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Memorandum M-1691

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Werner I. Frank

October 20, 1952

ELECTRICAL ENGINEERING DEPARTMENT

BACHELOR'S THESIS PROPOSAL

1. TITLE: RECTANGULAR HYSTERESIS LOOP MATERIALS IN A NON-DESTRUCTIVE READ SYSTEM

2. PROBLEM:

It is proposed to investigate applications of rectangular hysteresis loop materials to memories which will truly retain their information no matter how often this information is used or read out.

3. WHAT HAS BEEN DONE:

As soon as magnetic memories for computers were being considered, such as M. I. T.'s coincident-current magnetic-core memory, [1,2] some disadvantages of this type of memory were noted, two important items being the following:

1) In order to make use of stored information, this information has to be destroyed. If that same information is to be used again, it has to be rewritten into the core after every read-out.

2) It takes a certain time for a core to switch in order to yield its information, ranging from about ½-microsecond for a ferrite core to about 8 microseconds for the best metallic-type core in a conventional-type, 2:1-selection-scheme memory.

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

2. William N. Papian, A Coincident-Current Magnetic Memory Unit, Project Whirlwind Report R-192, Servomechanisms Laboratory, Massachusetts Institute of Technology, September 8, 1950.

As a result, a constant search for non-destructive read systems and for faster core materials is being conducted.

In March, 1952, Dudley A. Buck proposed a non-destructive read system [3] based on the tendency of oriented magnetic materials to maintain their remanent flux in certain easy directions of magnetization; a quadrature field applied to that flux could deviate it from that easy direction of magnetization, thus changing the effective length of the magnetic vector. But as soon as the quadrature field were removed, the core flux would return to the easy direction. This would result in a positive pulse for a stored ONE and a negative pulse for a stored ZERO. Since no hysteresis loss is involved (no domain boundaries are formed or destroyed in this process), the method promises to be very fast. Preliminary experimental verification of this theory was obtained, yielding good discrimination between states of magnetization (i. e., distinguishing between ONE and ZERO). Read-out time apparently was limited only by the rise time of the pulse setting up the temporary quadrature field, in our case, approximately 0.2 microseconds.

4. PROPOSED INVESTIGATION:

An attempt will be made to find ways of applying this theory to existing materials and equipment, to determine what voltage magnitudes may be obtained and how much driving current or power would be needed to bring these outputs into practical ranges. The very first results showed negative ZERO outputs and positive ONE outputs of less than 1/10 of a volt when driven with 360 ampere turns and sensed by a 10-turn winding.

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[3] Dudley A. Buck, A Non-Destructive Read System for Magnetic Cores, Engineering Note E-454, Digital Computer Laboratory, Massachusetts Institute of Technology, March 24, 1952.

Once a practical system for the use of this theory had been devised, many interesting applications could be found. Time permitting, some of these might be tried out as part of this thesis. For instance:

A "permanent register" could be built consisting of, say, 16 cores which might be set up by individual toggle switches. If their quadrature fields could be pulsed in series, or possibly if they could all be disturbed by the same quadrature field, all 16 cores could yield their information simultaneously, without the necessity of rewriting the information.

Dudley Buck also suggested the use of non-destructively-pulsed cores as one-way transformers, in which, although power is transferred from the primary to the secondary, no impedance change in or other disturbance to the secondary would be reflected back into the primary.

Finally, Dr. M. S. Blois suggested the ferromagnetic relaxation oscillator. Using the deviation of the magnetic vector under the influence of the quadrature field and the gyroscopic precession to which this vector would be subject as the basis for the oscillator might result in very high stability (since only atomic phenomena are involved) in an ultra-high frequency region not accessible to quartz resonators. Frequency should be about 5 megacycles per gauss.

5. EQUIPMENT AND TECHNICAL ASSISTANCE:

The thesis work is to be done at the M. I. T. Digital Computer Laboratory, where the equipment and materials needed are, for the most part, already available. Mr. Dudley A. Buck of that laboratory has agreed to supervise the work, and the technical and financial assistance of the Digital Computer Laboratory has also been assured.

6. SIGNATURE AND DATE:

Werner I. Frank

Werner I. Frank
October 20, 1952

7. SUPERVISION AGREEMENT:

The undersigned agrees to supervise the research and evaluate the thesis.

D. A. Buck

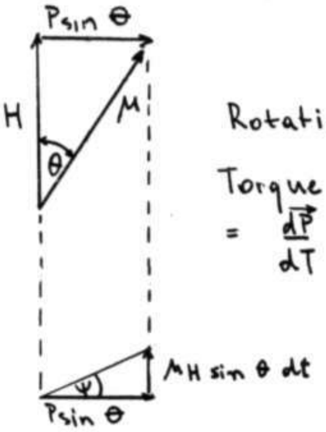
Dudley A. Buck

WIF/bs

APPENDIX I

CALCULATION OF FREQ. OF "BLOIS OSCILLATOR"

by George R. Briggs



Rotating charge of magnetic moment μ

Torque developed $= \vec{T} = \vec{\mu} \times \vec{H} = \mu H \sin\theta$

$= \frac{d\vec{P}}{dT}$ out of the paper, upward.

Then $d\Psi = \frac{dP}{P\sin\theta} = \frac{\mu H \sin\theta \, dt}{P\sin\theta}$

$= \frac{\mu H \, dt}{P}$

From which $\omega' = \frac{d\Psi}{dt} = 2\pi f_{Larmor} = \frac{\mu H}{P}$

and $\underline{f_{Larmor} = \frac{\mu H}{2\pi P}}$

By quantum mechanics for an electron $\mu = \frac{\sqrt{3}\, e\hbar}{4\pi mc}$

$\mu = \sqrt{3}\; 9.27 \times 10^{-21}$ erg oersted^{-1}

and $P = \frac{1}{2} \frac{\hbar}{2\pi} = \frac{1}{2} \frac{6.624 \times 10^{-27}}{2\pi}$ erg sec

$f = \frac{\mu}{2\pi P} H = \frac{\sqrt{3}\; 9.27 \times 10^{-4}}{\frac{1}{2}\, 6.624 \times 10^{-27}} H$ oersted^{-1} sec^{-1} $\underline{\underline{= 4.86 \times 10^{6} \frac{\text{cps}}{\text{oersted}}}}$

with $\mu_0 = 1$, $B = \mu_0 H = H$ $\underline{\underline{f \cong 5 \text{ mc/gauss}}}$