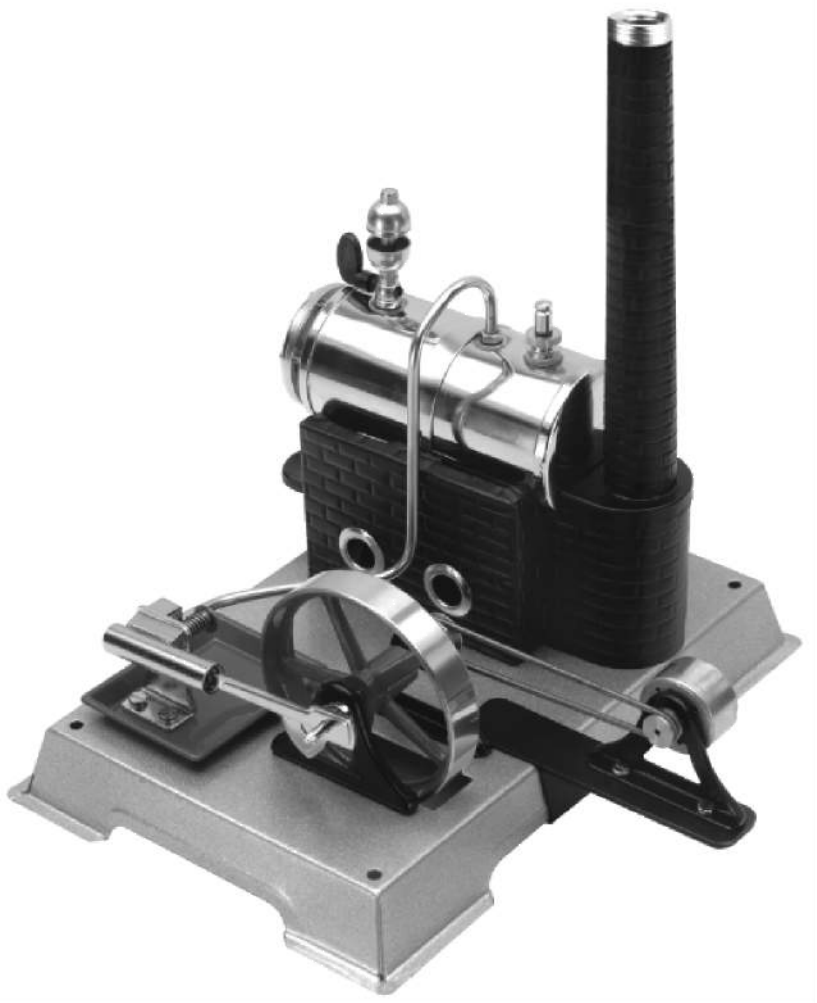
Steambox D 100 E

E-Box E 50



Steambox D 100E and E-Box E50

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Important information:

Please read the instructions carefully before using the product. There you find important information for a successful use.
Any damages caused by not following the instructions or the safety advices will not be treated as guarantee cases!
We do not take any responsibility in case of following up damages!

All the information has been worked out with great care. On the other hand one cannot exclude that mistakes may happen. We kindly advise you that neither Wilesco nor the author will take any guarantee cases, juristically responsibilities or assume any kind of liability as consequences of wrong instructions or experiments.
Wilesco invites to send comments about possible mistakes via mail.

A symbol in a triangle is indicating a possible dangerous situation, which needs more caution and attention.

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Preface:

With this Steam Box or the E–Box 50 in combination with a steam engine model and the booklet one can experience practically how the steam engine and the transformation into electricity functions. Wilesco has joined for you all the needed components in the Steam Box D 100E and the E-Box 50.
You are the owner of the Steam Box D 100E and now you build step by step your own steam engine as a model. Through joining the different parts one gets aware of the developed concept and the principle of the steam engine, which has been invented by Denis Papin, James Watt and others. This model does not only help to understand how a steam engine works, it also creates a lot of joy to develop it even further.
With the Steam Box and the E-Box 50 and its components you can practically experience and understand the transforming processes, beginning with the thermo energy, through the mechanical energy and finally turned into electrical energy. The experiments are structured and build up one on the other. They are easy and in short time to realize.
In the booklet you also find information about the modern standard of the steam engine and examples and possibilities of developments in the present time.

I also would like to bring you this beautiful hobby of steam engine model construction a little closer and wish you a lot of fun building this and other steam engine models and the experiences you gain with it.

Yours
Ulrich Stempel

Inhaltsverzeichnis

1. Basics about the steam engine

Steam engines are heat engines and they work in contrary to the combustion motors without inner combustion. Mechanical energy is provided through the pressure of the steam. One can use different sources of heat to make the engine work; so all liquid, solid and gaseous fuels. Steam engines are also capable to transform solar energy and growing fuels for our needs. They do this in a low emission and climate neutral way.

1.1 The steam engine and its development

Constructions and their precursors, which work with steam pressure, have been already used in the Greece antique. It is described that the doors of the temple after lightening the holy fire would open in a magic way due to a construction which worked with steam.

Leading steps in the development of the steam engine principles happened during the time of the industrial revolution, f. ex. through Denis Papin. 1690 he invented the pressure cooker, where he developed a first prototype of a steam engine with cylinder and piston. In 1698 the British engineer Thomas Savery constructed an engine, working on steam, which was supposed to pump the groundwater. In 1712 the engineer Thomas Newcomen developed the principle even further into an atmospheric steam engine.

Information:
The atmospheric steam engine is a precursor model with the following function: water steam is pressed into the space of the cylinder below the piston, which cools down through added cold water and finally condenses. This causes a negative pressure and because of the higher external atmospheric pressure now the piston is pressed into the cylinder. Through the flywheel mass and the opened steam valve the piston is again pressed into the cylinder. The energetic efficiency of this construction is about 1%.

In 1769 James Watt managed to patent a double functioning steam engine. In this construction the piston is alternately shifted from one side to the other through steam. This increased the efficiency enormously. James Watt described the out put of his engine in horsepower, which had been used as a measurement for power engines for a long period of time, f. ex. with automobiles.

At that time the steam engine brought a lot of possibilities in the areas of transport and construction. From the first rotation on the engine brings a high torque to the axis and is able to work forwards and backwards. Steam automobiles can start moving under load and do not need clutch and gearing.

1.2 Knowledge about the steam engine

Right behind the wind power the steam power is one of the ancient methods of humankind to produce mechanical energy. The name steam engine is already indicating the energy source; steam. The energy source steam was and is transformed into other energy forms through different constructions, f. ex. piston steam engine or steam - turbines.

Basically we need two components regarding to the principle of the steam energy: the steam boiler and the piston steam engine or the steam – turbine. This principle has not changed till nowadays. Still changes have happened within the modern steam engine regarding to the technical designs, modern materials and a profound knowledge how to increase the efficiency.

In earlier times the efficiency of the piston steam engine was very low. Especially to generate electricity they were mainly substituted through steam turbines, which worked more efficiently. Nowadays functioning nuclear power bases are so to speak modern steam engines, working with the same principle. Here one uses the problematic nuclear energy to heat up the water.

1.2.1. How to change water into steam

To transform the liquid state of H2O into water steam, we need to heat it up till it boils. Once the water is boiling, which normally happens at 100 degrees C and 1013 hPa (the boiling temperature depends on the altitude of the place, more exact - on the external air pressure) it changes into steam. The boiling temperature of water (in general with liquids) changes when the external air pressure raise. Assuming we have 2 bar pressure in the steam boiler the boiling temperature raises up to 120 degrees C (theoretical value).

The heating up needs a certain quantity of energy which is called heat of evaporation. There are needed 4,2 joule to heat up 1 gram of water for 1 degree C. On the other hand it needs 2257 joule to evaporate 1 gram of water. This high energy consumption can be explained through the enormous expansion of the volume of the water steam in relation to its liquid state.1 litre of boiling water will transform into 1673 litres of steam (these values are related to normal air pressure).

Keeping the arising steam in a closed vessel will produce a very high pressure, which can even lead to an explosion of the boiler.

Therefore the steam engines have safety valves which open with high pressure so the steam can escape.

One uses the pressure of the steam by moving a piston in a cylinder, which produces mechanical energy.

Information:
In physics we use the parameter "p" for pressure, which acts with a power "F" on a surface "A".

When the steam cools down a contrary process is taking place, the steam condenses. Now the energy which has been used to evaporate is set free. Water steam condenses f. ex. on colder metals and is then visible in little water drops.

1.2.2 The boiler

There are different designs of the steam boiler depending on the use and form of the steam engine. The main intension is to provide constantly enough steam so that the pistons of the steam engine are moving.

1.2.3 The flywheel

The steam engine transforms the back- and forward movement into a rotating movement.

The classical steam engine has a heavy flywheel to provide an even rotation. This helps to overcome the upper and lower dead centres. The flywheel is an energy storage, which stores the energy of the "power strokes" and therefore bridges the passive time.

1.2.4 The oscillating steam engine

With the help of the oscillating principle one easily can realize a functioning steam engine model. The oscillating steam engine regulates the in and outlet of the steam through the moving cylinders. Constructions of centred rotatable bearings provide the needed flexibility of the cylinder. Through a coil spring the cylinder is compressed against the holder. The sliding surfaces need to be even.

Fig. 1.01: The oscillating cylinder: steam engine model of the steam box

On the back of the cylinder we find a hole which is called steam hole. On the connected surface of the fixing bracket we find a steam supplying hole and a steam exhausting hole. Steam enters into the cylinder when the steam hole of the cylinder is exactly positioned on top of the steam supplying hole. The piston moves out of the cylinder and the lifting movement is transformed into a rotating movement through the rod bearing and the crank (eccentric bearing). The flywheel mass leads the piston back so that the cylinder is tipping backwards with its steam hole on top of the steam exhausting hole and the used steam escapes. When the piston has overcome the rear dead centre the steam hole moves again on top of the steam supplying hole, steam enters the cylinder again and the explained process repeats itself.

The principle of the oscillating steam engine
The water steam provided by the boiler enters through the steam supplying hole into the cylinder and presses the piston out of the cylinder. Through the crank movement the cylinder moves on and the steam inlet is closed.
Through the uplifting movement of the piston the cylinder moves on and reaches the steam exhausting hole. The cooled water steam is pressed out and escapes to the sides. The process starts again.

The advantage of this type of engine is a much easier construction. It is a complete and powerful engine and was used in steam navigation.

1.2.5 The valve–controlled steam engine

Contrary to these simple constructions there are also valve-controlled models available, such as the steam engine model D9/D10, D20 and other models from Wilesco.

The valve-controlled steam engine works like this:

Water steam provided by the boiler enters the slide box and a slider presses on one side of the piston within the cylinder. The high pressure steam pushes the piston into the cylinder. As the piston is connected with the crankshaft through a connecting rod the flywheel now turns on half a rotation. Now the slider is moved. The steam feed happens now on the other side of the piston, which is then pressed backward through the steam.

The cooled steam leaves through the steam outlet, f. ex. through the chimney of the steam engine model. The process starts again.

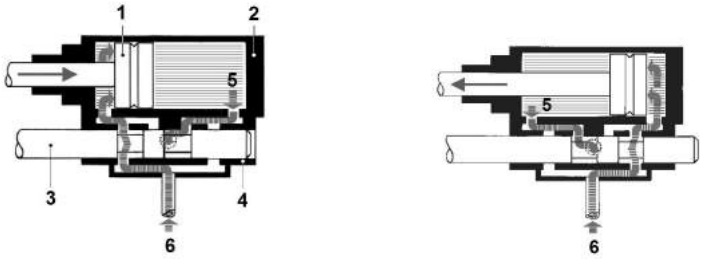


Fig.1.02

The principle of the valve-controlled steam engine (a cut through cylinder and slider) a) steam presses the piston (1) to the right, b) to the left. 1= piston, 2= cylinder, 3= slider rod, 4= slider box, 5= steam outlet, 6= steam inlet

The steam engine can consist out of one or several cylinders. The advantage of several cylinders is a continuous power transfer.

1.3 Power and efficiency

One of the real advantages of the steam engine is that through the external combustion he does not depend on high quality fuel. He works with any kind of fuel, f. ex. coal, wood, oil, peat, any kind of waste etc. This is not true for the steam engine model, they are fed with dry spirit tablets. Another advantage of the steam engine is that they produce relatively little operating noise. What one can hear is the noise of the mechanics and the exhaustion of the steam, the engine itself runs almost silent.On the other hand we have a very essential disadvantage. The steam engine has a very low efficiency; only 10 to 12%, which means only 12% of the involved energy of the fuel is transformed into kinetic energy.

1.3.1 Comparison: oscillating and valve-controlled steam engine

With the model Steam Box and the model D20 one can explore easily the difference between the oscillating and the valve-controlled steam engine. Also with the experiments of the Steam Box one can point out the differences very clearly.

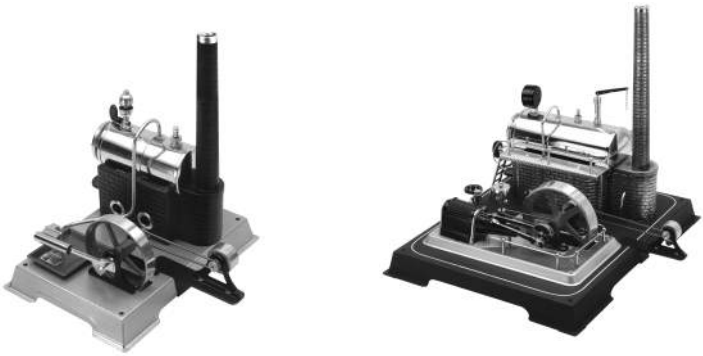


Fig.1.03 on the left side the steam engine model of the Steam Box with the oscillating cylinder, to the right the model D20 (valve-controlled).

Beside the different technical structures both models also differ in power transfer and efficiency. For the same amount of power the Steam Box model needs more fuel then the D 20 model. The generator is excellent to explore the power transfer.

1.4 What function has the steam engine nowadays?

In the area of the power engines the steam engine was substituted through the combustion engine. Because of the high energy content of the fuel (10-12 kWh per litre) one gains a higher efficiency together with less weight and more comfortable operation. Today there are still areas of use for the steam engine. These constructions are used in the coal mining and conveyor belts. Here the steam engine works as well as a winding machine for coal and at the same time as a brake to let down filling material. The kinetic energy which is produced through the letting down movement is used to heat up the steam.

Now and again there are engineers who pick up the principle of the steam engine and bring it into the world with modern materials. One advantage to the combustion engine is the external combustion process and the use of a variety of fuels. Another one is the overload capacity of the steam engine. Overload capacity means that the nominal value and the continuous power transfer can be shortly and without problems exceeded. One can prove this in the described experiments, f. ex. by short-circuiting the generator.

Modern steam engines with low emission combustion produce steam efficiently and then similar like a diesel engine they inject the steam through nozzles. Those engines work in the 2-stroke process and do not need common lubricants, because the mechanical parts are made out of carbonic components.

1.4.1 Hybrid systems consisting photovoltaic constructions and the steam engine

There exist different explorations and examinations regarding to hybrid systems consisting modern photovoltaic in combination with modern concepts of the steam engine.

These combined systems make sense in climate regions where solar energy mainly is used in the summer season and a complement is needed for the

winter season. A combined heat and power production serves well, mainly for the heating season. Systems like this provide f. ex. for private households or internal consumers, an all year round and energy self-sufficient concept.

Instead of the steam engine one also can use a Stirling engine. Both constructions can work with all kinds of solid and liquid fuels, f. ex. wood, coal, biogas etc.

Information: If you work with the E-Box 50 or a different model you can skip this chapter (2) and move on to the next (3) and continue to experiment with the steam engine model you have.

2. Assembling the model

Depending whether you work with the Steam Box D100 E or you already have a fixed model this chapter continues with putting together the steam engine model. The following chapter shows experiments with an already existent steam engine model.

2.1 Tricks and tips for a successful assembling

Sometimes it seems a little difficult to screw in some screws in an inaccessible positions, like in the area of the flywheel. It is very useful to fix a little magnet on the screwdriver so that it becomes magnetised. Now the screw can easily be lead to the prepared drilled hole.

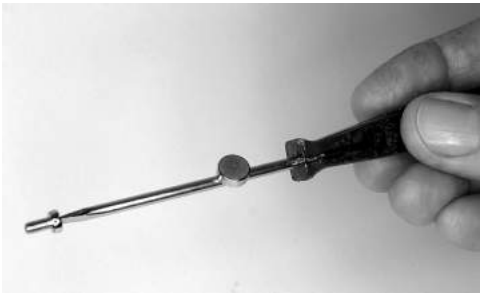


Fig.2.01:
Screwdriver becomes magnetised and holds the screw.

To tighten the screw properly it makes sense to use the screwdriver on the one side and on the other side hold the screw-nut with a spanner.

It is helpful to put all the small pieces like screws, nuts and seals into a flat container so they do not get lost.

How to lubricate the moving parts:

A good service brings a small disposable syringe, with a blunt needle (the peak of the needle can be cut of or grinded down). This allows injecting the steam engine oil well measured onto the oil needing parts.

Do not use any liquid oil for lubricating the piston and cylinder. Please only use Wilesco steam engine oil.

Fig. 2.02: Lubricating with a disposable syringe

Before lightening the dry spirit tablets check whether the burner slide moves easily in and out of the burner slide box (in the boiler house of the steam engine model). If not you can slightly widen the sides of the burner slide box.

2.2 Assembly instructions step by step

All the parts that you require to build this steam engine, including the tools, are contained in the Steam Box D 100E. The instruction leaflet is divided into assembling steps, and each step is illustrated.

Please follow the instructions exactly and step by step, so that the operation of the steam engine is successful.

Step 1: Assembly of the boiler

Insert the fixing bracket of the boiler through the boiler house (2) from beneath until the angled sides fit against the upper flanges of the boiler house (2). Locate in the centre notches to restrict sideways movement, now the bracket will stay in place due to its own tension. Push the boiler (3) according to the Fig. 2.2.1 (The water level glass has to stay on the side of the fire place) between the fixing bracket (4) and the boiler house. Now push the boiler up against the bracket, and at the same time slide it forwards until it locks on the rear boiler support.

Fig. 2.2.1: mounting the boiler

Step 2: Mounting the burner slide and boiler house

CAUTION work carefully because of sharp edges! Insert the tabs on the burner slide (5) with the point facing towards the front into the corresponding slots on the base plate (1). Turn the base plate (1) over, and tap the burner slide tabs outwards, using the screwdriver handle. This is best done by resting the burner slide on the edge of a table.

Now insert the long tab on the boiler house into the long slot in the base plate (1), locate the remaining two tabs into the corresponding slots and tap these over as well. This is best achieved by resting the chimney vent on the edge of the table. Attach the stickers "watch water level" on the base plate (1) under the water level glass and the sticker of the model number next to it.

Fig.2.2.2: mounting the burner slide and the boiler house

Step 3: Assembling and mounting the flywheel.

On the short side of the flywheel axle (8) fit one bearing frame (7) and then screw on the crank plate (12). On the other side of the axle slide onto in the following order the distance bush (9), the second bearing frame (7) and 1 washer (11), then screw on the pulley wheel (10) again. Now tighten the crank plate (12) and the pulley wheel (10) against each other. This flywheel unit is now fixed onto the base plate (1) using the screws M3x6 (24) and the nuts (25) so that the crank plate faces towards the outside.

To mount this part is a little difficult, so please look under tricks and tips using the idea with the magnet on the screwdriver.

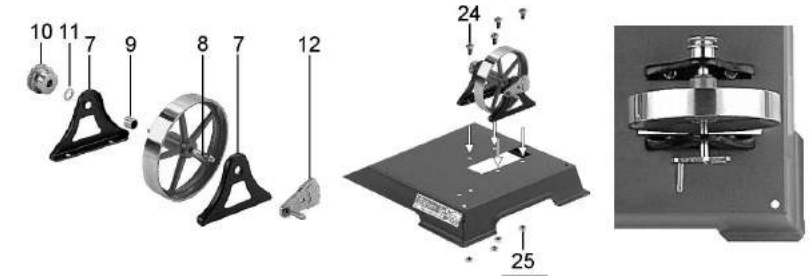


Fig.2.2.3: mounting the flywheel

Step 4: Assembling the cylinder unit.

Mount the cylinder unit first by fitting the spring (18) and the baffle plate (15) onto the screw M3x16 (17). Now tighten her into the threaded hole on the cylinder (20) by turning the screw only 1-2 times. Do not turn further otherwise this will damage the cylinder. Now fit the baffle plate and the condensed water tray to the base plate using two screws (24) and nuts (25). Insert the screws from underneath the base plate.

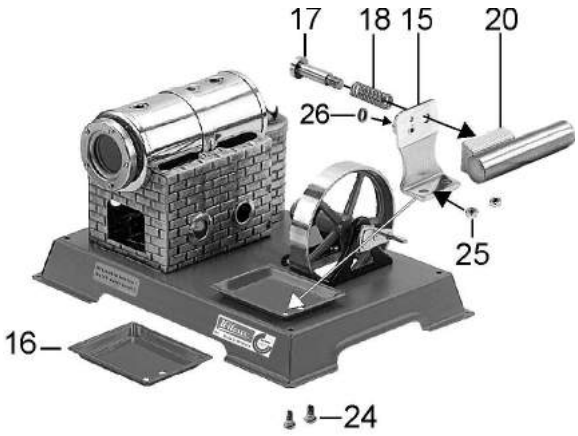


Fig.2.2.4 mounting the cylinder unit

Step 5: Mounting the steam pipe, chimney and final assembly

On the boiler are three threaded holes. Put a gasket (26) into the middle one and in the threaded bush on the baffle plate (15). Slide the cover (14) over the packing screw (13-1) on the baffle plate end of the steam pipe (13) and lightly (first by hand) screw both ends of the steam pipe into the gasketed holes. Now insert the piston rod (19) into the cylinder and over the crank plate (12) pin. Check that the cylinder is at right angles to the flywheel axle, are any adjustments necessary loosen the nuts holding the baffle plate, adjust and retighten. Now with the use of the supplied spanner tighten the steam pipe connections. Put a large gasket onto the whistle (22) and the spring loaded safety valve (21) and fix it by hand (not using a tool) on the boiler. Using a combination of gaskets you can position the whistle correctly and tighten both by hand. Insert the burner tray (6) under the boiler and fit the chimney (23) over the vent and fix it with 2 metal screws. Now the assembling of the steam engine is finished. Stick on the sticker: Baumusterprüfung vom TÜV/Nord

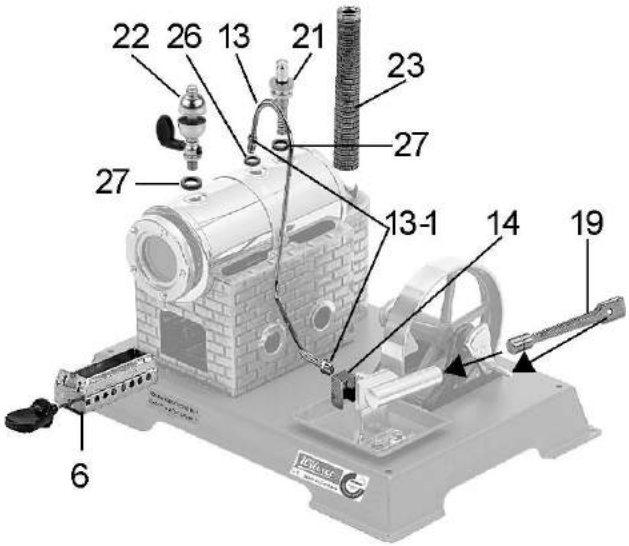


Fig.2.2.5: Final assembling

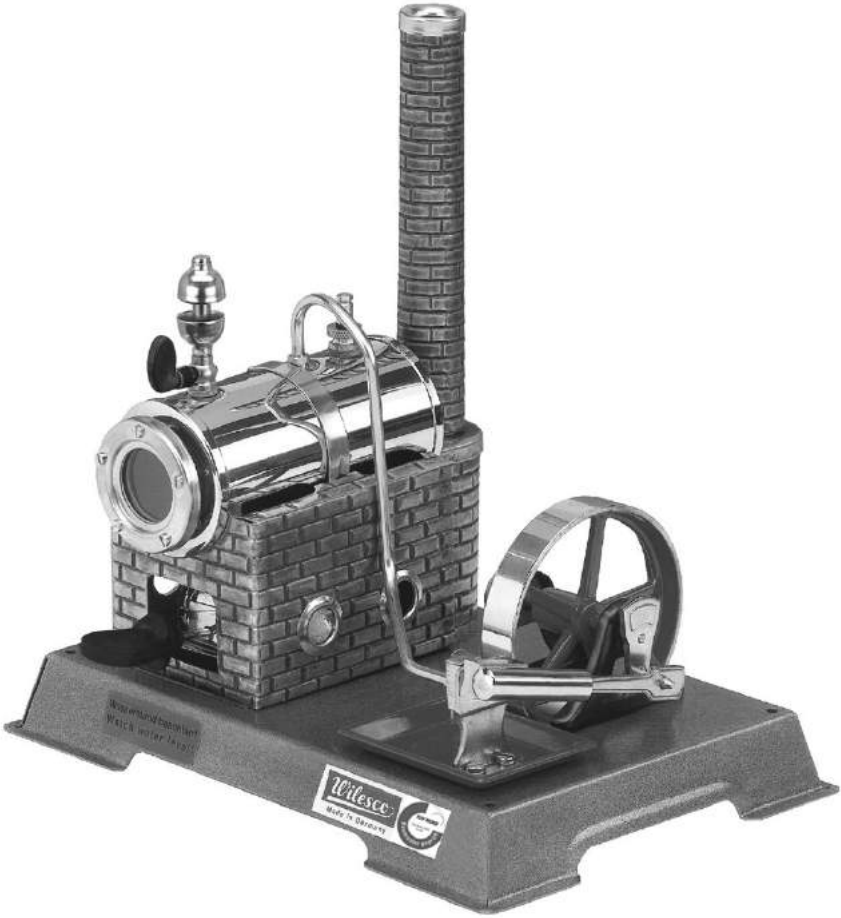


Fig 2.3.1: A complete steam engine model without generator

Before operating read the instructions carefully. We wish you lots of fun in building and operating this steam engine.

2.3 Precaution instructions

Attention! Important information and safety precautions for your own safety:

1. **For safety reasons, children should run the steam engine only under supervision of adults (recommended age: from 8 years on, not recommended for children under 36 months). During the operation of the steam model until its complete cooling the engine must be under constant observation.**

Important!

Never operate the engine without safety valve. Only use WILESCO steam engine oil and dry fuel tablets!

1. Each irregularity during operation has to be repaired by a competent and authorized person or by WILESCO themselves. Otherwise any warranty expires.

2. Any unauthorized change, repair or manipulation to the standard specification will also invalidate the warranty.

3. All parts which are under steam pressure so as boiler, spring loaded safety valve etc. leave our works only after a 100% examination. The spring loaded safety valve must not be manipulated. **The operation of the steam engine without any spring loaded safety valve is not allowed** The function of the spring loaded valve has to be checked before each operation by pressing the spring or by a small pull on the upper valve rod. If lime residues caused by hard water are visible on the spring loaded safety valve, it has to be replaced immediately.

4. **High temperatures:** The principles on which the engine works mean that the burner slide, boiler, boiler house, the spring loaded safety valve, the steam pipes etc. become very hot. Do not touch in order to avoid the risk of burns.

5. Safety precautions: in the course of the running, take care that children do not touch any of the moving parts.

6. **Danger if the boiler is heated without enough water!** Always ensure that there is enough water in the boiler of the steam engine. Caution: When refilling WiTabs dry fuel tablets also refill up to the max. level.. **The water must <u>always</u> be visible at least at the lower end of the sight glass**, otherwise the joints become leaking and the boiler will be destroyed. Any resulting claim, damage or consequential damage cannot be accepted.

7. If the boiler or any steam leading part leak, stop the steam model immediately by removing the burner slide. Any necessary repair should be carried out by authorized staff or at the WILESCO company.

8. The steam engine meets all safety standards and actual regulations. Every boiler has been submitted to a bursting pressure and water test of 5 bar. The operating pressure is maximally 1,5 bar.

9. Imperatively keep the operating instructions together with your steam box.

10. We advise you to place the stationary steameEngine on a non sliding surface or fix it onto a coated chipboard (approx. 16 mm thick) with 4 wooden screws (3,4 x 45 mm). The size of the board depends on how many models will be running with the steam engine.

Caution: Don't operate the steam model near flammable objects or on a temperaturesensitive surface. Operation only under windless condition.

2.4 Preparation for the first test run

Components: distilled water, steam engine oil, dry spirit tablets

Please operate the steam engine model only according to the instructions and the safety instructions.

Operating instructions

1. Filling with water at the first operation and after cooling of the boiler: Unscrew the spring loaded safety valve and fill the boiler with the funnel up to the water level maximum (upper end of the sight glass), if possible with warm water. Lift the funnel slightly during filling so that the air inside the boiler can escape. Use only deficient in lime water or, even better, water without any lime (e.g. distilled water). Then refit the spring-loaded safety valve.

2. Screw the steam whistle onto the boiler. When screwing in the steam whistle, the lever should point outwards (use washers if necessary) so that the operation of the whistle is possible without having contact with the boiler. Do not pull or pull out the lever, only move it carefully from side to side.

Note: The steam whistle makes it possible to regulate easily any overpressure in the boiler or check before oiling whether the boiler is still under pressure.

3. Only oil the piston when there is no pressure in the boiler. To check this, operate the steam whistle several times. When the piston needs to be oiled remove the piston rod from the pin of the crank disk and apply abt. 2-3 drops of Wilesco steam engine oil onto the piston and abt. 2-3 drops into the cylinder itself. 2-3 drops oil are sufficient for approx. 10 minutes operating time. Oil lightly all of the bearings and linkages. Before refilling the boiler with water, check that no pressure is in the boiler through operating the steam whistle.

4. Place 1 1/2 WiTabs dry fuel tablets upright in the burner slide (not more than 1 1/2 pcs.) and light them. Use only the original WILESCO burner slide. Caution:

because of the risk of danger from an open flame, always take the necessary safety precautions. The burner slide is adjustable. The oxygen supply and the flame height can be adjusted by moving the burner slide in relation to the air holes of the burner slide guide in the boiler housing. Before adding new fuel tablets, always check the water level and refill the boiler with water to ensure that the boiler does not run dry. The portion of fuel tablets to the quantity of water in the boiler is designed so that the boiler cannot run dry without any added fuel tablets. The burner slide must be completely pushed in. Important: After the heating process, remove the burner slide from the guide whilst it is still hot, otherwise not burnt fuel may cause the slide to stick. If the slide is stuck, it can be removed by tilting it slightly to the left or right.

Caution: dry fuel tablets require a lot of oxygen to burn properly. That is the reason why, for an indoors use, the room should be well ventilated.

To prevent unpleasant smells, the fuel tablets should be burnt out - they should not be blown out. If there is not enough water in the boiler, place the burner slide on a fireproofed surface until the tablets have burned out completely.

5. When steam can be seen turn the flywheel by hand to let the condensation in the pipes and the cylinder escape. Then the steam engine will start to operate.

6. After the use of the steam engine and its cooling, the engine should be serviced. Pour out any water left in the boiler. For this, unscrew the spring loaded safety valve and take off all of the loose parts before tipping over the engine. Be very careful if the water is still hot! Water left in the boiler cannot do any damage but might leave sediment on the sight glass. Any lime formation on the sight glass or in the boiler should not be removed by using vinegar or corrosive agent (advise: use a lime dissolving agent which does not attack the brass and the solder). The building of soot on the lower side of the boiler does not influence the function and can be removed with a brush. Finally, dry the model using a clean piece of cloth.

Fig.2.3.2: Steam engine of the Steam Box with generator

3. Experiments with the steam engine and additional components

Together with the added components and the steam model one now can start to build electrical and electronic circuits.

3.1 The components and their description

Here are described the qualities and the use of the added components in the Steam Box D 100E and the E-Box 50

3.1.1 The generator

You find a permanently excited current machine in the Steam Box D 100E and the E-Box 50, which is used in the experiments mainly as a generator. To be more precisely there does not exist any difference between an engine and a generator. Depending on the use and the electrical wiring a machine works as an engine or a generator.
The generator with its permanent excitement has the advantage to create the field for induction/generating electricity through a permanent magnet instead of using a coil. This construction saves energy which is normally used to establish the electric field. In cases of low rotating speed of a steam engine it avoids that there is more energy consumed then being produced.
The direct current generator has a rotor (a coil out of enamelled copper wire), which turns within a constant magnet field (stator). This rotor coil is connected through a brush-like commutator to the generator connections (red and black connection cable). With each half rotation of the rotor the commutator changes the polarity of the coil.

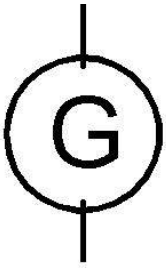


Fig.3.0.1: circuit symbol, generator

Fig.3.0.2: direct current machine with mounting support

The connecting cables (red/black) are made out of flexible strand and can be connected f. ex. with crocodile clips with the bread board.

3.1.2 Transmission belt

Through twisting the enclosed transmission belt it is joined together or pulled apart. Therefore hold - likewise in Fig.3.0.3 – the left end and take the right end and give it 1-2 turns to the left (a). Now the transmission belt itself stays without tension. Take the conical end – in the Fig.3.0.3 the right end - and stick it into the cylindrical end and screw it in with 1-2 turns. The dismounting you do in the reversed order.

Fig.3.0.3: connecting the transmission belt, a) first step, b) second step

The Steam Box contains transmission belts. One can cut with a strong scissor the transmission belt into the right length. For the transmission of the mechanical power of the steam engine to the generator a length of 175 to 185 mm is optimal. It is important to make the cut on the cylindrical end and leave the conical end for putting together both ends of the belt.

3.1.3 The bread board

The bread board, also called patch panel, consists in his inside contact springs, which are connected to one another in a system of rows.
The bread board is excellent for realizing electronic circuits in combination with the steam engine. The electronic parts, such as the LEDs, resistances and connecting wires can be repeatedly used and inserted into the contacts. It allows that the experiments can be configured without soldering or screwing. One can design circuits and experiment with them by changing or exchanging different components.
Dates: This bread board has 170 contacts in a 2,54mm grid. The 170 contacts in the middle range are each connected by vertical strips in rows of five.

- measurements: 45mm x 33mm x 9mm
- distance of contacts: 2.54 mm (100 mil)
- cable connection - size: 0.3 - 0.8 mm (AWG 20 - 28)
- shape of the hole: rectangular
- fixation: adhesive foil at the back side

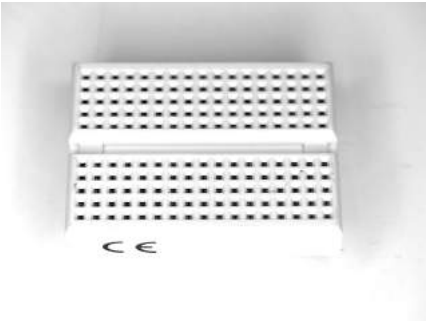


Fig.3.04: bread board

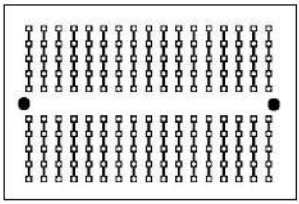


Fig.3.05: internal circuit system of the bread board (connection of the contacts by vertical strips in rows of five)

When the bread board is new, initially it can be difficult to stick in the pieces and wire jumpers. It helps to prepare the contacts with a thin needle, which should not be thicker then 0,3 – 0,6 mm, otherwise the contact spring wears out to an extend that the contacts to the wire connection might suffer.

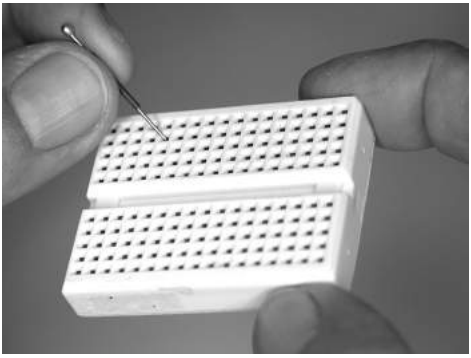


Fig.3.06: carefully widen the contact with a needle

All parts can be stuck in directly without soldering. It needs some practice, so that the connection wires do not bend over. Hold the wire right at its end and stick it vertically with a little bit of pressure into the contact. The use of flat pliers can be helpful.
Cutting the end of the wire diagonally with a side cutter is also supportive. Short wires – like you find at the LEDs – you stick in with flat piers or a pincer, so they do not bend over. One can cut some jumpers with a diameter of 0,6 mm out of the jumper wire.

Measure the approximately length of the jumper and add the length of the ends, which will stick in the contacts. Remove the cable insulation at the ends. Either you use a wire stripper or cut around the wire with a knife and remove the insulation.

The bread board can be fixed on a surface, f. ex. a well proportioned prepared piece of wood. The back side of the bread board has an adhesive foil. Take of the protection paper and glue it now onto a plain and dust-free surface.
Attention: Once you glued the bread board onto a surface it is difficult to remove without damaging it.

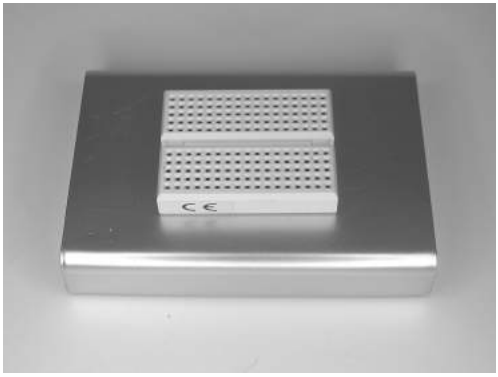


Fig.3.07: bread board glued to a mounting board (mounting board not included)

3.1.5 LEDs

Compared to a normal diode the LED (light emitting diode) has one further characteristic! It shines when voltage is applied. You find a red, an orange, 2 white shining LEDS and a red flashing LED. You can identify the flashing LED through its black spot within its red enclosure. The dark spot is the integrated circuit which causes the LED to flash as soon as the correct voltage is applied.

LEDs should always be operated with a series resistor for current limiting, otherwise they can break.

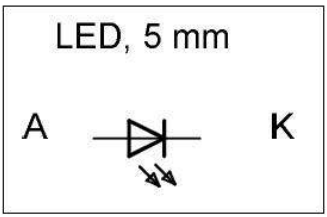


Fig.3.08: circuit symbol, LED, the arrow shows the technical direction of the electric current, A symbolises anode (+) and K cathode (-)

In some experiments together with the generator are series resistors with 100 Ohm to 1K-Ohm recommended.
Compared to the normal light bulb the LED does not have a filament. They have a long durability and do not consume a lot of energy.

Fig.3.09: The connections of the LED: the longer end of the wire is the cathode, the "negative connection", also marked through a flattened enclosure

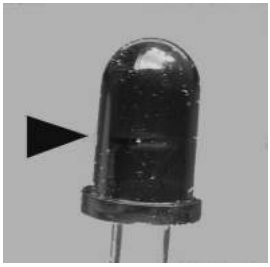


Fig.3.10: flashing LED with integrated flash-IC

3.1.6 Electrolytic (Electrolytic capacitors)

Electrolytic capacitors have a high capacity compared to normal capacitors. One can imagine the capacitor with 2 metal plates (as it is usually shown in the circuit symbol). The first "plate" insulated by an oxide-layer (dielectric). The "second" plate consists out of an electrolyte, which gives the name to the capacitor. Due to the electrolyte, an electrolytic capacitor is polarity-dependent and the connections are designated with a positive pole and a

negative pole. When it is connected “the wrong way around” over a longer period, the electrolyte of the capacitor will be destroyed.
Do not exceed the imprinted maximum voltage indication, because otherwise the insulation layer can be destroyed.
Enclosed you find radial electrolytic capacitors with the following capacities: 1000µF and 4700µF

Fig.3.11: circuit symbol, electrolytic capacitors, left the positive pole

Information: µF means “microfarad”; the unit µ is one millionth of the basic unit.

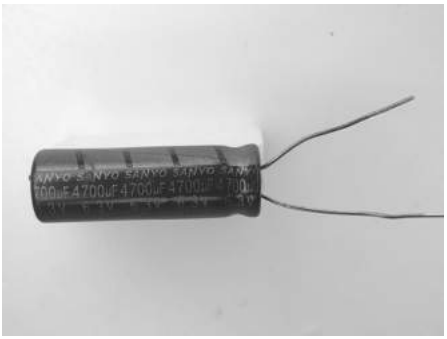


Fig.3.12: Electrolytic capacitor with connecting wires. The positive pole is the longer connection wire. In addition the negative pole is designated with a bright line on the enclosure.

For simplicity, the term “electrolytic capacitor” is sometimes shortened to “electrolytic”. This abbreviation is mainly used in the US.

3.1.7 Diode

Diodes let the current pass in only one direction. For that reason, they are used to rectify AC voltages and to block undesirable polarity with DC voltage, among other things. You can picture the functioning of a diode in normal operation most easily as a non-return valve (water installations). When pressure (current) is directed onto the valve (diode) in blocking direction then the current will be blocked.

Fig.3.13: circuit symbol, Scottkydiode, the left side signed with A is the anode (+), the right side signed with K is the cathode (-)

The pressure has to built up in contrary direction (direction of the arrow) to overcome the spring pressure of the valve. The valve opens and the current flows. The pressure, which is mentioned in this mechanical model to overcome the spring pressure, corresponds to the forward voltage of the diode. A certain voltage in the flowing direction of the diode is needed to move into a conductive state.

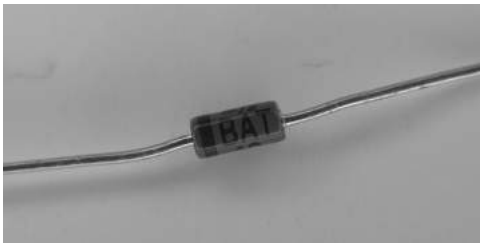


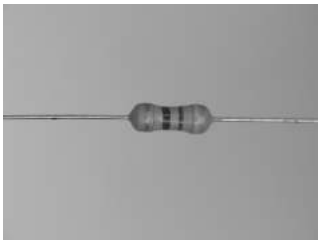
Fig.3.14: Schottykdiode, type BAT48. The cathode of the diode can be recognized by the imprinted black ring, the other connection wire is the anode. The technical current direction goes from the anode to the cathode.

Information: With the enclosed Schottky diodes the current begins to flow at 0,25V in forward direction (circuit symbol: arrow). This allows an almost loss-free transmission.

3.1.8 Resistors

A resistor is a passive component in electric and electronic circuits. Its main task is the reduction of the flowing current to “reasonable” values. The most famous resistors are the cylindrical ceramic type with axial connection wires. The resistance values are imprinted in the form of coded coloured rings. Enclosed are carbon-film resistors with the different values, shown in the following table.

amount	**Resistor - value**	**1. ring 1. number**	**2. ring 2. number**	**3. ring Multiplica-tor**	**4. ring Tolerance**
1	1 Ohm	brown	black	gold	gold
1	10 Ohm	brown	black	black	gold
1	100 Ohm	brown	black	brown	gold
2	1 K-Ohm	brown	black	red	gold



R = resistor

Fig.3.15: to the left a photo of a resistor, to the right the circuit symbol of the resistor. It does not matter on which side it is connected.

3.1.9 Crocodile clips (red/black)

With the red and black experimental wires, which have the crocodile clips on their ends, you can easy and fast connect and combine different electric parts (without soldering). It makes sense to use the red wire for the positive pole, the black one for the negative pole.

Fig.3.16: experimental wire with crocodile clips

3.1.10 Hook-up wire (red/black)

Enclosed you also find hook-up wire. You can make jumpers by estimating or measuring the approximate length of the jumper (plus the length for the wire ends that will be inserted into the plug contacts). The ends are stripped of insulation for ca. 8 mm. Connection wires pinched off diagonally with the wire cutter make insertion in the bread board contacts easier. With these wires you can establish the electric connections between the single contacts of the bread board. Once the jumpers are made, they can be used again and again.

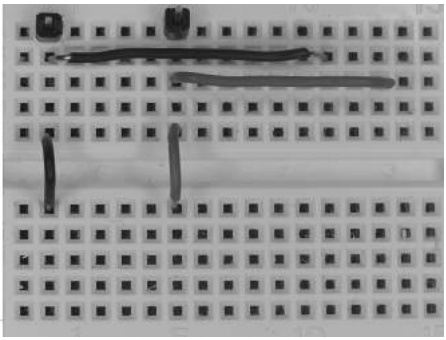


Fig.3.17: Possible applications of the hook-up wire. One can see the pins for the connection to the crocodile clips in the upper contacts. The upper 5 rows are connected to the lower 5 rows.

3.1.11 Switch

According to the figure you find one switch. This type with 2 connections is suitable for the use on the bread board. The electric flow is as long established as the switch is pressed. Letting go of the switch is stopping the flow again. Please mount the 4 legs of the switch as shown in the figure. The switch will not work with wrongly twisted mounting, because the connections are internally connected.

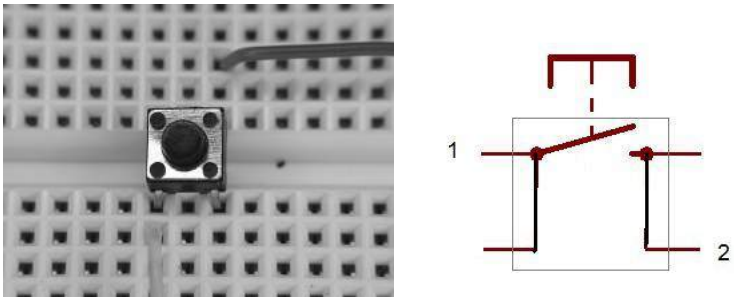


Fig.3.18: a) switch on the bread board and b) connecting assignment

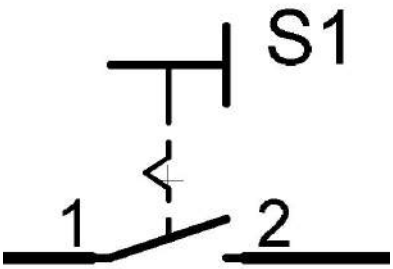


Fig.3.19: circuit symbol: switch

Components in an overview:

amount	type	detail
1	generator, permanent excited, current machine	
1	generator bracket	
1	bread board	170 contacts
1	switch	
1	LED, red	5 mm
1	LED, orange	5 mm
2	LED, white, extra bright	5 mm mind. 2500 mcd
1	flash-LED, red	5 mm
1	electrolytic	1000µ, 10 V (or higher)
2	electrolytic	4700µ, 10 V (or higher)
1	Diodes, Schottky	BAT 48
2	Crocodile clips	red, black
2	pins	
5	resistor, carbon ¼ Watt	1, 10, 100 Ohm, 2x 1K
0,5m	wire, rot	0,6 mm
0,5m	wire, black	0,6 mm

Note:
It is recommended to follow the instructions and the order given in the booklet. This facilitates the understanding and eases the mounting and changes. Later on you can repeat the experiments in your own order of choice.
Recommendation of the following order:

- read the instructions
- mount the experiments
- check the mounting
- prepare the components for the experiments
- start and run the steam engine

Only use the generator for the here designed purposes!

3.2 From the mechanic energy to the electric energy

To gain electricity out of steam we need a couple of steps. First happens the transformation from steam energy into mechanical energy and then from mechanical energy into electricity. In our day to day life electricity has the advantage that we can already use the existing installation and its use is universal.

3.2.1 Connection and function of the current machine

The Steam Box D 100E and the E-Box 50 contain a permanent excited current machine, which is used in the experiments as a generator. From the perspective of the electro technique there does not exist any difference between an engine and a generator; only depending on the use they are named engine or generator.
You will experience the qualities and functions of the generator in the following chapters through the practical experiments. In the text the current machine is named generator when transforming mechanical energy into electricity.

Connecting the generator:

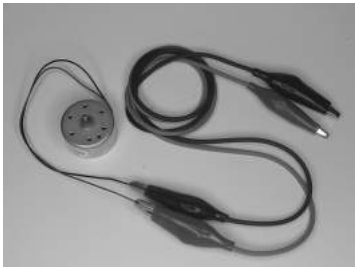
Components: generator, crocodile clips

The generator has two connections, one with a red and another one with a black cable. He generates pulsating direct current. You have a positive and a negative pole same like with a battery. At the exit of a direct- current generator one receives two half cyclic wave forms. Connect the cables of the generator with the crocodile clips for the following experiments.

Connect the black cable to the black crocodile clip, the red cable to the red clip, like shown in Fig.3.20. The connections of the generator can maintain like this in most of the following experiments.

Note:For a stable contact between connection cable of the generator and the crocodile clips it is helpful to bend the stripped ends of the

connection cable towards the insulation and then stick all into the clip. This connection can maintain like this in most of the following experiments.



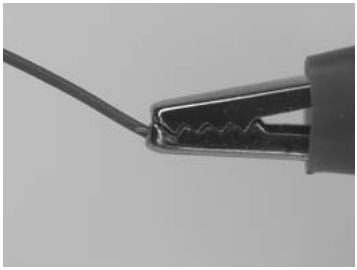


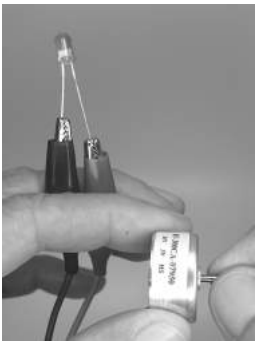
Fig.3.20:a) connection of generator cable and crocodile clips, b) detail, how to put in the cable to provide a stable contact.

Do not connect the generator to the steam engine for the first experiments!

3.3 First experiments with the generator

Components like before, 1 orange LED added

For the first experiment with generator (not connected to the steam engine) you mount a circuit with an orange LED. The longer wire of the LED is the positive pole and shows into the direction where the red connection of the generator is connected. When all parts are assembled one turns the axis of the generator (together with the belt wheel) forward and backward, holding it between thumb and index finger. In one direction the LED will flash, in the other direction she does not shine.



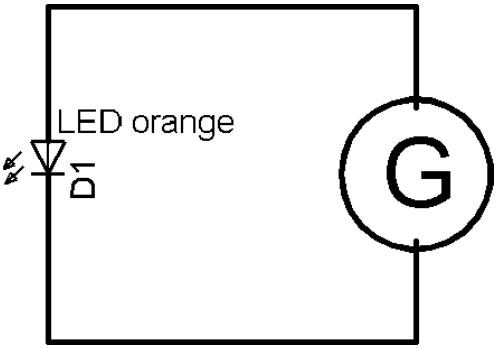


Fig.3.21: a) assembly of the experiment and b) circuit diagram

Note:
The orders of the experiments build up on each other. You do not have to dismount everything after each experiment, but parts can be joined, taken away or changed.

3.4 Rotation direction indicator

With this circuit you can construct a rotation direction indicator. Depending in which direction you move the generator one or the other LED flashes. Also one can exercise whether the LEDs are properly connected or not.

3.4.1 The transfer of the circuit

The transfer of a circuit diagram into a circuit on the bread board will be described in the following example with the rotation direction indicator and two LEDs. In the Fig.3.22a) is the circuit diagram shown. It contains symbols of the electronic components.

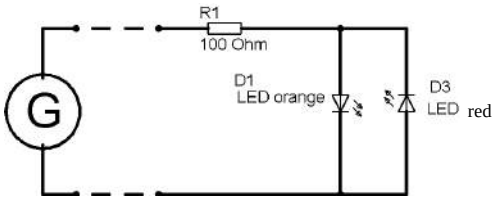


Fig.3.22a) The first circuit diagram, G for generator, R1 for series resistor, D1 for the orange LED and D3 for the red LED

The electronic components such as resistor R1 or the D1 orange LED or the D3 red LED can be plugged into the bread board without soldering. Through the internal connections of the contacts of the bread board and the added jumpers` one gains the electronic circuit and the electrical circuit.

It does not matter which direction you stick in the resistor (f. ex. R1 series resistor). It is oposite with the diodes and the LEDs. The LEDs have a longer and a shorter connection wire. The longer wire is the positive pole, the anode, the shorter one is the negative connection, the cathode. Even when they are connected the wrong way around they will not break.

The cables coming from the generator, connected with the red and black crocodile clips are plugged into the bread board through the pins. The black cable (negative pole) to the left and the red one (positive pole) to the right, as shown in the picture.

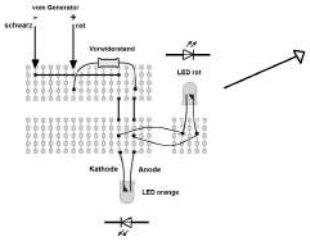


Fig.3.22b) Composition of the components on the bread board, on the right a photo of the LED.

In Fig.3.22b) one can see the connections and also the structure of the LEDs within its enclosure.

The cathode has a shorter connection wire and the metal end within the transparent enclosure has the shape of a triangle. In the figure you can see how the LEDs are plugged into the bread board. For an easier overview the red LED is pictured apart on the right side. One also can recognize the contacts of the bread board (in rows of five) and their vertical connections (in grey).

Mounting of the experiment:
Components as before, additional: one red LED, one series resistor 100 Ohm. It makes sense to use the LEDs only in combination with a series resistor to avoid their destruction when there is a high rotation and therefore a high voltage of the generator.

In the first experiments the generator is used separately from the steam engine. You can make the LEDs flash by using your thumb and index finger and turn the axis of the generator strongly. With the correct mounting of this simple circuit, in each direction only one LED flashes. F. ex.: right turns the red LED, left turns the orange one (or opposite around). If both LEDs are flashing when turning in one direction, then one LED is wrongly plugged in.

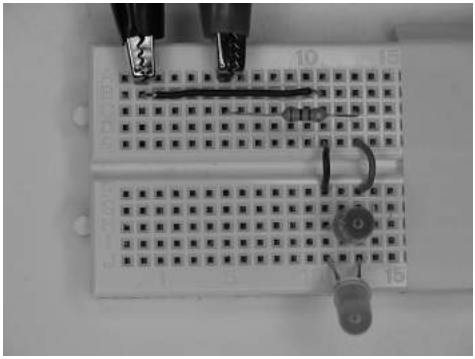


Fig.3.23: Composition of the bread board, 2 LEDs, anti-parallel, series resistors, cables with crocodile clips, generator

3.4.2 The technical and the real current direction

In which direction do the electrons flow within an electric circuit?

Information about technical and real current direction:
Observing the flow of the electrons (f. ex. with the electrolysis), one can see that the electrons really flow from the negative pole to the positive pole. This is named the "physical current direction" in contrary to the "technical current direction", where is defined, that the electric current flows from the positive pole to the negative one. The technical current direction is always used in circuit diagrams (f. ex.: with LEDs, diodes and the generator).

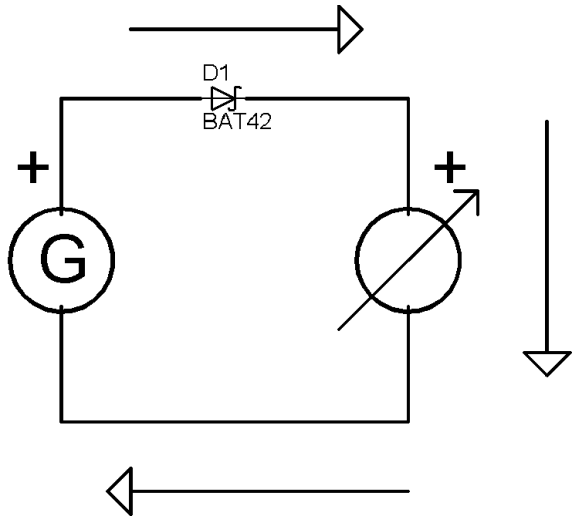


Fig.3.25: Diagram of the principle of the technical current direction (in a closed electric circuit) from the positive pole to the negative pole

The diode works like a valve, which allows the current to flow in one direction and stops it in the other direction.

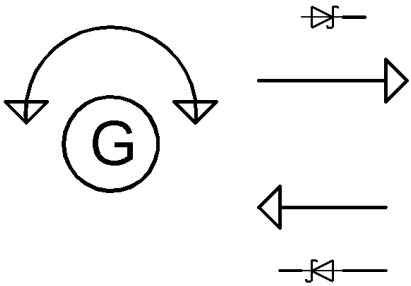


Fig.3.24: Principle of the direction of the rotation and current direction

3.5 Mounting the generator

Components: generator with mounting support, pulley belt, generator holders, screws

To mount the generator on the basic plate of the steam machine one uses a two-piece compression fitting in combination with the generator mounting support.

You can install the generator to almost all basic plates of the Wilesco steam engine models.
Depending on the type of the steam engine model they produce rotations from 1000-2000R/min at the axis of the flywheel.

Fig.3.26: Parts for mounting the generator, a) two-piece holder of the generator, b) mounting support of the generator and adjusting screw

Position the lower part underneath the basic plate and the upper part above and connect together with the generator mounting support/ generator with two screws and nuts. Before tightening the screws, adjust the holder of the generator that both pulley wheels – that of the generator and that of the flywheel of the steam engine – are in one line. Now tighten the screws and finally also the compression fitting underneath, so that the generator is well fixed.

Fig.3.27: Assembling of the generator: a) both pulley wheels in one line, b) compression fitting, underneath the basic plate

3.5.1 Generator, to connect mechanically with the flywheel of the steam engine

Assemble the transmission belt and arrange it on the pulley wheel of the generator and the pulley wheel of the shaft of fly wheel. Arrange the tension of the transmission belt so that the transmission is easy and smoothly.

Fig.3.28: The right tension of the belt is important for a successful work!

The right tension of the belt helps that the transmission of the mechanical energy to the generator flows optimally and without gaps and at the same time as less loss as possible through friction occurs. Is the belt too tight, it is hard for the steam engine to move the generator and he can not establish the appropriate rotational speed.

Important information:
Please use only the small pulley wheel even if you have access to more potent steam engine models. With the big pulley wheel (on the shaft of fly wheel) the rotational speed and the voltage of the generator will become so high, that the generator and the electric circuits might get damaged.

3.5.2 Measuring the voltage of the generator

Components: generator, multimeter

Now you can measure the voltage of the generator using a multimeter. Put the multimeter on the indicator for direct current, f. ex. the area till 20V.
With the steam engine model of the Steam Box D 100E you can measure 2.9 to 3V running it full power, bigger steam engine models generate more then 7V.

Fig.3.29:
measuring the voltage of the generator with a multimeter

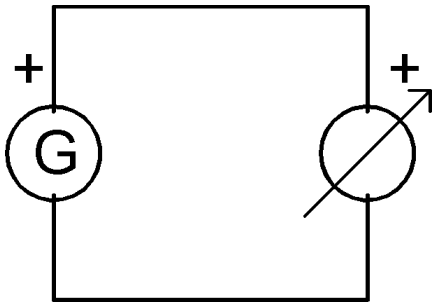


Fig.3.30: Symbols of the circuit diagram, left the symbol for the generator, right the symbol for the measuring instrument

Note: Please do not put the bread board with the electronic circuits too close to the steam outlet (cylinder). Use the cables with the crocodile clips and put the board with the electrical circuits in an appropriate distant to the steam engine and continue doing your experiments.

Fig.3.31 appropriate place for the bread board

The voltage is depending on the maximal possible rotational speed of the steam engine model and the transmission to the generator. Especially the bigger steam engine models allow you to experiment with the rotational speed by closing or opening the steam inlet more, or less.

3.5.3 The direction of the rotation of the steam engine and the generator

Depending on the steam engine model you use, one can make experiments with the direction of the rotation of the steam engine in connection with the generator.

Oscillating steam engine models like the Steam Box D 100 E model only have one possible rotation direction, other models like the D10 or D20 model are able to rotate in both directions. The following experiments use the direction of the rotation of the fly wheel in clockwise direction (looking directly onto the fly wheel with the boiler in the background).

3.6 Using steam energy to generate electricity

We need a generator to generate electricity out of steam. The word "generator" has its origins in the Latin language and means freely translated "to bring out" or "to produce". Though looking more exactly, energy can not be produced, only changed from one state into a different one. So in this sense a generator is an energy transformer.
The generator, which is used here, is a direct current generator and has a permanent magnet.
Electricity is induced into the rotor (runner), the permanent magnet is on the outside. The generated electricity will be rectified with a commutator and can then be taken from the red and black connection cable.
The actual voltage depends on the rotational speed, the actual electricity depends on the construction of the generator and the torque of the steam engine.

3.6.1 Evaluating the power of the steam engine and of the generator

Components: generator, orange LED, series resistor 1K-Ohm, resistors according to the description

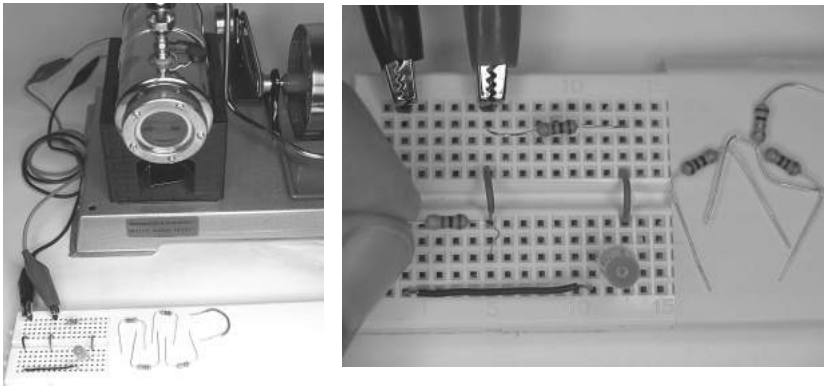


Fig.3.32: Stress test with several resistors, a) mounting the experiment, b) mounting of the bread board

Here you find once more the colours and values of the resistors listed and the sequence of their use within the experiment.

Value of the resistor	**1. ring**	**2. ring**	**3. ring**	**4. ring**
1000 Ohm	Brown	black	red	Gold
100 Ohm	Brown	black	brown	Gold
10 Ohm	Brown	black	black	Gold
1 Ohm	Brown	black	gold	Gold
ca. 0 Ohm =	Wire			

Prepare the resistors before starting the engine and then you can stick them into the bread board while the engine is running. You have a little more than 5 minutes to run the experiment if you take 2 dry spirit tablets and the according amount of water. The orange LED will show you optically whether the voltage of the generator is dropping or continuous. Wait till the rotational speed of the steam engine has established and the LED is continuously shining and only then start with the experiment.

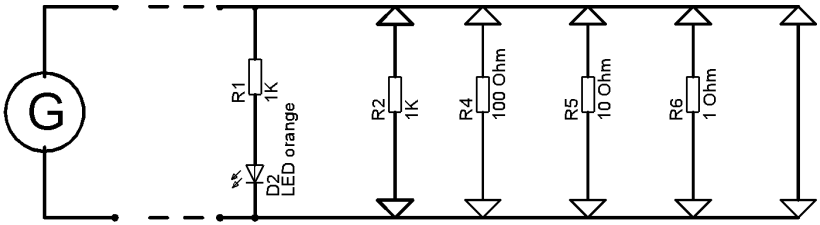


Fig 3.33 circuit diagram to the stress test

Observations while testing, in connection with the steam engine model of the Steam Box D 100E:
One can not observe almost any change when the 1K resistor is installed. The additional need of electricity is only about a couple mA. When you plug in the following resistor of 100 Ohm you recognize that the orange LED starts to flicker and the rotation of the steam engine model slows down. The additionally needed electricity is now by 20mA. With the 10 Ohm resistor the LED does not flash at all and the steam engine slows down even more. The additional needed electricity is about 40mA. With the 1 Ohm resistor the additional needed electricity lays around 45 to 50 mA and the rotation of the engine reduces a lot. The jumper brings a short cut at the generator and now the short-cut electricity of the generator flows. It might happen that the drive belt slides of or the steam engine model decelerates drastically. This process does not harm the generator nor the steam engine model.

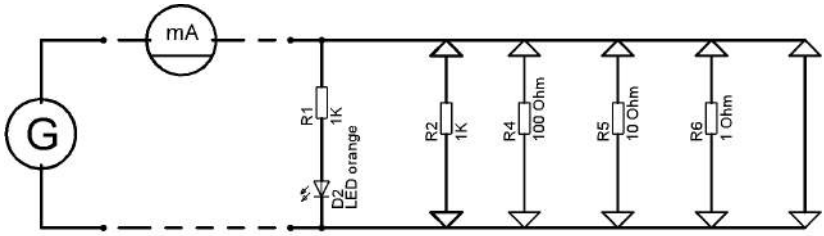


Fig.3.34: principle of the circuit: Stress test with a multimeter in the circuit, to show the power indicator

If there is a multimeter available you can start the steam engine model again and plug one resistor after the other into the bread board. Depending on the steam engine model you use, you can observe a direct reaction of the engine related to the different needs of electricity, which are simulated through the resistors.
To explore this systematically one can write down the values of the resistors and the measured electricity into a table. Now you can work out the power of the generator or the steam engine. You can define the power in milli-watt according to the formula you find in the annex.

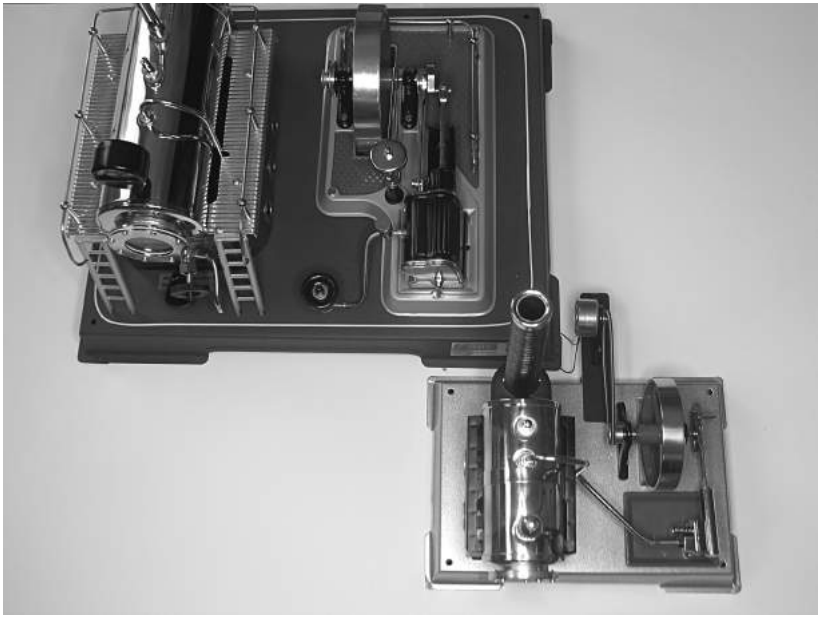


Fig.3.35: Two different steam engine models and their different power capacities. Steam Box D 100E and D20 in comparison

The steam engine model of the Steam Box D 100E and of the D20 are two extremely different models, also in their powers. The experiments with the resistors show that a bigger steam engine model has no problems with an additional need of electricity.
If you have a multimeter you also can measure the current.

3.7 Step by step generating bright light out of steam

Components: generator, prepare electrolytic capacitor 1000µF and electrolytic 4700µF, series resistor 1 K-Ohm, white LEDs, crocodile clips

Through plugging the different components into the bread board according to the figure you can now mount the circuit.

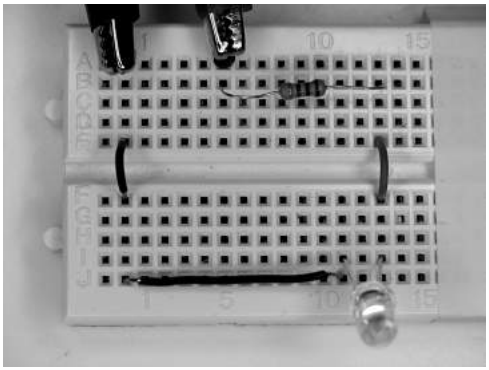


Fig.3.36: Light through steam, the circuit. You see the series resistor (above on the right side), the jumpers` and the white LED (below on the right side), the longer connection wire (+) of the LED on the right side

Prepare the steam engine model as described in chapter 2.4. The pulley wheel of the generator and the steam engine model are connected with the transmission belt. For each steam engine model you choose the transmission in a way that the small pulley wheel on the shaft of fly wheel of the steam engine model is connected through the transmission belt with the pulley wheel of the axis of the generator.

Note: Using a higher transmission towards the generator – working with more powerful steam engine models – does harm the generator and the electronic, because the rotational speed is too high and the voltage at the generator can become more then 10V.

Connect the cables of the generator with the crocodile clips. Do not connect them straight away to the circuit on the bread board. Start the steam engine model and wait till its touring properly. Now connect the generator to the circuit of the bread board.

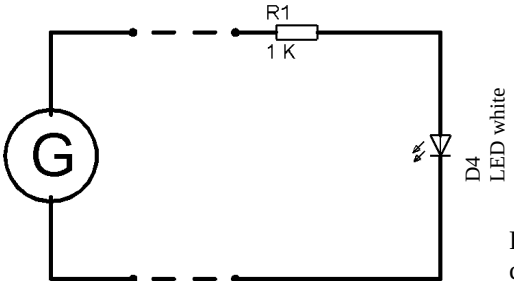


Fig.3.37: The diagram of the circuit: light through steam

Especially with the smaller steam engine models one can observe that the rotational speed of the steam engine slows down and the white LED starts to shine. The LED shines bright when the rotational speed has stabilized, probably still with a little pulsating or flashing. Measuring the initial voltage with an oscilloscope (a professional instrument to show the voltage in a graphical diagram) would show us a wave, caused by the continuous interruptions of the commutator of the generator.

One can use the mounting of the experiment and the running engine and continue with more experiments to gain an improvement:

In the next experiment one can integrate an electrolytic capacitor, if you wish to smooth the “wavy” voltage. Make sure that you connect the positive (+) pole of the electrolytic with the red cable and the negative (-) pole with the black cable onto the bread board.

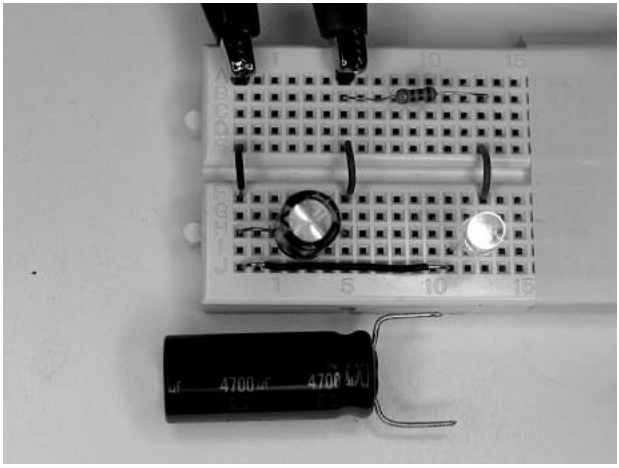


Fig.3.38: first plug in the electrolytic with 1000µF onto the bread board respecting the right polarity, then alternatively the electrolytic with 4700µF

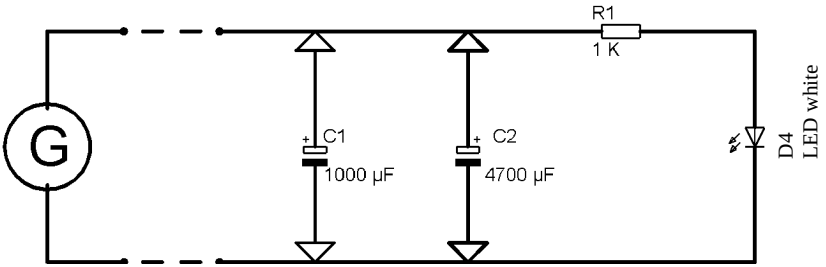


Fig.3.39: circuit diagram, both electrolytic are marked in with an arrow to show that they are used alternatively

The light of the LED goes out shortly and then starts to flash a little less bright after plugging in the electrolytic 1000µF. Now you replace the electrolytic 1000µF with the 4700µF in the next step and a calm light will shine. If you would measure with an oscilloscope the smoothed voltage you would almost see no wave at all on the diagram.

Picturing the electronically smoothing process:
To create a picture for the expression "smoothing electricity through an electrolytic" we imagine that electricity behaves like water. We can compare an electrolytic with "a water bucket with a hole in the bottom"
If you fill intermittently the bucket with a ladle with water, it would continuously flow out of the hole in an uninterrupted stream.

3.7.1 More light with 2 white LEDs

Assembly of the experiment: components like before, add one white LED and plug it parallel next to the first one. Both LEDs are connected with the series resistor 1 K-Ohm (brown, black, red, gold).

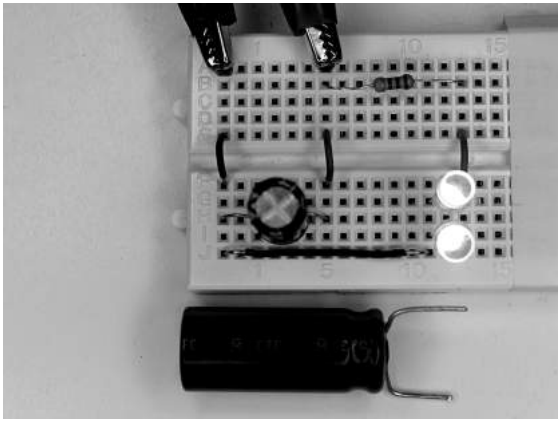


Fig.3.40: Assembly of the bread board with a second white Led parallel to the first white LED. Both LEDs have the connection wire (+) on the right side

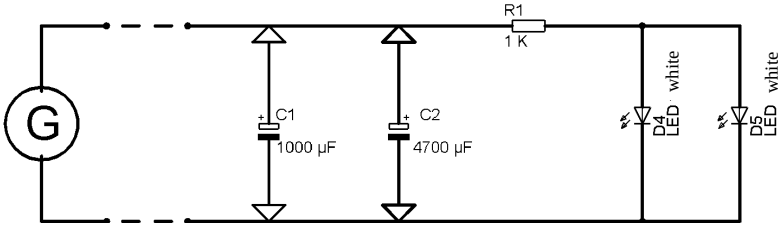


Fig.3.41: circuit diagram with two LEDs, here the electrolytic can also be used alternatively

3.7.2 Light from four LEDs generated through the steam engine

All LEDs (except the flashing one) are in use and one can observe how powerful the small steam engine of the Steam Box D 100E is.

Plug in the series resistors and the red LED in the upper part of the bread board, like shown in the left picture. The current is lead through the switch and the jumpers to the LEDs and to the electrolytic in the lower part of the bread board. The right figure shows the diagram of the circuit on the bread board, taken from the other side. Once the circuit is connected to the running generator the red and orange LED are shining. Also both white LEDs are shining when you press on the switch.

Here you have an overview of the series resistors for the LEDs:

Value of the resistor	**1. ring**	**2. ring**	**3. ring**	**4. ring**
1 K-Ohm	brown	black	red	gold
100 Ohm	brown	black	brown	gold

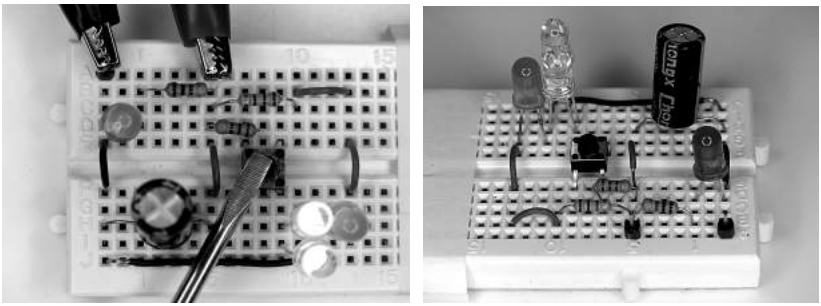


Fig.3.42: Assembly of the bread board and b) detail of the assembly (a picture taken from the other side)

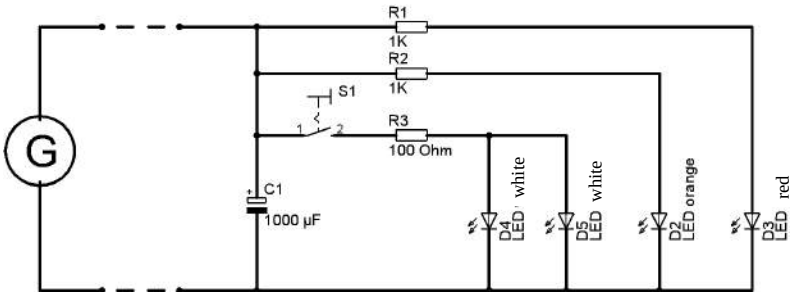


Fig.3.43: circuit diagram with more LEDs

Note: When the steam engine is decelerating one can try to slow down the fly wheel, even hold it for a short while and then start it again. The LEDs then will shine brighter again.

3.8 Storage of the electric energy

We explore in this experiment whether the energy generated by the steam engine can be stored.

Picturing the process of storage as followed:
Again we take the example of the water bucket. Now the hole on the bottom of the bucket is replaced through a crane. The level of the water raise when the crane is closed and one continues filling in water with a ladle. The water bucket (capacitor) represents the storage; now at any time when opening the crane we can take out water (voltage).

3.8.1 Charging the capacitor storage through the steam engine

There are different types of energy storages. One possibility of storage we find in the electrolytic. The advantage is that they last a long time. There capacity of storage is little compared to a battery. Though for the experiments it works well and one can explore the principle of storage within a short time term.

Note: To explore the effect of charge realistically, please discharge the electrolytic before each experiment. Attention: the discharge might create a harmless sparkle.

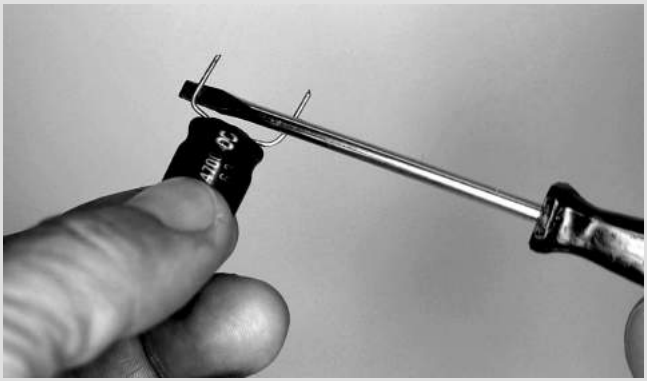


Fig.3.44: Before the experiments discharge the electrolytic with a screwdriver

Assembly of the experiment: generator, bread board, one red and one black cable with crocodile clips, orange LED, series resistor 1 K-Ohm (red, black, brown, gold), 2x electrolytic 4700µF

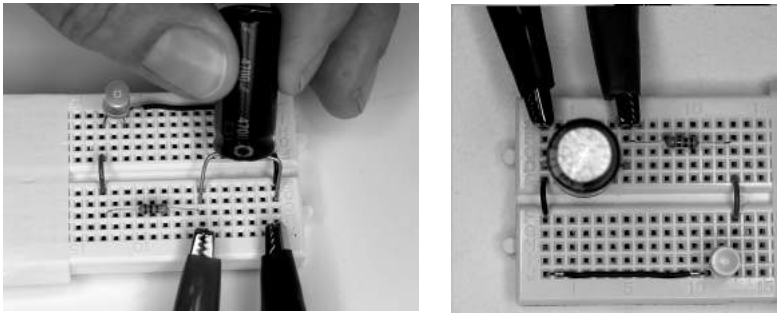


Fig.3.45: a) circuit of charge and b) with one electrolytic and LEDs as charge- respectively consumption indicator

Steps of the experiment:
Mount the circuit according to the figure, circuit diagram. Plug one electrolytic into the bread board (the positive pole is especially marked) and charge it through the generator for a couple of seconds while the steam engine is running.

Additional experiment: slow down and stop the fly wheel of the steam engine shortly, and then let it run again. The orange LED flashes while the generator works, it goes of when stopping the fly wheel.

Additional experiment: take away one crocodile clip from the bread board; the current to the generator is now disconnected. Still the LED continues to shine.

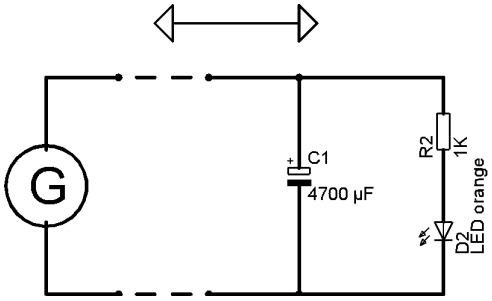


Fig.3.46: circuit diagram of the electronics of charge

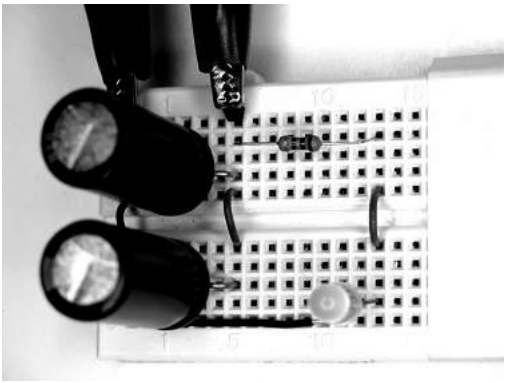


Fig.3.47: circuit of charge with two electrolytic and one LED as charge- and consumption indicator

One can repeat those experiments, this time with an additional electrolytic plugged in parallel. The steam engine charges simultaneously both electrolytic through the generator.

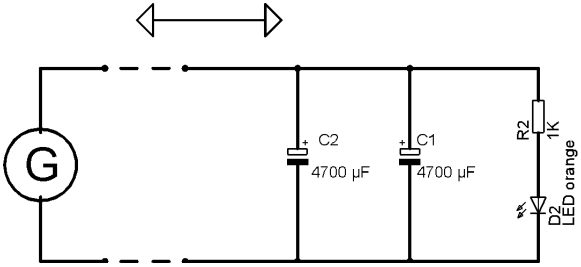


Fig.3.48: circuit diagram with 2 electrolytic and one LED as a charge- and consumption indicator

In both experiments you can observe that the energy storage does not keep the charge, when the steam engine or the generator is shortly stopped. Still the Led continues to shine for a short while, when the generator is disconnected from the bread board (one crocodile clip).

Is there a leak or what is happening?
With this charging system the electrolytic is discharging backwards into the generator. Here it is not possible to store the energy efficiently and continuously. We do need an electrical valve, which allows the current to flow only in one direction and stop it in the other one, to avoid the discharge. With this valve the electricity flows into the storage and does not discharge unwanted.

3.8.2 Diode blocking discharge, Schottkydiode

Components: like before, additional one Schottkydiode BAT 48

As you could observe in the former experiments, the stored energy of the electrolytic is discharged backwards into the generator. It is important to install a blockage for the current not to flow backwards, like a diode when charging an energy storage f. ex. the use of an electrolytic, Gold-Caps or a battery. The diode works like a valve which allows the current to flow in forward direction, whereas in the reverse direction the current flow is blocked.

With siliceous diodes the current starts flowing with a voltage from ca 0,6 till 0,7V or 700mV (mini Volt). A Schottkydiode allows the current to flow already with 0,25V.

Note: blockage - diodes avoid the discharging of the storage. Normal siliceous diodes "destroy" about 0,6V of the generated voltage; Schottkydiodes only 0,25V.

Using a charge system we have to take the loss of energy into account because here minimal voltages are important. Depending on the type of diode we use, an amount of 0,6V to 0,25V will get lost and not be stored. In the following experiment we can recognize that less voltage is charging the electrolytic, because an additional diode is connected. Especially when the voltage of charging is relatively low, it is easy to observe.

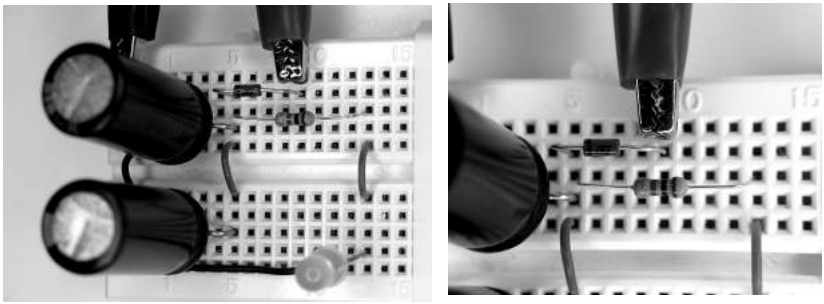


Fig.3.49: Assembly of the experiment, b) detail: mounting of the diode, the black ring (cathode) is on the left side of the picture

This experiment shows that the electrolytic is charged by the generator, is keeping the voltage and storing it.

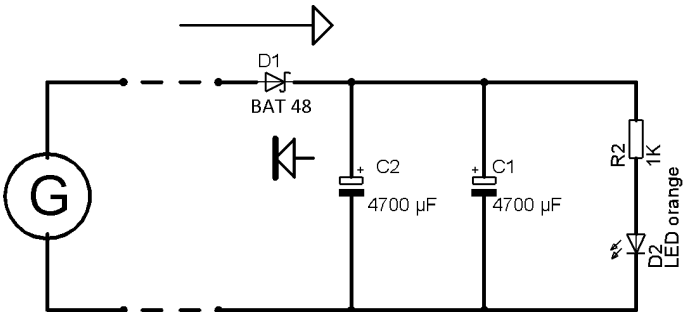


Fig.3.50: circuit diagram: discharge protection diode

You can measure the voltage which is stored in the electrolytic with a multimeter. Switch the multimeter onto the direct current measuring area (DC,20V).and connect the cables of the multimeter with the connection wires of the electrolytic according to the polarity.

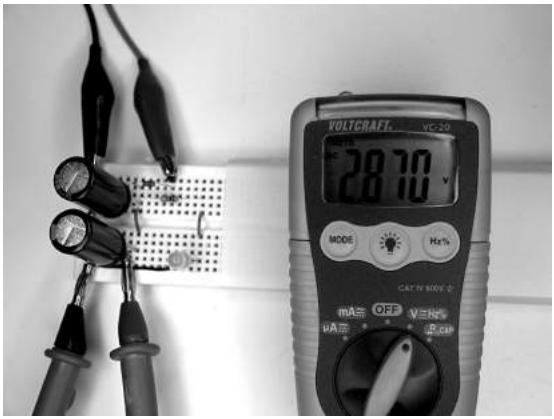


Fig.3.51: Measuring the voltage with a multimeter, you can see the cables of the multimeter (in the lower part of the picture on the left) connected to the electrolytic connection cable.

The following questions come up while charging the storage: is he empty, half full or full? If you have a multimeter you easily can find out by measuring the voltage of the input. The next experiment shows a simple electronic indicator, using a flashing LED.
In the next part you see the construction of a simple charge indicator, which shows the state of charge of the electrolytic through the voltage indicator.

3.8.3 Charge indicator for the electrolytic

Assembly of the experiment: components like before, additional one more series resistor 1 K-Ohm (red, black, brown, gold), 1 red flash LED

Mount the circuit by plugging the components into the bread board according to the figure. In the upper part of the bread board the electrolytic, the positive pole to the right and in the same line the connection wire of the diode (cathode, with a mark on the enclosing) and a jumper to the switch. In the lower part the series resistor, the flash LED and the orange LED (the longer connection wire to the right side).

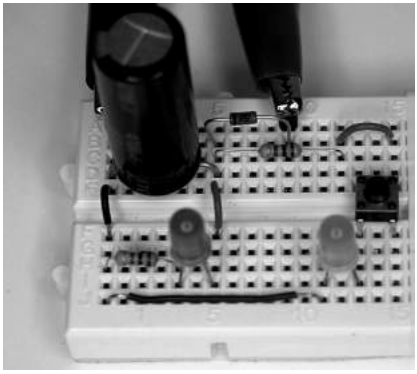


Fig.3.52: Charge indicator with the flash LED, assembly of the circuit on the bread board

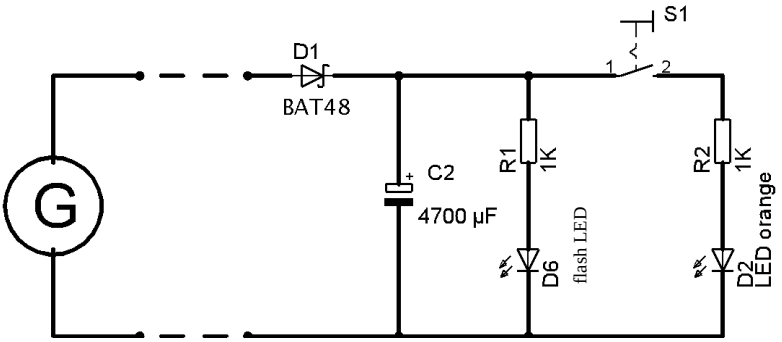


Fig.3.53: circuit diagram of the charge indicator

Please make sure that the electrolytic is empty before starting the experiment; f. ex. join both connection cables of the electrolytic through a screwdriver.
Now prepare the steam engine according to the instructions in chapter 2.4.
The pulley wheel of the generator and the steam engine are connected with the transmission belt.
Start the steam engine and wait till the fly wheel is running properly. Then connect the crocodile clips which are connected to the generator with the pins on the bread board. One can observe after a couple of minutes that the red flash LED first flashes weakly and then becomes stronger and stronger. The weak flashing of the red flash LED shows a voltage of ca. 1,7V, the bright flashing around 2,5V.

With this assembly and the running steam engine you can continue to explore more experiments, like f. ex.:

- Disconnect for a short time the red crocodile clip next to the diode from the pin, wait and then connect again.
- Plug in another electrolytic 4700µF parallel to the first one. The LED stops flashing shortly after the electrolytic has been plugged in. After a while the LED flashes again. The reason is that the additional electrolytic first needed to be charged.

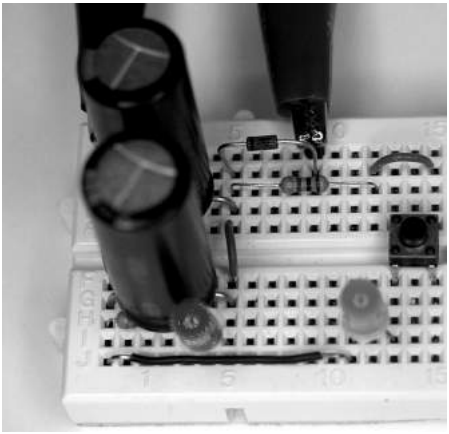


Fig.3.54: plug in an additional electrolytic, underneath of the second electrolytic we find the series resistor of the flash LED, in the lower part of the picture on the left side

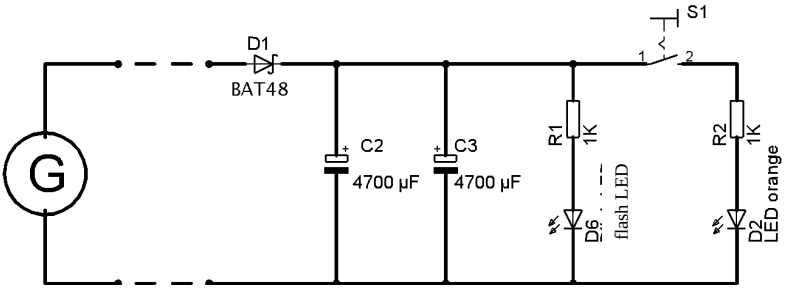


Fig.3.55: circuit diagram with charge indicator and two electrolytic

3.8.4 Using stored energy

Assembly of the experiment: the circuit of the former experiment will be slightly changed. Take out the LEDs and the series resistors, plug in the pin of the positive pole on the very right of the bread board and put in the schottkydiode so that she is parallel connected to the switch. Now it is possible to bridge the schottkydiode by pressing the switch and to connect the electrolytic directly to the generator.

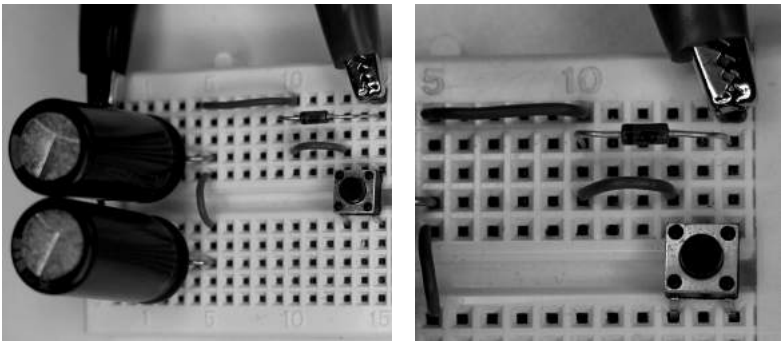


Fig.3.56: circuit of the storage on the bread board, b) detail, in the picture the diode with the cathode (ring on the enclosing) is turned to the left

After sufficient time of charging, slow down the fly wheel, take of the belt and press the switch. Now you bridge the diode. The stored energy flows out of the electrolytic into the electrical machine, which works like an engine now. The axis of the engine turns for a short while.

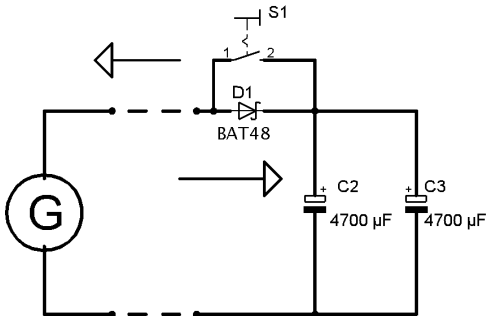


Fig.3.57: circuit diagram with the switch to bridge the blockage diode

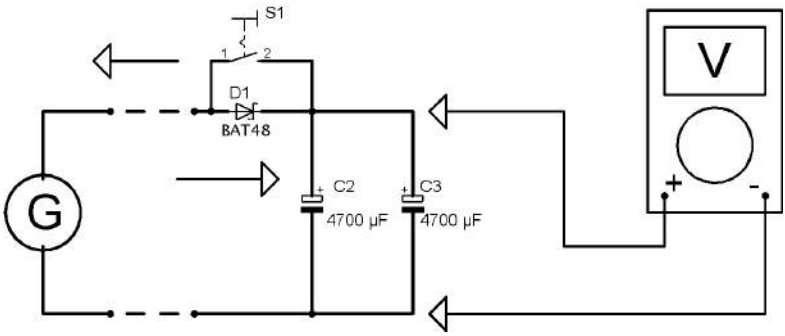


Fig.3.58: measuring the voltage of the electrolytic with a multimeter

3.8.5 The steam engine as a charging station for the torch.

Assembly of the experiment: we use the assembly of the second last experiment. We plug in two white LEDs instead of the orange LED.
You can disconnect the crocodile clips after a short charging period through the steam engine and generator.

Now both LEDs will shine for a while when you press the switch. Then you can connect the bread board with the "LED torch" to the charging station "steam engine" again.

It is amazing how long the LEDs are shining with this charge regarding to the small storage capacity of the electrolytic.

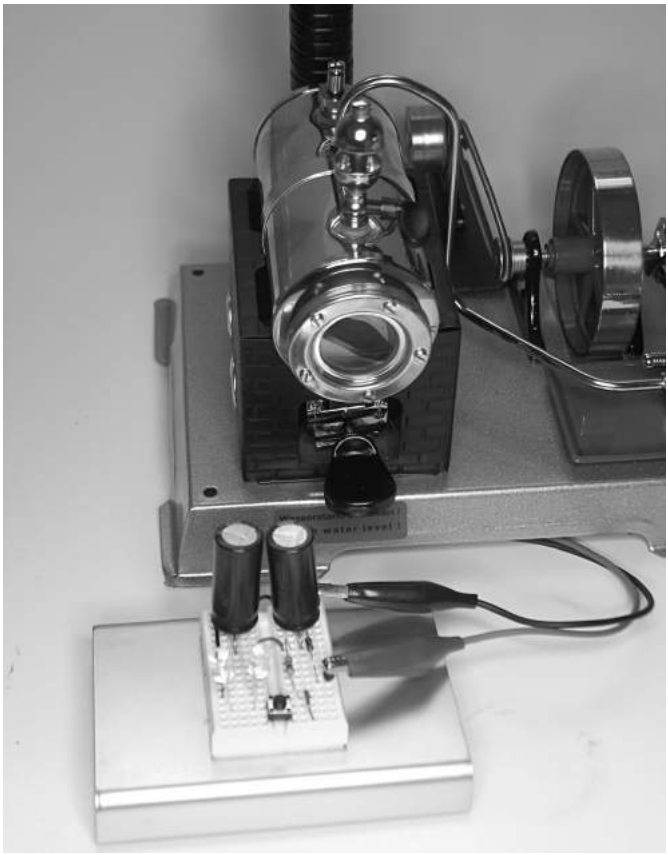


Fig.3.59: Charging station, LED with the steam engine model

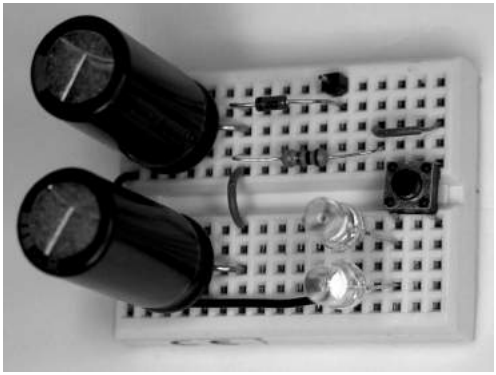


Fig.3.60: Assembly of the bread board, with two parallel plugged in electrolytic 4700µF, Schottkydiode, switch, two white LEDs and jumpers`

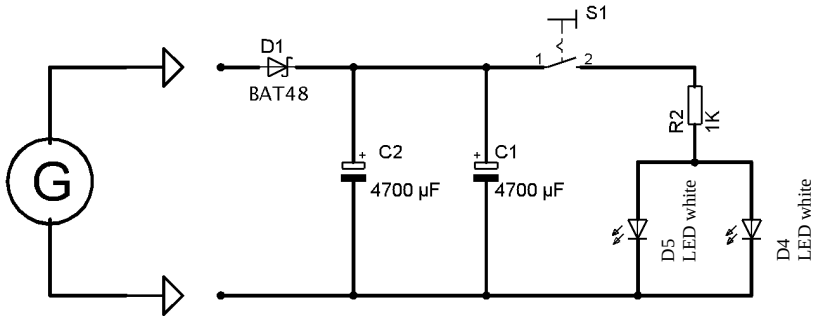


Fig.3.61: circuit diagram of the charging station

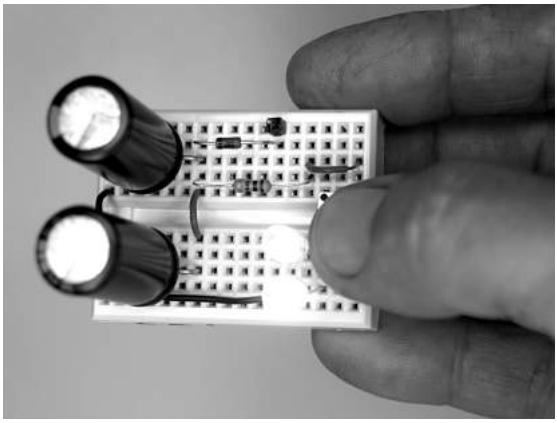


Fig.3.62: disconnected "LED torch" in action

One can create a lot more experiments with the Steam Box D 100E and with the E-Box 50.

I wish you a lot of fun and creativity!

4. Annex

4.1 Collection of the formularies

Here you find some formularies for basic circuits we have been applying and exploring in the experiments.

4.1.1 Voltage, current and resistance

The most important values of the electronic technique are voltage, current and resistance, gathered in the law of Ohm with the following symbols and values.

	symbol	unit
voltage	U	V
current	I	A
resistance	R	Ω

The flowing current is increased within a circuit when the given voltage of an electric circuit is increased. The power of current (I) is proportional to the given voltage.
The flowing current diminishes when the resistance is raised along with a constant voltage. This process is used f. ex. in the alimentation of the LEDs with electricity. The current "I" behaves opposite proportional to the resistance "R".
With the following formularies you can work out the three values:

Current = voltage/resistance; or as a formulary:

$$I = \frac{U}{R}$$

Example:
Voltage U = 3V
Resistance R = 100 Ohm
Calculated current I = 3V/100 Ohm = 0,03A or 30mA
We can develop the following formularies from here:
Voltage = resistance x current; or as a formulary:

$$U = R \cdot I$$

And resistance = voltage/ current; or as a formulary:

$$R = \frac{U}{I}$$

4.1.2 Parallel circuit of resistors

When connecting two resistors R1 and R2 parallel the following total resistance R results:
R = (R1 x R2) / (R1 + R2)

Example:
Resistance R1 = 1 k-Ohm parallel to the resistor R2 = 100 Ohm
Calculated total resistance R = (1 x 100) / (1 + 0,1) = 99,9 Ohm
The total resistance becomes less.

Another example shows when two similar resistors of 1 k-Ohm are parallel connected:
(1 x 1) / (1 + 1) = 0,5 k-Ohm
The total resistance is reduced to a half

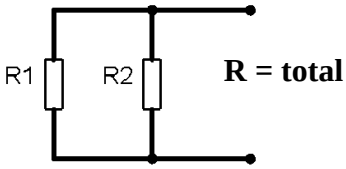


Fig.4.01: parallel circuits of resistors

4.1.3 Series connection of resistors

When you connect resistors one after the other in a row, you add the values of R1 and R2 to the total resistance: R = R1 + R2

Example:
Resistance R1 = 100 Ohm and resistance R2 = 1 k-Ohm
Calculated total resistance: R = 100 Ohm + 1 k-Ohm = 1100 Ohm

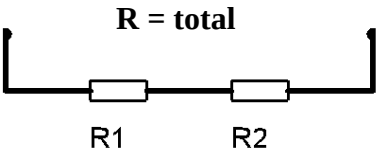


Fig.4.02 series connection of two resistors

4.1.4 Calculation of the power

You can use the following formulary to calculate the electric power:
P = U x I (P=electric power, U=voltage, I= current)
"P" is measured in Watt, "U" in Volt and "I" in Ampere.

Example of a calculation:
A direct current generator generates a voltage of 3,0 Volt and provide a current output of 50mA.
3,0V x 0,5mA has a power of 0,015Watt.

4.2 Troubleshooting

Here you find some tips and hints in case the steam engine does not run properly or the electronic does not function at all or is unstable.

4.2.1 The steam engine

In general the smoothness and the leak tightness of a steam engine model do not influence the basic function. Never the less it is important that the steam engine runs easy and smooth. For all models and as well for the steam engine model counts: the smoother they run the better they function.
A small steam engine model is not able to run with its full power when the belt of the fly wheel towards the generator is too tight. The generator needs at least 1000 rotations/min coming from the steam engine, to generate sufficient voltage, to make the LEDs flash.

The power is also depending on the leak tightness. Make sure that the seals are fitting well between the boiler, the steam tubes and the cylinder and that the connections are properly tightened and no steam is escaping.

Please adjust the timing if the valve - controlled steam engine does not work properly. Use the instruction and the figure to set the timing.

4.2.2 The electronic

Please pay attention to the following points when a circuit on the bread board does not function properly:

- When nothing happens after mounting the circuit do not get nervous and prove the current coming from the generator. Are all connections plugged in well? Sometimes the connection cable of the generator is not properly connected to the crocodile clip.
- Does the steam engine have enough rotational speed? One can use a multimeter or mount a simple circuit with one red LED to prove the generated voltage of the generator. You can connect the LED straight away to the crocodile clips for a short while; the red clip to the longer wire of the LED.
- Now prove the components of the mounting of the circuit. Are the polarities (positive and negative pole) correct? Is there a part which is not plugged in properly?
- Are all parts plugged in with the right polarity, f. ex. the LEDs? The longer connection wire is the positive pole.
- The longer connection wire of the electrolytic is also the positive pole and additionally you find a minus symbol on the enclosing of the negative pole.

- Does the circuit work but the results are not satisfactory?
- Please ask yourself first whether this steam engine model can generate sufficient power?
- If you have not found any mistake so far and the steam engine is running full power, please control the circuit and all connections, starting from the generator to the electrolytic and to the rest of all components. May be one part is still missing?

4.3 Supplier sources for spare parts and electronic parts

Consumables (see below and others) and spare parts for steam engines are available through Wilesco distributors or: www.sell-it-easy.de (info@sell-it-easy.de).

Electronic parts are available for example with www.conrad.de

4.3.1 Consumables for steam engines

Designation	Content	Item-no.
Driving belt, 260mm long Z80	1 package = 5 spirals	00800
Dry-spirit tablets Z81	1 package = 20 tablets	01020
Steam engine oil Z83	1 Plastic bottle 30ccm	00801
Accessory bag „electronic parts“	divers electronic parts	01459
Generator holder	1 piece	01460
Generator with mounting support	1 piece	01461

4.4 Warranty:

All WILESCO Steam Engines are carefully checked before leaving the factory. However if a problem arises, you can return the Steam Engine to a specialized distributor or directly to WILESCO. We are sure you will understand that already fired or used models cannot be exchanged for new ones. The most frequent claims are leaking boilers. The solder will be destroyed if your Steam Engine runs without enough water in the boiler. In such cases, the solder liquefy drop-shaped and the boiler leaks. This is an obvious proof that the boiler was fired without enough water. Please watch always carefully the water level, because the heating without enough water excludes any demand for warranty.

This Steam Engine is only designed for the above described function.
Technical data can be amended without prior notice.

WILESCO wishes you lots of fun with your steam engine and „full steam ahead“!

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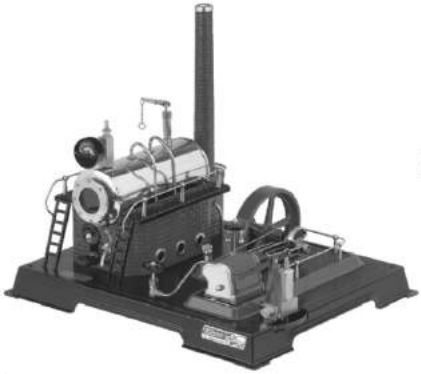
The qualified internetshop -
The complete Wilesco range on stock



Steam engine D21

The classic steam roller D365

Dry-spirit tablets Z81

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