Digital Computer Laboratory
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SUBJECT: Trips to ERA and University of Illinois

To: R. R. Everett

From: C. L. Corderman

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Abstract: This memorandum reports on visits to ERA and the University of Illinois. Both groups are working on computers using Williams'-type memory systems with operation at 1024 spots per tube.

At ERA the proposed memory is undergoing tests in a setup similar to our STRT. Their measure of successful operation is the number of repetitive reads which may be carried out on a point without destroying adjacent information. The goal is a minimum of 1024 reads since this will allow a useful read operation between each regeneration.

The memory at the University of Illinois is an integral part of the ORDVAC machine and consequently is being tested under actual computer conditions. Using a test similar to the repetitive read test above, they encounter a few spots on about 10% of the memory tubes which have a maximum number of reads in the range of 10 - 20. Such spots are attributed to blemishes on the tube surfaces and repetitive operation on them is avoided by programming.

I visited ERA on the afternoon of December 27, 1951, spending about five hours at the plant in St. Paul. They have two people working full-time on Williams' storage, Edward Zimmer and Tom Rowan. Frank Mullaney is the Project Leador.

The equipment being used for tube testing is entirely in bread-board form mounted on a line of about six eight-foot racks. It accommodates five 5" cathode-ray tubes operating in parallel except for the deflection voltage. In this case, there is a common deflection voltage generator, but a separate cathode follower (1/2 5687) for each plate of each storage tube. The deflection is set up from either of two registers, one being a counter for regeneration and the other presettable for selection of any point. There are no temporary storage flip-flops provided so that cycling tests such as we use are not available.

The index for comparing tubes is the number of repetitive reads which may be carried out on any point before an adjacent dot is filled to the extent that it reads out as a dash. They felt the worst condition had been chosen in requiring tubes to pass this test at 1024 repetitive reads both in the center and at the four corners for the same focus voltage. As I understood it, it was not their practice to check every point in turn through the tube at 1024 reads for prolonged periods of time. This may account for the relative freedom from blemish troubles which they report. They feel that the major improvement in tube operation is to be obtained by having better focused guns with less deflection distortion. This feeling is apparently strengthened by the fact that most any point on a tube may be made to operate at 1024 reads by adjusting the focus voltage. I was able to observe a tube which they had under test at 1024 reads. No failures were produced in the center and two of the corners, but at the other two corners several errors were made. A slight change of focus voltage removed these errors.

They are using a 1 μsec. gate of about 18 volts for reading and/or writing a dot; and a 2 μsec., 28 volt gate for writing a dash. Since the gun is the 5UP and was being operated at 2,500 volts, these gates would give currents in the range of 3 - 5 μa. Although the charge used in sensing was admittedly a compromise between best readout and best digging of a dot "well", they did not feel that the separation of these two functions, nor the possible use of selective write, was worth the added complexity. The total operation time for a read or a regeneration was 6 2/3 μsec. They mentioned that better results were obtained when the deflection array consisted of four interlaced 256 spot arrays rather than the single 32 x 32. This seems to be a rather neat way of doing it. In this way, all points immediately adjacent to a test point are regenerated on an average of less than 1024 counts. There was no further improvement in going to 16 arrays of 64 spots each, however.

I got the impression that they were not completely happy with presently available tubes for 1024 spot operation at a 1:1 regeneration ratio but felt confident that improved tubes would be available and were actively engaged in building a memory system on this basis.

I arrived at the University of Illinois about 5:30 p.m. on January 3, 1952, and visited until 8:00 p.m. I was with Professor Meagher for 1 1/2 hours and spent the remainder of the time with Dr. Kintner, who is going to be in charge of ORDVAC at the Aberdeen Proving Ground. During the time I was there, ORDVAC was operating without any errors on a so-called "leap-frog" routine which is somewhat equivalent to our test program IIE, with the program being advanced one point in the memory after some number of correct solutions. The program takes eight minutes to proceed through the entire 1024 points after which a zero is typed out if there have been no errors; otherwise, a print out takes place which aids in trouble location. The teletype input is a definite handicap and a PETR is going to be added to the second machine of the ORDVAC type being built by the University. This machine is near completion except for the memory, and should be in operation by the end of the year. Williams'-type memory is planned for this machine also.

Although the need for programming to avoid spot interaction is present, Professor Meagher felt this to be preferred over an increase in the regeneration ratio either by timing or by decreased storage capacity. The same feeling prevailed here as at ERA, that improved tubes would someday remedy the situation. One interesting comment in answer to specific questioning was that the dot amplitude on readouts was about 10% less when most of the other spots were dashes than when they were dots.

A discussion of the error frequency in storage led to the conclusions that the two systems cannot be logically compared since our expected reliability is defined on the basis of margins which to them are non-existent, and subsequent program alarms are not unequivocally traced to storage. Before one is even able to quote error figures of this sort, it seems that something akin to our parity check is needed.

At the present time my feeling on interaction effects in Williams' tubes is that three distinct mechanisms are present. First, the residual beam current, which strikes the entire surface whenever any point is bombarded, has the effect of filling in dot "wells", both by raising the average level around a well and by reducing the well depth with secondaries from the area surrounding a well. The evidence for this effect is the deteriorated dot readout when the rest of the tube holds dashes. Second, the exponential region of the beam covers spots adjacent to a test spot with a much higher current than the residual current. However, its effect would seem to be the same. Finally, the secondaries which are released by the spot under test are able to fill adjacent wells as they spread out in a radial sheet toward the third anode. This is particularly true when the negative ring surrounding a well has been levelled off by the first two agencies and only the positive well remains. Successful operation is obtained when the Gaussian region is well-focused so that the high-current densities give relatively deep wells, which can then accommodate more filling before reading out as a dash. However, it would seem that with 5 μa. out of a 5UP gun at 2,500 volts and a throw of about 6" (3KP4), one is operating near the theoretical maximum current density. On this basis the remaining improvements will quite possibly come from a new gun design which cuts down the fringe currents and introduces less deflection distortion. Blemishes, while coming in for a good deal of discussion, could certainly be eliminated in processing or by choosing a different storage surface material.

Signed C. L. Corderman

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