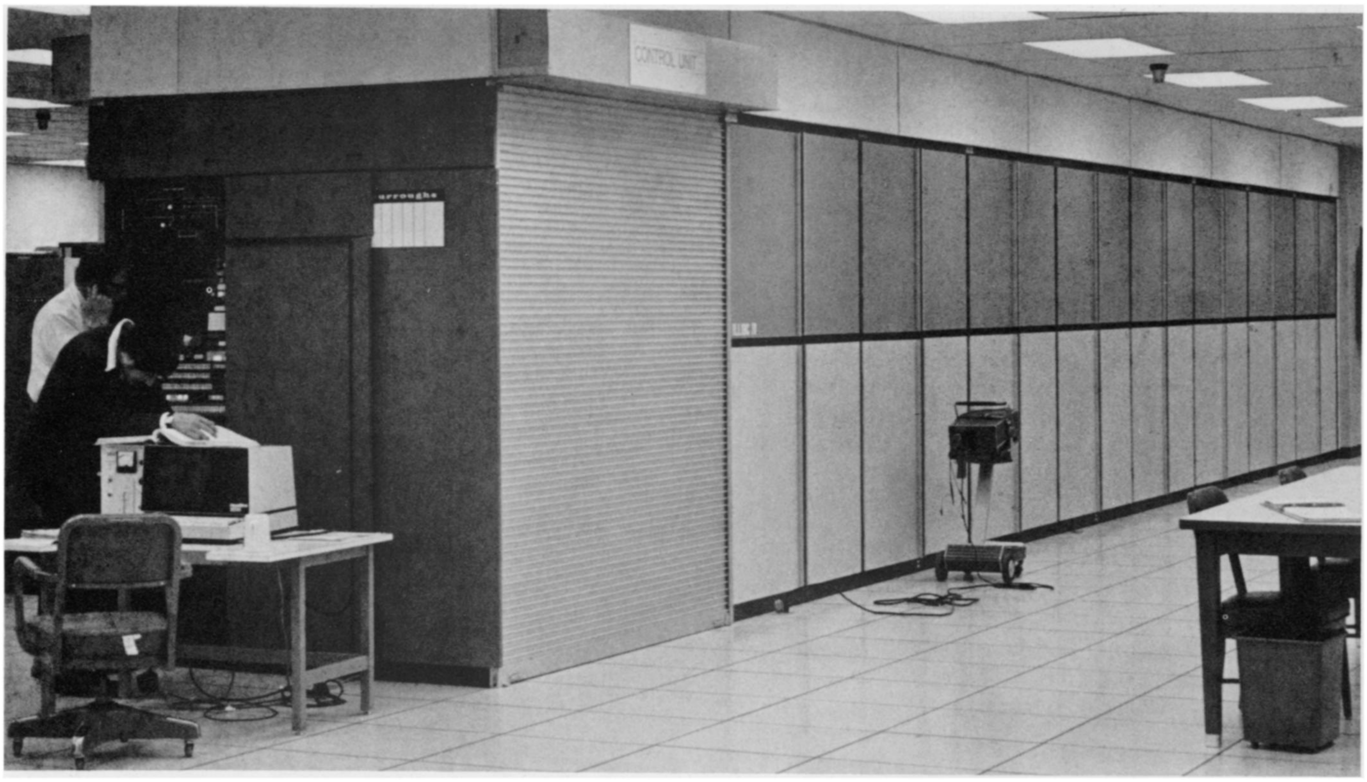


Photos: John H. Douglas

Illiac IV, heart of the world's most powerful computer facility, located at the Ames Research Center in California.

The computer gang called Illiac IV

With 64 separate computer units in tandem, Illiac IV attacks problems never attempted before

by John H. Douglas

They can do arithmetic in a few billionths of a second and call up from memory any one of millions of facts almost instantaneously, but modern computers have still hardly begun to touch several kinds of important problems. With top computing speeds leveling off but costs of individual components rapidly decreasing, computer engineers have taken a new tack in creating the next generation of computers, by operating several computers in parallel, all working on different parts of a problem at once.

The first computer built on the philosophy that 64 heads are better than one is being gradually put into operation this year at the NASA Ames Research Center, Moffett Field, Calif. Called ILLIAC IV, the computer is actually a team of 64 separate electronic computing elements operating under centralized command. ILLIAC IV operates at about 10 to 20 times the speed of the fastest conventional computer, the CDC 7600.

The system also has a laser-operated UNICON memory unit, capable of storing 85 billion characters on-line. All together, the $30 million installation is billed by its owners as "the single most powerful computational facility available in the world today."

ILLIAC IV is the brainchild of Daniel Slotnick of the University of Illinois, who began working on the idea almost two decades ago and initiated development in 1965. The Burroughs Corp. built the machine, originally designed to have 256, rather than 64, electronic computing elements. Such a large computer was not practical without further developments in basic electronics.

Many conceptually simple, but computationally very involved, problems have eluded computer men for years. In fluid motion, for example, the swirls and eddies so quickly grasped by the eye can be described mathematically only by equations that tediously consider every point in space and every moment in time separately. Such "differential equations," which could theoretically describe most of the physical phenomena of the universe, seldom have simple solutions—the kind worked out with pencil and paper. Scientists traditionally have either had to approximate solutions, using often invalid assumptions, or to create physical models that allow the phenomena to be studied in the laboratory.

Wind tunnels and the tiny, toy-like imitations of giant reentry spacecraft represent the largest scale, present day examples of such modeling. Costing $1,000 an hour to operate, such testing procedures constitute one of the major expenses in designing new spacecraft. With the creation of ILLIAC IV, NASA hopes for the first time to be able to replace such expensive physical testing with "computer modeling."

By being able to describe the motion of air past many points of a surface at once, ILLIAC IV will be able to give spacecraft designers the capability of quickly modifying grossly faulty design characteristics before building a few physical models for final wind tunnel testing. Ronald S. Schwartz, Deputy Director of the Ames Institute for Advanced Computation, which runs ILLIAC IV, told a visiting SCIENCE NEWS reporter that such computer modeling could save NASA considerable time and money in designing the new space shuttle, narrowing down design possibilities from perhaps a hundred at the outset to less than a dozen, which would require the precision of wind tunnel testing to choose between them.

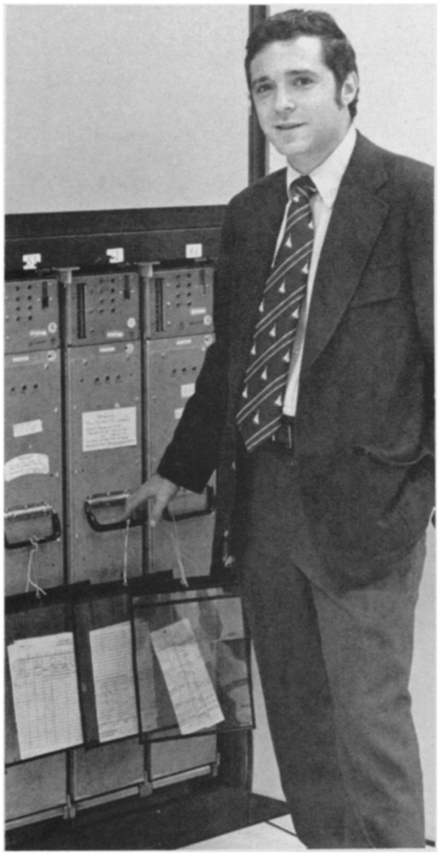
Such parallel processing systems may also find uses in weather prediction, earthquake evaluation and economic forecasting—almost any problem with large numbers of independent but interrelated variables. The Rand Corp. has already begun climate modeling, hoping to develop a system capable of predicting long-term weather trends, as well as to investigate the short-term atmospheric effects of pollution and hurricanes. The project may also provide answers to the long-standing question of what factors could cause melting of the polar ice-caps.

To solve such problems, the new facility offers versatility as well as size and speed. Tied into the national computer network of the Department of Defense's Advanced Research Projects Agency (ARPA), ILLIAC IV can be tapped remotely from any of three dozen computer facilities scattered throughout the country at universities and governmental laboratories, and ARPA plans to extend the network abroad. When many-decimal-place precision is not required, programmers can effectively have each of the 64 processing elements handle two or even eight separate streams of information, giving ILLIAC IV the ability to perform as many as 512 separate, though identical calculations simultaneously.

Problems involving atmospheric or geological data require enormous repositories of information as well as billions of separate calculations to solve, and the UNICON system, combined with various disk and tape storage units, gives the Ames installation a total memory of over a trillion binary "bits." The UNICON system consists of a drum upon which is wound a Mylar strip with up to 1.5 billion "bits" of binary data, burned permanently into the Mylar by a laser. Each strip can hold the information of 20 reels of standard magnetic tape—equivalent to the entire surviving output of the Greek and Roman civilizations. A carrousel beneath the drum keeps 450 strips available for immediate access. By reducing the volume of the Encyclopedia Britannica to a paper-thin strip, such laser memory devices will provide almost unlimited memory capacity for computers of the future.

Already, more advanced machines are on the drawing boards. Britain's giant ICL computer company has proposed a computer with 576 separate streams, each generated by a processing element of only four integrated circuits. The proposed ICL computer would work perhaps 50 times faster than ILLIAC IV.

Though some critics maintain that such simple-minded paralleling will still be unable to solve many computational problems, Schwartz says "if you take some bright young grad students, it's surprising how often you can come up with a parallel approach to solving problems." □



Schwartz shows one of 64 modules that comprise the Illiac IV system.

Mylar strip from Unicon memory unit with microphoto of stored data "bits."