March 19, 1957

MEMORANDUM TO: Mr. C. A. Bergfors

SUBJECT: Preliminary E. R. A. D. Proposal

Introductory Note

This memorandum is an experiment in reporting ideas to Patent Engineering and Exploratory Research at an earlier stage, perhaps before they are sufficiently congealed to fit into your normal procedure. The occasion which precipitated these ideas into this memorandum was the talk by Mr. D. W. Rubidge on Friday, March 8, on the patent situation within our company.

This material has been assembled without careful checking on the basis that in this area it may be a sounder policy to run the risk of making errors in the process of forming more general ideas. The material of Tables I and II has not been checked for original source of the ideas presented, so the inclusion of an item in this memorandum does not constitute an invention claim.

Abstract

The problem of obtaining the inventions needed in our business in the future requires some looking ahead as to what problems we will encounter in the future. My present feelings on the future needs are summarized below:

(1) Input/Output Devices. New input and output devices will be needed for greater communication between humans and computers. The range of possibilities of new input devices appears to be limited. The range of new display and printing devices does not appear to be thoroughly exploited. A list of physical phenomena is included for checking possible areas of output display developments. In connection with this listing a division of display device between "separate" and "integral" type is proposed.

(2) Communication Circuits. Research in the area of new methods of communication is important to fully utilize the bandwidth available in the present methods and to develop more economical error-free systems.

(3) High Frequency Computer Circuits. Examination of a curve of computer memory access time and addition time plotted against year of development shows a trend toward higher and higher frequencies. If this trend continues we will need many techniques in the millimicrosecond pulse length (or frequencies in the kilomegacycle range).

(4) Systems Research. Since the major problems of our civilization are now in the areas of communication and control, it is important that some engineers in IBM fully understand all feedback processes and models such as the "homeostat" regardless of the present field of application, i.e., medicine, psychology, economics, or information theory. Directions for experimental and computer models are suggested for preliminary work.

(5) Associative Access Memory. The increasing volume of journal articles in every field of science and technology makes the searching for particular information more difficult. The storage of information in a computer memory usually has to be filed by the memory address. For large memories of the future it would be an advantage to be able to broadcast the identification field of the desired information into the memory and have the address of the desired data come out.

I. Input / Output Devices

A. Input Devices

(1) Brain Wave Error Probability Checking.

A new error checking device is proposed which samples the brain waves of the operator to determine when the operator is overfatiqued, or otherwise disabled. An inductive pickup system between reference tranducers installed in the housing of the earphones and/or in the safety glass temples required in the work. For example, if safety glasses are not required, a display device requiring a light filter to observe the screen could be used.

(2) Dual Beam Keying Onto Cathode Ray Tube.

A system is proposed for selecting from a choice of reservations displayed upon a cathode ray tube. At the left of CRT display there would be a column of numbers, one for each choice. These numbers are sent out from the computer and are stored on the tube face of say a dark track tube. These numbers are eraseable by the main tube control and externally by focussing a beam of say ultra-violet light on the chosen number. The computer directs a scanning beam from inside the CRT to find the chosen number which is erased. The operators erasing (or choosing) beam pencil has a non-erasing beam also. This non-erasing beam is for identifying the chosen line prior to erasing.

B. Display Devices.

(1) List of physical phenomena potentially utilizable for display devices. (See Tables I and II.)

(2) Color TV Output Display for 3-Dimensional Field P oblem.

It is suggested that color TV be used to monitor three dimensional field calculations in order to keep the three planes distinct in the display. For example the six points about a three-dimensional field point might be in different colors as follows: four net points in center plane in blue; point in back plane in red; point in front plane in yellow.

TABLE I

List of Computer Display or Printer Systems
(Separate from Buffer Storage)

DISPLAY	SELECTION		
	Mechanical	Electro-Mechanical	Electronic
TRANSFER of carbon or ink	Type Bar Type Wheel Wire Printer Helix & Bar		
ELECTROLYTIC dye - Alfax, Hogan ELECTRIC dry- Teledeltos, Timefax		Helix & Bar Facsimile Continuous Scan Electrode Wire Matrix Parallel Wires Column of Character Row of Line	
pH - INDICATOR		Continuous Scan Electrode Wire Matrix Parallel Wires Column of Character Row of Line	
IONS: Ink on paper Ions in cloud chamber			Electrostatic deflection: Permanent record Temporary
ELECTROSTATIC PRINTING		Charging of mechanically moved paper past electrically charged parallel wire electrodes followed by dusting.	CRT scanning of page or line of characters, followed by dusting.
MAGNETIC IMAGE	Reluctance code plate or type wheel (non-contact), followed by dusting.	Parallel set of magnetic heads, followed by dusting.	
INFRA-RED Thermofax		Light through stencil (printing from backside)	

DISPLAY	SELECTION		
	Mechanical	Electro-Mechanical	Electronic
OPTICAL Photographic	Code Plate	Code Plate	Pulsed light sources
ULTRA - VIOLET Chalkley		Code plate (printing from back side possible)	
PHOSPHOR SCREEN Short term		Magnetic drum buffer storage.	
Barrier Grid Storage		Charactron, typotron, memotron	
Active centers in crystals		Dark trace tube	
LUMINESCENCE		Matrix switching, electrical holding	Matrix switching,(ultra-violet holding electrofors)
GLOW DISCHARGE			Wire matrix switching Cathode ray controlled.
OPTICAL SHUTTER			Kerr electro-optic effect in mitrobenzene cells or Bu TiO_3.
OPTICAL RESONANGE IN GAS			?
KERR MAGNETO-OPTIC EFFECT			?
OPTICAL DISPLAY FROM MAGNETO-HYDRODYNAMIC WAVES.			?

TABLE II

List of Potential Computer Display Techniques
(Integral Delay Line Type)

DISPLAY	SELECTION		
	Electromagnetic	Magnetic	Acoustic
OPTICAL			
PHOSPHOR SCREEN			
LUMINESCENCE			
GLOW DISCHARGE			
OPTICAL SHUTTER			
OPTICAL RESONANCE IN GAS CELLS		Magnetic double refraction of polarized light through gas.	
KERR MAGNETO - OPTIC EFFECT		Elliptical polarization of plane polarized light incident upon magnetic disk.	
OPTICAL DISPLAY FROM MAGNETO - HYDRODYNAMIC WAVES			Acoustical delay line storage in mercury coupled by strong magnetic field into mechanical motion of reflectors setting up light image.

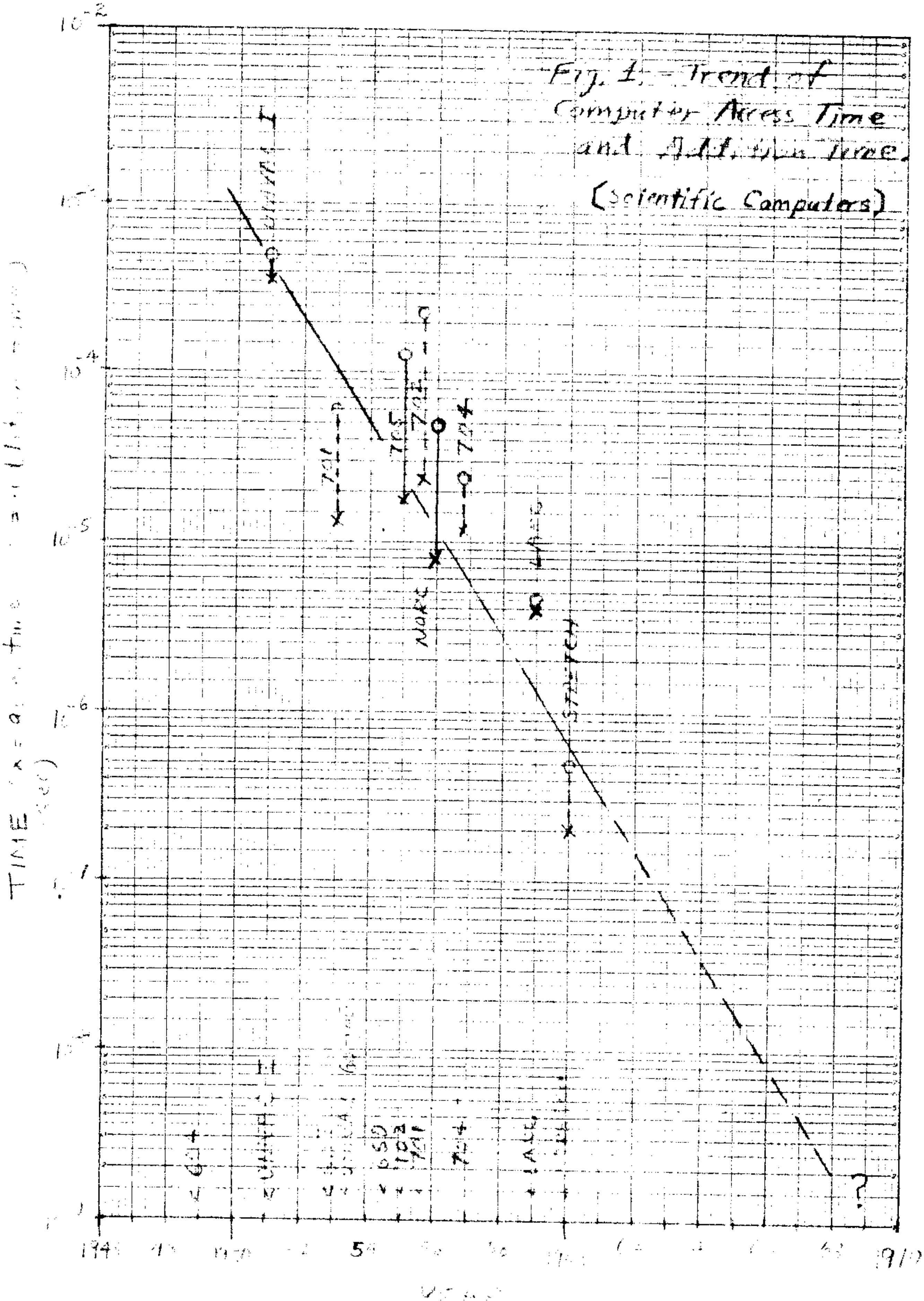

Fig. 1 - Trend of Computer Access Time and Addition Time (scientific Computers)

3-16 57 (BW)

III. High Frequency Computer Circuits.

An approximate curve showing the trend of computer development in regard to access time to the high speed memory and the addition time is shown in Fig. 1. If we extrapolate this data we find that computer speeds are going up by a factor of ten every three or four years. This is partly misleading, because part of the gain in speed is due to overlapping. Only part is due to faster components.

As more complicated scientific problems are given to computers, faster access and addition times become more important. The area of application which may eventually force the development of speeds is the associative access memory.

IV. Systems Research

A. Business Systems Research

The immediate problems appear to be covered by a thorough program in Advance Planning and Advanced Engineering. It is proposed that models be made and operated of larger domains than those directly applicable to present IBM equipment. We are proceeding from small systems within a business toward more complete mechanization. If we were to also approach the problem of future system development from the other end, namely an oversimplified analog of the world economy, we might learn in advance of some of the systems requirements beyond the present foreseeable hardware developments.

B. Biological, Psychological & Economic Systems

(1) Error Signals in Biological & Social Systems

There may be possibilities of developing a feeling for a balance between error-checking and diagnostic procedures through study of biological and social systems where pain and social distrubances are the error-checking elements. Comparisons between situations where the system uses the error signals as diagnostic aids and systems where an attempt is made to suppress the errors by higher power or some other brute force method, may lead to useful ideas in development of computer and communication systems.

(2) Principle of Having Gadgets & Systems Available for Engineers to Play with for the Purpose of Generating New Ideas.

The making available of simple experimental equipment to demonstrate (a) physical phenomena such as the Kerr magneto-optic effect, mangeto-hydrodynamic waves, etc., and (b) analog computer components for building up complex systems, might help increase the generation of new ideas.

(3) Study of Ultra-stable Systems such as W. Ross Ashby's Homeostat.[1, 2]

Ashby's homeostat consisting of four groups of components interconnected with a complicated set of feedback loops may be a small scale sample of some of the more complicated feedback loops in our society. The actual construction and operation of such a device might possibly help give engineers a feeling for the operation of such complicated feedback networks. This activity might help stimulate the development of ideas for other models which might come close to representing more specific areas in our society for which computer systems are needed. This experimental work could be done in two ways; (a) Building of physical model, and (b) setting up a program to represent the system and the running of the program on a computer such as the 650.

(4) Application of Feedback Circuits in Psychological Processes.

The consideration of analogies in psychological process by the use of equivalent inverse feedback circuits may be of significance in the utilization of man's potential creative ability.

(5) Economic Analogs

The economic analogs described by Otto J. M. Smith[3] are a very useful tool in understanding economic systems. It is proposed that experiments with models of economic systems be performed on analog computers to develop techniques of approximating the performance of the world economy. This might lead to improved ways of using digital computer programs to represent large systems. The analog systems of digital representations of them could be used to determine what parameters in a real economic system could more usefully be kept up to date on a digital computer system.

Developments like the above could lead to the possibility of a United Nations computing center under supervision of UNESCO. The development of advanced system techniques would make possible the computation of the principal consequences in money, manpower, and time of alternative solutions of important problems such as the conflict between Israel and the Arab nations. The basic economic conflicts between capitalist and socialist countries could be ameliorated through the projected UNESCO systems analysis bureau. Thus research on computer systems could make a significant contribution toward the economic stability of the various economic systems in the world. This could help narrow down the areas of conflict between nations to the real issues of respect for human dignity and freedom.

1. Ashby, W. Ross, Design for a Brain, London (1952)
2. Ashby, W. Ross, Design for an Intelligence Amplifier," Automata Studies ed. by Shannon and McCarthy, Princeton (1956) pp 215 - 234.
3. Smith, Otto J. M., "Economic Analogs" Proc. I. R. E. 41, Oct. 1953, pp. 1514 - 1519.

V. Associative Access Memory

The report by T. I. Ress[4] suggests some lines of attack upon the problem of developing rapid, associative retrieval. His three examples, (a) mechanical selection, (b) magnetic cores, and (c) spectral encoding, illustrate the nature of the problem.

A. Spectral Encoding Associative Access.

The spectral encoding system appears to be a system in which each digit space in a word is assigned a narrow band within the bandwidth of the system. The presence of energy in frequency band $\Delta f_n = f_{n+1} - f_n$ indicate a "1" in the nth digit of the word.

B. Recirculating or Delay-Line Type Memory

The use of a delay line type high speed memory appears to offer a fast way of comparing the contents of memory with a reference code sent through a parallel delay line with some kind of an "and" circuit between the two delay lines.

C. Printed Circuit Microwave Delay Line Memory

A suitable delay line for an associative access memory can conceived in the form of a microwave waveguide structure and then transformed into a printed circuit system or to lower frequency components. Possibly an integral memory, amplifier, and switching system can be derived from the concept of layers of travelling wave tubes.

(1) Magic T

A waveguide magic T, printed circuit magic T, or a magnetic amplifier hybrid circuit could possibly be used as an associative field "and" circuit.

(2) Ferrite

Another way of developing a message "and" circuit would be to have a row of ferrite rotators in a delay-line (waveguide or printed circuit) which are controlled by setting up a magnetic field corresponding to the desired class of information.

---

4. Ress, T. I., "Associative Access Memory", Feb. 3, 1956.

F. B. Wood

F. B. Wood

FBW:hp

cc: Dr. W. A. Christopherson Mr. R. B. Johnson
Mr. R. L. Haug