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ORDNANCE DEPARTMENT DEVELOPS ALL-ELECTRONIC CALCULATING MACHINE

A new machine that is expected to revolutionize the mathematics of engineering and change many of our industrial design methods was announced today by the War Department.

Designed and constructed for the Ordnance Department at the Moore School of Electrical Engineering of the University of Pennsylvania by a pioneering group of Moore School experts, this machine is the first all-electronic general purpose computer ever developed. It is capable of solving many technical and scientific problems so complex and difficult that all previous methods of solution were considered impractical.

This mathematical robot, known as the ENIAC (Electronic Numerical Integrator and Computer), is the invention of Dr. J. W. Mauchly and Mr. J. Presper Eckert, Jr., both of the Moore School. Begun in 1943 at the request of the Ordnance Department to break a mathematical bottleneck in ballistic research, its peacetime uses extend to all branches of scientific and engineering work.

The ENIAC is capable of computing 1000 times faster than the most advanced general-purpose calculating machine previously built. The electronic methods of computing used in the ENIAC make it possible to solve in hours problems which would take years on a mechanical machine--a time so long as to make such work impractical.

Containing close to 18,000 vacuum tubes in its mechanism, the new machine is a giant of electronic precision. It occupies a room 30 by 50 feet and weighs 30 tons.

Although the machine was originally developed to compute lengthy and complicated firing and bombing tables for vital ordnance equipment, it will solve equally complex peacetime problems such as nuclear physics, aerodynamics and scientific weather prediction.

Official Army sources made it known that research laboratories of several large industrial firms have expressed active interest in the machine. These include manufacturers of electron tubes, jet engines, gas turbines, and other types of engines. Spending vast sums of money yearly for experimentation and design research on their products, these firms are naturally interested in any means of reducing such costs. It is further felt that better, more scientific design will now be possible, as a result of the new machine's facility for handling hundreds of different factors in one computation. Much lengthy and costly design experimentation, often involving the construction of a seies of expensive models, a common practice in airplane design, might also be eliminated. It was explained that such trial-and-error methods were successful in Edison's and Marconi's day, but would not suffice to deal with complex phenomena arising, for instance, from the blast of an atomic bomb.

The new machine does not remove the need for legitimate experimentation, whose purpose it is to discover fundamental principles and factors which affect these principles. Likewise, it was pointed out that the electronic calculator does not

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replace original human thinking, but rather frees scientific thought from the drudgery of lengthy calculating work. The work of the English physicist, Dr. D. R. Hartree, who spent 15 years in calculations on the structure of the atom, was given as an example of lengthy computation attendant on modern science.

Cost estimates of the ENIAC run to about $400,000. This includes all research and development work; future machines of this type could be produced much more cheaply.

Built at the Moore School of Electrical Engineering of the University of Pennsylvania for the Amy Ordnance Ballistic Research Laboratory at Aberdeen, the ENIAC is the result of a fortunate combination of men and circumstances. The origininal idea for the electronic general purpose calculator was that of Dr. John W. Mauchly, of the Moore School faculty. Dr. Mauchly, previously faced with many physical and meteorological problems requiring voluminous calculation, had conceived electronic devices for handling large computing problems in mass-production style. Captain Herman Goldstine, mathematician and ballistic expert for Army Ordnance, saw in these plans a powerful tool needed by the Ballistic Research Laboratory, which was confronted with overwhelming computational work, and he enthusiastically promoted the interest of the Ordnance Departnent in undertaking development of the ENIAC. Administrative supervision of the project was assumed by Dr. J. G. Brainerd, of the Moore School. Mr. J. Presper Eckert, Jr., a recent graduate of the Moore School, joined with Dr. Mauchly in elaborating the plans for the ENIAC and took charge of the technical and engineering work. Mr. Eckert and Dr. Mauchly have to their credit a number of inventions relating to improved methods of electronic computing.

The ENIAC was begun in July, 1943, and finished in the Fall of 1945. That a development of this magnitude was completed in so short a time is largely due to the close cooperation between Amy Ordnance and the Moore School. The appointment of Captain Goldstine to maintain technical liaison was an important factor.

The ENIAC was sponsored by Colonel Paul. N. Gillon, a 38-year-old West Pointer with a graduate degree from Massachusetts Institute of Technology. He has given his enthusiastic support through the trying period which characterizes all pioneering developments in science. Colonel Gillon, when at the Ballistic Research Laboratory, was first interested in the project by Captain Goldstine. A transfer to Office, Chief of Ordnance, enabled Colonel Gillon to give the necessary wholehearted support to the project. He sums up his role in this connection by saying his part was "confined to such things as decisions on scope and flexibility; overall supervision and support; and fighting off the competition of apparently more urgent but actually less important conflicting projects through the war period."

The designers of the ENIAC speak of it as a "digital" or "discrete variable" computing machine, as opposed to the "continuous variable" type of machine, of which the differential analyzer is an outstanding example. The latter are devices that can handle only a restricted class of problems. But it was the experience of the sponsors of the ENIAC that modern physical problems could no longer be handled adequately by existing types of calculators.

Early in the emergency, the non-existence of ultra-rapid calculating facilities was recognized as a potential bottleneck in the swift delivery of vital ordnance materiel to troops in event of war. Artillery, for instance, after being built and tested, cannot be put into use until firing tables, indispensable to the operation of the guns, are supplied. Consequently, combat equipment could pile up at shipping depots, waiting for the proper firing tables. That this situation did not occur was due to the enormous effort that the Ordnance Department expended in utilizing all possible computational arrangements in facilities and personnel to prevent it. The Ordnance Department had its own differential analyzer, in addition to the one it was using at the University of Pennsylvania. These analyzers performed many labor-saving calculations up to a certain point; beyond that, a staff of about 200 trained conmputers was needed to complete the tables. A general purpose digital type of machine was needed, so that all calculating operations could be performed by machine. The construction of such a machine was being undertaken by another institution, but, because of its mechanical nature, its speed was nowhere near as high as that desired. At this point the team of Eckert-Goldstine-Mauchly, under Colonel Gillon's supervision, began to function and work commenced on the all-electronic general purpose computing machine, the ENIAC.

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The speed of this computer is phenomenal. The first problem put on the ENIAC, which would have required I00 man-years of trained computer's work, was completed in two weeks--of which two hcurs was actual electronic computing time, and the remaining time devoted to review of the results and details of operation. If used to complete capacity, the ENIAC will carry out in five minutes more than ten million additions or subtractions of ten-figure numbers. The machine performs a simple addition in 1/5000 of a second (and can do a number of distinct additions simultaneously); a single multiplication by a ten-digit multiplier in 1/360 of a second; a nine-digit result in division or square rooting in 1/38 of a second.

It is felt that the tremendous speed and flexibility of the machine will permit many immediate industrial uses, as well as application to far-reaching investigations of natural phenomena. Although the cost of such a machine might seem fairly high, value received in elimination of expensive design processes would easily cover the initial investment in a short period of time. Many electrical manufacturing firms, for instance, spend many thousands of dollars yearly in building "analogy" circuits when designing equipment. A continuous-type of calculator used in this work is the "network analyzer." Like the differential analyzer, it can solve only certain restricted types of problems and then only up to a certain point.

Sponsors of the ENIAC point out that it can carry out numerous "logical" operations but that it cannot do creative thinking. The mathematician, physicist or engineer is still needed--in fact, more than ever, to analyze the problem mathematically and set up the sequence of operations in the machine. It is expected, moreover, that machines of this type will bring a greater "mathematics consciousness" to engineering and production.

In the latter connection several large organizations, whose work involves much statistical work, have expressed interest in the ENIAC. Among these are the National Bureau of Standards and the Army Air Forces Weather Service.

A very successful place for the new machine is expected in the science of weather forecasting. Amy and Navy officials are most interested in this application. Instead of makeshift techniques, the machine would make possible the scientific analysis of the large mass of meteorological data that has been collected over the years. Not only would long-range accurate weather predictions be made possible, but weather in any spot in a given area could be determined almost instantaneously, when the "boundary data" are known.

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