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SUBJECT: TRIP REPORT: Trip to IRE, Bell Telephone Laboratories, Glenco, Naval Ordnance Laboratory, Professor Pulvari, Cavitron, Mullard, RCA, and NSA, March 23-31, 1954.

To: D. R. Brown

From: Dudley A. Buck

Date: April 13, 1954

Abstract: A trip was made to various laboratories investigating ferroelectric and ferromagnetic materials for information storage and switching. Information is listed by topics.

Ferroelectrics

Walter Merz of Bell Telephone Laboratories has made important contributions to an understanding of the switching mechanism in ferroelectric single crystals of barium titanate. He calculates that 180° domain walls in ferroelectrics are much narrower than in ferromagnetic materials--of the order of two or three lattice constants rather than several hundred. This is due to the small exchange energy (the equivalent of which is dipole-dipole interaction in ferroelectrics) and much higher anisotropy. Domain-wall thickness is of the order of the square root of the exchange parameter divided by the anisotropy. For this reason, 180° walls do not tend to move broadside through the material. Large numbers of dagger-shaped spikes of reverse polarization pierce the ferroelectric from electrode to electrode during switching. Formation rate of these domains of reverse polarization is a function of the temperature and applied electric field. At room temperature, very low fields applied for long periods of time eventually switch the polarization. This may mean that large numbers of half-amplitude disturb pulses will eventually switch a ferroelectric.

I saw a new batch of barium titanate crystals being removed from the growth furnace. Excess fluoride flux is poured off immediately so that its solidification does not strain the new crystals. These crystals grow in thin plates, twinned, and in a background of little cubic crystals, which modification also grows at the temperature they use but at a slower rate.

Reid Anderson of Bell Labs. has several 16 x 16 ferroelectric storage arrays in toggle-switch operation. Switching times are slow because of high-resistance evaporated electrodes. On the present matrices, the row and column stripes are 4 mils wide. The sheets are 2 mils thick and an electric polarizing process is used to make them essentially c-domain plates. Pulvari says they polish their plates down to a uniform 2 mils.

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Lee Johnson of Glenco has performed an experiment in which he switches a ferroelectric by dipping it in a hot bath, above the Curie temperature. Switching time of the order of seconds is exhibited and with a double-hump switching voltage at the condenser terminals. As the temperature of the bath is increased, the second hump gets larger and comes in closer to the origin. This experiment may shed some light on the switching mechanism proposed by Merz. I put the two men in touch with one another.

Pulvari has a new theory to account for the slow velocity of switching in ferroelectrics. Computed velocity, electrode to electrode, is about 300 meters per second, slower than even acoustical waves in the medium. His theory treats the statistics of the titanium atom jumping from one stable point to another in the lattice at any given temperature. Reams of numerical analysis have yielded velocities of the correct order and also have predicted coercive forces of the observed magnitude. Pulvari has a 10 x 10 matrix of individually selected condensers made from recrystallized ceramic sheets. His apparatus steps through the matrix at relay speeds, reading and writing in each individual cell. He plans to leave this development for the present and continue work on his ferroelectric-tape recorder.

Metallic-Core Fabrication

I visited the Naval Ordnance Laboratory, White Oaks, Maryland, to see the pulse-test equipment of Van Sant and Burnside. They are testing magnetic cores for magnetic-amplifier and switching circuits by observing current waveforms due to an applied voltage step. The step is generated by a hand-operated mercury relay and a battery, and measurements are made from scope photographs.

At the same Laboratory, I saw the two rolling mills, the Rohn and the Sendzimir, for making ultra-thin metallic tapes; vacuum melting and casting furnaces; and a hot-rolling mil. In one place, they have all the necessary equipment for compounding, melting, casting, rolling, wrapping, and annealing magnetic cores.

I had a very brief progress report on the work of the Corona group. They have been able to eliminate hydrogen annealing of their evaporated mo-Permalloy cores by using a heated substrate. Effectively, they are annealing as they deposit the core.

I found out that the electroplated-core project at Battelle Memorial Foundation is sponsored by the Michigan Bumper Corporation. RCA has volunteered to evaluate the square-loop material they are making.

Ultrasonic Machine Tool

We have been working with the Raytheon Ultrasonic Machine Tool for sometime on a loan basis and are now considering the purchase of one. I made a comparison shopping visit to Cavitron and International Electric

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(Mullard Distributors). Mullard has no machine for cutting and will not quote on one. Cavitron has a machine equal in every respect to the Raytheon machine but somewhat more expensive. I made a sample cut with the Cavitron equipment. It will satisfy our requirements.

Signed Dudley A. Buck
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Approved DRB
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