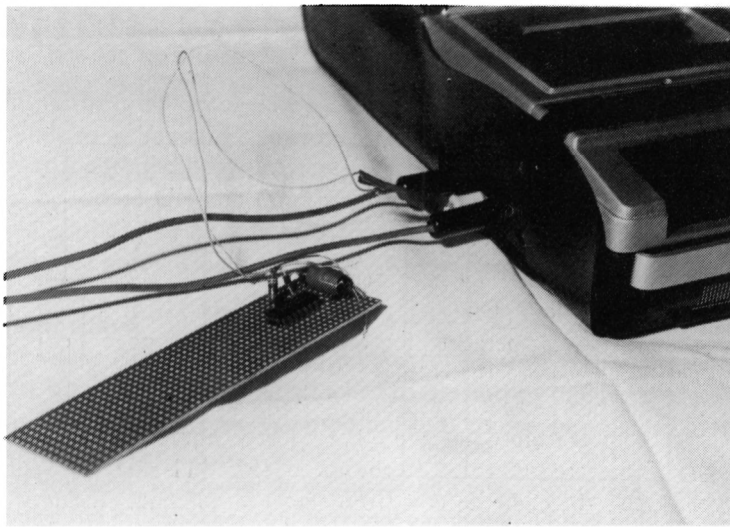
What then is a reed relay? It consists of a glass tube containing two fine magnetic strips, each having the same magnetic pole at its tip. As like poles repel, the strips are kept apart and the switch open. When a magnet is introduced, it overcomes the strips' magnetism and the switch closes. The glass tube contains a vacuum, which means that the contacts never get dirty or corrode. This magnetic field may be supplied by a simple bar magnet and can be seen operating some Burglar Alarms. A magnet is fixed to the movable part of the door or window and the reed is opposite, on the frame. Whenever the magnet moves away from the reed the circuit is broken and the alarm rings. The magnet can also be an electromagnet, which is what we shall use.

Our magnet will consist of a coil of wire which, when a DIRECT CURRENT (D.C.) is passed through it acts just like a magnet. Alternating current (A.C.) will not produce a magnet. The coil is wound directly over the glass reed and consists of 1600 turns of 40 S.W.G. enamelled wire. S.W.G. means Standard Wire Gauge, which indicates the diameter of the wire. The 40 S.W.G. wire is quite thin and the enamel coating insulates the wire. The enamelling needs to be scraped off the wire at both ends of the coil using sandpaper before you will be able to solder it. The coil is best wound using a hand drill held in a vice by the handle. The reed is first insulated from the coil by winding one layer of insulating tape around it. Then it is placed in the jaws of the drill and LIGHTLY gripped. Tape the end of the wire to the chuck (the bit that you turn to tighten the jaws) and start to turn the handle. Hold the wire taut with one hand and turn the handle of the drill with the other remembering that one turn of the handle gives many turns of the reed. The coil does not have to be absolutely accurate, so a few turns more or less will make no difference.

Once the reed relay has been made up, the rest of the circuit can be started. Only one gate of the I.C. is shown (there are four in total) the other gates can be used to drive more reed relays if wished. The connections are shown in the monitor project. The 68 ohm resistor limits the current through the gate, but still leaves enough to operate the coil. The diode is there just to protect the I.C. When the current to the coil is turned off, the magnetic field collapses, and in doing so creates another voltage, opposite to the one initially created. Although this voltage only exists for a few microseconds, the voltage created can be quite large. The diode, being a one-way device, will not affect the circuit when the coil is operating, but when the reverse voltage occurs, it conducts, which shorts the voltage out.

The circuit works as follows: The bit 0 of the output port goes to Binary 1, which because the gate INVERTS the input signal, sets the output of the gate to 0 volts. As the end of the coil is now at 0 volts, current flows through the coil from the + 5 volt line, closing the switch. The closing of the switch turns on the cassette motor ready for LOADing or SAVEing. When the bit 0 is returned to Binary 0, the output of the gate is restored to + 5 volts and there being + 5 volts on both ends of the coil the switch opens. This turns off the motor of the cassette recorder.

The following shows how to make use of this in programs, it may also be used to SAVE and LOAD data, if you want to write your own machine code routines.



PROGRAM

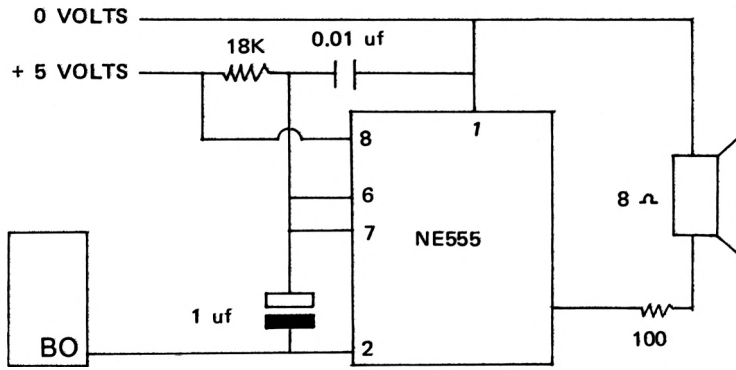
SAVE

```
2000  PRINT''PRESS PLAY AND RECORD BUTTONS''
2010  PRINT''THEN PRESS NEW LINE''
2020  INPUT A$
2030  POKE PORT, 1
2040  REM USE USR IF NECESSARY
2050  SAVE''TAPE''
2060  POKE PORT, 0
2070  REM REST OF PROGRAM
```

LOAD

```
1000  POKE PORT,1
1010  LOAD''TAPE''
1020  REM REST OF PROGRAM IGNORED
```

Figure for Mini-Tone



QUANTITY	COMPONENT
1	OUTPUT PORT
1	8 OHM LOUDSPEAKER
1	18K OHM RESISTOR, ¼ WATT
1	100 OHM RESISTOR, ¼ WATT
1	1 uf ELECTROLITIC CAPACITOR 15 VOLTS
1	0.01 uf CERAMIC CAPACITOR
1	NE555 I.C.
1	+ 5 VOLT POWER SUPPLY 200 MA

MINI-TONE

One of the disadvantages of a ZX81 is not having a means of making sounds to accompany games etc. This project goes part of the way towards curing this by providing a cheap, one note oscillator which can be turned ON and OFF by an OUTPUT port. Only one bit is used, so the other bits can be used to control other things, even seven other one note oscillators.

Construction

The whole circuit can be built on a small piece of veroboard, complete with loudspeaker and attached to the port by one piece of wire. The 0 volt line of the power supply must, of course, be attached to the 0 volt line of the ZX81.

If you wish, or the family get upset with your monotone, you can change the loudspeaker to a personal earphone. This should be of 8 ohms impedence and should be of the same type as can be used for portable radios, tape recorders etc.

The 1 μf capacitor is not a critical component and could easily be changed for another of lower value. It could even be changed to an ordinary capacitor, try it and see. The 18K ohm resistor controls the frequency of the tone generated and a 50K ohm variable resistor could be substituted, in order to alter the frequency. the I.C. should be fitted into a socket, if you are not confident about soldering it. Although the I.C. is quite heat-tolerant, a socket also means that you can check all the connections before inserting the I.C.'s. The layout of the components is not critical, I have left that up to you.

HOW IT WORKS

Before we have a look at what the I.C. does, it is important to find out something about capacitor's, as the circuit depends on their use.

A capacitor is like a large water cistern. If the cistern is empty, the capacitor is said to be DISCHARGED. To fill the cistern with water, we need to open a tap which will allow a certain rate of water into the cistern. We call this CHARGING the capacitor. Now, the length of time the cistern takes to fill, or become COMPLETELY CHARGED depends on two things, the size or capacity of the cistern and rate at which the water flows into the cistern (current). In an electrical circuit, this consists of the capacitors CAPACITANCE in FARADS and the rate at which the current flows depends on the circuit's

RESISTANCE in OHMS. As in a cistern of water, when it is full, the capacitor will not take any more current.

As a one FARAD capacitor would take up the size of a large room, we have to use some smaller unit of capacitance. This is called a MICROFARAD and is 1 millionth of a FARAD, that is 1×10^{-6} FARADS.

What we are interested in however, is the TIME taken to charge the capacitor. This can be worked out by multiplying the CAPACITANCE in FARADS by the RESISTANCE in OHMS. If the resistance or capacitance is lowered (just like increasing the capacity of the tank or opening the tap some more), the TIME taken will go down. As it is not easy to change the high capacitance values we are using, it is easier if we change the resistance instead.

The NE555 I.C. compares its input (pin 6) constantly with its supply voltage (in this case + 5 volts) and if it is lower than two thirds of the supply voltage, it outputs + 5 volts on pin 3. When the input reaches two thirds of the supply voltage, the I.C. connects pin 7 to 0 volts and changes the output to 0 volts. This will now stay in this position until it receives a pulse of 0 volts on its pin 2 (down to 0 volts from the normal + 5 volts and back again). This is called the TRIGGER input pin and it will operate in reaction to pulses as short as one microsecond. The I.C. then outputs + 5 volts on pin 3 again and starts the whole thing over again. The time taken to reach two thirds of the supply voltage will depend on how long the capacitor takes to charge on pin 6 and pin 7. The capacitor voltage rises, relative to the charge it has taken in. When the pin 7 (the discharge circuit) changes to 0 volts, the capacitor will be drained of all voltage as there is 0 volts on both ends, i.e. a short. The capacitor will not be able to charge up again until this short is removed as it bypasses the current to charge the capacitor. When, however, pin 2 is pulsed to 0 volts again, the discharge circuit (pin 7) disconnects the 0 volts and the capacitor starts to charge again, through the current supplied by the 18K ohm resistor. The circuit only charges up the 0.01μf capacitor, as the 1μf capacitor is already connected to the + 5 volts at the pin 2, and is discharging (as the other end is rising to + 5 volts). Having the same voltage at both ends of the capacitor is just like shorting it out, remember?

As the 0.01μf capacitor fills up, the voltage on pin 6 rises, when it has reached two thirds of the supply voltage (3.33 volts), the discharge circuit operates and discharges the 0.01μf capacitor, providing pin 2 with the pulse it needs to get started again. This is because pin 2 starts

off at 0 volts (the 1μf capacitor was discharged) and as the 1μf capacitor charges up, pin 2 slowly returns to +5 volts. All this charging and discharging of the 0.01 capacitor causes the output to change between +5 volts, 0 volts and back again. This changing voltage causes a change in the current flowing in the loudspeaker. Thus the loudspeaker cone moves in and out, the result being the tone, at a frequency which is determined by the capacitor's charging and discharging.

The frequency of this tone can be calculated by the time taken to charge the capacitor to two thirds of the supply voltage divided into 1. This will give us the number of cycles in one second, the frequency. The frequency therefore equals $1/R \times C$ approximately, where R is the resistance in OHMS and C is the capacitance in FARADS. In our example $1/0.01 \times 10^{-6} \times 18 \times 10^{3}$ which equals a frequency of 5,555 cycles per second.

The next question is; how do we control it from the ZX81?

If the pin 2 is at +5 volts, (Binary 1) then all works normally and this is guaranteed by connecting it to the OUPUT port BO. If however the BO of the port changes to 0 volts (Binary 0), then the pin 2 cannot get back to +5 volts in order to start again. Thus the tone is only heard when the output port is Binary 1.

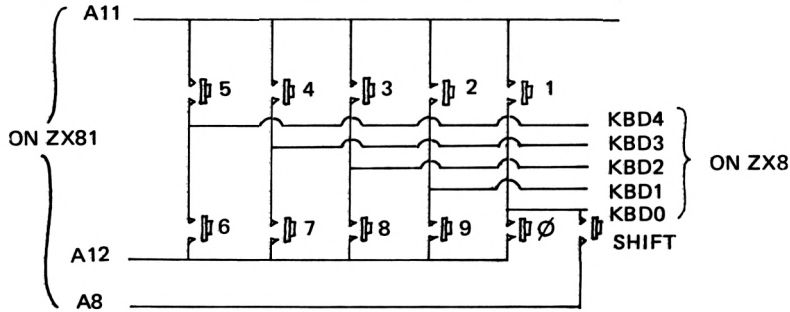
All we need to do then is to alter BO by changing the number poked into the port from an odd to an even number to turn the tone first ON, then OFF. A program to demonstrate this is shown below.

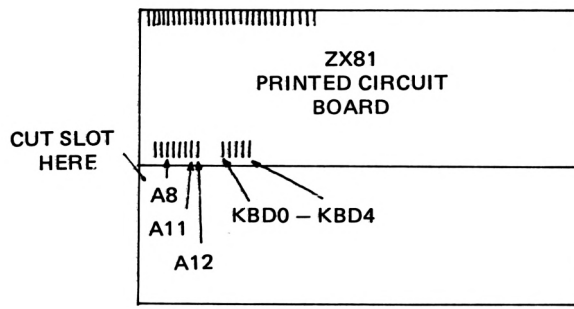
THE PROGRAM

```
10    FOR X = 1 TO RND*50
20    POKE PORT,1
30    NEXT X
40    POKE PORT,0
50    POKE X = 1 TO RND*50
60    NEXT X
70    GOTO 10
```

The program turns the tone on and off for a time determined by a random number between 0 and 50, generated by using the command RND.

Figure for A Numeric Keypad for the ZX81





QUANTITY	COMPONENT
11	KEYBOARD 'PUSH-TO-MAKE' SWITCHES
8	PIECES OF WIRE 18 INCHES LONG
1	BOX

1	2	3
4	5	6
7	8	9
SHIFT	Ø	

SUGGESTED LAYOUT

A NUMERIC KEYPAD FOR THE ZX81

The ZX81 keyboard is a matrix of switches which each connect ONE address line and ONE data line input. As there are five data inputs (KBDO-KBD4) and eight address lines to the keyboard, the maximum number of combinations is forty ($8 \times 5 = 40$) keys.

The numbers keys are usually the most used, and are not very convenient keys to use when great accuracy is required. If you use number keys a lot in games or business programs, you might like to build a separate numeric pad. This will enable you to speed up the entry of numbers because you can "feel" the keys positively hitting the end stop, and thus release it quickly. As the Sinclair Keyboard is made out of three thin pieces of plastic film, there is very little distance between the top and the end stop of the key movement (0.1 inch). It is therefore not easy to tell whether you have pushed the key down far enough to make the switch close. The movement of most keyboard "PUSH TO MAKE" switches is at least 0.5 inch, which gives the keys much more positive feel when pressed.

The best type of key switches to use are those with a removable clear plastic top. You can then place a piece of paper under the covers, on which the keyboard symbols can be written. Eleven keys are required, as the numbers Ø-9 are not a lot of use if you cannot RUBOUT any mistakes, except by going back to the Sinclair keyboard. The RUBOUT key requires the pressing of two keys together, Ø and SHIFT. Therefore the SHIFT key must be included on the numeric pad. Pressing the SHIFT key on its own does nothing, so hitting it accidentally does not give an error on INPUT.

Having the SHIFT key on the numeric pad also means that all the cursor moving keys are also available, SHIFT 5(←), SHIFT 6(↑), SHIFT 7(↓) and SHIFT 8(→). These can be used to quickly EDIT programs, along with the EDIT key which is SHIFT 1. As all of these keys can be reached with one hand if they are grouped in a square, it means the other hand is free to do other things, such as follow a program in a book or a set of data to be INPUT. This can be very useful, as it is easy to lose one's place when trying to watch the screen and the written program at the same time.

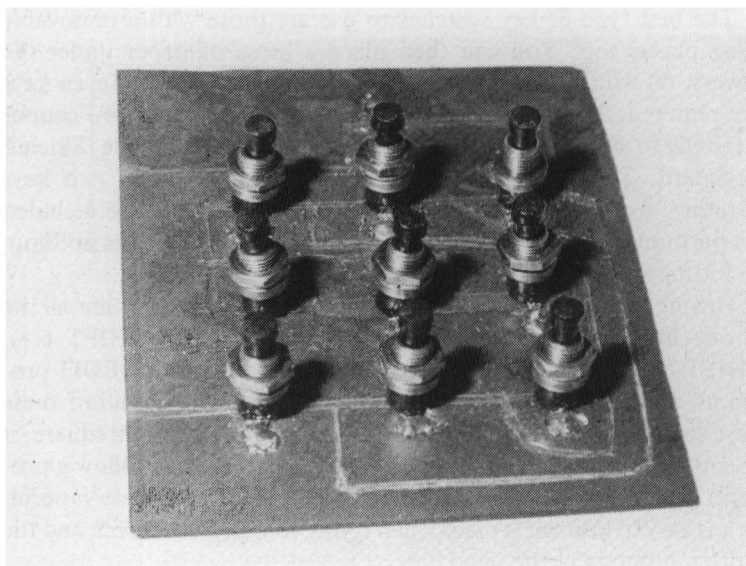
Construction

As the keys 1-5, 6-Ø and SHIFT are all on different address lines, all three must be included on the numeric keypad. These are A8 (SHIFT), A11 (1-5) and A12 (6-Ø). We also need ALL of the (K)EY-(B)OARD-(D)ATA lines (inputs to the computer) KBDO — KBD4.

The keyboard port KBDO-4 is addressed by the ZX81 ROM as INPUT PORT 254 (FE in HEXADECIMAL). BUT because of the way Sinclair addresses his ports, the keyboard port appears at every EVEN INPUT PORT address. That is when address line AO is at Binary 0, the $\overline{\text{IOREQ}}$ and the $\overline{\text{WR}}$ are Binary 0.

The upper eight address lines (A8-A15) reflect what was in the B register at the time of calling for an input from the port. So the setting of a bit in the "B" register to Binary 0 addresses that key (the address line to 0 volts) and then looks at the result on the data lines. When a key is pressed, the appropriate data line will also be Binary 0.

These actions are all done by the BASIC ROM when using INPUT or INKEY$. This information has only been included for the machine code programmer.



We must open up the casing of the ZX81 to get at the connections on the printed circuit board inside, and thereby the data lines.

If you turn the ZX81 upside down, you will see four stuck-on rubber feet. Under three of these feet are screws which need to be removed before the case can be opened. They are under the front two feet and the back left side foot. There are a total of six screws to be removed, ALL of them need to be removed with a small-headed screwdriver, in order not to damage the slot in the screw. Once the screws are taken out, the bottom half of the casing can be removed and the printed circuit board can be seen in the top half, secured by two more cross-cut screws into the top casing. By the bottom left hand side of the printed circuit board you can see the two white plastic strips which connect the Sinclair keyboard to the printed circuit board. These must not be damaged by dropping hot solder on them, so cover them up with a piece of paper. These keyboard strips go into two sockets on the underside of the printed circuit board. The solder strips on the top of the printed circuit board which connect the sockets to the rest of the ZX81 is where we will solder the wires, which we will use to attach the numeric keyboard.

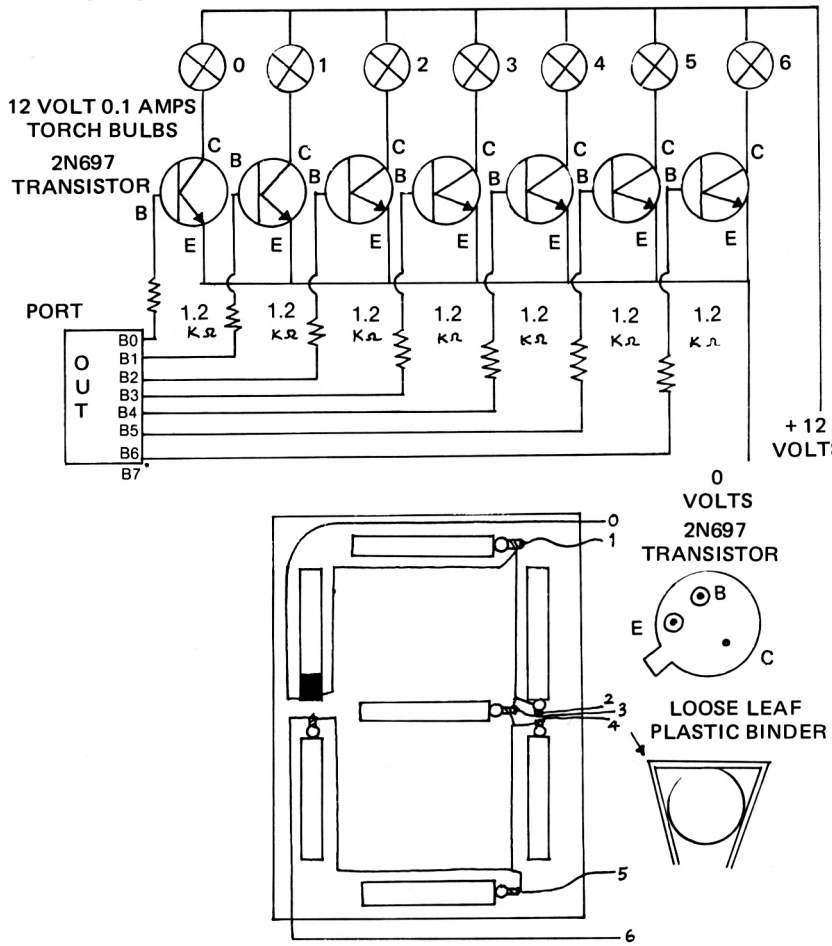
These solder connections consist of a group of eight address strips and a group of five KBD strips. Soldering onto these strips, will NOT disconnect any of Sinclair's keyboard functions. None of the wires connecting the ZX81 and the numeric keypad must be over 18 inches long or this causes problems in operating BOTH keyboards. Also make sure that no shorts are made between the strips (see the SOLDERING instructions).

A slot must be cut in the left hand side of the bottom casing to lead the wires out. This may be done by making two saw cuts $\frac{1}{2}$ inch apart, $\frac{1}{4}$ inch deep, with a small hacksaw. Then with a pair of pliers, grip the area between the saw cuts and bend the plastic backwards and forwards until the piece breaks off.

The wiring to the keys in comparison to the ZX81's is a piece of cake. The connections are shown in the circuit diagram. The keys have only two tags and these can be connected either way round. The address lines connect five keys and must be wired from key to key, using the wire now attached to the ZX81. There is only one data line (KBD) to each key and only one address line to each key. The SHIFT key only must be wired to address line A8.

The Keys can be arranged in any order you like, but a suggested layout is given which gives an ergonomic (work saving) device. It is not worth buying cheap push buttons, instead of keys, as they only work intermittently and it is better to have reliable ones.

Figure for Giant Seven Segment Display



QUANTITY	COMPONENT
7	12 VOLT 0.1 AMP TORCH BULBS
7	2N697 N.P.N. TRANSISTORS
7	1.2 K RESISTORS
1	OUTPUT PORT
7	½x¼x4 INCH PERSPEX
1	+ 12 VOLT SUPPLY (1 AMP)
1	BLACK PAINTED BOARD

GIANT SEVEN SEGMENT DISPLAY

This is a giant version of a seven segment display used in pocket calculators, and when mounted on a board, gives a display of over one foot high. It can be used for all sorts of sporting events and as it runs from a + 12 volt supply may be run off batteries or mains. Its attachment to the ZX81 means that an automatic scoring system can be implemented with a constantly updatable display, big enough for anyone to see. Each of the seven elements can be lit separately so you are not restricted to just the numbers 0-9. There are over 127 combinations of the seven segments available.

Construction

Seven pieces of CLEAR perspex need to be cut, four inches long, $\frac{1}{2}$ inch wide and $\frac{1}{4}$ inch thick. A junior hacksaw is best suited for this purpose. The $\frac{1}{4}$ inch edge is then glued with an impact adhesive to the black back board. The top should now be $4 \times \frac{1}{4}$ and be ridged by the saw cuts.

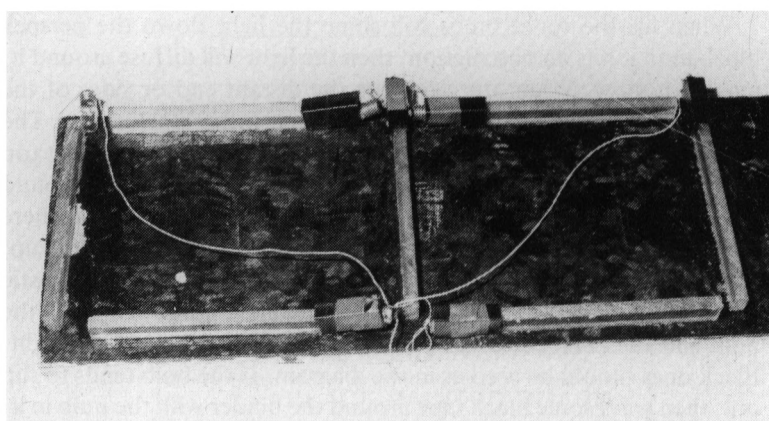
It is necesary to have rough edge at the top as we need to diffuse the light through the ridges into the perspex. Otherwise a lot of the light is lost bouncing about inside the perspex block off its shiny walls. The six other pieces of perspex are than glued on to the board as shown in the diagram, leaving plenty of space to fit in the bulbs. The actual size covered by the perspex is up to you, but do not move them too far apart, otherwise the whole display will look peculiar.

When lit, the torch bulbs will shine the light down the perspex block until it hits an obstruction, then the light will diffuse around it, making it glow. When the light hits the distant end or sides of the block, most of the light is reflected back into the block again. The only part of the block which should glow then, is the saw cuts at top and bottom. When the block is not lit, then the black background shows through. The bulbs point down the perspex, as this is where most of the light comes out. The rest of the bulb must be covered up, so only the glow of the perspex can be seen. I have found that plastic loose leaf binders, when cut up into one inch lengths, grip both the bulb and the perspex, while quite effectively shutting out the light. Black ones should be used as in the diagram. If the bulb tends to slip out, then wind some black tape around the binder with the bulb in it.

The binder can be glued to the end of the perspex, if you wish to make it permanent, it still allows you to extract the bulbs when they need changing. The screw of the bulb should be connected to all the other bulb screws and then one wire only is required to go to the positive terminal of the + 12 volt supply. The "pip" should be wired away to the COLLECTOR (C) of the transistor. The length of the wires connecting the transistors and the display can be quite long, provided that the length of the wires does not have enough resistance to drop the current to the bulb. The longer the wires, the greater the resistance.

The wiring can be tidied up more than that shown, by making holes in the board and taking all the wiring to the back of the display, using the binders to cover up the holes.

The transistors shown have metal cases, which are connected to the collector (C), so the cases of the transistors must not be allowed to touch each other. Also, do not allow any bare wires near them, as they are easily damaged. Always leave plenty of length on the leads of the transistor and before soldering them, cover them with some sort of insulated tubing. When soldering, ALWAYS use a heat sink. This can be just a pair of pliers gripping the metal of leads between the soldering iron and the transistor. All of the transistors' EMITTERS (E) are connected to the 0 volts line (this must also be connected to the ZX81's 0 volt line). The (C) COLLECTORS are all connected via their torch bulb to the + 12 volt line. The transistors are therefore only being used as a switch to turn ON and OFF the torch bulbs. When the port bit goes to BINARY 1, the voltage at that bit is + 5 volts (because it is connected to the + 5 volt line not the + 12 volt



line). This means that the voltage difference between BASE (B) and the EMITTER (E), which is at 0 volts, is + 5 volts. Now a transistor's resistance (between the collector and emitter) varies from very high to very low depending upon what the base voltage is. If the base (B) is connected to 0 volts, the resistance (from the collector to emitter) is so large and the current flowing through it so small, that the torch bulb will not light. If, however, it has a voltage of only + 0.6 volts on the base, it starts to drop its resistance. If + 5 volts is applied to the base, then the resistance is so low that it will pass all the current which the torch bulb needs to light (almost 0 ohms). The transistor is turned OFF by setting the port bit to Binary 0(0 volts). A transistor is used because the torch bulb takes 0.1 amp of current to glow brightly enough to be seen properly. If you used an I.C. to switch this current, it would soon overheat and blow up inside. The transistor 2N697 can take up to 0.5 amp quite safely, without over heating. The transistor should only be used on a D.C. (Direct Current) supply and should be connected the right way round, otherwise you can damage it.

The 1.2 K ohm resistors protect the transistor and the port by limiting the amount of current flowing between them. The resistor can be connected either way round.

NOW we have built the display, we must have a program to run it.

THE PROGRAM

```
 1    REM ØØØØØØØØØ
 2    FOR A=Ø TO 9
 3    INPUT B
 4    POKE 16514+A,B
 5    NEXT A
 6    INPUT A
 7    POKE PORT,PEEK(16514+A)
 8    GOTO 6
1Ø    FOR A=Ø TO 127
2Ø    POKE PORT,A
3Ø    INPUT A$
4Ø    IF A$<> "" THEN PRINT A;A$;
5Ø    NEXT A
```

First replace PORT in lines 7 and 20 with the location of your memory mapped OUTPUT port. If you use a machine code routine to write to your port, then substitute the correct POKE, followed by the USR routine.

Now RUN 10 and you will see zero OUTPUT to the display (all the lamps should be OFF). Press NEW LINE and the next number will be POKE'd into the port. If you like this combination, you can store its number on the screen by pressing another key before NEW LINE. I suggest that this other key be the letter or number you think it looks like. The number of the combination is then printed on the screen, followed by the key (or keys) that you pressed before NEW LINE. The Display now shows the next combination.

The second program starts by pressing RUN 1, then NEW LINE. The following numbers should then be put in:— 123@10@55@31@78@93@125@11@127@79@, pressing NEW LINE instead of @. This POKE's these numbers into the first line which is a REM containing ten Ø's. The first Ø is location 16514 and has 123 POKEd into it. These numbers are the combinations required to produce the digits 0-9 in the correct order, so PEEK 16514 + 9 = 9. Line 6 to 8 asks for a number to be INPUT (from 0-9), and then POKE's it on to the display. It then waits for the next number.

One word of warning, the number 126 (HEX 7E) cannot be put in a REM line as it signals the end of a REM line and would corrupt the listing.

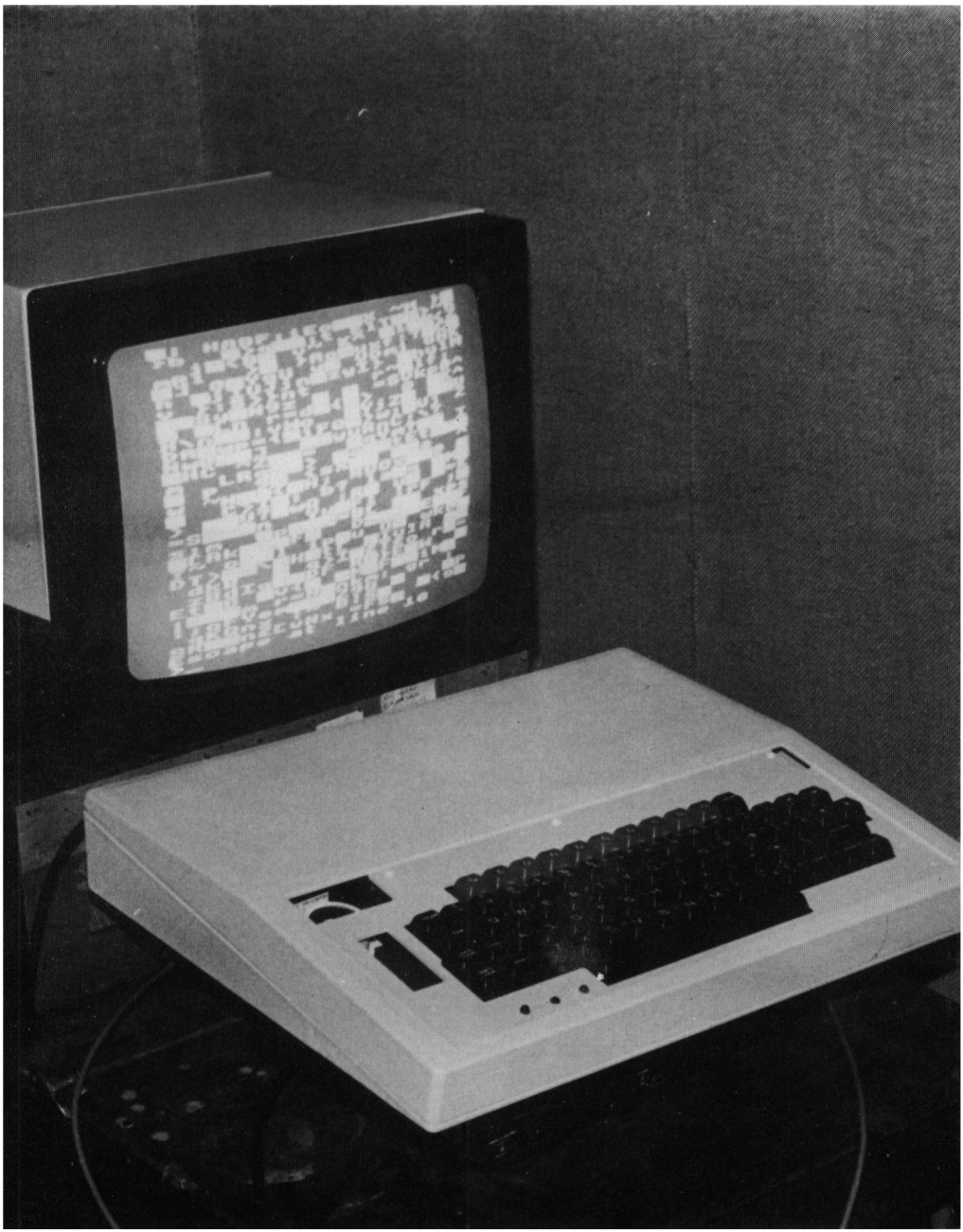
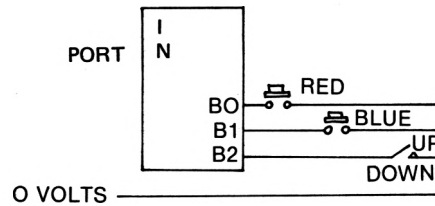
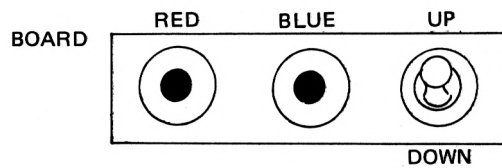


Figure for Score Board





QUANTITY	COMPONENTS
2	'PUSH TO MAKE' SWITCHES
1	LOCKING SWITCH
1	BOX
1	INPUT PORT

SCORE BOARD

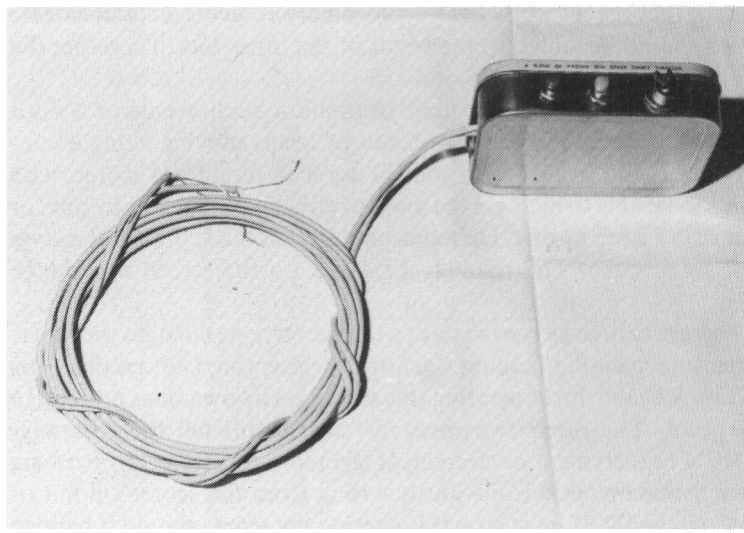
The purpose of this project is to show how the ZX81 can make decisions on external events. The inputs to the computer are three switches, two push-to-make and one 'locking'. They are connected to the bottom three bits of the input port (B0-B2) and thus give a combination of values between 0 and 7. As the rest of the inputs are not connected, they are all set by the port to Binary 1, giving a count of 248, which should be added to the result of the other bits. Therefore the count can vary between 248 and 255.

These switches could be used to monitor such events as a door opening, a water level or even a can of beans moving along a conveyor belt. But in this case, we will use it to monitor a scorer, who wants to be able to increase the score of either of two teams by one, or reduce the score by one. He wants no mistakes made if he presses two keys by mistake. The result is displayed on the screen for him to check.

There are three keys available to the scorer, one changes the score, either incrementing (adding one) or decrementing (subtracting one) and back again. Just operating this switch on its own does nothing to the score. The other two (one for each team) tell the computer WHEN to increment or decrement the score of that team. Pressing them simultaneously is obviously wrong from the scorer's point of view, so the ZX81 must stop this altering the score, should it happen accidentally.

Each switch, when operated, causes that bit to change to Binary 0 by connecting it to the 0 volt line of the computer. If any of the switches are left open then, that bit is held to Binary 1 (+5 volts) by a resistor connected inside the port. Therefore if the RED count is to be incremented, the input should be 254 in decimal, with the RED switch only operated (11111110). If the BLUE count is to be decremented, then the BLUE and the UP/DOWN switches are operated giving a result of 249 (11111001). If the RED and BLUE switches are not pressed, the result is 251 (if the UP/DOWN switch is operated) and 255 if no switches are operated. Line 60 in the program sends the ZX81 back to have another look at the switches, if no RED or BLUE switch has been pressed. Not affecting the score, when BOTH RED and BLUE switches are pressed, is managed by not having an IF line which will react to this number. To use the program replace PORT with the location of your memory mapped port or USR routine for your INPUT/OUTPUT port.

There is nothing to stop you changing the program to read the results from up to eight switches, one switch to each bit, or checking for more combinations from the switches given. Giving the switches another use, the display could show you how many cans of beans you like in a week!



THE PROGRAM

```
 1Ø    LET B=Ø
 2Ø    LET C=Ø
 3Ø    PRINT AT Ø,Ø; "[R][E][D]"; TAB 7; "SCORE", "[B][L][U][E]"
 4Ø    GOTO 11Ø
 5Ø    LET A=PEEK PORT
 6Ø    IF A=255 OR A=251 THEN GOTO 5Ø
 7Ø    IF A=25Ø THEN LET B=B-1
 8Ø    IF A=249 THEN LET C=C-1
 9Ø    IF A=254 THEN LET B=B+1
1ØØ    IF A=253 THEN LET C=C+1
11Ø    PRINT AT 1,1; B;" ";TAB 18;C ,""
12Ø    GOTO 5Ø
```

[R][E][D] and [B][L][U][E] are inverse characters.

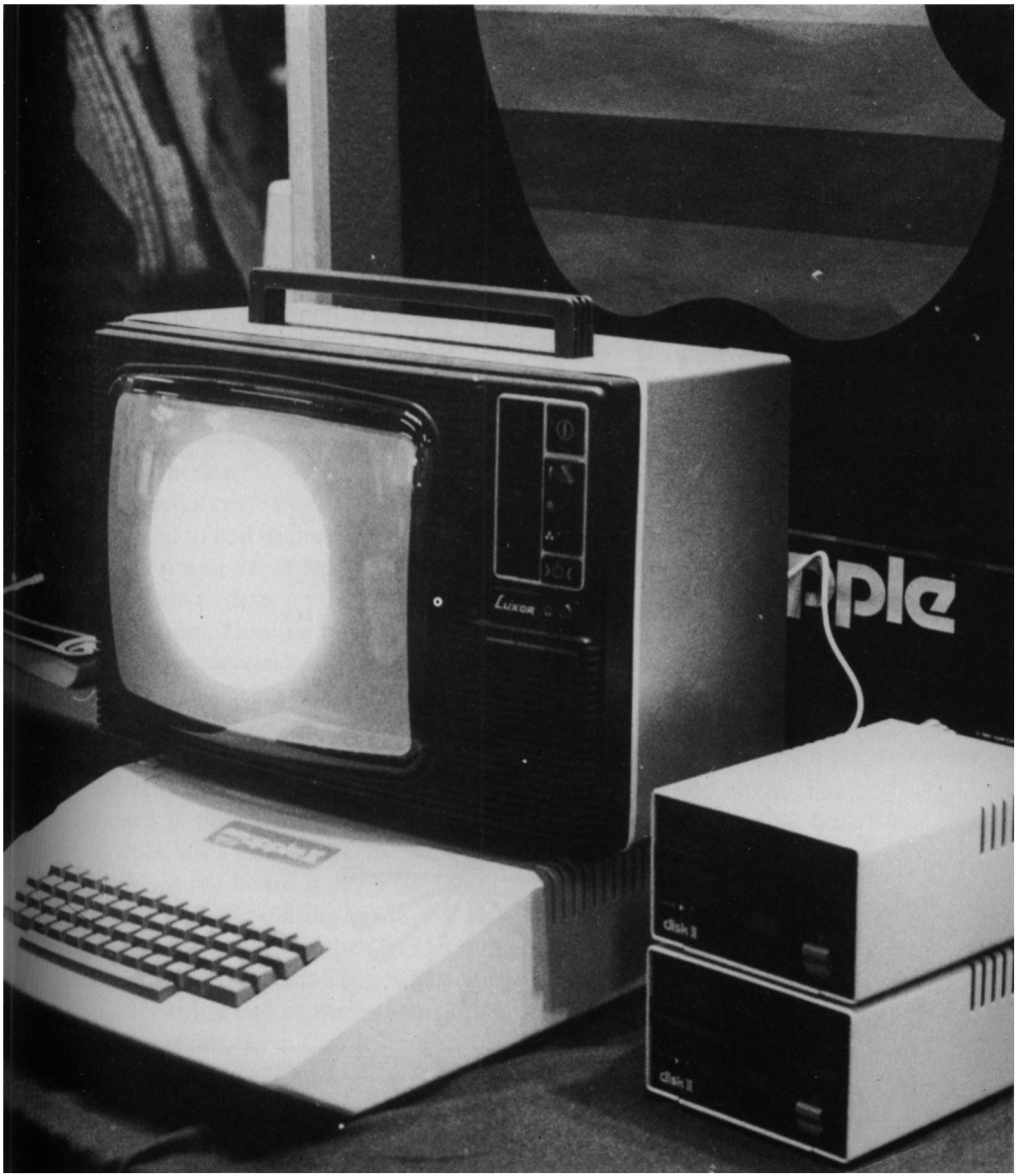
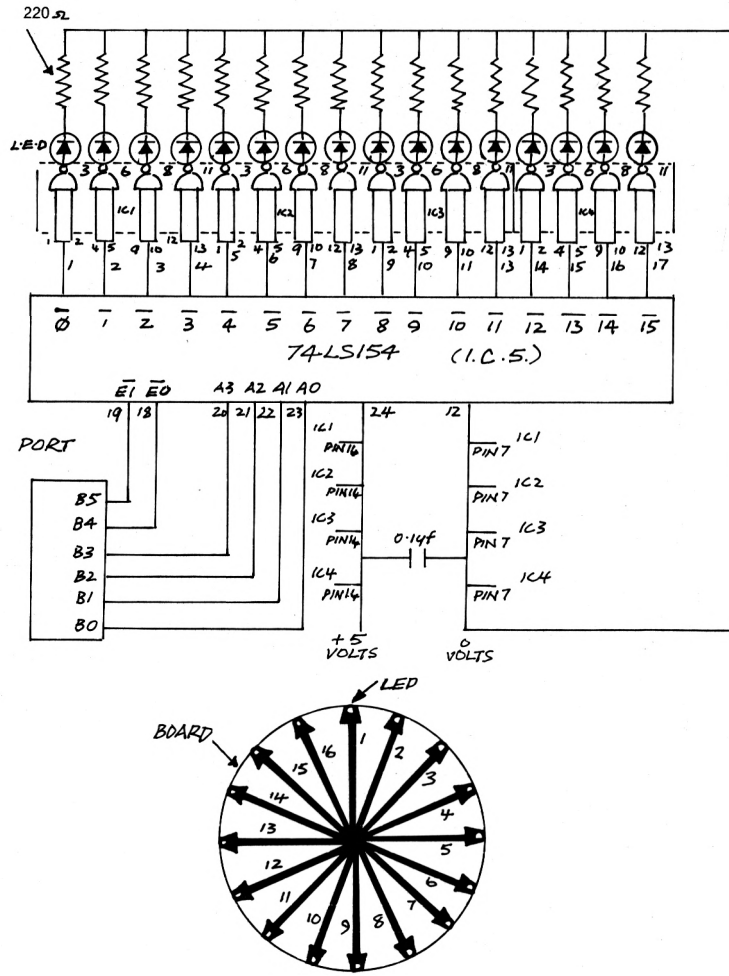

LUXOR
disk I
disk II

Figure for Wheel of Fortune



QUANTITY	COMPONENT
1	OUTPUT PORT
4	7400 OR 74LS00 I.C.'s (IC1-IC4)
1	74LS154 I.C. (I.C.5)
16	LIGHT EMITTING DIODES (L.E.D.'s)
16	220 RESISTORS, ¼ WATT
1	0.1 uf CERAMIC CAPACITOR OR 60 VOLTS
1	+ 5 VOLT SUPPLY (500MA)
1	WOODEN BOARD

WHEEL OF FORTUNE

This project produces a computerised version of the spinning wheel of fortune, seen at fairs and fetes. Instead of a pointer, we shall use sixteen LIGHT EMITTING DIODES (L.E.D.'s) which light up one at a time around the circle.

The ZX81 can OUTPUT a number of rotations, before counting up to a number chosen at random, using the RND command on the last turn. The winner of course, is the person who has chosen the number of the L.E.D. on which the count stops. With the 16K RAM pack, the ZX81 can even publish the name of the winner on the screen.

Construction

We need a circle bigger than ordinary school compasses will give us so we need to add to the component list a pencil and some string. Tie the string round the centre of the pencil and mark on the string the radius you want to draw on the board which will be the display of your wheel of fortune. Holding the string in place where the centre of the circle will be, rotate the pencil around in a half circle. Then change the hand holding the string and draw the other half circle. Draw three concentric circles altogether, one for the outside, one for the L.E.D.'s ($\frac{1}{2}$ inch in from the first) and one for the numbers from zero to sixteen. Drill sixteen equally spaced $\frac{1}{4}$ inch holes, around the second circle. The board is now ready for painting your design before inserting the L.E.D.'s.

When the board is dry, insert the L.E.D.'s into the holes with the ANODE lead pointing to the outside of the circle. This is the smallest of the two leads. To the CATHODE, now pointing inwards, solder the 220 ohm resistor. The resistor can be connected either way round. To the other end of the resistor, solder a circle of wire connecting up all the resistors.

Now wire up the I.C.'s to the OUTPUT port on a piece of board near the port. The I.C.'s need to be wired up the correct way round, so check the pin layout at the back of the book. Make sure that the address lines of the 74LS154 are connected to the correct bits of the OUTPUT port. The wires from the L.E.D.'s go to the outputs of the NAND gates in I.C.'s 1-4 and the wire circle on the display goes to the 0 volt line. There are four NAND gates in each I.C. and the right L.E.D. MUST go to the right gate output. The output of the gate con-

nected to the NOT Ø ($\overline{Ø}$) output of I.C.5. must go to L.E.D. number 1, output NOT 1 ($\overline{1}$) to L.E.D. number 2 etc. The 0.1μf capacitor must be fitted on the I.C. board, between the supply rails. Don't forget to connect the 0 volt rail to the ZX81's own 0 volt rail, otherwise there will be no communication between the port and the circuit.

HOW IT WORKS

Most of the work is done for us by 74LS154 (I.C.5.), this I.C. will DECODE a Binary input of 0 to 15 into 16 individual outputs. Now a Binary input of 15 can be expressed as only four bits and this is how the number is output by the port on bits B0-B3. The ZX81 does the conversion from decimal to Binary before POKEing the number into the port. If you are not sure about Binary, read the chapter on GETTING IN AND OUT OF THE COMPUTER again.

The output consists of a single pin, which will go to Binary 0 ONLY when the correct Binary number is input to the I.C. This is why it is called a NOT output, i.e. if Ø is input (all the pins A0-A3 are Binary 0), then the $\overline{Ø}$ pin will go to Binary 0. In other words the DECODED output goes DOWN to Binary 0, not UP to Binary 1 as is usual. So the output is INVERTED to normal and hence the bar above the number meaning NOT.

Each output has a 7400 I.C. gate acting as source of current for the L.E.D., because if it was attached directly to I.C.5. it might overheat. This has been used many times in this book, so for a further explanation of how this works, see the explanation in the monitor project.

The two lines connected to the output port bits B4 and B5 ($\overline{E0}$ and $\overline{E1}$) must be at Binary 0 in order for the 74LS154 to work, otherwise I.C.5. ignores any inputs at all.

The internal workings of the 74LS154 consist of 16 NAND gates, one for each output. A NAND gate output will change from Binary 1 to Binary 0 ONLY when all the inputs are Binary 1.

FOUR of the inputs are driven from the ADDRESS lines (A0-A3), either directly operating the gate to a Binary 1 input or through an INVERTER included in the chip, which means the gate operates to Binary 0. Each gate has different combinations of direct and inverted ADDRESS Lines, thus all 16 combinations are covered.

ONE of the inputs is driven from a combination of the inputs $\overline{E0}$ and $\overline{E1}$, which will stop ALL of the gates from going to an output of Binary 0, by keeping one of the inputs at Binary 0.

The main use of this I.C. is to ADDRESS sixteen different locations in memory, (just as our L.E.D.'s are operated) by turning on

the appropriate chip ONLY when the correct Binary number is input. The input lines need not all be from the address lines (A0-A15 on the ZX81). To have a memory location addressed, three signals are required, $\overline{\text{MREQ}}$ (NOT Memory REQuest), $\overline{\text{RFSH}}$ (NOT a ReFreSH address, used on the ZX81 to output the character set) and the ADDRESS lines. The $\overline{\text{MREQ}}$ must be Binary 0, the $\overline{\text{RFSH}}$ must be Binary 1 and the address correct, in order to turn on the chip at the correct time. I.C.5. can cope with all of this, $\overline{\text{MREQ}}$ operates both $\overline{\text{E0}}$ and $\overline{\text{E1}}$. The address consists of $\overline{\text{RFSH}}$ connected to A3 and the ADDRESS lines A0-A2 connected to the same lines on the ZX81. This means we can only use the top eight outputs, as the A3 line is connected to the $\overline{\text{RFSH}}$ and *only* when this is Binary 1 will it be right. Therefore the address outputs $\overline{0}$ to $\overline{15}$ will be equal to the ADDRESS input on the other lines A0-A2. But there is a problem, we have left out ADDRESS lines A3-A15 on the ZX81, therefore the ADDRESS lines are correct every count of eight. We must make use of another chip to cope with A3-A15 so that, when they are all Binary 0, the input to $\overline{\text{E1}}$ is Binary 0. So now $\overline{\text{MREQ}}$ only operates $\overline{\text{E0}}$ and $\overline{\text{E1}}$ is operated by all the ADDRESS lines being Binary 0, thus using the outputs from I.C.5. to operate chips at addresses A0 to A8 from outputs $\overline{0}$-$\overline{15}$. This is called ADDRESS DECODING.

Not to worry, we only have to cope with SIX inputs and we can OUTPUT all of them from the OUTPUT port. We need to POKE the correct number at the correct port and the ZX81 will do the rest. Here is a program to demonstrate that fact.

THE PROGRAM

```
10    LET A$="1111111111111111"
20    PRINT "NUMBERS LEFT"
30    GOSUB VAL "500"
40    INPUT B
50    IF B < VAL "1" OR B > LEN A$ OR A$(B) =
      "1" THEN GOTO 40
60    LET A$(B)="0"
70    GOSUB VAL "500"
80 "  IF C=VAL "1" THEN GOTO 40
90    CLS
100   LET B=VAL "16"
110   FOR A=VAL "1" TO VAL "5"
120   GOSUB VAL "600"
130   LET B=INT(RND * 15)
```

```
140    PRINT "THE WINNER IS";B+1
150    STOP
500    LET C=VAL "0"
510    FOR B=VAL "1" TO VAL "16"
520    PRINT AT B,10;B
530    IF A$(B)="0" THEN PRINT AT B,10;"□□"
540    IF A$(B)="1" THEN LET C=1
550    NEXT B
560    RETURN
600    FOR X=C TO B
610    POKE PORT,X
620    FOR N=C TO VAL "200"
630    NEXT N
640    NEXT X
650    RETURN
□      □ INVERSE SPACES
```

One thing about this program is that we have had to use VAL"1", instead of 1 etc., in order to get all of it to fit into a 1K ZX81. The record of numbers which have been sold is kept in a string A$ and every time one is sold, INPUT B after checking that it makes the character in A$ equal to 0. Subroutine 500 prints the numbers not sold down the centre of the screen, variable C keeping an eye open to see if all the numbers have been used. When all the numbers have been used, the L.E.D.'s are illuminated in rotation five times before they stop on the random number. All of the program must be run in the FAST mode to speed things up.

If you have a 16K RAM pack add the following lines to also record the name of the winner.

```
  5    DIM B$(16,32)
 45    INPUT B$
145    PRINT B$(B+1)
```

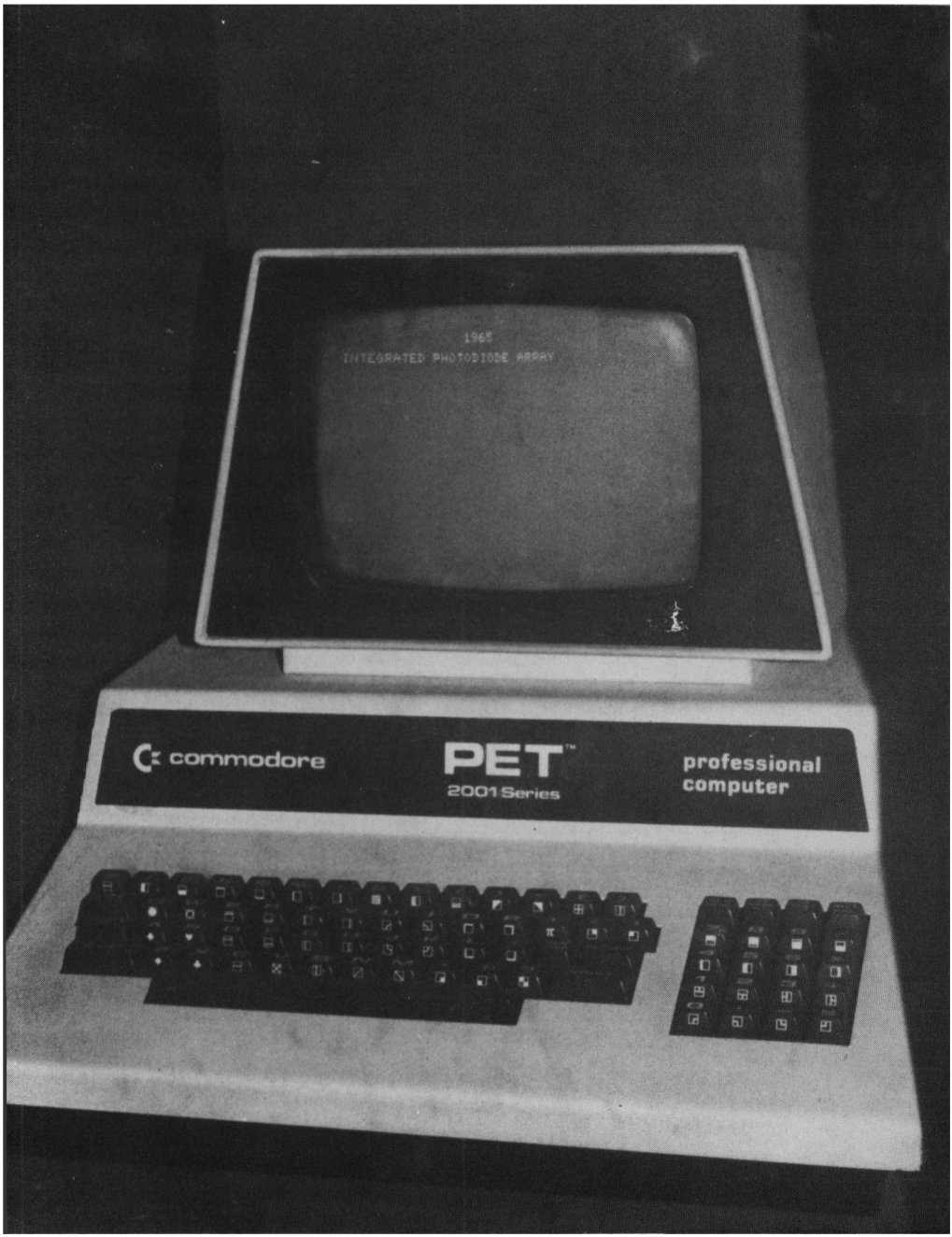
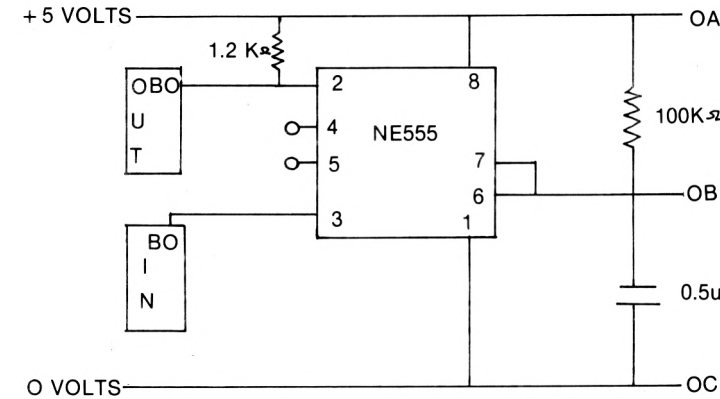
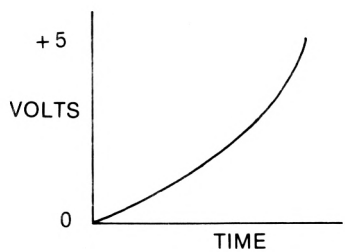
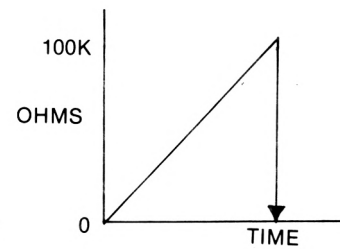

1965
INTEGRATED PHOTODIODE ARRAY
commodore
PET™
2001 Series
professional
computer

Figure for Analogue to Digital Converter







QUANTITY	COMPONENT
1	1.2 K OHM RESISTOR, ¼ WATT
1	100 K OHM RESISTOR, ¼ WATT
1	0.5 uf POLYSTYRENE CAPACITOR
1	NE555 I.C.
1	INPUT PORT
1	OUTPUT PORT
1	REGULATED POWER SUPPLY + 5 VOLTS 200 MA

ANALOGUE TO DIGITAL CONVERTER

Commonly called an A/D, this device is very useful for anything which needs measuring, in fact it is so useful that we shall be using it as a base for other projects within this book.

This device allows us to input a level to be measured at one end and arrive at a number at the other end which can be read by the ZX81. The level input will vary the number given out. The speed at which this can be done is quite fast when using a machine code routine (> 5Oms). It can be done using a BASIC FOR/NEXT loop to count the number, but the time taken could be up to 5 seconds for each measurement. Using the machine code routine given it is as fast as many commercial A/D converters, but so much cheaper! The cost of components apart from the power supply and the ports comes to less than £1.00.

Construction

All the joints in this project MUST be well made as the measurements taken need to be as accurate as possible. As an example, with the program given, the only inaccuracy in the number returned is caused by the air temperature changing. This can cause a change of ± 1, by a change of just one third of a degree centigrade. So unless the joints are very good, their resistance will vary and give a wrong reading.

All the wiring to connect the I.C. should be wired on to a I.C. socket and the I.C. only inserted when all the connections to the socket have been checked. There are only eight connections to the NE555, four per side, two of these are left unconnected (pins 4 and 5). The wiring should be kept as short as possible and the board containing the A/D converter should be as close to the port as possible.

A +5 volt REGULATED supply MUST be used, to prevent voltage changes affecting the measurements from one reading to another.

HOW IT WORKS

We convert the level to a number, using a two stage process.

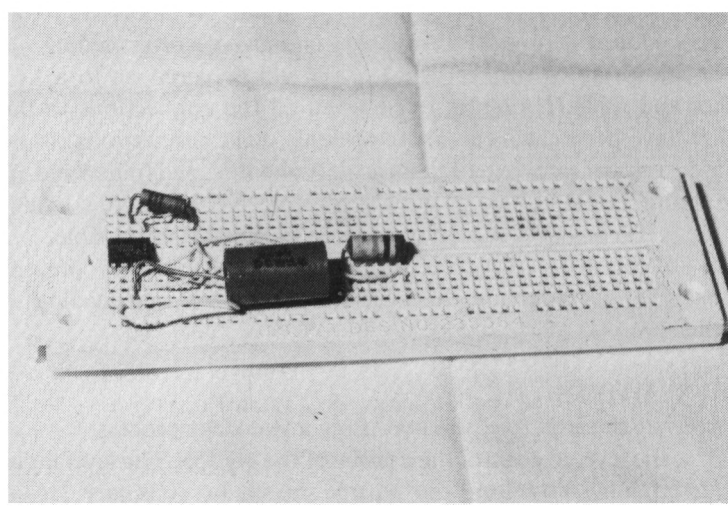
1. Use the level to control the output of the NE555. The level input determining how long the output should be at Binary 1 (+5 volts). The higher the level the shorter the pulse.

2. Measure the length of the pulse. This is done by using a machine code loop to count the number of times the NE555 has set the INPUT port to Binary 1, after being started off by a change in the OUTPUT port. The longer the TIME before the INPUT port returns to Binary 0, the larger the number. A preset limit is used so that the 50 ms. limit is not exceeded.

The whole project depends then on controlling the TIME of this pulse. In order to understand the timing of the NE555 we must first go into the workings of a capacitor as it is essential to understand how this works.

The capacitor is the equivalent of a cistern in the electrical circuit. It can be filled with voltage in the same way as a cistern is filled with water. When nearly full the voltage flowing into the capacitor slows down and when it is full it will take no voltage from the supply. This is because it is now at the same voltage as the supply and is said to be FULLY CHARGED. A empty capacitor is said to be DISCHARGED.

If the capacitor is placed directly across the + 5 volt supply, it will charge almost immediately. If, however, a resistor is put in series with it, this restricts the amount of voltage available and the capacitor takes longer to charge. This is just like restricting the amount of water that the tap can supply to the cistern. Thus both the capacitor and the cistern take longer to fill. Therefore, the greater the resistance, the greater the time taken to charge the capacitor.



The time taken to charge the capacitor also depends on the capacity of the capacitor. The larger the capacity, the longer it takes to fill. Therefore the TIME taken to charge the capacitor depends on both the series RESISTANCE and the CAPACITANCE. In fact the TIME = RESISTANCE × CAPACITANCE, where the RESISTANCE is OHMS and the CAPACITANCE is in FARADS.

A ONE FARAD capacitor would fill a fairly large room, so we have to use smaller capacitors and thus a smaller measurement, this is called a MICROFARAD and is 1/1,000,000 of a FARAD or 10^{-6} FARADS.

This resistance and capacitance arrangement is seen connected between the +5 volts and 0 volts of the circuit, with the junction of the capacitor and resistor connected to pins 7/6. The time taken to charge the capacitor FULLY is therefore 10^3 (100,000) OHMS × 0.5 × 10^{-6} MICROFARADS, which equals 0.05 seconds or 50 ms. (50 × 10^{-3}).

The NE555 is a comparitor I.C.: it takes a input from pin 6 and compares it to two thirds of supply voltage (in this case +5 volts). When triggered with pin 6 at two thirds the supply voltage, the I.C. resets itself. This resetting consists of connecting pin 7 to 0 volts and keeping it there until the I.C. is triggered again. When triggered, the output on pin 3 is +5 volts (Binary 1), until the I.C. is reset, when it returns to its normal state of 0 volts (Binary 0).

Pin 2 is the trigger input and starts the I.C. off by going from +5 volts (Binary 1) to 0 volts (Binary 0) and back to +5 volts (Binary 1).

When triggered by the OUTPUT port going from Binary 1 to Binary 0 and back to Binary 1, operating pin 2, the I.C. first changes pin 3 to +5 volts (which is connected to the INPUT port (B0)) and causes that bit to be set to Binary 1. The 0 volts is removed from pin 7 and the capacitor now starts to CHARGE via the 100K ohm resistor.

After a period of time (set by the capacitor and resistor), the voltage rises to two thirds of the supply voltage. As this is connected to pin 6, this resets the I.C. The Output changes to Binary 0, and 0 volts is put on pin 7 until another trigger pulse is received. Because pin 7 and pin 6 are connected, both of the ends of the capacitor are connected to 0 volts and therefore the same, the capacitor empties itself. This 'SHORT' means that the capacitor no longer has a difference of voltage, and is DISCHARGED. It will remain this way until pin 2, triggered again, removes the SHORT.

If a Binary 0 is OUTPUT on BO of the PORT and then restored to Binary 1, this starts the timing under control of the

resistor/capacitor. Binary 1 is INPUT on BO of the port until the timing finishes. If we alter the value of the resistance by putting another resistor across it, it will change the time and therefore the number returned to BASIC.

The program given is in two parts. The first part is in BASIC to insert the machine code into a REM statement at the first line of the program. In the second part, the machine code routine checks the INPUT from the port after the OUTPUT has triggered the I.C. and returns when it returns to 0. The register BC counts the number of times the routine loops through checking the INPUT bit. This is the number returned from the machine code routine to BASIC. The machine code routine MUST be run in the FAST mode or the time counted will vary, due to the SLOW mode interrupting the processor to output the screen. The speed of each count on my own system was about 20μsec. The SLOW mode must be restored if the screen is used without INPUT, stopping the program to display the screen.

MACHINE CODE ROUTINE for collecting number

INSTRUCTION	HEX	DECIMAL	COMMENT
LD HL,PORT LOCATION	21 xx xx	33 xx xx	Ignore if your port uses a machine code routine.
LD BC,0	01 00 00	1 Ø Ø	Start count at Ø.
LD A,255	3E FF	62 255	Value port should be if no other bits used.
LD (HL),B	70	112	Set bit low (call machine code routine if necessary).
LD (HL),A	77	119	Set bit high (call machine code routine if necessary).
CP (HL)	BE	190	Compares port to A register (call routine to place value of port into D register, then CP,D). A REGISTER IS NOT CHANGED, only flags are changed.
RETNZ	CO	192	RETURN if A not same as port.
INC BC	03	3	INCrease count by 1 as bit is still Binary 1.

JR back to CP			
(HL	18 FB	24 251	THIS NEEDS TO BE ALTERED IF CALLING MACHINE CODE ROUTINES TO COMPENSATE.

This routine is entirely relocatable and in the BASIC program is stored at location 16514, the first byte after the REM byte in the first line of the program.

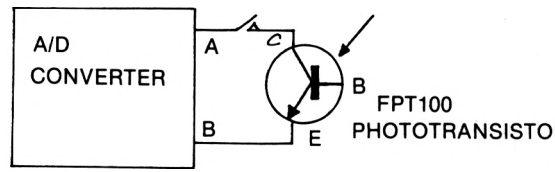
The BASIC program

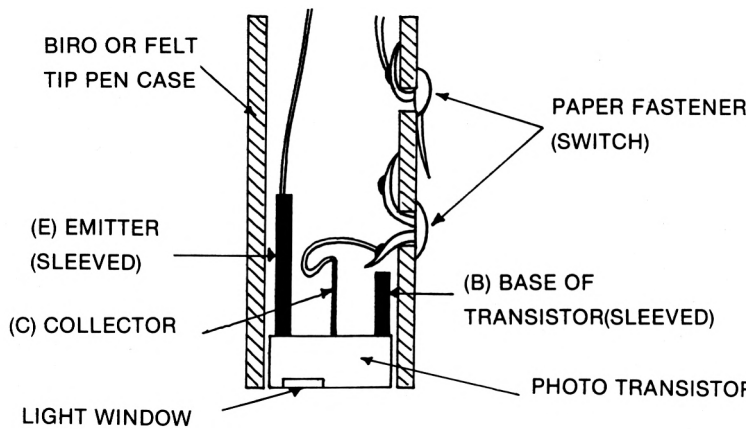
```
10  REM MACHINE CODE ROUTINE
20  REM SET UP PORT IF NECESSARY
100 REM ENTER MACHINE CODE
110 LET X = 16514
120 PRINT "ENTER EACH NUMBER THEN PRESS N/L"
130 PRINT "33 0 0 1 0 0 62 255 112 119 190", "192 3 24 251"
140 LET N = 0
150 INPUT A
160 POKE X + N,A
170 IF A = 251 THEN GOTO 200
180 LET N = N + 1
190 GOTO 150
200 LET A = PORT LOCATION
210 LET B = INT(A/256)
220 LET C = A - B*256
230 POKE X + 1,C
240 POKE X + 2,B
250 FAST
260 LET C = USR X
270 SLOW
280 PRINT C
290 INPUT A$
300 CLS
310 GOTO 250
```

RUN the program, after changing line 110 to the location of the machine code routine if necessary and changing the port location to a number.

Line 10 has enough bytes to contain the machine code routine, one letter for each byte. If you need it any longer, just add more letters to line 10 before running the program. Line 250 calls the machine code routine in line 10 via the USR command at location X. If the port requires the use of a machine code routine, then change the amount and the string of numbers in line 130. The result printed will be the time taken.

Figure for Light Pen





QUANTITY	COMPONENT
1	FPT100 PHOTO-TRANSISTOR
2	19mm PAPER FASTENERS
1	OLD BIRO OR FELT TIP PEN
1	A/D CONVERTER PROJECT

LIGHT PEN

A light pen can be very useful for many purposes, from reading BAR CODES printed on packets and tins in the supermarket, to reading options from the T.V. screen by changing spots on the screen from BLACK to white. A BAR CODE is the set of Black lines on a white background that you find on the side of, say, a packet of cornflakes and is a numeric code based on the thickness of the lines. The light is reflected from the white and absorbed by the black lines.

CONSTRUCTION

This is the most important part of the project. A old felt tip pen or clear ball-point pen case is required, as we are going to fit into it the photo-transistor which is shown in the circuit diagram.

The end should be removed so that the photo-transistor will slide up the midde of the pen with the refill removed. Although I have specified a FPT 100 photo-transistor, any type could be tried. I obtained mine from my local TANDY store. Drill two 1/8th inch holes in one side of the pen case, at least $\frac{1}{2}$ inch apart. Then cut DOWN one side of each brass paper fastener to $\frac{1}{4}$ inch. Solder a wire on to one long strip of a paper fastener and another insulated one on to the short strip of the other paper fastener. Push the INSULATED wire attached to the short strip down the hole furthest away from where the photo-transistor is going to be put. Push this wire up towards the top of the pen pulling the paper fastener after it, making sure that the long strip remains on the outside of the pen, pointed towards the tip of the pen. The other wire should be pushed down towards the tip of the pen, pulling both strips of the paper fastener down inside the pen after it. The two paper fasteners form the switch in the circuit diagram, which should be pressed every time a reading is required.

The base of the photo-transistor is covered in insulation tape or rubber sleeving to insulate it from the rest of the wires. The wire from the long paper fastener strip first has a rubber sleeve pushed over it. This sleeve should be long enough to cover the whole of the transistor collector. Bare the end of the wire and solder it to the collector using a heatsink between the transistor and the soldering iron. Next pull the rubber sleeve over the bare collector wire. Push a wire down the pen from the top to the tip and push a rubber sleeve over the wire which will be long enough to cover up the emitter wire. Then solder the bared wire to the emitter wire and push the rubber sleeve over it. Push

the transistor into the tip of the pen, pulling the wire attached to the emitter out of the top of the pen as you go.

The two wires coming out of the pen should be long enough to connect up to the A/D converter project. The emitter wire MUST go to the connection marked B or it will not work. To use the pen, press the brass strip on to the brass button of the other paper fastener when you are in the correct place.

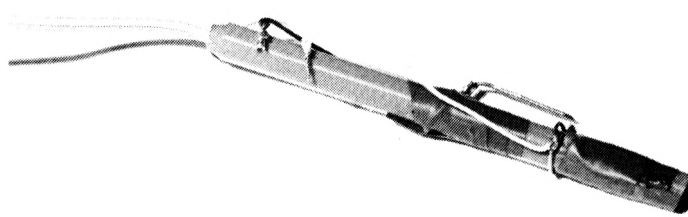
HOW IT WORKS

The window in the front of the transistor lets the light in and alters the resistance between the (E)mitter and the (C)ollector. This is placed across the 100K ohm timing resistor by connecting it to the A/D converter's terminals A and B.

The emitter must be connected to terminal B because the current will flow only through the transistor from collector to emitter and the terminal A is connected to the +5 volt line. The base is left unconnected, as only the light alters the resistance of the transistor.

The resistance number can vary between 0 and 2500 with the higher number being the darkest. This means that the difference can be detected between black and white squares on a page lit only by daylight.

I leave the programs to use this light pen to you, as the number from the A/D converter's machine code routine can be checked to see if it is within limits set by the program. The sensitivity of the light pen is determined by the resistance number which must, of course, be within the limits of the program.



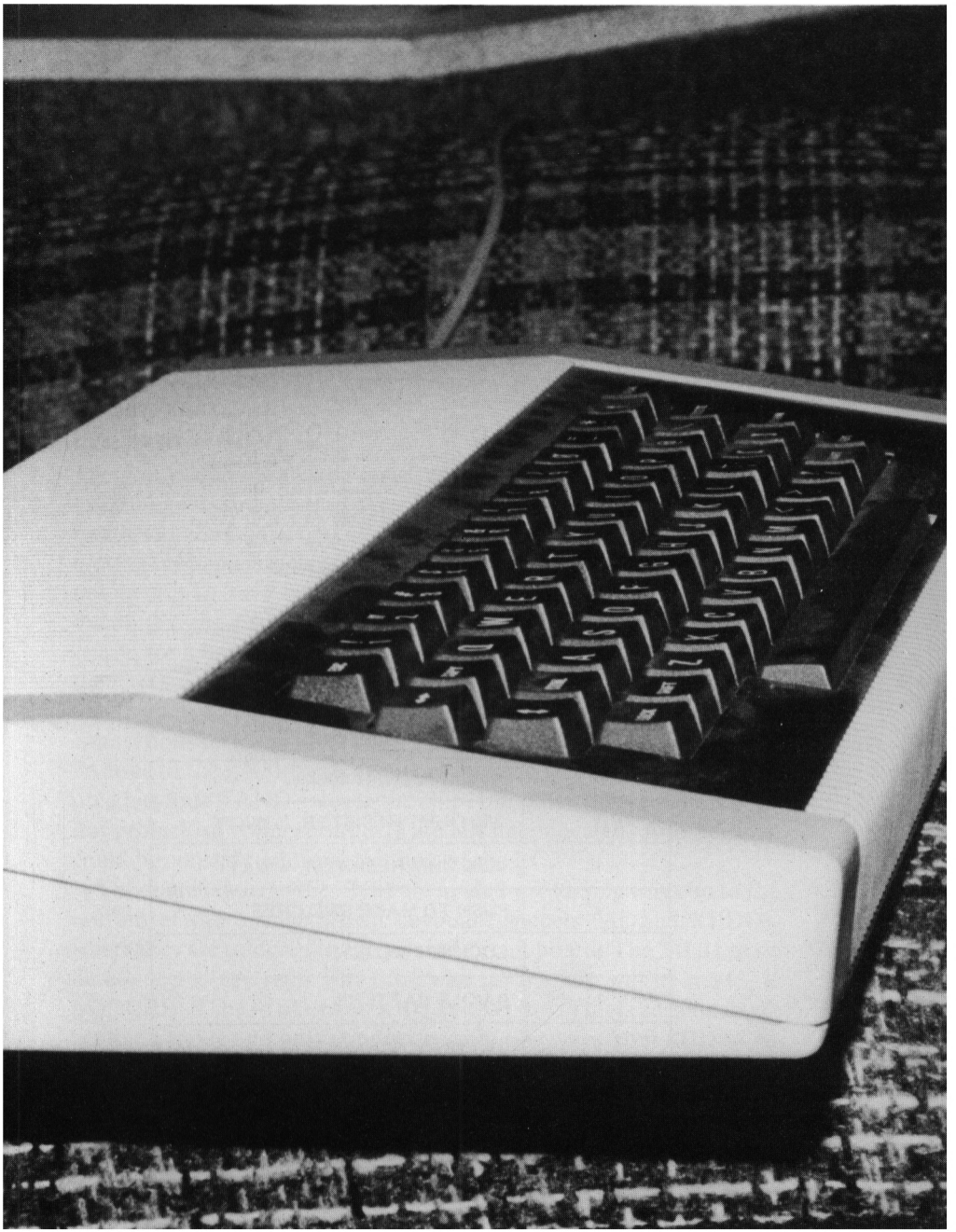
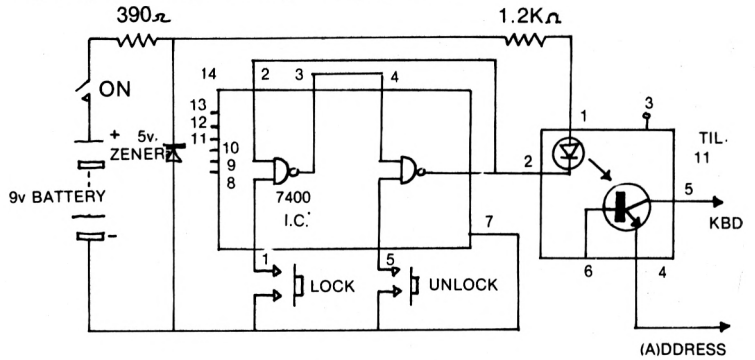
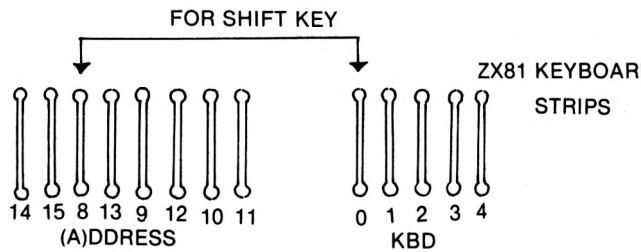


Figure for A Shift Lock for Keyboards





QUANTITY	COMPONENT
1	TIL11 OPTICAL ISOLATOR
1	7400 NANDGATE I.C.
1	5 VOLT ZENER 400MW
1	390 OHM RESISTOR, ¼ WATT
1	1.2K OHM RESISTOR, ¼ WATT
2	PUSH TO MAKE SWITCHES
1	LOCKING SWITCH
1	9 VOLT BATTERY
1	BATTERY CONNECTOR

A SHIFT LOCK for KEYBOARDS

This provides a SHIFT LOCK for single contact keyboards, such as the ZX81, it will allow the user to hold the SHIFT contact closed, after momentarily closing a switch, until another momentary switch is operated. This means that two key operations can be done with one finger. To RUBOUT, press the SHIFT LOCK KEY and release it, then press the Ø key. This will RUBOUT the letter or number to the left. In order to be able to type in non-shifted letters and numbers, the UNLOCK key must be pressed to restore the keyboard to normal.

CONSTRUCTION

The whole unit should be constructed on a board to fit onto the external keyboard if you have one, or can be built into a separate board with the LOCK and UNLOCK keys on top. The ON switch is a locking type and is included so that the unit can be switched off when not in use to save battery power. It can be omitted, if you can disconnect the battery every time you have finished using it. One reason for a battery being used is that it does not place any strain on the internal regulator of the ZX81, BUT more importantly it means that the only connections needed to the ZX81 are the keyboard socket connections on the printed circuit board. Therefore NO damage can be done to the ZX81 by shorting out any connections. The 7400 I.C. used has four NAND gates in the chip, but only two are required for this project, so connections 8-13 are left unconnected. Another lock could be constructed using this half of the I.C.

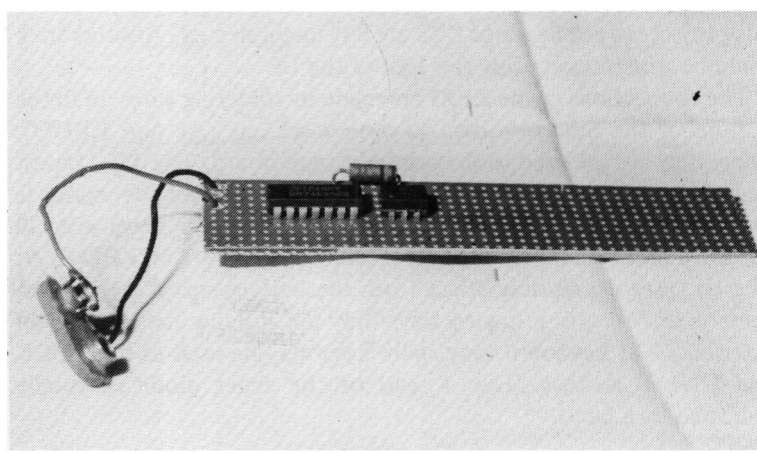
The connections to the ZX81 are made by soldering wires on to the bottom of the Sinclair's own keyboard sockets (A8 and KBDO), where they are soldered to the printed circuit board. The TIL11 must be connected the right way otherwise no contact will be made, ie (A)DDRESS line to pin 4 and KBD line to pin 5. This is because it will act like a diode and only conduct current one way, from KBD to A. The circuitry draws only 10ma from the battery so a PP3 will last some time. As spring loaded keys only are usually included on an external ZX81 keyboard, any spare keys may be used as the LOCK and UNLOCK keys. The + end of the zener diode is usually indicated by a band.

HOW IT WORKS

The device used here is called a LATCH and is used to short out the SHIFT key on the ZX81, only to be released when another key is pressed. The LATCH is made from a 7400 I.C. and once operated will not be released by the same key.

When switched ON, the inputs to NAND gates are held to Binary 1 by internal resistors. So pins 1 and 2 are at Binary 1, this operates the NAND gate and it drops its output to Binary 0. This stops the second gate from operating, as its input pin 4 is connected to the output of the first gate. A NAND gate must have Binary 1 on both inputs to operate. This means that there is Binary 1 output by the second gate and stops the L.E.D. from lighting up, as it needs a voltage DIFFERENCE of at least 1.2 volts to operate. The L.E.D. has +5 volts at both ends at this stage. As pin 6, the output of the second NAND gate, is connected to the input of the first gate, the first gate remains operated as long as the LOCK key is not pressed.

When the LOCK key is pressed this connects pin 1 to Binary 0 (0 volts) and the NAND gate releases, as it now has only one Binary 1 input (pin 2). The output therefore changes to Binary 1 and operates the second gate as pin 5 is also connected to Binary 1. This drops the output of the second gate to Binary 0, lighting the L.E.D. in the TIL11. The lighting of the L.E.D. shines light on the photo-transistor also included in the same I.C., which turns fully ON, (just like a switch) so that there is a 500 ohm contact between the COLLECTOR (pin 5) and the EMITTER (pin 4). This acts just like operating the SHIFT key on the ZX81.

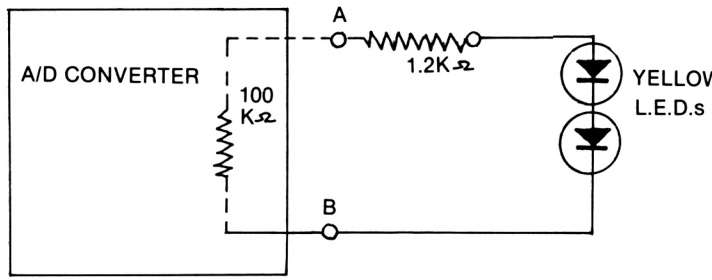


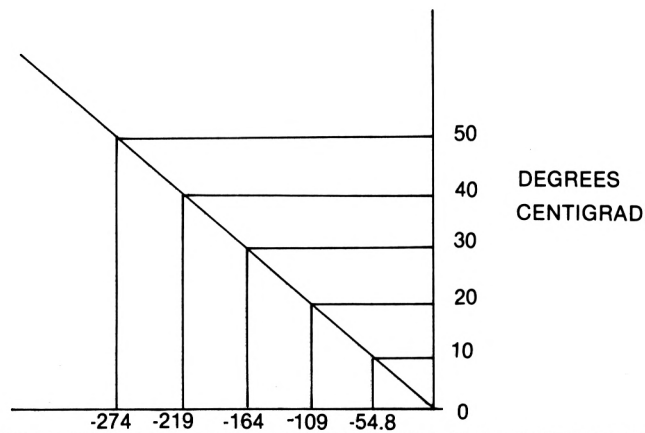
The output of the second gate is also connected to the input pin of the first gate, so this now changes to Binary 0 also, stopping any change in the input pin 1 from having any effect. The NAND gate will always output Binary 1 if either of its inputs are Binary 0. So the output is said to be LATCHED, as it cannot be changed by releasing the key that operated it.

When the UNLOCK key is pressed, it connects the input of the second gate to Binary 0, releasing the gate which changes the output (pin 6) to Binary 1. This turns off the L.E.D. inside the TIL11 and removes the contact between pin 5 and pin 4. The photo-transistor now gives a resistance of many million ohms and the ZX81 believes the keyboard has released the SHIFT key. The output of the second gate is now Binary 1 and as it is connected to input pin 2, turns on the first gate because the other input (pin 1) is also connected to Binary 1 (via the I.C.). This changes the first gate's output to Binary 0, stopping the second gate from changing its output due to a change in the UNLOCK key. Thus it is now LATCHED into the Binary 1 output until the LOCK key is pressed again.

The 1.2K ohm resistor is included to limit the current flowing through the L.E.D. and the second gate to stop any damage. The zenor diode maintains a constant +5 volts across its terminals by altering its resistance up or down, until it is +5 volts. The excess voltage of four volts is dropped across the 390 ohm resistor. If you want to supply enough current to operate a L.E.D., then the value of this resistor will have to be reduced. The total current taken by this device is a measly 10 milliamps, so it can be operated from any 9 volt battery.

Figure for A Cheap Thermometer





QUANTITY	COMPONENT
1	1.2K OHM RESISTOR, ¼ WATT
2	YELLOW L.E.D.'s
1	A/D CONVERTER PROJECT

A CHEAP THERMOMETER

This is a very cheap thermometer as it uses two yellow L.E.D.'s as the sensor. The ZX81 attached to the A/D and this thermometer makes a very sensitive instrument, with approximately six divisions per degree centigrade. If you forget the cost of the A/D converter and power supply, the thermometer comes to a grand total of 50p.

CONSTRUCTION

The variation in temperature is doubled by using two L.E.D.'s mounted next to each other. The 1.2K ohm resistor should be mounted next to the A/D converter, so that its temperature is unaffected by temperature changes of the sensor.

The L.E.D.'s, if expected to measure air temperature, should be well insulated from any metal as this thermometer would measure the temperature of the metal instead. If you want to use the thermometer in a corrosive atmosphere or liquid, like an aquarium, mount it inside a test tube sealed by a rubber bung. The P.V.C. covering of the cables should be epoxy resined to the bung. One advantage of this thermometer is that there is no mains flowing through the sensor and even if you broke the protective glass tube, the water would only disable the thermometer until the L.E.D.'s were repaired. The only thing that could hurt the fish would be rust. It can also be used in an explosive atmosphere with safety as all the glowing elements are sealed in plastic!

NO DAMAGE TO THE POWER SUPPLY OR A/D CAN OCCUR

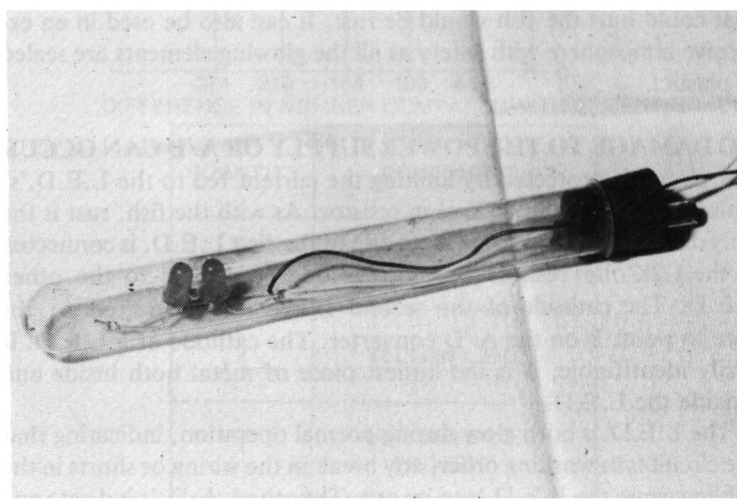
The circuit is protected by limiting the current fed to the L.E.D.'s. This is done with the 1.2K ohm resistor. As with the fish, rust is the only danger to the sensor. The anode of the first L.E.D. is connected to the 1.2K ohm resistor and its cathode connected to the other L.E.D. The cathode of the second L.E.D. is connected to the wire to point B on the A/D converter. The cathode of a L.E.D. is easily identifiable, it is the largest piece of metal both inside and outside the L.E.D.

The L.E.D.'s both glow during normal operation, indicating that the circuit is in working order, any break in the wiring or shorts in the cabling cause the L.E.D.'s to go out. Thus the L.E.D.'s indicate any fault in the sensor network.

HOW IT WORKS

The resistance of a diode through which current is passing varies very slightly with temperature. We can, therefore, get a condition called THERMAL RUNAWAY, during which a point is reached when some of the current causes heat to be created INSIDE the diode or transistor. This current causes a rise in temperature which drops the resistance of the diode or transistor. The drop in resistance means that more current can flow, creating more heat inside the diode or transistor. This accelerates until the diode or transistor melts due to the heat created within it.

We don't want either of the diodes (L.E.D.'s) to melt, so we have included a 1.2K ohm resistor to limit the current flowing through them. This current should be enough to ensure that the L.E.D.'s conduct the power (indicated by their glowing), but not enough to melt them. It is not sensible to use this form of thermometer for any temperatures in excess of 50 degrees centigrade. The resistor is also mounted out of harm's way, next to the A/D converter, so that if anything should happen to cause a large drop in resistance, the resistor can keep the current down to a safe level, i.e. one that the A/D converter can handle with ease.



A PROGRAM FOR AN AQUARIUM THERMOMETER

```
10    REM MACHINE CODE ROUTINE
20    REM SET UP PORT IF NECESSARY
30    LET A = USR 16514
40    IF A > MAX THEN POKE PORT, 2
50    IF A < MIN THEN POKE PORT, 0
60    IF A = 0 OR A = DANGER THEN LET A = 0
70    IF NOT A = 0 THEN GOTO 30
80    POKE PORT, 128
90    PRINT "CIRCUIT FAILURE"
```

Remember to change PORT for the output port location or call the appropriate machine code routine. Change MAX and MIN to the numbers that correspond to the temperature range that you want to use. DANGER level is the maximum number expected from the A/D converter. The PORT is arranged that BO operates the A/D, B1 operates a heater switch, Binary 1 on B1 turning it on and Binary 0 turning it off. B7 of the OUTPUT port is used to turn on an alarm of some sort, maybe the MINI-TONE project by the Bit going to Binary 1. If the number returned by the routine is too high or too low (0) for the circuit to be working then the alarm sounds. A delay should be included between lines 60 and 70 to give time for the heater to have some effect, but the length of time is your own choice.

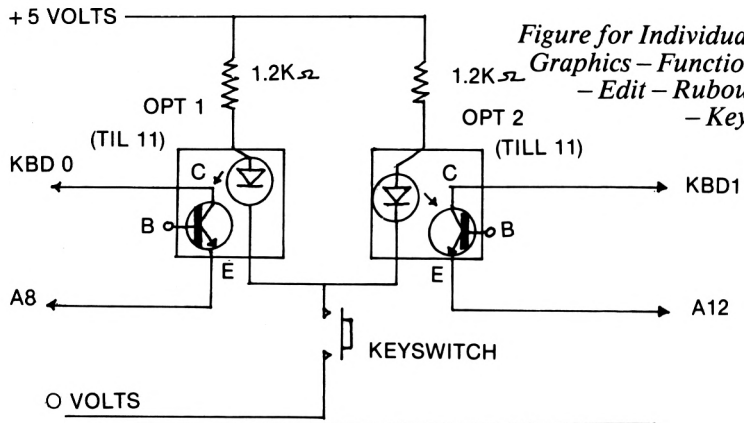


Figure for Individual Graphics – Function – Edit – Rubout – Keys

FUNCTION	A	KBD0
GRAPHICS	12	1
FUNCTION	14	0
EDIT	11	0
RUBOUT	12	0

QUANTITY	COMPONENT
2	TIL11 OPTICAL ISOLATORS (OR EQUIVALENT)
2	1.2K OHM RESISTORS, ¼ WATT
1	KEY SWITCH (PUSH-TO-MAKE)
1	+ 5 – + 9 VOLT POWER SUPPLY
1	BOARD OR BOX

INDIVIDUAL GRAPHICS - FUNCTION-EDIT - RUBOUT - keys

This is really four projects — it shows how to give a push-button keyboard the four most useful TWO key operations, for the Sinclair keyboard, on four SINGLE keys. All of these would normally require the SHIFT key held down first, then keys 1-9-Ø or NEW LINE pressed for whatever function you require. All of these functions can now be put on individual keys. This saves time in programming and correcting mistakes, it can even be used to move the cursor via SHIFT 5-6-7 or 8. Also other combinations, as long as the KEYBOARD DATA line (KBDO-KBD4) and ADDRESS line (A8-A15) is known for that key.

CONSTRUCTION

The TIL11 I.C.'s used in the construction of this project can only be damaged by the heat of the soldering iron, as reversing any of the pins will only achieve one thing: the device will not work!

So use a 14 pin I.C. socket, enabling it to take both I.C.'s and solder all the wires to the correct pins on the I.C. socket. The TIL11's are then inserted, when all the wiring has been confirmed as being the correct way round. The circuit requires a supply of +5 to +9 volts which can be obtained from the ZX81's own +5 volt supply on the edge connector (pin 1B) OR the +9 volts supply next to it on pin 2B. The connections are numbered from the end nearest the slot in the P.C.B.'s expansion port and B stands for the fact that they are the underneath connections. This supply however obtained MUST be kept away from the rest of the keyboard wiring as it can CRASH the ZX81 and if the +9 volt supply is used, you may even blow up the Sinclair power pack!

The supply therefore should go direct to the board on which you are mounting the unit and be soldered direct to the junction of the two resistors. Also take care that there is no way the power supply can touch the 0 volts line. The 0 volts connection is taken from pins 4B and 5B, which are just to the left of the slot if looked at from the back of the ZX81. The keyswitch should be a proper push-to-make type and as it is used regularly, it is best to get a good one. If you are at-

taching it to the original keyboard, the key may be mounted either next to or on top of the box containing the extra circuitry.

HOW IT WORKS

The TIL11 is an optical-isolator and contains an L.E.D. and a photo-transistor mounted in an I.C. type package. This package only has six pins, three each side, but they are the same width as an ordinary I.C. The L.E.D. has no physical connection with the photo-transistor, they are just mounted close to each other, so that the light from the L.E.D. shines on the photo-transistor.

When the L.E.D.'s are turned on by operating the switch, light reaches the photo-transistor. This causes the photo-transistor's resistance to drop to 500 ohms, enough to operate the ZX81's keyboard, connecting up both sides of the switch that would normally be pressed by you. As both L.E.D.'s are operated by the switch, the ZX81 thinks that two keys have been pressed at the same time. In the circuit diagram given, this is the SHIFT and the '9' key. So that when the keyswitch is operated, the cursor changes to a inverse 'G' showing that you are now in the GRAPHIC's mode.

When the key is released however, the L.E.D.'s go out and its photo-transistor's resistance is greater than a million ohms. This makes the ZX81 think that the key has been released and it starts scanning for another key press. The ZX81 will only accept one key combination at a time, so pressing any combination other than SHIFT and another key will be ignored. So don't hold down this key and another of the forty odd keys or it will ignore both.

If the key is wired up to the connections shown in the SHIFT-LOCK project then the existing keyboard is not affected and can be used as well.

The photo-transistor is very much like a diode, i.e. it will only pass current one way, from collector (C) to emitter (E). So the emitter MUST be connected to an ADDRESS (A?) and the collector to the appropriate KEY BOARD DATA line (KBD?). The L.E.D. MUST be connected to the power supply the correct way round, that is the cathode to the keyswitch and the anode to the resistors. The cathode is identified as the point of the arrow with the bar across it. The table shown gives the ADDRESS lines and the KEY BOARD DATA lines for each key attached to OPT 2, OPT 1 being wired up the same way, as it imitates the SHIFT key. L.E.D.'s don't like to work with each other and if you put two in parallel, only one will light, due to the fact that the first one to light will bypass the other by drawing all the available current, so we use two resistors to overcome the problem.

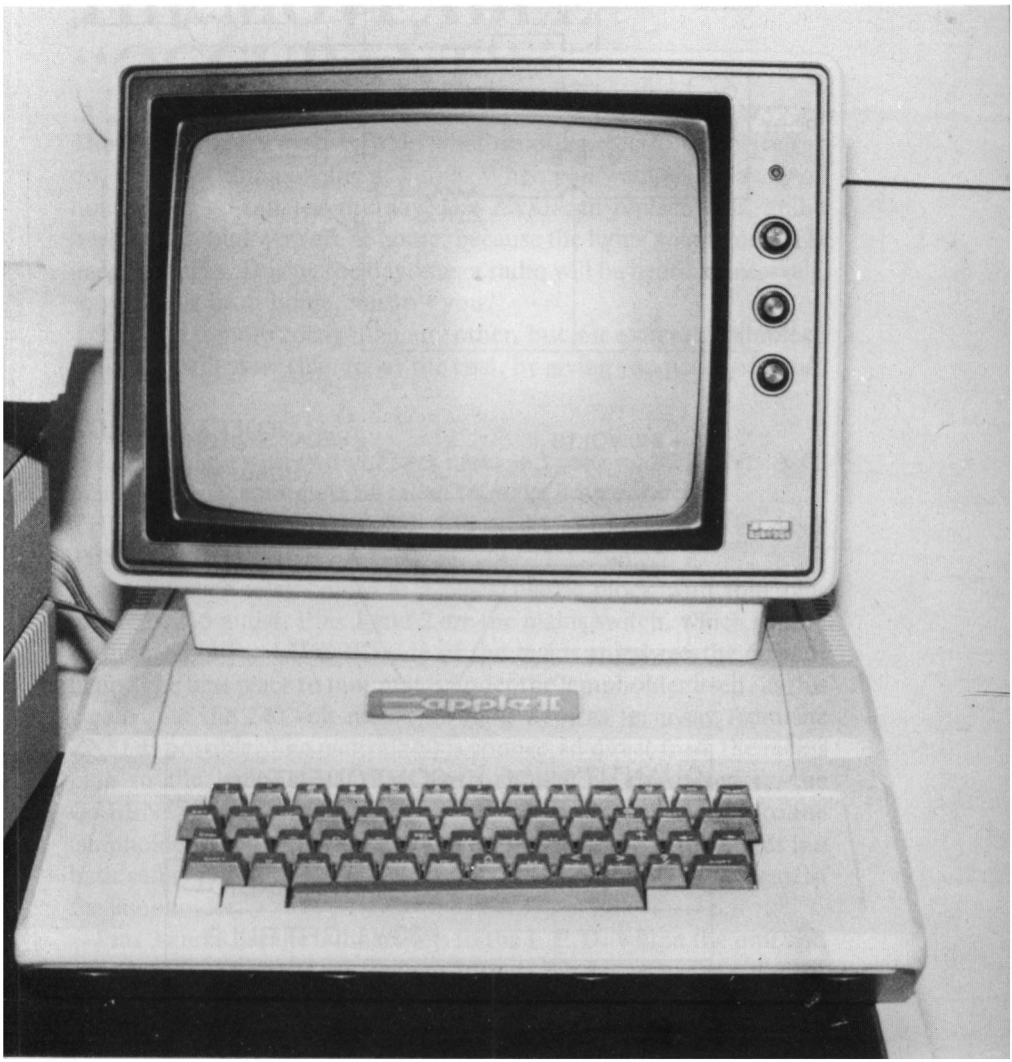
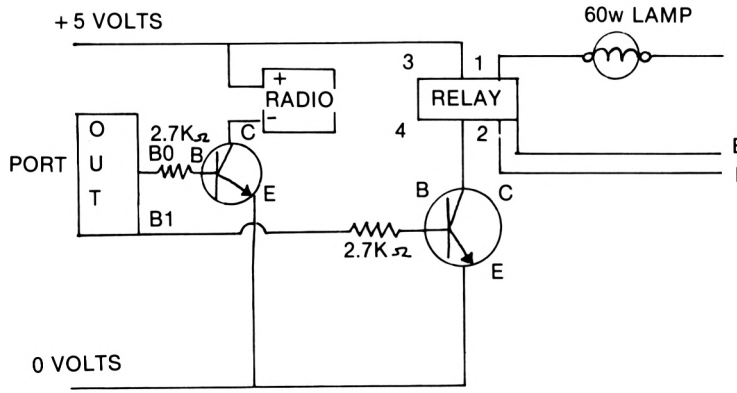
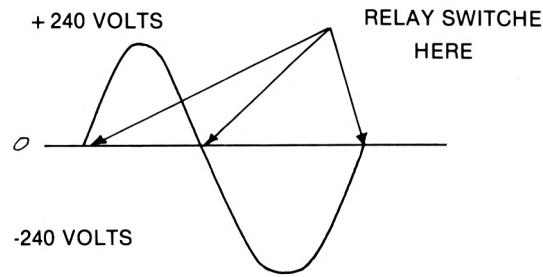

apple II

Figure for The Moveable "Occupant"





QUANTITY	COMPONENT
1	OUTPUT PORT
1	PORTABLE 9v RADIO
1	60w LIGHT BULB
1	LAMPHOLDER 240v
1	SOLID STATE RELAY 2.5a
1	5a MAINS CABLE,3 CORE
2	2N697 TRANSISTORS
2	2.7K ohm RESISTORS ¼ w
1	BATTERY CONNECTORS
1	+ 5v POWER SUPPLY

THE MOVEABLE "OCCUPANT"

The idea of this project is to do what no other electronic device can do, imitate a human being at home. When you want to get away on holidays or go out for the day, the ZX81 can replace you, and a burglar will think you are at home, because the lights go on and off at irregular times. During the daytime, a radio will be heard at intervals, so you must be at home, mustn't you?

The unit is more costly than any other, but it is extremely simple to make and will more than repay the cost, by giving you peace of mind.

CONSTRUCTION

We are dealing with two voltages here, + 5 volts and 240 volts A.C. mains, so great care must be taken to make it up correctly.

THE MAINS PLUG MUST BE REMOVED BEFORE ANY TESTING IS DONE!!

The solid state relay comes as a black plastic block with four pins marked 1-2-3 and 4. Pins 1 and 2 are the mains switch, which should be inserted in the LIVE (L) side of the mains supply to the 60 watt lamp. The best place to mount it is under the lampholder itself, as this means that the 240 volt mains wiring is kept as far away from the ZX81 as possible. The neutral (N) is connected direct from the mains plug to the lampholder. The earth should be connected to the GREEN/YELLOW wire in the mains plug, and go all the way to the lampholder where it is insulated from the rest of the wiring. This is a basic safety precaution as the earth protects the cable all the way up to the lampholder.

Pins 3 and 4 are the connections to the L.E.D. within the unit and must be connected the correct way round. Pin 4 goes to the collector (C) of the transistor. Pin 3 goes to the + 5 volt supply. Two wires are connected to pins 3 and 4, then led away from the lampholder, to a separate board containing the port and the two 2N697 transistors. These wires are to be kept well away from the mains wiring and should NOT be run back to the ZX81 alongside the mains cable.

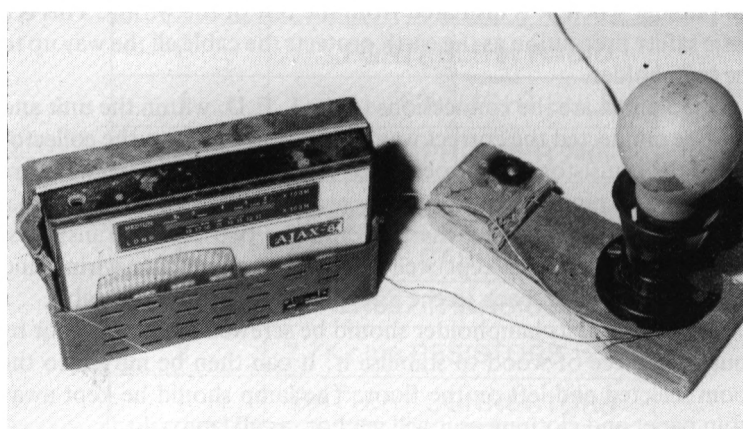
The lamp and its lampholder should be screwed down to a four by four inch piece of wood to stabilise it. It can then be moved to the room selected and left on the floor. The lamp should be kept away from paper and clothing as it will get hot, as all lamps do.

The radio can be in the same room as the 60 watt lamp or in a different one. The cables connecting the radio should be kept short, so I suggest that you keep it in the same room as the ZX81. The +5 volt supply should NOT be from the ZX81's own +5 volt supply, as surges created by switching on and off the radio may lead to it crashing the ZX81's program.

The transistors used are 2N697's and these have the collector (C) connected to metal casing. Therefore the cases of the two transistors MUST be kept apart. The usual warnings about soldering transistors apply, as does making sure they are the right way round. The radio used should be of the portable type, run by a PP3, 9 volt battery. Larger types might draw too much current from the +5 volt supply and the maximum the transistors can take is only 500ma before any damage is done.

HOW IT WORKS

The program given, times a twenty-four hour period and can switch on either the radio or the lamp depending on the time of day. This is to make sure that the "occupant" does not disturb the neighbours. The port data either turns on the radio by setting BO to Binary 1 or turning on the lamp by setting B1 to Binary 1. This is done by POKEing the port with either 1 or 2, if required the nighttime occurrences could POKE the port with 3, thus turning on the lamp and the radio. If your port requires the use of a machine code routine to get information into it, then substitute the appropriate POKE, followed by the call to the routine, via the USR command.



The transistors reduce their emitter (E)/ collector (C) resistance to about 0 ohms, when the + 5 volts from the port is applied to its base (B) (Binary 1). The 2.7K ohm resistor stops the damage to the transistor and the port bit by limiting the amount of current flowing into the base. Thus when the port turns that bit to Binary 1, the collector (C) is virtually at 0 volts. This turns on the radio which you will already have tuned in to the station, and adjusted the volume control. On the components list is a battery connector, which should be used to connect the radio. This should be wired in reverse to normal, i.e. black to the positive (+) supply and red to the negative (−), collector connection. This is because it replaces the battery for the radio.

The mains switch is also operated by the collector/emitter resistance being at 0 volts. This means that there is now enough voltage across the L.E.D. inside the mains switch to light it. The L.E.D. operates a photo-transistor, which in turn operates an A.C. switching device, called a TRIAC. A TRIAC can be operated at any time during the A.C. cycle, which means that it can switch on at any voltage. It acts just like a light switch. This means that the instantaneous voltage at switch on can vary from − 240 volts to + 240 volts. If the instantaneous voltage is very high, then a noise 'SPIKE' is created which bounces through all the electrical mains wiring in the house. Now the ZX81 is also connected to the mains (unless you are on a standby battery supply, in which case this does not apply), so it also receives this HIGH ENERGY noise SPIKE! This 'SPIKE' will upset the ZX81 by creating a sudden surge in voltage which will corrupt the RAM and crash the program. So switching things on and off on the mains supply can easily crash the ZX81. When we need to control things on the mains by computer, we need a way of stopping these mains 'SPIKE's from being created.

Such a device is called a ZERO VOLTAGE SWITCH and it is contained in the black block of the mains switch, between the photo-transistor and the TRIAC. This will only turn on the TRIAC when there is no voltage, and therefore no current flowing, i.e. every time the voltage changes from positive to negative and back to positive again. As there is no voltage or current flowing, no 'SPIKE' can be produced, and the voltage rises from the 0 volts to the maximum as normal. This means that when we turn on the L.E.D., we may have to wait up to 1/100th of a second before the TRIAC is turned on. But as this prevents the program crashing, I think it is worthwhile. All this extra circuitry has to be paid for, and the device is quite expensive, but it will deal with electric motors as a bonus. The device here costs

about £8, but heavier current devices up to 30 AMPS are available at about £25.

Because of the zero switching facility being built in, it can quite safely be operated by the ZX81. There is no physical contact between the mains supply and the port circuit. The switch is rated at 2.5 AMPS and that means that it can cope with INDUCTIVE (motors etc.) and RESISTIVE (lamps, electric fires) loads up to 750 WATTS in safety. It would not be worth saving costs by substituting a relay for the switch as the 'SPIKE' would reappear.

This switch is only available from RADIO SPARES (No. 348-341) and you would need to order it through a shop.

The PROGRAM

```
10   REM SET UP PORT IF NECESSARY
20   PRINT "INPUT HOUR 1-24"
30   INPUT N
40   IF N> 24 OR N< 1 THEN GOTO 30
50   PRINT "WORKING"
60   FOR Y = N TO 24
70   IF Y> 8 AND Y< 16 AND RND*8> .5 THEN POKE
     PORT, 1
80   IF Y> 19 AND Y< 23 AND RND*8> .5 THEN POKE
     PORT, 2
100  GOSUB 200
110  POKE PORT, 0
120  NEXT Y
130  LET N = 1
140  GOTO 60
200  FOR H = 1 TO 60
210  PAUSE 3000
220  NEXT H
230  RETURN
```

The timing is being done in this program by the subroutine 200, which PAUSEs for 3000 × 1/50th second, which is approximately one minute. This is done sixty times, so that call to GOSUB 200 provides a delay of one hour before any device is switched off by the POKE in line 110. All timing is done to a twenty-four hour clock, so one o'clock in the afternoon is thirteen hundred hours etc.

The PRINT between the inverted commas in line 50 is in inverse letters.

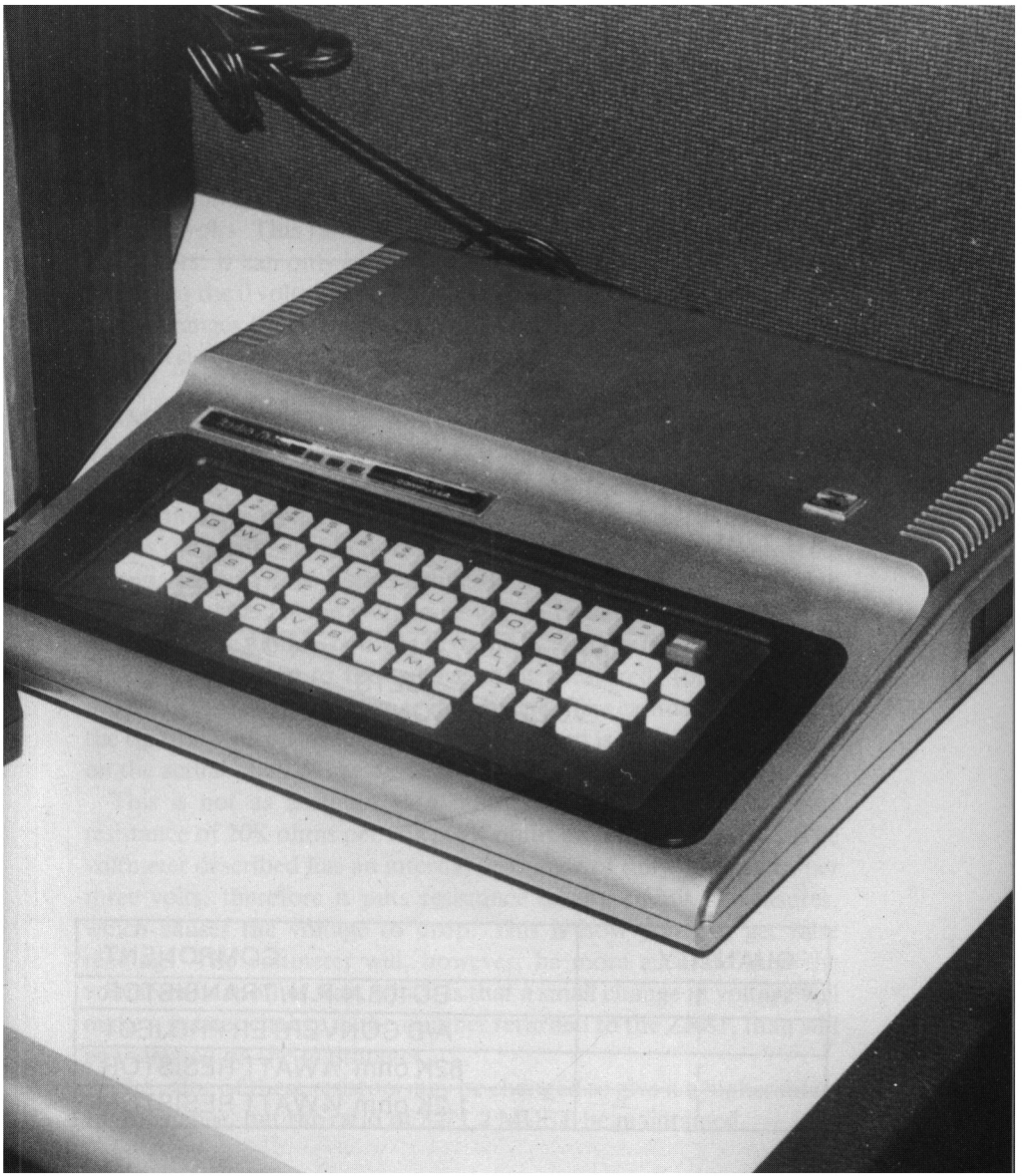
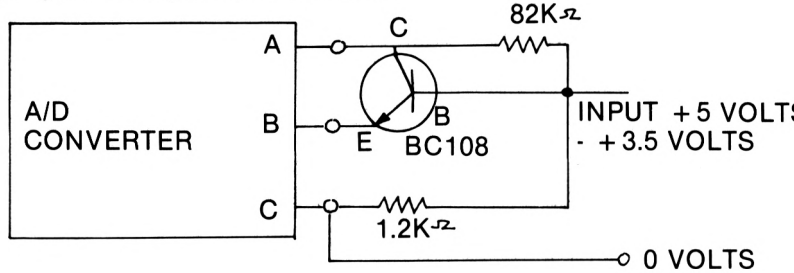
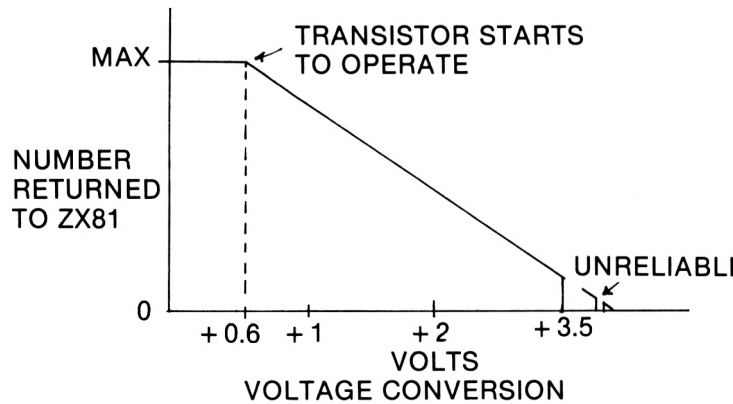


Figure for A Computerised Voltmeter





VOLTAGE CONVERSION

QUANTITY	COMPONENT
1	BC108 N.P.N. TRANSISTOR
1	A/D CONVERTER PROJECT
1	82K ohm ¼WATT RESISTOR
1	1.2K ohm ¼WATT RESISTOR

A COMPUTERISED VOLTMETER

The circuit given here enables you to use the A/D converter project to measure voltages. These voltages can be anywhere from +0.5 volts to +3.5 volts. This range is very small, but is larger than most A/D converters. It can only be used to measure POSITIVE voltages with respect to the 0 volts line. It can, however, be extended to cover most voltage ranges found on the normal voltmeter by adding suitable external resistors to drop the extra voltage.

CONSTRUCTION

The transistor etc. can be built as a separate unit, or on the same board as the A/D converter. The wiring to the connections of the A/D converter from the transistor should not be greater than a few feet as the reading depends on the resistance of the transistor across terminals A and B. A diode might have to be included, for protection of the transistor, if the voltages could go negative at any time. The cathode of the diode is connected to the base of the transistor, and the anode is connected to the voltage to be measured, (or the resistor dropping the rest of the voltage if included). The cathode of a diode is the tip of the arrow on the diode symbol, and is marked with a band on the actual body of the diode.

This is not as accurate as a multimeter which has an internal resistance of 20K ohms per volt, 60K ohms on a three volt scale. The voltmeter described has an internal resistance of only 1.2K ohms per three volts, therefore it puts resistance in any circuit it measures, which causes the voltage to drop. This is how you can get false readings. The voltmeter will, however, be more accurate than the voltmeter in another way, which is that a small change in voltage will make a greater change in the number returned to the ZX81, than will be indicated on the multimeter.

The value of these resistors may be changed to give it a higher internal resistance, but the ratio of 82/1.2 MUST be maintained.

HOW IT WORKS

A transistor is used as a variable resistor, as the resistance between its EMITTER (E) and the COLLECTOR (C) varies with the voltage on its BASE (B). The transistor shows a very high resistance when the

BASE voltage is below 0.6 volts and has virtually no effect on the 100K ohm resistor across terminals A, B. This 100K ohm resistor controls the timing and so the number returned to the ZX81. If the voltage rises above 0.6 volts, the transistor's resistance across the 100K ohm resistor starts to come down at the same rate at which the voltage rises. As the 100K ohm resistor is more and more bypassed by the lower resistance of the transistor, more voltage reaches the timing capacitor and the more quickly it charges. Therefore, the higher the voltage, the shorter the pulse from the A/D converter. This means that the higher the voltage, the lower the number returned to the ZX81 BASIC from the machine code collecting routine.

As any voltage below 0.6 volts has virtually no effect on the timing I decided to eliminate this, by setting the lower limit to be measured at a constant 0.6 volts. This is done to keep the transistor permanently in the varying resistance range, it will then react to any small increase in voltage above 0.6 volts. This is done by having two resistors fixed to the BASE (B) of the transistor. The other ends of the resistors are connected to the + 5 volts supply and the 0 volts line. This is called a POTENTIAL DIVIDER, as it divides the potential or voltage according to the ratio of the resistors. The BASE of the transistor has virtually no effect on this calculation and can be ignored. As the 82K ohm resistor is the higher value of the two, it drops the most voltage across itself. Therefore between the BASE and the 0 volts line the voltage is + 5/(12K ohms/82K ohms + 1.2K ohms), that is the total voltage divided by the individual resistance which has been divided by the total resistance. This should equal 0.6 volts.

The unit has to be calibrated by setting up a voltage from an external power supply and using a multimeter which has been set to the voltage range. The voltmeter should be used to measure the voltage at the base of the transistor as the numbers from the machine code routine are noted. The power supply should be increased in steps of 0.5 volt and the readings stored in the ZX81 for later reference. The 0.5 volt steps can be calculated from the readings obtained, as the difference between them is in linear form, i.e. the number varies in direct proportion to voltage applied.

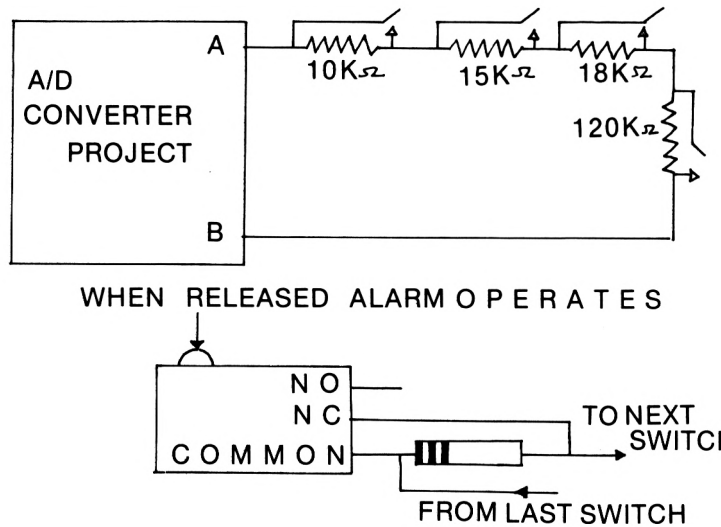
To extend the ranges, a suitable resistor must be put in series with the input voltage. The resistance is calculated from the POTENTIAL DIFFERENCE formula, i.e.

$$\frac{\text{MAXIMUM VOLTAGE}}{3.5 \text{ volts}} = \frac{\text{X ohms}}{1.2 \text{ K ohms}}$$

Therefore $X = \frac{\text{MAXIMUM VOLTAGE} \times 1.2}{3.5}$ KILO OHMS

The maximum range is limited because the transistor is nearly fully turned on and a small change in voltage makes almost no difference in the number collected by the ZX81. The range available with my equipment gives a variation from 5545 to 960, with an accuracy of ± 1 on the count. This means considerable sophistication of the measurement of voltages within the 0.6-3.5 volt range.

Figure for Unbeatable Burglar Alarm



QUANTITY	COMPONENT
1	10K ohm RESISTOR ¼ WATT
1	15K ohm RESISTOR ¼ WATT
1	18K ohm RESISTOR ¼ WATT
1	120K ohm RESISTOR ¼ WATT
1	A/D PROJECT
4	MICRO SWITCHES

UNBEATABLE BURGLAR ALARM

This is yet another project which uses the A/D converter project (useful isn't it!). In this one the A/D is used to measure the resistance of a series of resistors, which are connected to switches attached to doors, windows, etc. Each switch is closed by the opening of a door or window and sets off the alarm. If the alarm wire is cut, the alarm goes off. If the switch is short circuited by wiring across the switch with a piece of wire, the alarm goes off. If the resistor is spotted and the resistor is substituted for another, the alarm goes off. Boring isn't it? But it proves the point that it cannot be beaten, except by turning off the ZX81. It can also tell EXACTLY where the alarm has been set off and this from the literally hundreds of switches which could be attached to this one burglar alarm. It only requires one set of wires, too!

CONSTRUCTION

The A and B terminals of the A/D converter are connected to a chain of resistors across which are connected microswitches, one for each resistor. The switches must be set to close when the object is moved or a door or window is opened, I leave it up to you. A few suggestions for alternatives to the microswitches are:—

1. TILT switches which operate when they are moved greater than thirty degrees.
2. Reed switches operated by magnets in the door or window.
3. Pressure mats under carpets.

The resistor should be soldered across the switch with a connection which is as short as possible, so that the switch cannot be cut away from the resistor, while leaving the resistor in circuit. Attach the wires so that there is only one wire going in and one wire coming away from the switch, it makes it easier to identify this later if you want to add to or change the circuit in any way.

The wire used can be any length as long as it doesn't run into miles, as this can be compensated for within the program. Switches are identified by each having a resistor of unique value. The joints between the wires and the microswitch should either be soldered or very well made as this would possibly set off the alarm by changing its resistance. The program should be adjusted by setting off the alarms

AFTER they are ALL installed as they will be different with each one.

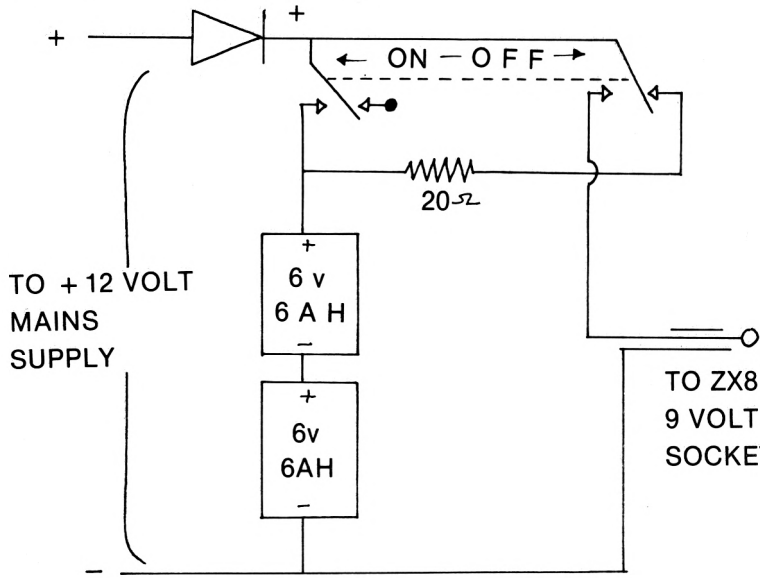
HOW IT WORKS

The A/D project measures the resistance across the terminals A and B, by seeing how much the 100K ohm resistor within the unit is bypassed. The first reading must therefore be taken to see what the normal resistance is. This should be checked by the program and ONLY if it is different from normal should any checks be made on what has caused the alarm to operate. This saves time as the checks could run into minutes, if quite a few switches are used. The normal response time of the A/D converter and machine code program is less than 50 milliseconds, leaving little time to "fiddle" the circuit or by pass it. The total resistance of the circuit is measured continuously, but when one of the switches is operated, even momentarily, the total resistance changes as one of the resistors has been removed from the circuit. The total resistance of the chain can be calculated by adding up all the values of the individual resistors. The total resistance should not exceed 10 MEGA ohms. The resistors used can be of any tolerance as the individual resistances are unlikely to be exactly the same. If you run out of preferred values, that is the ones that are normally available, you can join two together to get additional values.

The total value of resistors used should not be below 11 kilo ohms as it is easy to detect large changes in resistance and this still leaves a choice of 10,000 combinations. The resistance can be checked to see which switch has been operated by taking its value away from the normal value (when no switch is operated). The result should be compared against the value for when the switch was pushed on setting up the system. If it matches, within ± 5, the alarm location should be printed on the screen and an alarm sounded by using the output port to operate a tone generator, bell, etc. The number of locations covered by a 1K basic model will obviously be limited, a 16K model would be required for a large installation. The program could also include variations designed to your own specification, e.g. a bedroom in use could be left unguarded. It could also incorporate a timer which allows further sophistication of the system. I will leave you to write your own program as you can incorporate your own ideas and it will be unique to your house, business, etc. Even when buying a ZX81 plus port etc., especially for this project, it costs less than some simple alarm systems. It is also easily adapted, and can be reprogrammed at any time.


E_S T E
100a
"Hello I'm Presby
Buzby's younger brother
I'm presenting
ESTE
the vide ranging information
service from the Post Office
that works on your TV set at
the press of
a button
and see"

Figure for Standby Power Supply



QUANTITY	COMPONENT
2	LEAD ACID JELLY CELLS
1	6v, 6 AMPERE HOUR 5a POWER DIODE
1	DOUBLE-POLED CHANGEOVER SWITCH
1	20 ohm, 5w RESISTOR
1	3.5mm JACK PLUG
1	12v REGULATED POWER SUPPLY - at least 1 AMP

STANDBY POWER SUPPLY

This useful addition to a ZX81 system will not only eliminate those annoying 'Whiteouts' due to mains fluctuations, but also provide a completely portable system independent of ANY power supply.

This can be used for raising money at fetes, exhibitions and even when camping!

The unit supplies +12 volts from two batteries, with enough power to supply a T.V., ZX81, and 16K RAM pack for up to THREE HOURS.

The amount of power required for the system is calculated in WATTS and is arrived at by multiplying maximum amount of current required in AMPERES by the voltage supplied. Thus the ZX81 and 16K RAM pack which takes 1 AMP (short for AMPERE) from a 12 volt supply needs a 12 watt supply (12x1). The television that I took as an example is a VEGA 402D-12 volt D.C./240 volt A.C. portable with a 6 inch black and white screen. This takes only 7.5 watts from a 12 volt supply. That means that the total computing system takes only 19.5 watts and weighs only 11.4 lbs. I have omitted the cassette recorder as it is usually a portable one with its own built in battery supply.

Batteries are rated by the number of AMPERES (AMPS) that they can supply over a given period. Normally quoted in AMPERE HOURS, that is 1 AMP for 1 HOUR, if a battery is rated at 6 ampere hours, it can supply a maximum of 6 amps for one hour or 1 amp for 6 hours. A car battery could be used to provide enough ampere hours for the system, but would be extremely heavy and costly. Also car batteries can be messy and need to be kept topped up with distilled water. There is however a cheaper, easier to maintain alternative, which are called LEAD ACID JELLY CELLS. They are small, light, sealed and RECHARGEABLE. Mainly used for emergency lighting, a 6 volt, 6 ampere hour cell measures $4\frac{1}{2} \times 2 \times 3\frac{1}{2}$ inches and weighs only 2.5 lbs.

As we need 12 volts we will have to use two of these batteries in SERIES, that is one after the other, giving a 12 volt battery capable of 6 ampere hours. We now have a battery which can supply 72 WATTS per HOUR. The whole system only consumes 19.5 WATTS per HOUR, so we can power it from the battery for 3.6 HOURS

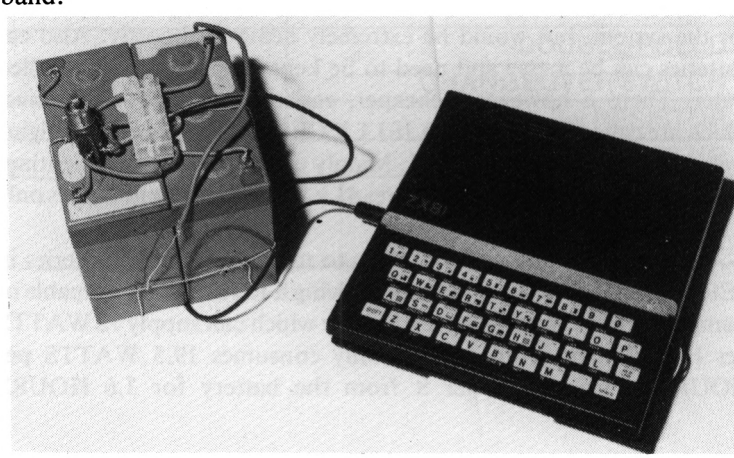
(72/19.5). The battery is normally left attached to the ZX81 via a 3.5 millimetre plug and when the ZX81 is switched off, the battery can be recharged via the 20ohm resistor. The resistor is necessary as the battery must be charged at not more than 1/10th of the AMPERE HOUR rate. In this case 0.6 AMPS. The diode should always be included and it should have as high a rating as possible so that it will drop little voltage across its own internal resistance.

If the main power supply can provide more than 1.6 AMPS, the battery can be recharged whilst using the ZX81 with the mains supply. But if the battery cannot supply the ZX81 on its own, it should be left to charge with the mains supply on, but the ZX81 system switched off, for 10 to 12 hours. The diode ensures that the batteries cannot discharge through the mains when the power supply is switched off, as it only allows the current to flow in the direction of the arrow in the diode symbol (positive to negative), and stops the flow of current from the positive of the battery back to the negative.

CONSTRUCTION

The 3.5 mm. plug must be wired the correct way round with the 'knob' connected to the positive of the supply (+). The switch should be rated at least 2 AMPS and is a DOUBLE POLED CHANGE-OVER switch. The switch may also be used as a reset switch to save wear on the 3.5mm jack socket on the ZX81. It is best not to use a slide switch as they tend to be unreliable after short periods of heavy current, causing a sudden power loss.

The rest of the construction is not critical, the layout can be of your own choice except to locate the diode and the battery the right way round. The positive end of the diode is usually the end marked with a band.



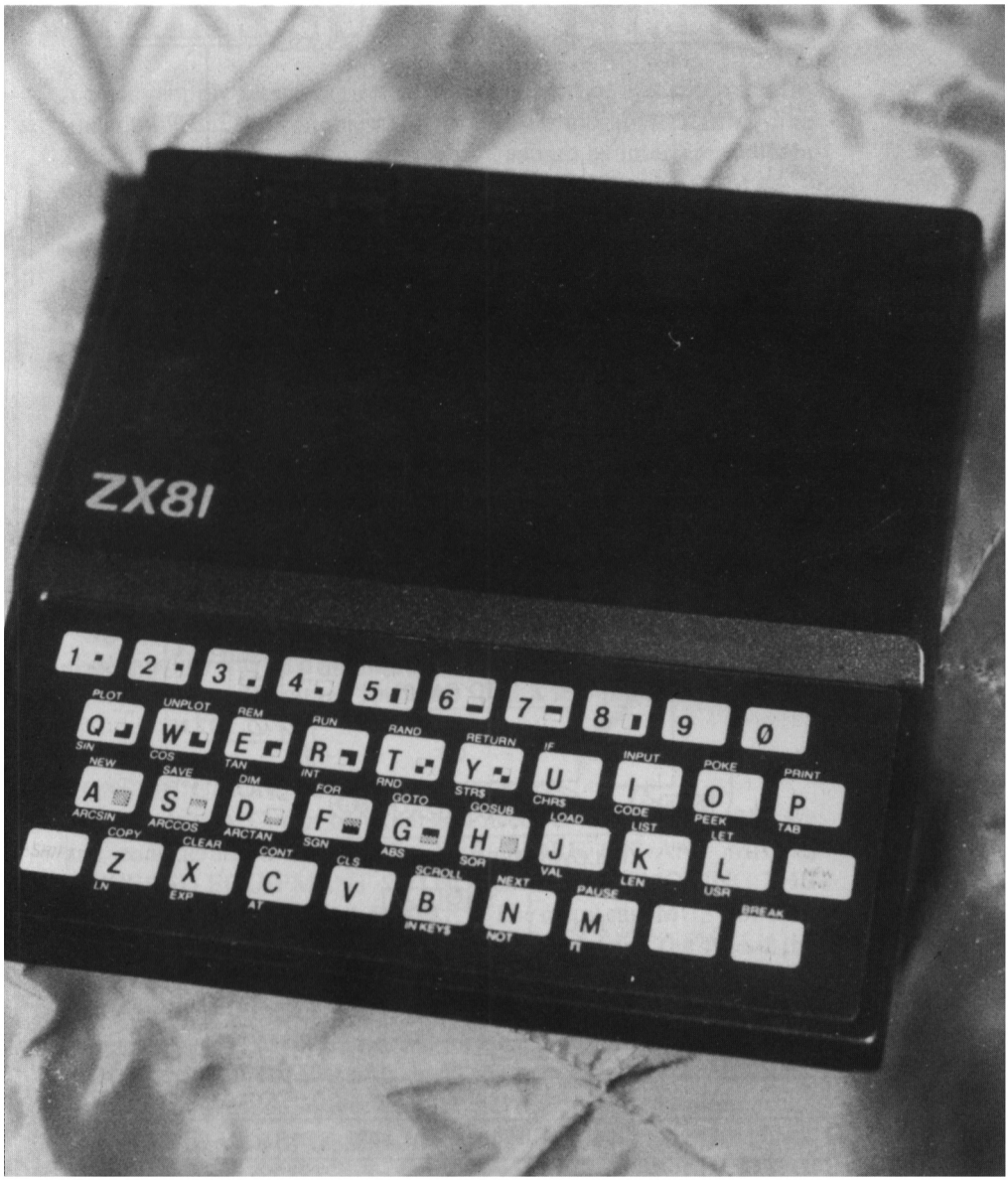
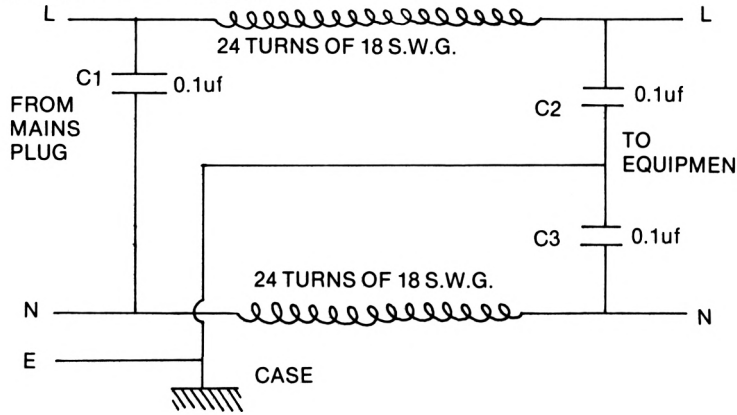
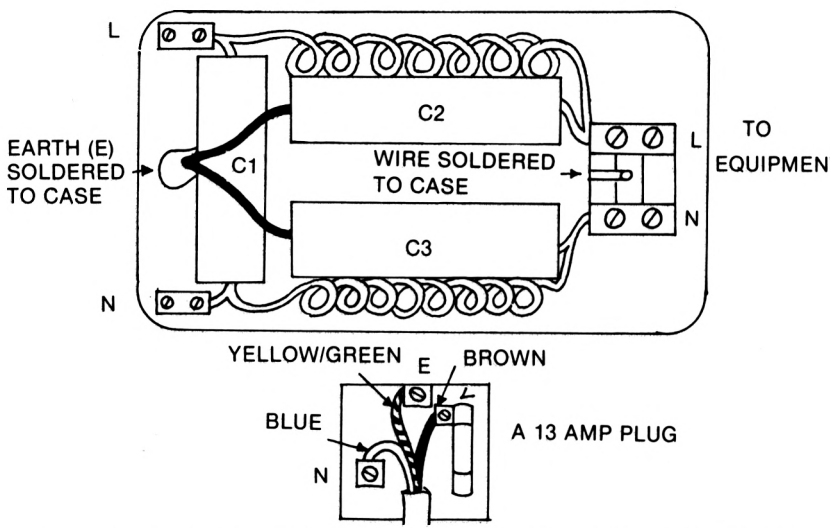

ZX81

Figure for Mains Supply Filter





QUANTITY	COMPONENT
1	20z TOBACCO TIN
4	FT. of 18 S.W.G. WIRE
3	0.1uf 700v AC CAPACITORS
1	¼" DIA. ROD
4	SA. CHOCOLATE BLOCK CONN.
SOME	3 CORE MAINS FLEX

MAINS SUPPLY FILTER

A mains supply filter is an essential component of any computer installation from the humblest ZX81 to a 60 megabyte I.B.M. The ZX81 tends to suffer from "whiteouts" caused by interference from the mains supply, which can corrupt the data held in the RAM.

This interference comes in many forms, MOTOR circuits turning on or off cause surges due to their large inductance, RADIO interference is picked up from overhead wires or even the house wiring. Sudden surges also occur, often caused by large changes in current such as the operation of heaters and television sets.

The filter cuts out this interference by allowing any LOW frequencies, such as the 50 cycles A.C. mains, through. Any high frequencies have difficulty getting through for two reasons:-

1) The higher the frequency, the higher the A.C. resistance (IMPEDENCE) to a flow of A.C. current.

2) The higher the frequency, the lower the IMPEDENCE presented by the capacitors which are sitting across the mains supply. So the capacitors tend to short out higher frequencies.

The trouble caused by high frequency noise 'spikes', is mostly eliminated by the filter. It will NOT, however, cope with large fluctuations in mains voltage for more than a few milliseconds.

CONSTRUCTION

The 240 volts A.C. can be lethal and needs to be handled with care and consideration. DO NOT EVER WORK ON ANY MAINS POWERED EQUIPMENT WITHOUT FIRST REMOVING THE PLUG FROM THE WALL SOCKET. The metal case MUST be connected to EARTH (E) as it protects you by blowing the fuse if the mains touches the case. The filter should be placed as near the mains transformer or Sinclair power pack as possible, because the mains lead can also act as a radio aerial picking up interference. The case must be made out of metal to shield the two coils and prevent them from acting like a radio receiver and picking up more interference.

The 240 A.C. is connected to the unit inside the case by plastic 'chocolate block' connectors. The output side plastic block is secured by a piece of 18 S.W.G. (Standard Wire Gauge) wire soldered to the bottom of the case and then poked through the hole in the plastic between the two terminals. Bend the wire over at the top, so that it holds

the plastic block in place. The input end is secured by soldering the joint of C2/C3 to the case as close to the capacitors as possible. The capacitors should be arranged as shown, as they form a support for the coils.

The coils are wound from four feet of 18 S.W.G. enamelled wire on a $\frac{1}{4}$ inch diameter wooden rod. The 24 turns are wound as close together as possible along the rod. After the coil is removed from the rod, space out the turns so that none of the turns touch each other. This should leave you with a coil of wire about two inches long. After scraping the enamel off to bare the copper on each end, solder the coils directly to the capacitors. Make sure that the coils are at least $\frac{1}{4}$ inch away from any part of the metal case. All of the leads in this unit should also be as far away from the metal case as possible.

If you cannot get hold of a metal tobacco tin, or similar, then obtain an aluminium box of at least $4\frac{1}{2} \times 3 \times 1$ inches. As aluminium cannot be joined with ordinary solder, you will have to solder all the case connections to solder tags and then screw them to the box.

If you have an ohmmeter, check that there are no shorts to the case with the cover on, if not make sure you check it visually. GOOD LUCK.

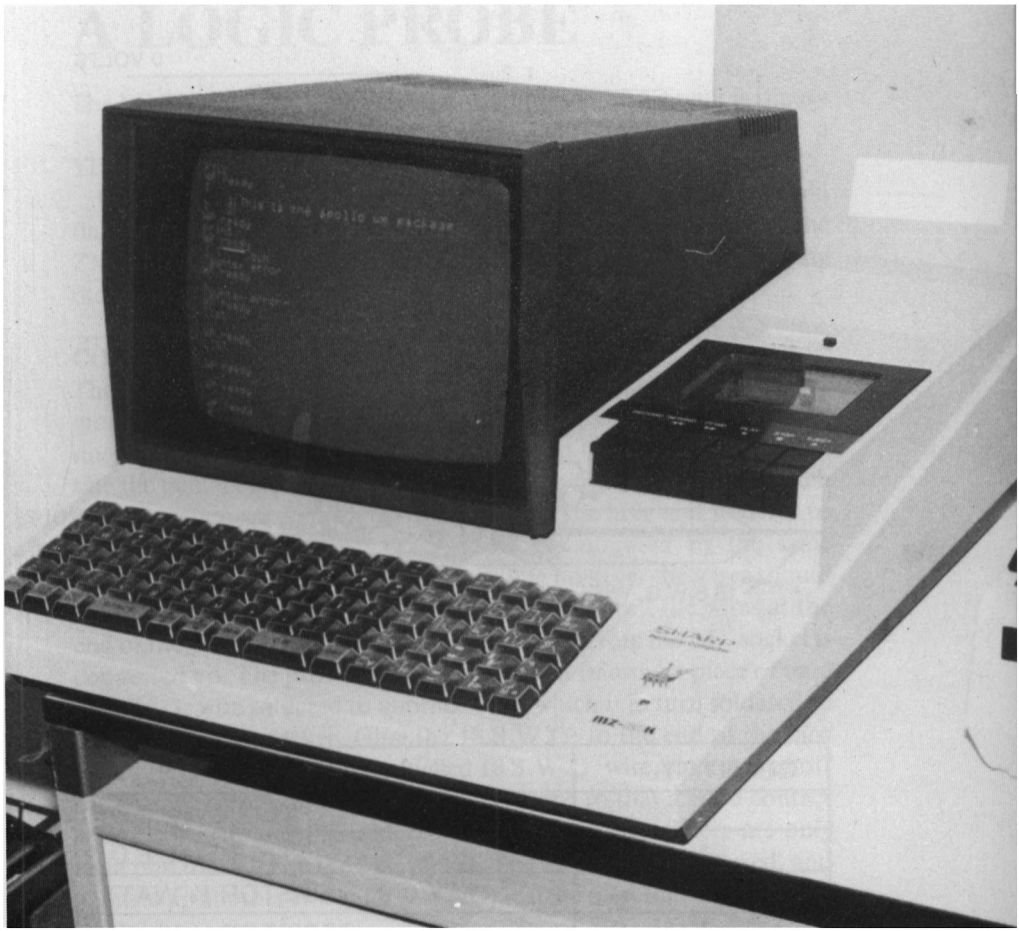
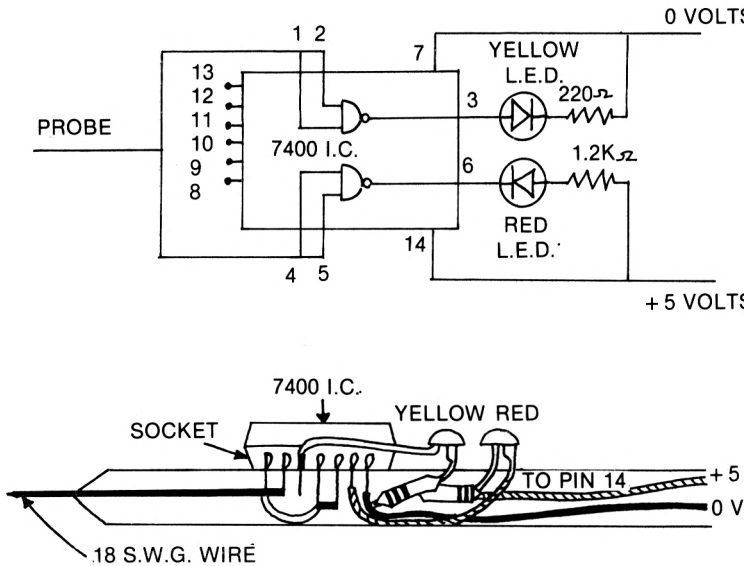

SHARP

Figure for A Logic Probe



QUANTITY	COMPONENT
1	YELLOW L.E.D.
1	RED L.E.D.
1	1.2K ohm RESISTOR ¼ WATT
1	220 RESISTOR ¼ WATT
1	7400 I.C.
1	14 PIN I.C. SOCKET
1	BIRO OR FELT-TIP PEN
1	18 S.W.G. COPPER WIRE
1	+ 5 VOLT POWER SUPPLY

A LOGIC PROBE

The LOGIC PROBE tests to see if the condition on a circuit is Binary 1 or Binary 0, lighting either a RED light emitting diode or a YELLOW one, thereby testing the ZX81.

If the condition being tested is a series of pulses, both L.E.D.'s will flash. This can be used to test any logic circuit including that of the ZX81 without affecting its operation. It can also be operated using the power supply from the ZX81.

CONSTRUCTION

The basis of this project is a felt tip or biro pen case, on top of which is mounted the I.C. socket containing the 7400 I.C. The wires connecting the I.C. socket should first be soldered to the components inside the pen. Then after making a hole in the side of the pen for each pin to be connected, push the wire through the hole and solder it to the I.C. socket. The L.E.D.'s should be mounted by the same method through holes in the case, this time however the wires should be soldered on to the L.E.D.'s first. Then draw out the wires at the end of the pen and solder them to the resistor before the I.C. socket is connected up. The probe should be made out of a short piece of bare 18 S.W.G. wire soldered to another wire, which is in turn soldered to pin 1 of the I.C. socket. Glue the 18 S.W.G. to the end of the biro case. If you have got only enamelled 18 S.W.G. wire, then scrape off the enamelling at both ends of the wire probe so that a good contact with the circuit and the soldered wire can be made. There are only eight pins to solder on the I.C. socket. The six which are not used, and connect up another two gates (NAND), can be used for other things if you wish.

The power drawn from the power supply is only 20 ma, so can be attached to the ZX81's +5 volt output on the expansion port if necessary. The +5 volt supply is obtained from pin 1B and is on the bottom of the edge connector, nearest the cassette sockets.

The I.C. should not be plugged into the socket before all of the connections have been soldered and checked. This saves damage to the I.C.

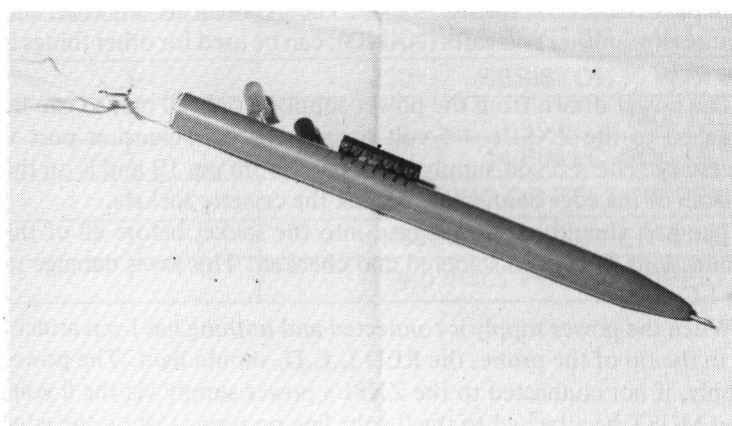
When the power supply is connected and nothing has been attached to the tip of the probe, the RED L.E.D. should light. The power supply, if not connected to the ZX81's power supply via the 0 volts line, MUST be attached to the 0 volts line on pins 4/5B on the edge

connector. This could be done by attaching a crocodile clip to the T.V. lead's outer metal conductor as this is also at 0 volts, if you don't want to solder a connection. When testing circuits NOT connected to the ZX81, attach the 0 volt line of the power supply to the 0 volt line of the circuit to be tested.

HOW IT WORKS

The probe's tip is connected to a point on the circuit which is at one of two levels, Binary 1 or Binary 0. This is +5 volts and 0 volts on T.T.L. (TRANSISTOR – TRANSISTOR – LOGIC) which all of the projects in this book use in their I.C.'s. There are other types of logic which use different methods and voltages to communicate Binary 1's and 0's, but T.T.L. is the most common. These others cannot be tested as the voltages used might be greater than the input voltage allowed for these 7400 I.C.'s and would damage the tester.

A Binary input to both pins 1 and 2 causes the NAND gate to react like an inverter, i.e. if a Binary 1 is input the output is Binary 0 and vice versa. When the input is Binary 1, the output is 0 volts (Binary 0) and the YELLOW L.E.D. will not light because it has not got sufficient difference across it to light, both ends being at 0 volts. The RED L.E.D. however has +5 volts at the end of its resistor and will light, because its gates inputs also cause it to change the output to 0 volts. When the input is changed to Binary 0, the YELLOW L.E.D. will glow and the RED L.E.D. will go out. Thus the RED L.E.D. gives an indication of a Binary 1 on the input and a YELLOW L.E.D. gives an indication of Binary 0 input. When the circuit to be measured is con-



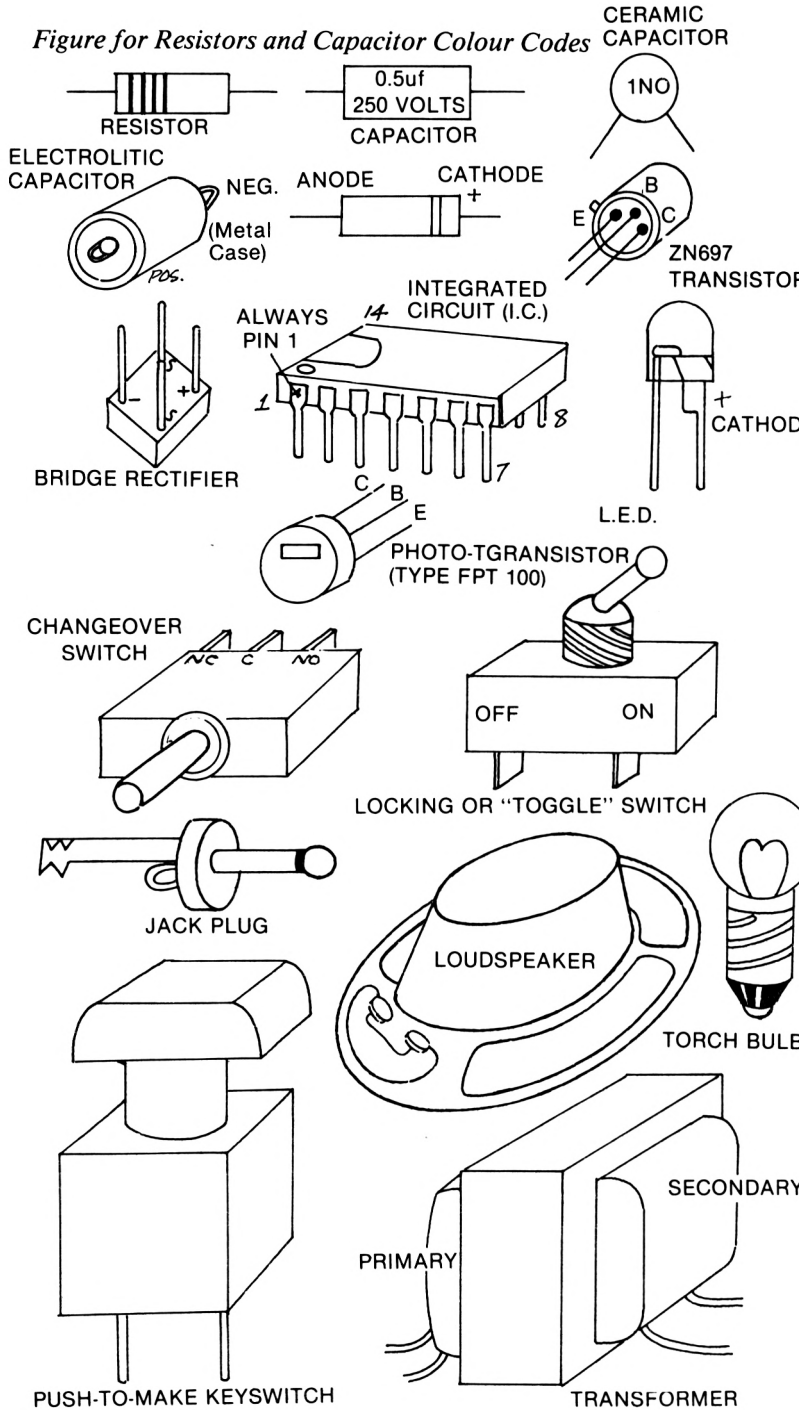
stantly changing between Binary 1 and Binary 0 or PULSING, then both L.E.D.'s will start to flash at the rate at which the pulse changes. If the pulsing rate is too high, all that will be seen on the L.E.D.'s will be a faint flicker.

There are many uses of the logic probe: finding out whether the correct address is operating the correct $\overline{CS}$ pin as in the WHEEL OF FORTUNE project, checking that none of the address lines are short circuited, checking the data sent to a port on a particular bit to name but a few.

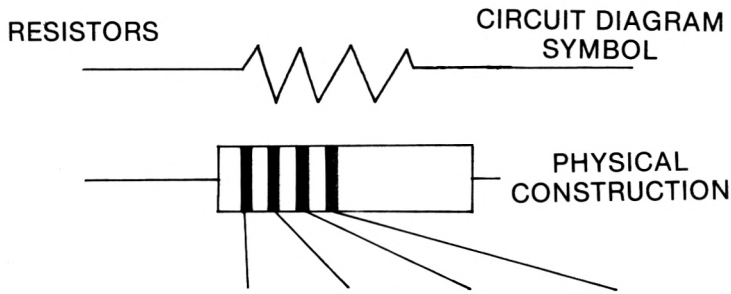
One thing to remember is that the logic probe will indicate no connection by Binary 1. This is because the 7400 I.C. keeps all its inputs at Binary 1 by means of resistors within the chip connecting the + 5 volt supply and the input.

The resistors used reflect the various resistances involved, inside the output of a gate, the 220 ohm resistor is smaller than the 1.2K ohm resistor because of the resistance through which it must travel within the chip from the + 5 volt line. This can be up to 10K ohms, so a small resistor is needed to keep the current down to a reasonable level. The resistance to the 0 volt rail, when the output is Binary 0, is only that of a transistor's emitter/collector junction. This is very small when turned on, so a larger resistor must be used.

Figure for Resistors and Capacitor Colour Codes



RESISTORS AND CAPACITOR COLOUR CODES



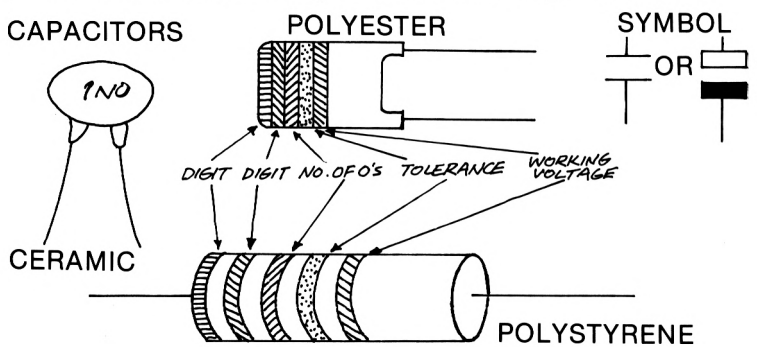
COLOUR	DIGIT	DIGIT	NUMBER OF 0's	TOLERANCE
BLACK	0	0	NONE	NOT USED
BROWN	1	1	0	1%
RED	2	2	00	2%
ORANGE	3	3	000(K)	COLOUR NOT USED
YELLOW	4	4	0K	
GREEN	5	5	00K	
BLUE	6	6	000K(M)	
VIOLET	7	7	0M	
GREY	8	8	00M	
WHITE	9	9	000M	
GOLD	NOT		DIGIT ● DIGITALΩ	5%
SILVER	USED		NOT USED	10%

The resistor is coloured at one end by three or four bands which give the value and percentage tolerance. The three bands at the front give the value in OHMS as shown in the table above. Note that the three '0's can be replaced by a K for KILO. So BROWN/BLUE/YELLOW comes to 160 KILO OHMS. The million ohms can be replaced by M or MEGA. Thus ORANGE/RED/BLUE is 32 MEGA OHMS. If the third band is GOLD, then insert a decimal point between the two digits. Thus GREEN/YELLOW/GOLD is 5.4 OHMS. The OHM is usually written as Ω.

The tolerance shown on the fourth band is either 1%, 2%, 5% or 10% and this is the plus or minus percentage within which the actual resistance falls:

The tolerance is 20% if there is no fourth band. The tolerance shows the range of the actual resistance, compared to its stated value as indicated by the coloured bands. Thus a 1.2K ohm resistor can vary in resistance from 1.44K ohms to 0.96K ohms if its tolerance was 20%.

The resistors WATTAGE is the amount of power the resistor can take without overheating. Overheating a resistor can cause it to increase its value or burn out just like an electric light bulb.



Capacitors use the same colours for numbers as the resistor except that instead of OHMS we are measuring in PICO-FARADS. One pico-farad symbol 'pf' is 1×10^{-12}Farads or a million-millionth of a farad. There are one million pico-farads in a micro-farad (μf). The fifth band gives the working voltage, which is the number corresponding to the colour multiplied by 100. Thus GREEN is 500 volts working. White indicates 1,000 volts working, not 900 volts. The ceramic capacitor shown has a value indicated in NANO-FARADS, symbol 'N', which is 100pf or 0.001 μf. Thus the value shown is 1 nano-farad, the 'N' being used as a decimal place.

A LIST OF USEFUL ADDRESSES

Buffer Shop,
374a Streatham High Road,
London SW16
01-274 6674

Computer Keyboards,
Glendale Park,
Fernbank Road,
Ascot

Frome Computers,
20 Ashtree Road,
Frome,
Somerset BA11 2SF

Bolton Electronics,
44 Newland Drive,
Bolton,
Lancs BL5 1DP

DK 'tronics,
23 Sussex Road,
Gorleston,
Gt. Yarmouth,
Norfolk

Fuller Micro Systems,
Sandfield Park East,
Liverpool L12 9HP

Ground Control,
Alfreda Avenue,
Hullbridge,
Essex SS5 6LT
0702-230324

Henry's Radio,
404 Edgware Road,
London W2 1ED
01-402 6822

Haven Hardware,
4 Asby Road,
Workington
Cumbria, CA14 4RR

Marshalls Components Ltd.,
Kingsgate House,
Kingsgate Place,
London NW6 4TA
01-624 0805

H.L. Smiths,
Edgware Road,
London W2
01-723 7395

Thurnell Engineering,
95 Liverpool Road,
Cadishead,
Manchester M30 5BG

William Stuart Systems,
Dower House Ltd.,
Herongate,
Brentwood,
Essex CM3 3DS

R.D. Labs.,
5 Kennedy Road,
Dane End,
Ware,
Herts. SG12 OLU

Maplins Electronics,
PO Box 3,
Rayleigh,
Essex
0702-552911

National ZX80/ZX81 Users Club,
44-46 Earls Court Road,
London W8 6EJ

Quicksilva,
95 Upper Brownhill Road,
Maybush,
Southampton

Redditch Electronics,
21 Ferney Hill Avenue,
Redditch,
Worcs. B97 4RU

Sinclair Research,
6 Kings Parade,
Cambridge,
Cambridgeshire CB2 1SN

Technomatics,
17 Burnley Road,
London NW10 1ED
01-452 1500

Watford Electronics,
33/35 Cardiff Road,
Watford,
Herts.
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Radio Spares,
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