8. ENERGY CONVERTER

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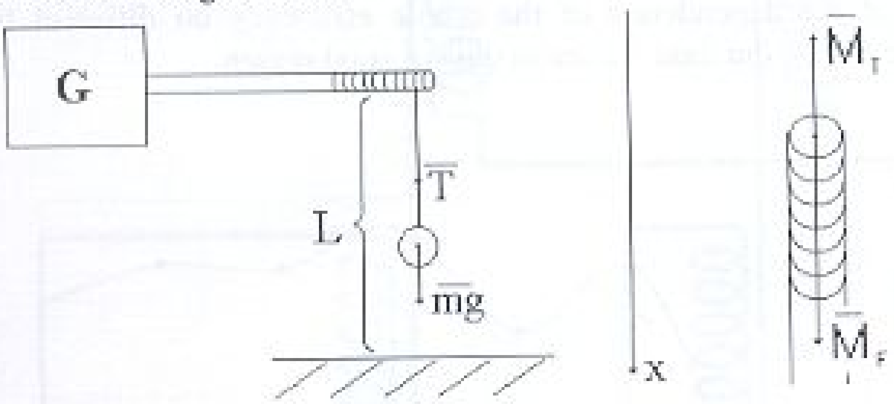
The main aim of our problem is to charge a capacitor, which we reach by converting the potential energy of falling body into electric energy. We tie the body of 1 kg. to rope of 1 m, which is winded round the rod of the generator. The fall of body makes the rod of the generator to rotate.

At first let's consider the ideal case, when the potential energy of falling body is converted into the electric energy without any loses, so:

$\eta^{id} = 100\%$ then $U^{id}_{max} \approx 447v$

This means, that the maximum voltage, to which we can charge the capacitor to equals to 447 v.

The generator and the rod are shown on the picture 1, with the forces applied to the body and to the rod of the generator.



Pic. 1

We can write the following system:

$$\begin{bmatrix} I\dot{\omega} = T_1 R - M_F \\ ma = mg - T \\ T = T_1 \\ a = R\dot{\omega} \\ L = \dfrac{at^2}{2} \end{bmatrix} \quad \omega = at \qquad a = const \quad \Rightarrow \omega = \sqrt{2L\frac{mgR - M_F}{(I + mR^2)R}} \qquad M_F \approx 7{,}7 \cdot 10^{-3}\ \text{Nm.}$$

Where I – is the inertia momentum of rod rotation, R – the rod radius, M_F – the friction momentum, which we measured from our experiment, ω - the angular velocity of rod rotation.

We can consider our problem in two stages: In first stage the potential energy of falling body converts into the kinetic energy of rod rotation. In the second stage the kinetic energy of rod rotation converts into the electric energy. At first let's consider the first stage.

Let's find the efficiency of converting potential energy into kinetic one:

$$\eta_1 = \frac{1 - \frac{M_F}{mgR}}{1 + \frac{mR^2}{I}} \approx 0{,}69$$

From the formula we see that with the decrease of M_F, η_1 is increased.

Now let's consider the ideal case, when the kinetic energy of rod rotation converts into the electric energy, than we'll have:

$$E_K = E_{El}^{Id} \qquad U_{max} \approx 371\ \text{V}$$

Now we sea that the maximum voltage we can charge the capacitor to equals to 371 v.

Now let's consider the real case, and find out the efficiency of converting kinetic energy into electric. From the experiment we saw that the value of voltage to which we could charge the capacitor equals to 220 v. then we'll have:

$$\eta_2 = \frac{E_{El}^R}{E_K} \approx 0{,}35$$

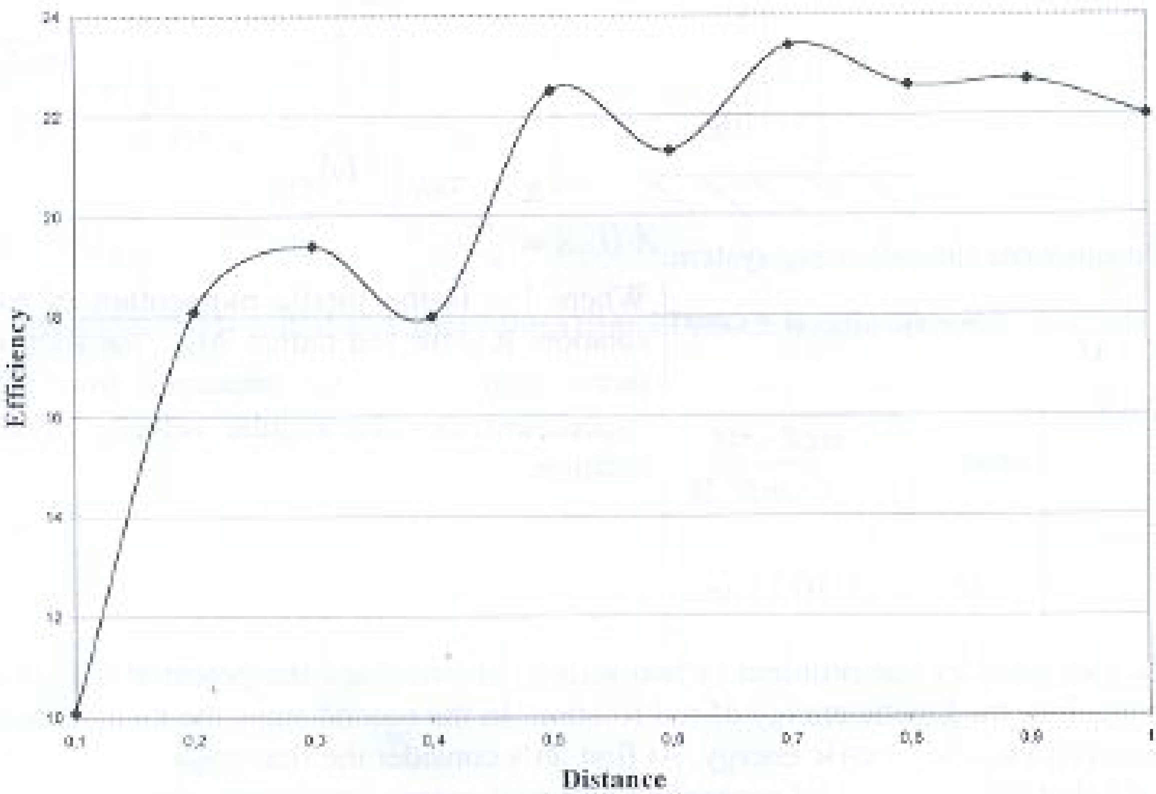
The whole efficiency, or the efficiency of converting the potential energy into electric will be:

$$\eta = \eta_1 \eta_2 \approx 0{,}24$$

This means, that we use 24% of released potential energy to charge the capacitor.

We built the graph of the dependency of the whole efficiency on different heights, (picture 2) from which we see that in our case we are in quite a good region.

Pic. 2

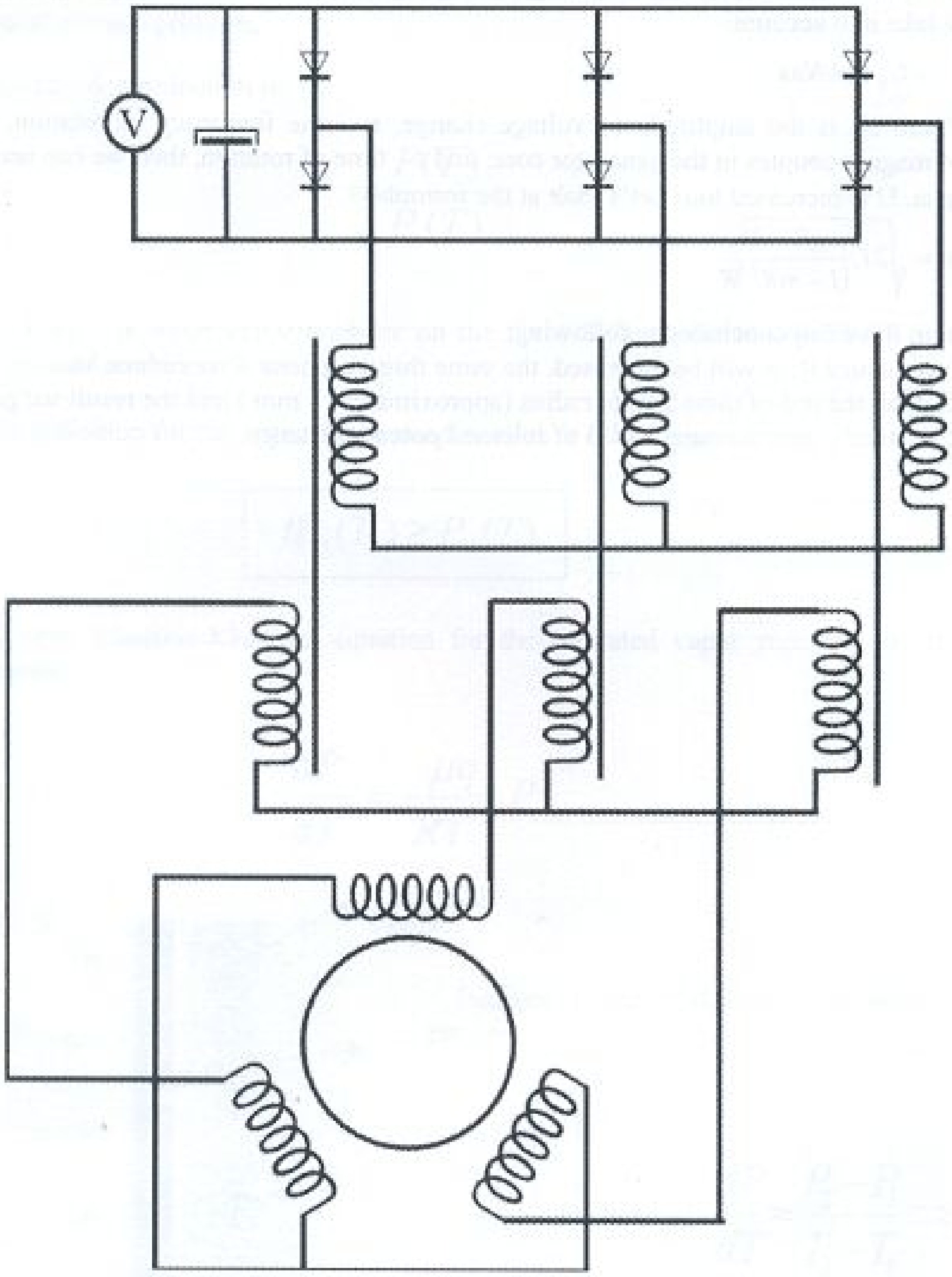


Now about the way we charge the capacitor:

We took 3-phase generator (picture 3), in order to have the minimum lose of voltage. The position of coils is shown on the picture 3. This position of coils is optimal in our case. They are shifted from each other by the angle 120°. Then we took 3-phase step-up transformer and connected each of the coils to the appropriate winding. The generator produces approximately 6 v. and then transformer steps it up.

The transformer in its way is connected to the special rectifiable diode system (chosen by us), by help of which we charge the capacitor and voltmeter shows the voltage it's charged to.

Pic.3



Now let's consider in details the principle of work of our rectifiable diode system.

The rotation of core in the generator emerges the maximum and minimum value of voltage on the coils. This changes in time. As the coils are connected to the appropriate transformer windings, and they in their way are connected to the proper diode couple, so work only those diode couples, which are proper to the maximum and minimum voltage value. For the maximum voltage lower diodes work (picture 3), for the minimum voltage – higher, and the current goes always by the same direction.

In the end let's speak about the way to improve achieved result. One of the ways is to increase the number of transformer windings, but we can't increase it infinitely. Another way is that, if we take into account:

$$U = U_0 \cos N\omega t$$

Where U_0 is the amplitude of voltage change, ω - the frequency of rotation, N - the number of magnet couples in the generator core, and t – time of rotation, then we can see, that by increasing ω, U is increased too. Let's look at the formula:

$$\omega = \sqrt{2L\frac{mgR - M_F}{(I + mR^2)R}}$$

From it we can conclude the following:

If we reduce R, ω will be increased, the same thing happens if we reduce M_F.

We took the rod of quite a little radius (approximately 3 mm.) and the result we got in this case is 220 v. that's approximately 24% of released potential energy.