Digital Computer Laboratory
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SUBJECT: INSPECTION TRIP OF COMPUTERS ON THE ATLANTIC SEABOARD

To: N. H. Taylor

From: W. H. Ayer,

Date: May 25, 1953

Abstract: During the week of April 22nd through May 2nd, a trip was made by W. H. Ayer and J. D. Bassett of MIT and J. Montgomery and W. Hughes of IBM to inspect the packaging technique employed in a dozen computers located between Washington and New York. Logical physical design, size of pluggable units, signal and power distribution systems, cooling systems and types of mechanical construction were investigated.

COMPUTERS VISITED:

1) SEAC - National Bureau of Standards, Computer Laboratory, Washington, D.C.
Dr. Sam Alexander

2) DYSEAC - National Bureau of Standards, Computer Laboratory, Washington, D.C.
Mr. Harold Belcher

3) UNIVAC - Bureau of Census, shown by Mr. Harold Belcher of NBS

4) Logistics Computer (ERA) - George Washington University
Capt. R. B. Hunt, USN Ret.

5) Data Processing Equipment - Martin Aircraft, Baltimore, Maryland
Mr. Royce; Mr. Center

6) ENIAC - Aberdeen Proving Grounds, Maryland
Lt. Col. Sam Cumpston

7) EDVAC - Same as above.

8) Burroughs Lab Machine - Burroughs Adding Machine Company,
511 N. Broad St., Philadelphia, Pa.
Mr. Robert V. D. Campbell

9) Beam I Manipulator - Same as above.

10) MSAC - Moore School, University of Pennsylvania, Philadelphia 4, Pa.
Dr. Weyjand; Mr. Simon Gluck

11) Mark VI Relay Computer - Bell Labs, Murray Hill, N. J.
Mr. C. N. Hebbert

12) NORC Havens Computer - Watson Scientific Computing Laboratory,
Columbia University
Mr. Byron Havens

In the following paragraphs a brief description of the physical arrangement and mechanical design of each of the above computers will be given.

1) SEAC

This is an experimental computer built several years ago by the Bureau of Standards. It is a walk-in design, made up of two bays 12 ft. long and 7-1/2 ft. high, mounted back to back with a 2 ft. walk in between. Each bay is broken up into seven vertical racks with a door in front of each. Flat panels similar to those used in WWI are mounted four to a rack with the tubes facing the door side. Considerable use is made of turret plugs that plug into octal sockets on the same side as the tubes. Plug-in delay lines and diode pods, as well as internal panel wiring, are on the inside of each panel. In this way all heat producing elements are separate, cooling air being channeled up the front of the panel from a duct on the bottom of each bay. This air is exhausted through a central duct in the middle of the machine approximately 7 ft. above the walk.

Power wiring is distributed vertically through Jones plugs so that power enters the bottom panel, emerges through a plug and cable into the second panel and so on up the rack. Signal connections, both between panels and between racks, are done by flexible test lead wire with special individual plugs for each wire. These signal wires are simply draped from point to point and loosely tied to vertical and horizontal supports.

2) DYSEAC

This is a mobile computer that has been mounted inside a large trailer truck. The truck is divided into roughly four sections: a control console, an arithmetic element and control bay, an acoustical memory and the air conditioning equipment. The main mechanical structure of the arithmetic element and control bay is made up of air conditioning ducts. The cold air comes in the bottom, flows up inside the vertical supports, through hollow shelves that are used to support the pluggable units, then through grommets in the shelves into each pluggable unit. The pluggable unit is arranged in such a manner that the air flows across the diodes, then over two or three power resistors and the tube, and out into the bay.

DYSEAC (Continued)

An exhaust duct runs across the top of each bay to collect this exhaust air. Each pluggable unit holds one tube and from 20 to 40 diodes. The diodes and components are attached to two etched circuit panels that form two sides of a pluggable unit. Since the 40 diode unit may be used to replace any unit with fewer diodes, this master unit and a standard delay unit comprise the only pluggable units necessary to service the machine.

Power wiring is brought in the top of the machine above the exhaust air duct and is distributed across the face of the vertical air ducts and then horizontally into the back of the pluggable units. Signal wiring consists of flexible test leads draped from point to point with no attempt at cabling.

3) UNIVAC

This is a large walk-in machine containing 5,500 tubes and 15,000 diodes. It consists entirely of 12 tube pluggable units of a design similar to the IBM 701 unit, except that standard terminal boards are used instead of islands for mounting the components. The basic frame of the machine is a rectangle approximately 15 ft. long and 11 ft. wide. Doors around the outside of the unit allow access to the pluggable units. All wiring is done on the inside of the machine, with signal wires strung from point to point on miniature telephone poles where necessary. Cooling is accomplished from a central duct below the bays that blows cooled air up over the tubes and pluggable units. A central exhaust duct collects the air and pulls it out the top. The noise level inside the machine is quite high due to this air flow, and the addition of acoustical memory drums on the inside of the machine makes quarters quite cramped and renders servicing difficult.

4) Logistics Computer

This computer consists of three bays, each approximately 15 ft. long, with an independent air conditioning unit placed at the end of each bay to supply cool air. This air is distributed by means of a duct along the bottom of the machine which blows air over the pluggable units and out the top. The pluggable units hold a maximum of 22 tubes in two rows of 11 tubes each. Each bay of the machine has three or four racks containing an 8 x 4 array of pluggable units mounted vertically.

Power wiring is brought into the back of the panels in horizontal aluminum channels and distributed to each plug-in unit through cabled wires. Signal wires are twisted pair strung on telephone poles, following the most convenient path. The units are very similar in construction and appearance to the E.R.A. drum unit that is being used with WWI.

5) Data Processing Equipment

This equipment is packaged in typical rugged military type of construction which was necessary because of the original requirement of mobility. Large heavy bays approximately 3 ft. wide and 7-1/2 ft. long are mounted side by side on I beam pallets approximately 20 ft. long. Plans call for shipping equipment right on the pallet, probably on flat cars. Each bay consists of four to twelve large drawers mounted on Grant slides. At the final installation cold air at 55° F will be fed into each bay from a main duct at the top. An exhaust at the bottom will draw the air out of the bay past a damper that will be used to control the air flow.

6) ENIAC

This is one of the original electronic computers. It does not have electronic control as such, but instead uses a system of plug-in trays that must be re-wired or changed in order to change the program. The computer forms three walls of a large room and has a total of 20,000 tubes, the majority of which are in the 20 accumulators. The basic pluggable unit used in the accumulator has from 12 to 24 tubes in one line and uses two Jones plugs for connections to the panel. Air is drawn in through a filter at the base of the machine, passes over the tubes, which are on the outside of the room, and is drawn out through an exhaust air duct. It is very difficult to get at the back of a pluggable unit panel since the signal transfer trays, the plug-in order trays and the accumulator control panels block access to the backs of the plugs. All signal transfers are handled by means of these trays which consist of 15 or 20 pieces of bus wire mounted in a frame chassis with plugs at each end. Each tray is broad enough to be plugged from one accumulator to the next one. The same method is used with the plug-in order trays, to transfer control pulses around the machine.

7) EDVAC

This is a breadboard computer somewhat similar in design to SEAC, although it is not walk-in construction since only one bay is used. Large panels with tubes placed at random are mounted four to a rack. Four or five racks joined together side by side make up the computer. The unit is cooled by air that is pumped in from a central duct at the top, passes over the tubes, and comes out into the room at the bottom. Signal transfers from rack to rack are by means of coax cable, while transfers within a given panel are run on bare wire shielded by copper tubing.

8) Burroughs Lab Machine

This unit is built up entirely of standard Burroughs test units. It is constructed in the form of a "U" totaling 17 bays or racks of these units. All interconnecting cabling is by coax that is draped back and forth across the face of the machine. No special cooling system is used except for a few electric fans behind the machine blowing air directly on the tubes.

9) Beam I Manipulator

This unit consists of one bay approximately 15 to 20 ft. long and 7 ft. high. One tube pluggable units are used, and all diodes are mounted inside separate plug-in cans to provide thermal separation. The back of the panel is very clean due to the use of an etched circuit wiring board which consists of 16 parallel conductors with approximately 1/4" spacing. These boards are mounted in both vertical and horizontal lines across the back of the machine, connections being made to the plugs by means of short jumper wires. The bottom two feet of rack space is used for power distribution panels, filament transformers and blower motors. Ambient air is drawn in the front of the machine through filters, then forced up across the tubes and diodes and out the top. A power supply terminal panel is included at the end of each bay for connections to external power supplies.

10) MSAC

This is an open panel breadboard machine now under construction at the University of Pennsylvania. Since funds are rather restricted, no attempt is being made to achieve a well-packaged design, but instead the simplest techniques and the most inexpensive components are being used throughout. The machine will consist of several 20 ft. bays that hold an assortment of breadboard panels. No definite decision has been made on methods of cooling as yet.

11) Mark VI Relay Computer

This unit consists of several telephone type racks holding several thousand relays. Cabling and signal transfers are handled in a manner typical of telephone type construction.

12) Havens Computer

This computer is a large, very well packaged unit of the walk-in type of construction. It consists of two bays approximately 25 ft. long placed back to back and closed off at the ends to form a complete unit. Each bay consists of nine independent racks approximately 3 ft. wide and 7 ft. high that will be permanently fastened together. Horizontal pluggable units in three different sizes are available, 3, 6 and 13 tubes. Glass doors will close in the pluggable units, and air from a central compressor will be blown in the bottom of the racks up across the tubes and out through an exhaust duct on the top. The wiring is on the inside of the machine, both to make it easy to service without interruptions and because of the attractive appearance that will be gained by placing the tubes behind glass doors. A special inverted "T" section made of bakelite is used for power distribution in each rack. This consists of two rows of fuses extending across the entire width of the rack and a vertical terminal strip tied directly to the fuse strip. This vertical section has CTC lugs wired from the back in a previously determined pattern so that all necessary voltages appear at regular intervals, up and down the bay. Standard hookup wire is used to distribute power from the proper CTC lugs directly to the individual plugs in the back of the panel.

Havens Computer (Continued)

Approximately one foot of the bay below the inverted "T" section has space for filament transformers and power supply decoupling filters which will be wired directly to studs at the bottom of the "T" section. Signal leads are #26 bus wire inside a polyethelene sheath and have a capacity of 8 to 10 μμf per foot. These leads will be wired directly from plug to plug within the rack with no attempt to hold them away from ground. Signal leads going outside the rack run to Jones strips mounted on the side of the rack framework. When the racks are pushed up against each other to form a bay, the Jones strips line up an inch apart and short jumper wires will be used to connect them together.

The three sizes of pluggable units are mechanically interchangeable so that freedom of choice is maintained up until the time when the bay must be wired. The basic pluggable unit is similar to the IBM 701 unit except that it is much more rugged and is provided with a handle for easy insertion when used with the Cannon plug.

A comparison is given below of the various methods of construction used in the different computers.

I. Type of Construction

A. Open breadboard

1. SEAC
2. EDVAC
3. MSAC

B. Pluggable units

1. DYSEAC
2. UNIVAC
3. Logistics Computer
4. ENIAC
5. Beam I Manipulator
6. Havens Computer

C. Special

1. Martin Aircraft data processing equipment - military construction
2. Burroughs Lab Machine - test units
3. Bell Labs Mark VI - relays in telephone racks

II. Physical Arrangement

A. Racks or Bays

1. DYSEAC
2. Logistics Computer
3. Martin
4. EDVAC and MSAC
5. Beam I
6. Bell Labs

B. Walk-in

1. SEAC
2. UNIVAC
3. ENIAC
4. Burroughs Lab Machine
5. Havens

III. Removable Units

A. Panels - Used on open breadboard machines

B. Chassis - Burroughs and Martin

C. Pluggable Units

1. Range from 1 tube and 40 diodes in DYSEAC to 22 tubes in ERA Logistics and ENIAC
2. Number of different types in the computer ranged from 2 in DYSEAC to 50 to 100 in Havens and others.

IV. Cooling

A. Blowers mounted in the racks only in Beam I

B. Majority used a duct system to distribute cool air to the machine.

V. Signal Distribution Wiring

A. Insulated wire in majority

1. Point to point
2. Telephone poles and twisted pair on Logistics Computer
3. Draped test leads on SEAC and DYSEAC

B. Coax on EDVAC

C. Etched circuit on Beam I

VI. Power Wiring

A. Cabled in ducts from control distribution panels - SEAC, ERA, UNIVAC

B. Distribution panels for each 3 ft. rack - EDVAC, DYSEAC, Beam I

C. Havens "T" section

VII. Component Mounting

A. Etched circuit boards with holes for components - DYSEAC

B. IBM 701 type terminal strips - Havens

C. CTC lugs

D. Vector sockets

Listed below are several specific ideas gathered on the trip that seem to be worth considering in our own design.

1. The Havens inverted "T" section appears to be an excellent method of distributing a large number of power wires up into the racks in a machine. It does have the disadvantage, however, of taking up some horizontal space and may be excessively complicated for what we will need.

2. The Beam I Manipulator signal distribution boards results in an exceptionally clean appearance in the back of the panel. Whether such a distribution system could be used for 1/10 μsec pulses without excessive cross-talk is open to some question, unfortunately. They do have the advantage, however, of maintaining a more consistent impedance than almost any other form of open wiring strung on telephone poles or between CTC lugs.

3. There was general agreement among the people to whom we talked that the Amphenol Blue Ribbon Connector was definitely superior to anything that they had previously seen. However, this connector was not on the market in time for any of them to make use of it in a machine. Thus, all comment received on this connector was based on opinion rather than field experience.

4. Several people who had investigated cooling problems associated with this type of equipment all felt that it is desirable to pump the air in through a central duct system at 50 to 55° F, and either allow it to exhaust into the room at 70°, or, preferably, exhaust it into a special duct at 75 to 80° F. Use of duct distribution systems for the air instead of blowers located in the individual racks was highly recommended by all people to whom we talked.

5. The use of a master pluggable unit in DYSEAC, while only cutting down the pluggable units necessary for servicing from 5 to 2 in that machine, might be useful to us in keeping our number down to 15 or 20. It does have the disadvantage that the physical space must be left for the extra circuits even though they are not physically in any of the units of the machine except for the master unit.

Signed: William H. Ayer
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WHA/mmt

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