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Memorandum M-1347

Ligital Computer Laboratory
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SUBJECT: LISCUSSION OF MAGNETIC LRUM SYSTEMS AT ENGINEERING RESEARCH ASSOCIATES, 27-28 NOVEMBER, 1951

To: J. W. Forrester

From: E. S. Rich

Late: Lecember 7, 1951

Abstract: Representatives of this laboratory visited Engineering Research Associates in St. Paul for a two day discussion on magnetic drums. An outline of the status of the work done by E.R.A. indicates that satisfactory progress is being made. The buffer drum system was discussed in considerable detail and several major changes were requested in order to permit the use of this drum in our applications. Satisfactory agreements were worked out on these points and E.R.A. will revise their plans accordingly. Some details of circuitry were discussed. They have plans for using ferrite material in the cores of their magnetic heads. Final decision on whether this material can be used will be made after it is learned whether the desired core shape can be obtained by a molding process rather than by machining. The use of ferrite core materials promises an attractive simplification in their writing circuits. A schedule for breakdown of power wiring to provide marginal checking facilities was also worked out.

The following men were present for a discussion on magnetic drums at the Engineering Research Associates, St. Paul, on 27-28 November, 1951: from E.R.A., Jack Hill, Bill Butler and Bob Eulberg; from M.I.T., Taylor, Wieser, O'Brien, Walquist and Rich. The principal items discussed were the present status of their work, the changes in the systems which we thought necessary, and various details of circuitry.

A. STATUS OF WORK BY E.R.A.

1. Fabrication of the Magnetic Lrums. They estimate the magnetic drums to be about 80% complete. The work which remains to be done includes machining the surfaces of the drums, boring holes in the jacket for the magnetic heads, and reaming for the bearings.

2. Electronic Components. They have made a rough estimate of the electronic components which they are sure will be needed and have placed orders for these, particularly for items which they believe will be difficult to obtain. The parts ordered comprise approximately 80% of the total components needed. Remaining components will be ordered when a more detailed analysis of circuit design has been made. With present delivery schedules they do not expect to be able to obtain all the needed materials before July, 1952.

Crystal diodes were the one item which appears to present a bottleneck at the present time. They had decided to use Sylvania glass crystals but learned that the type they want (1N56A) is virtually unavailable. They have General Electric as an alternate supplier, although no order has been placed with them yet. We suggested that they contact Kemtron for availability of the crystals they need. It appears that they have little success in previous dealings with Kemtron, but we indicated that we could probably assist them in obtaining needed crystals from Kemtron.

3. Power Supplies. They plan to use motor generator sets for the d-c supplies and have placed orders for these. They had a question on what sort of supplies would be used for filament power. We informed them that within a week or two we would know whether we will have a filament supply of sufficient capacity to handle their drums. As a safety measure, however, they are planning to order an Inductrol regulator system from General Electric Company which can be used to supply regulated filament power. This unit costs in the neighborhood of $800 and therefore there would no hesitation to cancel the order later if necessary. They inquired about what type of primary power we can supply and were told that a 230 volt, 3 phase, 3 wire system would be the best choice. We agreed to make a week's recording of the voltage variations that occur on this line.

4. Cabinets. They have ordered materials for the metal cabinets for the equipment. These cabinets are to be 24" wide and 81" high and have been ordered in three 10' sections. It is estimated that the two drum systems will occupy approximately 12' and 18' of cabinet space respectively. This amount of cabinet space includes a safety factor so that it would take care of expansion of the systems at a later date. The changes in the buffer drum system which we requested will require some of this extra space. It is planned to mount the magnetic drums within these cabinets along with the circuits so that the only unit which must be located separately is the motor generator set. It is their plan to have all wiring to these drums come through the top of the cabinets. They estimated that approximately 7 k.w. of heat would be displaced in the two systems so that we should probably plan for at least 10 k.w. of air conditioning capacity.

5. Drawings. They estimated that their schematic drawings were about 80% complete. These drawings are suggested layout drawings of standard circuits on their standard chassis. A considerable amount of this work will have to be redone as a result of changes which we requested during our visit.

6. Magnetic Heads. At the present time they are hopeful of being able to change their head design from the use of metal core material to the use of ferrite cores. The use of the ferrite material, since it has a higher incremental permeability, permits one to cut down the MMF needed to accomplish recording, and their experience indicates that the use of such heads in conjunction with a red oxide coating on the drum will permit them to use a much simpler circuit. Specifically, they feel that this reduction will permit them to use a type 7AK7 tube for the recording circuit and thus combine the amplifier and gate. The biggest question on whether ferrite material can be used is a question of fabricating the cores. The experimental units which they have used to date were obtained by machining. There is some question whether they can be fabricated simply by a molding process. They hope to obtain an answer to this question by January 15, 1952 and therefore are not going to make a decision about the recording circuits until that time. Hill stated that he would place an order for sufficient ferrite cores to be shipped as part of an experimental group in July of next year. If these cores did not prove to be satisfactory it would be possible to obtain the necessary cores by machining, although at a considerable expense.

7. Packaging. They plan to use a new type of plug-in chassis which has been developed by another group at E.R.A. Principal changes in this new chassis are provision for using regular size tubes as well as miniature tubes. Also they are planning to use a screw type lug for mounting crystals to avoid soldering.

They have decided to discard the use of the type 5687 tubes and have chosen types 6AV5 (G.E.) and 6AU5 (Sylvania) as substitutes for hard tube writing circuits. These tubes would not be necessary for the single heads if they can use ferrite core materials, but they will be necessary for use with the dual heads since these can not be readily adapted for the ferrite cores.

B. CHANGES IN SYSTEM DESIGN

A considerable portion of the time during our visit was spent in discussing the block diagram layout of the buffer drum. The changes which we requested were the result of our study of the intended applications of this drum. The following changes in the system were agreed upon:

1. Angular Position Counter. They will design the flip flops of the counter so that output signals can be obtained to drive a matrix switch. Furthermore they will provide a matrix on three of the flip flops so that an 8 position output switch will be included. The outputs of this switch will be capable of driving two gate tubes each.

2. Coincidence Detector. They have decided to use 7AK7 gate tubes for the coincidence detector and has been planning to mix the outputs of all 11 digits into a single inverter-gate tube combination. We requested that they provide for three different coincidence pulses so they will separate the coincidence gates in such a manner that mixing will be done to three inverter-gate tube combinations to give the three coincidence pulses which we want.

3. Storage Address Register. The storage address register will be wired so that the left 11 digits can be cleared independently of the right 4 digits. We found out that they plan to construct one digit each of the angular position counter, the coincidence detector, and the storage address register on a single chassis. Actually, two such digit columns will be built on a chassis but will be independent of each other. The interlace between the storage address register and the angular position counter can be obtained by appropriate interconnection of the digits of the address register and of the counter.

4. Reading Amplifiers. They considered that it would be impossible to use a single set of reading amplifiers to read from one of four different groups of heads where recording was going on simultaneously in one or more of the other groups. To get around this problem it was agreed that they would provide two sets of reading amplifiers. Since it seems that we will also want to be reading from other groups of heads for functions not involving the four groups mentioned above, they are going to provide a third set of amplifiers which will be tied in with the group selector matrix for switching by the computer. To take care of equipment which may be reading from the drum entirely independently of the computer, a fourth set of reading amplifiers appears to be necessary.

Of the total of 64 reading amplifiers only 32 will be needed initially. Therefore they will plan to include 32 amplifiers with the equipment to be furnished on our present order, and will supply the additional 32 amplifiers upon receipt of a separate order.

5. Input and Output Registers. Since we cannot foresee any need for the input and output registers which we called for in the original proposal, it was agreed that these registers would be omitted. This partially balances the additional circuitry called for in the reading amplifiers.

On the auxiliary drum two slight changes were agreed upon. They are going to separate the storage address register so that the left 11 digits can be cleared independently of the right 4 digits. They also

are going to insert a 2 microsecond delay into the coincidence pulse line. This delay will permit a saving of about 6 microseconds in the read-pulse timing. A 2-microseconds value was chosen because they consider their flip flops require about this length of time to switch.

C. CIRCUIT DETAILS

Several of the details of their circuits were discussed and the following points are significant:

1. Pulse Length. They would like to use 0.5 microsecond pulses in their system instead of 0.1-0.3 microsecond pulses. It was learned that their flip flops will trigger satisfactorily on 0.1 microsecond pulses so it appeared that there will be no reason for them to retain the short pulses within their equipment. Therefore it was agreed for them to go ahead with the 0.5 microsecond pulse design with the understanding that we may have to standardize a few of the control pulses which pass between the drum system and the computer to obtain proper operation. The number of places where pulses will have to be lengthened or shortened should not be very large.

2. Single Wire Terminals. In a letter from Butler it had been stated that they intend to use "single wire terminals" for connections between the drums and the computer. This terminology refers to the way in which flip flops are set and means that inputs are provided only to the "1" side of the flip flops. Before a number can be read into a register the register must first be cleared. This is the same method which we use in WWI.

3. Magnetic Heads. There is a duty factor limitation in writing with magnetic heads which is imposed by heating within the cores. For the metallic-core heads writing should be limited to an average of 16 microseconds between pulses. With the ferrite heads they felt there might also be a similar limitation but as yet this has to be determined experimentally.

Transients produced in the reading amplifier as a result of switching between heads or of writing with a head disable the reading circuits for various lengths of time. If a head is to be used for reading following a writing operation, a minimum of 50 microseconds and preferably 64 microseconds is required for the transient to die out. If a head is to be used for reading following a switching operation a minimum of 16 microseconds and preferably about 30 should be provided for the transient to disappear. In switching from reading to recording, however, no delay is required so that a recording can take place on the next time pulse or 8 microseconds after switching.

4. Dual Heads. The dual heads that will be furnished with our equipment will be spaced 32 drum registers apart. Adjustment of the spacing between these heads will allow a change in separation by ±1 register. These heads are so designed that different spacings could be obtained if desired. The minimum separation is about 25 registers and maximum is 79 registers. This separation is controlled by the position at which the head casings are soldered on to the holder. They have not yet fully decided whether the two heads can be used interchangeably for reading and writing. At present they think this will be the case.

The buffer drum will be provided with 12 dual heads. If one wished a drum with all dual heads their present design would permit 4 such heads per axial inch, making a total of 56 heads on the 14" drum. They are making studies of the use of more than one head per track and have obtained successful operation of circulating registers in the laboratory. They are promoting the idea of using the term "revolver" to describe a circulating register.

The dual heads which will be used for the auxiliary marker channels on the buffer drum require a continuous erase. At present they propose to do this by means of a permanent magnet.

5. Spares. They are planning to provide spare parts for the drum equipment and have included this in their original contract price. These spares will be complete plug-in chasses and there will be a minimum of 10% of these spares. In cases where the same plug-in unit is found in both drums the spares will be figured on the basis of the total number of identical units in the two systems. They expect to have extra panel space in each of the two systems. After about September of next year they expect to stock standard panels and standard chasses so that these could be purchased at any time after that by a special order.

D. MARGINAL CHECKING

O'Brien and I examined their circuits in detail with Butler and Eulberg and worked out a plan for providing voltage variation in the drum systems for marginal checking purposes. We decided that the power wiring to the equipment should be grouped as follows for marginal checking:

1. Flip flop plates. (2 lines each)
   a. Angular position counter
   b. Storage address register. (left 11 digits)
   c. Group address register. (right 4 digits of SAR)
   d. Control flip flops and angular-coincidence-detector-alarm flip flop

2. Gate tubes. (1 line each)

   a. Angular-position-counter carry gates
   b. Storage-address-register carry gates
   c. Gates in control circuits and ACL alarm
   d. Output gates on reading amplifier
   e. CL series gates

3. Reading amplifiers (1 line each)

   a. Status head amplifiers
   b. Auxiliary marker amplifiers
   c. Information channel amplifiers
   d. Timing track amplifier
   e. Bracket track amplifier

4. Writing amplifiers. (1 line each)

   a. Status track writers
   b. Auxiliary marker writers
   c. Information track writers

The above breakdown of marginal checking requires a total of 21 voltage variation lines. It may be true that this breakdown is finer than is necessary but if so there will be no problem in combining some of these lines at a later date to reduce the number of voltage variation circuits.

SIGNED E. S. Rich

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