MEMORANDUM M-76

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Subject: Digital Computers in Science 

Reference: "Machine Computation of Power Network Performance" by L. A. Dunstan, A.I.E.E. Technical Paper 47-87, December, 1946

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In the preceding seminar discussions we have considered the nature of electronic digital computers and have studied some of the circuits used for arithmetical computation. Block diagrams of a computer system have been outlined and the nature of some mathematical problems which will be encountered in numerical analysis have been indicated by Dr. Loud.

One should emphasize certain characteristics of electronic digital computers which have already been touched upon. Electronic computers of the type discussed will be practical only when used in such a manner that vast amounts of computation can be accomplished in proportion to the amount of manual setup and programming which is required. One way in which this can be accomplished was outlined by Mr. Everett in his discussion of generalized matrix multiplication. The generalized program for matrix multiplication involves only forty-seven control orders and is capable of multiplying together any two matrices of size within the capacity of the machine. The forty-seven orders are sufficient to control a computation requiring up to hundreds of thousands of operations. The matrix multiplication is an example of use of the machine for computation of its own controlling program. The outline of the problem to be accomplished has been given to the computer, but details in the carrying out of the individual steps are computed by the machine as it carries out the required numerical operations.

Engineering has now reached a viewpoint long held by the mathematician in indicating the solution of a problem. The mathematician often considers his problem solved when the form of the solution is known and when it can be written down in a compact symbolism. Matrix operations give us one example of this symbolic notation. Others can be found in the summation of series and in many forms of mathematical shorthand. Since this mathematical shorthand notation contains in it all of the information necessary for the solution of the problem, it is entirely possible to mechanize the shorthand notation rather than the individual steps of the computation. The computer is, therefore, able to carry out a long series of operations, the plan for which has been indicated only in outline or symbolic form. Generalized programs of the same type illustrated for matrix multiplication could equally well be arranged for the solution of ordinary linear differential equations or the evaluation of determinants and for the evaluation and summation of series operations.

In the field of engineering we can also expect that similar shorthand methods of setting up problems will come into use. Take, for example, the solution of alternating current network problems. Mr. L. A. Dunstan of The Federal Power Commission gave a paper at the last American Institute of Electrical Engineers' Convention in New York City describing the manner in which he had used punched card calculating machines for the solution of alternating current power systems. Mr. Dunstan stated that even with punched card equipment and the relatively large amount of manual operation involved, it was still possible to solve a-c power systems in approximately the same amount of time required on the network analyzer. He also stated that approximately one-half of the total time was required in the planning of the problem and in the selection of the circuit loops which were to be solved. It can be readily imagined, however, that with a sufficiently powerful and flexible digital computing machine a generalized program could be established for the solution of the a-c network problem. Such a solution might be set up on a nodal basis. After sufficient information was provided through the input mechanisms to completely describe the power system, it should be unnecessary for the operator to describe the exact method in which the solution will be accomplished.

A generalized program for solution of the a-c network system involves mathematical operation in complex quantities and is equally well suited to computations in the fields of vibration and stress analysis.

Every advantage possible must be taken of the large scale digital computing machine. It is not sufficient that one merely use it to replace the human operator of a desk type calculating machine. Since the electronic digital computer can follow almost any operation of control or computation which can be described, it is essential that one use the computer insofar as possible for the preparation of original data and for the correlation and interpretation of results of computation. As an example, consider the solution of ordinary differential equations with time as the independent variable. Where the solution of several dependent quantities is obtained as a function of time, it is often desirable that these quantities be plotted against one another rather than against the independent variable.

In such a problem the computer should be used for the required sorting, interpolating, and plotting of the result in the exact form desired for final use.

Many research programs in physics and mathematics are now blocked by the excessive numerical computing necessary to the next step of progress. Correlation studies in economics, medicine, and the social sciences must have the solution of large determinants which only high speed computers and a better understanding of the underlying mathematics can provide.

After a large scale computer has been in use for a period of time, libraries of control programs will be built up and become available for use on future work. Programs for the solution of many classes of problems can be prepared and other programs for special problems can often be built up as composite groupings of sections from programs on file.

A large scale electronic digital computer will be an expensive piece of equipment, and in order to be practical it should be kept in operation most of the time. Furthermore, continuous operation of such a computer will be highly desirable for the reduction of vacuum tube failures and for the resulting increased reliability and freedom from operating trouble. To provide sufficient computing load, it may be necessary to extend the sphere of usefulness of the large scale machine by long distance teletype connections. Methods are now being considered for teletype transcribing equipment for the remote transmission of problems to large scale computing equipment. Plans are being formulated for mathematical centers in several sections of the United States where large scale electronic computers can be located. To these will go problems from organizations with insufficient computing load to justify large scale machines and operating staff of their own.

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