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Electronic
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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

APPLICATION
TO
THE ROCKEFELLER FOUNDATION
FOR
GRANT-IN-AID
FOR
ELECTRONIC DIGITAL COMPUTER RESEARCH

April 23, 1946

PROGRAM FOR
ELECTRONIC DIGITAL COMPUTER RESEARCH
CENTER OF ANALYSIS
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

INTRODUCTION

The reduction of computational limitations on the effective application of mathematical analysis in science and engineering has been a major effort for many years at the Massachusetts Institute of Technology. Its Center of Analysis, whose facilities and accomplishments are widely known, was organized and is functioning as the primary focus of this work. The next major step forward in this field is generally acknowledged to be the development of a digital electronic computing machine of great speed, flexibility, and power. There is every reason to expect that such a machine will go very far beyond present machines in extending the applicability of mathematical methods to physical problems.

In the Center of Analysis a substantial start on the development of such an electronic digital computer was interrupted by the war. This development is now being resumed under the initiative and organizational responsibility of the Center of Analysis but with substantially broader and more highly developed supporting interest of the Research Laboratory of Electronics and the Department of Mathematics.

The Massachusetts Institute of Technology proposes a two-year exploratory research in the electronic digital computer field to the Rockefeller Foundation as a project worthy of its consideration for financial support.

PROGRAM

More specifically, M.I.T. proposes a two-year program of research and development in the Center of Analysis, which is expected to yield a definite and well-founded program for the subsequent design and construction of a machine. The particular objectives of the present two-year program are the following:

a) To develop reliable and well-engineered designs of those components of an electronic computing machine for which the general characteristics are known. This refers particularly to the basic components which are used to perform the arithmetic processes of addition, subtraction, multiplication and division; to more specialized computing components which perform such operations as integration and "square-rooting"; and to highly specialized equipment for such purposes as storage of numbers, changing a number from one base to another, and the introduction of functions.

b) To investigate the related problems of switching, control, introduction of data and recording of results, and to develop equipment which will perform these functions reliably and at speeds comparable with computing speeds. It is expected that this part of the work will require the development of entirely new techniques of switching and control so that the flexibility achieved by means of electromagnetic relay systems can be realized at electronic speeds.

c) To study the over-all content and functional structure of an electronic computer. This includes:

1. Broadly conceived systems and apparatus engineering and
2. Simultaneous study of mathematical problems that do or may arise in arithmetical operations on the tremendous scale involved, such, for example, as:
 - a. Attenuation of significant figures.
 - b. Balance between size of variable increment and computing formula complication.
 - c. Machine size vs. time of solution.
 - d. Absolute limits on kind of problem solvable vs. size of machine.
 - e. Possible new numerical formulas or methods to exploit extreme speed of electronic unit operations.

This study coupled with (a) and (b) should yield the fundamental information necessary for a rational prospectus of a specific design and constructional program.

In order to reach the above objectives, seven principal divisions of the work are planned as indicated by the following headings:

1. Mathematical research
2. Electron tube design and engineering
3. Computing components and circuits
4. Number-storage units
5. Input-function equipment
6. Output (result-handling) equipment
7. System control studies and corresponding circuit design.

These work divisions are not intended to be final and lasting, nor are they completely independent. They represent some of the natural cleavages of the over-all problem as it is now visualized but they are subject to whatever modifications are dictated by the progress made.

This program of the Center of Analysis has the strong support of the Institute Administration. While the Center carries primary responsibility, the Research Laboratory of Electronics (RLE) has, as a stated part of its program of research, work on electronic components and techniques that are applicable in digital computation. The already close association between personnel of RLE and the Center of Analysis assures that the fundamental work of RLE will both contribute to and be conditioned by the developing ideas and needs of the Center's program. Similarly, the Department of Mathematics both by expressed policy and by existing working association between members of its staff and those of the Center of Analysis is an integral part of this endeavor. The nature of the mutual interest between the Center of Analysis and these two supporting groups is indicated by the letters and statements appended.

In addition, there is a Navy project at M.I.T. having a specific computational objective whose work may parallel that of the Center of

Analysis program over some areas. The situation with regard to co-operation between the two programs is very simple. It is agreed that if co-operation imposes no restrictions on the Center of Analysis program of a security or other nature, then full bilateral co-operation is mutually desired and will accelerate the progress of both groups. If any restrictions on full scientific availability of results of the Center of Analysis program were to accrue from such co-operation, then co-operation is deemed inappropriate. It is considered likely that there will not be such restrictions.

BUDGET

In the proposed two-year program certain of the costs can be borne by the Institute provided outside funds can carry the others. The Institute can carry the salary of the faculty supervisor, Professor Taylor, (as well as that of Professor Caldwell who is in charge of the Center). It can also provide normal capital items such as machine tools and certain laboratory equipment. On the other hand, it is hoped that costs of noncapital equipment as discussed below might be carried by the grant here proposed.

For the portion of the costs to be defrayed by a grant the following estimates are made:

Summary of Grant Requested for Two-Year Program

1. Salaries and wages	\$60,000
2. Materials	26,400
3. Noncapital equipment	7,500
4. Contingencies	6,100
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Total	\$100,000

Details concerning the various items of this summary are as follows:

1. Salaries and Wages

Research staff - seven men	\$21,000 per year
Shop staff - three men	7,500 per year
Secretarial	1,500 per year
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Total	\$30,000 per year

For a two-year program, total is \$60,000.

2. Materials

Estimated on the basis of \$100 per month per person (including research staff, shop staff, and secretarial), this item is \$100 x 11 persons x 24 months, or a total of \$26,400.

3. Noncapital Equipment

The existing Center of Analysis shop facilities, both electrical and mechanical, are heavily loaded with normal maintenance and refinement of present machines. The new program will require an entirely separate electrical shop and substantial addition to the mechanical shop facilities.

The Electronics Laboratory tube-making facilities are available for this work, but they cannot be used to the extent that we would block access by other workers, nor could we make effective use of facilities already in heavy demand by other workers. For these reasons, there will be required a certain minimum of basic tube-making facilities.

The estimated cost of all shop facilities above is \$15,000. Of this total, it is estimated that about \$7,500 will be required for items of a capital nature, such as laboratory furniture, machine tools, etc., and this is an Institute expense. The remaining \$7,500 of the estimate is for shop and laboratory equipment which is either expended in the course of the work (for example, high-temperature equipment of some types) or which has no substantial use in other work (for example, special tools, special test equipment). While much of this latter expense might properly be listed under the heading

"Materials", a separate estimate is given to emphasize the fact that we recognize our responsibility for providing the capital items.

Total estimate for noncapital equipment \$7,500.

4. Contingencies

The above estimates for salaries and wages are based on a break down of the project into seven main categories, the provisional assignment of one research worker per category on the average, and an estimated allotment of shop time per category.

The estimate for materials is based on average cost experience in this general field. The figure for noncapital equipment is derived as one-half of the total estimated equipment cost.

None of these estimates include any direct allowance for contingencies. It is proposed that a total of \$6,100 be allowed for that purpose.

SUMMARY

The Massachusetts Institute of Technology makes application to the Rockefeller Foundation for support of the above-stated program in the amount of One Hundred Thousand Dollars (\$100,000) to be used over a period of about two years.