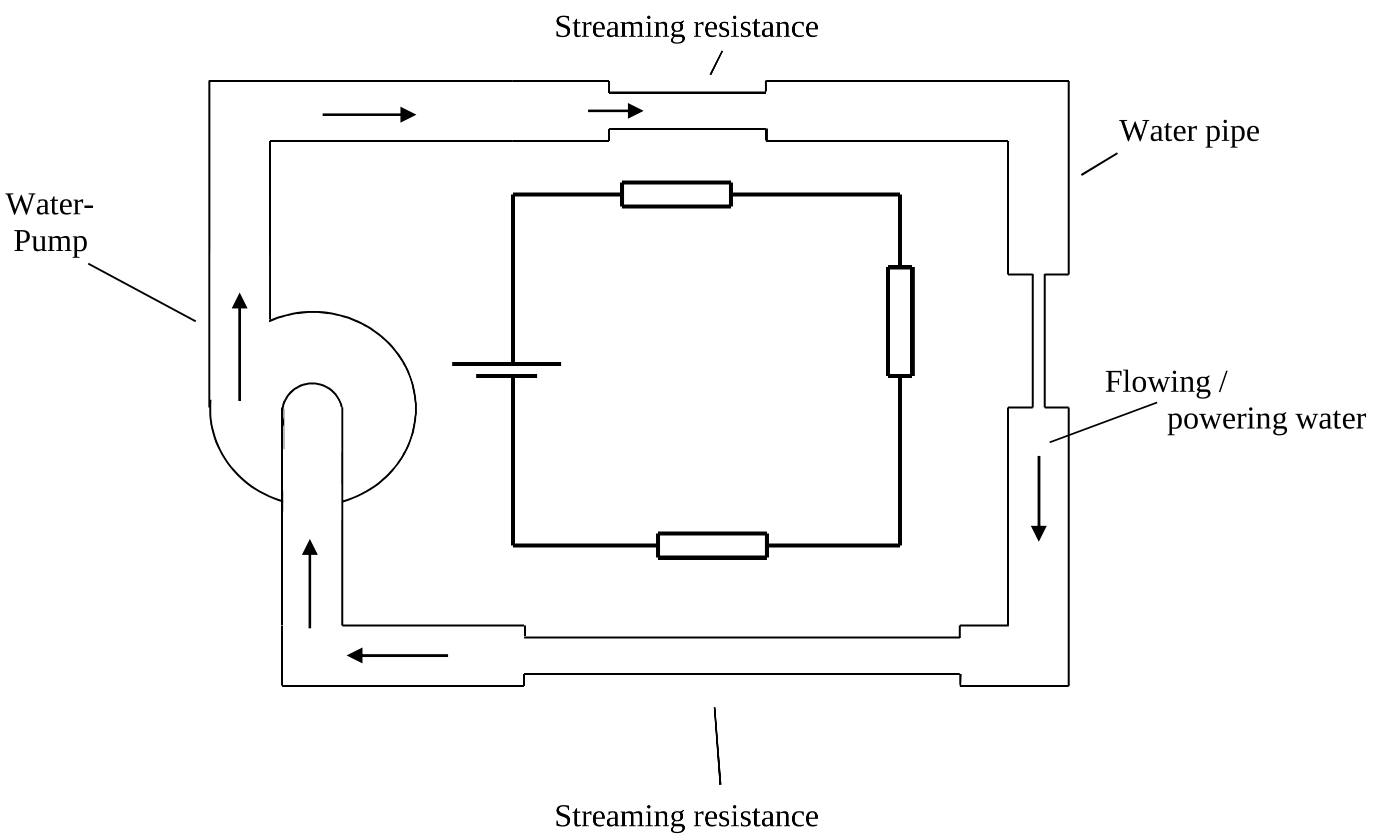
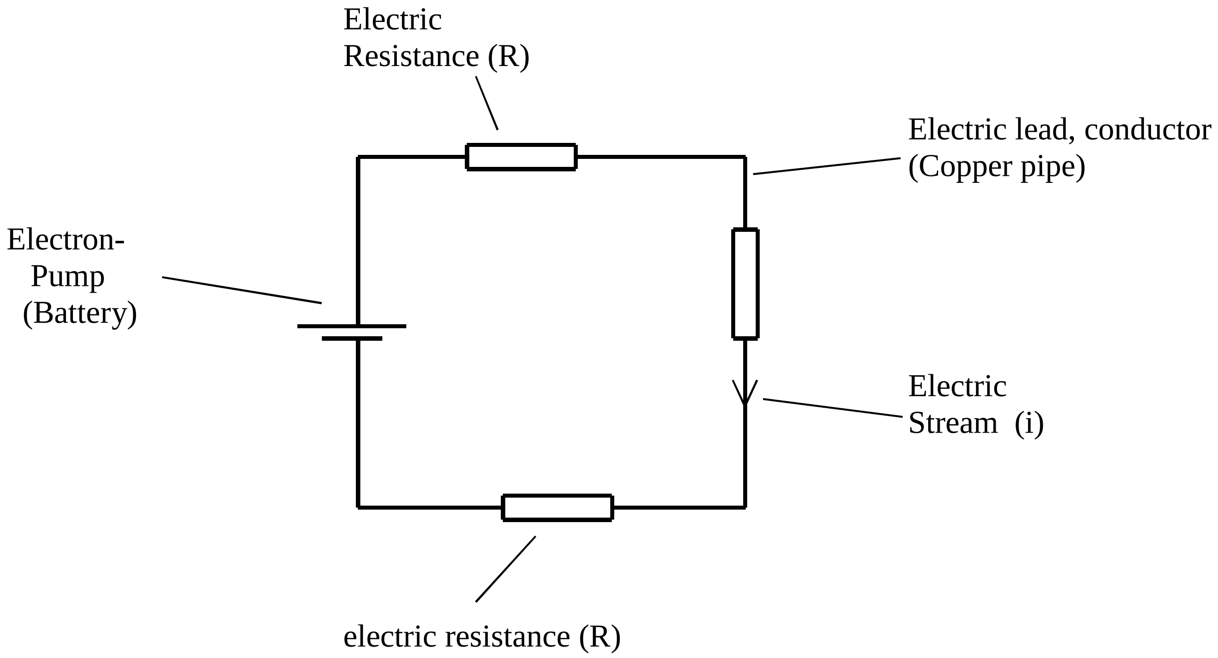
From the waterscheme to the electric current circuit





Water-circuit	Electric current circuit
Water-pump	Electron-pump
water-particles	electrons
pressure	voltage (U)
pressure-loss	voltage-loss
flowing/streaming water (water-stream) Flowing/streaming water-particles	electron-stream (i) (flowing/streaming electrons)
Fluid-streaming-resistance (pipe-reduction)	electron-stream-resistance (R) (conductor-reduction)
Pipe-conductor	electric pipe (p.e. copper-pipe)

<u>Electron-pump</u>

As the water-pump sucks water in an its one side and presses out at the other, the electron-pump sucks in the electrons an presses them out at the pressure-side.

<u>Electrons</u>

Just visualize the electrons as little particles, which carrie an electric charge (pickaback, as baggage). These little particles (electrons) are so small, they are able to move in metal-pipes (p.e. in copper-pipes) like the water-particles do in a (hollow) pipe.

<u>The voltage (U)</u> is in accordance with the pressure (the drive), the voltage presses the electrons into the cable und gives them „drive“, which they loose to the voltage-resistance thereafter (voltage-loss or voltage-drop).

<u>Electrons-power (i)</u>:At the point, the electrons-pump has built up a're n electric pressure, the electrons are starting to flow, this means, they are moving away from the pump through the copper-pipe. In doing so, they don't move so fast, as you may think. Tripping a light switch, the light bulb glows pretty fast, just if it would glow at once – it seems to us, anyway, as if the bulb would glow in the second we've tripped the light switch.

<u>The electrons</u> did not flow all the way from the light switch to the light bulb, they're moving much more unhurried: <u>a few centimeters per second</u>, so to say like taking a walk. The electrons-flow starts immediatly (at the point of) the switch is tripped, the electrons push each other one by one, just like billiard balls, it reminds of the domino effect. So, one electron pushes the next in the line (impulse-effect) and this electron again the next, this one pushes the next...... And this impetus-effect comes about with the <u>speed of light</u>, so that directly after tripping the light switch, the effect arrives at the bulb.

<u>The electron pump</u> must build up an electron-pressure (voltage), otherwise no current will flow. With the water the situation is different, there something flows topdown of its on volition (downhill). With the electrons, there is no top and no down, without voltage (electrons-pressure), nothing will flow there.

<u>Without voltage there's no electron-stream (i)!</u>

Electrons-streaming-resistance (R) or conductor-restriction. If the section of a copper-pipe gets thinner at a certain point (conductor-restriction), the electrons have to jostle through (squeeze through). In doing so, they rub against each other and against the atoms. Thereby, warmth is arising and drive (voltage) gets lost. They say voltage-loss or voltage-drop (power-fluctuation). The height (value) lesses.

Electric cable

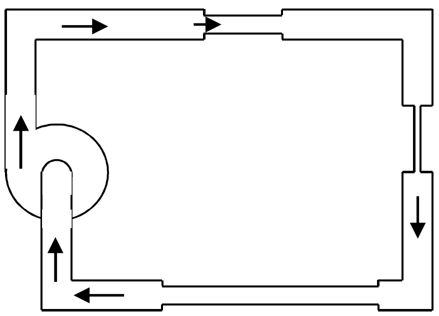
Electrons are so small, they can move freely in a metal-conductor (p.e. In a copper-pipe) just as water particles in a (hollow) pipe. There are elecrons all over inside the copper pipe, at each place of it. Just like the pipe systeme (in the water-scheme) is brimming with water, the copper pipe is „brimming“ with electrons. Unlike to the water, that can leak out of the pipe at a leakage (hole in the pipe), the electrons can't get off the copper pipe by a loophole. The electrons can move freely in the pipe, but they can't get off it.
In return, the electrons get to leave the copper-pipe in a different way: As soon as another electric conductor (iron/ferric (Fe), lead (PB), zinc (Zn), tin (Sn)...) or just another copper pipe touch this pipe, the electrons are able to flow into this other electric conductor. Electric conductors only need to touch another, so the electrons can flow also into another conductor. In this other conductor, the electrons cannot assemble (getting more an more). There are already electrons everywhere, and if none steps aside, none can come along. The electrons are only able to flow into another conductor, if other electrons get off.

Series connection

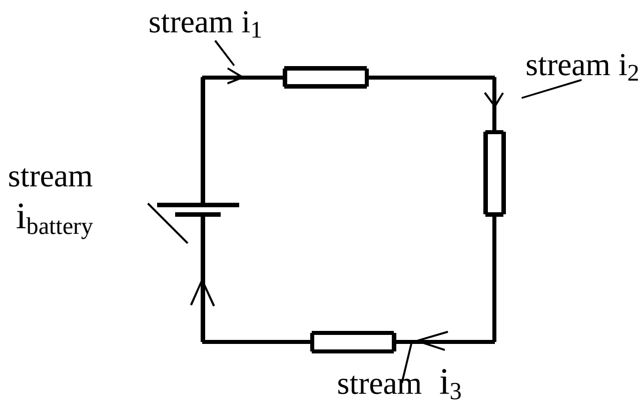
The circumstances in a single pipe heating system are alike, you don't just learn about electro-technics, but also something about heating engineering!

At the sequence (combination) of electric components two basic structures are to be differentiated: the series connection (in a line, one after the other) and the parallel connection (besides each other).

Water-circuit



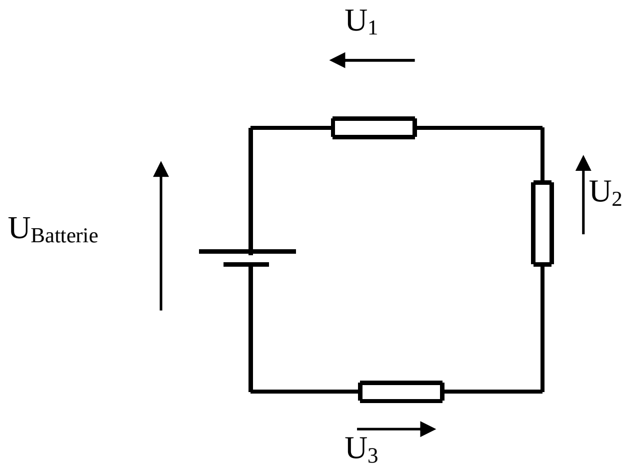
Electric current circuit



At a series connection all components are connected (have been linked up) one after the other (serial). The current/electricity (I) has to flow consecutively through each single component. Current/electricity is the same size everywhere, because it doesn't divert or add at any place.

$$i_{battery} = i_1 = i_2 = i_3$$

Voltages (pressures) are not the same height in this case! The maximum voltage is located at the voltage source: Voltages are emblematized (drawn) with arrowes above the components, voltage beginning (the voltage source) is in another direction than voltage-losses (drops) at the resistances.



$$U_{battery} = U_1 + U_2 + U_3$$

The unit voltage is measured in, is called Volt.
(Mr. **Volta, Alessandro, italian physicist, 1745 to 1827)**

Example:

Given: $U_1 =$ 12 Volt (V)
$U_2 =$ 24 V
$U_3 =$ 3,4 V

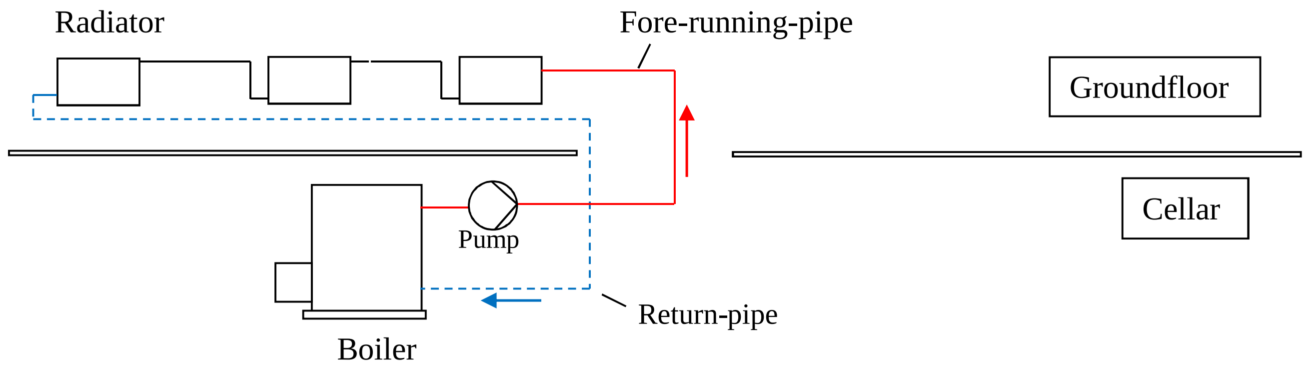
find out : $U_{battery}$

formula: $U_{Batterie} = U_1 + U_2 + U_3$

values applied: $U_{battery} = 12\ V + 24\ V + 3{,}4\ V$
$\underline{U_{battery} = 39{,}4\ V}$

Heating system

Principle schematic diagram* of an single-pipe heating (series connection):

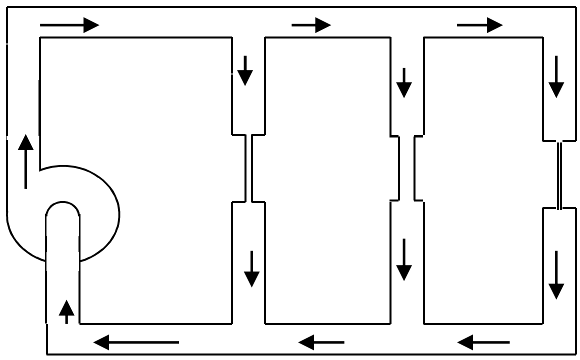


Exercise: Mark the **flow in red** and the **return in blue!**

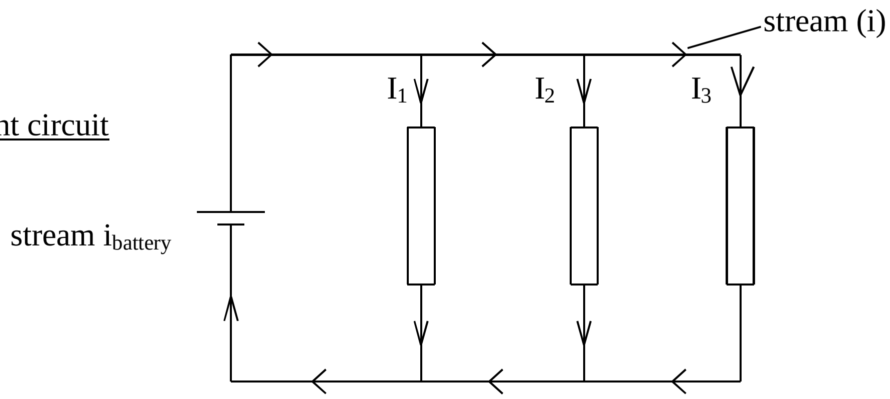
*Talking about heating engineering circuit diagrams are called „schematic diagrams“. Principle means, only the most important details (particulars) are illustrated, in fact, a heating engineering is more complex (a heating engineering has much more components).

Parallel connection

Water-circuit- scheme



Electric current circuit



In an heating system with two pipes, circumstances are alike, aside from electro-technics you also learn something about heating engineering!

At a parallel connection, all components are connected (have been linked up) next to each other (besides one another).

Current (I) is not compelled to flow consecutively through each component (as it is at the series connection). At first, electricity/current „is looking for“ the most comfortable way. If it finds out, that there is enough current flowing, it takes the less comfortable way, too. Through each resistance, electric current is flowing, but the more massive the resistance (the tighter the reduction), the smaller the current. The smaller the resistance (the wider the reduction), the easier the current gets through it = the major the current. When the current leaves the battery (gets pressed out) it splits in different partial currents – and after the partial currents have flown through the resistances, the partial currents unite as “battery-current” (overall-, total-, general-current).

$$i_{battery} = i_1 + i_2 + i_3$$

The unit electric current is measured in, is called AMPÈRE (Msr Ampère, André Marie, French physic 1775 to 1835) 1 A = 6,3 x 10^{18} electrons per second

10^{18} means a 1 with 18 zeros thereafter: 1.000.000.000.000.000.000

Example:

given: i_1 = 2,0 Ampère (A)
i_2 = 3,0 A
i_3 = 3,4 A

find out: $i_{battery}$

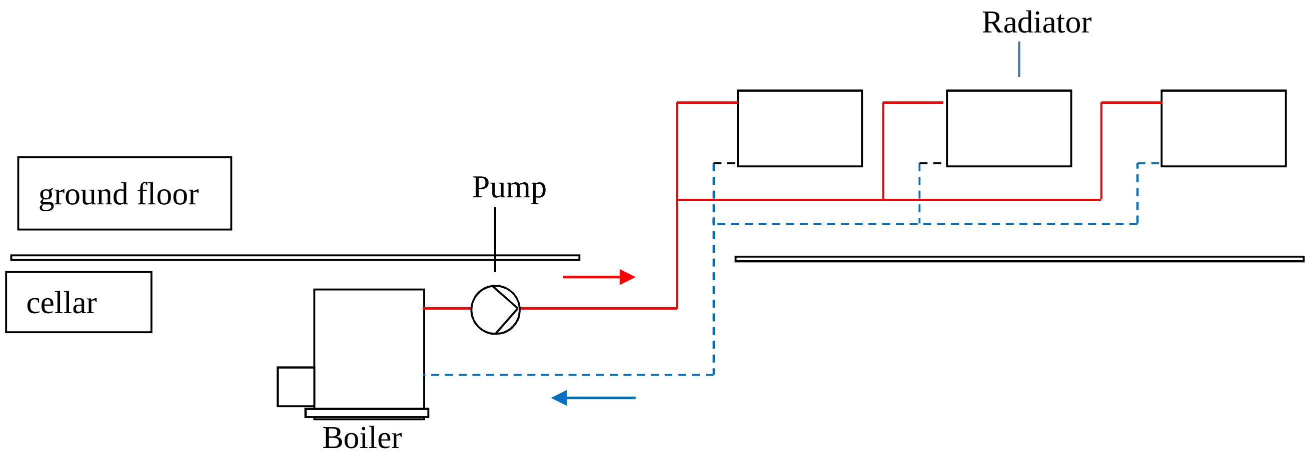
formula: $i_{battery} = i_1 + i_2 + i_3$

values applied: $i_{battery}$ = 2A + 3A+ 3,4A
$i_{battery}$ = 8,4 A

$U_{battery} = U_1 = U_2 = U_3$

Heating system

Principle schematic diagram* of a dual-pipe-heating (parallel connection)):



Exercise: Mark the **flow in red** and the **return in blue!**

*Talking about heating engineering circuit diagrams are called „schematic diagrams“. Principle means, only the most important details (particulars) are illustrated, in fact, a heating engineering is more complex (a heating engineering has much more components).

Exercise: Series- and parallel connection of electrical components:

1A Outline (by hand "thumbsketch" – no technical drawing) an electric current circuit with one voltage-source (battery) and four resistances in a series connection (serial connection)

1B Outline the partial currents i_1 to i_4, as well as the battery circuit $i_{Battery}$.

1C The partial current i_2 amounts 3,2A, the current i_3 amounts as well. How much Ampère will the other partial currents have?

Given:

$U_1 =$ 1,2 Volt (V)
$U_2 =$ 24 V
$U_3 =$ 4,2 V
$U_4 =$ 12 V

Find out : $U_{battery}$

formular: $U_{Battery} =$

values applied: $U_{Battery} =$

Result: $U_{Battery}=$ ________________

1D Outline (thumbsketch – no technical drawing) a single-pipe-heating (series connection with boiler, 3 radiators and a pump).

1E Mark the **flow in red** and the **return in blue!**

2A Outline (thumbsketch – no technical drawing) a current circuit with one voltage source (battery) and five resistances in parallel connection!

2B The partial voltage U_2amounts 24 V,
The partial voltage U_3 amounts also 24 V.
How much Volt do the other voltages amount?

2C Draw in the partial currents i_1 to i_5, as well as the battery current $i_{battery}$.

2D

Given:

i_1 =	2,3	Ampere (A)
i_2 =	4,3	A
i_3 =	3	A
i_4 =	4	A
i_5 =	1,2	A

Find out: : $i_{battery}$

formula: $i_{battery}$ =

values applied: $i_{battery}$ =

Result: $i_{battery}$ =

2E Outline (thumbsketch – no technical drawing) a dual-pipe-heating (parallel connection) with boiler, 3 radiators and a pump.

2F Mark the **flow in red** and the **return in blue!**

3 Complete the schedule!

Water-circuit	Electric current circuit
Water-pump	
water-particles	
pressure	
pressure-loss	
flowing/streaming water (water-stream) Flowing/streaming water-particles	
Fluid-streaming-resistance (pipe-reduction)	
Pipe-conductor	

Annotation to the analogy with the heating system

In a heating system apart from the transportation of pressure another character of water is used: the heat/thermic capacity. Water is able to accumulate heat (assimilate) and release this heat at another place. In a heating system the water gathers the heat in the boiler (temperature of the water increases) and gives it off while flowing through the radiators (temperature of the water drops). At the inlet flow (on the way to the radiators) the temperature of the water is higher than at the return flow (on the way back to the boiler). In a heating system, the pressure is only needed, to transport the (warmer) water to the radiators and thereafter back (colder) to the boiler. The pressure “gets lost” on this “journey”, means, it is converted in heat; but the heat quantity is so remote (little), it will not be noticed, it plays no role.

In a heating system two forms of energy will be sent on their way: Pressure and heat

In a current circuit also energy is transported (Voltage). This transported voltage (brought to another place) can be converted in heat, also (radiant heater). But the flowing current never has got different temperatures – before and after. Current has got no temperature at all. The difference (between before and after) merely (only) is the fact, that there is less voltage in stock. Voltage was converted into heat. The current flowing back to the electron pump possesses less voltage than the current that will be sent from the electron pump on his way again to the consumer (radiant heater).

In a current circuit only one form of energy will be sent on its way: The voltage

In the drinking-water-supply the drinking-water has got many characteristics

1. The water itself can be drunk (material/physical form)

2. Water has got a **heat carrying capacity**. You can cool something:
   a) A bottle of beer
   b) Extinguish a fire (this is cooling, too. At this, the needed reaction temperature is dectracted off the oxidising substances)

3. Water owns a **pressure**, which mostly is brought up to transport the water to the consumer, the consumer, however, can use this pressure:

   a) to constitute negative pressure with the help of a venturi nozzle (water switch in a gas-flow rate-water heater)
   b) to produce electric energy with the help of a kind of “hydro-generator” (in a gas-flow rate-water heater with battery power).

4. Water is able to absorb dirt and sweep it off:

   a) off our skin while taking a shower
   b) off the toilet, flushing
   c) off the floor, mopping

Result:

41,4 V	24 V	24 V		
	14,8 A	24 V		