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SUBJECT: DISCUSSION OF MAGNETIC DRUM SYSTEMS AT ENGINEERING RESEARCH ASSOCIATES, MARCH 25 AND 26, 1952

To: J. W. Forrester

From: E. S. Rich

Date: April 11, 1952

Abstract: The writer visited Engineering Research Associates, St. Paul, on March 25 and 26 to discuss their progress on the two magnetic drum systems being constructed for this project. In general, it seemed that satisfactory progress is being made and that no bottlenecks of procurement are in sight. However, scheduled delivery dates of a few critical components are close to the scheduled dates for construction so delay is possible if delivery schedules are not met. Their estimate for delivery of the Auxiliary Drum System was October 1952 and for delivery of the Buffer Drum System was January 1953. Some information on the mechanical characteristics of the two systems was obtained to assist us in planning room layout and power distribution.

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1.0 INTRODUCTION

The writer visited Engineering Research Associates, St. Paul, on March 25 and 26 to discuss the status of the work on our purchase order for two magnetic drum systems. J. L. Hill, W. W. Butler, and R. Eulberg were present from ERA for all of the discussions. Larry Reed, who is in charge of the mechanical design of these systems, was also present for some of the discussions.

2.0 PRESENT STATUS

2.1 General

The group working on our magnetic drum systems has recently moved to new quarters where the design, assembly, and test of our equipment will be carried out. Our drums are to be constructed in parallel with two other jobs for other customers. Some breadboard units of parts of the drum systems are now set up and are undergoing tests. The breadboards built to date are for the purpose of testing circuits which are essentially similar in all of the systems.

2.2 Auxiliary Drum

As was originally planned, the auxiliary drum is progressing ahead of the buffer drum. That part of the fabrication of the drum itself which had to be done outside the facilities of ERA has been completed, and the remaining phases of its construction are proceeding on schedule. A working block diagram of this system has been completed and the circuits have been broken down sufficiently to show all necessary types of chassis layout and numbers of plug-in chassis required. There are eleven different chassis types in this system. Their actual arrangement in the cabinet and therefore their interconnections have not been completely settled.

2.3 Buffer Drum

The fabrication of the buffer drum is somewhat behind that of the auxiliary drum. The casting into which the rotor is to be mounted was ruined by an error made by the outside vendor so a second casting had to be ordered. As yet this has not been received but the delay which has occurred is expected to cause no difficulties. Some work has been done on chassis layouts and chassis arrangement in the cabinets but several decisions remain to be made. Some of the special circuits in the system, particularly the switching circuits, have yet to be designed.

2.4 Circuits and Components

2.41 Writing Circuits

In a letter from W. F. Winget dated February 5, 1952, a new type of writing circuit was described which would permit more uniform recording-pulse signals than other systems have had. This new circuit was studied in some detail and it appeared to be satisfactory and to have definite advantages over the other methods used. Basically, it consists of two flip-flops and two gate tubes for each recording head although it utilizes only one 12AU7 and two 7AK7's. Each flip-flop is made up of one triode section in the 12AU7 and the cathode, control grid, and screen grid of one 7AK7. This means that the gate circuit and part of the flip-flop circuit are contained in a single 7AK7. This circuit is utilized so that the 7AK7 is normally completely cut off so that gate signals applied to the suppressor of the 7AK7 have no effect on the flip-flop. In fact, they pointed out that it is possible to design the circuit so that the flip-flop is inherently monostable. This would further insure that the flip-flop is always in the position which holds the 7AK7 cut off whenever a gate signal is applied to the suppressor grid. In this circuit the 7AK7 drives the recording head winding through a suitable transformer. The flip-flop is for the sole purpose of stretching a standard 0.5 microsecond timing pulse into a 1.5 to 2.0 microsecond writing pulse. The width of the writing pulse is controlled by a delayed "shut-off" pulse which is common to all writing circuits. By a simple rearrangement of the input leads, the information to be recorded can be supplied either as gating signals or as pulse signals. This means that the same circuit can be used in each of the two different types of recording circuits which are called for on the buffer drum.

2.42 Reading Group Switching

ERA has been unable to obtain response from Kemtron on the procurement of type 1N56 crystals which they originally planned for the reading-group switching circuits. In the meantime they have been investigating the new GT-10 series junction type diodes manufactured by the General Electric Company. The high current capabilities of these crystals make them appear to be even more desirable in the low impedance reading head circuits than the type 1N56. They have been negotiating with GE to re-package crystals similar to the G-10 series into a cylindrical unit about the size of a two-watt resistor. They have been informed that this should be a straightforward job and that they will receive samples the first of June, and if these are satisfactory, production quantities can be obtained by the first of August. The principal reason for wanting a redesigned package is to reduce the shunt capacitance of the diode. Excessive shunt capacitance would tend to cause some cross talk from non-selected reading heads. Actual tests have been made using GT-10 diodes, and it has been found that these will function satisfactorily provided it were impossible to get the new diodes on time.

A particularly desirable feature of this type of diode is that it has a low A-C resistance when sufficient D-C current is passed in the forward direction. ERA has specified to GE that these crystals have an A-C resistance of no more than 12 ohms at a frequency of 100 kc when 5 milliamperes D-C are flowing in a forward direction. The D-C forward resistance under such conditions is approximately 50 ohms. A definite order for a production quantity of these units has been placed with GE. At the present time they do not know of any equivalent unit which might be obtained as a substitute.

2.43 Tubes

They have selected type 6BL7 tubes for drivers for reading-group selection. Large currents are required for this job since 5 milliamperes per switching crystal must be provided. The 6BL7 was chosen to replace the 5687 which had formerly been used in this circuit. They have several of these tubes on life test at the present time to determine whether interface or poisoning troubles are apt to be encountered. The conduct of the life test and the pulse testing methods used seem to be adequate to spot difficulties of the types which we have run across in other tubes in this laboratory. The life test to date has run approximately 800 hours and no deterioration has been observed.

2.44 Pulse Timing

One point with regard to pulse timing in the buffer drum was brought out. This has to do with the fact that timing pulses which eventually accomplish recording are routed through the external circuits of the multiple input counters (input buffer registers). They have determined from experience with previous systems that the relative timing between pulses which write information and later pulses which alter this information must be held within 0.25 microsecond in order to obtain adequate alteration. This leeway is approximately the tolerance of the timing-pulse generating circuits themselves so it is essential that compensating delays be introduced at critical points to insure that the writing and the altering pulses have the same timing. Approximate estimates of these delays can be made in advance but final adjustments of them probably will have to be done when the system is integrated with the Whirlwind computer.

2.45 Relays

The relays which are needed for writing-group selection on the auxiliary drum will be Clare type R relays. These are small aircraft type relays similar to type K except with a slightly larger coil. They will be mounted in a standard plug-in chassis that can be fitted with dust covers. Although these relays do not have twin contacts, the effect of twin contacts will be obtained by using contacts on two separate relays in parallel. They will arrange the circuit so that either one or the other of each pair of relays can be disabled in order to check the condition of each relay contact. This appears to be a very satisfactory arrangement for this switching system and one which should be relatively trouble-free.

2.5 Mechanical Design

2.51 Magnetic Heads

ERA is negotiating with the General Ceramics and Steatite Corporation to obtain satisfactory molded ferrite cores for their magnetic heads. Two batches of samples have been submitted to date, the first of which was unsatisfactory from a mechanical standpoint, and the second one unsatisfactory from an electrical standpoint. Some upset was experienced by General Ceramics when they broke their die but it is expected that the third lot of samples due the first of April will be satisfactory in all respects. ERA is going ahead with plans for providing heads with ferrite cores in our systems. They have finished the design of a plastic holder for mounting the new cores in their standard shroud. This head cartridge will have four pins for connection to the cable plug. These pins are wired so that two pins are used in parallel for each of the two connections required. This is intended to minimize any difficulty that might arise from poor pin contact.

Experience both by Burroughs and by ERA that head inserts on drums have become loose after a period of time has led to the development of an improved method of fastening the steel inserts into the drum casting. These inserts now are staked at four points in addition to being pressed into the drum casting. This procedure makes the head mounting much more stable and should definitely avoid any trouble of the type encountered by Burroughs.

They have recently finished six production models of their latest dual head design, the first model of which is now undergoing tests. Dual heads are also to be used on a storage system which they are now constructing for another customer. The two types required by this customer have greater spans between the two single head units than we had requested for our system. Inasmuch as the present dual heads have metallic cores, ERA does not intend to standardize this design and therefore plans no further production beyond what is needed for the drum systems now being built. They have requested that we use the same head span that will be provided for this other customer since their present design is a difficult production item. They intend to develop a dual head using ferrite core materials which they probably will standardize. The nominal spans for the heads to be built for the other customer are 0.820" and 0.653" measured at the surface of an $8\frac{1}{2}$" diameter drum. The heads which we requested would require a span of 0.417". I agreed to inform them as soon as possible whether we could accept one of the types with a larger span.

2.52 Cabinets

The mechanical design of the drum cabinets is essentially complete. The auxiliary drum will be an entirely separate unit from the buffer drum. Its cabinet will be 117" long x 85" high x 30" wide. This cabinet will be divided into three bays, one of which will be used for the drum and voltage regulator circuits, and the other two for mounting plug-in chassis. The height dimension given includes space at the bottom which is utilized for an air duct as well as the space at the top in which filament transformers will be mounted and along which all wiring and cabling can run.

The buffer drum will be mounted in a cabinet having the same height and width dimensions except it will contain five bays and have a total length of 195". For shipping purposes this will be divided into two sections, one containing three bays and the other containing two bays. On receipt at our laboratory these two sections will be bolted together and become an integral unit. On both cabinets, double doors each 18" wide will be provided on both the front and the back for access to each bay.

They have determined that one should not attempt to supply cooling air to more than four bays through ducts of the size which will be provided in these cabinets. This means that the two drum systems can not be set end to end and cooled from a single input. A separate duct input, therefore, must be provided for each drum. In the case of the buffer drum, one bay containing the magnetic drum does not require cooling. An air duct opening is 9 3/4" high and extends across the width of the cabinet. The top of this opening is 16" from the floor.

2.53 Air Conditioning

The cooling-air requirements which have been used in the design of the air ducts are approximately as follows. Air should be supplied at the input at a static pressure not less than ½" of water and at a temperature not exceeding 60°F. Since this air will be warmed as it enters the cabinets the dew point can be between 50° and 60° F. They figure a minimum flow of air of 200 cubic feet per minute is needed per kilowatt of dissipation. The calculated dissipations are 7½ kw for the buffer drum and 3 kw for the auxiliary drum.

2.54 Cabling

It is definitely agreed that all wiring and cables will enter the drum cabinets from overhead. There will be space in the top of these cabinets for cables to be distributed along the panels. It was decided that the signal cables would be planned so that they will connect at suitable points on the wiring frame rather than to a central terminal strip. This arrangement permits connecting jacks to be placed close to the signal destination and eliminates the extra connection on the terminal strip. They will be able to furnish us with a list of cables needed showing approximate distances between the connecting jacks and the entrance to the cable duct in the cabinet.

2.55 Motor Generator Sets

The source of D-C voltages for the two drum systems will be a set of two generators driven by a common motor. One generator will supply +250 v. and the other will supply -125 v. These machines are standard commercial items and have been ordered from Star Kimball, 200 Bloomfield Avenue, Bloomfield, New Jersey. The motor is a $7\frac{1}{2}$ hp, 220/440 v., 3 phase machine. Its NEMA frame number is 284. The 250 v. generator is rated at 3 kw and has a frame number 254. The 125 v. generator is rated at $\frac{1}{2}$ kw and its frame number is 203.

2.56 Installation Drawings

Larry Reed, who is responsible for the mechanical design of these systems, plans to be in Cambridge during the last of April for the delivery of some drum equipment to the AFCRC Laboratories. He will plan to visit our laboratory for at least one day to discuss the mechanical features of our drum system. It is expected that he will bring completed drawings of the cabinets for use by our installation group.

3.0 SCHEDULES

The importance of planning schedules for delivery of the two drum systems as it affects other work which we have to do was discussed to some extent. Since mention has been made that the buffer drum is more vital to our program than the auxiliary drum, ERA was questioned as to whether any advantage would be gained in scheduling the delivery of the buffer drum first. Their comment was that trying to produce the buffer drum first actually would not speed its delivery significantly. They prefer to furnish the auxiliary drum first since it is a simpler system and it uses many of the same chassis which are contained in the buffer drum. In a sense, testing the auxiliary drum will assist in the buffer drum testing by making it possible to debug most of their new circuits in a relatively simple and standard system.

Their schedule for construction of the auxiliary drum is approximately as follows. The cabinet will be finished about May 15, wiring of the frame will be done during May, June, and part of July. Testing will then go on until about the end of September, and delivery, therefore, will be made around October 1.

The schedule of the buffer drum is not as well defined as that of the auxiliary drum since its design at present has not been as thoroughly worked out. They estimated that wiring of the frame would be done in July and August, and that testing would occupy the remainder of the year. Delivery might be expected around January 15, 1953.

These schedules, especially that of the auxiliary drum, should be regarded as tentative since they depend on delivery of components from vendors. The delivery date for one critical item is close to scheduled dates for construction, so delay is possible if delivery schedules are not met.

4.0 POWER DISTRIBUTION

At the time of my visit, ERA had not made definite plans for power distribution for the drum systems. During my visit we discussed a rough outline of the system they may use. In general, this is much less complex than the Whirlwind I system.

The arrangement of power distribution will be basically as follows. Filament power will be cycled on and off by the controls provided on the Whirlwind alternator. We will provide a 48 v. signal after the filaments are up to normal voltage which can be used to actuate the relays which turn on the D-C power to the drum circuits. They will arrange the necessary relay circuits to insure that bias voltages are applied before positive voltages are on. This 48 v. signal will be distributed through the following additional control circuits to each of the two systems: (1) an on-off switch located in the control room, (2) a local on-off switch at the drums, (3) a relay contact which is closed when filament voltage is available, and (4) a contact on a protective thermostat in the drum cabinet. This arrangement of controls makes it possible to shut down one drum independently of the other but no plans are intended for shutting down only a part of one system. In addition to contactors in the lines which distribute the various D-C voltages to the equipment, a Heineman circuit breaker will be provided in the line from each generator to the regulators within the drum cabinets.

They agreed that the drum motors should probably be turned on when heater voltage is first applied to the systems. Additional start and stop controls for each of these motors will be provided adjacent to the respective drums.

They do not plan to provide fuses for sections of the drum circuits, but rather will have a single fuse in the regulator for each different supply voltage. There did not seem to be any need for elaborate blown-fuse indication such as is contained in Whirlwind. Indicator lights in the control room that seem necessary are the following: drum power, filament power, negative voltages, and positive voltages. They provide fuses in the primary windings of all filament transformers. These fuses are paralleled with neon lamps located along the top of the frame near the associated transformer. To locate a blown fuse, therefore, it is necessary to examine the lamps in the rack.

5.0 TESTING

Possible tests which will be applied to the drums before shipment were discussed briefly. It was learned that they do not plan to perform elaborate systems tests in their laboratories. Their tests will be primarily for the purpose of determining that individual circuits function properly.

In order to go much beyond this point it would be necessary for them to set up a rather complicated control to simulate the functions of the computer. This would be particularly hard to do in the case of the buffer drum. From their past experience they feel that the circuit testing which they do is rigorous enough to guarantee a minimum amount of difficulty in getting the equipment to operate when integrated with the system.

Their design seemed to allow no convenient way of providing trigger inputs to all flip-flops so that they could be marginal checked by a complementing procedure. Since the number of flip-flops contained in this equipment forms a relatively small part of the total system it seems reasonable that adequate marginal checking of the flip-flops can be done using a computer program. Both local and remote flip-flop indicator lights will be available.

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