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MIT
Differential analyzer

A WORLD CENTER OF APPLIED MATHEMATICS

Recent developments are bringing nearer to fruition the plan for creating at Massachusetts Institute of Technology in Cambridge a world center of mathematical calculation and analysis.

Several years ago, when The Rockefeller Foundation made grants totaling $95,000 to the Institute to finance the development of a differential analyzer, a principal incentive was the argument that such an apparatus would serve world science. It would provide a calculating machine of unprecedented versatility and power for the solution of complicated mathematical problems in engineering and pure science. And, it was said, institutions and individuals in all lands would welcome the existence of a central well-equipped bureau of this kind.

Since then, many inquiries about and requests for service in mathematical computation and analysis have poured in upon the Institute, and during 1939 additional support of the program was voted by the Carnegie Corporation in an appropriation of $45,000.

Meanwhile, the construction and installation of the differential analyzer has pushed steadily forward. A crew of six young electrical engineers has been almost continually on a job in which overtime is never thought of as anything but an opportunity for exciting and gratifying experience in scientific work. A visit to the Institute one late afternoon in January found the group busily engaged with wires, tubes, relays, rotating discs, and other gadgets which together make up the automatic intelligence of this marvelous machine. At the end of January

completion of the job was in sight, with the analyzer better than ninety-five percent installed, and it was tentatively planned to begin operations in March. By then, if all goes well, every foot of the more than 300 miles of wire will be in place, every one of the 240 motors, the 1,800 vacuum tubes, and the hundreds of magnets, fuses, and other elements of the assembly will be connected, and the mathematical robot will be ready to solve problems which are actually beyond the capacity of any team of human computers.

In 1935, when the Foundation made a grant of $10,000 to enable Professor Vannevar Bush and his associates to put down in blueprints their idea for this machine, it was estimated that about three years would be required for construction. In 1936 the plans were completed, and a further grant of $85,000 was made to provide materials, labor, and design for the actual construction. But the task was unique, many a new trail of experimentation had to be blazed, and the three-year estimate proved all too meagre an allowance of time. During 1939 it also became apparent that additional funds would be necessary in the final stage of construction. A grant-in-aid of $3,000 was accordingly given last November, bringing the total of Foundation contributions to $98,000. Also $5,000 of the Carnegie Corporation's appropriation was allotted to the differential analyzer building fund, making the total cash investment in the big machine $103,000. In addition, the indirect contributions of Massachusetts Institute of Technology are of the order of $100,000. Allowing for several tons of automatic telephone equipment, donated by the Bell Telephone Laboratories and utilized in the construction, the total cost of the differential analyzer rises to still higher figures.

It is probably the largest computing machine ever constructed - it weighs nearly fifty tons and fills a 60x24-foot room - as it is certainly the most powerful and adept.

The big machine was designed to solve very difficult problems, but its construction raised some perplexing problems on its own account. "Indeed," said Professor S. H. Caldwell, "the whole job of building this machine has been a liberal education in the cussedness of inanimate objects. We had a feeling all along that we were trying to squeeze more than could be expected out of the material, and again and again we were met by what seemed at the time an impasse.

"There was, for example, the problem of the recording system. We contemplated an arrangement of electric typewriters to set down the result of the various mathematical operations performed by the machine. We found an electric typewriter that can type twenty strokes a second, which is fast enough - but how to measure the instantaneous position of the rotating system at a given moment without stopping the shafts, and at the same time translate these values of position into numerical quantities that can be typed on a moving tape? What was required was a process of swift decoding accomplished in the twinkling of an eye. Without it all the ingenious mechanisms were useless."

Somehow, with the assistance of the nimble genii of vacuum tubes and the obedient attendance of magnetic relays, the difficulty was solved. An arrangement has been devised by which every six seconds this instantaneous decoding system goes into operation: it picks up from the various rotating parts the solution as it stands in the machine at that moment, translates it into corrected numerical values, and the electric

typewriter flashes into action. Thus every six seconds the differential analyzer records the status of the problem on which it is working, and at the end of the process types the solution neatly on a white paper tape. It can accomplish in hours a solution that required weeks and even months on the old style mechanical analyzer, and that would require years of human computation, granted that brain and fingers were agile enough and persistent enough to follow these intricate calculations through to the end.

Several other types of computing machines, adapted to other kinds of problems, have been acquired independently by Massachusetts Institute of Technology. Together with the new analyzer, these give it unparalleled equipment for applied mathematics. Seismologists, electrical engineers, mechanical engineers, aeronautical designers, chemists, astronomers, cosmic-ray researches, and investigators of ballistics are among those who have brought problems of almost indescribable complexity here for the electro-mechanical robots to solve.