MASSACHUSETTS INSTITUTE OF TECHNOLOGY
DEPARTMENT OF ELECTRICAL ENGINEERING

Report No. 1

Prepared by D. A. Buck

PROGRESS REPORT TO THE DEPARTMENT COMMITTEE ON GRADUATE STUDY AND RESEARCH

SUBJECT OF RESEARCH: S. M. Thesis: An Investigation of Ferroelectrics for Digital Information Storage

Period Covered by this Report: November 23, 1951 to January 15, 1952

Student Working on Research: D. A. Buck

Building: Barta

Expected Date of Completion: May 16, 1952

Supervisor: Dr. A. R. Von Hippel

Detail of Work Currently Active: Pulse-testing of barium titanate ceramics to determine their suitability for digital information storage.

Expected Date of Completion of this Detail: February 15, 1952

PROGRESS

Since the thesis proposal was submitted (Digital Computer Laboratory Memorandum M-1335, 11/23/51) barium titanate condensers made from bodies supplied by the Glenco Corporation and by the General Ceramics and Steatite Corporation have been investigated. These bodies, containing certain impurities, were chosen because their hysteresis loops exhibit greater rectangularity than that of near-pure barium titanate (pure barium titanate is not ferroelectric at all!). In a visit to the Glenco Corporation, the needs of this thesis were discussed and both corporations have indicated a willingness to look for bodies with hysteresis loops of greater rectangularity.

Equipment has been assembled at the Digital Computer Laboratory to pulse-test single ferroelectric condensers in a way which closely approximates their operating conditions in a storage matrix. Voltage steps of from zero to 360 volts of either polarity are applied to the condenser under test by the discharge of a thyratron. Relays are used to reverse the polarity of the voltage and to select among two such voltages;

one of these is the read/write voltage and the other a lower-amplitude disturbing voltage. Application of the disturbing voltage simulates the condition to which an element of the storage matrix will be subjected when it is not the selected element. The setup is arranged to cycle at about thirty pulses per second in the following sequence: write--write--write--half-write--disturb--disturb--disturb--read. The first write pulse causes a current surge (about five amperes peak) which represents an "undisturbed ONE". Succeeding write pulses give "undisturbed ZERO's". The half-write pulse gives the noise contributed by a condenser which is not at the intersection of the selected row and column if that condenser contains a ZERO, while the disturb pulses give the noise if that condenser contains a ONE. The read pulse gives a "disturbed ONE".

The time required for the condensers to switch was found to be a function of the applied voltage. At the highest voltage studied one .025"-thick sample (38,000 volts/cm) of Glenco body "X-18" switched in 0.4 microseconds - much faster than expected. The area under the current-versus-time waveform for an undisturbed ONE was found to be twice that for an undisturbed ZERO at room temperature. The ratio of these two areas increased to about 5 to 1 as the sample was cooled below the -5°C transition temperature. Below the -95°C transition, however, no information storage was observed. The disturbed ONE has been difficult to observe due to equipment troubles. When changing from the read/write voltage to the disturbing voltage, the thyratron has a tendency to fire. Attempts to remove the transient associated with the change-over also slow the rise-time of the voltage step. On a slightly modified setup, however, body "X-18" retained substantially all of its information under fifty half-amplitude push button disturbances. This is the worst possible selection ratio (2-to-1) and therefore a most positive indication.

An attempt to fire a 4 x 4 matrix on a sample of this same body was a failure. The silvered electrodes blistered. Assurance has been given, however, that this problem will not be difficult to solve.

REFERENCES

C. F. Pulvari, "An Electrically Induced Permanent Memory", The Journal of Applied Physics, Vol. 22, No. 8, August 1951, pp. 1039-1044.

Dr. Pulvari has been able to store information in barium titanate in a somewhat different scheme. His two stable states are polarized and unpolarized. He goes from the former state to latter by heating with a short pulse of r.f. energy and in the reverse direction by cooling through the Curie point in a high field. He reads out by impressing an ultrasonic sound beam on the memory making use of the fact that barium titanate is piezoelectric when polarized. A visit was made to his Washington, D.C. laboratories.

Numerous other references were investigated but were found unrelated to the thesis problems. Data on fabrication techniques were copied down and may be of use when the Electrical Ceramics Laboratory fires experimental barium titanate sheets.

SIGNED Ludley A. Buck
Ludley A. Buck

APPROVED Walter J. Rigaian

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