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# REGENERATION OF THE ENERGY OR BASICS OF THE REGERATIVE ENERGETICS

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***Abstract***: *Reviewed some possibilities for multiple use of energy. There are given also some calculations and some experimental circuits and results from some laboratory experiments.*

# РЕГЕНЕРАЦИЯ НА ЕНЕРГИЯТА ИЛИ ОСНОВИ НА РЕГЕНЕРАТИВНАТА ЕНЕРГЕТИКА

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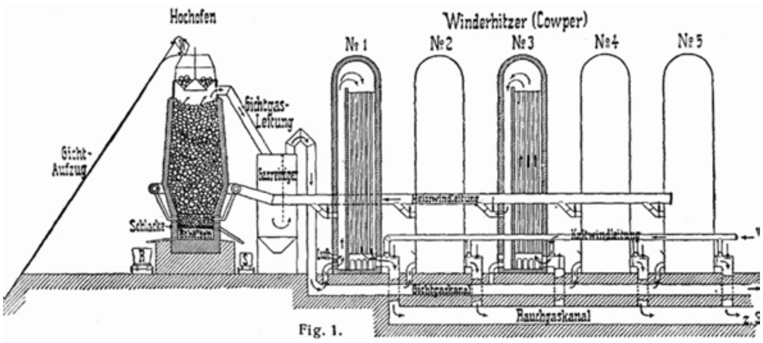
***Резюме:*** *Разгледана е възможността за няколкократно използване на една и съща енергия. Направени са теоретични пресмятания, които са послужили за създаване на лабораторен модел "Регенератор на електрическа енергия". Разгледана е работата на модела в различни режими, както и възможни приложението на регенерацията в системи за защита на населението*

## Introduction

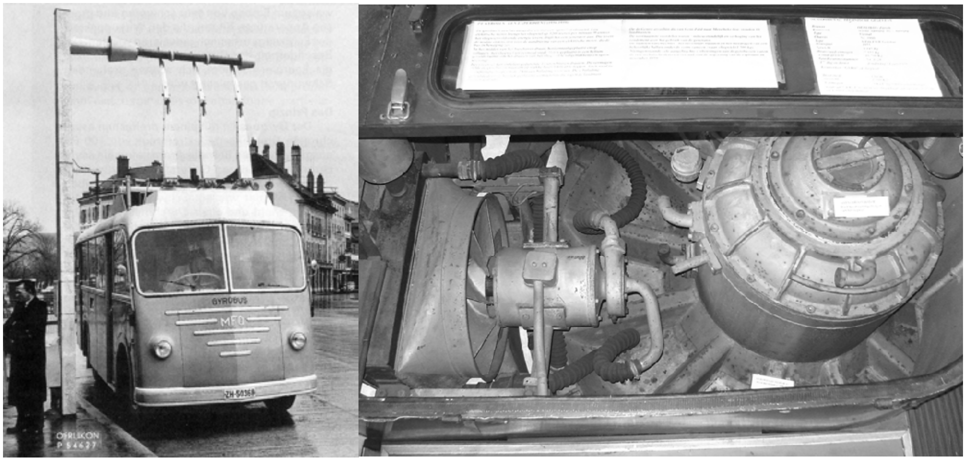
*What is regeneration of energy - using the same energy several times.*
*Conditions for the existence of regeneration - 1. Energy storing element and 2. Energy.*
*Examples: In metallurgy - air heater. In mechanics - flywheel. In electrical engineering - capacitor.* The oldest device - more than one hundred years old - a regenerative heat exchanger, or more commonly the regenerator, is the type of heat exchanger where heat from the hot fluid is intermittently stored in a thermal storage medium before it is transferred to the cold fluid. To accomplish this, the hot fluid is brought into contact with the heat storage medium, and then the fluid is displaced with the cold fluid, which absorbs the heat. In regenerative heat exchangers, the fluid on either side of the heat exchanger can be the same. The fluid may go through an external processing step, and then it is flowed back through the heat exchanger in the opposite direction for further processing. Usually the application will use this process cyclically or repetitively. Regenerative heating was one of the most important technologies developed during the Industrial Revolution when it was used in the hot blast process on blast furnaces. It was later used in glass and steel making, in high pressure boilers and chemical and other applications, where it continues to be important today. For living proof about higher economical effect. [http://en.wikipedia.org/wiki/Cowper]




Фиг. 1

Possible applications outside metallurgy - Nuclear Power Plant (NPP) using caupers can be recast as a Regenerative Thermal Power Plant - RTPP.

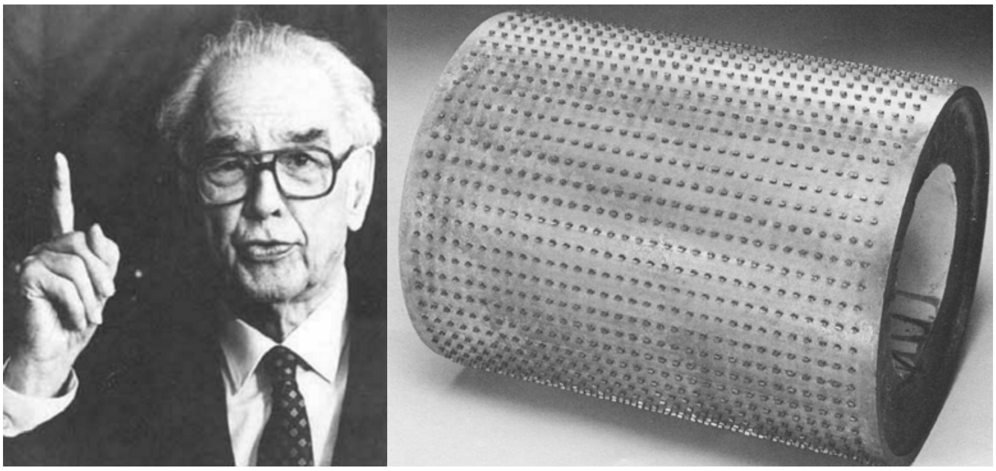
**GYROBUS**



Фиг. 2

A Gyrobus is an electric bus which uses flywheel energy storage, not overhead wires like a trolleybus. The name comes from the Greek language term for flywheel, gyros. While there are no gyrobuses currently in use commercially, development in this area continues. [http://en.wikipedia.org/wiki/Gyrobus]

**Regenerative Memory of Proff. John Atanasoff**



Фиг. 3

A classic example for regeneration of electrical energy. A memory made up of capacitors which have a tendency to discharge. That's why prof. Atanasoff must charge them again - i.e. to regenerate.

And now instead of waiting the capacitors to lose the charge, let us  charge and discharge them forcedly. The purpose of this work is to study the charge and discharge of capacitor with nonzero initial conditions.

**Theory:**

**Charge and Discharge of Capacitor in Nonzero Initial Conditions**

Taking into account, that the capacitor is charged only in one direction (polarity) - the other is discharged and refilled in the presence of a DC source, capacitor and connecting wire (usually copper wire with resistance R), the following diagram emerges - Fig. 4:

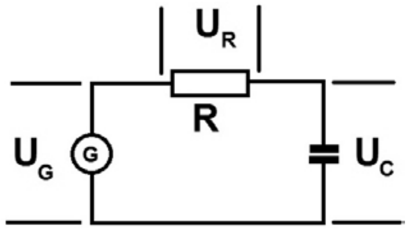



Fig.4

$$U_{C1} = U_G - \left(U_G - U_{C0}\right) e^{-\frac{t}{RC}}.$$

where $U_{C0}$ is the voltage of the capacitor C in t=0.

We can find the energy of the capacitor from the power, i.e. the portion (quanta) of energy, which necessary to charge from $U_{C0}$ to $U_{C1}$:

$$\Delta E_C = \frac{C}{2}(U_{C1}^2 - U_{C0}^2)\,.\ [1]$$

The charged capacitor can be discharged, if necessary, through a load. Let us, for a start assume that this load is constant in time. Let this load be n-times greater that the charging load (nR) Fig. 5.

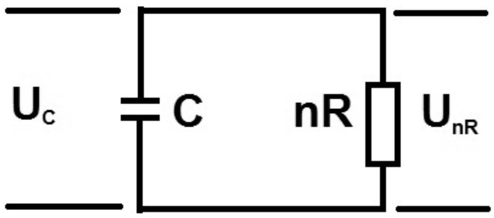



Fig. 5

$$\int_{U_{C0}}^{U_{C1}} \frac{dU_C}{U_C} = \frac{1}{nRC}\int_0^t dt \quad \text{And finally} \quad U_{C0} = U_{C1}.e^{-\frac{t}{nRC}}$$

**Cyclic Charge - Discharge**

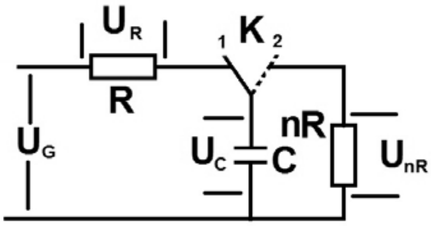



Fig. 6

It should be noted that *nR never consumed current from the power source ($U_G$), just from C*, when the switch K is in position 2. Let K switches rhythmically with a period T. In position 1 charge by $U_G$ trough R and in the position 2 discharges trough nR. The period T is chosen for the case of two capacitors and two switches. When one is in charge, the other gives energy on load nR and vice versa. Elementary has proved that in the push-pull case - with two capacitors - the result only doubles, so we consider only single-ended case [6].

The following task must be solved - to charge and discharge C from $U_1$ to $U_0$ and back again. The charge is via R, the discharge - trough nR. To simplify assume, that cycle is going and we "catch" it after time .10.R.C, i.e. in fixed mode. Discharge is following from the well-known equation [2]:

$$U_{nR} = U_C \text{ , } i_C = i_{nR} \text{ , } i_C = C\frac{dU_C}{dt} \text{ , } i_{nR} = \frac{U_C}{nR} \text{ , } C\frac{dU_C}{dt} = \frac{U_C}{nR} \Rightarrow$$

$$\int_{U_0}^{U_1} \frac{dU_C}{dt} = \int_0^T \frac{dt}{nRC} \Rightarrow U_0 = U_1 e^{-\frac{T}{nRC}} \text{ [2]}$$

The direction of integration is consistent with the mutual opposition of the charge and discharge currents to and from the capacitor. The power on nR for time T is [3]:

$$P = \frac{U_C}{nR} \quad U_C \in (U_0, U_1) \text{ [3].}$$

After integration we can obtain the portion (quantum) of energy ΔE [4]:

$$P = \frac{(U_1.e^{-\frac{T}{nRC}}}{nR} \Rightarrow \Delta E = \int_0^T P.dt = \frac{U_1^2}{nR}\int_0^T e^{-\frac{2t}{nRC}} = = \frac{U_1^2}{nR}\left(-\frac{nRC}{2}\right).\left| e^{-\frac{2T}{nRC}} \right|_0^T = \Delta E_{\substack{\text{полезна} \\ \text{разряд}}} \text{ [4]}$$

For the useful energy ΔE we have [5]:

$$\Delta E_{useful} = \frac{C}{2}(U_1^2 - U_0^2) \text{ [5]}$$

It follows - that in the charge from $U_0$ to $U_1$, in the capacitor always remains some stored energy: $E_0 = \frac{C}{2}U_0^2$.

During charging through R we lose some power $P_R$ in the form of heat, respectively, will lose energy $\Delta E_{lose}$, which is given by the equation $E_1 = \frac{C}{2}U_1^2$. the lost energy is $\Delta E_{lost} = \frac{C}{2}\left(U_1 - U_0\right).\left(1 - e^{-\frac{2T}{RC}}\right)$.

### Quantitative Evaluation of the Regeneration Process

The ratio of the portion useful and the lost energy we call coefficient of regeneration (factor of regeneration) and denote by $k_{RE}$ [6].

$$k_{\mathrm{Re}} = \frac{U_1 + U_0}{U_1 - U_0} \text{ [6]}$$

*The following question arises - is $K_{RE}$ efficiency in matter of fact?*

At first glance it looks probable, because $k_{\mathrm{Re}} = \frac{\Delta E_{usefull}}{\Delta E_{lost}} = \frac{\Delta P_{usefull}.T}{\Delta P_{lost}.T} = \frac{\Delta P_{usefull}}{\Delta P_{lost}}$, but only at first glance.

*1*: - The period T was chosen $T_{charge} = T_{discharge}$ but from this choice does not follow that $P_{charge}$ is lost for all the time T. In practice, the main part of it is lost at the beginning of T, and the end is reached $U_1$.

The Choice $T_{charge} = T_{discharge}$ follows from the assumption that the capacitors may be two and while one is charging, the other to discharging, so then switch places. In the presence of only one capacitor (single push-pull circuit), the two times vary depending on the values of n, R and C.

*2*: - The times $T_{charge}$ and $T_{discharge}$ are asynchronous and run one after the other, i.e. it is not correct to compare the processes that occur at different times.

*That's why we calculate the real efficiency* - we must take into account the zero (initial) energy that stays permanently loaded into the capacitor, namely:

$E_0 = \frac{C}{2} U_0^2$, than the efficiency is: or $\eta = \frac{\Delta P_{usefull}}{\Delta P_{lost} + \Delta P_0}$ [7]

*This relation is always less than one (1). I.e. the circuit does not generate and/or insert additional energy but only under the right conditions regenerates it. Or, between the plates of the ideal capacitor current doesn't flows - $P_0 = U_0 . i_0 = 0$ or power on C is always zero (or very little value in real capacitors), but its energy is $(CU^{2)})/2$.*

*What is common between the capacitor and the accumulator? - Energy!* If you equate the two energies - Faraday and Amp hours - got [8]:

$$E_F = C \frac{U^2}{2}\ ,\ E_{Ah} = U.I.t = 3600.U.I.t,[s],\ C_F = \frac{3600.I.t}{U}[F]\ [8]$$

*Or 12V battery with 1Ah in ampere hour's capacity has Faraday's capacity of 600 F.*

The following task can be formulated: - to make a regenerative energy source with two batteries. To compare how the system works with or without a regenerator. By "Regenerator" will mean twice the diagram shown in Fig.06, i.e. parallel push-pull two switches and two capacitors from the batteries to the load. The result is shown in Fig.07 with and without the battery and this result speaks alone - without an interpreter.

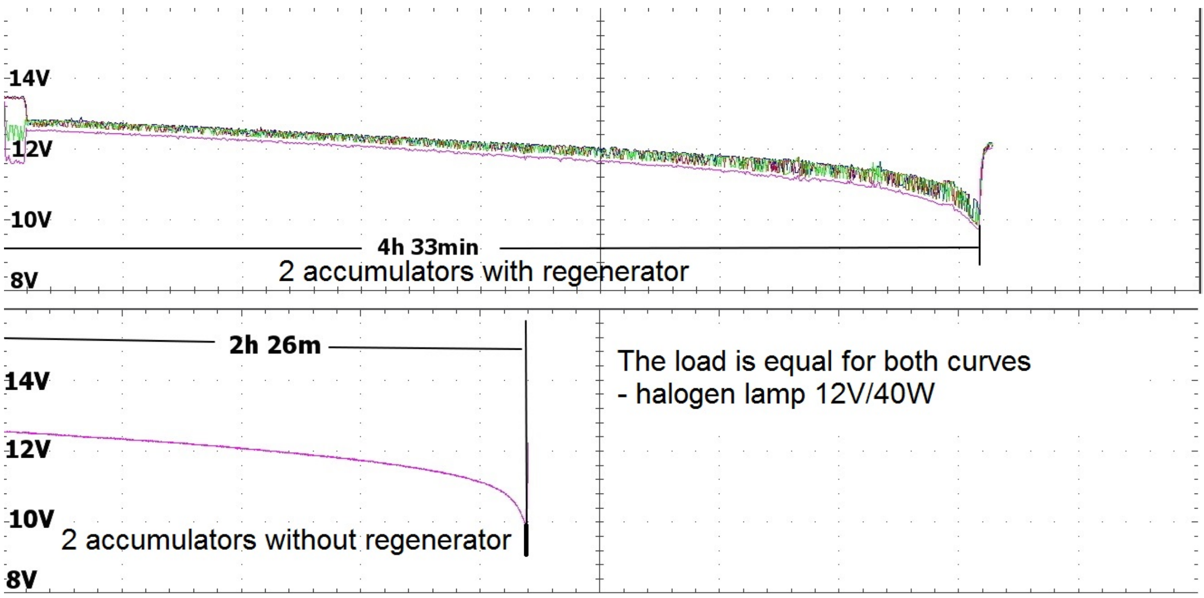



Fig. 7

On Fig.07 are shown two graphics - the upper (almost twice longer) is a graphic of two 12V accumulators with regenerator. Below is a graphic of two accumulators without regenerator - just in parallel. The load is equal for the both a halogen lamp 40W/12V.

**Conclusions:**

1. The possibility is proved for twice longer work time of the energy sources. This is a very real reason to continue active work on them.

2. The possibility is shown for a new life of all possible electric drives, working with batteries or accumulators.

3. For many reasons, we can't study here the accelerated charge of lead acid batteries. This idea is still "baby", but it's promising, because in the foundations of regeneration stays the idea to return back energy from "out" to "in". And how more susceptible is "in" - such higher is $K_{Re}$. It's another theory to follow and some day it will be possible to compare electric and gasoline cars with advantage for the electric ones. Mainly because of the possibility electric cars to regenerate the batteries alone in rest condition. Slowly and gently.