and requires a sub-routine to be stored only once in any part of the memory.

New Instructions

But for several minor exceptions, Univac II executes all Univac I instructions in exactly the same manner as Univac I. Certain of these instructions, however, have been assigned new functions which serve to extend their overall flexibility. The V instruction, for example, will now transfer from one to nine words instead of merely two as was formerly the case, and the Y-Z instructions will now transfer groups of words ranging from ten to sixty in number in steps of ten words. Formerly, ten words and only ten words could be transferred when using this instruction. As a further example of the greater flexibility permitted in Univac II, the extract function (or E instruction), formerly limited to register A, has been generalized so that it now covers all instructions which read out of the memory (A, B, D, L, M, N, P and S). The EF instruction permits recombination of selected characters from register A with the remaining characters of the word in memory location. Instruction A has been extended in usefulness also, and in addition, an I instruction (transfer from register L to memory) has been adopted as a standard command.

Overflow

With Univac II the addition of a 1 to the control counter reading following overflow is automatic. When using Univac I programs on Univac II a special switch will inhibit the addition of 1 to the control counter reading following overflow and cause the 3rd instruction digit to be interpreted in the memory switch as a decimal zero regardless of its actual value. Therefore, in Univac I programs where the 2nd and 3rd instruction digits have been used for overflow control, the presence of these digits will not influence the execution of the instruction.

Compatability Switch

A switch provides three circuit corrections to promote compatibility of Univac I and II programs. Any other incompatibility will require program corrections. With the switch in position to handle Univac I programs, the Univac II will treat the 3rd instruction digit as zero, for V, W, Z and Y instructions, treat the 2nd instruction digit as zero and restore the Univac I mode of overflow action on the control counter.

Tape Handling Operations

As many as 16 Uniservos may be connected to Univac by a metallic duct carrying the necessary cables. Univac can read from tapes mounted on these Uniservos with the tapes moving forward or backward. Univac can record on a tape moving forward. It can read from one Uniservo, write on a second and rewind all other Uniservos simultaneously. Unless there is another read, write or rewind instruction immediately following, Univac may continue to compute while the reading, writing and rewinding operations are being performed.

Tape recording for Univac II must be done according to the following:

Spacing per block	4.60 in
(with 1 in between blocks)	(3.60 in per block)
Pulse density per inch	200 nominal
Blocks per reel	4,000 (metallic) nominal
Read time per block	51 msec. minimum (metallic and mylar)
Per reel	3.4 minutes minimum (metallic)
Rewind time per reel	3.1 minutes (metallic)
Feet utilized	1,535 ft (metallic) 2,400 ft (mylar)

PROGRAMMING SPECIFICATIONS

Library and compiler routines for mathematical and commercial use, and service routines for maintenance uses, are available to the customer.

Modified or Added Instructions

I instruction providing for transfer of information from register rL to memory.

Field selection as specified by a second instruction digit F. For the instructions A, B, D, L, M, N, P and S it operates so that the word transferred from memory location M contains only those digits from the columns of "m" which correspond to the columns in register F containing "odd" characters. The remaining column positions of the word, transferred from "m" to the receiving register contain decimal zeros.

The EFm instruction permits insertion into a word in memory location "m" of the characters in those columns of register A which correspond to the columns containing "odd" characters in register F. "Odd" characters in the Univac code have a binary zero in the least significant binary position. rA will also contain the complete word which is restored at memory location "m".

Add to memory. The add to memory instruction is effected by adding a special designator (H) in the 2nd digit position of the A instruction. It results in the execution of an A instruction followed by an automatic H instruction. Register rA will retain the total (rX + rA) at the conclusion of the add to memory instruction. An equivalent subtractive operation is performed by the SH instruction.

Multiple Word Transfer

The Vn_1m_1, Wn_2m_2 word transfer instructions transfer one to nine words as specified by the numeric (n) appearing in the second digit position. Register rW provides the transfer storage. The transfer is made using V and W instructions as for Univac I except that no reversal of position occurs in a 2 word transfer as may in Univac I. Note also that if the second digits of the V and W instructions are not equal special transfers result. If $n_1 > n_2$. The first $(n_1 - n_2)$ words transferred from m_1 to rW are not transferred from rW to m_2. If $n_1 < n_2$. The $(n_2 - n_1)$ words transferred to rW by a previous V instruction are transferred to m_2 followed by the n_1 words of the current V instruction. When n = 0 the instruction will be processed as a skip instruction.

The Yn_1m_1, Zn_2m_2 pair of instructions permits the transfer of groups of 10, 20, 30, 40, 50, or 60 words as designated by a numeric (1 through 6) in the second digit position of the instruction. The Y, Z instructions use rZ as transfer storage. If the second digits of the Y and Z instructions are not equal, special transfers result. If $n_1 > n_2$. The first $n_1 - n_2$) tens of words transferred from M_1 to rZ will not be transferred to M_2. If $n_1 < n_2$. The $(n_2 - n_1)$ tens of words transferred to rZ by a previous Y instruction are transferred to m_2, followed by the n_1 tens of words of the current Y instruction. When n = 0, 7, 8, or 9, the instruction will be processed as a skip instruction.

Tape Writing Density Controls

5nm instruction causes writing of 200 pulses per inch except that manual countermanding pushbuttons will be provided to select one or more Uniservos on which the 5nm instruction will be interrupted as calling for a 124 pulse per inch writing density. These manual pushbuttons will be in addition to those available for block subdivision and delta (△) second digit decoding of in/out instructions.

7mm instruction causes writing at 50 pulses per inch. Block subdivision controls will operate as in Univac I with all densities. Block divisions (space between blocks) will be 1 inch except for the 124 ppi density. This will be 2.4 inches.

Memory Clear

A protected switch will provide for memory clear (rM) to decimal zero. Register rM will clear on read-in.

Buffer Register Clear

Registers r0, rI, rZ and rW clear only on read-in.

Instruction Execution Time

Basic machine cycle is reduced from four to three cycles (α cycle is omitted).

All instructions are performed at minimum latency rates.

USN ESO

Outstanding features include self-checking of the computer through use of duplicate circuitry in both the arithmetic and logical units.

Standard tape labelling techniques are used; storage, shipping, protection from humidity, temperature and physical handling problems are minimal. System operates with metallic magnetic tape. Back-up master tape files are stored in a remote location as protection against loss of information through electrical, fire or other damage to the tapes stored in computer center library.

This activity has experienced a high performance rate in the use of metallic magnetic tape with its ADP system. A number of tests have been made with various types of mylar base tape; but, to date, the performance of mylar tape on Univac II is unsatisfactory.

Metropolitan Life

Outstanding features are that the system is completely self checking and simple to operate. Each tape is kept in a cardboard box, labeled on the reel and on the edge of the box, stored like books on open shelving with stall dividers every three reels, in locked fenced-in area. No special humidity, fire, or dust protection needed for metal tapes.

Pacific Mutual

Outstanding features include self checking and duplicated circuitry affording basically error free output. The Unitypers allow a complete tape system, completely devoid of any type of punch card.

If anything, we have erred in over controlling for everything except humidity, which we do not control.

We feel that for our job we have the best equipment presently available and are trying to keep aware of the next generation.

USS

Metal cases are used for ordinary filing. Fireproof cabinets for some master tapes.

PRODUCTION RECORD

Number of systems delivered 32

FUTURE PLANS

USN ESO

No new components or modifications to the installed ADP system are contemplated by this activity.

It is planned to retire the present ADP system and replace it with a more powerful, solid-state ADP system during FY 1962.

Several new applications will be programmed for processing, in addition to the applications already in production on the present ADPs, at such time as the replacement system is installed.

Metropolitan Life

Plan to get from two to four more systems of the 3rd generation type such as Honeywell 800, IBM 7080, etc.

Plan to extend tape files from present 6 million policies, to include other types for about 40 million policies, and expect to run these files daily instead of bi-weekly, and extend the area of operations performed.

Plan to be installing in many areas of work previously deferred because of lower expected savings and/or greater planning effort.

Pacific Mutual

We have gone from Univac I to Univac II and anticipate moving to Univac IIII - IBM 701 - Datamatic 801-RCA 501 or some other system as soon as the new generation of computer renders ours so obsolete as to be impractical to retain. This could conceivably be in 1963, 64 or 65.

We are continually investigating, modifying, etc., our system and equipment and looking to add new applications.

USS

Additional applications of the same type as currently processed will be installed.

New systems being reviewed and evaluated for consideration.

INSTALLATIONS

U. S. Navy Electronics Supply Office
Great Lakes, Illinois

U. S. Department of Agriculture
Commodity Stabilization Service
Kansas City, Missouri

Metropolitan Life Insurance Company (3)
1 Madison Avenue
New York 10, New York

Metropolitan Life Insurance Company (1)
315 Park Avenue So.
New York City, New York

Pacific Mutual Life Insurance Company
Pacific Mutual Building
Los Angeles, California

United States Steel Corporation
1509 Muriel Street
Pittsburgh 3, Pennsylvania

U. S. Department of Agriculture
Kansas City Commodity Office
Kansas City, Missouri

UNIVAC III

Univac III Data Processing System

MANUFACTURER

Remington Rand Univac
Division of Sperry Rand Corporation

Photo by Remington Rand Univac, Division of Sperry Rand Corporation

APPLICATIONS

System is designed for commercial data processing as well as scientific applications. The UNIVAC III is a medium-cost, high performance electronic data processing system designed to meet the broadest possible needs of business and science. The magnetic core memory holds from 8,192 to 32,768 words in increments of 8,192 words each with a cycle time of 4.5 microseconds. Words can be pure binary, binary coded decimal, UNIVAC Xs-3, or any other form. UNISERVO III tape units allow reading, writing, and computing simultaneously. The read-write rate is 200,000 digits per second.

Up to thirty-two Uniservo III tape units and six Uniservo II tape units are possible. Auxiliary on-line units may include card-readers which operate at a rate of 700 cards per minute, high-speed printers at 700 lines per minute, card punch units at 300 cards per minute, mass storage and other devices. The UNIVAC III is compatible with other UNIVAC tape units or with those of other manufacturer.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary or binary coded dec
Binary digits/word	24
Decimal digits/word	6
Alphanumeric char/word	4
Instructions per word	1
Instructions decoded	75 (approx)
Arithmetic system	Fixed point
Instruction type	one-plus-one
Number range	
Binary	$\pm (2^{96} - 1)$
Decimal	$\pm (10^{24} - 1)$

Instruction word format

Parity	Indirect Address or Field Select Opt	IR	Oper Code	AR/IR'	m Address
27 26	25	24 21	20 15	14 11	10 1

Automatic built-in subroutines includes automatic interrupt.

Automatic coding includes COBOL and assembly system.

Registers includes four accumulator registers, fifteen index registers, and thirteen memory address counters.

All instructions are automatically modified by the Index Register designated. System is able to select as an operand from one bit to ninety-six bits through use of a field select control word. From one to four-word operands are possible.

All users of UNIVAC III will be provided with a comprehensive programming package. The initial pack will contain COBOL, SALT Assy (Symbolic Assembly Language Translator), sort and merge generators, and an executive routine including contingency and error check routines.

ARITHMETIC UNIT

	Incl Stor Access Microsec	Exclud Stor Access Microsec	
Add	8	8	6+6 Digits
Mult	48-124	48-124	6x6 Digits
Div	68-144	68-144	6/6 Digits

Arithmetic mode	Serial by digit Parallel by bit
Timing (Computer)	Synchronous
Operation (System)	Concurrent

The computer instruction execution cycle is such that the effective access time is zero.

STORAGE

Media	No. of Words	Decimal Digits	Access Microsec
Core	32,768	196,608	1.07
Drum (Mass Memory)	4,000,000/Drum	24,000,000	385

Magnetic Tape

No. of units that can be connected	32 Units
No. of chars/linear inch	1,333 Char/inch
Channels or tracks on the tape	9 Tracks/tape
Blank tape separating	0.68-0.78 Inches
Tape speed	100 Inches/sec
Transfer rate	133,300 Chars/sec
Start time	6.3 Millisec
Stop time	6.3 Millisec
Average time for experienced operator to change reel of tape	30 Seconds
Physical properties of tape	
Width	0.5 Inches
Length of reel	2,400 Feet
Composition	Mylar

In addition to the units described above, a maximum of 6 Uniservo II may be included in the system. Check during writing on Uniservo III. Digital representation (4 bits) 200,000 pulses/sec transfer rate, 2,000 digits/inch.

INPUT

Media	Speed
Cards	700 cards/min
80 or 90 column. No plugboard	
Uniservo III	200 pulses/sec (Digital)
Up to 32 in system	133.3 (Alphanumeric)
Parallel read-write	
Uniservo II	25 pulses/sec (Alphanumeric)
For compatibility with other Univac Tape Systems	
Paper Tape	

OUTPUT

Media	Speed
Cards	300 cards/min
80 or 90 column. No plugboard	
Card Printing	Print - 900 lines/min
Punch	Punch - 150 cards/min
Punches and prints same card in one pass.	
High Speed Printer	700 lines/min
Editing program controlled.	
Paper Punch	

CHECKING FEATURES

Modulus 3 word parity checking, arithmetic, transfer and comparison operations, and logical checks.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	75.2 Kw 94 KVA 0.80 pf
Volume, computer	900 cu ft
Area, computer	1,500 sq ft
Room size	43 ft x 43 ft x 12 ft
Floor loading	200 lbs/sq ft 1,100 lbs concen max
Weight, computer	27,225 lbs

Heat exhaust vents should be located at roof of each unit. Air conditioning output ducts should be near unit inlet vents. Total input line current 261 amperes/line. Recommended main circuit breaker 400 amperes/line. 115 volt convenience outlets should be located every 6-8 ft approximately 2 1/2 ft off floor.

These figures include the Univac III large system w/16 tape.

PRODUCTION RECORD

Number on order	25
Time required for delivery	18 months

COST, PRICE AND RENTAL RATES

Basic System Units	Price	Monthly Rental
Computer - 8 K Memory	$390,000	$ 8,000
High Speed Reader	35,000	750
Punch Unit	40,000	850
High Speed Printer	79,000	1,650
Uniservo III Synchronizer-Max. 16 Uniservos	145,000	2,900
Uniservo III Power Supply	17,500	350
Uniservo III	24,000 ea.	500 ea.
Additional Equipment Units		
Card Punching Printer	$ 197,500	$ 4,300
Uniservo II	20,000	450
Uniservo II Synchronizer	92,500	1,925
Uniservo II Power Supply	17,500	350
Memory-Add. 8 K -	67,500	1,400
Add. 24 K	193,500	4,030
[illegible]nd Uniservo III [illegible]chronizer or Mass [illegible]mory Device	145,000	2,900

Maintenance/service contracting is included in rental price.

PERSONNEL REQUIREMENTS

Training made available by the manufacturer to the user includes a program-systems course for experienced programmers of 5 weeks duration and for inexperienced programmers of 8 weeks duration.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

The system is completely self-checking.

ADDITIONAL FEATURES AND REMARKS

Outstanding features are modularity, field selection, multiple word operand, index registers, scatter-read-gather write, and indirect addressing.

Unique system advantages includes automatic interrupt, combined with above features.

The normal procedures for handling Mylar tape may be used.

A one addressable modulus 24 hour clock is included. It keeps time in tenths of a second and has a digital output which can be read by the computer program.

As faster components become available and more powerful input-output units are developed, they will be incorporated in this system without requiring program changes.

Typical Basic System

Diagram by Sperry Rand Corporation, Remington Rand Univac Division

Typical Expanded System

Tape Line Configurations

Diagram by Sperry Rand Corporation, Remington Rand Univac Division

UNIVERSAL DATA TRANS

Universal Data Transcriber

MANUFACTURER

Naval Weapons Laboratory
Dahlgren, Virginia

Photo by U. S. Naval Weapons Laboratory, Dahlgren, Va.

APPLICATIONS

Located at the Naval Proving Ground, the system is used for conversion of scientific or management data from one medium or format to another, primarily in the processing of input and output for the NORC or other computers.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	36
Binary digits/character	8 + 1 check bit
Instruction word format	

MO	M1		M2	M3
8 1	8 6	5 1	8 1	8 1
Operation Code	B-Register Specification	Address Specification of Reference to Memory		Limit Value of Bx

Since there are no multiply or divide orders, the operating binary point may be considered to be in any convenient location. The carry (borrow) bit may be propagated from character to character in addition (subtraction) with use of double precision orders. A single reference to the memory brings out four characters designated as MO, M1, M2, and M3 into the memory register. Addresses evenly divisible by four always correspond to the character read out as MO. Instruction words consist of the four characters MO, M1, M2, and M3. Instruction words are logically divided into 4 fields as shown above, namely: Operation Code, B-Register specification, Address Specification of reference to memory and the Limit Value of Bx.

The operation of the system depends upon the micro-programming of the computer to generate special orders which will transfer data from the particular external input device currently in use to the computer memory and from the memory to the external output device currently in use. The use of micro-programming, which is accomplished by use of a plugboard, allows an efficient transfer of data between the computer memory and the external devices with a minimum of special equipment. Conversion of the data within the memory from one form to another is accomplished by the use of an appropriate stored program. This gives a very flexible system since all that is required to change the system from one job to another is to change the connections to the external equipment, insert a different plugboard, and load a new program into the computer memory. This system was conceived, designed and is under construction by the Computer Research and Development Branch of the Computation and Exterior Ballistics Laboratory of the U. S. Naval Proving Ground, Dahlgren, Virginia.

The system registers are:

1 Input register
1 Output register
2 Computing registers
6 B-registers (address modifiers)
1 Instruction register
1 Instruction counter
Indicator latches (single bit registers)
Other special registers

External devices communicate with the computer via the input and output registers under control of the computer. The input register can select at high speed from either of two different external devices. The output register is normally connected to only one unit. Indicator latches are used both to control the external devices and to signal the condition of the external devices to the computer. Special electronic signal generating equipment tailored to each type of external device is used to facilitate communication with the input register, output register, indicator latches and the external device.

CHECKING FEATURES

The computer has automatic circuitry built into the system to check the accuracy of its operation. This check adds a parity bit to the 8 bits in each character so that the modulo two sum of the binary one's of these 9 bits is always odd. This check bit is generated after data enters the input register, is corrected as the characters are modified by various orders, and is stored in the memory along with the character. An automatic check is made for the presence of the proper parity count as the data is transferred from the memory into the working registers or the instruction register. The values in the B registers are checked automatically as they are used and there are checks on the execution of the overlay and shifting operations in the computing registers.

Whenever possible checks will be made on the accuracy of data transmission between the computer and the external devices. For example, in card reading, data will be loaded into two independent shift registers from two reading stations, and after the card images are assembled in memory they will be checked against each other. In punching data into cards, the card will be read back into the computer after being punched and this card image will be checked against the card image sent out to the punch. When magnetic tapes are written the data will be read back into the computer and a check will be made on the correctness of the data.

ARITHMETIC UNIT

Operation time, incl 1 memory access	11 microsec
Operation time, incl 2 memory accesses	21 microsec

Two memory accesses are required for such orders as read out and store orders.

STORAGE

Medium	No. of Words	No. of Digits	Access Microsec
Magnetic Core	2,048	36 bits/word	10

INPUT OUTPUT

Media	Speed
Magnetic Tape (NORC)	70,000 dec dig/sec
Magnetic Tape (Potter 906)	37.5/75 in/sec
	200 char/inch
Paper Tape (Digitronics)	300/600 char/sec (read)
Paper Tape (Teletype)	60 char/sec (read)
Paper Tape (Flexowriter)	10 char/sec (read)
Paper Tape (Teletype)	60 char/sec (punch)
Paper Tape (Flexowriter)	10 char/sec (punch)
Magnetic Tape (Analogue, Ampex Model FR-100A)	
Speeds are 1.875, 3.75, 7.5, 15, 30 and 60 in/sec.	
Cards (Remington Rand)	450 cards/min (read)
Cards (Remington Rand)	100 cards/min (punch)
Cards (IBM Model 101)	450 cards/min (read)
Cards (IBM Model 514)	100 cards/min (punch)
Typewriter (Flexowriter)	Keyboard (entry)
Typewriter (Flexowriter)	10 char/sec (print)

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	5 Kw	6 KVA	0.83 pf
Room size, computer		480 sq ft	

No special preparation. Air conditioned as a small part of a large system.

PRODUCTION RECORD

Number produced	1
Number in operation	1

COST, PRICE AND RENTAL RATES

Total approximate cost $350,000 for all units listed except IBM 101 and 514, which are rented.

PERSONNEL REQUIREMENTS

	Three 8-Hour Shifts
Programmers	3
Operators	4
Engineers	1
Technicians	1

Operation tends toward closed shop.
Methods of training used is on-the-job.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Time is available for rent to qualified outside organizations. System has been in use on several projects since January 1960. Some engineering work continues. It may be used by government agencies or contractors when time is available.

ADDITIONAL FEATURES AND REMARKS

The most outstanding difference between the computer of the Universal Data Transcriber and any other single address binary computer is the availability of the plugboard and the plugboard instructions. The plugboard is divided into three regions. The first region consists of information coming from equipment in the computer to the plugboard. This includes all of the registers, such as Register 1, Register 2, Input Register, Output Register, Instruction Register, Instruction Counter, B7, and the indicator latches, plugboard instruction specification and the internal clock. Also in this region are external inputs from the various input and output devices which have been converted to the proper signal levels. The second region of the plugboard consists of a set of approximately 75 logical packages. These packages are identical to those used in the construction of the rest of the computer. In the third region of the plugboard are exists from the plugboard of the control lines in the computer. These lines control the transfer of data from "register to register", use of the B Registers, controlling memory cycles, setting of indicator latches, shifting various registers, etc. Thus by using all three regions of the plugboard almost any conceivable (or desirable) cycle of actions can be controlled from the plugboard. This feature is primarily for use with external devices to get data to or from them and the memory of the UDT.

The indicator latches in the computer are used primarily for communication between the UDT and external devices. For example, some of the indicator latches could be wired, via the plugboard, to control the stopping, starting, or reading or writing of a tape unit. Other indicator latches could be used to indicate to the UDT that an external device is in certain conditions, for example, that a card reader is moving cards, or ready to scan one row of information, or that it is out of cards, etc. Thus the program can control external devices, and external devices can be sensed by the program by use of the indicator latches.

Another feature of the UDT is the "Program Interrupt" ability. If a particular exit on the plugboard is energized the computer will go into a program interrupt cycle. This exit can be energized from an indicator latch, or combinations of indicator latches and various conditions by wiring on the plugboard. When this condition occurs the computer will automatically make a program transfer to instruction location 4 at the end of the current instruction. The address (Y) of the instruction which would have normally been executed next, if the program interrupt condition had not occurred, will be automatically stored in character locations 1 and 2 in a form so that if the character in location 0 is the code for a program transfer (jump) command and the instruction at location 0 were to be executed, the computer would jump to the proper address (Y). When this feature is used the program, starting at location 4, must be suitable to take the appropriate action for the condition which caused the jump. After this is done, the program would normally remake the appropriate registers, and then jump to location 0, which would cause the jump back to the main program at the proper place. By using this feature the computer can react rapidly to external control information without requiring repeated sensing on the condition.

The major advantage of the Universal Data Transcriber is its flexibility. It is not tailored to any specific computer or type of data conversion and is therefore not likely to become obsolete as fast as many specialized converters. The micro-programming and stored program features makes it easy to implement almost any desired conversion with a minimum of engineering effort and special equipment. The major disadvantage to this approach is that it is more expensive than any single specialized converter.

To establish the capabilities of the Universal Data Transcriber several preliminary programs have been prepared. One program for converting 80 column alphanumeric IBM cards to NORC magnetic tape provides for arbitrary code and format conversion, specified by header cards, and converts data to magnetic tape at a rate of 450 cards per minute. Similar programs have been developed for conversion from one magnetic tape system to another. If there is a conversion in both the code representation of the data and in the format, but not in the number base, the system can convert 4, 5, 6, 7, or 8 bit characters from one form to another at a rate of approximately 3,000 characters per second. Conversion can be made from 48 bit binary words to decimal digit words at a rate of approximately 16 words per second. Conversion can be made from 13 digit decimal words to binary words at rates in excess of 50 words per second.

The Universal Data Transcriber is being designed and constructed at the U. S. Naval Proving Ground, Dahlgren, Virginia. Subcontractors are providing the memory, logical building blocks, and various specialized input and output circuitry.

The logical building blocks are all transistorized megacycle SEAC type circuitry built by Computer Control Company. Some of these are being modified to provide two phase operation where the extra speed is required. The memory is an all transistorized magnetic core memory with a full read-write cycle time of 10 microseconds, and operates in parallel on a 36 bit word or 4 characters of 9 bits each. The 80-brush reading station of the IBM 101, used as a 450 card per minute reader, will load the data from a row in the card in parallel into a magnetic shift register which will be shifted into the computer on four wires in 600 microseconds. A similar circuit will be used on the second reading station so as to provide a check on the reading. Data is punched into IBM cards at 100 cards per minute by serially shifting, one bit at a time, at a 100,000 cycle shift rate, the 80 bits in the row to be punched. This shift register will pick up relays which will control the punch magnets in an IBM 514. The reading station which follows the punching station will be equipped with magnetic shift register for reading back the data from the punched card for a check. The same shift register and relays which are used in punching is 120 bits long so that it can be used to control the printing on an IBM 407. A Flexowriter is permanently attached to the system to provide communication between the computer and the operator and is used as an input for the program tapes, and as an input or output of 5, 6, 7 or 8 channel paper tape. A NORC magnetic tape unit is used to provide communication to or from the Naval Ordnance Research Calculator.

INSTALLATIONS

Computation and Analysis Laboratory
Naval Weapons Laboratory
Dahlgren, Virginia

VERDAN

Autonetics VERDAN MBL-D9A Computer

MANUFACTURER

Autonetics
Division of North American Aviation

APPLICATIONS

The computer is used in real time control systems, such as inertial navigation, bombing, weapon system central digital computer, flight control, ground checkout and alinement, and process control.

As a data system, it is used for scientific computation, impact predicition, and mission readiness.

The VERDAN computer consists of three interconnected computational centers: (1) an incremental or DA section (2) a whole valve or GP section and (3) an input-output section. All three centers may be operated simultaneously. The GP section directs all computation.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	24
Binary digits/instruction	22
Instructions/word	1
Instructions decoded	52
Arithmetic system	Fixed point
Instruction type	One and 1/2 address format
Number range	As an integer: $-(2^{23} \leq W < (2^{23}-1)$
	As a fraction: $-1 \leq W < 1 - 2^{-23}$

Instruction word format

0 1	2 8	9 12	13 16	17 23
Not Used	Sector of Next Instruction	Operation Code	Channel	Sector
			Operand Address	

ARITHMETIC UNIT

	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add	160	80
Mult		2,000
Div		2,000

Construction (Arithmetic unit only)

Transistors	1,500
Diodes	10,670
Resistors	4,500
Arithmetic mode	Serial
Timing	Synchronous
Operation	Sequential

The clock rate is 332.8 kilocycles/sec. Above information is for the G.P. only.

STORAGE

Medium	No. of Words	No. of Bin Digits/Word
Rotating Disc Memory	1,664	24

The average access time is one half of a disc revolution, or 5 milliseconds.

Magnetic tape is under development.

INPUT

Media	Speed
16 DC Voltages (± 0.5% Range ±10V)	100 times/sec
3 Ternary Coded Pulse (using 8 integrators)	800 times/sec
32 Shaft Encoder (20 significant bits)	100 times/sec
3 Resolver Incremental (using 8 integrators)	800 times/sec
Tape Reader	
Manual Control	

OUTPUT

Media	Speed
15 DC Voltages	100 times/sec (±0.5% Range ±10V)
Serial Digital	332.8 bits/sec
16 Shaft Encoder	100 times/sec (20 significant bits)
4 Bin Code	100 times/sec
4 Ternary Code	100 times/sec
Nixie Display on control panel	
Paper Tape Punch	5 channel
Typewriter	

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Diodes	10,000
Transistors	1,500
Capacitors	670
Resistors	4,500

CHECKING FEATURES

Parity on input-output. The same problem can be run on GP and DDA internally and answers compared.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	0.320 Kw	0.8 pf 400 cycle, 3 phase
Volume, computer	1.4 cu ft	
Weight, computer	82 lbs	

Air conditioner is not normally required if input air is between $0^{o}F$ and $90^{o}F$. Blower must be supplied by user.

PRODUCTION RECORD

Number produced to date	180
Number in current operation	180
Number on order	883 (approx.)
Anticipated production rates	5/week
Time required for delivery	10 months

COST, PRICE AND RENTAL RATES

Basic system consists of the computer - VERDAN, manual control panel, and paper tape reader. Additional equipment includes paper tape punch, tape prep. equipment, test equipment - C297A, and typewriter. Prices are available upon formal request to Autonetics.

PERSONNEL REQUIREMENTS

This computer was primarily designed for unmanned control systems and thus can operate for long periods of time unattended.

Training made available by the manufacturer to the user includes programming course and operation and maintenance course.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Calculated mean time before failure, from parts count, is 160 hours. Realized MTBF under steady state operation is 250 hours.

ADDITIONAL FEATURES AND REMARKS

Outstanding features include multiple input-output, combination GP/DDA, and small size.

Due to the manner in which the inputs and outputs are handled - internally - the computer does not halt while inputing or outputing, thus the GP, DDA and input-output operations can proceed simultaneously, making this machine almost ideally suited to the real-time control problem.

The VERDAN contains a non-volatile magnetic memory. Provisions are incorporated such that in case of power failure, all intermediate information is stored on a memory channel. Upon resumption of power, the flip flops and registers etc., are reset and the program computation resumes at the point of interruption.

FUTURE PLANS

A digital, addressable magnetic tape reader and writer is under development as an accessory for this machine, in order to extend its capabilities.

INSTALLATIONS

Autonetics
Division of North American Aviation
9150 E. Imperial Highway
Downey, California

Photo by North American Aviation, Inc., Autonetics Division

WESTINGHOUSE AIRBORNE

Westinghouse Airborne Digital Data Processor

MANUFACTURER

Air Arm Division
Westinghouse Electric Corporation

Operand Memory

Photo by Westinghouse Electric Corporation

APPLICATIONS

System is used to process radar data, generate synthetic displays, and direct antenna. The computer is used also to conduct built in system tests, perform diagnostic tests of the Data Processor itself and generate calibration displays.

The Westinghouse Airborne Digital Data Processor is a problem oriented general purpose digital computer developed by Westinghouse for the Bureau of Aeronautics. Problem orientation of the Data Processor stems from its function as a sub-system of a radar processing system with multiple target handling capability.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	24
Binary digits/instruction	21
Instructions/word	One (two instruction words per memory line)
Instructions decoded	4096
Arithmetic system	Fixed point
Instruction type	One address
Number range	$-1 < n < +1$

Instruction word format

21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Inst. Field					Index		Address Field													

Field Designation for Instruction Word

Power Supply

Registers and B-boxes

Accumulator	X-Register
Q-Register	3 Index Registers
M-Register	IS-Register

Stored Data Processing program consists of many sub-routines.

Data-constant words are expressed in a complement form. Operand words are stored two words per operand memory line. Programmer has choice of left or right word, left or right half of left word, or left or right half of right word. These choices provide for maximum use of data locations.

ARITHMETIC UNIT

	Incl. Stor. Access Microsec	Exclud. Stor. Access Microsec
Add	3	1.4
Mult	20	20
Div	40	40

Construction (Arithmetic unit only)	
Transistors	2,600
Arithmetic mode	Parallel
Timing	Synchronous
Operation	Sequential

Photo by Westinghouse Electric Corporation

STORAGE

Media	No. of Words	No. of Dig/Words	Access Microsec
Magnetic Core	4096 Inst Words	21	0.2
Magnetic Core	1024 Oper Words	24	0.8

Magnetic Tape

No. of units that can be connected	1 Unit
No. of characters/linear inch	200 Chars/inch
Channels or tracks on the tape	7 Tracks/tape
Tape speed	75 Inches/sec
Start time	3 Millisec
Stop time	3 Millisec
Physical properties of tape	
Width	0.5 Inches
Length of reel	2,400 Feet
Composition	Mylar

Selected data recorded on tape compatible with IBM 727 tape unit.

Provides checking feature for processed data.

Input Unit

Photo by Westinghouse Electric Corporation

INPUT

Media	Speed	
Hi-speed Block Transfer	3 microsec/data word	
Voltage to Digital	75 microsec	0.1% Resolution
Sense Inputs	3 microsec	

Special input unit designed to receive information from radar and present it to Data Processing units.

OUTPUT

Media	Speed
Hi-speed Block Transfer	3 microsec/data word
Digital to D-C Voltages 0.1% Resolution	15 microsec read-out
Digital to A-C Voltages 0.2% Resolution	9 microsec read-out

Special output unit designed to receive data from the arithmetic/control unit, decode data, output to the antenna director, display of tracked targets on console, and output to tape unit.

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Diodes	15,985
Transistors	7,597
Magnetic Cores	113,600

Gating systems operate on DC levels with approximately 10 millimicroseconds of delay per stage.

Multi-aperture core Instruction Memory with Non-Destructive Read-out.

CHECKING FEATURES

Internally Programmed Self Test

Arithmetic/control monitor capable of testing and holding the contents of a particular register at any prescribed time.

Readily accessible test points permit rapid trouble shooting without removing cards or units from mounting structure.

Arithmetic/Control Unit

Photo by Westinghouse Electric Corporation

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer and power	1.8 Kw 1.8 KVA 1.0 pf
Volume, computer	6.5 cu ft
Area, computer	Dependent on mounting application
Weight, computer	250 lbs

Data Processor is designed for airborne use. Mounting structure depends on space available. Cooling required is a blower with a capacity of 200 cfm at max amb temperature $38^{o}C$ min air density .052 lbs/ft^2. System requires 115v, 400 cycle, 3-phase, 600 watts/phase, or 28v D.C. 3 wire.

PRODUCTION RECORD

Number produced to date	2
Number in current operation	2

Current operating models are prototype.

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

System features and construction techniques utilized by the manufacturer to insure required reliability include selected standard parts proven long life items with extensive life testing operations, electrical components derated to operate at 20% of nominal voltages and power ratings, and circuits designed to accomodate wide swings in component parameters.

ADDITIONAL FEATURES AND REMARKS

Outstanding features include Hi speed (300,000 operations/sec) in a ruggedized, small package, high reliability, and general purpose command repertoire with three Index Registers.

Unique system advantages include Non-Destructive Instruction Store with 1 microsecond memory cycle time, and split word storage, allowing programmer a choice of a 24 bit whole word or a 12 bit half word.

INSTALLATIONS

Westinghouse Electric Corporation
Air Arm Division
Avionics Systems Section (454)
Box 746
Baltimore 3, Maryland

WHIRLWIND II

The Whirlwind Computer

MANUFACTURER

Massachusetts Institute of Technology
Digital Computer Laboratory

Photo by Massachusetts Institute of Technology

APPLICATIONS

Manufacturer
Scientific and engineering computation. The research reported in this computing system description was sponsored by the Office of Naval Research.
Air defense experiments leading to development of the SAGE System.
The Whirlwind I Computer was declared excess to the needs of the M.I.T. Lincoln Laboratory in the spring of 1959. Subsequently, the computer was leased by the Office of Naval Research to the Wolf Research and Development Corporation, Boston, Mass. The Wolf Research and Development Corporation then undertook the disconnecting and moving of the computer from the M.I.T. Barta Building. This move which commenced about 1 January 1960 was successfully completed by 1 May 1960. The computer is presently stored in a Navy warehouse and it is planned to move the machine and make it operational at a new site during early 1961.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	16
Binary digits/instruction	16
Instructions/word	1
Instructions decoded	32
Instructions used	29
Arithmetic system	Fixed point
Instruction type	One address
Number range	$2^{-15} - 1$ to $1 - 2^{-15}$

Instruction word format

Operation	Address
0 – 4	5 – 15

The basic operation code has been supplemented by a comprehensive system of service routines, providing for direct read-in of Flexowriter-coded perforated paper tapes, the logging of each problem on film and paper tape for subsequent processing, assembly during read-in of a suitable set of instructions including interpretive programmed-arithmetic (optional floating

Photo by Wolf Research & Development Corporation

point), up to several hundred cycle counters (B-boxes), output routines, error detection, and automatic post mortems.

Routines are normally coded with mnemonic operations, symbolic addresses, relative addresses, program pre-set parameters, special psuedo-codes, and special control words.

The service routines are stored on magnetic tape and are selected automatically during read-in.

ARITHMETIC UNIT

	Incl Stor Access Microsec	Exclud Stor Access Microsec
Add	22	8
Mult	34-41	23.5
Div	71	57

Construction (Arithmetic unit only)

Type	Quantity
6145	517
7AK7	441
6SN7	96
3E29	14
6Y6	51

Basic pulse repetition rate	1 Megacycle/sec
Arithmetic mode	Parallel
Timing	Synchronous
Operation	Concurrent

STORAGE

Media		Access Microsec
Magnetic Core	6,144	7
Two Magnetic Drums	36,848	8,300
Five Magnetic Tapes	125,000/tape	
Toggle Switch	32	1
Flip-flop	5	1

A word consists of 16 digits plus a parity digit. Read-rewrite time is 7 microseconds. Drum access time is average value.

Magnetic Tape

No. of units that can be connected	4 Units
No. of words/linear inch of tape	13 Words/inch
Channels or tracks on the tape	6 Tracks/tape
Blank tape separating each record	0.6 Inches
Tape speed	30 Inches/sec
Transfer rate	390 Words/sec
Start time	6.0 Millisec
Stop time	6.5 Millisec
Average time for experienced operator to change reel of tape	60 Seconds
Physical properties of tape	
Width	1/2 Inches
Length of reel	800 Feet
Composition	Acetate

Magnetic core storage consists of two banks of 1024 words each and one bank of 4096 words. These are divided into 6 fields of 1024 words, any two of which may be used at a given time. A change fields instruction permits selection of the two fields to be used. A word consists of 16 digits plus a parity digit. Read-rewrite time is seven microseconds.

Magnetic drum storage consists of an auxiliary drum containing 12 groups each consisting of 2048 words plus six groups of 2048 words each contained on a buffer drum. The buffer drum contains four other groups which are used for input-output buffering of digital data.

A total of five magnetic tape units is available, of these a maximum of four may be connected to the computer at any one time and up to three may be connected to the associated delayed (off-line) printout system.

INPUT

Media	Speed
Paper Tape (Ferranti)	200 lines/sec
Paper Tape (Flexowriter)	14 lines/sec
Magnetic Tape	30 in/sec
Light Guns	Manual
Paper Tape (Teletype)	60 words/min
Switches	Manual
Digital Data Input	1,300 points/sec
Real Time Clock	60 pulses/sec

OUTPUT

Media	Speed
Magnetic Tape	188 char/sec
Oscilloscope-camera	200 char/sec
Paper Tape (Flexowriter)	10 char/sec
Oscilloscope-Camera	2 frames/sec
Oscilloscope-Display	6,000 points/sec
Printed Page (Flexowriter)	10 char/sec
Paper Tape (Teletype)	60 words/min
Printer (Teletype)	60 words/min
Digital Data Outputs	1,300 pulses/sec
Audible Alarm-Lights	4 words/sec

The oscilloscope displays vectors at the rate of 6,000 vectors/sec and characters at the rate of 3,000 char/sec. An IBM 523, modified, is used for reading and punching. Magnetic tape may be used for delayed Flexowriter output (off-line).

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Tubes	14,500
7AK7	6,145
6145	5,665
40 Types	
Diodes	14,000
Transistors	None
Magnetic Cores	104,448

Used in core memory only.

CHECKING FEATURES

Arithmetic element checks, parity checks of core memory and magnetic drums, and information transfer checks.

Marginal checking is done one hour daily to determine if any computer circuits have deteriorated during the past 24 hours.

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	200 KVA
Power, air conditioner	150 KVA
Volume, computer	4,400 cu ft
Volume, input-output	2,100 cu ft
Volume, air conditioner	4,200 cu ft
Area, computer	450 sq ft
Area, input-output	210 sq ft
Area, air conditioner	525 sq ft
Room size, computer	30 ft x 70 ft
Room size, input-output	25 ft x 40 ft
Room size, air conditioner	30 ft x 50 ft
Floor loading	12 lbs/sq ft
	60 lbs concen max
Capacity, air conditioner	110 Tons
Weight, computer	37,000 lbs
Weight, air conditioner	16,000 lbs

PRODUCTION RECORD

Number produced to date 1

PERSONNEL REQUIREMENTS

	One 8-Hour Shift	Two 8-Hour Shifts	Three 8-Hour Shifts
Supervisors	1	1	1
Librarians	1	1	1
Operators	1	2	3
Engineers	1	1	1
Technicians	2	4	6
In-Output Oper	2	2	2
Tape Handlers	2	2	2

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

Average error-free running period	19.4 Hours
Good time	3,172.3 Hours
Attempted to run time	3,237.9 Hours
Operating ratio (Good/Attempted to run time)	0.98

Figures based on period 15 May 56 to 24 Sep 56

Passed Customer Acceptance Test 1950

ADDITIONAL FEATURES AND REMARKS

Outstanding features are the display system including twenty-five 16" display scopes, 19 5" display scopes, 13 light guns, manual intervention switches and audible alarms. Digital data inputs and outputs via telephone lines, teletype input and output and real time clock.

INSTALLATIONS

Digital Computer Laboratory
Massachusetts Institute of Technology
Cambridge 39, Massachusetts

WISC

Wisconsin Integrally Synchronized Computer

MANUFACTURER

University of Wisconsin
Department of Electrical Engineering
Computing Laboratory

Photo by the University of Wisconsin

APPLICATIONS

General purpose scientific and engineering computation, engineering experimentation and training.

PROGRAMMING AND NUMERICAL SYSTEM

Internal number system	Binary
Binary digits/word	50
Binary digits/instruction	50
Instructions /word	1
Instructions decoded	16
Instructions used	16
Arithmetic system	Floating point
Instruction type	Three address

Number range 40 binary digits times $2^{\pm 255}$

Instruction word format

10	4	12	12	12
X SPECIAL	T TYPE	A ADDRESS	B ADDRESS	C ADDRESS
50 - 41	40-37	36 - 25	24 - 13	12 - 1

1 bit (#49) used to select fixed point operation, breakpoint operation, etc.
6 bits (#41-46) used (along with 12 bits) to allow completely general Extract operation: Extract any number of bits from any stored word, shift right or left any number of places, insert into any other stored word.

ARITHMETIC UNIT

	Incl. Stor. Access Microsec
Add	16,700
Mult	16,700
Div	16,700

Construction (Arithmetic unit only)

Type	Quantity
Tubes	
6211	400
5844	100
6AW8	4
6CM6	6
Diodes	
1N38	200

Rapid access word registers	7
Basic pulse repetition rate	100 Kc/sec
Arithmetic mode	Serial
Timing	Synchronous
Operation	Sequential Concurrent

Operations are carried out on four instructions simultaneously (Integral Synchronization) resulting in efficient use of access time. The four concurrent operations are read order N, locate two operands called for by order N-1, perform arithmetic of order N-2, and deliver result of order N-3. Floating point makes efficient use of otherwise long addition time.

STORAGE

Media	No. of Words	No. of Digits	Access Microsec
Magnetic Drum	1,024	51,200	0 - 16,700
Magnetic Drum	4	550	
Magnetic Drum	3	440	

INPUT

Media	Speed
Punched Paper Tape	10 sexadec char/sec
Flexowriter Keyboard	Manual

OUTPUT

Media	Speed
Punched Paper Tape	10 sexadec char/sec
Flexowriter Typewriter	10 sexadec char/sec
Oscilloscope Monitor	

CIRCUIT ELEMENTS OF ENTIRE SYSTEM

Type	Quantity
Tubes	
5844	650
6211	650
6AQ5 - 6CM6	100
6AW8	14
6AG5	32
Diodes	
1N38	400
1N1128	3
1N1128R	3

6AQ6 being replaced by 6CM6

CHECKING FEATURES

Manually operated marginal checking voltages
Set of diagnostic routines

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Power, computer	10.5 Kw
Power, air conditioner	7.5 Kw
Area, computer	40 sq ft
Area, air conditioner	15 sq ft
Capacity, air conditioner	7.5 Tons

PRODUCTION RECORD

Produced	1
Operating	1

PERSONNEL REQUIREMENTS

	One 8-Hour Shift
Engineers	1
Technicians	Students

ADDITIONAL FEATURES AND REMARKS

Extract instruction and floating point controls.

Remote control.

Digits in instructions corresponding to the sign of significant digits in numbers are not used in any instruction. Extract instruction is the only instruction which makes use of digits corresponding to exponent in numerical data.

System is financed by the Wisconsin Alumni Research Foundation and the University of Wisconsin, College of Engineering, Department of Electrical Engineering.

Design was governed largely by striving for simplicity of operation. Outstanding features include integral synchronization, general extract, fixed or floating point operation and a 50 bit word length.

FUTURE PLANS

Indirect addressing with automatic modification has been designed and a photoelectric reader and high speed punch have been acquired.

INSTALLATIONS

Computing Laboratory
Department of Electrical Engineering
College of Engineering
University of Wisconsin
Madison 6, Wisconsin

WRU SEARCHING SELECTOR

Western Reserve University Searching Selector

MANUFACTURER

Western Reserve University

Photo by Western Reserve University

APPLICATIONS

Located at 10831 Magnolia Road, Cleveland 6, Ohio, the system is used for the scanning of encoded abstracts of scientific publications for literature searching purposes. Applied to literature projects of American Society for Metals, American Diabetes Association, and Communicable Disease Center (Atlanta, Ga.).

STORAGE

Media
Paper Tape Library
Relays

The paper tape library is scanned at Flexowriter speeds.

INPUT

Medium	Speed
Paper Tape	10 char/sec

OUTPUT

Medium	Speed
Typed Page	10 char/sec
Paper Tape	10 char/sec

PERSONNEL REQUIREMENTS

	One 8-Hour Shift		Two 8-Hour Shifts	
	Used	Recomm	Used	Recomm
Analysts	1	1	1	1
Programmers	1	1	1	1
Operators	1	1	2	2

RELIABILITY, OPERATING EXPERIENCE, AND TIME AVAILABILITY

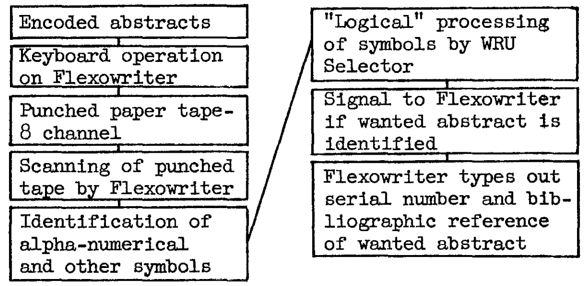
Good time 60 Hours/Week (Average)
Attempted to run time 70 Hours/Week (Average)
Operating ratio (Good/Attempted to run time) 0.86
Above figures based on period 1 Jan 60 to 1 May 60
Time is available for rent to qualified outside organizations.

ADDITIONAL FEATURES AND REMARKS

The starting point for designing this equipment was the realization that documentation systems are called upon to meet a wide variety of information requirements. These range from narrowly defined specific inquiries to comprehensive correlations. More detailed analysis revealed that any given requirement almost without exception involves a combination of several concepts. Both subject indexing, as ordinarily practiced, and the pigeon-hole type of classification systems make use of preestablished concept combinations insofar as such combinations are used at all. Hand-sorted punched cards and various mechanized systems have demonstrated during the past ten years that highly advantageous benefits may be realized by defining searching and selecting operations in terms of concept combinations not established or anticipated at the time of analyzing the subject contents of documents.

The Western Reserve Searching Selector permits an exceptionally wide range of concepts to be used in defining and conducting searching operations. Thus, the scope of a search may be defined not only in terms of specific substances, devices, attributes, processes, conditions, organisms, persons, locations, etc., but also in terms of generic concepts and their relationships to specific terms. Furthermore, observational relationships, for example the roles in a given experiment or situation of various substances, devices, etc, taken either specifically or generically, may also be designed as points of reference in defining searches.

This wide range of possibilities is accomplished by the ability of the Western Reserve Searching Selector to detect combinations of symbols and combinations of combinations at a multiplicity of levels. At each level, combinations may be defined in terms of logical product, logical sum, logical difference or derived complex logical relationships. The different combinational levels may be thought of as analogous to the combining of letters to construct sentences, sentences to construct paragraphs, etc. The machine is able automatically to detect the start and end of each organized symbolic unit analogous to word, phase, sentence, or paragraph.



Selector Operations

This use of analogy, though illuminating, must not be regarded as definitive. Actually, to avoid the complexity of phrasing and sentence structure encountered in natural language, well-defined rules for indicating relationship of a syntactical nature have been worked out. Application of these rules results in the expressing of the subject content of a given document in the form of a telegraphic-style abstract with syntactical relationships rendered explicit by carefully defined role indicator. Encoding the terminology in such abstracts explicitly indicates the relationship of each term to concepts of generic scope.

Prior to conducting a search, an information requirement is analyzed in terms of appropriate specific and generic terms, role indicators and logically defined relationships between them. The information requirement is thus analyzed on the same basis as is used to record the information contents of documents in the form of encoded abstracts. The searching step as performed by the Searching Selector consists of a series of logically defined matching operations involving the common set of terms used for analyzing the information requirement and the information contents of documents.

The Searching Selector has been designed so that ten searches may be conducted simultaneously. Such searches may be interrelated as to scope or completely independent.

FUTURE PLANS

The system has been replaced during 1960 with the GE 250 computing system.

INSTALLATIONS

Center for Documentation and Communication Research
Western Research University
Cleveland 6, Ohio

CHAPTER III

ANALYSIS AND TRENDS

ANALYSIS AND TRENDS

INTRODUCTION

The information for each of the 222 systems described in Chapter II has been subdivided into eighteen topics, permitting the data to be presented in an organized manner and simplifying the comparison of features of the different systems. The following paragraphs, paralleling the subdivisions of the systems descriptions of Chapter II, are an attempt to quantitatively analyze the data and show recent trends in the field of computing machinery. It is emphasized again that the information given in Tables II through XV in this Chapter is to be used with caution. The tables have been constructed only to show trends, permit limited comparison of systems and show the present state of the art. Information pertaining to a specific system should be obtained from the system description in Chapter II or directly from manufacturers and users.

DESIGNATION OF COMPUTING SYSTEMS

The names of various types of computing systems existing in the United States stem from different sources. It would have been convenient if some system of classification and standard nomenclature had been established many years ago. The nomenclature could have incorporated the name of the manufacturer and model number, the nature or application of the system, or the name or location of the operating agency. However, a system of nomenclature was not established, resulting in an odd mixture of names for computing systems. Many computing systems bear the name of the manufacturing organization, for example IBM 704, HONEYWELL 800, NATIONAL 304, ILLIAC, and RCA 501. The names of some machines indicate the nature or purpose of the system, for example WESTINGHOUSE AIRBORNE, VOTE TALLY SYSTEM, CUBIC AIR TRAFFIC, WHIRLWIND and EDVAC. Other machine titles indicate the name of the operating agency, such as DYSEAC, SEAC, NORC, OARAC, ORACLE and ORDVAC. Some titles are indicative of the location of the system, such as LARC. The names of some machines are trade names like UNIVAC II and ELECOM 125. There are some machines named after specific persons, as are ALWAC III E and JOHNNIAC. Arbitrary names, like GEORGE, also exist. Another trend in computing machine nomenclature has been to develop names which were contractions or pronouncable abbreviations of significant titles. Examples of this are EDVAC, for Electronic Discrete Variable Automatic Computer; MANIAC, for Mathematical Analyzer and Numerical Integrator And Computer; and ORDVAC, for ORDnance Variable Automatic Computer.

MANUFACTURERS OF COMPUTING SYSTEMS

In the interest of national defense, the development of electronic computing systems could not wait until normal economic laws brought about the supply of systems through commercial demand. The Department of Defense supported research and development in the field of electronic digital computers to be utilized for rapid scientific computation on defense projects.

The world's first electronic digital computer, the ENIAC, designed and developed by the Moore School of Electrical Engineering of the University of Pennsylvania, for the Ballistic Research Laboratories was placed in operation at the Aberdeen Proving Ground in January 1947. Many early electronic machines were manufactured at educational institutions such as the Institute for Advanced Study, MIT, Harvard and the Universities of Pennsylvania and California. Parallel research was performed by industry, and by 1950, large scale digital electronic computers were being delivered commercially. At the present time mass production of large scale systems is well underway. Several thousand large scale systems of various types have been mass produced, and thousands are on order. Table I shows the manufacturers of all the machines described in Chapter II and Table II shows the approximate quantities of these systems which have been produced.

APPLICATIONS OF COMPUTING SYSTEMS

The installation of the ENIAC, at the Ballistic Research Laboratories of the U. S. Army Ordnance Corps marked the beginning of the widespread use of electronic computing machines. Since the advent of the ENIAC, a large expansion has taken place in the computer field. Investment rates in computing equipment in the United States have risen from ten million dollars per year in 1953 to one hundred million dollars per year in 1956. Present expenditures for computing equipment has passed the billion dollars per year mark.

Almost every commodity industry such as oil, steel and rubber is utilizing computing equipment for both scientific and commercial applications. Service industries, such as banking, transportation, and insurance have applied large scale systems toward the solution of problems in the fields of accounting, reservations control, and bookkeeping. Manufacturers have used computing systems for design engineering and scientific research. Many systems are being utilized for inventory and stock control. The determination of manufacturing plant location and stock parts storage are being made by linear programming methods. Electronic computers are being utilized by the construction industry for design and location of structures and road nets. Many digital computers form a part of closed loop industrial process control systems.

Many problems require the processing of large quantities of data, such as is obtained from missile tracking, telemetering, mineral deposit prospecting and record keeping. The use of electronic computing equipment permits the processing of large quantities of such data over relatively short periods of time.

Many "on-line" applications of both general and special purpose computers are being made. These control applications include such examples as control of wind tunnel testing and continuous-flow manufacturing. Computers are being used for aircraft and missile fire and flight control, both as ground based and missile borne systems.

A discussion of applications of specific systems will be found under the sub-heading "APPLICATIONS" in the various computing systems descriptions given in Chapter II.

PROGRAMMING AND NUMERICAL SYSTEM

Internal Number System

Many types of number systems have been utilized for the development of logical designs of computing systems. Among these number systems are the straight binary, octal, binary coded decimal, straight decimal, sexadecimal, biquinary, binary coded alphanumeric, and binary coded decimal (excess three). Of 187 different relevant systems, 131 utilize a straight binary system internally, whereas 53 utilize the decimal system (primarily binary coded decimal) and 3 systems utilize a binary coded alphanumeric system of notation. Of course, in nearly every computing system, information is ultimately handled in binary form, particularly in storage and in arithmetic units. The primary method of storage exploits the inherent properties of material media, such as semiconductors, and ferroelectric and ferromagnetic materials. The state of conduction or the polarization of ferroelectric and ferromagnetic materials determine the nature of the information which is stored or being processed. Decimal digits are handled as groups of four bits, or tetrads. Alphanumeric data usually requires the use of six bits, permitting 64 different symbols. Some systems utilize seven bits for expressing a single character, permitting 128 different characters, or may utilize a single bit as an "odd-even" check bit. Programmers and coders preparing problems for solution on these systems may work with decimal or alphanumeric notation and need not be concerned with the binary coding performed automatically by the machine.

Word Length

The selection of word length for computing systems is based upon many considerations. For information words, the precision required for the solution of problems may be the major consideration. For instruction words, word space must be allocated to the address of the operand (or operands for multiaddress codes), the command, and perhaps spares, tags, or check digits. For example, the ORDVAC utilizes 39 bits plus sign for an information word. One-half of a word, or 20 bits, is subdivided into a 12-bit address portion (for 4,096 high speed storage locations), a 6 bit command portion for 64 commands, and a 2-bit spare digit portion for special applications and versatility. The variation of word length among existing systems is rather wide. Table III shows the word lengths of the 222 systems described in Chapter II, in ascending order of magnitude. The average or nominal word length for fixed word length machines is approximately 40 binary or 12 decimal digits.

Number of Instructions Per Word

In many systems the machine word structure permits several instructions to be expressed by a single word. Of 171 systems, 107 were reported as operating on a one instruction per word basis and 28 were reported as operating on a two instructions per word basis. Several systems required two words to express a complete instruction and, in some systems, several instructions could be expressed by a single word, at the option of the programmer.

Arithmetic System

Most of the earlier machines operated on a fixed point arithmetic system. The binary or decimal point was arbitrarily fixed at either the right or left end of the number. For some systems a centered decimal point permitted the direct expression of whole and fractional parts of numbers. Scaling is required, for example, when a decimal or binary point is located at the left end of a number, in which case all quantities must be scaled between the values of minus one and plus one.

Many of the later machines were manufactured with built-in automatic floating point equipment, permitting numbers to be expressed as fractional parts and exponent parts. The exponent usually is a power of two or ten. Floating point circuitry was added to many of the older systems. A review of this sub-heading in the systems descriptions found in Chapter II and an examination of Table III will show the distribution of fixed and floating point equipment.

Instruction Type

Internally programmed automatic computers require that part of the instruction word be devoted to the address (or addresses) of the operand (or operands). The question of how many addresses are to be incorporated into a single word has been answered in many ways. In single address machines, the address of one operand is given in the address portion of the instruction word. In two address machines, the address of two operands are given, for instance the addresses of the minuend and subtrahend are given for a subtract instruction. For three address machines, the address for storing the result, e.g., the sum, difference, product, quotient or square-root, is given. The three address machines usually refer automatically to the next storage location, in sequence, for the next three-address instruction word. Machines using the four-address instruction will express the location of two operands, the location for storing the results of the operation, and the location of the next instruction, all in one four-address word. In a 1 + 1 system of notation the address of an operand for the current instruction is given, along with the address of the next instruction to be performed. Coding for four-address machines is somewhat simplified, however, a more complex machine structure is necessary. The following table shows the distribution of different addressing systems among the types of computers described in the handbook.

Instruction Type	Different Systems Using Given Type Instruction
One-address	116
Two-address	23
One or two-address (optional)	13
Three-address	20
Four-address	7
One-plus-one and one-over-one address	8
One and one-half address	3
One or three-address (optional)	2

One or one-plus-one address (optional)	2
One, two, or three-address (optional)	2
One, two, or four-address (optional)	1
Modified three-address	1
Three or four-address (optional)	1
Variable up to five-address (optional)	1
Total	200

Instruction Word Format

Most systems require adherence to a specific format or sets of formats for preparing coded instructions, in the machine language. The instruction word format thus outlines the form in which the instruction is prepared. An accounting must be made of each digit or character of the instruction word.

ARITHMETIC UNITS

Operation Time

Since the primary function of an arithmetic unit in any computer is to perform repetitive arithmetic operations rapidly, the time required to execute an add instruction or a given sequence of arithmetic or logical instructions, is extremely important when selecting a computing system for a specific application. Tables IV and V were prepared to show at a glance the general state of the art with respect to arithmetic speeds. It must be emphasized that the values stated in the table are on an "as reported basis". The reader is reminded that the tables must be used with caution, since many clarifying or related remarks have been omitted for the sake of simplicity. Refer to the system descriptions of Chapter II for further detail.

Table IV shows the approximate relative order of add time when including the storage access time. In many systems, it is not possible to determine the time required for one addition without considering storage access. This may be due to the fact that in many types of operation, sums may form in an accumulator as the addend is brought from storage, hence access time may be inseparable from add time.

Construction of Arithmetic Units

Most of the computing systems described in this report utilize tubes or transistors as the basic driving element in the arithmetic unit. Several systems utilize magnetic cores in the arithmetic unit. Gating for arithmetic and logical units is most usually performed by diodes, transistors, or vacuum tubes. A review of the construction methods used in arithmetic units is discussed under this topic in the systems descriptions.

STORAGE

An extremely diverse and dynamic field of interest in the study of computing systems is the subject of storage devices. Many ingenious devices, utilizing the ability of various material media to store or record energy transformations, have been devised. Early forms of storage involved mechanical deformation of material media. These are exemplified by cams, springs, gears, music box cylinders, perforated player piano rolls, code wheels and perforated paper tape. All these storage devices required the movement of large masses of material and consequently long access time was inherent. The capacity, in terms of stored information per unit volume of material, was very low.

During World War II, the search for more rapid access storage devices led to the use of the vacuum tube. The two states, that of conduction and that of cut-off, permit information storage on a binary basis. This system, as was used on the ENIAC, proved effective from an access time consideration, however, the system was extremely bulky and required thousands of electronic vacuum tubes for a storage unit consisting of only 20 words of 10 decimal digits each.

Chronologically, the next development was the use of acoustic delay lines of mercury and quartz. A transducer at each end of a length of these materials permits energy conversions and allows the storage of information in the form of high frequency (e.g. 8 megacycles/sec) pulse packets. The information is continuously recirculated. Information is inserted or read out through the use of standard gating techniques. Among the computers utilizing acoustic mercury delay lines are the DYSEAC, EDVAC, ELECOM 125, SEAC and UNIVAC I. Quartz acoustic delay lines were also used. Other types of delay lines used for storage of information are the magnetostrictive and the electromagnetic or distributed L-C network. See Tables VI, VII and VIII, which list the computing systems utilizing delay line storage units. Although in operating principle there is no difference, it is necessary to make a distinction between a delay line used in a storage loop in which information is continuously circulated, and a delay line used only for purposes of timing the arrival of information at selected points for performing various logical operations. In the latter, the function is delay, or temporary storage, rather than permanent storage. Since delay lines store information serially as a train of electrical or sonic pulses, average random access time is limited to half of the time length of the delay line plus the time equivalent to one word length. Because of the serial nature of the system, delay line storage units are limited in speed. Notice how the delay line types of systems lie near the bottom of the Access Time of High Speed Storage, Table VI.

The search for shorter access time brought about the development of the electrostatic storage unit, also called the cathode ray tube storage device. The material medium in motion was now limited to electrons, i.e., in beams and on charged areas on the screen of a cathode ray tube. These charged areas behaved somewhat like an array of charged capacitors. Selection of storage locations and the transfer of information was efficiently performed by an easily deflected pencil or beam of electrons which was used for both writing and interrogation. Parallel transfer, in which all digits of a given word are transferred simultaneously, became possible with this type of storage system.

The electrostatic storage system, with the inherent problems associated with high accelerating voltages, screen imperfections and other tube failures, has all but yielded to the utilization of magnetic cores for the storage of information. A 32 x 32 array of ferrite cores, which might constitute a typical storage plane, may measure only a few inches on each side. The cores are placed at the intersection of the wires of a mesh, and a third winding may be threaded through all the cores for sensing stored data. The storage takes place in the form of magnetically oriented molecular or atomic dipoles which retain their orientation upon removal of the magnetizing force. Many manufacturers intend to provide computing systems with large capacity core storage units. Advances have been made in the use of perforated ferrite plates and magnetic films deposited on glass as a magnetic storage unit. Two such systems, the LINCOLN TX 2 and the UNIVAC 1107 utilize thin films. The storage principle is the same as for magnetic cores. Table VI shows the access time of high speed storage units in their approximate relative order of magnitude for the storage units used in various computing systems. It must be emphasized that the question of precisely what constitutes access time cannot easily be resolved unless a common understanding as to the definition is reached. In the usual sense, one may consider access time as the elapsed time between the initiation of a command to transfer an item of information, usually one word, from one address in the storage to another designated register, and the complete arrival of the item at the designated location. In many systems, particularly serial storage units, access time depends upon the time location of the word in the serially circulating group of words at the instant the transfer command is initiated. For this and other reasons, much misunderstanding can arise in the consideration of access time. the data presented in Table VI should therefore be considered to be approximate and should be used with caution.

The capacity of high speed storage units has risen during the past few years as rapidly as access time has diminished. Table VII shows the capacity of high speed storage units in terms of numbers of words and word lengths, arranged in relative order of magnitude of equivalent binary capacity.

Rapid access storage of limited capacity is usually supported by a larger capacity storage unit for a well balanced storage system. This permits the transfer of large blocks of information from the rapid access storage unit to the large capacity storage unit for use at another location or time in the computation process. The most prevalent devices for auxiliary storage of this type are the magnetic drum or the magnetic disc. The access time for large blocks of information is of the order of tens of milliseconds for most magnetic drum or disc units. Many computing systems utilize magnetic drums or discs as the primary storage unit. Several systems utilize large capacity drum or disc units particularly for commercial type applications, such as payroll, stock inventory, and personnel records where access times of the order of microseconds are not required. Table IX shows the capacity of various drum or disc storage systems currently in use. It should be remembered, when glancing at Table IX, that although an attempt was made to show maximum capability, additional drum or disc units can be attached to some systems. Many systems employ magnetic tape as a medium of storage. Although access time is relatively long because of its inherently serial nature, a large volume of data can be stored on tape with a high packing density in terms of data units per unit volume.

The characteristics of a storage device, namely, capacity and access time are two aspects of a storage system which come under consideration when designing or using a machine. The user or manufacturer of a system, at times, can trade capacity for access in the sense that under certain conditions he can accomplish an equivalent amount of computation with a large capacity, somewhat longer access time system as with a small capacity, short access time system. This is the old problem of trading time for space or vice versa. There are limits to this however, for example, when access time approaches the order of milliseconds, computation is seriously slowed down. Since large capacity and short access time are features to be desired, let us examine a quantity determined by the expression:

$$\text{Log}_{10}\ (\text{Capacity in Equivalent Binary Digits/Access Time in Seconds})$$

In early storage devices, such as music boxes and signal coding equipment, this number is of the order of two to three. Relay storage units have a number of the order of four or five. Tube registers of the ENIAC vacuum tube accumulator storage type, enabled this figure to be as high as 6.3. Magnetic drum storage units are in the region of 6 to 7. Acoustic delay line storage systems show that this figure is in the range 8.6 to 9.6. The cathode ray tube storage (electrostatic) raised the figure as high as 10.79. The magnetic core storage unit permitted an increase of this figure to over 12. Thin films have now arrived on the scene as a practical storage medium. The following table shows the growth, or increase of this number, as development of computing system components progressed:

Storage Device	Approx. Median Log_{10} Capacity/Access	Approximate Year of Development
Early Mechanical	2 - 3	Prior to 1930
Electromechanical	4 - 5	1935
Vacuum Tube	5 - 6	1940
Magnetic Drum	6 - 7	1945
Electrostatic (CRT)	9 - 10	1950
Static Magnetic (Mag. Core)	9 - 12	1955
Thin Film	10 - ?	1960

Table VIII is a tabulation of the Log_{10} Capacity/Access figures for the high speed storage units of various computing systems in approximate relative order of magnitude.

INPUT-OUTPUT

The above discussion on arithmetic units and storage devices have shown the great strides that have been made in these fields during the past several years. Arithmetic operation and storage access times have decreased and storage capacity increased. Yet, the communication link between the person and the machine still presents a major problem. Paper tape and cards, inherently bulky, are prevalent and relatively slow, particularly for scientific applications. The main convenience afforded by cards, particularly in commercial systems, is their capability of storing a complete item of information on one card, which may be handled separately or as part of a group, such as data on an insurance policy, a payroll line, a stock item, a set of corresponding test data, etc. There is no doubt that punching cards is a slow process. Paper tape perforators are also relatively slow in the sense that the data to be punched is usually available at a rate faster than paper may be mechanically perforated, although high speed perforators are being developed and are finding application. Keyboard input systems are useful primarily for the manual insertion of words for test or other special purposes.

In addition to paper tape and card readers and punches, many systems utilize high speed printers and magnetic tape units as a medium of input and output. Magnetic tape output still requires a conversion from magnetic tape to cards or printed page in order that the information be available to operating personnel. However, since human intervention is gradually being reduced, the use of magnetic tape for input, output and storage is increasing rapidly. The prevalence of various input-output media for the 222 computing systems described in this report may be determined by examining the data under the sub-heading "INPUT" and "OUTPUT" in the systems descriptions given in Chapter II.

One method for decreasing machine time spent waiting for reading and writing instructions to be carried out is to provide for concurrent operation. The later machines have built-in circuitry for permitting reading and writing to take place during computations. Apparently the only stipulation is that a given storage location does not become involved in reading, writing and computing at the same time. Many machines, for example, compute while punching and reading cards or while "looking-up" information on tape. Others fetch the next instruction out of storage while performing an operation.

Another method of reducing reading and writing time and to avoid a large amount of lost time when a large amount of machine reading and writing is necessary is to provide for reading and writing on a high speed device such as a magnetic tape or wire unit and allow "conversion" to another medium to take place off the machine at "leisure". Magnetic tape-to-card converters and inverters are becoming available as well as magnetic tape-to-printed-page converters. Paper tape and cards may sometimes be considered as forms of storage, since information recorded on these media may be returned to the machine. Considerable progress is being made in the field of printed page readers. See, for example, the IBM 1401 System.

It is often necessary to have computing systems capable of communicating with one another directly. For this reason, input-output media conversion is becoming quite prevalent and large conversion equipment is rapidly becoming available. Input-output schemes are so many and varied, that a complete treatment of this subject is beyond the scope of this report.

CIRCUIT ELEMENTS OF THE ENTIRE SYSTEM

There are many impressions which come to mind when one examines such things as transistor, tube and crystal diode counts in a large scale computing system. There is a tendency to visualize a large, sprawling system when the tube count is high. There may be large tube-changing programs based on experience in effect on these large systems. Failure rates, preventive maintenance techniques, tube life problems, design limitations and tube specifications must all be considered on a systematic basis when the tube count is high. Tube count and a knowledge of tube operating characteristics may yield an approximate estimation of some of the problems that may be encountered in the operation of the system. Table X shows the approximate number of tubes utilized in some of the computing systems described in this report. Maintenance of transistorized systems has become somewhat simpler than maintenance of vacuum tube systems. Power and space requirements for transistorized systems are considerably reduced.

The servicing of a large electronic computing system can be materially simplified by reducing the number of tube types in the system. Standards for tube testing need apply to fewer tube types and tube checking can be further systematized due to a reduced number of test variations. Of course, a test specification or test criterion must be established for the most severe application for which the particular tube type will be applied. A severe or special circuit requirement may be better served through the use of another tube type. This, then increases the number of tube types. Normally, it is possible to select a type of tube for a group of duties. In a given system, for example, a certain type is selected for driving, for voltage amplification, for flip-flop circuits, normally "on" or "off" conditions, etc. This establishes a number of tube types for a given system and any modification of the system usually should include this "tube type" complement.

The question of crystal diode reliability, diode testing techniques, and diode logical network design, such as individual clamps versus wired plug-in units, become subjects of interest when diodes are utilized. The quantity of diodes in a given computing system may be indicative of the nature of the servicing problem, but only when the failure rates, life and circuit demands placed upon the diode are known. To some extent, malfunctions due to diodes can be aggravated by elevated temperatures. The printed circuit logical package, containing a specific array of "And" and "Or" gates have become the most prevalent means of fabrication. The extent of crystal diode use is shown in Table XI.

Many recently developed systems utilize transistors for driving, switching (gating) and other logical functions. Reduced power and reduced space requirements are advantages of these systems. The question of reliability is rapidly being resolved, as printed circuits and packaging techniques continue to be improved. Table XII shows the quantity of transistors utilized in the various computing systems described in Chapter II.

CHECKING FEATURES

The question of what type of checking features should be incorporated into a given general purpose computing system is still being tossed about by various manufacturers. The type of built-in check varies from manufacturer to manufacturer and from system to system.

It is usually possible to check all machine calculations by programming techniques. A well designed system can proceed for many hours without a malfunction. If this is the case, it is entirely possible that the installation of a checking system can do more harm than good since the checking features can malfunction and cause an alarm or stoppage when a machine malfunction has not occurred. For example, the second unit of twin arithmetic units can malfunction, the comparer of a redundancy checker can malfunction, or a forbidden pulse combination decoder can malfunction, all yielding false indications of a machine malfunction. For those systems which do not have built-in checking circuits, the operator or programmer must program a check or the output may be reviewed.

About 87% of the 222 computing systems reported utilize some form of automatic built-in check. A redundancy or duplication check is used in about 8% of the systems. Some type of overflow or exceed capacity is used on about 23% of the systems and an odd-even parity check in one form or another is used on 50% of the systems. Interesting to note here is that in 1957 only 20% of the systems had a form of parity check. Various kinds of transfer checks are used on 19% of the systems. Approximately 28% of the systems established a checking system by detecting pulse combinations which are not supposed to occur anywhere in the system. Forbidden pulse combinations checking stations are scattered around the system, e.g. in memory transfer points, recording stations, reading stations, etc. The various names that have been applied to this type of check are forbidden pulse combination, unused order (instruction), unallowable order digit, improper operation code, improper command, false code, forbidden digit, non-existent code, and unused code. There is a distinction to be made between the terms order, instruction, and command. The preferred definitions are given in the glossary of computer engineering and programming terminology, Chapter IV. The following table shows the approximate distribution of checking methods in the systems described in this report. Many systems utilize more than one check technique.

Distribution of Automatic Checking Schemes Among 222 Different Computing Systems

Parity (arithmetic, transfer, storage, recording)	99
Overflow (underflow, exceed capacity, divide by zero, divide overflow, oversized quotient)	47
Transfer (echo, compare, validity)	38
Non-existent command	19
Non-existent memory address	15
Redundancy (equipment, operations)	15
Character code (non-numeric, illegitimate char, "all ones", sign)	14
Forbidden pulse combination (general)	14
Arithmetic (Modulo 3, 4, 9, 25, residue)	13
Timing (clock, synchronism, jitter)	12
Count (hole, address, row, block, word, random error)	9
Non-existent device	8
Miscellaneous (instruction-data, logic, inactivity, unwanted digit, free time)	7
No built-in check	26
Not reported	22

POWER, SPACE, WEIGHT, AND SITE PREPARATION

Important aspects of computing systems are the physical factors of power, space and weight. Power requirements may very well dictate the physical location of a large computing system within a building, particularly when the power required is in excess of 50 Kw. For most systems, however, the power is brought to the most favorable computer location from the point of view of personnel accessability for operation and servicing. Table XIII shows the power requirement of various domestic digital computing systems, operational or about to become operational in the United States.

An interesting figure might be the relation between the number of tubes utilized in a computing system and the power requirement. In order to determine whether or not a consistent tube to power ratio could be established, the ratio was determined for the computing systems for which the data was available. For the vast majority of computing systems the tube-power ratio is approximately 110 tubes/kilowatt. A sample taken of transistorized systems shows that the ratio of transistor quantity to power is about 6,000 transistors/kilowatt.

The problem of space requirements has been solved in so many ways it is impossible to determine a consistent relation between space requirement and any other factor. Large computing complexes have been installed in areas ranging from a corner of a basement to an entire floor of a large building. The pictorial coverage of computing systems and the space requirements discussed under the sub-heading "POWER, SPACE, WEIGHT, AND SITE PREPARATION" in the systems descriptions of Chapter II give the space requirements of the computing systems described in this report. The dimensions of various components of utilized systems are important when considering clearance in rooms, passages, doorways and elevators.

Air conditioning requirements vary considerably from system to system. Air conditioners for computing equipment may utilize water to absorb the heat from circulated air, use a secondary loop of air, force the heated air to the outside, or utilize an outdoor evaporator. The smaller systems circulate room air and depend on the ambient temperature to cool. Almost 100% of the power required by the system is dissipated in the form of heat and must be removed. The large systems usually require separate heat removal facilities. For many systems, humidity and dust control within the machine are required in order to maintain satisfactory operation.

The factor of weight can be important when the floor loading limits for distributed and concentrated loads are within the weight range of the computing equipment. Many systems may require reinforced or specially constructed buildings. Many items of peripheral equipment may cause concentrated loads in excess of maximum permissable concentrated loadings on some structures. Vibration and shock caused by some equipment such as tabulators and card punches can cause trouble in other components. Shock and vibration absorbing pads are required in such cases. When unitized construction is used, the weight of a single unit must also be considered when transporting and installing.

Many systems require extensive site preparations. Others may be "plugged in" to any convenient outlet. This topic is adequately discussed in the systems descriptions of Chapter II.

PRODUCTION RECORD

In almost any new and rapidly changing field there will be many instances in which an experimental prototype of a large piece of equipment will be built. This is the result of the normal course of events, namely, a feasibility study, a research effort, a development effort and a prototype construction. Mass production then occurs when the demand for systems is sufficient to warrant production in quantity.

A review of the sub-heading "PRODUCTION RECORD" will give an indication of the production status of various computing systems. The quantity produced, the quantity in current production, in current operation, and on order are given. Delivery times quoted show that immediate delivery is now possible for many computing systems. Table II shows the quantities of the various systems that have been produced. Information on unreported systems was considered proprietary by the manufacturer.

COST, PRICE AND RENTAL RATE

Perhaps the most elusive and intricate item considered in the systems descriptions of this report is the question of initial cost, blandly described as "approximate cost of basic system". Manufacturers are quite naturally quoting current prices for their respective systems. The "one of a kind" system usually includes all research, development, construction, overhead and sub-contracting costs. The "basic system" usually includes minimal input devices, the controls, the storage system, the arithmetic unit, and minimal output devices. All conversion equipment such as card-to-printed page (tabulators), card-to-tape, tape-to-card etc. are considered peripheral equipment, and both the quantity and type is dependent upon specific system application. These are not included in the cost or price of the basic system. Prices of these may be found under "Additional Equipment". In order to determine the cost of a given system, refer to the system description. Table XIV shows the approximate relative cost of various computing systems. No attempt was made to resolve or explain any discrepancies between prices quoted by manufacturers and those quoted by users. It should be remembered that users prices reflect old sales, rental rates were established by contracts written years ago, manufacturers are offering discounts on older systems, charging greater service rates for older systems, offering educational discounts, etc.

The methods of computing system or component acquisition include direct purchase at a fixed price, direct purchase on a cost plus fixed fee basis, continuous rental, and rental with all or part of the rental applicable toward purchase. Most forms of rental include servicing. Direct purchase can include a service contract. Rental rates are of the order of 3 per cent of the direct purchase price per month. The sale and lease policy of various manufacturers is given under the sub-heading "COST, PRICE AND RENTAL RATE" in Chapter II.

Table XIV shows the nominal price one may expect to pay for a basic system. For many systems, one might add 20 to 80 per cent for required peripheral equipment. Most prices include installation but not shipping costs. Some of the figures reflect prices which are not current and have not taken into account general price rises during the past several years. Some figures include initial service or some type of warranty. The figures quoted in Table XIV are for general consideration only, and are not for purposes of acquisition. Indeed, many systems are not available, even at the price quoted, since the price stated is actually the construction "cost" to the owner.

An attempt was made to discover whether a "system cost per tube" figure could be established. For the larger systems, the figure is of the order of 200 dollars per tube installed and for the smaller systems approximately 100 dollars per tube. However, a glance at Tables X and XIV will show that such a figure can be calculated with some difficulty. An attempt to determine a figure such as "cost per cubic foot" of electronic computing equipment would be equally difficult. Such exercises are left to the reader should such figures be of any interest.

PERSONNEL REQUIREMENTS

Personnel problems have confronted computing system operators and manufacturers from the very outset, in all phases of computer research, development, manufacture, installation, operation, improvement and servicing. Various grades of skills are required in the fields of engineering, physics and mathematics. Each large system has a crew of engineers and technicians for improving and servicing and a group of mathematicians and operators for problem analysis, coding and programming. In the very small systems, all of these functions may be performed by one or two persons. The systems descriptions in Chapter II show various estimates made by manufacturers and operators of what the personnel requirements are or should be for various systems. The estimates, in some cases, do not show the personnel required for overtime, vacations, illness and training purposes. Just as in any application of manpower to machines, it is necessary to provide sufficient manpower so as to maximize machine utilization whenever possible. Many installations consist of multimillion dollar computer complexes. Such large capital investments must be utilized at maximum efficiency in order to avoid severe losses. Twenty-four hour operation increases the daily output and provides for more efficient utilization of capital equipment. Ultimate requirements for personnel depend to a large extent upon the nature of the application, particularly as pertains to coders, programmers and analysts.

RELIABILITY, OPERATING EXPERIENCE AND TIME AVAILABILITY

The most discussed and most controversial issues in the field of computing machinery occur on the subjects of reliability, efficiency and system evaluation. The determination of the reliability of a system is difficult, primarily because of a lack of a common understanding or interpretation of the definitions of computer operating terms. What actually constitutes "good time" on a computing system? What is "down time", "scheduled engineering", "useful production and code checking"? An attempt has been made to provide working definitions of these and other terms in the revised Glossary of Computer Engineering and Programming Terminology given in Chapter V of this report. The very crude "Operating Ratio", as is used in the systems descriptions of Chapter II, is defined as the "Good Time" obtained on the machine divided by the total time one actually "Attempted (or Wanted) to Run" the system. The question arises as to where to put the time lost in scheduled engineering (preventive maintenance), since technically, one is not attempting to run the system during this period, yet the system is not actually "down". Many systems, are operated for 168 hours per week. The operating ratio for these systems would require that 168 be used as the denominator and the number of useful output hours as the numerator, yielding a much smaller (but perhaps truer) ratio than a system operated on an 8-hour 5-day week shift and using off-time for servicing. This latter type of operation may yield operating ratios of the order of .90 to 1.0 and give a false indication of reliability.

The question of how one determines the average error-free running period is also a difficult one. It may be estimated or calculated by actual counts of the periods of malfunction-free operation. It may be the period used as a guide by coders to prevent losses due to running for extended periods between obtaining output information, particularly where volatile storage media are being used. Many questions regarding the subject of "RELIABILITY, OPERATING EXPERIENCE AND TIME AVAILABILITY" are answered under this subheading in the computing systems descriptions given in Chapter II. A search of the system descriptions under this subheading will reveal those installations which have computer time available to organizations outside of the operating organization.

Many computing systems are approaching the age of retirement and replacement. Constant improvements have already replaced many of the original components of a system. The next few years will see the retirement of many of the older systems. Such retirement may take the form of salvage of parts, use for educational and training purposes, or scrap. Many older models are available at reduced prices. A used computer market is developing. In accepting a used computer, one must be prepared to accept a few headaches. Table XV shows how long some models of computing systems have been in existence.

ADDITIONAL FEATURES AND REMARKS

Under this subheading has been placed general information concerning specific computing systems which did not have a "place" in the previous fourteen subheadings. Included under this subheading are remarks concerning the pictures, information which arrived too late to be added to the system description under a proper heading, special features of the system and other miscellaneous items of information. Under this subheading one will find what manufacturers and users considered to be the outstanding features and unique system advantages of the particular system. Under this subheading are remarks concerning the labelling, storage, shipping and protection from humidity, temperature and physical, electrical, fire or other damage of magnetic tapes.

FUTURE PLANS

The electronic digital computer field is a dynamic one. Plans for acquisition and improvement of systems and components are continually being made and modified. The plans of various operators and manufacturers are given under the subheading "FUTURE PLANS" in ths systems descriptions of Chapter II. Interesting to note are the transitions to new systems being made by many users. "Second generation" (solid state) computers are now at hand.

INSTALLATIONS

A primary source of information concerning electronic digital computing systems is the operating organizations. The acquisitional and operational problems of one organization may have already been solved in one way or another by other organizations. Benefiting from the experience of others can be profitable, if only to avoid mistakes. Under the subheading "INSTALLATIONS" in the systems descriptions of Chapter II, a list of the owners and operators of specific systems is given in order that contacts between owners and prospective owners may be established. Many co-operative "plans" have come into existence, under which owners or operators of specific systems have engaged in sharing computer experience. Many computer sharing contracts have been drawn and many computer centers have been established, offering computer time and personnel for the solution of customers' problems.

TABLE I

MANUFACTURERS OF COMPUTING SYSTEMS

MANUFACTURER	SYSTEM
Airborne Instruments Laboratory Deer Park Long Island, New York	MODAC 404, MODAC 410, MODAC 414, MODAC 5014
Alwac Computer Division El-Tronics, Incorporated 13040 S. Cerise Avenue Hawthorne, California	ALWAC II, ALWAC III E
Argonne National Laboratory 9700 South Cass Avenue Argonne, Illinois	GEORGE
Automation Management Incorporated P.O. Box 217 25 Brigham Street Westboro, Massachusetts	PERK I II
Autonetics Division North American Aviation Corporation 9150 E. Imperial Highway Downey, California	AN/MJQ 1 REDSTONE, FADAC, JUKEBOX, RECOMP I CP 266, RECOMP II, REPAC, VERDAN
Bell Telephone Laboratories, Incorporated Whippany, New Jersey	LEPRECHAUN
Bendix Computer Division Bendix Corporation 5630 Arbor Vitae Avenue Los Angeles 45, California	BENDIX CUBIC TRACKER, BENDIX D 12, BENDIX G 15, BENDIX G 20
Brookhaven National Laboratories Upton, New York	MERLIN
Burroughs Corporation 6071 Second Avenue Detroit 32, Michigan	BURROUGHS 204, BURROUGHS 205, BURROUGHS 220, BURROUGHS D 103, BURROUGHS D 104, BURROUGHS D 105, BURROUGHS D 107, BURROUGHS D 201, BURROUGHS D 202, BURROUGHS D 203, BURROUGHS D 204, BURROUGHS D 208, BURROUGHS D 209, BURROUGHS E 101, BURROUGHS E 102, BURROUGHS E 103, UDEC I II III
Computer Control Company Western Division 2251 Barry Avenue Los Angeles 64, California	CCC REAL TIME, SPEC
Concord Control Incorporated 1282 Soldiers Field Road Boston 35, Massachusetts	NUMERICORD
Control Data Corporation 501 Park Avenue Minneapolis 15, Minnesota	CDC 160, CDC 1604
Cubic Corporation 5575 Kearny Villa Road San Diego 11, California	CUBIC AIR TRAFFIC, CUBIC TRACKER
Digital Equipment Corporation Maynard, Massachusetts	PROGRAMMED DATA PROCESSOR
Digitronics Corporation Albertson Avenue Albertson, New York	DIGITRONIC CONVERTER

TABLE I (CONTINUED)

MANUFACTURERS OF COMPUTING SYSTEMS

MANUFACTURER	SYSTEM
Electronics Corporation of America Business Machines Division Cambridge 42, Massachusetts	MAGNEFILE B, MAGNEFILE D
General Electric Company Computer Department 13430 N. Black Canyon Highway Phoenix, Arizona	GENERAL ELECTRIC 100 ERMA, GENERAL ELECTRIC 210, GENERAL ELECTRIC 225, GENERAL ELECTRIC 250, GENERAL ELECTRIC 312, OARAC
General Mills Mechanical Division 1620 Central Avenue Minneapolis 13, Minnesota	GENERAL MILLS AD/ECS, GENERAL MILLS APSAC
Geotechnical Corporation 3401 Shiloh Road Garland, Texas	GEOTECH AUTOMATIC
Hampshire Engineering Company 2300 Washington Street Newton Lower Falls 62, Massachusetts	CCC 500, HAMPSHIRE TRTDS 932
Hogan Laboratories, Incorporated 155 Perry Street New York 14, New York	CIRCLE
HRB Singer, Incorporated Science Park State College, Pennsylvania	HRB SINGER
Hughes Aircraft Company Digital Systems Department Florence and Teale Streets Culver City, California	HUGHES ADV AIRBORNE III, HUGHES BM GUIDANCE, HUGHES D PAT, HUGHES DIGITAIR, HUGHES LRI X, HUGHES M 252
International Business Machines Corporation 590 Madison Avenue New York 22, N. Y.	AN/ASQ 28(v) EDC, AN/ASQ 28(v) MDC, AN/FSQ 7 AN/FSQ 8 (SAGE), AN/FSQ 31(v), AN/FSQ 31, AN/TYK 7v INFORMER, ASC 15, IBM 305 RAMAC, IBM 604, IBM 607, IBM 608, IBM 609, IBM 610, IBM 632, IBM 650 RAMAC, IBM 701, IBM 702, IBM 704, IBM 705 I II, IBM 705 III, IBM 709, IBM 1401, IBM 1410, IBM 1620, IBM 7070, IBM 7074, IBM 7080, IBM 7090, IBM CPC, IBM STRETCH, NORC, STORED PROGRAM DDA
Intelex Systems Incorporated 67 Broad Street New York 4, New York	INTELEX AIRLINE RESERVATION
Iowa State University Ames, Iowa	CYCLONE
ITT Laboratories 500 Washington Avenue Nutley 10, New Jersey	ITT BANK LN PROC, ITT SPES 025
J. B. Rea Company, Incorporated 2202 Broadway Santa Monica, California	READIX

TABLE I (CONTINUED)

MANUFACTURERS OF COMPUTING SYSTEMS

MANUFACTURER	SYSTEM
Laboratory for Electronics 1079 Commonwealth Avenue Boston 15, Massachusetts	DE 60, DIANA, RASTAC, RASTAD
Leeds and Northrup Company 4901 Stenton Avenue Philadelphia 44, Pennsylvania	LEEDS NORTHRUP 3000
Librascope Division General Precision Incorporated 808 Western Avenue Glendale 1, California	LGP 30, LIBRASCOPE 407, LIBRASCOPE AIR TRAFFIC LIBRASCOPE ASN 24, LIBRASCOPE CP 209, LIBRASCOPE MK 38, LIBRASCOPE MK 130, LIBRATROL 500, LIBRATROL 1000
Lincoln Laboratory Massachusetts Institute of Technology Lexington 73, Massachusetts	LINCOLN CG 24, LINCOLN TX 0, LINCOLN TX 2
Litton Industries Electronic Equipments Division 5500 Canoga Avenue Woodland Hills, California	LITTON C 7000, LITTON DATA ASSESSOR
Marchant Calculators, Incorporated Electronic Division Oakland 8, California	MINIAC II
Massachusetts Institute of Technology Digital Computer Laboratory Cambridge 39, Massachusetts	WHIRLWIND II
Michigan State University East Lansing, Michigan	MISTIC
Minneapolis Honeywell Regulator Company 2753 4th Avenue South Minneapolis 8, Minnesota	DATAMATIC 1000, HONEYWELL 290, HONEYWELL 800
Monroe Calculating Machine Company 555 Mitchell Street Orange, New Jersey	DISTRIBUTAPE, MONROBOT III, MONROBOT V, MONROBOT VI, MONROBOT IX, MONROBOT XI, MONROBOT MU
National Cash Register Company Dayton 9, Ohio	NATIONAL 102 A, NATIONAL 102 D, NATIONAL 107, NATIONAL 304, NATIONAL 315, NATIONAL 390
Norden Division United Aircraft Corporation 3501 Harbor Boulevard Costa Mesa, California	NORDEN VOTE TALLY
Norden Division United Aircraft Corporation 58 Commerce Road Stamford, Connecticut	SCRIBE
Oak Ridge National Laboratory Oak Ridge, Tennessee and Argonne National Laboratory Argonne, Illinois, jointly	ORACLE
Oklahoma University Norman, Oklahoma	OKLAHOMA UNIV

TABLE I (CONTINUED)

MANUFACTURERS OF COMPUTING SYSTEMS

MANUFACTURER	SYSTEM
Packard Bell Computer Corporation 1905 Armacost Avenue Los Angeles 25, California	PACKARD BELL 250, TRICE
Pennsylvania State University Electrical Engineering Department University Park, Pennsylvania	PENNSTAC
Philco Corporation 3900 Welsh Road Willow Grove, Pennsylvania	AN/TYK 6v BASICPAC, AN/TYK 4v COMPAC, PHILCO 1000, PHILCO 2000, PHILCO 3000, PHILCO CXPQ
Radio Corporation of America Electronic Data Processing Systems Division Camden 2, New Jersey	BIZMAC I, BIZMAC II, RCA 110, RCA 200, RCA 300, RCA 301, RCA 501, RCA 601
Ramo Wooldridge Division Thompson Ramo Wooldridge, Incorporated 8433 Fallbrook Avenue Canoga Park, California	RW 300, RW 400
The Rand Corporation 1700 Main Street Santa Monica, California	JOHNNIAC
Remington Rand Univac Division Sperry Rand Corporation 315 Park Avenue South New York 10, New York	AF/CRC, AN/USQ 20, ATHENA, BOGART, LOGISTICS, TARGET INTERCEPT, UNIVAC 60, UNIVAC 120, UNIVAC 490, UNIVAC 1101, UNIVAC 1102, UNIVAC 1103 1103A, UNIVAC 1105, UNIVAC 1107, UNIVAC FILE 0, UNIVAC FILE 1, UNIVAC LARC, UNIVAC SOLID STATE 80/90, UNIVAC STEP, UNIVAC I, UNIVAC II, UNIVAC III
Rice University Houston 1, Texas	RICE UNIVERSITY
Royal McBee Corporation Port Chester, New York	RPC 4000, RPC 9000
Sylvania Electric Products, Incorporated 189 B Street Needham 94, Massachusetts	MOBIDIC A, MOBIDIC B, MOBIDIC C D AND 7A, SYLVANIA S 9400, SYLVANIA UDOFTT
The Teleregister Corporation 445 Fairfield Avenue Stamford, Connecticut	TELEREGISTER MAGNET BID ASKED, TELEREGISTER MAGNET INVENT CONT, TELEREGISTER TELEFILE, TELEREGISTER UNIFIED AIRLINE
Underwood Corporation 1 Park Avenue New York 16, New York	ELECOM 50, ELECOM 100, ELECOM 120, ELECOM 125 125 FP
University of California Los Alamos Scientific Laboratory P.O. Box 1663 Los Alamos, New Mexico	MANIAC I, MANIAC II
University of Chicago Institute for Computer Research Chicago 37, Illinois	MANIAC III
University of Illinois Digital Computer Laboratory Urbana, Illinois	ILLIAC, ORDVAC

TABLE I (CONTINUED)

MANUFACTURES OF COMPUTING SYSTEMS

MANUFACTURER	SYSTEM
University of Pennsylvania Moore School of Electrical Engineering Philadelphia, Pennsylvania	EDVAC
University of Wisconsin Department of Electrical Engineering Madison 6, Wisconsin	WISC
U. S. Army Ordnance Corps Ballistic Research Laboratories Aberdeen Proving Ground, Maryland	BRLESC
U. S. Navy Naval Research Laboratory Washington 25, D.C.	NAREC, UNIVERSAL DATA TRANS
U. S. Department of Commerce National Bureau of Standards Data Processing Systems Division Connecticut and Van Ness Avenues Washington 25, D.C.	AMOS IV, DYSEAC, SEAC, SWAC
Western Reserve University Center for Documentation and Communications Research Cleveland 6, Ohio	WRU SEARCHING SELECTOR
Westinghouse Electric Corporation Air Arm Division Box 746 Baltimore 3, Maryland	WESTINGHOUSE AIRBORNE

TABLE II

QUANTITY OF COMPUTING SYSTEMS MANUFACTURED OR OPERATIONAL

Quantity	System	Quantity	System
Over 2,993	IBM 604	Over 8	RECOMP II
(Est All Models) 1,500	IBM 650	8	GENERAL ELECTRIC 210
693	IBM CPC	8	NUMERICORD
462	LGP 30	Over 7	UNIVAC II
Over 400	LIBRATROL 500	7	AN/TYK 6v BASICPAC
Over 300	BENDIX G 15	7	CDC 160
Over 267	IBM 607	7	CUBIC TRACKER
(Incl E 101) 210	BURROUGHS E 103	7	MONROBOT XI
200	UNIVAC STEP	Over 6	PHILCO 2000
180	VERDAN	6	ELECOM 125 125FP
(Incl Mod 1) 164	UNIVAC FILE 0	6	NATIONAL 304
164	UNIVAC FILE 1	6	NATIONAL 390
127	BURROUGHS E 101	6	READIX
(Incl 204) 112	BURROUGHS 205	Over 5	BURROUGHS E 102
110	UNIVAC SOLID STATE 80/90	Over 5	DATAMATIC 1000
100	BURROUGHS D 104	5	BURROUGHS D 204
Over 90	IBM 1401	5	ELECOM 120
(Est) 70	IBM 704	5	FOSDIC
70	MONROBOT IX	5	TRICE
50	AN/FSQ 7 AN/FSQ 8 (SAGE)	Over 4	NATIONAL 102 D
48	LIBRASCOPE CP 209	Over 4	UNIVAC 120
45	UNIVAC 1105	4	GENERAL ELECTRIC 312
42	BURROUGHS 220	4	ILLIAC
Over 30	IBM 709	4	LIBRASCOPE ASN 24
25	UNIVAC III	4	RW 400
24	RCA 501	3	ALWAC III E
Over 18	IBM 701	(Incl All Models) 3	BIZMAC I
18	GE 100 ERMA	(Incl All Models) 3	BIZMAC II
18	RW 300	3	DIGITRONIC CONVERTER
16	NATIONAL 102 A	3	DISTRIBUTAPE
14	LIBRASCOPE MK 38	3	ELECOM 50
Over 13	IBM 702	3	ELECOM 100
Over 13	IBM 705 III	3	HRB SINGER
Over 13	UNIVAC 1103 1103A	3	PACKARD BELL 250
Over 12	BURROUGHS 204	3	UNIVAC 1102
12	TELEREGISTER UNIFIED AIRLINE	2	ALWAC II
10	CDC 1604	2	CIRCLE
10	JUKEBOX	2	GENERAL MILLS AD/ECS
10	RPC 4000	2	IBM STRETCH
10	RPC 9000	2	LIBRASCOPE AIR TRAFFIC
9	DE 60	2	PHILCO 3000
Over 8	IBM 7090	2	UDEC I II III

TABLE II (CONTINUED)

QUANTITY OF COMPUTING SYSTEMS MANUFACTURED OR OPERATIONAL

Quantity	System
2	WESTINGHOUSE AIRBORNE
1	AF/CRC
1	AMOS IV
1	AN/USQ 20
1	BOGART
1	BRLESC
1	BURROUGHS D 201
1	BURROUGHS D 202
1	CCC REAL TIME
1	COMPAC
1	CUBIC AIR TRAFFIC
1	CYCLONE
1	DIANA
1	DYSEAC
1	EDVAC
1	GENERAL MILLS APSAC
1	GEORGE
1	GEOTECH AUTOMATIC
1	HAMPSHIRE CCC 500
1	HAMPSHIRE TRIDS 932
1	INTELEX AIRLINE RESERVATION
1	ITT BANK IN PROC
1	ITT SPES 025
1	JOHNNIAC
1	LEPRECHAUN
1	LIBRASCOPE MK 130
1	LINCOLN CG 24
1	LINCOLN TX 0
1	LINCOLN TX 2
1	LOGISTICS
1	MAGNEFILE B
1	MAGNEFILE D
1	MANIAC I
1	MANIAC II
1	MANIAC III
1	MERLIN
1	MINIAC II
1	MISTIC
1	MOBIDIC A
1	MOBIDIC B
1	MOBIDIC C D & 7A
1	MODAC 404
1	MODAC 410

Quantity	System
1	MODAC 414
1	MODAC 5014
1	MONROBOT III
1	MONROBOT V
1	NAREC
1	NATIONAL 107
1	NATIONAL 315
1	NORC
1	NORDEN VOTE TALLY
1	OARAC
1	OKLAHOMA UNIVERSITY
1	ORACLE
1	ORDVAC
1	PENNSTAC
1	PERK I II
1	PHILCO 1000
1	PHILCO CXPQ
1	PROGRAMMED DATA PROCESSOR
1	RASTAD
1	RCA 200
1	RCA 300
1	RCA 301
1	RCA 601
1	RECOMP I CP 266
1	REPAC
1	RICE UNIVERSITY
1	SEAC
1	SPEC
1	STORED PROGRAM DDA
1	SWAC
1	SYLVANIA S 9400
1	SYLVANIA UDOFTT
1	TARGET INTERCEPT
1	TELEREGISTER MAGNET BID ASKED
1	TELEREGISTER MAGNET INVENT CONT
1	UNIVAC 490
1	UNIVAC 1101
1	UNIVAC LARC
1	UNIVERSAL DATA TRANS
1	WHIRLWIND II
1	WISC
1	WRU SEARCHING SELECTOR

TABLE III

WORD LENGTH OF COMPUTING SYSTEMS

WORD LENGTH DIGITS	ARITHMETIC POINT	INSTRUCTIONS PER WORD	ADDRESSES PER WORD	SYSTEM
Variable	Fixed	3	-	BIZMAC I
Variable	Fixed	3	-	BIZMAC II
Variable	Fixed	1	2	DIANA
Variable	-	-	-	FOSDIC
Variable	Fixed	-	2	IBM 305 RAMAC
Variable	Fixed	-	1	IBM 702
Variable	Fixed	-	1	IBM 705 I II
Variable	Fixed	-	1	IBM 705 III
Variable	Fixed	-	1 or 2	IBM 1401
Variable	-	-	-	IBM 1410
Variable	Fixed	-	2	IBM 1620
Variable	Fixed	-	1	IBM 7080
Variable	-	Variable	1	RASTAC
Variable	-	2	-	RASTAD
Variable	Fixed	Variable	2	RCA 301
Variable	Fixed	Variable	2	RCA 501
Variable	Fixed and Floating	1 or 2	1, 2 or 3	RCA 601
Variable	-	1 to 3	1	SCRIBE
Variable	Fixed	-	1	TELEREGISTER TELEFILE
Variable	Fixed	-	3	UNIVAC 60
Variable	Fixed	-	3	UNIVAC 120
3 Dec	-	0.5	1	AMOS IV
3 Dec	Fixed	2 or 4	1 or 2	NATIONAL 315
12 Bin	Fixed	1	1	CDC 160
13 Bin	Fixed	1	1	RCA 300
13 Bin	Fixed	1	1	SPEC
14 Bin	Fixed	1, 2 or 3	-	LIBRASCOPE CP 209
3 Dec + 5 Bin	Fixed	-	-	NORDEN VOTE TALLY
16 Bin	Fixed	0.5	-	BURROUGHS D 209
16 Bin	-	-	-	HRB SINGER
16 Bin	Fixed	1	1	WHIRLWIND II
17 Bin	Fixed	1	3 Mod	HUGHES DIGITAIR
17 Bin	Fixed	1	2	HUGHES ADV AIRBORNE III
3 or 5 Dec	Fixed	-	1 or 2	IBM 604
3 or 5 Dec	Fixed	-	1 or 2	IBM 607
3 or 5 Dec	Fixed	-	1 or 2	IBM CPC
17 Bin	Fixed	1	1	LEPRECHAUN
18 Bin	Fixed and Floating	1	1	HONEYWELL 290
18 Bin	Fixed	1	1, 2 or 4	LIBRASCOPE MK 38
18 Bin	-	1	1	LINCOLN TX 0
18 Bin	Fixed	1	1	PROGRAMMED DATA PROCESSOR

TABLE III (CONTINUED)

WORD LENGTH OF COMPUTING SYSTEMS

WORD LENGTH DIGITS	ARITHMETIC POINT	INSTRUCTIONS PER WORD	ADDRESSES PER WORD	SYSTEM
18 Bin	Fixed	0.5	1 + 1	RW 300
19 Bin	Fixed	1	3	HUGHES D PAT
19 Bin	Fixed	1	3	HUGHES LRI X
19 Bin	Fixed	1	1	LIBRASCOPE MK 130
20 Bin	Floating	1	1	BURROUGHS D 103
20 Bin	Fixed	-	-	CUBIC AIR TRAFFIC
20 Bin	Fixed and Floating	1	1	GENERAL ELECTRIC 225
20 Bin	Fixed	1 + 1	1	GENERAL ELECTRIC 312
20 Bin	Fixed	-	-	HAMPSHIRE CCC 500
20 Bin	Fixed	2	1	HUGHES M 252
20 Bin	-	0.5	1	MODAC 5014
20 Bin	-	-	1	RCA 200
6 Dec	Fixed	1	1	GENERAL ELECTRIC 210
6 Dec	Fixed	-	1	MODAC 404
6 Dec	Fixed	-	1	MODAC 414
21 Bin	Fixed	1	1	BURROUGHS D 201
21 Bin	Fixed	-	-	CUBIC TRACKER
21 Bin	Fixed	1 or 0.5	1 or 1 + 1	LEEDS NORTHROP 3000
21 Bin	Fixed	1	1	LITTON C 7000
21 Bin	Fixed	1	1	SYLVANIA UDOFTT
22 Bin	Fixed	1	1	BURROUGHS D 202
22 Bin	Fixed	-	-	HAMPSHIRE TRIDS 932
22 Bin	Fixed	1	4	LIBRASCOPE 407
22 Bin	Fixed	1	1	PACKARD BELL 250
22 Bin	Fixed	1	1 or 1 + 1	PHILCO 3000
22 Bin	Fixed	5	-	STORED PROGRAM DDA
23 Bin	Fixed	1	1	AN/ASQ 28 (v) MDC
7 Dec	-	-	-	GE 100 ERMA
24 Bin	Fixed	1	1	ATHENA
24 Bin	Fixed	1	1 + 1	BURROUGHS D 203
24 Bin	Fixed	1	1	BURROUGHS D 208
24 Bin	-	-	-	TELEREGISTER MAGNET BID ASKED
24 Bin	Fixed	-	1	RCA 110
24 Bin	Fixed	1	1	TARGET INTERCEPT
24 Bin	Fixed	1	1	UNIVAC 1101
24 Bin	-	1	1	UNIVAC 1102
24 Bin	Fixed	1	1 + 1	UNIVAC III
24 Bin	Fixed	1	1.5	VERDAN
24 Bin	Fixed	1	1	WESTINGHOUSE AIRBORNE
25 Bin	Fixed	1	1 + 1	CCC REAL TIME
25 Bin	Fixed	1	1 + 1	LIBRASCOPE ASN 24

TABLE III (CONTINUED)

WORD LENGTH OF COMPUTING SYSTEMS

WORD LENGTH DIGITS	ARITHMETIC POINT	INSTRUCTIONS PER WORD	ADDRESSES PER WORD	SYSTEM
25 Bin	Fixed	1	1	LINCOLN CG 24
26 Bin	Fixed	1	1 + 1	AN/ASQ 28 (v) EDC
26 Bin	Fixed	1	2	RW 400
27 Bin	Fixed	3	2	ASC 15
27 Bin	Fixed	-	-	TRICE
8 Dec	Fixed	-	-	BENDIX D 12
8 Dec	Fixed and Floating	1	3	ELECOM 120
8 Dec	Fixed	1	1	LIBRASCOPE AIR TRAFFIC
8 Dec	Fixed	-	1	MAGNEFILE B
29 Bin	Fixed	-	-	BENDIX CUBIC TRACKER
29 Bin	Fixed	1	2	BENDIX G 15
30 Bin	Fixed	1	1	AN/USQ 20
30 Bin	Fixed	1	3	ELECOM 100
30 Bin	Fixed	-	1	UNIVAC 490
9 Dec	Fixed	-	1 or 2	IBM 608
31 Bin	Fixed	-	1	BURROUGHS D 204
31 Bin	Fixed	1	1	LIBRATROL 500
32 Bin	Fixed	1	1	AN/FSQ 7 AN/FSQ 8 (SAGE)
32 Bin	Fixed	1	1	LIBRATROL 1000
32 Bin	Fixed	1	1	LITTON DATA ASSESSOR
32 Bin	Fixed	1	1	LGP 30
32 Bin	Fixed	2	1	MONROBOT XI
32 Bin	Fixed	1	1 over 1	RPC 4000
33 Bin	Fixed	0, 1, 2, 3, 4	1	ALWAC II
33 Bin	Fixed	2, 3, 4	1	ALWAC III E
33 Bin	1	1	1	BENDIX G 20
33 Bin	Fixed	1	1	ITT SPES 025
34 Bin	Fixed	1	1	BURROUGHS D 107
10 Dec	Fixed	-	-	AF/CRC
10 Dec	Fixed and Floating	1	1	BURROUGHS 204
10 Dec	Fixed and Floating	1	1	BURROUGHS 205
10 Dec	Fixed and Floating	1	1	BURROUGHS 220
10 Dec	Fixed	-	-	ELECOM 50
10 Dec	Fixed and Floating	1	2	ELECOM 125 125FP
10 Dec	Fixed and Floating	1	1	IBM 650 RAMAC TAPES
10 Dec	Fixed and Floating	1	1	IBM 7070
10 Dec	Fixed and Floating	1	1	IBM 7074
10 Dec	Fixed	1	1	INTELEX AIRLINE RESERVATION
10 Dec	Fixed	1	1	MINIAC II
10 Dec	Fixed	-	1	MODAC 410
10 Dec	Fixed	1	2	OARAC

TABLE III (CONTINUED)

WORD LENGTH OF COMPUTING SYSTEMS

WORD LENGTH DIGITS	ARITHMETIC POINT	INSTRUCTIONS PER WORD	ADDRESSES PER WORD	SYSTEM
10 Dec	Fixed and Floating	-	1	READIX
10 Dec	Fixed	2	1 or 2	UDEC I II III
10 Dec	Fixed	1	1.5	UNIVAC SOLID STATE 80/90
10 Dec	Fixed	1	1.5	UNIVAC STEP
35 Bin	Fixed	1	1 + 1	FADAC
36 Bin	Fixed	2	1	GENERAL MILLS APSAC
36 Bin	Fixed	2	1	IBM 701
36 Bin	Fixed and Floating	1	1	IBM 704
36 Bin	Fixed and Floating	1	1	IBM 709
36 Bin	Fixed and Floating	1	1	IBM 7090
36 Bin	-	1	2	PHILCO 1000
36 Bin	Fixed and Floating	1	2	UNIVAC 1103 1103A
36 Bin	Fixed and Floating	1	2	UNIVAC 1105
36 Bin	Fixed and Floating	-	1	UNIVAC 1107
36 Bin	-	-	-	UNIVERSAL DATA TRANS
9 Dec + 6 Bin	Fixed	1	3	NATIONAL 102 D
37 Bin	Fixed	1	1	AN/TYK 6v BASICPAC
37 Bin	Fixed	2	1	GENERAL MILLS AD/ECS
37 Bin	Fixed	1	4	SWAC
37 Bin	Fixed and Floating	1	1	SYLVANIA S 9400
37 Bin	-	-	-	TELEREGISTER MAGNET INVENT CONT
11 Dec	Fixed	1	3	NATIONAL 107
11 Dec	Fixed	1	1 + 1	PENNSTAC
38 Bin	Fixed	1	1	AN/TYK 7v INFORMER
38 Bin	Fixed	1	1	COMPAC
38 Bin	Fixed	1	1	LINCOLN TX 2
38 Bin	Fixed	1	1 or 2	MOBIDIC A
38 Bin	Fixed	1	1 or 2	MOBIDIC B
38 Bin	Fixed	1	1 or 2	MOBIDIC C D & 7A
40 Bin	Fixed	2	1	CYCLONE
40 Bin	Fixed and Floating	Variable	2	GEORGE
40 Bin	Fixed	2	1	ILLIAC
40 Bin	Fixed	2	1	JOHNNIAC
40 Bin	Fixed	2	2	JUKEBOX
40 Bin	Fixed	2	1	MANIAC I
40 Bin	Fixed	2	1	MISTIC
40 Bin	Fixed	2	1	ORACLE
40 Bin	Fixed	2	1	ORDVAC
40 Bin	Fixed	2	1	RECOMP I CP 266
40 Bin	Fixed and Floating	2	1	RECOMP II

TABLE III (CONTINUED)

WORD LENGTH OF COMPUTING SYSTEMS

WORD LENGTH DIGITS	ARITHMETIC POINT	INSTRUCTIONS PER WORD	ADDRESSES PER WORD	SYSTEM
40 Bin	Fixed and Floating	2	1	REPAC
12 Dec	Fixed	1	1	BURROUGHS E 101
12 Dec	Fixed	1	1	BURROUGHS E 102
12 Dec	Fixed	-	1	BURROUGHS E 103
12 Dec	Fixed	1	3	DATAMATIC 1000
12 Dec	-	-	2	IBM 609
12 Dec	Fixed	-	1	IBM 632
12 Dec	Fixed	1	1	ITT BANK IN PROC
12 Dec	Fixed	-	3	LOGISTICS
12 Dec	Fixed	1	4	NATIONAL 390
12 Dec	Fixed	6	1	RPC 9000
12 Dec	Fixed	2	1	UNIVAC I
12 Dec	Fixed	2	1	UNIVAC II
12 Dec	Fixed and Floating	1	1	UNIVAC LARC
42 Bin	Fixed	1	3	NATIONAL 102 A
44 Bin	Fixed	2	1	CIRCLE
44 Bin	Fixed and Floating	1	4	EDVAC
45 Bin	Fixed	1	3	DYSEAC
45 Bin	Fixed	1	3 or 4	SEAC
48 Bin	Fixed and Floating	2	1	CDC 1604
48 Bin	Fixed and Floating	1	3	HONEYWELL 800
48 Bin	Fixed and Floating	2	1	MANIAC II
48 Bin	Floating	1	2	MANIAC III
48 Bin	Fixed and Floating	1	1 or 2	MERLIN
48 Bin	Fixed	2	1	NAREC
48 Bin	Fixed and Floating	2	1	PHILCO 2000
48 Bin	Fixed	2	1	PHILCO CXPQ
50 Bin	Fixed and Floating	1	1	AN/FSQ 31 (v)
50 Bin	Fixed and Floating	1	1	AN/FSQ 32
50 Bin	Fixed and Floating	1	3	WISC
15 Dec	Fixed and Floating	-	1	IBM 610
52 Bin	-	-	-	BURROUGHS D 104
54 Bin	Floating	1	1 or 3	OKLAHOMA UNIVERSITY
54 Bin	Fixed and Floating	1	1	RICE UNIVERSITY
16 Dec	Fixed and Floating	1	3	NORC
10 Alphanum	Fixed and Floating	0.5 to 6	1 or 3	NATIONAL 304
62 Bin	Fixed	-	1	MONROBOT IX
18 Dec	Fixed	-	up to 5	DE 60
64 Bin	Fixed and Floating	1 or 2	1 or 2	IBM STRETCH
68 Bin	Fixed and Floating	3	1	BRLESC
20 Dec	Fixed	1	4	MONROBOT III
20 Dec	Fixed	-	4	MONROBOT V
20 Dec	Fixed	2	4	MONROBOT VI

TABLE III (CONTINUED)

WORD LENGTH OF COMPUTING SYSTEMS

WORD LENGTH DIGITS	ARITHMETIC POINT	INSTRUCTIONS PER WORD	ADDRESSES PER WORD	SYSTEM
12 Alphanum	Fixed	1	3	UNIVAC FILE 0
12 Alphanum	Fixed	13	3	UNIVAC FILE 1
96 Bin	Fixed	2	3	MONROBOT MU
42 Dec	Fixed	-	1	MAGNEFILE D
Variable	Fixed	3	-	BIZMAC I
Variable	Fixed	3	-	BIZMAC II
Variable	Fixed	1	2	DIANA
Variable	-	-	-	FOSDIC
Variable	Fixed	-	2	IBM 305 RAMAC
Variable	Fixed	-	1	IBM 702
Variable	Fixed	-	1	IBM 705 I II
Variable	Fixed	-	1	IBM 705 III
Variable	Fixed	-	1 or 2	IBM 1401
Variable	-	-	-	IBM 1410
Variable	Fixed	-	2	IBM 1620
Variable	Fixed	-	1	IBM 7080
Variable	-	Variable	1	RASTAC
Variable	-	2	-	RASTAD
Variable	Fixed	Variable	2	RCA 301
Variable	Fixed	Variable	2	RCA 501
Variable	Fixed and Floating	1 or 2	1, 2 or 3	RCA 601
Variable	-	1 to 3	1	SCRIBE
Variable	Fixed	-	1	TELEREGISTER TELEFILE
Variable	Fixed	-	3	UNIVAC 60
Variable	Fixed	-	3	UNIVAC 120

Systems indicated as "floating-point systems have built-in automatic "floating-point" circuitry.

"Fixed-point" systems may be programmed for "floating-point" operation through the use of subroutines.

TABLE IV

ARITHMETIC OPERATION TIME (EXCLUDING ACCESS) OF COMPUTING SYSTEMS

ADD TIME MICROSECONDS	MULTIPLY TIME MICROSECONDS	DIVIDE TIME MICROSECONDS	SYSTEM
0.75	300	600	PROGRAMMED DATA PROCESSOR
0.8	7.4	24	UNIVAC 1107
1	1,000	1,000	LINCOLN TX O
1 - 3.0	20	60	BRLESC
1.38 - 1.50	2.48 - 2.70	9.00 - 9.90	IBM STRETCH
1.4	5 to 17 (9x36 Bits)	17.2 to 75 (9/36)	LINCOLN TX 2
1.4	20	40	WESTINGHOUSE AIRBORNE
1.7	40.3	43	PHILCO 2000
2	25 - 100	100	BURROUGHS D 204
2	22	42	LITTON C 7000
2.5 - 27.5	14 - 61.5	5 - 63.5	AN/FSQ 31 (v)
2.5 - 27.5	14 - 61.5	56.5 - 70	AN/FSQ 32
3	56	68	BURROUGHS D 201
3	34	73	BURROUGHS D 202
3	-	-	ITT SPES 025
3 - 4	100	100	OKLAHOMA UNIVERSITY
3 - 7	26 - 485	27 - 595	GEORGE
3.5	130	320	MERLIN
4	39	40	SYLVANIA S 9400
4	8	28	UNIVAC LARC
4.8 - 12	7.2 - 72	72	UNIVAC 490
5	20	40	TARGET INTERCEPT
5	260	324	UNIVAC 1101
5.3	296	-	SWAC
5.5	130	200	PHILCO 1000
6.0	10.5	45.0	AN/FSQ 7 AN/FSQ 8 (SAGE)
6	48 - 90	48 - 90	LITTON DATA ASSESSOR
6	450	650	NAREC
6	10	25	RCA 601
6.4	1,000	1,800	CDC 160
6.6	-	-	NORDEN VOTE TALLY
7.8	-	-	FADAC
8	78	88	MOBIDIC A
8	78	80	MOBIDIC C D & 7A
8	-	-	ORACLE
9	76.5 - 185.5	76.5 - 312.5	UNIVAC III
9.6	35.2 - 112	112	AN/USQ 20
10	-	-	CUBIC TRACKER
10	385	385	JOHNNIAC
10	-	-	TELEREGISTER UNIFIED AIRLINE
12	240	240	COMPAC
12	74	74	LINCOLN CG 24
12	276	252	PACKARD BELL 250

TABLE IV (CONTINUED)

ARITHMETIC OPERATION TIME (EXCLUDING ACCESS) OF COMPUTING SYSTEMS

ADD TIME MICROSECONDS	MULTIPLY TIME MICROSECONDS	DIVIDE TIME MICROSECONDS	SYSTEM
12	86	156	RCA 300
12.7	376	400	AN/TYK 7v INFORMER
13	56	98	BENDIX G 20
13	-	-	SPEC
14	700	700	ORDVAC
15	31	227	NORC
16	16 to 400	16 to 436	LIBRASCOPE MK 130
17	264	340	UNIVAC 1102
18 + n/2	65	75	MANIAC III
20	230	480	GENERAL ELECTRIC 225
21.5	430,000	-	IBM 632
22	356	370	LIBRASCOPE AIR TRAFFIC
23/Dig	-	-	IBM 702
24	264	288	AN/ASQ 28 (v) MDC
24 or 48	444	444	IBM 701
25	50	-	CCC REAL TIME
26	700	750	BURROUGHS D 208
28	223	470	UNIVAC 1103 1103 A
32	518	1,168	GENERAL ELECTRIC 210
34	80	-	MOBIDIC B
36	-	-	NATIONAL 315
36	110	472	UNIVAC 1105
40	520	1,000	ATHENA
40	620 - 820	900	ILLIAC
40	75	75	RICE UNIVERSITY
40 to 130	-	-	INTELEX AIRLINE RESERVATION
43	-	-	BENDIX D 12
48	2,112	2,112	DYSEAC
48	2,112	2,112	SEAC
58	835	2,131	DATAMATIC 1000
59	59	177	LIBRASCOPE CP 209
60	800	920	GENERAL MILLS AD/ECS
60	1,260	3,420	NATIONAL 304
70	960	1,170	CYCLONE
80	1,000	1,000	MANIAC I
80	980	1,080	MISTIC
80	2,000	2,000	VERDAN
84	84/Bit	84/Bit	HUGHES D PAT
84	84/Bit	84/Bit	HUGHES LRI X
85	-	-	UNIVAC SOLID STATE 80/90
85	-	-	UNIVAC STEP
86	3,000	3,000	BURROUGHS D 203

TABLE IV (CONTINUED)

ARITHMETIC OPERATION TIME (EXCLUDING ACCESS) OF COMPUTING SYSTEMS

ADD TIME MICROSECONDS	MULTIPLY TIME MICROSECONDS	DIVIDE TIME MICROSECONDS	SYSTEM
88	968	1,936	HUGHES M 252
88 - 176	3,912	5,912	UDEC I II III
91	800	1,200	OARAC
94	2,985	5,076	PENNSTAC
96	1,920	2,496	GENERAL ELECTRIC 312
100	760	1,320	HONEYWELL 290
100	2,000	4,000	LIBRASCOPE 407
105	105 + 105/Bit	105/Bit	HUGHES DIGITAIR
80 + 16 (Aug + Add)	-	-	TELEREGISTER TELEFILE
120	1,500	-	GENERAL MILLS APSAC
120	1,680	2,990	UNIVAC II
130	2,730	2,730	LEEDS NORTHROP 3000
132	2,772	2,772	PHILCO 3000
156	3,276	3,276	AN/ASQ 28 (v) EDC
156	1,872	-	ASC 15
156	3,907	4,063	LIBRASCOPE ASN 24
120 + 40C	160 + 288N + 145MN	Prog	BIZMAC I
120 + 40C	-	-	BIZMAC II
170	680 - 10, 710	-	ITT BANK LN PROC
185	2,055	3,970	BURROUGHS 220
186	2,577	4,270	DIANA
200	1,700	1,700	HUGHES ADV AIRBORNE III
220	1,760	5,300	HAMPSHIRE TRTDS 932
220	11,000	13,420	IBM 608
230	1,980	3,520	RPC 9000
240	--	-	MODAC 404
240 - 420	1,900 - 9,600	1,300 - 2,400	RCA 501
250	250	-	CUBIC AIR TRAFFIC
250	17,000	17,000	LGP 30
250	15,000	15,000	LIBRATROL 500
250	16,250	16,250	LIBRATROL 1000
250	17,000	17,000	RPC 4000
270	-	-	BENDIX G 15
282.6	1,907.6	3,707.6	UNIVAC I
288	8,000	8,000	MODAC 414
330	18,300	18,700	ELECOM 120
330	18,300	18,700	ELECOM 125 125FP
428	8,500	8,000	HAMPSHIRE CCC 500
440	16,000	24,000	REDIX
450	13,600	14,800	MINIAC II
500	20,000	20,000	CIRCLE
500	14,000	17,000	IBM 604

TABLE IV (CONTINUED)

ARITHMETIC OPERATION TIME (EXCLUDING ACCESS) OF COMPUTING SYSTEMS

ADD TIME MICROSECONDS	MULTIPLY TIME MICROSECONDS	DIVIDE TIME MICROSECONDS	SYSTEM
520	12,940	15,700	IBM 607
540	10,800	11,340	JUKEBOX
540	10,800	10,800	REPAC
600	7,000	7,000	MODAC 410
650	39,000	-	ELECOM 50
672 - 768	2,210 - 19,600	6,000 - 23,400	IBM 650 RAMAC TAPES
760	13,180	15,480	IBM CPC
780	2,990	3,120	RW 300
1,000	32,000	32,000	ALWAC II
1,000	17,000	17,000	ALWAC III E
1,000	20,000	20,500	RECOMP I CP 266
1,200	16,300	20,000	UNIVAC FILE 0
1,200	16,300	20,000	UNIVAC FILE 1
1,350	12,400	12,700	RECOMP II
3,000	140,000	140,000	DE 60
3,000	-	-	MONROBOT IX
3,000	28,000	500,000	MONROBOT XI
4,000	15,000	15,500	NATIONAL 102 D
7,400	25,000	25,800	NATIONAL 102 A
42,500	241,500	291,500	BURROUGHS E 103
100,000	-	-	MAGNEFILE D
150,000	-	-	MAGNEFILE B
280,000	1,155,000	1,155,000	IBM 610

TABLE V

ARITHMETIC OPERATION TIME (INCLUDING ACCESS) OF COMPUTING SYSTEMS

ADD TIME MICROSECONDS	MULTIPLY TIME MICROSECONDS	DIVIDE TIME MICROSECONDS	SYSTEM
2.5 - 27.5	14 - 61.5	5 - 63.5	AN/FSQ 31 (v)
2.5 - 27.5	14 - 61.5	56.5 - 70	AN/FSQ 32
3	20	40	WESTINGHOUSE AIRBORNE
3.7 - 11.7	42.3 - 50.3	45 - 53.0	PHILCO 2000
4	26	46	LITTON C 7000
4	12.7	31	UNIVAC 1107
4	8	28	UNIVAC LARC
4.36 - 32.70	4.36 - 30.52	6.54 - 32.70	IBM 7090
4.8	9.6 to 19.2	19.6 to 80.0	LINCOLN TX 2
4.8 - 9.6	25.2 to 0.8N	63.6 - 66.4	CDC 1604
5	65	80	BURROUGHS D 103
5	300	600	PROGRAMMED DATA PROCESSOR
5	10	105	SYLVANIA UDOFTT
5 - 6	25	65	BRLESC
6	1,000	1,000	LINCOLN TX 0
6.4 - 19.2	-	-	CDC 160
7 - 16	108	108	OKLAHOMA UNIVERSITY
7.2 - 12	19.2 - 84	84	UNIVAC 490
8	140	330	MERLIN
8	43	44	SYLVANIA S 9400
9	76.5 - 184.5	76.5 - 312.5	UNIVAC III
9.75	13.75	28.75	RCA 601
10	40	80	BURROUGHS D 202
10	56	70	IBM 7074
10	25	45	TARGET INTERCEPT
10	-	-	TRICE
10.2 - 12.6	30 - 108	108	BURROUGHS D 204
12.0	16.5	51.0	AN/FSQ 7 AN/FSQ 8 (SAGE)
12	60 - 102	60 - 102	LITTON DATA ASSESSOR
13.08 (6 + 6)	140 (6 x 6)	210 (10/6)	IBM 7080
16	35.2 - 112	112	AN/USQ 20
16	-	-	ITT SPES 025
16	86	88	MOBIDIC A
16	86	88	MOBIDIC C D & 7A
17/Digit	-	-	IBM 705 I II
20	-	-	CUBIC TRACKER
20.7	392	425	AN/TYK 7v INFORMER
22	300 - 600	575 - 725	NAREC
22	-	-	STORED PROGRAM DDA
22	34 - 41	71	WHIRLWIND II
22 - 26	238 - 242	238 - 242	AN/TYK 6v BASICPAC

TABLE V (CONTINUED)

ARITHMETIC OPERATION TIME (INCLUDING ACCESS) OF COMPUTING SYSTEMS

ADD TIME MICROSECONDS	MULTIPLY TIME MICROSECONDS	DIVIDE TIME MICROSECONDS	SYSTEM
24	264	288	AN/ASQ 28 (v) MDC
24	252	252	COMPAC
24	162	450	HONEYWELL 800
24	84	84	LINCOLN CG 24
24	96	168	RCA 300
24 + n/2	71	81	MANIAC III
24 - 84	24 - 240	36 - 240	IBM 704
24 - 84	24 - 240	36 - 240	IBM 709
25	75	75	BURROUGHS D 201
25	75	-	CCC REAL TIME
25	400	400	JOHNNIAC
26	700	750	BURROUGHS D 208
27	70	112	BENDIX G 20
32	-	-	BURROUGHS D 209
32	366	380	LIBRASCOPE AIR TRAFFIC
32	-	-	MODAC 5014
33	-	-	NORDEN VOTE TALLY
36	80	128	RW 400
36 or 60	456	456	IBM 701
40	230	426	BURROUGHS D 107
40	250	500	GENERAL ELECTRIC 225
40	375	520	LEPRECHAUN
40	40 to 424	40 to 460	LIBRASCOPE MK 130
42	88	-	MOBIDIC B
42	294	1,044	NATIONAL 315
44	239	486	UNIVAC 1103 1103 A
45	-	-	PHILCO CXPQ
50	85	85	RICE UNIVERSITY
50 to 140	-	-	INTELEX AIRLINE RESERVATION
56	728	868	RCA 110
59	59	177	LIBRASCOPE CP 209
60	116	508	UNIVAC 1105
64	550	1,200	GENERAL ELECTRIC 210
64	368	-	SWAC
70	370 - 590	590	ORACLE
72 (10 + 10)	672 to 1,488 (10 x 10)	792 to 984	IBM 7070
80	840	940	GENERAL MILLS AD/ECS
84	84 + 84/Bit	84 + 84/Bit	HUGHES LRI X
86	3,000	3,000	BURROUGHS D 203
90	300 - 1,700	-	AF/CRC
93	665 - 865	950	ILLIAC

TABLE V (CONTINUED)

ARITHMETIC OPERATION TIME (INCLUDING ACCESS) OF COMPUTING SYSTEMS

ADD TIME MICROSECONDS	MULTIPLY TIME MICROSECONDS	DIVIDE TIME MICROSECONDS	SYSTEM
95.8	770.8	3,159.2	IBM 705 III
100	990	1,200	CYCLONE
100	1,000	1,100	MISTIC
108	372	348	PACKARD BELL 250
120	1,520	16,200	GENERAL MILLS APSAC
120	540	540	MONROBOT V
120	1,320	3,480	NATIONAL 304
160	1,720	3,030	UNIVAC II
160	-	-	VERDAN
170	680 - 10, 710	-	ITT BANK IN PROC
176 - 264	4,000	6,000	UDEC I II III
192	2,016	2,592	GENERAL ELECTRIC 312
160 + 16 (Aug + Add)	80 + 16	80 + 16	TELEREGISTER TELEFILE
192 - 1,536	2,208 - 3,552	2,256 - 3,600	EDVAC
192 - 1,536	2,304 - 3,648	2,304 - 3,648	DYSEAC
192 - 1,540	2,300 - 3,650	2,300 - 3,650	SEAC
200	2,070	3,985	BURROUGHS 220
200	860	1,420	HONEYWELL 290
210	105 + 105/Bit	105/Bit	HUGHES DIGITAIR
210	7,800	-	RCA 301
220	1,760	5,300	HAMPSHIRE TRTDS 932
221	-	-	SPEC
224	13,860 (6 x 6)	17,640 (6/6)	IBM 609
230.4	1,008	2,304	DATAMATIC 1000
250	250	-	CUBIC AIR TRAFFIC
264	1,144	2,112	HUGHES M 252
300	1,960	2,170	IBM 1401
312	2,028	-	ASC 15
400 - 17,000	10,000 - 26,000	10,000 - 26,000	OARAC
428	8,500	8,000	HAMPSHIRE CCC 500
440	25,000	40,000	READIX
500	500 - 1,000	-	LOGISTICS
500	17,000	17,000	RPC 4000
525	2,150	3,950	UNIVAC I
540	2,430 - 16,700	2,430 - 16,700	BENDIX G 15
540	10,800	11,300	RECOMP II
560	3,137	4,830	DIANA
624	3,744	3,744	AN/ASQ 28 (v) EDC
625	4,219	4,375	LIBRASCOPE ASN 24
780	2,990	3,120	RW 300
910	3,600	3,600	LEEDS NORTHROP 3000

TABLE V (CONTINUED)

ARITHMETIC OPERATION TIME (INCLUDING ACCESS) OF COMPUTING SYSTEMS

ADD TIME MICROSECONDS	MULTIPLY TIME MICROSECONDS	DIVIDE TIME MICROSECONDS	SYSTEM
924	4,224	4,224	PHILCO 3000
960 (10 Dig)	17,700 (10 Dig)	16.8	IBM 1620
1,000	17,000	17,000	ALWAC III E
1,000	17,000	17,000	LIBRATROL 1000
1,019 - 1,188	9,300	12,680	BURROUGHS 204
1,019 - 1,188	9,300	12,680	BURROUGHS 205
1,110	2,860	3,520	RPC 9000
1,360	1,275	1,275	UNIVAC SOLID STATE 80/90
1,360	1,275 +	1,275 +	UNIVAC STEP
1,980	22,240	22,740	REPAC
2,000	21,000	21,500	RECOMP I CP 266
3,445	5,335	7,426	PENNSTAC
3,500	22,000	22,000	ELECOM 125 125FP
7,750	23,000	23,000	LIBRATROL 500
7,800	21,000 to 49,100	21,000 to 53,200	NATIONAL 102 D
8,000	17,000	17,000	LGP 30
8,000	8,000	8,000	MODAC 414
8,000	68,000	77,000	MONROBOT MU
8,700	23,800	27,500	UNIVAC FILE 0
8,700	23,800	27,500	UNIVAC FILE 1
9,000	34,000	500,000	MONROBOT XI
9,590	19,850	20,390	JUKEBOX
11,000	250,000	400,000	NATIONAL 390
11,200	24,300	25,600	MINIAC II
12,000	13,500	54,000	MONROBOT IX
15,000	40,000	40,000	NATIONAL 107
16,700	16,700	16,700	WISC
17,010	-	-	TELEREGISTER UNIFIED AIRLINES
19,900	37,500	38,500	NATIONAL 102 A
20,000	-	-	ELECOM 100
25,000	-	-	MODAC 404
30,000	60,000 - 190,000	100,000 - 370,000	IBM 305 RAMAC
50,000	250,000	250,000	BURROUGHS E 101
50,000	250,000	250,000	BURROUGHS E 102
51,000	250,000	300,000	BURROUGHS E 103
60,000	220,000	200,000	DE 60
110,000	2,500,000	-	IBM 632
120,000	540,000	540,000	MONROBOT III
135,000	600,000	600,000	MONROBOT VI

TABLE VI

ACCESS TIME OF HIGH SPEED STORAGE UNITS

ACCESS TIME MICROSECONDS	STORAGE MEDIUM	SYSTEM
0.2 - 0.8	MC	WESTINGHOUSE AIRBORNE
0.3 and 1.8	MC and TF	UNIVAC 1107
0.5 - 2.18	MC	IBM STRETCH
0.88	DL	RPC 9000
0.9 - 1.5	MC	RCA 601
1.0	-	MANIAC III
1.07	MC	UNIVAC III
1.9	MC	UNIVAC 490
2	MC	BRLESC
2	MC	BURROUGHS D 202
2	MC	BURROUGHS D 208
2 or 10	MC	PHILCO 2000
2.1	MC	HONEYWELL 800
2.2 and 3.4	MC	LINCOLN TX 2
2.4 and 15	MC and CRT	MANIAC II
2.5	MC	AN/FSQ 31 (v)
2.5	MC	AN/FSQ 32
2.5	MC	BURROUGHS D 201
2.8	-	TARGET INTERCEPT
2.18	MC	IBM 7080
2.18	MC	IBM 7090
3	MC	LINCOLN TX 0
3	MC	NAREC
3	MC	RCA 300
3 - 4	MC	NORDEN VOTE TALLY
4	MC	IBM 7074
4	MC	LITTON C 7000
4	MC	SYLVANIA S 9400
4	MC	UNIVAC LARC
4.5/Alphanum	MC	IBM 1410
4.8	MC	CDC 1604
5	MC	BURROUGHS D 103
5	MC	PROGRAMMED DATA PROCESSOR
5	MC	SYLVANIA UDOFTT
6	MC	AN/FSQ 7 AN/FSQ 8 (SAGE)
6	MC	IBM 7070
6	MC	ITT BANK IN PROC
6	MC	LITTON DATA ASSESSOR
6	CRT	MERLIN
6/Alphanum	MC	NATIONAL 304
6	MC	NATIONAL 315
6.4	MC	CDC 160
7	MC	RCA 301
7	MC	WHIRLWIND II
7.5	MC	GEORGE
8	MC	AN/TYK 7v INFORMER
8	MC	AN/USQ 20
8	MC	GENERAL MILLS AD/ECS

TABLE VI (CONTINUED)

ACCESS TIME OF HIGH SPEED STORAGE UNITS

ACCESS TIME MICROSECONDS	STORAGE MEDIUM	SYSTEM
8	MC	ITT SPES 025
8	MC	LEPRECHAUN
8	MC	MOBIDIC A
8	MC	MOBIDIC B
8	MC	MOBIDIC C D & 7A
8	CRT	NORC
8	CRT	OKLAHOMA UNIVERSITY
8	CRT	SWAC
8	MC	UNIVAC 1103 1103 A
8	MC	UNIVAC 1105
8 to 16	CRT	MANIAC I
8.4	MC	BENDIX G 20
9.3	MC	IBM 705 III
10	MC	GENERAL MILLS APSAC
10	MC	INTELEX AIRLINE RESERVATION
10	MC	LIBRASCOPE AIR TRAFFIC
10	MC	NUMERICORD
10	CRT	RICE UNIVERSITY
10	MC	RW 400
10	DL	TRICE
10	MC	UNIVAC 1101
10	MC	UNIVERSAL DATA TRANS
10/Bit	-	CUBIC TRACKER
11.5	MC	IBM 1401
12	MC	AN/TYK 6v BASICPAC
12	MC	COMPAC
12	MC	DATAMATIC 1000
12	MC	IBM 701
12	MC	IBM 704
12	MC	IBM 709
12	MC	LINCOLN CG 24
12	MC	PHILCO 1000
12	MC	PHILCO CXPQ
12 and 216	CRT and DL	SEAC
14	MC	SCRIBE
15	MC	BURROUGHS 220
15	MC	JOHNNIAC
15	MC	ORDVAC
15	MC	RCA 501
16	MC	TELEREGISTER TELEFILE
17	MC	IBM 702
17	MC	IBM 705 I II
18	CRT	ORACLE
18 - 36	CRT	ILLIAC
20	MC	BIZMAC I
20	MC	BIZMAC II
20	MC	DIGITRONIC CONVERTER
20	MC	GENERAL ELECTRIC 225

TABLE VI (CONTINUED)

ACCESS TIME OF HIGH SPEED STORAGE UNITS

ACCESS TIME MICROSECONDS	STORAGE MEDIUM	SYSTEM
20	MC	HONEYWELL 290
20	MC	IBM 1620
20	MC	LIBRASCOPE MK 130
20 and 20	CRT and MC	MISTIC
21.5	MC	IBM 632
22	DL	STORED PROGRAM DDA
22/Bit	MC	NATIONAL 390
24	MC	AN/ASQ 28 (v) MDC
30	CRT	CYCLONE
32	MC	GE 100 ERMA
32	MC	GENERAL ELECTRIC 210
34	MC	DIANA
40	MC	ATHENA
40	MC	UNIVAC II
40.4 to 404	DL	UNIVAC I
48 - 384	DL	DYSEAC
48 - 384	DL	EDVAC
84	MC	HUGHES D PAT
88	MC	UDEC I II III
96 - 129	VT	LOGISTICS
208	DL	SPEC
220	MC	IBM 608
250 - 500	DL	CCC REAL TIME
288	MC	MODAC 414
500	MC	ALWAC III E
500	VT	IBM 604
520	VT	IBM 607
625	MC	HUGHES BM GUIDANCE
760	VT	IBM CPC
900	MC	UNIVAC FILE 1
3,000	MC	BURROUGHS D 104

KEY TO SYMBOLS

CRT	Cathode Ray Tube (Electrostatic)
MC	Magnetic Core (Static Magnetic)
DL	Delay Line (Sonic, Electric, Magnetostrictive)
VT	Vacuum Tube
TF	Thin Magnetic Film

TABLE VII

CAPACITY OF HIGH SPEED STORAGE UNITS

CAPACITY WORDS - DIGITS/WORD	STORAGE MEDIUM	SYSTEM
16,384 to 262,144 - 64 Bin	MC	IBM STRETCH
81,920 to 163,840 - 50 Bin	MC	AN/FSQ 32
65,536 to 131,072 - 50 Bin	MC	AN/FSQ 31 (v)
97,500 - 12 Dec	MC	UNIVAC LARC
69,632 - 38 Bin	MC	LINCOLN TX 2
65,536 and 128 - 36 Bin	MC and TF	UNIVAC 1107
69,632 - 32 Bin	MC	AN/FSQ 7 AN/FSQ 8 (SAGE)
up to 262,144 Alphanumeric Char	MC	RCA 501
4,096 to 32,768 - 48 Bin	MC	PHILCO 2000
32,768 - 48 Bin	MC	CDC 1604
262,144 - 6 Bin (Var)	MC	RCA 601
up to 32,000 - 12 Dec	MC	HONEYWELL 800
32,768 - 38 Bin	MC	SYLVANIA S 9400
32,768 - 36 Bin	MC	IBM 7090
up to 32,768 - 36 Bin	MC	IBM 704
4,096 to 32,768 - 36 Bin	MC	IBM 709
65,536 - 18 Bin	MC	LINCOLN TX 0
20,000 - 16 Dec	CRT	NORC
4,096 - 32,768 - 33 Bin	MC	BENDIX G 20
32,768 - 30 Bin	MC	AN/USQ 20
16,384 to 32,768 - 30 Bin	MC	UNIVAC 490
40,000 to 160,000 Alphanumeric Char	MC	IBM 7080
16,384 - 49 Bin	MC and CRT	MANIAC II
16,384 - 48 Bin	MC	NAREC
32,768 - 24 Bin	MC	UNIVAC III
1,024 and 16,384 - 40 Bin	CRT and MC	MISTIC
16,384 - 34 Bin	MC	BURROUGHS D 107
16,384 - 33 Bin	MC	ITT SPES 025
8,192 - 63 Bin	CRT	OKLAHOMA UNIVERSITY
40,000 or 80,000 Alphanumeric Char	MC	IBM 705 III
8,192 - 54 Bin	CRT	RICE UNIVERSITY
12,288 - 36 Bin	MC	UNIVAC 1103 1103 A
4,096 to 12,288 - 36 Bin	MC	UNIVAC 1105
2,000 to 40,000 - 3 Dec	MC	NATIONAL 315
8,192 - 49 Bin	CRT	MERLIN
8,192 - 48 Bin	-	MANIAC III
to 16,384 - 22 Bin	MC	PACKARD BELL 250
10,000 - 10 Dec	MC	BURROUGHS 220
2,000 to 10,000 - 10 Dec	MC	INTELEX AIRLINE RESERVATION
5,000 or 9,990 - 10 Dec	MC	IBM 7070
5,000 or 9,990 - 10 Dec	MC	IBM 7074
2,048 to 16,384 - 20 Bin	MC	GENERAL ELECTRIC 225

TABLE VII (CONTINUED)

CAPACITY OF HIGH SPEED STORAGE UNITS

CAPACITY WORDS - DIGITS/WORD	STORAGE MEDIUM	SYSTEM
8,192 - 40 Bin	MC	MOBIDIC A
8,192 - 40 Bin	MC	MOBIDIC B
8,192 - 40 Bin	MC	MOBIDIC C D & 7A
12,236 and 15 - 25 and 14 Bin	-	TARGET INTERCEPT
4,096 - 72 Bin	MC	BRLESC
2,400 to 4,800 - 10 Alphanum	MC	NATIONAL 304
40,000 Alphanumeric Char	MC	IBM 705 I II
40,000 Alphanumeric Char	MC	IBM 1410
8,192 - 27 Bin	MC	LINCOLN CG 24
4,096 - 52 Bin	MC	CDC 160
20,000 to 60,000 Decimal Digits	MC	IBM 1620
4,096 - 48 Bin	MC	PHILCO CXPQ
8,189 - 22 Bin	MC	SYLVANIA UDOFTT
4,096 - 42 Bin	MC	GEORGE
4,096 - 40 Bin	MC	JOHNNIAC
4,096 - 40 Bin	MC	ORDVAC
4,000 or 8,000 - 6 Dec	MC	GENERAL ELECTRIC 210
4,096 - 38 Bin	MC	AN/TYK 6v BASICPAC
4,096 - 38 Bin	MC	AN/TYK 7v INFORMER
4,096 - 38 Bin	MC	COMPAC
4,096 - 37 Bin	MC	GENERAL MILLS AD/ECS
4,096 - 18 or 36 Bin	MC	IBM 701
4,096 - 36 Bin	MC	PHILCO 1000
20,000 Alphanumeric Char	MC	RCA 301
4,096 and 1,024 - 21 and 24 Bin	MC	WESTINGHOUSE AIRBORNE
4,000 - 8 Dec	MC	LIBRASCOPE AIR TRAFFIC
8,192 - 13 Bin	MC	RCA 300
256 to 4,096 - 24 Bin	MC	RCA 110
4,096 - 24 Bin	MC	UNIVAC 1101
6,144 - 16 Bin	MC	WHIRLWIND II
1,400 - 16,000 Alphanumeric Char	MC	IBM 1401
4,000 - 7 Dec	MC	GE 100 ERMA
2,048 - 45 Bin	CRT and DL	SEAC
2,048 - 40 Bin	CRT	ORACLE
2,000 - 12 Dec	MC	DATAMATIC 1000
2,000 - 12 Dec	MC	UNIVAC II
4,096 - 19 Bin	MC	LIBRASCOPE MK 130
1,024 to 4,096 - 18 Bin	MC	HONEYWELL 290
1,024 or 4,096 - 18 Bin	MC	PROGRAMMED DATA PROCESSOR
2,048 - 36 Bin	MC	UNIVERSAL DATA TRANS
10,000 Alphanumeric Char	MC	IBM 702
15,000 Decimal Digits	MC	TELEREGISTER TELEFILE

TABLE VII (CONTINUED)

CAPACITY OF HIGH SPEED STORAGE UNITS

CAPACITY WORDS - DIGITS/WORD	STORAGE MEDIUM	SYSTEM
8,192 Alphanumeric Char	MC	BIZMAC II
256 and 1,536 - 29 and 27 Bin	MC	BURROUGHS D 204
1,024 - 44 Bin	DL	EDVAC
1,024 - 40 Bin	CRT	CYCLONE
1,024 - 40 Bin	CRT	ILLIAC
1,024 - 40 Bin	CRT	MANIAC I
1,000 - 12 Dec	DL	UNIVAC I
200 to 10,000 Decimal Digits	MC	DIANA
1,024 - 32 Bin	MC	LITTON DATA ASSESSOR
1,280 - 22 Bin	MC	LITTON C 7000
4,096 Alphanumeric Char	MC	BIZMAC I
512 - 46 Bin	DL	DYSEAC
1,024 - 23 Bin	MC	AN/ASQ 28 (v) MDC
512 - 36 Bin	MC	GENERAL MILLS APSAC
1,024 - 18 Bin	MC	LEPRECHAUN
512 - 32 Bin	MC	BURROUGHS D 104
256 and 512 - 24 and 16 Bin	MC	BURROUGHS D 208
512 - 22 Bin	MC	BURROUGHS D 202
600 - 17 Bin	MC	NORDEN VOTE TALLY
600 - 17 Bin	MC	SCRIBE
256 - 39 Bin	CRT	SWAC
200 - 12 Dec	MC	NATIONAL 390
320 - 25 Bin	DL	CCC REAL TIME
256 - 24 Bin	MC	ATHENA
1,024 - 6 Bin	MC	DIGITRONIC CONVERTER
100 - 12 Dec	MC	ITT BANK LN PROC
100 - 10 Dec	MC	UDEC I II III
219 - 15 Bin	DL	STORED PROGRAM DDA
77 - 12 Dec	DL	RPC 9000
128 - 21 Bin	MC	BURROUGHS D 201
128 and 20 - 13 and 21 Bin	DL	SPEC
20 - 12 Alphanum	MC	UNIVAC FILE 1
32 - 12 Dec	MC	IBM 609
81 - 16 Bin	MC	BURROUGHS D 209
64 - 8 to 20 Bin	-	CUBIC TRACKER
40 - 9 Dec	MC	IBM 608
334 Decimal Digits	MC	NUMERICORD
32 - 33 Bin	MC	ALWAC III E
15 - 12 Dec	VT	LOGISTICS
12 - 10 Dec	VT	UNIVAC 120
20 - 20 Bin	MC	BURROUGHS D 103

TABLE VII (CONTINUED)

CAPACITY OF HIGH SPEED STORAGE UNITS

CAPACITY WORDS - DIGITS/WORD	STORAGE MEDIUM	SYSTEM
15 - 22 Bin	MC	HAMPSHIRE TRTDS 932
8 - 12 Dec	MC	IBM 632
16 - 20 Bin	MC	RCA 200
9 - 22 Bin	MC	HAMPSHIRE CCC 500
9 - 3 or 5 Dec	VT	IBM 604
9 - 3 or 5 Dec	VT	IBM CPC
37 Decimal Digits	VT	IBM 607
3 - 19 Bin	MC	HUGHES D PAT
2 - 6 Dec	MC	MODAC 414
1 - 27 Bin/Module	DL	TRICE
Var - 7 Dec	MC	RW 400

KEY TO SYMBOLS

CRT	Cathode Ray Tube (Electrostatic)
MC	Magnetic Core (Static Magnetic)
DL	Delay Line (Sonic, Electric, Magnetostrictive)
VT	Vacuum Tube
TF	Thin Film

TABLE VIII

LOG_{10} CAPACITY/ACCESS TIME OF HIGH SPEED STORAGE UNITS

LOG_{10} CAPACITY/ACCESS	STORAGE MEDIUM	SYSTEM
13.527	MC	IBM STRETCH
12.515	MC	AN/FSQ 32
12.418	MC	AN/FSQ 31 (v)
12.242	MC	RCA 601
12.134	CRT	NORC
12.118	MC	UNIVAC 1107
12.054	MC	LINCOLN TX 2
11.997	MC	UNIVAC LARC
11.896	MC	PHILCO 2000
11.867	MC	UNIVAC III
11.794	MC	HONEYWELL 800
11.733	MC	IBM 7090
11.713	MC	UNIVAC 490
11.644	MC	IBM 7080
11.633	MC	WESTINGHOUSE AIRBORNE
11.594	MC	LINCOLN TX 0
11.594	-	MANIAC III
11.569	MC	AN/FSQ 7 AN/FSQ 8 (SAGE)
11.418	MC	NAREC
11.168	MC	BRLESC
11.109	MC	BENDIX G 20
11.090	MC	AN/USQ 20
11.040	-	TARGET INTERCEPT
11.021	MC	RCA 501
10.992	MC	IBM 709
10.983	MC	IBM 704
10.922	MC	MANIAC II
10.875	MC	IBM 7074
10.833	MC	NATIONAL 315
10.830	MC	ITT SPES 025
10.824	CRT	MERLIN
10.809	CRT	OKLAHOMA UNIVERSITY
10.766	MC	IBM 7070
10.742	MC	UNIVAC 1103 1103 A
10.742	MC	UNIVAC 1105
10.727	MC	IBM 1410
10.713	MC	IBM 705 III
10.681	MC	NATIONAL 304
10.646	CRT	RICE UNIVERSITY
10.614	MC	BURROUGHS D 107
10.611	MC	MOBIDIC A
10.611	MC	MOBIDIC B
10.611	MC	MOBIDIC C D & 7A
10.556	MC	SYLVANIA UDOFTT
10.550	MC	RCA 300

TABLE VIII (CONTINUED)

LOG_{10} CAPACITY/ACCESS TIME OF HIGH SPEED STORAGE UNITS

LOG_{10} CAPACITY/ACCESS	STORAGE MEDIUM	SYSTEM
10.542	CRT and MC	MISTIC
10.532	MC	INTELEX AIRLINE RESERVATION
10.521	MC	CDC 160
10.516	MC	CDC 1604
10.493	MC	SYLVANIA S 9400
10.474	MC	GE 100 ERMA
10.360	MC	GEORGE
10.356	MC	BURROUGHS 220
10.289	MC	AN/TYK 7v INFORMER
10.278	MC	GENERAL MILLS AD/ECS
10.266	MC	LINCOLN CG 24
10.234	MC	RCA 301
10.215	MC	GENERAL ELECTRIC 225
10.214	MC	PHILCO CXPQ
10.168	MC	PROGRAMMED DATA PROCESSOR
10.150	MC	IBM 705 I II
10.146	MC	WHIRLWIND II
10.122	MC	AN/TYK 6v BASICPAC
10.113	MC	COMPAC
10.090	MC	PHILCO 1000
10.088	MC	IBM 701
10.038	MC	JOHNNIAC
10.038	MC	ORDVAC
10.037	MC	LIBRASCOPE AIR TRAFFIC
10.008	MC	IBM 1620
9.992	MC	UNIVAC 1101
9.922	MC	IBM 1401
9.868	MC	UNIVERSAL DATA TRANS
9.855	MC	BURROUGHS D 208
9.846	MC	LITTON C 7000
9.832	MC	DATAMATIC 1000
9.750	MC	BURROUGHS D 202
9.736	MC	LITTON DATA ASSESSOR
9.710	CRT	MANIAC I
9.708	MC	GENERAL ELECTRIC 210
9.658	CRT	ORACLE
9.590	MC	LIBRASCOPE MK 130
9.584	CRT	SEAC
9.566	MC	HONEYWELL 290
9.553	DL	RPC 9000
9.548	MC	IBM 702
9.531	MC	NORDEN VOTE TALLY
9.504	MC	TELEREGISTER TELEFILE
9.390	MC	BIZMAC II
9.364	MC	LEPRECHAUN
9.356	CRT	ILLIAC
9.310	MC	UNIVAC II
9.265	MC	GENERAL MILLS APSAC

TABLE VIII (CONTINUED)

LOG_{10} CAPACITY/ACCESS TIME OF HIGH SPEED STORAGE UNITS

LOG_{10} CAPACITY/ACCESS	STORAGE MEDIUM	SYSTEM
9.135	CRT	CYCLONE
9.097	CRT	SWAC
9.090	MC	BIZMAC I
9.032	MC	BURROUGHS D 201
9.004	DL	UNIVAC I
9.000	MC	DIANA
8.992	MC	AN/ASQ 28 (v) MDC
8.973	DL	EDVAC
8.844	MC	ITT BANK LN PROC
8.728	MC	SCRIBE
8.709	DL	DYSEAC
8.570	MC	NATIONAL 390
8.487	MC	DIGITRONIC CONVERTER
8.186	MC	ATHENA
8.184	DL	STORED PROGRAM DDA
8.056	MC	NUMERICORD
7.904	MC	BURROUGHS D 103
7.587	MC	UDEC I II III
7.204	DL	CCC REAL TIME
7.183	MC	IBM 632
7.000	DL	SPEC
6.806	-	CUBIC TRACKER
6.805	VT	LOGISTICS
6.746	MC	IBM 608
6.738	MC	BURROUGHS D 104
6.431/Module	DL	TRICE
6.324	MC	ALWAC III E
6.284	VT	IBM 607
6.204	MC	UNIVAC FILE 1
5.832	MC	HUGHES D PAT
5.401	VT	IBM 604
5.218	VT	IBM CPC
5.154	MC	MODAC 414

KEY TO SYMBOLS

CRT	Cathode Ray Tube (Electrostatic)
MC	Magnetic Core (Static Magnetic)
DL	Delay Line (Sonic, Electric, Magnetostrictive)
VT	Vacuum Tube

TABLE IX

CAPACITY OF MAGNETIC DRUM OR DISC STORAGE UNITS

CAPACITY WORDS - DIGITS/WORD	SYSTEM
2,097,152 to 67,108,864 - 64 Bin	IBM STRETCH
652,000,000 Alphanum Char	DIANA
72,000,000 - 12 Dec	UNIVAC LARC
24,050,000 - 10 Dec	UNIVAC SOLID STATE 80/90
23,040,000 - 10 Dec	UNIVAC STEP
6,500,000 - 36 Bin	UNIVAC 1107
6,000,000 - 38 Bin	SYLVANIA S 9400
62,000,000 Decimal Digits	RASTAC
62,000,000 Decimal Digits	RASTAD
600,000 to 4,800,000 - 10 Dec	IBM 7070
600,000 to 4,800,000 - 10 Dec	IBM 7074
3,750,000 - 38 Bin	AN/TYK 7v INFORMER
20,000,000 Alphanum Char	IBM 305 RAMAC
20,000,000 Alphanum Char	IBM 1401
10,000,000 to 20,000,000 Alphanum Char	IBM 1410
24,000,000 Decimal Digits	UNIVAC III
32,768 to 1,048,576 - 48 Bin	PHILCO 2000
6,250,000 - 8 Bin	MOBIDIC B
6,000,000 Alphanum Char	IBM 705 III
1,114,112 - 30 Bin	UNIVAC 490
139,264 to 557,056 - 50 Bin	AN/FSQ 31 (v)
139,264 to 557,056 - 50 Bin	AN/FSQ 32
21,000 to 117,000 - 4 to 60 Dec	LOGISTICS
600,000 - 10 Dec/Unit	IBM 650 RAMAC TAPES
1,070 to 151,070 - 12 Alphanum Char	UNIVAC FILE 0
1,070 to 151,070 - 12 Alphanum Char	UNIVAC FILE 1
256,000 - 8 Dec	LIBRASCOPE AIR TRAFFIC
135,168 - 32 Bin	AN/FSQ 7 AN/FSQ 8 (SAGE)
65,536 - 33 Bin	ITT SPES 025
20,010 - 96 Bin	MONROBOT MU
24,576 - 72 Bin	BRLESC
1,500,000 Binary Digits	TELEREGISTER MAGNETRONIC INVENTORY CONTROL
1,300,000 Binary Digits	TELEREGISTER UNIFIED AIRLINE
4,096 to 51,200 - 24 Bin	RCA 110
8,500 - 42 Dec	MAGNEFILE D
16,384 to 32,768 - 36 Bin	UNIVAC 1105
2,048 to 50,000 - 20 Bin	GENERAL ELECTRIC 312
16,384 - 48 Bin	PHILCO CXPQ
40,728 - 19 Bin	HUGHES D PAT
8,192 or 16,384 - 18 or 36 Bin	IBM 701
16,384 - 36 Bin	IBM 704
8,192 or 16,384 - 36 Bin	IBM 709
16,384 - 36 Bin	UNIVAC 1103 1103 A
36,864 - 16 Bin	WHIRLWIND II
26,624 and 6,656 - 16 and 24 Bin	AN/ASQ 28 (v) MDC

TABLE IX (CONTINUED)

CAPACITY OF MAGNETIC DRUM OR DISC STORAGE UNITS

CAPACITY WORDS - DIGITS/WORD	SYSTEM
4,096 to 32,000 - 18 Bin	HONEYWELL 290
12,800 - 40 Bin	ILLIAC
12,288 - 40 Bin	JOHNNIAC
12,800 - 10 Dec	INTELEX AIRLINE RESERVATION
11,000 - 11 Dec	NATIONAL 107
10,000 - 12 Dec	ITT BANK LN PROC
20,000 - 6 Dec	MODAC 404
10,032 - 40 Bin	ORDVAC
10,000 - 40 Bin	MANIAC I
8,192 - 48 Bin	NAREC
16,384 - 24 Bin	UNIVAC 1101
10,000 - 11 Dec	OARAC
10,000 - 37 Bin	GENERAL MILLS AD/ECS
3,770 - 96 Bin	BURROUGHS D 103
60,000 Alphanum Char	IBM 702
60,000 Alphanum Char	IBM 705 I II
16,260 - 22 Bin	LEEDS NORTHROP 3000
8,064 to 16,256 - 22 Bin	PHILCO 3000
4,000 to 10,000 - 10 Dec	ELECOM 125 125FP
8,192 or 16,384 - 20 Bin	GENERAL ELECTRIC 225
8,192 - 38 Bin	SWAC
12,800 - 22 Bin	LITTON C 7000
7,936 or 15,520 - 18 Bin	RW 300
8,320 - 33 Bin	ALWAC III E
1,000 to 10,000 - 8 Dec	ELECOM 120
12,256 - 22 Bin	BURROUGHS D 202
8,064 - 32 Bin	LIBRATROL 1000
8,008 - 32 Bin	RPC 4000
4,608 - 44 Bin	EDVAC
10,000 - 20 Bin	MODAC 5014
8,192 - 24 Bin	UNIVAC 1102
32,736 Alphanum Char	BIZMAC II
4,096 - 46 Bin	CIRCLE
5,300 - 10 Dec	UDEC I II III
5,000 - 10 Dec	MODAC 410
4,096 - 41 Bin	AN/MJQ 1 REDSTONE
4,096 - 41 Bin	JUKEBOX
4,096 - 12 Dec	REPAC
4,096 - 40 Bin	RECOMP II
5,014 - 32 Bin	BURROUGHS D 203
4,128 - 35 Bin	FADAC
4,160 - 10 Dec	READIX
4,096 - 10 Dec	MINIAC II
8,192 - 17 Bin	ATHENA
4,080 - 10 Dec	BURROUGHS 204
4,080 - 10 Dec	BURROUGHS 205

TABLE IX (CONTINUED)

CAPACITY OF MAGNETIC DRUM OR DISC STORAGE UNITS

CAPACITY WORDS - DIGITS/WORD	SYSTEM
4,096 - 32 Bin	LGP 30
4,160 - 31 Bin	LIBRATROL 500
6,004 - 6 Dec	MODAC 414
6,784 - 18 Bin	LIBRASCOPE MK 38
4,040 - 8 Dec	MAGNEFILE B
5,225 - 21 Bin	BURROUGHS D 201
18,000 Alphanum Char	BIZMAC I
10,000 - 3 Dec	AMOS IV
100,000 Binary Digits	TELEREGISTER MAGNETRONIC BID ASKED
3,840 - 26 Bin	AN/ASQ 28 (v) EDC
99,584 Binary Digits	ASC 15
2,048 - 48 Bin	BURROUGHS D 104
2,500 - 11 Dec	PENNSTAC
2,064 - 40 Bin	RECOMP I CP 266
2,560 - 32 Bin	LITTON DATA ASSESSOR
22,000 Decimal Digits	AF/CRC
2,112 - 33 Bin	ALWAC II
3,000 - 22 Bin	LIBRASCOPE 407
2,560 - 25 Bin	LIBRASCOPE ASN 24
2,176 - 29 Bin	BENDIX G 15
1,031 - 50 Bin	WISC
1,024 - 42 Bin	NATIONAL 102 A
1,664 - 24 Bin	VERDAN
1,024 - 9 Dec + 6 Bin	NATIONAL 102 D
1,992 - 17 Bin	HUGHES ADV AIRBORNE III
1,024 - 32 Bin	MONROBOT XI
784 - 40 Bin	SCRIBE
1,025 - 20 Bin	CUBIC AIR TRAFFIC
300 - 20 Dec	MONROBOT V
650 - 8 Dec	BENDIX D 12
1,024 - 16 Bin	HRB SINGER
512 - 30 Bin	ELECOM 100
200 - 20 Dec	MONROBOT III
200 - 20 Dec	MONROBOT VI
32 to 160 - 18 Dec	DE 60
220 - 12 Dec	BURROUGHS E 101
220 - 12 Dec	BURROUGHS E 102
220 - 12 Dec	BURROUGHS E 103
84 - 31 Dec	IBM 610
100 - 10 Dec	ELECOM 50
114 - 29 Bin	BENDIX CUBIC TRACKER
15 - 18 Dec	MONROBOT IX
Variable	RW 400
Variable	TELEREGISTER TELEFILE

TABLE X

TUBE QUANTITY IN COMPUTING SYSTEMS

TUBE QUANTITY	SYSTEM
5	PERK I II
6	BURROUGHS D 201
10 to 30	MONROBOT XI
13	RW 300
14	DE 60
15	AF/CRC
22	NORDEN VOTE TALLY
28	LINCOLN CG 24
48	PHILCO CXPQ
65	HAMPSHIRE TRTDS 932
74	MONROBOT IX
113	LGP 30
130	MAGNEFILE B
140	MAGNEFILE D
150	DISTRIBUTAPE
150	IBM 632
150	RASTAC
150	RASTAD
160	BURROUGHS E 101
160	BURROUGHS E 102
160	ELECOM 50
164	HAMPSHIRE CCC 500
175	LIBRATROL 500
215	UNIVAC SOLID STATE AD/90
215	UNIVAC STEP
230	ELECOM 100
240	BENDIX G 20
250	ALWAC II
250	BURROUGHS E 103
263	READIX
302	LIBRASCOPE CP 209
400	ELECOM 120
400	NATIONAL 102 A
409	HUGHES DIGITAIR
425	NATIONAL 102 D
440	LINCOLN TX 0
450	ELECOM 125 125 FP
450	PHILCO 2000
481	HUGHES ADV AIRBORNE III
535	MODAC 5014
600	MODAC 410
600	NUMERICORD
700	BENDIX D 12
765	LINCOLN TX 2
780	ALWAC III E
800	MONROBOT III
800	MONROBOT V
800	NATIONAL 107
800 - 1,000	CIRCLE
835	BENDIX G 15
850	MINIAC II
900	DYSEAC
1,000	MODAC 404
1,200	FOSDIC
1,200	OARAC
1,202	BURROUGHS 204
1,202	BURROUGHS 205
1,250	IBM 604
1,300	DIANA
1,300	NAREC
1,342	PENNSTAC
1,376 - 5,467	IBM 650 RAMAC TAPES
1,500	IBM CPC
1,800	BURROUGHS 220
1,800	SYLVANIA UDOFTT
1,800	WISC
2,000	MODAC 414
2,000	OKLAHOMA UNIV
2,044	IBM 305 RAMAC
2,148	UNIVAC 60
2,200	BURROUGHS D 103
2,281	SEAC
2,396	CYCLONE
2,400	MANIAC I
2,500	SWAC
2,584	IBM 607
2,610	MISTIC
2,695	UNIVAC 1101
2,700	UNIVAC 1102
2,942	MERLIN
3,000	UDEC I II III
3,430	ORDVAC

TABLE X (CONTINUED)

TUBE QUANTITY IN COMPUTING SYSTEMS

TUBE QUANTITY	SYSTEM	TUBE QUANTITY	SYSTEM
3,500	GEORGE	5,190	MANIAC II
3,556	RICE UNIVERSITY	5,200	UNIVAC I
3,600	DATAMATIC 1000	5,200	UNIVAC II
3,907	UNIVAC 1103 1103 A	5,937	EDVAC
4,000	IBM 701	6,120	BRLESC
4,427	ILLIAC	7,000	BURROUGHS D 104
4,500	LOGISTICS	8,293	UNIVAC 1105
4,500	TELEREGISTER UNIFIED AIRLINE	9,800	NORC
5,000	BIZMAC II	10,000	IBM 702
5,000	IBM 704	14,500	WHIRLWIND II
5,000	JOHNNIAC	30,000	BIZMAC I
5,000	ORACLE	50,000	AN/FSQ 7 AN/FSQ 8 (SAGE)

TABLE XI

CRYSTAL DIODE QUANTITY IN COMPUTING SYSTEMS

CRYSTAL DIODE QUANTITY	SYSTEM	CRYSTAL DIODE QUANTITY	SYSTEM
1	MONROBOT V	2,200	BENDIX D 12
40	MAGNEFILE B	2,200	ELECOM 100
100	MONROBOT III	2,265	GENERAL ELECTRIC 312
115	PHILCO CXPQ	2,292	RCA 300
150	MODAC 5014	2,300	MONROBOT XI
164	IBM 632	2,400	LIBRATROL 1000
200	ORACLE	2,500	ELECOM 125 125FP
240	MAGNEFILE D	2,500	NATIONAL 107
300	LEPRECHAUN	2,385	UNIVAC 1101
300	RCA 200	3,000	HAMPSHIRE TRTDS 932
350	WISC	3,000	LEEDS NORTHROP 3000
350	LINCOLN TX 0	3,000	MODAC 410
406	IBM 305 RAMAC	3,000	MODAC 414
500	JOHNNIAC	3,000	PROGRAMMED DATA PROCESSOR
500	MANIAC I	3,000	TELEREGISTER UNIFIED AIRLINE
886	STORED PROGRAM DDA	3,000	UNIVAC 1102
915	ORDVAC	3,050	MANIAC II
950	AN/TYK 6v BASICPAC	3,364	HUGHES ADV AIRBORNE III
1,000	HAMPSHIRE CCC 500	3,500	ALWAC II
1,000	MONROBOT IX	3,500	COMPAC
1,113	IBM 1620	3,553	LIBRASCOPE ASN 24
1,200	PHILCO 2000	3,800	BURROUGHS 204
1,250	CUBIC TRACKER	3,800	BURROUGHS 205
1,344	TARGET INTERCEPT	3,943 - 11,428	IBM 650 RAMAC TAPES
1,450	LIBRATROL 500	4,000	HUGHES M 252
1,500	LGP 30	4,000	NATIONAL 390
1,500	LIBRASCOPE AIR TRAFFIC	4,000	RW 300
1,617	SPEC	4,000	SWAC
1,626	BURROUGHS D 209	4,075	READIX
1,800	BURROUGHS E 101	4,200	PHILCO 3000
1,800	BURROUGHS E 102	4,289	HUGHES DIGITAIR
1,964	DISTRIBUTAPE	4,395	AN/ASQ 28 (v) EDC
2,000	BURROUGHS E 103	4,400	BENDIX G 15
2,000	CUBIC AIR TRAFFIC	4,500	ELECOM 120
2,000	DE 60	Over 4,500	LIBRASCOPE CP 209
2,000	ELECOM 50	4,700	NORDEN VOTE TALLY
2,000	FOSDIC	5,000	LOGISTICS
2,000	MINIAC II	5,000	NUMERICORD
2,000	MODAC 404	5,000	SCRIBE
2,000	SYLVANIA S 9400	5,194	IBM 609

TABLE XI (CONTINUED)

CRYSTAL DIODE QUANTITY IN COMPUTING SYSTEMS

CRYSTAL DIODE QUANTITY	SYSTEM
5,194	IBM 609
5,200	BURROUGHS D 201
5,224	LINCOLN TX 2
5,316	JUKEBOX
5,400	HUGHES D PAT
5,768	PENNSTAC
6,000	GEORGE
6,000	MOBIDIC A
6,000	MOBIDIC B
6,000	MOBIDIC C D 7A
6,000	UDEC I II III
6,213 - 14,171	IBM 1401
6,314	AN/TYK 7v INFORMER
6,900	BURROUGHS D 203
7,000	BURROUGHS D 208
7,000	CDC 160
7,000	OARAC
7,000	RECOMP I CP 266
8,000	NATIONAL 102 A
8,000	NATIONAL 304
8,000	RASTAC
8,000	RASTAD
8,500	NATIONAL 102 D
8,956	UNIVAC 1103 1103 A
9,000	HONEYWELL 290
10,000	IBM 704
10,000	RECOMP II
10,000	VERDAN
11,090	BURROUGHS D 204
12,000	BURROUGHS D 202
12,000	EDVAC
12,000	REPAC
12,800	IBM 701
13,000	RICE UNIVERSITY
13,076	AN/ASQ 28 (v) MDC
13,160	BURROUGHS D 107
13,500	ALWAC III E
14,000	BURROUGHS D 103
14,000	WHIRLWIND II
14,500	BIZMAC II
14,515	LIBRASCOPE MK 130
15,000	GENERAL MILLS AD/ECS
15,500	TELEREGISTER TELEFILE
15,651	LIBRASCOPE MK 38
15,985	WESTINGHOUSE AIRBORNE
16,000	OKLAHOMA UNIV
16,415	UNIVAC 1105
16,540	MERLIN
17,000	IBM 702
18,000	UNIVAC I
18,000	UNIVAC II
20,000	GENERAL MILLS APSAC
20,000	MANIAC III
20,000	SYLVANIA UDOFTT
22,000	CCC REAL TIME
23,000	LITTON DATA ASSESSOR
24,000	SEAC
24,500	DYSEAC
25,000	BURROUGHS D 104
30,000	HONEYWELL 800
30,000	ITT BANK IN PROC
30,000	NAREC
30,000	NORC
33,000	ATHENA
33,200	LINCOLN CG 24
33,787	AN/USQ 20
36,505	UNIVAC SOLID STATE 80/90
36,505	UNIVAC STEP
38,000	BENDIX G 20
50,000	ITT SPES 025
60,000	DATAMATIC 1000
62,000	DIANA
70,000	BIZMAC I
90,417	UNIVAC 1107
100,000	CDC 1604
126,300	BRLESC
170,000	AN/FSQ 7 AN/FSQ 8 (SAGE)
229,000	AN/FSQ 31 (v)
305,000	AN/FSQ 32

TABLE XII

TRANSISTOR QUANTITY IN COMPUTING SYSTEMS

TRANSISTOR QUANTITY	SYSTEM	TRANSISTOR QUANTITY	SYSTEM
0-211	IBM 650 RAMAC TAPES	1,600	CUBIC TRACKER
6	PENNSTAC	1,600	RECOMP I CP 266
16	BENDIX G 15	1,683	HUGHES LRIX
64	DISTRIBUTAPE	1,697	AN/ASQ 28 (v) MDC
75	AIWAC III E	1,800	HUGHES D PAT
100	ORACLE	1,820	BURROUGHS D 208
100	RASTAC	1,887	IBM 609
100	RASTAD	1,900	RICE UNIVERSITY
Over 100	LIBRASCOPE CP 209	2,000	RECOMP II
200	BIZMAC I	2,000 - 3,000	OKLAHOMA UNIV
200	DE 60	2,091	ORDVAC
279	SPEC	2,563	LIBRASCOPE MK 38
300	NUMERICORD	2,572	GENERAL ELECTRIC 312
309	STORED PROGRAM DDA	2,600	CUBIC AIR TRAFFIC
328	EDVAC	2,700	CCC REAL TIME
382	LIBRASCOPE ASN 24	2,700	PROGRAMMED DATA PROCESSOR
383	MONROBOT XI	3,000	FOSDIC
400	PACKARD BELL 250	3,088	IBM 1620
500	DATAMATIC 1000	3,100	LITTON DATA ASSESSOR
500	SYLVANIA UDOFTT	3,470	BURROUGHS D 107
580	RW 300	3,500	LINCOLN TX O
592	AN/ASQ 28 (v) EDC	3,500	SCRIBE
650	LIBRATROL 1000	3,500	TELEREGISTER TELEFILE
700	BURROUGHS D 209	3,900	NORDEN VOTE TALLY
703	AN/FSQ 7	4,000	NATIONAL 304
820	MERLIN	4,200	BURROUGHS D 104
885	JUKEBOX	4,315 - 9,805	IBM 1401
900	HAMPSHIRE TRTDS 932	4,800	NAREC
919	UNIVAC SOLID STATE 80/90	5,000	BURROUGHS D 202
919	UNIVAC STEP	5,000	LEPRECHAUN
1,100	HUGHES M 252	5,400	RCA 300
1,148	UNIVAC 1105	5,550	PHILCO CXPQ
1,150	NATIONAL 390	6,000	HONEYWELL 800
1,160	MANIAC II	6,500	BURROUGHS D 203
1,200	UNIVAC II	6,600	BURROUGHS D 201
1,300	LEEDS NORTHROP 3000	7,015	LIBRASCOPE MK 130
1,400	CDC 160	7,500	ATHENA
1,500	GENERAL MILLS AD/ECS	7,597	WESTINGHOUSE AIRBORNE
1,500	GENERAL MILLS APSAC	8,500	BURROUGHS D 204
1,500	HONEYWELL 290	8,740	BRLESC
1,500	PHILCO 3000	8,900	BENDIX G 20
1,500	RCA 200	10,000	COMPAC
1,500	REPAC	10,000	ITT BANK LN PROC
1,500	VERDAN	10,000	LOGISTICS

TABLE XII (CONTINUED)

TRANSISTOR QUANTITY IN COMPUTING SYSTEMS

TRANSISTOR QUANTITY	SYSTEM	TRANSISTOR QUANTITY	SYSTEM
10,265	AN/USQ 20	30,000	MOBIDIC C D 7A
10,789	AN/TYK 7v INFORMER	32,000	MOBIDIC A
12,000	MANIAC III	36,000	SYLVANIA S 9400
14,188	AN/TYK 6v BASICPAC	Over 36,000	IBM 7080
18,930	LINCOLN CG 24	51,000	ITT SPES 025
20,000	GEORGE	56,000	PHILCO 2000
20,000	TARGET INTERCEPT	61,533	LINCOLN TX 2
23,000	LIBRASCOPE AIR TRAFFIC	138,000	AN/FSQ 31 (v)
25,000	CDC 1604	200,000	IBM STRETCH
25,522	UNIVAC 1107	201,000	AN/FSQ 32
30,000	MOBIDIC B		

TABLE XIII

APPROXIMATE POWER REQUIREMENT OF COMPUTING SYSTEMS

POWER KILOWATTS	SYSTEM
0.010	HRB SINGER
0.020	RCA 200
0.029	STORED PROGRAM DDA
0.030	HUGHES BM GUIDANCE
0.060	SPEC
0.10	PACKARD BELL 250
0.13	LIBRASCOPE ASN 24
0.13	RCA 300
0.15	ASC 15
0.15	DE 60
0.16	LEPRECHAUN
0.20	RPC 9000
0.22	BURROUGHS D 208
0.25	AN/ASQ 28 (v) EDC
0.25	LIBRASCOPE 407
0.30	HUGHES D PAT
0.30	RECOMP I CP 266
0.31	AN/TYK 7v INFORMER
0.32	VERDAN
0.37	HUGHES M 252
0.40	CCC REAL TIME
0.50	JUKEBOX
0.50	RECOMP II
0.50	RW 300
0.60	LEEDS NORTHROP 3000
0.60	MAGNEFILE B
0.60	REPAC
0.67	MONROBOT IX
0.70	CDC 160
0.70	FADAC
0.70	PHILCO 3000
0.73	RPC 4000
0.75	IBM 632
0.80	AN/ASQ 28 (v) MDC
0.80	PROGRAMMED DATA PROCESSOR
0.85	HUGHES LRI X
0.85	MONROBOT XI
0.86	BURROUGHS D 203
0.86	GENERAL MILLS APSAC
0.90	BURROUGHS D 201
0.90	TRICE
0.95	LITTON C 7000
1.0	AN/MJQ 1 REDSTONE
1.0	BURROUGHS D 107
1.0	CUBIC TRACKER
1.0	GENERAL MILLS AD/ECS
1.0	GEOTECH AUTOMATIC
1.0	HAMPSHIRE CCC 500
1.0	IBM 609
1.0	MAGNEFILE D
1.1	LGP 30
1.2	PHILCO 1000
1.4	HONEYWELL 290
1.5	HAMPSHIRE TRTDS 932
1.5	HUGHES ADV AIRBORNE III
1.5	IBM 610
1.5	LITTON DATA ASSESSOR
1.8	BURROUGHS D 202
1.8	BURROUGHS E 103
1.8	LIBRASCOPE CP 209
1.8	WESTINGHOUSE AIRBORNE
1.8	BURROUGHS D 204
2.0	DISTRIBUTAPE
2.0	ELECOM 50
2.0	IBM 1620
2.0	LIBRATROL 1000
2.0	MANIAC III
2.1	IBM 608
2.5	AN/USQ 20
2.5	LIBRATROL 500
2.5	MONROBOT III
2.5	TARGET INTERCEPT
2.7	SCRIBE
2.9 - 12	IBM 1401
3.0	BURROUGHS E 101
3.0	BURROUGHS E 102
3.0	CIRCLE
3.0	LIBRASCOPE AIR TRAFFIC
3.0	MODAC 404
3.1	BENDIX G 20
3.5	BENDIX G 15
3.5	ELECOM 100
3.6	COMPAC
4.0	ALWAC II
4.0	GENERAL ELECTRIC 312
4.0	MODAC 410

TABLE XIII (CONTINUED)

APPROXIMATE POWER REQUIREMENT OF COMPUTING SYSTEMS

POWER KILOWATTS	SYSTEM	POWER KILOWATTS	SYSTEM
4.3	BENDIX CUBIC TRACKER	14	BURROUGHS 204
4.3	NATIONAL 390	14	BURROUGHS 205
4.5	LIBRASCOPE MK 38	14	IBM 7080
4.5	NORDEN VOTE TALLY	15	UNIVAC 1101
4.5	RCA 110	16	IBM 650 RAMAC TAPES
4.6	LINCOLN CG 24	17	IBM 7070
5.0	ALWAC III E	17	LOGISTICS
5.0	ELECOM 120	18	MISTIC
5.0	ELECOM 125 125FP	18	SYLVANIA S 9400
5.0	FOSDIC	19	CYCLONE
5.0	LIBRASCOPE MK 130	20	AN/TYK 6v BASICPAC
5.0	MINIAC II	20	LINCOLN TX 2
5.0	MODAC 414	20	RICE UNIVERSITY
5.0	MONROBOT V	21	OARAC
5.0	UNIVERSAL DATA TRANS	22	SEAC
5.5	ATHENA	22	UNIVAC 1102
5.6	RCA 501	24	SYLVANIA UDOFTT
5.8	IBM 7090	25	NAREC
6.0	ITT BANK LN PROC	26	IBM 7074
6.0	NUMERICORD	26	RCA 301
6.8	IBM 604	27	ILLIAC
7.2	PENNSTAC	29	BURROUGHS D 103
7.5	BENDIX D 12	30	BURROUGHS 220
7.5	CDC 1604	30	ITT SPES 025
7.7	NATIONAL 102 A	30	MOBIDIC A
7.7	NATIONAL 102 D	30	SWAC
8.0	READIX	30	UDEC I II III
8.0	UNIVAC 120	30	UNIVAC 1107
8.5	IBM CPC	31	UNIVAC 490
9.0	GENERAL ELECTRIC 210	32	HONEYWELL 800
9.0	PHILCO CXPQ	33	MANIAC II
10	LINCOLN TX 0	34	MOBIDIC B
10	RW 400	35	BRLESC
10	WISC	35	MANIAC I
11	IBM 305 RAMAC	37	BIZMAC II
12	DYSEAC	38	NATIONAL 304
12	IBM 607	39	UNIVAC SOLID STATE 80/90
12	OKLAHOMA UNIV	40	MERLIN
13	AF/CRC	40	ORDVAC
13	GENERAL ELECTRIC 225	45	MOBIDIC C D & 7A
13	RASTAC	45	PHILCO 2000
13	RASTAD	45	RCA 601
13	UNIVAC STEP	50	GEORGE

TABLE XIII (CONTINUED)

APPROXIMATE POWER REQUIREMENT OF COMPUTING SYSTEMS

POWER KILOWATTS	SYSTEM	POWER KILOWATTS	SYSTEM
52	EDVAC	95	DATAMATIC 1000
55	JOHNNIAC	100	IBM STRETCH
60	BURROUGHS D 104	107	AN/FSQ 32
69	IBM 705 I II	109	AN/FSQ 31 (v)
71	UNIVAC FILE 0	113	IBM 709
71	UNIVAC FILE 1	124	UNIVAC II
74	UNIVAC 1103 1103 A	131	IBM 705 III
75	IBM 702	150	GE 100 ERMA
75	ORACLE	160	UNIVAC 1105
75	UNIVAC III	167	UNIVAC LARC
76	IBM 701	168	NORC
76	IBM 704	180	WHIRLWIND II
81	UNIVAC I	246	BIZMAC I
90	DIANA	750	AN/FSQ 7 AN/FSQ 8 (SAGE)

TABLE XIV

APPROXIMATE COST OF COMPUTING SYSTEMS
(BASIC OR TYPICAL SYSTEM)

COST	SYSTEM	COST	SYSTEM
$ 1,000	PERK I II	$ 86,074	MONROBOT V
6,000	IBM 632	87,500	RPC 4000
9,650	MONROBOT IX	95,000	RECOMP II
15,000	HRB SINGER	97,000	ELECOM 120
17,000 to 20,000	ITT BANK LN PROC	97,500	UNIVAC 120
18,000	DE 60	98,000	RW 300
19,195	SPEC	100,000	MODAC 404
20,000	GEOTECH AUTOMATIC	100,000	PENNSTAC
20,000	MAGNEFILE B	110,000	PROGRAMMED DATA PROCESSOR
22,500	ELECOM 50	120,000	MODAC 410
24,500	MONROBOT XI	120,000	RPC 9000
29,750	BURROUGHS E 101	125,600	IBM 1401
29,750	BURROUGHS E 102	127,000	FOSDIC
29,750	BURROUGHS E 103	141,980	GENERAL MILLS AD/ECS
36,000	IBM 609	150,000	MODAC 414
40,500	PACKARD BELL 250	155,000	ELECOM 125 125FP
45,000	DISTRIBUTAPE	160,000	BURROUGHS D 204
49,500	BENDIX G 15	167,850	IBM 305 RAMAC
49,500	LPG 30	170,000	HONEYWELL 290
50,000	ALWAC II	175,000	UNIVAC STEP
50,000	HAMPSHIRE CCC 500	182,000	IBM 650 RAMAC TAPES
50,000	MAGNEFILE D	185,000	OARAC
50,000	TRICE	196,000	RCA 301
50,000 to 100,000	HAMPSHIRE TRTDS 932	200,000	BURROUGHS 204
55,000	BENDIX D 12	200,000	BURROUGHS 205
55,000	IBM 610	200,000	GENERAL ELECTRIC 225
56,300	NATIONAL 390	200,000	RASTAC
60,000	CDC 160	200,000	RASTAD
60,000	ELECOM 100	225,000	GENERAL ELECTRIC 210
64,000	IBM 1620	225,000	NUMERICORD
65,000	NATIONAL 102 D	230,000	IBM 701
70,000	NATIONAL 102 A	250,000	MANIAC I
70,000	READIX	257,000	RCA 501
75,000	IBM CPC	300,000	ILLIAC
75,000	UNIVAC 60	300,000	TELEREGISTER MAGNET INVENT CONT
76,950	ALWAC III E	300,000	UNIVAC FILE 1
80,000	AN/MJQ 1 REDSTONE	300,000	UNIVAC FILE O
80,000	CIRCLE	320,000	BURROUGHS 220
82,500	NATIONAL 315	347,500	UNIVAC SOLID STATE 80/90
84,500	LIBRATROL 500	350,000	MANIAC II
85,000	MINIAC II	350,000	UNIVERSAL DATA TRANS
85,000	MODAC 5014	354,000	LOGISTICS
85,200	GENERAL ELECTRIC 312	358,000	IBM 702

TABLE XIV (CONTINUED)

APPROXIMATE COST OF COMPUTING SYSTEMS
(BASIC OR TYPICAL SYSTEM)

$ 366,600	NATIONAL 304
400,000	RICE UNIVERSITY
400,000	SWAC
467,000	EDVAC
478,000	BENDIX G 20
500,000	AN/TYK 6v BASICPAC
500,000	GEORGE
500,000	UDEC I II III
500,000 (Donated)	UNIVAC 1101
600,000	MERLIN
600,000	NORDEN VOTE TALLY
600,000	ORDVAC
700,000	UNIVAC III
750,000	CDC 1604
750,000	UNIVAC I
800,000	AF/CRC
813,250	IBM 7070
839,700	RCA 601
895,000	UNIVAC 1103 1103A
970,000	UNIVAC II
975,000	HONEYWELL 800
1,000,000	ITT SPES 025
1,000,000	LINCOLN CG 24
1,000,000	NATIONAL 107
1,284,350	IBM 7074
1,400,000	UNIVAC 1102
1,500,000	NAREC
1,500,000	UNIVAC 490
1,600,000	PHILCO CXPQ
1,640,000	IBM 705 I II
1,800,000 to 2,700,000	UNIVAC 1107
1,932,000	UNIVAC 1105
1,994,000 (Excluding Discount)	IBM 704
2,000,000	BRLESC
2,179,100	DATAMATIC 1000
2,200,000	IBM 7080
2,500,000	NORC
2,630,000	IBM 709
2,898,000	IBM 7090
4,500,000	BIZMAC I
6,000,000	UNIVAC LARC

TABLE XV

CHRONOLOGICAL ORDER OF INITIAL DATE OF OPERATION OF COMPUTING SYSTEMS

INITIAL DATE OF OPERATION	SYSTEM
May 1950	SEAC
1950	WHIRLWIND II
Mar 1951	SWAC
Mar 1951	UNIVAC I
1951	EDVAC
Mar 1952	MANIAC I
Mar 1952	ORDVAC
Sep 1952	ILLIAC
1952	ELECOM 100
Mar 1953	LOGISTICS
Apr 1953	OARAC
May 1953	IBM 701
Aug 1953	MAGNEFILE D
Aug 1953	UNIVAC 1103 1103 A
Dec 1953	UDEC I II III
1953	IBM 604
1953	NATIONAL 102 A
Feb 1954	MAGNEFILE B
Mar 1954	JOHNNIAC
Apr 1954	DYSEAC
Jun 1954	ALWAC II
Jun 1954	CIRCLE
Jul 1954	MODAC 5014
Sep 1954	MODAC 404
1954	BENDIX D 12
1954	BURROUGHS 204
1954	BURROUGHS 205
1954	IBM 650 RAMAC TAPES
1954	LGP 30
1954	WISC
Feb 1955	IBM 702
Feb 1955	MONROBOT III
Feb 1955	NORC
Mar 1955	MINIAC II
Mar 1955	MONROBOT V
Aug 1955	UNIVAC 1101
Nov 1955	BIZMAC I
1955	ALWAC III E
1955	BURROUGHS E 101
1955	IBM 705 I II
1955	MODAC 410
1955	PENNSTAC
1955	UNIVAC 60
1955	UNIVAC 120
1955	UNIVAC 1102
Feb 1956	READIX
Apr 1956	AF/CRC
Apr 1956	IBM 704
Oct 1956	MODAC 414
1956	BENDIX G 15
1956	BIZMAC II
1956	ELECOM 50
1956	ELECOM 120
1956	ELECOM 125 125FP
1956	IBM 608
1956	LEPRECHAUN
1956	MONROBOT MU
1956	NAREC
1956	PHILCO 1000
1956	RECOMP I CP 266
1956	TELEREGISTER MAGNET INVENT CONT
Sep 1957	GEORGE
Sep 1957	UNIVAC FILE 0
Nov 1957	AN/FSQ 7 AN/FSQ 8 (SAGE)
1957	IBM 709
1957	LINCOLN TX 0
1957	MANIAC II
1957	PHILCO 2000
May 1958	UNIVAC II
Sep 1958	AN/MJQ 1 REDSTONE
1958	IBM 610
1958	LINCOLN TX 2
1958	WRU SEARCHING SELECTOR
Jan 1959	RCA 501
Feb 1959	BURROUGHS 220
Feb 1959	UNIVAC 1105
Jul 1959	GE 100 ERMA
Sep 1959	FOSDIC
Nov 1959	NATIONAL 304
1959	AN/TYK 6v BASICPAC
1959	GENERAL ELECTRIC 210
1959	LIBRASCOPE AIR TRAFFIC
1959	LIBRASCOPE ASN 24
1959	RASTAD

TABLE XV (CONTINUED)

CHRONOLOGICAL ORDER OF INITIAL DATE OF OPERATION OF COMPUTING SYSTEMS

INITIAL DATE OF OPERATION	SYSTEM
1959	RPC 9000
1959	RW 300
1959	TRICE
1959	UNIVAC SOLID STATE 80/90
Jan 1960	CDC 1604
Jan 1960	HUGHES BM GUIDANCE
Jan 1960	UNIVERSAL DATA TRANS
Apr 1960	SYLVANIA UDOFTT
Apr 1960	UNIVAC LARC
Aug 1960	BENDIX CUBIC TRACKER
Oct 1960	BURROUGHS D 209
1960	AMOS IV
1960	AN/USQ 20
1960	CUBIC AIR TRAFFIC
1960	CUBIC TRACKER
1960	DIANA
1960	FADAC
1960	GENERAL ELECTRIC 225
1960	GENERAL MILLS APSAC
1960	GENERAL MILLS AD/ECS
1960	GENERAL ELECTRIC 312
1960	HAMPSHIRE TRTDS 932
1960	HRB SINGER
1960	HONEYWELL 800
1960	HUGHES DIGITAIR
1960	INTELEX AIRLINE RESERVATION
1960	IBM 1401
1960	IBM 1410
1960	7070
1960	IBM 7080
1960	IBM 7090
1960	IBM STRETCH
1960	LEEDS NORTHROP 3000
1960	LIBRASCOPE MK 130
1960	LIBRASCOPE 407
1960	LIBRATROL 1000
1960	LITTON DATA ASSESSOR
1960	MANIAC III
1960	MERLIN
1960	MOBIDIC A
1960	MOBIDIC B
1960	MOBIDIC C D & 7A
1960	NATIONAL 315
1960	NATIONAL 390
1960	NORDEN VOTE TALLY
1960	ORACLE
1960	PACKARD BELL 250
1960	PERK I II
1960	PHILCO 3000
1960	PROGRAMMED DATA PROCESSOR
1960	RCA 200
1960	RCA 300
1960	RPC 4000
1960	RASTAC
1960	RW 400
1960	REPAC
1960	SCRIBE
1960	SPEC
1960	STORED PROGRAM DDA
1960	SYLVANIA S 9400
1960	TARGET INTERCEPT
1960	UNIVAC III
1960	UNIVAC STEP
1960	WESTINGHOUSE AIRBORNE
Apr 1961	BRLESC
Jul 1961	RCA 601
Nov 1961	UNIVAC 490
1961	AN/TYK 7v INFORMER
1961	IBM 7074
1961	ITT BANK LN PROC
1961	ITT SPES 025
1961	OKLAHOMA UNIV
1961	RCA 110
1961	RICE UNIVERSITY
1962	UNIVAC 1107

CHAPTER IV

BIBLIOGRAPHY

BIBLIOGRAPHY

1. Bell, Wm. D. "A Management Guide to Electronic Computers", McGraw-Hill, 1957.

2. Berkeley, E. C. "Computers: Their Operation & Applications", Reinhold, 1956.

3. Berkeley, E. C. "Giant Brains", John Wiley, 1949.

4. Caldwell, Samuel H. "Switching Circuits & Logical Design", John Wiley, 1958.

5. Canning, Richard G. "Installing Electronic Data Processing Systems", John Wiley, 1957.

6. Canning, Richard G. "Electronic Data Processing for Business & Industry", John Wiley, 1956.

7. Casey, R. S. and Perry, J. W. "Punched Cards", Reinhold, Copyright 1951, Second printing 1952.

8. Chapin, Ned "An Introduction to Automatic Computers", Van Nostrand, 1957.

9. Charnes, A., Cooper, W. W., Henderson, A., et. al. "Introduction to Linear Programming", Wiley, 1953.

10. Culbertson, James T. "Mathematics & Logic for Digital Computers", Van Nostrand, Copyright 1958.

11. Doss, Milburn P. "Information Processing Equipment", Reinhold, 1955.

12. Dwyer, P. A. "Linear Computations", Wiley, 1951.

13. Eckert, W. J. and Jones, R. "Faster, Faster", McGraw-Hill, 1955.

14. Gottlieb, C. C. and Hume, J. N. P. "High-Speed Data Processing", McGraw-Hill, 1958.

15. Grabbe, E. M., Ramo, S. and Wooldridge, D. E., (Editors) "Handbook of Automation, Computation and Control", Vol I: Control Fundamentals; Vol II: Computers & Data Processing; Vol III: Systems & Components, Wiley, 1959.

16. Gregory, R. H. and Van Horn, R. L. "Automatic Data Processing Systems", Wadsworth Pub. Co., 1960.

17. Harvard University, Staff of Computation Lab. "Synthesis of Electronic Computing & Control Circuits", Harvard University Press, 1951.

18. Harvard University, Staff of Computation Lab. "Description of a Magnetic Drum Calculator", Harvard University Press, 1952.

19. Householder, Alston S. "Principles of Numerical Analysis", McGraw-Hill, 1953.

20. Keister, Wm., Ritchie, A. E., Washburn, S. H., et. al. "Design of Switching Circuits", Van Nostrand.

21. Korn, G. A. and T. M. "Electronic Analog Computers", McGraw-Hill, 1956.

22. Kozmetsky, G. and Kircher, P. "Electronic Computers & Management Control", McGraw-Hill, 1956.

23. Lewis, I. A. D. and Wells, F. H. "Millimicrosecond Pulse Techniques", Pergamon, 1955.

24. McCracken, D. D. "Digital Computer Programming", Wiley, 1957.

25. Millman, Jacob & Taub, H. "Pulse & Digital Circuits", McGraw-Hill, 1956.

26. Montgomerie, G. A. "Digital Calculating Machines & Their Application to Scientific & Engineering Work", Van Nostrand, 1957.

27. Murphy, John S. "Basics of Digital Computers", John F. Rider, Copyright 1958.

28. Ore, Oystein "Number Theory & Its History", McGraw-Hill, 1948.

29. Phister, M., Jr. "Logical Design of Digital Computers", Wiley, 1958.

30. Pressman, Abraham I. "Design of Transistorized Circuits for Digital Computers", John F. Rider, 1959.

31. Richards, R. K. "Arithmetic Operations in Digital Computers", Van Nostrand, 1955.

32. Richards, R. K. "Digital Computer Components & Circuits", Van Nostrand, 1957.

33. Scott, N. R. "Analog & Digital Computer Technology", McGraw-Hill, 1960.

34. Smith, Charles V. L. "Electronic Digital Computers", McGraw-Hill, Copyright 1959.

35. Soroka, W. W. "Analog Methods in Computation & Simulation", McGraw-Hill, 1954.

36. Stewart, W. Earl "Magnetic Recording Techniques", McGraw-Hill, Copyright 1958.

37. Stibitz, Geo. R. and Larrivee, Jules A. "Mathematics & Computers", McGraw-Hill, 1957.

38. Svoboda, Antonin "Computing Mechanisms & Linkages", McGraw-Hill, 1948.

39. Tompkins, C. B., Wakelin, J. H. and Stifler, W. W., Engineering Res. Associates "High Speed Computing Devices", McGraw-Hill, 1950.

40. Wass, C. A. A. "Introduction to Electronic Analogue Computers", Pergamon, 1955.

41. Wilkes, Maurice V. "Automatic Digital Computers", Wiley, 1956.

42. Weik, Martin H. "A Survey of Domestic Electronic Digital Computing Systems", Ballistic Research Laboratories Report No. 971, Reprinted by United States Department of Commerce Office of Technical Services, PB111996.

43. Weik, Martin H. A Second Survey of Domestic Electronic Digital Computing Systems", Ballistic Research Laboratories Report No. 1010, Reprinted by United States Department of Commerce Office of Technical Services, 111996 R.

44. Automatic Data Processing Systems: Department of the Army Regulations and Pamphlets

Acquisition and use for business type operations: policies, procedures, etc.	AR 1-250
Catalog of commercially available	DA Pam 1-250-4
Conducting studies	DA Pam 1-250-1
Industrial, scientific, and office types, Logistics responsibilities	AR 701-7440
Introduction	DA Pam 1-250-3
Program planning guide	DA Pam 1-250-2

CHAPTER V

GLOSSARY OF COMPUTER ENGINEERING AND PROGRAMMING TERMINOLOGY

(REVISED)

AC

a suffix meaning "automatic computer" as in ORDVAC, EDVAC, ENIAC, etc.

ACCESS, RANDOM

access to storage under conditions in which the next position from which information is to be obtained is in no way dependent on the previous one.

ACCESS TIME

(1) the time interval between the instant at which information is: (a) called for from storage and the instant at which delivery is completed, i.e., the read time; or (b) ready for storage and the instant at which storage is completed, i.e., the write time. (2) the latency plus the word-time.

ACCUMULATOR

the "zero-access" register (and associated equipment) in the arithmetic unit in which are formed sums and other arithmetical and logical results; a unit in a digital computer where numbers are totaled, i.e., accumulated. Often the accumulator stores one operand and upon receipt of any second operand, it forms and stores the sum of the first and second operands.

ACCURACY

freedom from error. Accuracy contrasts with precision; e.g., a four-place table, correctly computed, is accurate; a six-place table containing an error is more precise, but not accurate.

ADDER

a device capable of forming the sum of two or more quantities.

ADDRESS

a label such as an integer or other set of characters which identifies a register, location of device in which information is stored.

ADDRESS, ABSOLUTE

the label(s) assigned by the machine designer to a particular storage location; specific address.

ADDRESS, RELATIVE

a label used to identify a word in a routine or subroutine with respect to its position in that routine or subroutine. Relative addresses are translated into absolute addresses by the addition of some specific "reference" address, usually that at which the first word of the routine is stored, e.g. if a relative address instruction specifies an address n and the address of the first word of the routine is k, then the absolute address is n + k.

ADDRESS, SYMBOLIC

a label chosen to identify a particular word, function or other information in a routine, independent of the location of the information within the routine; floating address.

ALLOCATE

to assign storage locations to the main routines and subroutines, thereby fixing the absolute values of any symbolic addresses. In some cases allocation may require segmentation.

AMPLIFIER, BUFFER

an amplifier used to isolate the output of any device, e.g. oscillator, from the effects produced by changes in voltage or loading in subsequent circuits.

AMPLIFIER, TORQUE

a device which produces an output turning moment in proportion to the input moment, wherein the output moment and associated power is supplied by the device, and the device requires an input moment and power smaller than the output moment and power.

ANALOG

the representation of numerical quantities by means of physical variables, e.g. translation, rotation, voltage, resistance; contrasted with "digital".

ANALYZER, DIFFERENTIAL

an analog computer designed and used primarily for solving many types of differential equations.

AND-OPERATOR

a logical operator which has the property such that if P and Q are two statements, then the statement "P and Q" is true or false precisely according to the following table of possible combinations:

P		Q		P and Q	
false	0	false	0	false	0
false	0	true	1	false	0
true	1	false	0	false	0
true	1	true	1	true	1

The "and" operator is often represented by a centered dot (·), or by no sign, as in P · Q or PQ; the term conjunction is applied to this operator.

AND-GATE

a signal circuit with two or more input wires which has the property that the output wire gives a signal if and only if all input wires receive coincident signals.

AQUADAG

a graphite coating on the inside of certain cathode ray tubes for collecting secondary electrons emitted by the screen.

ARITHMETIC UNIT

that portion of the "hardware" of an automatic computer in which arithmetic and logical operations are performed.

ASSEMBLE

to integrate subroutines (supplied, selected, or generated) into the main routine, by adapting, or specializing to the task at hand by means of preset parameters, by adapting, or changing relative and symbolic addresses to absolute form, or incorporating, or placing in storage.

ATTENUATE

to obtain a fractional part or reduce in amplitude an action or signal. Measurement may be made as percentage, per unit, or in decibels, which is 10 times $\log_{10}$ of power ratio; contrasted with amplify.

AUTOMATION

the entire field of investigation, design, development, application and methods of rendering or making processes or machines self-acting or self-moving; rendering automatic; theory, art of technique of making a device, machine, process or procedure more fully automatic; the implementation of a self-acting or self-moving, hence, automatic process or machine.

AVAILABLE-TIME, MACHINE

time during which a computer has the power turned on, is not under maintenance, and is known or believed to be operating correctly.

AZIMUTH

the angular measurement in an horizontal plane and in a clockwise direction from a specific reference direction, usually a form of North, i.e., true azimuth is measured from true north, magnetic azimuth from magnetic north, grid-azimuth from grid north or thrust or base line.

BAND

a group of recording tracks on a magnetic drum.

BASE

a number base; a quantity used implicitly to define some system of representing numbers by positional notation; radix.

BEAM, HOLDING

a diffused beam of electrons used for regenerating the charges stored on the screen of a cathode ray storage tube.

BIAS

the average D.C. voltage maintained between the cathode and control grid of a vacuum tube; a fixed reference located with respect to a neutral or zero reference.

BINARY

a characteristic or property involving a selection, choice or condition in which there are but two possible alternatives.

BINARY, NUMBER

a single digit or group of characters or symbols representing the total, aggregate or amount of units utilizing the base two; usually using only the digits "0" and "1" to express quantity.

BIQUINARY

a form of notation utilizing a mixed base; see Notation, Biquinary.

BIT

a contraction of binary digit; see Digit, Binary.

BLOCK

a group of words considered or transported as a unit; an item; a message; in flow charts, an assembly of boxes, each box representing a logical unit of programming, usually requiring transfer to and from the high speed storage; in circuitry, a group of electrical circuits performing a specific function, as in a "block" diagram, in which a unit, e.g., an oscillator, is represented as a geometric figure (symbol).

BLOCK, INPUT

a section of internal storage of a computer reserved for the receiving and processing of input information; input buffer.

BOOTSTRAP

the special coded instructions at the beginning of an input tape, together with one or two instructions inserted by switches or buttons into the computer; in circuitry, a positive feedback or regenerative circuit

BORROW

a negative form of carry; see Carry; normally arising in direct subtraction by raising a lower order (less significant digit) and compensating by lowering a higher order digit e.g. when subtracting 67 from 92, a tens digit is "borrowed" from the 9, thus the 7 of 67 is subtracted from 12, yielding 5 as the units digit of the difference and then 6 is subtracted from 8 (or 9-1) yielding 2 as the tens digit. Thus, 25 is the difference.

BRANCH

a conditional jump; a point of decision in a program where a new routine or sub-routine is entered upon.

BREAKPOINT

a point in a routine at which the computer may, under the control of a manually-set switch, be stopped for a visual check of progress.

BUFFER

an isolating circuit used to avoid any reaction of a driven circuit upon the corresponding driving circuit, e.g. a circuit having an output and a multiplicity of inputs so designed that the output is energized whenever one or more inputs are energized. Thus, a buffer performs the circuit function or isolation which is equivalent to the logical "OR".

BUS

a path over which information is transferred; a trunk; an electrical conductor, channel or line; a heavy wire or heavy lead upon which many connections are made.

CABLE

an electrical conductor designed to provide common electric potential between two or more points.

CABLE, COAXIAL

a transmission line consisting of two conductors concentric with and insulated from each other.

CALL-NUMBER

a set of characters identifying a subroutine and containing information concerning parameters to be inserted in the subroutine, information to be used in generating the subroutine, or information related to the operands; a call-word when exactly one word is filled.

CAPACITANCE

the property of two or more bodies which enables them to store electrical energy in an electrostatic field between the bodies; a measure of the ability to store electric charge.

CAPACITY

the upper and lower limits of the numbers which may be processed in a computer register, e.g., in the accumulator, e.g. the capacity of a computer may be ten decimal digits or the capacity of a computer may be +.00000 00001 to +.99999 99999. Quantities which exceed the capacity usually interrupt the operation of the computer in some fashion; the quantity of information which may be stored in a storage unit; see Capacity,Storage.

CAPACITY, STORAGE

maximum number of words or characters which a device is capable of storing; a measure of the ability of a device to store information for future reference.

CARD

heavy, stiff paper of uniform size and shape, adapted for being punched in an intelligible array of holes. The punched holes are sensed electrically by wire brushes, mechanically by metal feelers, or photoelectrically. One standard card, is 7 3/8 inches long by 3 and 1/4 inches wide and contains 80 columns in each of which any one or more of 12 positions may be punched.

CARRIAGE, AUTOMATIC

a typewriting paper guiding or holding device which is automatically controlled by information and program so as to feed forms or continuous paper to a set of impression keys and to provide the necessary space, skip, eject, tabulate, or performing operations.

CARRIER WAVE

the basic frequency or pulse repetition rate of a signal, bearing no intrinsic intelligence until it is modulated by another signal which does bear intelligence. A carrier may be amplitude, phase, or frequency modulated. For example, in a typical mercury delay line memory of a digital computer, the 8 megacycle/second sound wave carrier is amplitude (pulse) modulated by a 1 megacycle/second pulse code signal, the presence or absence of a pulse determining whether or not a one or a zero is present in the binary number being represented.

CARRY

(1) A signal, or expression, produced as a result of an arithmetic operation on one digit place of two or more numbers expressed in Positional Notation and transferred to the next higher place for processing there; (2) Usually a signal or expression as defined in (1) above which arises in adding, when the sum of two digits in the same digit place equals or exceeds the Base of the number system in use. If a carry into a digit place will result in a carry out of of the same digit place, and if the normal adding circuit is bypassed when generating this new carry, it is called a High-Speed Carry, or Standing-on-Nines Carry. If the normal adding circuit is used in such a case, the carry is called a Cascaded Carry. If a carry resulting from the addition of carries is not allowed to propagate (e.g., when forming the partial product in one step of a multiplication process), the process is called a Partial Carry. If it is allowed to propagate, the process is called a Complete Carry. If a carry generated in the most significant digit place is sent directly to the least significant place (e.g., when adding two negative numbers using nine complements) that carry is called an End-Around Carry. (3) In direct subtraction, a signal or expression as defined in (1) above which arises when the difference between the digits is less than zero. Such a carry is frequently called a Borrow. (4) The action of forwarding a carry. (5) The command directing a carry to be forwarded.

CARRY, COMPLETE

see Carry

CARRY, CASCADED

see Carry

CARRY, HIGH-SPEED

see Carry

CARRY, PARTIAL

see Carry

CARRY, STANDING-ON-NINES

see Carry

CATHODE-FOLLOWER

a vacuum-tube circuit in which the input signal is applied to the control grid and the output is taken from the cathode, possessing high input impedance and low output impedance characteristics.

CELL

storage for one unit of information, usually one character or one word; a location specified by whole or part of the address and possessed of the faculty of store; specific terms such as column, field, location and block, are preferable when appropriate.

CELL, BINARY

an element that can have one or the other of two stable states or conditions and thus can store a single bit of information.

CHANNEL

a path along which information, particularly a series of digits or characters, may flow. In storage which is serial by character and parallel by bit (e.g., a magnetic tape or drum in some coded-decimal computers), a channel comprises several parallel tracks. In a circulating storage a channel is one recirculating path containing a fixed number of words stored serially by word.

CHARACTER

one of a set of elementary symbols such as those corresponding to the keys on a typewriter. The symbols usually includes the decimal digits 0 through 9, the letters A through Z, punctuation marks, operation symbols, and any other single symbols which a computer may read, store, or write; a pulse code representation of such a symbol.

CHECK

a means of verification of information or operation during or after an operation.

CHECK, BUILT-IN AUTOMATIC

any provision constructed in "hardware" for verifying the accuracy of information transmitted, manipulated, or stored by any unit or device in a computer. Extent of automatic checking is the relative proportion of machine "hardware" devoted to checking.

CHECK, CODE

to check a particular coded problem for errors; to de-bug a code.

CHECK-DUPLICATION

a check which requires that the results of two independent performances (either concurrently on duplicate equipment or at a later time on the same equipment) of the same operation be identical.

CHECK-FORBIDDEN-COMBINATION

a Check (usually an Automatic Check) which tests for the occurrence of a nonpermissible code expression. A self-checking code (or error-detecting code) uses code expressions such that one (or more) error(s) in a code expression produces a forbidden combination. A parity check makes use of a self-checking code employing binary digits in which the total number of 1's (or 0's) in each permissible code expression is always even or always odd. A check may be made for either even parity or odd parity. A redundancy check employs a self-checking code which makes use of redundant digits called check digits. Some of the various names that have been applied to this type of check are forbidden pulse combination, unused order (instruction) unallowable digits, improper operation code, improper command, false code, forbidden digit, non-existent code, and unused code.

CHECK, MATHEMATICAL or ARITHMETICAL

a check making use of mathematical identities or other properties, frequently with some degree of discrepancy being acceptable; e.g., checking multiplication by verifying that $A \cdot B = B \cdot A$, checking a tabulated function by differencing, etc.

CHECK, MODULO $\underline{N}$

a form of check digits, such that the number of ones in each number A operated upon is compared with a check number B, carried along with A and equal to the remainder of A when divided by N, e.g., in a "modulo 4 check", the check number will be 0, 1, 2, or 3 and the remainder of A when divided by 4 must equal the reported check number B, or else an error or malfunction has occurred; a method of verification by congruences, e.g. casting out nines.

CHECK, ODD-EVEN

a check system in which a one or zero is carried along in a word depending on whether the total number of ones (or zeros) in a word is odd or even.

CHECK, PARITY

a summation check in which the binary digits, in a character or word, are added (modulo 2) and the sum checked against a single, previously computed parity digit; i.e., a check which tests whether the number of ones is odd or even.

CHECK, PROGRAMMED

a system of determining the correct program and machine functioning either by running a sample problem with similar programming and known answer, including mathematical or logical checks such as comparing A times B with B times A and usually where reliance is placed on a high probability of correctness rather than built-in error-detection circuits; a check system built into the actual program being run and utilized for checking during the actual running of the problem.

CHECK, REDUNDANT

a check which uses extra digits, short of complete duplication, to help detect malfunctions and mistakes.

CHECK, SUMMATION

a check in which groups of digits are summed, usually without regard for overflow, and that sum checked against a previously computed sum to verify accuracy.

CHECK, TRANSFER

verification of transmitted information by temporary storing, re-transmitting and comparing.

CHECK, TWIN

a continuous duplication check achieved by duplication of hardware and automatic comparison

CHECKING, MARGINAL

a system or method of determining computer circuit weaknesses and incipient malfunctions by varying the power applied to various circuits, usually by a lowering of the D.C. supply or filament voltages.

CLAMPING-CIRCUIT

a circuit which maintains either amplitude extreme of a waveform at a given voltage level, or potential.

CLEAR

to replace all information in a storage device by ones or zeros as expressed in the number system employed.

CLOCK, MASTER

the source of standard signals required for sequencing computer operation, usually consisting of a timing pulse generator, a cycling unit and sets of special pulses that occur at given intervals of time. Usually in synchronous machines the basic frequency utilized is the clocking pulse.

CLOSED-SHOP

this is intended to mean that mode of computing machine support wherein the applied programs and utility routines are written by members of a specific specialized group whose primary professional concern is the use of computers.

CODE

a system of symbols or their use in representing rules for handling the flow or processing of information; to actually prepare problems for solution on a specific computer.

CODE, COMPUTER

the code representing the operations built into the hardware of the computer; reperatoire of instructions.

CODE, EXCESS-THREE

a coded decimal notation for decimal digits which represents each decimal digit as the corresponding binary number plus three, e.g. the decimal digits 0, 1, 7, 9 are represented as 0011, 0100, 1010, 1100, respectively. In this notation, the nines complement of the decimal digit is equal to the ones complement of the corresponding four binary digits.

CODE, INSTRUCTION

an artificial language for describing or expressing the instructions which can be carried out by a digital computer. In automatically sequenced computers, the instruction code is used when describing or expressing sequences of instructions, and each instruction word usually contains a part specifying the operation to be performed and one or more addresses which identify a particular location in storage. Sometimes an address part of an instruction is not intended to specify a location in storage but is used for some other purpose. If more than one address is used, the code is called a multiple-address code.

CODE, INTERPRETER

a code which is acceptable to an interpretive routine.

CODE, MULTIPLE-ADDRESS

an instruction or code in which more than one address or storage location is utilized. In a typical instruction of a Four-Address Code the addresses specify the location of two operands, the destination of the result, and the location of the next instruction in the sequence. In a typical Three-Address Code, the fourth address specifying the location of the next instruction is dispensed with, the instructions are taken from storage in a preassigned order. In a typical Two-Address Code, the addresses may specify the locations of the operands. The results may be placed at one of the addresses or the destination of the results may be specified by another instruction.

CODE, OPERATIONAL

that part of an instruction which designates the operation to be performed.

CODING

the list, in computer code or in pseudo-code, of the successive computer operations required to solve a given problem; repertoire of instructions.

CODING, ABSOLUTE, RELATIVE or SYMBOLIC

coding in which one uses absolute, relative, or symbolic addresses, respectively, i.e., coding in which all addresses refer to an arbitrarily selected position, or in which all addresses are represented symbolically.

CODING, ALPHABETIC

a system of abbreviation used in preparing information for input into a computer such that information is reported in the form of letters, e.g., New York as NY, carriage return as CN, etc.

CODING, AUTOMATIC

any technique in which a computer is used to help bridge the gap between some "easiest" form, intellectually and manually, of describing the steps to be followed in solving a given problem and some "most efficient" final coding of the same problem for a given computer; two basic forms are Routine, Compilation and Routine, Interpretation.

CODING, NUMERIC

a system of abbreviation used in the preparation of information for machine acceptance by reducing all information to numerical quantities; in contrast to alphabetic coding.

COLLATE

to combine two or more similarly ordered sets of items to produce another ordered set composed of information from the original sets. Both the number of items and the size of the individual items in the resulting set may differ from those of either of the original sets and of their sums, sequence 23, 24, 48 may be collated into 12, 23, 24, 29, 42, 48; to combine two or more sequences of items according to a prescribed rule such that all items appear in the final sequence.

COLLATOR

a machine which has two card feeds, four card pockets and three stations at which a card may be compared or sequenced with regard to other cards so as to select a pocket in which it is to be placed, e.g., the machine is suitable for matching detail cards with master cards, merging cards in proper sequence, etc.

COLUMN

one of the character or digit positions in a positional notation representation of a unit of information, columns are usually numbered from right to left column, zero being the right-most column if there is no point, or the column immediately to the left of the point if there is one; a position or place in a number in which the position designates the power of the base and the digit is the coefficient, e.g., in 3876, the 8 is the coefficient of 10^2, the position of the 8 designating the 2.

COMMAND

a pulse, signal, or set of signals initiating one step in the performance of a computer operation; that portion of the instruction word which specifies the operation to be performed; See instruction and order.

COMPARATOR

a device for comparing two different transcriptions of the same information to verify the accuracy of transcription, storage, arithmetic operation or other process, in which a signal is given dependent upon the relative state of two items, i.e. larger, smaller, equal, difference, etc.

COMPARE

to examine the representation of a quantity for the purpose of discovering its relationship to zero, or of two quantities usually for the purpose of discovering identity or relative magnitude.

COMPARISON

determining the identity, relative magnitude and relative sign of two quantities usually in order to initiate an action.

COMPARISON, LOGICAL

the operation concerned with the determination of similarity or dissimilarity of two items, e.g. if A and B are alike, the result shall be"1" or yes, if A and B are not alike or equal, the result shall be "0" or no, signifying "not alike".

COMPILER

a program making routine, which produces a specific program for a particular problem by determining the intended meaning of an element of informatinn expressed in pseudo-code, selecting or generating the required subroutine, transforming the subroutine into specific coding for the specific problem, assigning specific storage registers, etc. and entering it as an element of the problem program, maintaining a record of the subroutines used and their position in the problem program and continuing to the next element of information in pseudo-code.

COMPLEMENT

a quantity which is derived from a given quantity, expressed to the base n, by one of the following rules and which is frequently used to represent the negative of the given quantity. (a) Complement on n; subtract each digit of the given quantity from n-1, add unity to the least significant digit, and perform all resultant carrys. For example, the twos complement of binary 11010 is 00110; the tens complement of decimal 456 is 544. (b) Complement on n-1: subtract each digit of the given quantity from n-1. For example, the ones complement of binary 11010 is 00101; the nines complement of decimal 456 is 543.

COMPUTER

any device capable of accepting information, applying prescribed processes to the information, and supplying the results of these processes; sometimes, more specifically, a device for performing sequences of arithmetic and logical operations; sometimes, still more specifically, a stored-program digital computer capable of performing sequences of internally-stored instructions, as opposed to calculators on which the sequence is impressed manually (desk calculator) or from tape or cards (card programmed calculator).

COMPUTER, ANALOG

a calculating machine which solves problems by translating physical conditions like flow, temperature or pressure into electrical quantities and using electrical equivalent circuits for the physical phenomenon.

COMPUTER, ASYNCHRONOUS

a calculating device in which an operation is initiated by a signal generated upon completion of a previous operation; contrasted with Synchronous Computer.

COMPUTER, AUTOMATIC

a calculating device which handles long sequences of operations without human intervention.

COMPUTER, DIGITAL

a calculating device utilizing numbers to express all the variables and quantities of a problem. The numbers are usually expressed as a space-time distribution of punched holes, electrical pulses, sonic pulses, etc.

COMPUTER, SYNCHRONOUS

a calculating device in which the performance of all operations is controlled with periodic signals from a master clock.

CONJUNCTION

in logical design, normally an "And" function; see And-Operator.

CONTENTS

the information stored in any storage medium. Quite prevalently, the symbol ( ) is used to indicate "the contents of"; e,g., (m) indicates the contents of the storage location whose address is m; (A) indicates the contents of register A; (T_2) may indicate the contents of the tape on input-output unit two.

CONTROL

(1) Usually, those parts of a digital computer which effect the carrying out of instructions in proper sequence, the interpretation of each instruction, and the application of the proper signals to the arithmetic unit and other parts in accordance with this interpretation. (2) Frequently, one or more of the components in any mechanism responsible for interpreting and carrying out manually-initiated directions. Sometimes called manual control. (3) In some applications of mathematics, a mathematical check.

CONTROL, CASCADE

an automatic control system in which various control units are linked in sequence, each control unit regulating the operation of the next control unit in line.

CONTROL-SEQUENCE

the normal order of selection of instructions for execution. In some computers, one of the addresses in each instruction specifies the control sequence. In most other computers the sequence is consecutive except where a Jump occurs.

CONTROL, SEQUENTIAL

a manner of operation of a computer such that instructions are fed to or stored in the computer in a given order during the solution of a problem and the computer executes these instructions in a given order.

CONTROL-UNIT

that portion of the hardware of an automatic digital computer which directs the sequence of operations, interprets the coded instructions, and initiates the proper commands to the computer circuits to execute the instructions.

CONVERT

to change numerical information from one number base to another (e.g., decimal to binary) and/or from some form of fixed point to some form of floating-point representation, or vice versa; occasionally to transfer information from one recorded medium to another.

CONVERTER

a unit which changes the language of information from one form to another so as to make it available or acceptable to another machine, e.g., a unit which takes information punched on cards to information recorded on magnetic tape, possibly including editing facilities.

COPY

to reproduce information in a new location, replacing whatever was previously stored there, and usually leaving the information unchanged at the original location.

CORE, MAGNETIC

a magnetic material capable of assuming and remaining at one of two or more conditions of magnetization, thus capable of providing storage, gating or switching functions, usually of toroidal shape and pulsed or polarized by electric currents carried on wire adjacent the material.

COUNTER

a device, register, or storage location for storing numbers or integers, permitting these integers to be increased or decreased by unity or by an arbitrary number or integer, and capable of being reset to zero or to an arbitrary number.

COUNTER, CONTROL

a device which records the storage location of the instruction word, which is to be operated upon following the instruction word in current use. The control counter may select storage locations in sequence, thus obtaining the next instruction word from the subsequent storage location, unless a transfer or special instruction is encountered.

COUNTER, RING

a loop of interconnected bistable elements such that one and only one is in a specified state at any given time and such that, as input signals are counted, the position of the element in the specified state "moves" in an ordered sequence around the loop.

COUPLING

the means by which energy is transferred from one circuit to another; the common impedance necessary for coupling.

COUPLING, CAPACITIVE

a method of transferring energy from one circuit to another by means of a capacitor that is common to both circuits.

COUPLING, DIRECT

a method of transferring energy from one circuit to another by means of resistors common to both circuits.

CRT

cathode ray tube; a device yielding a visual plot of the variation of several parameters by means of a proportionally deflected beam of electrons.

CYBERNETICS

the comparative study of the control and intracommunication of information handling machines and nervous systems of animals and man in order to understand and improve communication.

CYCLE

a set of operations repeated as a unit; a non-arithmetic shift in which the digits dropped off at one end of a word are returned at the other end in circular fashion; cycle right and cycle left. To repeat a set of operations a prescribed number of times including, when required, supplying necessary address changes by arithmetic processes or by means of a hardware device such as a B-box or cycle-counter.

CYCLE COUNT

to increase or decrease the cycle index by unity or by an arbitrary integer or number.

CYCLE-CRITERION

the total number of times the cycle is to be repeated; the register which stores that number.

CYCLE-INDEX

the number of times a cycle has been executed; or the difference, or the negative of the difference, between that number and the number of repetitions desired.

CYCLE, MAJOR

the maximum access time of a recirculating serial storage element; the time for one rotation, e.g., of a magnetic drum or of pulses in an acoustic delay line; a whole number of minor cycles.

CYCLE, MEMORY

a repeated, periodic sequence of events occurring when information is transferred to or from the storage device of a computer. Storing, sensing, and regeneration form parts of the storage sequence. Usually a "timing chart", showing pulse times on all leads to a storage cell describe such a cycle.

CYCLE, MINOR

the word time of a serial computer, including the spacing between words.

CYCLE, RESET

to return a cycle index to its initial value.

DAMPING

a characteristic built into electrical circuits and mechanical systems to prevent rapid or excessive corrections which may lead to instability or oscillatory conditions, e.g., connecting a resistor on the terminals of a pulse transformer to remove natural oscillations; placing a moving element in oil or sluggish grease to prevent overshoot.

DATA-REDUCTION

the art or process of transforming masses of raw test or experimentally obtained data, usually gathered by instrumentation, into useful, ordered, or simplified intelligence.

DATA-REDUCTION, ON-LINE

the processing of information as rapidly as the information is received by the computing system or as rapidly as it is generated by the source.

DEBUG

to isolate and remove all malfunctions from a computer or all mistakes from a routine.

DECADE

a group or assembly of ten units, e.g., a decade counter counts to ten in one column; a decade resistor box inserts resistance quantities in multiples of powers of 10; ten years.

DECIMAL, CODED, BINARY

decimal notation in which the individual decimal digits are represented by some binary code, e.g., in the 8-4-2-1 coded decimal notation, the number twelve is represented as 0001 0010 for 1 and 2, respectively, whereas in pure binary notation, it is represented as 1100. Other coded decimal notations are used, e.g., 5-4-2-1, excess three, 2-4-2-1, etc.

DECODE

to ascertain the intended meaning of the individual characters or groups of characters in the pseudo-coded program.

DECODER

a device capable of ascertaining the significance or meaning of a group of signals and initiating a computer event based thereon; matrix.

DECREMENT-FIELD

a portion of an instruction word set aside specifically for modifying the contents of a register or memory location specified by the tag digits of the same instruction word.

DEFLECTION-SENSITIVITY

in connection with Cathode Ray Tubes, it is the quotient of the displacement of the electron beam at the place of impact by the change in deflecting as was. It is usually expressed in millimeters per volt applied between the deflection electrodes, or in millimeters per gauss of the deflecting magnetic field.

DELAY-LINE, ELECTRIC

a transmission line of lumped or distributed capacitive and inductive elements in which the velocity of propagation of electromagnetic energy is small compared with the velocity of light. Storage may be accomplished by re-circulation of wave patterns containing information, usually in binary form.

DELAY-LINE, MAGNETIC

a magnetic medium along which the velocity of propagation of magnetic energy is small relative to the speed of light. Storage is accomplished by recirculation of wave patterns containing information, usually in binary form.

DELAY-LINE, MERCURY or QUARTZ

a sonic or acoustic delay-line in which mercury or quartz is used as the medium of sound transmission, with transducers on each end to permit conversion to and from electrical energy; See Delay-line, Sonic or Acoustic.

DELAY-LINE, SONIC or ACOUSTIC

a device capable of transmitting retarded sound pulses, transmission being accomplished by wave patterns of elastic deformation. Storage is accomplished by re-circulation of wave patternsn containing information, usually in binary form.

DENSITY, PACKING

the number of units of useful information contained within a given linear dimension, usually expressed in units per inch, e.g., the number of binary digit magnetic pulses stored on tape or drum per linear inch on a single track by a single head.

DESIGN, LOGICAL

(1) The planning of a computer or data-processing system prior to its detailed engineering design. (2) The synthesizing of a network of logical elements to perform a specified function. (3) The result of (1) and (2) above, frequently called the logic of the system, machine, or network.

DIAGRAM, BLOCK

a schematic representation of a sequence of subroutines designed to solve a problem; a coarser and less symbolic representation than a flow chart, frequently including descriptions in English words; a schematic or logical drawing showing the electrical circuit or logical arrangements within a component.

DIAGRAM, LOGICAL

in logical design a diagram representing the logical elements and their interconnections without necessarily expressing construction or engineering details.

DIFFERENTIATOR

a device whose output function is proportional to a derivative of its input function with respect to one or more variables.

DIGIT

one of the n symbols of integral value ranging from 0 to n-1 inclusive in a scale of numbering of base n, e.g., one of the ten decimal digits, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9.

DIGIT, BINARY

a whole number in the binary scale of notation; this digit may be only 0 (zero) or 1 (one). It may be equivalent to an "on" or "off" condition, a "yes" or a "no", etc.

DIGIT, DECIMAL, CODED

one of ten arbitrarily-selected patterns of ones and zeros used to represent the decimal digits.

DIGITAL

the quality of utilizing numbers in a given scale of notation to represent all the quantities that occur in a problem or a calculation.

DIGITIZE

to render an analog measurement of a physical variable into a numerical value, expressing the quantity in digital form.

DIGITS, EQUIVALENT BINARY

the number of binary digits required to express a number in another base with the same precision, e.g., approximately 3 1/3 times the number of decimal digits is required to express a decimal number in binary form. For the case of coded decimal notation, the number of binary digits required is 4 times the number of decimal digits.

DISJUNCTION

in logical design, normally an "OR" function; see OR-Operator

DOWN-TIME

the period during which a computer is malfunctioning or not operating correctly due to machine failures; contrasted with available time, idle time or standby time. Scheduled maintenance time is also considered down-time, in as much as the computer is unable to operate during this period.

DRUM, MAGNETIC

a rotating cylinder on whose magnetic-material coating information is stored in the form of magnetized dipoles, the orientation or polarity of which is used to store binary information.

DUMMY

an artificial address, instruction, or other unit of information inserted solely to fulfill prescribed conditions (such as word-length or block-length) without affecting operations.

DUMP, A. C.

the removal of all A. C. power, intentionally, accidentally or conditionally from a system or component. An A. C. dump usually results in the removal of all power.

DUMP, D. C.

the removal of all D.C. power, intentionally, accidentally, or conditionally, from a system or component.

DUMP, POWER

the removal of all power accidentally or intentionally.

ECCLES-JORDAN (TRIGGER)

a direct coupled multivibrator circuit possessing two conditions of stable equilibrium. Also known as a flip-flop circuit or "toggle".

ECHO CHECKING

a system of assuring accuracy by reflecting the transmitted information back to the transmitter and comparing the reflected information with that which was transmitted.

EDIT

to rearrange information. Editing may involve the deletion of unwanted data, the selection of pertinent data, the insertion of invariant symbols such as page numbers and typewriter characters, and the application of standard processes such as zero-suppression.

ELECTRONIC

pertaining to the application of that branch of science which deals with the motion, emission and behavior of currents of free electrons, especially in vacuum, gas or phototubes and special conductors or semi-conductors. Contrasted with electric which pertains to the flow of large currents in wires or conventional conductors.

ELEMENT, LOGICAL

in a computer or data-processing system, the smallest building blocks which can be represented by operators in an appropriate system of symbolic logic. Typical logical elements are the and-gate and the flip-flop, which can be represented as operators in a suitable symbolic logic.

ELEVATION

the angular measurement in a vertical plane from a specific reference, usually the horizontal plane.

ENCODER

a network or system in which usually one input is excited at a time and each input produces a combination of outputs. Sometimes called matrix.

ERASE

to replace all the binary digits in a storage device by binary zeros. In a binary computer, erasing is equivalent to clearing, while in a coded decimal computer where the pulse code for decimal zero may contain binary ones, clearing leaves decimal zero while erasing leaves all-zero pulse codes.

ERROR

the amount of loss of precision in a quantity; the difference between an accurate quantity and its calculated approximation; errors occur in numerical methods, e.g. an error introduced by the truncation of a power series defining a transcen dental function. This may be classified as an error introduced by the numerical method, there is no mistake involved and the computer is operating properly; mistakes occur in programming, coding, data transcription, and operating; thus, usually humans make mistakes, e.g., assigning a wrong address when coding a problem; malfunctions occur in computers and are due to physical limitations on the properties of materials. An error is sometimes considered to be the differential margin by which a controlled unit deviates from its target value.

ERROR, INHERITED

the error in the initial values; especially the error inherited from the previous steps in the step-by-step integration. This error could also be the error introduced by the inability to make exact measurements of physical quantities.

ERROR, ROUNDING

the error resulting from deleting the less significant digits of a quantity and applying some rule of correction to the part retained. A common round-off rule is to take the quantity to the nearest digit. Thus, pi, 3.14159265..., rounded to four decimals is 3.1416. Note; Alston S. Householder suggests the following terms: "initial errors","generated errors", propagated errors" and "residual errors". If x is the true value of the argument, and x^* the quantity used in computation, then assuming one wishes $f(x)$, $x-x^*$ is the initial error; $f(x) - f(x^*)$ is the propagated error. If f_a is the Taylor, or other, approximation utilized, then $f(x^*) - f_a(x^*)$ is the residual error. If f^* is the actual result then $f_a - f^*$ is the generated error, and this is what builds up as a result of rounding.

ERROR, TRUNCATION

the error resulting from the use of only a finite number of terms of an infinite series, or from the approximation of operations in the infinitesimal calculus by operations in the calculus of finite differences.

EXCHANGE

to interchange the contents of two storage devices or locations.

EXCLUSIVE-OR-OPERATOR

a logical operator which has the property that if P and Q are two statements, then the statement $P \not\equiv Q$ (i.e. $\not\equiv$ is Exclusive-Or Operator) is true or false depending whether the variables are odd or even, e. g.

P	Q	$P \not\equiv Q$	
0	1	1	(odd)
1	0	1	(odd)
1	0	1	(even)
0	0	0	(even)

Note that the Exclusive-OR is the same as the Inclusive-Or, except that the case for both inputs present yields no output. See Inclusive-OR; $P \not\equiv Q$ is True if P or Q are true, but not both. Primarily used in comparator circuits.

EXTRACT

to remove from a set of items of information all those items that meet some arbitrary criterion; to replace the contents of specific parts of a quantity (as indicated by some other quantity called an extractor) by the contents of specific parts of a third quantity, e.g., if the number 01101 is stored, the machine can remove and act upon or according to the third digit, in this case a 1.

FACTOR, SCALE

one or more coefficients used to multiply or divide quantities in a problem in order to convert them so as to have them lie in a given range of magnitude, e.g., plus one to minus one.

FEED, CARD

a mechanism which moves cards serially into a machine.

FERROELECTRIC

a phenomenon exhibited by materials within which permanent electric dipoles exist and a residual displacement in the D-E plane occurs, where $D = E + 4\pi P$, (vectorial), in which D is the electric displacement vector, E is the applied electric field strength and P is a measure of the degree of polarization. Thus, E is measurable, e.g., as potential difference per unit length force per unit charge, or lines of force per unit area. The polarization P, is measured in dipoles per unit volume or charge moved across a unit area upon application of an electric field. In ferroelectric materials there is a residual polarization, P_r .

Note the similarity for ferromagnetics: $B = H + 4\pi M$, where B is the magnetic induction, i.e. total lines of force per unit area, H is the magnetic field intensity usually produced by a distribution of electric currents and M is the magnetic polarization. It is because of the similarity of behavior, described by these two equations, that the phenomenon of ferroelectricity is described using the prefix "ferro", i.e. "pertaining to or like unto iron".