Remanent Magnetism as an Energy Source

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1. Introduction

Everyone skilled in the science of magnetism or electromagnetism knows about remanent magnetism, the magnetic field B_R that exists within ferromagnetic material after the current that creates the field is turned off. There are two features of ferromagnetic materials that are important: -

- For permanent magnets it is desirable that the remanent field remains permanent throughout its operating environment. Temperature affects this, at temperatures above the Curie point the field disappears completely and near the Curie point the field degrades. "Hard" materials for permanent magnets have been developed to maximise their B_R values and to have high Curie temperatures well above their operating environment, leading to magnets that hold their magnetization for tens of years or more.
- For transformer cores it is desirable to have zero remanent field. This is not achievable, but "soft" materials have been developed to have sufficiently small B_R that the resultant area of their BH loop is small, thus minimising core losses. As transformers use alternating polarity fields the remanence alternates hence any permanent nature of the B_R field is of little consequence.

Throughout the years of power transformer development, it appears that no attention has been paid to materials that might exhibit semi-permanent magnetism, where the magnetism is ephemeral, presumably no one could see any practical use. Here the material is magnetized to a field B_R with a current pulse, then with no further current input the field decays to zero. It is expected that this might happen at temperatures near the Curie point, so this feature could be a thermal effect. That this might happen at ambient temperature has not been a consideration, hence it appears no work has been carried out to achieve this. Until now!

The SEMP Research Institute [1] is a South Korean Group that has a partnership with Global Solutions for Project Management in Abu Dhabi. Their AI Smart Electromagnetic Generator (AISEG) recently demonstrated at the COP28 Summit held in Dubai is claimed to have efficiency significantly greater than 100%, and a study of their patent applications [2] [3] [4] reveal they use within their transformers a unique core material, pure iron that has undergone a special form of treatment. They claim this treatment yields a demagnetization time that can be as little as 1/450 seconds (2.22mS), but they do not define what they mean by "demagnetization time". Also they do not state how their system uses this feature, but further study of their patent applications shows that it relies on ephemeral remanence B_R where the magnetic field decays naturally with that order of demagnetization time. A study of their waveforms reveal that the magnetizing is performed by narrow pulses of current at a pulse rate of 120 per second. Their claimed over-unity efficiencies reach highest values at the narrowest pulse widths where they quote a 0.5% duty cycle. That is 41.7µS pulses repeated every 8.33mS. During the 8.29mS off-time a separate series of coils obtain induced voltage from the decaying magnetism that then feed current to the load. With their heat treatment process creating such short demagnetization times the field decay can be completed within the 8.29mS off-time ready for the next magnetizing pulse. During this time energy is being delivered to the load but no electrical energy is input. They alternate the magnetizing direction each 8.33mS so the output voltage waveforms appear as pseudo 60Hz AC. The question then remains, can energy in each output pulse exceed the initial input energy needed to magnetize the iron? The standard answer to this question given by most scientists is NO, Conservation of Energy (CoE) demands this. But during the output pulse Lenz's Law tells you that the induced current is trying to stop the remanent B_R decay, something at present unknown is causing that decay and that is the driving force for the output energy. Thus, that unknown driving force could be the source of excess energy, and when that is considered CoE can be satisfied. If the SEMP claims of efficiencies far exceeding 100% are true, then perhaps the answer to the above question is YES. This paper investigates this possibility.

It should be noted that ephemeral remanence (B_R fields that decay naturally without any electrical stimulation) is an unknown feature of magnetism that is currently not taught or studied. One possibility is that this is a thermal phenomenon, thermal agitation of the atomic dipoles responsible for the magnetism causes them to lose their spatial alignment. If so, then excess energy could be received thermally, the system could extract heat energy from the environment, in effect acting as a heat pump. A magnetic refrigeration heat pump is a known process that currently uses exotic materials like gadolinium and praseodymium. Clearly iron is a much cheaper material for that use. The iron cores used in the SEMP system are not solid but are thin-walled tubes through which air is passed. Although they claim this is for cooling purposes it could equally be the opposite.

A second possibility is that the B_R decay comes from quantum uncertainty disturbing the dipole alignments in which case energy is extracted from the aether in which everything lies. Until this ephemeral B_R is investigated, we will not know, but in view of the SEMP claims such investigations should take place.

2. Magnetization Energy

Figure 1 shows a typical BH curve for the magnetization of a core from a single pulse of current. The green area is an energy density that when multiplied by the volume of the core yields the input energy input needed to obtain the remanent magnetization with flux density B_R. Thus, knowledge of the BH characteristics enables us to estimate the energy input. Even without this data a good estimate is obtained with just the known relative permeability μ_R and saturation flux density B_R of the core. The slope of the dotted line in Figure 1 is the notional permeability $\mu_R\mu_0$ and it is noted that the area to the left of that line represents an energy density that is close to the designated green area. Thus, the energy needed to magnetize the core is in the order of $B_R^2/(2\mu_R\mu_0)$ multiplied by the volume of the core.

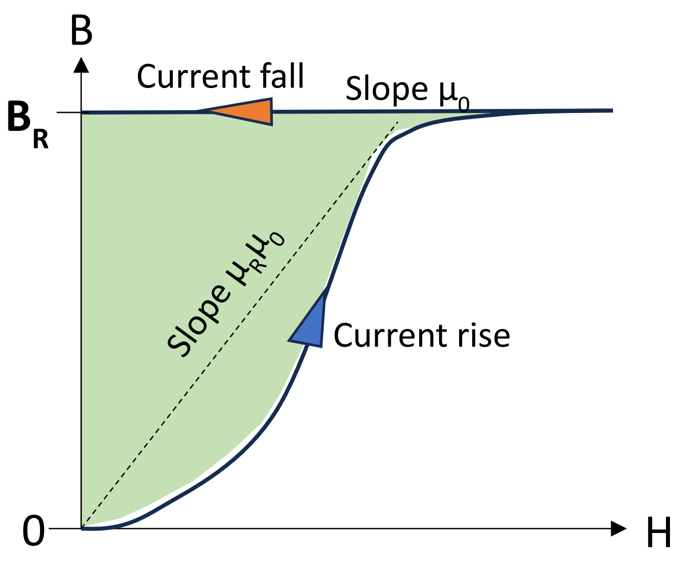

Figure 1. BH curve for magnetizing pulse

If the input energy is derived from measurements, it is more convenient to convert Figure 1 into a Flux v. Ampere-turns chart Figure 2 where the area now represents energy directly, eliminating the need to know the core volume. Ampere-turns is known or measured, and the flux is easily obtained from integrating the voltage across the coil over the rise and fall of current. Note that the slope of any line represents inductance, hence the dotted line shows the high value of inductance of the coil carrying the rising magnetizing current, but this changes to a very low value during the current fall.

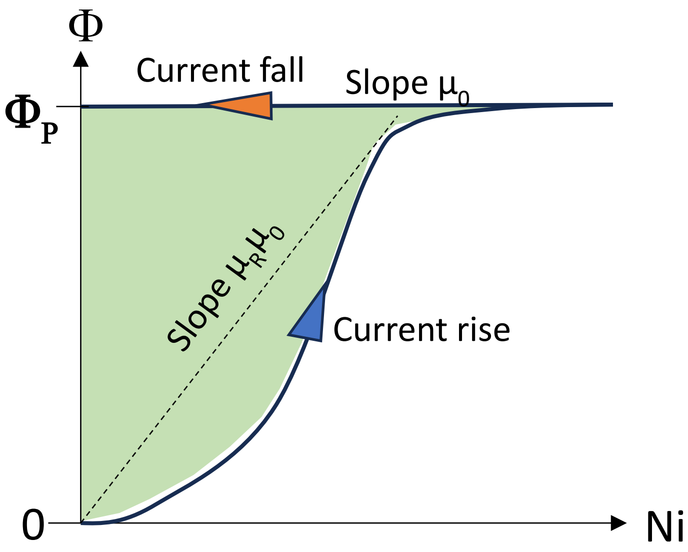

Figure 2. Flux v current curve.

3. Demagnetization Energy

If we now consider B_R or Φ_R falling to zero naturally while under no external influences, that fall inducing voltage into a load resistor, the current so produced will create a magnetic field opposing the fall (Lenz's Law), thus we can assume the load current will rise and fall in the directions shown in Figure 3. Note the curve goes round the green area in a CW direction notifying this is an energy output.

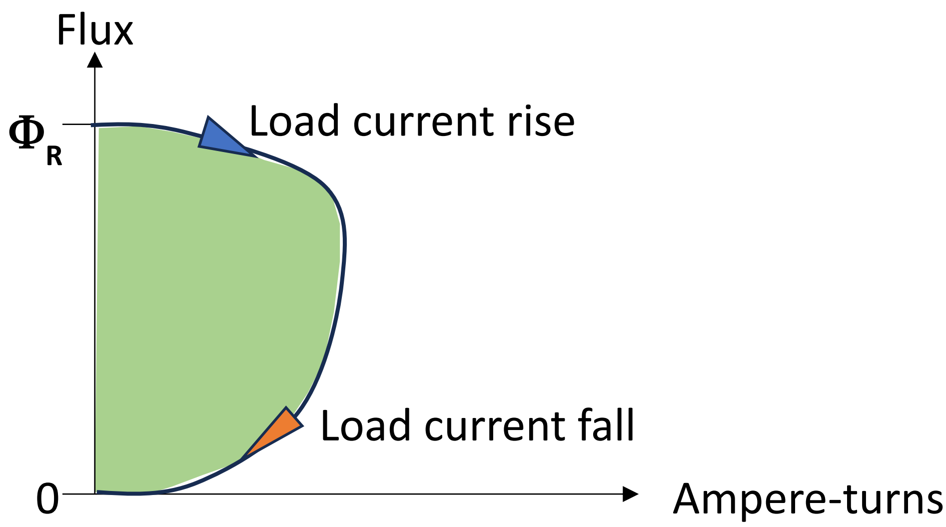

Figure 3. Demagnetizing curve.

As the area within this loop now represents the energy delivered to the load, is there any way we can estimate the loop from known material characteristics? One clue to this is the initial very low inductance of the coil before Br falls, the magnetized core responds as though it were air. Thus, this natural demagnetization can be expected to initially drive high current through very low values of load resistor. This is the exact opposite of the situation during the magnetizing pulse where the high value of inductance allows the magnetization to occur using low value of current. There is good reason to believe that the output current v. flux will follow the shape shown in Figure 4, yielding an output energy (pink) more than the input (green).

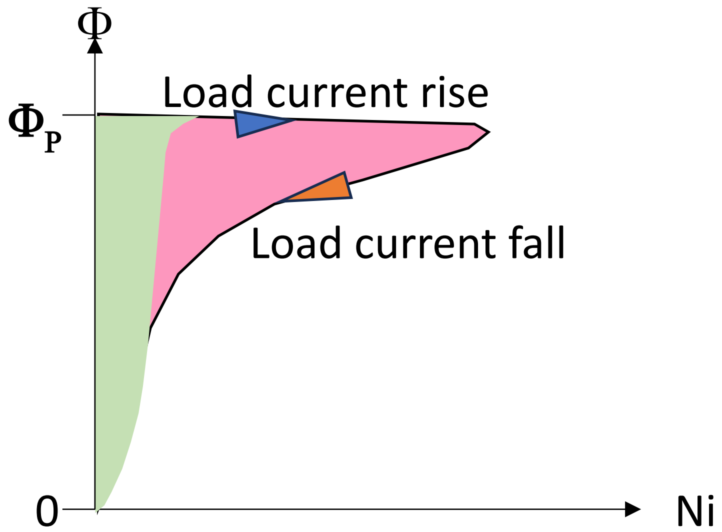

Figure 4. Expected demagnetizing curve.

4. What features create this natural demagnetization?

The SEMP patent applications shows demagnetization time as a function of the time taken to cool the iron during its heat treatment regime. The iron is heated to between 1000 and 1300°C within burning charcoal, then the charcoal and iron is slowly cooled during which time the iron absorbs a quantity of carbon that gives it the required characteristics. A long cooling period of 10 hours is needed to get the low demagnetization time. Figure 5 is the chart taken from the SEMP patent application showing demagnetization time against cooling time, with the actual times shown there taken from the patent text. It is assumed that the normal process of rapid quenching creates so-called permanent magnetism where the demagnetization time runs into years. The long cooling process of both iron and charcoal together that creates semi-permanent magnetization, reducing natural demagnetization time from years to milliseconds is new to science.

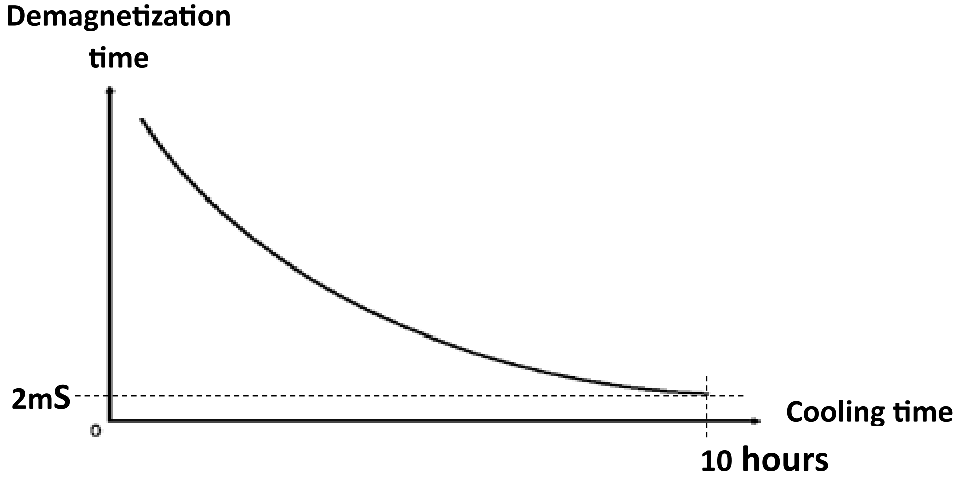

Figure 5. Demagnetization time v. cooling time

5. More data taken from the patent applications.

Figure 6 shows the arrangement of coils on the iron core (40) that is a thin-walled tube. Each coil sits between two iron annuli (90) that are separated by plastic annuli (80). The three coils (20) are driven to magnetize the core while the intermediate coils (10) deliver output to the load during the demagnetizing time. Although this shows 5 coils along the central iron tube, but the patent discloses the use of more than 5. The stacks used in the SEMP demonstration at the COP28 summit in Dubai have 13 coils.

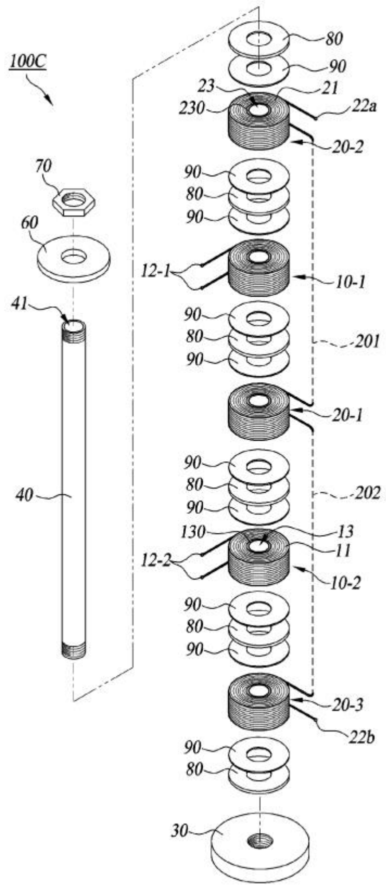

Figure 6. Core and coils

Figure 7 is a FEMM run for a stack of 9 coils showing the field lines for the coil-core arrangement. No dimensions are given in the patent applications, so this is a general view using guesswork. The iron tube is taken to be 20mm ID, 2mm wall thickness and 178mm long. The iron annuli are a tight fit to the tube, have an OD of 33mm and are 2mm thick. The axisymmetric mode in FEMM is a true 3D model and figure 7 shows the view in the r-z plane of the r-θ-z cylindrical co-ordinate system. Here alternate coils along the core are carrying current to magnetize the core 5 coils in total. The 4 intermediate coils are connected in series to be used as the output. It is seen that there is significant flux within the whole length of the iron tube wall that appears black, but the expanded view shows the individual flux lines.

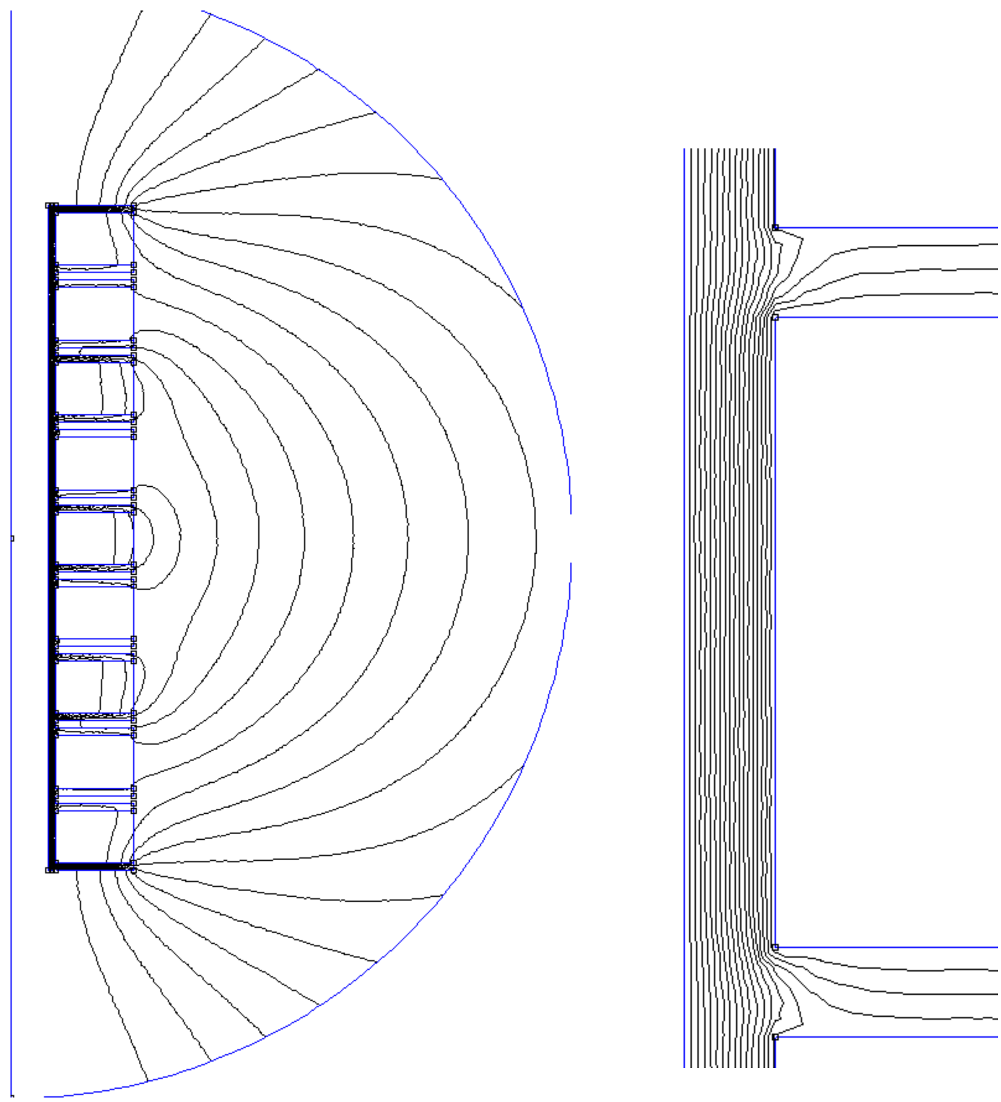

Figure7. FEMM simulation

The next figure shows the tangential B field within the tube wall where the flux within each of the nine coils is easily recognized. Each coil is 100 turns, and the five magnetizing coils are in series carrying 1 amp.

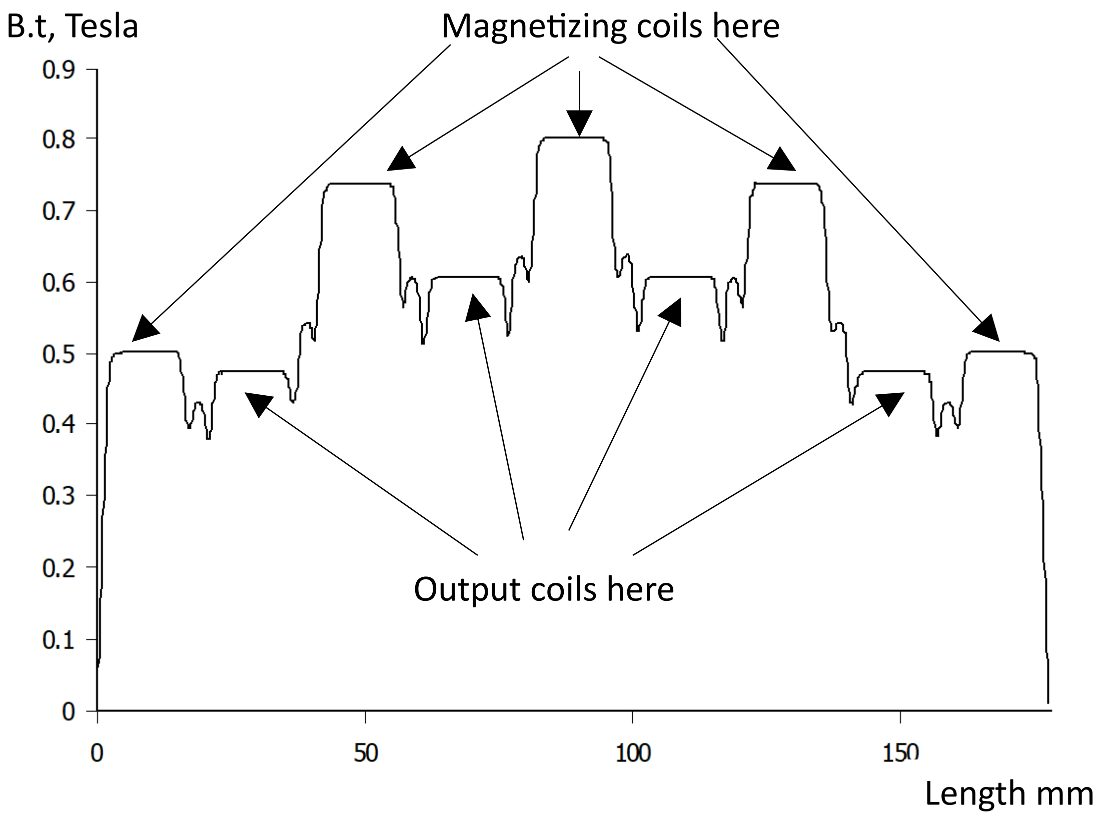

Figure 8. Flux density along the core

Flux within all the driven coils could be made to achieve a fixed value by adjusting the number of turns, with the outer coils having more turns than the inner coils, and this would also equalise the flux in the output coils. For the values shown here the core was given a relative permeability μ_R of 1000.

To get some idea of the remanent magnetism B_R likely to occur, Figure 9 shows the BH curve for Armco iron taken from a Bell System Technical Journal document [6] that compared this iron to permalloy. This old document used Gauss and Oersted values for B and H respectively. It is seen that Armco iron driven at H=1 Oersted (79.58 ampere-turns/meter) gets magnetized to a B_R value of 4,000 Gauss (0.4 Tesla) after the current is removed. Note that the FEMM result in Figure 8 shows that order of field within the output coils. SEMP claim that the likely 0.4T remanent field in their treated iron will decay naturally to zero within milliseconds, thus inducing voltage and load current into the output coils. Extracting that output energy is something new to the field of electrical engineering.

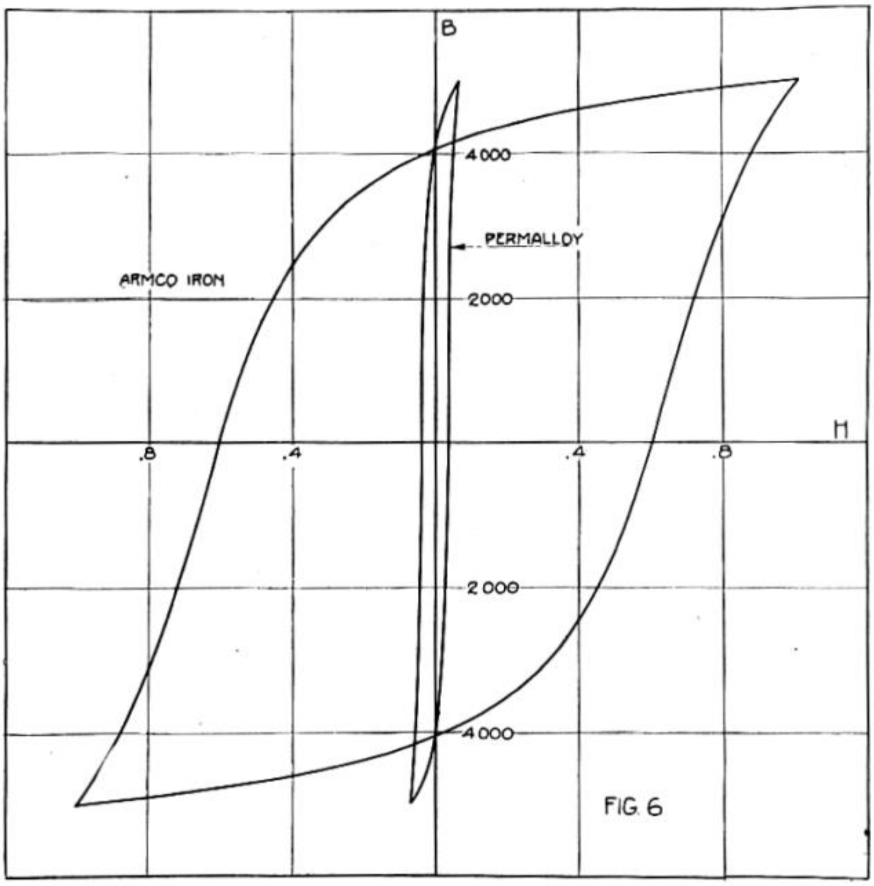

Figure 9. BH loop for Armco iron

Iron for use in power transformer cores is normally treated to create transformer steel that minimises the area of the BH loop. That loop is traversed CCW at the operating frequency (50 or 60 Hz) and represents energy loss per cycle that is minimised by the treatment. Thus, the remanent magnetization B_R (here at 4000 Gauss, 0.4T) is swept away through the AC cycle and only plays its part in the width of the BH loop and therefore core losses. It appears that throughout the 200 years of power transformer development no-one (until now) has considered the possibility that B_R can be made to decay naturally, and power can be extracted from that natural feature. All the people involved in this 200-year development have been brainwashed into classifying ferromagnetic material as being "hard" (exhibiting permanent magnetic behaviour) or "soft" (exhibiting no significant permanent magnetic behaviour). There is no classification for semi-permanent magnetism that decays naturally over small timescales. The revelation that such behaviour can yield more energy than that needed to create the remanent magnetization opens the door to new work in the field of alternative energy production.

6. Conclusion

A forensic examination of the English-language public-domain data on the SEMP AISEG electric generator reveals that it makes use of ephemeral remanent-magnetism, remanent-magnetism being the magnetic field within an electrical transformer core that remains after the current that magnetizes the core is turned off. Remanent magnetism is a well-known phenomenon, what is new is the evidence that this remanent field can be made to decay, to leak away of its own accord, with no further electrical input. Current scientific dogma says that the remanent field stays permanent, any decay would take years. This is not a serious problem in electrical transformers as there is further electrical input, the remanent magnetism gets swept away by the alternating input current. SEMP have discovered they can treat iron used for transformer cores so that a remanent field will decay of its own accord in time scales not years but milliseconds, and their system uses this effect. Clearly a field decay with this short time-constant can induce significant voltage into a coil hence also significant current into a resistive load yielding output energy. It is not known what causes this natural magnetic-field decay, it could be a thermal effect in which case the output energy would come from the heat source. This is a hitherto unknown means for converting heat energy into electrical energy.

7. References

[1] SEMP web site
https://www.semp.or.kr/en/%EB%B0%9C%EC%A0%84%EA%B8%B0%EC%9D%98-%EC%97%AD%EC%82%AC

[2] Korean patent application

https://www.overunityresearch.com/index.php?action=dlattach;topic=4563.0;attach=49839

[3] Korean patent application with English translation

https://www.overunityresearch.com/index.php?action=dlattach;topic=4563.0;attach=49838

[4] European patent application

https://www.overunityresearch.com/index.php?action=dlattach;topic=4563.0;attach=49864