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Electronic Computer Division
Servomechanisms Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

To: Whirlwind Planning Group

From: E.S. Rich, J.A. O'Brien, N.H. Taylor

SUBJECT: A VISIT TO:

Engineering Research Associates
St. Paul, Minnesota

Aircraft Radiation Laboratories
Wright Field
Dayton, Ohio

General Precision Laboratories
Pleasantville, New York

Federal Telecommunication Laboratories
Nutley, New Jersey

Date: January 6, 1949

The week of December 12 to 16 was spent by J.A. O'Brien, E.S. Rich, and N.H. Taylor in visits to Engineering Research Associates, St. Paul, Minnesota, Aircraft Radiation Laboratories, Wright Field, Dayton, Ohio, General Precision Laboratories, Pleasantville, New York, and Federal Telecommunication Laboratories, Nutley, New Jersey. This report discusses the impressions gained on these visits and a general evaluation of what they are doing as it may apply to the future activities of Whirlwind.

Engineering Research Associates in St. Paul, Minnesota, is a company of some 550 employees with a staff of about 150 engineers. They have some 16 projects which deal mainly with the problems of information handling, and most of their work has to do with the digital type of information processing. The principal persons whom we met are the following: Dr. Engstrom, Mr. Norris, Captain Creaser (Navy), Mr. Hill, and Mr. Butler.

During our one day visit to this organization we visited and discussed 5 projects. The first is a complete computing system which is a portion of Task 13 from the Bureau of Ships. This computer uses magnetic drum storage with an 8 millisecond access time. It will have some 2500 vacuum tubes, most of which are 6AS6 gates, and 12AU7 flip-flops. Some

5687 tubes and 6AN5's are used for driving purposes. As far as we could gather, the arithmetic element and the control were patterned very largely after the Whirlwind system. The pulse rate is 400 kc. Delay lines are used instead of the carry register, but a high speed carry which by-passes these delay lines is also available. The mechanical layout of the system is very similar to Whirlwind, except a great saving in space has been realized by utilizing the third dimension and folding the panel boards along the sides of the tubes. A two digit B register becomes a package about 12 x 6 x 6 inches. The whole 24 digit arithmetic element can be housed in a rack about 14 feet long by 7 feet high by 18 inches deep. The connections between racks or digit columns were only 6" long and were open wire lines mounted on plastic standoffs on the rear of the racks. These open wire lines were at an impedance level of 100 ohms and the lines were about 1/2 inch apart and about 1" above the panel. They have had no trouble as yet with cross talk between these lines.

The only components mounted on the rear of the racks were bathtub condensers used to decouple the push button lines.

The power lines were also open wire and were spaced about 1/4" apart and perhaps 3/8" away from the rack. With the exception of the bathtub condenser being mounted on the rack all other construction and components were JAN approved.

One tenth microsecond pulses are used. Pulse transformers similar to Whirlwind units are used throughout.

Multiplication time of 300 microseconds is achieved.

The multiple position switches, 32 and 64 position, were patterned after our 32 position switch, and a translator similar to our control matrix was indicated. ERA engineers stated that most of their basic designs originated from the Whirlwind reports which they had studied in great detail, and that such refinements as they had added were possible due to the 5 to 1 reduction in speed and other changes in their over-all specifications which allowed them some flexibility in design. The part of this project which we were able to visit made us feel that Whirlwind II as we have sometimes planned is in essence being built at ERA.

J. Hill told us quite a bit about their magnetic equipment, about the same information as is contained in their report on the same except that they have doubled the density of storage to about 1200 digits per square inch. The magnetic heads are spaced about 0.002 inches from the surface of the drum. The adjustment is made possible by a differential screw arrangement in the mounting. The magnetic head is molded into a threaded cylinder of about 7/16" in diam. and 2" long. The threads are 32/in. This mounts in a collar which is threaded at a pitch of 32/in on the inside and 24 threads per inch on the outside. This collar is then screwed into the mounting plate covering the drum. Thus if the head is prevented from rotating when the collar adjustments are made, then one turn of the collar will advance it approximately

10 mils. Back lash of the threads is prevented by partially cutting the collar perpendicular to its axis and then distorting it so that the threads are under spring tension at all times.

The gap in the magnetic head is only one mil in width and is controlled by a 1 mil strip of silver foil that is inserted in it. This silver foil is very important, because of the eddy current effects.

The space allocated on the drum for recording one digit is about 62.5 x 12.5 mils. Spots are 80/in along the periphery and the tracks are spaced 1/16" of an inch apart. They used to be 1/8" apart. They have recorded 120 pulses per inch along a track. The actual recorded spot is only 6 mils by 30 mils and is centered in the assigned space or cell.

The drum that we observed was about 8 inches in diameter, and it rotated at 3600 revolutions per minute.

We were next shown the operation of the storage by means of a control unit and neon lights on flip-flop registers. The visible part of the control was an extremely compact collection of neon lights and push buttons. We should inquire further about their push buttons and associated circuits.

Mr. Hill was able to show us by pushing push buttons(setting up operations and addresses in control) all of the operations on storage; reading, writing, writing opposite numbers in adjacent spaces, and selective writing which is similar to our td operation.

The second project we visited has to do with a photoelectric reader of punched paper tape. This equipment reads in parallel 7 hole tape at a rate of 400 lines per second. This equipment may prove very useful as a part of our input output medium. We have requested block diagram drawings and a price on this equipment.

The third project has to do with high speed printing of decimal numbers or alphabetical characters. This equipment can display on an oscilloscope 1500 characters per second. These may be photographed from the face of the scope by high speed films. This contract is under the control of the Bureau of Standards and is aimed at printing some 10,000 characters per second. The technique used is to engrave on a magnetized plate the necessary information in the X, Y, and Z coordinates so that magnetic pickup receives the proper information to cause an oscilloscope beam to write the characters. When connected to a computer or other high speed binary devices, the particular character desired would be selected by a gating process under the control of the computer. This equipment is the only medium that we have found which is capable of reproducing information at a rate comparable with the output of Whirlwind I.

The fourth project at ERA was concerned with the development of a magnetic type flip-flop circuit. The work was described by Mr. Miles. The technique used follows that employed in magnetic amplifiers. His preliminary investigations show that switching rates of between 400 and 500 kilocycles are readily available. He feels sure that 1 megacycle rates are not far away. He has used these magnetic flip-flops to control crystal gates, the signal and gating levls are below 3 volts. He has successfully made shifting and counting registers using these techniques.

Discussions of the fifth project with Mr. Kalb of ERA concerns the application of magnetic drum storage to the airlines' reservation problem. This proposal is being made by ERA in conjunction with the Automatic Electric Company for use by Northwest Airlines.

A round-table discussion of an hour and a half was held, and we were questioned by a dozen of their senior engineers concerning tube reliability, crystal problems, relays, etc. They were interested in our trouble location techniques, storage tube work, and indicated that they studied carefully most of the reports which had come from the Whirlwind project.

WRIGHT FIELD

The day at Wright Field was spent in discussing two distinct phases of computer activity. Mr. Boyd joined us for these meetings. In the morning some new types of memory devices which are being investigated were discussed. Mr. Colbert had assembled several representatives from various technical groups around the field to take part. The new recording methods mentioned were (1) use of a tape coated with dielectric material such as barium titanate in which the recording consists of variations in dielectric constant produced by an electric field at the tip of a suitable stylus, and (2) a system in which alteration of the dipole moments in a suitable media represents the information to be recorded. It was thought that the dielectric storage might allow much higher recording densities than can be obtained with magnetic tape.

It appeared that all of the research on recording equipment being done at Wright Field or by their subcontractors is for analogue information such as sound and telementering data. This applies to the new recording methods mentioned above as well as to the work being done on magnetic recording which was discussed with Mr. Boyd and Mr. Rich in the afternoon. No pulse-recording work has been done so relatively little information of value to computer input-output problems was obtained. It was stated that a contract has recently been let to Armour Research Foundation, Chicago, for research to improve the high frequency response on magnetic tape.

Boyd and Rich also had some discussion with Mr. Althouse, who has had considerable experience in miniaturization of equipment for aircraft applications. He stated that, in his opinion, at present there are three general methods by which miniaturization may be obtained without sacrifice of

reliability. They are:

1. Reduction in size of components.

2. Use of ceramic molds into which silver is poured to form the wiring between components.

3. Imbedding components in a thermoplastic.

He favors keeping equipment large enough so that it can be air-cooled to avoid using liquid cooling.

In the afternnon Mr. O'Brien and Mr. Taylor discussed the problems of display with Mr. M. Warwick, Dr. Beil, and Mr. Christianson. These discussions led to consideration of new applications for high speed computer. It seems that the Air Force is concerned with a flight simulator containing a cockpit for testing pilot reactions under extreme flight conditions. A contract for such a device is apparently under consideration. The Wright Field men were very anxious to have the work which Whirlwind originally did in this field reviewed before such a contract was signed.

A second problem concerns the interception of enemy aircraft. At present the only method available to the Air Force uses GCA equipment with certain manual aids which are quite unsatisfactory to cope with the problem. The application of a high speed computer such as Whirlwind to this problem seems to be very desirable to all those participating in the discussion. We plan to return to Wright Field and discuss this possibility with others who are closely associated with this problem.

General Precision Laboratories

At General Precision Laboratories we were met by Mr. Greenwood who had made arrangements for our visit. He introduced us to Dr. Everett B. Hales who carried on almost the entire General Precision Laboratories side of the conversation for the duration of our visit.

The time at General Precision Laboratories produced very little new information concerning terminal equipment suitable for Whirlwind I. Most of the information that we obtained consisted of report numbers of reports for which we could write and which might contain material of interest.

General Precision Laboratories has worked out a 10 digit binary to analog converter used in reading binary numbers from film for one of their Navy projects. The decoder is an interesting variation of the weighted current type in which relays were used as the switching element. They used Western Electric mercury contact relays, and advised us to be careful of Stevens Arnold relays. The relays were controlled by thyratrons, and separate output channels used separate decoders thus eliminating some

holding problems. They had also made a study of the precision requirements of the resistors used in the decoders. All of this information is contained in a report to the Special Devices Center titled The Three-Channel Film Translator.

Dr. Hales also told us that General Precision Laboratories has done a great deal of work on simulation, but most of their work was with analog devices. They did do some work on the same type of a scope display system as we have proposed. This work was done by a group under a Mr. Gillette who was not available at the time we were there, but we have the titles for several reports on the work and we shall request copies from the Special Devices Center.

We told them of our tube life studies of which they were unaware, and we also mentioned the fact that work has been done by Prof. Linvill on the sampled date servo problem. We told them that we would send them additional information on these subjects.

Dr. Hales gave us a copy of a memo he had written two years ago on "Displays for Whirlwind Demonstration." In this memo he gives a brief description of a display system similar to the one which we recently proposed.

Federal Telecommunications

Mr. Robert Grieg and Mr. A. Levine gave us a quick review of the pulse code modulation coding system used on the TRC25 development from Cole Signal Laboratories. In conjunction with this system a cathode-ray coding tube has been developed which has the ability to transpose voltage amplitude information into a cyclic progression code. This code can readily be changed to a binary system by the use of a flip-flop circuit. The tube can convert a voltage to a 6 digit number in approximately 5 microseconds. Indications are that 8 digit accuracy can be obtained but increased accuracy may be difficult. The 6 digit tube is available. We may be able to use it effectively as a part of our rapid input equipment. The decoding of binary information to an analogue voltage is accomplished by current addition similar to our own circuitry. We plan to study the details of these coding systems at a later date.

Mr. Grieg also mentioned a matrix coder using crystals which had as an input the analog voltage to be coded and gave the coder output on separate output lines. We did not have time to discuss this unit any further. Federal has also developed their own delay lines and has packaged them in plug-in unit. They use a tapped delay line feeding a current-adding network to decode their serial signals. They suggested that we write for additional information on delay lines

During the afternoon session we discussed some of the problems associated with applying a high speed digital computer to an air traffic control system. Those present included Mr. H. Busignies, Mr. A.O. Richardson,

Mr. Paul Adams, Mr. Sandretto, and Mr. Deschamps. Mr. Paul Adams had very definite ideas on the use of a digital computer for the air traffic problem. He feels that distance measuring equipment similar to that developed by Federal will be necessary before the data from a given airplane can be fed into the computer. A 3 element Selsyn system is available which averages out many adjacent readings from a given aircraft and makes available to the computer information relatively free of radar and pilot noise. This shaft position type of input data will have to be converted to digital information, and he indicated that Federal is interested in this problem. He warned against using the computer itself as a means of purifying directly the data obtained from a radar. In his opinion the internal storage is much more valuable if used on the main traffic problem.

Regarding the problem of display, Mr. Adams and Mr. Sandretto feel that any attempt to reproduce a PPI display with refinements as to target identification represents a step in the wrong direction as far as the traffic problem is concerned. The main problem is to assimilate a tremendous amount of varying information, and it has already been demonstrated that one human is incapable of absorbing all that can be displayed on a simple PPI. He feels that a checking computer should be used to detect any deviation in a traffic pattern, and that the use of a display oscilloscope should only be used to study the situation in a very small segment of this pattern. For purposes of demonstration and program study, it still seems to us that some sort of display is necessary. Mr. Adams has been in charge of the Navascreen equipment. We have some literature on this system and will be able to obtain whatever help we need in obtaining some display for our purposes.

Mr. Adams and Mr. Sandretto are both associated with and keenly aware of the ANDB activity in the air traffic problem. They seem very anxious to cooperate with our air traffic project to learn how to use the Whirlwind computer in conjunction with their own radio aids to navigation. Mr. Adams is apparently spending considerable time on our reports and is practicing the writing of some simple codes for the Whirlwind computer. A return visit to Federal on these items is certainly in order. We invited Mr. Adams to visit our project as soon as he finds it convenient.

Mr. A.O. Richardson has recently initiated a project on the conversion of digital information to a binary shaft position. He intends to use the cyclic progression code mentioned above in conjunction with some photoelectric reading techniques which have been developed at the Federal Laboratories. He was quite anxious to design his equipment so that a machine such as Whirlwind could use it as an output medium. He also would like to visit our project in the near future.

There are so many activities at the Federal Laboratories which tie in quite closely with our immediate problem of formulating plans for terminal equipment that a return visit to Nutley seems to be in order to study in more detail the various systems which they propose for use with digital equipment.

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