to G.E. KAPL Kolsky

IBM

July 1, 1959

General Electric Company
Knolls Atomic Power Laboratory
Schenectady, New York

Attention: Dr. Richard Ehrlich, Manager, Advanced Development Activity

Gentlemen:

To assist you in your evaluation of the IBM STRETCH Computer System for purposes of your recommendation to Naval Reactors, AEC, we are submitting this proposal. All purchase and rental prices are special quotations. In view of your stated interests, rental prices are used throughout.

We recommend that a minimum STRETCH Computer be installed at Knolls Atomic Power Laboratory in the first quarter of 1961.

The proposed system rents for $136,900 per month including total IBM service -- maintenance, parts, local sales service, Applied Science service, educational service, Applied Programming aids, publications. The cost of one shift of operation of this STRETCH Computer in 1961 compares favorably with the $80-$90,000 per month which you are paying for a multiple shift IBM 704 operation now, in 1959.

The additional cost for STRETCH in 1961 amounts to an increase of only 3 percent over the total KAPL operations budget for 1958-59 fiscal year.

For these additional monies, the General Electric Company will possess a balanced high performance computer system of the most advanced type. IBM has spent 4 years of intensive research and development in producing the best computer of which IBM engineering and experience is capable. The STRETCH which we recommend has a relative speed of 34 times the 704; the larger system has a relative speed of 168 times. (See Performance Section.)

The STRETCH Computer will offer the General Electric Company many prime advantages:

1. For the first time it will be practical and economical for the General Electric Company to solve reactor problems in three dimensions.

2. The problem "turn-around-time" will be slashed. The minimum STRETCH Computer will produce in one minute the engineering results which presently take 34 minutes.

3. The cost per calculation for prime shift use will be the lowest possible. For a minimum system, the unit cost will be 8.5 percent of your present 704. For a larger system, it will be 2.8 percent.

4. It will assist G. E. in maintaining a position of leadership in nuclear reactor design. A gain in experience, knowledge and results by KAPL scientists and engineers is a gain by the General Electric Company in its commercial reactor development.

5. STRETCH Computer is a "leap forward" in computer technology. It will grow with your needs. It may serve your computing load through 1965. It eliminates the need for interim computers with their attendant expense of installation, training, and programming.

6. G. E. will be in a position to take better and immediate advantage of:

   - breakthroughs in knowledge of the behavior of atoms in their environment.

   - applied mathematics developments.

   - programs developed by Los Alamos AEC for their STRETCH Computer.

7. It enhances G. E.'s competitive position in attracting contract awards.

8. It will extend the creative and productive capacity of scientists and engineers many fold. In turn, it will attract these professional people to the General Electric Company.

32-0077
Printed in U.S.A.

IBM

9. KAPL will retain the support and total services of IBM. KAPL can continue to benefit from the continuous flow of those new product developments which relate to the STRETCH Computer System and its periphery.

Two of these minimum systems, one at KAPL and one at Bettis Laboratory, is approximately the same price as one large system. With one at each location, the AEC will have:

1. Self-insured back-up.
2. Flexible scheduling of workloads.
3. Programming compatibility.
4. The answer to their long range needs.
5. Benefits from the output at two equal and competitive laboratories.

It is our belief that the IBM STRETCH Computer is an excellent answer to your needs of 1961-1965.

The contents of this proposal are indicated on an Index sheet. An addendum by Dr. Hadnot will be completed by July 6. The contents of the whole proposal are proprietary.

Under appropriate contractual arrangements we will plan to manufacture and deliver the system in the first quarter of 1961. This delivery commitment expires on July 15, 1959 if you do not state your intentions to enter into negotiations. Terms of the contract will be specifically defined during the negotiations.

We appreciate both your continued interest and the opportunity which you always give us in representing our Company to you, an important IBM customer.

Very truly yours,

F. A. Fisher, Sales Representative

P. B. Hazard, Branch Manager

IBM Data Processing

INDEX

221-0078
Printed in U.S.A.

HISTORY OF DIGITAL COMPUTING

High speed digital computing became a reality in 1953 with the delivery of the 701 Electronic Data Processing Machines to many major scientific and engineering organizations in the United States. This tool opened new frontiers in digital computing by virtue of the speed increase over previous methods. Large problems were solved by the 701 with a hundred or more fold increase in speed over the Card Program Calculator which in its day had represented a giant step over manual methods.

Though the 701 represented a tremendous increase in capability over previous methods, it was recognized by the users that substantial improvements in speed, memory, input/output, and in language would be required to solve many of the problems at hand. The Atomic Energy Commission Laboratory, for example, has problems that would require thousands of hours to solve. The available machine time thus would not permit solution.

IBM faced the problem both in terms of an immediate and a long range solution The immediate solution was product improvement designed to gain maximum utilization of the components that were well enough developed in 1954 to permit volume production of computing systems The 704 and 709, each with their own contribution, have yielded a substantial improvement over the state of the art in 1953.

IBM in 1955 had developed the drift junction transistor which operated effectively at a switching rate of ten megacycles per second. It also appeared that these transistors could be mass produced in sufficient volume to justify building large scale systems. The best magnetic core storage techniques at this time gave a read/write cycle of six microseconds. These factors plus the demonstrated reliability of the solid state components provided the basis for the design of a computing system which would represent a hundred fold increase in performance over the 704.

A contract was entered between the Atomic Energy Commission and IBM in 1956 to develop a machine with one hundred times the performance of the 704 and which would be delivered in the first-half of 1960. The project was called STRETCH.

32 0077
Printed in U.S.A.

In the fulfillment of this contract, a machine meeting the mutual objectives of both the AEC and IBM has been developed. Technological advances such as fast magnetic cores with 2.0 and 0.5 microsecond cycles, improved intermediate access storage, and high capability imput/output devices have simplified the design task. New concepts of logical organization have been developed which properly exploit these new components to yield a high performance system.

The design and fabrication of the system have progressed on schedule with each objective met. The completed system will be delivered to the AEC's Los Alamos Laboratories in May, 1960.

With the build up in your computing load at KAPL, and your desire to obtain more detailed information concerning reactor behavior, it was felt that a computer of the STRETCH magnitude would be of value to your laboratory. It would permit three Dimensional Diffusion, Monte Carlo and Transport Theory problems to be run more economically.

Accordingly the following reports were made to KAPL concerning STRETCH.

August 1958

Initial presentation on STRETCH Computer Philosophy made to a group of approximately 15 KAPL Engineers.

September 1958

Demonstration of STRETCH Components at Poughkeepsie, New York made to Computer Information Group.

October 1958

Progress report on STRETCH presented to a group of 17 KAPL Engineers. Systems configuration, Component Characteristics and area Purchase Prices for entire system given.

32-0077
Printed in U.S.A.

IBM

<u>February 1959</u>

Letter received from KAPL expressing their interest in STRETCH and their desire to have IBM present a machine proposition.

<u>March 1959</u>

Presentation of manuals to KAPL on STRETCH. Additional meetings held with KAPL personnel discussing various features of the machine and command structure.

<u>April 1959</u>

Presentation of Purchase and Maintenance Prices by components on STRETCH in New York City.

<u>May 1959</u>

Presentation of rental prices with various systems configuration possible.

32-0877
Printed in U.S.A.

IBM

1

SYSTEM FEATURES

The primary objective in the design of the STRETCH system has been a balanced high performance system that will efficiently solve both large and small scale problems at speeds that cannot be approached with present generation machines. High performance pertains not to unique high-speed features but to a total problem-solving ability which results in a minimum problem "turn-around time" and maximum utilization of the machine components.

High performance is gained through the use of advanced components and through a sophisticated machine organization that permits many events to occur simultaneously. The advanced components include magnetic cores with one-half and two microsecond cycles, and drift junction transistors capable of switching at a ten megacycle rate. The events include multiple references to memory, separate index arithmetic, a separate input/output computer called the Exchange, and continuous monitoring of exceptional conditions.

The logical organization of STRETCH is the result of experience gained with a large family of data processing systems and has been tested through simulation on small machines so that it represents a machine well balanced between computing efficiency, memory utilization and input/output capability. The simulation efforts have permitted the designers to evaluate the system performance against representative problems and determine the effects of different combinations of overlapped memory, of overlapped input/output, and of arithmetic speeds. The use of the technique has led to a machine that is high in performance and that obtains optimum utilization of its components.

The word size of 64 bits has been chosen because of several reasons. The most important is that it affords adequate precision so that most computation may be done in single precision. A second direct benefit is that two instructions are packed per word, giving an excellent instruction to data reference ratio. The 64 bit word also provides a modulo addressing means for defining all bits within memory. The STRETCH word provides a twelve bit exponent and a forty-eight bit fraction for floating point. The remaining four bits are used as the fraction sign and as identity.

STRETCH has built-in hardware to assist in determining the effect of roundoff in floating point arithmetic. This feature, called the "Noisy Mode", changes the rules of roundoff so that the difference between

32-9077
Printed in U.S.A.

the normal and Noisy Mode computation indicates the effect of round-off. This feature is an invaluable aid to the numerical analyst in testing the validity of his solution.

Multiple precision arithmetic is simple on STRETCH because of the large (128 bit) accumulator. This, together with commands that permit accumulation to be treated as a double precision quantity, provide a rapid means of doing multiple precision arithmetic with a minimum of instructions.

The size of memory has in the past proved a limitation to solution speed because of the inability to contain many problems in the working memory. STRETCH offers memory with direct addressing up to 262,144 words in steps of 16,384 or 32,768 words. It is necessary that memory be a multiple of 32,768 except in the case where only 16,384 is required. The large memory of STRETCH thus offers significant speed advantages because of the ability to contain larger problems.

The speed of a machine is directly related to the effective access time for memory. If arithmetic operations are faster than the memory, then the machine becomes memory bound. The total processing time becomes the sum of memory accesses for instruction, data, and input/output references. If memory speed can be made faster than the arithmetic speed, additional memory time will be available to meet the requirements of instruction and input/output references without penalty to the arithmetic speed.

STRETCH has increased the memory effective speed by a factor equal to the number of memory modules in the system. Thus, a system with 65,536 word storage or four modules may achieve an effective memory cycle of up to 0.5 microsecond in contrast to the 2.0 microsecond cycle of a single module. The speed increase is achieved by parallel operation of the memory modules so that each is processing a separate reference. The technique of distributing memory references so that all units share the load is called overlapping. The central processing unit receives the memory word stream from the Look Ahead unit at the augmented rate.

Fast arithmetic units are essential to utilizing the capabilities of the STRETCH memory system. The arithmetic unit has been especially designed to perform floating point arithmetic at the fastest rate possible using advanced techniques and components.

320072
Printed in U.S.A.

IBM

The following speeds are illustrative:

Floating Point Load	0.6 microsecond
Floating Point Add	0.9 microsecond
Floating Point Multiply	1.8 microsecond
Floating Point Divide	7.0 microsecond
Floating Point Store	0.5 microsecond

Separate index arithmetic unit and register storage permit address modifications to be computed simultaneously with normal arithmetic. This parallel operation makes possible a higher central arithmetic efficiency than has ever before been possible. The combined ability of the overlapped memory to yield data at rates of up to one half microsecond and of the index units' ability to perform the necessary address modification will yield efficiencies of the main arithmetic unit of up to 90% on inner loop computations. This is compared with peak efficiencies on previous machines of 40%.

An improved instruction set that combines several functions into a single instruction is another of the ways in which STRETCH performance is improved. The efficiently is demonstrated by the fact that a 704 program can be recoded for STRETCH with 20% fewer instructions. The index set of commands is a significant step in reducing the number of housekeeping instructions. Commands such as Count Branch and Refill combine the function of stepping the index register, recognizing the end of a sequence and initializing the register for its next sequence. Swap and Rename provide for optimum utilization of the registers.

The ability to manage by exception is another means of increasing performance. If the probability of occurence is low for an event, then the program time spent testing for the condition is wasted. STRETCH embodies a concept called Program Controlled Interrupt that eliminates the need to test for unusual events each time through a loop.

32-0077
Printed in U.S.A.

IBM

An example might be the testing for an exponent overflow which should occur infrequently. The early method was to examine the arithmetic results by programming with the resultant loss of time for the negative cases. In contrast, the STRETCH will interrupt its normal routine only if the condition occurs and then branch to the alternate routine. Upon completion of the alternate routine, control is passed back to the original program.

The Programmed Controlled Interrupt is a powerful tool because of its scope and flexibility. The interrupt conditions include machine malfunctions, input/output activity (e.g., unit not ready, transmission complete, and operator signal), floating point results, and flags within the data. The programmer has the option as to when any of these events will be effective and as to where the program control will be transferred.

One interesting aspect of the Program Controlled Interrupt is the provision for identifying data for special handling. Three bits of a word are flag bits to be used as a marker such as for the boundary of an irregular mesh or lost significance words. When the word with a flag is called into the arithmetic section, an interrupt would be instituted thus eliminating the need for testing each word.

Time is of the essence in the successful operation of a computer. STRETCH has an elapsed time clock and an interval timer. The elapsed time clock permits direct reading of time to one part in 1,024 of a second. The timer may be preset to any interval of 0 to 8 minutes in steps of 1/1,024 seconds. The computer will be interrupted at termination of the event. These devices are essential to proper management of an automated computing system.

Address monitoring is a technique whereby memory reference outside of the designated area is an error. STRETCH has memory boundary registers for defining the upper and lower boundary of a program area. Violation of the boundaries will result in an interrupt. This feature facilitates multiprogramming when several different programs are in the machine. Program memory references are confined to the working program area.

32-0077
Printed in U.S.A.

A significant portion of the work in any computing installation will be data processing as contrasted to computing. This will include program compilation, debugging, and input/output translation. These activities require the ability to efficiently work with partial fields, to convert radices, to operate on data of varying formats and to perform linear translations on data. Partial fields arise because efficient handling of data words shorter than 64 bits requires "packing" of the data to obtain good memory utilization.

The Variable Field or Integer Arithmetic feature of STRETCH permits direct handling of data with partial fields and of a variety of formats. The variable field commands can handle words from 1 to 64 bits in length without regard to word boundaries. A further feature is the inclusion of both binary and decimal arithmetic. The decimal arithmetic directly handles characters of 4 bits through 8 bits.

Among the unique commands are the conversions and the logical set. The convert commands, in a single step, convert a number between binary and decimal. The logical set with its 16 connectives is a powerful editing tool and is most useful in data translation.

The Exchange is a limited vocabulary computer, charged with the responsibility of transferring information between main memory and the entire input/output environment. The environment includes high speed magnetic tapes (62,500 characters per second), 1000 card per minute readers, 600 line per minute printers, 250 card per minute punches, and consoles.

The Exchange logically interconnects the desired I/O unit to memory and places the Exchange under a stored program control contained in main memory. The stored program will define the memory area, the amount of data to be transmitted, and the conditions for terminating the transmission. The message may be placed or received from scattered memory areas and may involve several records on the I/O side. The Exchange has the responsibility of gaining access to memory in accordance with the I/O requirements. The overlapped memory feature permits the I/O activity to have little or no effect on the computing rate.

IBM

The Exchange also interconnects the high speed disk storage units into the system. The same philosophy of operation is used for the disk storage as the rest of the input/output equipment. The fundamental difference is the data transfer rate of 250,000 words per second between the disk and storage.

The Exchange philosophy gives STRETCH a significant increase in performance over systems requiring direct computer control for data transfer to and from the environment. The Exchange can transfer data at rates of 500,000 words per second with only a 15% loss in computing efficiency for a system having a 65,536 word memory. The capability to handle such volumes of data and to communicate with many units simultaneously permits STRETCH to achieve maximum utilization of the central computer.

An important factor in system performance is availability and reliability. This will be a measure of the net productive time which would be total time less maintenance and rerun of programs interrupted by error conditions.

STRETCH utilizes two general techniques for insuring maximum productivity. These are the use of high reliability components throughout the system and the use of error detecting and correcting hardware.

Solid state components are used exclusively within the STRETCH system. These components include drift and alloy junction transistors and ferrite cores. Each of the components have demonstrated proven reliability both within the laboratory as well as in field operation.

The possibility of machine malfunction exists even with high reliability components. Error detecting circuitry covering all data transfers and arithmetic results provides instantaneous detection of an error at the time of occurrence. Mere detection is not enough. STRETCH is able to correct all single errors and to advise the programmer of multiple errors. In addition, a log is made of all errors as to time, place, and type of failure.

The result of the comprehensive error detecting and correcting system is that the machine will give normal performance even though experiencing component failure. A further benefit is that the customer engineer has a document that actually describes the fault and its location thus insuring that the machine repair time will be a minimum.

32-0077
Printed in U.S.A.

IBM

In summary, these features contribute to STRETCH's high performance on problems that will be solved by Knolls Atomic Power Laboratory.

1) Fast Large Capacity Memory providing up to 262,144 words of directly addressed storage and effective access rates of up to 2,000,000 words per second.

2) Highest Speed Arithmetic Unit available in any computer as represented by Floating Point Multiply in 1.80 microseconds.

3) High Capability Intermediate Access Storage providing data transfers at the rate of 250,000 words per second and providing up to 1,422,707,916 characters of storage in multiples of 44,459,622 characters.

4) Overlapped Computing and Input/Output data transfer.

5) Simultaneous Operation of up to 33 I/O units providing a gross transfer rate of up to 350,000 words per second.

6) Powerful Instruction Set requiring 20% less instructions per program.

7) Efficient Logical Organization permits arithmetic unit to achieve maximum performance.

8) Automatic Error Detection and Correction to insure maximum availability and reliability.

9) Program Controlled Interrupt to eliminate programmed testing of low activity functions.

10) Integer Arithmetic to improve memory utilization.

11) Convert instructions translate between binary and decimal quickly with a single instruction.

12) Memory Protection guards selected memory areas from inadvertent alteration arising from either programmer or machine fault.

32-0077
Printed in U.S.A.

13) Generality of Design provides high performance on both large and small scientific and data processing problems.

The concept of a memory whose speed is much faster than either the arithmetic unit or the input/output yields a high performance system with overlapped operations. STRETCH is able to achieve this by the techniques of overlapping and lookahead using several separate units of two microsecond memory. The following discussion explains this technique.

Consider the following instruction sequence: Add A, multiply B, repeated continuously. Add A is the first instruction of the program and instructions and data are in consecutive locations. This sequence will be timed for the following various hypothetical machines with an assumed add time of 1 us and multiply time of 2 us:

1) 4 us memory
2) 2 us memory
3) .5 us memory
4) 2 us memory but 2 instructions per word
5) same as above plus 2 levels of lookahead and 2 overlapped memories
6) same as #4 plus 4 levels of lookahead and 2 overlapped memories
7) same as #4 plus 4 levels of lookahead and separated overlapped memories. 2 overlapped boxes for data (say addresses 16,000 - 48,000) and one box of instructions (addresses 0 - 16,000).

The vertical lines represent 1 us time intervals. I is instruction fetch time, D data fetch time, A add time, and M multiply time. The time to complete an add and multiply cycle is:

CASE #	time in microseconds
1	16
2	8
3	3
4	6
5	5
6	4
7	3

Case #1 shows a computer which is grossly overbalanced for this type of problem. The memory is working full time but the CPU is active only 19% of the time.

Case #2 shows a computer more nearly in balance. The CPU is now active for 37% of the time.

For Case #3, the memory is fast enough to allow the CPU to work full time. Although the memory is 4 times faster than for Case #2, there is only a 2.6 increase in problem solution time and further increases in memory speed would not affect the problem time. With the present technology a memory speed increase by 4 causes a much greater swing in price and therefore other means are used to increase the speed.

For Case #4, one memory cycle is eliminated for every 4 taken, giving a 25% speed increase The CPU still loafs along.

For Case #5, the decoding mechanism of the lookahead allows the CPU to determine where the next piece of data is to come from and overlapping allows two simultaneous references for data. There is a slight delay between these two because of the memory bus transfer time. The two levels of lookahead limit the number of instructions which can be stacked up.

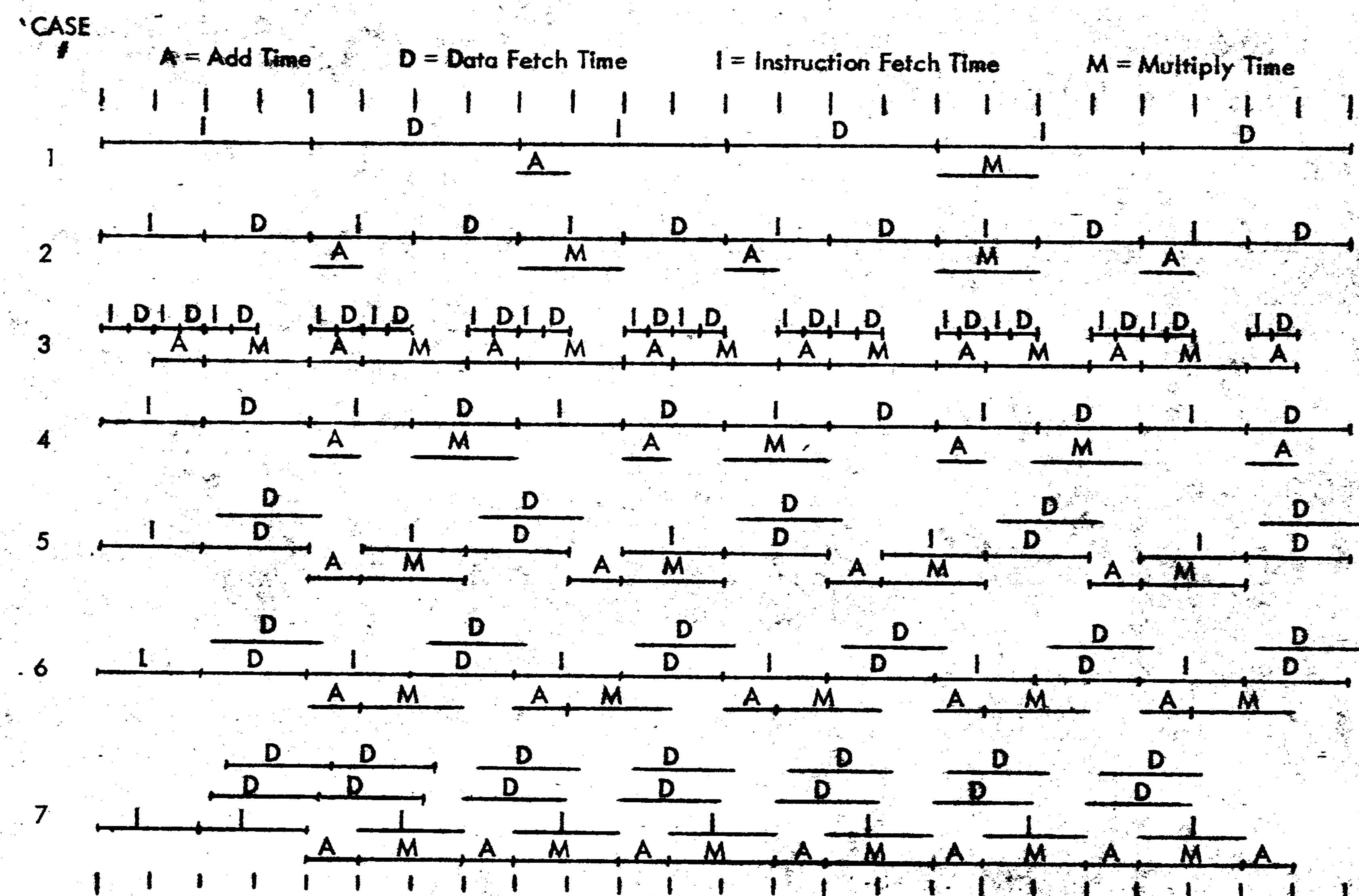
In Case #6, this stacking up problem has been eliminated and the determining factor becomes memory fetching. Because data and instructions are in the same box there are memory conflicts.

In Case #7, these conflicts have been resolved and the CPU is allowed to run at full speed. Note that this chart would be different if the instructions and data were intermixed in 2 overlapping boxes. There would be periodic conflicts, with consequent delays when data and instructions make references to the same box.

32-0077
Printed in U.S.A.

32-0077
Printed in U.S.A.

SIMPLIFIED COMPUTER TIMING



A schematic layout of the computer is shown on the next page. It shows the logical relationships between the I/O units, Exchange memory, lookahead, index arithmetic, and central processing unit.

The memory units are tied in parallel to the memory bus, so that lookahead or Exchange memory references can occur simultaneously in different boxes.

The index arithmetic and storage is separate from the central processing unit and can operate at the same time.

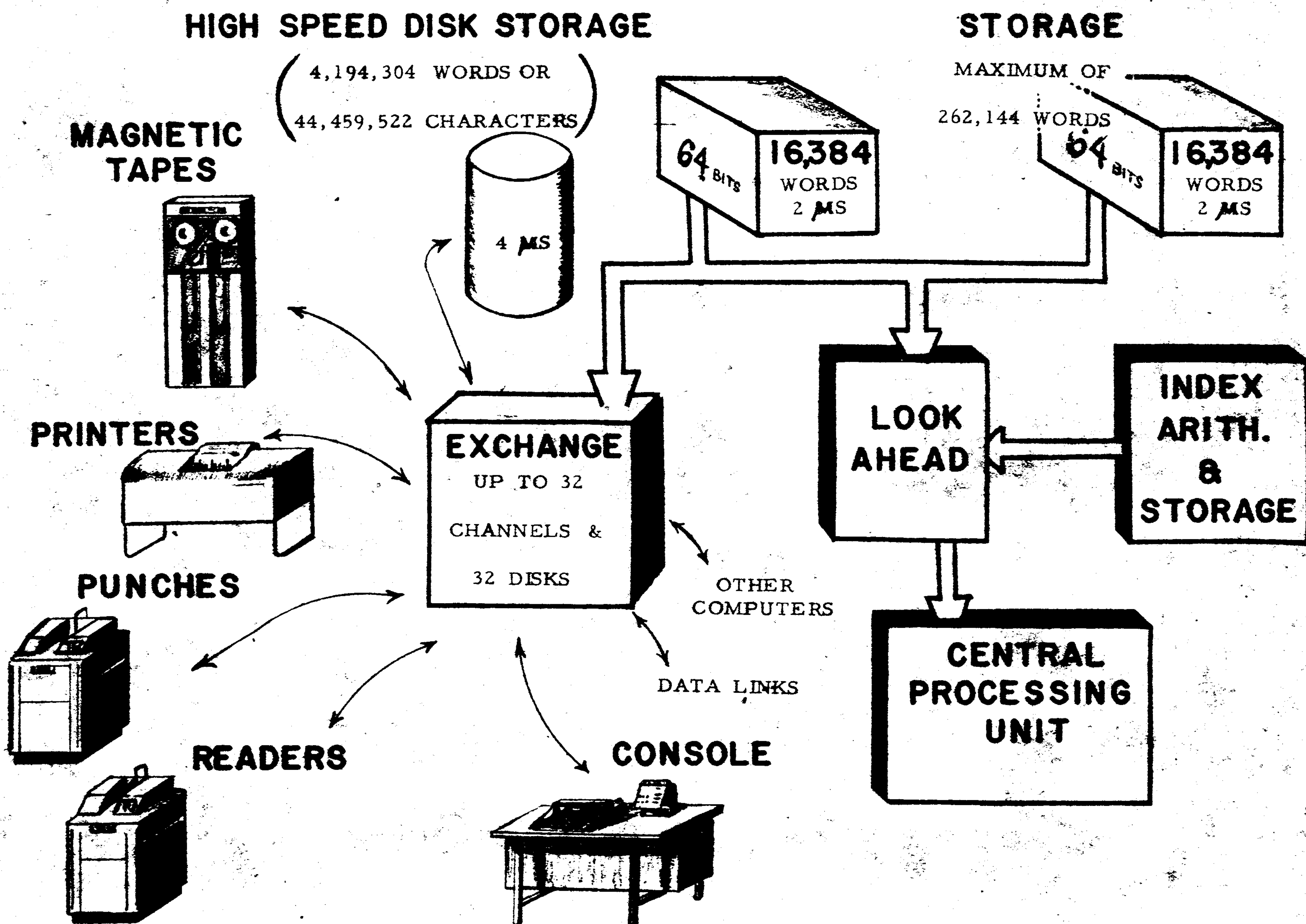
The central processing unit is buffered from memory by the lookahead unit and is not limited by memory speed.

The exchange is in parallel with the lookahead and can make memory references without disturbing central processing unit activity.

The I/O devices are tied in parallel to the Exchange and can operate simultaneously.

221-0078
Printed in U.S.A.

STRETCH SYSTEM:



IBM

PROGRAMMING SYSTEMS

Because there are only 85 basic instructions in the STRETCH language, it will be easy for programmers to learn and remember the language. By the use of instruction modifiers, this language is stretched out to a vocabulary of over 2,000 instructions. This large number of choices makes it easier for the programmers. With such a wide vocabulary, instruction sequences are set down in a straightforward manner with no need to think of devious ways and means to code the problem, and programs will average 20% less instructions than the equivalent 704 program.

STRAP (Stretch Assembly Program) language which will allow program assembly on either the 704 or STRETCH provides a means for easy, simple, and convenient program preparation. Confusing mnemonics have been eliminated and simple special characters or single letters have been provided. The program to compute C(A + B) = D would be written as:

L, A	(which	Load factor A in the Accumulator.
+, B	is	Add factor B.
*, C	equivalent	Multiply the sum by C.
ST, D	to)	Store the product in D.

These factors also help to reduce the turn-around time of any problem. Since there are fewer instructions in a problem, and fewer characters per instruction, the total number of characters to write a program will be reduced. This reduces the number of clerical errors and allows the programmer to see more clearly the logic of his program without being lost in a maze of details.

Many features of STRAP resemble those of high level compilers. Data description is straightforward, allowing for easy entry and arrangement of data. For many programs, a higher level compiler will not be necessary.

Because of the fast speed of STRETCH, it may be feasible for STRAP to appear only as a load and go version. The programmer would handle only STRAP cards; these would be assembled as they are fed into the computer and the program would commence running immediately upon completion of loading. As there would not be any binary cards, it would be unnecessary for programmers to learn the machine language.

There will be a STRETCH simulator for the 704 - 709 - 7090 series. This program will aid in the debugging of inner loops of STRAP coded problems.

An algebraic compiler with Fortran compatibility is being developed to augment STRAP.

32 0077
Printed in U.S.A.

IBM

PHILOSOPHY OF OPERATION

The primary concern of the environment external to the computer is first of all, can the computer handle the given problem? Then, if the computer can handle it, the turn-around time is the next concern. This is, the time from problem inception to completion. Then, what will be the through-put time? This is, how fast the computer can process the problem.

The computer time per job can be considered in two parts. In one part, the computer talks to the external environment to receive problems, data, and return the appropriate answers. In the other part, the computer talks to various elements within itself to generate the required information. In many cases this may actually consist of talking to a pseudo external environment such as intermediate data tapes. However, this is still under computer control.

As the size and speed of computers change, the time relationships between the various parts also change. With a CPC calculator, the operator time was small in comparison to the computer solution time, and as computer costs were relatively small, the operator time was not a significant part of the problem cost. As the systems speed increased, the operator time became an increasingly important part of the job cost. Many 704 installations found that an automatic operator increased their efficiency up to 400% over manual systems with a corresponding decrease in job costs.

The following analysis shows the relationship between these elements:
Let

C_i = cost per unit of time on i th computer.

T_i = job time on i th computer.

Then for computer i to be more economical than computer j

$$C_i \, T_i \leq C_j \, T_j$$

but T_i is made up of the following elements:

a_i = computing time.

b_i = I/O time not associated with computing.

c_i = I/O time overlapped with computing.

d_i = Idle computer time spent in operator set up and decision.

32-0077
Printed in U.S.A.

IBM

Another method of reducing the total I/O time is to provide for more overlap with computing. Early computers were hampered by having to shut down all other operations when obtaining external information.

The most advanced and efficient method in handling input and output is used in STRETCH. A separate small computer is placed between the central computer and the outside. The central computer then asks the small computer to obtain information for it. This small computer is called the Exchange.

The central computer then continues with its main task while the Exchange handles the I/O. The Exchange transfers the necessary information between the I/O units and the main memory and notifies the main computer when it is finished. Under this method of operation, there are only minor computing delays which may develop when both the Exchange and central computer talk to the same part memory at the same time. STRETCH can accept over 1/4 million words per second and maintain 85% of its computing capacity.

The concepts of overlapped I/O and a large high speed memory have been combined in the STRETCH Disk Files. These files allow a complete systems reorientation of the problem to provide for maximum computer efficiency. Because the word transfer rate of the disk files approximates the internal processing speed of STRETCH, the central computer often does not care whether information comes from internal memory or disks. Problems which use more than 3 instructions per piece of data are compute bound and are not concerned with the I/O capabilities of the disk system. The impact of this powerful hardware is felt in the nuclear diffusion problem. Although STRETCH tapes are 4 times as fast as 704 tapes and internally STRETCH is about 70 times as fast for this problem, it will process a nuclear diffusion time in 0.6% of the time of a 704.

Because the STRETCH Disk Files cost less than 1/4 of 1/100 of a penny per bit per month, they are an extremely economical means of storing other information besides intermediate data. Full programs, subroutines, supervisors, and final results can all be stored on disks and file interrogations made for needed information. During the design of a reactor, for instance, it may not be necessary for the computer to output the flux at every point within the reactor but only at selected points. The engineer would then interrogate the file to find the flux at any other point. This would reduce the I/O volume. Debugging calls on the computer to deliver large amounts of unneeded data to the external world. Allowing the programmer to interrogate the disk file for the necessary data would lessen this volume.

32-00/7
Printed in U.S.A.

thus $a_i + b_i + c_i + d_i = T_i$

Equation 1 then reduces to the following table:

$\frac{C\,x}{C\,s} \geq$	X	STRETCH
$\frac{a_s + b_s + d_s}{a_x + b_x + d_x}$	compute	compute
$\frac{a_s + b_s + d_s}{b_x + c_x + d_x}$	compute	I/O
$\frac{b_s + c_s + d_s}{b_x + c_s + d_x}$	I/O	I/O

The first table line says that if both STRETCH and computer x are compute bound, then for STRETCH to be more economical, the cost of x divided by the cost of STRETCH must be greater than or equal to

$$\frac{a_s + b_s + d_s}{a_x + b_x + d_x}.$$

In all of these equations, both some part of I/O time and operator time are present. These times are dependent upon the systems orientation while computing time is a function of the problem. A more expensive computing system then must not only have a speed increase to be economical but it must also provide hardware for a new systems orientation which would reduce I/O and operator time.

One way of reducing I/O time is to provide larger size memories and reduce the amount of communication with the external environment. STRETCH provides this expansion facility by providing a sectional memory with a total storage capacity of greater than a quarter of a million words. This is room enough for one-half a million instructions, or four million digits of data.

In many cases a large internal memory is economically impractical. It is more feasible to provide an external, less expensive, and slower storage medium that does not cripple the machine operation.

Another way of reducing the I/O time is to allow the programmer complete flexibility to form the data into record lengths which are appropriate for his file A significant part of I/O time can be spent in passing over the gaps between grouped data. If this space is of the same size as the data, then the effective I/O rate is one-half the instantaneous value. Both the disk and tape units allow for variable length grouping.

In many problems, data is not used in a sequential manner. For instance, in compiling a program, the compiler may want to use a program which is several records away from the present reading point. On the 704 tapes the average wait time is over 3 minutes while on STRETCH disks the time is under .1 of a second. Problems can now be organized to allow random as well as sequential references to data.

As the computer time for a given problem decreases, the operator time becomes more important. The importance of this concept was brought out with the advent of the 704. It was then feasible for the computer to take under 1 minute to solve a complicated problem. If it then took another minute for the operator to set up for the next problem, the computing cost was essentially doubled. This problem is even more aggravated by the advent of STRETCH. Problems which take several hours of 704 time will take under a minute on STRETCH. Thus, operators as known on many 704 systems may be completely unacceptable on a STRETCH system.

The first step in reducing human operator time was in the form of automatic operators. Most "automatic" operators suffer because of hardware limitations. When a program comes to an unexpected halt, the operator has to decide what to do next and then initiate the action. This requires several seconds, enought time for STRETCH to run many programs. Automatic operators needed extremely intelligent human operators to monitor the computer via the console lights.

Because of its fast speed, STRETCH cannot afford to rely on these methods. For instance, during the human reaction or button pushing time of .1 of a second, STRETCH would have executed 100,000 instructions or about the equivalent of one hour of 650 time. This does not take into account the amount of time necessary to make the decision. Even though a STRETCH automatic operator might have to make several thousand decisions, enough for an extremely complicated and sophisticated operator, this would only take a few milliseconds.

IBM

For these reasons several new concepts have been added to STRETCH. There is a clock which allows the automatic operator to interrogate and monitor the program. All stop codes have been removed from the instruction set so that control automatically reverts to the operator at the end of the program. The console is an input-output device which allows a human to talk to the computer and is treated as such. The computer presents necessary data to the console for operator use and decisions. While the operator is deciding upon a course of action, the computer forges ahead and problem solution is not delayed. When the operator has made his decision at his own leisure without being under the pressure of knowing that he is delaying a multi-million dollar machine, he signals the computer to read his instructions. The large capacity high speed disk files will store more information internally and reduce the amount of tape handling and changing necessary.

An automatic operator is used to usher problems sequentially through the computing facility in a minimum amount of time. The operator is only concerned with computer utilization in a passive way and does not fully use all the various computer organs. A multi-program supervisor is capable of interrupting one program substituting another one and then returning to the first program in order to maintain optimum usage of the computer. In a primitive sense, as is presently being programmed for several computers, the supervisor will allow simultaneous card to tape, tape to card, and tape to printer operations while running the main program. However, examination of any work queue for a given time period may show several jobs which are I/O bound while others are computer bound. By interleaving these jobs, there will be a significant increase in computer utilization with only a small increase in problem turn-around time.

STRETCH has provided many features to facilitate multi-programming. The disks allow for the storage of a large number of problems, data, and intermediate results in close proximity to the main computer. Address protection allows several programs to occupy the main memory at the same time and be protected from each other and the working program can be of any length or in any part of memory. Powerful operation codes allow rapid changes from one job to another, at rates greater than 10,000 per second.

Program controlled interruption allows the scheduling of machine facilities to be dependent upon programs needs instead of hardware limitations. Because interruption occurs at the cessation of activity of a facility, there is no time wasted in making job status inquiries.

A simple but extremely flexible supervision system could operate as follows. One section of the monitor would contain a list of the jobs to be completed and their relative priorities. Another set of lists would exist for the machine facilities. Under each facility such as reader, printer, punch, or CPU would be listed the job presently being run and the list of jobs waiting to use the facility. When a job completes its use of a facility, it interrupts and automatically notifies the supervisor. The type of interruption implies the facility which the program was using and the facility which it wishes to use. The supervisor would examine the list of the vacated facility for the job number and place this number in the queue of the desired facility. It would then examine the queue of the vacated facility, determine which job has the highest priority, and transfer control of the facility to it. The supervisor would also examine the queue of the requested facility to be sure that the latest addition does not have a higher priority than the one using the facility. If the new one does have the higher priority, it would replace the old job.

This type of supervising places no restriction upon the programmer or the installation. The only determining factor is the priority rule and this can be established by the installation. The queue could be determined by a job shop scheduling type of program in order to minimize computer usage. In other situations a job could be given top priority and proceed through the computer as though no other program were present.

The supervisor could also be set up to consider any request from the console as having the highest priority. The human operator could signal the computer to rush through a high priority job and ignore other jobs that it may be doing. Because of the extremely fast speeds of the computer, the console operator really feels that the computer is his alone.

32-0077
Printed in U.S.A.

IBM

Console debugging becomes an economical means of reducing turn-around time with no sacrifice in system computing abilities. While the human operator is sitting and thinking, the computer can be running another program. While he is pushing the console button, the computer could do a lengthy program which would not be noticed by the operator. Console debugging can cut down considerably debugging time and effort.

As a supervisor is general in nature, it does not care what type of program it handles. It could as easily be an assembly or a production run. The interruption signaling the supervisor could also be externally generated by a remote device. The supervisor would then answer, and service the remote device, but would not see any difference between this request and that of any other computer facility. The remote facility could be debugging consoles in other rooms or tapes hundreds of miles distant.

Many STRETCH installations will act as a central computer complex and have equipment capable of talking to remote locations. These remote locations might contain only input/output equipment to handle information processed by STRETCH. They might be computers which would handle certain types of problems and prepare data for convenient communication with STRETCH. The remote facility might also be another STRETCH which would act as a backup computer on a leased time basis.

A data transmission link is fundamental to the concept of a centralized computer complex with remote input/output stations. If the station is remote from the computer by only a few hundred feet, the communication link can be a simple extension of the normal inter-machine cables with the attendent problems of powering. Communications over greater distances require the use of different facilities and techniques.

The communication network established by the telephone companies is the most attractive media available for the rapid transmission of data. It is necessary to recognize the design objective of the telephone companies in establishing this network. Their concern has been to establish circuits adequate for voice and telegraphic communication throughout our country. The result is that the voice quality lines are the only type of facility generally available for point to point communication. Any other type of service such as high quality or broad band service would require special engineering with its associated lead times and expenses.

Printed in U.S.A.

The theoretical information capacity of a transmission line as expressed by Shannon is

$$C = f_o \log_2 (1 + \frac{S}{N}) \text{ bits/sec.}$$

where f_o is the bandwidth in cycles per second and S/N is the signal to noise ratio. For a bandwidth of 2500 cycles/second and a signal to noise ratio of 20 decibels, the capacity should be 15,000 bits per second.

Telephone channels do not adhere to this formula because of several unique characteristics. The amplitude phase characteristics which do not affect the intelligibility of speech, seriously limit the channel capacity. The effect is a phase shift which is a function of frequency. The second effect is impulse noise that is induced from other channels within a cable. The impulses are DC switching such as dialing and teletype. The impulse noise is easily confused with a data at the upper rates. These factors, together with losses from tandem connections, restrict the maximum data rate to 15% of the theoretical limit.

The initial work done in data transmission has been based upon standard quality voice circuits subject to the restraints described above. The efforts include the SAGE communication network, the digital subset, and work by other companies including IBM.

The digital subset, developed by Bell Telephone Laboratories, is designed to utilize the standard available telephone lines at the maximum data rate consistent with a low error rate. The subset accepts a serialized DC input and converts this to a frequency modulated signal for transmission over phone lines. The receiving terminal will convert the signal to a serialized DC output. The subset is capable of transmitting data at rates up to 2, 000 bits per second.

IBM has had extensive experience in data transmission over telephone lines with its Data Transceiver. The transceiver can transmit between four sets of card punches at a rate of 32 cards per minute. The checking circuits have proven effective in catching the errors inherent in the transmission medium. A disadvantage in the system has been the need for manual intervention to retransmit error cards.

Printed in U.S.A.

The experience gained has led us to establish the following criteria for an advanced data transmission system:

1. The message should be checked with an error checking code using a level high enough to insure detection of more than single bit errors. The four out of eight coding systems have proven quite adequate on the transceiver and will be used.

2. The output of the system should contain only good data. This means that if an error is detected during a transmission, it should be corrected before being recorded on the output medium.

3. The terminal equipment should be simple in the interest of reliability and costs.

4. The transmission rates should not necessitate special transmission facilites in order to insure availability of adequate lines particularly in the event of rerouting as occasioned by line faults.

5. Buffering such as cards or magnetic tape should be used at each terminal to avoid complete system dependence on the data link. Later experience will dictate the feasibility of on-line operation; e. g., a remote printer directly driven through a telephone link.

To meet these objectives, IBM has developed serial card readers and punches and slow speed magnetic tape which will efficiently utilize the capacity of the digital subset. The equipment will be capable of operating with all combinations such as card to card, card to tape, tape to card, and tape to tape. The elements will be a serial card reader-punch capable of punching 45 cards per minute and reading up to 180 cards per minute. The cards will normally be considered as Hollerith though the possibility exists for column binary transmission at a reduced speed.

The magnetic tape units will read and write the standard 200 character per inch magnetic tapes in either binary or binary coded decimal. The unique feature of the tapes is the ability to read and write at the speed of the data link thus eliminating the need for buffers as has previously been the case.

32 0077
Printed in U.S.A.

The speeds that may be expected with this equipment will be:

Card or Tape to Card	45 Cards/Minute
Card to Tape	100 Cards/Minute
Tape to Tape	125 Characters/Second

The choice of equipment will be a function of the data rate and cost as related to urgency.

Consider that the output requirement is for five hours of high speed printing or about 30,000,000 characters per day. The alternatives are to use mail service for 24-hour response, 2 sets of tape-to-tape equipment for 15 hours, 3 sets of equipment for 10 hours, 4 sets for 7.5 hours, or 5 sets for 6.0 hours. The speed increase is a step function controlled by the number of parallel systems required.

Another approach often considered is the use of broader band circuits or of different modulation techniques that achieve better utilization of the available band width. The problems encountered are that specially engineered circuits as well as more elaborate terminal equipment is required. At the present time, the added cost of higher performance circuitry does not make this a more economical solution than the approach outlined using conventional telephone lines.

If the need exists for very high data rate transmission the telephone companies can engineer a special facility A West Coast aircraft company is obtaining a microwave facility that will transmit magnetic tape at 15,000 characters per second

The philosophy of the STRETCH design has been to provide as flexible a machine as possible. This allows each computer installation to use the machine as they see fit with few if any hardware restrictions. Extremely short programs can be run with the same economical benefits that usually accrue only from very long programs. The installation can run programs sequentially or simultaneously. The computer can talk to any type of device with equal facility or ease, be they tapes, consoles or remote locations.

The size and flexibility of STRETCH will allow it to handle almost any type of problem. Its extremely fast speed reduces the through-put time. The facility to do multi-programming will reduce the through-put time for the entire workload. Console debugging flexible instruction sets, and powerful codings systems will reduce turnaround time..

PERFORMANCE

The performance of a STRETCH system cannot be measured only in terms of add times. A fixed point add of 10 digits can take longer on STRETCH than on the 7090. A disk system will have a slower internal computing speed, while the disks are running, than one without disks. Yet some test problems are 170 times as fast as the 7090 or 1700 times as fast as the 704. A three-dimensional nuclear diffusion problem will run in 1/4 of the time and for the same cost as a two-dimensional problem on the 704. This accomplishment is brought about because of STRETCH's faster internal speed, more powerful instruction set, and better input/output communications.

A STRETCH timing simulator was coded for the 704. The 3 dimensional nuclear diffusion problem (the six-neighbor problem) was then coded and run on the simulator. The results of this are summarized in the following table along with the results for other computers. The times are in microseconds and are the average expected times needed to compute a new flux value at a point. The performance times are based upon straightforward coding and do not necessarily represent the fastest times possible.

Using the Variable Field length feature, more floating point data words, can be more economically packed into 16K of STRETCH memory than 32K of 704 memory. The throughput time for a problem will be greatly reduced because there is less tape to pass and the increase in computing time does not matter because it is hidden within the input/output time.

Hand computed time estimates were made for a 1 memory box STRETCH for either a 24 bit (STRETCH-24) or 32 bit (STRETCH-32) floating point word. The allocation of the bits to the exponent or fraction part of the word is immaterial. The 16K of memory could then hold either 44K or 32K data words depending upon which word size was chosen. The economics of this system make it very attractive.

The attached graph shows the relative computing speeds for the Monte Carlo type of problem as a function of the number of memory units and the type of input/output equipment. The computing speed bears an inverse relationship to the disk data transfer rate due to the simultaneity of memory demands which is evident only at peak data rates.

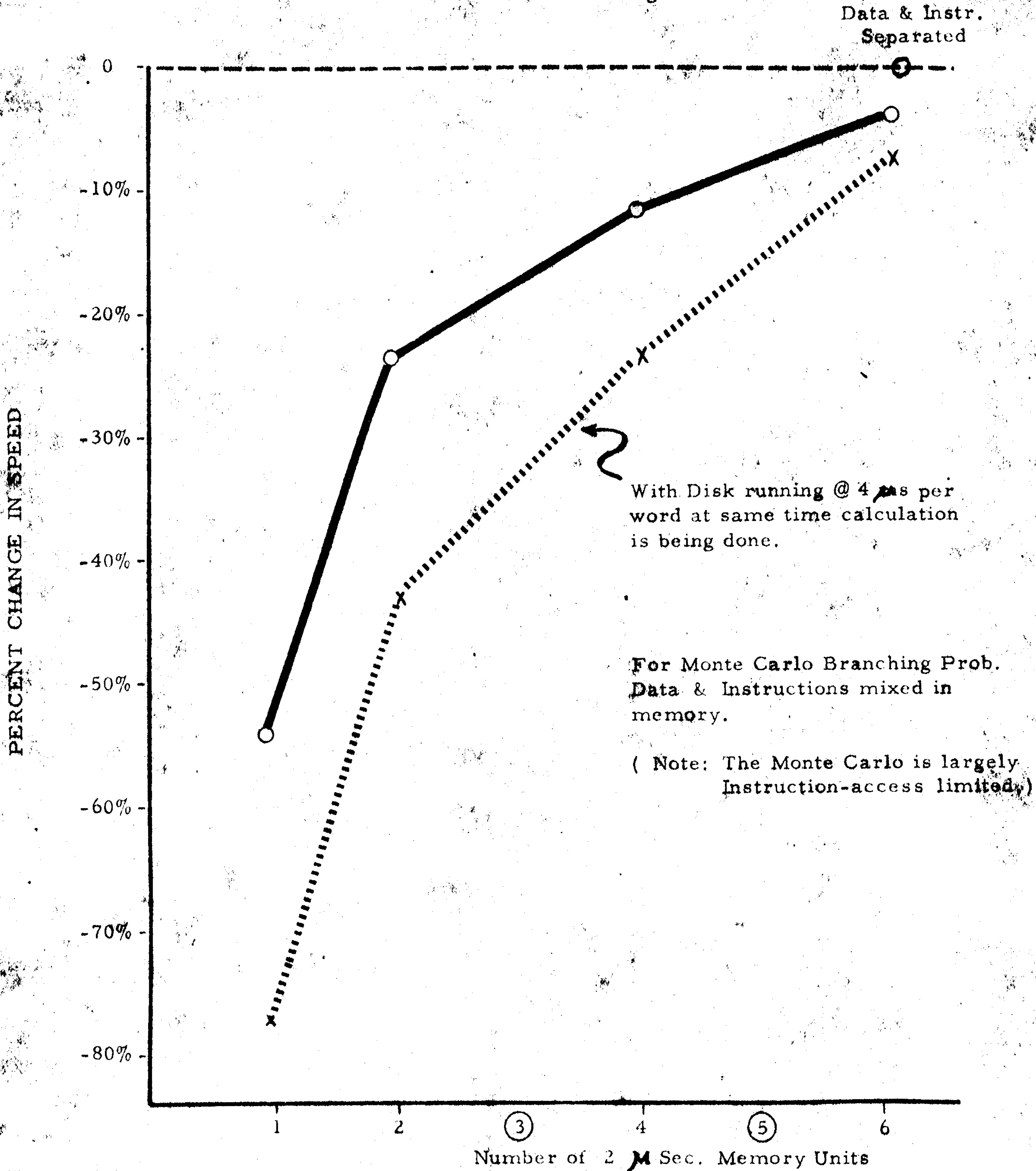
32 0077
Printed in U.S.A.

32-0077
Printed in U.S.A.

COMPUTER SYSTEM	NUMBER MEMORIES	I/O UNIT	NUMBER OF CHANNELS	COMPUTE TIME	I/O TIME	TOTAL TIME	RELATIVE COMPUTE TIME	RELATIVE THROUGHPUT TIME
704		727		2640	3600	6240	1.0	1.0
709		727	2	2640	2000	2640	1.0	2.4
7090		729-IV	2	528	480	528	5.0	11.8
7090		729-II	2	528	870	870	5.0	7.1
STRETCH	6	3 Disks		37	36	37	71	168
STRETCH	6	1 Disk		37	37	37	71	168
STRETCH	4	1 Disk		37	38	38	71	164
STRETCH	2	1 Disk		51	41.5	51	52	122
STRETCH	2	729-IV	5	40	192	192	66	32.5
STRETCH	2	729-IV	4	40	288	288	66	21.6
STRETCH	2	729-IV	2	40	480	480	66	13.0
STRETCH-24	1	729-IV	2	95	180	180	27	34.4
STRETCH-32	1	729-IV	2	95	240	240	27	25.8
STRETCH-24	1	729-IV	4	95	108	108	27	57.
STRETCH-32	1	729-IV	4	95	144	144	27	43.

(MONTE CARLO)

STRETCH: Speed of Internal Computation vs. Number of Memory Units with and without Disk running.



IBM

PHYSICAL FACILITIES

A tentative layout of the STRETCH System in KAPL's 704 room is attached. The system is much larger than the ones under consideration in order to emphasize the expandability possible within such a facility.

The power requirements for the system will not exceed 150 KWH. The system will require two types of 208 volt, 3 phase power with a line frequency of 60 and of 400 cycles per second. The exact requirements will be based on the configuration chosen. This figure is offered as a guide for planning.

The same requirements for air conditioning prevail for the STRETCH System as for the 700 series equipment. These limits are 60% relative humidity and 80° room temperature. The 700 series manual of Physical Planning provides detailed information on the requirements.

The average floor loading of the STRETCH System will not exceed 100 pounds per square foot. The maximum caster load will be 1,200 pounds. These requirements are in line with the 700 Series equipment.

The following abbreviations have been used in the attached layout:

T	Tape Drive
CCU	Console Control Unit
PCU	Punch Control Unit
TCU	Tape Control Unit
CRCU	Card Reader Control Unit
PRCU	Printer Control Unit

Printed in U.S.A.

IBM

SYSTEM EXPANDABILITY

STRETCH has been designed as an expandable system. Using presently designed and working components, a speed increase of one order of magnitude can be obtained without changes in programming. A multi-disk, large memory size STRETCH will solve certain problems in 1/10 the time of a basic type STRETCH. The performance chart for the nuclear diffusion problem shows a performance gain of 8.

As the Exchange channels are general purpose, they can be used to talk to any other device. Therefore, it is possible to tie two STRETCHES together via their Exchanges. There is no reason why this could not be a remote hookup. For faster and more direct communication between systems, provision is made for directly tying central processing units together.

The adaptability of STRETCH is shown by its use in the Harvest system. Harvest is an attachment of equal size added to the STRETCH system. It uses STRETCH to perform routine operations and store data while it performs higher level functions.

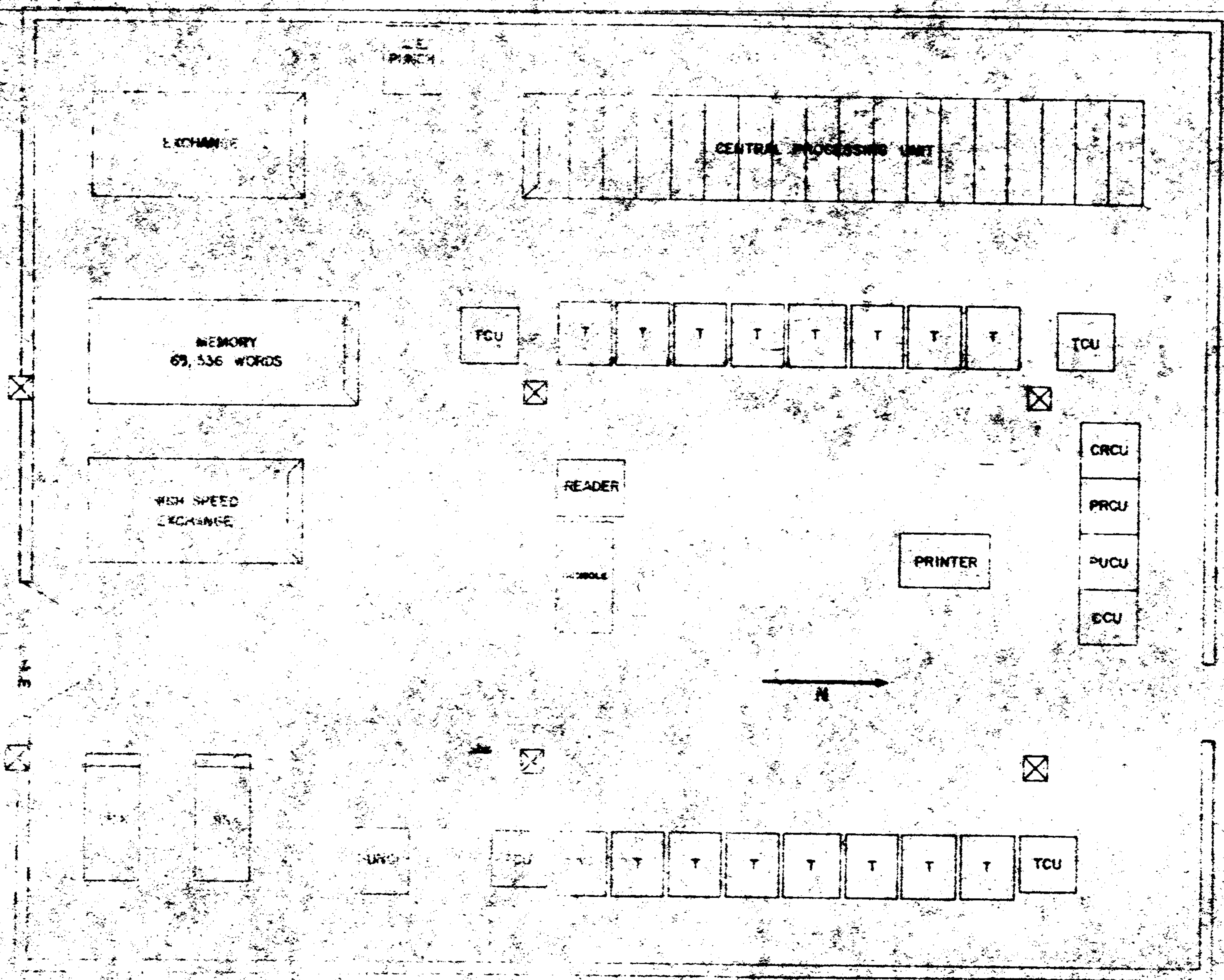
The asynchronous nature of STRETCH will allow it to take advantage of any new technological developments. Faster memories will be easily attached. Automated wiring and design will allow the use of the latest advances in transistor technology. Separation of functions allows replacement of large logical elements. For instance, the multiplier unit is a separate box. With a new development in methods of multiplication, this box could be exchanged with another one bringing the latest technological development to a STRETCH user without the danger of having the complete system obsoleted.

Advances can also be expected in programming technology and systems. Many concepts on STRETCH are new to the computing industry. At the outset these facilities will probably not be used to their fullest extent because of lack of experience. As programmers become accustomed to the new features and begin to use them, there will be a significant gain in computer efficiency. Similar advances were noticed in the use of 704's. Early machines were often used in a card mode. With increased knowledge of systems organization, the mode of operation was advanced to tape and then automatic with gains of 200 - 400% in efficiency. Obviously, there will be similar gains with STRETCH.

32-0077
Printed in U.S.A.

32.077
Printed in U.S.A.

IBM



RETCH SYSTEM

IBM

PRICE SCHEDULES AND COST INFORMATION

A basic system would include the central processing unit, 16,000 words of core storage, a tape control unit, 4 tape and the set of card equipment. The operator console is not included since the system may be operated without a console. For comparison purposes four systems are shown.

1 - System A (Basic)
2 - System B (Tape System with 32K)
3 - System C (Disk Unit with 32K)
4 - System D (Disk Unit with 96K)

The bar graph shows the job costs for the 3 dimensional nuclear diffusion problem with the above configurations relative to the 704.

The value of an installation is based upon the total problem mix and workload, although the job costs are representative of the savings of a STRETCH System, they should not be the only determining factors in a system configuration.

32-0077
Printed in U.S.A.

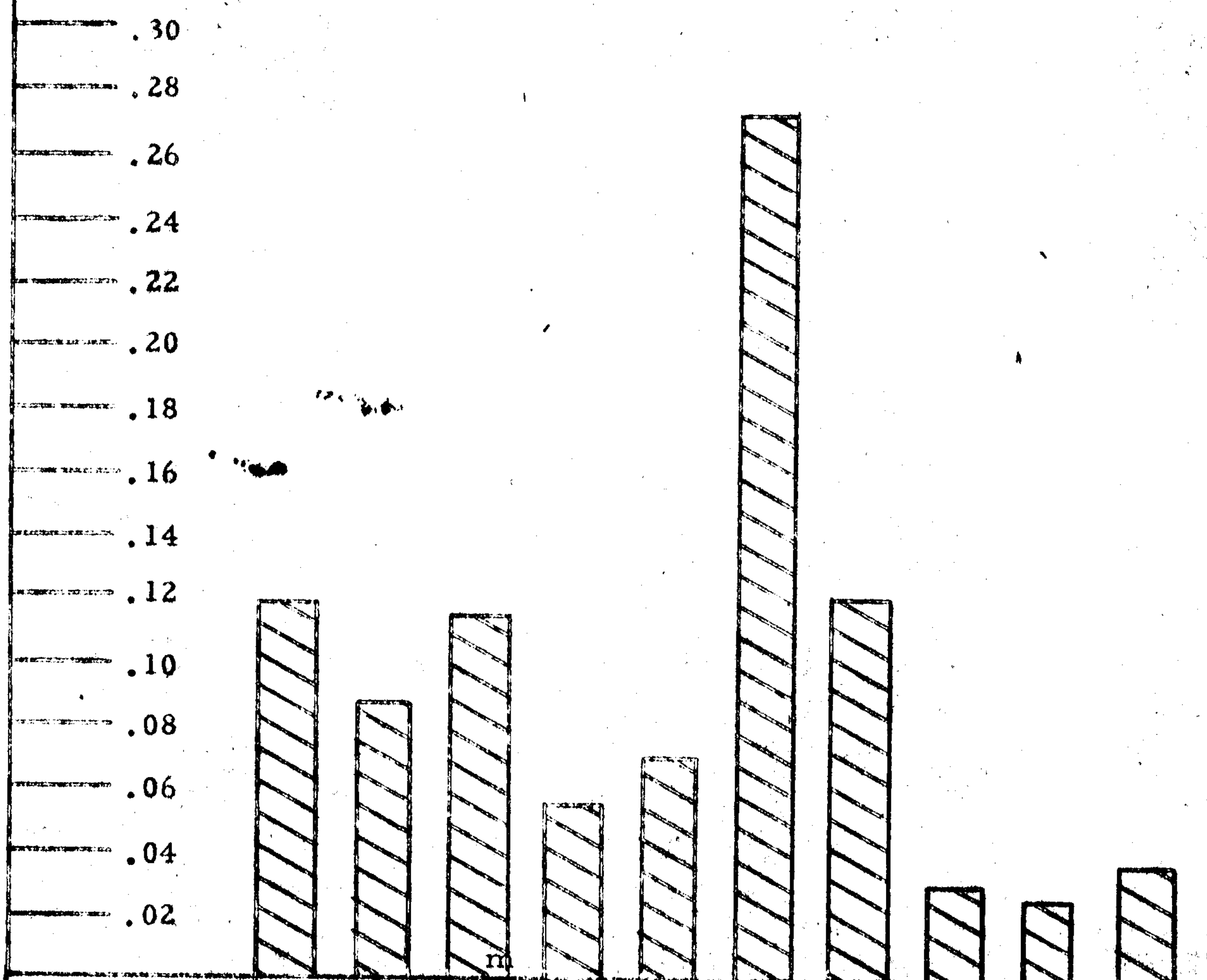
IBM

RELATIVE COMPUTER COSTS

NUCLEAR DIFFUSION PROBLEM

(COSTS ARE FOR SINGLE SHIFT

RELATIVE TO 704 USAGE)



COMPUTER	7090	S	T	R	E	T	C	H		
TAPE CHANNELS	2	2	2	4	4	2	5	2	2	2
MEMORY BOXES	-	1	1	1	1	2	2	2	4	6
DISK FILES	-	-	-	-	-	-	-	1	1	1
WORD LENGTH (IN BITS)	36	24	32	24	32	64	64	64	64	64

32 0077
Printed in U.S.A.

IBM

Price Schedule - Purchase and Rental

Machine Type	Purchase	Rental
Central Processing Unit and Exchange	$4,432,500	$100,500
Core Storage Unit (16,000 words)	950,000	19,800
Disk Synchronizer Unit	563,500	13,100
High Speed Disk File	231,000	5,500
Magnetic Tape Control Unit	67,500	1,600
Card Reader (1000 cpm)	18,000	400
Card Reader Control Unit	60,500	1,450
Card Punch (250 cpm)	24,600	550
Card Punch Control Unit	59,000	1,400
Printer (600 lpm)	43,000	745
Printer Control Unit	89,500	1,695
Operator's Console and Control Unit	135,500	3,200
Type 729-IV Tape Unit	48,500	900

32-6077
Printed in U.S.A.

IBM

Price Schedule - Maintenance Agreement

	Monthly Maintenance Prices		
	0-36 mos.	37-72 mos.	73-108 mos
Central Processing Unit and Exchange	$2,800	$2,850	$2,975
Core Storage Unit	960	960	960
Disk Synchronizer Unit	275	295	315
High Speed Disk File	300	335	420
Magnetic Tape Control Unit	42	45	48
Card Reader	44.75	51	61
Card Reader Control Unit	49	53	56
Card Punch	36.75	43.75	54
Card Punch Control Unit	33	36	39
Printer	160	190	260
Printer Control Unit	40	43	46
Operator's Console and Control Unit	70	75	80
Type 729-IV Tape Unit	191	191	191

32-0077
Printed in U.S.A.

IBM

System A (Basic)

1 Control Processing Unit and Exchange	$100,500
1 Core Storage (16,000 words)	19,800
1 Tape Control Unit	1,600
4 Magnetic Tape Units (729-IV)	3,600
1 Card Reader (1000 cpm)	400
1 Card Reader Control Unit	1,450
1 Printer (600 lpm)	745
1 Printer Control Unit	1,695
1 Punch (250 cpm)	550
1 Punch Control Unit	1,400
	131,740
1 additional channel (Total of 2)	1,600
4 additional tapes (Total of 8)	3,600
	136,900
2 additional channels (Total of 4)	3,200
4 additional tapes (Total of 12)	3,600
	143,700
1 additional channel (Total of 5)	1,600
2 additional tapes (Total of 14)	1,800
	147,100

32-0077
Printed in U.S.A.

System B - - Tape System with 32 K

1 Central Processing Unit and Exchange	$100,500
2 Core Storage Units (32,000 K)	39,600
2 Tape Control Units	3,200
14 Magnetic Tape Units (729-IV)	12,600
1 Card Reader (1000 cpm)	400
1 Card Reader Control Unit	1,450
1 Printer (600 lpm)	745
1 Printer Control Unit	1,695
1 Punch (250 cpm)	550
1 Punch Control Unit	1,400
1 Console	3,200
	165,340
2 additional channels (Total of 4)	3,200
	168,540
1 additional channel (Total of 5)	1,600
	170,140

32-0077
Printed in U.S.A.

IBM

System C - Disk Unit with 32 K

1 Central Processing Unit and Exchange	$100,500
2 Core Storage Units (32,000 words)	39,600
2 Tape Control Units	3,200
4 Magnetic Tape Units (729-IV)	3,600
1 Card Reader (1000 cpm)	400
1 Card Reader Control Unit	1,450
1 Printer (600 lpm)	745
1 Printer Control Unit	1,695
1 Punch (250 cpm)	550
1 Punch Control Unit	1,400
1 Disk Unit	5,500
1 Disk Control Unit	13,100
1 Console	3,200
	$174,940

32-0077
Printed in U.S.A.

IBM Data Processing

System D - Disk Unit with 96K

1 Central Processing Unit and Exchange	$100,500
6 Core Storage Units (96,000 words)	118,800
2 Tape Control Units	3,200
4 Tape Units	3,600
1 Card Reader (1000 cpm)	400
1 Card Reader Control Unit	1,450
1 Printer (600lpm)	745
1 Printer Control Unit	1,695
1 Punch (250 cpm)	550
1 Punch Control Unit	1,400
1 Disk Unit	5,500
1 Disk Control Unit	13,100
1 Console	3,200
	$254,140

IBM

Communication Cost Consideration

A communication link will consist of the reading unit and its control, a modulator, a transmission line, a demodulator, and the recording unit with its control. The reading and recording units would be supplied by the computer manufacturer. The modular and demodulator which are called Digital Subsets would like the telephone lines be provided by the Telephone Company.

Area prices that may be used for planning purposes are:

Serial Card Reader Punch and Control	$500 per month
Slow Speed Tape Terminal	$900 per month
Digital Subset	$ 40 per month
Line Cost	$3.00 per mile per month

Thus a Tape to Tape link for 300 miles would be:

2 Tape Terminals	$1800
2 Digital Subsets	$ 80
300 miles line	$ 900
	$2780 per month

32-0077
Printed in U.S.A.

IBM

IBM SERVICE

The comprehensive training, assistance, and service facilities available from the manufacturer are of paramount importance to any agency considering the installation of an EDPM system.

IBM has had the opportunity to benefit from the education acquired as a result of the manufacture and installation of approximately 300 large scale systems.

The services and assistance that are available with the STRETCH System are not the result of an accelerated effort. The machine was planned and has evolved over many years.

To underestimate the value of such services and "know-how" is to assume a substitute for experience. The knowledge which IBM has gained since the early systems were installed proves the importance of experience on an every day operating basis.

IBM services are many. Each is described briefly in the following pages.

39-0077
Printed in U.S.A.

CUSTOMER ENGINEERING SERVICES

The one most important IBM service is Customer Engineering. You, as an experienced user of computers, are well aware of the importance of this service, of the need for the highest quality of service, of the significance which this service has to meeting deadlines for making important engineering decisions based on computer results.

We have over 9,000 of the best trained customer engineers in the office equipment business. In the Schenectady Branch Office alone, there are over 40 of these engineers and 5 managers, one of whom is in charge of the engineers at KAPL. EDPM Customer Engineers are selected from this group and are men who have demonstrated outstanding aptitude for comprehending the concepts of such equipment. Schenectady has 13 engineers handling large scale systems representing 37 man years of computer engineering experience.

To illustrate the type of customer engineers we have today in our 3 local 700 series installations, we point out that all but 3 have associate engineering degrees (2 have engineering degrees). All of these men have a very intensive training program, both in classes and actual work on the machine, after having been selected for this phase of our business. This very complete training at our factories and in the field prepares them to give the best possible service to our customers.

For example, the customer engineers selected to service your STRETCH computer will aid in the final assembly and product testing at the Poughkeepsie Plant. They will be fully acquainted with STRETCH and will know intimately the resources available to them as maintenance engineers.

Customer Engineering is a dynamic service. Standards of performance are always being upgraded. A proven reporting procedure assures that the computer performance is under constant scrutiny. As a result, the system is being up-dated continuously with engineering changes. As the engineering level is raised, benefits accrue to the user.

Our engineers are equipped with the latest and specially designed test equipment. They follow tried and proven operating procedures for maintaining the system.

Preventative maintenance programs are based on many years of experience. It is our humble belief that IBM's installed computers have had a remarkable record of low down-time and high operating time.

EDUCATIONAL SERVICES

IBM recognizes its responsibility in providing education to our customers. Education is a continuous process. This is so because

1 - Our customers have a continuous turnover of people who must have various degrees of understanding of computers to do their assigned jobs.

2 - IBM's continuous flow of new product and programming announcements demand that we bring our customers up to date on improvements and explain fully new concepts which are embodied in many of the new products.

IBM educational service includes local Branch office Schools for Customers. Nowhere in Schenectady have we devoted more time to education than at KAPL.

Locally we have been priviliged to offer the following educational services:

1 - Seminars on Machine Computing. In 1958, 90 people attended 6 Seminars, conducted on your premises by local IBM instructors.

2 - 704 Programming -
Miss Gloria Bauer, Syracuse, taught the first programming courses.

3 - Fortran Class -
During the summer a year ago, 60 people attended our classes on Fortran. An additional class was conducted on your premises in January of this year.

4 - Special Fortran Class -
G. A. Lemieux, local representative, conducted a special course this Spring in which he taught the latest additions to the Fortran language.

IBM educational services includes special computer seminars for our users. IBM is host at these 2-5 day sessions held at one of our Education Centers in Poughkeepsie, Endicott and San Jose.

32 0077
Printed in U.S.A.

These Seminars offer the opportunity for our customers to exchange ideas, concepts, techniques and experiences. Usually, the Seminars are conducted for specific industries. For example, recently, meetings have been held for the Aircraft, Chemical, Petroleum, and Civil Engineering industries. At these meetings, distinguished members present papers in the related fields on computer solutions to complex problems. The published papers are distributed to interested parties.

IBM educational services at the Education Centers include Customer Executive Schools of many types. One example is IBM Data Processing School for Engineering Executives (one week).

This is designed to acquaint customers' executives with IBM Data Processing Machines, as applied to computing problems in research, design engineering and production engineering. Prior to his transfer, Mr. F. Creever, the former general manager of KAPL, was scheduled to attend this class last February.

This course covers organization, operation characteristics, capacities and application considerations. Discussions are included on the organization of a computing center, automatic programming of mathematical problems, and special input devices for data reduction and automatic recording and control applications. New and unusual applications to computing problems on research and engineering work are described. As you can see, executives are given the opportunity to gain an awareness of and some insight into the proper place of computers in our society.

32-0077
Printed in U.S.A.

APPLIED SCIENCE CONSULTING SERVICES

IBM maintains a staff of Applied Science Representatives throughout the country assigned to individual branch offices. At the present time, there are over 100 qualified representatives whose function it is to keep abreast of scientific applications being developed and running on digital computers. Three such representatives are assigned to the Schenectady office.

The majority of these men have Master's or PhD's in Mathematics and related fields.

Applications of general scientific nature developed by IBM, universities or commercial concerns are widely distributed by a central Sales Promotion and Publication Department to all our representatives and to our customers. In this fashion many useful techniques are available to our customers who would otherwise have to spend considerable time and money in developing them. Our Applied Science Representatives are trained in all phases of electronic computing, theoretical and practical, and are called on many times to teach courses at customer installations and at our own Educational Centers. In addition, they are called upon to deliver lectures and seminars to engineering groups, college math and engineering clubs, etc. (See Educational Services)

In addition, there are regional Applied Science teams possessing all of the talents necessary for problem formulation, analysis, and system definition. An example of such a team is the efforts of Dr. Hadnot, [illegible], McClelland, Stone and Worthington in providing system knowledge to you.

IBM

APPLIED PROGRAMMING SERVICE

IBM recognizes that programs are equal to hardware in importance to a computer user. This is demonstrated by the fact that preparation of programs has represented an investment of equal magnitude to the computer for many customers.

Reduction of the clerical effort associated with programming is a major objective in minimizing this expense. The second objective is to choose a language familiar to the user that eases his ability to communicate with the machine.

The Applied Programming Department was formed in 1952 to develop program aids such as assembly programs, subroutines, compilers, translators, and supervisors. The magnitude of the effort is best illustrated by the 200 skilled programmers and mathematicians in the group.

The Fortran programming system which is an algebraic compiler, permits the user to write a problem in mathematical notation without the need for a detailed knowledge of the computer. The computer accepts the mathematical language and then generates the appropriate set of machine instructions.

Fortran provides an expansion between source and machine language of up to 100 to 1 depending upon the expression. This minimizes the communication and eliminates errors because of the reduced volume and the need to think only in terms of the physical problem.

The background of Fortran is embodied in the development of the program systems for the STRETCH. These systems include an assembly system, a compiler compatible with Fortran, and supervisory programs.

Research is being done on higher level systems aimed at common language and at greater automation. In the area of common language, the International Algebraic Language is being considered.

Printed in U.S.A.

IBM Data Processing

PUBLICATIONS

IBM supplements the customer's library of technical publications with documents relating to programs, to techniques, to procedures, and to systems.

The intelligence derived from this material enables our customers to better utilize their equipment through greater efficiency and effectiveness of operation.

The publications are in many forms and include the following:

Library Abstracts: A brief resume of the purpose and specifications of the programs in our library. The complete program is available on request.

Programming Bulletins: A description of the Applied Programming developments and improvements.

Systems Bulletins: Describes the capabilities of systems, components and special features.

Applications Bulletins: Describes the solutions of particular problems as relating to an industry or application.

Technical Bulletins: Describes methods, techniques and special devices that represent an improved method of achieving an objective.

32-0077
Printed in U.S.A.

IBM

MANUFACTURING FACILITIES

An added advantage to KAPL is the proximity to IBM's major manufacturing facility in Poughkeepsie.

Poughkeepsie is the "home of the STRETCH Computer". Poughkeepsie will manufacture STRETCH, will develop the many support services for STRETCH installations, and will maintain expert engineering advice on this computer system.

Other major manufacturing facilities are located at:

Endicott, New York
Owego, New York
Kingston, New York
Rochester, Minnesota
Lexington, Kentucky
San Jose, California

Printed in U.S.A.

SPECIAL ENGINEERING

In recognition of the special equipment requirements of our customers, IBM has a Special Engineering Department at each of its manufacturing plants. The engineers of this department design the special features requested for any product within our product line. The range of modifications will include extra capacity features, new functions, interconnections of new types of equipment with standard equipment, and specialized input/output equipment. Examples include such things as special magnetic tape, analog input/output, data transmission, and advanced components in addition to the more obvious special features. The role of Special Engineering is to tailor a system to meet your requirements.

Printed in U.S.A.

IBM

IBM MAGNETIC TAPE CENTER

MINNEAPOLIS, MINNESOTA

In March, 1955, IBM opened its new Magnetic Tape Center in Minneapolis, Minnesota. The tape center was created to maintain, improve and safeguard the quality of the magnetic tape which IBM supplied to its customers. Here every inch of magnetic tape supplied to customers is completely tested and inspected in accordance with very rigorous specifications. This insures that the tape is of the highest quality for its important function as a storage medium. Simulating actual use in the field, the rigid tests check each of the 40 million bits in a 2400 foot reel. 100% tested tape is shipped to our customers.

The test center is staffed with 80 people, made up of engineers, test operators, quality control inspectors, administrative and clerical employees. It is now being operated on a three shift per day basis.

32-0077
Printed in U.S.A.

PHYSICAL PLANNING ASSISTANCE

Well in advance of installation, IBM physical planning engineers will assist you. They will develop your requirements for electric power, space, air conditioning and floor loading, and will advise on the layout.

IBM Data Processing

PRODUCT DEVELOPMENT

Tomorrow is equally as important to users of computing machines as today. The manufacturer's consistent capability to market new products successfully is an important consideration of any user.

One important reason for IBM's maintaining its position of leadership in the past has been its product development activity. A continuous flow of new IBM products and devices into the market place has been maintained. In the months and years ahead, this will accelerate.

Our development planners and engineers number in the thousands. They have elaborate facilities in Product Development Laboratories located in:

New York, New York
Kingston, New York
Vestal, New York
Poughkeepsie, New York
Owego, New York
Yorktown Heights, New York
San Jose, California
Zurich, Switzerland

RESEARCH

Research today, of course, assures product development and announcement tomorrow. Our programs are extensive, as you know. We prefer you to IBM's publication, the IBM Journal of Research, of which you are a subscriber.

Research Laboratories are maintained at:

Poughkeepsie, New York
Yorktown Heights, New York
San Jose, California
Zurich, Switzerland
New York, New York