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Observations of Rotational Switching in Ferrites*

Recent measurements of the switching times as a function of applied field for square-loop ferrites indicate that three mechanisms are responsible for the process of flux reversal. Toroidal specimens were subjected to fast-rise, rectangular pulses, and the switching times were measured from 10 to 5000 mμsec as a function of the applied field. The resultant switching curve (reciprocal of switching time versus applied field) possesses three nearly linear segments. The inverse slope of this plot, known as the switching constant, may be plotted as a function of applied field for a convenient representation of the variation in switching constant. Such a plot is shown in Fig. 1 for a Mg-Mn ferrite. All square-loop ferrites that have been investigated show similar properties.

Our study has been facilitated by the use of fast-rise (1 mμsec) pulse generators and the development of convenient techniques for the measurement of switching times as short as 5 mμsec. This development will be described in a forthcoming paper.†

The three constant segments of Fig. 1 are interpreted as due to three mechanisms of flux reversal. Previous investigators have found only one linear segment and have not agreed on the responsible mechanism.[1,2]

Experimental waveforms and switching times over the lower range of applied field are consistent with a theory

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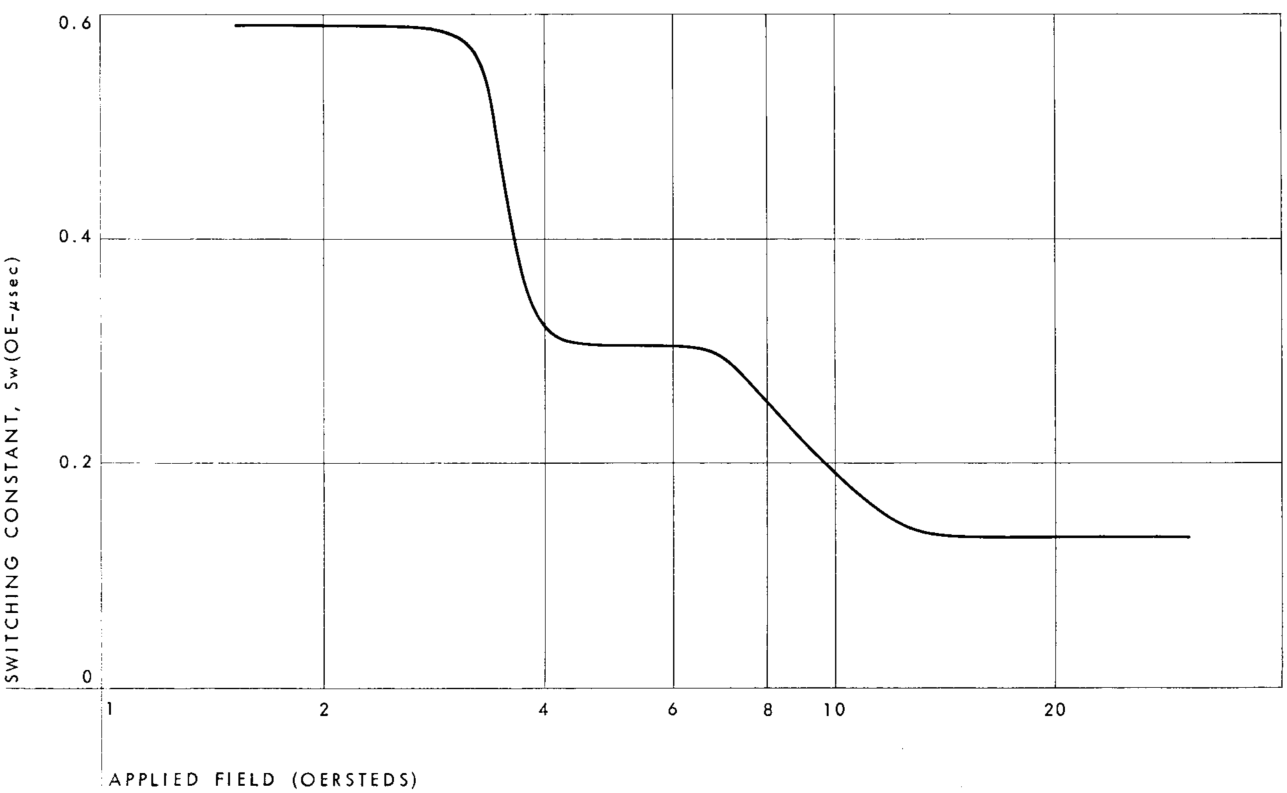
Figure 1 **Plot of switching constant versus applied field for a Mn Mg ferrite.**



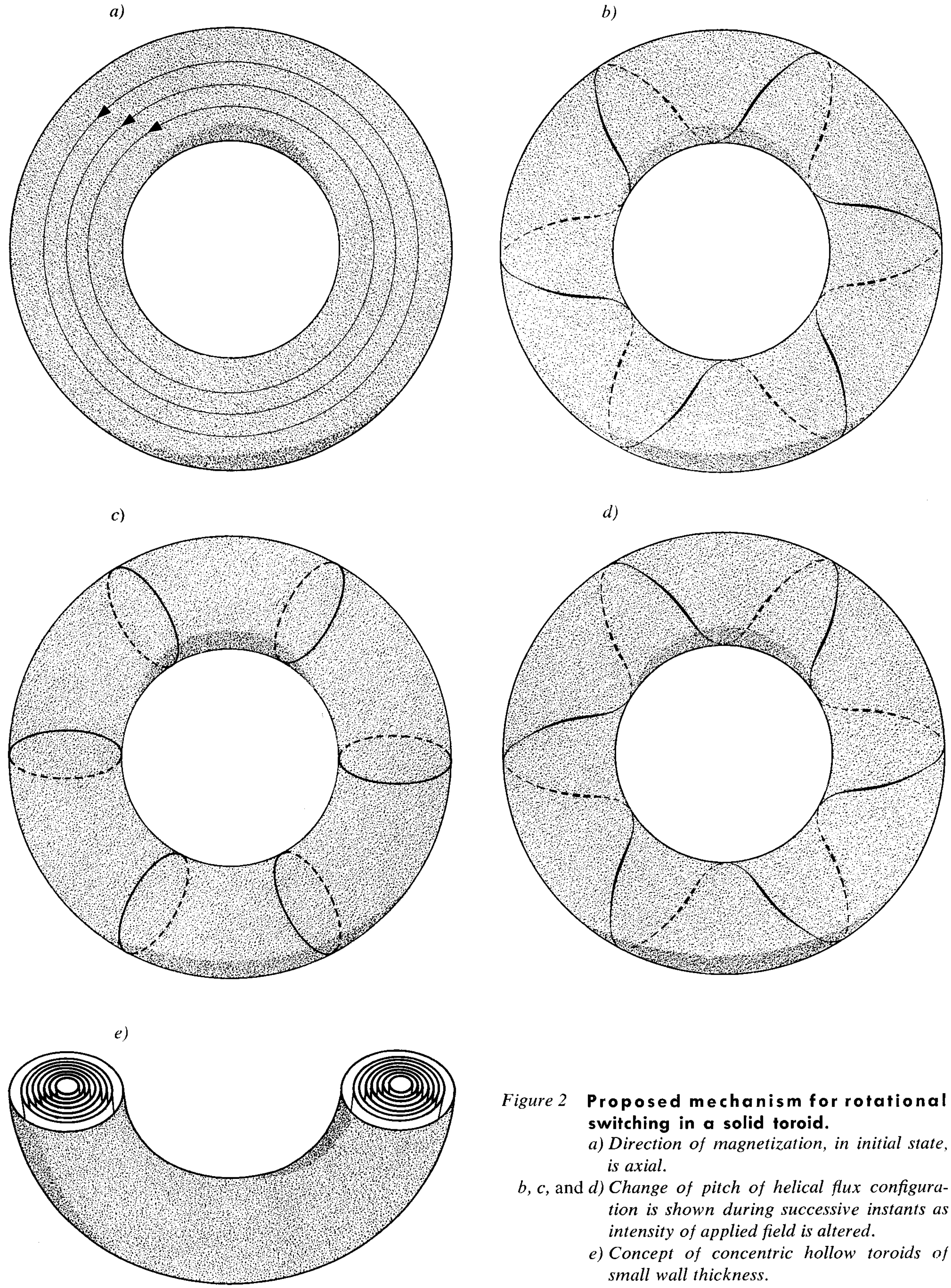


Figure 2 **Proposed mechanism for rotational switching in a solid toroid.**

a) *Direction of magnetization, in initial state, is axial.*

b, c, and *d)* *Change of pitch of helical flux configuration is shown during successive instants as intensity of applied field is altered.*

e) *Concept of concentric hollow toroids of small wall thickness.*

of domain-wall motion.[3] This first mode may be characterized by a threshold field and a switching constant. A second threshold appears at a value of field intensity of from two to five times the wall-motion threshold, and the switching constant decreases to a value of 0.11 to 0.41 oe-μsec, depending on the ferrite material. This mode of switching appears to be in agreement with a proposed incoherent rotational model.[2]

A third threshold appears at fields larger, by an order of magnitude, than the wall-motion threshold. Measured switching constants for various ferrites for this region of the switching curve fall in the range 0.04 to 0.20 oe-μsec. These are the lowest switching constants reported for ferrites to date. This decrease in switching time from the incoherent rotational model is felt to be due to the onset of a coherent rotational mode; that is, a uniform rotation of the magnetization vectors occurs within the ferrite.

Previous investigators have held that such a mechanism is impossible for structures such as a toroid.[2,4] A model for this mechanism is proposed here. Consider the solid toroid shown in Fig. 2. The direction of magnetization in the initial state is nearly axial. This condition is shown in Fig. 2a. When a field of sufficiently high intensity is applied, the flux configuration then becomes helical. The reversal process then consists of the continuous change of pitch of the helix from large negative values through zero to large positive values. Figs. 2b, c, and d show the directions for helical paths at successive instants during the reversal process. Note that flux closure through air is not required. For the same reasons as in the case of thin films,[4] lower switching constants are expected for this coherent rotational model than for an incoherent model. The solid toroid may be considered to be composed of many concentric hollow toroids, each of small wall thickness. The sign and magnitude of the pitch for the helical flux path of any one shell may be independent of that for the other shells. See Fig. 2e.

Conclusions

Three mechanisms of flux reversal are proposed for the flux reversal in square-loop ferrites, each mechanism being dominant over a certain region of the switching curve.

A coherent rotational model is proposed, and experimental evidence supporting the mode yields the lowest values of switching constants for ferrites reported to date. Details of this work, including studies of several ferrites and of dependence on temperature and ceramic process variables, are to be published.

Acknowledgments

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