Inductive conversion of heat environmental energy to electrical energy

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Abstract

The author gives a ground for realization of the cycle "magnetization – demagnetization" of inductance with a magnetic core in the mode, which provides generation of excess energy during "demagnetization". Experiments, which prove these conclusions, are described in details. Realization of the ratio ***φ = energy of demagnetization / energy of magnetization > 1*** *in the device based on inductance with magnetic core. The author believes that presence of spontaneous magnetization in the area $H=(1,2\div1,4)H_c$ is a basis for φ>1, when demagnetization is made by the due to the factor of kT (i.e. heat environmental energy).* ***The author experimentally confirmed φ>2 at 1 kHz.*** *The author called this heat converter "ferrocassor" (concentrator of environmental energy).*

A task of detailed consideration of energetic aspects of the cycle "M-D" (magnetization – demagnetization) is to find a way to realize the ratio

$$\frac{A_D}{A_M} = \frac{energy"D"}{energy"M"} = \varphi > 1 \qquad (1)$$

A foundation for realization of (1) is the evident difference of A_M and A_D in Nature, which is not usually mentioned. The work A_M is sum of the part of energy ("injection"), which came from the outer source ${}_1A_M$ and energy of spontaneous magnetizing ${}_0A_M$ (it is free energy of magnetic core), which is "mobilized" by the work ${}_1A_M$. The work A_D (demagnetization) takes place only due to the disordering effect of the factor kT, i.e. due to heat energy of magnetic, which is renewable energy from environmental. This is a principle difference of our research of energy of "M-D" cycle (we are considering rectangular impulses with V_0=const and duration of t_u) from other engineering solutions of applied problems [1-6], when apriory the work is considered as $A_D > A_M$ *and* $\frac{A_M}{A_D} < 0$. In similar tasks the time t_u is about 10 μs and calculations are made with canonic ratios [7, page 140]:

$$i = \frac{V_0 \cdot t_u}{\omega L} e^{-\alpha t}[\omega \cos \omega - \alpha \sin \omega t] \qquad (2)$$

where $\alpha = \frac{R}{2L}, \omega = \sqrt{\frac{1}{LC} - \alpha^2}$.

However, it is strictly proved in [8], **similar expression (since it was got from Maxwell's equations) cannot be applied for impulses (incomplete circuits).** As the author [8] states, δ-functions, Duhamel's integral and staircase function can not be used for such sort problems. Apparently, these recommendations can be a basis for other vision of energy processes in inductances and in their main component (magnetic core) with pulse currents in particular.

Thus, the ratio $\mu = \frac{B}{\mu_0 \cdot H}$ can be presented as

$$\mu = \frac{BH}{\mu_0 \cdot H^2} \qquad (3)$$

and it should be then interpreted as a ration of energy, which is existing in inductance (per 1 m^3) to the energy of primary magnetic field in vacuum (in 1 m^3), since this primary field called the formation of energy BH.

Further, there is the question about possible way of maximum economical creation of the field $\mu_0 H$ and about the extraction of the energy $\frac{BH}{2}$ (even particularly).

The energy available for selection on the step "D" ideally is:

$$\Delta = \frac{1}{2}\mu_0 \cdot H_2(\mu - 1)\frac{J}{m^3} \qquad (4)$$

but really:

$$\Delta = \frac{1}{2}\mu_0(\frac{\mu_{max}}{\mu_{init}} - 1) \cdot H^2 \cdot \mu_{init}\frac{J}{m^3} \qquad (5)$$

In other way:

$$\varphi = \frac{\mu_{max}}{\mu_{min}} - 1 \qquad (6)$$

A prospect in integral form looks like this.

The special features of current impulses with a steep (sharp) front are the "terra incognita" land long since the engineering investigation of ignition systems in combustion engines.

Thus, in [9] authors note that during t_0 (short stage of impulse) the current in inductance changes so quickly, almost steps-wise, **that we can doubt in adaptability (or efficiency) of the second Kirhof's law during t_0**:

$$L\frac{di}{dt} + RI = V(t) \qquad (7)$$

Really, in the experiment [9] it is similar the first term seems to be absent. To find the way out, in [9] they use sufficiently "fine" admissions to have no doubt in classical physics. But we can do it in another way, we can keep (7) to be true if we'll introduce $L\frac{d^2i}{dt^2} \cdot \delta t_0$ instead of $L\frac{di}{dt}$.

Thus, the "short stage" of the impulse, which was noted by the authors in [9] is an interval of time when $\frac{d^2i}{dt^2} \neq 0$.

We have got positive results with an inductance, which consists of 16 separate ring coils with two identical windings on each, L_1=L_2. 16 coils of L_1 are jointed in parallel (first winding), and 16 coils of L_2 are jointed in series (second winding). With H_c about 2A/m, the current i_c=9,4 mA (measurements are made according to GOST 12119-66 inductive method), Fig.1.

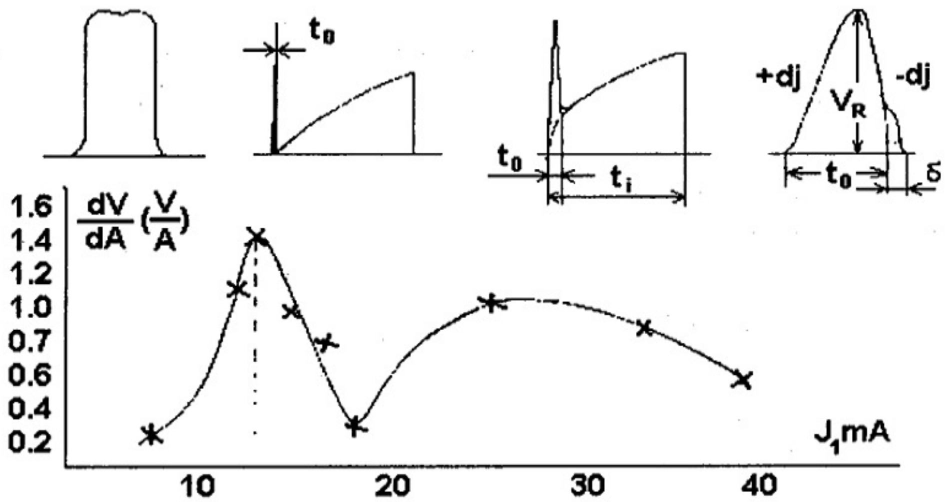

Fig.1

Reaching of maximum current in a short stage before the event of key (on breach) we can consider to be the result of immediate magnetization. **It is the most secret enigma of formation of magnetic energy in a magnetic core that was suggested before in [10]. The initial magnetic field with intensity of $_0H(i)$ appears in vacuum very quickly, i.e. in a fraction of t_0 and it calls (provokes) a spontaneous magnetization, which goes avalanche-like (like chain reaction).** It takes place, according to the theory of magnetism, particularly on the area of reversible displacement and in Relay's area [11-13]. Here, as it is known, there are enough small, "fuse" or "touch string" external field to call the inner (Veiss's) field, which is in ~10^3 times more than this external field. The action of the field H during t_0 can be compared with an impact, and effect of this impact tells upon in magnetic for a long time as a fading "ringing".

Editor's: According to N. Tesla we call this effect ***free vibrations.*** *He used non-sinusoidal impulse (arc dischargers) primary source and then his circuits generate resonance sinusoidal oscillations due to its capacitance and inductance. Also N. Zaev's understanding is similar to free energy conception, which was suggested by Thomas E. Bearden, USA in his famous article "Final secret of free energy". The initial primary source should produce short impulse "activation" of some "collector" and then in period of "relaxation" time it can be possible to take energy from this collector free of the primary energy source.*

During the time t_0 the most part of magnetic energy $\frac{BH}{2}$ appears (is created) and "payment" for this appeared energy is really symbolical. On the Fig. 1.2 and Fig.1.3 we can see the growth of current after t_0 in the area of rotation of vectors of magnetization. It is evident, the "payment" for the increase of $\frac{BH}{2}$ on this stage is incomparably higher than on the area H_c.

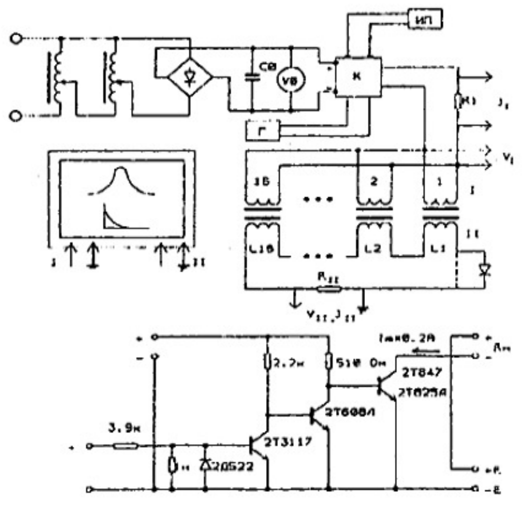

Fig.2

On the Fig 2 there is a scheme of measuring device with necessary explanations. The screen of the oscillograph is 8x10 cm. Reading is with an error of ±3%. The object of this research was the mentioned above totality of 16 inductances. Any of them is a toroidal core made of permalloy 79HM of 0,05 mm width (D_{ext}=90 mm, D_{int}=83 mm, h=16 mm, volume is 15,2 cm^3). Its magnetic properties corresponds to GOST 10160-75, first class; $\mu_{initial} \cong 20\cdot 10^3$, $\mu_{max} \sim 115300$, $\frac{\mu_{max}}{\mu_{init}} \sim 6$. There are 60 turns of cooper enamel wire on every core. This wire is of Ø0,43 m, R=0,4 Ohm, i.e. this $L_{max}=107\cdot 10^{-3}H$. Rated inductance of the first winding (16 windings connected in parallel), its μ_{max} equal to :

$$L_I = \frac{1}{16}\cdot 107\cdot 10^{-3}H = 6{,}69\cdot 10^{-3}H\ ;$$

rated inductance of the secondary winding (16 windings connected in series) $L_{II}=16\cdot 107\cdot 10^{-3}=1{,}712H$. The current in the impulse (at the upper level of picture on the screen) of the first winding for $\mu_{max}\sim 160$ mA, resistors are of MLT type. The value of nominals according to the digital ohmmeter is given to within ±0,8%. The calculation of energy is made by the squares under the curvature of voltage V^2 – t or by means of the step multiplication $\Delta t\cdot(V_i\cdot i_i)$ with the following addition of the results.

To check the changes of $\mu(i)$ for inductance L_I (in assemble of all coils) it was made determination of changes $\frac{\Delta V_{II}}{\Delta V_I}$ at the frequency of 50 Hz; and you can see the results on the Fig. 1.5, which correspond with official technical ratings of this magnetic core.

Let's make numerical estimations of ratio between heat energy of inductance (without windings) and its maximal magnetic energy.

The volume of all 16 cores is about 243 cm^3 and their mass is about 2 kg (with the density of 7.8 $g\cdot cm^{-3}$). The heat capacity of permalloy is about 0.46 kJ/(kg·K), that's why the cores contain $255.7\cdot 10^3$ J with the temperature of 20°. With μ_{max} $L_I=6.7\cdot 10^{-3}$, current is about 10 mA in every winding, and all magnetic energy

$$A_0=0{,}5L_I\cdot i^2=0{,}5\cdot 6.7\cdot 10^{-3}\cdot (0.16)^2=85.6\cdot 10^{-6}\text{ J}$$

Therefore, magnetic energy is only $\frac{85.6\cdot 10^{-6}}{255.7\cdot 10^3}=3.35\cdot 10^{-8}$ part of heat energy. Really, it's a drop in the bucket of heat.

(Editor's: So, this metod of direct heat-to-electricity energy transformation is very perspective and technically it can made as a very compact device with a great output power).

Recession of the current of impulse-leader up to the point a (Fig. 1.4) is called by increase of L(i). At first the current grows (due to the smallness of $\mu\sim\mu_{initial}$) as at the absence of inductance. But from the moment of start of spontaneous process (when H(t) reaches some startup level $H_{st} \ll H_s$)

$$i=\frac{1}{R}\left(V_0-L(i)\frac{di}{dt}\right) \qquad (8)$$

growth of the current slows down $\left(+\frac{di}{dt_1} \prec +\frac{di}{dt_2}\right)$; at maximum $i\frac{di}{dt}=0$ and then $\frac{di}{dt}$ becomes negative, the current falls before the break in circuit (Fig. 1.4).

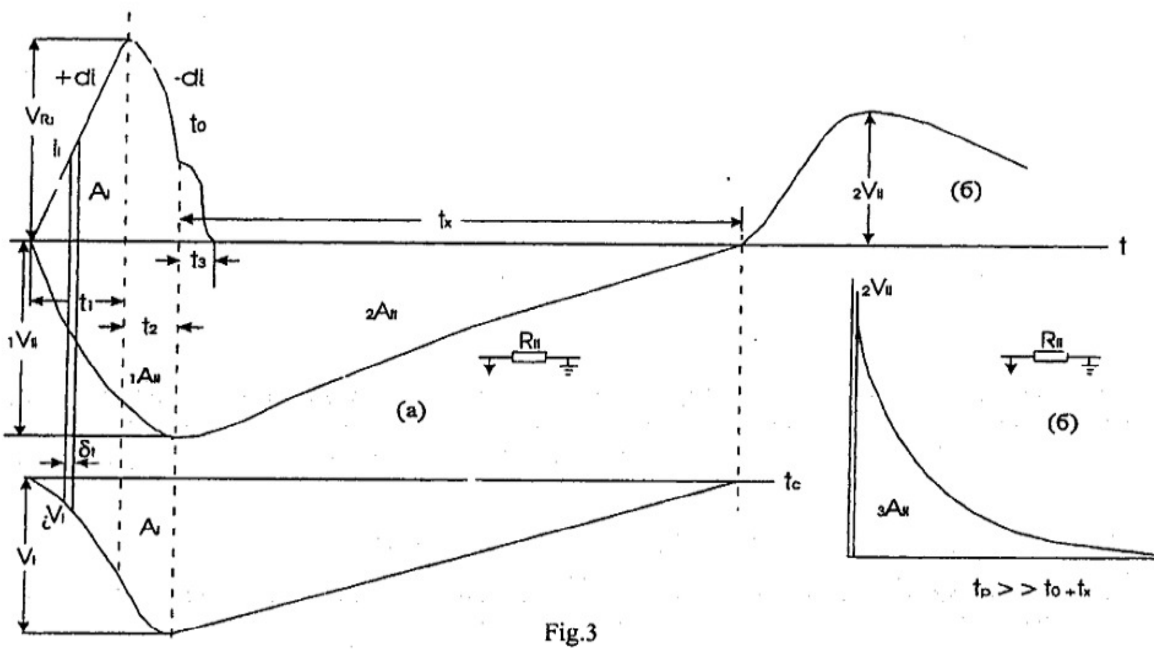

Fig.3

However, the process of magnetizing didn't stop (Fig. 3a) but the step (sharp) growth $\frac{dV_{II}}{dt}$ changed to be more gentle recession, considering it from the achieved level of the flow Φ_0. We can see it from the changes of V_{II}: from $_{II}V_{max}$ to $_{II}V = 0$ the decrease goes during t_x.

The phenomenon of growth of Φ_0 after t_0 is known. Thus, it is mentioned in [14] that in ferromagnetic materials with quick changes of tension of field induction lags. Particularly it becomes apparent with small tensions of field in the area of maximal values of permittivity of materials with high value of μ. The same you can find in [11] and in full in [13]. Usually this phenomenon is attributed to **magnetic viscosity** and quantitatively the intensity of its kinetics is usually described by the expression

$$\Delta M = (M_{\infty} - M_0)\left(1 - e^{-\frac{t}{\tau}}\right) \qquad (9)$$

where M_0 is the magnetization immediately after the change of magnetic field (t=0), M_{∞} is a new equilibrium value of magnetization, τ is the time of relaxation (it can be from 10^{-9}sec up to many hours). **Diffusion of dirt and defects or thermal fluctuation are considered to be the energy basis of ΔM effect.** In the last case (according to Neel) the fluctuations contribute to overcoming of energy barriers by domains, which provides the growth of μ and Φ. **More common name of this viscosity is magnetic accomodation.** With the growth of t(with τ=const)

$$\Delta M \to (M_{\infty} - M_0) \qquad (10)$$

i.e. the growth of magnetization stops when reaching M_{∞}. But in our results the changes of ΔM has two sings: positive at the beginning +ΔM and then negative when $M_{\infty} \to 0$. **This circumstance becomes the basis of technology of energy trapping from magnetic core of the inductance.**

There were some attempts to use "Magnetization - Demagnetization" cycle to transform heat energy of magnetic material. Thus, in [15] the application of rare-earth gamete-ferrite at T_N (Neel's temperature) is described, when magnetization on ΔM_S changes (in presence of the field H). If the sample is in the coil, then the transformation of energy of spontaneous magnetization $F\Delta M^2_S$ (F is the exchangeable parameter) to the electric energy takes place. Then the sample is cooled again with the change ΔM_S; but the efficiency here is not more then for standard Carno's cycle. Another method [16] is based on the spin re-orientation of magnetic moment, when it changes at 90°, for example, in the crystal $Nb{\cdot}Co_5$ in the interval 245 - 225. Negligible efficiency and complexity of transition between two states condemned these methods to the full oblivion.

An idea of total asymmetry (is action equal to reaction?) of energy of force impulse, which acts on the system and energy of answer, i.e. energy of its reaction, appeared in 1964 from the work by P.A. Florensky ("Dielectrics and their technical application". M. 1924) and also from analysis of equation of inner energy of dielectric by B.B. Golitzin, who added the third member in the equation, which has the kind of both heat and electrical energy ("Selected works", M. 1960, Vol. 1).

So, it was derived by Golitzin already in 1893!

Conclusions

1. **A possibility to convert environmental heat energy to electrical energy by means of non-linear magnetic material and dielectrics** (it was also earlier discussed in [17, 18]) is experimentally proved here.
2. The area of energy conversion in magnetic material (core of an inductance) is determined by the interval of impulse current, which creates intensity H = (1÷3)H_c with duration of impulse-leader t_0~$10^{-2}\tau$, when η~30÷50 with L_{II}>>L_I.
3. In the given interval (according to our measurements) the magnetic viscosity of material 79HM is bipolar, that's why that phenomenon can be called more exactly as the **"magnetic inertia"**.
4. Phenomenology of energy generation or, rather, energy transformation, seems to be a non-linearity of processes in "Magnetization-Demagnetization" cycle; their thermodynamics is in thermofluctuational exchange of energy with spontaneous orientation of domens according to Neel's theory.
5. Increase of coefficient of transformation from the achieved one (~3) to 8÷10 is possible by increase of H_c up to 10÷15 A/m, i.e. by selection of material for magnetic core.
6. Increase of power density is possible by increase of H_c, increase of frequency, by separate selection of energy $_1A_{II}$ and $_2A_{II}$ from energy $_3A_{II}$, and also by means of additional diode in the circuit II, if it can provide high operating speed.

The described inductive converter of environment heat energy, which consists of generator of impulses, inductance with magnetic and receiver of energy, I suppose to name as FERROomagnetic Concentrator of Environmental Energy – FERROCEE or "ferrocassor" in Russian.

In conclusion, I express my thanks to Spiridonov J.S. and Stepanov I.N. for their invaluable help in difficult and long measurements.

Notations

A_M is the energy of the source of current, which is spent for magnetization;

A_D is the energy received on the load during demagnetization;

k is Bolzman's constant;

T is temperature, K;

t_u is duration of impulse, sec;

i is current, A;

V_0 is EMF, V;

ω is circular frequency, sec^{-1};

α is attenuation constant;

L is inductance, H;

R is resistance, Ohm;

C is capacity, Ф;

μ is relative magnetic permittivity;

H is intensity of magnetic field, A/m;

B is magnetic inductance, Tl;

μ_0 is magnetic constant $1{,}2566 \cdot 10^{-6}$ H/m;

φ is coefficient of conversion;

η is coefficient of using of current of magnetization;

M is magnetic energy, J;

Q is heat energy, J;

τ is time constant, sec;

$$x = \frac{t_u}{\tau};$$

z is coefficient of using of magnetic energy in the circuit II;

t_0 is duration of "short" stage of current impulse when $t_u \gg t_{0-} - t_{0+}$;

Φ_0 is magnetic flow, Wb;

w is quantity of turns.

References

1. Alexandrov F.I., Sivakov A.R. Impulse converters and stabilizers of direct voltage. L., Energy, 1970.
2. Vdovin S.S. Designing of impulse transformers. L., Energoatomisdat, 1991.
3. Calculation and designing of impulse devices. M., Svyas', 1975.
4. Itzkhoki L.S. Impulse transformers. M., Sovietskoye radio, 1949.
5. Goldenber L.M. Theory and calculation of impulse devices on semiconductors. M., Svyas', 1969.
6. Neyman L.R., Demirtchan K.S. Theoretical principles of electrotechnology. L., M., Energiya, 1966, vol. 1.
7. Kontorovitch M.I. Operational calculation and nonstationary phenomena in electrical circuits. L., M., G.I. Techn.-Teor. Literatury, 1949, p. 140.
8. Shvarzburg A.B. Videoimpulses and noncyclic waves in dispersive mediums. UFN, vol.168, #1, 1998, p. 85-103.
9. Burtzev V.A., Kalinin N.V., Lutchinsky A.V. Electrical explosion of conductors and its application in electrophysical units. M., Energoatomisdat, 1990, p.157.
10. Zaev N.E. Genesis of inductance energy. Electrotekhnika, #10, 1997, p. 35-36.
11. Preobrazhensky A.A. Magnetic materials and elements. M., Vysshaya shkola, 1976.
12. Madelung O. Theory of solid body. M., Nauka, 1980.
13. Vonsovsky S.V. Magnetism. M., 1976.
14. Kifer I.I. Testing of ferromagnetic materials. M., L., Gosenergoisdat, 1962.
15. Belov K.P. Rare-earth magnetics and their application. M., Nauka, 1980.
16. Oholushi M.J. Appl. Phys. Japan. Vol. 15, 1976, p. 2019-2020.
17. Zaev N.E. journal of Russian physical idea. Reutov, Obschestvennaya pol'sa, 1991, #1, p. 49-52; Himiya i zhizn' (Chemistry and life), #3, 1984; report on section of MOIP at MSU "Cooling of some dielectrics by changeable field with generation of energy" 12.02.80; the same about ferrites 18.03.80; applications on invention "Method of transformation of heat energy to the electric one" #30601726/25(084904) of June 3, 1983 together with Gorshunov E.S. and #306017225/24(084905) of June 3, 1983.
18. Zaev N.E., Spiridonov J.S. Capacity converter of environmental heat to the electric energy. Electrotekhnika, #12, 1998, p.53-55.