

Memorandum M-2332

Page 1 of 5

Division 6 - Lincoln Laboratory  
Massachusetts Institute of Technology  
Cambridge 39, Massachusetts

**SUBJECT:** WEST COAST TRIP, JULY, 1953**To:** David R. Brown**From:** Dudley A. Buck**Date:** July 31, 1953

**Abstract:** A recent trip to the West Coast included visits to several laboratories engaged in the development of magnetic materials for digital-computer applications. Evaporated molybdenum Permalloy cores at NBS, Corona, have rectangular hysteresis loops but high coercivities. At UCLA, lithium ferrite is being investigated for memory-core application by a group under the supervision of Prof. W. D. Hershberger; usable materials have been obtained. An investigation of the switching mechanism in metal-ribbon cores has been initiated at Armour Research Foundation. Wire cores are believed promising.

National Bureau of Standards Laboratory, Corona, California, July 6, 7, 8, 13, 14

Thin-ferromagnetic-film work has progressed to the point where 10-layer cores are being evaporated in one vacuum operation. The layers of magnetic material, about 1000-Angstroms thick, are separated by thinner layers of low-conductivity non-magnetic material. Original experiments used pure iron for the magnetic material but molybdenum Permalloy is now being used. The molybdenum Permalloy is held in a ceramic crucible and heated by r-f induction. The extent of fractional distillation has not yet been investigated. The insulating layer was originally a silicon-monoxide film, but the best of recent results have been achieved with a magnesium-fluoride film. Coercivity of these films is high (about 125 oersteds). Magnetometric experiments have proven most valuable in this study. Hydrogen annealing is being investigated as a means to lower the coercivity. The hysteresis loop of a thin Molybdenum-Permalloy film was observed by evaporating a thin layer on Cellophane, and then wrapping the Cellophane as a ribbon-wound core of 120 wraps. The resulting loop had sharp corners but was badly sheared and had high coercivity as would be expected with the Cellophane acting as an air gap. The coercivity of the Cellophane core dropped from about 50 oersteds to 25 oersteds in 5 days due to relief of local stresses on the film by diffusion. In brief, the work since my last visit (January, 1953) has been to solve many of the mechanical problems associated with the evaporation of ferromagnetic films and insulating layers.

In the same Laboratory, ferroelectrics are being investigated for high-speed switching elements with no new progress to report. The arithmetic-element group has designed a fast carry-propagation scheme for addition which uses distributed amplifiers and which causes a delay of only 4 millimicroseconds

Memorandum M-2332

Page 2 of 5

per stage--about 10 times as fast as present-day fast-carry circuits. The group has not yet built such a fast-carry circuit, however.

While still at that Laboratory, I talked with Mr. Lode of Minnesota Electronics who described a magnetic-core pulse amplifier invented by them. It takes advantage of the fact that the nucleating field of some metallic cores exceeds the coercive field so that switching can be made to progress at a lower field than that field needed to initiate switching. The core is biased between the two fields (Figure 1). A pulse to be amplified starts the core switching; it continues to switch after the pulse is removed. A second winding on the core delivers the amplified pulse. The core must be reset after each use. Mr. Lode said that development of this amplifier has not been pursued.

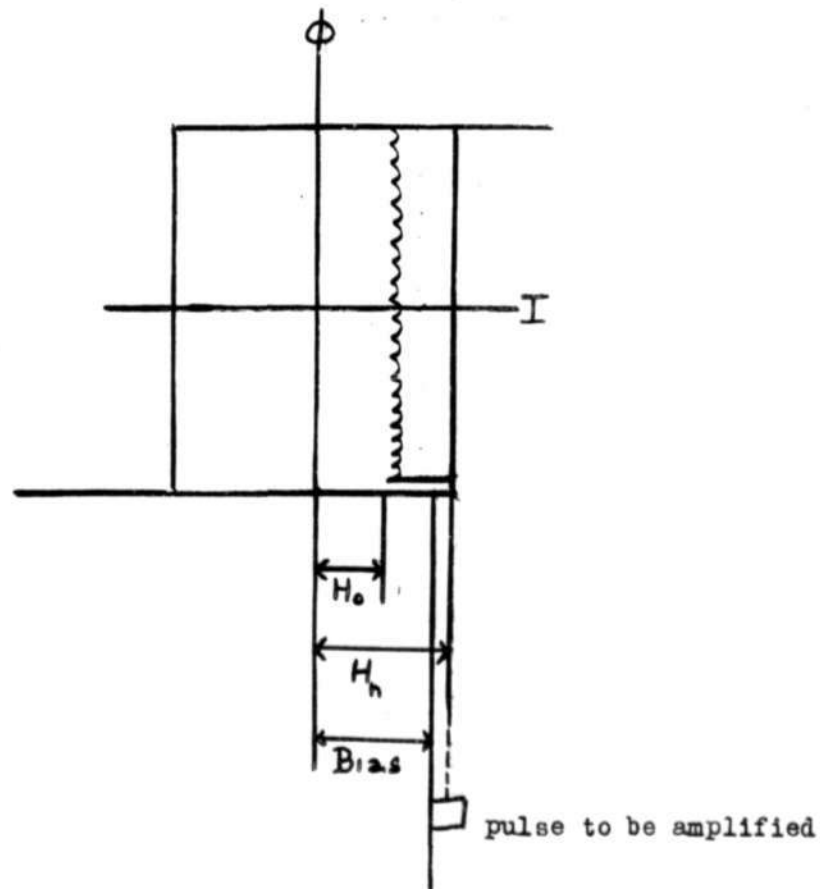


Figure 1

Minnesota Electronics Pulse Amplifier

Computer Research Corporation, Hawthorne, California, July 9

Ferroresonant flip-flop development has progressed to a point where units can now be operated at a counting rate of 100 kc. Series triggering is now used, and the diode in the triggering circuit has been eliminated. The units use for a nonlinear element a solenoid containing a piece of 1/8-mil molybdenum Permalloy about 1/2-inch long. They are wound as in Figure 2 and connected for a flip-flop as in Figure 3. CRC has succeeded in operating a 32-stage ring counter using 32 single elements (one side of flip-flop) with a common series-load impedance. I believe CRC is marketing 10-stage counters of this type.

How this flip-flop triggers is still not understood--even by CRC. Engineers there feel that the amount of third-harmonic coupling into the trigger winding from the a-c winding is important. Attempts to tune the trigger winding to the third harmonic have improved operation. In actual units, the number of turns in the trigger winding is critical--going from 350 turns to 300 or to 400 make the unit less stable. In one experiment, they were able to trigger a single element as a flip-flop.

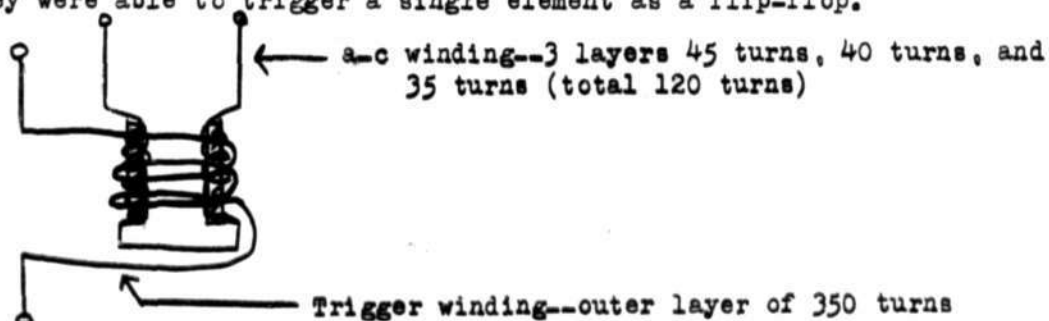


Figure 2 Ferroresonant Element - CRC

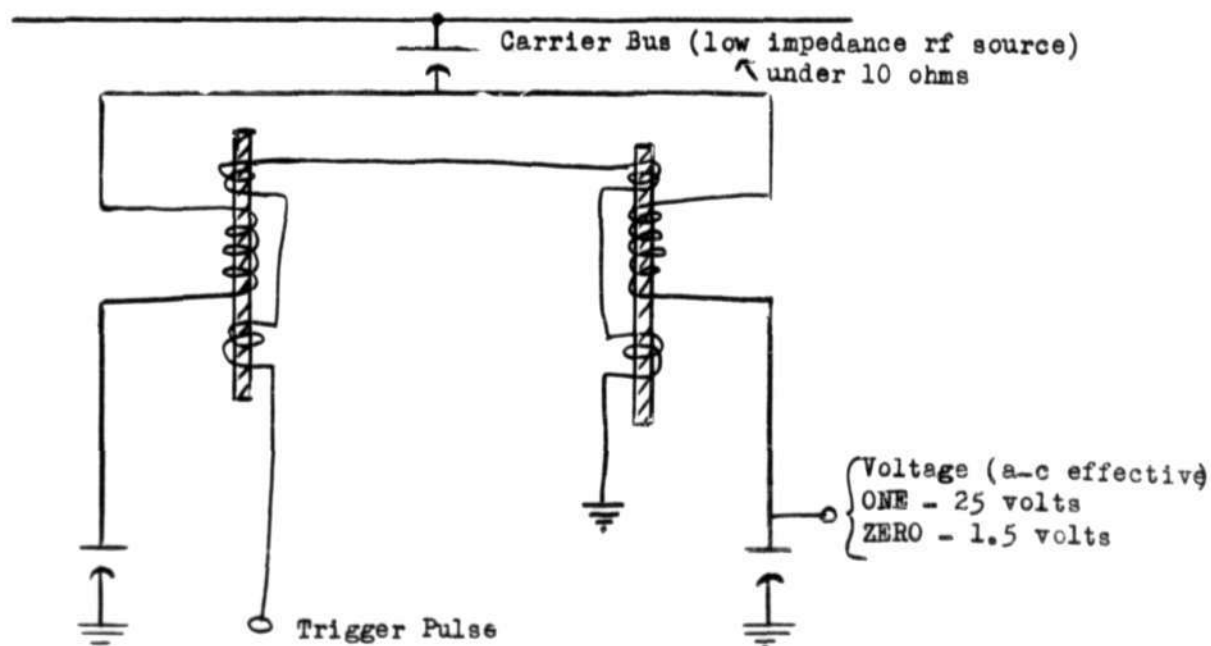


Figure 3 Ferroresonant Flip-Flop - CRC

Memorandum M-2332

Page 4 of 5

UCLA, July 16

I saw Prof. W. D. Hershberger and discussed ferrite synthesis with him. He is supervising this work with two ends in sight--magnetic-memory cores (in close cooperation with International Telemeter Corp.) and gyrator bodies (in close touch with Hughes Aircraft Corp.). In his magnetic-memory core work, he has been investigating lithium ferrites and lithium ferrite mixed with other ferrites. He has made at least one square-loop body of lithium ferrite whose hysteresis-loop family looks about like MF-1326-B at a glance and whose coercivity is about 2.5 oersteds. He plans to reproduce this body and make small deviations of the ceramics parameters about the present recipe.

He conducted me on a tour of his lab where he is also supervising microwave spectroscopy of electroluminescent materials and fabrication of ceramic fins and noses for rockets.

Also at UCLA I visited SWAC. Their drum memory is now operating. It stores 32 words, 40-bits long, serially around the drum. Spacing is 50 bits per inch.

International Telemeter Corporation, Los Angeles, July 17

George Brown, Milton Rosenberg, and Raymond Stuart-Williams have added extra windings to their switch cores and connected them so that no core gets more than two units of bias. They feel that it is important to stay close to the same hysteresis loop and not go indefinitely far into the saturated region. Their memory-driving scheme has been modified so that all disturbed cores receive alternating-polarity disturb pulses--never unipolar disturb pulses--because once again they stress the importance of staying near to a constant hysteresis loop.

Driving waveforms are as shown in Figure 4. This mode of driving involves column-driving selection circuitry for each digit plane; the row drivers can still be common to all planes. The digit-plane winding is eliminated.

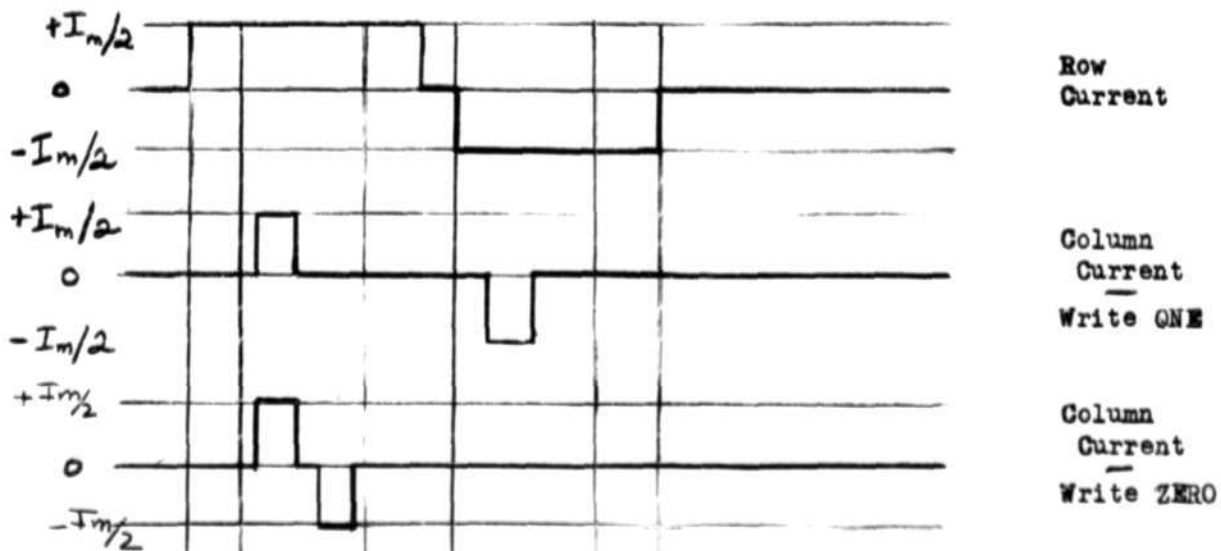


Figure 4 I.T.C. Current Waveforms

Memorandum M-2332

Page 5 of 5

University of Washington, Seattle, Washington, July 22

I talked with Warren Proctor regarding the current state of the nuclear-induction spin-echo memory. He has a scheme which involves the quadrupole moment of certain nuclei to provide the field within which the protons of the same nuclei can precess and hence store spin echos. This scheme would eliminate the need for an external magnet as in present spin-echo memories. To date, he has not been able to store information in this manner.

Also at the University of Washington, I saw paramagnetic-resonance measurements being made on ferroelectric potassium dihydrogen phosphate to investigate the magnetic state of electrons above and below the Curie temperature.

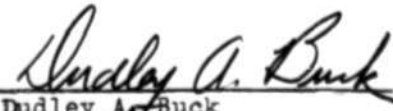
Engineering Research Associates, St. Paul, Minnesota, July 23

The memory work at ERA has progressed to a point where they are about to test one 32-by-32 plane using cores of the MTC type. The sensing winding was being installed when I was there. Coordinate wires will be tube-transformer driven; one-half of a 6AS7 will drive a transformer which uses one of their standard head-driver transformer cores (cup core of Ferroxcube 101--formerly Ferroxcube 1-90-1). Memory cores for this array were handled by an automatic machine during testing; the machine is being rebuilt for the smaller F-394 cores now being made by General Ceramics.

Armour Research Foundation, Illinois Institute of Technology, Chicago, Ill., July 24

A group has been set up to study metallic memory cores. They are starting a program to study switching time as a function of thickness and width, with and without magnetic anneal. They will investigate electropolishing instead of rolling for thin ribbons. Their first experiment will be to pulse various cores coaxially and with many small pickup windings around the periphery of a core; they will look for time displacement of the output voltage from one winding as compared to each of the others. This will tell them if switching begins at any certain spot on the periphery and progresses around, or if switching starts everywhere at once. Then they will tackle the ribbon width by making controlled batches of cores of various widths to see if switching starts at ribbon edges and progresses across. In the limit of very thin ribbons, they will use wire, and they are indeed optimistic that wire-wound cores will be easier of fabrication and superior in performance to ribbon-wound cores. The Foundation has much experience with fine-drawn ferromagnetic wires for wire recorders. They feel that the problems involved in rolling thin ribbons are overwhelming as compared to those involved in fine wire-drawing.

Signed

  
Dudley A. Buck

DAB/jk

Approved

  
David R. Brown