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ELECTRICAL ENGINEERING DEPARTMENT

MASTER'S THESIS PROPOSAL

TITLE: An RF Readout System for a Coincident-Current Magnetic-Core Memory

STATEMENT OF THE PROBLEM:

It is the purpose of this thesis to evaluate the utility of the proposed system of high-frequency nondestructive readout and to compare it with existing pulse readout systems.

HISTORY OF THE PROBLEM:

During the past year several magnetic-core memory planes have been constructed and operated. These successes have done much to establish the soundness of the coincident-current-memory idea that was first proposed by Jay W. Forrester.[1]

Two types of operations are performed with any memory: information is written in, and information is read out. Experience with our working memories has shown that coincident-current selection allows a very positive-acting method of writing information into any memory core without destroying the information stored in any other core. The readout problem, however, contains some fundamental difficulties that are basic to this type of memory. At present, reading out of a core is accomplished by writing a "zero" into it. If it contains a "one," flux reversal will occur, and this will induce voltage in a sensing winding which is threaded through every core in the memory plane. If the core contained a "zero," no flux reversal would take place, and the induced voltage would be very much smaller than for the "one" case. This process is destructive to the information, so provision must be made for rewriting if the information is to be retained. The signal induced in the sensing winding during readout is not due exclusively to the selected core because the sensing winding links not only the selected core but also the cores that are placed along the X and Y driving lines common to the selected core. The "half-selected" cores produce in cascade a noise which places a limitation on the maximum size of a memory plane that may be made up of cores having given characteristics.

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1. Jay W. Forrester, Digital Information Storage in Three Dimensions Using Magnetic Cores, Servomechanisms Laboratory, Massachusetts Institute of Technology, Report R-187, May 16, 1950.

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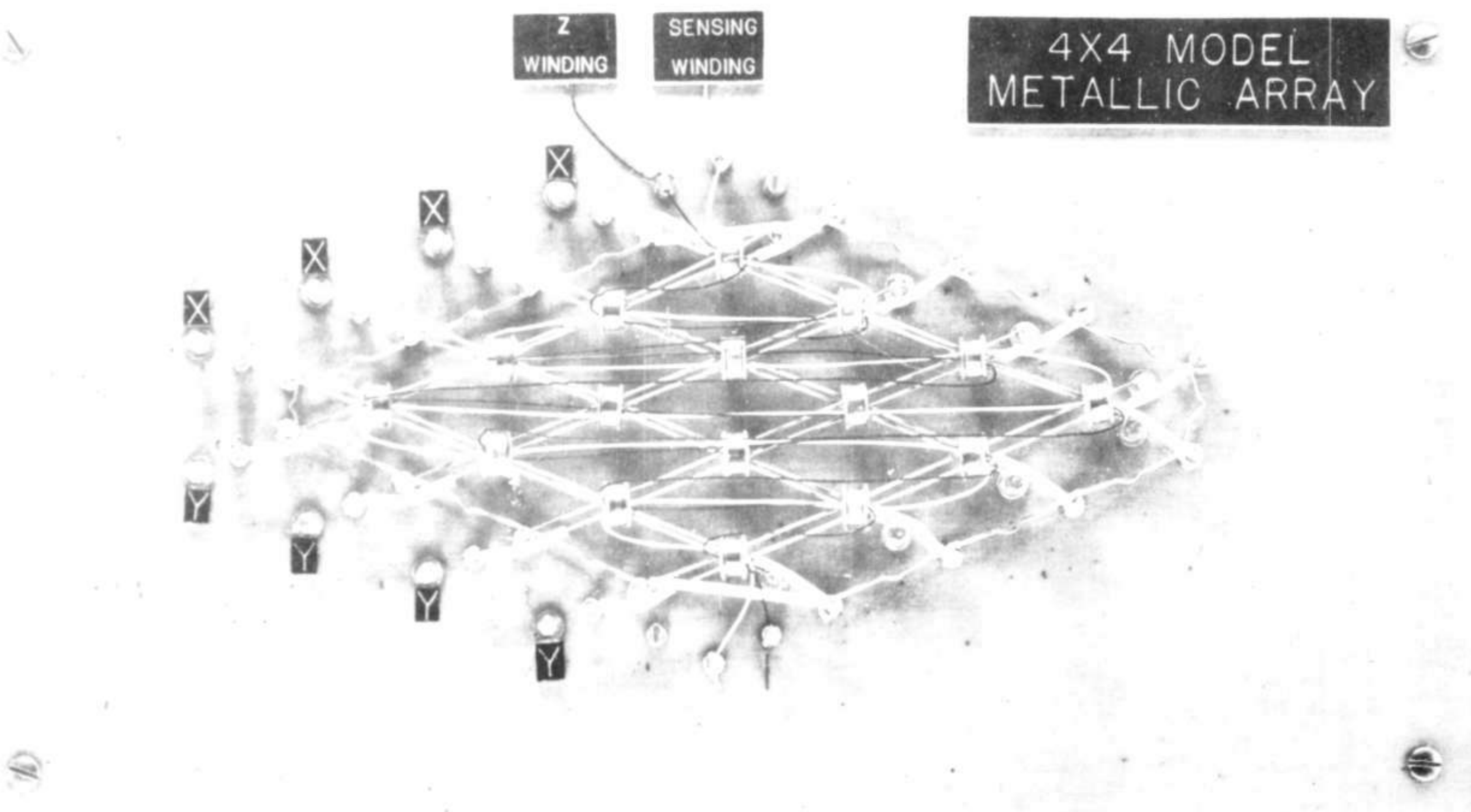

4x4 MODEL OF THE METALLIC CORE ARRAY

F-1581

FIG. 1

The possibility of using filters to separate signal and noise is proposed as a means of improving the signal-to-noise ratio. The memory array is to be excited by currents in such a way that the spectra of the noise signals do not overlap the spectrum of the desired signal.

THE RF READOUT SCHEME:

A memory array plane consists of two sets of parallel driving lines (X and Y) and a sensing winding. The driving lines form a two-dimensional supporting matrix for the magnetic cores with a core situated at each X-Y crossing. Figure 1 is a 4 x 4 model of a metallic-core array. Any core in this array may be set in either of its remanent flux states by selecting the corresponding X and Y lines and applying, to each, half of the total amount of current required for switching. The proposed scheme of readout would require a selection and driving system that could supply not only "d-c" pulses for reading in but also "a-c" pulses for RF readout. The selected X and Y lines would carry bursts of RF currents whose carrier frequencies differ slightly. The selected core, a non-linear device, is capable of inducing a beat-frequency voltage in the sensing winding. The noises produced by the other cores lying along the selected X and Y driving lines must be of either fundamental driving frequency or their higher order harmonics. Thus, a filter tuned to the beat frequency (or difference frequency) is capable of extracting a signal originating at the selected core from the sensing-winding voltage. What one can do with this beat signal to detect the information contained in the selected core will now be shown.

Recent experiments have indicated that when a single core is excited by two simultaneously applied RF current bursts of frequencies, ω_1 and ω_2, the phase of the resultant beat may be reversed by 180 electrical degrees by switching the core to its alternate remanent flux state. These discrete beat phases correspond to the opposite curvatures of two RF hysteresis loops (minor loops) of a core having a rectangular d-c hysteresis loop. (See Figure 2. In general, RF loops cannot be simply derived from the d-c loop, but it is fairly certain that the RF loops exhibit the same type of symmetry relative to each other as that between the "upper" portion of the d-c loop and the "lower" portion.)

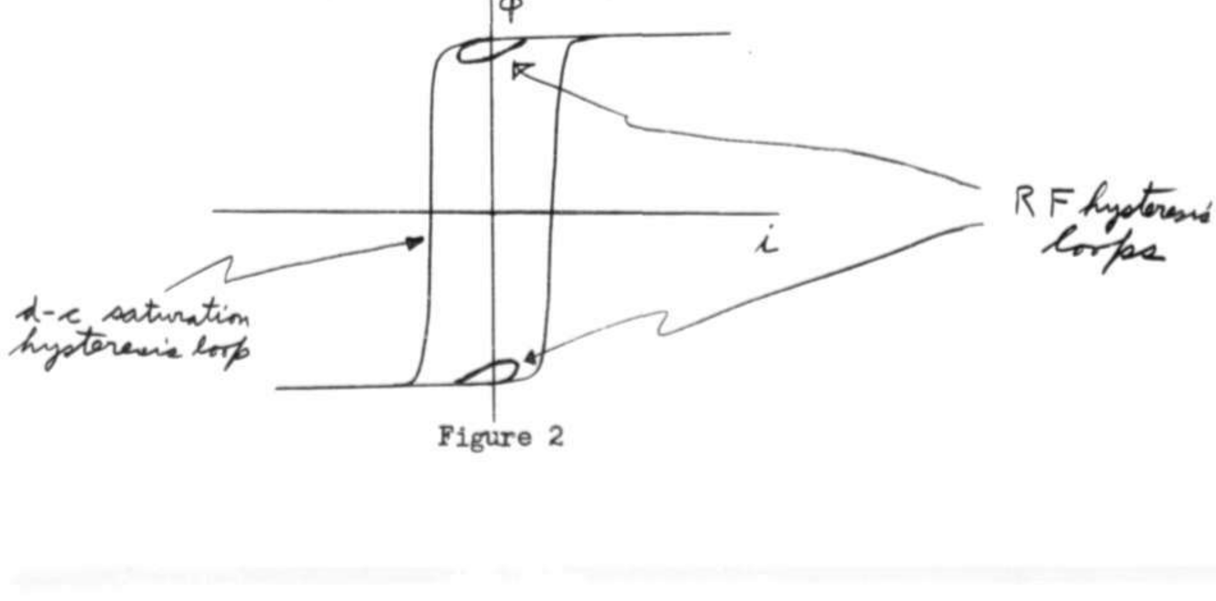

Figure 2

The phase reversal of the beat signal allows sensing. The output of the tuned filter may be applied to a phase-sensitive detector or directly to a gate tube which may be pulsed at a definite time to afford time discrimination. A system that does this is shown in Figure 3.

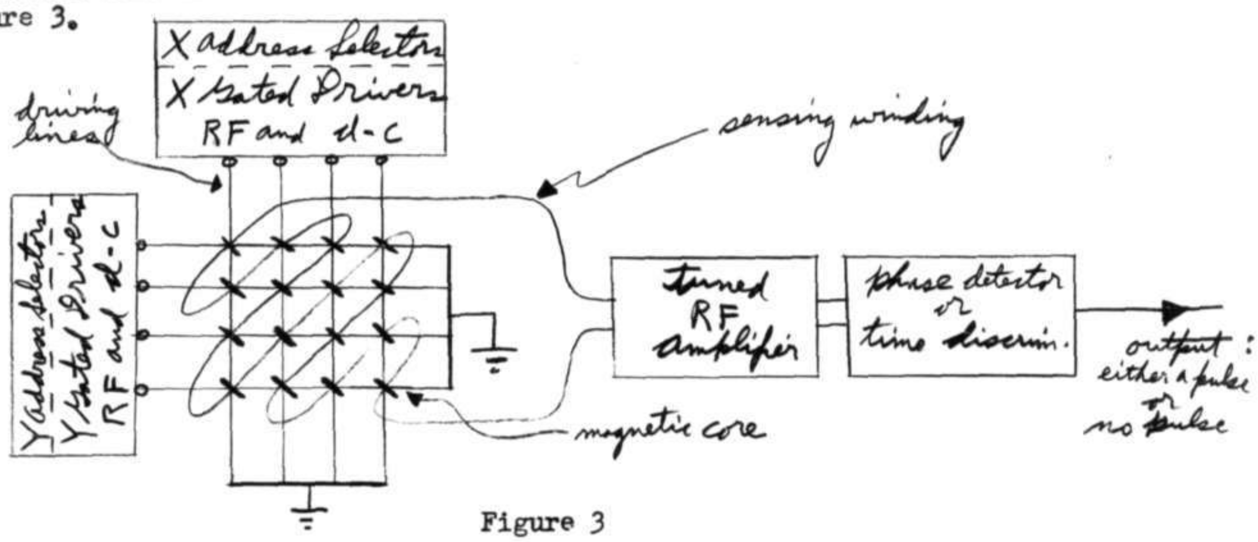

Figure 3

The RF readout is also nondestructive. Experiments with metallic cores have shown that RF pulsing does not destroy the stored information or cause any slow deterioration. It therefore relieves the necessity of rewriting after reading, and promises to make reading, which is done about five times as often as writing, much faster. Hence, the overall speed of the memory may be greatly increased.

PROPOSED PROCEDURE:

The proposed procedure will be composed of the following four parts:

a) Fundamental Problems of Beat Generation

An attempt will be made to explain, in terms of a mathematical model, what actions are taking place in metallic and ferritic cores that give rise to the beating processes. As an aid in this investigation, the salient parameters will be varied to determine which are significant.

Experiments will be made to determine the amplitude of the beat signal and the noise signals from a single core when driven by RF currents of various frequencies and amplitudes. The RF and d-c disturbances that a core in a memory may be subjected to during reading out and writing in will be simulated, and their effects with respect to the phase and amplitude of the desired beat output will be determined. Experiments already made do not show any phase shift due to these disturbances.

b) Separation of Signal and Noise

An analytic study of the noise problem will be made. It is expected that the signal-to-noise ratio will depend upon core characteristics, the size of the memory, the frequencies of the driving currents, the shapes of the envelopes of these driving currents, and the frequency response of the sensing amplifier. The analysis will be carried out in the frequency domain, and use will be made of filter theory.

c) Evaluation of the RF Readout

By applying the criteria derived from the above-described process (b) to the measured characteristics of the available metals and ferrites of (a), optimum operating conditions will be determined for certain sizes of array planes made up of the various types of cores. It will then be possible to predict operating speeds and signal-to-noise ratios which may be compared with the already known results of pulse readout.

d) RF Readout Applied to an Experimental Memory Plane

If time permits, an attempt will be made to incorporate the RF readout in a memory test setup that will allow electronic selection of the X and Y memory driving lines. It is likely that this will be largely a circuits problem. Such a setup will be valuable because it will not only test the results of this thesis but in addition will demonstrate the feasibility of RF driving of a memory plane when using present electronic techniques.

EQUIPMENT NEEDS

All necessary measuring equipment is available at the M. I. T. Digital Computer Laboratory. Use will be made of the standard pulse test equipment of that laboratory, and its facilities will be available for the construction of any special units that may be needed during the course of this thesis.

The cores to be used in the research will be supplied by Group 63 of Division 6, Project Lincoln.

ESTIMATED DIVISION OF TIME:

(a) Preparation of Proposal - - - - - - - - - - - - - - - -50

(b) Further Study of the Literature - - - - - - - - - - 25

(c) Experimental Work and Analysis - - - - - - - - - - 150

(d) Correlation of Results and Formulation of Deductions and Conclusions - - - - 100

(e) Preparation of Thesis Report - - - - - - - - - - - - 75

(f) TOTAL - 400

SIGNATURE AND DATE:

December 19, 1952

Bernard Widrowitz

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SUPERVISION AGREEMENT:

The problem described herein seems adequate for a Master's research. The undersigned agrees to supervise the research and evaluate the thesis.

William K. Linvill

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BW/bs

Drawing Attached:
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