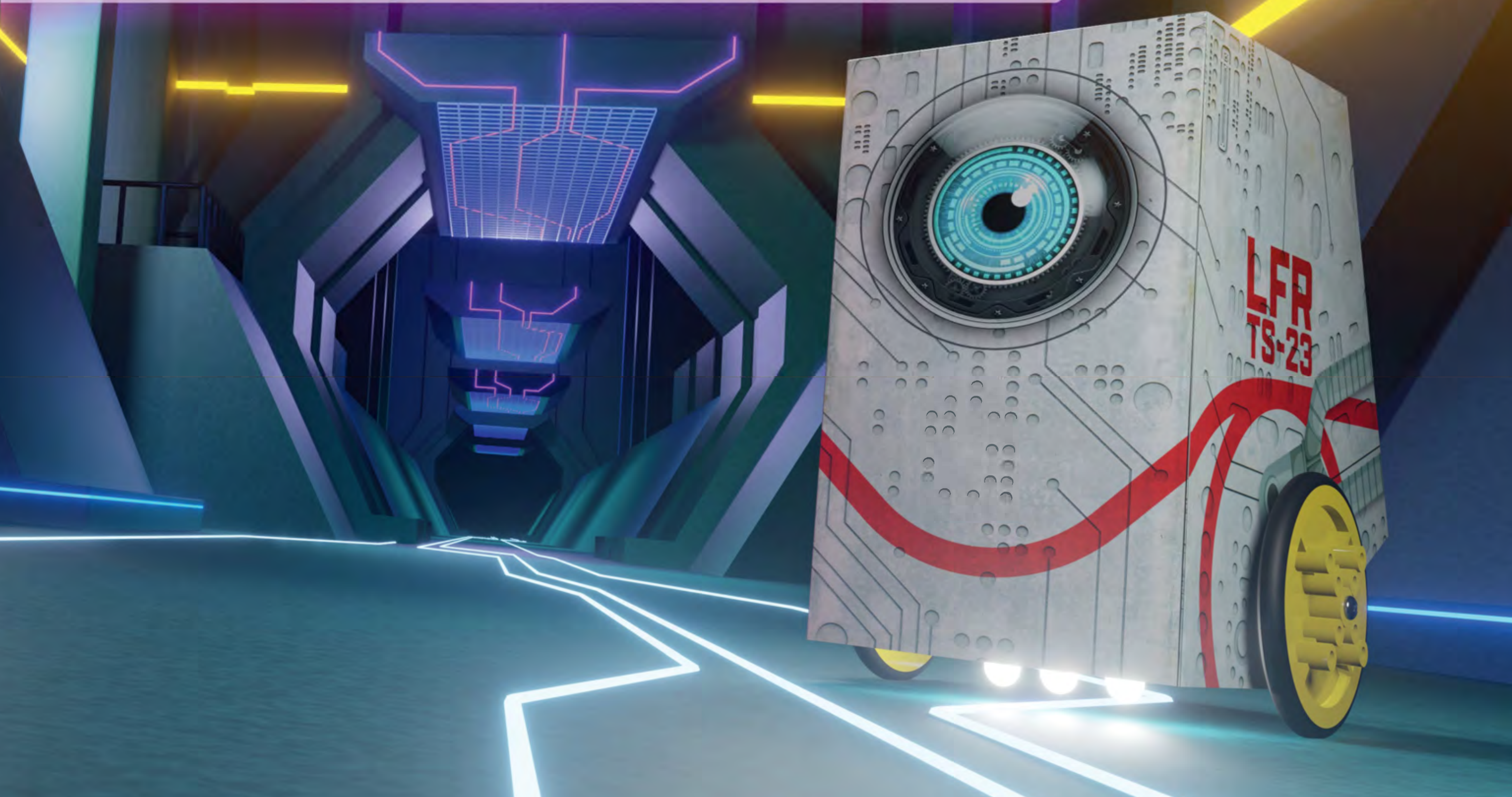
ROBOT ADVENT CALENDAR

EIGHT
GREAT STUFF TO MAKE



SAFETY NOTES

Please read this manual carefully for information on proper and safe use of the product. Keep this manual for future reference.

CAUTION! EYE PROTECTION AND LEDS

Do not look directly into an LED from a short distance as this can cause retinal damage! This is particularly the case for bright LEDs in a clear housing as well as power LEDs. The apparent brightness of white, blue, purple and ultraviolet LEDs gives a false impression of the actual risk for your eyes. Particular caution should be “exercised” when using converging lenses. Use the LEDs as described in the instructions; do not use larger currents.

BATTERY INFORMATION

Always:

- Make sure battery compartments are secure.
- Charge rechargeable batteries under adult supervision.
- Use batteries of the correct size and type.
- Fit batteries correctly observing the plus (+) and minus (-) marks on the battery and compartment.
- Replace a whole set of batteries at one time.
- Remove dead batteries from equipment and dispose of responsibly.
- Remove batteries from appliance that will not be used again for a lang time.
- Remove rechargeable batteries from the product before recharging.
- Please remember that small button cells and AAA batteries should be kept away from young children as they could be easily swallowed. Seek medical advice if you believe a cell has been swallowed.

Never:

- Mix different types of batteries.
- Mix old and new batteries.
- Short circuit the supply terminals.
- Dispose of batteries in a fire.
- Attempt to recharge ordinary batteries.
- Non-rechargeable batteries are not to be recharged.

INTRODUCTION

Robots, in one form or another, have been around for a long time. In the ancient world, engineers built automata – ingenious mechanical devices. More recently, manufacturing industry has used robots for decades. The first industrial robot was called Unimate. It was developed in the 1950s for car giant GM and started working in one of their factories in 1961.

If you search online for "Handbuilt by Robots 1979", you'll find an iconic TV advert from the late 70s for an Italian car maker which used robots extensively.

Robots have now found their way into our homes and public spaces. Robotic vacuum cleaners, lawnmowers, toys and even cleaning robots at the airport or shopping centre are all now commonplace.

This advent calendar will introduce you to the electronic components and concepts that are the basic foundations for a line-following robot. Like all robots, it will use sensors to monitor its environment and then use this information to determine its behaviour. Each day of the calendar will provide new components.

We'll start slowly with some simple experiments and circuits, then gradually increase the complexity as we start to assemble the final robot.

Before you begin, please read the notes at the beginning of this manual.

If you're having problems at any stage please read the Troubleshooting Guide on page 52.

If that doesn't solve your issue or you're missing a component, please get in touch with us via our website for help:

Go to ***www.eight-innovation.com***
and click on **CUSTOMER SUPPORT**

BEFORE YOU START

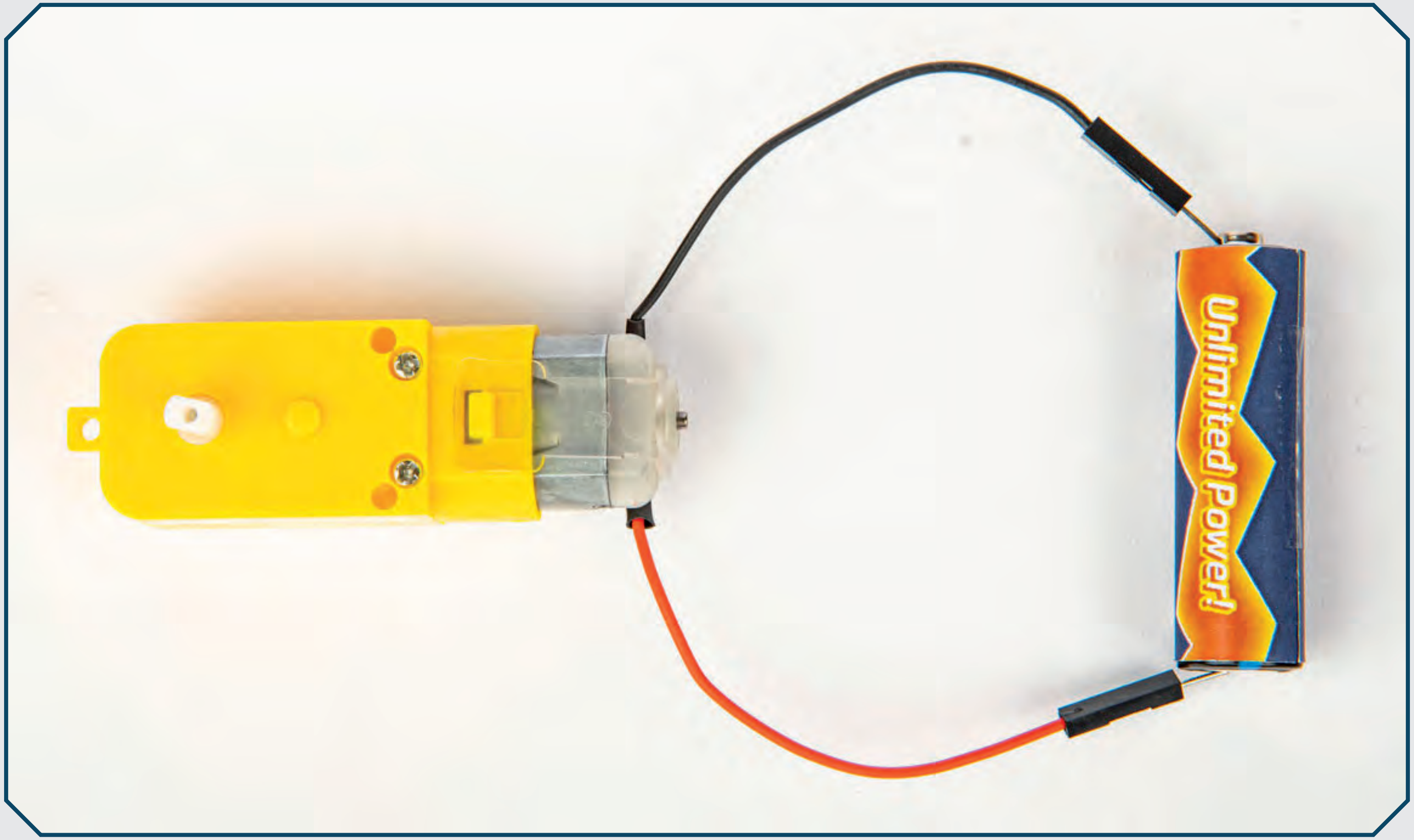
Please note:

- In all the component diagrams appearing in this manual, the components are shown in the clearest-possible way to ensure identification. Although it may look as if some of the components have had their legs bent so that the components are laying on the breadboard, there is no need to do this in reality, and you should avoid bending the components legs too much and allow the components to sit vertically above the circuit board.
- Some wires are shown as blue – this is just to make the layout clearer – please use the bundle of wire included in this calendar…whatever its colour!
- Take care to connect the components correctly, as described in the instructions, as some components may be damaged if they are connected incorrectly.
- You will need 3 x AA (1.5V) batteries to build the robot (not included).
- Slide the battery case switch to "OFF" before building each new circuit.

Did you know?
The word "robot" is derived from the Czech word "robota" which, roughly translated, means "forced labour"!

MOTOR AND TRANSMISSION

An electric motor with integrated gearbox is behind the first door of the calendar. For the following tests, you'll need three 1.5V AA batteries (not included). A single AA cell is sufficient for a first test. If you hold the connecting cables of the motor to both poles of the battery, it starts to run. You'll hear a humming sound and the axle of the gearbox will rotate slowly.

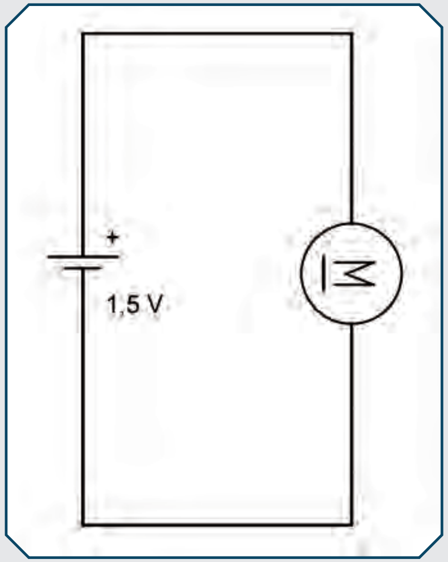


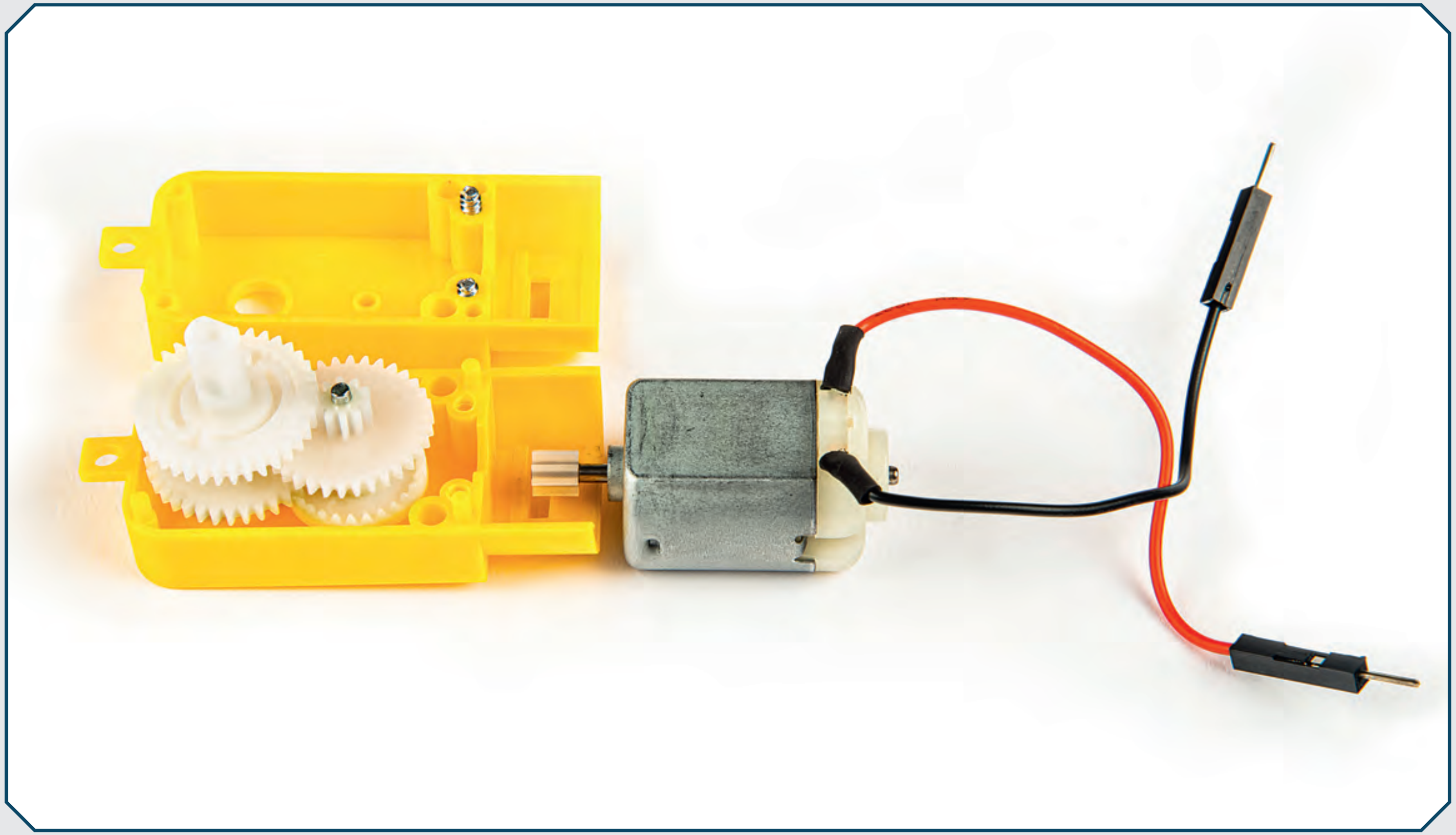
As with any DC motor, you can change the direction of rotation by reversing the poles of the battery. And you can make the motor run faster by increasing the voltage. With two cells connected in series and a total of 3V, the motor runs twice as fast.

To see the transmission, you have to take a look inside the housing (please don't do this at home!). A total of four gear wheels ensure a high reduction ratio – this means a wheel attached to the axle turns more slowly than the motor itself.

It also has many times the turning force, or torque.

It's almost impossible to hold the gearbox axle with bare fingers while the motor is running.



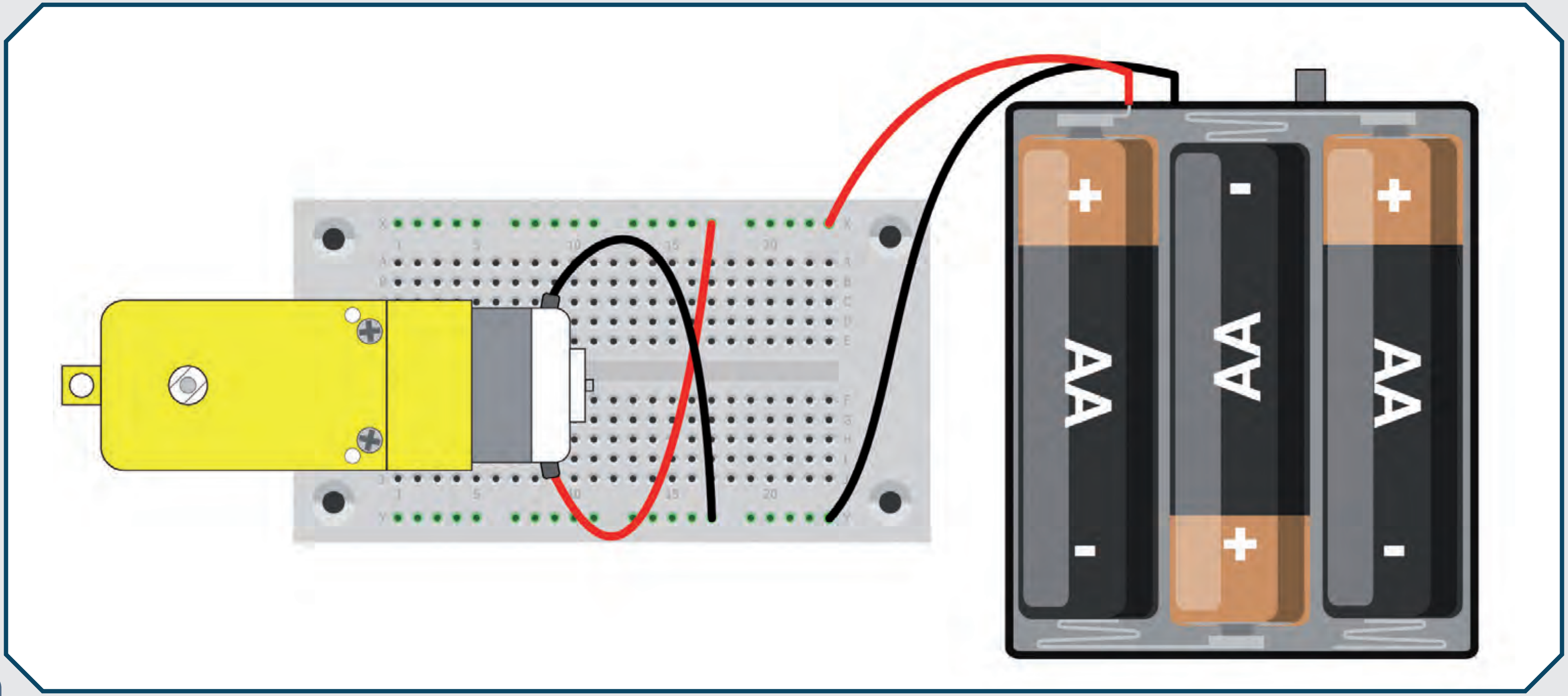


DAY 2

STABLE CONNECTIONS

The second door contains a battery case with connection leads and ON/OFF switch, and also a breadboard.

The breadboard allows you to build complicated circuits easily by pushing the component wires into the breadboard's contacts.



The board has a total of 270 contacts, and provides a reliable way of connecting the components without the need to solder wires. The board also allows mistakes to be corrected easily.

In the centre of the board, there are 230 contacts, arranged in vertical groups of 5: 23 upper groups of 5 and 23 lower groups of 5. The upper groups are not connected to the lower groups. Within each group, the 5 contacts are connected together, so to connect components together, push the wires into contacts within the same group of 5. Additionally, along each long side of the circuit board, there is a set of 20 contacts (two sets: 40 contacts in total) to which the battery positive (top set of contacts) and negative (bottom set of contacts) leads can be connected.

To connect the components and wires to the circuit board, push them into the contacts from directly above the contact. To avoid breaking the wires, grip them as close as possible to the breadboard, and try to push them in straight – using a pair of tweezers or small pliers may help. Make sure that the tinned (shiny) ends of the connecting wires and battery connector are pushed into the board without bending them.

The motor should now be connected to any of the contacts on row X and Y.

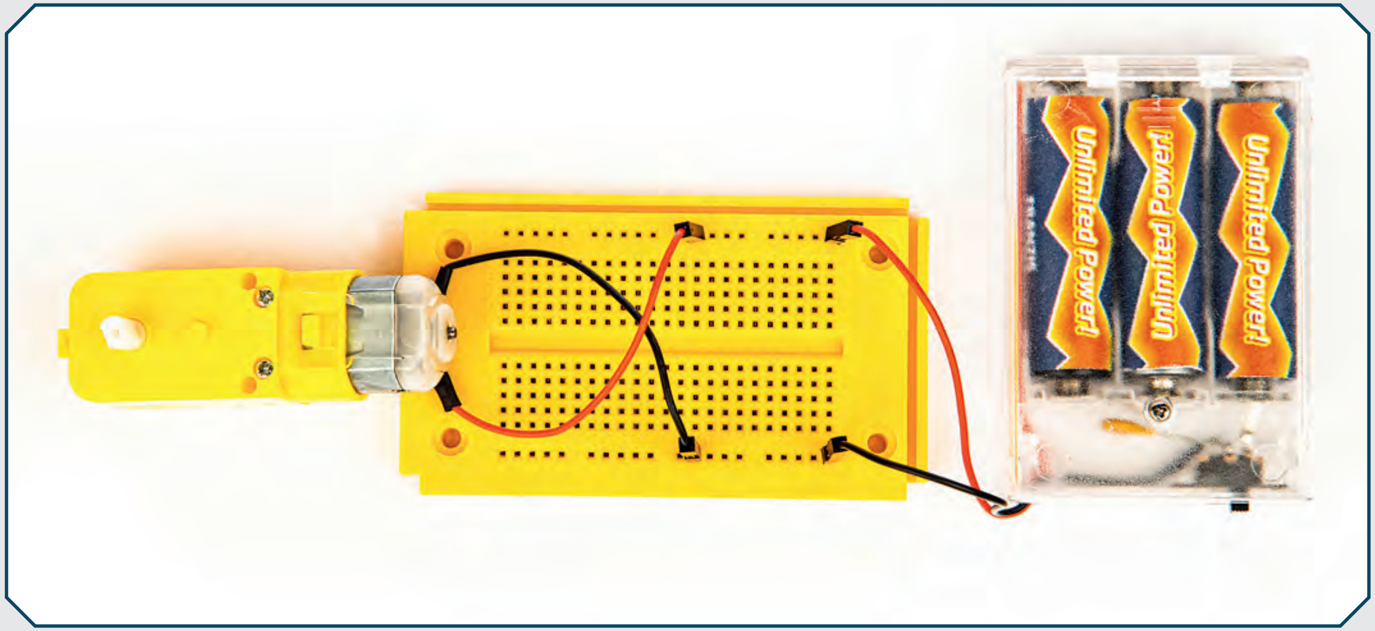
Once the first circuit has been built, the batteries can be inserted into the battery compartment. The switch on the battery case must be set to "OFF". Loosen the screw to open the case then insert three AA batteries taking care to match the + and – symbols on the batteries and on the case.

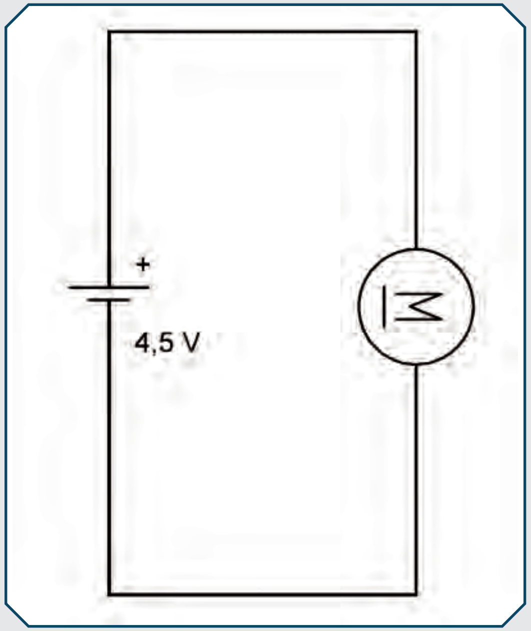
Replace the cover and tighten the screw to secure.

Now check to ensure that the finished circuit matches the diagram and then slide the switch to "ON".

The marking of the poles is crucial. The red wire is the positive pole, the black one is the negative pole. In all the following assembly drawings, the connecting cables are only indicated.

When switched on, the motor should run quickly and powerfully. The direction of rotation can be changed by swapping the motor cables. After each change and after each attempt, the switch on the battery compartment should be moved to the "OFF" position. This switches off the battery and prevents accidental short circuits as well as reducing battery consumption.

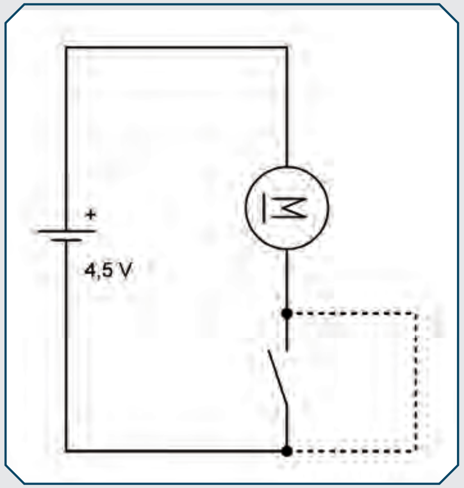


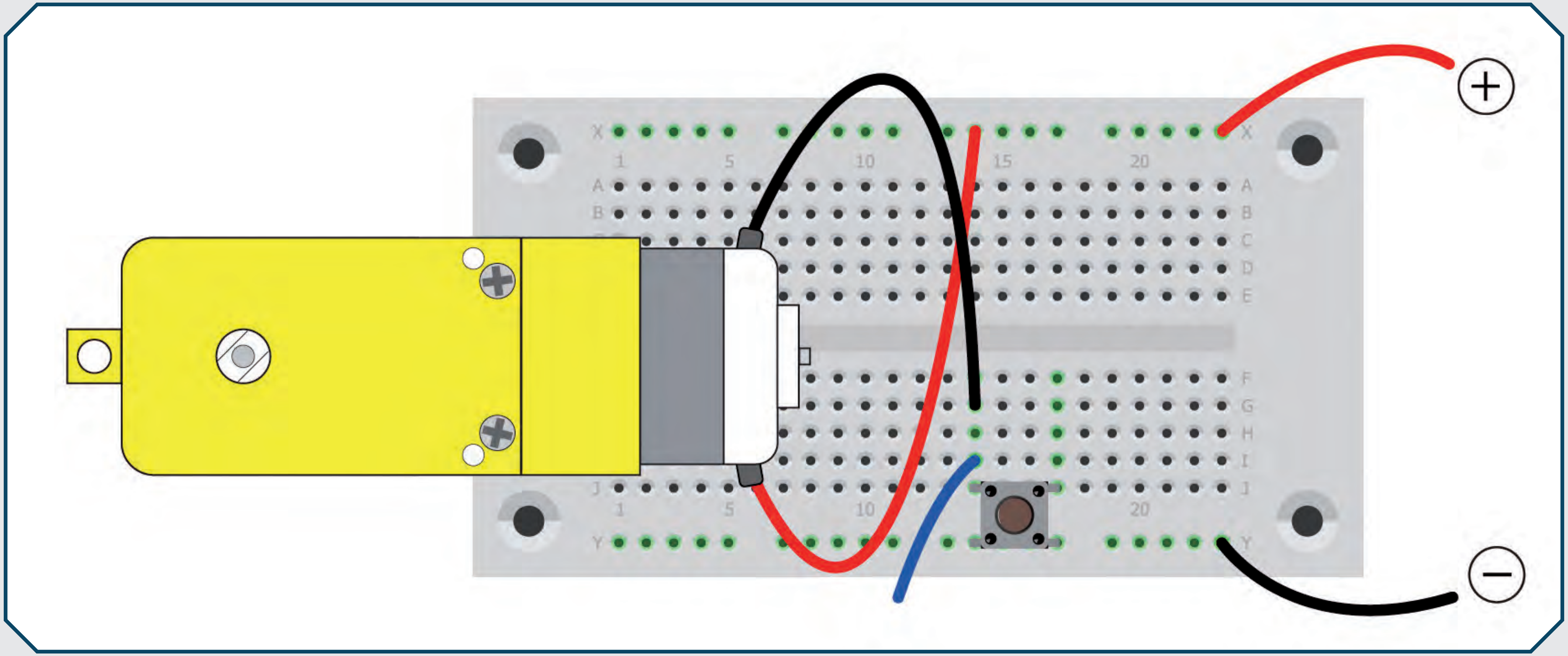


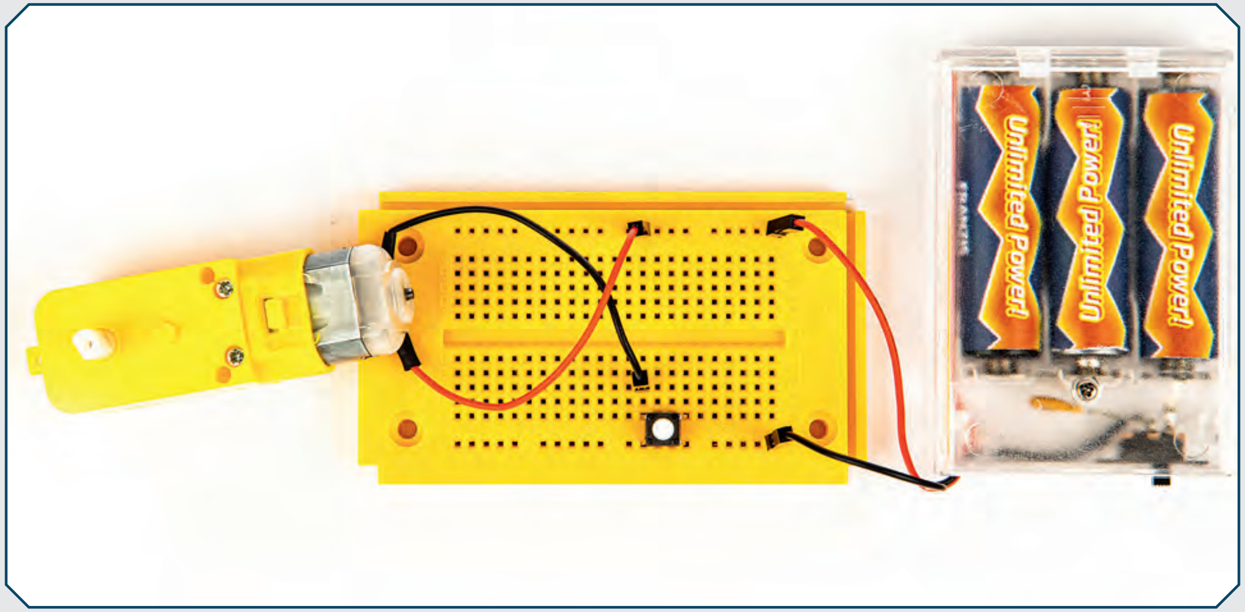
DAY 3

AT THE PUSH OF A BUTTON

Behind door number three you'll find a bundle of wire and a push button. The push button has four legs, two of which are connected lengthwise. Inside there is a bent metal plate that connects both sides when it folds over under pressure. The button can now be used to start and stop the motor.



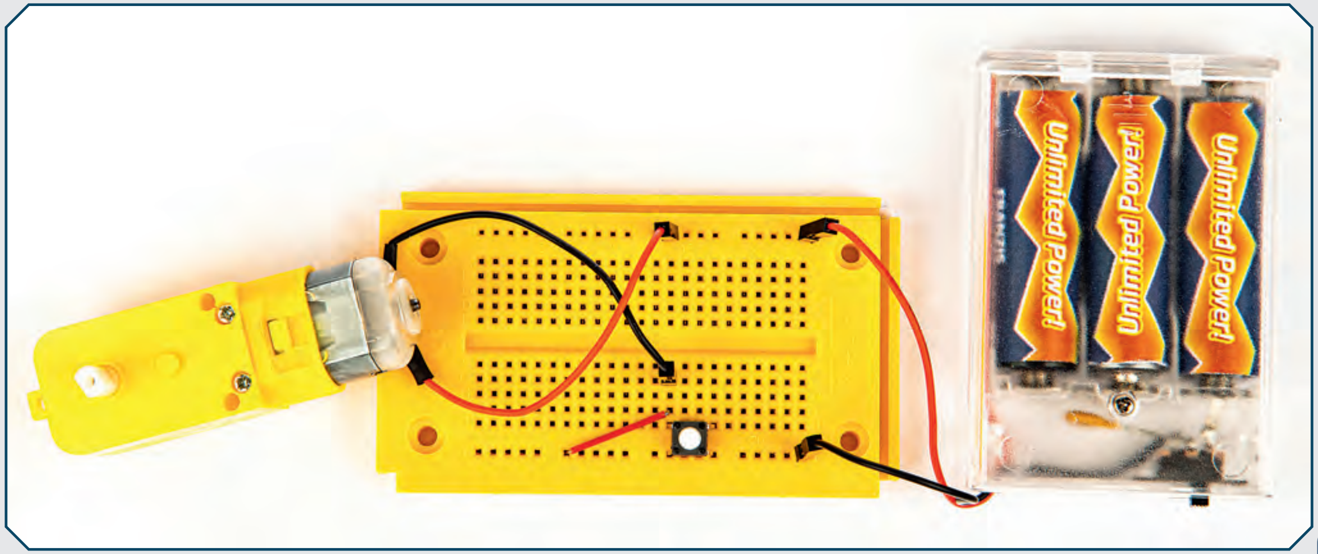




Day 3 without the wire. If the button is pressed, the motor starts.

The motor can also run continuously with the help of a wire. To do this, cut a piece of wire 3 cm long and remove about 5mm of the red insulation from both ends. In the diagram, only one end of the wire is plugged in. However, if you connect the free end to the negative line (Y), the push button switch is bridged as shown in the photo.

Tip:
If the experiment doesn't work, it may be because the button has been mounted in the wrong orientation and needs to be rotated by 90 degrees. Each contact of the switch has two opposite connections. If the switch is installed wrongly (rotated by 90 degrees) the connection is always closed and the test won't work.



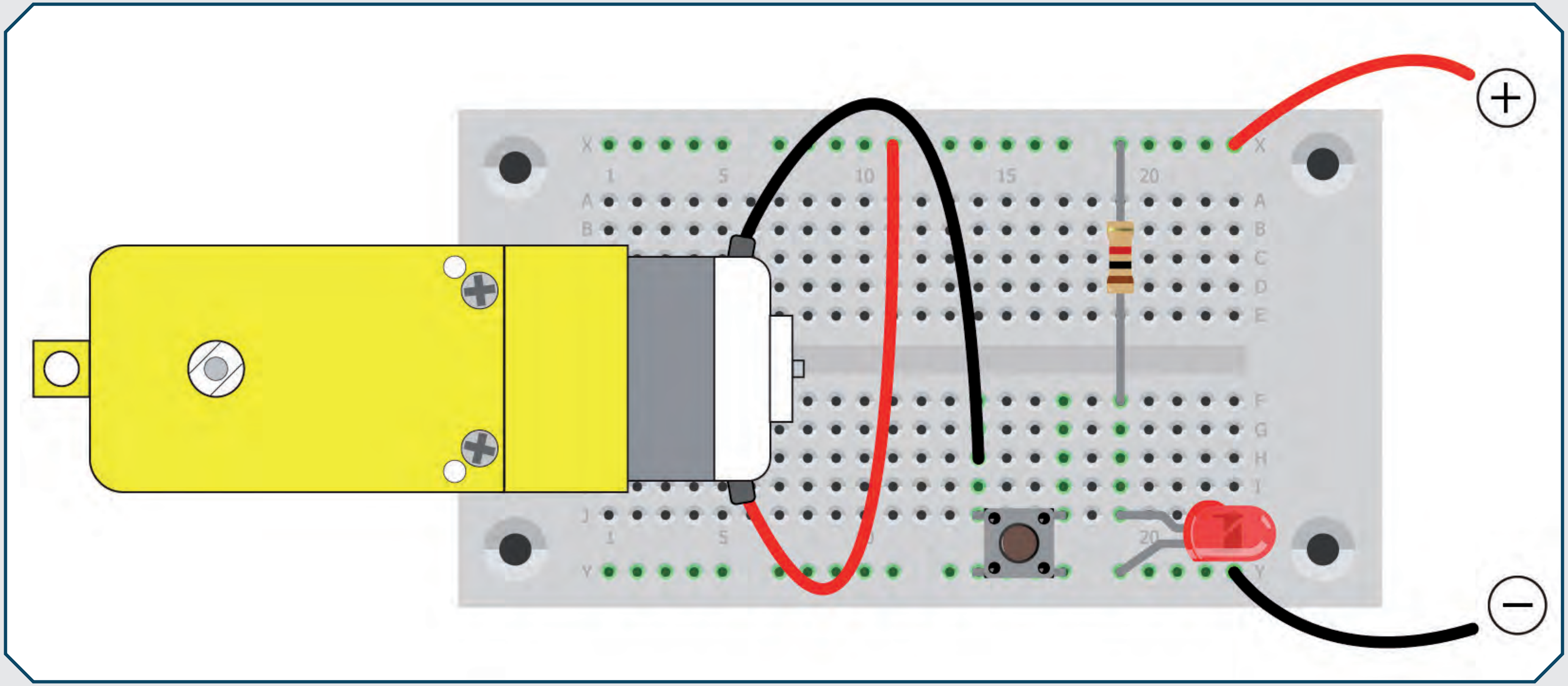
The motor runs when the wire is plugged in.

DAY 4

RED FLASHING LIGHT

Today the calendar provides you with a red LED and a one kiloohm resistor (1 kΩ, brown, black, red). When it's switched on for the first time, you'll see that this is a special LED – an automatic flashing LED. LEDs have legs of different lengths. The shorter leg is the negative pole (cathode), the longer the positive pole (anode). In addition, the negative pole has a flattened side on the lower collar of the housing.

Please note: an LED always requires a resistor to ensure that is not overloaded. This also applies to the flashing LED. The resistor determines the current and brightness with which the LED is operated. A direct connection without a resistor can destroy the LED. The LED can withstand a current of up to 20 mA (20 milliamperes). With a resistance of 1 kΩ, a current of less than 3 mA flows.



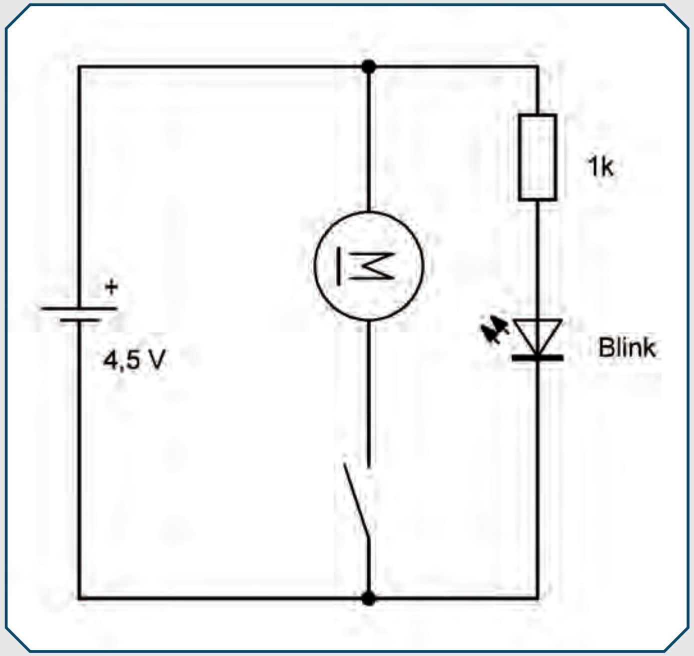
When the battery is switched on, the red LED flashes. Almost every industrial robot and every autonomous vehicle has a flashing warning light like this. It's very important for accident prevention.

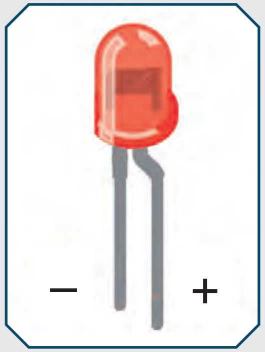
The motor only starts running when the button is pressed. In most cases, however, the flashing stops immediately. This is due to interference generated by the motor. Short pulses on the operating voltage disrupt the function of the flashing LED. We'll find a method to prevent this interference later.

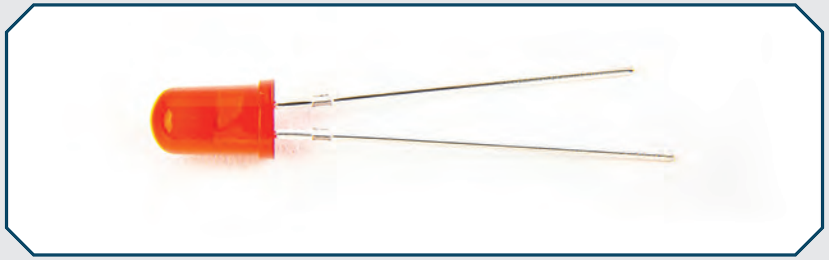
The polarity of LEDs must always be observed. The negative connection is called the cathode and is the shorter leg. The positive connection is the anode. Inside the LED you can see a holder for the LED crystal, which is located at the cathode. The anode connection is connected to a contact on the top of the crystal with an extremely thin wire.

Caution: LEDs must never be connected directly to a battery. A resistor is always required.

LEDs are available in many different colors. A white LED is actually a blue LED which is coated with a yellowish phosphor. The phosphor is illuminated from the inside in blue and emits white light.





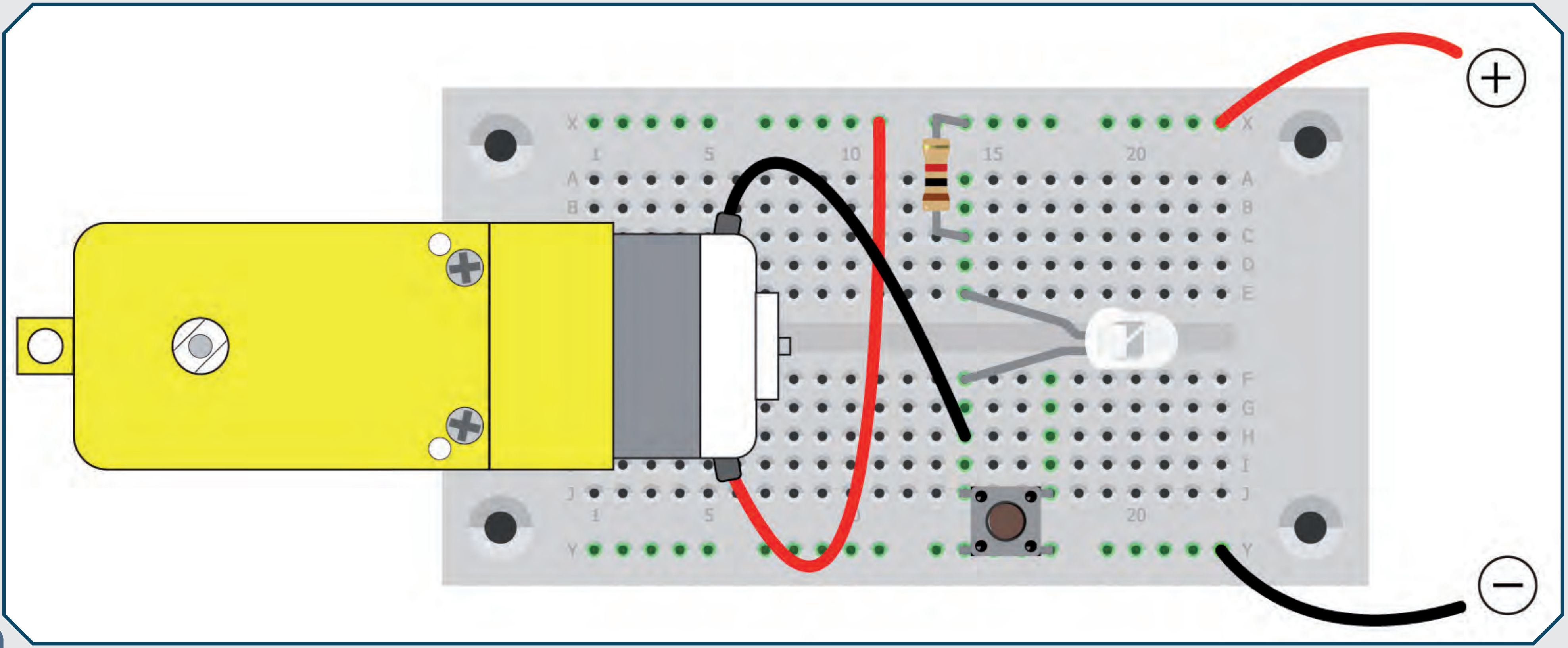


Day 5

ELECTRICAL ILLUMINATION

The white LED from today's window is used instead of the flashing LED. It'll later serve as a headlight so the robot can see where it's going. Using the 1 kΩ resistor gives a medium bright light.

A small additional experiment shows that the motor also functions as a generator. To do this, switch off the battery and turn the gear axle. This requires a relatively large amount of force due to the high transmission ratio. In one direction of rotation nothing happens, in the other direction the LED starts to light up. It only lights up when the polarity of the voltage is correct. The motor creates electrical energy as a generator. This feature of electric motors is often used for energy recovery when braking eg. in electric cars.

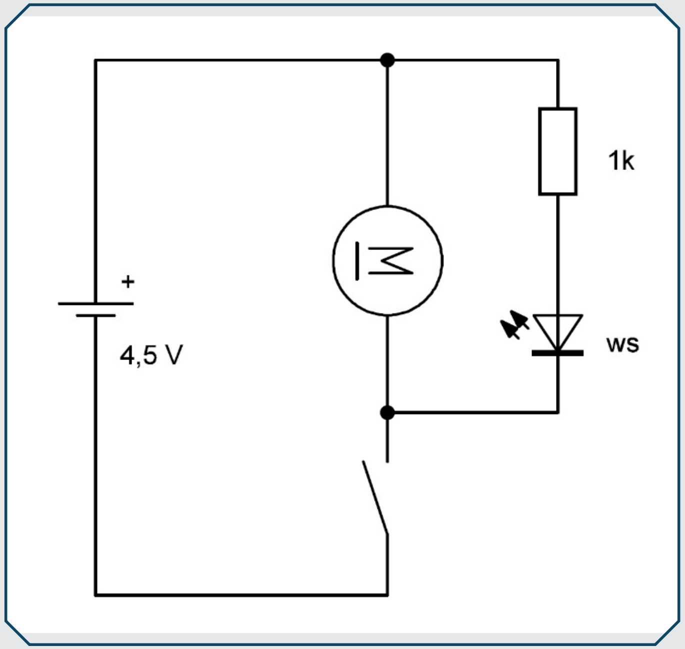


WHAT'S A RESISTOR?

A resistor has two terminals, and 'resists' (limits) the current flow in an electrical circuit. Resistors can also be used to lower the voltage in a circuit. Each resistor has a fixed resistance measured in units called ohms (Ω).

Resistors and their colour rings

The coloured rings on the resistors represent numbers. They are read starting from the ring that is closer to the edge of the resistor. The first two rings represent two digits, the third for added zeros. Together they indicate the resistance in ohms. A fourth ring indicates the accuracy. All resistors in this package have a gold ring. This means that the value can be 5% larger or smaller than indicated by the coloured rings.
The first resistor is read as follows: Brown = 1, black = 0, red = 00, together 1000 Ohm, i.e. 1 kΩ.



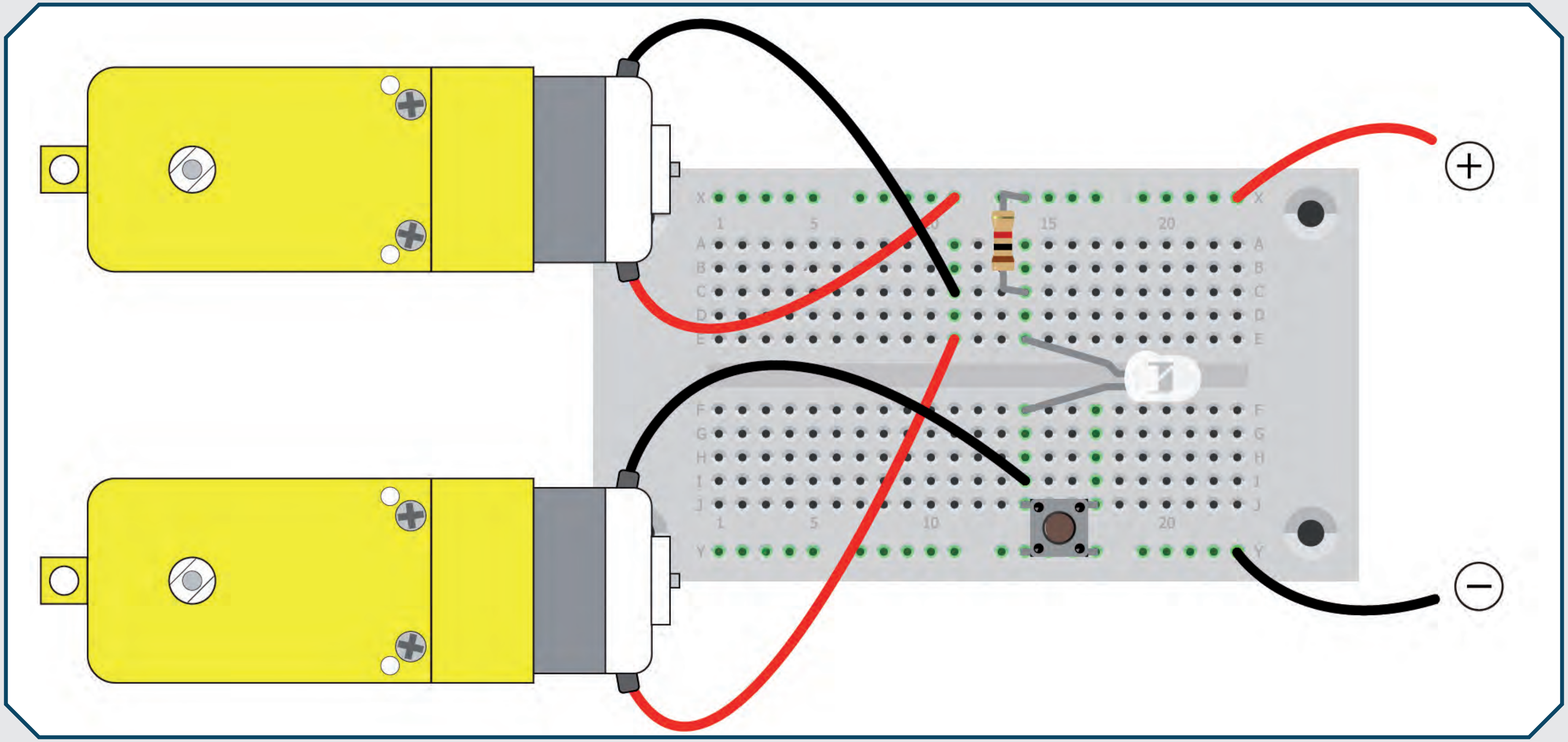
	First Digit	Second Digit	Third Digit	Tolerance
Black	Nil	0	1	Nil
Brown	1	1	10	± 1%
Red	2	2	100	± 2%
Orange	3	3	1000	± 3%
Yellow	4	4	10000	± 4%
Green	5	5	100000	± 0,5%
Blue	6	6	1M	± 0,25%
Violett	7	7	10M	± 0,10%
Grey	8	8	100M	± 0,05%
White	9	9	1G	Nil
Gold	Nil	Nil	÷ 0,1	5%
Silber	Nil	Nil	÷ 0,01	10%

DAY 6

MOTORS WORKING TOGETHER

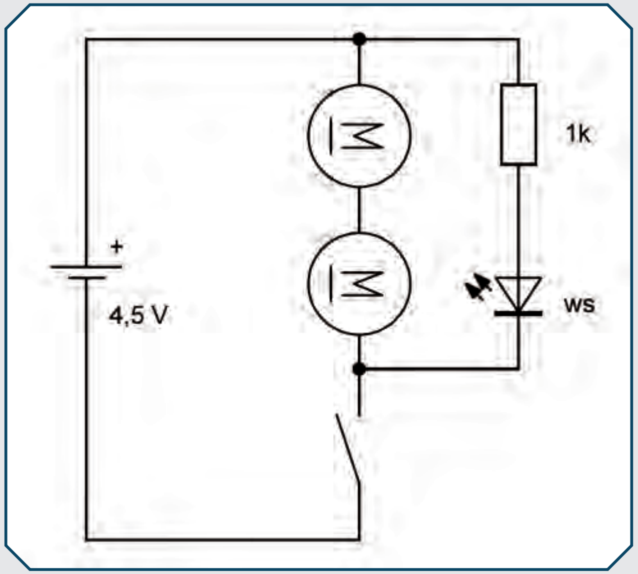
A second motor is in compartment number six. It should be connected in series with the first motor. Both motors now run at half voltage and half speed. However, if you slow down one of the motors, the other will speed up.

In the series connection, the same current flows through both motors. Both therefore deliver the same torque. This is comparable to the differential gear of a car.



Both driven wheels receive the same torque and therefore deliver the same power to the road, but the speed can be different, which enables cornering. In the case of electric motors, both have the same voltage at the same speed. Each receives half of the battery voltage of around 4.5 V, i.e. around 2.25 V. However, if one motor is slowed down with the fingers, its working voltage drops. The other motor then receives more voltage and rotates correspondingly faster.

The motors require a current of around 100 mA when idling. If they are braked, the speed drops and the current consumption increases with the greater torque. The battery voltage remains almost unchanged as long as the batteries are still fresh.



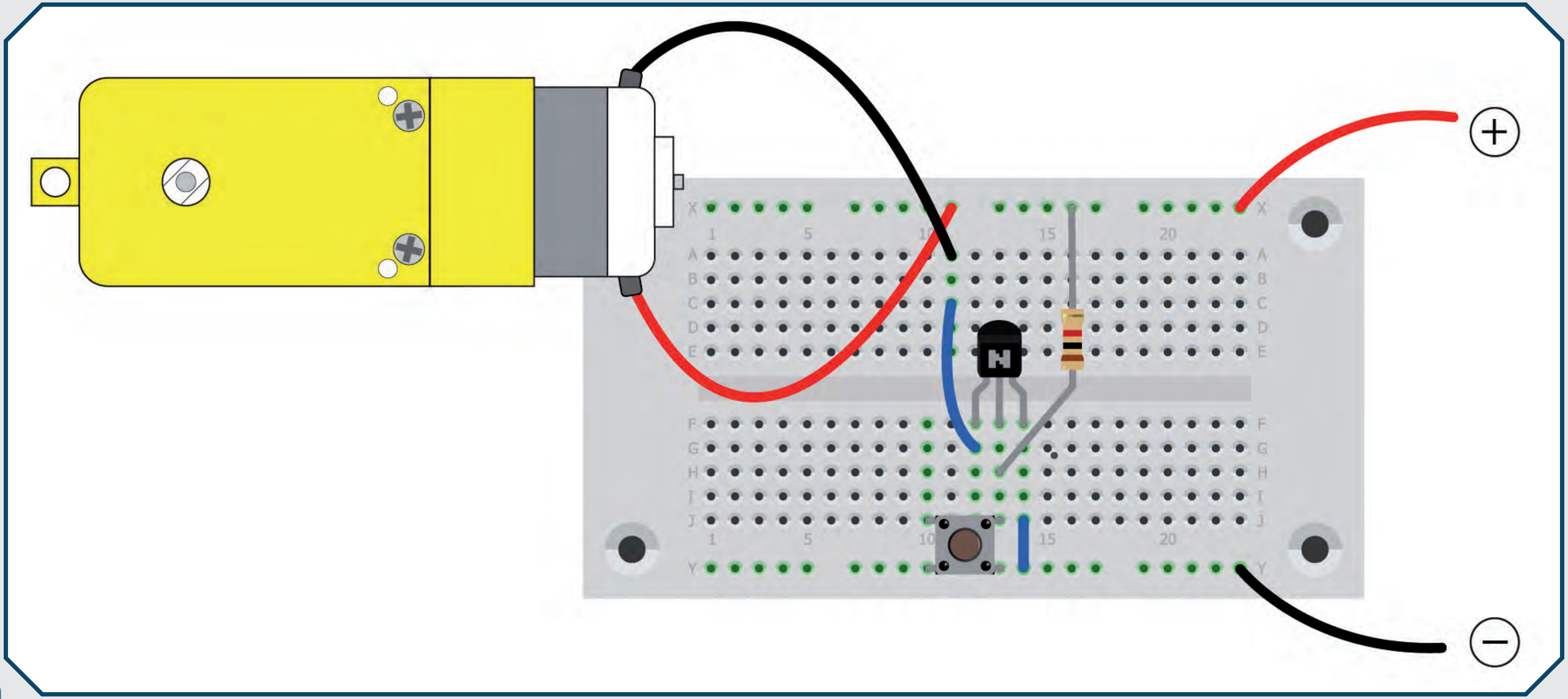
With heavily used batteries, however, the voltage drops with the load, which can be recognised by a change in the LED brightness.

If one motor is completely stopped, the other motor runs at full speed. If you then let go of the axle, the stationary motor will usually no longer start on its own. However, the other motor can also be slowed down considerably. This increases the current through the motors so that the first motor also starts up again. Another method is to release the button briefly and then press it again. This starts both motors. At first, a larger current flows, which then decreases as the speed increases.

DAY 7

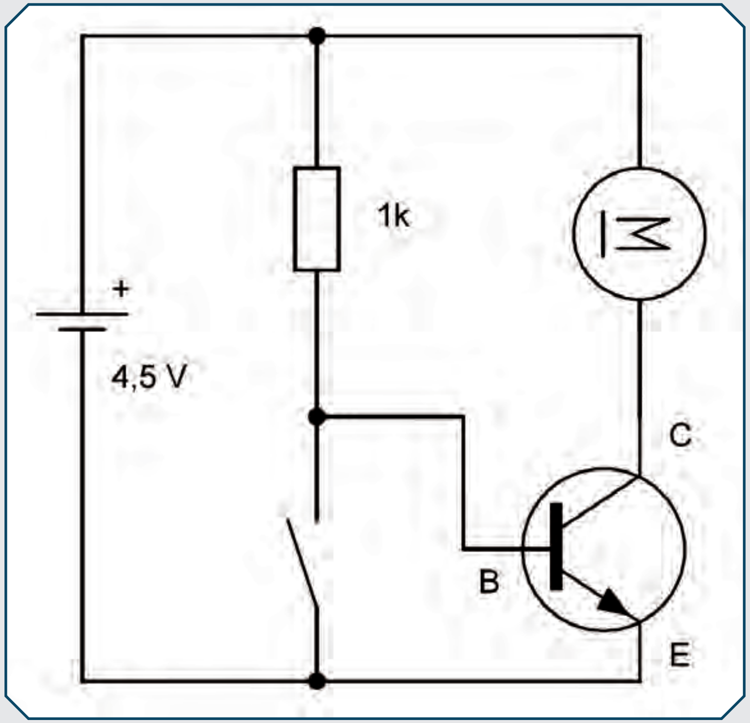
AMPLIFIED CURRENT

Compartment number seven contains a component with three legs – a BC337 transistor. A transistor is a component for amplifying current. It has three connections: From right to left, these are the emitter (E), the base (B) and the collector (C). The connections must not be mixed up. The emitter is connected to minus, a small current flows through the base and the amplified current flows through the collector.



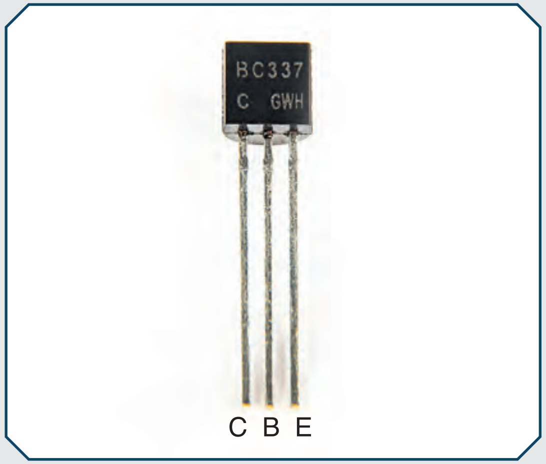
Transistors

A transistor contains a crystal of silicon. Silicon (Si) is contained in large quantities in normal quartz sand (quartz = silicon oxide). It is a semiconductor, i.e. a material that neither conducts electricity well like metals nor insulates well like glass or rubber. In order to achieve a specific conductivity, tiny traces of other substances are added to pure silicon. Depending on the type of these substances, N-silicon or P-silicon is obtained. The transistor used has three layers: NPN. Other types have a different layer sequence, namely PNP. They function similarly, but with a different current direction.



The motor runs when the battery is switched on. If you press the button, the motor stops. If you release the button but pull out the resistor, the motor also stops. Only a small current of around 4 mA flows through the resistor. If this small current flows through the base of the transistor, it switches on a much larger collector current that flows through the motor. When the push button switch is closed, current still flows through the resistor, but no longer through the base. The collector current is thus switched off.

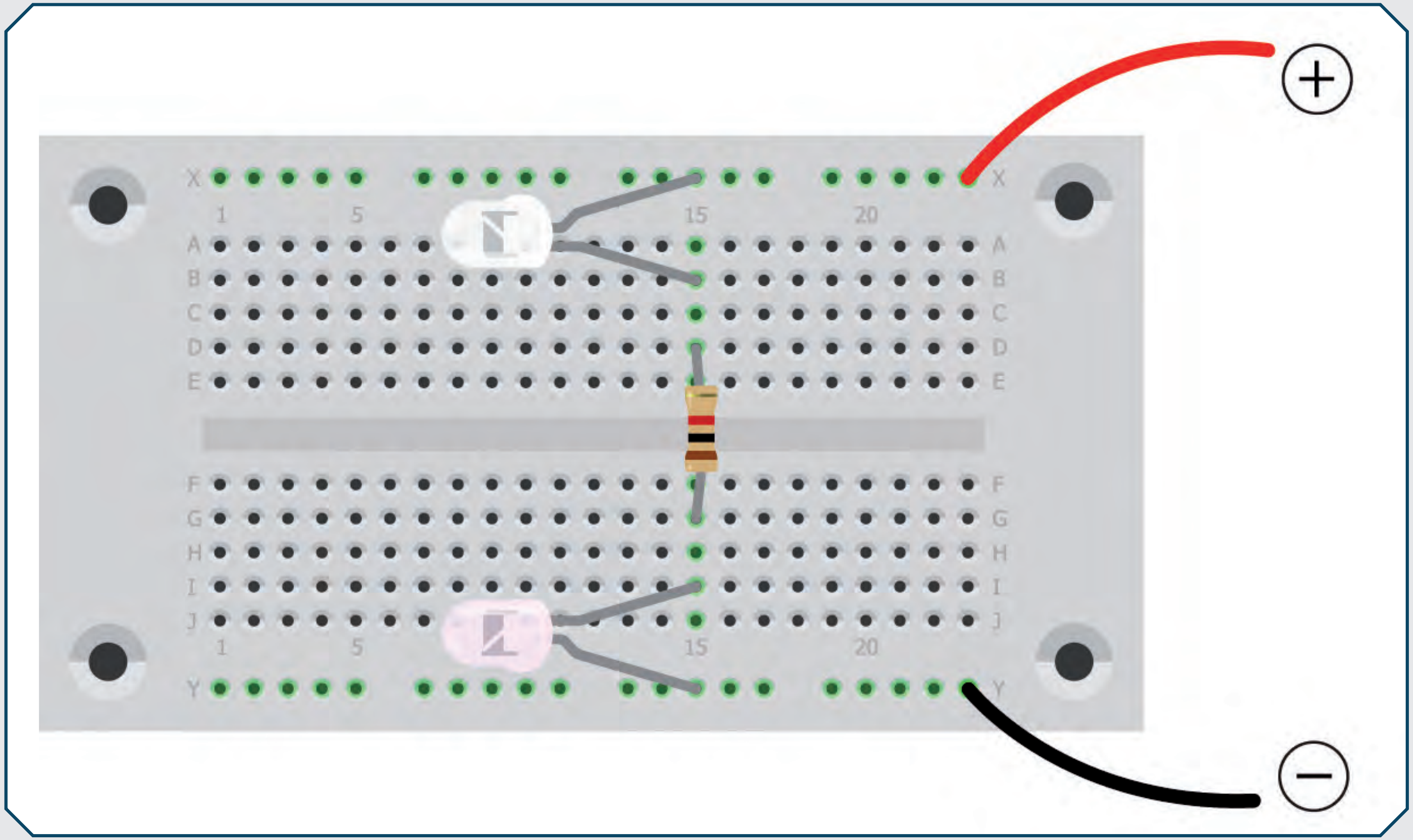
The BC337 transistor used is well suited to this task because it has a high current amplification factor and can handle relatively high currents.



DAY 8

SWITCHED BY LIGHT

A phototransistor is behind door number 8. At first glance, the component looks like a white LED. But if you look closely at it, you'll see a small, dark rectangle. This is the light-sensitive surface. The phototransistor has only two connections: the collector (short leg) and the emitter (long leg). Although there is also a base, it has no connection to the outside. The base current is generated by the incoming light.

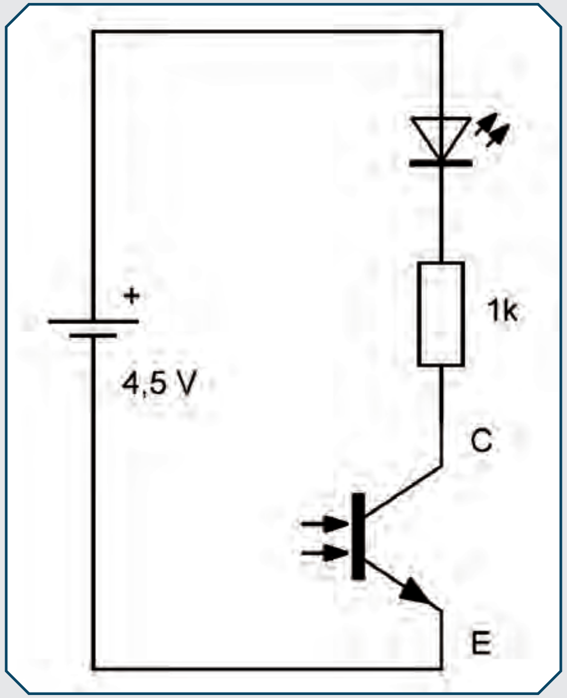


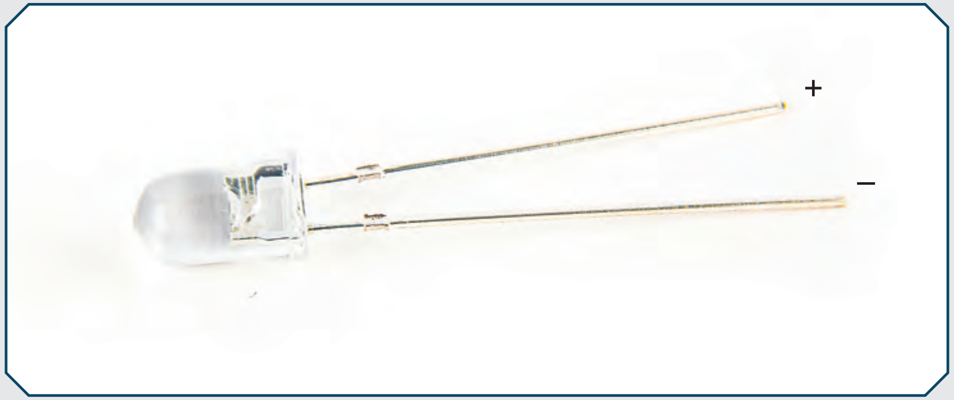
When the phototransistor is installed, the longer leg is connected to the negative pole – completely different to an LED. The collector current flows through the resistor and through the white LED. If enough light shines on the phototransistor, the LED is switched on. If there is little light, it lights up correspondingly weaker. This still works even when there is little light. The circuit works like a light amplifier – the white LED is always many times brighter than its surroundings.

The base connection of the phototransistor is not accessible from the outside, so the component has two connections and is installed in a clear LED housing. The collector is the positive pole and is located at the short leg, the emitter is located at the long leg and serves as the negative pole. The phototransistor therefore appears to be installed the other way round to an LED.

Phototransistors

The phototransistor is a light sensor with the basic structure of a silicon transistor. The base collector diode serves as a large-area photodiode whose current is amplified by the transistor. The collector current depends on the brightness and can reach up to 20 mA in very bright light.

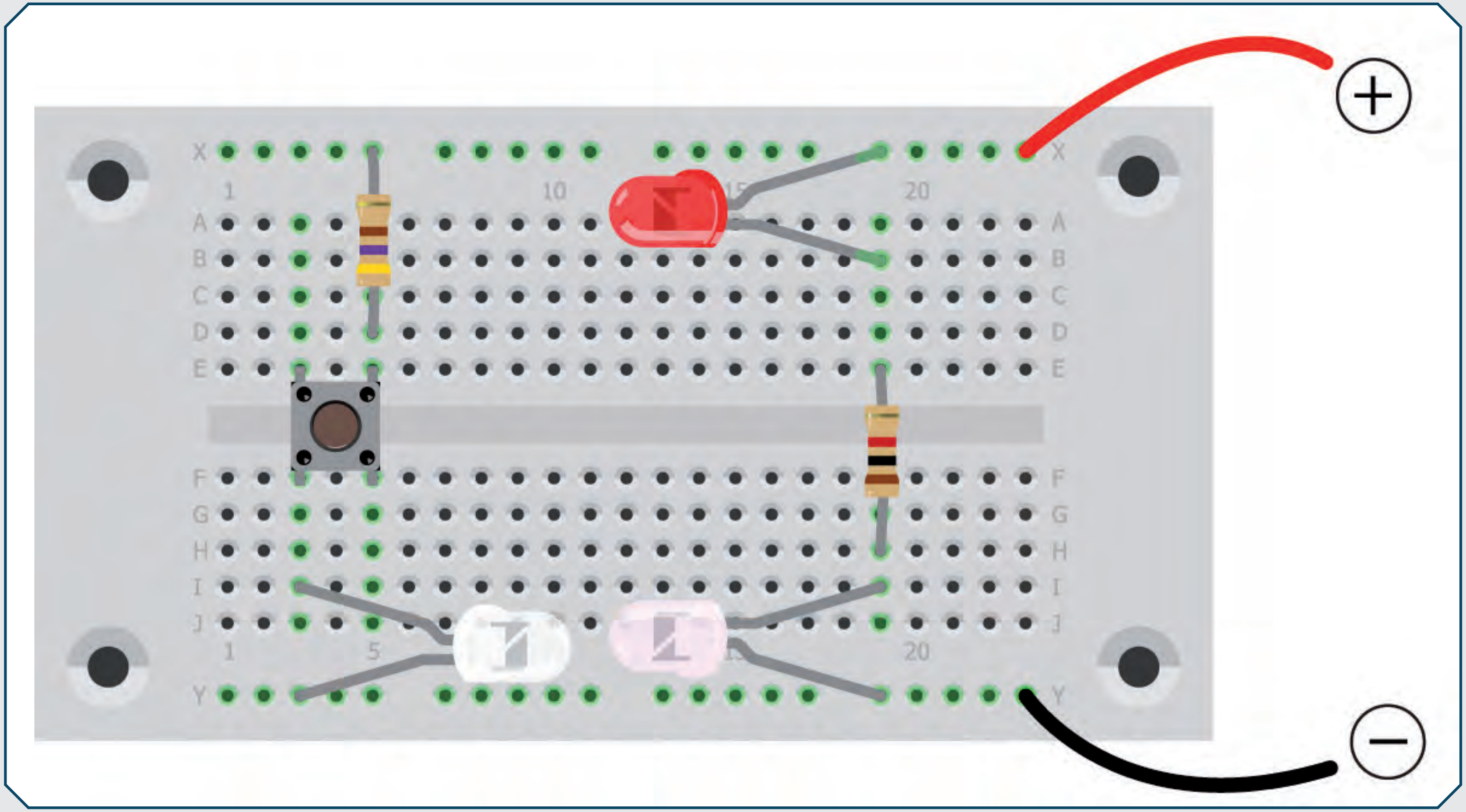




DAY 9

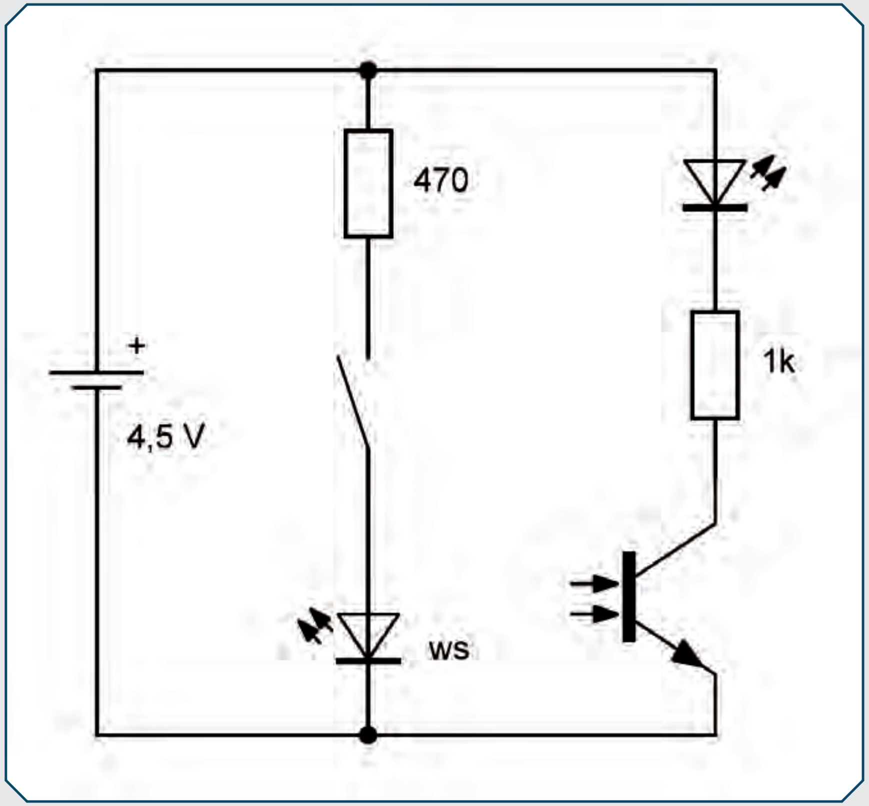
LIGHT SWITCHES LIGHT

A 470 ohm resistor (470 Ω, yellow, violet, brown) is in the ninth compartment. This can now be used to create two independent circuits – one with the white LED and one with the red flashing LED and the phototransistor.



If you press the push button, the white LED comes on and the red LED starts to flash at the same time. To do this, the white LED and the phototransistor must be angled so that the white LED shines into the front of the phototransistor.

It’s easy to prove that the flashing LED is actually switched with light – insert a black sheet of paper (or other completely opaque sheet) between the white LED and the phototransistor. It shades the light and thus prevents the flow of current through the phototransistor.

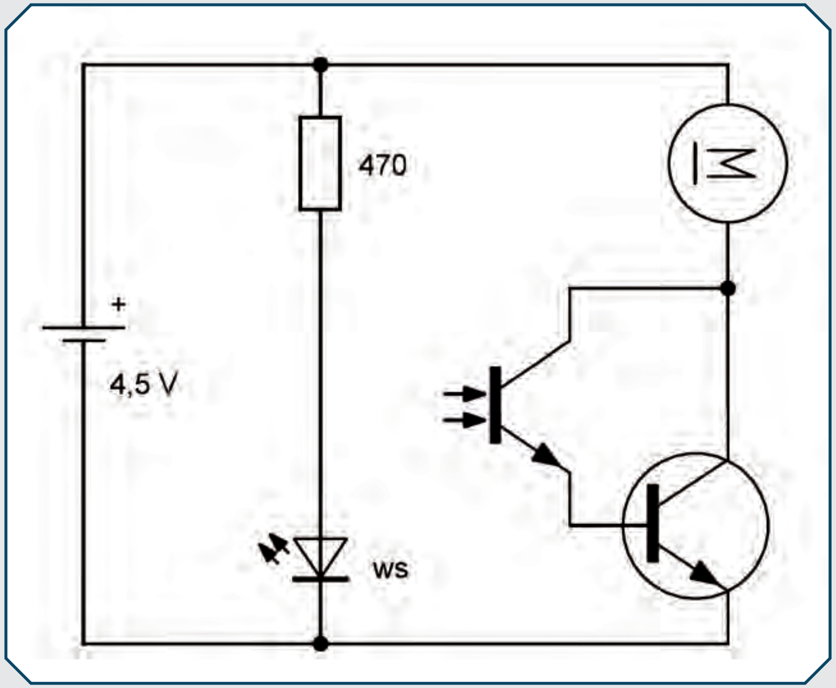


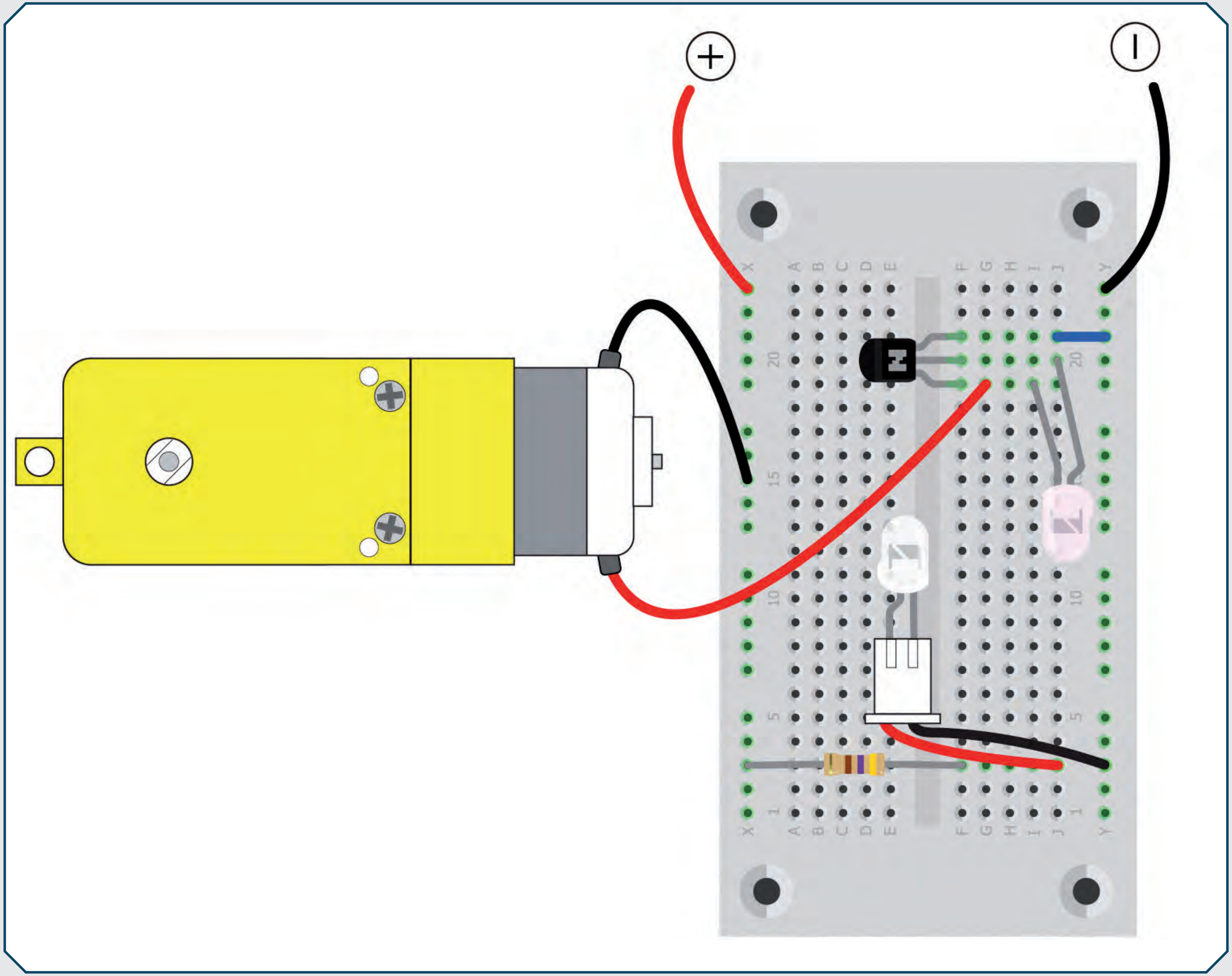
DAY 10

LIGHT SWITCHES ON THE MOTOR

Today you'll find two double cables with plugs and sockets. They can be used to flexibly extend the LED connections. The white LED from the last assembly is now fitted with a cable so that the small LED spotlight can be directed where necessary. Only one double cable is needed for the assembly today. However, both cables will be used later in the robot.

This time, a motor is going to be controlled by light. The phototransistor by itself only supplies small currents that are just enough to operate an LED. But with an additional transistor as an amplifier, it's also sufficient for the motor. The motor remains at rest but runs when the phototransistor is illuminated directly. The speed can be reduced by directing the light slightly to the side. If the surrounding light is bright enough, the motor can also be controlled by shading the phototransistor by hand.





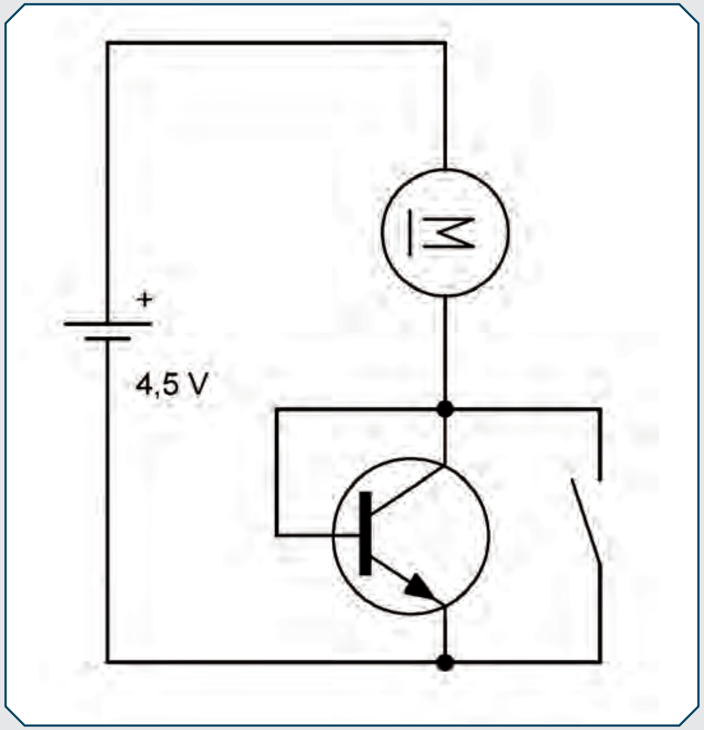
Day 11

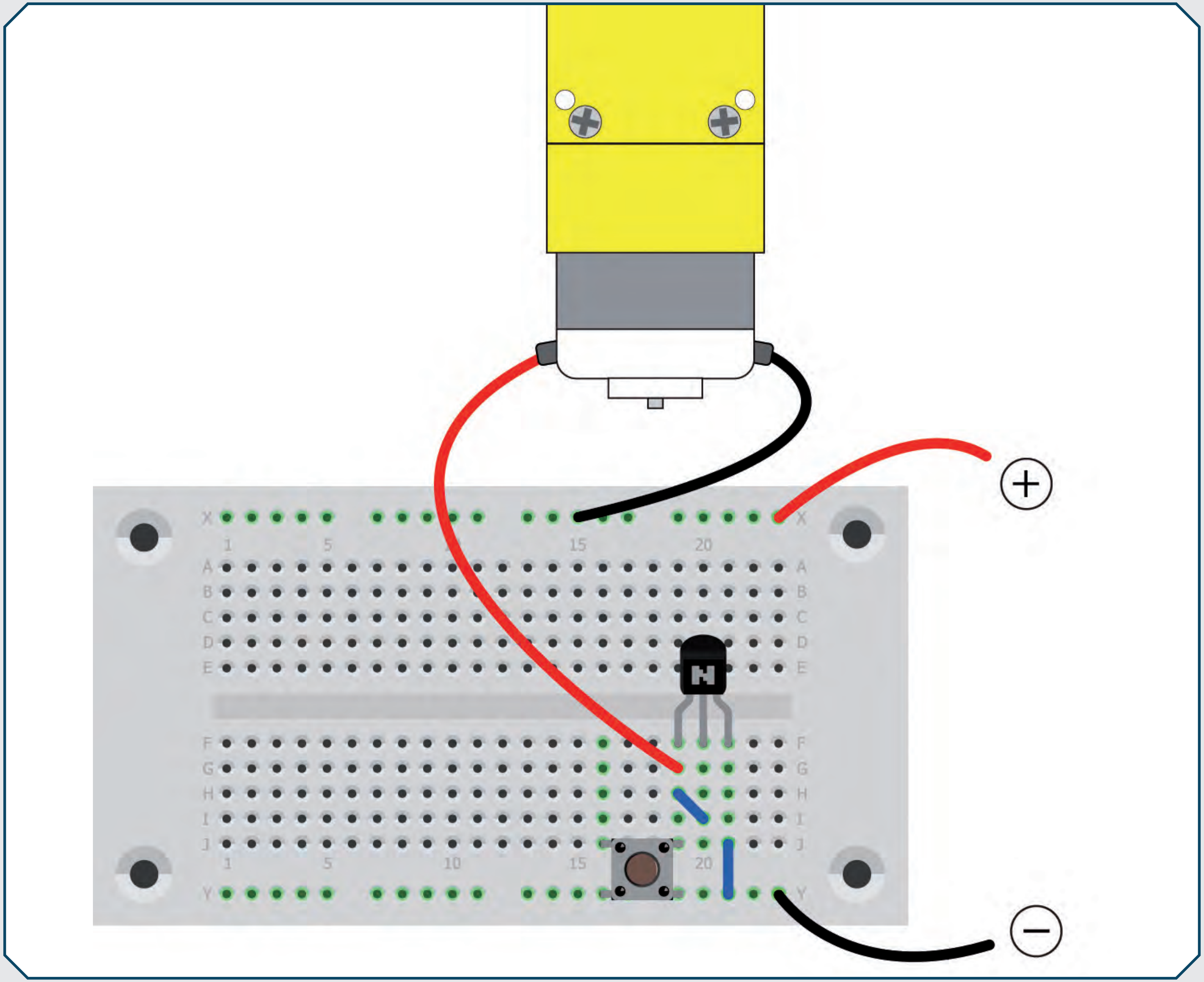
REDUCED SPEED

Behind door number eleven there's another BC337 transistor. As the last experiment has already shown, a transistor can not only switch on the motor, but also run it at a reduced speed. Today, the motor should run with only a slightly reduced voltage. If you press the switch, the motor runs at full speed again. You can clearly hear the difference.

If the base and collector are connected directly, the transistor causes a voltage drop of around 0.8 V. This reduces the motor voltage by around 20%. This reduces the motor voltage by around 20%. When the switch is closed, there is a direct connection and the motor receives the full voltage again.

Since there are now two transistors, the circuit can also be set up twice and two motors can be slowed down.

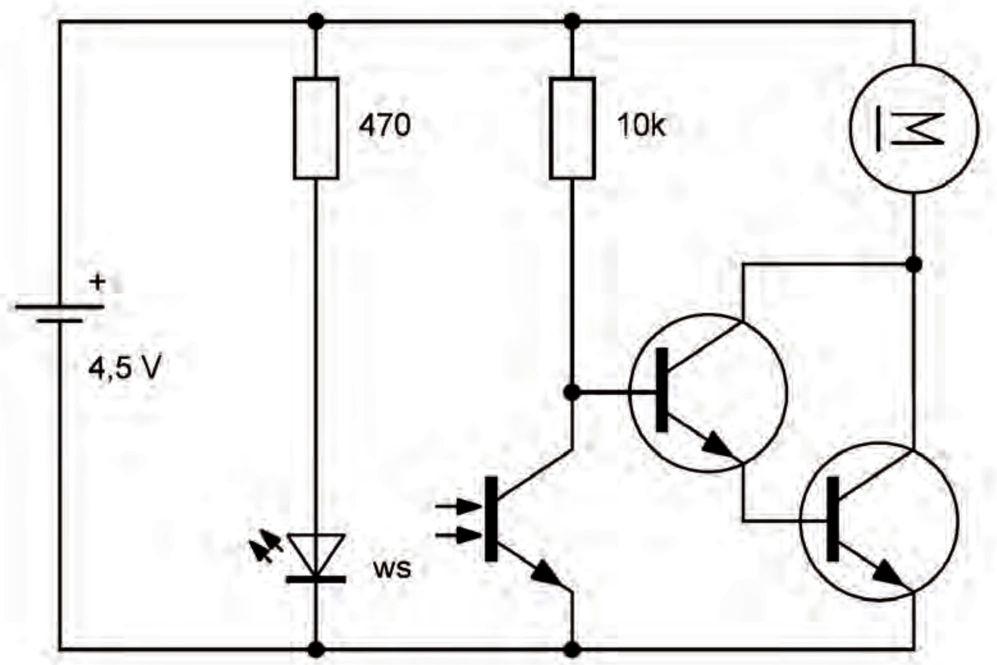



X
1
5
15
20
A
B
C
D
E
F
G
H
I
J
10
Y

LIGHT SWITCHES OFF THE MOTOR

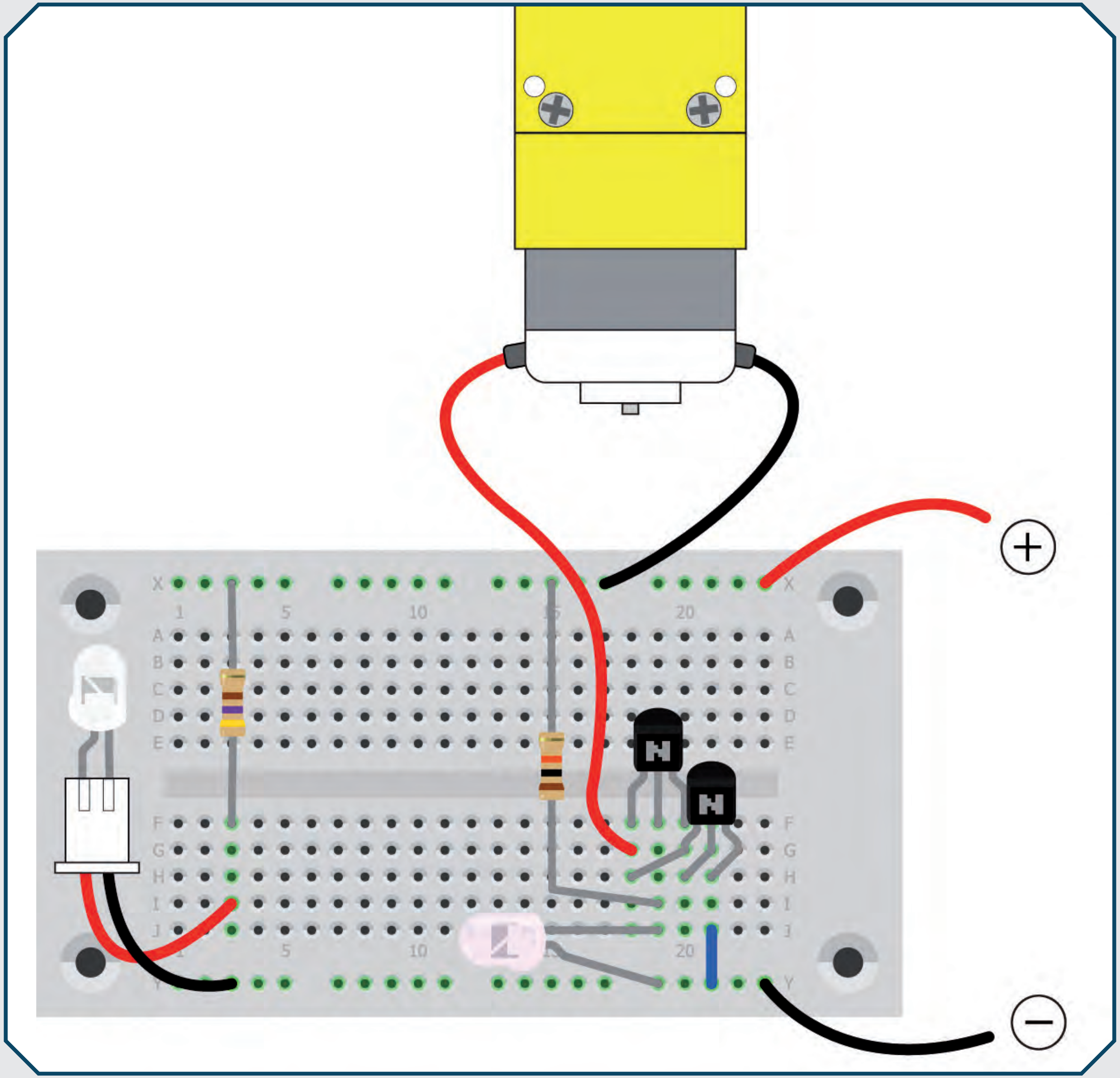
Compartment number twelve reveals a 10 kΩ resistor (brown, black, orange). It's used for a circuit where the motor runs as normal but stops when light falls on it. This time two transistors are used for even more amplification. Only a small current flows through the resistor, which is amplified high enough to switch on the motor. However, if enough light falls on the phototransistor, the control current is diverted so that no more base current flows and the transistors switch off the motor.

The experiment can be carried out with the LED spotlight on the circuit board, but also with a bright flashlight or bright daylight. If the light is bright enough, the motor stops but can be restarted by casting a shadow over the phototransistor with your hand.



The Darlington Pair circuit

The connection of two transistors as shown in the circuit diagram is called a Darlington Pair circuit. Two transistors amplify more than one. This is particularly true of this circuit, in which the already amplified current is amplified again by a second transistor. The name comes from its inventor Sidney Darlington, who came up with this idea back in 1952. Both collectors are connected and the emitter current of the first transistor flows to the base of the second. The Darlington circuit behaves like a single transistor with very high amplification

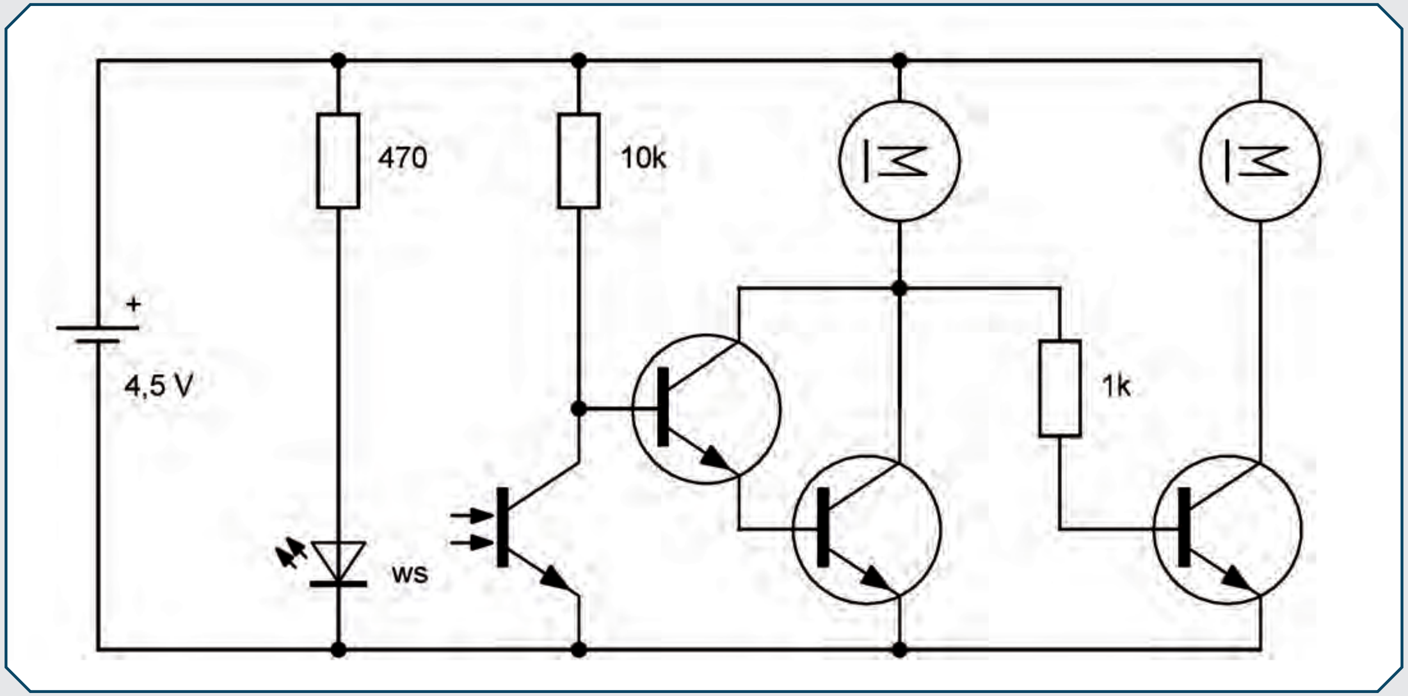


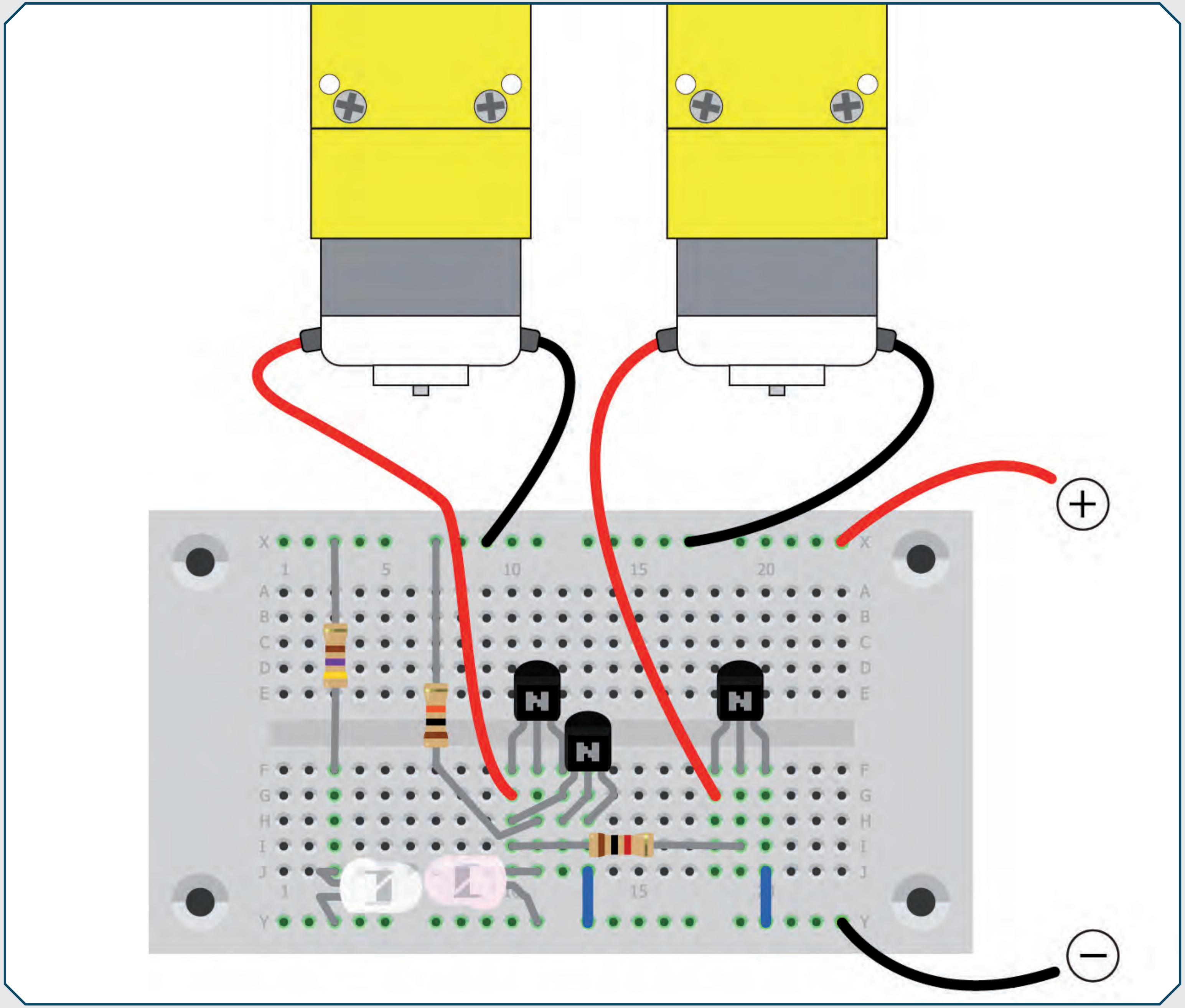
DAY 13

RIGHT OR LEFT

A third BC337 transistor is in the 13th compartment. It's now used for a further switching stage that controls the second motor. Whenever the left motor is running, the right motor should stop and vice versa. The entire experiment can be controlled again with the light source, either with the LED moving on the cable or by shading.

"On" becomes "off", "off" becomes "on" – such a circuit is called an inverter. The base current for the right-hand transistor comes from the collector of the left-hand transistor. Whenever the left-hand motor is switched on, the collector voltage is low so that no or very little current flows to the base of the right-hand transistor. If, on the other hand, the left-hand motor is switched off, the voltage at the base resistor is high, so that the right-hand transistor becomes conductive.





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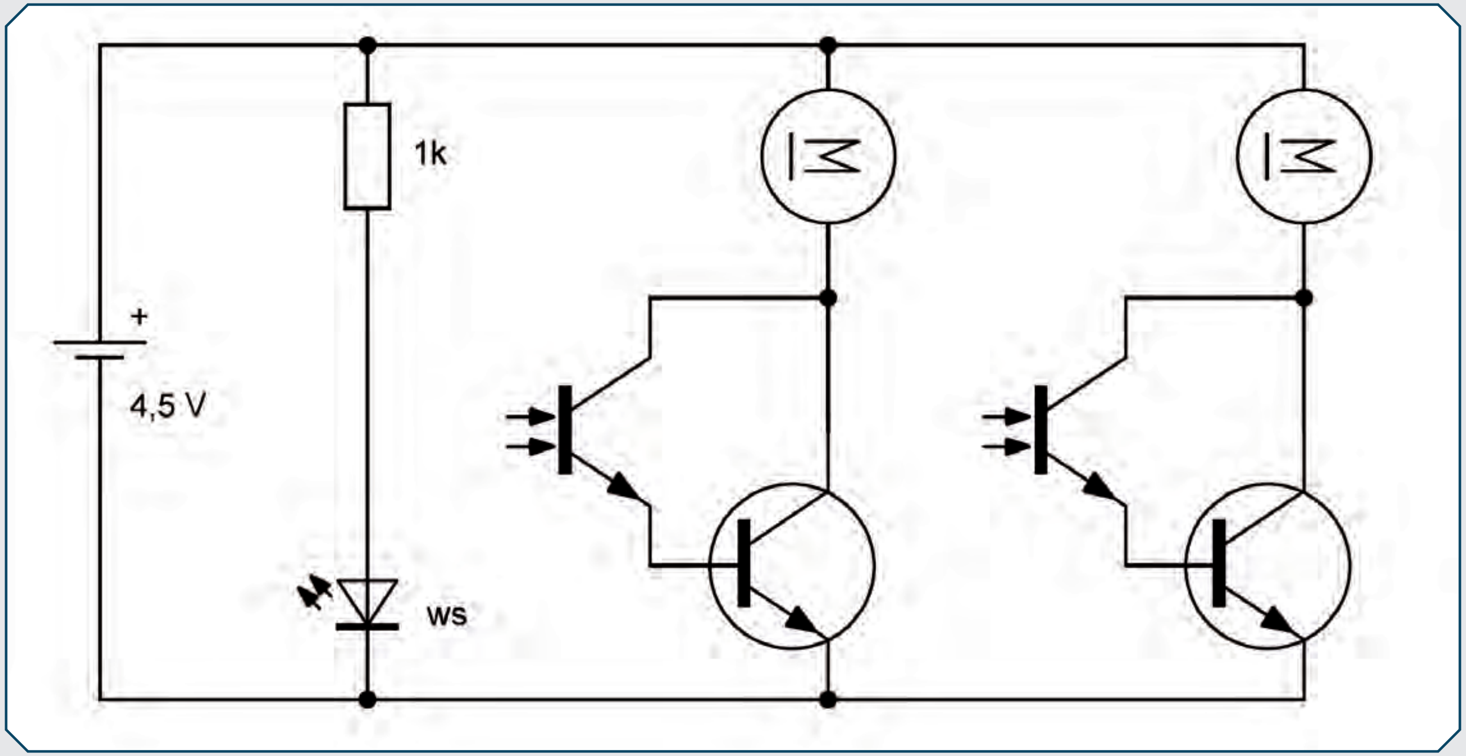
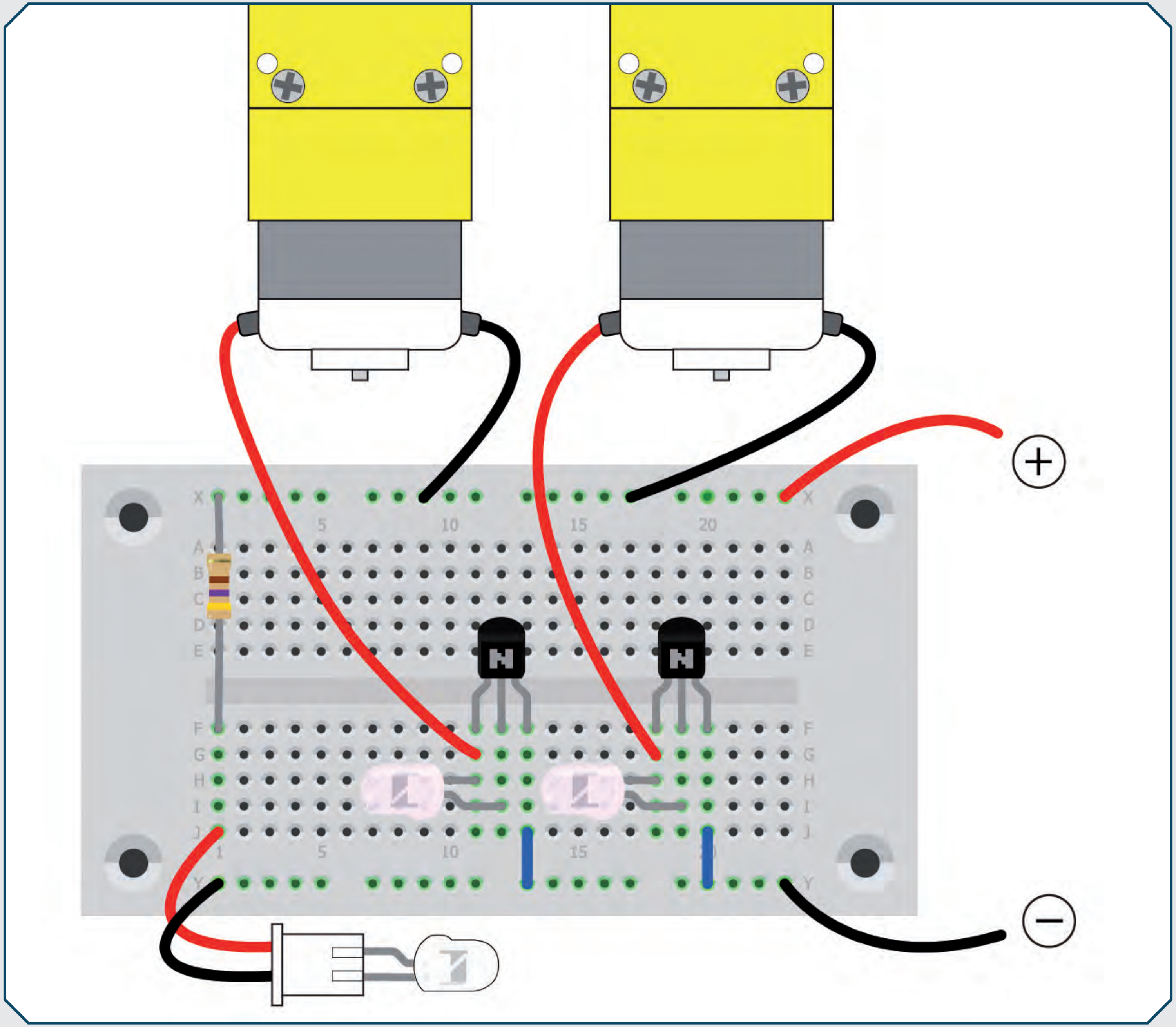
DAY 14

RIGHT-LEFT LIGHT CONTROL

A second phototransistor is in compartment number 14. This allows both motors to be controlled independently of each other. Whenever one of the phototransistors receives sufficient light, the corresponding motor is switched on. The LED on the cable or an external lamp can be used for control. With a suitable light source, both sensors can also be illuminated simultaneously so that both motors run.

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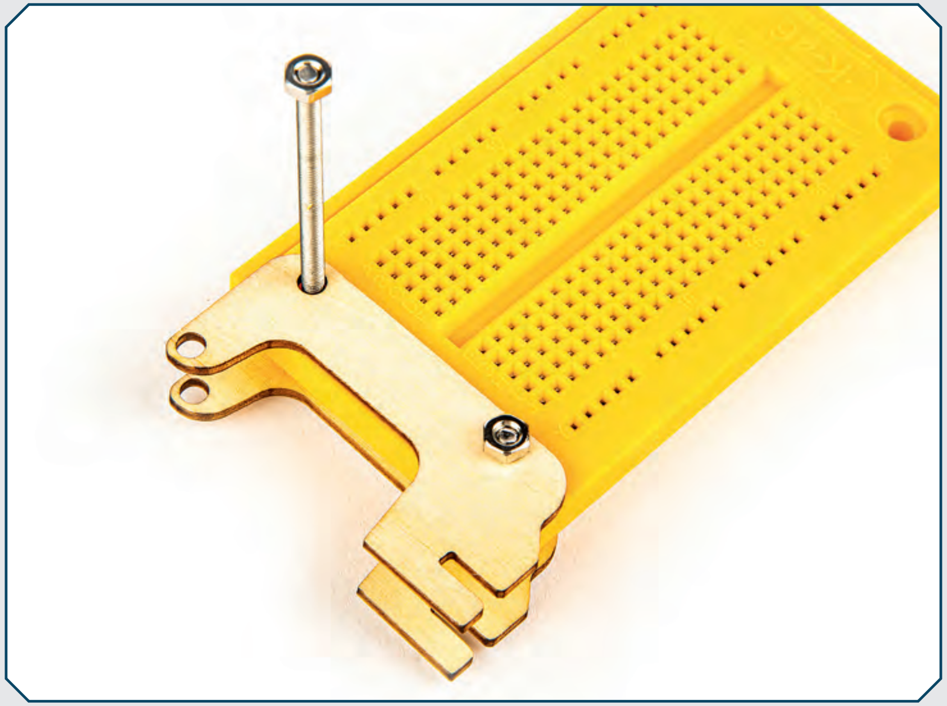
DAY 15

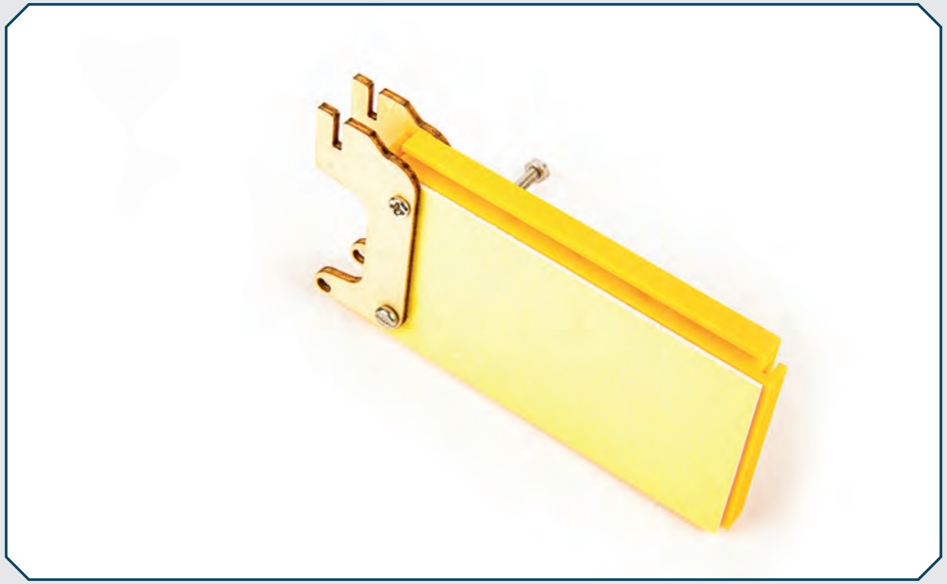
BUILDING THE ROBOT

So far, we've been experimenting with the various electronic circuits that will drive the robot. But now it's time to build the robot itself.

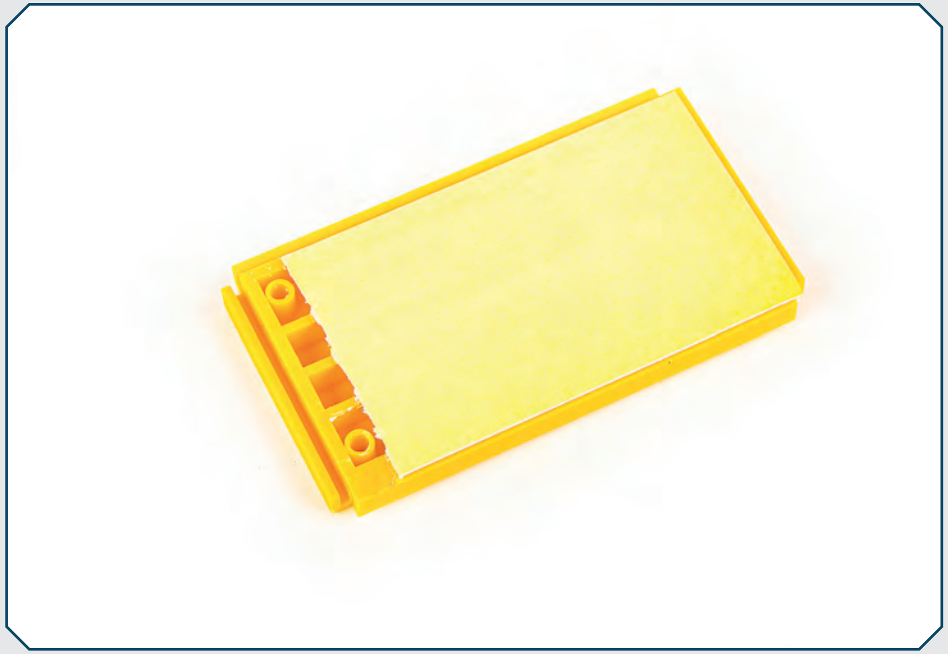
Behind today's door, there are two wooden parts, two long bolts, one shorter bolt, three nuts and a short, black plastic tube.

The two wooden plates should first be screwed on to the breadboard as a trial run. Assemble them so that the longer "arms" with their slots are closest to the Y contact row of the breadboard. The Y-contact row will later be at the bottom and will be connected to the negative connection.

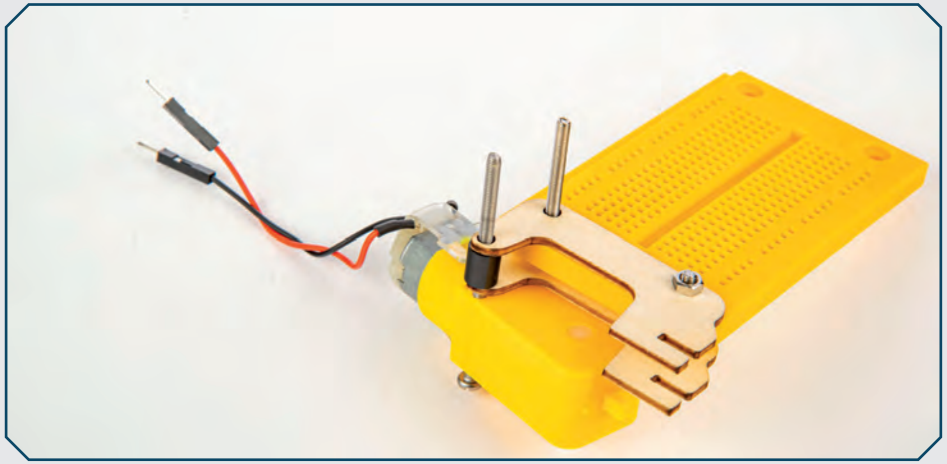


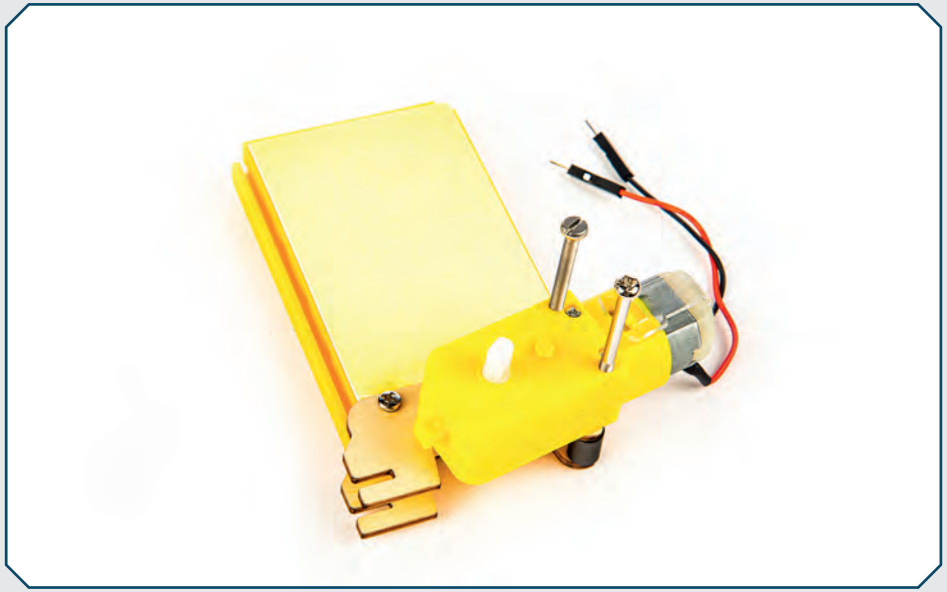


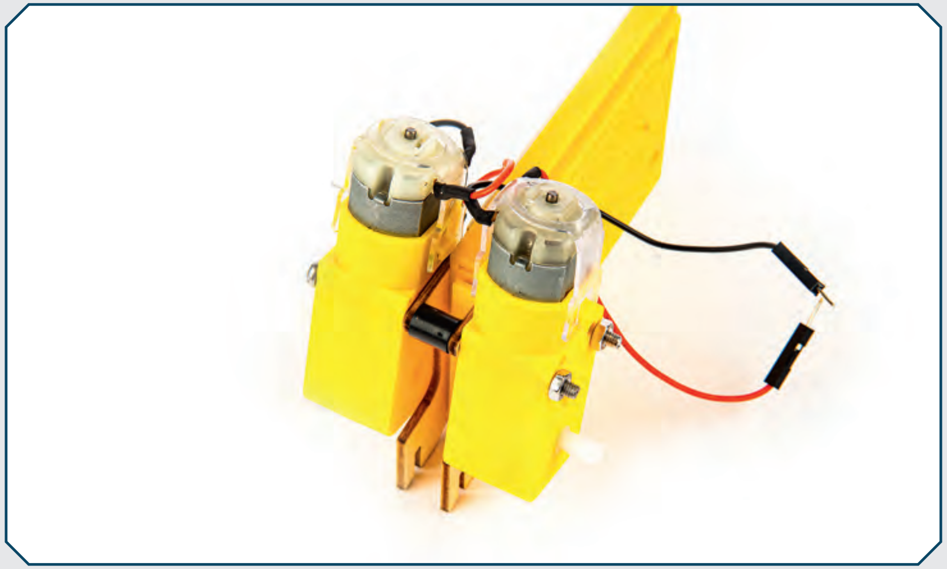
Next, we need to remove part of the adhesive pad on the back of the breadboard. Use the edge of the wooden part as a guide and **carefully** make a straight cut with a sharp knife.



Then, unscrew the bolts, remove the wooden parts and peel away the narrow strip of adhesive foam from the breadboard. This can be a bit fiddly but don't worry if a small amount of foam remains - this won't be a problem.

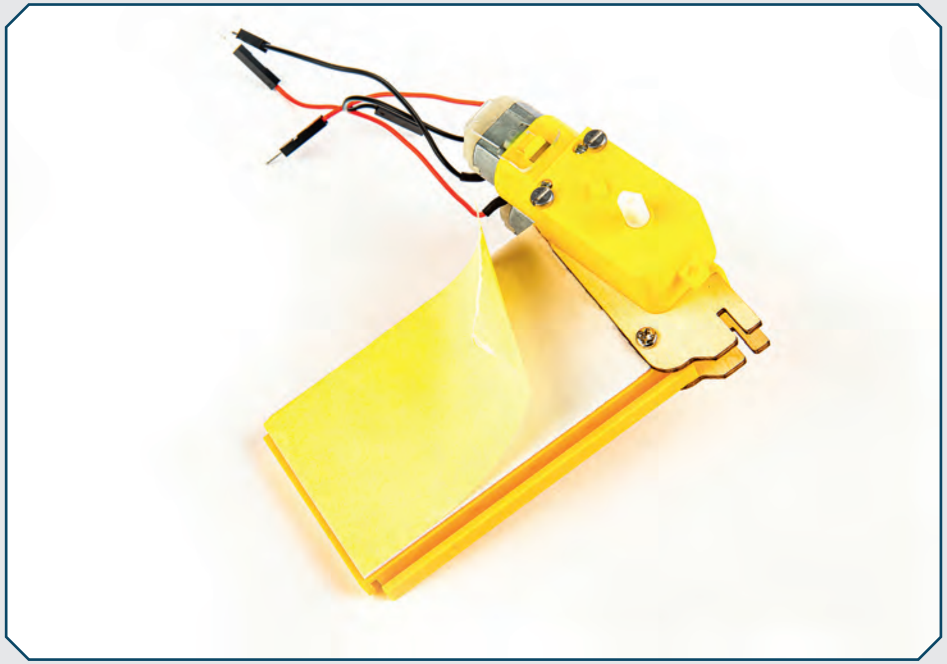


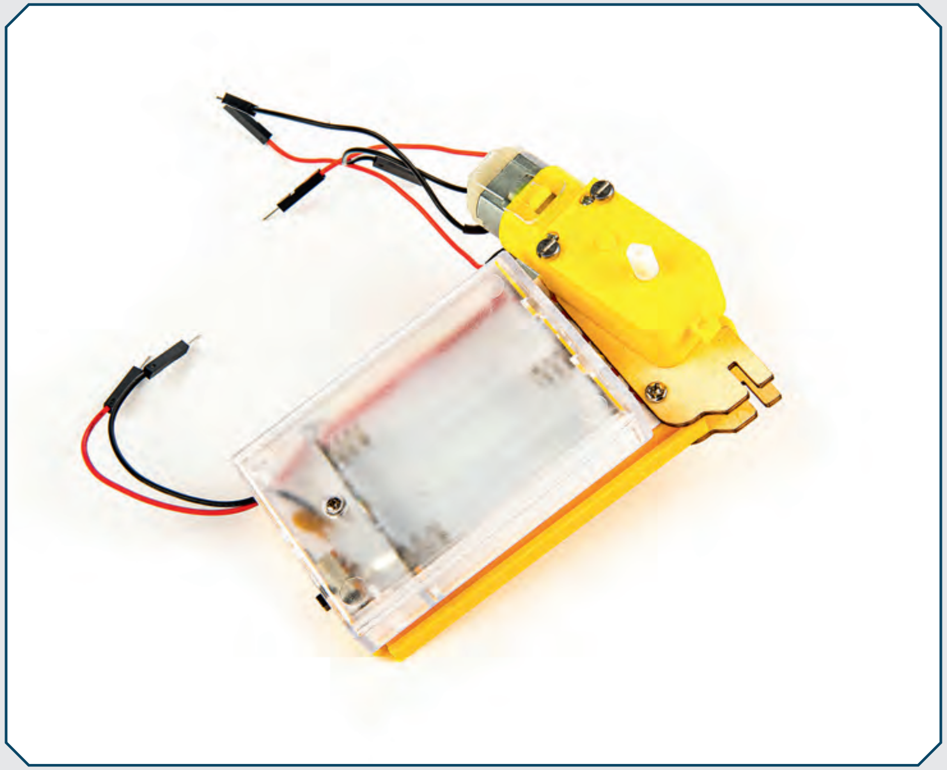




Now for the final assembly. Mount the wooden plates either side of the breadboard and fasten the short bolt near the Y-rail first.

Then, insert the two long bolts through both motors, both wooden parts, the breadboard and the black spacer tube. Tighten the nuts to fasten everything together.





Finally, we need to stick the battery case to the back of the breadboard. To do this, peel off the white protective sheet from the back of the foam pad and carefully position the battery case so it sits aligned with breadboard, with its leads and the on/off switch furthest away from the motors.

Make sure to stick the side without the screw (and case cover) to the adhesive pad!

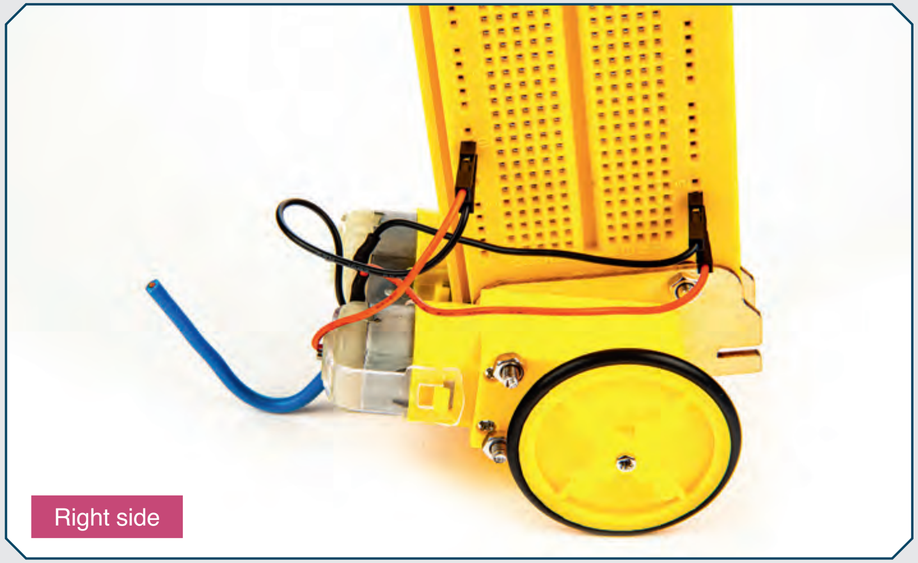
Day 16

ON ITS OWN WHEELS

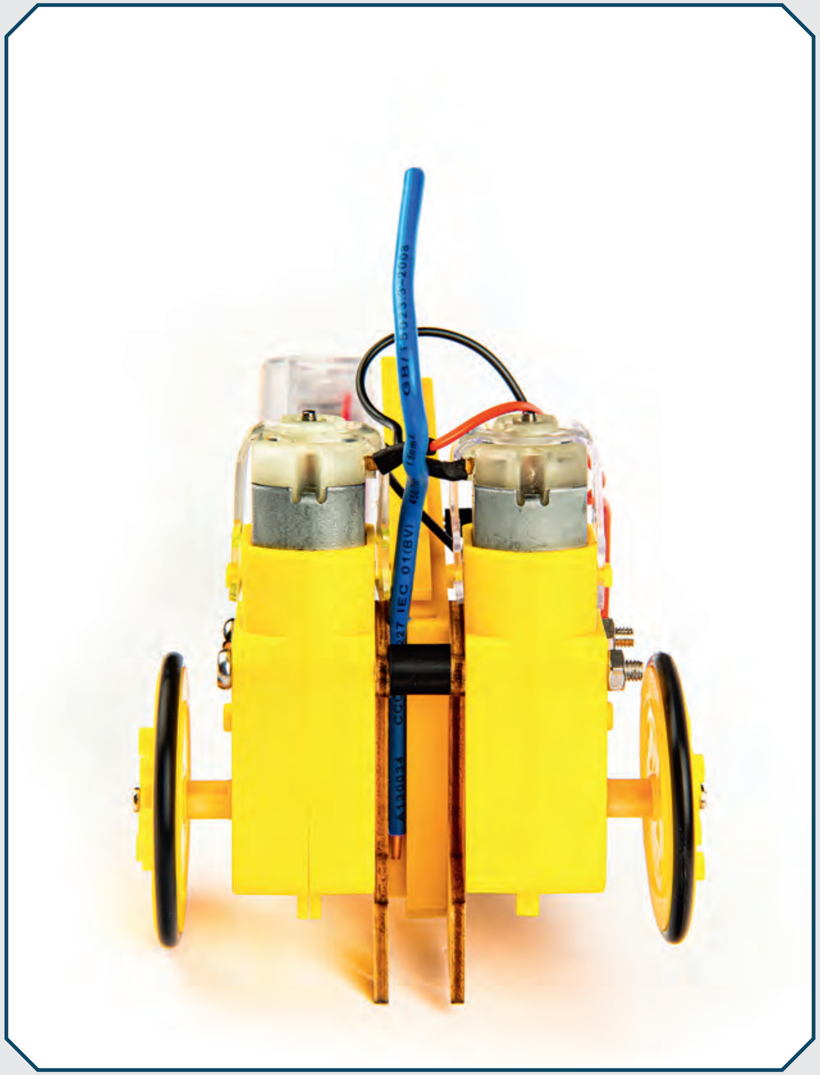
Compartment number 16 contains the wheels, tyres and fastening screws as well as a thick, insulated copper wire. First, put the tyres on the wheels. Then, mount the wheels on the axles making sure to match the flats on the axles to the flat sides on the recesses on the wheels. Finally, use the screws to fix the wheels to the axles. Be careful not to over-tighten the screws.

At this stage, when you stand the robot on its wheels, the motors rest on the floor.

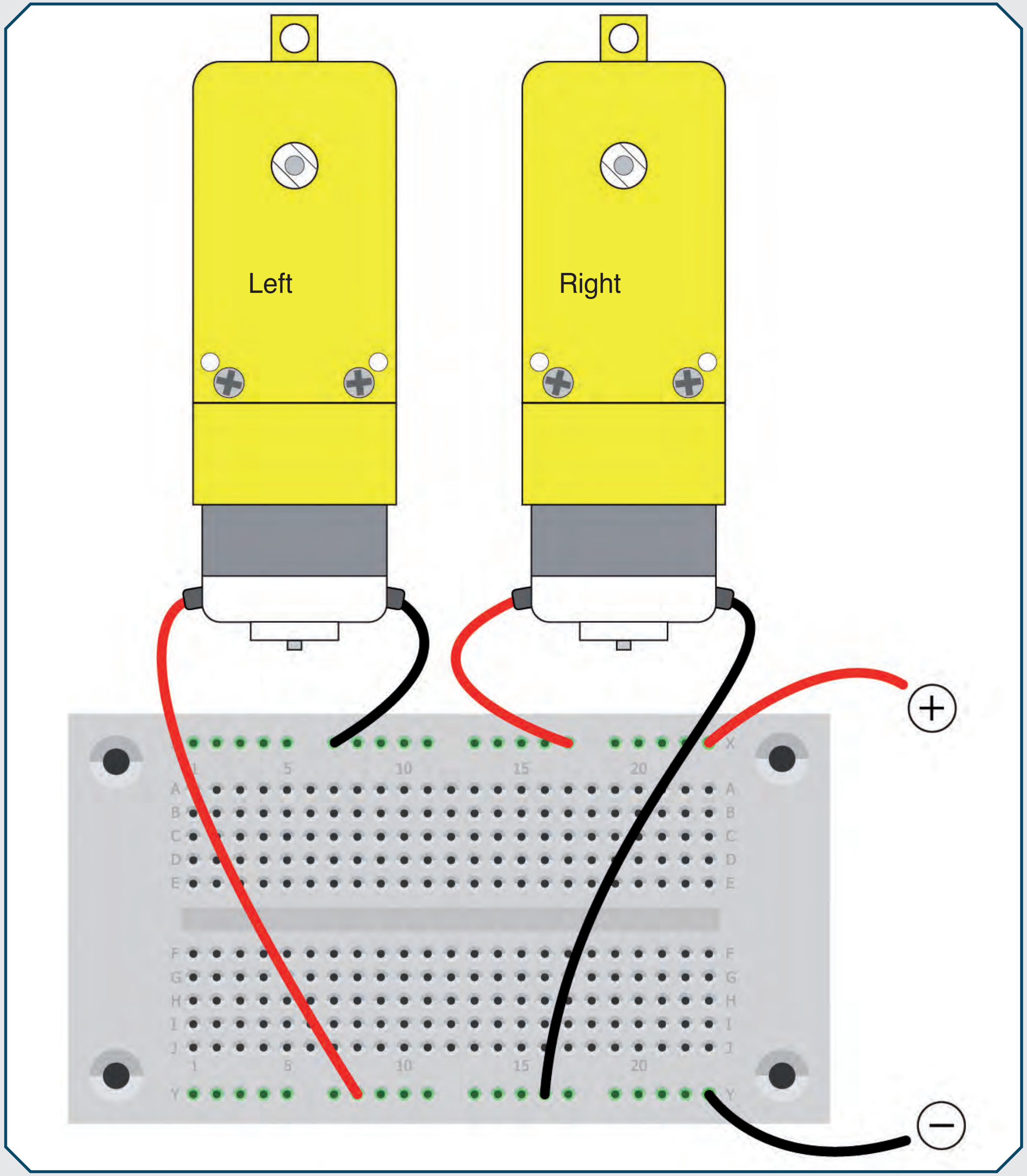
To prevent this and allow the robot to move smoothly, we need to add a skid. We'll form this from the thick wire. The wire is clamped at the lower edge between the plug-in board and the wooden plate. To do this, loosen the fastening screws of the motors once and tighten them again at the end. When the wire is clamped, it should be form an arc that rests on the floor so that the bottom edges of the motors are parallel to the ground.



Right side



Now for the first test: the robot should simply drive straight ahead. To do this, both motors are connected in parallel. To ensure that both wheels turn in the same direction, the cables must be plugged in differently. If the robot moves backwards, the connections must be swapped. Because both motors do not usually run at exactly the same speed, the robot will not drive perfectly straight ahead, but instead in a large curve.


Left
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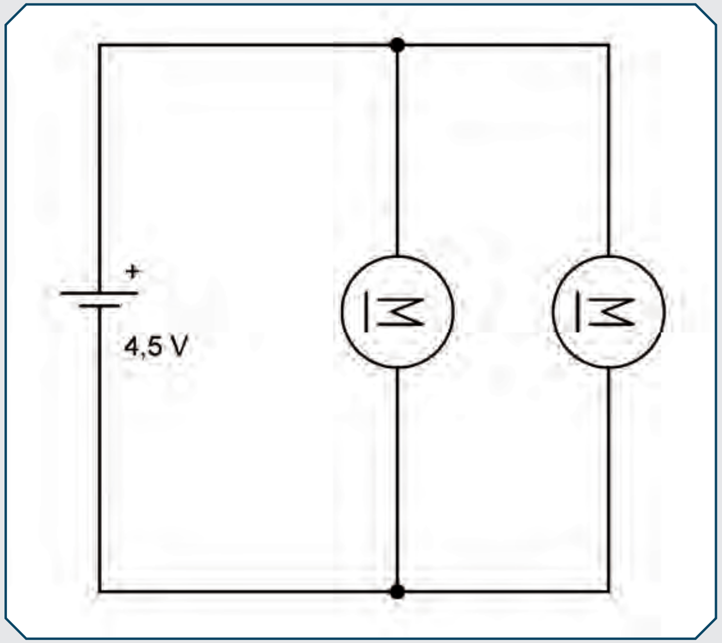
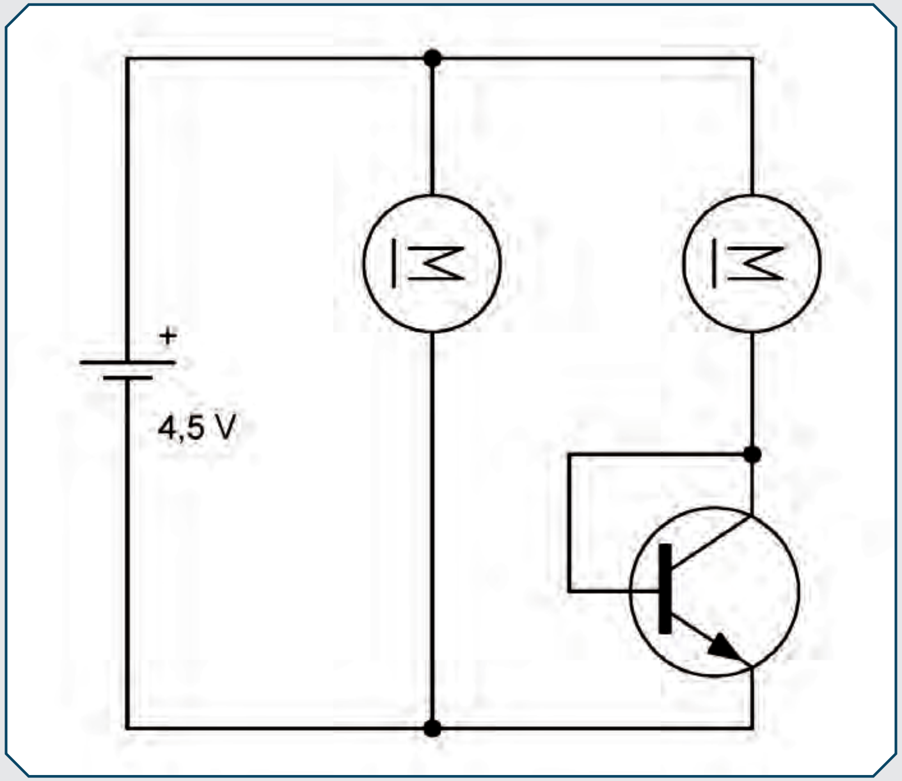

+
4,5 V

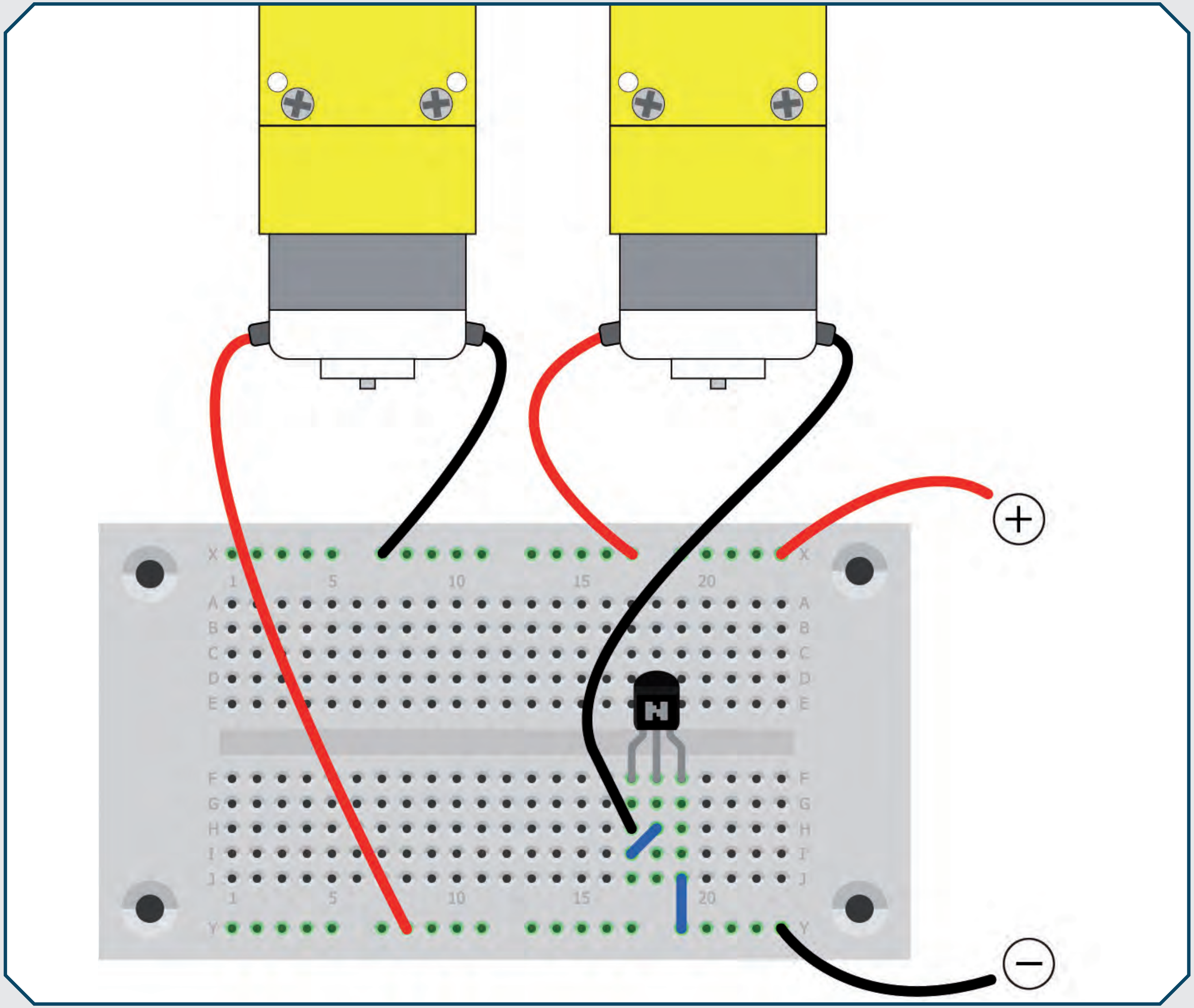
DAY 17

DRIVING IN CIRCLES

Another BC337 transistor is behind today's door. This transistor is used to make one of the two motors run a little slower. The circuit should be familiar: The base and collector are short-circuited, resulting in a voltage drop of around 0.8 V. If one motor runs slightly slower than the other, the robot moves in an exact circle.

The circle has a diameter of approx. 1 m. Whether it moves clockwise or anticlockwise depends on which motor runs slower. You can place a bottle or a vase in the centre of the circle. Uninitiated observers may then think that a higher intelligence is at work, either constantly measuring the radius or carrying out complicated path calculations. Nobody needs to know that the truth is much simpler than that!

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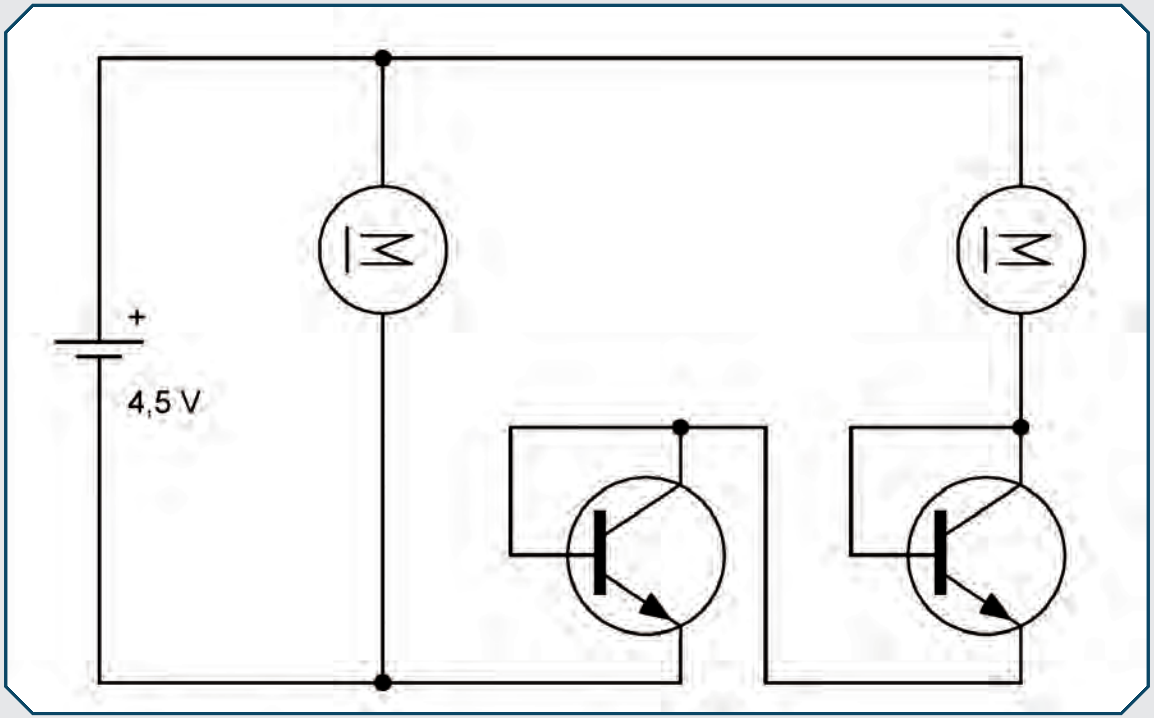
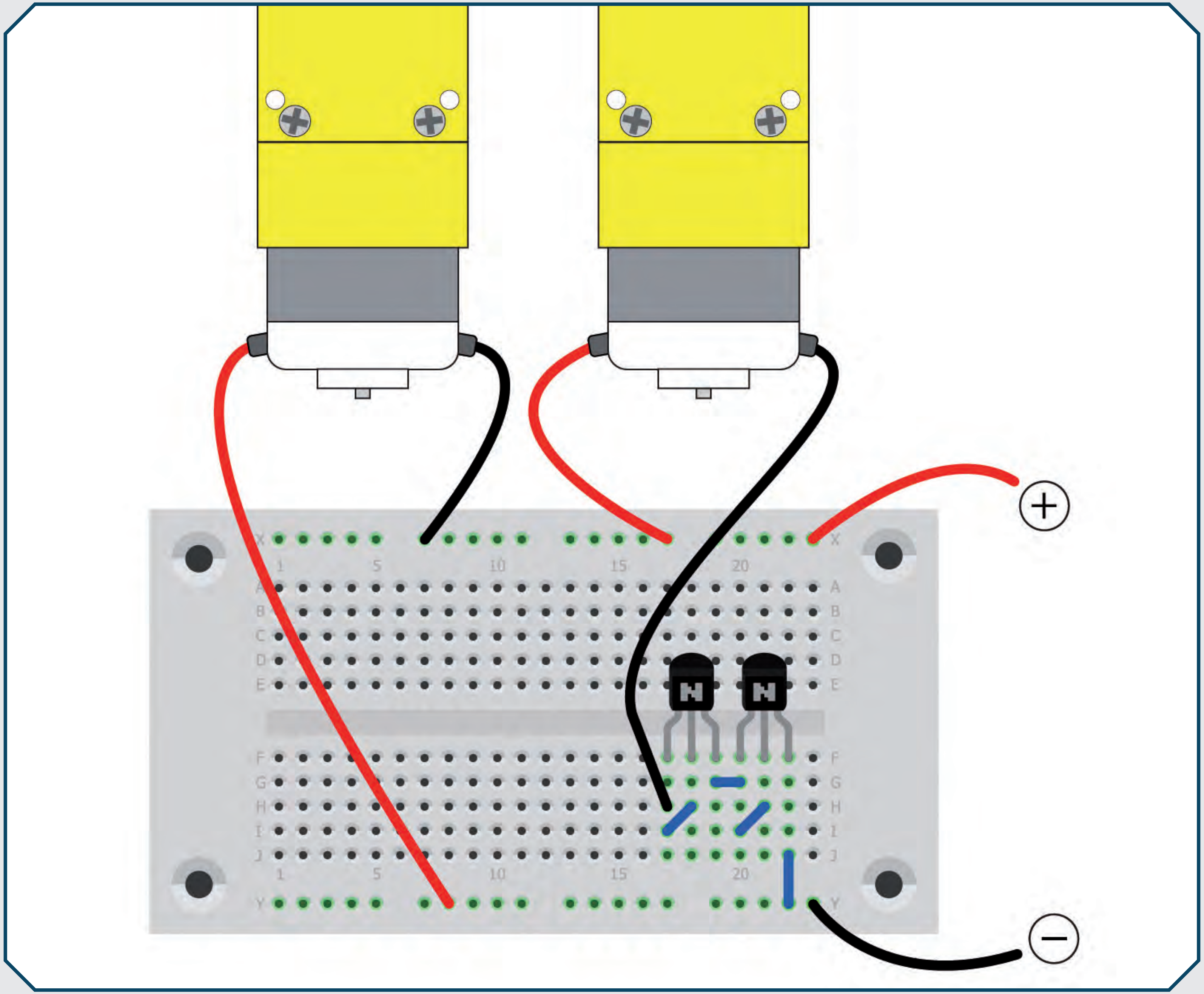
Day 18

CHANGE THE RADIUS

A little flag appears behind door number 18. Cut it out so it can will later embellish the robot's skid.

Back to the robot: Today reduce the radius of the circle. To do this, connect a second transistor in series with the first. Now the voltage drop is around 1.6 V. The circle radius is now significantly less than 50 cm.





N
N
+
−

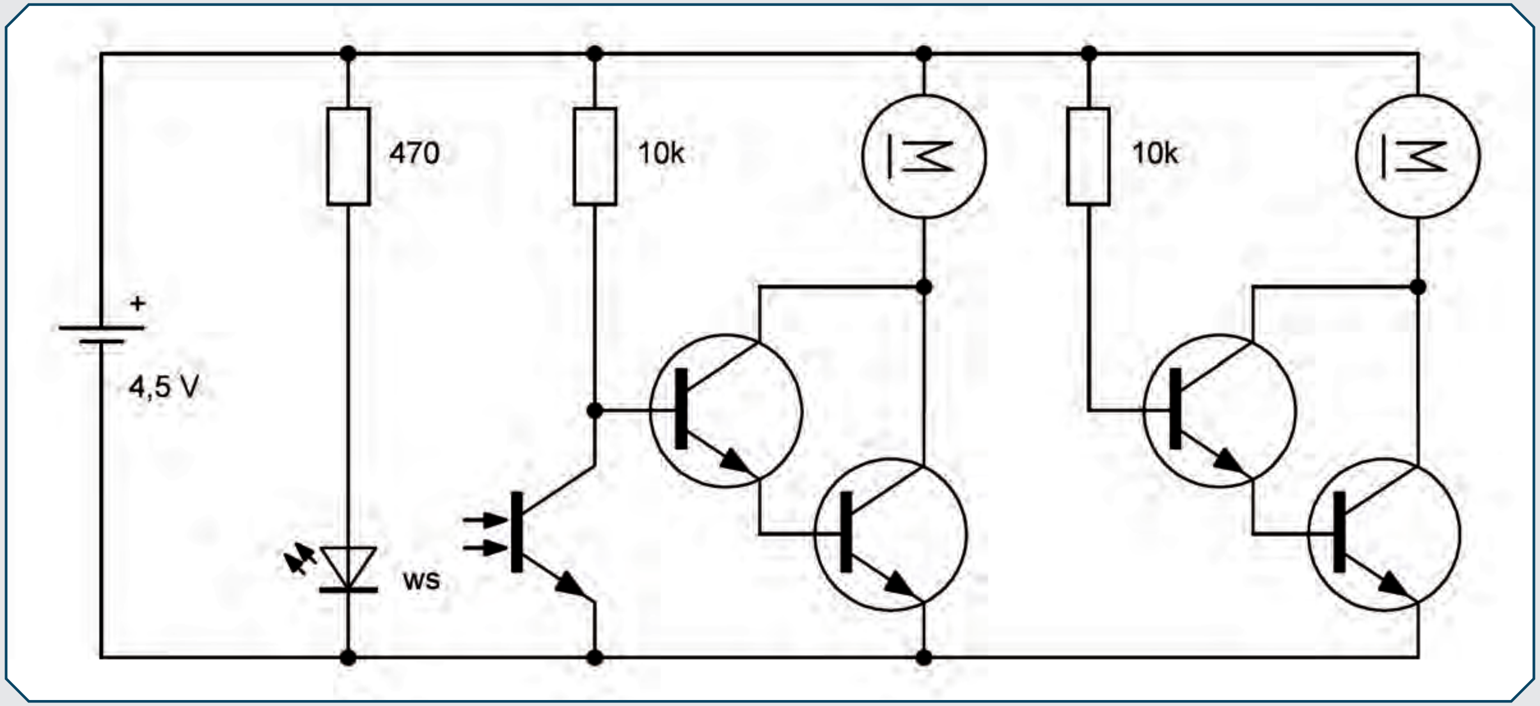
Day 19

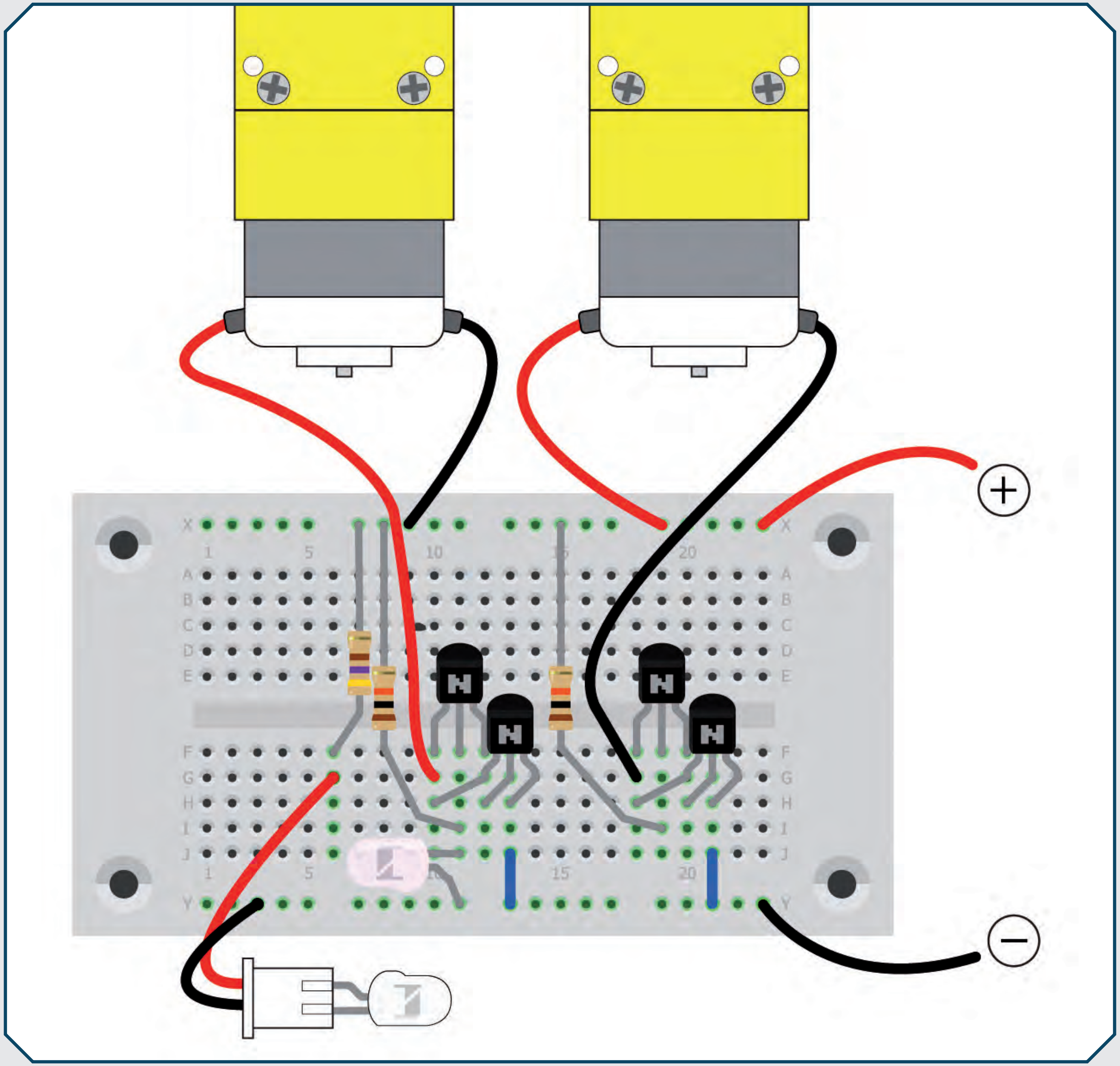
CONTROLLED DIRECTION

Compartment 19 contains another 10 kΩ resistor (brown, black, orange). This allows two identical amplifier stages to be set up so that the robot drives straight ahead in its basic state. However, one side is connected to a phototransistor that can be used to stop the motor. So when the lights are on, the robot drives in a tight curve.

The first test can still be carried out with the white LED on the cable. This can also be used to test whether the robot turns left or right when the lights are on. To change the direction, simply connect the phototransistor to the other transistors. In real use on the floor, the robot can be controlled with a flashlight. Whenever the phototransistor is hit, the robot changes direction. With a little skill, you can direct it to any place in the room. However, the room may need to be darkened a little.

If you want to automate the control even further, you can set up several lamps in the room to allow the robot to travel a defined route. Whenever it comes within the range of a lamp, it changes direction until the phototransistor has turned out of the light. With a lot of skill, you could even get the robot to drive through the same course several times.



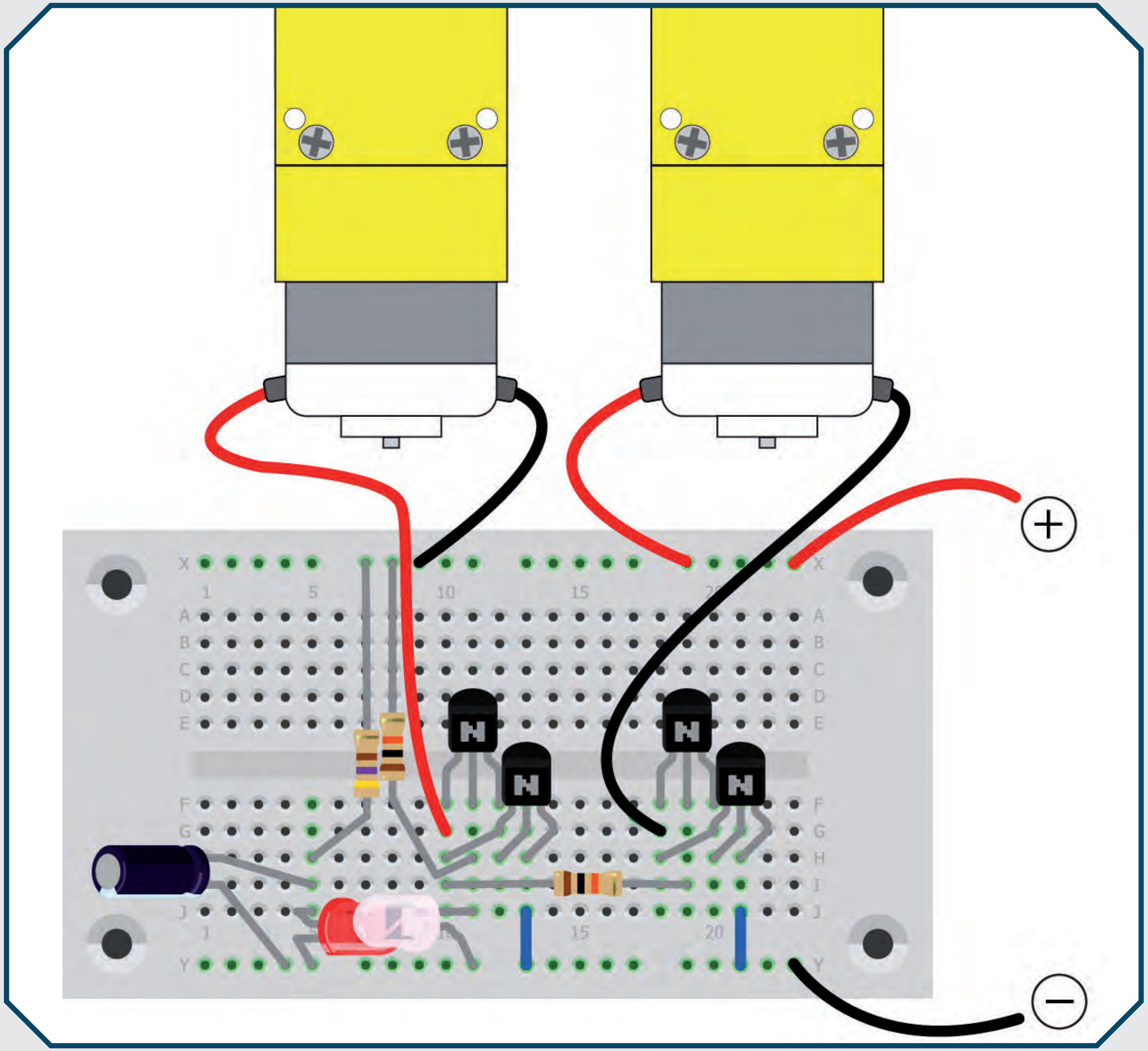


Day 20

THE WADDLING GAIT

A 100 µF electrolytic capacitor can be found behind door number 20. It’s needed to operate the red flashing LED together with the motors. This is because the motors generate pulse interference that can disrupt the steady flashing of the LED. The capacitor smoothes the LED voltage and ensures interference-free operation. This is important because the flashing LED is now the central control unit of the robot, its brain, so to speak.

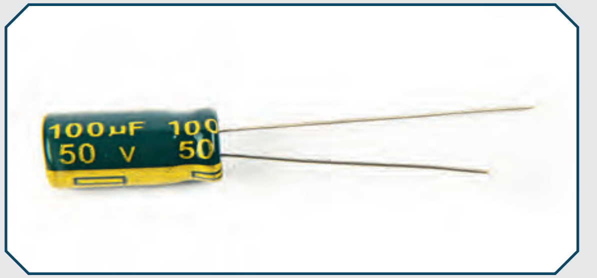
The LED illuminates a phototransistor that switches off the left-hand motor. Whenever the left motor stops, the right motor runs and vice versa. This gives the robot a waddling gait similar to that of a duck. This is still not a mental feat, but it looks impressive. The robot’s brain is nowhere near the performance of a duck’s brain and doesn’t even come close to a sparrow’s brain. There is still room for improvement!

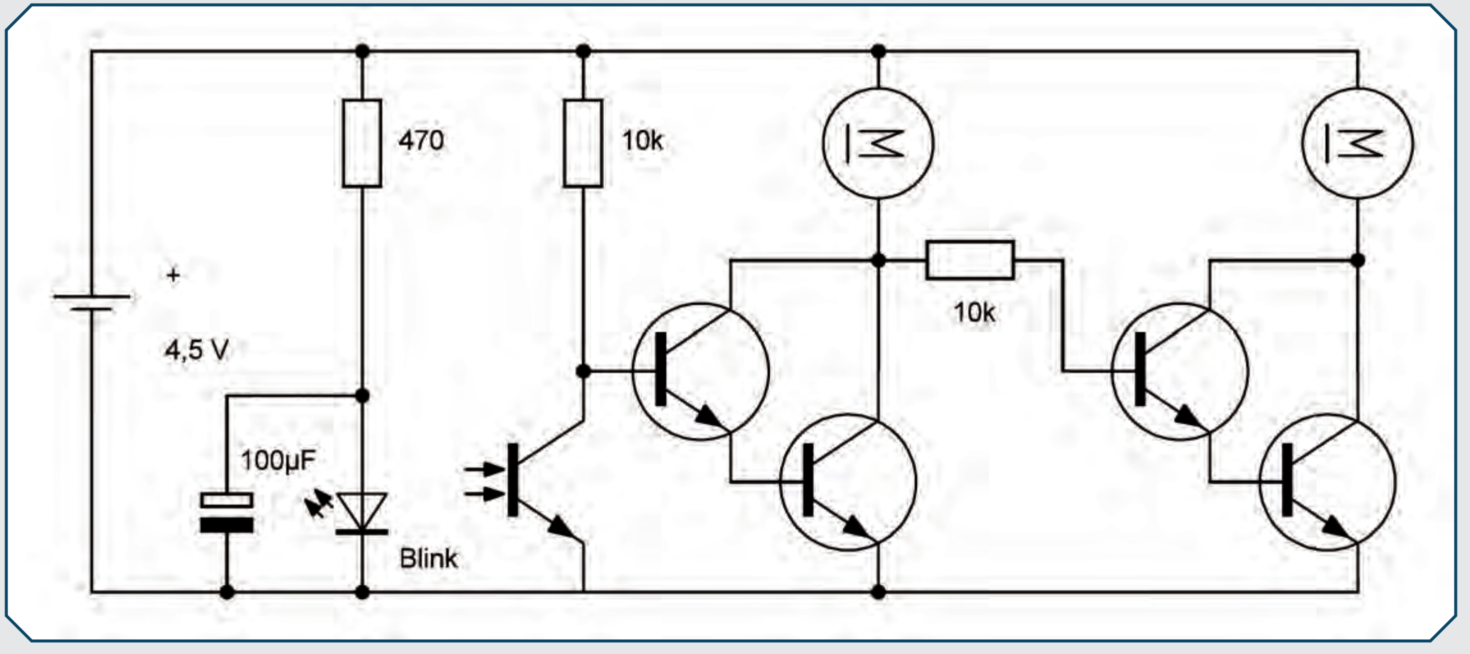


Capacitors

A capacitor consists of two metal surfaces and an insulating layer. If an electrical voltage is applied, an electrical force field is formed between the capacitor plates, in which energy is stored. A capacitor with a large plate surface and small plate spacing has a large capacitance, i.e. it stores a lot of charge for a given voltage. The capacitance of a capacitor is measured in farads (F), for small capacitors in microfarads (µF), nanofarads (Nf) or picofarads (pF).

The insulating material (dielectric) increases the capacitance compared to air insulation. Plastics or a special ceramic material are used to achieve large capacities with a small design. Even greater capacitance is achieved with electrolytic capacitors (electrolytic capacitors). The dielectric consists of a very thin layer of aluminium oxide. The electrolytic capacitor contains a conductive liquid and wound aluminium foils with a large surface area. The voltage may only be applied in one direction. A leakage current flows in the wrong direction and gradually degrades the insulation layer, leading to the destruction of the component. The negative pole is marked with a white stripe and has the shorter leg.





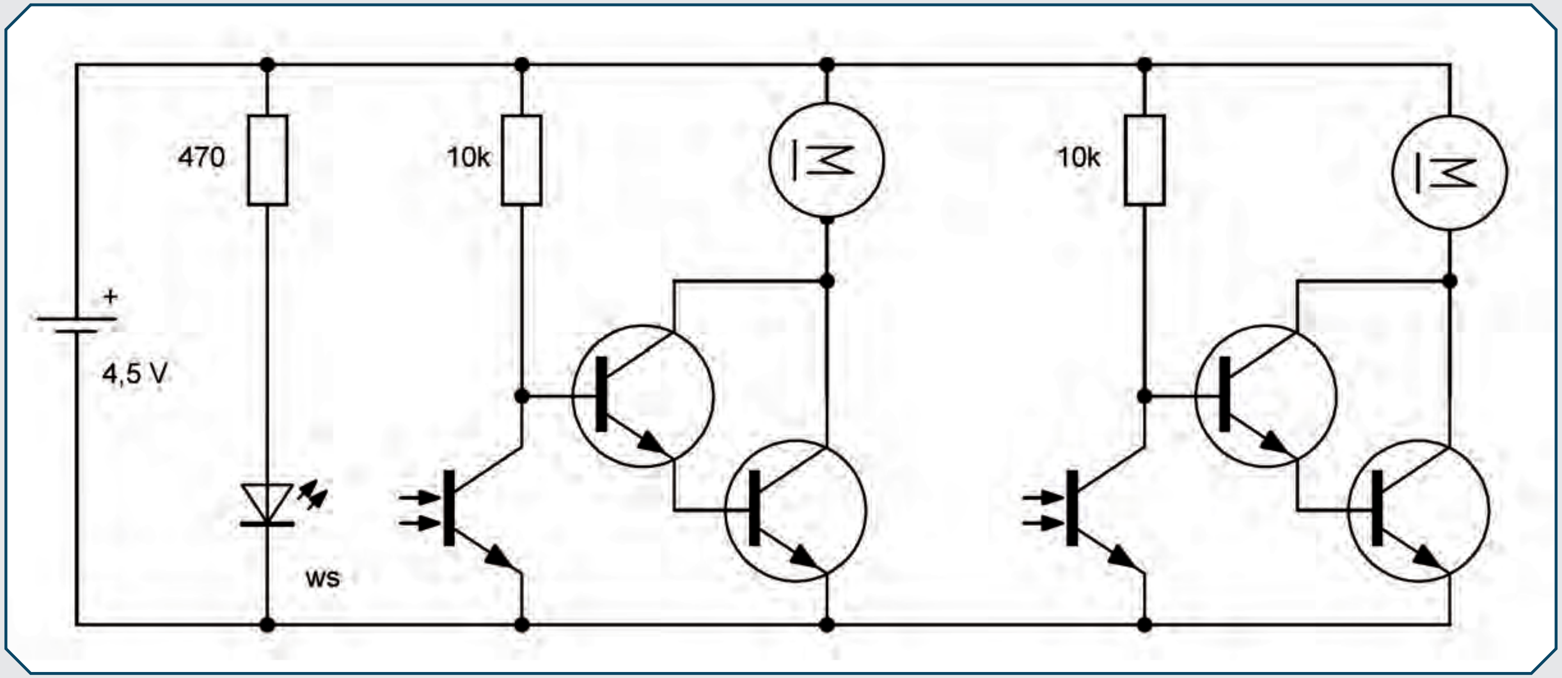
DAY 21

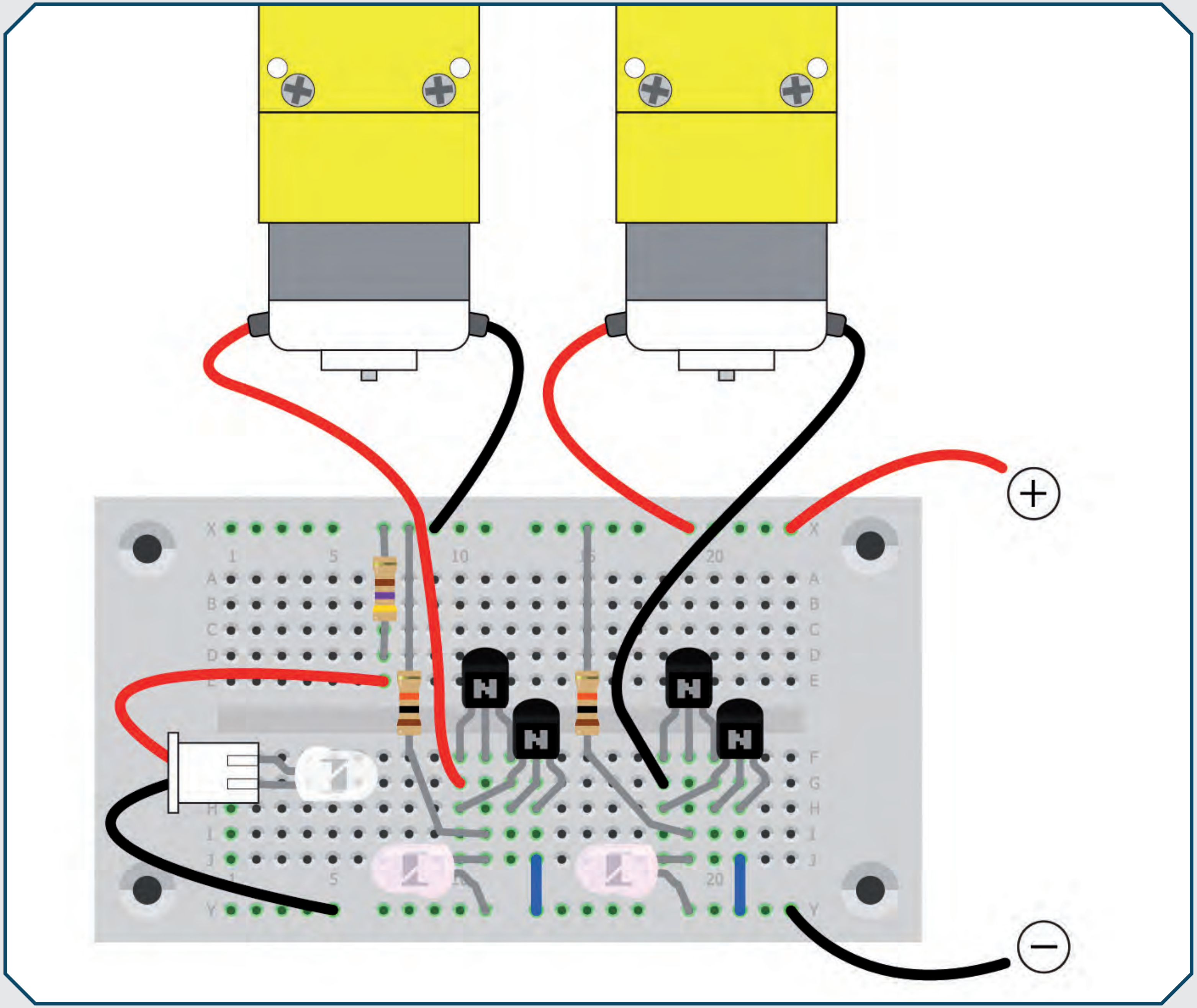
TWO-CHANNEL LIGHT CONTROL

Two more double cables with plugs and sockets are in compartment 21. This means that the phototransistors can now also be used on extended cables. This opens up new possibilities for control via light signals. The extension cables are not shown in the assembly drawings because, depending on the experiment, it is also possible to work with directly plugged-in components.

The robot is now controlled by two phototransistors that can switch off a motor independently of each other. It should now follow the black line printed on the enclosed cardboard Robot Test Track. Direct control with a flashlight is suitable as a simplified preliminary experiment. You can illuminate one of the phototransistors to change the direction. Or you can illuminate both to stop the robot.

For this experiment, both phototransistors can be placed either on the circuit board or at the end of the extension cables. The position can be changed so that control with a flashlight is possible either from above, from the side or from the front or rear.



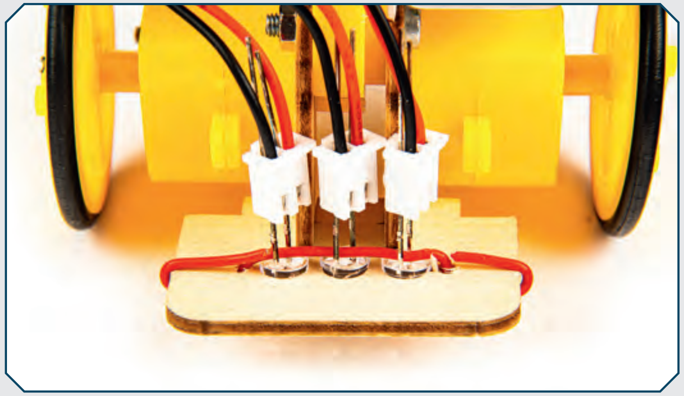


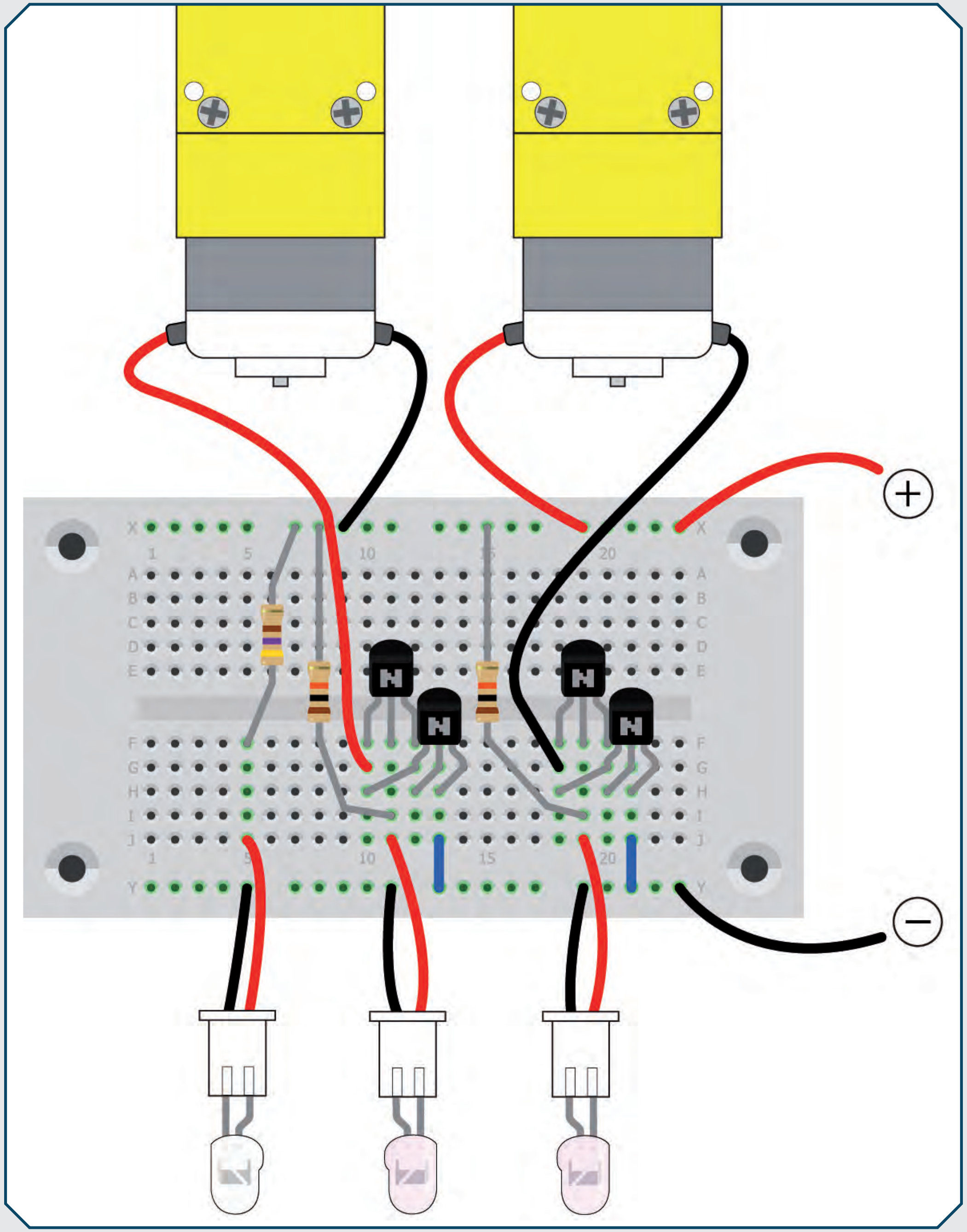
Day 22

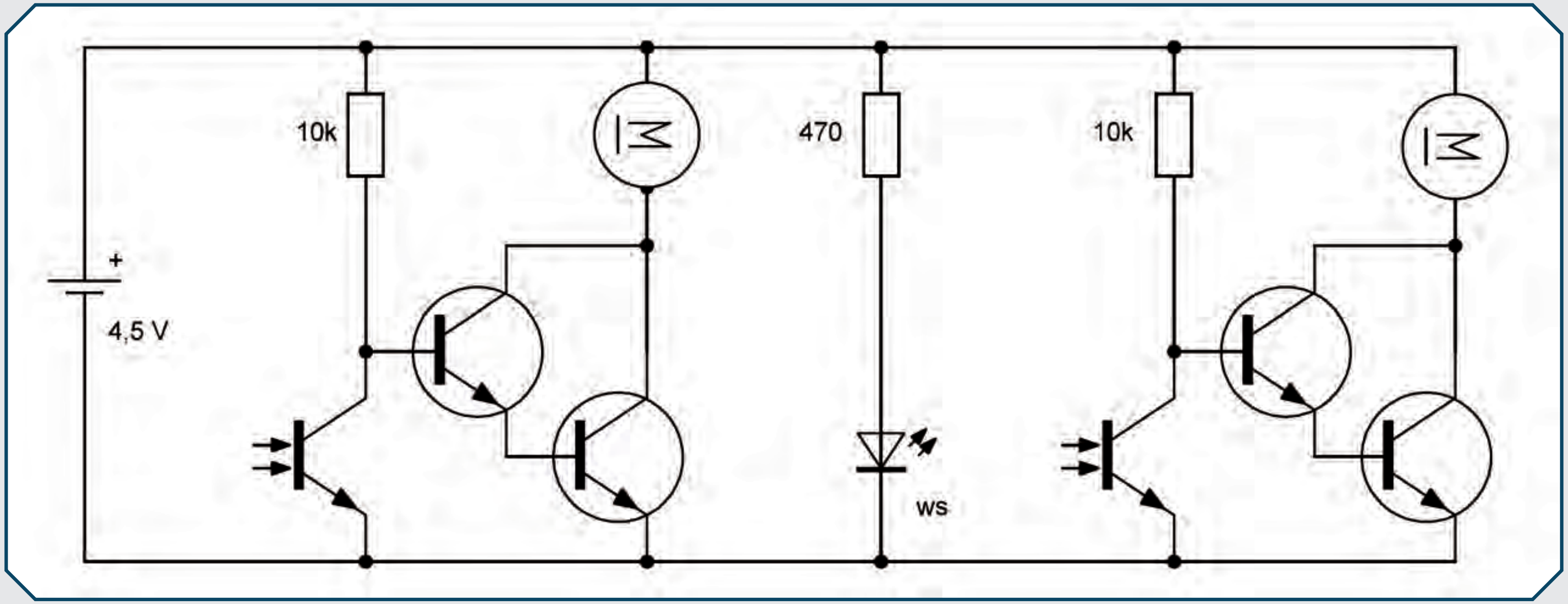
RIDING THE LINE

Today, a small plate with three holes for holding the LED and the phototransistors appears behind the door. It has two rectangular cut-outs and should be inserted into the front of the two side plates. The LED must then be inserted into the middle hole, the phototransistors to the right and left of it. Both should point downwards at the front edge of the robot and control it so that it moves exactly on the black line on the Robot Test Track.

All three components should be pressed in firmly. If necessary, they can be secured against slipping out with an additional wire fed through the side holes. At the end, the extension cables are plugged in in such a way that the black wire is connected to minus, i.e. to the short wire of the LED and the long wires of the phototransistors.







For the best performance, the LED and the phototransistors must hover as close to the ground as possible (between approx. 1 to 3 mm). To do this, you need to tilt the robot slightly forwards by bending the skid at the rear end to a greater angle. The white LED should produce a round spot of light that is slightly narrower than the black line.

If the LED hovers in the middle above the black line, the light is absorbed and doesn't reach the phototransistors. However, if there is a deviation, some light falls on the white surface and is reflected from there. The phototransistor on the corresponding side receives the light and switches off the motor on the other side so that the direction is corrected

If everything is set up and adjusted correctly, the robot should be able to follow the black line on its own. The movements are jerky, and if the settings are not quite optimal or the ambient light is too bright, the robot may jump off the track. But then it stops automatically because both phototransistors receive light. It is therefore impossible for it to take the wrong path. This behaviour corresponds to Asimov's first robot law: a robot must never injure a human being or put them in danger.

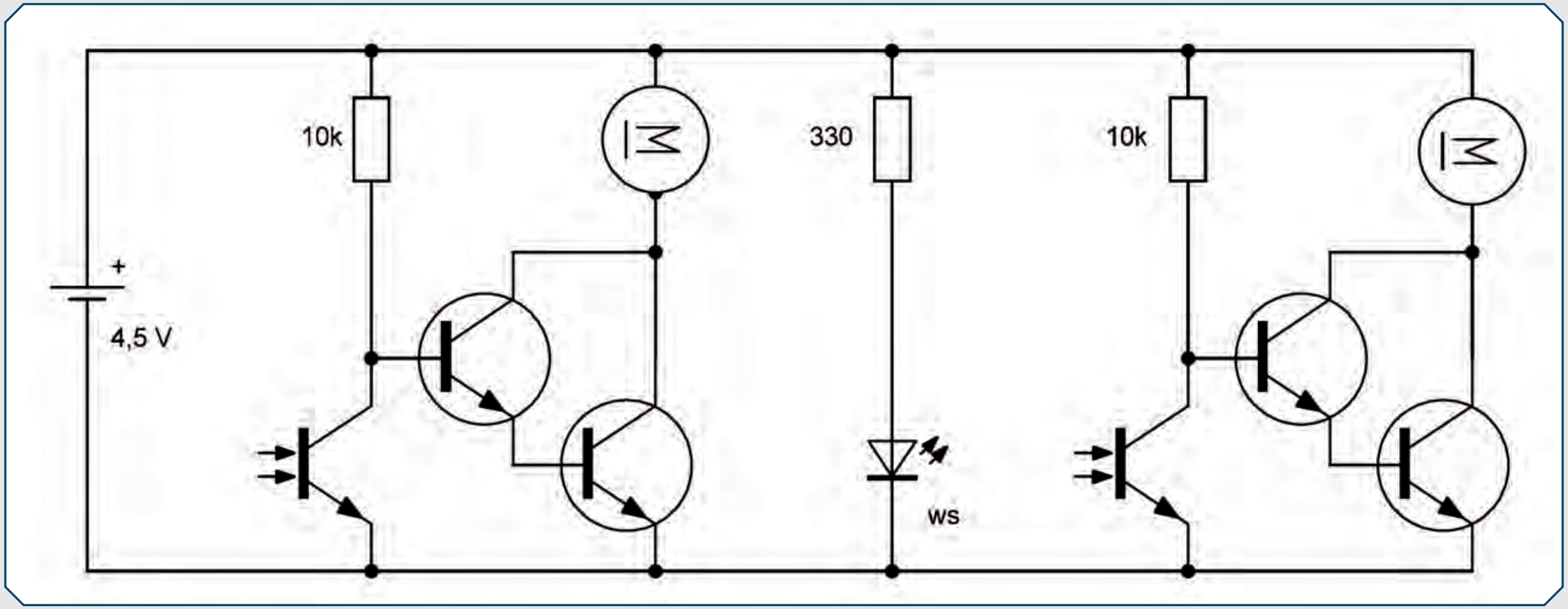
Don't forget: The phototransistor on the left belongs to the motor on the right and vice versa.

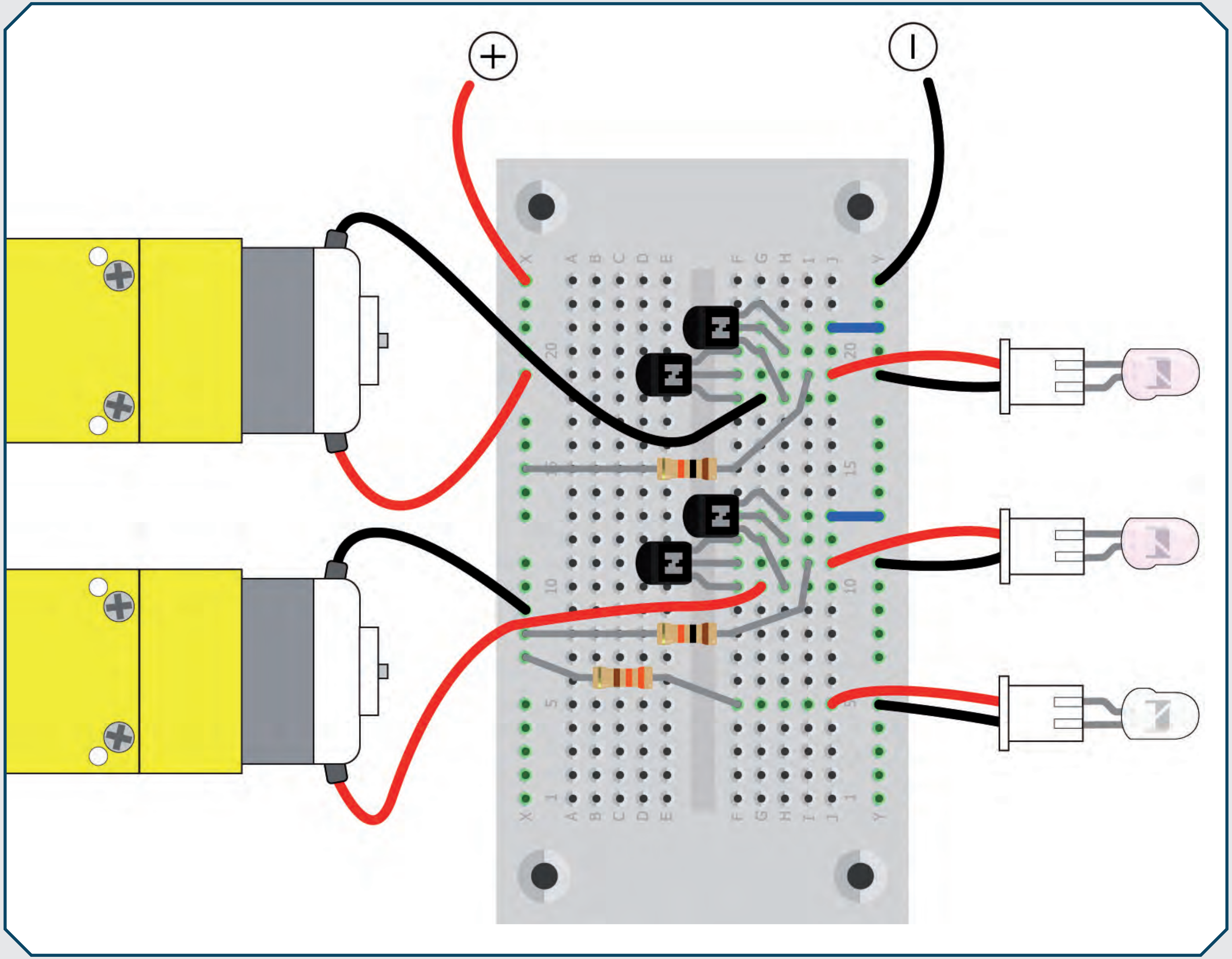
DAY 23

MORE LIGHT

On this day, another resistor appears. The resistor is 330 Ω (orange, orange, brown) and can replace the previously used series 470 Ω resistor of the white LED. This makes the LED slightly brighter. You can test with which of the two resistors the control works more reliably. This also depends on the ambient brightness of the room.

Now that everything is almost ready, the robot should fly the flag! Therefore, the flag from day 18 or today's flag should be attached to the protruding wire of the loop. Attach it with glue or tape.





Day 24

DRIVING ROUTES

Behind the last door of the calendar is a small piece of paper with a download link for different test tracks to print out yourself plus a 680 Ω resistor (blue, grey, brown). This can be used as a series resistor for the white LED to test another variant of the brightness setting, or alternatively as a series resistor for the red flashing LED. It's installed as the last modification to draw attention to the robot when it's operating.

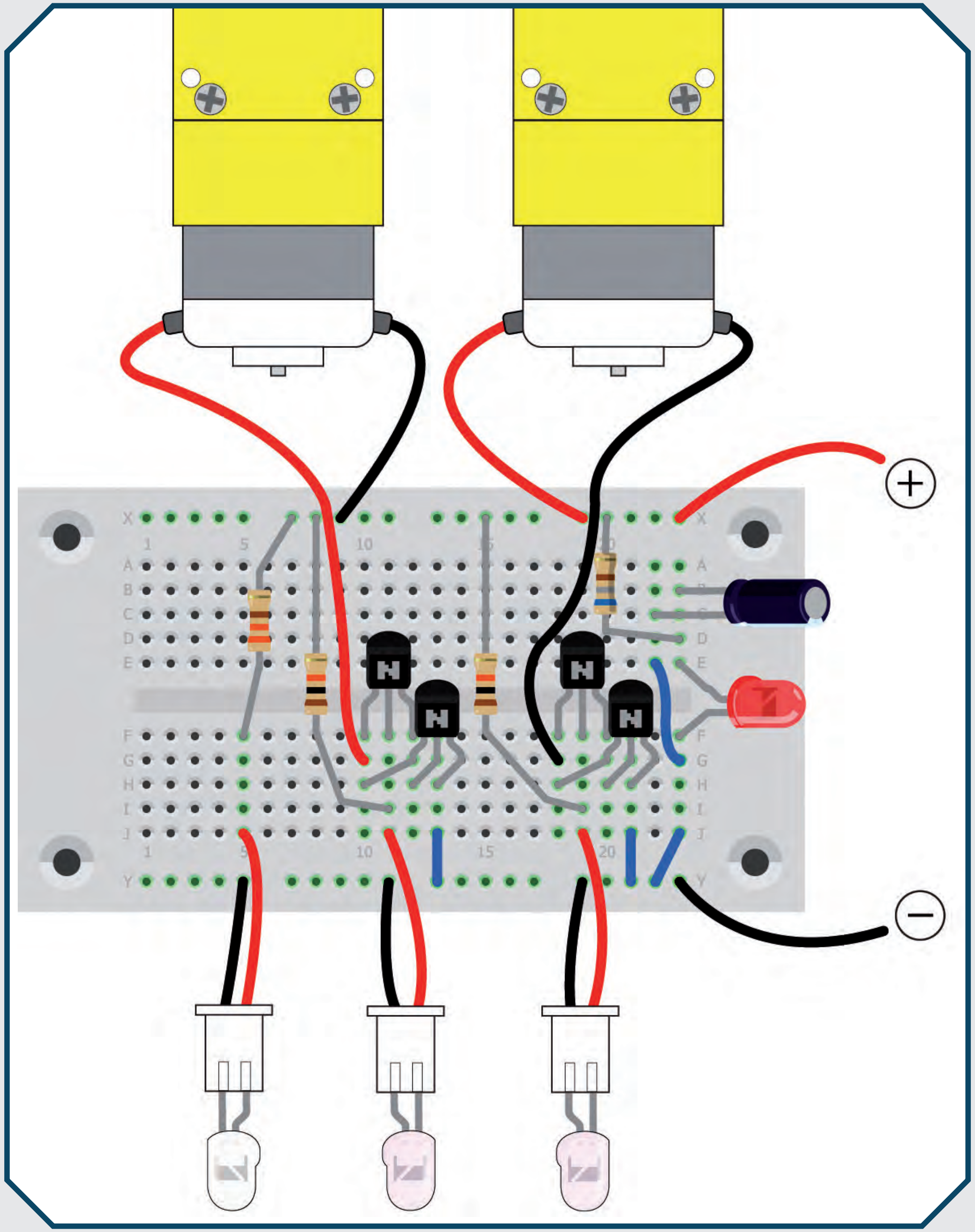
This will allow the robot to cover longer distances on a self-printed course or throughout your home. All you have to do is lay out a paper track with a black line. Who knows, maybe it can then make itself useful and deliver written messages or small gifts to other member of your household?!

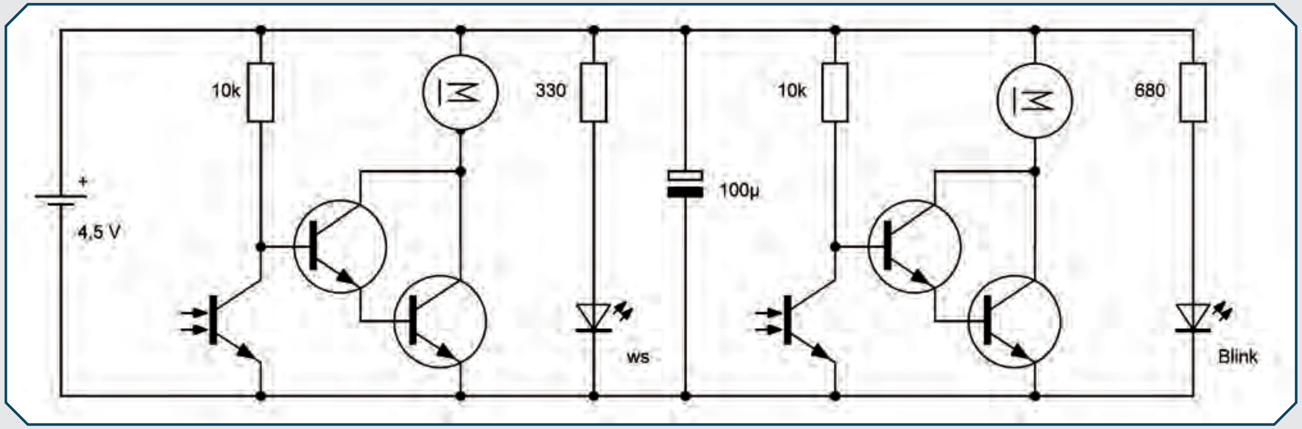
The switch on the battery box is also very important. Everyone who shares their living space with a robot must know where the power switch is and be able to turn it off at any time.

Countless science fiction movies have shown what can happen if you don't!

The very last thing to do is cut out the printed robot bodies from the included cardboard sheet. Fold and glue (or sticky tape) the pieces as shown, then simply drop the body of your choice over the electronic assembly. The cut-out arch-shapes at the bottom should mount onto the axles of the wheels.

Finally, enjoy your robot!




10k
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330
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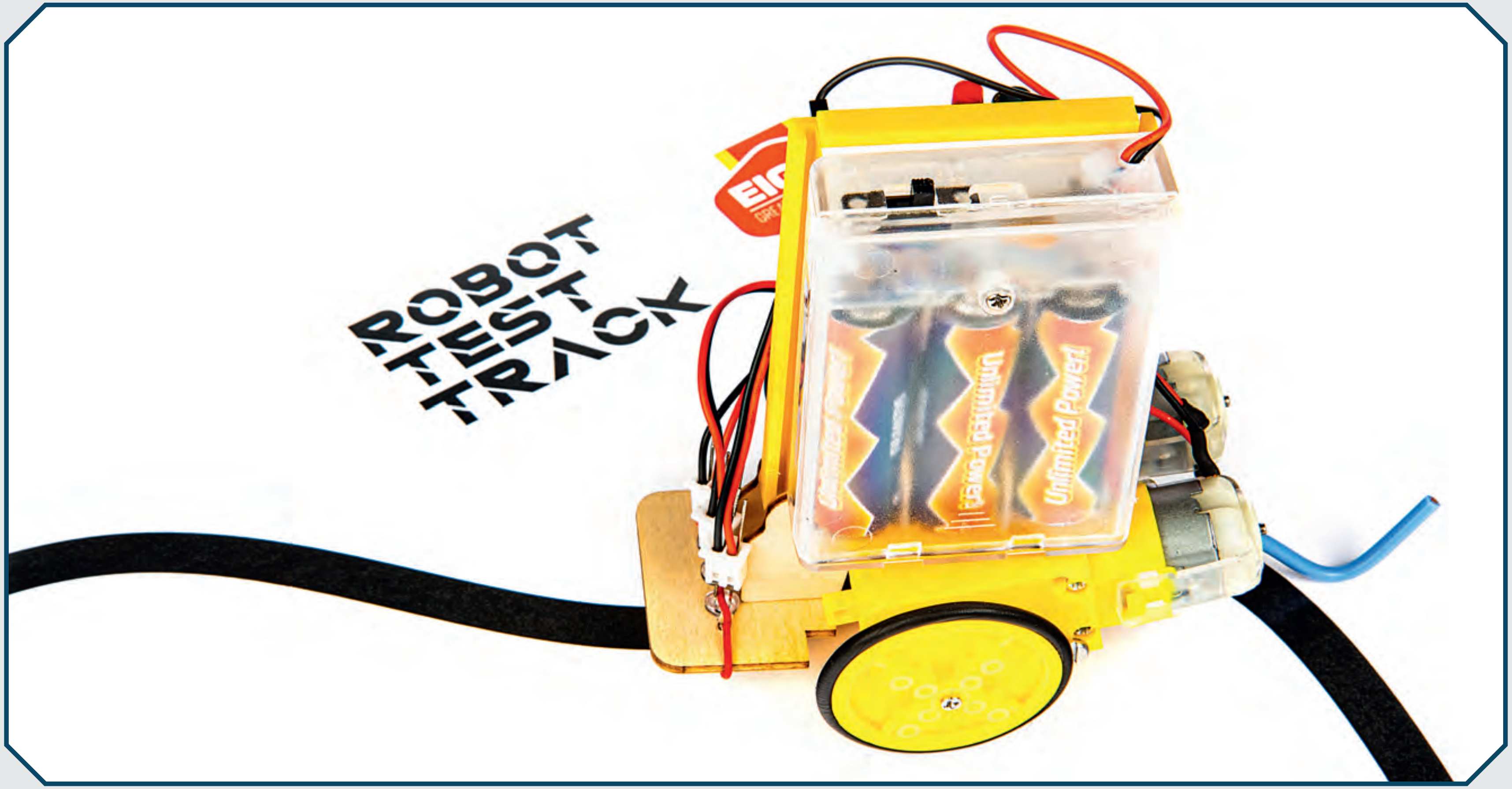
10k
M
680
4,5 V
ws
Blink


ROBOT
TEST
TRACK
Unlimited Power!
Unlimited Power!

TROUBLESHOOTING

What to do...

... when nothing works:

- The batteries could be flat. A test with LED and series resistor provides an initial indication. However, this is not always sufficient, as a dead battery may still supply 1 mA, but this is no longer sufficient for the entire circuit.
- Small mistakes can easily occur when making connections on the breadboard. Double check what you've built with the diagram and the photos. It's always helpful to get someone else to check it over as well. Four eyes are better than two!
- There may be a contact problem if a wire is not pushed into the breadboard deeply enough.
- A transistor could be installed the wrong way round.
- A phototransistor could be installed the wrong way round – the long leg is the emitter.

... if an LED does not light up:

- The most common fault is incorrect polarity – the LED is mounted the wrong way round. The negative leg is the shorter one.
- An LED only lights up from a certain voltage, from 1.6 V to 2.5 V depending on the colour.
- A wiring mistake could be the cause. Double check the circuit.

... if a motor doesn't run as expected:

- The batteries could be low.
- It could be due to a wiring mistake in the circuit.

... when a component gets hot:

- Quickly slide the battery case switch to "OFF"
- This is usually due to a short circuit.
- Some assembly error or mix-up of the resistors could be the reason.

... if you think that one components could be faulty:

- LEDs and transistors can burn out due to overload.
- Building the circuit from a previous day can help identify this. You should repeat a circuit that has already worked.
- If the component still works in a basic test then it's not defective. Re-check the circuit you've assembled against the diagrams and photos.

Imprint

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&
FRANZIS GmbH, 85540 Haar, Germany
Made in P. R. China
2024/01
Author: Burkhard Kainka
Product Management: Tobias Schärtl
Layout: PC-DTP-Satz und Info GmbH
Art & Design (Cover): ideehoch2

UKCA This product was manufactured in accordance with current EU guidelines and therefore carries the CE mark. Its authorised use is described in the accompanying instructions.

CE You alone are responsible for complying with applicable regulations when carrying out any modifications to the product or using it for any other means. Therefore, build the circuits exactly as described in the instructions. The instructions must be provided when giving this product to other people.

Disposal and Recycling Information

The consumer has a significant role to play in reducing the impact of waste electrical and electronic equipment through the re-use or recycling such products. If you are unable to re-use or recycle your product it should be disposed of at a civic amenity site/local authority recycling facilities. More details and the recycling of electrical waste in the UK, including details of your nearest collection site can be found at www.recycle-more.co.uk

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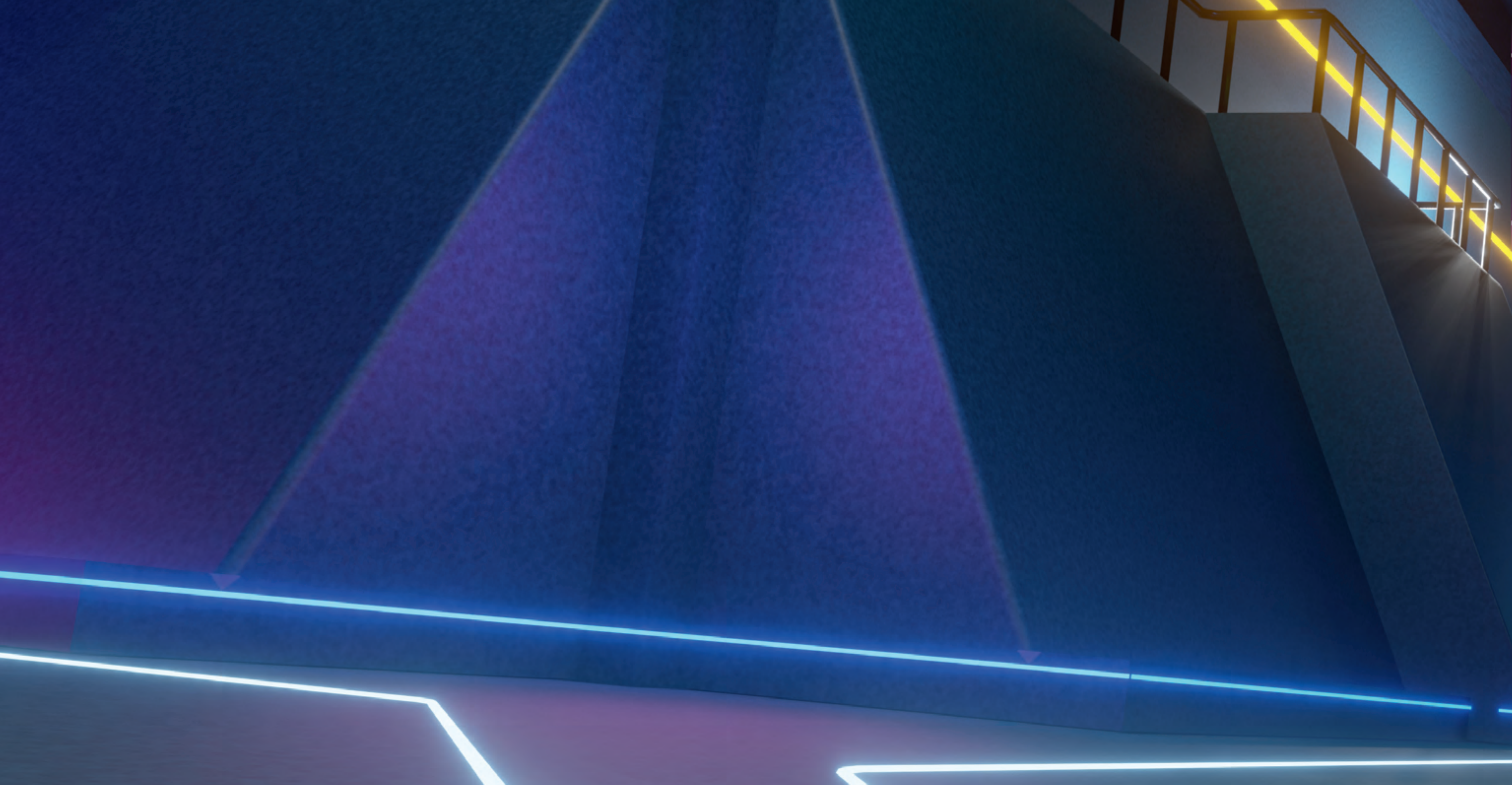
Waste Electrical and Electronic Equipment (WEEE)

The crossed out wheelie-bin symbol on this product is to remind you that waste electrical and electronic products, batteries and accumulators should not be disposed of with household waste. Same of the components used in electrical and electronic equipment may contain hazardous substances that can damage the environment and present a risk to human health if not properly disposed of.



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Contents may vary from those shown in the photographs

Made in P. R. China

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2024/01

Item no. E67161

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