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PHYSICAL ASPECTS, OPERATION OF ENIAC ARE DESCRIBED

The ENIAC (Electronic Numerical Integrator and Computer) is a large scale electronic general purpose computing machine, It occupies a room 30 by 50 feet in size. It weighs 30 tons and has 100 feet of front panels.

This machine is the most intricate and complex electronic device in the world, requirinig for its operation 18,000 electronic tubes. Some idea of the machine's complexity can be gained when it is compared with an average radio, which has ten tubes, the largest radar set having 400 tubes and the B-29 bomber with less than 800 tubes. Included in its circuits are 500,000 soldered joints, 70,000 resistors, and 10,000 capacitors.

While there are no moving parts in the computer, the heat generated by the multitude of vacuum tubes is dissipated by a temporary blower system which does create some noise. This condition will not exist when the ENIAC is installed in its specially designed air-conditioned building at its permanent location at Aberdeen Proving Ground. External to the ENIAC, but a part-of the total installation are two comparatively small machines which feed information into the ENIAC from punched cards and receive the results therefrom in a similar manner.

The forty main panels of the ENIAC are arranged in a large U, with 16 of the panels on each leg and 8 panels on the end. Viewing the U from the inside, the 40 panels arranged from left to right are:

1. Control and Initiating Unit
2. Cycling Unit
3, and 4. Master Programmer
5, and 6. First Function Table
7, and 8. Accumulators 1 and 2
9. Divider and Square Rooter
10 - 17. Accumulators 3 - 10
18 - 20. Multiplier
21 - 28. Accumulators 11 - 18
29, and 30. Second Function Table
31, and 32. Third Function Table
33, and 34. Accumulators 19 and 20
35 - 37. Constant Transmitters
38-40. Printer

The ENIAC consumes 150 kilowatts. This power is supplied by a three-phase regulated, 240-volt, 60-cycle power line, The power consumption may be broken up as follows; 80 kilowatts for heating the tubes 45 kilowatts for generating d.c. voltages, 20 kilowatts for driving the ventilator blower and 5 kilowatts for the auxiliary card machines.

Special test equipment allows many of the circuits to be easily tested. This includes a special, test bench with its own power supply and electronic and oscillographic equipment, so that individual units may be withdrawn and tested without interfering with the operation of the ENIAC.

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The operational characteristics of the ENIAC may be classified as follows: arithmatic elements, memory elements and control elements.

There is also "magnitude discrimination" which is not in itself distinct since it partakes of both arithmetic and control characteristics. This function consists of comparing the size of two numbers and, on the basis of such comparison, selecting which of two computational courses is to be follwed. This ability is essential to any autcmatic computing device.

The arithmetic elements of the ENIAC exist in a number of units listed in the preceding physical description. The most important of these are as follows: 20 accumulators, 1 multiplier and 1 combination divider and square rooter. The accumulators provide means for storing numbers computed in the course of a problem and for allowing the addition or subtraction of a second number to or from the stored number. They are capable of performing these operations on numbers having as many *as* ten decimal digits and indicate the associated plus or minus sign. The multiplier can find the product of two decimal numbers, each having as manv as ten digits. The combination divider and square rooter can find the quotient of two nine-digit decimal numbers or the square root of *a* nine-digit decimal number.

Memory elements of the machine can be divided into two groups: "internal memory" and "external memory." The former exist in all memory devices within the machine, thus being of limited capacity, while the latter exist outside of the machine in the form of punched cards and is accordingly of unlimited capacity. Communication between the internal and external memory takes place at speeds which are set by the mechanical punch card devices.

Internal memory can be further subdivided in three ways. First, there is memory for numerical data which are calculated in the course of the computation and which must be available for other portions of the computation. The accumulators provide the means of memory for numerical data. Second, memory for information such as empirical data that are known before the machine is started must be provided. Such data can be remembered by the setting of switches on the function tables. The constant transmitter which can store data, read from punch cards and introduce these data as required into the ENIAC provides for both numerical data memory and empirical data memory. Third, there is a memory for instructions. This causes transfer between the various memory and arithmetic units and caused the arithmetic units to perform desired operations on the numbers.' Each unit of the ENIAC contributes to this third form of internal memory by following a specific routine established for it in advance. This is accomplished by the setting of program switches which permit program input signals to be received in one or more units thus causing the unit or units to function within themselves and on the completion of this internal functioning to emit program output signals to cause other units to function. The master programmer coordinates this kind of memory function for the *entire* ENIAC.

The control elements of the ENIAC include the initiating unit, concerned mainly with starting and stopping the ENIAC, and the cycling unit which generates the fundamental signals used in the ENIAC. Since the ENIAC contains a number of trunk circuits and because all units are synchronized by pertinent electrical connection with the cycling unit, operations between pairs of ENIAC units can be carried out simultaneously. The cycling unit contains an oscillator which generates electrical impulses at the rate of 100,000 per second, each pulse having a duration of two microseconds (millionths of a second). These pulses are fed into a 20-position electronic stepping switch or "counter," which enables the cycling unit to put out a special impulse or "program pulse" at every 20th pulse of the "clock" (oscillator) and a train of other fundamental pulses during the interval between program pulses. The program pulses form the basis of the programing system and set off the beginning and end of the addition cycles which are the basic arithmetical intervals of the machine. The addition cycles thus are repeated at 1/20 of the "clock" rate or. at the rate of 5000 per second. The addition cycle or addition time, 1/5000 of a second or 200 micro seconds, is so named because one such cycle is required to complete an addition in the ENIAC.

The important fact to be remembered in connection with the ENIAC is that it does not replace creative thinking. Rather, it encourages further original thought by freeing the scientist from the tine-consuming burden of routine calculation.

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The general method of handling a problem with this machine is as follows: First, the scientist must analyze his problem so that he can write down mathematical equations that express the phenomena involved. Second,he must break down the mathematcal formulation into a sequence of additions, subtractions, multiplications, divisions, square rootings and transfers from unit to unit of the ENIAC so that the ENIAC can be instructed to make the computations. Finally, a small amount of time is required in preparing the ENIAC for a problem by such steps as setting program switches, putting numbers into the function table memory by setting its switches, and establishing connections between units of the ENIAC for the communication of programming and numerical information.

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