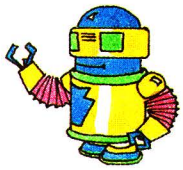
HOW TO MAKE COMPUTER MODEL CONTROLLERS

FOR C64, VIC 20, SPECTRUM & BBC

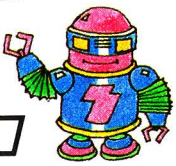
620 IF G$="OP"
630 GOSUB 66
640 IF G$=
650 GO
660

STEP BY STEP COMPUTER PROJECTS FOR ABSOLUTE BEGINNERS

USBORNE ELECTRONIC WORKSHOP



HOW TO MAKE COMPUTER MODEL CONTROLLERS

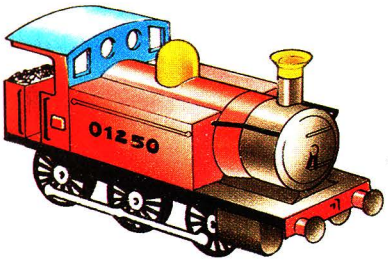


Tony Potter

CONTENTS

Model controllers designed by
Chris Oxlade and Tony Potter

Programs by Chris Oxlade



Designed by Tony Potter
Illustrated by Jeremy Gower
and Jeremy Banks.

Additional illustrations by Chris Lyon,
Sue Walliker and Simon Roulstone.

Technical consultants:
John Hawkins and Colin Motteram.

About this book

This book shows you how to build simple electronic circuits so you can control model trains and cars, like those shown here, with one of these computers: **Commodore 64, VIC 20, BBC Model B** and **Spectrum**.* There are three electronic circuits to make and each enables you to do different things. With the power controller circuit you can switch a model's electric power on and off with your computer. The switch sensor circuit enables the computer to detect the position of a model as it touches a trackside switch. The light sensor is similar, but works without touching the model. The computer programs in this book make the circuits work in different ways. There is also a special board to build, called the control centre, to connect the circuits to your computer.

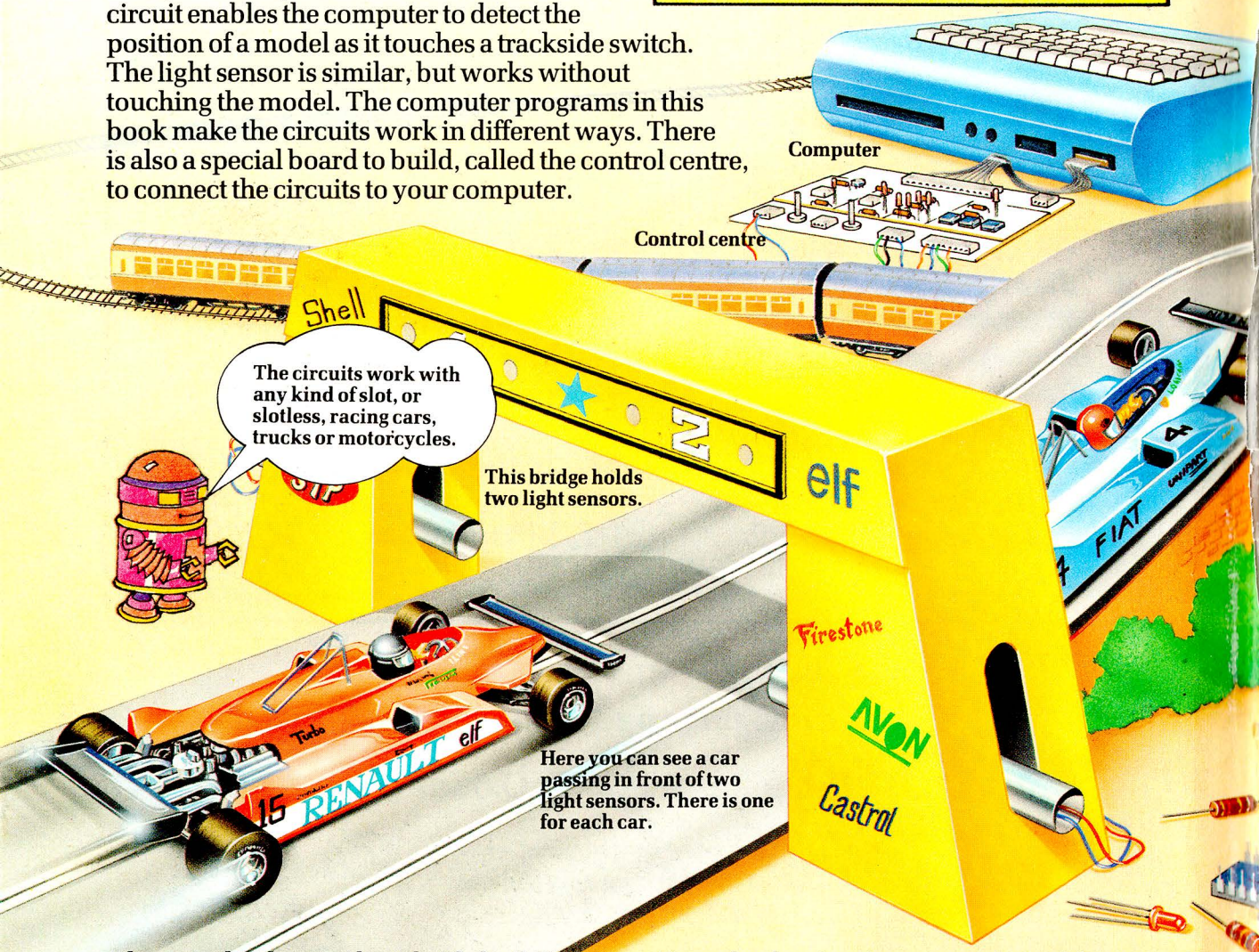
Key to projects

- Power controller
- Switch sensor
- Light sensor

Instructions for cars.

Instructions for trains.

Find the model controllers you want to build by looking for a coloured triangle on the corners of the pages.



There are bridges and trackside buildings to make, to disguise parts of the circuits. At the back of the book there are templates (patterns) to help you make the buildings.

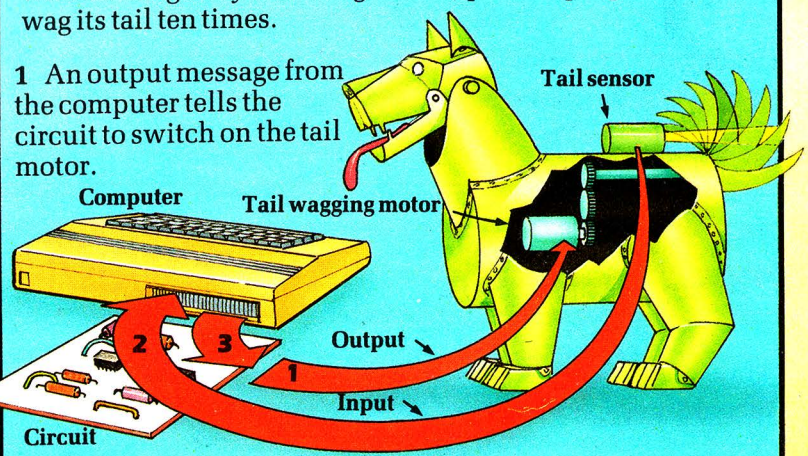
To make the circuits you need to solder electronic components to a special board. There are step-by-step instructions showing how to solder with lots of tips on electronics.

*You need to buy a special circuit for the Spectrum – see page 41.

Computer control

Computers control models and other machines in two ways. They send messages, called output, to motors to switch them on and off. They also receive messages, called input, from sensors, which tell the computer what the machine is doing. The input and output messages are sent via a circuit, often called an interface. These can be separate from the computer, or built in. The circuits in this book are interface circuits and they connect to one of the computer's sockets, called an input/output port.

The picture below shows how computer control works with an imaginary robot dog. Its computer is programmed to wag its tail ten times.



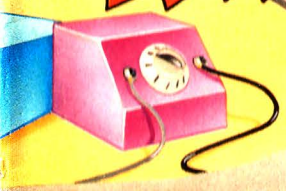
1 An output message from the computer tells the circuit to switch on the tail motor.

2 The tail sensor sends one input message to the computer for every wag it detects.

3 After counting ten wags, the computer tells the tail motor circuit to switch off.

Switch sensor and trackside building.

NEVER interfere with your model's transformer or power supplier mains electricity lead. MAINS ELECTRICITY CAN KILL!



You can use any gauge of train running on electrically powered tracks.

This train is passing a switch sensor.

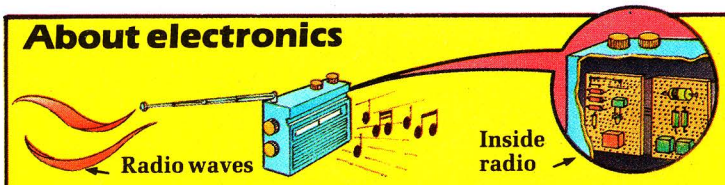
One of the switch sensors is inside this trackside building.

Electronic components and soldering iron.

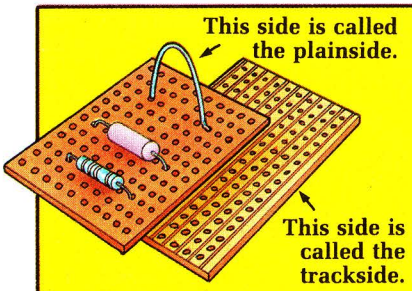
Electronics and soldering

The circuits in this book are made by soldering electronic components in the holes of a special board, called Veroboard. It is very important to solder accurately, or your circuits may not work. Practise soldering before you begin using spare components.

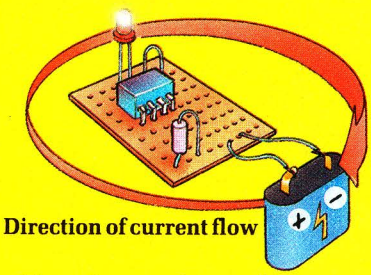
About electronics



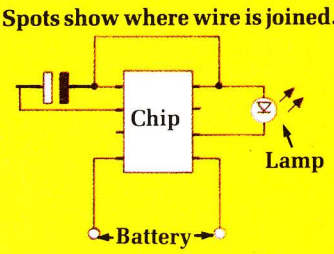
Electronics is about controlling electricity with devices called components to create a certain effect – those in a radio change radio waves into amplified sound, for instance. Components soldered together are called circuits. There are lots of components to do different jobs, and their effect depends on how they are arranged in a circuit.



Circuits are built on a board called Veroboard. This has rows of holes linked by copper tracks. You push components through the holes and solder them to the tracks. Current flows along the tracks and is routed around the circuit by either breaking tracks or linking them with wire.

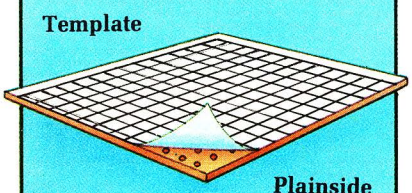


The picture above shows a battery-powered circuit, designed to make a light flash on and off. Current always flows from the positive to the negative battery terminal, via the components. This causes them to behave in a certain way – to make the lamp flash in this circuit, for example.



Symbols are used to make drawings, called circuit diagrams, of how components in a circuit are connected. This is the diagram for the circuit beside it. Find out how to identify components and their symbols over the page. There are diagrams for the circuits in this book on page 47.

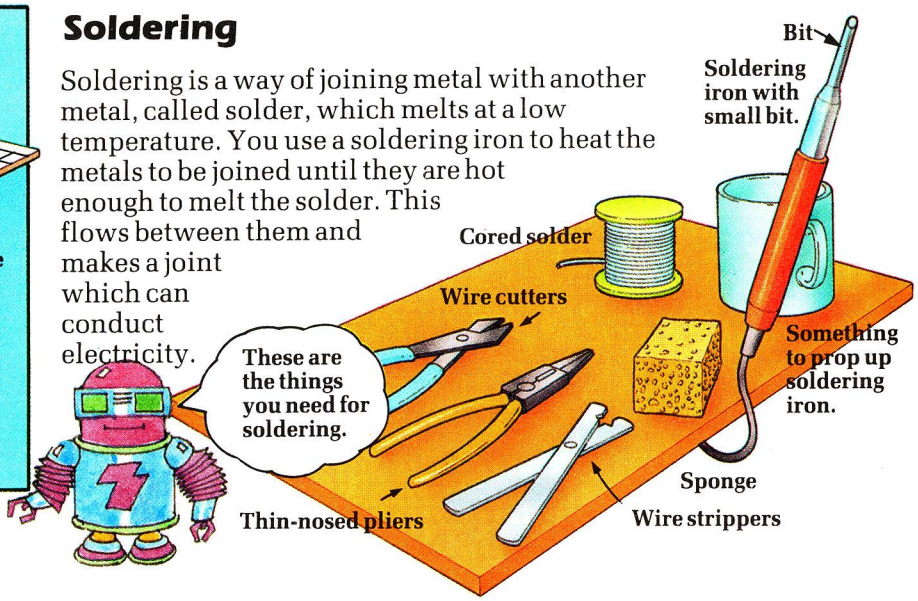
Circuit templates



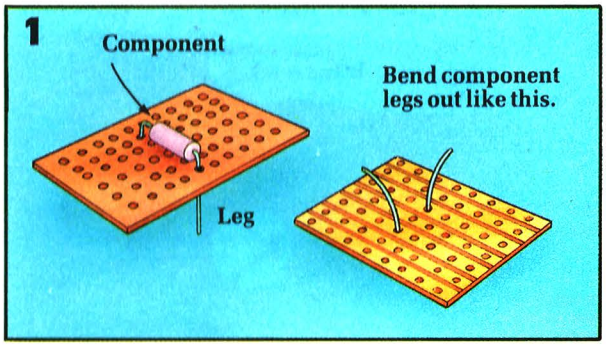
There are templates on page 43 to photocopy and glue to Veroboard. These are used to find the correct holes for the components, as described in the circuit instructions.

Soldering

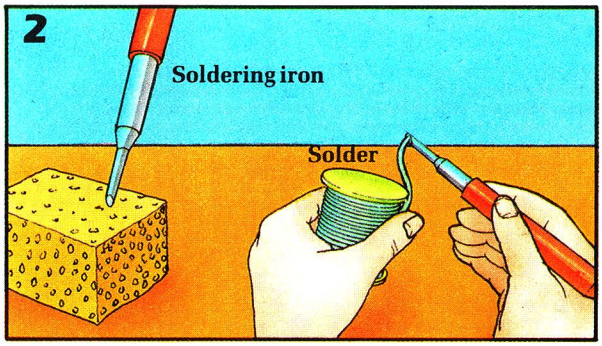
Soldering is a way of joining metal with another metal, called solder, which melts at a low temperature. You use a soldering iron to heat the metals to be joined until they are hot enough to melt the solder. This flows between them and makes a joint which can conduct electricity.



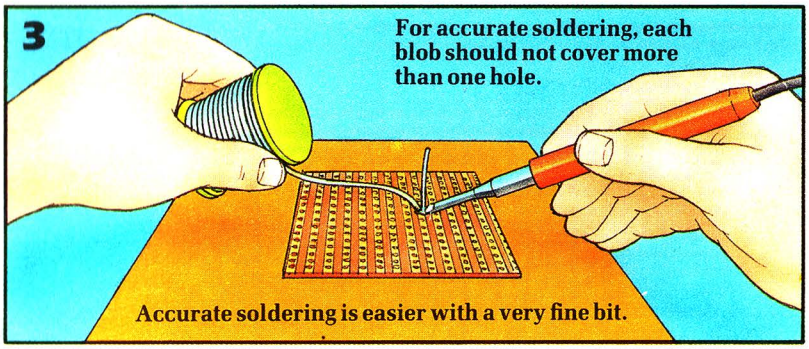
How to solder components



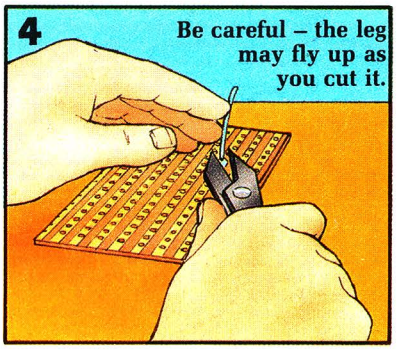
Push the component's legs through holes in the plainside of the Veroboard. Turn the board over and bend the legs slightly to prevent the component falling out before you solder it.



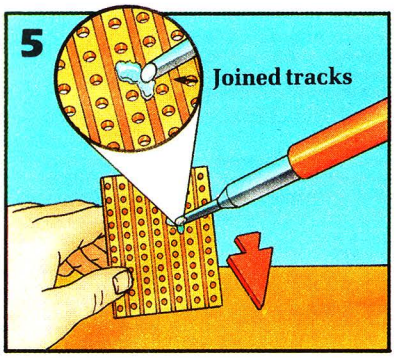
Plug in the soldering iron, let the bit heat up and wipe it on a damp sponge to remove old solder. Touch the bit with solder so a drop clings to it. This is called "wetting" the bit.



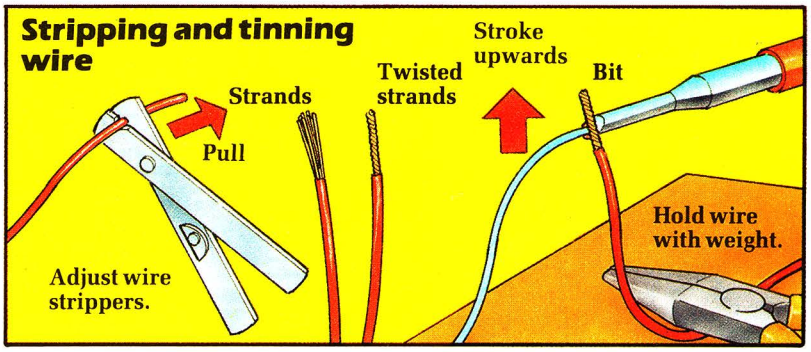
Touch the bit on one side of a leg and the solder on the other, close to the track. Hold them there for about a second until a blob of solder flows round the leg. Let the joint cool and make sure it looks shiny. Re-heat dull looking joints.



Hold the board away from you, pressing the leg gently with your finger. Trim it close to the track with wire cutters.



Remove solder accidentally joining tracks. Run the hot bit along the groove between the joined tracks as shown above.

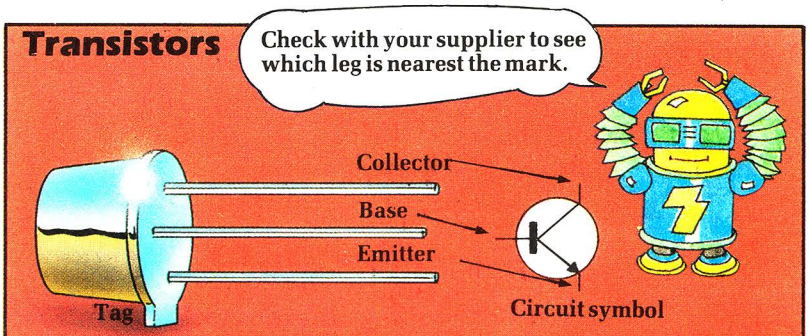


To strip wire, remove 15mm (½") of plastic from each end using wire strippers. Twist the bare strands and stroke them with the bit and solder until lightly coated. This is called "tinning" and makes good electrical connections.

Electronic components

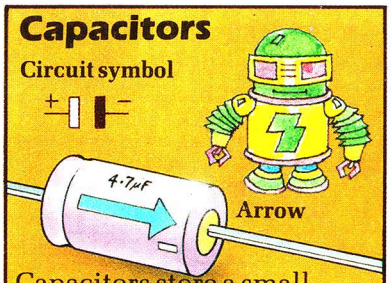
These pages show how to identify the different types of components and explains how they work. The symbols used to represent them in circuit diagrams are shown alongside the components. Don't worry if components you buy look different, as makes vary.

Transistors



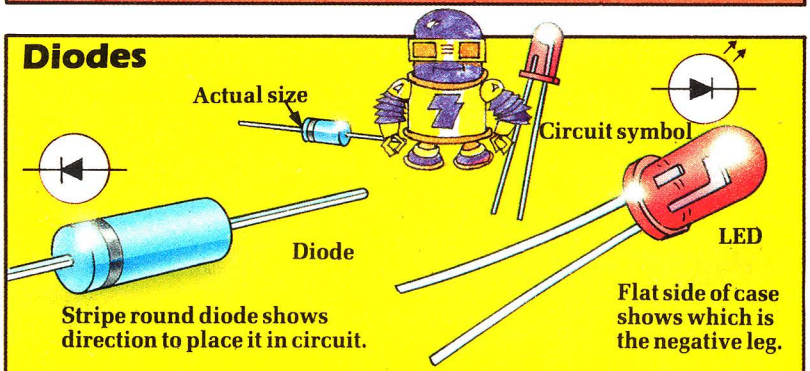
Transistors are used as switches to turn current on and off, or to control its strength. The legs have special names – collector, base and emitter. The emitter is next to a tag, spot or other mark on the case for those used in this book.

Capacitors

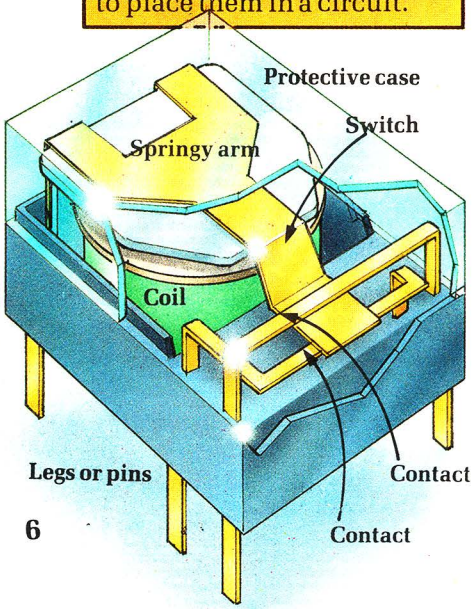


Capacitors store a small amount of electricity called a charge. This is released by the action of other components in a circuit. Charge is measured in microfarads (written μF) or nanofarads (nF) for tiny amounts. Capacitors have an arrow or mark to show which way to place them in a circuit.

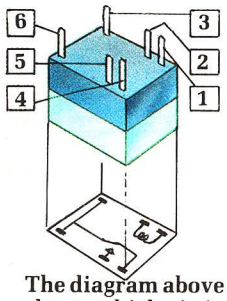
Diodes



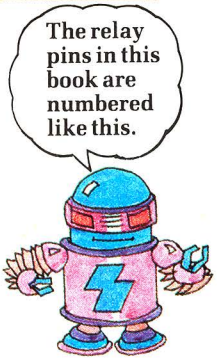
Diodes are like one-way streets for electricity, allowing current to flow in only one direction. LEDs (Light Emitting Diodes) glow like tiny lamps when current goes through them. The pictures above show how to identify their legs.



Relays



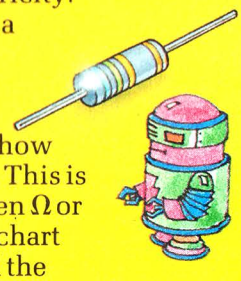
The diagram above shows which pin is which.

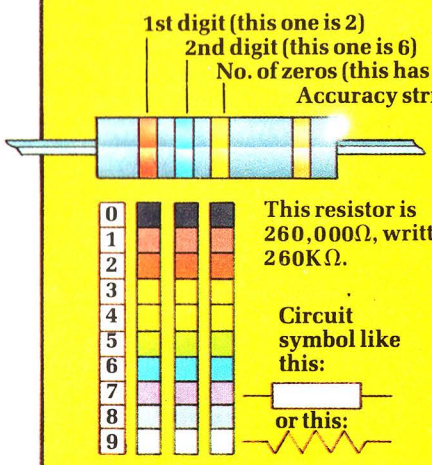


This cut-away picture shows the insides of a relay – a special kind of switch activated by an electromagnet. The coil in the centre becomes magnetic when current is passed through it. This attracts the springy arm above, switching it from one contact to another. The arm flicks back to the first contact only when the electromagnet is switched off. Current reaches the coil and contacts through legs, or pins, under the relay. There are many types of relay, some with more than one switch inside. See page 41 to see which you need.

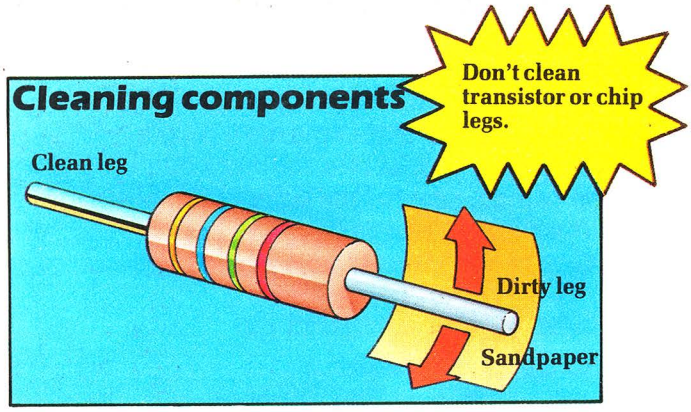
Resistors

These components cut down the amount of current passing through them, by resisting the flow of electricity. Some resistors do this by a fixed amount and others are adjustable. Coloured stripes round fixed resistors tell how strong their resistance is. This is measured in ohms (written Ω or KΩ for 1,000 ohms). The chart below shows how to read the code. The first and second stripes give the first two digits in the number of ohms, and the third shows how many noughts to add.



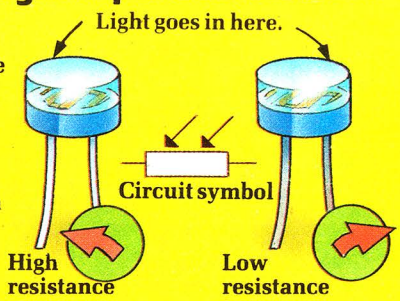


Cleaning components



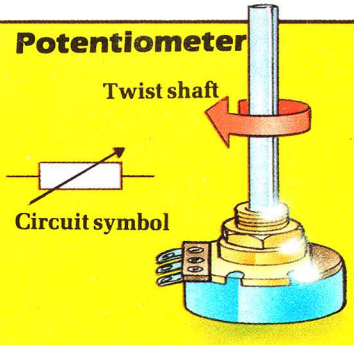
When you buy components the legs are often dirty, making it difficult to solder them and get a good electrical connection. It is a good idea to lightly clean the legs with sandpaper.

Light dependent resistors



The resistance of LDRs varies from low when light enters the "window" on top, to high when less light falls on them.

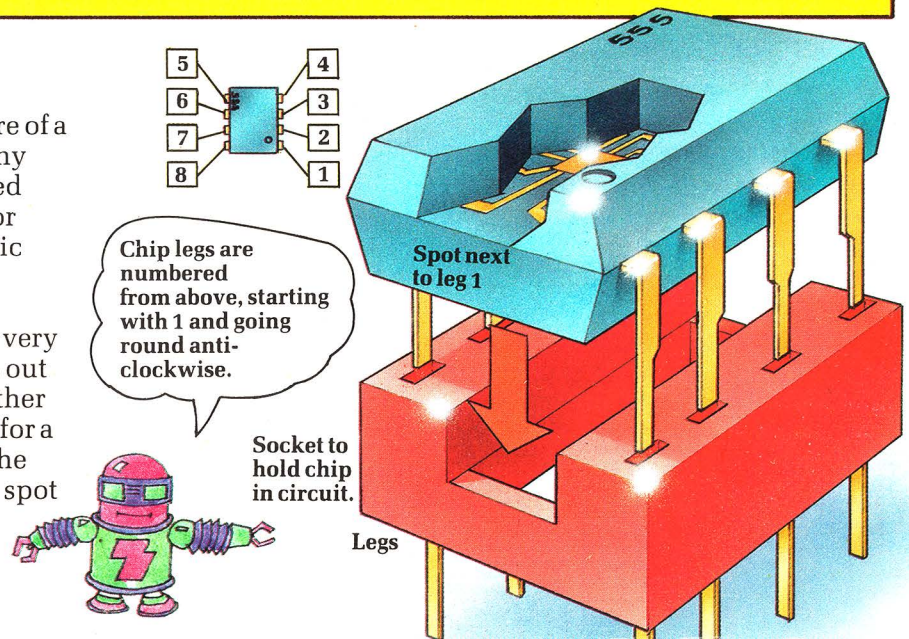
Potentiometer



Turning the shaft of a potentiometer adjusts its resistance. You connect wires to tags on its base.

555 timer chip

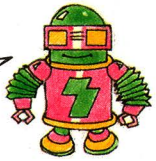
This is a cut-away picture of a timer chip. A chip is a tiny flake of a substance called silicon, with hundreds or thousands of microscopic circuits etched into its surface. There are many different types. This is a very simple one which sends out pulses of electricity to other components in a circuit for a certain length of time. The chip itself is the tiny red spot in the centre.



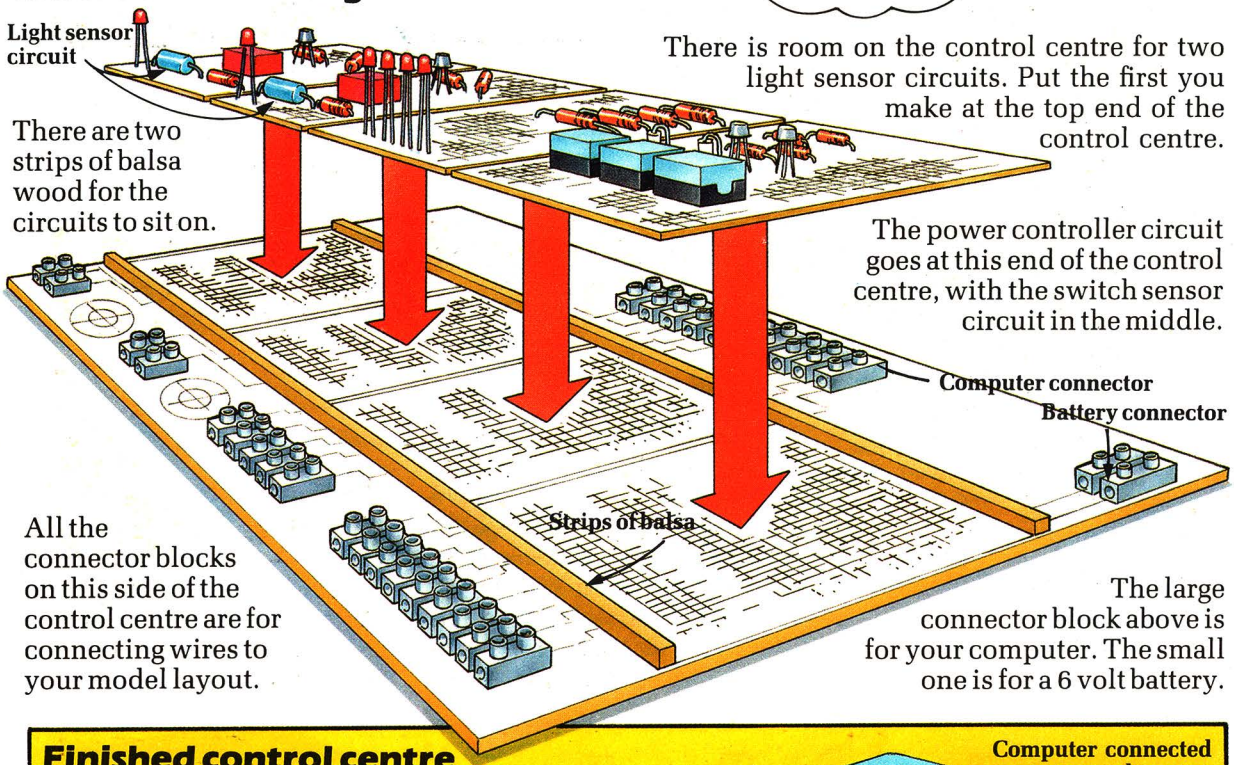
Control centre

These pages explain how to make a wooden board, called the control centre, on which you can assemble the circuits you make. The control centre has sets of plastic connector blocks (sometimes called terminal blocks). One is for connecting to your computer and the others are for wiring-up to your model layout and to a 6 volt battery.

There is a template on page 43 which you need to photocopy twice. Use one copy to make the control centre and keep the other to help make all the circuits.

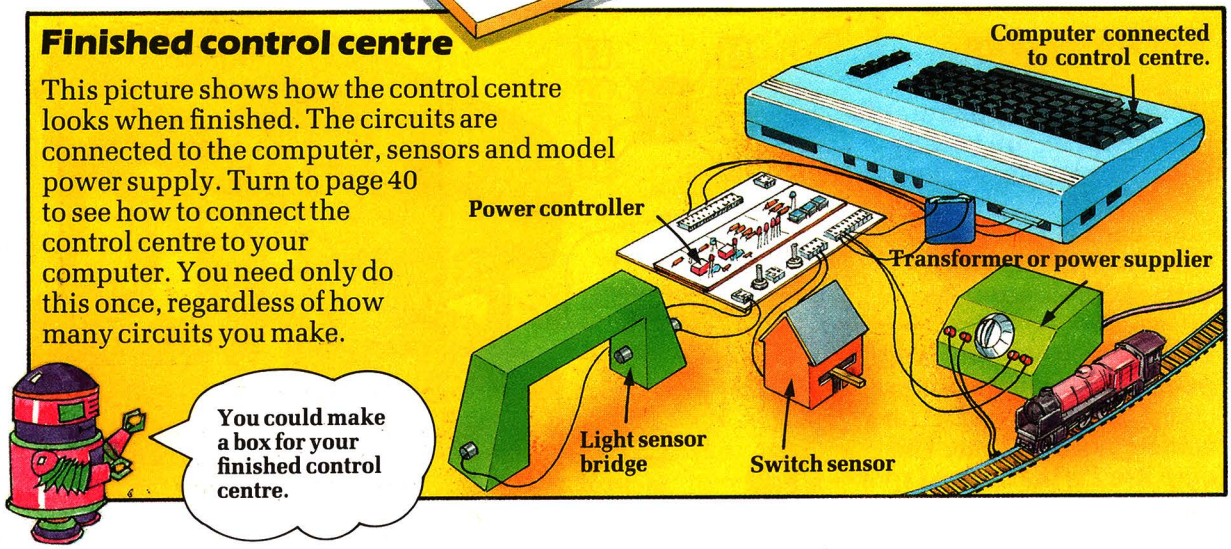


Where the circuits go



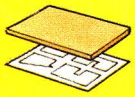
Finished control centre

This picture shows how the control centre looks when finished. The circuits are connected to the computer, sensors and model power supply. Turn to page 40 to see how to connect the control centre to your computer. You need only do this once, regardless of how many circuits you make.



Making the control centre

Things you need

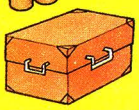

Wooden board up to 6mm (¼") thick.

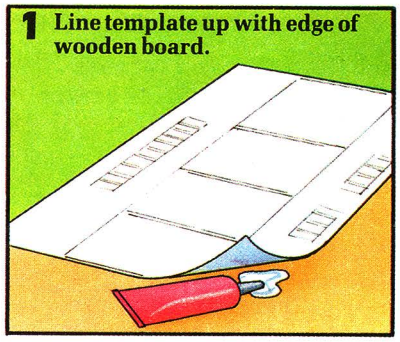

Copies of template (page 43)

Connector blocks

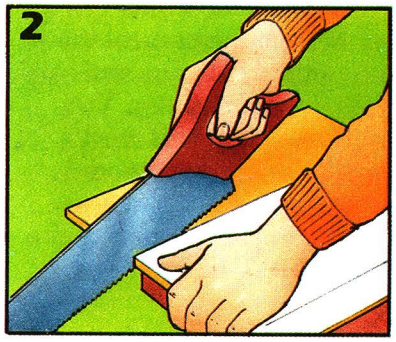

6mm balsa spar (stick shape)


2 corks for feet

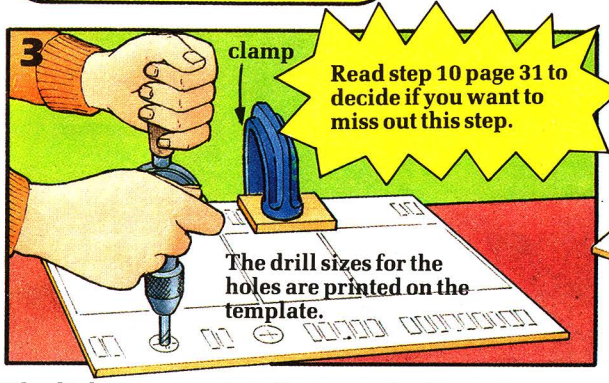

Tool kit



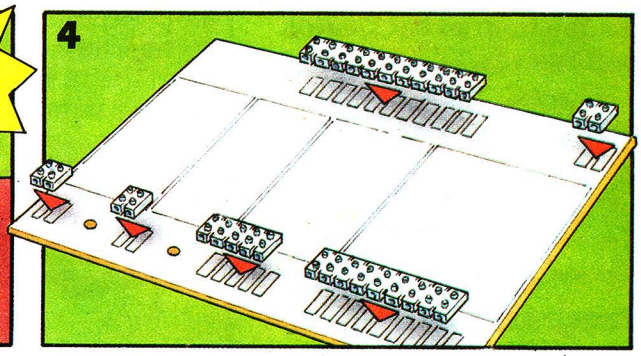
Glue a copy of the control centre template to a wooden board up to 6mm thick (¼") using clear glue.



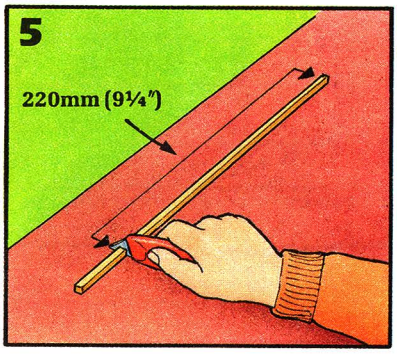
Cut round the template with a saw. Then sand the edges with a piece of sandpaper wrapped round a block.



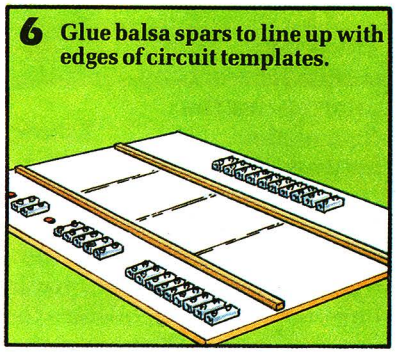
The light sensor circuits use potentiometers, screwed or glued to the board. If you decide to screw them to the board, drill through the hole positions printed on the template.



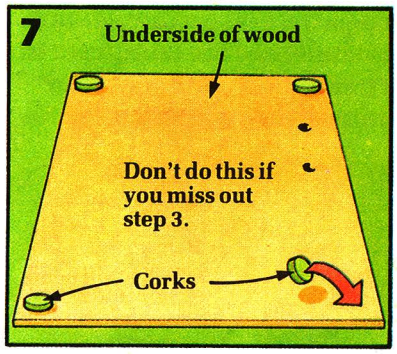
Cut three connector blocks with a craft knife so that you have one with 10 pairs of holes, one with 5, one with 9 and three with 2 pairs. Then glue them where marked on the template.



Cut two 220mm (9¼") lengths of 6mm square balsa spar. Use a craft knife to cut half way through both sides.



Glue the pieces of spar along the edges of the circuit positions on the templates as shown here.



Cut four 15mm (⅝") lengths of cork with a knife. Glue one piece under each corner of the control centre to make feet.

Power controller

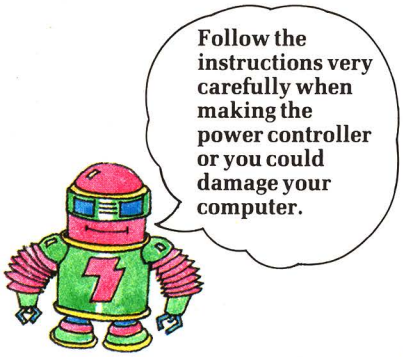
The power controller circuit enables you to control the movement of trains and cars with your computer. You can find out how it works with both kinds of models on these pages. Follow the yellow page flashes to make and use it. This is what it does:

1 Switches power on and off to the track.
2 Reverses the power to make a train go backwards or forwards.

1 Switches power on and off to either car on the track. This works for both slot and slotless cars.

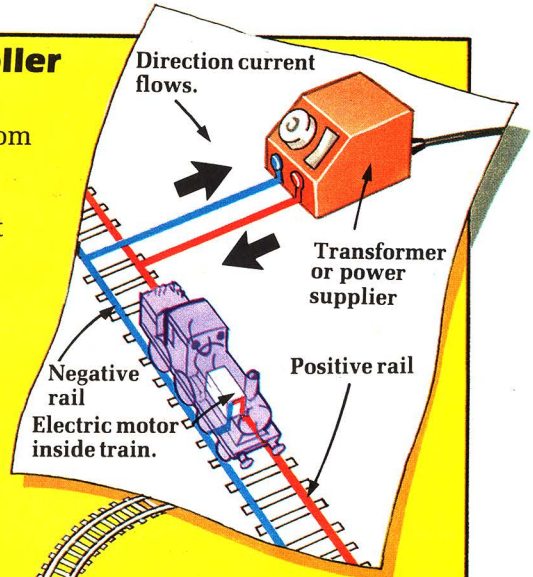
Programs

There are programs on pages 16-17 to use with the power controller, and on 36-39 to use with the power controller and the sensors. These let you do things such as challenge the computer to a motor race, or make your trains run automatically.

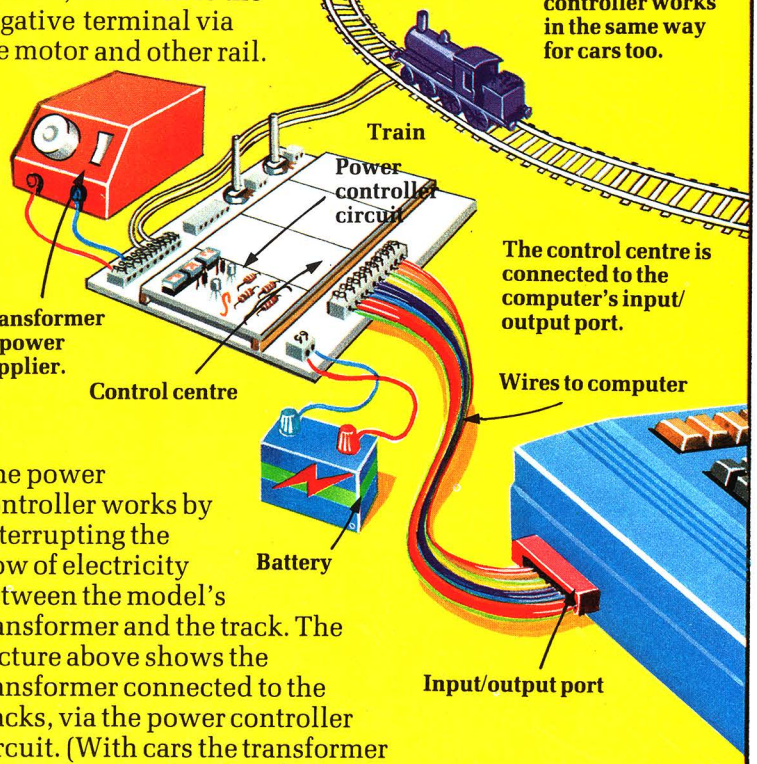


About the controller

Model trains and cars are powered by electricity from devices called transformers (or power suppliers). These convert the strong mains voltage which is very dangerous, into low voltage power which is safe to use with models. The picture on the right shows how thin wires connect between the transformer and track. Electricity flows from the positive terminal of the transformer, through one rail, and back to the negative terminal via the motor and other rail.



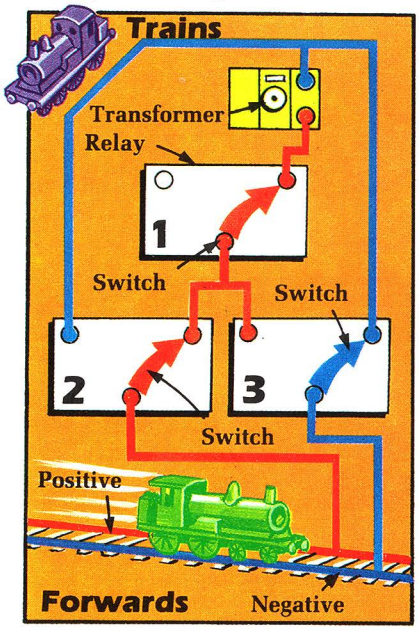
The power controller works in the same way for cars too.



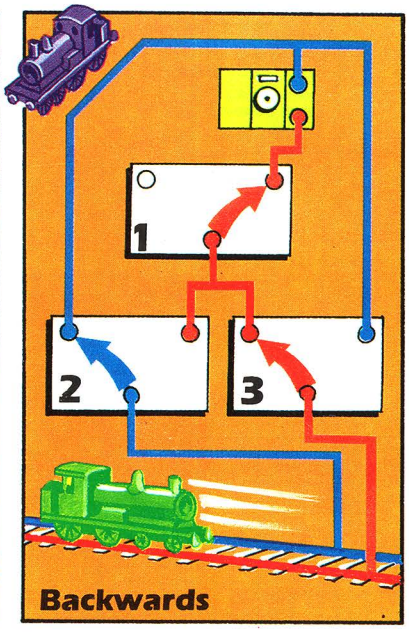
The power controller works by interrupting the flow of electricity between the model's transformer and the track. The picture above shows the transformer connected to the tracks, via the power controller circuit. (With cars the transformer is connected to their hand controllers too.) There are three electronic switches in the circuit. These are controlled by computer to switch the model's power on and off. With trains, they also reverse the flow of electricity to make the train run backwards.

How the switches work

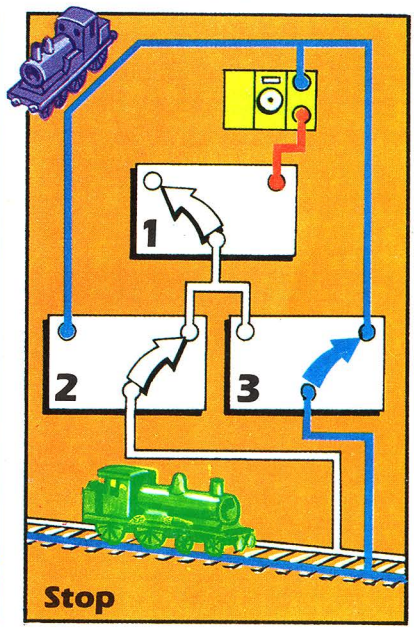
The three electronic switches in the circuit are called relays (see page 6 to find out how they work). The diagrams below show how the computer makes the switches (represented by arrows in rectangles) inside the relays work, to control the movement of trains and cars.



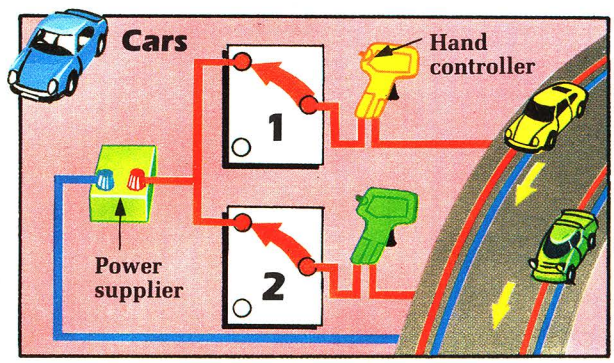
There are two contacts inside each relay. All the switches normally face the same way, allowing current to flow through the contacts and switches as shown above. The train goes forwards, as current flows from positive to negative.



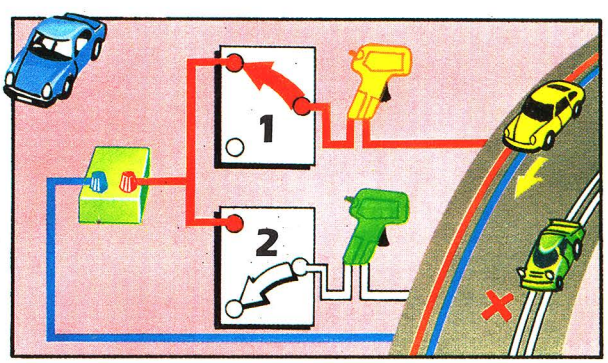
When the computer instructs relays 2 and 3 to switch over to the other contact (but not relay 1), the current is reversed on the tracks. This makes the train motor go in the opposite direction, causing the train to run backwards.



Relay 1 controls the flow of current to the other two relays. If the computer instructs it to switch to its other contact, it breaks the flow of current and stops the train. No power reaches relays 2 and 3 or the track.



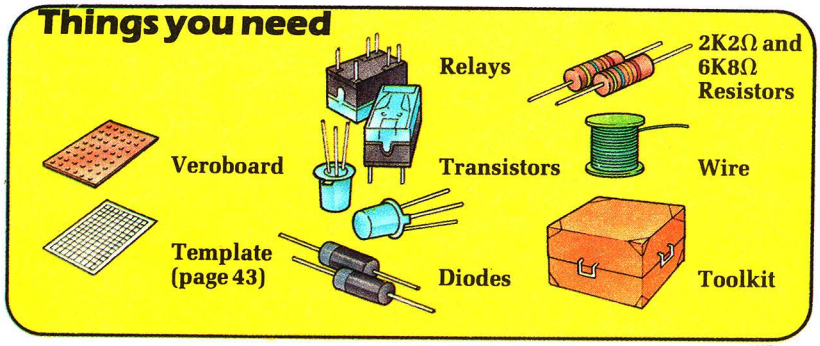
Only two relays are used to control the supply of electricity to the hand controllers. Usually, the switches touch the same contact, allowing power to both cars at the same time.

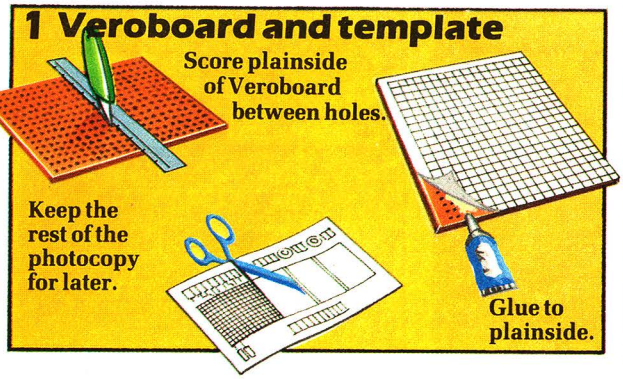


If the computer instructs the switch in relay 1 to touch the other contact, power to the red car is cut off. Both cars can be turned off by changing both relays at the same time.

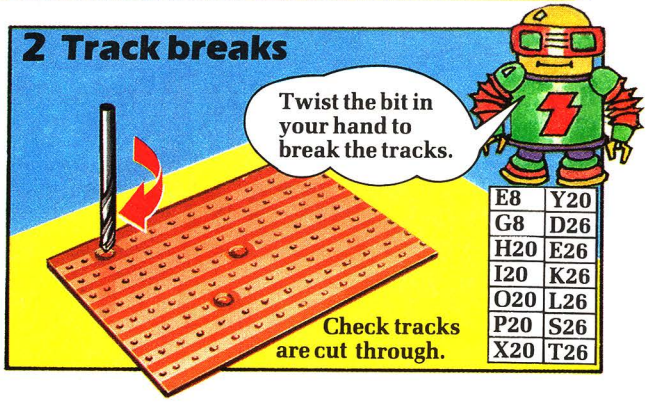
Making the power controller

These pages explain how to make the power controller circuit. Follow the instructions carefully, as one tiny mistake could stop the circuit from working. Read page 5 first if you are not sure how to solder. It's a good idea to practise first before you begin.

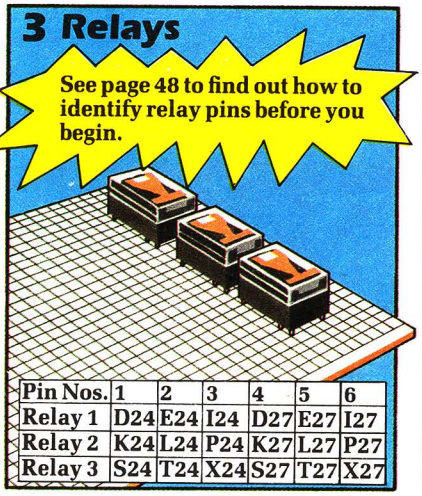




Cut a piece of Veroboard 28 tracks wide by 30 holes long, by scoring it with a craft knife and then breaking it. Glue a copy of the power controller template to the plainside.

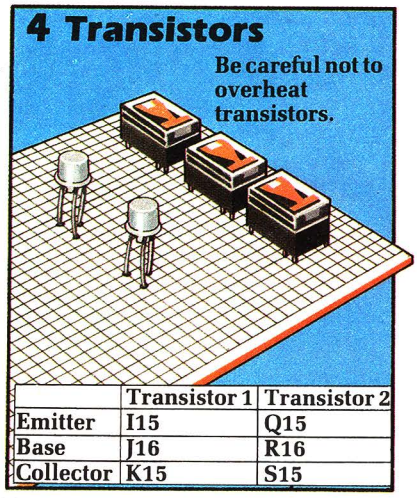


In the holes listed above, pierce the template with a pin. Turn the board over, hold it up to the light and mark the track under the holes. Cut the track with a drill bit.



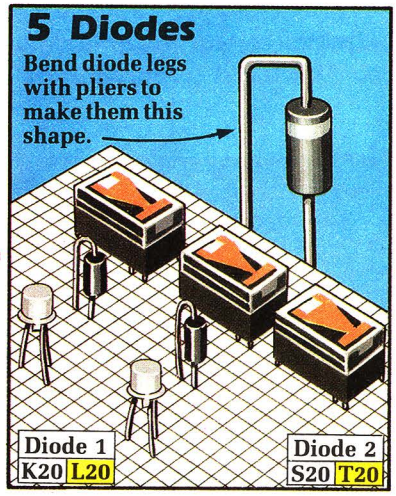
Pin Nos.	1	2	3	4	5	6
Relay 1	D24	E24	I24	D27	E27	I27
Relay 2	K24	L24	P24	K27	L27	P27
Relay 3	S24	T24	X24	S27	T27	X27

Push the pins of three relays through the holes shown above. Then carefully solder the pins to the track.

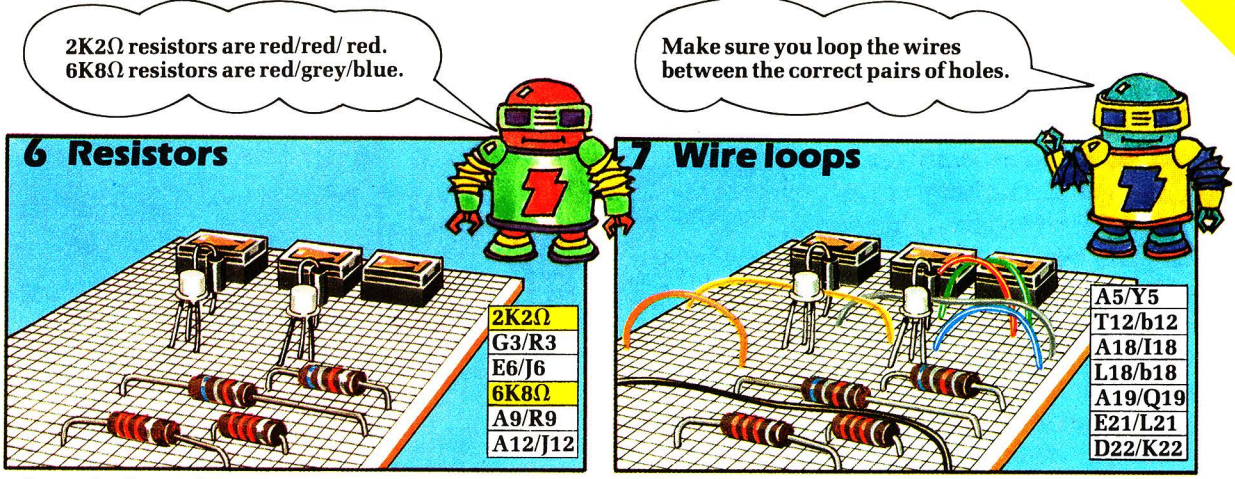


	Transistor 1	Transistor 2
Emitter	I15	Q15
Base	J16	R16
Collector	K15	S15

Put the legs of two transistors in the holes above so they just poke through the track. Then solder them in place.

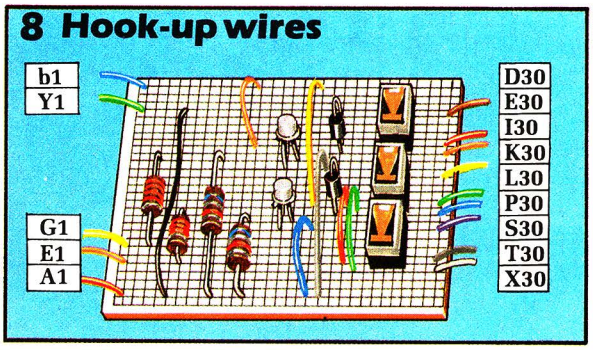


Bend the legs of two diodes. Solder them in the holes above, with the striped end in the hole marked in yellow.

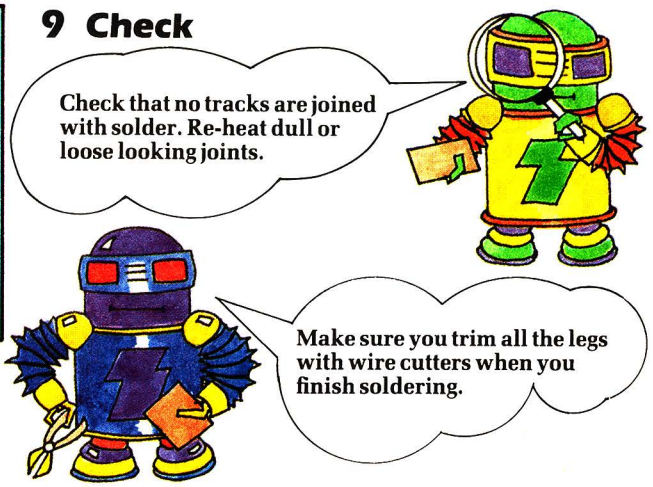


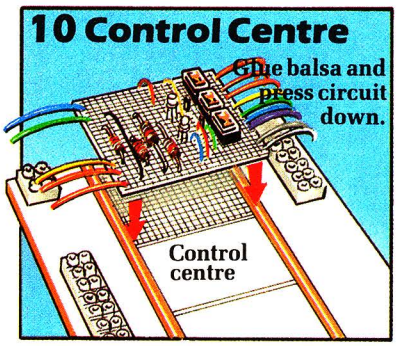
Clean the legs of two 2K2Ω and two 6K8Ω resistors with sandpaper, or scrape them with a craft knife. Push the resistor legs through the holes shown and solder them to the track.

Cut seven pieces of wire about 100mm (4″) long. Strip and tin both ends. Loop each wire between the holes shown and solder them to the tracks.

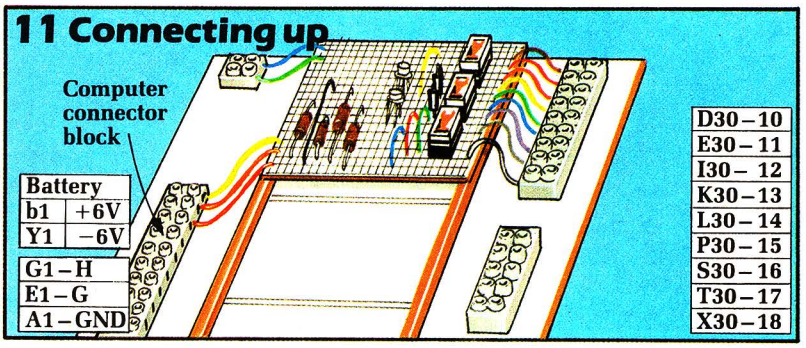


Cut 14 wires, 150mm (6″) long. Strip and tin the ends and solder one end of each wire into the holes shown. "Hook-up" wires connect the circuit to the control centre.





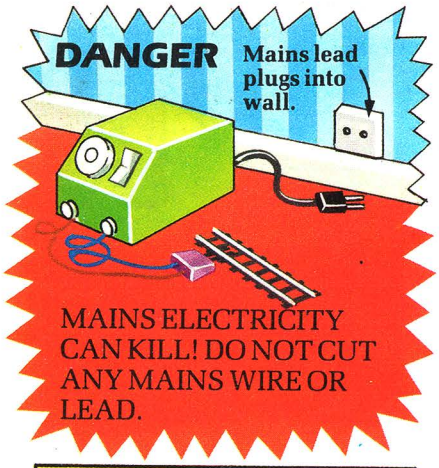
Stick the circuit board to the balsa strips on the control centre with glue, the same way round as shown above.

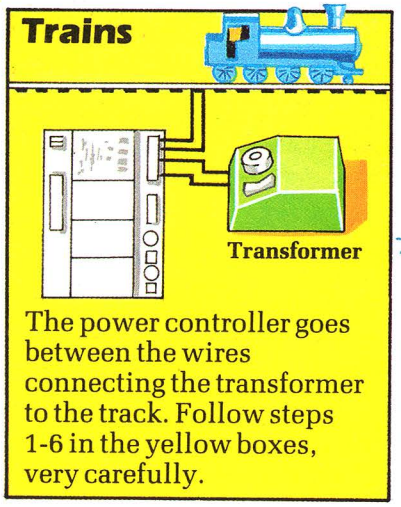


Screw the wires into the connector blocks at either end of the circuit as shown. Use the lines printed on the control centre template as a guide to see where the wires go. Check each wire is in the correct hole when you finish.

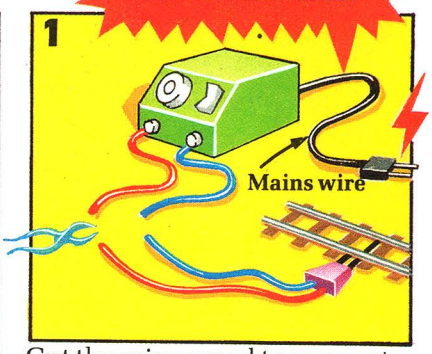
Power controller connections

Here you can find out how to connect the power controller to a railway or car layout. Don't worry if the wires for your model do not look like those illustrated here, as different makes vary. Read the model manual or ask someone to help, if you are not sure how to identify any of the wires shown on these pages. DO NOT touch the transformer* mains wire. DO NOT plug the transformer into the mains until you have finished *and* checked your circuit connections.

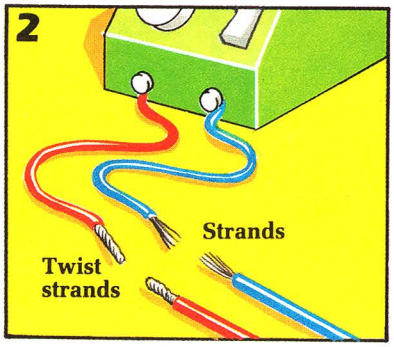




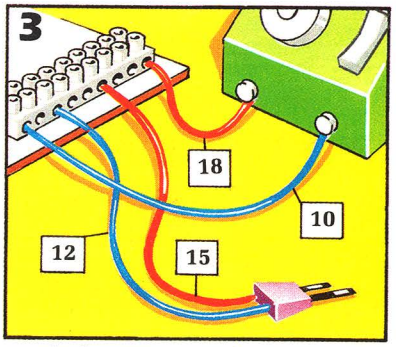
The power controller goes between the wires connecting the transformer to the track. Follow steps 1-6 in the yellow boxes, very carefully.



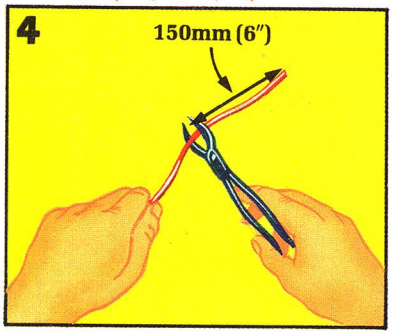
Cut the wires used to connect the transformer to the track with wire cutters. DO NOT CUT THE MAINS LEAD.



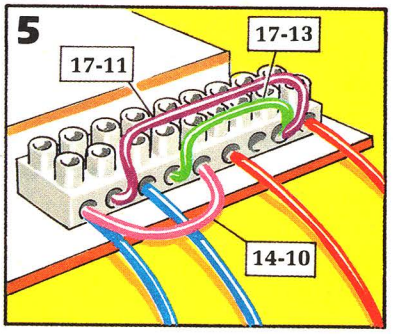
Strip a short length of plastic off the wires. Twist the strands together. See page 5 to see how to do this.



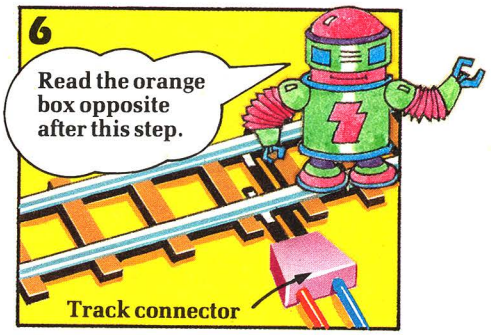
Push the wires into the control centre connector block holes shown. Tighten each screw with a small screwdriver.



Cut three pieces of wire 150mm (6") long. Strip 15mm (½") of plastic from the ends and twist the strands together.



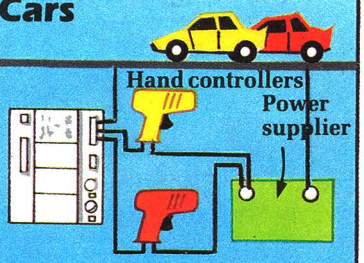
Loop the wires cut in step 4, between the control centre connector block holes shown above. Tighten the screws.



Connect the transformer wires to the track as usual. Your track connector may not look like the one above.

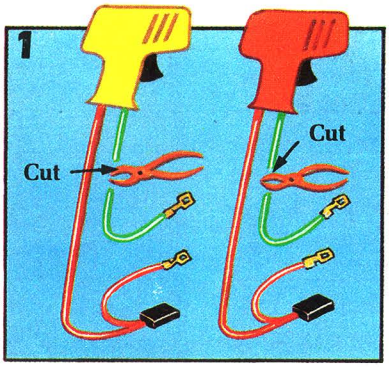
*May also be called a power supplier, power pack or other name in your model instruction book.

Cars



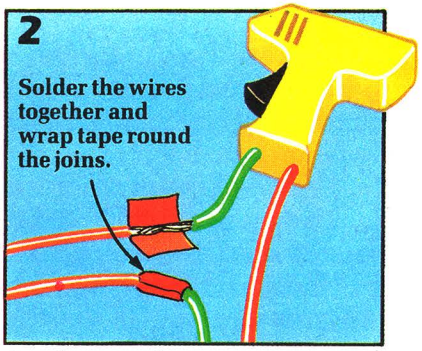
The power controller connects between *one* of the two wires from each hand controller. Your hand controller may not look like those shown here.

1



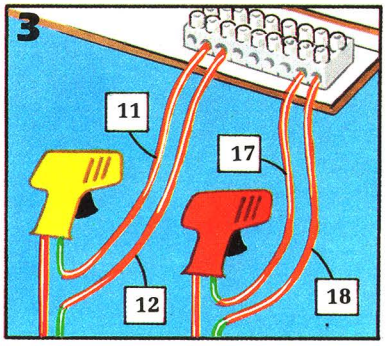
Cut one wire from each hand controller with wire cutters and strip a short length of plastic from the cut ends.

2



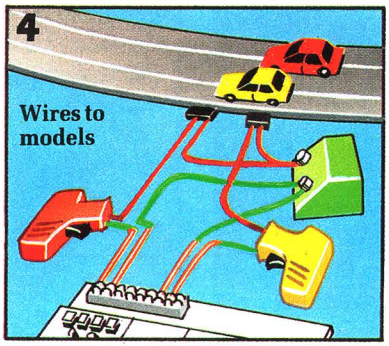
Cut four 2m long (6′) wires and strip the ends. Join one wire to each cut hand-controller wire by twisting them together.

3



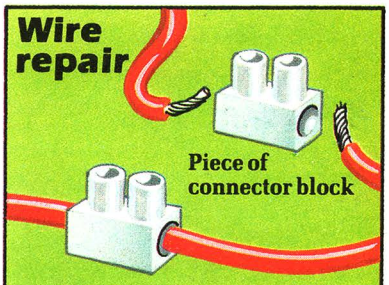
Push the new wires into the control centre connector block holes as shown. Tighten each screw with a screwdriver.

4



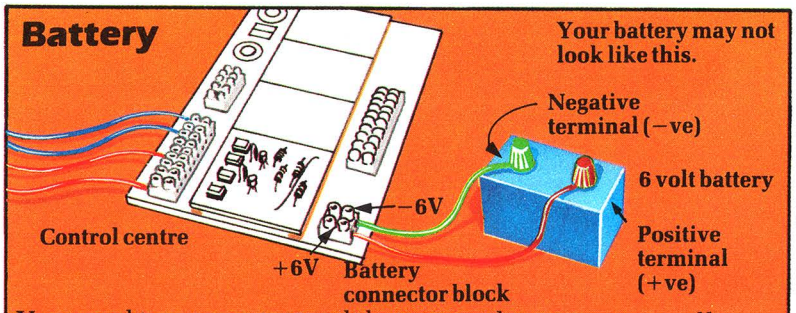
Connect the transformer and track wires in the usual way. DO NOT plug in yet – see the orange box below.

Wire repair



Use a length of connector block if you want to reconnect your model's wires after using the power controller.

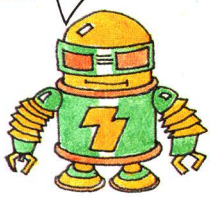
Battery



You need to connect a 6 volt battery to the power controller circuit. This provides electricity to operate the coil inside each relay in the circuit. Cut two wires about 300mm (1′) long, strip the ends and twist the strands together. Connect the wires between the battery terminals and the control centre as shown above.

STOP

Do not plug your power supplier into the mains yet. Get someone else to check your wiring and read how to connect your computer on page 40 first.



Power programs

There are three programs on these pages to use with the power controller. Two are for cars and one for trains. Here is what to do before you begin:

1 Read the program notes on page 39.
2 Test the program, using the notes on page 39 which tell you how to do it.
3 Choose which power controller program you want to run and type it into your computer.
4 Turn back to page 39 and type in the extra lines listed in boxes A and B.

Make sure you type in the program labelled for your computer.

Test programs

Type this test program for your computer before using the power controller. The program checks to make sure the relays in the circuit are working. Type RUN, then RETURN and then type the numbers in this chart. After each number the relays shown in the chart should make a clicking noise. Check your connections, soldering and battery if this does not happen.

Number to type in	Result (double relays are those closest together on the circuit).
0	All relays off (no clicks)
64	Single relay on, double relays off
128	Single relay on, double relays off
192	All relays on

C64

```
10 POKE 56579,192
20 PRINT "TYPE NUMBER"
30 INPUT X:POKE 56577,X
40 GOTO 20
```

VIC 20

```
10 POKE 37138,192
20 PRINT "TYPE NUMBER"
30 INPUT X:POKE 37136,X
40 GOTO 20
```

BBC

```
10 ?&FE62=192
20 PRINT "TYPE NUMBER"
30 INPUT X:?&FE60=X
40 GOTO 20
```

Spectrum*

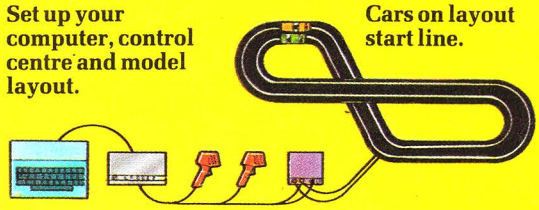
```
10 PRINT "TYPE NUMBER"
20 either POKE port number,
   X or OUT port number,X
   30 GOTO 10
```

*Spectrum: The output port number and POKE or OUT commands you use depend on the interface you buy.

Race the computer

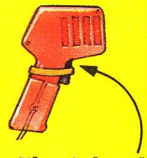
Set up your computer, control centre and model layout.

Cars on layout start line.



This program lets you challenge your computer to a race, using two cars – one for you and one for the computer. The computer's car starts first, then your power comes on later. See how many times you can lap the computer's car before the computer switches off the power.

First find out which is the computer's car, like this:
Place both cars on the track. Type in the program, type RUN and then RETURN. Squeeze both hand controller triggers. The car that starts first is the computer's. While the program is running, put an elastic band round the trigger of the computer's car to make it go at an even speed. Experiment to find the best speed. If the elastic band is too tight, the car may come off the track on bends.



Elastic band

When the program stops, type RUN and then RETURN to re-start it. The computer will ask you to put both cars on the start line, ready to begin your race.

```
10 GOSUB 2800:GOSUB 3000
20 LET SP=0:GOSUB 2600
30 clear screen
40 PRINT:PRINT "PREPARE CARS"
50 PRINT "THEN PRESS RETURN"
60 INPUT X$
70 LET SP=P(1):GOSUB 2600
80 GOSUB 160
90 FOR I=1 TO T:NEXT I
100 PRINT:PRINT "YOU HAVE POWER!"
110 LET SP=P(1)+P(2):GOSUB 2600
120 GOSUB 160
130 FOR I=1 TO T*10:NEXT I
140 LET SP=0:GOSUB 2600
150 PRINT "!! RACE OVER !!":STOP
160 LET T=INT(RND(1)*1000)+1000
170 RETURN
Spectrum: 160 LET T=INT(RND*1000)+1000
Change 1000 in line 160 if the race is
too long or too short
```

Power off

Power to computer's car.

Delay before player starts.

Power to player's car

Length of time race lasts.

Power off to both cars.

Now type the lines in boxes A and B on page 39.

Autotrain

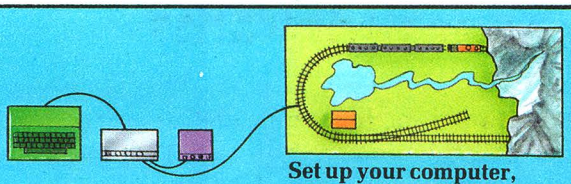
With this program you can instruct your train to make it run automatically. It will go forwards or backwards a specified distance or stop for a certain length of time.

Type your instructions, called data, in line 150 of the program. If there is not enough space, add as many extra lines as you like, numbered 160, 170, 180 and so on. Here's an example of a data line:

```
150 DATA "F",1000,"S",500,"B",1000,"*"
```

"F" makes the train go forwards
"B" makes the train go backwards and
"S" makes it stop.

The numbers move or stop the train for a certain time. The higher the number, the longer the train will travel or stop.



Set up your computer, layout and control centre like this.

Experiment with the numbers, as they will make the train go different distances according to the computer and the model.

Build up a complex sequence of movements by typing lots of data lines. Always put a "*" at the end of the last data line. This tells the computer that there are no more instructions. Type RUN and then RETURN for the computer to carry out your instructions.

```
 10 GOSUB 2800:GOSUB 3000
 20 LET SP=0:GOSUB 2600          ---- Power off
 30 clear screen
 40 READ X$                      ---- Reads instructions.
 50 IF X$="*" THEN LET SP=0:GOSUB 2600:STOP
 60 IF X$="S" THEN LET SP=0
 70 IF X$="F" THEN LET SP=P(2)   ---- Forwards
 80 IF X$="B" THEN LET SP=P(1)+P(2) -- Backwards
 90 READ T                       ---- Reads time(T) instruction lasts.
100 GOSUB 2600
110 PRINT TAB(5);X$;"  ";T       ---- Prints instructions.
120 FOR I=1 TO T                 ---- Pauses
130 NEXT I
140 GOTO 40
150 DATA "F",1000,"S",500,"B",1000,"*"  ---- Data for instructions.
```

Now type the lines in boxes A and B on page 39.

Grand Prix quiz

This program is a race for two players with nerves of steel. The computer will randomly switch off both players' power during the race. To get it back you must work out the multiplication or division sum that appears on the TV screen and type the answer on the computer keyboard. If the answer is wrong, your power stays switched off. Challenge a friend to a race over 20 laps and see who wins.

Place both cars on the start line and type the program into your computer. Type RUN and RETURN . The power will come on to both hand controllers straight away for you to start your race.

```
 10 LET V$="GALLON":LET S$="MPH"
 20 GOSUB 2800:GOSUB 3000
 30 LET SP=P(1)+P(2):GOSUB 2600  ---- Power on to both cars.
 40 DEF FNR(X)=INT(RND(1)*X+1)
 50 clear screen
 60 PRINT "GRAND PRIX QUIZ"
 70 PRINT "================"
 80 FOR T=1 TO 200:NEXT T        ---- Random time
 90 IF FNR(5)>1 THEN GOTO 80     ---- before question.
100 LET N=FNR(2):LET SP=P(3-N)   ---- Computer switches off chosen driver's power.
110 GOSUB 2600
120 PRINT:PRINT "QUESTION FOR"
130 PRINT "DRIVER ";N
140 PRINT:PRINT
150 LET QT=FNR(2)
160 IF QT=1 THEN GOSUB 200
170 IF QT=2 THEN GOSUB 260
180 LET SP=P(1)+P(2):GOSUB 2600
190 GOTO 50
200 LET T=FNR(8)+1:LET V=FNR(6)*5
210 LET M=T*V
220 PRINT "HOW FAR WILL YOU GO"
230 PRINT "IN ";T;" HOURS AT ";V;" ";S$
240 INPUT A:IF A<>M THEN GOTO 240
250 RETURN
260 LET R=FNR(6)+1:LET M=FNR(9)+1
270 LET L=M*R
280 PRINT "HOW LONG WILL IT TAKE"
290 PRINT "FOR YOUR ";L;" ";V$;" TANK"
300 PRINT "TO EMPTY IF IT LEAKS AT ";R
310 PRINT V$;"S AN HOUR"
320 INPUT T:IF T<>M THEN GOTO 320
330 RETURN
```

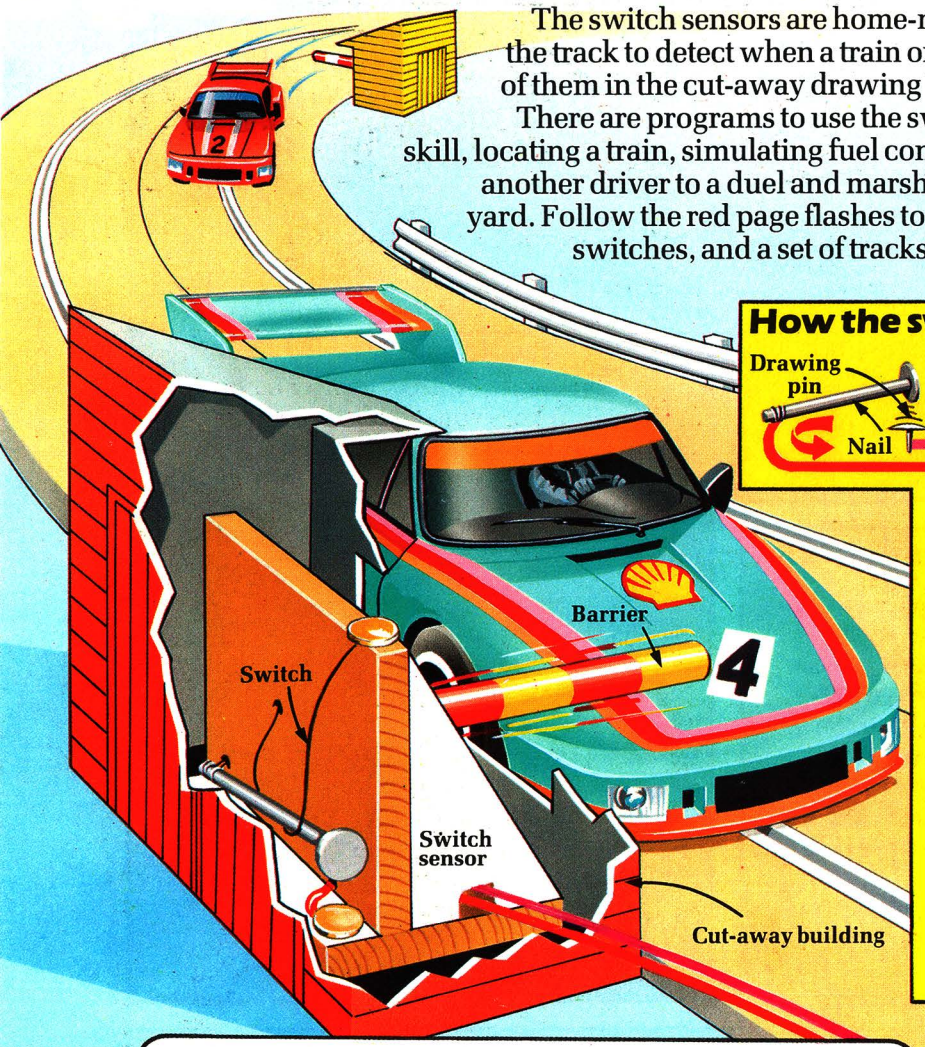
Spectrum: 40 DEF FN R(X)=INT(RND*X+1)
Change the 200 in line 80 to a higher number if the computer asks too many questions

Now type the lines in boxes A and B on page 39.

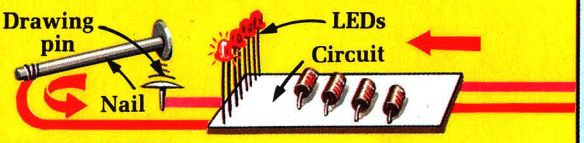
Switch sensors

The switch sensors are home-made switches which sit beside the track to detect when a train or car goes past. You can see one of them in the cut-away drawing below.

There are programs to use the switches for testing your driving skill, locating a train, simulating fuel consumption in a car, challenging another driver to a duel and marshalling your trains in a shunting yard. Follow the red page flashes to make the circuit and up to four switches, and a set of trackside buildings to disguise them.



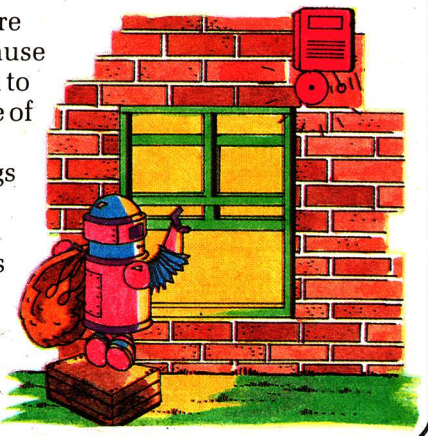
How the switches work



There are two electrical parts to each switch – a nail soldered to a length of wire and a drawing pin soldered to another wire. Electric current flows from the circuit down one wire, through the drawing pin and nail, and back along the other. Cars or trains colliding with the barrier cause a piece of thread to lift the nail and break the flow of current. An LED in the circuit lights up when a switch opens so you can see that it works.

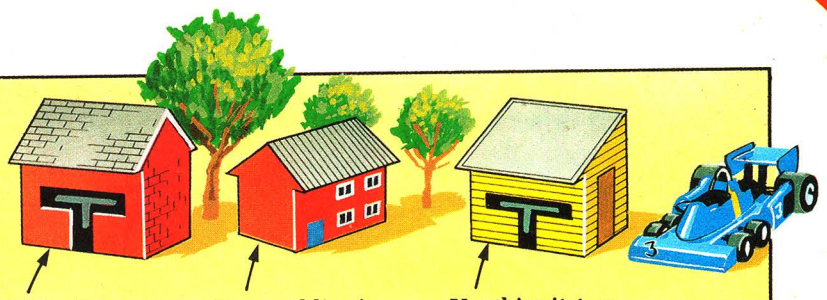
Contact sensors

Switches used as sensors are called contact sensors because a physical action is needed to make them work. This type of sensor can be linked to a computer, or used for things like burglar alarms and automatic machines. You could use the switch in this book as a computerized burglar alarm on a door or window by writing your own program to use with it.



Trackside buildings

There are three different scales of trackside buildings to make to disguise the switches. They also insulate them from accidental short circuits caused by their electrical parts touching your model's live track.



This building is for HO gauge trains.

This building is for N gauge trains.

Use this pitstop building for cars.

Railway switch sensors

The picture below shows some ideas for positioning the switches on a railway layout. It also gives some alternative ways of disguising the switches instead of using the buildings. Where you decide to position the switches depends on the programs you use, so read page 26 before deciding what to do.

You could position one of the buildings in this book next to an existing building on your layout.

This switch is disguised inside a group of trees. You can see the barrier, painted with stripes, sticking out over the track. Make sure the movement of the barrier is not obstructed by branches. The switch below is positioned inside a tunnel. Make sure you can get at it if you decide to do this.

Computer

Switch beside track.

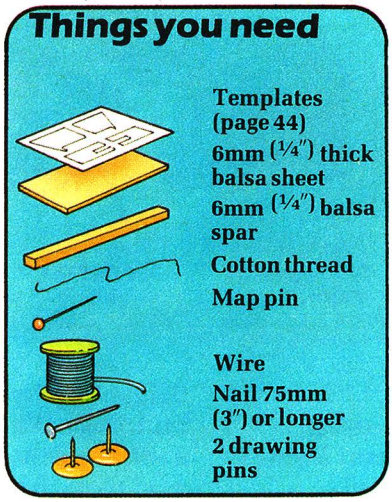
Control centre

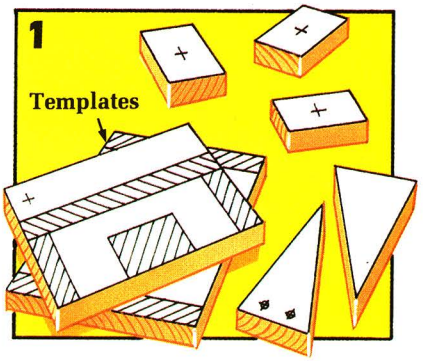
Tunnel

Hide the switch wires under the base board by drilling small holes beside each switch, then feeding the wires through them.

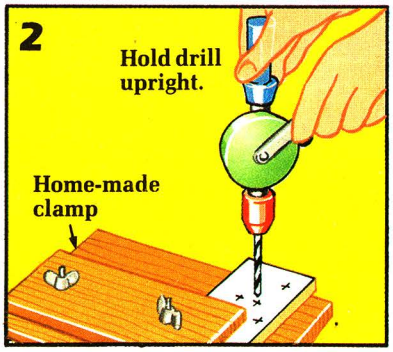
How to make the switches

These pages show how to make the trackside switches from balsa wood. The computer programs in this book are for two to four switches, so it is a good idea to look at the programs first to decide how many to make. The instructions here describe how to make one switch. Repeat all the steps for each switch you make. There are some construction tips on page 42 if you are not sure about using balsa.

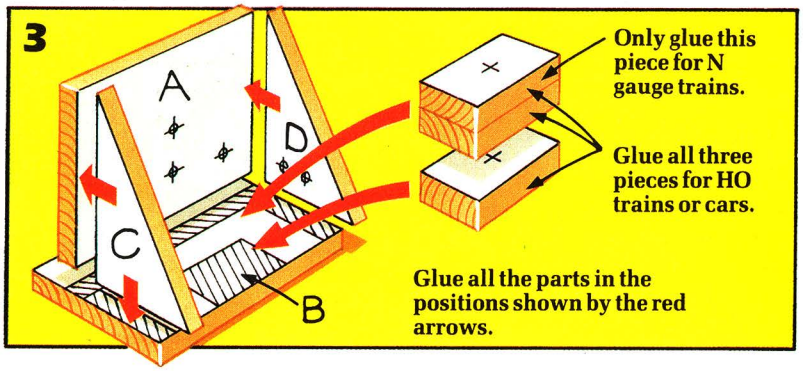




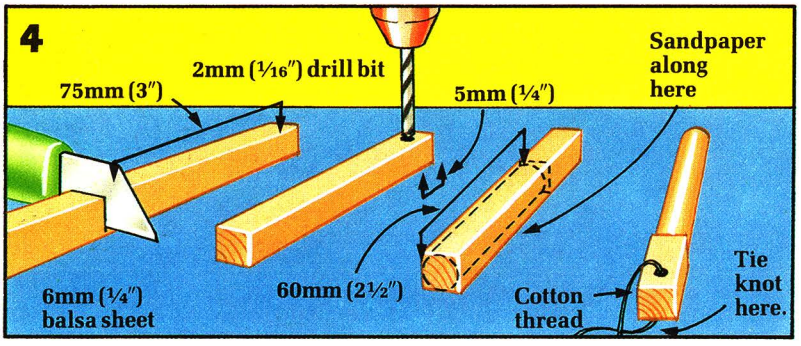
Cut out copies of templates A-G on page 44. Glue them to 6mm (¼") balsa sheet and cut round them with a craft knife.



Drill 2mm (1/16") holes through parts A and D where printed on the templates. Start the holes with a pencil point for accuracy.

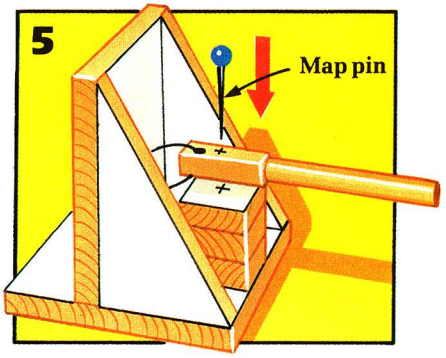


Glue parts A, B, C and D together as shown by the glueing positions printed on the templates. For N gauge trains, glue part E where shown by the arrow. For HO gauge and for cars, glue parts E, F and G in a stack as shown.

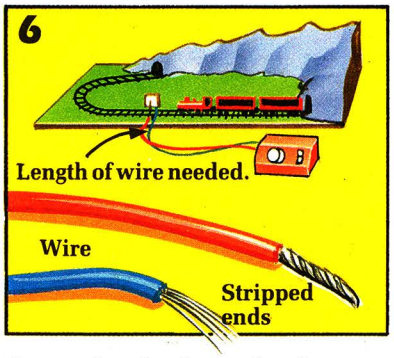


Cut a 75mm (3") length of 6mm (¼") balsa spar to use for a barrier. Drill a small hole about 5mm (¼") from the square end.

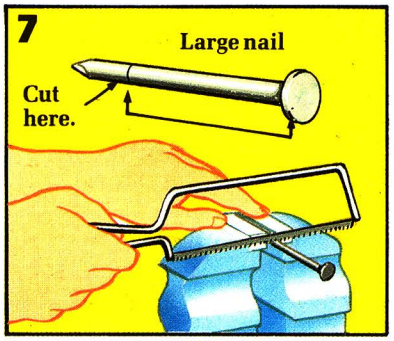
Then round the corners with sandpaper. Thread a 150mm (6") length of cotton through the hole and tie a knot.



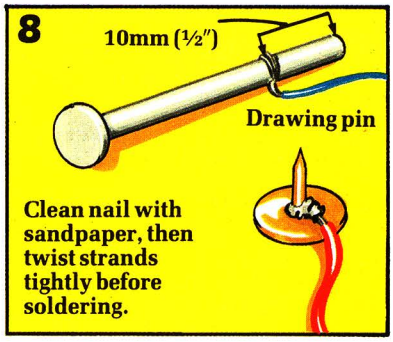
Push a pin through the square end of the balsa. Stick the pin in the centre of part E (for N gauge) or G (for HO and trains).



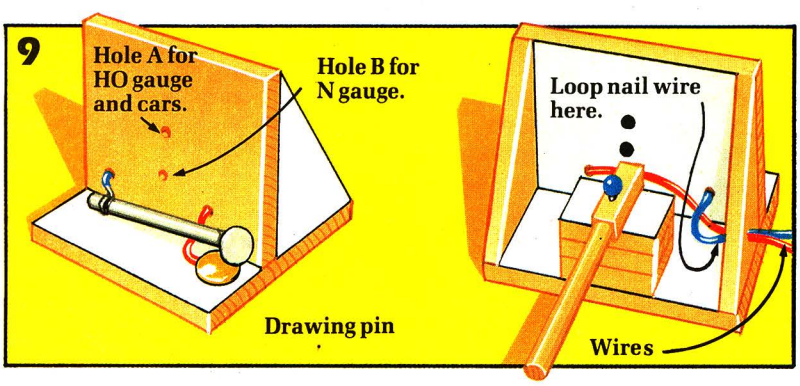
Cut and strip the ends of two wires, to reach from the control centre to where you want to put the switch.



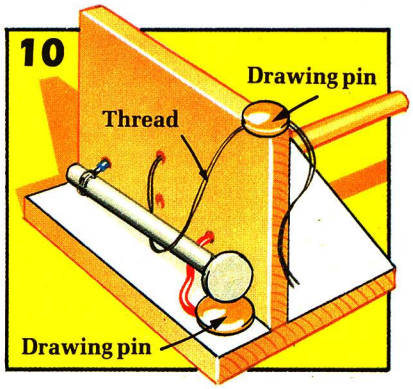
Saw the end off a large steel nail to make it 55mm (2⅛") long. A large nail is needed for its weight.



Twist one wire round the nail, near the end, and the other round the point of a drawing pin. Solder them in place.



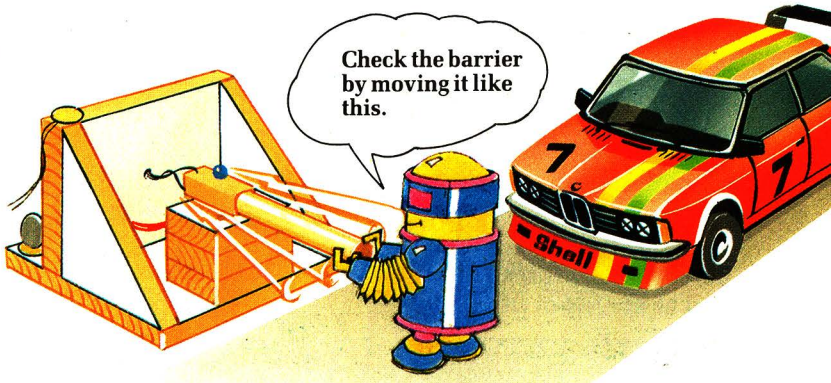
Push the drawing pin into part B where printed on the template. Then thread the nail and drawing pin wires through the holes shown in part A. Make sure the nail wire loops as shown, so that the nail head rests easily on the drawing pin.



Thread the cotton through hole A or B, under the nail. Trap the thread with a drawing pin pushed into part A.

About switches

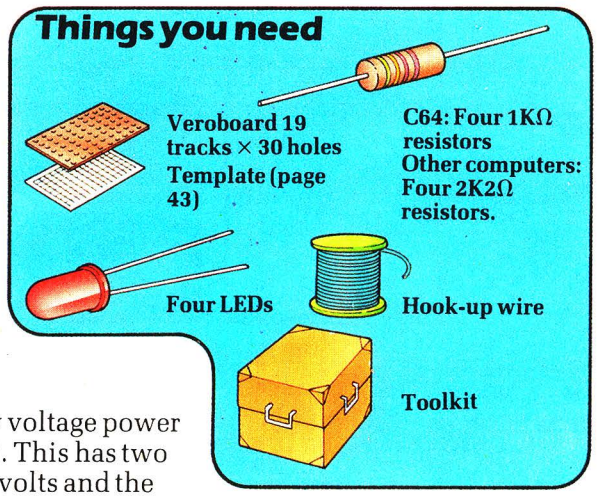
There are many kinds of switches, from complex electronic devices to simple home-made ones like those in this book. They all work by interrupting the flow of electricity in a circuit.



Adjust the length of cotton under the drawing pin so that the nail lifts as the barrier moves. The barrier must move freely. If not, wiggle the pin holding it in place. Press the drawing pin in firmly when the adjustment is correct.

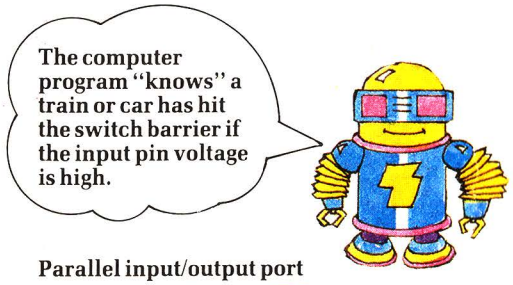
Making the switch sensor circuit

This page explains how the switch sensor circuit works. You can find out opposite how to make the circuit and connect it to the control centre. The circuit is designed to work with up to four switches and is quite simple and cheap to build. It is best to make the complete circuit even if you decide to make only two switches, as it is easier to do this than add to the circuit later if you make more switches.



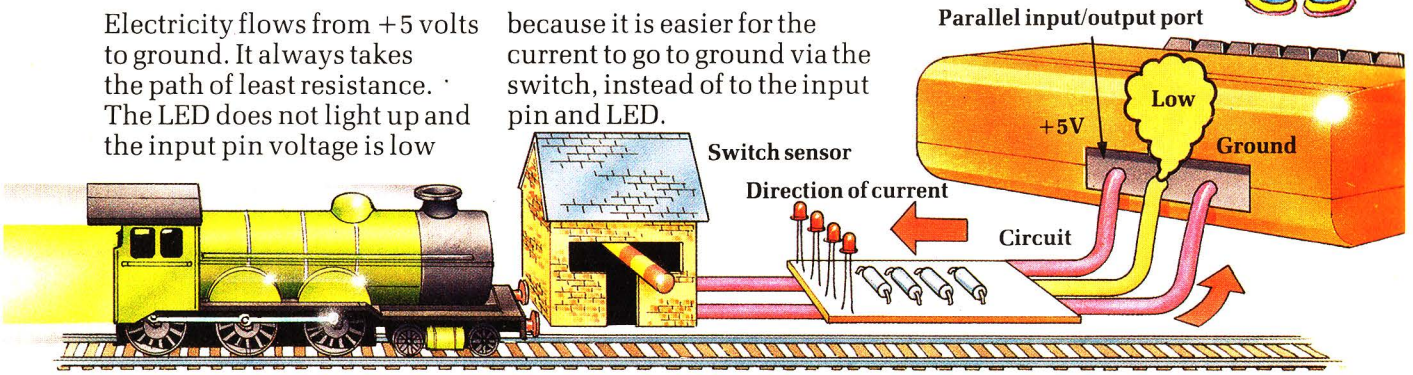
How the circuit works

The circuit contains four sets of the same components – one set for each switch you connect to it. Each has an LED which lights up so you can check to see if the circuit works properly when a switch opens. Instead of using a battery to power the circuit, it is connected directly to the computer's low voltage power supply (5 volts). This has two pins, one at +5 volts and the other at 0 volts, called ground (GND for short). The circuit works by making one of the computer's input pins receive either a high or low voltage according to whether a switch is open or closed.*



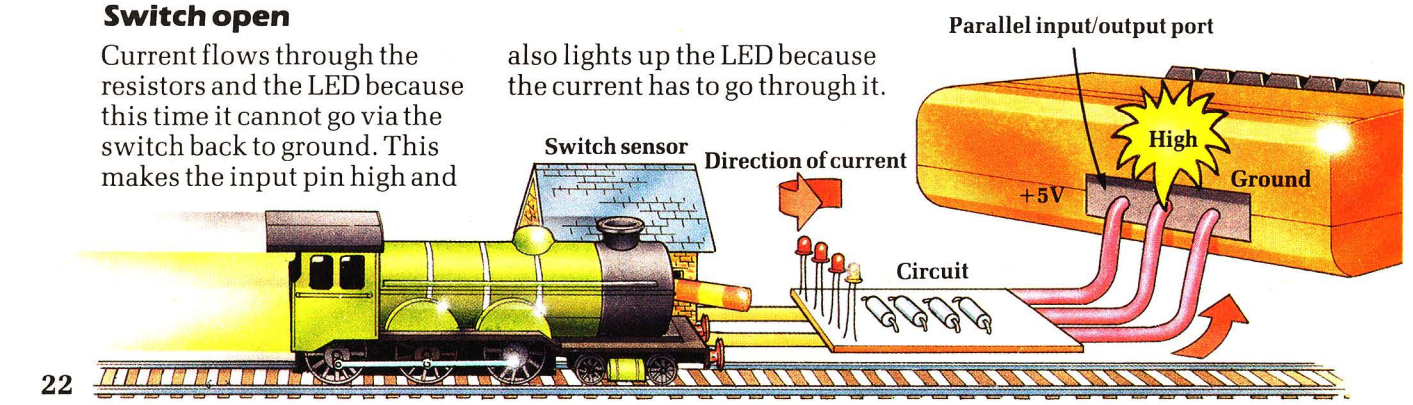
Switch closed

Electricity flows from +5 volts to ground. It always takes the path of least resistance. The LED does not light up and the input pin voltage is low because it is easier for the current to go to ground via the switch, instead of to the input pin and LED.

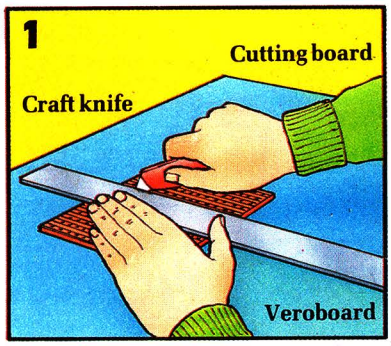


Switch open

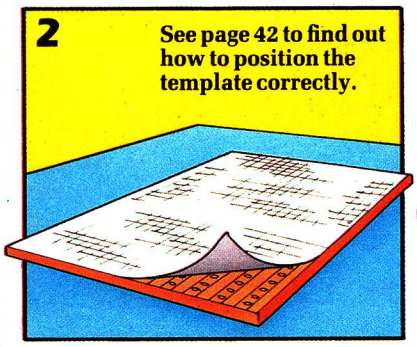
Current flows through the resistors and the LED because this time it cannot go via the switch back to ground. This makes the input pin high and also lights up the LED because the current has to go through it.



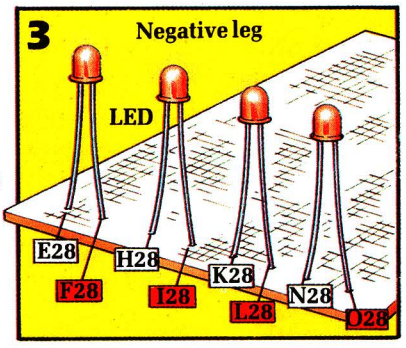
*Page 40 shows the input pins for your computer.



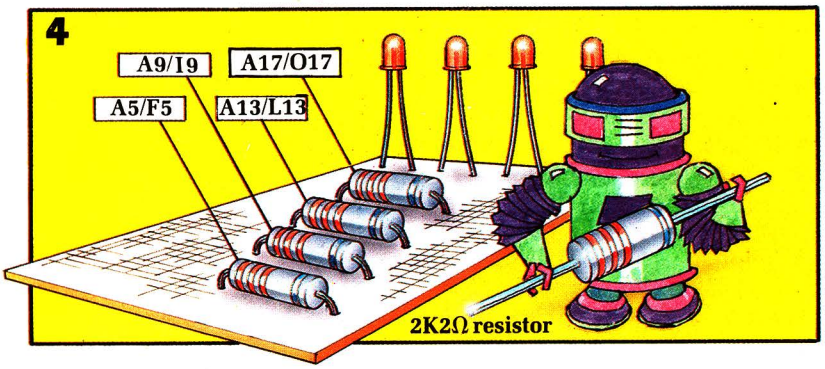
Cut a piece of Veroboard 19 tracks wide by 30 holes long. Score between holes with a craft knife and snap the board.



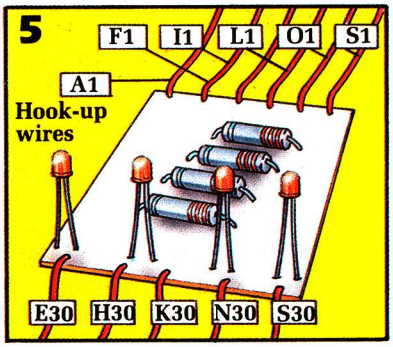
Cut out a copy of the switch sensor template on page 43. Glue it to the plainside of the Veroboard.



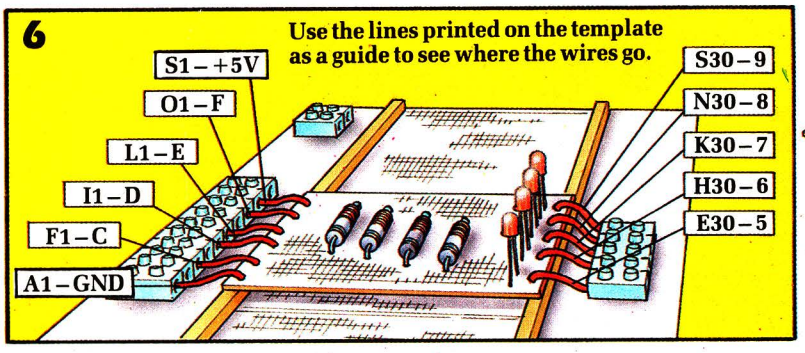
Solder four LEDs between the holes shown above. The holes for the negative leg are marked in red.



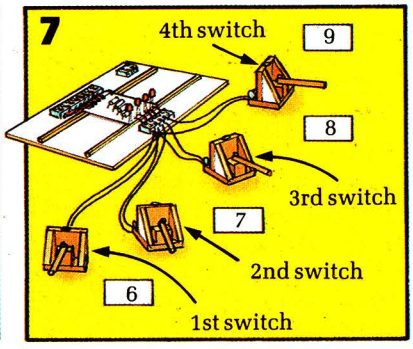
Solder the correct resistors for your computer into the holes shown above. Use 1KΩ resistors for the C64. These have brown/black/red stripes. Use 2K2Ω resistors, with three red stripes, for other computers.



Strip and tin the ends of 11 hook-up wires about 150mm (6″) long and solder them in the holes marked above.



Glue the circuit with glue to the balsa wood strips on the control centre. The circuit sits over the original template position. Then connect the hook-up wires between the circuit and connector block holes as shown.



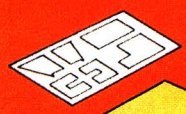
Put one wire from each switch into control centre connector block hole 5. The other wire goes into the hole shown.

Switch disguises

Here you can find out how to make and customize the trackside disguises. There is also a test to do to check your switches work before trying them with your computer. Some tips are given, too, on positioning the switches so they work best with either trains or cars.

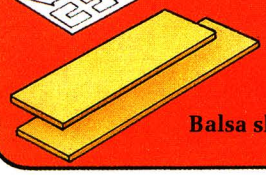
Things you need

Brush and paints, or coloured pencils



Templates on pages 44-46

Sandpaper

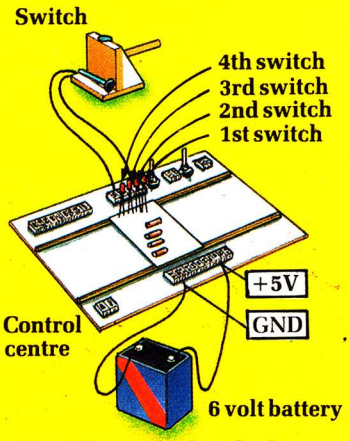


Balsa sheet

Old model magazine

Scraps of card

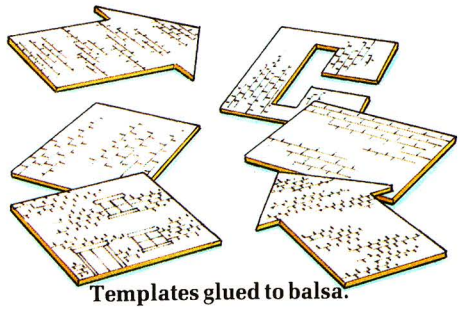
Testing the switches



Test the switches before using them with your computer. Strip the ends of two wires and connect them between the computer connector block holes and a 6 volt battery as shown above. Use the same battery as the power controller if you have made one.

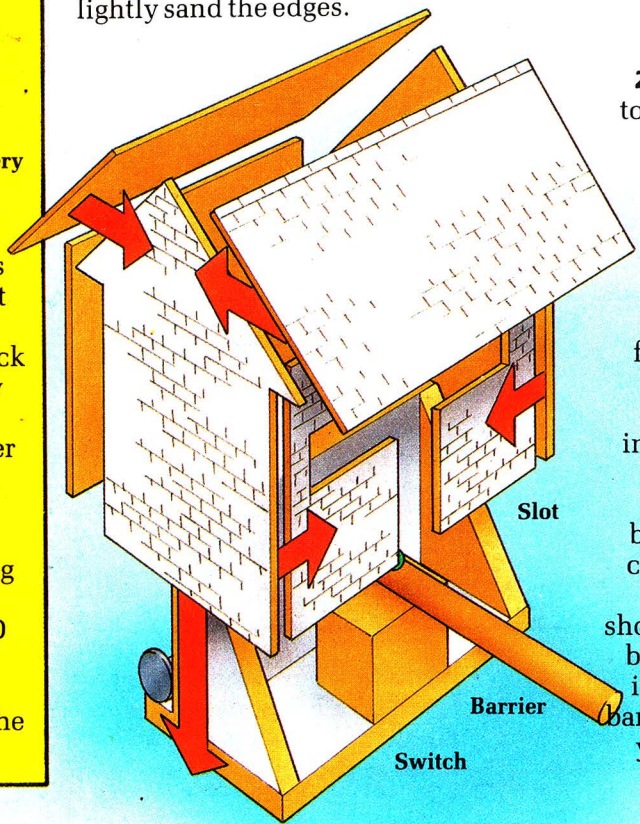
You can see if the switches work by moving their barriers and watching to see if an LED lights up, in the order shown. Check all your soldering and wiring if the test does not work.

Making a building



Templates glued to balsa.

1 Cut out copies of the set of templates on pages 44-46 for your model. There are three sizes – N and HO gauge for trains, and a pitstop building for cars. Details, like windows and bricks, are already printed on the templates. Glue them to sheets of balsa, according to the thickness printed on the template. Cut round the templates with a craft knife, and then lightly sand the edges.



2 Glue all the parts together in the order shown on the left. The railway buildings look like this, but the pitstop building has a flat roof made from one part. Glue the parts with the templates on the inside if you want to paint your own details on the buildings. Slide the completed building over the switch as shown. Make sure the barrier moves freely in the slot. Sand the barrier down a little if you can't get it to fit properly.

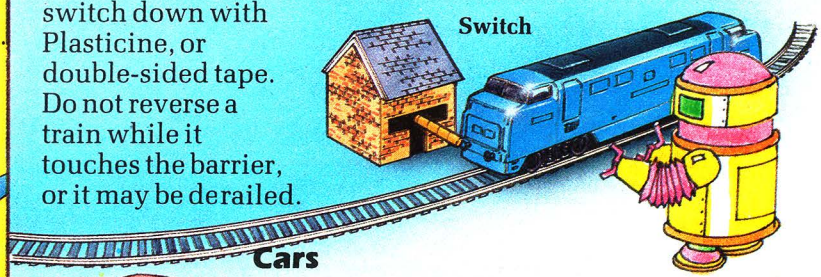
Positioning the switches

These pictures show how best to adjust the switches to suit your model. The program pages show where to position them.

Trains

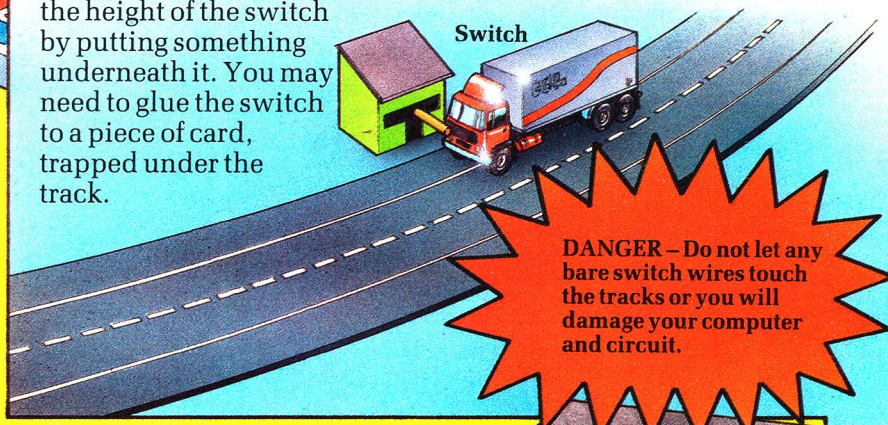
Position the switch where you want it on the layout. Slide a train along the tracks to make sure it hits the switch about two-thirds of the way along the barrier.

Then stick the switch down with Plasticine, or double-sided tape. Do not reverse a train while it touches the barrier, or it may be derailed.



Cars

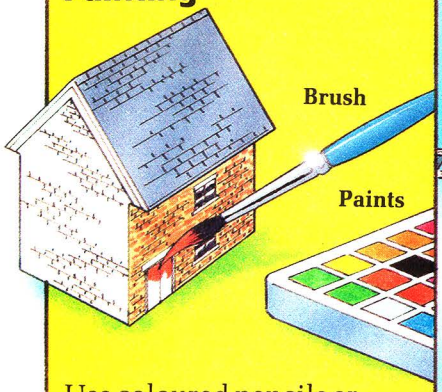
Place the switch beside a level part of either the inside or outside track. Slide a car past the barrier to make sure the car will move it. If not, adjust the height of the switch by putting something underneath it. You may need to glue the switch to a piece of card, trapped under the track.



Customizing ideas

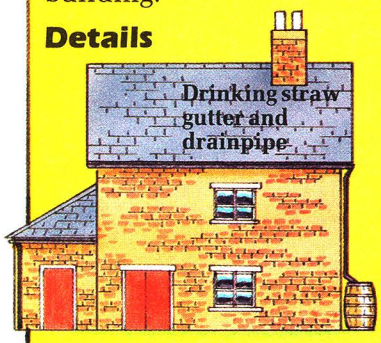
The pictures in this box give some tips on how to make the buildings fit into the style of your layout. You could also adapt existing buildings to fit the switches, or design your own.

Painting



Use coloured pencils or watercolour paints to colour in the details printed on the templates. Be careful not to get the paper too wet or it will buckle and spoil the look of the building. Paint the bare edges of the balsa to match the rest of the building.

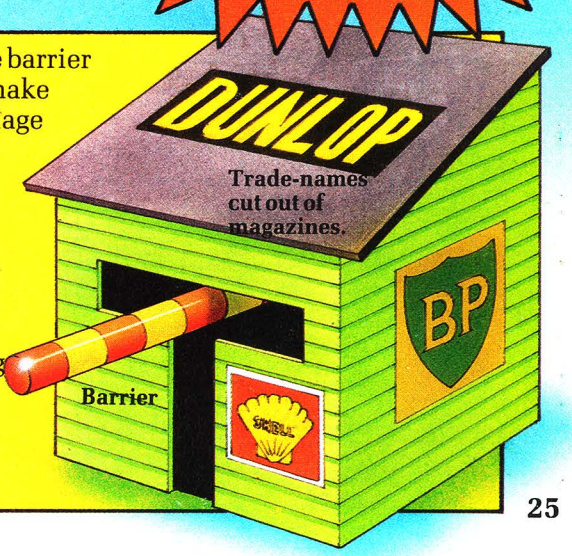
Details



Create your own details by adding extra parts like chimneys and sheds.

Improve the look of the barrier by painting stripes to make it stand out, or camouflage colours to blend in with your layout.

Make pitstop buildings more convincing by cutting out trade names from colour magazines to use as stickers. Leaning wheels and spare parts against the building looks good too.



Switch programs

The programs here are for trains and cars, to use with up to four switches. Here is what to do before you begin:

1 Read the program notes on page 39.
2 Test the switch sensors, using the program here and notes on page 39 which tell you how to do it.
3 Choose which switch sensor program you want to run and type it into your computer.
4 Turn back to page 39 and type in the extra lines listed in boxes A and B.

Make sure you type in the program labelled for your computer.

Test program

Type the test program for your computer before using the switch sensors. The program checks to make sure they are working properly before using the main programs.

Type RUN and then RETURN after entering the program. A number will appear on the screen. As you move the barrier of each switch in turn, the number will decrease by the amount shown in the chart. Check the nail and drawing pin movement if this does not happen. Then check your circuit connections and soldering if you still cannot get it to work.

Switch number (printed on template)	Number on screen decreases by this amount:
1	4
2	8
3	16
4	32

C64

```
10 POKE 56579,192
20 PRINT PEEK(56577):
   GOTO 20
```

VIC 20

```
10 POKE 37138,192
20 PRINT PEEK(37136):
   GOTO 20
```

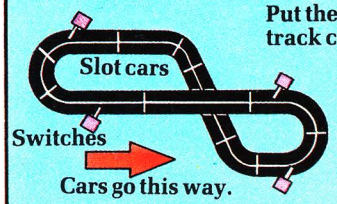
BBC

```
10 ?&FE62=192
20 PRINT ?&FE60:GOTO 20
```

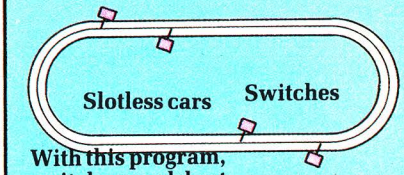
Spectrum*

```
10 PRINT either PEEK (port
number) or IN port number
20 GOTO 10
```

Skilful driving



Put the switches on the outside track corners with slot cars – avoid swinging out and hitting them with your car.



Place switches on either side of the track with slotless layouts. Avoid hitting barriers by changing lanes.

With this program, switches work best at an angle like this:

This program tests your skill at negotiating bends with slot cars, or steering with slotless cars. You position up to four switches on or around the track as shown in the diagrams, and try to avoid hitting the switch barriers.

You get penalty points for hitting a switch. The more switches you hit, the more points the computer scores against you. Points are scored all the time while your car is touching a barrier, so it's best to drive as fast as possible.

This game is for one driver at a time. Challenge a friend to see who scores the lowest points over ten laps. Type the program into your computer, then type RUN and RETURN when you are ready.

```
 10 GOSUB 2800:GOSUB 3000
 20 LET SP=P(1)+P(2):GOSUB 2600
 30 clear screen
 40 PRINT:PRINT "MAKE SURE ALL SENSORS"
 50 PRINT "ARE OFF THEN PRESS RETURN"
 60 INPUT X$
 70 GOSUB 2000:LET NR=FP
 80 clear screen
 90 PRINT:PRINT ".SKILFULL DRIVING."
100 LET X=1:LET Y=5:LET A$="POINTS :"
110 GOSUB 2400
120 LET P=0:LET Y=5:LET X=10
130 GOSUB 2000:IF FP=NR THEN GOTO 130
140 LET P=P+1
150 LET A$=STR$(P):GOSUB 2400
160 GOTO 130
```

Switches power on to track.

NR = Score when sensors are off.

Screen display

Waits for a sensor to come on.

Increase points when sensors come on.

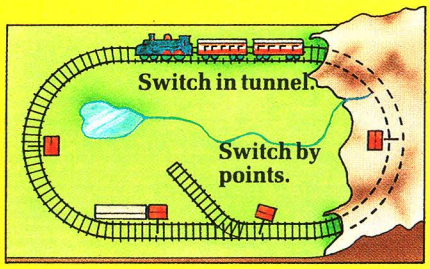
Now type the lines in boxes A and B on page 39.

*Spectrum: The output port number and POKE or OUT commands you use depend on the interface you buy.

Train finder

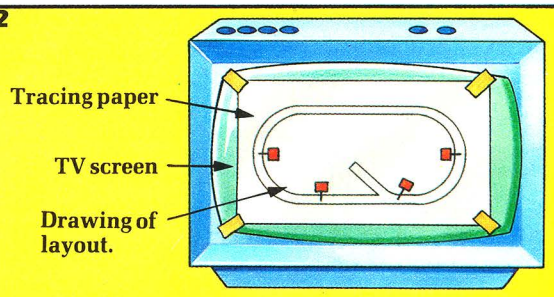
With this program you can locate a train on the track by looking at your TV screen. Switches placed around the track are represented by a spot on the screen, which lights up each time a train passes a switch. The steps below show how to use the program.

1



Place a switch anywhere you like around the track. It's a good idea to put them at particular places, like stations, tunnels, points and signals.

2



Draw a diagram of your track layout, using a felt pen on tracing paper, large enough to cover your screen. Draw spots to show where the switches are. Then tape the tracing paper over the screen.

3 Type the program below into your computer. Change the number in line 10 according to the number of switches you use, up to a maximum of four. Then type RUN and RETURN.

```
 10 LET NS=4
 20 GOSUB 2800:GOSUB 3000:GOSUB 130
 30 LET SP=P(2):GOSUB 2600
 40 clear screen
 50 FOR I=1 TO NS
 60 LET TN=2+I:GOSUB 2200
 70 LET X=X(I):LET Y=Y(I)
 80 IF TF=0 THEN LET A$=">"
 90 IF TF=1 THEN LET A$=" "
100 GOSUB 2400
110 NEXT I
120 GOTO 50
130 DIM X(4):DIM Y(4)
140 FOR I=1 TO NS
150 READ X(I),Y(I)
160 NEXT I
170 DATA 3,3,20,3,20,10,3,10
180 RETURN
```

No. of sensors

Switch power on.

Print spot if sensor on.

Print space if sensor off.

Read co-ordinates of sensors.

Now type the lines in boxes A and B on page 39.

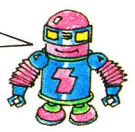
4 Up to four small spots will appear on the screen, according to the number you type in line 10. By changing the numbers in line 170 you can move them around the screen so they appear under the switch marks on your tracing paper.

```
170 DATA 3,3,20,3,20,10,3,10
```

Numbers for 1st switch
Numbers for 2nd switch
Numbers for 3rd switch
Numbers for 4th switch

Each pair of numbers is the co-ordinate for one switch spot on the screen. The first number in each pair moves the spot horizontally and the second moves it vertically, one screen character at a time. Experiment with the numbers until you get the spots where you want them.

Your model's motors may cause some interference on the TV screen. See page 48 for some tips on reducing the problem.



Light sensors

There are two light circuits to make, and a bridge to hold the parts which go beside the track. These tell the computer when a train or car goes past them. You can see what all the parts look like below, and find out how they work opposite.

The computer programs enable you to use the light sensors to start a race, work out your fastest speed according to the scale of your model and control trains from a signal box.

Each circuit detects one car or train. Look at the programs to decide whether to make one or two. Follow the blue or grey corner flashes to make the circuits and bridge.

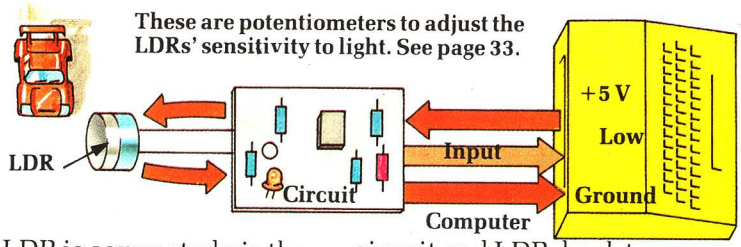
The sensor is a paper tube with a light dependent resistor (LDR) inside.

When a train or car goes past, it casts a shadow over the end of the tube, which cuts down the light reaching the LDR, altering its resistance. This is detected by the computer.

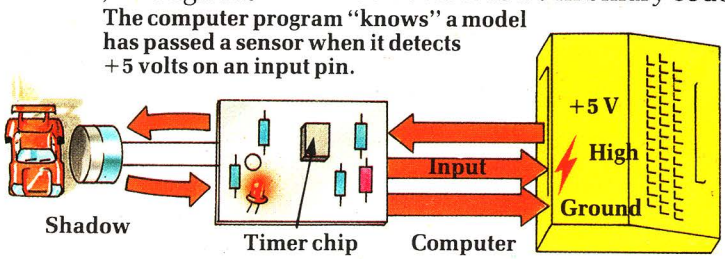
Slotless racing cars

Because slotless cars change tracks, you need to identify the cars so that each LDR detects only one car. Tape white card to one side of a car and dark to the other. Put the card on the opposite side of the second car. See page 33 to adjust the LDRs.

How the circuit works

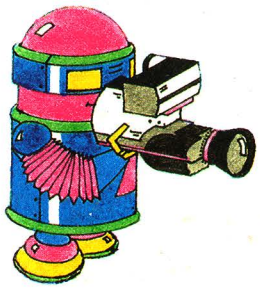


The LDR is connected via the circuit to the +5 volt and ground pins and an input pin in the computer's input/output port. Current travels from +5 volts, through the circuit and LDR, back to ground and to the input pin. The circuit normally sends about ½ volt to the input pin, which the programs in this book detect as a 0 in binary code.



Shadows from trains or cars lower the LDR resistance, making the circuit send about 3½ volts to the input pin. This happens so quickly that the program would not have time to detect any change. A timer chip in the circuit increases the time the pin voltage is high, giving the program long enough to detect it as a 1 in binary code.

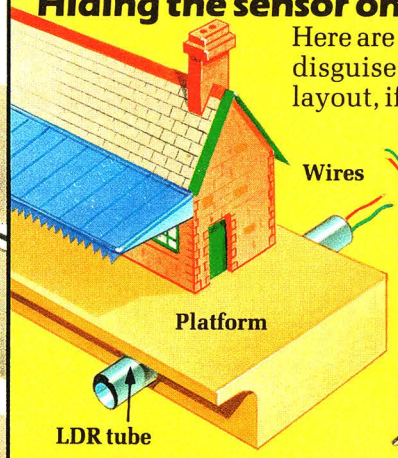
Non-contact sensors



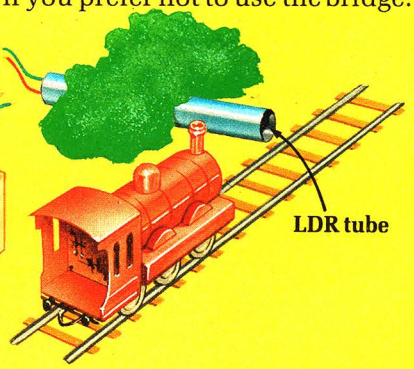
Light sensors are called non-contact sensors because they do not have to touch anything to work. There are many types of non-contact sensors – video cameras for instance. By connecting them to computers with special interfaces, they give machines a limited sense of "sight". This is called machine vision.

Hiding the sensor on railway layouts

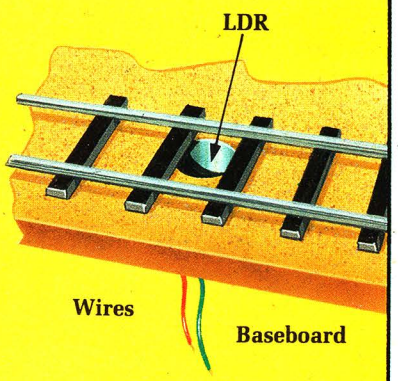
Here are some ideas for other ways to disguise the light sensor on a railway layout, if you prefer not to use the bridge.



Cut a hole in a platform or railway building. Slide the tube in and conceal the LDR wires under the baseboard.



Hide the tube amongst trees or bushes. Conceal the wires by drilling a small hole in the baseboard to pass them through.

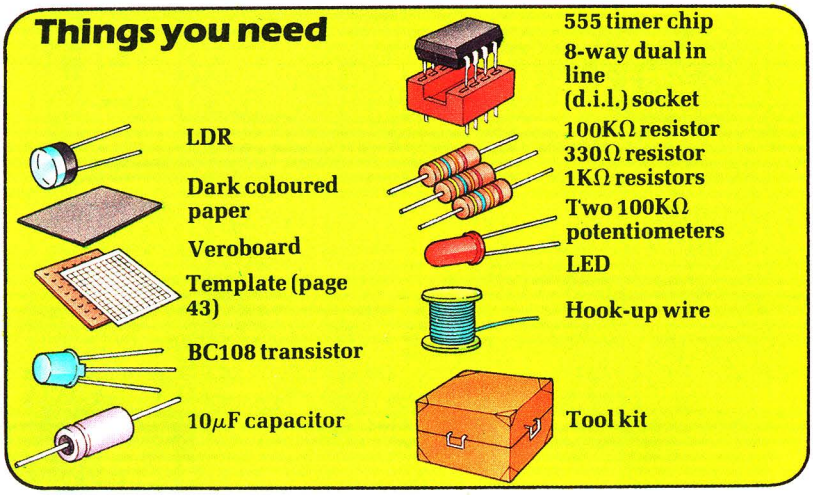


Cut a hole in the baseboard under the track. Position the LDR without its tube so it points up under trains.

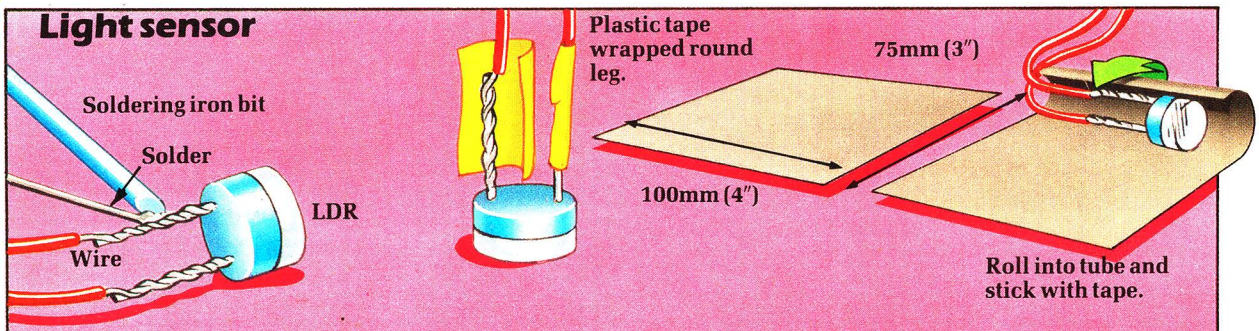
Making the light sensor and circuit

These instructions explain how to make one light sensor and circuit. You need to repeat the steps to make two circuits and potentiometers. Steps 10 and 11 show how to connect two circuits to the control centre. Trim all the component legs, then check your soldering very carefully to make sure the joints look bright and shiny and that there are no joined tracks.

Things you need

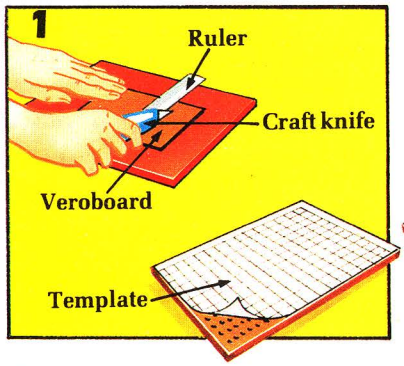


Light sensor



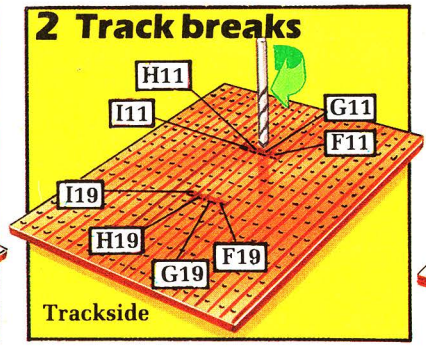
Cut and strip two wires, long enough to reach between the control centre and where you want the light sensor on the model layout. Solder one wire to each leg of an LDR. Then wrap tape round the bare legs. Cut a piece of dark paper the size shown above and wrap it tightly round the LDR to make a tube, sticking it with tape.

1



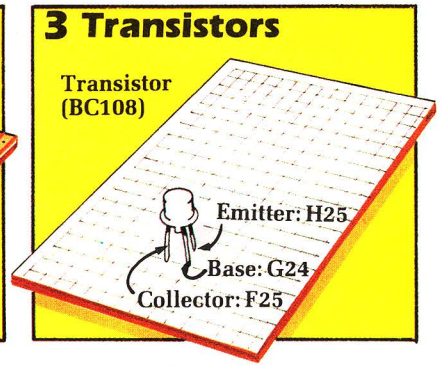
Cut a piece of Veroboard 16 tracks wide by 30 holes long. Glue a light sensor circuit template to it.

2 Track breaks

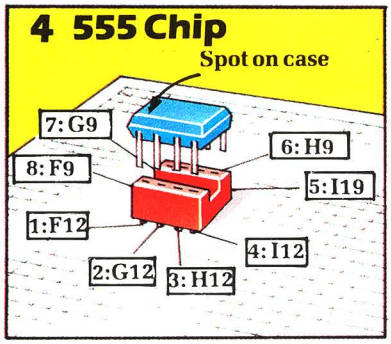


Cut the track with a 5mm (¼″) drill bit at the holes shown, by twisting the drill in the holes to break the track.

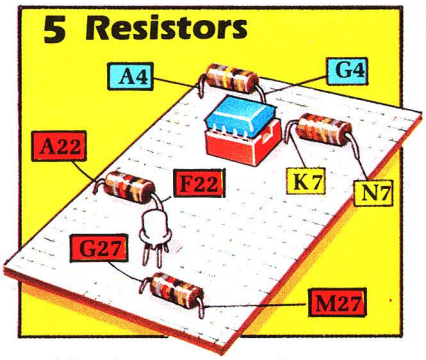
3 Transistors



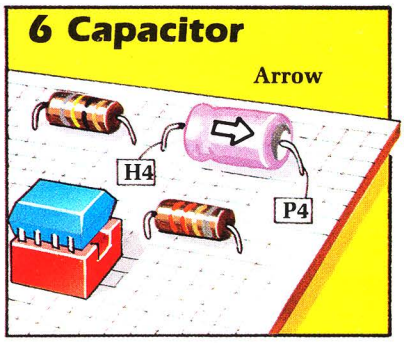
Solder the legs of the transistor into the holes shown. Page 6 shows how to identify the legs.



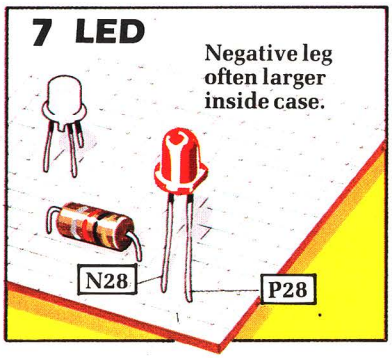
Solder an 8-way d.i.l. socket in the holes above, then gently push a 555 chip into the socket with the spot over hole F12.



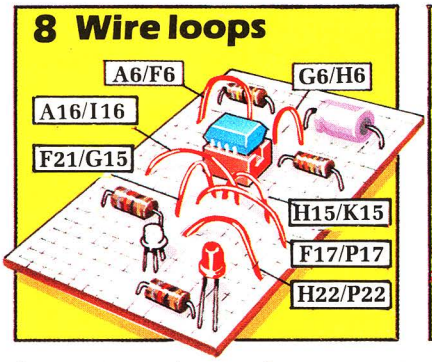
Solder four resistors between the holes shown. Holes marked in red are for 1KΩ in blue, 100KΩ and in yellow, 330Ω.



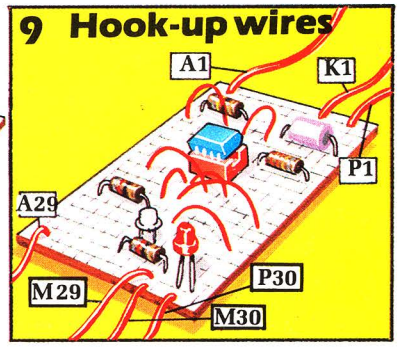
Solder a 10μF capacitor between the holes shown above. Make sure the arrow on the capacitor faces hole P4.



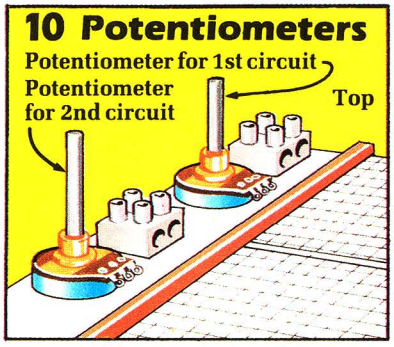
Solder an LED in the holes shown. The negative leg goes in the hole marked in red. See page 6 to identify LED legs.



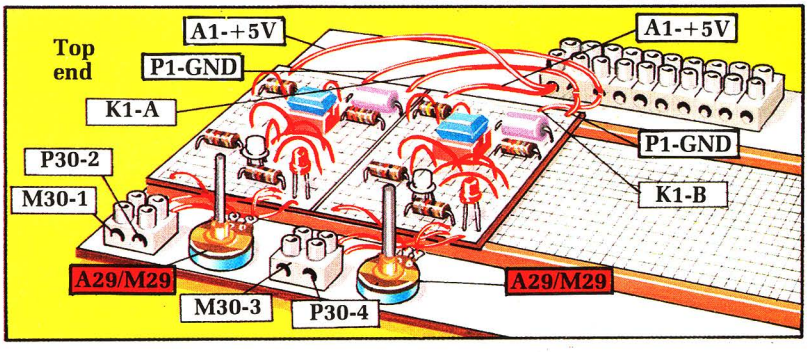
Cut, strip and tin eight pieces of wire 100mm (4") long. Solder them as loops between the pairs of holes above.



Strip and tin the ends of seven 150mm (6") lengths of wire. Solder one end of each wire in the holes listed above.



Glue the potentiometers either to the position on the control centre, or fix it in the hole drilled in step 3, page 9.



Glue the circuits to the control centre. Use the end position if you make only one circuit. Solder the wires marked in red to the centre and outside tags of the potentiometer. Screw the other wires in the connector block holes shown.

Using the light sensors

These pictures explain how to make the bridge for use with trains or cars. There are also instructions showing how to connect, test and use the light sensor. Check the electrical connections carefully when you finish, before connecting to your computer.

Things you need

3mm (⅛") balsa sheet

Templates on page 46-47

Old model magazine

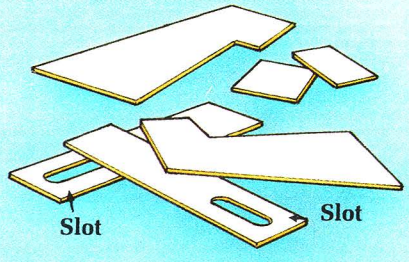
Paint and brushes.

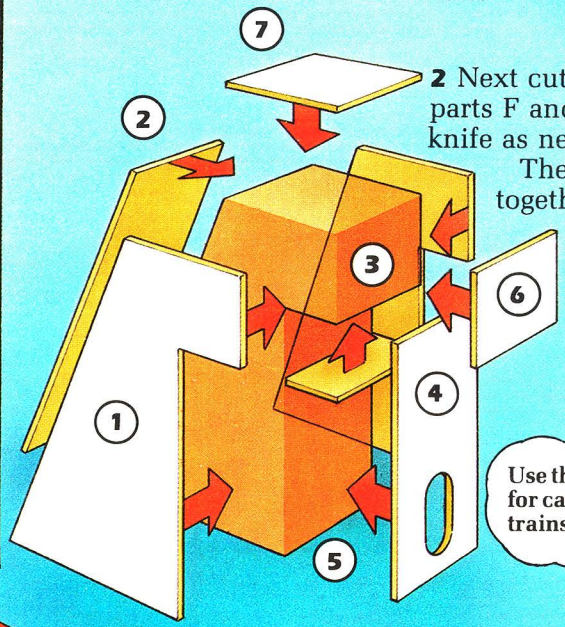
Toolkit

Making the bridge

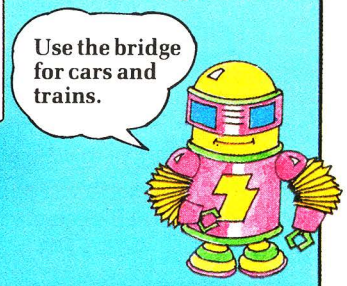
1 Glue copies of the bridge templates on pages 46-47 to 3mm (⅛") thick balsa sheet. Cut round each piece with a craft knife and a ruler.

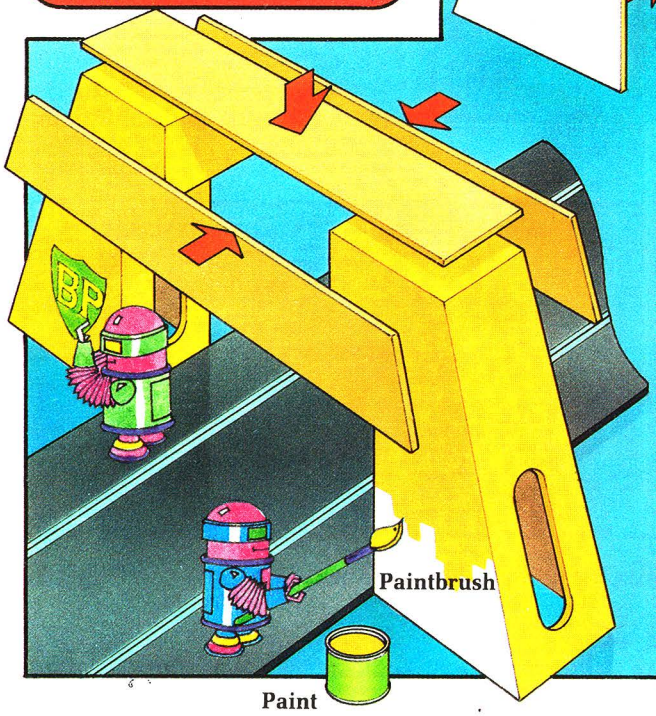
Templates glued to balsa.





2 Next cut out the slots in parts F and G with a craft knife as neatly as you can. Then glue the parts together as shown on the left. The numbers show which order to work in. Hold the pieces together while the glue sets.

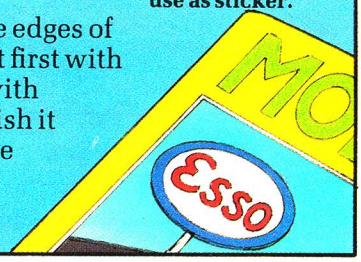




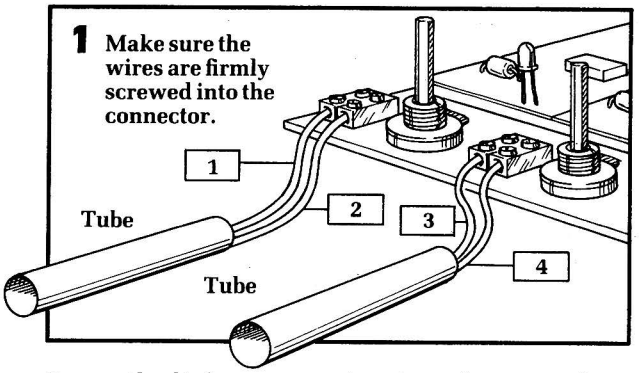
3 Repeat steps 1-2 to make another bridge half for a second sensor. Then position them on either side of a flat part of the track as shown on the left. Measure across the top, back and front and cut three pieces of balsa or card to fit. Glue the pieces in place to complete the bridge.

Trade name to use as sticker.

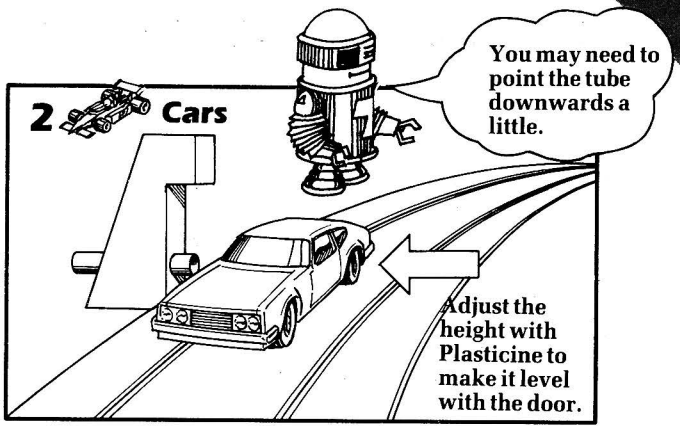
4 Lightly sand the edges of the bridge. Paint it first with undercoat, then with gloss enamel. Finish it by glueing on trade names cut from magazines.



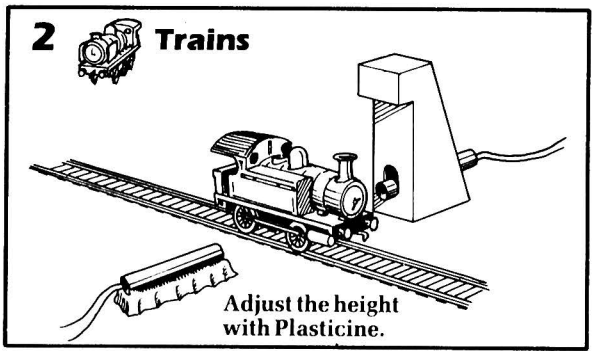
Connecting the light sensors



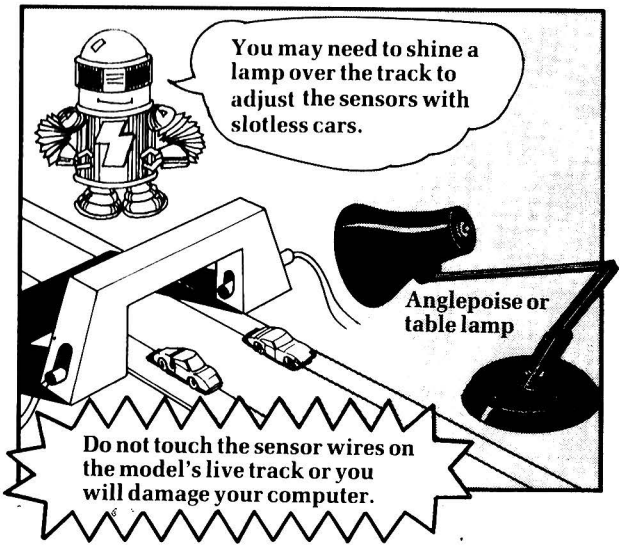
Screw the light sensor wires into the control centre connector block holes shown above. It does not matter which way round the wires go. Use holes 1 and 2 if you make only one sensor.



Push the tube through the slots in the bridge. Slide it in until the tube is about 10mm from a car, half-way up the door. Adjust the height with Plasticine under the tube.

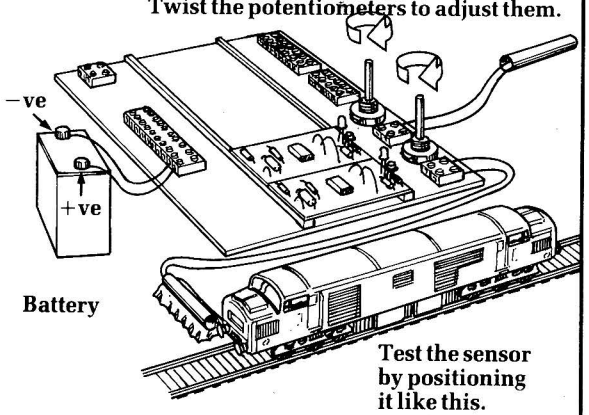


Position the light sensor beside the track half-way up and 10mm (⅜") away from the side of a train. You may need to point the tube downwards a little when you test the sensor.



3 Testing the sensor

Connect the −ve terminal of a 6 volt battery to the computer connector block hole marked "GND" (ground), and the +ve to the hole marked "+5V". Use the power controller battery, if you have made one.



Place a car or train in front of the sensor tube. Adjust the circuit's potentiometer until the LED just lights up. Take the model away; about 1 second later the LED should go out. Push the LDR up or down the tube if you can't get the adjustment right. If it still does not work, check all your connections and circuit soldering and replace the battery with a fresh one. Disconnect the battery after the test.

Light sensor programs

The programs here are for trains and cars, to use with two light sensors. Here is what to do before you begin:

1 Read the program notes on page 39.
2 Test the light sensors, using the program here and notes on page 39 which tell you how to do it.
3 Choose which light sensor program you want to run and type it into your computer.
4 Turn back to page 39 and type in the extra lines listed in boxes A and B.

Make sure you type in the program labelled for your computer.

Test program

Type the test program for your computer before using the light sensors. The program checks to make sure they are working properly before using the main programs.

Type RUN and then RETURN after entering the test program. A number will appear on the screen. As you place your hand over the end of each sensor tube in turn, the number will increase by the amount shown in the chart. If this does not happen, adjust the potentiometer, with your hand still over the tube, until the circuit LED lights up. Then check your circuit connections and soldering if you still cannot get it to work.

Light sensor number (printed on template)	Number on screen increases by this amount:
1	1
2	2

C64

```
10 POKE 56579,192
20 PRINT PEEK(56577):
   GOTO 20
```

VIC 20

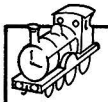
```
10 POKE 37138,192
20 PRINT PEEK(37136):
   GOTO 20
```

BBC

```
10 ?&FE62=192
20 PRINT ?&FE60:
   GOTO 20
```

Spectrum*

```
10 PRINT either PEEK(port
   number) or IN port number
20 GOTO 10
```



Scale speed

This program calculates the approximate speed of a train, according to its scale. You need to use two light sensors for this program.

Position the sensors exactly one metre (39") apart, as shown in the track layout diagram. You need to do this as the program works out the speed from the length of time taken for the train to travel one metre (39").

The speed displayed on the screen is controlled by the number in line 20 of the program. The box on the right gives numbers to use in line 20 according to your computer and the scale of your train.

Type the program into your computer. Set your train going at the speed you want with the dial on the transformer. Follow this procedure to find out the train's speed:

1 Type RUN and RETURN when you are ready.
2 Then type RETURN again before the train reaches the first sensor. After the train passes the second sensor, its speed is displayed on the screen.

Repeat this procedure to find out the train's speed again.

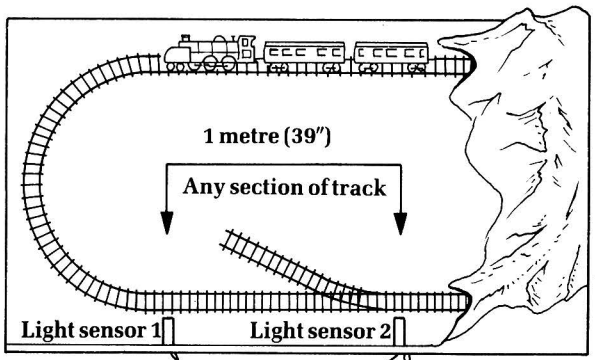
Speed/lap display

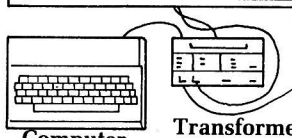
This program is for one or two drivers. It works out your speed for each lap, and counts the number of laps completed. This information is displayed for each driver on the TV screen and is updated every lap.

The speed displayed on the screen is controlled by the number in line 10 of the program and varies according to the computer you use. The box on the right suggests a number to use for your computer. Try this number first. You may need to try a slightly higher or lower number to get a realistic speed for the scale and size of your layout.

Set up one or two light sensors as shown. Then type the program into your computer. Type RUN, then RETURN when you are ready.

*Spectrum: The output port number and POKE or OUT commands you use depend on the interface you buy.






```
10 GOSUB 2800:GOSUB 3000
20 LET K=number from chart
30 LET SP=P(2):GOSUB 2600
40 clear screen:PRINT "PRESS RETURN AS TRAIN"
50 PRINT "APPROACHES FIRST SENSOR"
60 INPUT X$
70 LET TN=1
80 GOSUB 2200:IF TF=0 THEN GOTO 80
90 PRINT:PRINT "PASSED FIRST SENSOR"
100 LET T=0
110 LET TN=2
120 GOSUB 2200:IF TF=0 THEN LET T=T+1:GOTO 120
130 PRINT:PRINT "PASSED SECOND SENSOR"
140 LET S=K/T
150 PRINT:PRINT "MEASURED SPEED ";INT(S);" KMH"
160 PRINT "OR ";INT(S*0.621);" MPH"
170 STOP
```

Switches power on in case power controller circuit is connected.

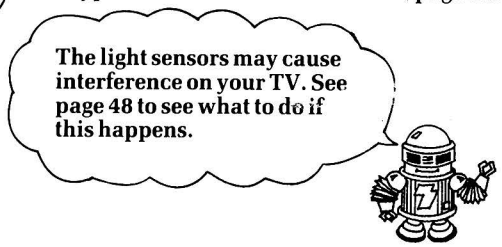
Waits for first sensor to switch on.

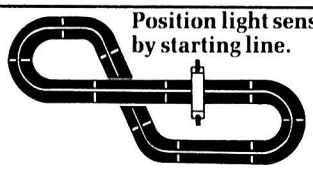
Records time until second sensor switches off.

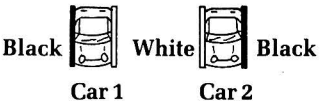
Calculates train's speed.

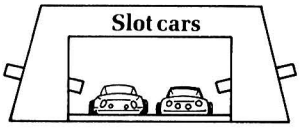
Now type the lines in boxes A and B on page 39.

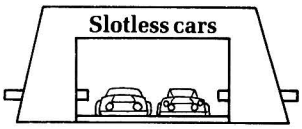
Computer	Train gauge	
	00/H0	N
C64	7600	13700
VIC 20	9500	17100
BBC	30000	54000
Spectrum	4000	7200











Adjust one potentiometer at a time until the circuit LED lights up as the car passes the sensor tube at speed.

Adjust the potentiometers as for slot cars. Identify cars 1 and 2 with black and white card as shown on page 28.

Computer	Number for line 10
C64	600
VIC 20	1300
BBC	1000
Spectrum	3000

```
10 LET K=number from chart
20 GOSUB 2800:GOSUB 3000:GOSUB 230
30 LET SP=P(1)+P(2):GOSUB 2600
40 clear screen
50 PRINT:PRINT TAB(3);"LAP COUNTER"
60 PRINT:PRINT TAB(0);"DRIVER 1  DRIVER 2"
70 PRINT:PRINT "-LAPS------LAPS---"
80 PRINT:PRINT:PRINT
90 PRINT "-SPEED-----SPEED--"
100 FOR I=1 TO 2
110 LET T(I)=T(I)+1
120 LET TN=I:GOSUB 2200
130 IF TF=1 AND F(I)=0 THEN GOSUB 170
140 IF TF=0 THEN LET F(I)=0
150 NEXT I
160 GOTO 100
170 LET L(I)=L(I)+1:LET F(I)=1
180 LET V=INT(K/T(I)):LET T(I)=0
190 LET X=10*I-9:LET Y=7
200 LET A$=STR$(L(I))
210 GOSUB 2400:LET Y=11:LET A$=STR$(V)+" "
220 GOSUB 2400:RETURN
230 DIM F(2):DIM L(2)
240 DIM T(2)
250 RETURN
```

Now type the lines in boxes A and B on page 39.

More model controller programs

There are programs for trains and cars over the next three pages, to use with various combinations of model controllers. Here is what to do before you begin:

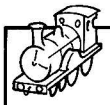
1 Read the program notes on page 39.

2 Test the model controllers for the program you want to use, using the relevant test programs.

3 Choose which program you want to run and type it into your computer.

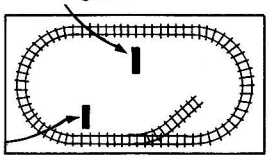
4 Turn back to page 39 and type in the extra lines listed for your computer.

Make sure you type in the program labelled for your computer.



Signal box

For this program you need:
Power controller
Light sensors 1 and 2

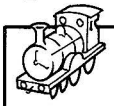


Give your layout computer-controlled signals with this program. Set up two light sensors beside the track as shown in the diagram. Type the program into your computer. Type RUN and then RETURN. Then start your train with the dial on the transformer. The train will stop at the first light sensor "signal" it reaches. Press any key on your computer keyboard to start the train again.

```
10 GOSUB 2800:GOSUB 3000
20 LET SP=0:GOSUB 2600
30 clear screen
40 PRINT:PRINT "MAKE SURE BOTH SENSORS"
50 PRINT "ARE OFF THEN PRESS RETURN"
60 INPUT X$
70 LET SP=P(2):GOSUB 2600
80 GOSUB 2000:LET NR=FP
90 GOSUB 2000:IF FP=NR THEN GOTO 90
100 LET SP=0:GOSUB 2600
110 PRINT "PLEASE PRESS RETURN"
120 PRINT "TO CHANGE SIGNAL"
130 INPUT X$
140 LET SP=P(2):GOSUB 2600
150 GOSUB 2000:LET NR=FP
160 GOSUB 2000:IF FP=NR THEN GOTO 160
170 GOTO 70
```

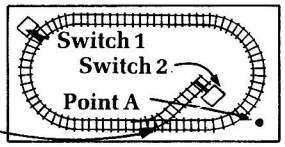
Power to go forwards.
Waits for either sensor to come on.
Power off
Waits for sensor to go off.

Now type the lines in boxes A and B on page 39.



Marshalling yard

For this program you need:
Power controller
Switch sensors 1 and 2



This program allows you to control the train with your computer to make it reverse into a siding. Here is what you have to do:

1 Set up the model controllers as shown in the diagram above. Switch the points to send the train round the track anti-clockwise.

2 Type the program into your computer. Type RUN, then RETURN.

3 Set the transformer dial to move the train to point A.

4 Type RETURN. Then the train will stop.

5 Make sure the transformer is turned to go forwards and press RETURN again. The train will move to switch 1 and then stop. The computer will ask you to change the points. Then press RETURN.

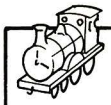
6 The train will reverse up the siding and stop at switch 2.

7 Re-run the program, move the train to point A using the transformer dial and repeat the whole procedure to do the manoeuvre again.

```
10 GOSUB 2800:GOSUB 3000
20 LET SP=P(2):GOSUB 2600
30 clear screen
40 PRINT:PRINT "PLEASE MOVE TRAIN"
50 PRINT "TO POINT A":GOSUB 220
60 LET SP=0:GOSUB 2600
70 PRINT:PRINT "NOW TURN ON POWER"
80 GOSUB 220
90 LET SP=P(2):GOSUB 2600
100 LET TN=3:GOSUB 190
110 LET SP=0:GOSUB 2600
120 PRINT:PRINT "PLEASE CHANGE POINTS"
130 GOSUB 220
140 LET SP=P(1)+P(2):GOSUB 2600
150 LET TN=4:GOSUB 190
160 LET SP=0:GOSUB 2600
170 PRINT:PRINT "TRAIN NOW IN SIDING"
180 STOP
190 GOSUB 2200
200 IF TF=1 THEN GOTO 190
210 RETURN
220 PRINT "THEN PRESS RETURN"
230 INPUT X$:RETURN
```

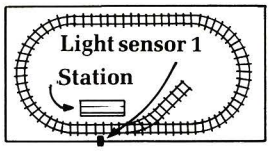
Power on
Waits for first switch to come on.
Power off
Reverses power.
Waits for second sensor to come on.

Now type the lines in boxes A and B on page 39.



Dead man's handle

For this program you need:
Power controller
Light sensor 1
Switch sensor 1



Many real trains have a safety device called a dead man's handle, which stops the train if the driver is ill or falls asleep. By using a switch sensor barrier as a dead man's handle, this program gives you realistic control of your train.

Place light sensor 1 by a station, and position switch sensor 1 so you can hold the barrier easily. Type the program into your computer; type RUN and then RETURN. The train only receives power if you move the barrier to the left or right. You can only release the handle if the train stops in front of the station, opposite the light sensor. You get a warning message on the screen if you let go at any other time.

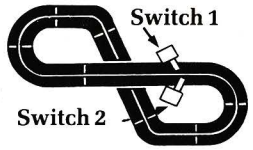
```
10 GOSUB 2800:GOSUB 3000
20 clear screen
30 LET SP=P(2):GOSUB 2600
40 LET TN=3:GOSUB 2200
50 IF TF=0 THEN GOTO 40
60 LET TN=1:GOSUB 2200
70 IF TF=1 THEN GOTO 40
80 LET SP=0:GOSUB 2600
90 PRINT:PRINT "YOU LET GO !"
100 LET TN=3:GOSUB 2200
110 IF TF=1 THEN GOTO 100
120 clear screen
130 GOTO 30
```

Power forward
Waits for switch sensor to go off.
Goes back to line 40 if light sensor is on.
Waits for switch sensor to go on.

Now type the lines in boxes A and B on page 39.

Fuel guzzler

For this program you need:
Power controller
Switch sensors 1 and 2



This program is for two drivers. The computer gives each driver a tank full of petrol at the start of a race. Your fuel level is displayed on the screen, and is gradually used up as you race round the track. To re-fuel you must stop your car in front of the pitstop barrier, as shown in the diagram. If you run out of petrol, the computer cuts off your power and the other driver wins the race.

Type the program into your computer. Then type RUN and RETURN when you are ready.

```
10 GOSUB 2800:GOSUB 3000:GOSUB 200
20 LET SP=P(1)+P(2):GOSUB 2600
30 clear screen
40 LET Y=6
50 PRINT:PRINT "DRIVER 1  DRIVER 2"
60 PRINT "========  ========"
70 PRINT:PRINT "  FUEL      FUEL"
80 FOR I=1 TO 2
90 LET TN=I+2:GOSUB 2200
100 IF TF=0 THEN LET F(I)=F(I)+2
110 LET F(I)=F(I)-1
120 IF F(I)<0 THEN GOTO 160
130 LET X=10*I-8:LET A$=STR$(F(I))+" "
140 GOSUB 2400:NEXT I
150 GOTO 80
160 LET SP=P(3-I):GOSUB 2600
170 PRINT:PRINT "DRIVER ";I;
180 PRINT " OUT OF FUEL!!"
190 STOP
200 DIM F(2):LET F(1)=100
210 LET F(2)=100:RETURN
```

Power on both cars.
Sets screen display up.
Fills up tank if car at sensor.
Prints fuel level on screen.
Stops car if it runs out of fuel and prints message.
100 units of fuel to start.

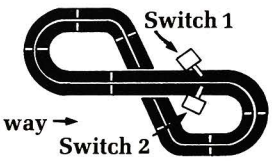
Now type the lines in boxes A and B on page 39.

Racing duel

Challenge another driver to a duel with this program. Position a switch sensor on either side of the track. Start racing, and then stop your car briefly in front of your switch barrier. This makes the computer add up points on the screen against the other driver. When the score reaches a certain number (depending on your computer), the other driver's power is cut off for a few seconds. The winner is the first to complete an agreed amount of laps.

Type the program into your computer. Then type RUN and RETURN when you are ready.

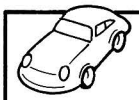
For this program you need:
Power controller
Switch sensors 1 and 2



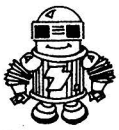

```
10 LET PL=1000:LET FT=15
20 GOSUB 3000:GOSUB 2800:GOSUB 140
30 LET SP=P(1)+P(2):GOSUB 2600
40 FOR I=1 TO 2
50 LET TN=I+2:GOSUB 2200
60 IF TF=0 THEN LET T(I)=T(I)+1
70 IF T(I)>FT THEN GOSUB 100
80 NEXT I
90 GOTO 40
100 LET SP=P(3-I):GOSUB 2600
110 FOR T=1 TO PL:NEXT T
120 LET SP=P(1)+P(2):GOSUB 2600
130 LET T(I)=0:RETURN
140 DIM T(2):RETURN
    Change the 1000 in line 10 to make
    the cars stop for a longer or shorter time
```

Both cars on
Tests sensor.
Increases score if car touches sensor.
Power on to car 2.
Power on to both cars.

Now type the lines in boxes A and B on page 39.



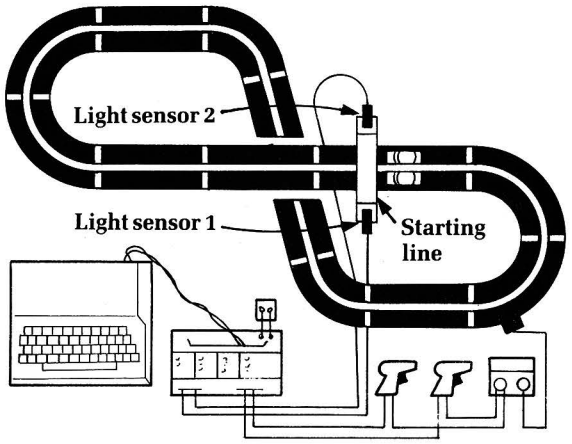
False start



For this program you need:
Power controller
Light sensors 1 and 2

Prevent cheating on the starting line with this program. A red signal appears on the screen to warn you that your power has been switched on by the computer. Start your race as soon as you see a green light on the screen. If you cross the line before the green light comes on, the computer will cut off your car's power for a few seconds, allowing the other driver to race off down the track.

Set up two light sensors on your track as shown in the diagram. Type the program into your computer. Then type RUN and RETURN when you are ready.




```
10 LET CS=700
20 GOSUB 2800:GOSUB 3000
30 LET SP=0:GOSUB 2600                    Power off
40 clear screen
50 LET LT=INT(RND(1)*CS)+CS               Calculates time
60 PRINT:PRINT "PLEASE PLACE CARS"
70 PRINT "BEHIND START LINE"
80 PRINT:PRINT "THEN PRESS RETURN"
90 INPUT X$
100 LET SP=P(1)+P(2):GOSUB 2600           Power on to
110 GOSUB 2000:LET NR=FP                  both cars.
120 GOSUB 300                             Red light
130 LET T=0
140 LET T=T+1:GOSUB 2000                  Waits for a
150 IF FP=NR AND T<LT THEN GOTO 140       time.
160 GOSUB 400                             Green light
170 IF T=LT THEN GOTO 270                 Final time
180 LET CN=0                              reached, so no
190 FOR I=1 TO 2:LET TF=0:LET L=S(I)      one has
200 GOSUB 2210:IF TF=1 THEN LET CN=I      cheated.
210 NEXT I                                Works out
220 PRINT:PRINT "!! FALSE START !!"       who crossed
230 PRINT:PRINT "   ON LANE ";CN          the line.
240 LET SP=P(3-CN):GOSUB 2600             Power off to
250 FOR T=1 TO CS*10:NEXT T               one car.
260 LET SP=P(1)+P(2):GOSUB 2600
270 GOTO 270
    C64 / VIC    10 LET CS=100
    SPECTRUM     10 LET CS=70
    SPECTRUM     50 LET LT=INT(RND*CS)+CS
```

Now type the lines below for your computer before typing those in boxes A and B.

C64/VIC 20

```
300 PRINT CHR$(147)
310 LET L$=CHR$(18)+CHR$(160)+CHR$(160)
    +CHR$(17)+CHR$(157)+CHR$(157)
320 LET L$=L$+L$+L$
330 LET M$=CHR$(19)+CHR$(17)+CHR$(17)
340 LET CX=10
350 PRINT CHR$(144);M$;TAB(CX);L$
360 PRINT:PRINT TAB(CX);L$
370 FOR T=1 TO 2000:NEXT T
380 PRINT CHR$(28);M$;TAB(CX);L$
390 RETURN
400 PRINT CHR$(144);M$;TAB(CX);L$
410 PRINT CHR$(30);
420 PRINT:PRINT TAB(CX);L$
430 RETURN
```

BBC

```
300 MODE 5
310 VDU 23,224,255,255,255,255,255,255,255,255
320 VDU19,2,2;0;
330 COLOUR131:CLS
340 L$=CHR$(224)+CHR$(224)+CHR$(10)+CHR$(8)+CHR$(8)
350 L$=L$+L$+L$
360 COLOUR0:PRINTTAB(7,5);L$;TAB(7,10);L$
370 FOR T=1 TO 3000:NEXT
380 COLOUR1:PRINTTAB(7,5);L$
390 RETURN
400 COLOUR0:PRINTTAB(7,5);L$
410 COLOUR2:PRINTTAB(7,10);L$
420 RETURN
```

Spectrum

```
300 CLS
310 LET L$=CHR$(143)+CHR$(143)+CHR$(143)
320 INK 0:GOSUB 500:GOSUB 550
330 FOR T=1 TO 300:NEXT T
340 INK 2:GOSUB 500
350 RETURN
400 INK 0:GOSUB 500
410 INK 4:GOSUB 550
420 RETURN
500 FOR L=1 TO 3
510 PRINT AT 2+L,10;L$:NEXT L
520 RETURN
550 FOR L=1 TO 3
560 PRINT AT 7+L,10;L$:NEXT L
570 RETURN
```

Program notes

This is what to do to use the programs:
1 Connect your computer as shown on page 40.
2 Set up the model controllers as shown for each program.
3 Switch the computer on and type in the test program for the model controller you want to use, to check that it works.
4 Stop the test by typing one of these commands: **C64/VIC 20:** RUN/STOP then NEW, **BBC:** ESCAPE then NEW, **Spectrum:** BREAK then NEW.
5 Type in the program you want to use.
6 Type in the lines for your computer from box A, then add the lines in box B.
7 Type RUN, then RETURN (or your computer's words to start the program).

Clear screen commands

Wherever you see the words "clear screen" in the programs, replace them with the following commands for your computer:
C64/VIC 20: PRINT CHR$(147)
BBC and **Spectrum:** CLS

Shunter

For this program you need: Power controller

With this program you can make your train move round the track simply by pressing keys on your computer.

Type the program into your computer. Set the dial on your transformer to make your train go at the speed you want. Then type RUN and RETURN. Press the following keys to make the train move:
F for forwards
B for backwards
S for stop
Reverse the dial on the transformer if the commands make the train go the wrong way. The train will move or stop until another key is pressed.

```
10 GOSUB 2800:GOSUB 3000
20 LET SP=0:GOSUB 2600
30 clear screen
40 PRINT:PRINT "PRESS KEYS "
50 PRINT "F, B AND S TO MOVE TRAIN"
60 GET I$
70 IF I$="" THEN GOTO 60
```

Power off

```
80 IF I$="F" THEN LET SP=P(2)
90 IF I$="B" THEN LET SP=P(1)+P(2)
100 IF I$="S" THEN LET SP=0
110 GOSUB 2600
120 GOTO 60
```

Forwards
Backwards
Stop

```
BBC        60 LET I$=INKEY$(0)
SPECTRUM   60 LET I$=INKEY$
```

Now type the lines in boxes A and B

Box A

C64

```
2000 FP=PEEK(56577)
2010 RETURN
2200 LET L=S(TN):LET TF=0:GOSUB 2000
2210 IF (FP AND L)=L THEN LET TF=1
2220 RETURN
2400 PRINT CHR$(19);:FOR LL=1 TO Y:PRINT:NEXT
2410 PRINT SPC(X);A$:RETURN
2600 POKE 56577,SP
2610 RETURN
2800 POKE 56579,192
2810 RETURN
```

VIC 20

```
2000 FP=PEEK(37136)
2010 RETURN
2200 LET L=S(TN):LET TF=0:GOSUB 2000
2210 IF (FP AND L)=L THEN LET TF=1
2220 RETURN
2400 PRINT CHR$(19);:FOR LL=1 TO Y:PRINT:NEXT
2410 PRINT SPC(X);A$:RETURN
2600 POKE 37136,SP
2610 RETURN
2800 POKE 37138,192
2810 RETURN
```

BBC

```
2000 FP=?&FE60
2010 RETURN
2200 LET L=S(TN):LET TF=0:GOSUB 2000
2210 IF (FP AND L)=L THEN LET TF=1
2220 RETURN
2400 PRINT TAB(X,Y);A$
2410 RETURN
2600 ?&FE60=SP
2610 RETURN
2800 ?&FE62=192
2810 RETURN
```

Spectrum

```
2000 LET FP=either IN port number or PEEK port number
2010 RETURN
2200 LET TF=0:LET L=S(TN):GOSUB 2000
2210 LET X=FP/(L*2):LET X=2*L*(X-INT(X))
2220 IF X>L-1 THEN LET TF=1
2230 RETURN
2400 PRINT AT Y,X;A$
2410 RETURN
2600 either OUT port number,SP or POKE port number,SP
2610 RETURN
2800 REM not needed
2810 RETURN
```

Now type the lines in box B.

Box B

```
3000 DIM S(6):DIM P(2)
3010 FOR I=1 TO 6
3020 LET S(I)=2^(I-1)
3030 NEXT I
3040 LET P(1)=64:LET P(2)=128
3050 RETURN
```

Computer connections

This page shows you how to connect your computer to the control centre. Follow steps 1-3 *very* carefully. Do not switch on until you have checked all the connections, or you may damage your computer. Spectrum users: see notes on page 41 about the interface you need to buy.

1 Computer connectors

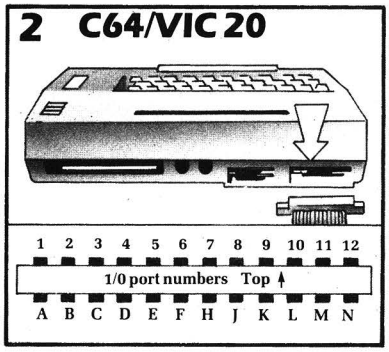
To connect your computer to the control centre you need:

For the **C64/VIC20:** an edge connector, with ribbon cable soldered to its pins.

For the **BBC:** an I.D.C. plug (Insulation Displacement Connector) and lead.

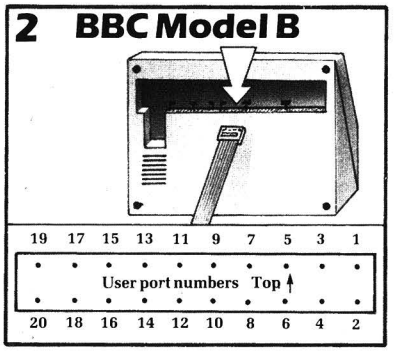
For the **Spectrum:** an input/output interface with ribbon cable soldered to it (see shopping list).

2 C64/VIC 20



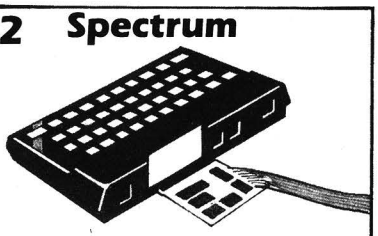
The I/O port pins are identified as shown in the diagram above. Push the edge connector into the I/O port. You need to solder ½m (18″) of 10-way ribbon cable to those tags on the connector corresponding to these port pins: 2,N,C,D,E,F,H,J,K,L.

2 BBC Model B



The input/output port pins are identified as shown in the diagram above. Push the I.D.C. plug, with lead already attached, into the socket marked "User port". Ask your supplier which wires in the lead match those in the diagram.

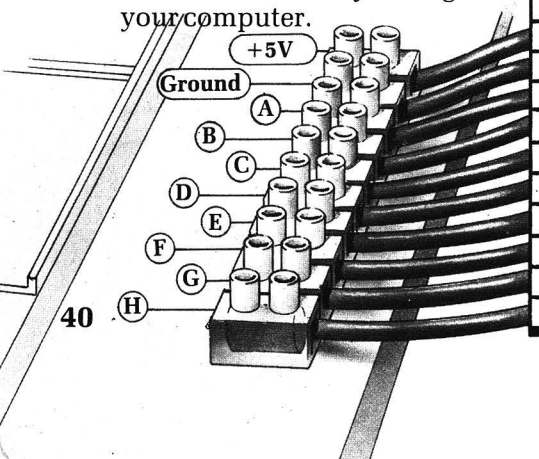
2 Spectrum



Push the interface circuit into the expansion port.

Read the interface maker's instructions carefully and identify the input and output lines shown in the chart below. Following the maker's instructions, connect ½m (18″) of 10-way ribbon cable to these lines. You may need to solder the wires to the interface.

3 Identify the wires in your computer's plug, then connect them to the control centre computer block as shown below. Be *very* careful – muddled wires may damage your computer.



C64/VIC 20 User I/O pin numbers (as shown in step 2).	BBC B User port pin numbers (as shown in step 2).	Spectrum Interface output and input pin numbers (see instructions).	
2	1	+5V	Input lines
N	19	−0V	
C	6	0	
D	8	1	
E	10	2	
F	12	3	
H	14	4	
J	16	5	
K	18	6	Output lines
L	20	7	

Shopping list

Modeller's materials

Most of these parts are available from model making shops.

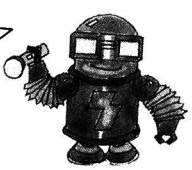
Control centre
5mm (¼") thick plywood or hardboard, 170mm × 230mm (6¾ × 9")
6mm (¼") square spar (stick shape) × 750mm (30") long. This leaves enough over for the switch sensors.
2 corks (optional)
Switch sensors (for each switch):
6mm (¼") thick balsa sheet × 70mm (2¾") wide × 60mm (2¼") long
2 drawing pins (thumbtacks)
1 steel nail over 75mm (3") long
1 map or dressmaker's pin
Cotton thread
For each trackside hut:
3mm (⅛") thick balsa sheet × 75mm (2¾") wide × 300mm (12") long (may need less depending on scale used).
1½mm (1/16") thick balsa sheet × 75mm (3") wide × 150mm (6") long (or less)
Light sensor bridge (for each bridge side):
3mm (⅛") thick balsa sheet × 90mm (2") wide × ½m (18") long
1½mm (1/16") thick balsa sheet × 45mm (1¾") wide × 1m (39") long
Dark coloured paper 75mm (3") × 200mm (8") (enough for two tubes)
Odds and ends
Fine-grade sandpaper
Paintbrush
Undercoat
Gloss or enamel paint
Turps substitute
2 tubes clear glue or cement
Roll of insulating tape
Plasticine or Blu-tack
Workboard
Roll of sticky tape

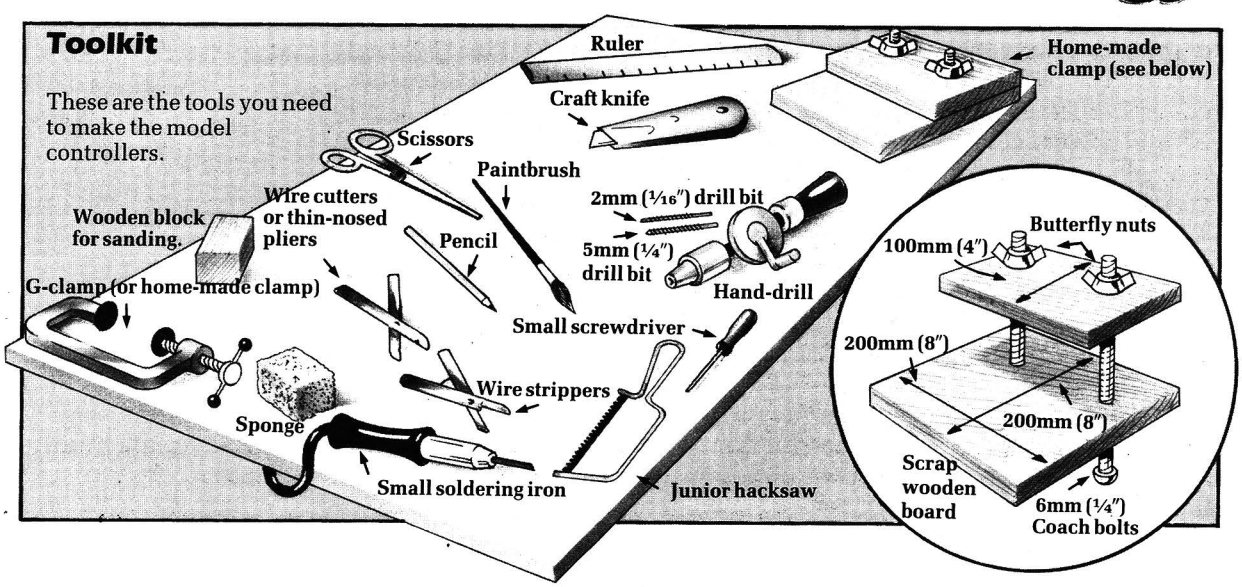
Electronic components

Buy components from a components shop or by mail order (addresses on page 48). Ask in your TV repair shop to find your nearest supplier. Ask for equivalent types of components if they don't have those listed here.

Key to quantities you need:
CC = control centre, **PC** = power controller, **SS** = switch sensor, **LS** = light sensor (buy double quantities for two sensors).
Veroboard: Ask for 0.1 inch size. **PC** 28 tracks × 30 holes, **SS** 19 tracks × 30 holes, **LS** 19 tracks × 30 holes (one for each circuit).
Relays: PC 3 sub-miniature single-pole changeover relays, coil voltage 5V a.c. or 6V d.c. (see notes on page 48)
Transistors: Ask for BC 108 or BC 107. **PC** × 2, **LS** × 1
Electrolytic capacitor: LS 1 × 10μF
555 timer chip and socket: LS Ask for standard or low power
Resistors: Ask for ¼-½ watt with 5%-10% tolerance. **PC** 2K2Ω × 2, 6K8Ω × 2, **SS** 2K2Ω × 4, **LS** 1KΩ × 2, 100KΩ × 1, 330Ω × 1
Potentiometers: LS 1 × 100KΩ LIN or LOG
LEDs: Ask for standard type. **SS** × 4, **LS** × 1 (each circuit)
LDR: LS 1 × ORP 12
Wire: Thin "bell" or "hook-up" wire × 5m. You may need more depending on model size. Do not use mains cable as it is too thick.
Battery: 1 × 6V. IT IS VERY DANGEROUS TO USE CAR OR MOTORCYCLE BATTERIES.
Connector (or terminal) blocks: 3 × 10 or 12 pairs of holes (cut to size to fit control centre).
Computer connectors
BBC: 20-way I.D.C. (Insulation Displacement Connector) connector and cable
C64/VIC 20: 0.156 inch pitch female edge connector with 24 pins (two rows of twelve). Also buy ½m (18") of 10-way ribbon cable.
Spectrum: Buy a parallel input/output interface board. Look for advertisements in computer magazines or write to one of the companies on page 48. Use either IN and OUT or PEEK and POKE commands for the programs, depending on the make of interface you buy. Most makes have 8 input and 8 output lines. Use output lines 6 and 7 and input lines 0-5.

See page 48 for mail order addresses.



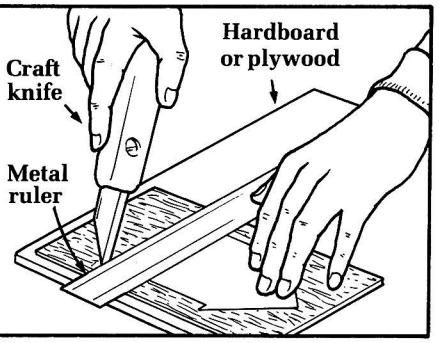


Construction tips and templates

To be successful you need to make all the model controller parts as accurately as you can. There are templates printed on the next few pages which help you to do this. This page shows how to use the templates and also gives some construction tips.

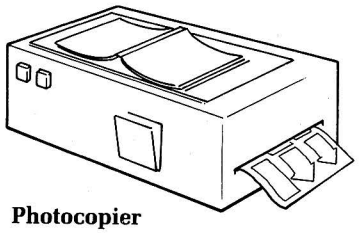
Cutting balsa

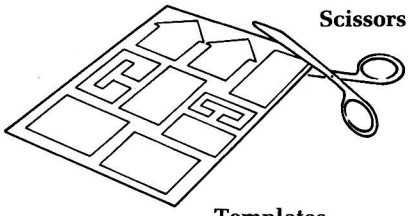
Cut balsa with a sharp craft knife. Use a metal rule as a guide and a piece of hardboard or plywood to work on. Hold the knife firmly. Stand to one side and cut towards yourself but away from your body.



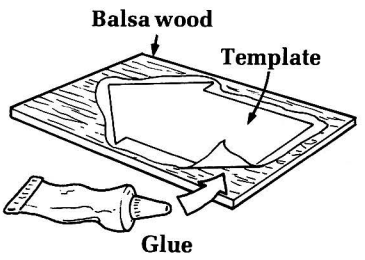
Templates

Templates are patterns which you use to make the model controllers. Those on pages 44-47 are used for all the parts made from sheets of balsa wood. The one on page 43 is used for the control centre and circuits.


Photocopier



Templates

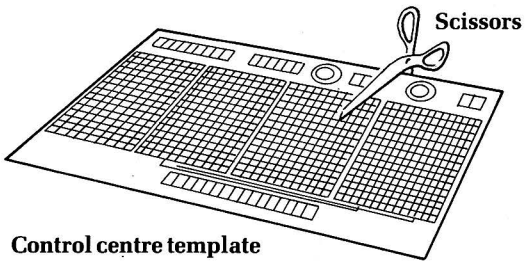


Photocopy template pages of this book, using the photocopier in a copy shop, post office or library.

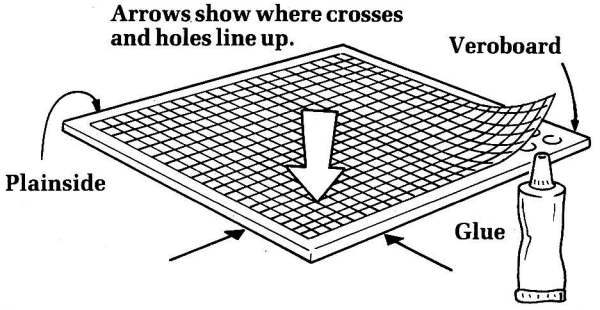
Carefully cut round each template with scissors. Make sure you cut just outside the template edge.

Glue each template to balsa using balsa cement. The balsa size to use is printed by the template.

Circuit templates

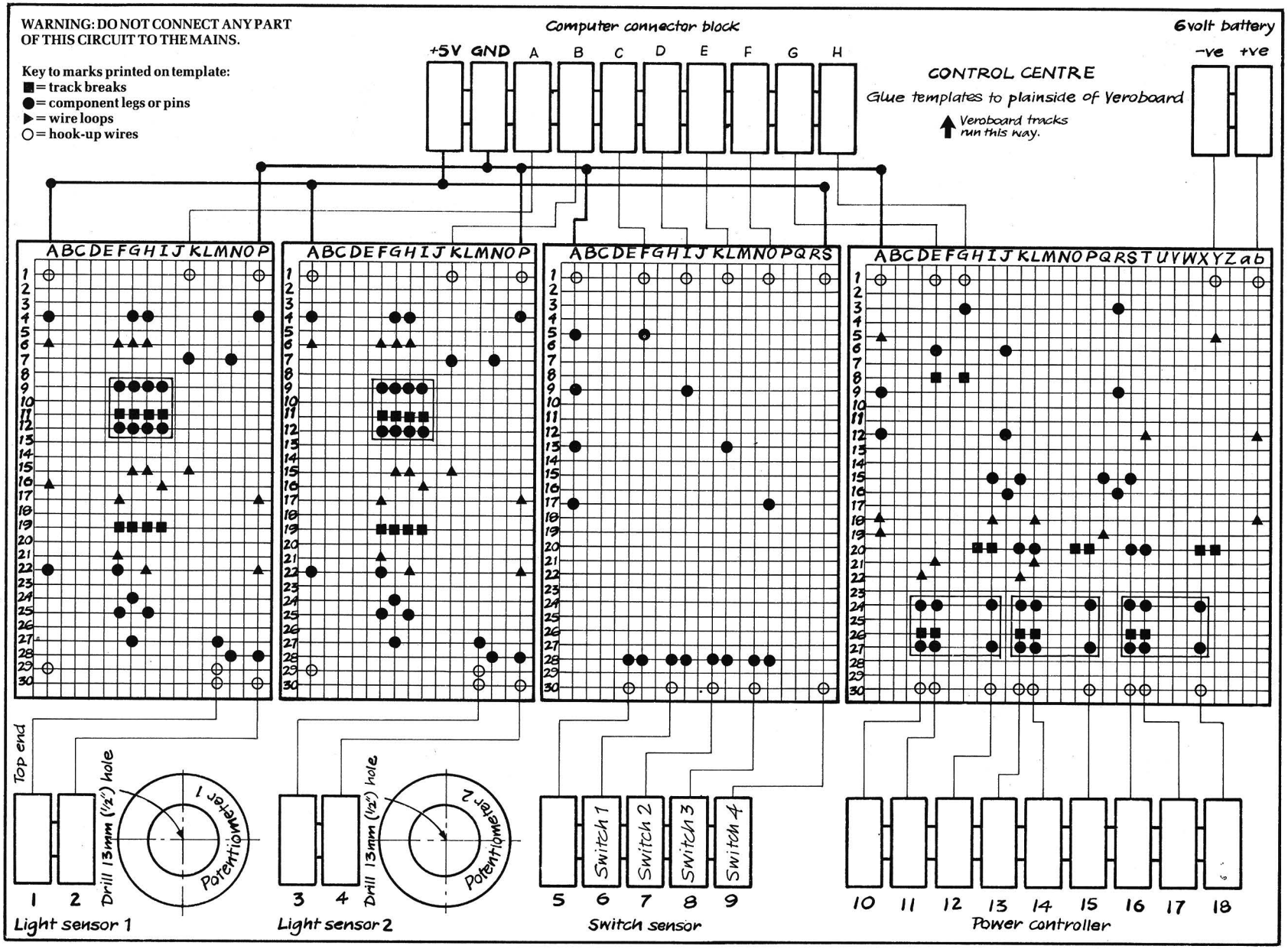


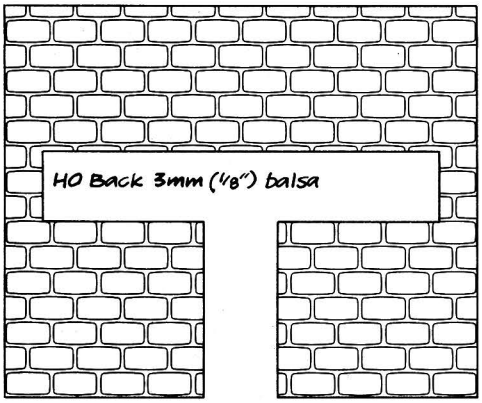
Control centre template

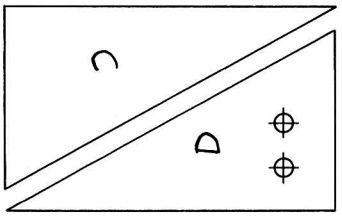


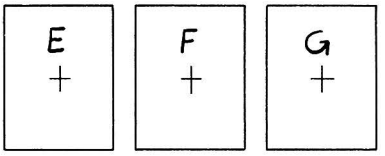
Photocopy the template on page 43 twice. Use one for the control centre and one for the circuits. Cut round the circuit template you need from the second copy.

Glue the template to the Veroboard, making sure that all the crosses on the template line up with the holes in the Veroboard.

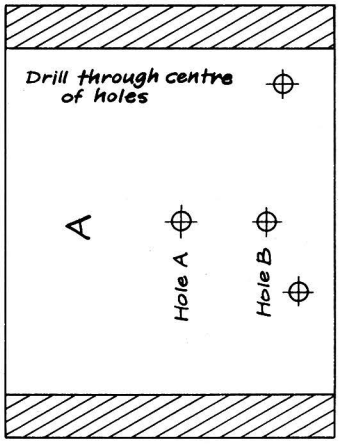

WARNING: DO NOT CONNECT ANY PART OF THIS CIRCUIT TO THE MAINS.
Key to marks printed on template:
■ = track breaks
● = component legs or pins
▶ = wire loops
○ = hook-up wires
Computer connector block
+5V GND A B C D E F G H
6volt battery
-ve +ve
CONTROL CENTRE
Glue templates to plainside of Veroboard
Veroboard tracks run this way.
A B C D E F G H I J K L M N O P
A B C D E F G H I J K L M N O P
A B C D E F G H I J K L M N O P Q R S
A B C D E F G H I J K L M N O P Q R S T U V W X Y Z a b
Top end
Drill 13mm (½") hole
Potentiometer 1
Potentiometer 2
Switch 1
Switch 2
Switch 3
Switch 4
1 2
Light sensor 1
3 4
Light sensor 2
5 6 7 8 9
Switch sensor
10 11 12 13 14 15 16 17 18
Power controller

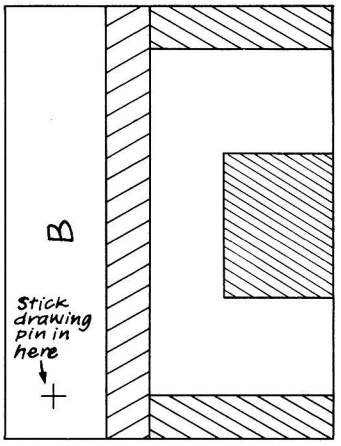


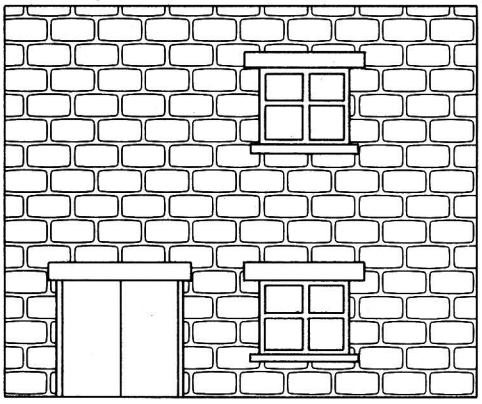




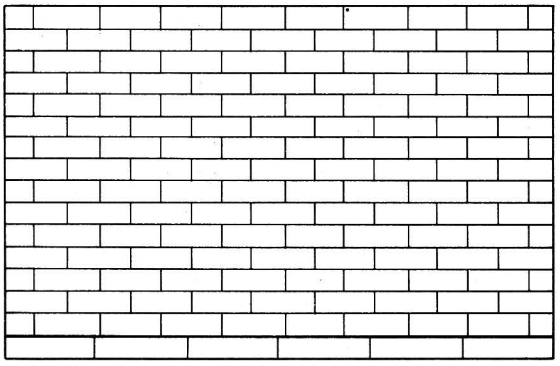
Glue parts A, B, C, D, E, F, G to 6mm balsa



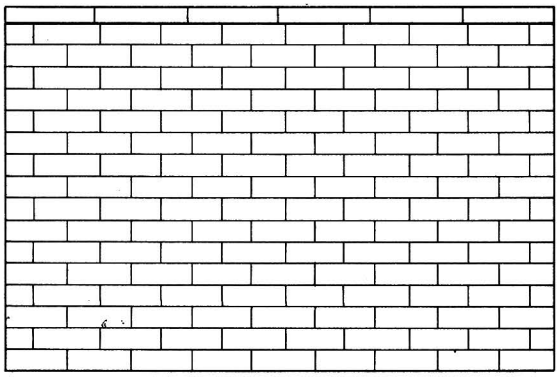




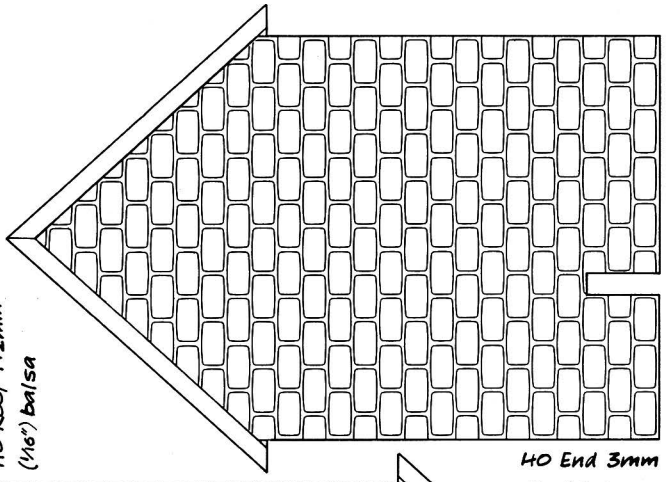
HO Front 3mm (1/8") balsa



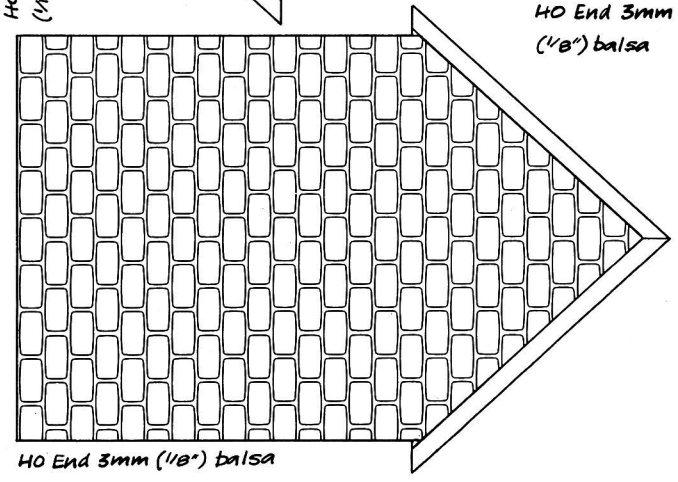
HO Roof 1½mm (1/16") balsa



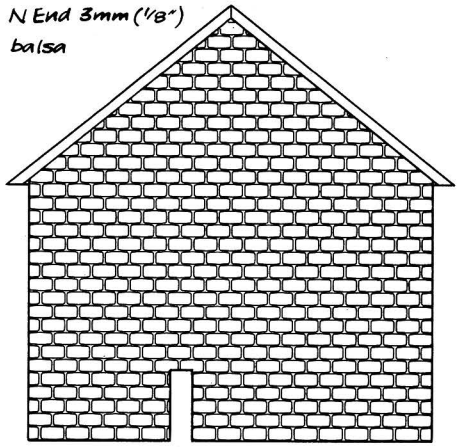
HO Roof 1½mm (1/16") balsa

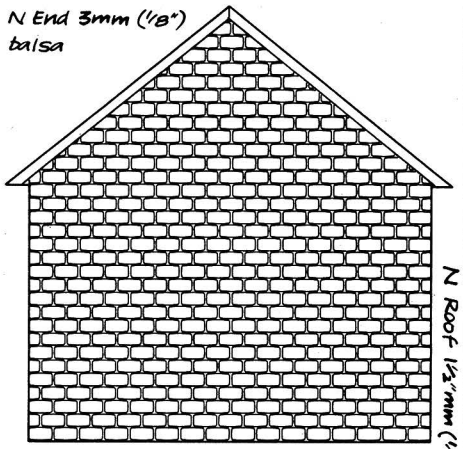


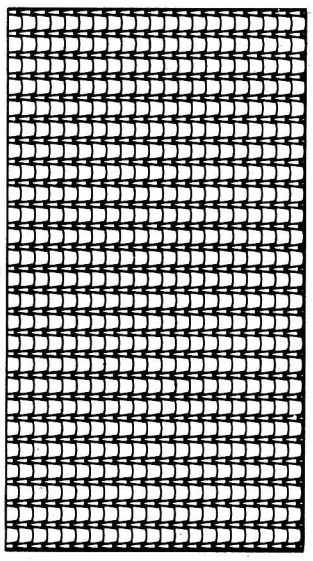
HO End 3mm (1/8") balsa

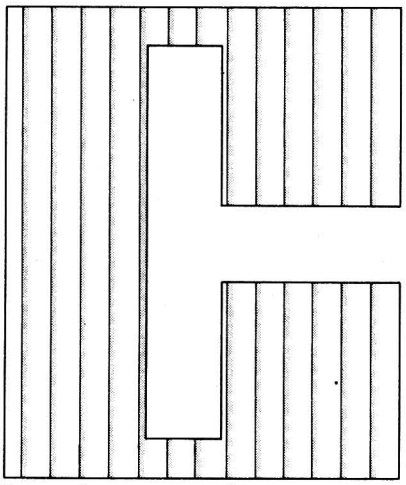


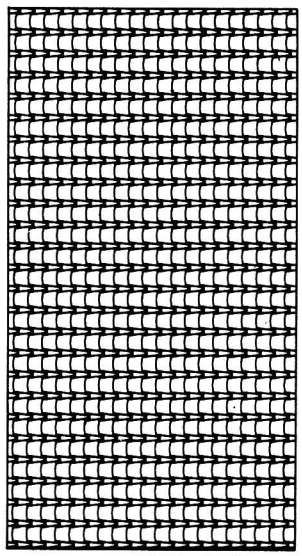
HO End 3mm (1/8") balsa

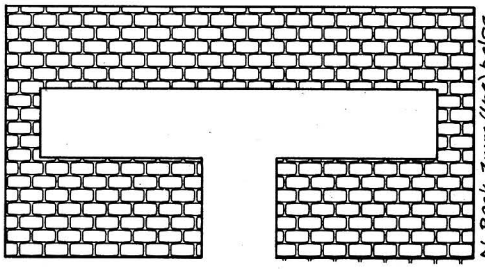

N End 3mm (1/8") balsa

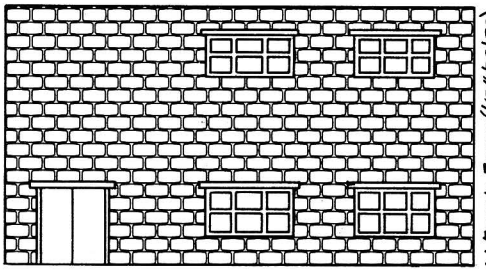

N End 3mm (1/8") balsa

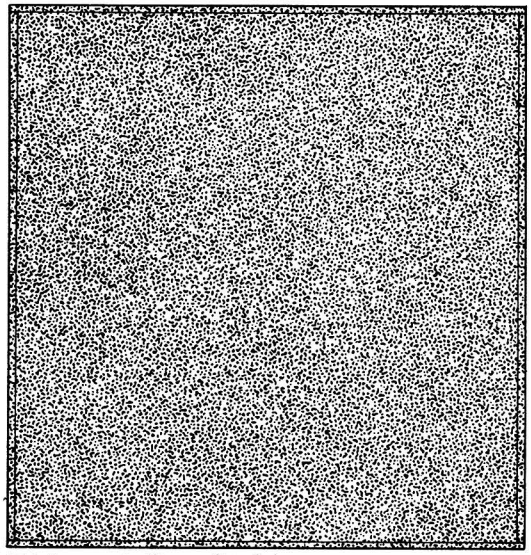

N Roof 1½mm (1/16") balsa

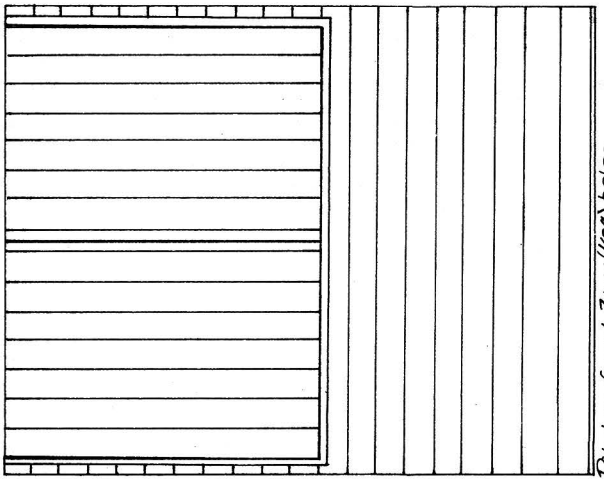

Pitstop back 3mm (1/8") balsa

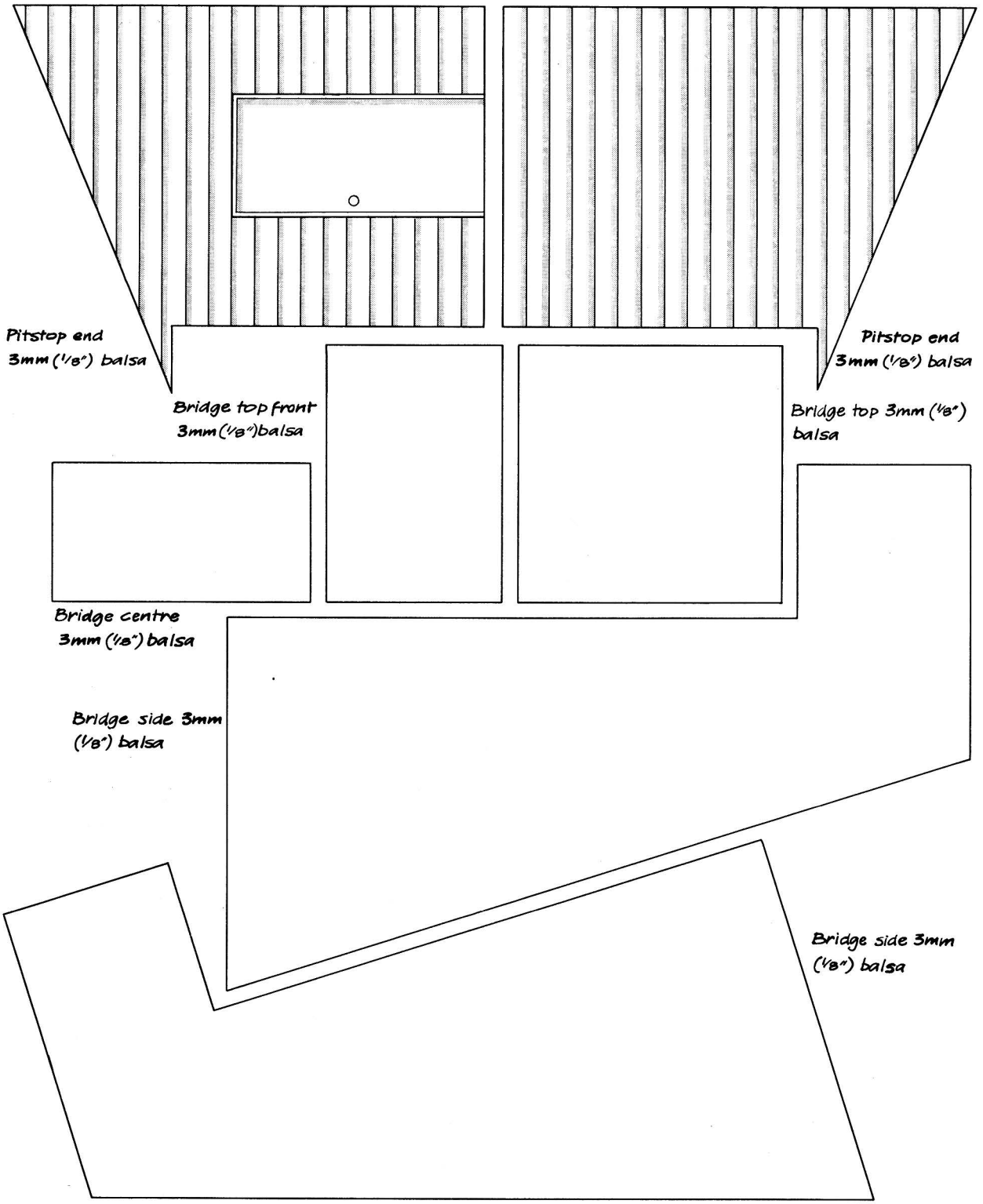

N Roof 1½mm balsa

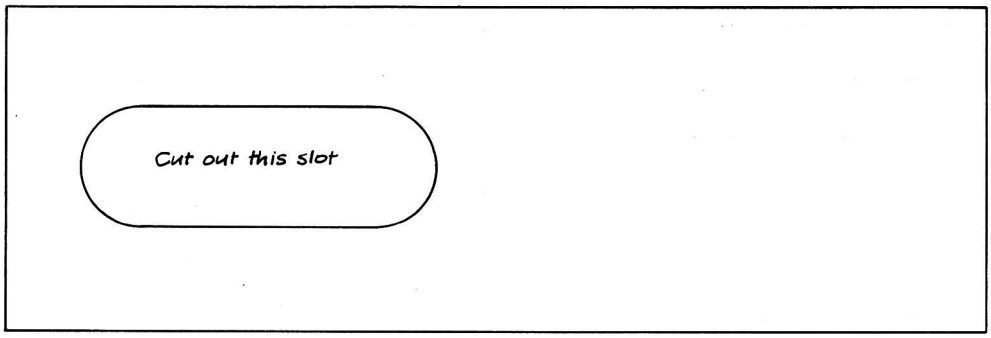

N Back 3mm (1/8") balsa


N Front 3mm (1/8" balsa)

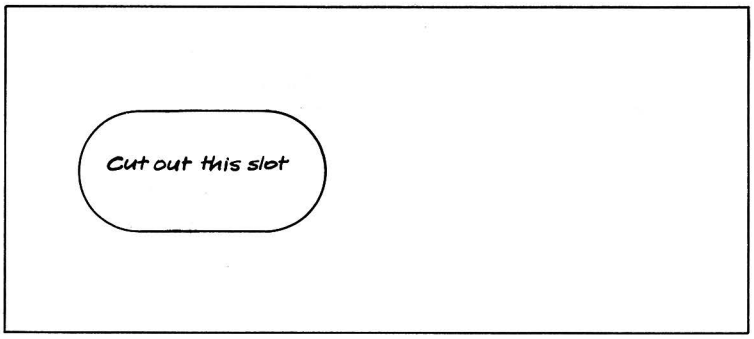

Pitstop roof 1½mm (1/16") balsa


Pitstop front 3mm (1/8") balsa


Pitstop end
3mm (1/8") balsa
Pitstop end
3mm (1/8") balsa
Bridge top front
3mm (1/8") balsa
Bridge top 3mm (1/8")
balsa
Bridge centre
3mm (1/8") balsa
Bridge side 3mm
(1/8") balsa
Bridge side 3mm
(1/8") balsa



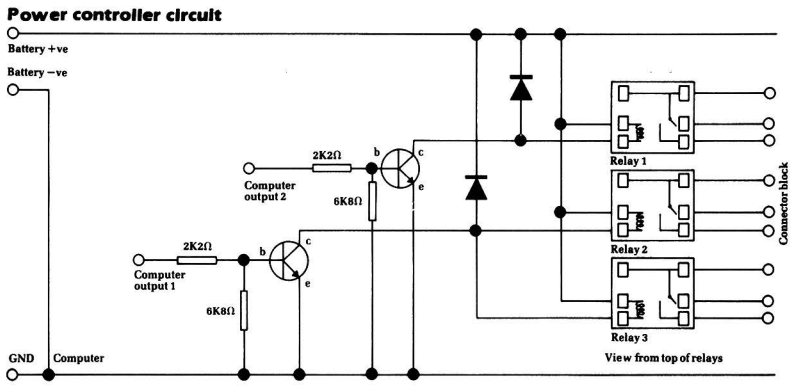
Bridge back 3mm (⅛") balsa



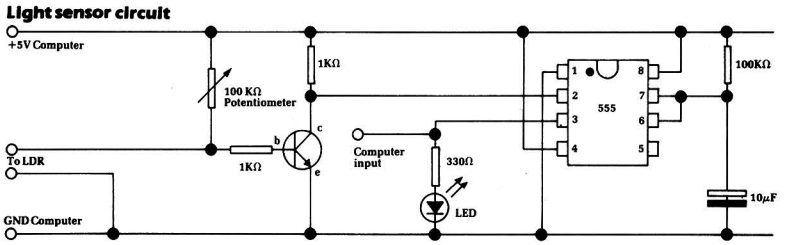
Bridge front 3mm (⅛") balsa

Circuit diagrams

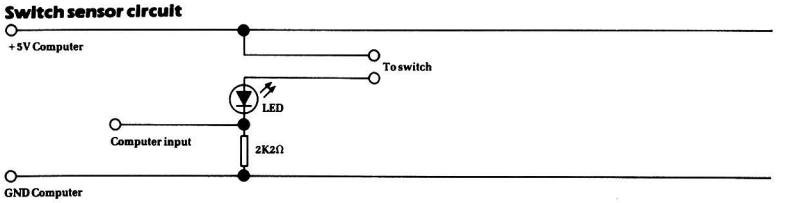
The diagram on the right shows the circuit for the power controller.



The diagram on the right shows the circuit for the light sensor.

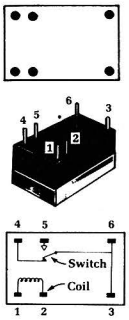


The diagram on the right shows the circuit for the switch sensor. This is repeated four times in the actual circuit.



Index and useful information

Relay notes



Coil must be in this position

1 Put pins of relay over this guide. It will not fit circuit unless they line up with the dots.

2 Turn relay on its back. Use numbers shown to identify pins.

3 You may get a circuit diagram like this to identify relay pins. Use the numbers shown here. This diagram is a "pin view" which means you identify the pins with them facing you.

It is very important to use the correct type of relays for the power circuit. There are several makers of the same type and they number the pins differently. Number your pins as shown above as these are used in the circuit instructions. Listed below are manufacturers' type numbers.
Fujitsu FBR211 series type B or E
RS Components number 348-510

Interference

You may find that dirty tracks or your model's motors will cause interference on your TV. This may switch the light sensors on when not wanted. If this happens, this is what to do:

1 Wrap aluminium cooking foil around the LDR wires, from the paper tube to the control centre.

2 Twist the foil at the end nearest the control centre and screw it into the connector block hole 2 for the first sensor and 4 for the second.

3 Tape the foil-covered wires down to the model baseboard or floor. Do not let the foil touch the model's live track or you could damage your computer.

Useful addresses

Relays

Tempatron Ltd., 6 Portman Road, Battle Farm Estate, Reading RG3 1JQ England.

Fujitsu Component Europe B.V, Rijnkade 19B, 1382 GS Weesp, The Netherlands.

Fujitsu America Inc. 918 Sherwood Drive, Lake Buff, Illinois 60044, USA.

Fujitsu Limited, 6-1 Marunouchi 2-chome, Chiyoda-ku, Tokyo 100, Japan.

Electronic components

Maplin Electronic Supplies Ltd., P.O. Box 3, Rayleigh, Essex SS6 8LR, England.

Spectrum Interface

Glanmire Electronics, Meenane, Watergrasshill, Co. Cork, Eire.

William Stuart Systems Ltd., Quarley Down, Cholderton, Salisbury, Wiltshire, SPQ 0DZ, England.

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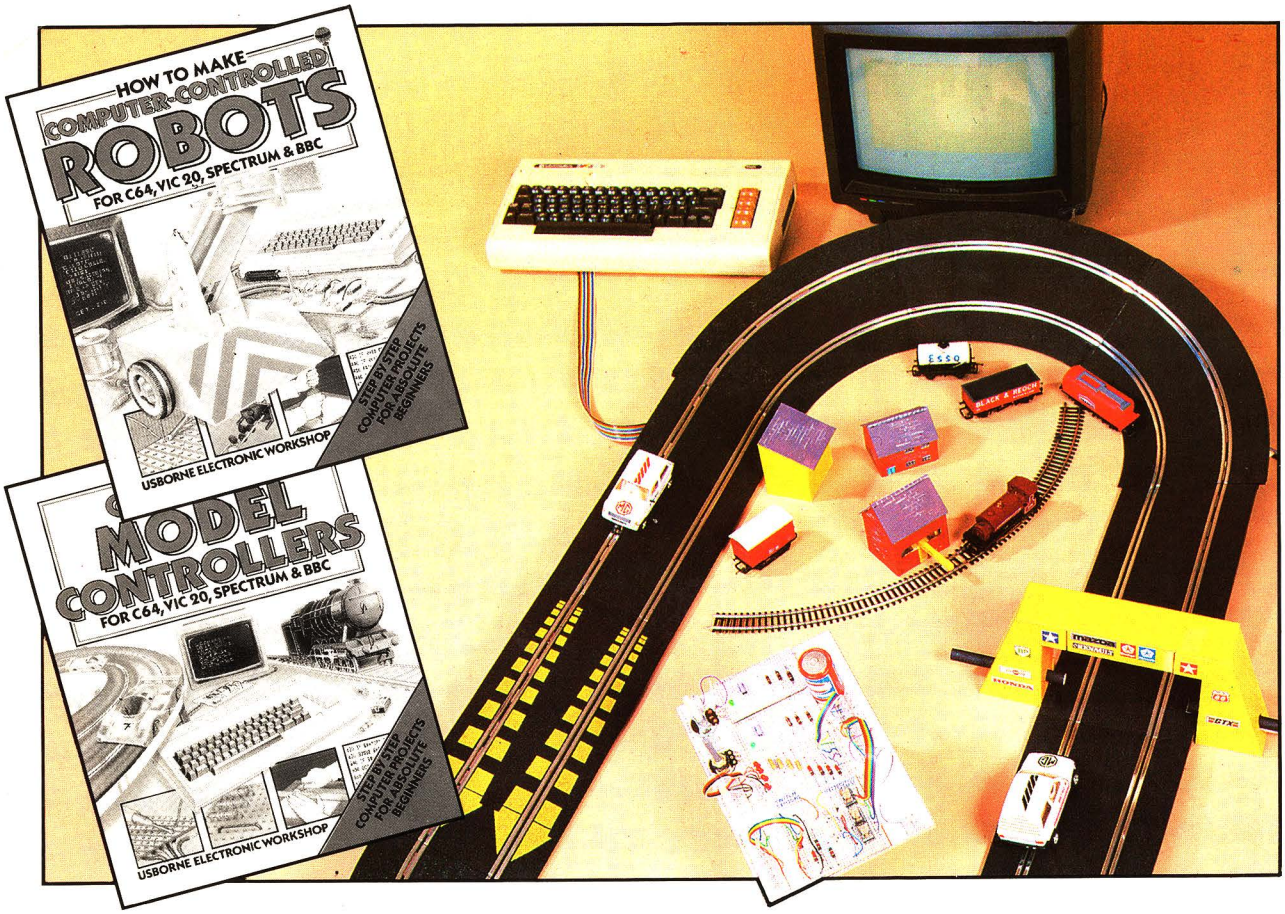

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