## 9.9 Application of Communication Theory to Data Communication

This is a listing and abstraction of various pertinent notes, memoranda, and reports. The objective of this listing is to preserve a record of secondary ideas that are not too important to immediate projects, but which have potential value in the distant future. It is my philosophy that ideas not directly applicable to a particular project, should be communicated to engineers and scientists on other projects in IBM so that if the ideas are of value, the people who need them can have the benefit of them.

### 9.9.1 F. B. Wood, "Preliminary E.R.A.D. Proposal" memorandum of March 19, 1957.

This memorandum was an experiment in reporting preliminary ideas of a speculative nature over a broad spectrum of subjects. One patent disclosure resulted from it in an unanticipated way. The memorandum included fragmentary material on (1) Input/Output Devices, (2) Communication Circuits (3) High Frequency Computer Circuit, (4) Systems Research, and (5) Associative Access Memory. The one disclosure resulted from the organization of Table I (list of Computer Display or Printer Systems) into a matrix with the different display phenomena forming the rows and the selection means forming the columns. This matrix was then partially filled in with known display methods. The blank squares were then reviewed for possible new systems. One of the potential display systems, resulted in Disclosure 80579, Peltier Effect Thermofax Printer. The residual items still of interest are Figure 1: Trend of Computer Access Time and Addition Time. (p. 9-51)

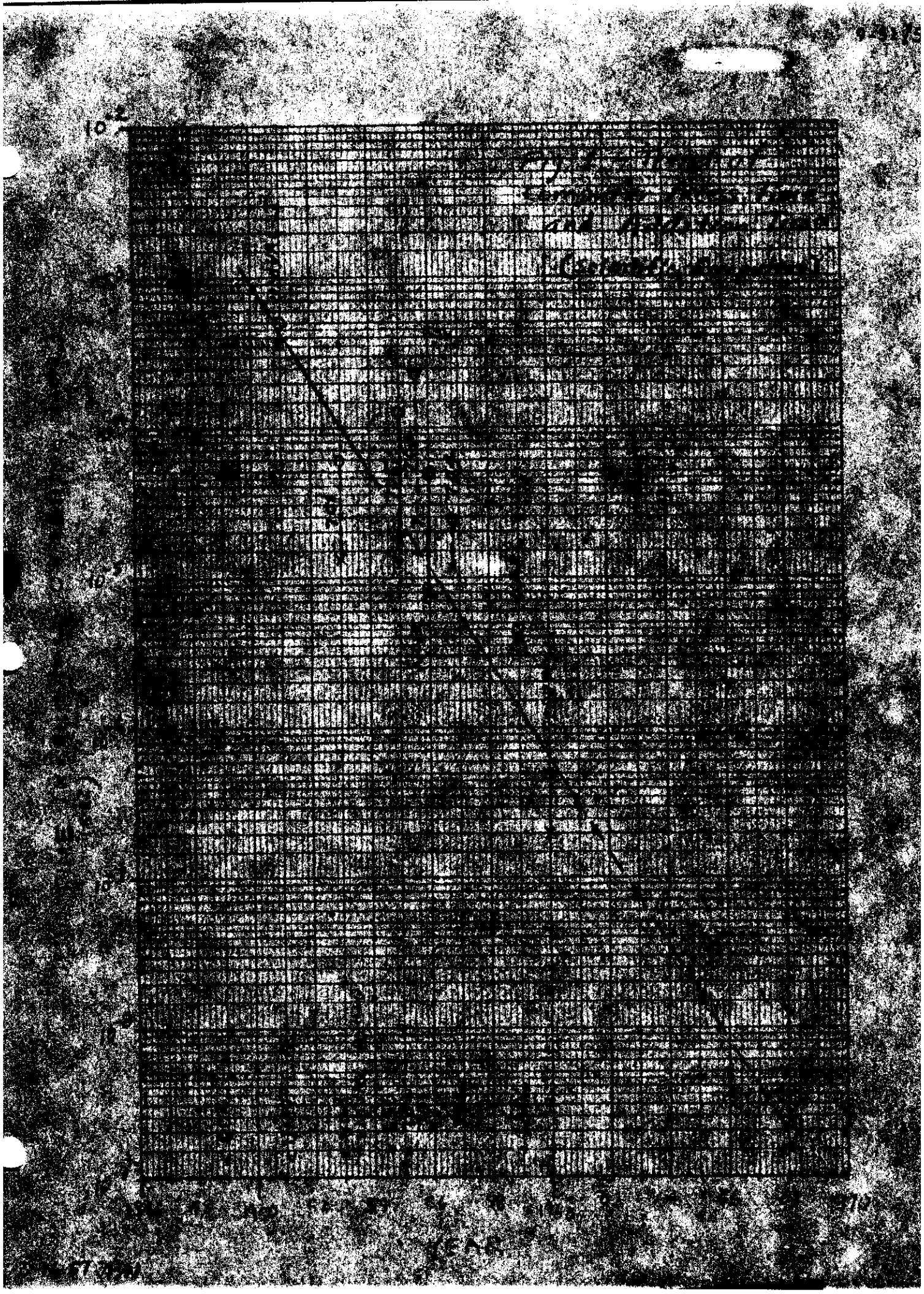
IV. Systems Research

A. Business System Research

"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." Perhaps some of the cooperative university computing centers IBM has established can deal with this level of the problem.

B. Biological, Psychological and Economic Systems.

(1) Error Signals in Biological and Social System



(2) Principle of having gadgets and systems available for engineers to play with for the purpose of generation of new ideas.

(3) Study of Ultra-Stable System such as W. Ross Ashby's Homeostat.

(4) Application of Feedback Circuits in Psychological Processes.

(5) Economic Analogs.

9.9.2 F. B. Wood, "Communication Project", Draft Memorandum, April 12, 1957.

Most of the items in this memorandum have been incorporated into other reports. Only the paragraphs which have not been utilized are listed below:

2. Study of the Rate of Increase of the Complexity of Industrial Organization.

To understand the kind of a time-table communication research must adopt to keep pace with the natural growth of industry, a measure of complexity of organization and a theory of the relationships of the complexity of organization to some measurable quantity such as total power production or per capita power production. It is predicted that this "complexity of organization" quantity will turn out to be a quantity similar to negative entropy or information. This tentative hypothesis comes from the comparison of the elementary description of why information is logarithmetic (Bell p__) with the curves of world power production. The normal doubling period for world power production is about thirteen years.

4c. Theoretical Comparison of Error Checking with Periodic Feedback with Redundant Error Correction Codes.

Comparison of efficiency of error checking with feedback signals for repetition of last group of characters with redundant error correction codes. In addition to the mathematical analysis, an applied psychologist will have to study the relative effect on confidence and morale of the human operators. Some lessons can be learned from error signal systems in biological and social systems.

4d. Comparison of Facsimile Character Signals with More Compact Transmission Codes.

The use of a 35-bit facsimile character code for transmission of output data from a computer eliminates the need for error-checking over a

large range of operating conditions, but uses about five times the channel capacity of an 8-bit code.

4e. Multilevel Transmission.

Research in the application of multilevel channel theory developed by Information Research Group (Poughkeepsie) to increase the channel capacity of commercially available carrier systems.

5b. Automatic Machine to Machine Communication.

(1) Two Machine System -- To prevent oscillatory loop from being developed some theoretical analysis of two inverse feedback networks connected back to back should be developed.

(2) Three or More Machines -- Except where all except one machine are slaves an ultrastable feedback network system having characteristics similar to the "homeostat" would be required. This requires a preliminary study of complex feedback networks like W. Ross Ashby's homeostat.

6. Integral Memory - Communication System.

Comparing the complexity of the nervous system of different levels the animal kingdom leads to the concept of a system in which memory and logic elements are distributed in small groups along the communication channel. This would be similar to a delay-line with distributed logic elements added along the line where input or input-output connections must be provided at close intervals.

a. Slow Speed Neuron-Like Delay Line Channels.

Research on simple KCl crystal delay lines based on progressive dielectric breakdown with voltages, pulse lengths, and repetition rates comparable to those in biological systems. These would be investigated for low cost production control systems in small factories.

b. High Speed Single Channel System.

A central waveguide might have ferrite storage element distributed along its length with a wamoscope type travelling wave tube oscilloscope display unit for the central control station output.

9.9.3 F. B. Wood, "Preliminary Notes on the Application of Statistical Decision Theory to Business Data Systems", Memorandum SJC-12, June 6, 1957.

The application of Middleton's formulation of statistical decision theory to the analysis of business data transmission systems provides a perspective from which to compare different data detection systems. Statistical decision theory does not automatically solve any of our problems. It helps in the comparison of different systems with each other and with theoretical optimum systems.

Study of statistical decision theory has resulted in the development of a system diagram in which each sub-section is to be considered as a data transmission system. This may assist in developing a perspective of all the links in a business data transmission system which would be of value to the systems group.

The exploitation of statistical decision theory in an applied research laboratory offers a potential gain through the establishment of a philosophical expression of the role of applied research in applying the techniques of basic science and mathematics to social use. The utilization of mathematical techniques having basic validity and application in related fields helps build up a perspective which releases energy for the more direct specialization on the practical problems.

9.9.4 F. B. Wood, "Problems Proposed for Analysis in 1958", Memorandum, December 19, 1957.

6. Distributed Memory Machine Theory (Memo of 9/12/57: 6b)

Preliminary survey of the potential range of new types of computers which might be possible if we consider the division points between the input/output communications lines, multiplexing components, trunk communications links and the central computer to be adjustable. Adjusting these division points over a range of possibilities might give us a chart of possible types of computers suited to different stages of automatic factory operation. This study might lead to a series of families of computer systems such as:

a) Central Computer/Strategic Multiplex Unit/Communication Lines to Input Output Stations.

b) Central Multiplex Unit/Several Small Computers on Main Data Link/Communications Lines to In-Out Stations.

c) Distributed Computer Logic, Memory, and In-Out Stations along Communications Line Controlled by Synchronizing of any Two Stations. (This system could be cut into parts and each sub-section could "grow" a multiplex control unit through synchronizing of sections of two stations. This is an idea derived from low order biological systems such as worms which grow the missing parts when cut).