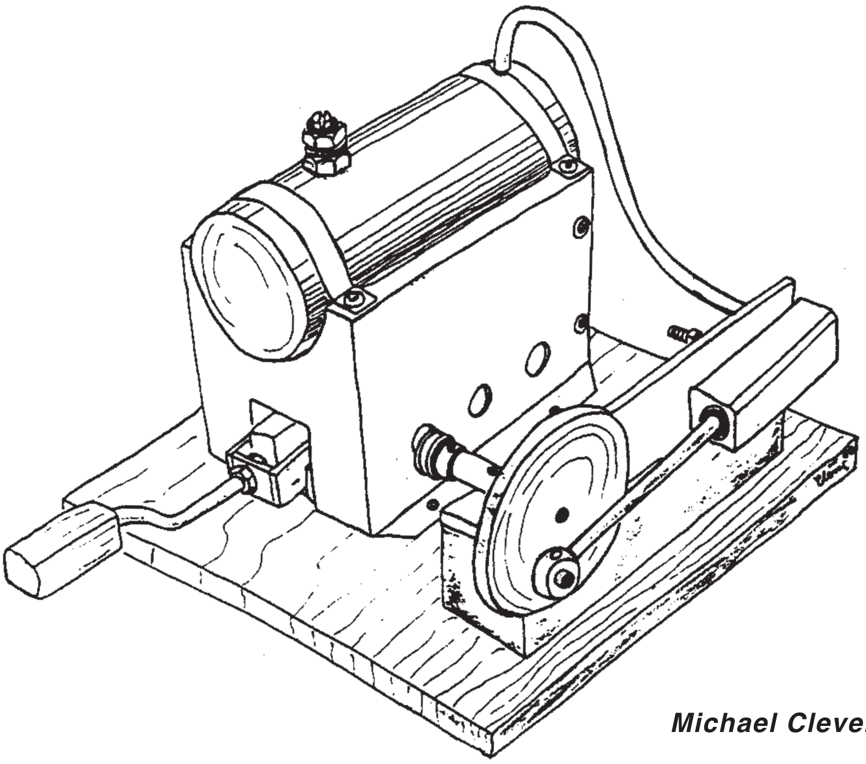
OPITEC

# 1 1 2 . 4 2 0
# Steam Engine



*Michael Clever / Rolf Kiefer*

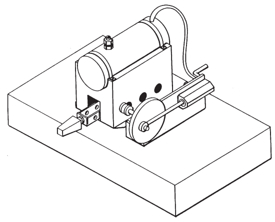
***Tecnical Data:***

| | | | |
|---|---|---|---|
| ***Boiler:*** | | ***Machine:*** | |
| ***Boiler Volume:*** | ***110 $cm^3$*** | ***Piston:*** | ***8 mm*** |
| ***Working Pressure:*** | ***1,5 bar*** | ***Stroke:*** | ***24 mm*** |
| ***Tested to:*** | ***4,5 bar*** | ***Idling Speed:*** | ***ca. 800 rpm*** |
| ***Water:*** | ***50 - 60 ml*** | ***Construction Year:*** | |

***Please Note***
The OPITEC range of projects is not intended as play toys for young children.They are teaching aids for young people learning the skills of Craft, Design and Technology.These projects should only be undertaken and tested with the guidance of a fully qualified adult.
The finished projects are not suitable to give to children under 3 years old. Some parts can be swallowed. Danger of suffocation!

## CONTENTS

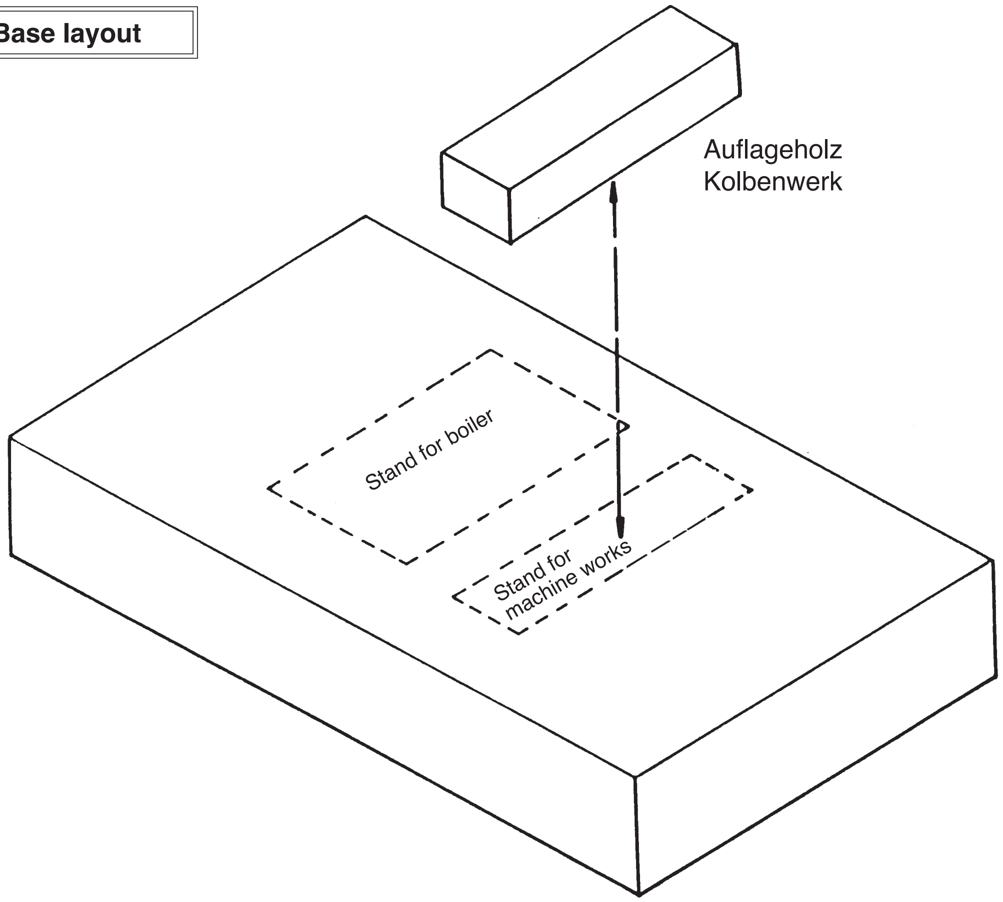
## MATERIAL LIST FOR OPITEC STEAM ENGINE



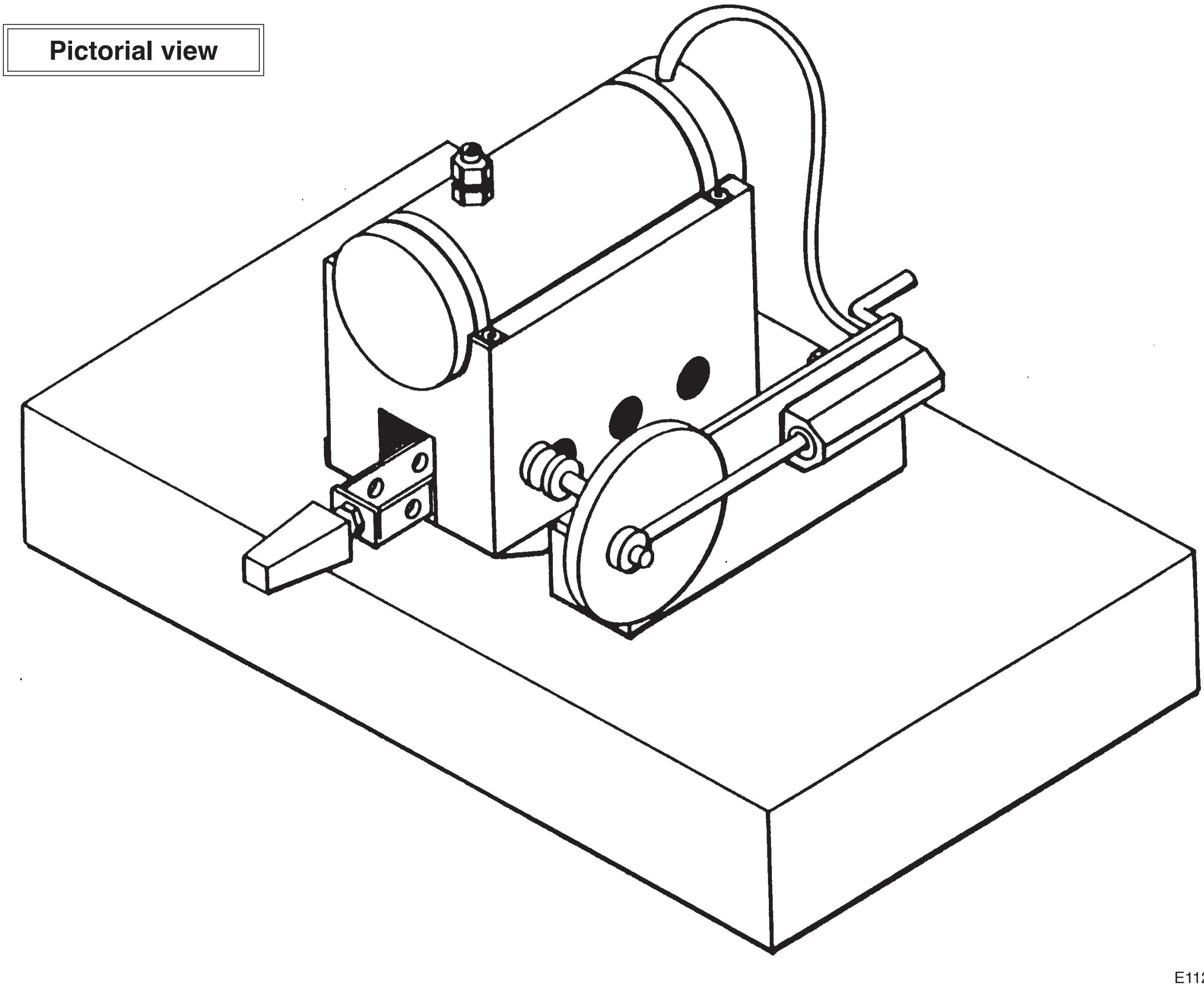
The list below contains all the parts to build ONE model steam engine (Special fuel tablets and silver solder must be ordered extra).

| Part No. | Quant. | Description | Size | For use in | |
|---|---|---|---|---|---|
| 1 | 1 | aluminium u-section | 16,5 x 100 | firebox | I |
| 2 | 1 | aluminium u-section | 19,5 x100 | slider | |
| 3 | 2 | self-tap screw | 2,9 x 13 | fixing | |
| 4 | 4 | washers, galvanized | 3,2 | fixing | |
| 5 | 1 | nut, galvanized | M4 | fixing | |
| 6 | 1 | cheese head screw, galv. | M4 x 25 | fixing | |
| 7 | 1 | sheet metal, brass 63 | 0,4 x 165 x 75 | boiler | II |
| 8 | 8 | rivets copper | 3 x 4 | boiler and fixing | |
| 9 | 5 | self-tap screws | 2,2 x 6,5 | fixing | |
| 10 | 1 | tube, brass 63 | 40 x 1 x 100 | boiler | |
| 11 | 2 | tube ends, brass 58 | 40 x 3 | boiler | |
| 12 | 1 | nuts, brass 63 | M6 | boiler | |
| 13 | 1 | bolt, brass | M6 x 10 | valve | III |
| 14 | 1 | cheese head screw | M3 x 30 | valve | |
| 15 | 1 | nut, brass | M3 | valve | |
| 16 | 1 | spring | 0,4 x 4 x 17,5 x 8,5 | valve | |
| 17 | 1 | O-ring | 3 x 1 | valve | |
| 18 | 1 | paper gasket | 10 x 5,8 x 1 | valve | |
| 19 | 1 | R.A. bracket, brass | 100 x 20 x 20 x 2 | bearing | IV |
| 20 | 4 | countersunk screws, brass | 3 x 20 | beaing | |
| 21 | 1 | tube, brass | 40 x 15 x 15 | cylinder | V |
| 22 | 1 | piston, brass | 8 x 12 | piston | |
| 23 | 1 | spring, stainless steel | 0,4 x 4 x 17,5 x 8,5 | bearing | |
| 24 | 1 | nut, brass | M3 | bearing | |
| 25 | 1 | threaded rod, steel | M3 x 20 | bearing | |
| 26 | 1 | washer, brass | 3,2 | bearing | |
| 27 | 1 | rod, brass | 4 x 68 | connecting | |
| 28 | 1 | washer | 50 x 4 | flywheel | VI |
| 29 | 1 | rod | 4 x 10 | flywheel | |
| 30 | 1 | ring | | flywheel | |
| 31 | 1 | tube | 6 x 1x 20 | flywheel | |
| 32 | 1 | rod | 4 x 36 | flywheel | |
| 33 | 2 | washers | 4,3 | flywheel | |
| 34 | 1 | disc | | flywheel | |
| 35 | 1 | cooper tube | 4 x 1 x 160 | steam tube | VII |
| 36 | 1 | wood base | 140 x 140 x 10 | base | VIII |
| 37 | 1 | hard wood block | 100 x 20 x 25 | | |
| 38 | 1 | dowel | 8 x 50 | | |

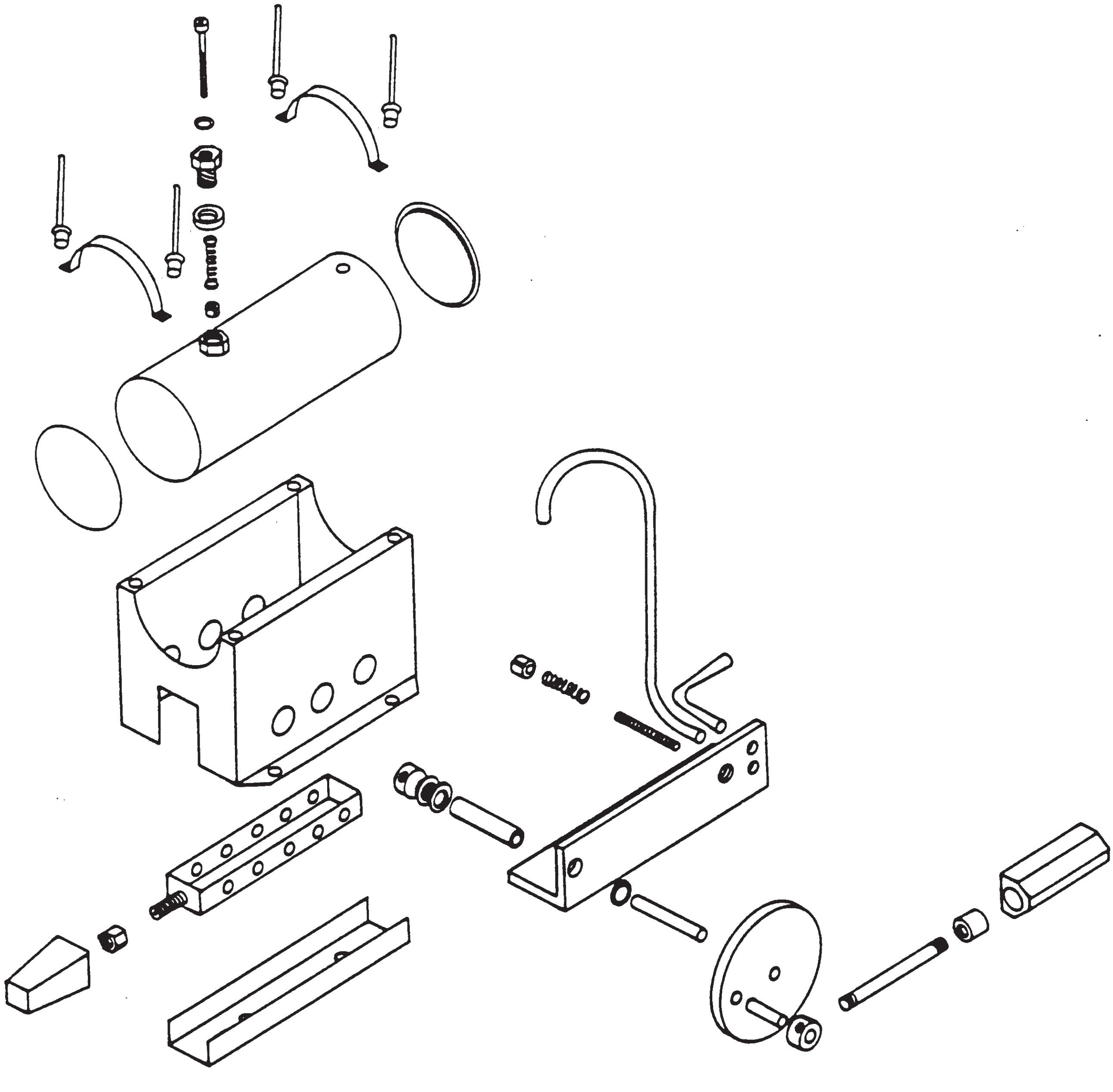
## Base layout




## Pictorial view



## Exploded view



## THE BASIC PRINCIPLES OF THE STEAM ENGINE

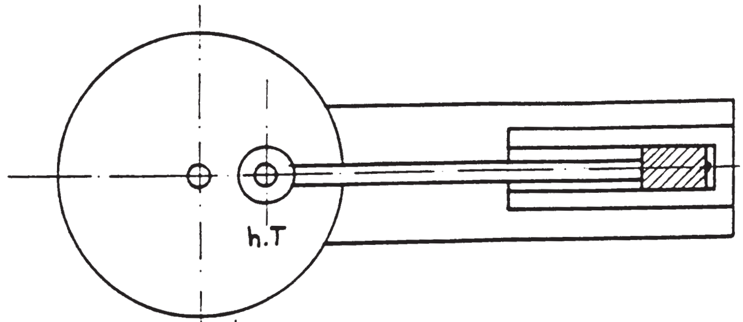
Steam engines are an example of energy exchange. The steam is produced by chemical energy which is then in turn converted to mechanical energy.
The steam engine uses an external from of energy e.g. coal as opposed to an internal combustion system, lide that of safety, which burns fuel in the cylinder. In the interest of safety, this model will use especially designed fuel tablets.
The mechanical energy from the steam engine is achieved in 2 stages.

1. The water in the boiler is heated until it is converted to steam which expands and builds up pressure.

2. The pressure from the steam is then used to drive the mechanical parts of the engine.

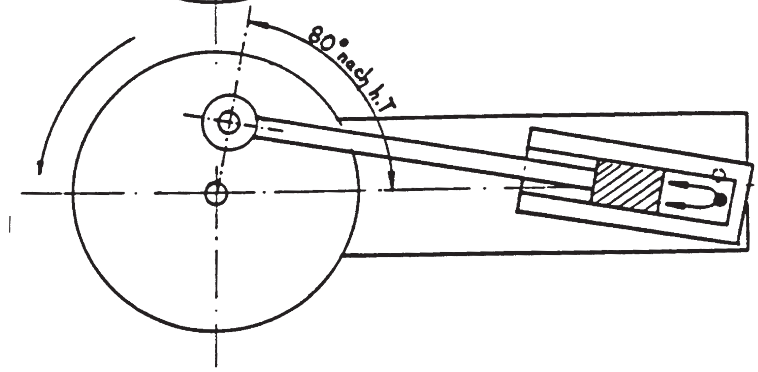
This conversion of water to steam, e.g. from a liquid to a gas, can be expressed through the following formula. To heat 1 mg of water by 1°C only 4,2 joules are needed; however, to convert 1 mg of water into steam 2257 joules are required.
This additional energy requirement is due to the large volume increase of the steam in comparaison to water, 1673 times at normal pressure.
Because the boiler has a limited volume, a pressure builds up as the steam expands. This pressure can be used to drive a piston backwards and forwards. As the pressure increases, the boiling point changes, e.g. at 2 bar the boiling point is approx. 120°C.
This principle is used in a pressure cooker to cook food in shorter times saving energy and loss of vitamins from the food. The reverse process e.g. steam to water is called condensation. Here, the same amount of energy is set free that made the steam in the first place. You can see condensation as water droplets when steam hits a cooler surface, but as a gas it is invisible.

## THE WORKING CYCLE OF AN OSCILLATING STEAM ENGINE



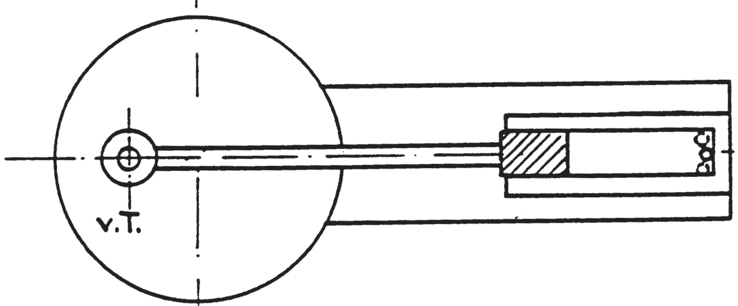

Position I

Piston is about 1 mm from the end of the cylinder, both ports are now closed. The connecting rod is at the rear dead point (R.D.P.)



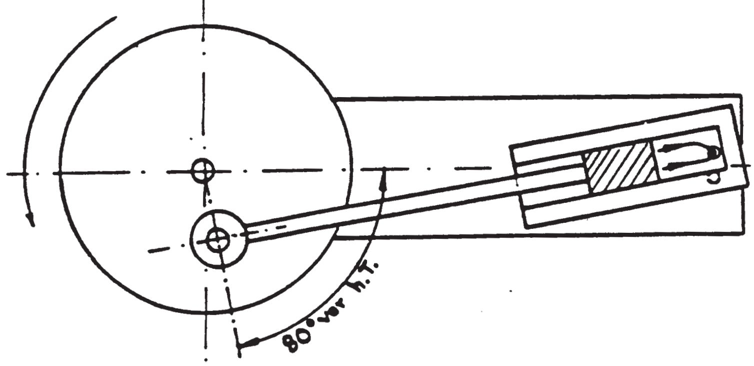

Position II

The connecting rod is at 80° past the R.D.P. The hole in the cylinder now lines up with the inlet port in the angle plate.
Steam is let into the cylinder and the piston is pushed forward (see double arrow).




Position III

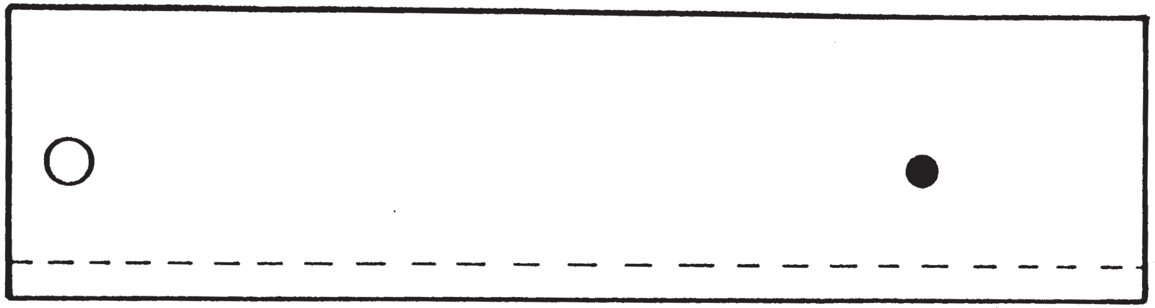
The connecting rod is now at the forward dead point (F.D.P.). The hole in the cylinder now lies between the inlet and outlet ports and the left over steam is exhausted (see double arrow).



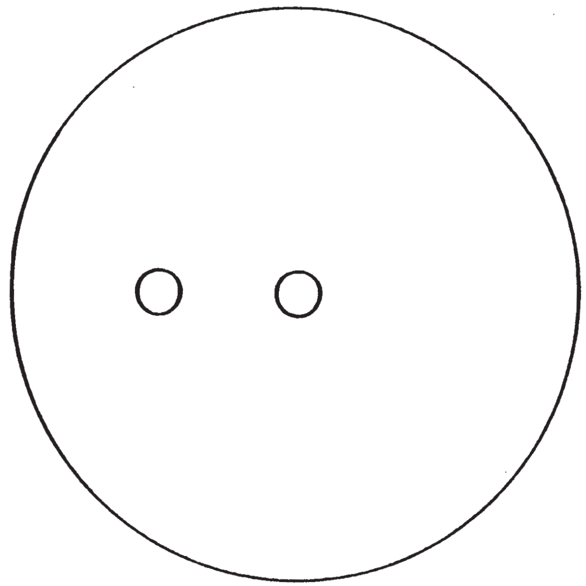

Position IV

The connecting rod is now about 80° before R.D.P.
The cylinder hole lines up with outlet port and the left over steam is exhausted (see double arrow).

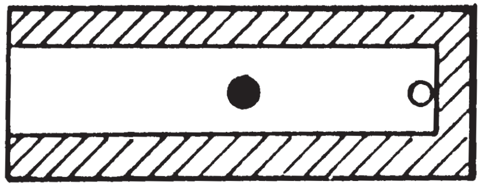
**angle-plate**



**flywheel and hole positions**



**cylinder**



**Tip:**

Make a model first using card split fasteners or make an acrylic model

**Tip:**

Construct model from card first to see how it all works.

**connecting rod and piston**

**COPY FOR OVERHEAD-PROJECTION SHEET ON MODEL CONSTRUCTION**

**E 1,5 : 1**

## USEFUL TOOLS FOR THE CONSTRUCTION OF THE STEAM ENGINE

- hacksaw
- files, fine and coarse
- metal work vice with protective jaws
- machine vice
- hammer 200 gm
- screwdriver
- side cutters
- try square
- steel rule
- tape measure
- drawing pins
- centre punch
- HSS drills 2, 2.5, 3.1, 3.5, 3.9, 4 and 6 mm
- thread tap M3, M6
- thread die M3, M4
- countersink drill
- needle files
- hole saw
- metal shears, straight & curved
- pop riveter
- drilling machine
- silver solder equipment with propane gas cylinder (5 kg) with fine and medium burners
- heat proof working surface
- compressor
- letter scales

## OTHER USEFUL MATERIALS

- wood and metal off-cuts
- silver solder with 40% silver, 1,5 mm dia.
- flux
- soft solder & flux
- thread sealant (to stand temperatures of 150°C)
- emery clothes
- steel wool
- metal polish
- drill coolant
- machine oil
- cotton cloth

**SAFETY MEASURES FOR THE BOILER CONSTRUCTION AND WORKING PRACTICES**

The boiler, when properly constructed, should be to DIN standard 660 70/ and European standard (EN 71) for safety. Great care in construction and use should be emphasized. The following points are taken from the above standards.

1. No sharp corners to be left.
2. Adequate protection from corrosion.
3. Do not exceed recommende temperature levels.
4. Heat only with special fuel tablets.
5. The boiler should not be larger than 2 ltr. and have a working pressure of not be larger than 1,5 bar.
6. A non-adjustable safety valve with a working pressure of max. 3 bar made from a rust-free mate rial (2 x working pressure of the boiler).
7. The boiler should be able to take at least 4,5 bar before any damage occurs (3 x working pressure).
8. The water level in the boiler should be visible.
9. Every model should be marked with its:
   a) volume of water for the boiler
   b) working pressure
   c) testing pressure
   d) name of maker
   e) date of finish

Point 8 is not easy to achieve in a school workshop situation. Great care must be taken with the water level in the boiler, too little or no water can, in extreme cases, lead to the boiler leaking but not to an explosion!

CONSTRUCTION DETAILS OF THE STEAM ENGINE

Material choice Copper - Brass

The use of these metals in the steam engine construction is based on their ease of working and their ability to conduct heat. The universal material for building model boilers is copper because it is resistat to corrosion and has excellent conductive properties. Copper has approx. 4 times the conduction rate of brass.

Unfortunately, due to heat loss, this advantage changes when soldering. Therefore, we are using brass for the boiler and machine parts to make joining easier.

Brass is a mixture of copper and zinc and is available in many different profiles e.g. as bars, sheets and as tubings. It is reasonably easy to work and retains its strength even in this sections. However, it should be noted that brass hardens with age and the boiler could develop cracks after much use

The ratio of copper/zinc in brass is available in differing quantities. Each ratio has its own particular properties e.g. soft, medium & hard. The strength and hardness of brass increases with the greater proportion of zinc. By heating to approx. 600°C, the brass will become more maleable, too high a temperature makes it brittle.

Tests

A strip of brass is hard to bend and springs back to its original shape.

When heated to approx. 600°C, it becomes soft and will retain the shape into which it is bent.

Technical Data:

| Material | Formula | Mixture | Density | Melting Point | Conductiviy | Strength |
|---|---|---|---|---|---|---|
| Copper | Cu | 99,9% Cu | 8,9 $\frac{g}{cm^3}$ | 1083°C | 372 $\frac{W}{m \cdot K}$ | ≈ 250 $\frac{N}{mm^2}$ |
| Brass 300-400 | CuZn | Cu 67% Zn 33% | ≈ 8,6 $\frac{g}{cm^3}$ | 930-1100°C | 93 $\frac{W}{mK}$ | 300-400 $\frac{N}{mm^2}$ |

**DETAILS OF THE CONSTRUCTION**

Start with the base made either from hardwood or plastic coated chipboard. Suggested size: 14 cm x 14 cm

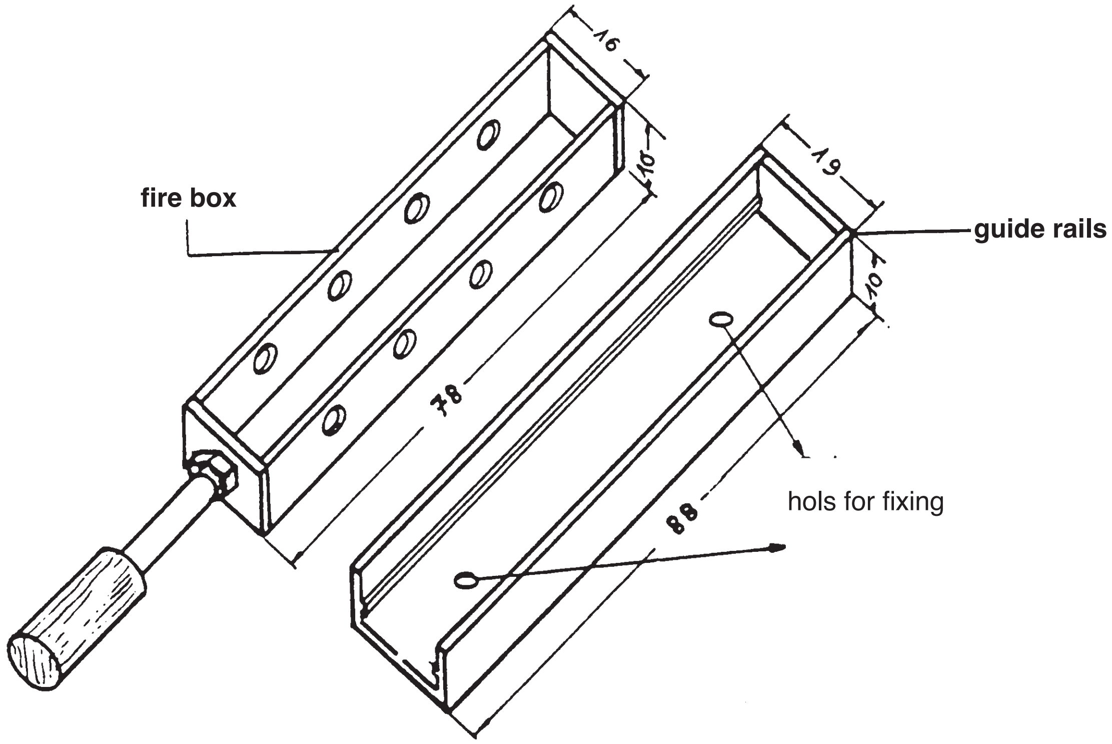
First, begin by building the FIREBOX and the GUIDE RAILS :
These are made from the u-section aluminium. Using guide rails for the fire box ensures that the lighted fuel can be placed directly under the boiler without fear of an accident. The guide rails can only be screwed into place after the rest of the steam engine is finished.

From the brass sheet, cut out the boiler housing and the fixing straps which are 5 mm wide. It is advisable to make a card pattern beforehand to eliminate any possible mistakes. The boiler housing is easier made in two parts. By laying both halves on top of each other all the drillinng and cutting can be achieved in one go. Before final bending, ensure that all the holes and shapings have been done. To make the semi-circle in the outside shape use a tank cutter or hole saw. The two halves of the housing can finally be joined using pop rivets or similar.

The BOILER is made from brass tubing which is closed at either end with discs. The hole for the safety valve must be drilled before assembling the boiler to allow the trapped air to escape during soldering. Silver solder with a high silvert content is recommended for joining, as this can be melted with a hand held gas torch.

The completed boiler should be tested for leaks and pressure under water with a compressor to a maximum of 4,5 bar. Only after testing should the boiler and housing be completed.

## Fire box and guide rails




## Construction:

a) <u>making the fire box rails (from 19 mm aluminium u-section)</u>

- cut off 98 mm length from the alu-u-section
- at one end mark off 10 mm and make two saw cuts, bend up the base to form an end stop
- saw away unwanted parts and clean up with a file
- drill two fixing holes (ø3 mm)

***NOTE:*** Do not screw the rails direct to the wood block but place several washers in between to stop any heat conducting through.

b) <u>making the fire box</u>

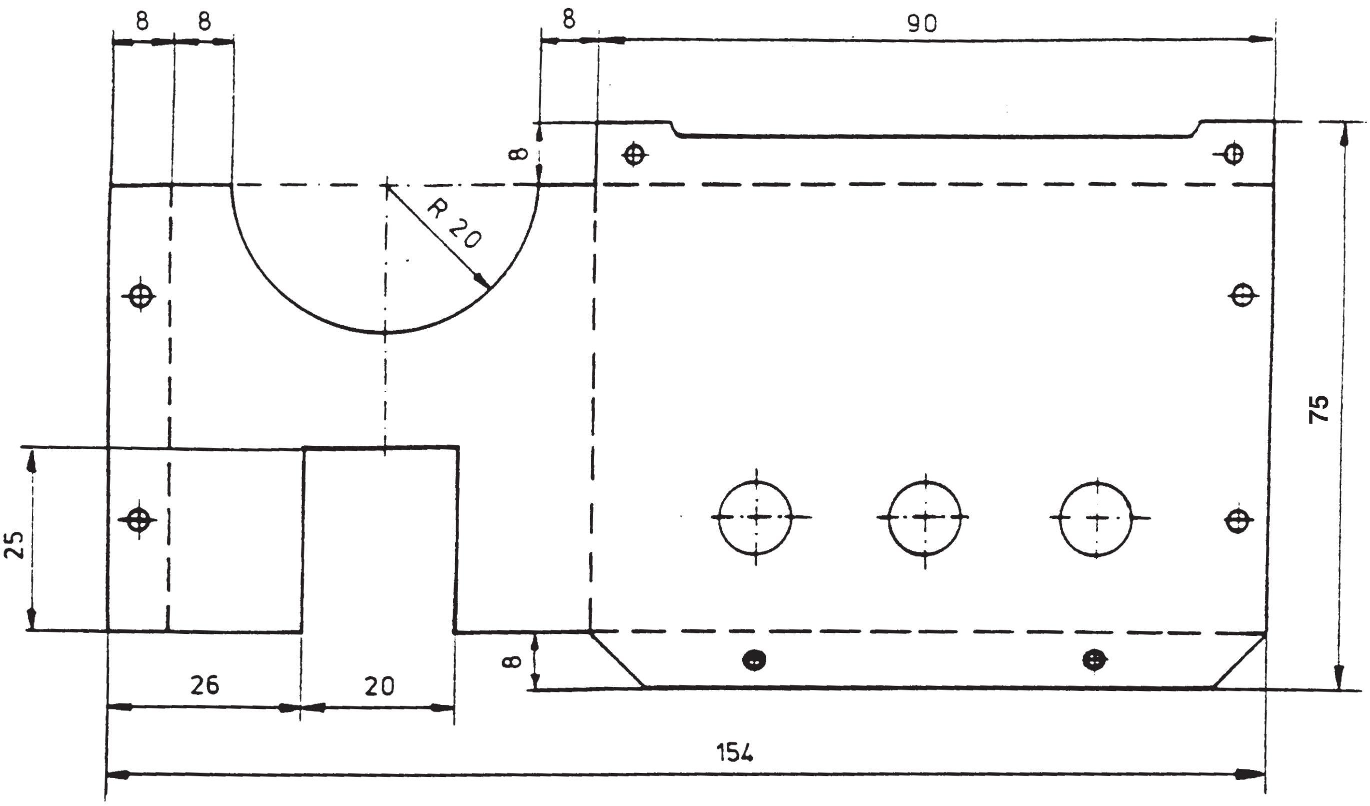
The fire box runs in the rail section and will hold two fuel tablets. The air needed for combustion is delivered through holes drilled in the side of the fire box. Although these are half covered, they are still goog enough.

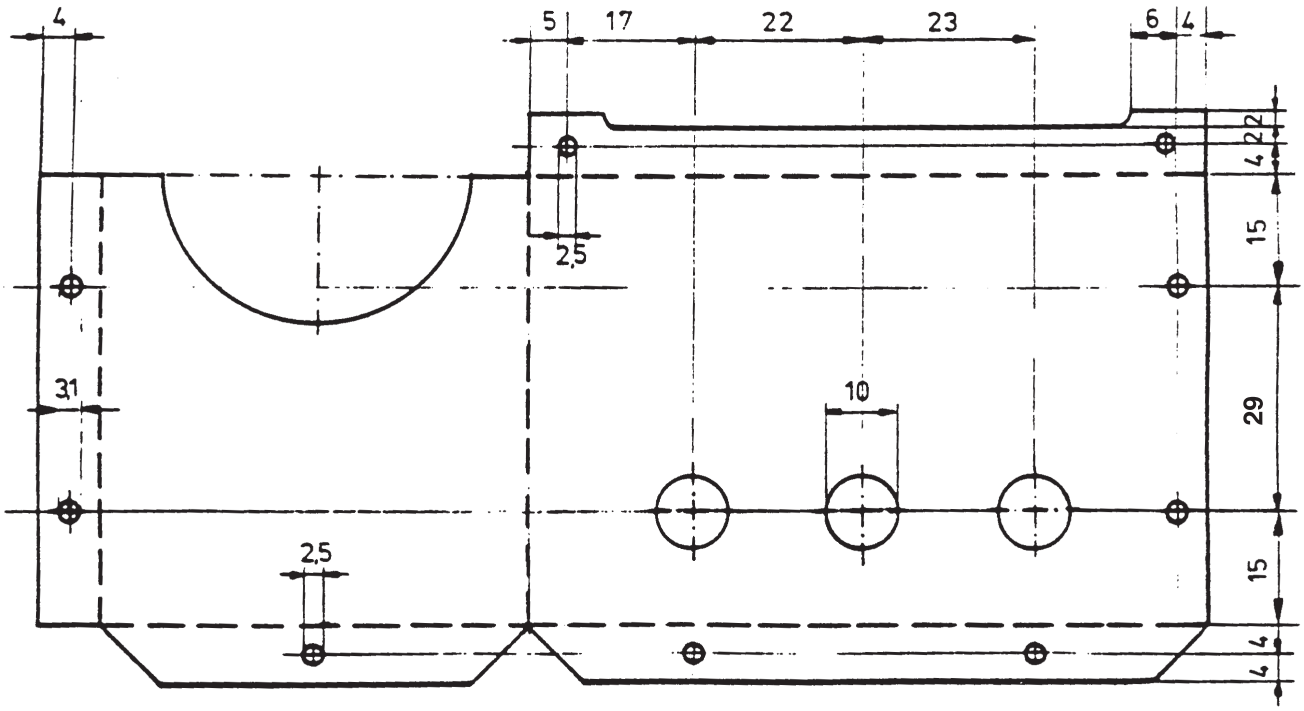
- cut off aluminium section at 98 mm
- mark out and make saw cuts at either end and bend up base to enclose the box
- drill a 4 mm hole at one end to make a M4 x 25 cheese head screw, which can be held in place with 2 nuts
- drill 4/5 4 mm air holes in each side (drill both sides at one go)
- use M4 x 25 bolt as handle and a piece of dowel as hand grip

***NOTE:*** In some packs the aluminium parts are already cut to size.

## Development of the boiler housing

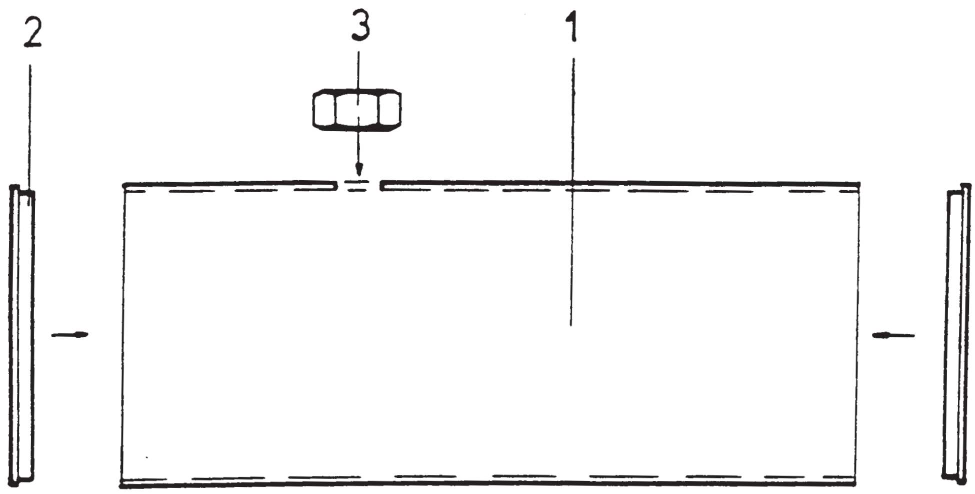
**S 1 : 1**



## Boiler

## S 1 : 1




## Parts List

| No. of pcs. | Description | Material | Size |
|---|---|---|---|
| 1 | boiler tube | Cu Zn 37 | 98 x 40 x 1 |
| 2 | end caps | Cu Zn 39 Pb 3<br>(Ms 58) (brass) | Outer ø 40<br>Inner ø 38 |
| 3 | hexagonal nut | Cu Zn 37 | M6 (DIN 934) |

## Construction

- cut off brass tube at 98 mm length
- file the ends smooth
- drill 6 mm hole in position 3 as shown in the diagram
- flatten off slightly so that M6 nut will stay in position whilst being soldered
- clean up area with steel wool
- flux and then silver solder the nut in position
- clean up and position ends, then flux, use silver solder to join
- let all the solder joints cool naturally after heating
- test to 4,5 bar under water
- polish up with steel wool

***NOTE:*** In some packs all the material may be already cut to size.

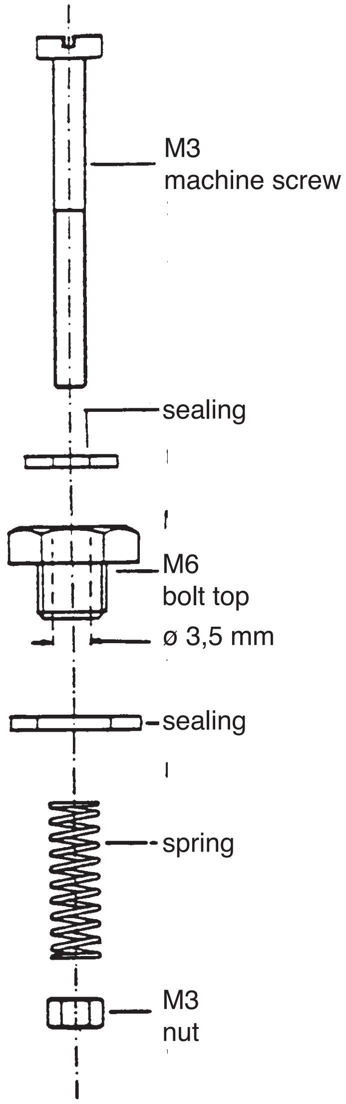
## CONSTRUCTION AND PARAMETERS OF THE SAFETY VALVE

The safety valve is an important part of the steam engine and protects the model against too high a working pressure.

The following description is for a direct working spring loaded valve which also serves as the filling point for the boiler.

It can be constructed from a M6 brass bolt head, a M3 bolt, a push spring and a home-made rubber seal.

The M6 bolt must be shortened as in the diagram and driller centrally to 3,5 mm.
The M3 bolt should be located through the M6 bolt head which has been pre-drilled. A rubber seal is needed on either side of the brass M6 bolt head to make sure the joint is tight. The spring is held in place with an M3 nut (see diagram).




The formula for working out the correct spring pressure is as follows.

We start with the diameter of the opening in the boiler (d = 0,35 cm). Then, using the following formula, the working pressure of the safety valve can be reached.

$$A = \frac{\pi}{4} \cdot d^2 = \frac{3{,}14 \cdot 0{,}35^2}{4} \approx 0{,}1\ cm^2$$

When the valve is under say 2 bar pressure...
The following formula can be used:

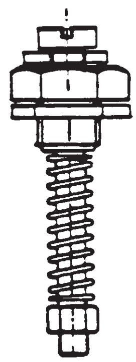
$$\text{pressure} = \frac{\text{force}}{\text{area}} \qquad p = \frac{F}{A}$$

Spring pressure $F = p \cdot A$

also: $$F = 20\frac{N}{cm^2} \cdot 0{,}1\ cm^2 = \underline{2\ N}$$

This means that the self-constructed safety valve, subjected to a weight of 200 gm, will open.
Before mounting the valve in the boiler, it can be adjusted and tested using a kitchen scale. However, it should not be adjusted to more than double the working pressure (opening when subjected to a weight of 300 gm).

**Safety valve**



## THE CONSTRUCTION OF THE STEAM EXCHANGE

In the steam exchanger, the energy from the steam in the boiler is changed into movement. The parts of the system exchanger are;

- angled plate, cylinder mount and cylinder - and flywheel bearing
- cylinder and piston
- connecting rod and bearing
- flywheel with drive

The construction of the steam exchange unit requires patient and careful work.
The details of the construction are shown in the following stages:

### I. CYLINDER MOUNT

- mark out and cut brass angle plate (this may already be done)
- file any sharp edges
- drill both holes for the fixing screws and countersink them
- mark out and drill the holes for the cylinder and flywheel mountings (use flat plate and block mounted scriber to ensure correct marking)
- the surface on which the cylinder slides must be absolutely flat and finely polished
- check this carefully with an accurate edge from a steel ruler (every scratch or unevenness will allow steam to escape)
- cut the bearing tube for the flywheel to length
- drill oil hole
- set up the bearing tube in position
- soft solder into position

### II. FLYWHEEL

- drill hole for bearing on the marked line (r = 12 mm)
- If the shaft (7) fits tightly into the flywheel press it in position, making sure that it is at right angles to the flywheel (A metal working vice makes a good pressing tool, remember use safe jaws) or if it is a looser fit soft solder it to the flywheel.
  Press shaft (13) into the flywheel in the same way making sure that it is at right angles. (Use a vice as a press)
- push bearing shaft into the bearing tube (clean out with 4 mm needle file, if necessary)
- drill centre of small pulley to 4 mm dia.
- mount completed flywheel with washers and pulley

### III. CYLINDER

- see page with detailled drawing and instruction

### IV. PISTON AND CONNECTIONG ROD

- measure out connecting rod, 70 mm long
- cut M4 thread to screw into the piston
- drill bearing with oil hole

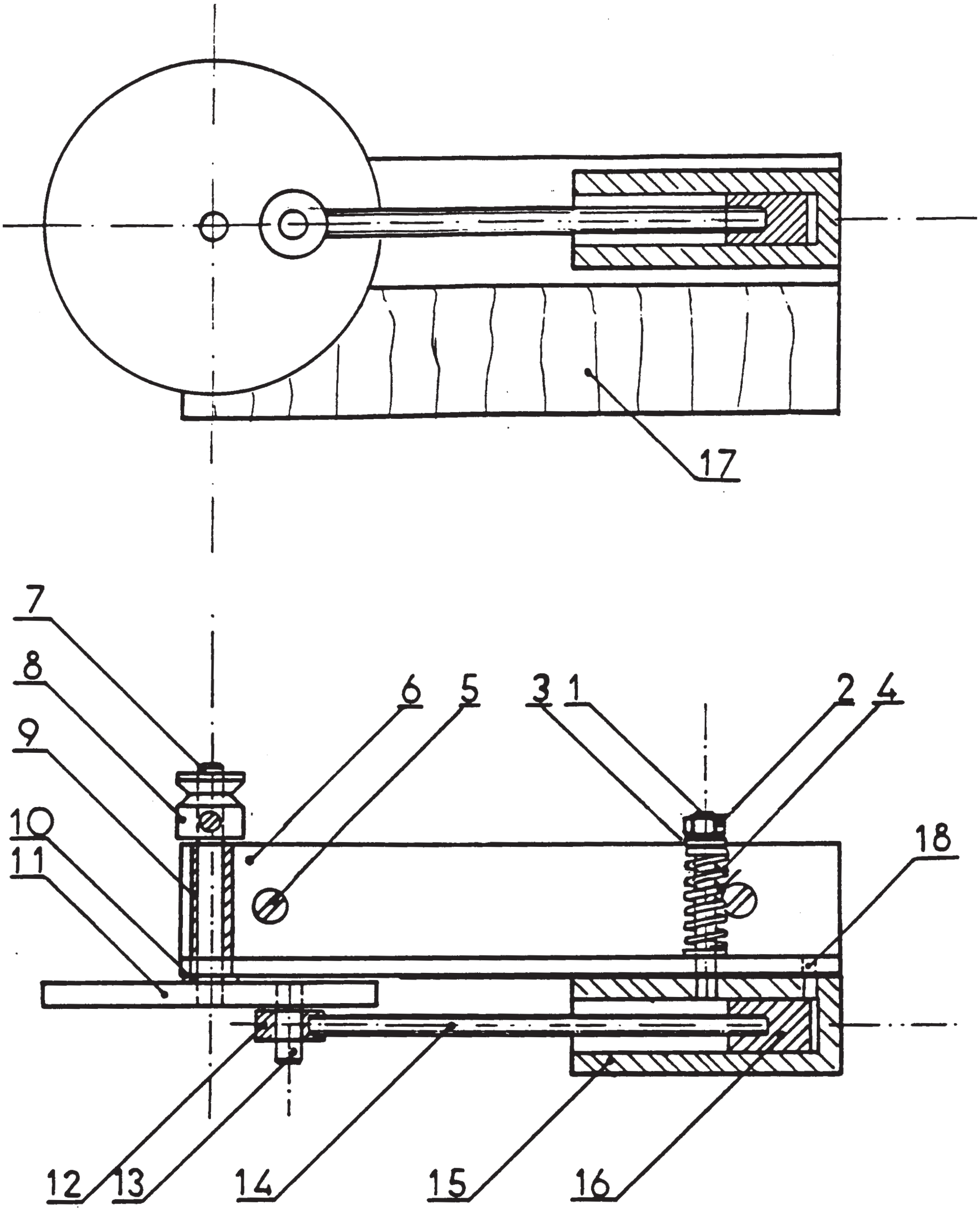
The trial assembly of all the parts can be carried out after finishing all the parts.

The cylinder is held tight against the polished surface of the angle. The mounting is done with an adjustable spring.

**NOTE:** In some packs the materials may already be cut out size.

**Steam exange without measurements**

**S 1 : 1**

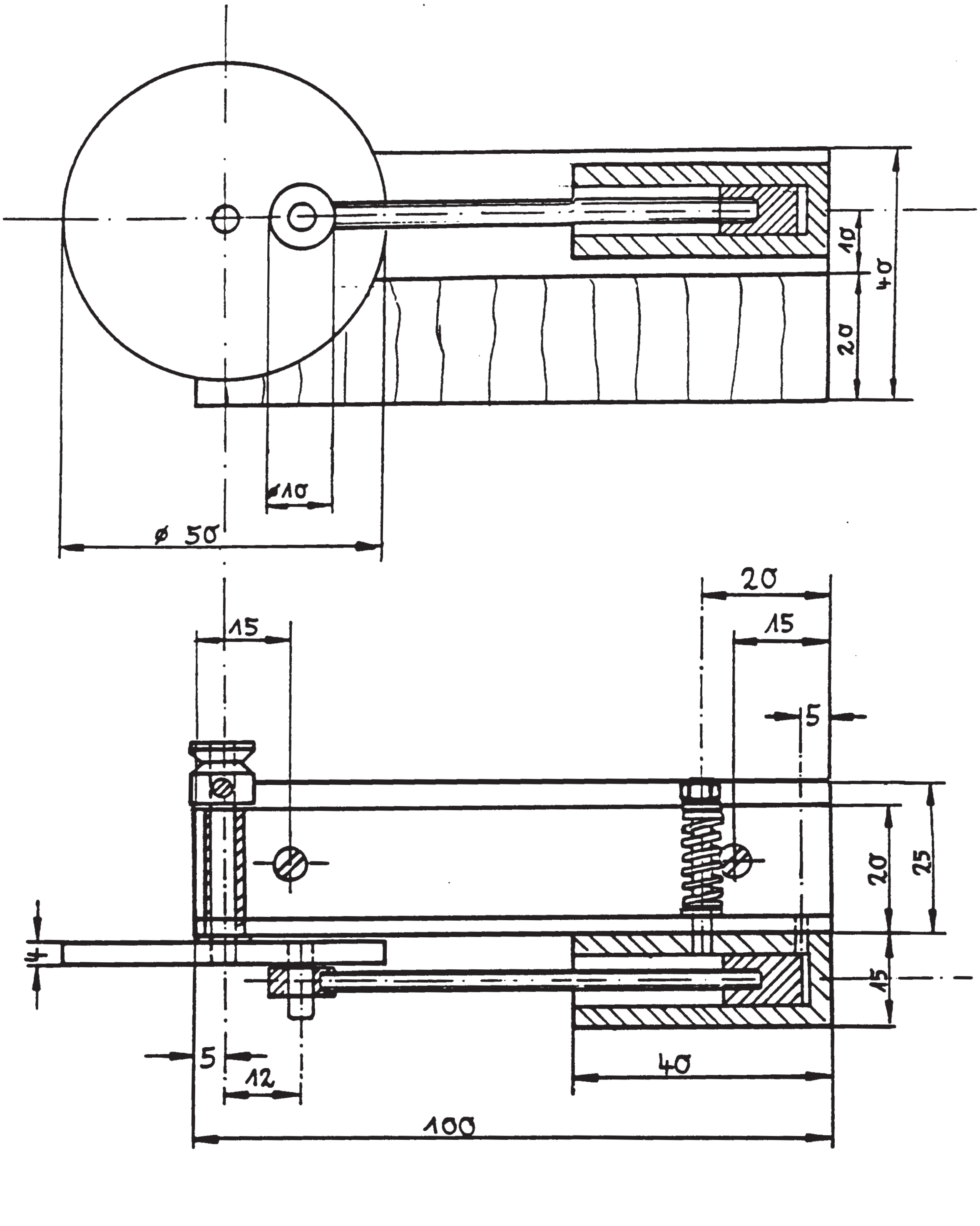


| No. | Description | Size | Location |
|---|---|---|---|
| 1 | cylinder mounting | M3 x 20 | threaded rod fixed with loctite |
| 2 | pressure nut | M3 | |
| 3 | washer | Ø3 mm | |
| 4 | spring | ready made | |
| 5 | fixing screw | 3 x 20 | hole in plate 3,5 |
| 6 | angle plate | 100 x 20 x 20 | polished side outwards cylinder<br>mount 3 mm flywheel mount 6 mm |
| 7 | flywheel shaft | 4 x 36 | If it is a tight fit, press the shaft into the flywheel.<br>If it is a loose fit ,solder the shaft into the flywheel |
| 8 | working pulley | | hold with grub screw hole 4 mm |
| 9 | flywheel bearing tube | Ø6 x 20 | solder to angle plate drill 1,5 mm oil<br>hole |
| 10 | washers | Ø4 mm | |
| 11 | flywheel | ready made | mark out eccentric hole 2 mm from |
| 12 | fixing ring | | centre drill to 3,9 mm<br>drill 1,5 oil hole reduce by 1 mm |
| 13 | eccentric shaft | Ø4 mm x 10 | press into flywheel |
| 14 | connecting rod | Ø4 mm x 68 | make 4 mm thread at one end (5 mm<br>long) |
| 15 | cylinder | ready made | screw to con. rod end |
| 16 | piston | ready made | |
| 17 | wood support | 100 x 20 x 25 | see special instructions first |
| 18 | inlet & outlet parts | Ø2 | |

All materials are from brass unless stated otherwhise.

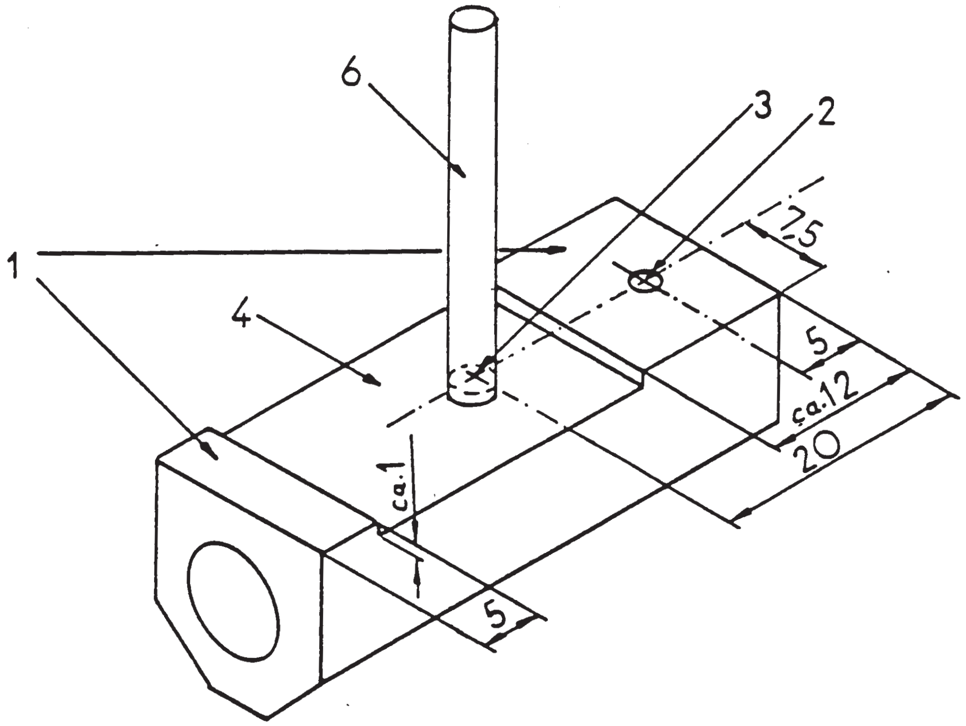
**Steam exchanger with measurements**

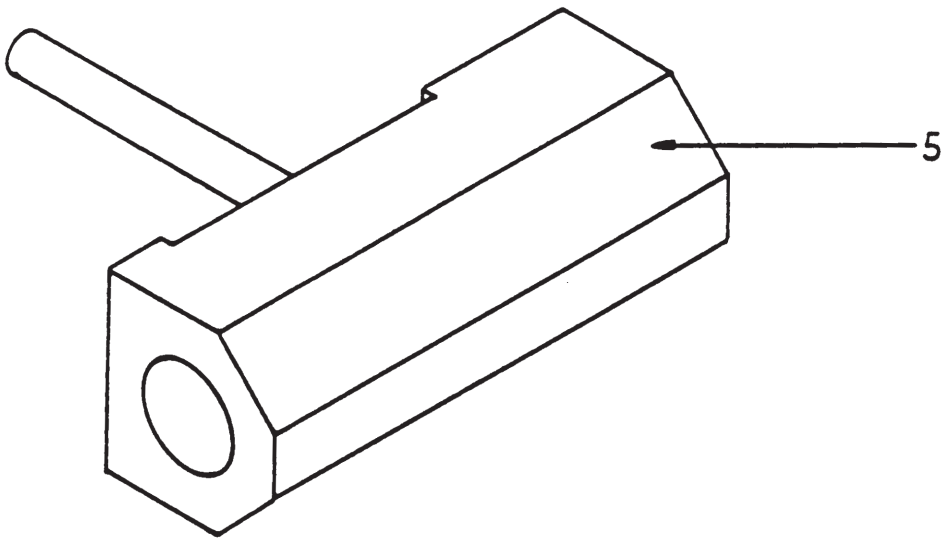
**S1 : 1**



## Cylinder

**S 1 : 1**




## Construction

- file flat and polish surfaces (1) (4)
- drill holes
- steam hole (2) 2 mm dia.
- shaft hole (3) 2,5 mm dia.
- M3 tapped hole (3) after drilling
- outside edge to be filed (5) to shape
- cylinder threaded shaft (6) to be fixed with locatite or similar thread glue

***NOTE:*** The shaft must not intrude into the cylinder. Clean up the inside of the bore, if necessary, with 8 mm engineers scraper.

## LOCATING THE POSITIONING OF THE STEAM INLET AND OUTLET PORTS IN THE ANGLE PLATE

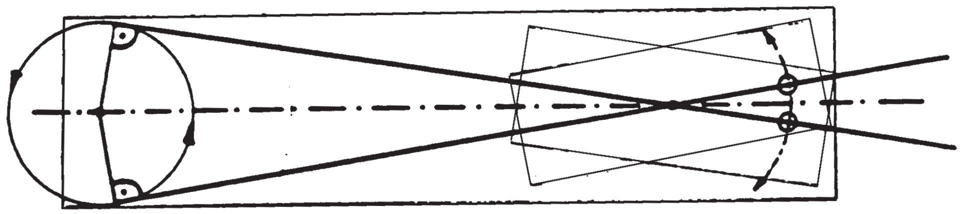
The position of the inlet and outlet ports are fixed by the movement of the cylinder (see diagram below).

Steam must be able to come in behind the piston. This is possible when the connecting rod is at right angles to the flywheel. When taken through to the opposite position the outlet port can be found.

The easiest way to locate the positions of the ports is to use the end off a pop rivet which has been sharpened to a fine point, 1 - 2 long, and stuck in the steam hole in the cylinder. The cylinder, piston and connecting rod, along with the flywheel, should be assembled and turned by hand. The cylinder should then move smoothly over the polished surface of the mounting bracket. This way, through the movement of the cylinde, the inlet and the outlet positions will be made ready for drilling by using a centre punch and finally driller out to 2 mm dia.

When everything is re-assembled, a trial run can be made using air pressure max. 2 bar. By reducing the air pressure gradually, it can now be seen how efficient it will be. The joint between the boiler and the machine parts can now be made. A 4 mm hole should be drilled and the correctly formed copper tube set in and soft soldered into position.

**ATTENTION:** Before the first run, oil all moving parts position of parts



Scale 1:1

## THE WORKING STEAM ENGINE

When all the mechanical work on the boiler, firepan & machine parts is finished and the engine is assembled, plus being bench tested with air pressure, the model can now be tried with steam. This proving stage is the one that most pupils forget to go through. It must be remembered that all newly constructed machines are taken through a dry run before finally being put into action. Although, the model looks robust, it can still be damaged by rushing into starting it up without checking.

The most important first step is SAFETY, so try the completed model once more using air pressure at approx. 3 bar. Now test the safety valve and all the moving parts, making sure they are well oiled and work freely.

Only when all this has been carried out, should the model be finally started. At this stage, the quality and quantity of the water in the boiler will play an important role. It is recommended that distilled water is used and tha boiler is only filler to 2/3 of its volume. Too little water will lead to overheating and too much water will lead to boiler and machine parts damage. When the boiler has been made properly to the plan (length 100 mm internal dia. 38 mm), its volume should be in the region of 113,4 cm thus giving an optimal water filling of 60 - 70 ml. This should require then only 2 special fuel tablets to bring it up to temperature.

**Example of reckoning:**

To heat 60 ml water from 20° to about 120°
(at a pressure of 1,5 bar) it needs

0.06 x 100 x 4,2 = 25.20 kJ

To change 60 ml water to steam it needs

0.06 x 2257 = 135.42 kJ

Total energy 160.62 kJ

So, to change the water to steam, it needs almost 6 times as much energy as to heat the water!

The boiler operating temperature in simple cylinder boiler is at about 60%, so that for the heating and changing to steam of 60 ml water about 267,67 kJ
are needed.

A fuel tablet of 3,9 gm according to the markers can produce 110.00 kJ

With 2 fuel tablets the following can be produced 220.00 kJ

From this example, it can be seen that with 60 ml of water and the use of two fuel tablets, the danger of over-heating is ruled out.

The use of tablets for fuel as opposed to methylated spirit means that they can be lit without danger. However, the tablets contain formaldehyde and should only be used in a well ventilated room.
Before lighting up for the first time, the pupils should be made aware of the dangers from fire. Also that all the working parts will become very hot and could cause burns. The other thing to be aware of is scalding and steam.

When in use, the pupils should be encouraged to spend enough time making notes as to the quality of their work and how it could be improved. Also, they should be encouraged to see how efficient their model is in comparison with others. They may also think up different applications of the principles involved.

After use, it will be seen that the modell will need to be cleaned and oiled also the boiler emptied.

To preserve the finished model, a spray with special metal varnish will suffice to stop any corrosion.

## PRACTICAL TIPS

**Fire box and rails**
- place one inside the other and saw through together
- drill all holes before bending

**Boiler housing**
- hold both halves together with masking tape on a wooden former made from scrap so that holes can be drilled through without problem
- using a scrap tube (25 mm dia. ), bend the boiler holding strips to pre-form their shape and then eventually join them t the boiler housing using 3 mm rivets.

**Cylinder**
- M3 thread bore hole should be made using pillar drill, the final thread can be made likewise holding the tape in the drill and turning the chuck by hand
- also the piston can be made to slide fit in the cylinder using the same technique (use special paste or toothpaste to achieve fine polish)

**Flywheel**
- balance by drilling small holes or removing material
- press in the shaft using a vice or pillar drill to ensure square location

**Connecting rod**
- do not put the connecting rod uptight in the piston, this will allow a little adjustment to be made

**Polished surfaces**
- use fine and dry paper 500 grit with machine oil on a glass plate as a flat surface, finish with brasso

**Copper tubbing**
- keep it as short as possible to stop steam condensing back to water
- it is also possible to insulate this tubing with string or similar boune around it

**EXTRA SHEET FOR STEAM ENGINE MODEL**

Dear Teacher,
You have chosen a worthwhile metal based project to dry with your pupils. The OPITEC package allows every pupil a chance to produce a working model and, at the same time, to gain knowledge and experience in the use of materials, plus the theory of energy exchange.
However, as a teacher you are responsible for the SAFETY OF THE PUPILS. We strongly recommend that you follow the check list below to ensure that no accidents can occur.

1. TEST BOILER with 3 times working pressure.
2. Make sure the SAFETY VALVE works with pressure of 1,5 bar and is firmly mounted in the boiler.
3. MARK THE FINISHED MODEL with the date and the following other data:
   - Test pressure 4,5 bar
   - Working pressure 1,5 bar
   - Water capacity 0,06 litres
4. WHEN THE MODEL has run successfully mark with T for tested.
5. TEST SAFETY VALVE each time before starting.
6. USE ONLY DISTILLED WATER in the cylinder.
7. CHECK THE LEVEL of water in the boiler before starting.
8. USE only 2 FUEL TABLETS to heat the boiler.
9. WEAR SAFETY GLASSES and protective gloves.

If you ensure that the pupils follow this code, it will become part of their learning experience. Finally, they should be made aware once more of the danger from scalding and burns.

Have fun with your model and see what you can drive!!