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The origin of noise and hysteresis in permalloy ring-core fluxgate sensors

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in permalloy ring-core fluxgate sensors a single phenomenon may cause both fluxgate noise and magnetic hysteresis. It also provides an explanation for Barkhausen noise, remanence and coercivity. It can also resolve the "domain nucleation problem."

in the unmagnetized state a high-quality permalloy foil takes a domain structure generally referred to as "stripe domains," which present at the free surface as parallel, uniformly spaced domain walls bounding regions of alternating 'in' and 'out' leakage flux, and domain walls crossing the entire thickness of the foil. The leakage flux is a requirement of the random orientation, grain-by-grain, of magnetic easy axes' angles with respect to the foil free surface, and creates a free space field with a magnetostatic energy cost. This together with domain wall energy determines an energy budget to be minimized. Throughout the magnetization cycle the free surface domain pattern remains essentially unchanged, due to the extreme magnetostatic energy cost such a change would elicit. Thus domain walls are 'pinned' to free surfaces.

As the fluxgate core is driven to saturation, domain walls pinned at the free surfaces first bulge then reconnect to form a new domain configuration this author has called "channel domains", which are attached to free surfaces. Energy released during the domain wall reconnection manifests as Barkhausen noise, while the reconnection itself manifests as a Barkhausen jump. The approach to saturation now continues as reversible channel domain compression. Driving the permalloy into deep saturation will compress the channel domains to arbitrarily small thickness, but will not cause them to denucleate. Returning from saturation the channel domain structure will survive through zero drive H, thus explaining remanence. The Barkhausen jumps being irreversible, exothermic events are sources of fluxgate noise.

It is also the case that fluxgate signal power is proportional to B-H loop curvature, that is to the second derivative of B. The degree to which Barkhausen jumps coincide with loop curvature is a measure of fluxgate noise that accompanies fluxgate signal. B-H loops with significant curvature beyond the open hysteresis loop may be used to advantage to acquire fluxgate signal with much reduced fluxgate noise.