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J. W. Forster*

**PROJECT
WHIRLWIND**

Contract N5ori60



ALTERNATIVE
PROJECT WHIRLWIND
PROPOSALS
SEPTEMBER 21, 1948

L-4

**SERVOMECHANISMS LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY**

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ALTERNATIVE

PROJECT WHIRLWIND

PROPOSALS

Report L-4

by

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Project DIC 6345

September 21, 1948

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SUMMARY

The digital computation program of Project Whirlwind might be operated by the Massachusetts Institute of Technology in many ways. Three representative levels are proposed in the attached curves and charts covering the period 1949 to 1953. Plan 1, at \$1.8 million per year, shows the research, development and limited experimental computer operation which could be carried out under a continuation of approximately the present rate of expenditure. Plan 2, increasing to \$3.8 million per year, adds a substantial operating force for the efficient solution of engineering and scientific problems. Plan 3, increasing to \$5.8 million per year, adds further a group devoted to the application of digital computers to the field of control and military uses.

The funds presently allocated to Project Whirlwind will, at the present rate of expenditure, be exhausted in February 1949. Immediate plans must be made for continued support or revision of project objectives.

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STAFF DISTRIBUTIONFigure No. 1

Staff distribution for the three plans for the years 1949, 1951, and 1953 is shown in Figure 1. Activities are grouped as (a) research and development, (b) computer operation, (c) application studies. The total staff, or the staff devoted to each activity in any year, may be read from the scale at the right-hand side of the chart. The lower number in each box gives the staff on that activity under Plan 1. The upper numbers in the boxes give the added (not total) staff under Plan 2 and Plan 3. Under Plan 2 the greater portion of added staff is devoted to computer operation; under Plan 3, to application study and development. Under the latter two plans, not all the staff is added to those specific activities since some are added to research and development to provide equipment for these activities.

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ANNUAL COSTS

Figure No. 2

The annual costs of Plans 1, 2 and 3 are given in Figure 2. Plan 1 carries on the present rate of expenditure of \$1.8 million. Plan 2 assumes \$2 million added by 1953 to permit the addition of computer operation. Plan 3 assumes a further \$2 million by 1953 for active application studies. The costs plotted for the years 1949-1952 were determined by the rate at which personnel and facilities could be efficiently added at M.I.T. to accomplish the objectives of the respective plans.

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ACTUAL PAST EXPENDITURES

and

EXTRAPOLATED FUTURE EXPENDITURES

Figure No. 3

Figure 3 is presented to show on a large scale the behavior of the actual monthly expenditures of Project Whirlwind from the beginning of digital computer research in October 1945 through August 1948. This curve is then extrapolated and shown in relation to the beginning of Plan 3 of this report.

Past experience shows that the rate of growth of the project has been exponential. The amount of work to be done in the computer field is great enough so that this exponential increase could be maintained. If allowed to do so, the size of the project could rapidly exceed even that allowed for in Plan 3 or that which Massachusetts Institute of Technology alone could undertake.

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EXTRAPOLATED EXPENDITURES SHOWING
RELATION TO PROPOSALS

Figure No. 4

Figure 4 combines on one graph the actual monthly expenditure curve of Figure 3, the extrapolation of this curve, and the approximate monthly expenditures as they would be for each of the three alternative proposals in this report.

An explanation of this extrapolation will be found in the discussion of Figure 3.

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TOTAL ACCUMULATED COSTS

Figure No. 5

Figure 5 shows the accumulated total expenditures at the end of each year for the three plans. These curves were obtained by integrating the annual cost curves in Figure 2. The initial value of \$2.4 million at the end of calendar year 1948 was obtained from recorded expenses plus estimated expenses and encumbrances to that date.

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POSSIBLE ACTIVITIES IN ALTERNATE FUTURE PROGRAMS

Figure No. 6

Figure 6 shows the expected distribution of staff time and the estimated results of that effort for each of three alternate proposals for Project Whirlwind.

Activities are divided into three groups: (1) computer research and development, (2) Whirlwind I operation, and (3) applications. Under each activity the staff distributions for the three plans are given by numbers and the progress for each year listed, followed by the status at the end of the five-year period. The meaning of the chart may be summarized as follows:

PLAN I.

With an annual expenditure rate of \$1.8 million available, research and development on computers can be maintained at about the 1948 rate. No new design beyond design studies can be carried out during the period.

Whirlwind I can be completed and maintained in operating condition although no staff would be available to allow operation more than a small percentage of the time. Mathematical research and problem coding, with access to Whirlwind I, would be continued.

Only preliminary applications studies could be made during this period.

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PLAN II.

With an additional annual expenditure of \$2 million bringing the total to \$3.8 million per year, Whirlwind I can be put into efficient operation with a staff sufficient to handle a high-speed problem flow network. (See discussion of Figure 8.)

Sufficient staff would also be available to increase the research activity and carry out the design of a new computer by the end of 1953.

To the preliminary applications study could be added the design of experimental data conversion equipment.

PLAN III.

A total annual expenditure rate of \$5.8 million will allow completing some detailed studies and experimental demonstrations of computer control applications.

The design and research groups could be increased to allow construction (but not installation or test) of a new computer by the end of 1953.

Whirlwind I operation would not be increased except to provide computer time for control studies. These studies would be carried out by the applications staff.

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DISCUSSION OF ORGANIZATION CHART D-32880-1

Figure No. 7

This chart shows the present assignments of sixty-six (66) staff members working on Project Whirlwind. In addition are indicated vacancies into which present activities might advantageously be expanded. This chart does not correspond to Plans 1, 2 or 3 of the remainder of this report.

The unfilled activities are independent of the outcome of existing activities and could be carried in parallel to accelerate progress.

Training, mathematics, block diagrams, storage, and applications are most critical and should be strengthened in the order given.

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COMPUTER CENTER ORGANIZATION CHART

Figure No. 8

This chart is an estimate of the personnel which will be required to operate a computing center handling a high density of traffic flow for scientific and engineering problems. Non-Staff personnel are indicated under the staff groups. The problems assumed are routine, well within the available high speed computer capacity, and of types where formulation and method of solution are straightforward. Problems are handled in a manner corresponding to telegraph messages in a communications system.

Problems are set up and coded by those using the services of the computer organization, not by the staff on Figure 8. The staff of the central group would provide some training and the formulation and coding of library programs, and handle machine operation and traffic flow. Communications between computing equipment and user can be by mail and teletype.

It is believed that such central computer organizations, operated either privately or by government activities and if properly equipped and organized, can provide the most efficient and lowest cost computation service of the next few years. Capital investment and maintenance staff and cost will limit the number of computers which can be obtained for specific applications.

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Page 12.

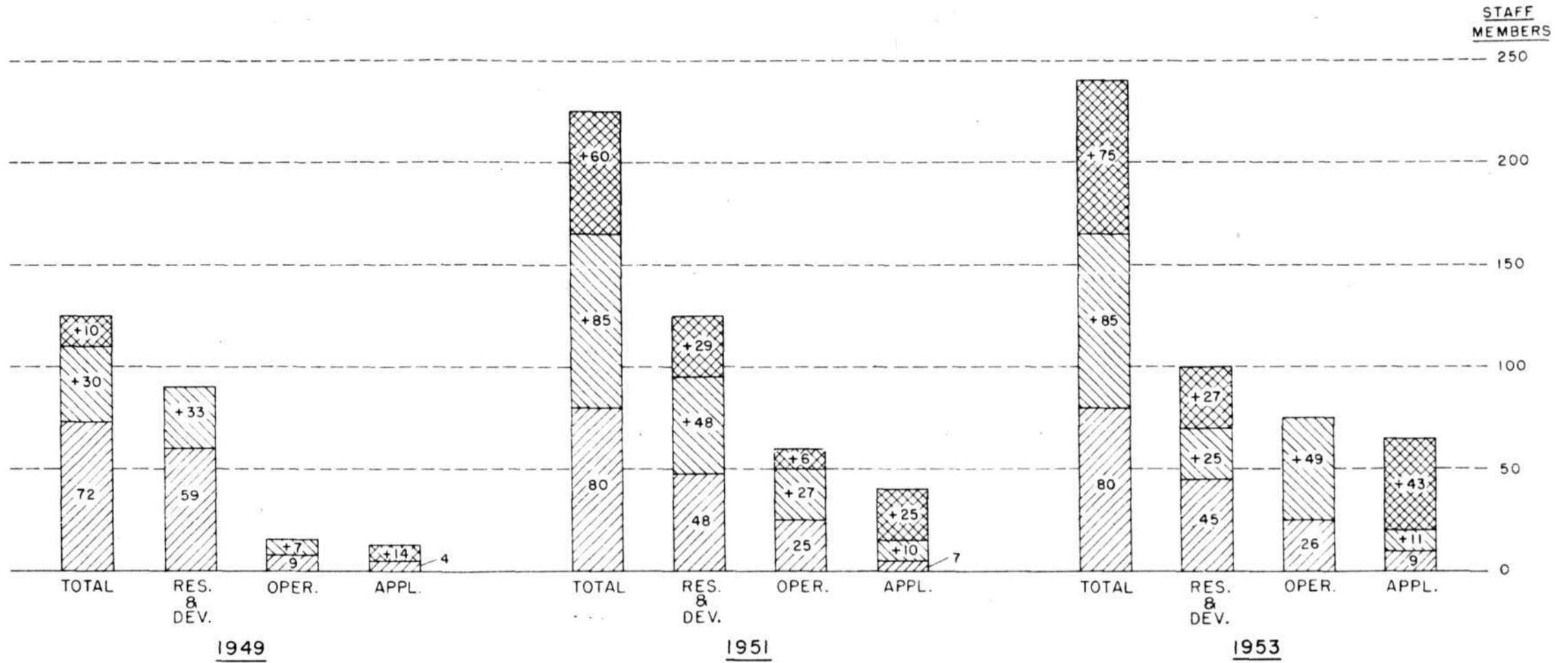
DRAWING LIST


| | | |
|------------|---|-----------|
| Figure 1 | - | B-32944 |
| Figure 2 | - | A-38552-G |
| Figure 3 | - | B-38553-G |
| Figure 4 | - | B-38556-G |
| Figure 5 | - | A-38555-G |
| Figure 6 | - | D-32945 |
| Figure 7 | - | D-32880-1 |
| • Figure 8 | - | D-32881-1 |


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PLAN 1 STAFF \$ 1.8 MILLION / YEAR MAX. 

PLAN 2 ADDITIONAL STAFF \$ 3.8 MILLION / YEAR MAX. 


PLAN 3 ADDITIONAL STAFF \$ 5.8 MILLION / YEAR MAX. 

FIGURE 1
STAFF DISTRIBUTION

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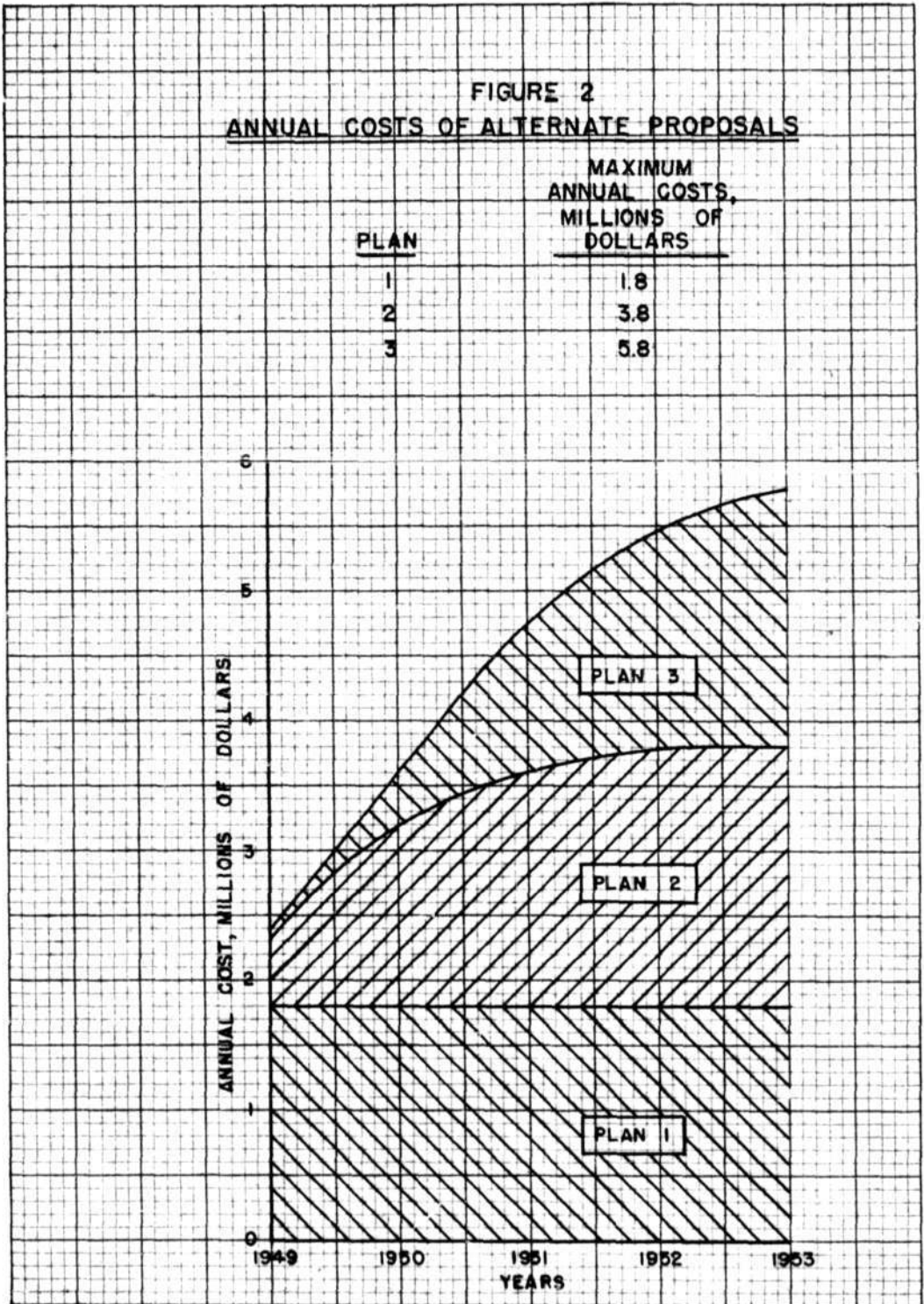
M.I.T. SERVOMECHANISMS LABORATORY

KEUFFEL & ESSER CO., N. Y. NO. 887-66
5 X 8 1/2 IN. 14 1/2 IN.
MADE IN U.S.A.

A-38552-G

FIGURE 2
ANNUAL COSTS OF ALTERNATE PROPOSALS

| PLAN | MAXIMUM ANNUAL COSTS, MILLIONS OF DOLLARS |
|------|---|
| 1 | 1.8 |
| 2 | 3.8 |
| 3 | 5.8 |



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FIGURE 2

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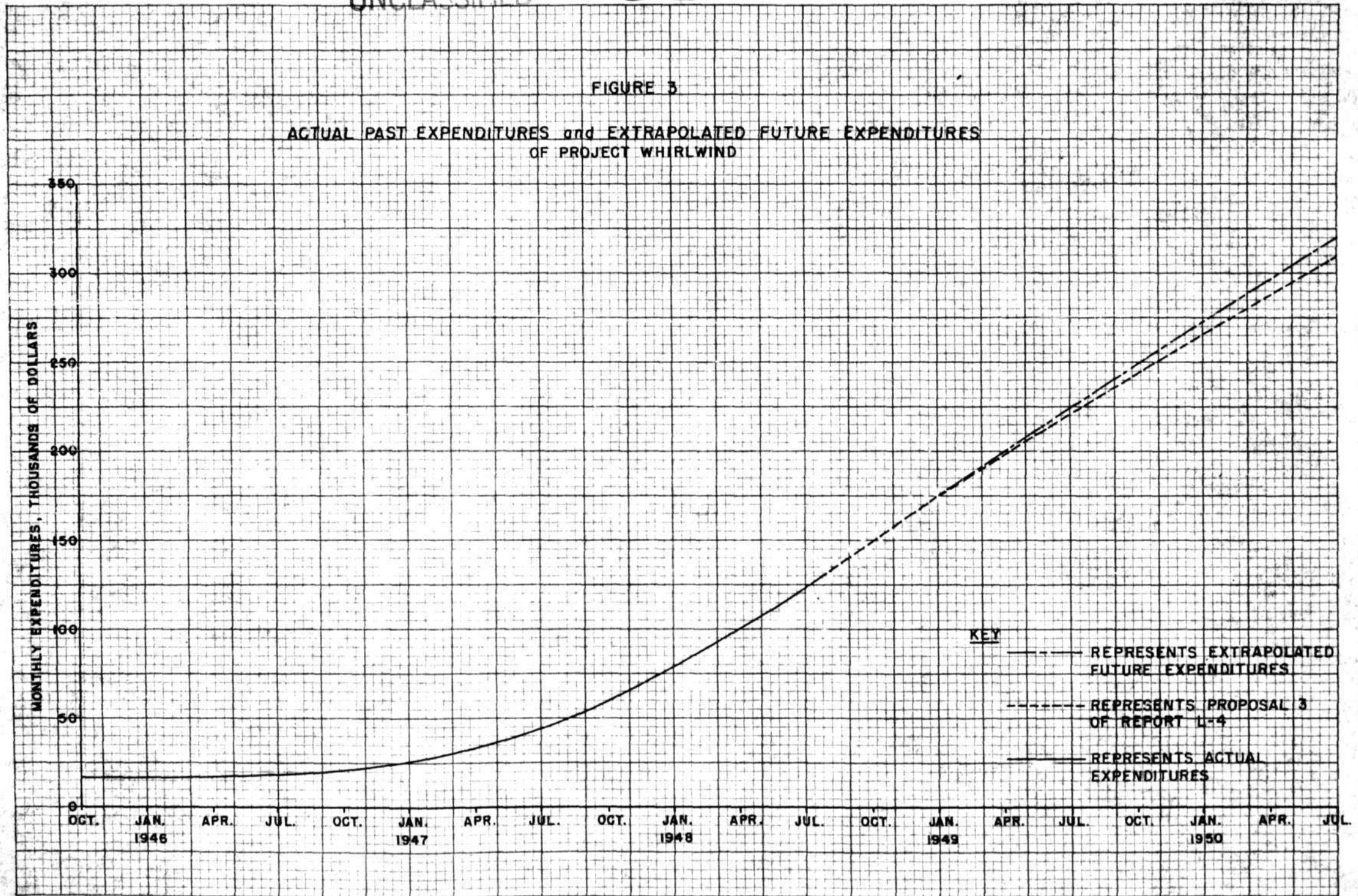
M.I.T. SERVOMECHANISMS LABORATORY

KEUFFEL & ESSER CO., N. Y. NO. 358-410
5 X 5 to the 1/2 inch.
MADE IN U.S.A.

B-38553-G

FIGURE 3

ACTUAL PAST EXPENDITURES and EXTRAPOLATED FUTURE EXPENDITURES
OF PROJECT WHIRLWIND



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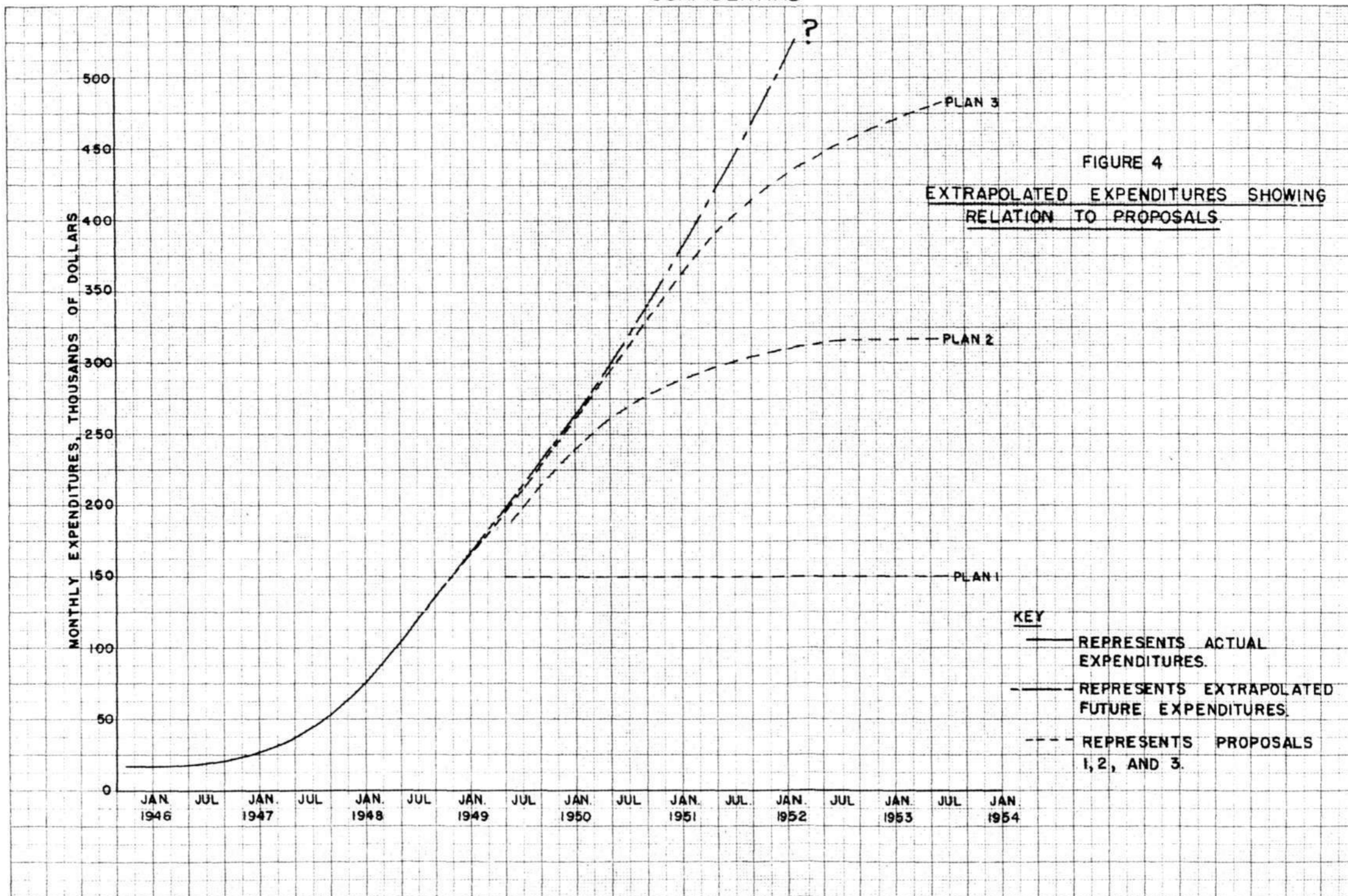
FIGURE 3

M.I.T. SERVOMECHANISMS LABORATORY

B-38556-G

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FIGURE 4

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M. I. T. SERVOMECHANISMS LABORATORY

REUPPEL & BERER CO., N. Y. NO. 8887-42
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MADE IN U.S.A.

A-38555-G

FIGURE 5
TOTAL ACCUMULATED COSTS

| PLAN | MAXIMUM ANNUAL COSTS, MILLIONS OF DOLLARS |
|------|---|
| 1 | 1.8 |
| 2 | 3.8 |
| 3 | 5.8 |

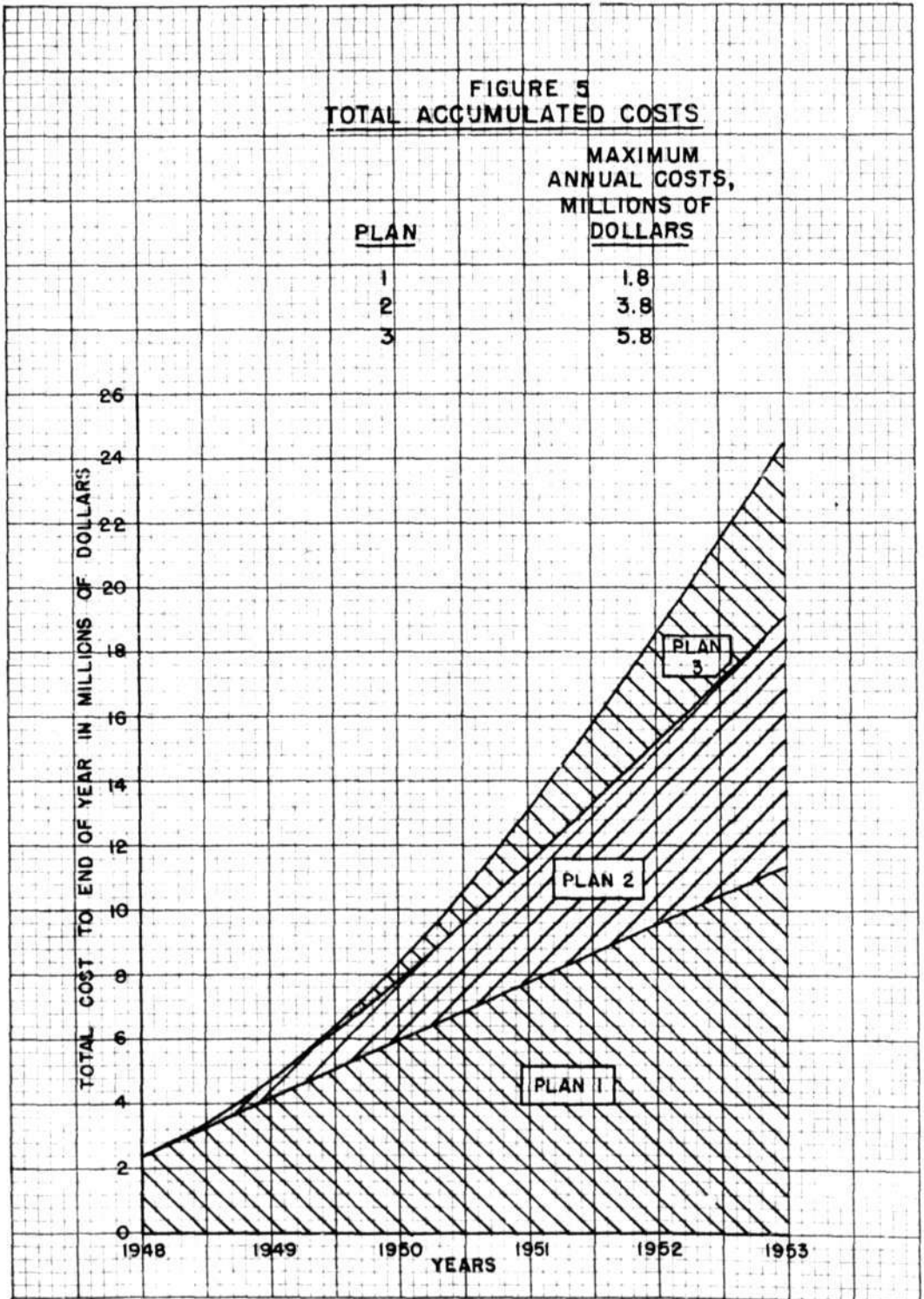


FIGURE 5

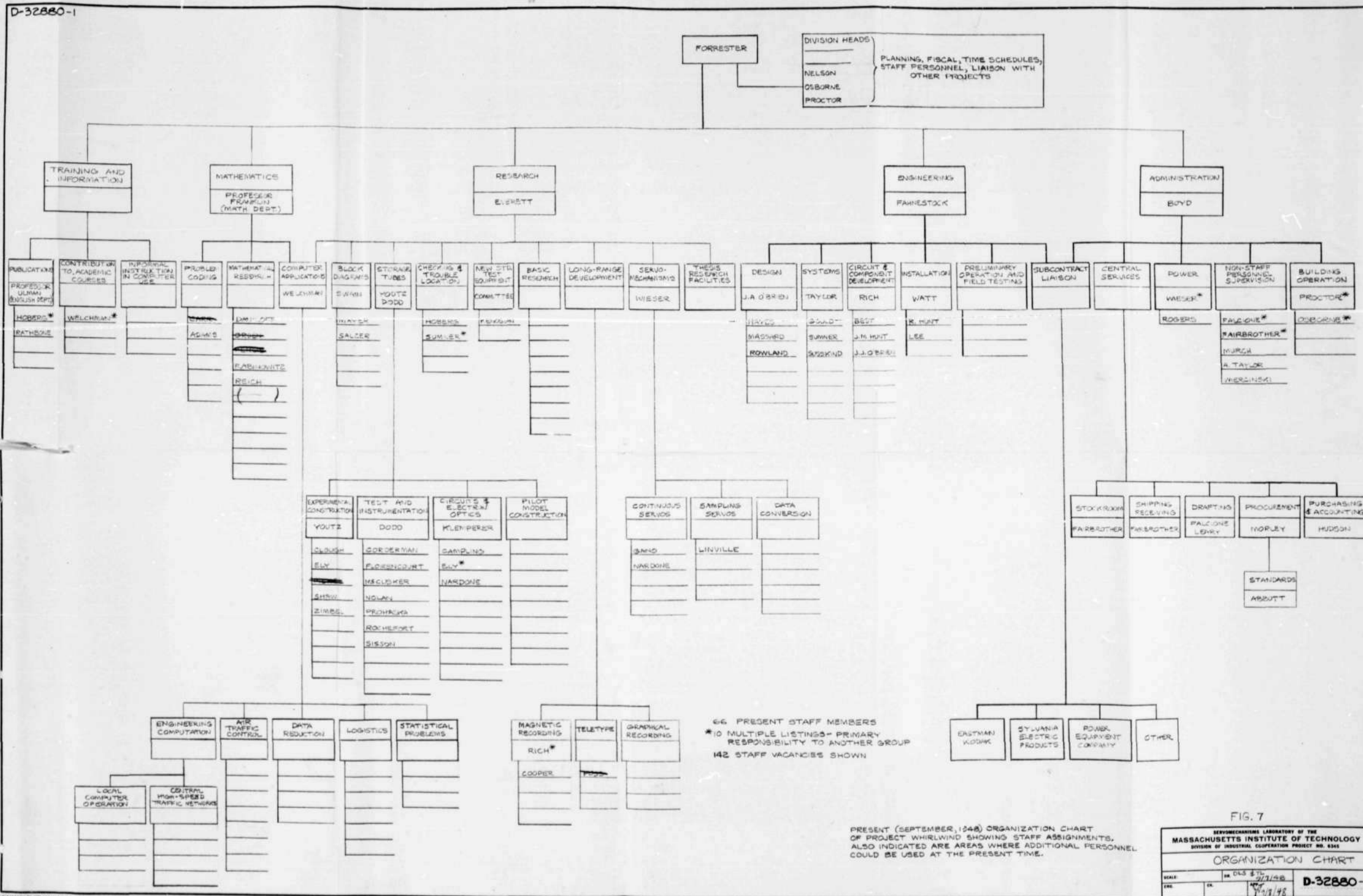
| | | | 1949 | 1950 | 1951 | 1952 | 1953 | STATUS |
|-----------------------------------|---|--------------------------------------|---|--|---|--|--|--|
| COMPUTER RESEARCH AND DEVELOPMENT | WWI COMPLETION STORAGE RESEARCH CIRCUIT AND COMPONENT RESEARCH NEW DESIGN AND CONSTRUCTION | PLAN 1 \$1.8 MILLION/YEAR | 59 WWI ASSEMBLED EXCEPT FOR STORAGE STORAGE TUBES AVAILABLE IN SMALL NUMBERS | 51 WWI COMPLETE WITH MINIMUM INPUT-OUTPUT CHECKING METHODS AND TROUBLE LOCATION STUDIES CIRCUIT RESEARCH FOR WWI IMPROVEMENT | 48 RESEARCH AND DEVELOPMENT OF STORAGE, COMPONENTS, AND CIRCUITS AT 1948 LEVEL | 45 (1948 LEVEL) | 45 (1948 LEVEL) | STORAGE AND COMPONENTS DEVELOPED TO POINT WHERE NEW COMPUTER DESIGN COULD BE STARTED. |
| | | PLAN 2 \$3.8 MILLION/YEAR MAXIMUM | 92 STORAGE TUBE EXPANDED PROGRAM | 98 START NEW DESIGN STUDIES RESEARCH AND DEVELOPMENT ACTIVITY AT TWICE THE ABOVE LEVEL AND MOVED TO NEW QUARTERS | 96 DESIGN STUDIES | 78 DESIGN OF NEW COMPUTER SOME STAFF TRANSFERRED TO WWI OPERATION | 70 DESIGN CONTINUED STORAGE AND COMPONENT RESEARCH CONTINUED AT 80% OF 1951 LEVEL | NEW COMPUTER DESIGN COMPLETED. |
| | | PLAN 3 \$3.8 MILLION/YEAR MAXIMUM | 92 SAME AS PLAN 2 | 109 RESEARCH INCREASED NEW STORAGE METHODS STUDIED | 125 INCREASED DESIGN WORK COMPUTER PACKAGING STUDIES. | 116 COMPLETE NEW COMPUTER DESIGN | 102 NEW DESIGN OF COMPUTER UNDER CONSTRUCTION | NEW COMPUTER READY FOR INSTALLATION AND TEST |
| WWI OPERATION | MATHEMATICAL RESEARCH TRAINING OPERATION WWI MAINTENANCE AND IMPROVEMENT | PLAN 1 | 9 TEST PROBLEMS BEING CODED | 24 MATHEMATICAL STUDIES WWI MAINTENANCE GROUP SET UP | 25 | 26 | 26 | WWI MAINTAINED IN OPERATIVE CONDITION NO OPERATING STAFF AVAILABLE |
| | | PLAN 2 | 16 INCREASE MATHEMATICAL RESEARCH START TRAINING IN PROBLEM PREPARATION | 49 BUILD UP OPERATING GROUP EXTEND INPUT-OUTPUT EQUIPMENT STUDY HIGH SPEED PROBLEM FLOW NETWORKS | 52 PRELIMINARY WWI OPERATION | 69 TRIALS OF HIGH SPEED COMPUTER PROBLEM NETWORK | 75 WWI IN OPERATION WITH TELETYPE COMMUNICATIONS SYSTEMS | WWI IN USE ON SCIENTIFIC AND ENGINEERING PROBLEMS MATHEMATICAL RESEARCH AND CODING OF LIBRARY PROGRAMS |
| | | PLAN 3 | 16 SAME AS PLAN 2 | 49 SAME AS PLAN 2 | 58 PLANNING USE OF WWI IN CONTROL INVESTIGATIONS | 75 PRELIMINARY CONTROL USE OF WWI | 75 WWI OPERATION AS ABOVE ALSO ONE SHIFT OPERATION TO STUDY CONTROL APPLICATIONS (USED BY STAFF IN BOTTOM LINE) | AS ABOVE WITH TIME AND TERMINAL EQUIPMENT ALLOCATED FOR CONTROL RESEARCH. |
| APPLICATIONS | CONTROL STUDIES LOGISTICS DATA REDUCTION DATA CONVERSION EXPERIMENTAL EQUIPMENT | PLAN 1 | 4 PRELIMINARY STUDY ONLY | 5 | 7 | 9 | 9 | BASIS FOR DETAILED STUDIES ESTABLISHED |
| | | PLAN 2 | 4 SAME AS PLAN 1 | 13 DATA CONVERSION RESEARCH ADDED | 17 | 18 | 20 | SAME AS PLAN 1 WITH DATA CONVERSION EQUIPMENT DESIGNED FOR EXPERIMENTAL PURPOSES. |
| | | PLAN 3 | 14 APPLICATION GROUP STARTED PRELIMINARY STUDY | 27 STUDY SUCH APPLICATIONS AS GUIDED MISSILE CONTROL AND DATA EVALUATION, AIR TRAFFIC, LOGISTICS AS STAFF BECOMES AVAILABLE | 42 | 43 STAFF USING WWI FOR EXPERIMENTAL WORK | 63 | SOME DETAILED STUDIES AND DEMONSTRATIONS OF COMPUTER CONTROL APPLICATIONS COMPLETED |

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PROJECT WHIRLWIND

POSSIBLE ACTIVITIES

FIGURE 6

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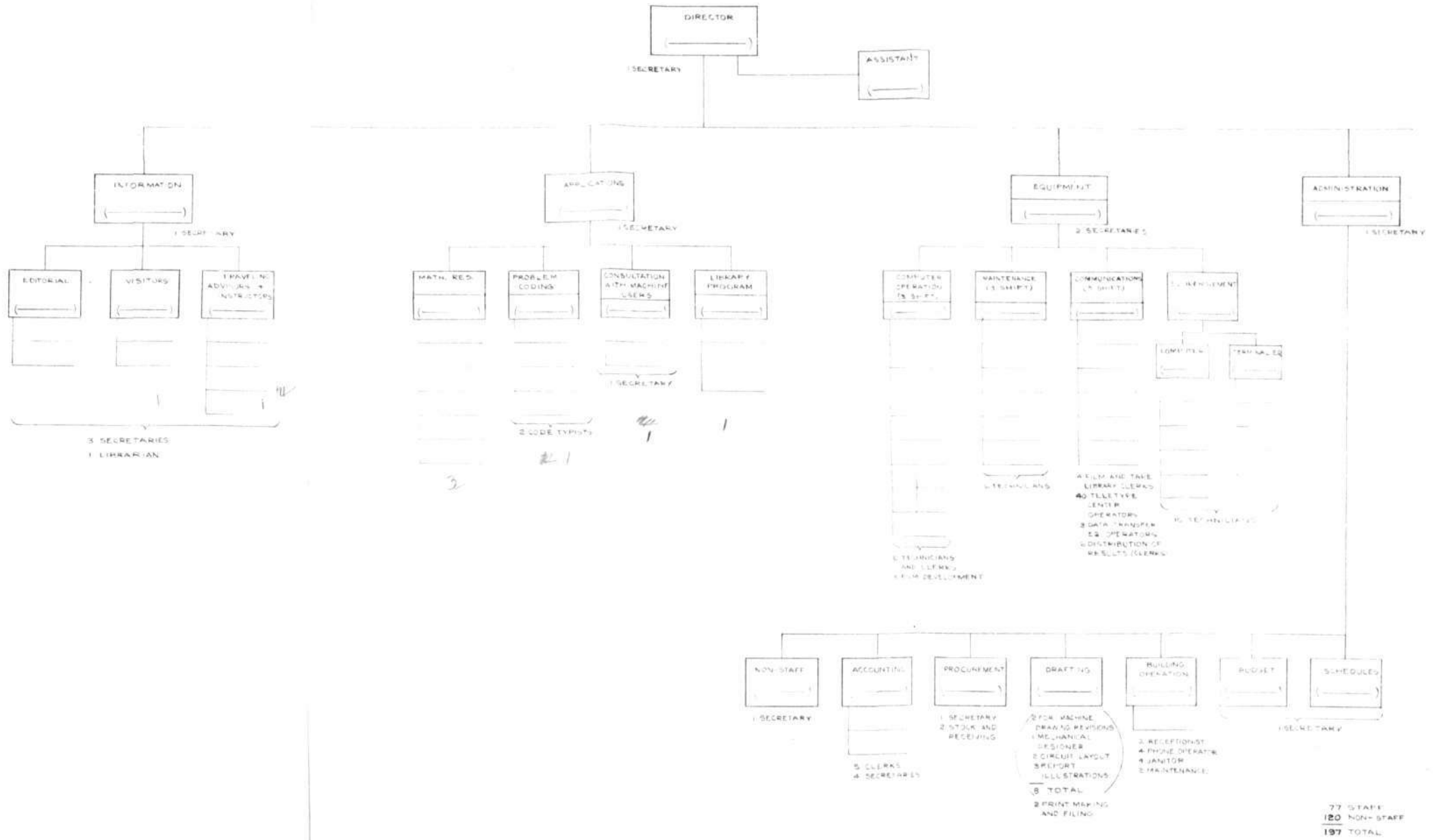


FIG. 8

| | | | |
|---|----|------|-----------|
| SERVOMECHANISMS LABORATORY OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY | | | |
| DIVISION OF INDUSTRIAL COOPERATION PROJECT NO. 4345 | | | |
| ORGANIZATION CHART | | | |
| COMPUTER OPERATIONS CENTER | | | |
| SCALE | DR | DATE | 9/7/48 |
| ENR | CR | APP | 7/8/48 |
| | | | D-32881-1 |