File Number 1440-01
Form A26-5666-0

IBM Systems Reference Library

IBM 1440 System Component Description
1441 Processing Unit
1447 Console

This manual contains a brief description of the complete 1440 Data Processing System and a detailed description of the Processing Unit and Console. An introduction to stored program concepts, and a detailed discussion of operation codes is also included. This manual contains a character coding chart and a complete list of instruction times for all instructions used in the 1440 Data Processing System.

Address comments regarding the content of this publication to IBM Product Publications, Endicott, New York

CONTENTS

IBM 1440 Data Processing System

INTRODUCTION

The IBM 1440 Data Processing System represents a major advance in low-cost data processing systems. The IBM 1440 offers small companies the functional capabilities of large data processing systems, but at speeds and costs in keeping with their needs and abilities. The input and output devices of the 1440 enable it to be effective in system areas where there has long been a need for a data processing system but not the volume of work to justify such a system. Processing methods of the 1440 are similar to those of the IBM 1401 Data Processing System.

The IBM 1440 is a solid-state system with compact components and input/output devices that enable it to be located in an area approximately 15' x 15'. In addition to its features of compactness and low-cost, the 1440 presents a new concept in data processing with the introduction of the removable disk pack.

In 1953 the introduction of IBM magnetic tape systems provided data processing systems with the ability to process large volumes of input and output data at very high speeds. Magnetic tape offered the advantage of providing virtually unlimited storage capacity. In 1956 the RAMAC® Disk File introduced a new concept in data processing, permitting, as it did, storage of large volumes of data that were accessible in a random sequence. The removable disk pack combines the large volume and sequential processing advantages of tape systems with the random access abilities of a RAMAC file. The disk pack is an operator removable package of six disks that is placed on an IBM 1311 Disk Storage Drive.

The 1311 Disk Storage Drive for the 1440 Data Processing System provides virtually unlimited random and sequential access storage. A disk pack containing 2,000,000 characters of information can be removed from the 1440 system and another pack put into its place in one to two minutes.

The ease of mobility of a disk pack (the weight of the pack is less than 10 lb) and the simplicity of its removal from the file means that 2,000,000 characters of data can be placed in the system within seconds. Data can be organized in the disk pack in random or sequential order; regardless of how the data is located on the disk pack, it can be retrieved by the system in a random or sequential order with equal facility, depending upon individual requirements. Up to five disk drives, each equipped with one disk pack, can be attached "on line" to provide 10,000,000 characters of information available at one time (equivalent to 125,000, 80-column IBM cards).

The 1440 is primarily a file system, providing a group of balanced input/output devices to work in conjunction with the high-speed 1441 Processing Unit and with the 1311 Disk Storage Drive. For operations that require extensive calculating ability and do not need disk storage, the 1440 functions as a powerful card system.

The IBM 1440 is available in various configurations to satisfy the requirements of individual users. It can be ordered to meet the basic requirements of an accounting system, and then increased in size as data processing requirements increase. If the 1440 is expanded to its maximum size and data processing requirements continue to grow, procedures and systems developed for the IBM 1440 can be readily adapted for processing on the medium-size IBM 1401. With continued expansion and growth, adaptation to the larger size IBM 1410 can be made.

This is why we refer to the 1440 as a member of the 1400 series family.

PHYSICAL FEATURES OF THE IBM 1440 DATA PROCESSING SYSTEM

The units that make up the 1440 system are compact, modern in design, and mobile — features permitting an operating arrangement that is both convenient and efficient. The IBM 1440 Data Processing System is composed of five units described in the following publications:

1440-01

The IBM 1441 Processing Unit, Model A-3 contains 4,000 positions of alphameric core storage. The Model A-4 contains 8000 positions of storage, the Model A-5 12,000 positions, and the Model A-6 16,000 positions.

The IBM 1447 Console, Model 1 contains the operating keys, lights, and switches that permit operator control over the entire 1440 system. The 1447 Model 2 has the additional feature of a Console Printer for direct input and output to the Processing Unit and to the Disk Storage unit and for altering and displaying data located in core storage. The Console Printer, located on the table top in front of the console panel, prints output data at a rate of 14.8 characters per second. The speed of entering input data depends upon the typing speed of the operator.

1440-03

The IBM 1442 Card Read Punch is available in two models. Model 1 reads cards at a rate of 300 cards per minute (cpm). Punching speed depends upon the last column punched; and ranges from 50 cpm when all 80 columns are punched, to 180 cpm when the first 10 columns are punched. The Model 2 reads at a rate of 400 cpm. Punching speed is 91 cpm when all 80 columns are punched and 270 cpm when the first 10 columns are punched.

The IBM 1443 Printer, Model 1 is capable of printing from 120 to 430 lines per minute, with a print span of 120 positions per line of alphabetic and numerical data. The print span can be expanded to 144 positions as a special feature.

1440-07

The IBM 1311 Disk Storage Drive equipped with a disk pack can store 2,000,000 characters of information.

1440-13

Special Features are available to add speed, flexibility, and additional capacity to the 1440 Data Processing System. For example special features available with the IBM 1440 include the Track Record feature, the Direct Seek feature, and Print Storage. The Track Record feature when used with the disk pack enables it to store up to 2,980,000 characters. As many as five Disk Storage drives can be placed on a line, increasing storage from a total of 10,000,000 characters to a total of 14,900,000 characters with the Track Record feature. Average access time is 250 milliseconds (ms), maximum access time is 400 ms. With the Direct Seek feature, the average access time is 150 ms, maximum access time is 250 ms. The Print Storage feature permits faster throughput in programs characterized by large amounts of printed output data.

The Processing Unit (Figure 1) contains the magnetic core storage unit and the logic and arithmetic units that control the entire system.

The Processing Units stores both program instructions and data. It employs a variable-word-length concept in which each storage position is addressable. Each of the storage positions is identified by an address consisting of three characters. The first 1000 positions of storage have the addresses 000 through 999. The remaining storage positions require the use of an alphabetic or special character in the hundreds position of the address. Figure 2 illustrates the coding method used for 4000 positions of core storage. The coding methods used for core storage positions greater than 4000 positions is shown in the publication 1440 System Component Description, Special Features 1440-13.

This variable-word-length principle in which words are not limited to any predetermined number of character positions in the storage unit, is one of the most important characteristics of the IBM 1440 Data Processing System.

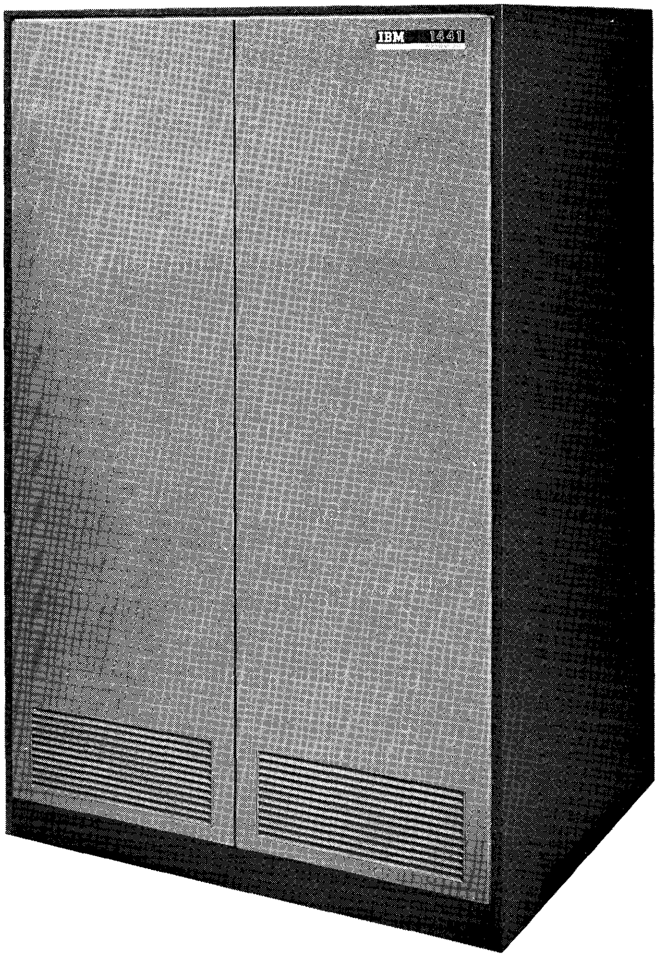


Figure 1. IBM 1441 Processing Unit

Coded Addresses in Storage

Actual Addresses		3-Character Addresses
000 to 999	No zone bits	000 to 999
1000 to 1099		‡00 to ‡99
1100 to 1199		/00 to /99
1200 to 1299		S00 to S99
1300 to 1399		T00 to T99
1400 to 1499	A bit	U00 to U99
1500 to 1599	using 0-zone	V00 to V99
1600 to 1699		W00 to W99
1700 to 1799		X00 to X99
1800 to 1899		Y00 to Y99
1900 to 1999		Z00 to Z99
2000 to 2099		!00 to !99
2100 to 2199		J00 to J99
2200 to 2299		K00 to K99
2300 to 2399		L00 to L99
2400 to 2499	B bit	M00 to M99
2500 to 2599	using 11-zone	N00 to N99
2600 to 2699		*O00 to O99
2700 to 2799		P00 to P99
2800 to 2899		Q00 to Q99
2900 to 2999		R00 to R99
3000 to 3099		?00 to ?99
3100 to 3199		A00 to A99
3200 to 3299		B00 to B99
3300 to 3399		C00 to C99
3400 to 3499	A and B bits	D00 to D99
3500 to 3599	using 12-zone	E00 to E99
3600 to 3699		F00 to F99
3700 to 3799		G00 to G99
3800 to 3899		H00 to H99
3900 to 3999		I00 to I99

* Letter O followed by zero zero

Figure 2. Storage Address Codes

PROCESSING

VARIABLE WORD LENGTH

Stored programming involves the concept of words. A 1440 word can be a single character, or a group of characters, that represent a complete unit of information. Because IBM 1440 words are not limited to a specific number of storage positions -- i.e., have variable word length -- and because each position of core storage is addressable, each word occupies only the number of core storage locations actually needed for the specific instruction or data field.

Word Mark

The use of variable length instructions and variable length data requires a method of determining the length of individual instructions and the length of data fields in storage. This identification is provided by a word mark.

The word mark is a special bit that is added to BCD (binary-coded-decimal) coding in core storage. The word mark associated with a character in core storage serves the same function as a surveyor's stake located at the edge of a property line; it defines the length of a data record and separates one data record from another.

The word mark has three basic functions:

1. To indicate the beginning of an instruction.
2. To define the length of a data word.
3. To signal the end of execution of an instruction.

The rules governing the use of word marks are:

1. In planning the program, word marks must be assigned locations. These predetermined word marks are normally expected to remain in these locations throughout the complete program. The word marks are set into storage locations by a loading routine.
2. Word marks are not moved with data during processing, except when a load instruction is used (see MOVE and LOAD).
3. In an arithmetic operation, a defining word mark must be placed in the field in which the answer is developed (B field). The factor used to modify the B field (the A field) must have a word mark only when it is shorter than the B field.
4. The word mark and data from one field (A field) is moved to another field (B field) by a load instruction which clears any other word marks in the designated B field, up to the length of the A field.
5. When moving data from one location to another, only one of the fields need have a defining word mark, because the move instruction implies that both fields are of the same length.
6. A word mark must be associated with the leftmost character (which is the operation code) of every instruction.
7. A word mark must follow each instruction. The Unconditional Branch instruction and the two-address Set Word Mark instruction are exceptions to this rule.

Two operation codes are provided for setting and clearing word marks during program execution.

STORED PROGRAMMING INSTRUCTIONS

All system functions are performed in accordance with the instructions retained in storage. These instructions have a particular format.

Instruction Format

OP code	A or I address	B address	d character
X	XXX	XXX	X

The OP code is always a single character that defines the basic operation to be performed. A word mark is always contained within the operation code position of an instruction.

The A address always consists of three characters. It may contain the storage address of the rightmost position of the A field, or it can be used to select an input/output device or a special unit or feature.

The I address is used by instructions that cause the program to branch from one instruction to another, to specify the location of the next instruction to be executed if a branch occurs.

The B address is always a three-character storage address that may contain the storage address of the rightmost position of the B field. In input/output operations it specifies the leftmost position of a record storage area.

The d character makes individual program operations flexible. One operation code can be used with many variations, depending upon the particular d character used with it. The d character is a single alphabetic, numerical, or special character, positioned as the last character of an instruction.

Address Registers

There are three address registers in the IBM 1441 Processing Unit: one controls program sequence, the other two control the transfer of data from one storage location to another.

I-ADDRESS REGISTER. The I-(Instruction) address register always contains the storage location of the next instruction character to be used by the stored program. The number in this register is increased by one as the instruction is read from left to right.

A-ADDRESS REGISTER. The A-address register normally contains the storage address of the data in the A-address portion of an instruction. As the instruction is executed, the number in this register is normally decreased by 1 after each storage cycle that involves the A address.

B-ADDRESS REGISTER. This register normally contains the storage location of the data in the B-address portion of an instruction. As a storage cycle involving the B address is executed, the storage address in the B-address register is normally decreased by one. For file and input/output instructions, the register is increased by one.

Character Registers

The A-character and B-character registers and the OP register are single-character registers used to store data during execution of an instruction.

OP REGISTER. The OP (operation) register stores the operation code of the instruction in process for the duration of the operation. The operation code, together with the check bit but excluding the word mark, is stored in BCD code.

B REGISTER. Each character leaving 1440 core storage enters the B register. The character is stored in 8-bit form (BCD code, check bit, and word mark). On every storage cycle, the B register is reset and filled with a character from core storage.

A REGISTER. The A register is reset and filled with the character from the B register during each storage cycle that involves the A address, and during all instruction cycles except the first and last I (instruction) cycle of each instruction. Data is stored in 8-bit form.

Chaining Instructions

In some programs it is possible to perform a series of operations on several fields located in consecutive storage locations. Some basic operations, such as ADD, SUBTRACT, and MOVE have the ability to be chained so that less time is required to perform the operations, and less storage space is required for the instructions.

As an example of the chaining technique, assume that four 5-position fields stored in sequence are to be added to four other sequential fields. This operation could be done using four 7-character instructions:

	A address	B address
A	700	850
A	695	845
A	690	840
A	685	835

At the completion of the first instruction, the A-address register would contain 695 and the B-address register would contain 845. These are the same numbers that are in the A and B addresses in the second instruction. Eighty storage cycles would be required to execute these instructions using .888 milliseconds of operation time and 28 positions of storage for the instructions.

By taking advantage of the fact that the A-address and B-address registers contain the necessary information to perform the next instruction, this same sequence of operations can be executed by connecting instructions or chaining as it is called. For example, if the instructions are:

	A address	B address
A	700	850
A		
A		
A		

The first add instruction contains both the A and B addresses. The following three instructions contain only the operation code for those instructions. The A and B addresses are the results left in the A- and B-address registers from the previous instruction.

This type of operation requires 62 storage cycles and takes .688 ms to execute. Storage of these chained instructions requires only ten storage positions.

The ability to chain a series of instructions depends not on the use of the same operation code -- chained instructions may have various OP codes -- but on the sequential location of the fields. All the A fields must be in sequence and all B fields must be in sequence. As another example, suppose the instructions are:

	A address	B address
A	900	850
M		
A		
M		

Assume that the data fields are each ten characters long.

The ten characters at location 900 are added to 850.

The ten characters at location 890 are moved to 840.

The ten characters at location 880 are added to 830.

The ten characters at location 870 are moved to 820.

Using the information on the contents of the address registers that appears in the Instruction Times in Appendix A, the programmer can determine whether chaining is practical in specific cases.

NOTE: Instructions containing other than 1440 storage addresses cannot be chained. For example, M %Gn xxx R is a Read Card instruction. The Card Read Punch is signaled as the machine reads the instruction. Although the A-address register contains %Gn after the operation, chaining is impossible because the machine does not select the unit from the contents of the A-address register.

Most single-address instructions (OP code and an A-address) cause the A address to be inserted in both the A-address and B-address registers (for example A xxx). However, MOVE, LOAD, and STORE A-address register, or STORE B-address register (OP codes, M, L, Q, and H) do not disturb the B-address register, and therefore permit the programmer to use the previous contents of that register as part of the instruction.

All no-address instructions (OP code only) use the previous contents of the A-address and B-address registers.

The contents of the B-address register after a branch instruction (OP code and I address) depend on whether the Store Address feature is installed in the 1440:

1. With the Store Address feature installed, the B-address register contains the address of the next sequential instruction, if a branch occurs.
2. Without the Store Address feature installed, the B-address register is cleared to blanks whenever a branch occurs.

The description of the operation codes in this manual contains the machine language operation codes and the 1440 Autocoder Programming Mnemonic operation codes.

Autocoder

The IBM 1440 Autocoder is designed to simplify the preparation of programs for 1440 systems. The Autocoder enables the user to write programs using meaningful names (symbols) for data and instruction locations, rather than actual machine location numbers. A program to compute a payroll operation can use such names as MANNO, HRSWKD, RATE, and FICA. Also, instruction locations can be named symbolically when they are referred to by other instructions.

Source programs written in Autocoder language are punched into cards, and are then read into the 1440 and acted upon by an assembly program (Processor) provided by IBM. This program causes the 1440 to produce an equivalent machine language program in punched card form.

The Processor contains a listing routine that causes the symbolic source program to be printed out. The programmer can thus check it for accuracy before assembling the machine language (object) program. The object program is punched in cards and includes a self-loading routine.

When the object program and the data cards are processed together on the 1440 system the desired computations are carried out.

More detailed information about programming with Autocoder can be obtained from the IBM 1440 Autocoder Bulletin and the IBM 1440 Programmer's Guide.

ARITHMETIC OPERATIONS

The IBM 1440 Data Processing System adds and subtracts, by applying the add-to-storage method. The two factors to be combined are added and stored in core storage without the use of special accumulators or counters. Because any storage area can be used as an accumulator field, the capacity for performing arithmetic functions is not limited to standard-size accumulators or to predetermined number of accumulators within the system. In arithmetic operations, the 1440 system considers blanks and zeros the same. An unsigned field is considered positive by the system.

The design of the IBM 1440 Data Processing System provides for two types of add operations:

1. True Add
2. Complement Add

The type of operation performed depends on the operation code and the algebraic signs of the factors. The resultant sign depends on the algebraic values of the factors (Figure 3).

A negative sign is indicated by a B bit in the rightmost position of a field. Any other zone-bit combination in the rightmost position is considered a plus sign (A bit and B bit, A bit no-B bit, or no-A bit no-B bit). Either A and B bits or no-A no-B bits should be used for signing a positive field.

True Add

In a true add operation the result always carries the sign of the B field (Figure 4).

Complement Add

If a complement add is initiated (see Figure 3), the machine converts the A field to its tens complement

A field sign	+	–	+	–
B field sign	+	–	–	+
Type of add	True	True	Comp	Comp
Sign of result	Sign B	Sign B	Sign of B field unless A > B	

Figure 3. Algebraic Sign Control for Add Operation

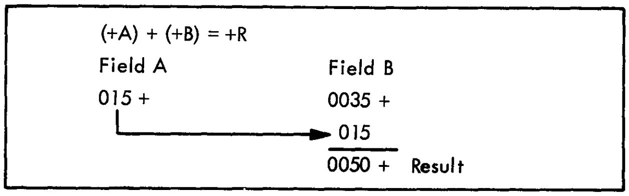


Figure 4. True Add

figure and adds it to the B field. The machine tests to determine whether a carry occurred from the leftmost position of the B field. The presence of a carry indicates that the result in the B field is the true answer and the operation is terminated. The sign of the B field is the sign of the result (Figure 5).

If there is no carry from the leftmost position of the B field, it indicates that the A field was algebraically larger and that the result is not a true figure but is stored in its tens complement form. A recomplement cycle is performed automatically to convert the answer to true form.

To do this, the machine examines each digit in the B field from the leftmost to the rightmost position until it detects a B bit. The B bit, located in the sign (rightmost) position of the field initiates the actual recomplement of the result. It changes the sign of the result and converts (from right to left) each digit to true form (Figure 6).

Add

Mnemonic	OP code	A address	B address
A	A	xxx	xxx

The data in the A field is added algebraically to the data in the B field. The result is stored in the B field.

The B field must have a defining word mark, because it is this word mark that stops the add operation.

The A field must have a word mark only if it is shorter than the B field. Transmission of data from the A field stops after an A-field word mark is sensed. Zeros are inserted in the A register until the B-field word mark is sensed.

If the A field is longer than the B field, the leftmost positions of the A field that exceed the limits imposed by the B-field word mark are not processed. For overflow conditions and considerations, assume that the A field is the same length as the B field.

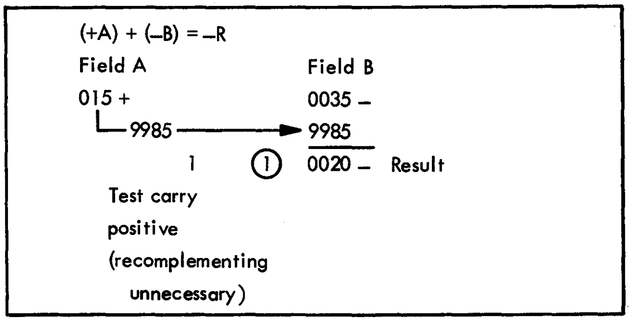


Figure 5. Complement Add with no Recomplementing

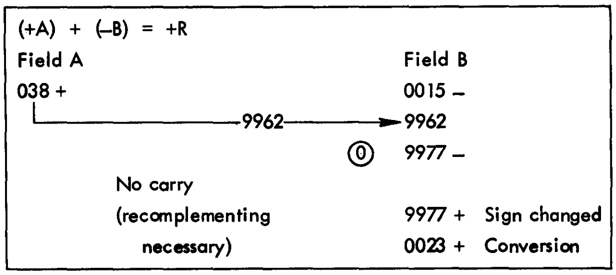


Figure 6. Complement Add with Recomplementing

If a recomplement cycle is automatically taken, the sign of the B (result) field is changed and the result is always stored in true form.

In a true-add operation, if the fields to be added contain zone bits in other than the leftmost position of the B field or the sign positions of both fields, only the digits are used. B-field zone bits are removed except for the rightmost and leftmost positions. If a complement add takes place, zone bits are removed from all but the rightmost position of the B field.

If an overflow occurs during a true-add operation, a special overflow indicator is set, and the overflow indications are stored over the leftmost digit of the B field:

Condition	Result
First overflow	A bit
Second overflow	B bit
Third overflow	A and B bits
Fourth overflow	No A or B bits

For subsequent overflows, repeat conditions 1 - 4.

The Branch If Indicator On (B xxx Z) instruction tests and turns off the overflow indicator and branches to a special instruction or group of instructions if this condition occurs. There is only one overflow indicator in the system. It is turned off by a Branch If Indicator On instruction, or by pressing the Start Reset key.

Add (Single Address)

Mnemonic	OP code	A address
A	A	xxx

This format of the Add instruction causes the data in the A field to be added to itself.

The A field must have a defining word mark. It is this word mark that stops the add operation. This instruction must be followed by a word mark in the position after the A address.

Zero and Add

Mnemonic	OP code	A address	B address
ZA	?	xxx	xxx

This instruction is similar to the Add instruction, except that the entire B field is set to zero before the data is added. The data from the A field moves directly from A register to storage. Zone bits are stripped from all positions except the rightmost position. Blanks in the A field are stored as blanks in the B field.

A word mark is required for definition of the B field. It is required in the A field only if it is shorter than the B field. If the A field is shorter than the B field, all extra leftmost B field positions will contain zeros. But the transmission of data from A stops when the A-field word mark is detected.

Subtract

Mnemonic	OP code	A address	B address
S	S	XXX	XXX

The numerical data in the A field is subtracted algebraically from the numerical data in the B field (Figure 7). The result is stored in the B field.

A word mark is required to define the B field. An A field requires a word mark only if it is shorter than the B field. In this case, the A-field word mark stops transmission of data from the A field.

Subtract (Single Address)

Mnemonic	OP code	A address
S	S	XXX

A field sign	+	–	+	–
B field sign	+	–	–	+
Type of add	Comp	Comp	True	True
Sign of result	Sign of B field unless A> B		Sign B	Sign B

Figure 7. Algebraic Sign Control for Subtraction

This format of the subtract instruction causes the data at the A address to be subtracted from itself. If the A-field sign is minus, the result is a minus zero. If the A-field sign is plus, the result is a plus zero.

The A field must have a defining word mark. This instruction must be followed by a word mark in the position after the A address.

Zero and Subtract

Mnemonic	OP code	A address	B address
ZS	!	XXX	XXX

This code performs an operation similar to the subtract instruction, except that the B field is set to zero before the subtract operation takes place. The data from the A field is moved to the B field. Zone bits are stripped in all but the sign (rightmost) position. Blanks in the A field are stored as blanks in the B field.

If the A field is positive, the B field result is negative. If the A field is negative, the B field result is positive.

A word mark is required to define the B field. If the A field is shorter than the B field, the A field must have a defining word mark to stop transmission of data to B. The extra leftmost B-field positions contain zeros if A is shorter than B.

Zero and Subtract (Single Address)

Mnemonic	OP code	A address
ZS	!	XXX

This instruction causes the sign of the A field to be changed.

The data in the A field requires a word mark in its leftmost position.

LOGIC OPERATIONS

The logic operation codes provide the decision-making ability of the IBM 1440 Data Processing System. They allow the program to test for conditions that can arise during processing, and to branch to predetermined sets of instructions or subroutines as a result of a specific condition.

For example, if an overflow occurs in an arithmetic operation, a special routine to handle this condition can be initiated by a BRANCH IF INDICATOR ON instruction.

Any operation that terminates with a successful branch to another portion of core storage for the next instruction address operates as follows:

> The B-address register is reset to blanks during the next instruction operation (I-OP) cycle.
>
> If the Store Address special feature is installed on the system, the next sequential instruction (NSI) is placed in the B-address register and during the following instruction the B-address register is not set to blanks.

Branch Unconditional

Mnemonic	OP code	I address
B	B	XXX

This instruction always causes the program to branch to the instruction specified by the I address. It is used to interrupt normal program sequence and to continue the program at any desired point, without testing for specific conditions. It must be followed by a word mark or a blank in the next position.

Word marks are not affected.

Branch If Indicator On

OP code	I address	d character
B	XXX	X

The d character specifies the indicator tested. If the indicator is on, the next instruction is taken from the I address. If the indicator is off, the next sequential instruction is taken. Figure 8 shows characters that are valid for the d character and for the indicators they test.

Word marks are not affected.

d Character		Branch on	Reset by	Mnemonic
b̸		Unconditional		B
9		Carriage Channel #9	Branch Test or Channel #1 Hole	BC9
@		Carriage Channel #12	Branch Test or Channel #1 Hole	BCV
A		"Last Card" switch (sense switch A)	Manual	BLC
B	*	Sense Switch B		BSS †
C	*	Sense Switch C		BSS †
D	*	Sense Switch D		BSS †
E	*	Sense Switch E		BSS †
F	*	Sense Switch F		BSS †
G	*	Sense Switch G		BSS †
N		Access Inoperable	Next Disk Storage operation	BIN †
\ (left oblique)		Access Busy	Next Disk Storage operation	BIN †
P	*	Printer Busy		BPB
/ (Diagonal)		Unequal Compare (B ≠ A)	Next Compare or Disk Storage operation	BU
S		Equal Compare (B = A)		BE
T		Low Compare (B < A)		BL
U		High Compare (B > A)		BH
V		Disk Error	Next Disk Storage operation	BIN †
W		Wrong-Length Record		BIN †
X		Unequal-Address Compare		BIN †
Y		Any Disk Condition		BIN †
Z		Overflow	Branch Test	BAV
%		Processing Check with Process Check Switch Off	Branch Test	BIN †
?		Read Error (If I/O Check Stop switch is off)	Reset by Test; must be reset before next operation	BIN †
!		Punch Error		BIN †
‡		Printer Error		BIN †

* Special Feature

† d-character must be coded in operand portion of instruction

Figure 8. d-character for Branch Instructions

Branch If Character Equal

Mnemonic	OP code	I address	B address	d character
BCE	$\underline{B}$	XXX	XXX	X

This code causes the single character at the B address to be compared to the d character. If it has the same bit configuration as the d character, the program branches to the I address, otherwise the program continues sequentially. The d character can be any combination of the six BCD code bits (AB 8421).

Word marks in the location tested have no effect on the operation.

Branch If Word Mark and/or Zone

OP code	I address	B address	d character
$\underline{V}$	XXX	XXX	X

The single character at the B address is examined for a particular bit configuration, as specified by the d character. If the bit configuration is present as specified, the program branches to the I address for the next instruction:

Mnemonic	d character	Condition
BW	1	Word mark
BWZ	2	No zone (No A, No B bit)
BWZ	B	12 zone (AB bits)
BWZ	K	11 zone (B, No A bit)
BWZ	S	Zero zone (A, No B bit)
BWZ	3	Either a word mark, or no zone
BWZ	C	Either a word mark, or 12 zone
BWZ	L	Either a word mark, or 11 zone
BWZ	T	Either a word mark, or zero zone

Word marks in the character are not affected.

No Operation

Mnemonic	OP code
NOP	$\underline{N}$

This code performs no operation. It can be substituted for the operation code of any instruction to make that instruction ineffective. It is commonly used in program modification to cause the machine to skip over specific instructions.

The program operation resumes at the next operation code identified by a word mark.

NOTE: If characters without word marks follow an N operation code, these characters enter the A-field and B-field registers.

Compare

Mnemonic	OP code	A address	B address
C	$\underline{C}$	XXX	XXX

The data in the A field is compared to an equal number of characters in the B field. The bit configuration of each character in the two fields is compared. The comparison turns on an indicator that can be tested by a subsequent BRANCH IF INDICATOR ON instruction. The indicator is reset by the next compare instruction or next disk operation.

The first word mark encountered stops the operation. If the A field is longer than the B field, extra A-field positions at the left of the B-field word mark are not compared. If the B field is longer than the A field, an unequal compare results.

NOTE: Both fields must have exactly the same bit configurations to be equal. For example, 00? (?= $\overset{+}{0}$) compared to 00! (! = $\bar{0}$) results in an unequal comparison.

All characters that can appear in storage can be compared. The ascending sequence of characters is provided in the Character Coding Chart, Appendix B.

Halt

Mnemonic	OP code
H	$\underline{.}$

This instruction causes the machine to stop and the Stop-key light to turn on. Pressing the Start key causes the program to start at the next instruction in sequence.

Word marks are not affected.

Halt and Branch

Mnemonic	OP code	I address
H	$\underline{.}$	XXX

This is the same as HALT, except that the next instruction is taken from the core storage location specified in the I address.

Word marks are not affected.

CONTROL OPERATIONS

Specific storage areas must be allocated for efficient processing of data. To specify these, it is necessary to set word marks in the proper locations in storage.

Because the IBM 1440 operates with variable length data and instructions, and because word marks control the definition of each instruction or data field, special attention must be given to the proper positioning of the word marks required. Extraneous word marks are as damaging to program operation as is the absence of a word mark.

Move and Load operations transfer data from one location to another, but only the Load operation transfers the word mark as well as data.

Clear Storage

Mnemonic	OP code	A address
CS	/	XXX

The execution of this instruction will clear as many as 100 positions of core storage of data and word marks. Clearing starts at the location specified in the A address and continues leftward to the nearest hundreds position. The cleared area is set to blanks.

Word marks are not required to stop the operation.

Clear Storage and Branch

Mnemonic	OP code	I address	B address
CS	/	XXX	XXX

This is the same as the CLEAR STORAGE instruction, except that the clearing starts at the location specified in the B address. The I address specifies the location of the next instruction.

Word marks are not required to stop the operation.

Set Word Mark

Mnemonic	OP code	A address	B address
SW	,	XXX	XXX

A word mark is set at each address specified in the instruction. The data at each address is undisturbed.

Word marks are set at both the A and B address specified. This instruction does not need to be followed by a word mark.

Set Word Mark (Single Address)

Mnemonic	OP code	A address
SW	,	XXX

This format of the SET WORD MARK instruction causes a word mark to be set at the A address only. Data at this address is undisturbed.

Clear Word Mark

Mnemonic	OP code	A address	B address
CW	⌑	XXX	XXX

This instruction clears word marks at the locations specified by the A and B addresses, without disturbing the data there.

Clear Word Mark (Single Address)

Mnemonic	OP code	A address
CW	⌑	xxx

This format of the CLEAR WORD MARK instruction causes the word mark to be cleared only at the A address. Data at the A address is not disturbed.

Move Record

(Move characters to Record Mark or GM-WM)

Mnemonic	OP code	A address	B address
MRCM	P	xxx	xxx

This operation code makes it possible to move an entire record from one core storage area to another, regardless of the presence of word marks in either field. The A and B addresses specify the leftmost position of the respective areas. Transmission starts from the leftmost addresses, and continues until a record mark (A82 bits) or a group mark with a word mark (WMBA8421 bits) is sensed in the A field. The record mark or group mark transfers to the B field.

Word marks within the area do not affect the MOVE RECORD instruction. Any word marks in the B field remain unchanged. A-field word marks are not transmitted to the B field.

Move Characters

(Move characters to A or B word mark)

Mnemonic	OP code	A address	B address
MLC	M	xxx	xxx

The data in the A field is moved to the B field.

If both fields are the same length, only one of the fields must have a defining word mark. The first word mark encountered stops the operation. If the word mark is sensed in the A field, the machine takes one more B cycle to move the leftmost character from A to B. At the end of the operation, the A-address register and the B-address register contain the addresses of the storage locations immediately to the left of the A and B fields processed by the instruction. The data at the A address is unaffected by the move operation. Word marks in both fields are undisturbed.

NOTE: If the fields are unequal in length, chaining can produce undesirable results, because one of the fields has not been completely processed and thus, one of the registers will not contain the address of the rightmost position of the left-adjacent field.

Move Characters (Single Address)

Mnemonic	OP code	A address
MLC	M	xxx

This format of the MOVE CHARACTER instruction can be used when it is desired to assemble A fields from unrelated locations and to store them sequentially in the B area. It saves program storage space and time, because the B address is automatically taken from the B-address register, and does not have to be written or interpreted as part of the instruction.

A word mark is required over the leftmost position of the A field. The first word mark encountered stops the move operation.

Move Characters and Suppress Zeros

Mnemonic	OP code	A address	B address
MCS	Z	xxx	xxx

The data in the A field is moved to the B field. After the move, leftmost zeros and commas are replaced by blanks in the B field. A decimal in the A field causes zero suppression to begin again. The sign is removed from the rightmost position of the data field.

The A-field word mark stops transmission of data. B-field word marks, encountered during the move operation, are erased.

Move Numerical

Mnemonic	OP code	A address	B address
MLNS	D	xxx	xxx

The numerical portion (8-4-2-1 bits) of the single character in the A address is moved to the B address. The zone portions (AB bits) are undisturbed at both addresses. The entire character in the A address is left undisturbed.

Word marks are not required at either address because the nature of the instruction always specifies that only one digit is to be transmitted.

Move Zone

Mnemonic	OP code	A address	B address
MLZS	Y	xxx	xxx

Only the zone portion (AB bits) is moved from the A address to the B address. The digit portions (8-4-2-1 bits) are undisturbed at both addresses. The entire character in the A address is left undisturbed.

Word marks are not required at either the A or B addresses, because this instruction involves a single character.

Load Characters

(Move characters and word mark from A field)

Mnemonic	OP code	A address	B address
MLCWA	L	xxx	xxx

This instruction is commonly used to load data into printer or punch areas of storage, and also to transfer data or instructions from a read-in area to another storage area. The data and word mark from the A field are transferred to the B field, and all other word marks in the B field are cleared.

The A field must have a defining word mark because the A-field word mark stops the operation.

NOTE: If the B field is larger than the A field, the B-field word mark is not cleared. That portion of the B field which is larger is left undisturbed.

Load Characters (Single Address)

Mnemonic	OP code	A address
MLCWA	L	xxx

This format can be used when several A fields (not necessarily in sequence) are to be loaded sequentially in the B field. This instruction causes the A-field data and word mark to be moved to the B field. B-field word marks are cleared, up to the A-field word marks.

The A-field word mark stops the operation. Therefore, B-field word marks, beyond the left limit of the A field, are not cleared.

EDITING OPERATIONS

Editing, in the IBM 1440 Data Processing System, consists of punctuating printed output data, and includes the automatic control of zero suppression and the insertion of identifying symbols. A single edit instruction causes all desired commas, decimals, dollar signs, asterisks, credit symbols, and minus signs to be automatically inserted in a numerical field. At the same time, unwanted zeros to the left of significant digits are suppressed (Figure 9).

In editing, two elements are required: the data field and a control word. The control word governs how the numerical information in the data field is to be edited. It not only specifies the location of identifying symbols, but also controls the printing of zeros. The data field and control word are compared, character-by-character under control of editing rules.

The control word has two parts: the body (which punctuates the data field) and the status portion (which contains the dollar sign, sign symbols, and classes-of-totals asterisks). The sign of the data field determines whether or not sign symbols will print. The sign of the data field is removed.

	OP	A address	B address
Edit instruction	E	789	300
		A field (data)	B field (control word)
Storage		00257426	$ bbb, bb0 .bb &CR&**
			B field
Result of edit		00257426	$ 2,574.26 **

Figure 9. Editing

Preparatory to editing a data field, a LOAD CHARACTERS instruction is given to load the control word into an output area. This puts the control word in the exact core storage positions into which the edited information will eventually go. Then, a MOVE CHARACTERS AND EDIT instruction (with the same B address as the previous load instruction) performs the editing function as it moves the data to the output area.

Move Characters and Edit

Mnemonic	OP code	A address	B address
MCE	E	xxx	xxx

The MOVE CHARACTERS AND EDIT instruction modifies the data in the A field by the contents of the edit control word in the B field, and stores the result in the B field. The following rules control the editing operation.

Rule 1. All numerical, alphabetic, and special characters can be used in the control word. Some of these, however, have special meanings:

b (blank). This is replaced with the character from the corresponding position of the data field.

0 (zero). This is used for zero suppression and is replaced with a corresponding character from the data field. The rightmost "0" in the control word indicates the rightmost limit of zero suppression.

. (decimal). This remains in the edited word in the position where written. When used with the Expanded Print Edit feature, it has an additional function.

, (comma). This remains in the edited word in the position where written. It is removed during a zero suppress operation if it is to the left of the leftmost significant digit.

CR (credit). This is undisturbed if the sign in the data field is negative. It is blanked out if the sign is positive. It can be used in the body of the control word without being subject to sign control.

- (minus). This is the same as CR.

& (ampersand). This causes a space in the edited word. It can be used in multiples.

* (asterisk) This can be used singularly or in multiples, usually to indicate class of total. When it is used with the Expanded Print Edit special feature, it takes on an additional function.

$ (dollar sign). This is undisturbed in the position where it is written. When used with the Expanded Print Edit feature, it has an additional function.

Rule 2. A word mark in the leftmost position of the control word controls the MOVE CHARACTERS AND EDIT operation.

Rule 3. When the word mark in the data field is sensed, the remaining commas in the control word are set to blanks.

Rule 4. The body of the control word is that portion beginning with the rightmost blank or zero, and continuing to the left of the control character, that governs the transfer of the last position of the data field. The remaining portion of the control word is the STATUS portion.

Rule 5. If the data field is positive, and if the CR or symbols are located in the status portion of the control word, they are blanked out.

Rule 6. Zero suppression is used if unwanted zeros to the left of significant digits in a data field are to be deleted (Figure 10). A special zero is placed (in the body of the control word) in the rightmost limit of zero suppression.

A field	0010900
Control word (B field)	$ bb,bb0.bb
Forward scan	← $ 00,109.00
Reverse scan	→ $ bbb109.00
Results of edit	$ 109.00

Figure 10. Zero Suppression

Forward Scan:

1. The positions in the control word in the output field at the right of this special zero are replaced by the corresponding digits from the data field (A field).
2. The special zero is replaced by the corresponding digit from the data field when it is detected in the control word.
3. A word mark is automatically set in this position of the B (output) field.
4. The scan continues until the word mark in the highorder position of the control word in the output area is sensed and removed.

Reverse Scan:

1. In the output field, blanks replace all zeros and punctuation, except hyphens, at the left of the first significant character (up to and including the zero suppression code position).
2. When the automatically set zero suppression word mark is sensed, it is erased and the operation ends.

Rule 7. The data field can contain fewer, but must not contain more positions than the number of blanks and zeros in the body of the control word. Dollar signs and asterisks are included in the body of the control word with the Expanded Print Edit special feature.

THE IBM 1447 CONSOLE, MODEL 1

The IBM 1447 Console contains operating keys, lights, and switches, and is designed to give the operator external control for setting up and checking system operation. Several features are provided to facilitate program testing.

The left side of the console panel shows the results of data as it moves from one storage area to another, including address registers, characters registers, and storage addresses.

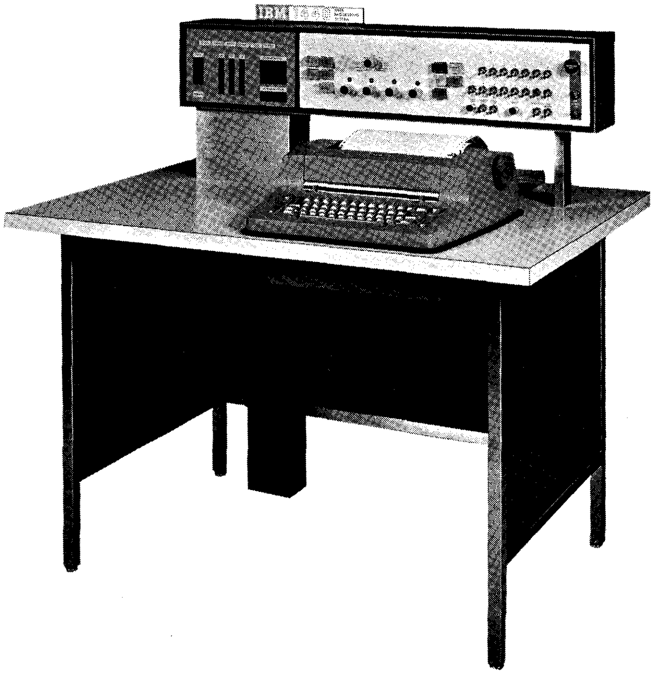


Figure 11. IBM 1447 Console, Model 2

Special lights indicate operating conditions of the processing and disk units, the card read punch, and the printer. If an error is detected while the system is running, a red light comes on to show which unit requires the operator's attention.

The operator can display the contents of any storage location and control the course of program execution by setting sense switches in an ON or OFF position, if the program has been designed to take advantage of this flexibility.

The main power supply for the system is controlled by switches located on the console. A special switch is provided to disconnect all power from the system in case of emergency.

A mode switch facilitates machine operation and program testing by permitting:

1. Single cycle operation for detailed examination of program functions.
2. The display of the contents of a particular storage area.
3. The manual change of the contents of any address register or storage location.
4. The contents of storage to be printed with word mark identification.
5. The scanning of storage for invalid characters.
6. The operator to stop the execution of the program at a predetermined point. This provides an opportunity to bypass program steps that have already proven accurate and to stop at instruction areas which need to be examined step by step.

Figure 11 illustrates the 1447 Console, Model 2 which features the Console Printer.

DISPLAYING INFORMATION

Display lights are provided to indicate the bit configuration of the data in the system registers.

The console keys are illuminated. When lit, they indicate that the particular function is on or is operative. When a key is pressed during a manual operation, the light comes on indicating that the function is controlled by the key.

The console employs a back-lighting concept to display data. The bit configuration of each character in each of the machine's logical elements is shown in binary-coded-decimal form (including check bit and word mark status). The data is displayed, one character at a time. Also, an error at any display location is indicated by a red light that glows in the legend directly above the character display.

Process Light

This light comes on when an error occurs in the processing unit. The light and the error indicator are reset by pressing the Check Reset key. Machine operation is resumed by pressing the Start key.

RAMAC Light

This light comes on when an error occurs in one of the 1311 Disk Storage Drives. It is turned off when the next disk instruction is executed.

External I/O Light

This light comes on when a unit attached to the Serial I/O Adapter channel is selected for operation. It is turned off when the operation is satisfactorily completed.

Reader Light

This light is turned on when an attached 1442 Card Read Punch is selected by the program for reading operation. It is turned off when the operation is complete.

Punch Light

This light is turned on when an attached 1442 Card Read Punch is selected by the program for a punching operation. It is turned off when the operation is complete.

Printer Light

This light indicates the selection of the Printer by the program. When the Printer operation is complete, the light is turned off.

Storage Light

This light comes on when a parity check occurs on a character as it is read into core storage. This light

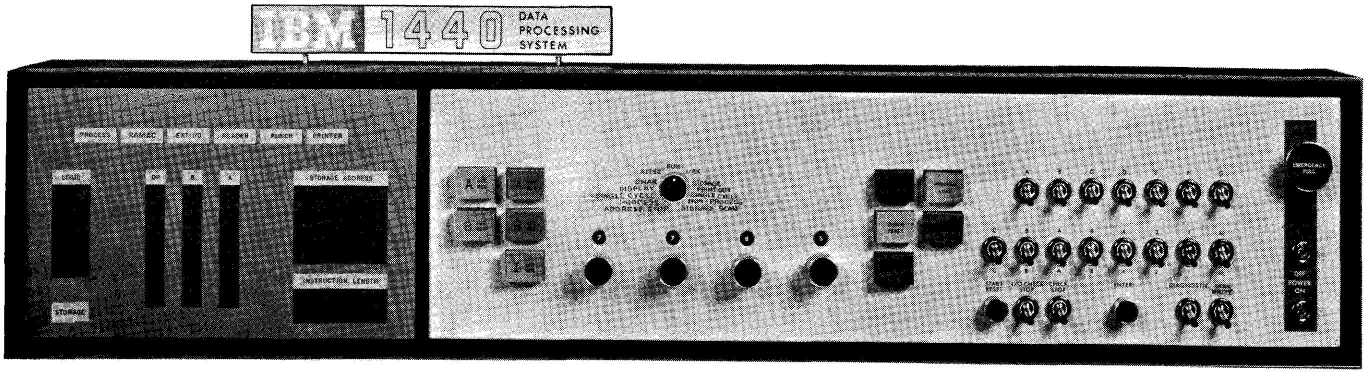
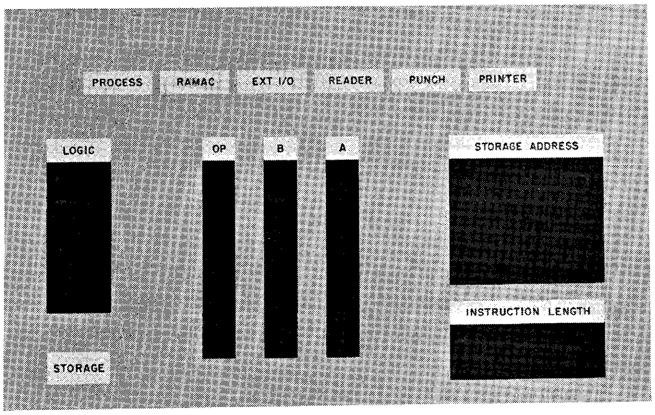


Figure 12. Console Panel

is reset by pressing the Check Reset key. Pressing the Start key restarts the machine.

B Light

This light comes on when a B Register parity check occurs. The lights below the B-Register light indicate the coded character, check bit status, and word mark status of the B register. This light is reset by pressing the Check Reset key. Pressing the Start key restarts the machine.



A Light

This light comes on when an A Register parity check occurs. The lights below the A-Register light indicate the coded character, check-bit status, and the word mark status of the A Register. This light is reset by pressing the Check Reset key. Pressing the Start key restarts the machine.

Logic Light

This light comes on when an error occurs in an arithmetic operation. It is reset by pressing the Check Reset key, and the machine is restarted by pressing the Start key.

O-Flow Light. This light comes on when an overflow condition exists in the machine. The light remains on until the Overflow indicator is turned off by a programmed test, or until the Start Reset key is pressed.

B≠A Light. This light comes on when an unequal condition exists during a compare instruction.

B = A Light. This light comes on when an equal condition exists during the high, low, equal compare instruction. The light is used by the scan disk operation, when the Scan Disk special feature is included on the system.

B > A Light. This light works with the high, low, equal compare instruction and comes on if the value of the B field is greater than the value of the A field, or if the A field is shorter than the B field. The light is used by the scan disk operation, when the Scan Disk special feature is included on the system.

B < A Light. This light also works in conjunction with the high, low, equal compare instruction and comes on when the value of the B field is less than the value of the A field. The light is used by the scan disk operation, when the Scan Disk special feature is included on the system.

Bit Display Lights. These lights show the bit configuration of the sum of the characters being displayed in the A and B registers.

REGISTER LIGHTS

OP Register Light

The OP light comes on when an invalid operation code or incorrect parity exists in the OP register. The lights below indicate the BCD code of the character in the OP register.

Instruction Length Lights

These lights indicate which character of the instruction is being read out during the instruction cycle.

Storage Address Light

This light comes on when an Address Register parity check occurs, or when an invalid storage address is given, or when a wrap-around error occurs. (See Input/Output Operations for a description of a wrap-around error condition.)

REGISTER KEY LIGHTS

I Address Register Key Light

When this key is pressed, it turns the light on and displays the contents of the I Address Register in the Storage Address Display lights. If the machine is stopped during the I (instruction) cycle, the I Address Register light is on and the Storage Address Display lights indicate the last I address that addressed storage.

A Address Register Key Light

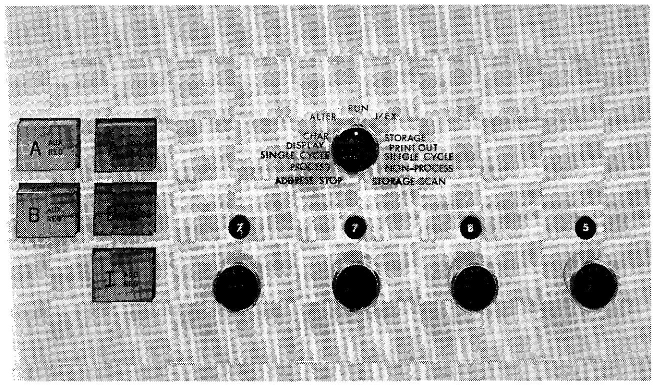
This operates in the same way as the I Address Register key light except that it refers to the A Address Register and the A cycle of the processing operation.

B Address Register Key Light

This is the same as the I address Register Key light except that it refers to the B Address Register and the B cycle of the processing operation.

A and B Auxiliary Register Key Lights

Pressing either the A or the B auxiliary Register key light displays the contents of the corresponding register. The auxiliary registers are part of the multiply-divide special feature.



STORAGE ADDRESS DIAL SWITCHES

The four dial switches labeled Manual Address, select the address to be entered in the storage address register. These switches are effective only with these selected positions of the Mode switch:

1. Character Display
2. Alter
3. Address Stop
4. Storage Printout
5. Storage Scan (core storage)

Mode Switch

The Mode switch selects the nine modes of machine operation:

Run. When the Mode switch is set to RUN, the system is under control of the stored program.

I/EX (Instruction Execution). When the Mode switch is set to I/EX and the Start key is pressed for the first time, the machine reads one complete instruction from storage and then stops. This is called the instruction phase.

The next time the Start key is pressed, the machine executes the instruction. This is called the execution phase.

Subsequent pressing of the Start key results in alternate instruction and execution phases. Where the operation requires no execution phase, pressing the Start key results in the next instruction being read.

Single Cycle Process. In this mode each pressing of the Start key causes the machine to take one 11.1 μsec storage cycle and to advance through the instruction and execution cycles of the program one character at a time.

Single Cycle Nonprocess. This is similar to the single cycle process mode, except that no data enters storage from the A register or from the logic unit. Data always enters storage from the B register only. This mode allows the operator to observe the results of arithmetic operations, in the logic display, one character at a time, without destroying the original data in the B field.

Character Display. When the machine is operating in this mode, pressing the Start key causes the character at the address selected by the manual address switches to be displayed in the B register. The I-, A-, and B-address registers are not altered by this operation.

Storage Printout. This mode of operation permits any 100-character block of storage to be printed on the 1443 Printer. The Manual Address switches are set to the zero one position of any hundreds block of core storage. Pressing the Start key on the 1447 Console starts the printout operation at the address set in the manual address switches (XX01). The 100 characters in the selected block are printed, following which there is an automatic print cycle that prints 1's on a subsequent line in positions corresponding to those in the block above that contain word marks.

Alter. With the Mode switch set to Alter, the operator can manually change the contents of any address register or storage location. To change the contents of address registers, he must:

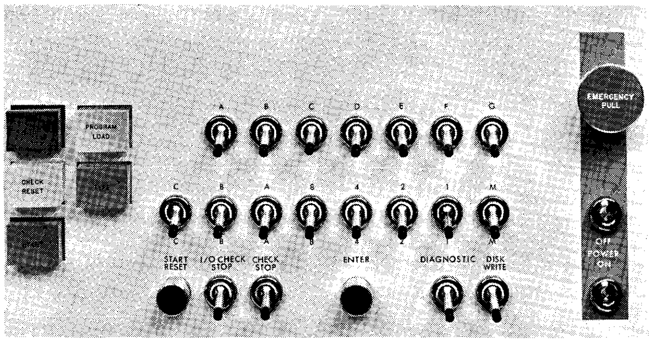
1. Set the Manual Address switches at the desired location.
2. Press the appropriate Address Register Key light.
3. Press the Start key.
4. Observe the selected address register for the new address.

To change the contents of a storage location, he must:

1. Set the Manual Address switches to the desired location.
2. Select the bit configuration of the character to be entered by setting the eight bit switches located on the console.
3. Press the Enter key.

Storage Scan. With the Mode switch set to Storage Scan and the Start key held down, the 1441 Processing Unit will start to read out of storage at the address set in the Manual Address switches, until it has read to the end of core storage. It will then start to read at the beginning of core storage. The program will continue to loop through storage until an invalid character is detected or until the Start key is released. If an invalid character is detected in storage, the Check light associated with the error is turned on. The storage position in error is shown in the Storage Address Display lights when the program stops. The B register displays the contents of the storage position in which the error was detected.

Address Stop. With the Mode switch set to Address Stop, pressing the Start key starts the program. The machine automatically stops when the machine encounters the address selected by the Manual Address switches. Address Stop is commonly used in program testing operations, except input/output operations, because the machine can be stopped at an address anywhere in the program.



CONTROL KEYS AND SWITCHES

Start Key Light

This key is used to initiate or resume machine operation after a manual, programmed, or automatic stop. The setting of the Mode switch conditions the operation of the Start key:

1. During a normal Run mode, or Address Stop mode, pressing the Start key starts the system.
2. During a single cycle process mode, the Start key causes the system to advance through the program.
3. Following a process error indication, the Check Reset key on the console must be pressed before the Start key is pressed to restart.

Start Reset Key

This key resets the system (except for the data in the storage address registers, data registers, error indicators, and core storage) so the operator can restart the operation. It turns off the overflow, instruction length, and last card indicator that were turned on by any previous program.

Stop Key Light

This key stops all processing in the system. It is not effective until the instruction being executed is completed. Similar stop keys (without lights) are provided on each of the other units within the system. This light is turned on only from a programmed stop.

Check Reset Key Light

An error that is detected by the processing unit check circuits lights this key. The key must be pressed following a processing error. Pressing the Start key will then restart the system.

Program Load Key

This key is used to initiate a program load routine. With the system reset and the #1 Card Read Punch in a ready condition, follow this procedure:

1. Set the Manual Address switches to the address in core storage where the instructions are to begin.
2. Set the Mode switch to ALTER.
3. Press the B Address Register and the I Address Register keys.
4. Set the Mode switch to RUN.

Pressing the Program Load key will then cause:

5. The #1 Card Read Punch to be selected to read.
6. 80 card columns to be read into core storage beginning at the address set into the B-address register.
7. A word mark to be set at the address in the B-address register.
8. The program to branch to the address set in the I-address register.

Type Key Light

This key lights whenever the Console I/O Printer is selected to operate.

Sense Switches

Seven sense switches are included in the 1441 Processing Unit (six of these switches are a special feature). The manual toggle switches that control them are located on the 1447 Console. Switch A is reserved for last card operation; the remaining six (B through G) can be assigned as required by the program.

Bit Switches

Eight bit switches are available for altering characters in storage. These switches are used in conjunction with the alter mode as explained in the Mode switch description.

Enter Key

Pushing this key causes the character selected by the Bit switches to enter into storage when the Mode switch is set to Alter.

Power On Switch

This switch controls the main power supply for the entire system.

Power Off Switch

This switch turns off the main power supply.

Emergency Off Switch

This is a pull switch, located on the 1447 Console. If this switch is pulled in an emergency, it will disconnect power from the entire system. The switch must be manually reset by a customer engineer before power is restored in the system.

I/O Check Stop Switch

When this switch is in the on position, the system stops at the completion of an Input/Output operation if an error condition has been detected during the operation. With the switch in the off position, error detection must be accomplished by programming.

Diagnostic Switch

In the off position, erroneous disk data is entered into core in correct parity.

In the on position, error data is entered in its erroneous form.

Write Disk Switch

When this switch is turned on, data cannot be written on any Disk Storage Drive.

APPENDIX A INSTRUCTION TIMES

Instruction	Timing (ms) .0111 X (L_I+:	Address Registers after Operation		Notes
		A Address	B Address	
Add (one address)	$1+2L_A)$	$A-L_A$	$A-L_A$	
Add	$1+L_A+L_B)$	$A-L_W$	$B-L_B$	No recomplement
Add	$1+L_A+4L_B)$	$A-L_W$	$B-L_B$	Recomplement
Branch Unconditional	1)or**2)	BI	BBB or **NSI	
*Branch If Bit Equal	2)	BI	B-1	
Branch If Character Equal	2)	BI	B-1	
Branch If Indicator On	1)or**2)	BI	BBB or **NSI	
Branch If WM and/or Zone	2)or**3)	BI	B-1 or **NSI	
Clear Storage	$1+L_X)$	Not used	x 00-1	
Clear Storage and Branch	$1+L_X)$or $**2+L_X)$	BI	x 00-1 or **NSI	
Clear Word Mark	3)	A-1	B-1	
Clear Word Mark (one address)	3)	A-1	A-1	
Compare	$1+2L_W)$	$A-L_W$	$B-L_W$	
Control Carriage	1)	---	---	Plus remaining form-movement time, if carriage is moving when instruction is given.
*Divide	$+2+7L_RL_Q+8L_Q)$	A minus length of divisor	Tens position of quotient	
Halt	1)	Ap	Bp	
Halt and Branch	1)	BI	BI or **NSI	
Load Characters	$1+2L_A)$	$A-L_A$	$B-L_A$	
Load Characters (one address)	$1+2L_A)$	$A-L_A$	$Bp-L_A$	
*Modify Address	9)	A-3	B-1 or B-3	
*Modify Address (one address)	9)	A-3	A-1 or A-3	
Move Characters	$1+2L_W)$	$A-L_W$	$B-L_W$	
Move Characters (one address)	$1+2L_W)$	$A-L_W$	$Bp-L_W$	
Move Characters and Edit	$1+L_A+L_B+L_Y)$	A Address minus length of A field	$B-L_B$	Without zero suppression
Move Characters and Edit	$1+L_A+L_B+L_Y)$	A Address minus length of A field	Location of control zero plus 1	With zero suppression
Move Characters and Suppress Zeros	$1+3L_A)$	$A-L_A$	B+1	
Move Numerical	3)	A-1	B-1	
Move Record	$1+2L_A)$	$A+L_A$	$B+L_A$	L_A (in A Register) includes GM/WM or RM
Move Zone	3)	A-1	B-1	
*Multiply	$+3+2L_C+5L_CL_M+7L_M)$	A minus length of multiplicand.	B minus length of product field.	Average time
No Operation	1)	Ap	Bp	
Print	+1)+376ms	B+197	B+197	
*Print (Print Storage) feature	Total Time = 2.4 ms	---	---	

*Special Feature
**If Store Address Register feature is installed.

INSTRUCTION TIMES (Contd.)

Instruction	Timing (ms) .0111 X (L_I+:	Address Registers after Operation		Notes
		A Address	B Address	
Punch Card	1)+12.5(L_B)ms	%Gn	B+L_B+1	
Punch Card	1)+6.25(L_B)ms	%Gn	B+L_B+1	High-speed Model
Punch and Feed	1)+12.5(L_B)ms	%Gn	B+L_B+1	
Punch and Feed	1)+6.25(L_B)ms	%Gn	B+L_B+1	High-speed Model
Read Card	1)+31+1.3(L_B+1)	%Gn	B+L_B+1	
Read Card	1)+25+1.0(L_B+1)	%Gn	B+L_B+1	High-speed Model
Read Console Printer	1)	%TO	B+L_B+1	Plus operator keying time.
Read Track Sectors w/Addresses	1)+62ms	B+8	B+2110 (Move) B+1910 (Load)	Assumes sector before index pulse is used for address comparison.
Read Sector Mode	1)+2N_S+22ms	B+5	B+$N_S S_S$+10	Assumes no cylinder overflow.
Read Sector Count Overlay	1)+2N_S+22ms	B+5	B+$N_S S_S$+7	Assumes no cylinder overflow.
Set Word Mark	3)	A-1	B-1	
Set Word Mark (one Address)	3)	A-1	A-1	
*Stacker Select	1)	---	---	
*Store A Address Register	5)	A-3	Ap	
*Store B Address Register	5)	A-3	Bp	
Subtract No recomplement	1+L_A+L_B)	A-L_W	B-L_B	
Subtract	1+L_A+4L_B)	A-L_W	B-L_B	Sign of result changed and stored in true form.
Subtract (one Address)	1+2L_A)	A-L_A	A-L_A	
Write Console Printer	1)+68(L_B)+800x (CR-1)	%TO	B+L_B+1	CR=Number of the returns of the Print element.
Write Track Sectors w/Addresses	1)+62ms	B+A	B+2110 (Move) B+1910 (Load)	Assumes sector before index pulse is used for address comparison.
Write Sector Mode	1)+2n_S+22ms	B+5	B+$N_S S_S$+10	Assumes no cylinder overflow.
Write Sector Count Overlay	1)+2N_S+22ms	B+5	B+$N_S S_S$+7	Assumes no cylinder overflow.
Zero and Add	1+L_A+L_B)	A-L_W	B-L_B	
Zero and Subtract	1+L_A+L_B)	A-L_W	B-L_B	
Zero and Subtract (one Address)	1+2L_A)	A-L_A	A-L_A	

*Special Feature

Key to abbreviations used in formulas:

L_A = Length of the A field
L_B = Length of the B field
L_C = Length of Multiplicand field
L_I = Length of Instruction
L_M = Length of Multiplier field
L_Q = Length of Quotient field
L_R = Length of Divisor field
L_S = Number of significant digits in Divisor (excludes high-order zeros and blanks)

L_W = Length of A or B field, whichever is shorter
L_X = Number of characters to be cleared
L_Y = Number of characters back to rightmost zero in control field
L_Z = Number of zeros inserted in a field
I/O = Timing for Input or Output cycles
Fm = Forms movement times
BI = Next Instruction if branch occurs

A = A address of instruction
B = B address of instruction
Ap = Previous setting of A-address register
Bp = Previous setting of B-address register
X = Thousands and tens of starting address
NS = Number of sectors
SS = Size of sections (100 or 90)
ms = Milliseconds

APPENDIX B CHARACTER CODING CHART

	CARD				52	52			CARD				52	52	
DEFINED CHARACTER	CODE	BCD CODE	13	39	A	H	63	DEFINED CHARACTER	CODE	BCD CODE	13	39	A	H	63
Blank		C	X	X	X	X	X	G	12-7	B A 4 2 1		X	X	X	X
Period	12-3-8	B A 8 2 1	X	X	X	X	X	H	12-8	B A 8		X	X	X	X
⌑ Lozenge	12-4-8	C B A 8 4			⌑	)	X	I	12-9	C B A 8 1		X	X	X	X
[Left Bracket	12-5-8	B A 8 4 1					X	! (- zero)	11-0	B 8 2			X	X	X
< Less Than	12-6-8	B A 8 4 2					X	J	11-1	C B 1		X	X	X	X
⯒ Group Mark	12-7-8	C B A 8 4 2 1					X	K	11-2	C B 2		X	X	X	X
& Ampersand	12	C B A			&	+	X	L	11-3	B 2 1		X	X	X	X
$ Dollar Sign	11-3-8	C B 8 2 1		X	X	X	X	M	11-4	C B 4		X	X	X	X
* Asterisk	11-4-8	B 8 4	X		X	X	X	N	11-5	B 4 1		X	X	X	X
] Right Bracket	11-5-8	C B 8 4 1					X	O	11-6	B 4 2		X	X	X	X
; Semicolon	11-6-8	C B 8 4 2					X	P	11-7	C B 4 2 1		X	X	X	X
△ Delta	11-7-8	B 8 4 2 1					X	Q	11-8	C B 8		X	X	X	X
- Hyphen	11	B	X		X	X	X	R	11-9	B 8 1		X	X	X	X
/ Diagonal	0-1	C A 1			X	X	X	ǂ Record Mark	0-2-8	A 8 2			X	X	X
, Comma	0-3-8	C A 8 2 1		X	X	X	X	S	0-2	C A 2		X	X	X	X
% Percent Mark	0-4-8	A 8 4			%	(	X	T	0-3	A 2 1		X	X	X	X
⋎ Word Separator	0-5-8	C A 8 4 1					X	U	0-4	C A 4		X	X	X	X
\ Left Oblique	0-6-8	C A 8 4 2					X	V	0-5	A 4 1		X	X	X	X
⧻ Segment Mark	0-7-8	A 8 4 2 1					X	W	0-6	A 4 2		X	X	X	X
ƀ Substitute Blank	2-8	A			X	X	X	X	0-7	C A 4 2 1		X	X	X	X
# Number Sign	3-8	8 2 1			#	=	X	Y	0-8	C A 8		X	X	X	X
@ At Sign	4-8	C 8 4			@	'	X	Z	0-9	A 8 1		X	X	X	X
: Colon	5-8	8 4 1			X	X	X	0 (Zero)	0	C 8 2	X	X	X	X	X
> Greater Than	6-8	8 4 2					X	1	1	1	X	X	X	X	X
√ Radical	7-8	C 8 4 2 1					X	2	2	2	X	X	X	X	X
? (Plus Zero)	12-0	C B A 8 2			X	X	X	3	3	C 2 1	X	X	X	X	X
A	12-1	B A 1		X	X	X	X	4	4	4	X	X	X	X	X
B	12-2	B A 2		X	X	X	X	5	5	C 4 1	X	X	X	X	X
C	12-3	C B A 2 1		X	X	X	X	6	6	C 4 2	X	X	X	X	X
D	12-4	B A 4		X	X	X	X	7	7	4 2 1	X	X	X	X	X
E	12-5	C B A 4 1		X	X	X	X	8	8	8	X	X	X	X	X
F	12-6	C B A 4 2		X	X	X	X	9	9	C 8 1	X	X	X	X	X

INDEX

A26-5666-0

IBM 1440-1441-1447 Printed in U.S.A. A26-5666-0

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

621210MVO

IBM Technical Newsletter

System/File No. 1440-01

Re: Form No. A26-5666-0

This Newsletter No. N24-0062

Date: January 22 , 1963

Previous Newsletter Nos. — None

Additions to IBM 1440 System Component Description, 1441 Processing Unit, 1447 Console, A26-5666-0

Page 6:

Replace paragraph describing the IBM 1443 Printer, Model 1, with the following:

The IBM 1443 Printer is available in two models. Model 1 is capable of printing from 120 to 430 lines per minute. Model 2 is capable of printing from 200 to 600 lines per minute. Both models are equipped with a standard print line of 120 character positions. This can be expanded to 144 positions as a special feature.

Page 24:

Replace paragraph describing Character Display mode with the following:

When the mode switch is set to Character Display, pressing the start key causes a B-register display of the contents of the core-storage address specified by the manual address switches. The I-, A-, and B-address registers are not altered by this operation.

With the mode switch set to this position, pressing the type key on the 1447 Model 2 initiates a printout on the console printer of the contents in core storage beginning with the address set in the manual address switches. In this operation, word marks are printed as inverted circumflexes preceding the characters with which they are associated. The operation is stopped by pressing the stop key on the console.

Page 24:

Replace the paragraph describing the Storage Printout mode with the following:

When the mode switch is set to Storage Printout, pressing START causes one line (120 or 144 characters) to be printed on the IBM 1443 Printer. The printout begins at the address set in the manual address switches. Unless the machine is equipped with the print storage feature, the address switches must be set to a zero-one band of storage (XX01).

After the line is printed, an automatic print cycle prints 1's on a subsequent line in positions corresponding to those that contain word marks.

International Business Machines Corp., Product Publications Dept., Endicott, N. Y.

Page 26:

Replace the section on Print instruction times with the following:

Instruction	Timing (ms) .0111 x (LI +:	Address Registers afterOperation A-address	 B-address	Notes
Print	+ 1)+ 376 ms	B	B + 197	Model 1 (52 char-set)
Print	+ 1)+ 226 ms	B	B + 197	Model 2 (52 char-set)
Print (Print Storage Feature)	Total Time = 2. 4 ms	B	B + 197	Models 1 and 2 (all char. sets)