Digital Computer Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

SUBJECT: TRIP REPORT OF VISIT TO BELL TELEPHONE LABORATORIES, IBM, GLENCO NAVAL RESEARCH LABORATORY AND DR. C. F. PULVARI

To: David R. Brown

From: Dudley A. Buck

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Abstract: A trip was made at the conclusion of the thesis work on ferroelectrics for digital information storage and switching to compare progress and to exchange ideas with other researchers in this field. In addition, one visit was made to a cryogenics laboratory to obtain an opinion as to the feasibility of the magnetoresistive gate. During these visits, contact was made with workers in other fields which are of interest to this laboratory. The following summarizes briefly the visits.

A. FERROELECTRICS

1. Dr. C. F. Pulvari, Catholic University of America, Washington, D.C. Dr. Pulvari's work at present seems to be paralleling ours. His original scheme for ultra-sonic read and r.f. write has been dropped in favor of the scheme on which we are working. He feels that a materials development is the logical tack at this time. He has noticed, as we have, that thicker (.025") pieces of a given ceramic material seem to exhibit more nearly rectangular hysteresis loops than do the thinner (.010") pieces. Dr. Pulvari and his two assistants employ a novel and accurate method for testing ferroelectrics. A charge is "written" in the ferroelectric condenser under test with a pulse of the desired length (1/2 to 100 μs) and amplitude. A switch is then thrown which connects the ferroelectric to a coulombmeter which is viewed through a microscope. As the ferroelectric condenser is randomized by heating, jumps equivalent to Barkhausen discontinuities are observed, and total charge is measured. This method, while slow, gives accurate plots of charge stored by a pulse as a function of temperature, pulse length, and pulse amplitude. Dr. Pulvari was able to exceed the D. C. breakdown voltage of his ferroelectric condensers by using short pulses. Breakdown is believed to be largely of a thermal nature.

2. Mr. J. R. Anderson, Bell Telephone Laboratories, Murray Hill, New Jersey. Many single crystals of barium titanate have been grown. One matrix has been fabricated. Row and column driving problems are being attacked. Mr. Anderson and his assistant plan to have a coincident-voltage selection memory in operation at the earliest possible date.

3. Mr. J. M. Brownlow, The Glenco Corporation, Metuchen, New Jersey

Mr. Brownlow and myself have outlined an exploratory procedure for finding better ferroelectric ceramics for our purposes. For all samples, we have standardized on a sample size of 1/2" x 1/2", silvered, thicknesses of .011", .020" and .040".

The first investigation will be to eliminate silvering variations as a parameter. The silver paste that Glenco uses for fired electrodes contains a small quantity of glass to increase adhesion. A condenser whose electrodes are fired onto a ceramic body has a maximum dielectric constant only within a certain range of electrode firing temperatures, above or below which range the dielectric constant drops off. It will be determined if the properties desirable for memory applications also drop off in this way. It is strongly suspected that they do.

The second investigation will be to investigate crystal (grain) size as a parameter. .011" sheets of production body XB8 will be compared with samples to be prepared of XB8N, the same body with smaller crystals, and XB8L with larger crystals.

The third investigation will be to explore among different compositions, some containing lead titanate, to look for better bodies.

Ten samples, representing variations of XF8, X24, X56, X62 and XB8N were obtained for pulse testing. Hysteresis loops were observed at Glenco and certain of these looked about as good as the best ceramic samples yet observed.

4. Dr. D. R. Young, Advanced Development Laboratories, IBM, Poughkeepsie, New York. Dr. Young and his staff are growing barium titanate single crystals and at the same time working with ceramics for ferroelectric memory investigations. Their pulse-test equipment is essentially the same as ours. Their planning for ferroelectric research is on a large scale. Dr. Young and his staff will soon move into a 2-story building (plus basement) which will be used entirely for ferroelectric memory research.

B. THE MAGNETORESISTIVE GATE

Dr. R. B. Alers and Dr. R. T. Webber of the Naval Research Laboratory, Washington, D. C., report changes in the resistance of bismuth by factors exceeding 2×10^6 in high (35 Kilogauss) magnetic fields at 4.2° K (liquid helium). Even in moderate fields (700 gauss) changes by factors of 1,000 are observed.

Their work has been with bismuth crystals grown there. These crystals are grown at solder-pot temperatures, and as such are much easier to grow than barium titanate crystals. Some grown crystals are ductile, some brittle, depending on the orientation of the crystal axis with respect to the growth axis. Magnetoresistance is much lower in the commercially available "ductile bismuth wire."

Fabrication techniques for a bismuth multi-coincidence gate were discussed. Cooling bismuth in a glass tube, from the bottom up, and then sealing in leads would form a base on which many single-layer or multi-layer windings could be placed as control windings. Any control winding, acting alone, would be enough to increase the resistance by a large factor, turning the gate OFF.

These control windings, when matrix-connected, will make possible switching and other computer operations.

Bismuth is available at about $1 per pound. The group at N. R. L. gave a most favorable opinion as to the feasibility of this proposed computer component. They gave me 2 pounds of bismuth and wished me luck.

C. OTHER RESEARCH

1. Magnetic Amplifiers

Messrs. D. R. Scorgie, T. G. Wilson and N. W. Mathews of the Naval Research Laboratory have constructed an 8-stage ring counter and other computer-like devices using carrier-operated magnetic amplifiers like those of R. A. Ramey. The Ramey circuit has a one-half-cycle response time. Their work has been at 60 cycles and 400 cycles. Relatively thick (.001" - .002") Deltamax, Hypersil, and 4-79 Mo Permalloy ribbons have been used as wound-core materials.

A. B. Haines and B. E. Stevens of Bell Telephone Laboratories, Murray Hill, New Jersey, have made 60 cycle and 400 cycle magnetic amplifiers for the military. Their amplifiers are for the most part designed to control two-phase motors. I did see one very small core, however, which was part of a minaturization program. It was a wound Mo-Permalloy core without a porcelain spool, whose estimated dimensions are 25 wraps of 1/16"-wide tape, .200" OD. It was wound with many turns of fine (about #40) wire and plastic encased along with other circuit components.

2. Stepping Registers

Mike Haynes of IBM has advanced the stepping register art to somewhat higher speeds. His "slow" stepping register, using Deltamax, operates at 100 kc while the "fast" one, using 1/2" Mo Permalloy cores and IN56 germanium diodes (one per stage) advances at rates near one megacycle. He uses 3 advance pulses instead of the usual 2. They are interested in the stepping register as an element in computer control.

3. Magnetic Materials

A. G. Ganz, V. E. Legg, and P. P. Cioffi of Bell Telephone Laboratories, Murray Hill, are using ferrite cores for transcontinental TV 8-mc transformers. The windings, in order to achieve high dimensional stability, are plated in grooves cut in fused quartz cylinders. The primary, plated on one cylinder, is mounted concentrically with the secondary plated on a second cylinder and a cylindrical sleeve is placed between the two as a shield.

4. Germanium, transistors

Contact was made with a great deal of transistor work at Bell Labs. John Linvill, on leave from M. I. T., is working on the synthesis of linear circuits containing active elements. His recent work has been with a negative resistance transistor amplifier for line amplification. A transistor broadcast receiver was operated from a thermocouple. A Bunsen burner provided the source of heat, and a number of stations were tunable. Listening was by earphones.

IBM is growing their own germanium, but for transistors, they are using dismantled commercially available germanium diodes. Using jigs, one man can make up to 15 per day. They are making hole-cleanup studies and find that relatively impure germanium is often superior for pulse operation because of its short hole-cleanup time.

5. Miscellaneous

A very clever method for photographically recording pulse amplitude distributions of stationary time series was seen at Bell Labs. This method involved a cathode ray oscilloscope, a variable density filter and a high-contrast photographic plate. The pulse amplitude distribution curve occurs directly on the photographic plate.

Hall effect studies are being made at IBM to determine electron mobility in germanium. Also at IBM, I saw a paramagnetic resonance measurement equipment which involves a rotating disc.

At Bell Labs, I talked with R. O. Grisdale and C. L. Hogan regarding ferrites for their gyrator. They have a gyroscope model of the gyrator set up to demonstrate the phenomenon.

Signed Dudley A. Buck
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Approved DRB
David R. Brown

DAB/jk

cc: Group 63 Staff
J. Forrester
H. Fahnestock
R. Everett
N. Taylor
W. Papian
G. Briggs
J. O'Brien
R. Best
E. Rich
K. Olsen
J. Jacobs
P. Youtz