Digital Computer Laboratory
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SUBJECT: A NON-DESTRUCTIVE READ SYSTEM FOR MAGNETIC CORES

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Abstract: A non-destructive read system for magnetic cores is proposed which involves a quadrature field and which promises to be fast.

The process of recalling information stored in the M. I. T. coincident-current magnetic-core memory is called destructive. The reading process destroys the information stored in a memory core, leaving that core in the "cleared" state regardless of whether it contained, just prior to reading, a ONE or a ZERO. The information which was destroyed during reading is re-written in the core as a routine part of the memory's operating cycle.

A non-destructive read system is proposed which would allow magnetic cores to be read repeatedly without loss of information. The system involves the use of a second magnetic flux path at the right angles to the first. When pulsed, the flux in the second path causes a momentary drop in the residual flux in the first path. If the residual flux is positive, the drop represents a negative change of flux; if, on the other hand, the residual flux is negative, the drop represents a positive change of flux. These changes are coupled to a sensing circuit via the write winding or via a separate sensing winding. A more detailed description of the proposed system follows.

Ring-shaped cores (Fig. 1a) of highly grain-oriented Molybdenum Permalloy are used as the memory cores in one of the M. I. T. memories. As a result of the rolling and magnetic annealing steps in the fabrication of these cores, their hysteresis loops are nearly rectangular, and they behave, in many respects, like single ferromagnetic crystals with easy directions of magnetization in the direction of rolling. A crystal of the material (Fig. 1b) is a cube with easy directions of magnetization along the cube edges. The magnetization vector of the crystal will, in the absence of an external field, lie along one of the cube edges.

Between any two directions of easy magnetization there is a hard direction (Fig. 1c). If the magnetization vector of the crystal were pulled to a hard direction by an external field, and then the external field were removed, the magnetization vector would snap back to the closest easy direction. This is the process that takes place on the upper and lower parts of the hysteresis loop for a magnetic material with a not-too-rectangular hysteresis loop. As one goes from the residual induction point to saturation (A to A' in Fig. 1d), the magnetization vectors of the domains in the material rotate into alignment with the applied field, increasing the induction. When the field is removed, each vector drops back to its closest easy direction and the material is once again at the residual induction point. In the grain-oriented metal cores, easy directions of magnetization already lie along the direction in which the field is applied, so that the hysteresis loop is almost perfectly flat on top.

If a field is applied at right angles to the residual induction vector (Fig. 2a), the vector will be rotated away from its residual direction toward a hard direction. If the 90° field is not too strong, the vector will snap back to its residual induction position when the 90° field is removed. When the vector is rotated out of position, its component along the residual induction path drops in magnitude. The read/write winding on this path will see a change of induction and therefore it will send a voltage to the sensing circuit. As already mentioned, the drop in residual induction represents a negative change if the residual induction is positive (Fig. 2b) and a positive change if the residual induction is negative (Fig. 2c). The polarity of the voltage induced in the read/write winding will tell the sensing circuit in which residual state the core is resting, and therefore, whether it contains a ONE or a ZERO.

A hollow toroid (Fig. 3a) is one possible geometrical arrangement for using this system. The read/write winding occupies the same position as it does on presently used toroids while the 90°-field winding lies circumferentially inside the hollow. When the 90°-field winding is pulsed, the residual induction vectors on the inside circumference of the toroid are deflected in a direction opposite to that in which the residual induction vectors on the outside circumference of the toroid are deflected. Similarly, the vectors on the top and bottom of the toroid are deflected in opposite directions. The net effect is a drop in the magnitude of the component of the residual induction around the toroid as the vectors are twisted (Fig. 3b). If the toroid is sliced length-wise, as shown, to facilitate putting in the 90°-field winding, the air gap thus introduced does not affect the rectangularity of the main hysteresis loop; it merely dilutes the 90° field.

The maximum value of the 90° field is that value not quite large enough to pull the magnetization vector up to a hard direction of magnetization. The maximum change in residual induction is seen to be (Fig. 4):

$$dB_{max} < B_s (1 - \cos 45^{\circ})$$
$$< .293\, B_s$$

It is interesting to note that when using a material having a rectangular hysteresis loop, this system is a unidirectional transformer. A signal inserted in the 90°-field winding will appear across the read/write winding but a signal fed into the read/write winding will not appear across the 90°-field winding. The 90°-field circuit will not load the core during writing; nor will writing transients feed back into the 90°-field circuit.

Finally, the sensing operation does not involve the destruction and formation of domain boundary walls. Therefore, there is no hysteresis loss associated with this system; the 90° field does not have to supply any energy in the form of hysteresis loss because switching of the material does not take place. For this reason the scheme promises to make possible a non-destructive read system which is fast.

Signed Dudley A. Buck
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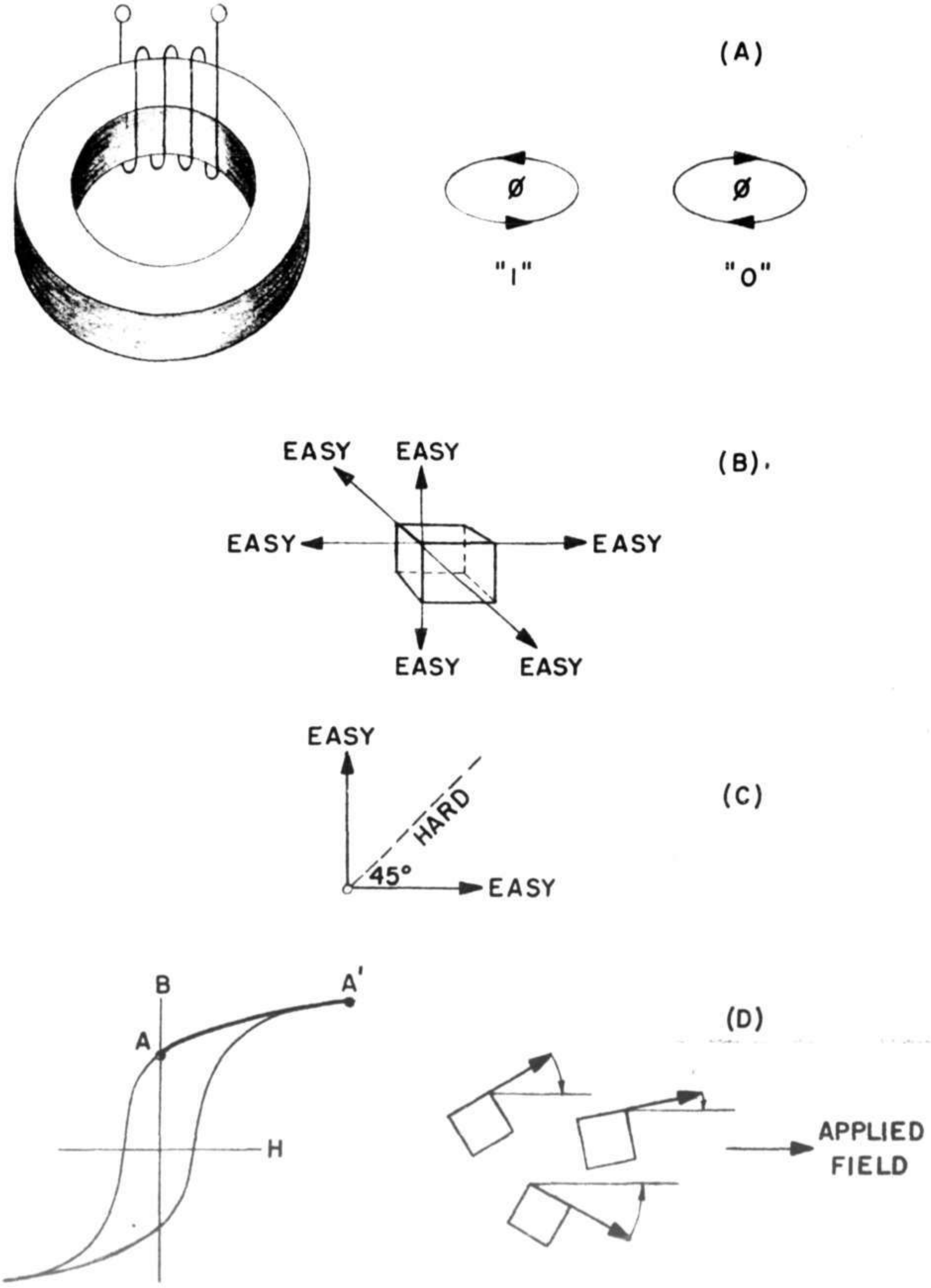
Drawings attached:

A-51080 **Fig. 1**
A-51081 **Fig. 2**
A-51082 **Fig. 3**
A-51083 **Fig. 4**



NON-DESTRUCTIVE READ
(DOMAIN MAGNETIZATION VECTORS)

FIG. 1

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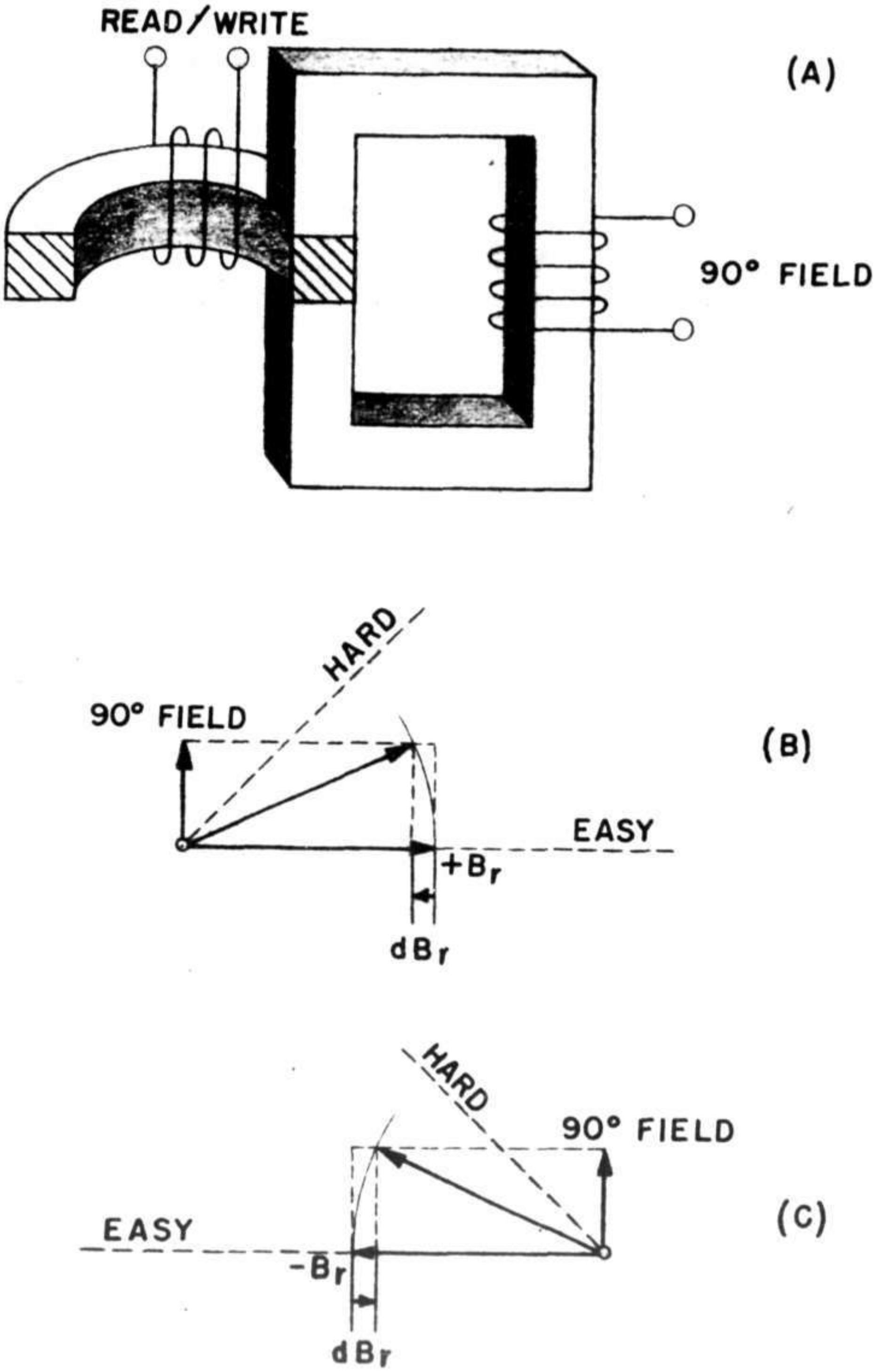
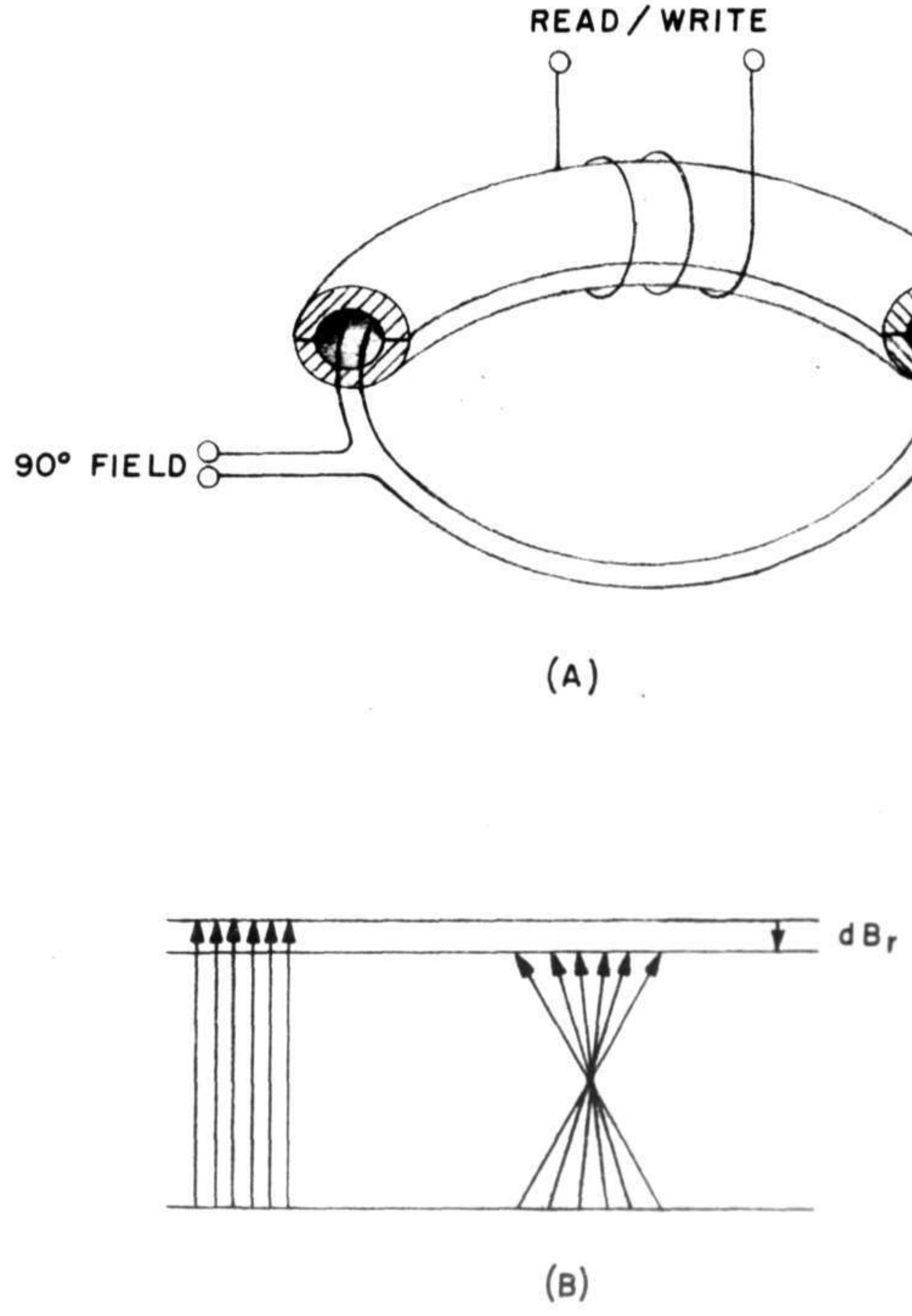


NON-DESTRUCTIVE READ
(90° FIELD WINDING)

A-51081

FIG. 2



NON-DESTRUCTIVE READ
(HOLLOW TOROID)

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FIG. 3

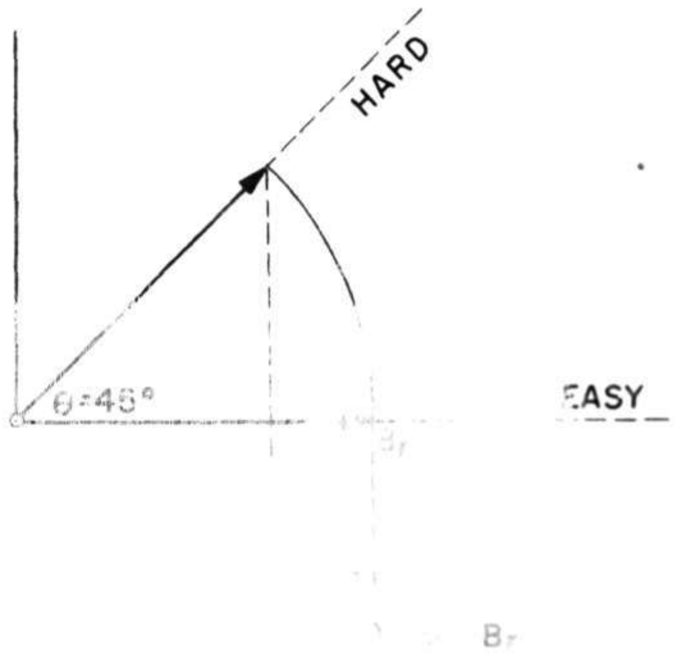

FIG. 4