Energy from Spin-flips

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1. Introduction

There are authentic accounts of excess energy being derived from magnets that have been conditioned in special ways. Two devices that share a common theme are those invented by Floyd Sweet and Arthur Manelas. These each use a large billet of ceramic ferrite material that has thee orthogonal windings on it. Unfortunately both inventors are now deceased and attempts to reconstruct or replicate working models of their devices have failed. Neither inventor left enough information for the inner workings of their device to be discovered. This paper offers a potential mode of operation that should allow some exploratory work to be carried out to see whether it is viable or not.

2. Pinned Spins

Ferromagnetism is the result of atomic electron orbits or spins that act as magnetic dipoles supplying the magnetism that we measure outside the magnets. What we see is the collective result of huge numbers of these dipoles, and our knowledge and theories of magnetism come from that collective behaviour. Down at the individual atom or dipole level the behaviour is quite simple, the dipole can have only two possible orientations that in the world of spintronics are labelled spin-up or spin-down. The up or down refers to the orientation of the dipole axis relative to the ambient magnetic field, which at the atomic level may come from neighbouring atoms. Within a suitably applied magnetic field an individual atomic dipole can be made to flip from one state to the other, and since this then changes the ambient field of an adjacent atom it can initiate a chain reaction of dipole flips through the crystal lattice, the leading edge of that wavefront being considered as a domain wall.

Of interest here is nano-grained material where the grain boundaries destroy that inter-atom collective behaviour, where each grain acts like a giant atom having a dipole axis pinned in a given direction, the grain is in effect a single domain. This feature is used in the manufacture of high permeability soft ferrite ceramics. The material is ground down to a very fine grain size, the grains are pressed into a mould, then with the grains in a strong magnetic field that aligns their dipoles the ceramic is fired. This creates anisotropic material with extremely high permeability in the easy axis, where only a small change in applied field causes a huge change in magnetization that almost resembles one huge Barkahusen jump. The same process used in the manufacture of ferrite permanent magnets yields magnetic material that is highly anisotropic, it has a preferred magnetic axis of aligned grains that supplies the highest magnetism. If such material is de-magnetized by taking it above its Curie temperature, then re-magnetized along the “wrong” axis, the resulting magnetization is much lower. It is not known whether the Manelas ferrite is isotropic or anisotropic.

Whether considering hard or soft magnetic material, cycling between the two magnetization states always results in energy loss, the M-H or B-H hysteresis loop is always traversed counter-clockwise. This is counter intuitive to the situation at the atomic level where quantum rules dictate the two alignments for electron spin. There it requires an energy input to switch the spin from the up (aligned) state to the down state, but that energy can be regained when switched the other way. The down state is a form of unstable equilibrium that only requires a small nudge to get it to switch back into alignment. The reason we don’t observe this in macro systems is due to the collective behaviour of the many atoms that cause the overall system up and down states to both be in stable equilibrium. The area inside the hysteresis loop represents input energy, but how that energy gets converted into heat remains a mystery. It is known that switching from one state to the other occurs in a series of Barkhausen jumps, when the applied field reaches a certain level some internal spin flips occur to produce that jump. One explanation for the loss of energy to heat is that each jump or spin-flip is a fast transient that radiates electromagnetic energy from the flip site, and that energy gets absorbed by the surrounding material as heat, effectively it increases the thermal vibrations throughout the material.

In this paper we take the view that a Barkhausen jump is a source of energy, since no energy is consumed or delivered while bringing the applied field up to the point where the jump occurs. This is reasonable since between jumps the flux is constant and there is no induced voltage to "load" the applied rising current or to deliver voltage to a load. It is posited that a small amount of energy is consumed to initiate the jump, but once initiated the jump can't be stopped. Energy can be retrieved from the jump, from the flipping domain, in the form of a voltage pulse induced into a coil. *The energy available from that flip could be in excess of the energy needed to initiate it*. The reason we don't observe that characteristic in materials is because the Barkausen voltage pulse is induced into the coil supplying the drive field, and we do not have the ability to turn off the drive current fast enough to stop the Barkhausen voltage pulse from loading the current source. Generally we observe a smoothed out series of pulses that appear as a continuous voltage loading the rising current. That voltage agrees exactly to the voltage obtained from integrating the rise of flux with the result that the area inside the hysteresis loop exactly agrees with the integral of the current × voltage product. However if we could turn off the drive current once the jump is initiated, we could still get the jump but without the voltage pulse drawing power from the current.

It will be clear that this approach demands fast switching of currents, which in inductive circuits is nigh on impossible. An alternative approach uses two coils, one to supply the drive field and the other to extract energy from the flips. The two coils are mounted orthogonally, each at 45 degrees to the magnetic easy axis. The drive coil still sees induced voltage from the flips, and still suffers from hysteresis loss. The output coil extracts energy from the Barkhausen voltage pulses into a load, but can draw considerable current since *the field that this current creates cannot turn off the flip*. It is posited that the result of many pulses as the material is cycled around its loop produces greater power into the load than that lost to hysteresis. But this situation only applies if the hysteresis loop consists of a small number of Barkhausen jumps, ideally just one jump between states. It will not apply to the normal situation of many jumps for the reasons outlined above. Therefore we cannot consider bulk material driven around its loop, we must effectively use small-sized cores. Nano engineering may one day produce an array of small cores each with their own coils, but until then we must consider means for producing small spin-flip regions in large cores.

The Manelas device uses a large ferrite slab with coils wound onto its three axes. The wire used for this is of special form called "twirled wire". This is similar to a twisted pair, but unlike the twisted pair one wire is straight and the other wire forms a helix around it.

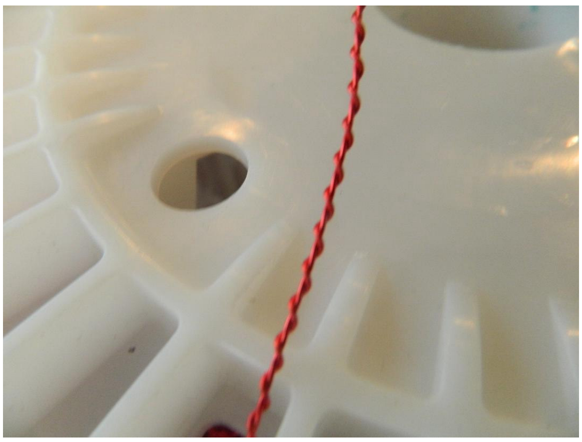

Figure 1. Twirled wire

It is a form of bifilar wire and when used as a coil its far end is shorted with current supplied only to one end. When wound onto the ferrite slab only the helical wire touches the surface of the ferrite at intervals. If that wire is used as the magnetizing coil the current in the helical wire supplies field to small regions along the surface of the ferrite only where it touches.

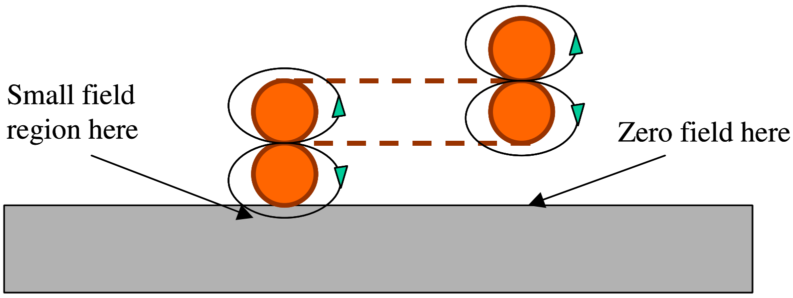

Figure 2. Helical wire creates field in ferrite only where it touches.

If we could view that field we would see a series of broken lines across the surface. The field is strongest at the surface and does not penetrate very deep because of the field cancellation from the reverse current in the straight wire. Thus the special form of twirled wire has the desired effect of only addressing small spatial regions of the bulk ferrite. This is shown in figure 3 for a single wire which is said to have 7 turns per inch.

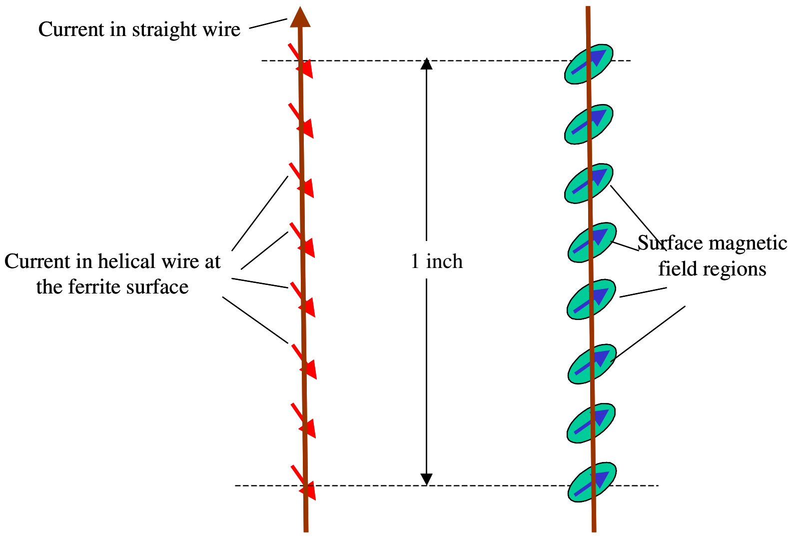

Figure 3. Domains induced into ferrite by the helical wire

Figure 4shows a small surface covered in these domains (the Manelas slab would show a much greater density).

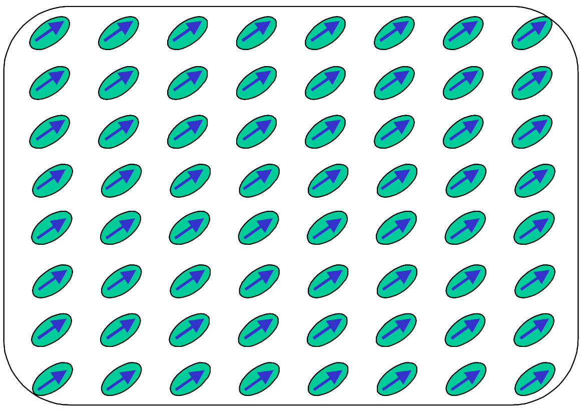

Figure 4. Surface covered in domains

It may be noted that this array of domains looks very much like a bubble memory, except that the domains are much larger than those used in such memories. In bubble memories the domains that represent the digital information are made to shift across the surface so that they move from the writing head to the reading head, and this is done by having a pair of orthogonal coils as shown in figure 5 taken from Wikimedia Commons. The slab containing the domains is orthoferrite.

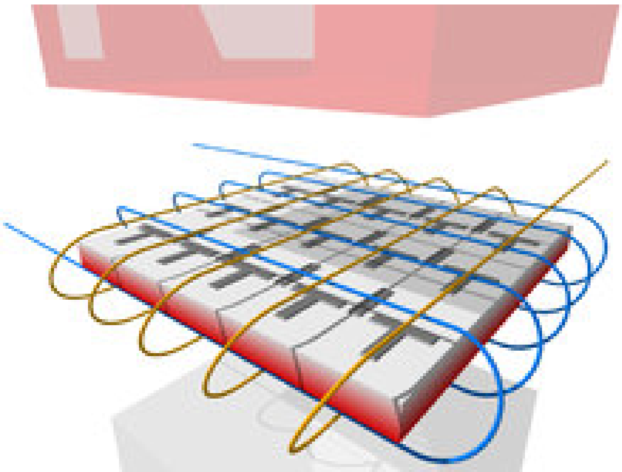

Figure 5. Bubble memory

This is redolent of the Sweet/Manelas devices and suggests a possible mode of operation. The T shapes shown on the surface in figure 5 are deposited soft ferromagnetic regions (eg Fe) that get magnetized by the large magnet hovering overhead, effectively there is now an array of permanent magnets on the surface. Then the orthogonal coils are driven so as to produce a rotating field that modifies this array of PM's creating field gradients that pull the binary domains along the surface.

The method of moving bubble domains across a surface was discovered by P.C.Michaelis and published in US Patent 3,454,939 in July 1969 as "Magnetic Domain Propagation Device". This acts as a shift register in two dimensions.   This involves hairpin conductors close to the surface pointing along the wanted propagation direction. It may be noted that parallel bifilar conductors are simply hairpins and a coil using bifilar connection creates a magnetic field equivalent to an array of hairpins. Thus using the inner bifilar coil to initially write the magnetic "data" as a series of binary 1's, the orthogonally wound bifilar coils will have the capability of shifting those 1's sideways, hence out of register with the writing conductors. The more I look into this approach the clearer the picture becomes. Both the Sweet and the Manelas devices use bubble memory techniques in a manner that shifts a large array of established magnetic domains into and out of register with a large array of reading heads all connected in series. That produces a high voltage "signal" output, and the result is a greater power output than that needed to shift the domains.

3. Possible mode of operation.

Firstly the large ferrite slab is demagnetized by heating to above its Curie temperature. After cooling it is wound tightly with the Manelas twirled wire. Initially this wire connected in bifilar mode is strongly energized in order to "paint" the domains onto the surface. Later the wire is used as the collector. The domains are then made to jitter in and out of spatial correlation with the helical wire, and in doing so voltage pulses are induced into that wire. The jittery movement is created by applying pulses to the other two orthogonal windings on the slab. Since the other two wires are also of twirled form they create the localized gradient fields needed to move the domains about, but it is rather a hit and miss operation. The important thing is that the inner winding must be firmly attached to the ferrite so that the helix remains in spatial synchronization with the average position of the written domains. Better response would be obtained if the other windings also obtained spatial coherence with those domains, so there is room for improvement.

Continuing with the Bubble memory analogue, an array of binary 1's are imprinted onto the ferrite surface by an array of write heads. These write heads are also the reading heads. The binary 1's are caused to move out of alignment with the read heads then back again inducing signals into the read heads. All the read heads are in series yielding a large signal output.

Although Bubble memories use orthoferrite, it is quite likely that Ba or Sr ferrite would work in the same way. It is known that in hard ferromagnetic materials, for which few Barkhausen noise measurements have been reported in the literature, the Barkhausen noise is not due to the motion of domain walls, but exclusively to grain reversal.