Technical Information

International Business Machines Corporation - Data Processing Division - 112 East Post Road - White Plains, New York

FOR RELEASE:
A. M. 's, Wednesday
April 19, 1961

FROM: Arnold Lerner
WHite Plains 9-1900

acceptance tests ... end of March 5-7 in Pok
May 15-17 in LA
LASL
LRL
Bettis - AMRC
CEIR
W Burn
NWL - Dahlgr
MITRE

100 x 100 Matrix in 10 sec!

FACT SHEET

The IBM STRETCH System for Los Alamos Scientific Laboratory

The IBM STRETCH computer is the most powerful and versatile data processing system ever built. It was designed and constructed over a five-year period at IBM's laboratories in Poughkeepsie, N. Y., for the Los Alamos Scientific Laboratory under contract to the U. S. Atomic Energy Commission. The Los Alamos laboratory is operated for the commission by the University of California.

The STRETCH computer features unrivaled speed, memory capacity, input-output flexibility, checking and multiprogramming capability. This solid-state system is extremely fast and efficient in solving large technical problems. Its general purpose design also provides facilities for high-speed, flexible handling of variable field length data and decimal arithmetic.

SPEED --- STRETCH can perform more than thirty billion multiplications during a twenty-four hour period. Working with fourteen-digit numbers (figures in the trillions), the system can make an addition in 1.5 microseconds; a multiplication in 2.7 microseconds; a division in about 10 microseconds. This speed makes possible solutions to problems for which equations are known, but which previously were too large or complex for solution for a reasonable cost or in a reasonable length of time.

SIMULTANEOUS OPERATION --- STRETCH technology attains its high speeds through the use of ultra-fast circuits, transistors and circuit components. But it is the principle of simultaneous operation that provides the really large increase in performance over previous systems. The STRETCH computer is organized like an assembly line. As each part completes a task, it passes the work on to another machine element and immediately starts its next task, while the other parts continue with theirs. As a result, the main arithmetic unit is free for almost continuous, top-speed calculation. Facilities in STRETCH also provide new concepts in multi-programming -- having a number of problems available to the computer so that its various elements can work on different problems at the same time. As many as nine programs have been run simultaneously in this fashion during test periods.

- more -

MEMORY --- Operation of internal core storage is overlapped, to vastly increase the effective data flow. The Los Alamos Scientific Laboratory STRETCH system has six magnetic core storage units of 16,384 words each---a total core storage of 98,304 words. This is equivalent to more than 1,500,000 decimal digits, with data retrievable from any unit in 2.1 millionths of a second. Instruction addresses allow a capacity of up to 262,144 words for future expansion.

Since the system is organized to operate several of these storage units at the same time, a continuous flow of more than a million words a second can take place, with a peak flow rate capability of about three million words a second.

A feature of core storage is the large word size---seventy-two bits per word. Of these, sixty-four are information bits and eight are for error checking and correcting. The use of words of this size, the largest available in any computer today, provides greater precision in solving complex mathematical problems. By making use of fractions totaling more than fourteen decimal digits, the word size helps eliminate errors caused by truncation. Multiple precision procedures often may be avoided in working with numbers of this size, simplifying programming operations.

A further simplification can be achieved because of the unique addressing features of STRETCH's variable field length operations. These operations allow a single instruction to address any sequence of up to sixty-four bits, regardless of their position--even if it crosses a word boundary. On the major data paths, the eight error checking and correcting bits in each word provide automatic correction of single bit errors.

DISK STORAGE FILE --- Since the Los Alamos STRETCH computer will use information at a high rate, even its large internal storage may not be sufficient for many of the problems to be encountered. Accordingly, the system has been equipped with a new large-capacity magnetic disk storage file to supplement internal core storage.

This unit will store 2,097,152 words, each comprising sixty-four information bits. The equivalent of 1,200,000 digits of information can be transferred from the file to STRETCH core storage units, or back, in one second. It would take less than half-a-minute to read the entire disk file's capacity to or from core storage.

The file includes a stack of fifty magnetic disks which rotate continuously at 1,750 RPM. Information is stored on seventy-eight of the 100 disk faces. The information disks are arranged in two modules, or sets, with a comb-like arrangement of forty arms extending over each module to write information on or read information from the disks. The arms move in and out over the disk faces, but no vertical motion is required.

Even numbered tracks of information are located on one disk module, odd numbered tracks on the other. Information is stored on the disks in such a manner that they are read out in half words, in parallel. The file reads thirty-two information bits and seven error checking and correcting bits, then repeats the process for the other half of the word. The information is sent to a synchronizer to generate a word with sixty-four information and eight error checking and correcting bits.

Because of the use of two modules, approximately two-thirds of the track-to-track record seeking time is overlapped when the file is used in sequential operations. Each comb of arms can position while the other is reading.

The disk file will be used at Los Alamos to store -- for rapid accessibility -- programs commonly used as sub-routines, as well as for data storage. Information may be entered, through core storage, onto the disks from magnetic tape, punched cards or the operators console.

INPUT-OUTPUT --- The STRETCH system utilizes a wide variety of input-output equipment. Multiple units may be in operation simultaneously, sending information to storage or receiving it from storage. Included as on-line input-output units are IBM 729 Model IV magnetic tape units; a 1,000 card-a-minute card reader; a 250 card-a-minute card punch, and a 600 line-a-minute alphameric printer. The operator's console, described below, also functions as an input-output unit.

OPERATOR'S CONSOLE --- A new approach is employed in this console, which is logically separated from the main computer and functions as an input-output device. The keyboard, switches, lights, digital display and console printer all are subject to programmed interpretation and control. The interpretive program, therefore, may endow this console with as much sophisticated control function as a programmer may wish to devise, permitting a close man-machine relationship that would be quite uneconomical in previous systems.

On the console are ninety-six binary keys and switches, each of which can be programmed to perform any specific function desired. A flick of a switch, for example, could be used to initiate a transfer of storage from memory to disks, cards or tape; to initiate a trace of instructions within the system for display on the console printer; to change programs; to utilize different information in running a program than was used in previous runs.

The interpretive approach of the STRETCH console offers exceptional flexibility and makes possible console facilities that will not be outmoded as new operating techniques are developed. Program control of console functions also permits monitoring and logging functions which would be uneconomical as built-in equipment.

The console's digital display has a capacity of sixteen positions, in which the operator can see numerals or special characters representing a number of factors. These could include a display of the contents of any storage location; a count of how many times a program loop has been run, or the result of successive iterations to show the approach to a final answer of a problem. The digital display eliminates the need for reading a complex of console lights.

THE EXCHANGE --- A new peak of efficiency in handling input-output devices is provided by a specialized computer within the system. It is called the Exchange. This acts as a switching center, routing information between the internal core storage of the system and eight channels -- each able to handle up to eight tape units, a card reader, a card punch, console or printer. The Exchange is capable of controlling the flow of 800,000 characters a second from the input-output equipment. Processing may proceed without delay within the central processing unit simultaneously with the operation of the various input-output units.

CENTRAL PROCESSING UNIT --- Completely new concepts have been built into the central processing unit to provide a high degree of overlapped operation. Thus, maximum utilization of the various sections of the central processing unit is assured at all times. Specifically, the arithmetic unit is provided with a pre-processed flow of instructions and data ready for execution. This substantially increases its efficiency.

The central processing unit may be considered functionally as three sections, each contributing to the high degree of overlapped operation and each able to function simultaneously during program executions. The three are:

The Instruction Processor: The instruction processor is a small computer within the central processing unit, having its own storage and arithmetic unit. Its function is to obtain instructions from core storage, pre-process them for execution in the arithmetic and logical unit and forward them to the Look-Ahead, described below. As they are transferred to Look-Ahead a request is made for the data required for their execution. Some instructions actually may be executed entirely within the instruction processor. This preliminary processing may be performed for as many as ten instructions in advance of the instruction currently being executed in the arithmetic unit.

The Look-Ahead: A new concept in processor design is incorporated in this unit. The Look-Ahead serves as a "reservoir" of pre-processed instructions together with their data, for the use of the very high-speed arithmetic unit. By providing a flow of information to the arithmetic unit, Look-Ahead effectively increases the storage speed many times, to fully utilize the tremendous speed of the arithmetic circuitry.

The Arithmetic and Logic Unit: The arithmetic and logic unit of STRETCH includes two high-speed arithmetic units, both of which may be operating during the execution of an instruction, providing yet another degree of overlap in instruction execution. One of these units utilizes a ninety-six-bit parallel adder to perform high-speed floating point arithmetic. The other unit operates in serial fashion in variable field-length processing and adjusts its mode of operation between decimal, binary or logical operations as specified by the instructions.

All of the above functions of the central processing unit are carried on concurrently with the operation of the high-speed disk file and the various input-output units.

AUTOMATIC INTERRUPTION -- The STRETCH system has the ability to put aside what it is doing to turn to special conditions requiring immediate action. These may be conditions completely outside the computer's sphere of operations. The computer could interrupt its work upon a major problem to make priority calculations on another problem presented to it for rapid solution. All other parallel functions in the system would continue without pause. After the priority problem is completed, the interrupted elements of the system would continue their previous work. This "interrupt" feature is vital in allowing many users quick access to the computer.

In addition, automatic interrupts may be based on conditions within the computer -- conditions recognized by the computer itself as requiring special action. As many as forty-seven separate interrupt conditions are possible. This ability to selectively and automatically monitor so many machine or program conditions frees the programmer from tedious and time-consuming testing. It provides a positive signal should some exceptional condition arise so that corrective or alternative action may be initiated at once.

ACCURACY AND RELIABILITY -- The use of solid-state components throughout makes STRETCH inherently more reliable than its vacuum tube predecessors. In addition, it incorporates more self-checking features than any other computer. All data transfers and calculations are checked for accuracy and many errors are corrected automatically.

The reliability of the STRETCH system was indicated during pre-shipment tests at Poughkeepsie. The tests covered five consecutive days of 12 hours-a-day operation and were conducted with a series of programs written by personnel from the Los Alamos Scientific Laboratory. The system's functional capability, as well as its reliability and serviceability, were tested during these program runs. During the five-day period, the machine averaged 90% "good time" to "total time" -- well above the 80% which had been established as the test criterion.

# # #