fischertechnik® ec

Electronics

Instruction Booklet

Art. No. 6 39023 5 E

In order to be able to build the models described herein you require the Basic Kit 200 and the Motor Construction Kits mot.1 as well as the Electromechanics Kit em. (By the way, the latter corresponds to our previous Building Kit em 2, complemented by a push-button switch from the Extra Pack em 3.) For a power supply we recommend the use of our power units mot. 4 or mot. 8. Please do not use any railway transformer instead of our fischertechnik power supply: The electronic building blocks could be destroyed.

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Preface

The fischertechnik Building Kits form a system offering, to the user, many years of creative delights. This system begins with the kits for mechanics and statics and, via the electromechanical field, leads right up to electronics.

The fischertechnik Building Kit ec comprises the area of controlling, regulating and monitoring. The models which you will be able to construct with it are simple automatons capable of performing their tasks independently. Even today, the development of automatically operated machines is in full swing. It eventually includes machines referred to as "robots" because they are fitted with artificial sense-organs which enable them to act on the strength of their own perceptions. Your Building Kit ec, too, contains some of these organs of sense: a photo resistor used as an artificial eye, and a temperature-dependent resistor employed as a sense-organ which responds to the effects of heat.

No special know-how is required to construct these models. Therefore only a few short examples of use will be described in this booklet in an easy-to-understand way, and we are sure that you will soon have acquired enough skill and know-how to design and build up further interesting model systems.

Above all, the fischertechnik kits are designed to give everyone pleasure. In the stimulating hours spent in their company you will, quite incidentally, acquire a lot of knowledge – not only about electronics and automatic systems technology but also about the way to solve technical problems.

And now enjoy yourself with your fischertechnik Electronics!

The Rectifier Building Block

Electronic basic circuits cannot be operated with the ac voltage which is available at your wall socket. On the one hand, this voltage is much too high and dangerous to life, and, on the other hand, one requires a pure direct voltage such as is made available by batteries. Since batteries are quickly used up, however, the best thing to do is to use a fischertechnik power-supply unit (mot. 4 or mot. 8). In combination with the Rectifier Building Block of the ec kit you can now obtain the necessary pure dc voltage which corresponds approximately to the voltage of a 9-volt battery.

It does not matter whether you connect the rectifier-module jacks marked with the symbol for alternating voltage (~) to the dc or ac voltage jacks (present only at the power unit mot. 4). At the rectifier-module jack identified by "+" the is always positive electrical potential whereas negative potential is available at the jacks defined as minus or "–". Attention: You should never connect the "+" and "–" jack directly with the power supply; this might harm the Rectifier Building Block.

Internal circuit arrangements of the Rectifier Building Block can be seen from the symbols imprinted on it. One sign is repeated 4 times:

The arrow and the transverse stroke symbolize a blocking or cutoff condition. This component, a so-called diode, allows current to pass in only one definite direction.

In order to prove that current can flow through only in one direction, that is to say "rectification" takes place, the motor can be used. Please connect it to the "+" and "–" jacks (electrical symbol:  shown on the rectifier module) of the Rectifier Building Block. The motor will then always turn in the same direction even if you exchange the connections coming from the power unit.

This kind of rectification occurs also in the power supply packs mot. 4 and mot. 8. In addition, a large capacitor ensures that the voltage available is smoothed as in the case of a battery.

Rectifier

Power Supply mot. 8 Power Supply mot. 4 Building Block

The Relay Building Block

The switches which we know from our household are operated by hand. In electrical systems, particularly in automatically operating installations, switches which can be electrically actuated are necessary. The relay belongs to this type of switch. It essentially consists of an electromagnet and of electrical contacts which are brought into operation by the

magnet's armature as soon as current is sent through the winding of the magnet. With the aid of the Building Kit em you will already have constructed such a relay. As the name implies, our Relay Building Block, too, has such a built-in electromagnetic switch.

The internal circuitry of the Relay Building Block is imprinted onto the front plate. You will notice a new sign, a rectangle with a triangle inside it, the electrical symbol for an amplifier. We shall, however, not dwell on the circuit conditions of the amplifier here. From the diagram it can be seen which contact springs touch each other, that is they are closed when current does not flow through the relay coil.

For demonstrating the mode of operation of the Relay Building Block you are invited to construct the circuit shown on the opposite page. By inserting the red connecting plug between the Relay and Rectifier Building Blocks the relay module will automatically be made ready for operation.

An "on" push-button switch is attached to the "E" jack and to one "–" jack. When pressing the push-button, current flows through the coil of the relay, the relay picks up as the expert would say. The click which is heard is actually caused by the motion of the armature. When you release the push-button again, the relay de-energizes or it drops out.

With the aid of a lamp you will be able to confirm what the circuit diagram has already conveyed. One jack of the luminous-lamp holder is connected directly to the power supply. The other jack will be joined to the power unit via the connections $a_1 – a_2$ (see Wiring Diagram). The lamp illuminates when the relay has not picked up. The connection $a_1 – a_2$ is normally called closed contact. If you then connect the lamp to the power unit via $a_1 – a_3$, the exact opposite is going to happen. Now the lamp is on when the relay has picked up. That is why $a_1 – a_3$ is normally called open or make contact unit. Try this out, too. When use is made of all 3 connections as shown in the circuit diagram, this would be referred to as a changeover contact.

The relay armature in our Relay Building Block has 2 of these contact systems. You can prove to yourself the fact that the contacts designated by "b" operate in the same manner as the others.

page 8

The Artificial Eye

Doors opening and closing by themselves are known to belong to the favourite outfits of ghost castles in horror stories. What is caused there by the intervention of good or evil spirits is achieved by the technology of the present time by its own means as well. In department stores, railway stations and airports such doors are well-known and they are even more expedient than the doors moved by a spectre's hand, because they will open whenever somebody wishes to enter through it. Consequently, the door-opening system requires a device which is capable of determining when someone approaches the door – the best thing would be some artificial eye. And, as a matter of fact, we can avail ourselves of such technical sense-organs.

The "artificial eye" of engineering is the photo resistor. It consists of a material which considerably decreases its electrical resistance when it is exposed to light. Thus, a photo resistor can be taken as a switch that will close under illumination and open in darkness.

The principle of operation of a photo resistor can easily be shown when we install a photo resistor, instead of the push-button switch, in the circuit previously designed for lamp control. This is implemented in the model of a street lighting system below. The circuit diagram also shows the symbol used to represent a photo resistor, a rectangle with two arrow-heads incorporated:

And now you can test the function of the circuit and convince yourself! Illuminate the light-sensitive area of the photo resistor and observe whether or not the lamps come on.
And then obscure the photo resistor. The lamps which did not come on just now will light! This means that we have already built a fully automatic lighting system.

The Building Kit includes black "light-protective caps" with differently large holes. By placing these caps onto the resistor you can actually determine the degree of darkening at which the lamps are to turn on.

Light

electrical symbol.
of a
photo resistor

The Invisible Barrier

In the previous model the artifical eye, our photo resistor, was used to observe the conditions of light present in the surroundings. But we can also utilize it as an aid for monitoring, for instance in order to ascertain when an unwanted visitor approaches.

If the person has to open a door in the· process, the matter is fairly simple: the only thing required is to attach a contact to the door and that contact will close as soon as it is opened. Furthermore, this contact may serve, for example, to bring into operation an alert or a bell. Some kind of floor contact might otherwise be employed for a safeguard in cases where the door is to remain open for any reason. However, a much more elegant solution is offered by use of the light barrier. For this, we need nothing more than a photo resistor and a lamp illuminating it.

Before you have a go at building this circuit, please note the following remark: We recommend that the owners of the power supply mot. 4 connect the Rectifier Building Block to the ac voltage jacks laterally attached to the supply unit. The lamp for our light barrier, however, will be connected to the dc jacks of the power supply.

Afterwards, you can decide how to vary the brightness of the light barrier by means of the rotary control knob without affecting the operating voltage for the electronics. The same applies to the red pilot lamp.

Another practical hint: Do not connect the power supply to the

electrical system until the circuit is finished. Before putting the plug into the socket you should verify that all connections have been properly established!

And now you can build up the model of your monitoring equipment. In case someone traverses the light barrier hidden behind the door, he will obscure the photo resistor. (You can simulate this condition by covering the resistor with a component from the kit.) The current in which the relay coil is located will be interrupted, the relay drops out and a red pilot lamp connected to the power supply unit via the NC contact $a_1 - a_2$ will come on. That lamp indicates that someone has gone through the opened door.

You are free to extend this installation. For instance, an additional green lamp might be inserted into the circuit in such a manner that it will light only when the red lamp is off. It would thus indicate to you whether or not the installation is ready for operation.

page 12

Safeguarding against Thieves

A more refined application of the light barrier is known to you from the fight against crime. Particularly valuable objects, e.g. stamps or precious stones, can be safeguarded in such a way that they are free to be admired by the spectators in an exhibition but will be protected as soon as anybody comes up too close. Protection can be provided in two ways: on the one hand, an alert is caused, for example by means of a red alarm lamp or an audible signal. Such an alarm system could be extended by connecting a motor which operates a bell clapper. On the other hand, the object of value can be removed from the grasp of any potential thief by automatically enclosing it in a trap lid or door.

For our purposes, a paper-clip, an india-rubber or a fischer-technik component can be used as the "valuable object". It will be placed in a recess; in front of it, a transverse light barrier will be built up in just the same manner as has been done for the door safeguard. The connection of the red alarm lamp is identical, too.

Simultaneously with the illumination of the alarm lamp, the falling of the trap door must be initiated. This is not difficult to effect. The trap will be retained by an electromagnet as long as the light barrier is uninterrupted. This means: The magnet is to be connected to the power supply via an NO contact of the relay. When the beam of light is broken, the relay will switch off the electromagnet; the trap is going to fall down and lock the recess. As shown in the wiring diagram, the holding magnet as well as the alarm lamp are connected to the power supply pack. You can increase the holding force of the magnet by connecting it to the plus and minus jacks of the Rectifier Building Block via the contact $b_1 - b_2$.

Please try to draw the circuit diagram yourself.

Alarm systems of this kind can also be used for more harmless purposes. For instance, you might protect some sweets against access from children's hands, or you could determine whether a waiting visitor snoops about your private mail on your desk.

page 13

Automatic Counting System

The increasing utilization of electronic equipment has caused many people to fear that with it the supervision and control of man would become even more intense and that their personal freedom be further restricted. These apprehensions are not completely unfounded; as a matter of fact, there are quite a few refined possibilities of observing people without their noticing it or knowing it. We shall now construct a harmless system of this nature. It is an automatic counting system similar to those often used to determine the number of persons who, for instance, pass the gates in an exhibition.

A thin paper tape has to be glued onto the electromagnet or onto the iron plate since otherwise the control lever, as a result of the "rest-dual magnetism", will not release of its own. Via the NC or the NO contact, the magnet can be attached to the power supply or to the plus or minus jacks of your Rectifier Building Block.

Instead of the self-built counting mechanism you could also use the fischertechnik counter em 6. It is individually available and counts from 0 through 20.

Our model which is to illustrate the principle of construction only can count up to 40. The drive is effected by a control lever through an electromagnet which is controlled by a light barrier. You have to adjust this lever in such a manner that one arm (shown right in the picture) is heavier than the other. This is accomplished by moving the axles which are slid into the grooves of the basic building blocks. When the magnet is turned off, the right-hand arm of the lever must fall down onto the stop surface. A gap appears then between magnet and iron plate. This gap must be sufficiently large for the top of the control latch to cover a stretch, upon magnet pickup, which is somewhat longer than the distance of the tops of two gear-wheel teeth. Correctly setting the gap is done by shifting the magnet or the stop surface to and fro. The safety catch will maintain the gear wheel after each motion in its new position.

also see pages 16 and 17

safety catch

stop surface

control latch

control lever

without
dial

building stage 1

building stage 2

Long-Range Light Barrier

Perhaps you have noticed that in the light barriers which you have constructed so far the distance between the lamps and the photo resistors had to be relatively small for the light barrier to fulfill its purpose. This is caused by the fact that the lamp constantly radiates its light uniformly to all sides and that only a small portion of it can be made use of the resistor (Figure 1). The quantity of light incident on the light-sensitive area of the photo resistor will decrease as the distance becomes larger. And one would soon reach the limit of sensitivity. The entire circuit would then not be functional.

Light barriers having a long range can be built with the help of the lens lamp. This is a bull's eye lens placed onto the bulb of an incandescent lamp. It catches a portion of the radiated light and aligns it in parallel. This concentrated light will then be emitted in the shape of a beam whose brightness will decrease slowly as the distance rises (see Figure 2).

As is the case for any optical arrangement, this circuit, too, must be "adjusted" before it can be brought into operation. This means that the direction of the light rays requires a finer adjustment. For this purpose we shall have to use movable components; we will avail ourselves in this instance of the building blocks with the rotating (red) pivot. In order to observe the spot of light, a grey and weakly brilliant cardboard box with a hole in its center will be used.

The box will be positioned in front of the photo resistor so that the latter is located exactly behind the hole. With one of the rotatable building blocks the horizontal line will be set whereas the other block is employed to adjust the vertical until finally the light spot which is often a longish shape falls precisely on the photo resistor.

Now, the installation is ready for operation. You are in a position to study by experiments what light-barrier ranges can be achieved by it. Check also how the various light-protecting caps affect the range!

The lens lamp has enabled you to effectively secure and safeguard the doors and windows of your home. Of course, you will not use the component parts of the fischertechnik System to erect a permanent installation. However, there might be special cases where a light barrier will render good practical service to you.

Fig, 1

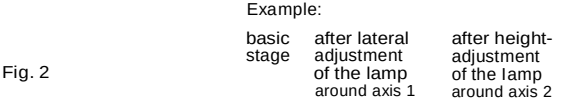


Fig. 2

1. Luminous-lamp rotatable
2, Luminous-lamp holder vertically rotatable and slidable

The Duped Thief

With the aid of the lens lamp you are in a position to construct many variations of alert and safety systems which are all

based on the principle of the barrier of light. When the lamp is removed from sight. the devices used can be mounted in such a way as to be invisible to the outsider – and then, of course, the effect of surprise is greater. (But please do not work with the protective caps here, they will heat up too much!)

In the model depicted on the following pages the "object of value" has been chained to an iron plate by means of a string. The plate has to be suspended to the magnet. It will be retained as long as the light barriers remains uninterrupted. As soon as someone reaches out for the valuable object, he will break the light barrier and the magnet will release the iron plate. The plate falls down and, via the string, it removes the object from the field of view of the thief. This will function properly only if you have chosen the correct length of string. At the same time, the lamp will go out. (The string is carried around the rear side of the model and is therefore concealed to a large extent to any observer. Again, it is necessary to firmly glue a paper strip onto the iron plate or the magnet.)

The model shown is enclosed by fischertechnik covering plates. For its accurate construction you require four 010 and one 011 Extra Packs. The photo resistor cannot be seen from the outside because it is fitted below the base plate. A lens serves the dual purpose of light source and illumination of the valuable object.

In the circuit and wiring diagrams you will recognize a push-button switch whose function will perhaps not be evident to you at first. When you press the push-button, the photo resistor will be bypassed. This circuiting arrangement is necessary because, as you know, after turning on the power supply no current can flow through the magnet and the lamp of the light barrier. Therefore, in order to connect the iron plate to the magnet, you must press the push-button switch. We shall call it "start button".

This installation can be extended in many ways – for example by hooking up an alarm lamp through the unused contacts of the Relay Building Block.

Also, the installations built by you can be used to playful and humorous effects. Thus, for instance, you might design a cigarette container which removes the cigarettes from the reach of anyone trying to fetch one.

page 21

Wiring Diagram
Building Stages 1 and 2
see Pages 22 and 23

page 23

building stage 1

page 24

Remotely Controlled Vehicle

The locomotive without engine-driver and the aircraft without pilot are no longer Utopian nowadays. Nevertheless it appears very fascinating when we observe how a passenger airliner approaches the airport in fog, riding on a radar guidance beam.

Radar is not available to us here, but what we can actually do is to implement the remote control of vehicles by means of normal light.

Again, a photo resistor is the important element of our arrangement. It controls the drive motor. Depending on the circuit chosen, the motor will run or stop when the photo resistor mounted on the vehicle is illuminated. If you select the arrangement shown on the wiring diagram, the motor runs when the light rays strike the lamp of the resistor. Where you select the connections according to our circuit diagram, the vehicle will alternately move back and forth.

For light control purposes a standard flash-light or a fischer-technik lens lamp may be used. When the photo resistor has been arranged to rotate, if desired, you are in a position to set it on that particular direction from which you wish to steer the vehicle. The angular range in which the vehicle responds to the beam of light can be further restricted when using a light-protective cap with very small holes.
Note that the closer you get to the vehicle, the smaller you have to design the cap hole.

The circuit arrangement illustrated overleaf has a little drawback: The vehicle will not move independently in the terrain but is connected to the control unit via 4 wires. Yet the vehicle will be free to operate, unrestrained by cables, when you use 2 battery cell bars or one battery bar and one 4.5 volts battery as your source of current. The circuit diagram shows this possibility.

The caterpillar vehicle travels over small obstacles, for instance your living-room carpet, without getting stuck. Together with friends and relatives you can now organize a skill competition in steering of the vehicle. These possibilities can be even enhanced. When you have available another motor and additional building blocks, vehicles with independent right-hand and left-hand drive can be built and the faster motor can be turned on and off through a photo resistor. Other objectives would also be possible: Thus, for instance, you might surprise your guests by setting in operation a counting mechanism by means of a flashlight and the like.

page 26

Tripping Clock with Adjustable Running Time

One of the surprising electronic tricks consists in switching on an electrical appliance at an exactly defined point of time, even if one is not present in person. An example of such a switching arrangement is a clock which effects tripping or turn-on of a device after a predetermined, i.e. presettable time. The running period of our model may be up to 2 minutes. The heart of the layout is a gear with a speed reduction of 9,600:1. This means that the axle of the drive motor will rotate 9,600 times until the final wheel has performed one revolution. On page 31, you will see how such a gear drive is to be designed.

A slotted paper disk is glued onto the last wheel of the gear in such a manner that the slot coincides with a notch of the wheel. The notch is then scanned with the small lamp and the photo resistor. As soon as the slot reveals the beam of light towards the photo resistor, the relay in our Relay Building

Block will pick up and switch the contacts desired to an energized condition.

Certainly, it would also be possible to perform the scanning operation in a different way, for instance through the use of a wheel-mounted cam which actuates a push-button. However the contactless mode of scan used for the photo resistor offers some special advantages. The wheel with its slot can be fitted quite loosely on its axle since scanning takes place without any physical contact. Therefore, the running time of the clock can be easily and quickly set. The start of the motor can be initiated by rotating the paper disk or by means of a push-button not shown in the circuit diagram. Where would you have to fit this button? The motor built into the circuit will automatically stop as soon as light strikes the resistor.

It is also possible, via the free contacts a_1–a_2–a_3, to turn on and off and to switch over a machine, a lamp or the like. Also, it would be possible to ensure that the device or appliance which is to be switched off at the end of preset time will be driven with the motor of the clock itself.

Where you require a clock with a shorter tripping time, the only thing to do is to modify the gearbox in a suitable manner. Those who possess additional gear wheels and worms can achieve even longer tripping periods.

see page 31 for building stage 1

A Flasher Installation

Relays are switching devices which can be used in many different ways. For instance circuits can be designed in which relays perform mutual switching. And another interesting capability consists in having a relay control itself. When, for example, the lead wire to the relay coil is laid via the relay's own NC contact, the relay will pick up and allow current to flow at the instant of connection to the power supply unit – and it will thereby again interrupt its own current circuit. At the time of drop-out, current is again allowed to pass so that the relay must pick up afresh. Consequently, the relay will energize and de-energize in rapid succession – actually a mode of operation which surely will not be too beneficial for it.

By using the capacitor incorporated in the Rectifier Building Block we shall succeed, however, in turning the "vibrator" into a "flasher". This conversion is due to the fact that the capacitor operates, say, as a sort of "delay element" which becomes effective upon each turn-on. You will find many interesting applications for time-delay circuits as well as a description of the switching combinations in the hobby Experimenter's and Model Book 4-1.

The lamp L_1 which is inserted into the line coming from the power supply and leading to the lower connection of the rectifier module will also extend the cycle of the flashing process. If the flasher is to operate at a faster rate, then you would be required to "by-pass" this lamp by means of a cable. On the other hand, the rhythm of operation could be further slowed down by connecting additional lamps in series.

Since for self-control of the relay we do not need more than the one changeover contact, the other one remains free and can be employed to switch on or off any device desired. This capability might be made use of by performing some sort of push-pull flashing of 2 different lamps operating in counter-cycles.

When you have found fun in flashing, please connect a photo resistor between jacks "E" and "–". Now your flasher functions only as long as the photo resistor is illuminated. It would also be possible to interrupt the flashing operation by longer darkness breaks. Then a lamp positioned on a rotating plate or turntable would have to be used for illumination of the resistor, instead of the standing light. Moreover, it is quite simple to provide for the tripping clock to bring the flasher system into operation in a delayed manner.

page 30

Using the Flasher Circuits as an Alarm-Clock

Out of the various applications for the flasher principle, a particularly interesting one will now be described. It is an alarm-clock which is capable of indicating the sun's rising.

Basically, it is the same arrangement as the one just described. The only difference lies in the fact that the photo resistor is located at the window-sill, towards East, somewhat inclined in an upwards direction so that it cannot be struck by head-lights etc. Through an appropriate choice of the light-protective caps placed in front of the resistor you can actually determine yourself in which phase of the sunrise the alarm-clock is to begin operation. It is true, of course, that the flashing of a small lamp will not wake up anyone fast asleep, yet the pickup and dropout of the relay can in fact be perceived as a snaring noise and this will normally not fail to achieve its purpose, particularly if the Relay Building Block is installed quite close to the pillow. This layout should best be tried out at first in the dusk of the evening.

This alarm clock will be especially suitable for the hard and fast lie-in-bed, since the choice of protective caps is going to determine that, say, the clock will not ring at all when the weather is dull or rainy. Anyway, the late riser will not be roused from sleep when the morning walk or the planned tennis match will have to be cancelled because of bad weather.

For the construction of this clock model you will surely not be in need of a circuit or wiring diagram. At best, the diagrams which can be of use in this application are to be found on page 29. The only difference: Photo resistor to be inserted between jacks "E" and "–".

page 31

re pages 26/27
clock with presettable
running time

building stage 1

building stage 2

page 32

A Paper-Tape Reader

Compared with the human eye the photo resistor, our electronic sense-organ, has but very restricted possibilities. Basically, it cannot perform more than any individual cell in the retina of the eye that is to determine the degree of brightness. Under these circumstances it would certainly be presumptuous to require a photo resistor to be able to read written characters. Yet this is really possible! However it is not the normal letter but rather one which is particularly adapted to the electronic eye. It actually is the "script" of punched holes in a paper tape. The letters, numbers and special symbols are coded on the paper tape in the form of punchings in the same way as all the alphabetic letters are represented by dots and dashes in the Morse code.

For the construction of your model you would best utilize a paper strip of 28 mm width in which you keypunch holes or slots by means of a standard office perforator. When the punched tape is then slid through the channel of the scanning device, the pilot or signal lamp will light every time a hole reveals the path for the light beam to reach the photo resistor. When moving the punched paper tape through the channel at a constant speed delivered by a motor, the lamp will go on at the rate of the punchings. Instead of mechanically punching the holes into the paper tape, you might also make use of a light-transparent paper strip which would be made non-transparent in those spots where you would provide punchings in tape. How do you have to connect the signal lamp? When you fit the characters punched or marked by means of Indian ink onto the underside of the tape or strip, one cannot see them.

This reader model could be completed, say, to form an automatically operation S.O.S. flasher light. With the help of an electromagnet and a felt pen the invisible signals of the punched paper tape can be made visible.

page 33

rear view
building stage 1

page 34

Electromagnetically Agitated Pendulum

When you cause a suspended body to go into a swaying pendulum-like motion, a typical mode of movement will result: first, the deflection is large, gradually it will become smaller until finally the motion comes to a standstill. This is due to the fact that the energy which is supplied upon the first deflection will progressively be lost as a result of friction at the pendulum axis and air friction; If one wants to attain a condition in which a pendulum swings freely to and fro without getting "tired", the energy lost must be replenished constantly and at certain intervals. In the case of the pendulum clock, this is achieved through the pull of the weight attached. A more elegant solution to this would of course be, for our purposes, to use an electromagnet which acts upon an iron plate fastened to the pendulum at a timely instant.

In our model here, the problem of the proper timing is solved automatically by the light barrier. It is the pendulum itself that determines the start and the duration of magnet action. The magnet is located on a building block equipped with a pivot. It must be adjusted in such a manner that it will never touch the iron plate on the pendulum in swinging motion. The light barrier is swivelable. Therefore it can be brought into operation at any desired point of the pendulum motion. Please try and draw the wiring diagram yourself. Does the installation operate even if you connect the magnet via the NC or break contact $a_1 - a_2$?

In order to start up the pendulum motion, you have to push it by hand. The magnet's force is not sufficient to handle this. Here, too, some interesting extensions could be implemented by you. For instance, it is possible to operate a counting mechanism with the aid of the pendulum. The counter will then function as an electric clock.

How to Rapidly Brake a Motor

When a running motor is switched off, it will continue to operate, while slowing down, for a short time. The reason for this is the same as in the case of a motor-car pedal being released: every motion contains energy which has to be consumed after interruption of the energy supply. This is caused by friction, both with the motor and the automobile. For some motor-operated machines and devices, especially for control motors, it is important, however, that the time between turndown of the motor and its standstill is made as short as possible. There is one trick by which this condition can be fairly easily achieved. For our demonstration we shall use the model of a merry-go-round. Perhaps you would like to try out, first of all, performing the following circuit layout on your own, using only the fischertechnik push-buttons rather than the Relay Building Block.

The trick consists in allowing the motor to function as a sort of electrical generator after it has been shut down. This could be implemented, for instance, either by means of a changeover push-button switch or, as shown in the wiring diagram, by using the changeover contact of the Relay Building Block. In this case, our motor will run as a current generator as soon as the motor is disconnected from the power supply. However, the lamp will light but for a short period because the motor comes to a fast standstill. And that is what we actually intended to achieve! In point of fact, the energy present in the motor armature will now be quickly consumed by heat-up of the filament rather than slowly through the action of friction forces. The motor will decelerate even faster when you "short-circuit" it directly, i.e. without inserting a lamp in-between, after shutoff. The energy of motion will be converted into heat in the motor almost immediately.

A quite significant comparison can be made between the deceleration times measured in the case of motor shutdown by opening of the circuit, under generator operating mode with one or several lamps connected in series or in parallel, and under direct short-circuiting conditions.

The circuit diagram on the right-hand side shows how you would have to connect a remote indication device which shows whether the motor is running or at a standstill. The lamp 2 will be on when the relay is energized. This will be the case when, as the technician would say, "E" is applied to "–".

The Self-Holding Behaviour of the Relay

In the models which we have built so far the switches used normally operate in a very transparent manner: As long as the switch is held depressed, the motor is running, the small lamp is lit, a vehicle is moving **...** However, under the conditions of practice, there are quite a number of cases in which one does not wish to depress the switch manually all the time, but where one would like to just give a sign for a beginning, so to speak a starting shot, by way of a short push on a switch or button.

This condition, too, can in fact be attained through the use of a simple trick in which again the relay will play a major role. The model on which we are going to show the principle of operation is a rotating table. You will find the building levels 1 and 2 on the page overleaf. For a preliminary test you would first place the fischertechnik push-button switch beside the machine; the button will be installed at a later stage at the location shown in the photo. Actually, this particular button has not been shown on the circuit diagram. The motor will cause the table to go into a rotating motion as soon as you press the self-constructed "On" push-button T_e. This will apply jack "E" to the minus jack and cause the relay to pick up and energize.

The motor will continue running when you release the button switch. This is due to the fact that the relay does control itself, namely via the normally open contact b_1 - b_3 which is connected parallel to the start button. As soon as the relay has picked up as a result of your actuating the push-button switch, the relay is capable of holding itself. That is why this mode is called "self-holding".

But how can we now turn off the installation again? The only thing required is to remove the self-holding condition which means that one of the wires leading to the self-holding contact b_1- b_3 must be interrupted. In our model this will be achieved with the aid of the fischertechnik push-button switch. which, in this particular case has been connected as an "Off" button switch. If you wish, you can try to extend the circuit diagram depicted below. This "Off" switch actually fulfills the same purpose when inserting it between "–" and b_1 rather than between "E" and b_3 as is indicated in the wiring diagram. Please try and draw this circuit layout, too.

Refer to page 41 for
building stages 1 and 2

To check on what you have sketched out, please compare your solution with the following circuit diagram:

If you want the turntable to come to an automatic stoppage after one rotation, then you would have to mount the off push-button T_a – as shown in the photograph – in such a

manner that it will be actuated by one of the cams of the table. This cam, however, must be wide enough to ensure that the motor will definitely come to a standstill before the cam slides from the push-button switch.

Again, this particular model offers the user a good opportunity of doing various tests and trials. For instance, how would you proceed to make sure that the motor, after opening of the circuit, stops promptly rather than slowing down quite gradually? In this case you have to arrange for the interrupter cam which is located on the underside of the rotating table to be smaller.

Without looking at the diagram below, please try to design your own diagram for the circuitry desired. And after that, compare the solutions. Our circuit layout below contains, in addition, a pilot lamp which is going to illuminate when the motor has stopped. In this case you are to insert the off switch T_a between "E" jack and contact b_3! Caution: The small pilot light is being operated here at a fairly high voltage! Therefore, this circuit should be used for only a limited period of time. Your lamp will live longer!
The line wire shown in a thick blue colour on this diagram is used to bring about the rapid braking of the motor. Perhaps you wish to add another signal lamp which lights as long as the motor is turning.

Re: pages 38/39
turntable model

Electronic Mousetrap

One area of application of the self-holding relay involves a trap in which small animals such as mice can be caught. On our photograph only the trap-door and the light barrier of the catching device are visible. Please design the cage in which the mouse is to be retained!

Basically, this is a straightforward alarm circuit. From earlier models it is distinguished only by the larger width of the light barrier which makes some adjustment necessary. It must be taken into account that the catching device has to be laid out in such a manner that its trap-door will easily slide on the two guide columns. It is only under such conditions that it will close rapidly enough before the magnet is turned off. Perhaps, you want to design yourself such a simple circuit arrangement similar to the burglar alarm.

The circuit diagram on the following page and the wiring diagram illustrate an important improvement. Since the alarm lamp – or an alarm bell – are to remain active even after the instant of releasing the light barrier again, one must fall back upon a circuit operating on the well-known principle of self-holding, but this time in a mode called "self-blocking". To achieve this type of lockout we shall take the wire between the photo resistor and the input jack "E" via a make contact of the relay. Contrary to the self-holding circuitry used previously, the relay contact is now parallel to the photo resistor. In order to bring the system into operation, we have to insert the start push-button T_S into the circuit connecting it in parallel with the contact of the relay.

The catching device will be made operational by lifting the door. When the start button is pressed, the magnet will hold the door.

Upon interruption of the light barrier the relay will drop out and break the circuit in which the electromagnet is located. The latter releases the door – and the mousetrap snaps to! The alarm lamp goes on. Due to the fact that the relay contact connected in series with the photo resistor is opened, too, fresh illumination of the resistor will have no effect at all. The circuit is blocked or "cut off'. That is why you will notice that the alarm lamp continues to light when the light beam of our barrier of light strikes the photo resistor again. The alarm lamp will not go out until the self-blocking effect is removed by pressing the start button.

page 44

Another Safety Device against Burglars

Again, we are put to the task of safeguarding a valuable exhibit against burglars. This time we are going to operate with a rotating table: As soon as someone grasps for the object on display, the table will be set in motion and carries the exhibit into the interior of a thief-proof container.

As a variation to previous models, the light barrier will be installed in a vertical position in this safety device. From a lens lamp a sharpened beam of light passes through the hole of a cross-hole brock striking the photo resistor mounted beneath it. As long as light is incident upon the resistor, the motor stands still.

The object of value – represented in our model by a fischer-technik axle – is positioned behind the light beam of the light barrier. If the barrier is interrupted, the relay will drop out. The motor connected via a normally closed contact of the relay begins to turn the table. By way of a self-locking arrangement in the circuitry it is possible to ensure that the following steps proceed automatically, no matter whether the thief remains in the light barrier or not.

Now we have yet to make sure that the motor stops after a semi-rotation – since otherwise it would again expose the valuable exhibit to the grip of the thief. For this purpose the broad cam attached to the rotating table is used; after half a revolution of the table it will press the fischertechnik push-button. This "On" button then by-passes the photo resistor and with it the relay contact which has been connected in series. This causes the self-locking state of the relay to be eliminated, and the motor stops.

After every attempt at stealing the exhibit, the table has to be returned to its original position by hand.

This safeguard against burglary can be extended, for example by way of an alarm lamp which illuminates as long as the motor turns. But since this short-duration signal might easily be overlooked, it seems better to maintain the state of alert with the help of a self-constructed relay (using the "self-holding" concept). A more suitable solution would be the use of the fischertechnik relay e-m 5 which also has 2 changeover contact units. This additional relay can serve to connect the lamp illumination in such a manner that it will extinguish when an alarm condition exists.

Covering plates taken from the Extra Packs 010 through 014

enable you to make a model which is even closer to reality. It will then be effectively removed from access by anybody – a surprising trick which you can try on your friends and acquaintances.

page 45

Refer to page 47 for building stages 1 and 2
Wiring diagram: page 46

page 46

towards photo
resistor

page 47

building stage 1 building stage 2

page 48

How a Light-Barrier Protects a Foundry

Alarm systems and thief-proof safeguards are means used in the prevention of crime. Electronic circuits, and especially light barriers, can additionally be utilized to safeguard man and machines. An example of such a type of application is the model of a foundry including a light-barrier protection.

In installations of this kind there is always the danger that a worker accidentally walks under the forging hammers. Certainly, it might be possible to sheath and jacket the moving parts of the machine. However, they would then be removed from an observer's sight, and when a modification is to be incorporated the sheathing must always be dismantled. A more elegant solution to this problem is the use of a light barrier. The light beam and the circuitry must be so arranged that the motor immediately stops when someone moves too close to the moving hammer.

First of all, you will have to build the foundry; then try to design yourself the circuit diagram. Where a single beam of light does not offer sufficient protection, you can also use the rays emitted from two lamps. It is recommended, however, that you select lamps having identical brightness values. The rays of both lamps are then directed onto the photo resistor. Through the use of an adequate light-protective cap and a variation in distance, it will be ensured that the relay will de-energize when only one of the 2 rays of light are broken.

It would of course not be too difficult to render accident-proof any other machine by using a kind of light-barrier protection. Besides, it might be mentioned at this point that there is still another very important mode of application of such light barriers: the control and guidance of machines. Again, let us take the foundry as an example. When plasticine material is used instead of iron or steel, it can be nicely shown how a workpiece is forged. Now a light barrier is to be employed which is capable of automatically turning off the motor at a time when the shape to be forged has been hammered sufficiently flat.

page 49

rear view

page 50

Curtain of Light

When you use 2 or even more beams for the light barrier, as was done in our last model, we usually speak of a "light curtain". Such an intense radiation of light is made use of for the type of sorting equipment which is shown on the next page. The red pilot lamp which is controlled by the relay will light as soon as a long object is pushed along the predetermined path through this curtain of light. Smaller components, however, do not cause the pilot light to go on.

The 2 lamps for the light curtain have to be arranged for our purposes in such a manner that a large object, e.g. a component, will interrupt both of the beams going to the photo resistor at the same time, while a small component will cover just one light beam. A pre-requisite for proper functioning of the system consists in moving the parts on the same guidance path at all times. One and the same body, once it is conducted along its path through the light curtain fairly close to the lamps will certainly produce a different response from another object which is moved on a route near the photo resistor.

Please choose 2 incandescent lamps which, if possible, have identical brightness values. Place the light-protective cap with the second smallest hole onto the resistor. And afterwards, perform the overall setting of the system: At first, turn on only one of the lamps. Then move the photo resistor up so close that the relay picks up. Please mark this distance! Then repeat this procedure with the second lamp. Finally, attach the photo resistor to the marked spot having the smaller distance to the associated lamp.

This kind of adjustment will result in the following: The light from each of the two lamps will alone be sufficient to energize the relay and keep it in its current-carrying position. So if only one lamp is obscured, the relay does not drop out. It is only a correspondingly large object covering both beams of light which will actually cause the relay to de-energize.

If you like to build the conveyor-belt equipment for sorting, you must connect the motor in such a way that it will promptly come to a standstill when a large component passes the "trial stretch". By moving the lamps and the photo resistor to different locations you can determine the exact geometrical conditions under which the resistor is going to respond properly.

These curtains of light beams do prove their practical value in those tasks, too, which we have already managed to solve: the safeguarding of valuable objects. Perhaps you want to try and design the model of a strong-room that is protected by a light curtain. In this particular case, an interruption of one light ray alone will have to initiate the alarm signal!

page 51

building stage 1

for a conveyor belt
(please add electronics and light curtain)

A Fire-Alarm

In most of the models which have been constructed by us so far we have based our design and installations on the "artificial eye" of electronics, on the photo resistor. The electronic kit ec does contain another "artificial sense-organ", a so-called thermistor. This is nothing more than a resistor whose resistance varies as a function of temperature. Under normal temperature conditions, the resistance of this component is relatively high; upon heat-up triggered, say, by holding it temporarily over the flame of a candle its resistance will sharply decrease. Please do not heat the thermistor for a prolonged period of time, because the coating applied on its surface does not stand temperatures in excess of 100°C.

When we connect the thermistor, much in the same way as the photo resistor, to the relay building block, it will also act as a control sensor or "probe". When the thermistor heats up, the relay will pick up; on the other hand, if it is cooled down, the relay will again de-energize.

A series of tests will aid you in getting a better knowledge of the behaviour of this component. You could, to cite an example, check, using hot water and a thermometer, at which temperature levels the relay picks up or releases.

There are, of course, many applications for control circuits incorporating "heat sensors". Obviously, it can easily be utilized as a fire-alarm. The warning device, here the relay module and the lamp or the bell, will be installed at a safe location – since it might otherwise be destroyed by the fire before the thermistor sensing element responds. And, quite certainly, you will use a "self-holding" circuit. Please try for yourself to build such a warning system! And may be, you could find a practical field of application for it.

Frequently, thermistors are employed for the control of temperatures on and in electrical heating and oil furnace installations. Since with the thermistor there exists no simple and easy-to-use possibility – similar, by the way, to the light-protective caps placed in front of a photo resistor – of modifying the "response sensitivity" of the control unit, electrical contrivances have to be used for this purpose. These would normally be adjustable amplifiers, for instance the Electronic Building Block from the fischertechnik system. More details about this can be found in the Experimenter's and Model Book for hobby 4, volume 1. There you will also find a more precise description of the operating principles of the thermistor.

electrical symbol for a thermistor

colour code "blue-black-orange" means: at 20°C, the thermistor has a resistance of 60 kohms

Freight Elevator with Rope Protection

Those of you who have already built models including motor-driven cranes of freight elevators and hoists will perhaps have experienced some occasional troubles with their instal-

lations. As a matter of fact, if you don't switch off the motor in due course as a load is raised, the motor will often pull the rope hook over the sheave pulley or the rope will tear up! This inconvenience can easily be removed by using an electronic safeguarding device, much in the same manner as is today being done in engineering practice.

In the case of freight elevators, hoists and cranes it is essential that the sense of rotation of the motor can in fact be reversed, if required. This purpose is fulfilled by the pole-changing switch which is offered in the fischertechnik Extra Pack e-m 3. You will need this switch to design and construct the elevator control units.

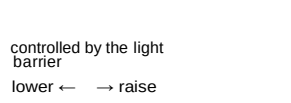
Operating principle of the pole-changing switch:

In the photograph shown on the next page you will recognize the model of a freight elevator protected against damage through the use of a light barrier. This barrier is housed beneath the rope idler pulley. As soon as the hook comes into the radiating range of the light barrier, the motor will be automatically shut off. The circuit of this can be taken from the Diagram 1 on this page. A slightly improved version is shown in the wiring diagram of this model. A sort .of short-circuit deaceleration or braking of the motor ensures that the elevator operation comes to an immediate stop upon interruption of the light barrier.

The two designs shown here have one small flaw: Once the operation has been shut down after an interruption of the barrier of light, the motor will not rotate any more, not even in the counter-direction. Therefore one has to provide a switch

circuit diagram 1

that is used to by-pass the contact opened via the relay. But when this push-button switch is inadvertently pressed before the direction of rotation has been reversed, there is again the menace of damaging the entire installation. This drawback can be .removed by making use of a different principle of construction – refer to circuit diagram.



circuit diagram 2
(shown in the "raise" position)

Again, similar to the models discussed previously, the motor will be switched off and short-circuited upon winding up of the rope and breaking of the safeguarding light beam. But there is still one difference: In the "down" position, it does not matter how the contact tongue of the rope safety switch is positioned. In the two possible states the wire leads to the negative pole of the power supply. Perhaps you like to draw the circuit diagram for the "down" position of the direction-of-travel switch.

The diagram 3 represents the complete system in an improved version.

circuit diagram 3

This installation can, of course, be perfected, for example by means of additional pilot lamps which would indicate when the light barrier has been brought into operation.

In practice, it is often desirable to control elevators and cranes by one "up" push-button and one "down" button rather than by way of a controller button and a direction switch. Using up and down buttons enables you, first of all, to determine the direction of motion and its duration through only one push on a switch. Moreover, there is a definite advantage in the concept of using push-button control: the crane or elevator driver will not overlook the turn-off position so easily as in the case of ordinary switches! Our circuit diagram 4 shows how this can be tackled.

Since the fischertechnik Extra Pack em 3 contains a push-button switch too, you could now try out this particular hoisting arrangement. The 2 connection terminals of the motor are joined to the centre contacts of the two push-buttons. If none of these buttons are depressed, the motor stands still. Even depressing both push-buttons will not cause the motor to turn.

It is only by pushing one of the 2 buttons that the motor starts up the hoisting equipment and the freight elevator will then move in either of the directions desired. If the up and down push-buttons have been inadvertently exchanged, you need only alter the location of the two cables leading up to the motor, and the circuit is correct.

Now what remains to be done is to insert the light-barrier safeguard. This is achieved by routing one of the motor leads – generally the one which carries current during the lifting operation – via the NO contact of the relay. The complete circuitry incorporating the rope safeguard should be sketched out by yourself.

circuit diagram 4

Light Signals Opening a Garage Door

Almost every car-driver will certainly feel angry when he has to leave his car and open the door to his garage before he can drive in. That is why some possibilities have been devised which allow him to open the gate from within the car. Again, electronics is the tool which is used. We are now going to demonstrate on a few models the solutions including light control.

For these models we need some special parts:

- a fischertechnik pole-changing switch, such as the one contained in the Extra Pack em 3;
- a cardboard box, size 124 mm by 95 mm, to serve as the garage door;
- a cable or ropeway of 280 mm length;
- a rubber ring as a replacement for a steel spring.

The cable is used to transmit the motor power onto the rope drum on which the rope for raising of the door is wound up. The length of the ropeway or cable control has been chosen to be 280 mm in order to be able to sling the entire rope 4 times around the gear axle. This allows us to achieve the necessary friction which will prevent any slipping. The ropeway is conducted through the hole in the white rocking lever of the switch. You should now pull the rope until the mid-point and make a knot on the right-hand and left-hand sides of the rocking lever at a distance of approx. 25 mm. This has to be carried out to make sure that by a single pull on the rope the pole-changing switch is being actuated. And now we have to proceed to a precise adjustment: For this purpose, we shall connect the

circuit diagram 1

Please leave out
push-button for
circuit diagram 1

motor directly to the pole-reversal switch. The switch must be so arranged, that by moving it up and down, one of the knots will actuate the rocking lever at the very moment of floor contact of the lower door edge. The position of the upper reversal point does not require particular attention.

And now we have really come to the point where all the different possibilities of switching arrangements for control of the garage door can be tested. The most straightforward circuit is shown in Figure 1. As can be easily seen, the motor is applied to the power unit via the NO contact of the relay. When the photo resistor is illuminated, the motor will run. The same is attained by pressing the push-button connected parallel to the photo resistor.

In order to avoid that the motor will be turned on by incident daylight, we shall mount the photo resistor at the end of a deep light-well. For this purpose, you might use the hole of a cross-hole block. This layout allows us to have the photo resistor respond only when the light strikes it from one particular direction.

Under practical conditions the flow of operations would then be as follows:

- The car-driver illuminates the photo resistor.
- The motor starts to run.
- The door is raised.
- The car-driver enters his car into the garage, the motor stops.
- After leaving the car, the driver will depress the button until the motor reverses its direction pf rotation at the upper return point of the door and the door will close again.

A more comfortable handling procedure can be accomplished when you base the operation on the self-holding concept of the relay. Such a capability is offered in our circuit diagram 2.

circuit diagram 2

towards pole-
changing switch

When the photo resistor is illuminated, the relay will pick up and will hold itself in the energized position through the NO contact. Now we still need a device that shuts off the door-opening system after the raising operations are completed. Here, we shall employ a cam fastened to the garage door. It actuates the "off" push-button T_{top}, a fischertechnik push-button switch. This action causes the self-holding condition to be removed. By mounting another push-button which we shall call button T_{down}, we have the possibility of closing the door after the act.

Those who find the prolonged depression of the button for door

closure a bit cumbersome can actually improve the installation. The circuit diagram 3 shows such an already highly automated arrangement.

circuit diagram 3

page 62

In the same way as in circuit 1, the relay can be caused to respond by simply pressing the T push-button. Since the relay is connected for self-holding, it will remain in the energized condition until it is switched off separately. The operating principle is identical to the circuit 2. For turn-off we need two push-buttons. In series to the T_{top} button another push-button switch will be provided: T_{bottom}. The top push-button has to fulfill the same aims as in the last circuit described. If it is actuated at the end of the lifting operation, the self-holding state of the relay is cancelled and the motor comes to a stoppage. By shortly depressing the T button the motor will be brought into operation again. Since the T_{top} switch closes immediately, the motor continues to rotate until, at the end of the door closing process, the button T_{bottom} cancels the self-holding condition anew. T_{bottom} is being actuated by another cam located on the rope drum at the very instant of door closing.

Those of you who like to tackle tricky mechanical problems can, of course, spare this push-button T_{bottom} by having the "up" control switch arranged such that it is always operated by 2 different cams on the rope drum. Where the height of lift of the door and the circumference of the rope drum are the same, a single cam will be sufficient. Adjustment of the push-button is not too easy because the button has to be actuated at the same moment as the pole-reversal control.

And now a final question to stimulate your inventing mind: Where do you insert an additional switch which is to act as a stop switch in emergency situations?

Notes and Suggestions

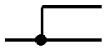
Electrical Symbols

4.5 volt battery

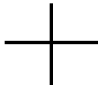
connection to d.c. voltage

connection to a.c. voltage

connection to d.c. or a.c. voltage



electrical line with branch off



2 lines (non-connected)

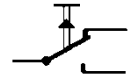
busbar with trolley

plug jack and plug

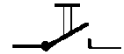
switching element, switching point

"on" push-button (NO contact unit)

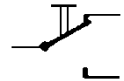
"off" push-button (NC contact unit)



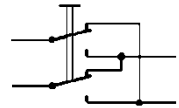
changeover push-button



on-off switch



changeover switch



pole-changing switch


incandescent lamp

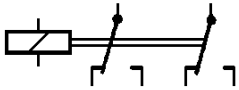

lens lamp

direct-current motor


electromagnet

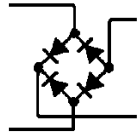
return-circuit plate


relay coil


relay with 2 changeover contacts


amplifier


diode


full-wave rectifier

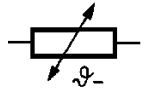

capacitor

electrolytic capacitor (note poles)


resistor


adjustable resistor


photo resistor



thermistor

For further symbols refer to Instruction Booklet em, page 3.

Parts List

Description	Extra Pack	Part No.	Quantity ec	Quantity hobby4
Rectifier building block	h 4 GB	2 30811 7	1	1
Relay building block	h 4 RB	2 30812 7	1	1
Electronic basic building block	h 4 G	2 30813 7	-	1
Microphone-loudspeaker module	h 4 ML	2 30814 7	-	1
Photo resistor	*	3 31361 1	1	2
Light-protective tube	*	3 31363 1	-	2
Light-protective cap 6 mm Ø		4 36532 5	1	-
Light-protective cap 4 mm Ø	*	4 31362 5	1	2
Light-protective cap 2.5 mm Ø		4 36531 5	1	-
Light-protective cap 1 mm Ø		4 36478 5	1	-
Connecting plug for electronic building blocks		3 36380 1	2	3
NTC resistor 2 kohms (red-black-red)		3 36386 1	-	1
NTC resistor 60 kohms (blue-black-orange)		4 36577 7	1	-
Capacitor 100 mf, incl. 2 plugs		3 36387 1	-	1
		3 36381 1	-	1
Base of luminous lamp	e-m4 *	3 31313 1	3	3
Ball-type lamp	e-m 4 *	4 31314 7	3	3
Lens lamp	*	4 31315 7	2	2
Luminous cap for lens lamp	e-m4 *	4 31321 5	1	1
Luminous cap, red	e-m 4 *	4 31316 1	1	1
Luminous cap, blue	*	4 31319 1	1	-
Luminous cap, green	e-m 4 *	4 31318 1	1	1
Luminous cap, yellow	e-m 4 *	4 31317 1	1	1

Description	Extra Pack	Part No.	Quantity ec	Quantity hobby4
Cover for luminous-lamp holder			4	-
Flat connector, green	*	2 31336 6	10	20
Flat connector, red	*	2 31337 6	10	20
Cable strand, single-conductor, blue 2000 long			1	1
Cable strand, single-conductor, green 2000 long			1	1
Cable strand, single-conductor, red 2000 long			1	1
Cable strand, single-conductor, blue 1000 long	*	4 31357 5	1	1
Cable, single-conductor, with plugs, various lengths			4	4
Changeover push-button	e-m 3 *	3 31332 1		2
Collecting lens f = 7.0 cm		3 31366 1	-	1
Collecting lens f = 3.5 cm		3 31365 1	-	1
Slotted diaphragm	*	4 31372 1	-	1
Cross diaphragm	*	4 31373 1	-	1
Concave mirror	*	3 36369 1	-	1
Convex mirror	*	3 31368 1	-	1
Mirror band		4 31370 2	-	1
Light guide bar		4 31374 1	-	1
Light guide angle	*	4 31375 1	-	2
Silicone hose		3 36389 1	-	2
Coupling axles 242 mm		4 31310 3	-	2
Block 15 with one round pivot	*	3 31059 1	-	3

Supplementary items in h 4: cartridge, connecting links, universal-joint block, blocks 15, axle holders.
The items marked by an asterisk * are available from every fischertechnik Service Dealer.

What Comes Now?

Now you have come to know a great number of uses of the technology of switching and connecting – above all with the help of photo resistors and thermistors. This is but a tiny section of the applications which you will come across in practice.

You can develop many other models with the fischertechnik Building Blocks. You will indeed gain a great deal from the Experimenter's and Model Book 4-1 which has been created for use with the hobby 4 kit. This stimulating manual is available from your specialized toy shop.

Step by step you may then proceed towards the hobby 4 building kit.

This will be easily achieved by acquiring additional electronic building blocks and accessories which you can buy separately from your special dealer. You will find your way by looking at the parts list on page 66. Another step towards controlling and regulating by means of light, heat and sound can then be achieved by you.

But you can go still further. Linked up with the control engineering sector is information processing, computer sciences, data technology. fischertechnik offers everybody an entry into these highly interesting areas of automatic machines capable of thinking and deciding. And actually you are not restricted to purely simulating the models. This Instruction Booklet has proved to you that any circuit design can be improved, extended or combined with other circuits. fischertechnik kits primarily are building kits for the inventing mind. That is why today fischertechnik can already be found in many laboratories and design offices of science and technology.

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