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Memorandum M-1810

Digital Computer Laboratory
Massachusetts Institute of Technology
Cambridge 39, Massachusetts

SUBJECT: MINUTES OF JOINT MIT - IBM CONFERENCE
Held at Hartford Connecticut January 20, 1953

To: All Conferees, H. Fahnestock, C. R. Wieser, D. R. Brown, S. H. Dodd, P. Youtz

From: A. P. Kromer

Date: January 26, 1953

ATTENDANCE:

IBM (Poughkeepsie)	MIT
R. L. Palmer	J. W. Forrester
E. H. Goldman	R. R. Everett
B. Housman	N. H. Taylor
D. J. Crawford	J. F. Jacobs
T. A. Burke	D. J. McCann
J. A. Goetz	R. P. Mayer
H. D. Ross	R. L. Best
B. L. Sarahan	W. N. Papian
W. H. Thomas	C. W. Watt
N. P. Edwards	K. R. Olsen
M. M. Astrahan	H. E. Anderson
J. M. Coombs	R. vonBuelow
	J. H. McCusker
IBM (New York	A. P. Kromer
G. Solomon	

The attached notes cover the highlights of the material presented by each speaker. Reference is made to other reports which contain further detail where applicable.

1. INTRODUCTION--PURPOSE OF MEETING - J. M. Coombs

The meeting was called to order by Mr. John Coombs who indicated that the purpose of the joint meetings was to afford opportunity to present to the large number of people engaged on different portions of the project a brief review of the work being done by others. Through this medium of exchange of information better coordination of all work should result. The meetings will be held at approximate monthly intervals to provide opportunity to summarize work done since the previous meeting, and outline the planned activity in the immediate future.

2. PRESENTATION OF WWII DEVELOPMENT PROGRAM AND DESCRIPTION OF TRANSITION SYSTEM - J. W. Forrester

The need for drastic improvement in the effectiveness of the Air Defense System for this country was pointed out. Some time back, when the military gave consideration to the problem of Air Defense, it was concluded that those organizations working on the matter at that time were not taking a sufficiently fresh approach to provide a real step forward. Consequently, Project Charles was set up as a study group in connection with this matter. It was the recommendation of the Project Charles study that digital techniques be applied to the Air Defense problem. Thus, when Lincoln Laboratories were established, the MIT Digital Computer Laboratory was made part of Lincoln. About one-half of the present Lincoln staff is working on the problem of Aircraft Control and Warning Systems.

Since Lincoln Laboratory is basically a research and development organization, it is not in a position to convert the results of this work into actual equipment or hardware. It is felt that this can best be done by collaboration between Lincoln and an industrial company who has facilities and know-how to do the necessary administration, design, construction, etc. It is this thought that has resulted in the MIT--IBM relationship, which is the first instance of this sort of association.

Mr. Forrester pointed out that throughout the entire military establishment, Project Lincoln is regarded as having a high amount of urgency, since the mid-fifties are considered a critical period, and availability of an improved Air Defense System during this time is important. As a result, we are considering a very tight schedule for the construction of the first prototype system by mid-1954; the system comprising not only the computer, but a great host of related equipment for data input, output and display purposes. Further, it is logical to assume that the construction of the prototype is not the end of the project. A typical installation in a sector has been proposed to the Air Force in the Report TM-20, recently issued by Lincoln Laboratories. Also, it is reasonable to assume that following such a trial installation the system would be extended further to continental United States Defense and possibly other applications.

PRESENTATION OF WWII DEVELOPMENT PROGRAM, ETC. (Continued)

In line with the purpose of the relationship between IBM and MIT, it seems desirable to have IBM accept the primary responsibility for the construction of the prototype model and for production planning. Further, their company has expressed a willingness and shown competence to do the job. Project Lincoln will also do detailed design work on portions of the system where necessary, and coordinate the engineering and design work so that the resultant system will be best suited to the overall Air Defense problem. But more and more should the responsibility for equipment rest with IBM.

In view of the existence of WWI, the 701 Computer and others, it is reasonable to raise the question: Why undertake the design of another computer? This question can be answered in two ways. First, fitting any one of the existing general purpose computing machines to an Air Defense application is in itself a big engineering job, in view of certain specialized problems and the large amount of additional electronic equipment required for input and output. Secondly, none of the existing computers are suitable for a military use when considered from the standpoint of reliability of operation and ease of maintenance. The latter might be regarded as the more important of the two reasons, since present radio and radar equipment presents serious maintenance problems to the military. In view of this, it is hard to visualize the magnitude of the problem that could arise when as large and complex a group of electronics as will be involved in an Air Defense system are put into field use. To offset this, no effort should be spared in having the design possess the greatest degree of reliability possible.

During the year 1953 the Computer Laboratory will be very busy with the Cape Cod experiment, i.e., providing WWI Computer with necessary associated equipment to represent a small but complete Air Defense system where all functions can be carried out in a manner similar to that contemplated in the ultimate system: including acceptance of radar data; target tracking; identification; track initiation; operations and weapon assignment; etc. This work will be of extreme importance to the overall project since the military will be evaluating the application of a digital computer to the Air Defense problem as the Cape Cod experiment is demonstrated and operated. It is suggested that IBM have a representative assigned to the MIT group working on the Cape Cod experiment for this will provide a large portion of the background on which decisions regarding the ultimate system will be based.

The Report TM-20 describes in considerable detail a transition system for Air Defense which was conceived with the idea that it could be placed into operation in a relatively short period of time. The system also recognizes the problem of permitting extremely close monitoring of the functioning of the equipment at all times to observe possible errors and to permit manual intervention to change the operation of the system whenever it may be desired. This is a significant factor which permits the system to be highly flexible and thus more useful to the military.

3. COMPARISON OF ARITHMETIC ELEMENT CIRCUITRY - J. F. Jacobs

Research and development study of arithmetic element circuitry has been carried on in three basic areas:

A. Transistor circuits
B. Existing vacuum tube and diode circuits
C. Vacuum tube and magnetic core circuits

Transistors are not considered suitable for application in the prototype WWII machine because at this time the procurement of satisfactory type units is an extreme problem. Study of existing circuits employing vacuum tubes and diodes has been made based on the circuitry employed by the National Bureau of Standards, IBM, WWI and ORDVAC. Laboratory work on magnetic core circuits indicates that those that can be produced now operate too slowly, and it is felt that considerable engineering time would be required to improve operation of this type of circuitry so that it would be comparable in speed to existing vacuum tube circuitry.

For the WWII machine, an objective of 20 μs has been established as the weighted average time for a single address order. Analysis of the types of operations encountered in the Air Defense problem indicates that the computer time is divided roughly as follows:

Addition and similar operations	50%
Multiply and similar operations	10%
Divide and similar operations	1%
Shift operations	5%
Transfer operations	30%
Sub-programs	20%

Using a ferrite core internal storage memory, it appears that the read access time will be in the order of 2 μs with a total read and write time of 7-1/2 μs.

Using existing circuit techniques, the time for a weighted average single address order involving 32 digits is 15 μs for WWI; 25 μs for IBM-701; 24 μs for NBS. With some relatively minor circuit modifications it is felt that the IBM average time could be reduced to something under 20 μs.

4. ARITHMETIC ELEMENT BLOCK DIAGRAMS - H. D. Ross

It is mutually agreed by engineers at both IBM and MIT that the arithmetic element is relatively cut-and-dried compared to other portions of the machine. Once decisions are made as to the type of circuitry to be employed, the development of an arithmetic element is quite straightforward. While final decisions regarding circuits can not be made at this time, study to date has resulted in certain tentative conclusions as follows:

ARITHMETIC ELEMENT BLOCK DIAGRAMS (Continued)

A. Haven's delay unit not reliable enough.
B. Flip-flop register probably most suitable type.
C. Diode gating for an adder like the 701 is desirable.
D. Ones complement system of arithmetic suits the problem nicely.
E. Wherever possible, direct connections instead of general purpose buss simplifies the machine and may reduce power requirements.

Other ideas are being studied, and one which seems to hold considerable promise is the capacitance storage couple arrangement proposed by Dave Crawford. It is expected that a proposal will be prepared soon with block diagrams and descriptions of how various operations will be carried out.

5. BASIC CIRCUITS CONTEMPLATED IN WWII - R. L. Best

The basic circuits to be used in the computer may be divided into several general groups. In some cases they re-occur in more than one group. At the moment, the following are considered as the circuits that will have to be developed. (Those marked * have only little known about them. Those marked ** represent complete unknowns.)

Pulse Logic

High-speed flip-flop (20 volts)
Cathode follower
Gate tube
Buffer amplifier
Pulse standardizer
Delay unit

Diode Logic

* Flip-flop (40 volts)
* Cathode follower
* Diode circuits
* Inverter
* Gate standardizer

Memory

* Current pulse generator
* Sensing amplifier

In-Out Logic

Flip-flop
Magnetic core circuits
Phone line coupling circuits

BASIC CIRCUITS CONTEMPLATED IN WWII (Continued)

In-Out Equipment

* Decoder (digital to analog converter)
* Scope deflection amplifier
** Character generator
** Drum circuits
** Tape circuits
* Photo-electric pickup circuit
Contacts

In addition to the above, power supply circuits will be involved.

6. PRINCIPLES OF DESIGN CRITERIA TO BE USED IN WWII - H. D. Ross

The study work in this field has recently been summarized in the report issued by IBM designated IM-9. This covers four phases of the problem.

1. The design of reliable circuits
2. Considerations in circuit design
3. Evaluation of circuit performance
4. Determination of design margin in a typical circuit

It is expected that continued effort will be given this subject, and the present report will be amplified from time to time so as to make it more comprehensive with respect to the subject.

Other matters which the study to date have brought to light is the feeling that diode logic is desirable to operate gate tubes for switching of narrow pulses; standardization of the signal levels must be determined; power supply voltages and the allowable variation tolerance for each must be standardized.

In addition to the circuit criteria, study is being given to the selection of standardized components. The first step in this direction is a list of preferred tube types covered by the report IM-10 just issued by IBM.

7. PROPOSAL FOR WWII COMPUTER - M. M. Astrahan

Reports IM-6, IM-7 and IM-8 have been issued by IBM outlining the initial thoughts of our logical design group regarding a computer for the Air Defense problem. The machine as proposed is basically similar to WWI, but having three acknowledged points of difference as follows:

1. It should have two complete arithmetic elements which operate simultaneously.	40 to 60% increase in number of operations performed in a given time will result.
2. It should have automatic indexing for program instructions.	This permits an estimated 25% increase in effective machine capacity.
3. In-out equipment should function simultaneously with program operations.	This can be done by having all types of in-out units look exactly alike to the computer.

Some of the points of similarity between the proposed computer and WWI are use of a ones complement system of arithmetic; operations such as addition, subtraction, multiplication, division, transfer, sub-program, etc. performed in same manner as WWI; word size of 15 bits including sign.

Mr. Astrahan further explained the logical operation of some of the items mentioned above, such as the inter-relationship of the two arithmetic elements and the function of the automatic indexing feature. These are covered in more detail in the reports referred to above.

This proposal has been discussed at some length by representatives of both organizations, and further conference discussion is planned for the near future. These meetings should lead to certain conclucions which will serve as the basis for design of the machine.

8. MAGNETIC MEMORY DEVELOPMENT - W. N. Papian

The background and operational experience of 16 x 16 metallic core and ferrite core arrays was reviewed. Since these have been tested using a variety of cycling programs, it is felt best not to draw final conclusions regarding the application of this type of memory to a computer until it has actually been operated in one. Consequently, the Memory Test Computer is presently being built at MIT and will be in operation in the Spring of 1953. The first of the 32 x 32 (1024 bit) array for this machine was exhibited. MTC will have 17 planes of this size. The cores will be vacuum tube driven, using 6AS7 tubes as drivers. One of the contemplated problems in making a ferrite core memory is the matter of actual construction. The first plane which was exhibited took 5 to 6 man days time to wire. Since the operator was experienced in handling this type of item, it is felt that future units can not be made in less than 5 days time. Attention to automatic or semi-automatic arrangements for wiring these planes is important.

MAGNETIC MEMORY DEVELOPMENT (Continued)

It is expected that by March 1, 1953 a test set-up will be available that will permit laboratory testing of the 17 planes for MTC to be completed by the end of that month, and thus make them available for inclusion into the MIT Memory Test Computer about April 1.

Not much effort has been given to the development of a memory for WWII since it is felt that this decision can be made only after MTC has been in operation. It is thought, however, that WWII will require approximately 30 digit planes, each being a 64 x 64 array. Vacuum tube driver circuits will probably be employed in this machine in the same manner as in MTC.

9. MAGNETIC CORE PRODUCTION - J. H. McCusker

Group 63 at MIT is concentrating on procurement of sufficient cores for MTC, while at the same time looking ahead to the matter of production of the larger number of cores that will be required if a magnetic core memory is used in WWII. The cores now being produced for MTC are made by General Ceramics Company and are known as type MF 1326 B. They require one ampere driving current, have a 1 μs switching time and a 100 millivolt output signal.

Production of cores having uniform difference in level between the disturbed and undisturbed one condition represents the current problem. When using a $\pm$ 15% tolerance for this characteristic, current experience indicates that only 45% of the cores manufactured can be accepted. The testing of cores is a time-consuming problem, but it is expected that sufficient cores for MTC will have been tested by mid-February. To handle the larger number of cores that will be required for WWII obviously will require development of an automatic testing device or at least automatic handling of the cores in connection with testing.

In an effort to learn more regarding the conditions encountered in the manufacturing process of the cores and their effect upon switching time, coercive force, etc., a laboratory is being installed at MIT at present.

10. STATUS AND PLANS FOR MTC - K. H. Olsen

MTC is basically the same as WWI insofar as logic is concerned, but certain changes in packaging of the electronic equipment have been made in the interests of improved reliability. The initial panels have been received, and are presently being installed into the machine. It is expected that the machine will be placed into operation as soon as the ferrite memory becomes available. This is expected about April 1.

STATUS AND PLANS FOR MTC (Continued)

In the interest of saving time, the control section of the computer has been built up of Burroughs units. It is interesting to note that this was assembled and placed into operation very quickly, and was from the very start remarkably free of trouble. In 750 hours operation only 20 unaccountable errors were registered. Sixteen of these are thought to be associated with wide swings in power supply voltage (operating off general laboratory supply which has been observed to vary as much as ± 20 volts). The remaining four errors are thought to be due to shorts in vacuum tubes.

In addition to the conventional toggle switch storage, arrangements are being made to permit program storage on an IBM plug board. Thus, various programs can be arranged on the plug board and inserted into the machine whenever desired. Also, IBM card equipment will be procured and associated with this machine about the middle of 1953 so as to develop experience with this medium as terminal equipment for a digital computer.

11. MAGNETIC CORES APPLICATIONS OTHER THAN MEMORY - N. P. Edwards

While most attention to date has concerned the use of magnetic cores in a memory, consideration of other applications indicates there may be circuits in which their use will provide considerable advantages from the standpoint of reduction in the number of vacuum tubes and, consequently, improved reliability. One case studied using cores as a buffer in connection with a printer indicates that the number of vacuum tubes can be reduced from 450 to 200 by the introduction of approximately 1500 cores which serve as a card image. In another study, use of cores in a counter indicates the reduction in vacuum tubes to 65% of the original requirement. In still another instance, a core stepping register associated with a time shared counter shows great promise of reducing significantly the number of vacuum tubes and perhaps the number of tracks on a magnetic drum. This entire subject is being studied further.

12. BUFFER STORAGE AND DISPLAY - E. H. Goldman

Study of the Lincoln Report TM-20 has been the basis for consideration of the types of display equipment considered desirable for the proposed system. The results of the study work done to date will be summarized and issued very shortly in a report IM-11. This will cover two general fields of activity associated with output displays:

A. Selection schemes
B. Generation of displays

The possibility of a character generator employing magnetic cores has been given preliminary study and appears to offer a means in which alphabetic or numerical characters can be displayed on a CRO tube in a very rapid manner.

13. COMPONENT RELIABILITY AND STANDARDIZATION - J. A. Goetz

Mr. Goetz suggested that the matter of standardization of components be deferred at this time in preference to the problem of securing reliable items. After we know what items are reliable, we can then standardize upon those components.

The first big step regarding component reliability was made several weeks ago, when a combined group from IBM and MIT visited leading representatives of the vacuum tube industry to discuss the needs of WWII with these people. It is important that these discussions be followed in the near future with decisions regarding the types of tubes to be used, so that commitments can be made to the tube manufacturers and thus get them started in actual engineering and manufacturing of tubes of the quality desired.

While tubes are probably the most outstanding item, attention is also being given to other electronic components to permit the preparation of a standards book for use by the design engineer. It is important to have the components selected as standards incorporated into Government JAN or MIL specifications, so as to insure continued availability of these high quality items as approved components for military computer applications. It is expected to pursue this work with industry representatives as well as organizations such as ASESA (recently visited), the Navy Components Group at New York Naval Yard, and the established standards committees of the various engineering societies.

14. SCHEDULES FOR WWII DEVELOPMENT AND PROTOTYPE - N. H. Taylor

As indicated earlier by Mr. Forrester, there is an extreme degree of urgency associated with the completion of the prototype and subsequent quantities of digital computers for Air Defense applications. In the interest of meeting the needs of the military, we have set an objective of having the prototype computer, with its associated equipment, installed and operating by January 1, 1955. In order to really see what this means to the engineering development phase of the project, we must consider two large blocks of time that occur prior to this date. The six months period between 7-1-54 and 1-1-55 will be required for final installation, testing and integration of the equipment into an Air Defense system. The nine months preceding this (10-1-53 to 7-1-54) will be required for procurement of material and construction of the model. It can be seen then that the time remaining between today and October 1 of this year is all that exists for engineering work in connection with the preparation of specifications, block diagram work, development of basic circuit units, actual equipment design and all the other things necessary to permit actual construction to begin. The schedule for this work is covered in more detail in Memorandum M-1753 issued by the Digital Computer Laboratory.

SCHEDULES FOR WWII DEVELOPMENT AND PROTOTYPE (Continued)

In view of the short period of time for the major amount of engineering work, it is obvious that a rapid build-up of manpower will be required. It is estimated that at the peak, which will occur about the end of this year, approximately 235 persons of professional level will be required on the program. This may seem to be a large number, but when these people are divided among the many fields to be covered, the number remaining in any one activity no longer appears large.

15. WWII PROGRAM -- STATUS IBM ACTIVITY - T. A. Burke

The first few months of IBM activity under the Lincoln Subcontract has been largely devoted to having their organization become familiar with the problem at hand, so that they may place into effect a program aimed at accomplishment of the task within the desired time interval. Latest thinking indicates a change in some of the requirements that were visualized several months ago, but a brief review of the status of IBM activity in several major categories is as follows:

Personnel

Compared with forecasted requirements of 25 developed last October, there are presently 26 people engaged on the project. (Twenty professional, 2 technical, 4 non-technical.) Further, 6 additional people are scheduled to be added to the Project HIGH group within the next two weeks.

Test Equipment

The Subcontract provides for procurement of test equipment valued at approximately $130,000. To date, requisitions have been issued for $60,000. worth of equipment, and actual receivals at the High Street Laboratory are valued at $28,000.

Material

The Subcontract authorized procurement of $75,000. worth of material for use in the High Street Laboratory. Purchase orders placed have a value of $3,000.; requisitions in process have a value of $5,000; requisitions being prepared have a value of $21,000; IBM parts furnished to MIT have a value of $5,000.

The IBM Company has procured the building at High Street solely for this project, and have authorized the necessary monies to make renovations to the building which will be required to carry on the work called for under the Lincoln Subcontract No. 20. The Company has authorized acquisition of the furniture and fixtures necessary for the first 5 or 6 months of operation on this project. Some of this is already on order.

WWII PROGRAM -- STATUS IBM ACTIVITY (Continued)

Since we are almost half-way through the period of time covered by the Lincoln Subcontract, it is urgent that consideration be given to having in effect an Air Force Prime Contract, so as to permit continued work beyond the end of April. With regard to this, the first meeting with the Air Force is scheduled for January 21. The matter will be pursued aggressively in the ensuing months to avoid having a gap occur in the work on this project.

Signed: Arthur P. Kromer
Arthur P. Kromer

APK/mmt