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This Week's Citation Classic

Bobeck A H. Properties and device applications of magnetic domains in orthoferrites. *Bell Syst. Tech. J.* **46**:1901-25, 1967.
[Bell Telephone Laboratories, Murray Hill, NJ]

Isolated magnetic domains can be manipulated to perform memory, logic, and transmission functions. This paper discusses the properties of orthoferrites that make them suitable for magnetic device applications. The stability conditions of cylindrical domains lead to a direct method for determining the domain wall energy density. [The *SCI*® indicates that this paper has been cited in over 230 publications since 1967.]

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"The work that led to this article began in the late-1950s as a dozen or so people at Bell Telephone Labs tried to adapt magnetic materials for the storage of information. Magnetic tape, disk, and drum recording were in hand, and the remanent properties of ferrite were being exploited for the now well-known ferrite core digital memory. The invention of the transistor spawned not only the 'transistor radio' but also the computer generation as well. Computers, and their communication equivalents, telephone switching systems, PBXs, etc., need memory—lots of memory—with an appetite that remains unsatisfied even today.

"Our search for low-cost, high-performance memory took us into numerous device implementations and a few—the ferrite sheet, plated wire, and twistor memories—actually achieved substantial manufacture. None, however, reached the superstardom of the aforementioned ferrite core. The thrust was eventually directed toward a solid-state equivalent of the magnetic disk. A concept emerged which was based on the notion that isolated magnetic domains could be moved within the volume of certain thin single-crystal platelets of magnetic material. The basis of this idea was a very simple and, once recognized, very obvious concept. If the direction of magnetization could be pointed perpendicular to the platelet surface then island domains could be moved freely in any direction whatsoever throughout the magnetic platelet.

"The layman might best visualize isolated domains by imagining a liquid containing bubbles to be trapped between panes of glass. Furthermore, the panes of glass are close to one another so that the trapped bubbles are compressed to a cylindrical rather than a spherical shape. Island magnetic domains, which can be seen with polarized light, have much the same appearance. Methods to move these domains, *magnetic bubbles* as they are now called,[1,2] have evolved. Binary data, 1s and 0s, are indicated by the presence or absence of magnetic bubbles streaming along precisely defined paths often as many as one million steps in length.

"Orthoferrite, a semitransparent material with an orthorhombic structure, was used in early experiments on bubble motion. My children sifted through hundreds of platelets produced by our crystal growers to find any that would support bubble-like domains. This selection utilized a colloid viewer which made visible the outline of any domain present. In modern magnetic bubble devices, orthoferrites are replaced by garnets which are grown epitaxially as thin layers on nonmagnetic garnet substrates.[3]

"Work on the magnetic bubble concept for data storage has progressed worldwide. This paper is highly referenced since it is the first publication dealing with the use of cylindrical magnetic domains (bubbles) for data storage. Numerous awards have resulted from this early work including the Stuart Ballantine Medal, Valdemar Poulsen Gold Medal, *Electronics* magazine Annual Technology Achievement Award, and the AIP Prize for Industrial Applications of Physics."

1. **Bobeck A H & Scovil H E D.** Magnetic bubbles. *Sci. Amer.* **224**(6):78-90, 1971.
2. **Bobeck A H & Della Torre E.** *Magnetic bubbles.* Amsterdam: North-Holland, 1975. 222 p.
3. **Bobeck A H, Bonyhard P I & Geusic J E.** Magnetic bubbles—an emerging new memory technology. *Proc. IEEE* **63**:1176-95, 1975.