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IBM 1460 Systems Summary

This publication contains brief descriptions of the machine features, components, configurations, and special features. Also included is a section on programming systems, and the programming publications that can be used for the 1460 system.

Publications providing detailed information on subjects discussed in this summary are listed in the IBM *1401/1460 Bibliography,* Form A24-1495.

This edition, A24-1496-1, is a major revision, and obsoletes A24-1496-0. This edition and *Special Features for 1401/1460*, A24-3071-0, obsolete Technical Newsletter N24-0089.

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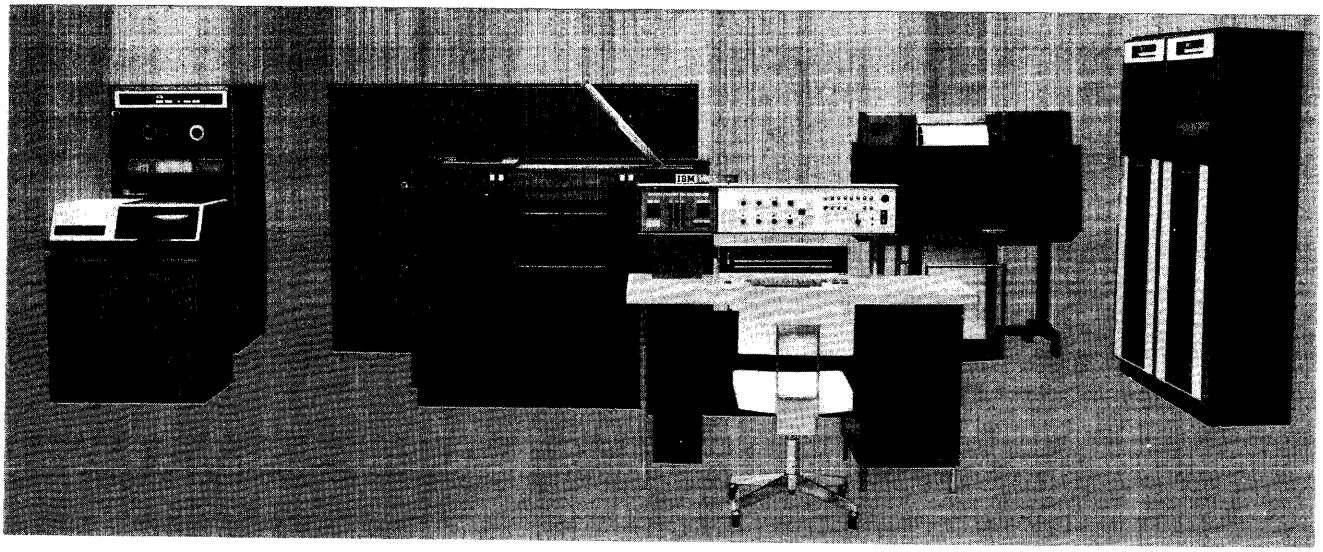

Figure 1. IBM 1460 Data Processing System

The IBM 1460 Data Processing System (Figure 1) utilizes the widely accepted 1401 instruction logic, an improved processing speed, and the latest advances in solid-state electronics to provide a new, powerful, 1401-compatible, data processing system.

Specifically designed as a 1401 growth system, the 1460 uses the same instructions as the 1401. Customers that have the 1401 can benefit immediately from the 1460's improved performance without incurring the traditional costs of retraining, reprogramming, and operating two systems during conversion.

The compatible design is of additional benefit to 1460 users because it permits use of released IBM 1401 programming systems on the 1460. Such valuable programming systems programs as Autocoder, Fortran, and Cobol may be used immediately to produce 1460 object programs.

Featuring a 6-microsecond processing cycle, the 1460:

- Provides up to double the 1401 work-capabilities by reducing the process time to one half.
- Permits the attachment of advanced input/output units, such as the IBM 729-VI Magnetic Tape Unit, with character rates of 90,000 characters per second.
- Extends the advantage of processing overlap through IBM 729-II Magnetic Tape Units by providing overlap of computing and tape reading or writing at character rates of 41,667 characters per second.
- Offers the performance benefits of the IBM 1311 Disk-Storage Drive and the IBM 1447 Console.
- Provides control, through the IBM 1448 Transmission Control Unit, for processing up to 40 simultaneous transaction messages from data communication system components.
- Adds a new, powerful, intermediate-range data processing system to the IBM 1400 series, offering every data processing user an unprecedented selection of related systems and components to meet both current and future cost-performance requirements.

The basic difference between the IBM 1401 and IBM 1460 is the internal processing speed. The internal processing speed of the 1401 system is 11.5 microseconds per cycle, and 6 microseconds for the 1460 system.

IBM 1401 systems and 1460 systems have the same basic instruction set. 1401 programs can be run on 1460 systems, and 1460 programs can be run on 1401 systems if the features and I/O units required by the programs are present on the system. Compatibility may be lost in those cases where execution of a program depends on internal cycle speed or the relationship between internal speed and input/output speed. For example, programs employing timing loops (such as in IBM 1419 operations) and programs optimized to read-release and punch-release timing restrictions must be re-evaluated to determine possible limitations.

System Concepts

The IBM 1460 can be considered in three major configurations: the card, tape, and disk-storage-oriented systems.

Card system configurations are planned for procedures involving large volumes of card documents as source data and output, with particular advantage to applications requiring re-entry data.

Tape system configurations accomplish data processing through the use of magnetic tape. This has the advantages of compact record handling and storage medium for high-speed data processing systems.

Disk-storage system configurations, through magnetic-disk storage, permit in-line data processing and increased storage capacity, in addition to all the advantages of a 1460 system.

The Stored Program

The main characteristic of data processing systems is self-controlled performance of procedures, carried to various degrees. Any such self-controlled performance simply includes a series of actions or movements, each depending on another and requiring no operator intervention in the completion of the series. The series can be very short, or very long. The series can be completely sequential, or the next action to be taken can be determined by the last action completed.

An automatic record player is a good example of a series of actions, each one depending on the one immediately preceding it. When records are loaded on the spindle and the record player is turned on, a record plays; the arm returns to a neutral position; the

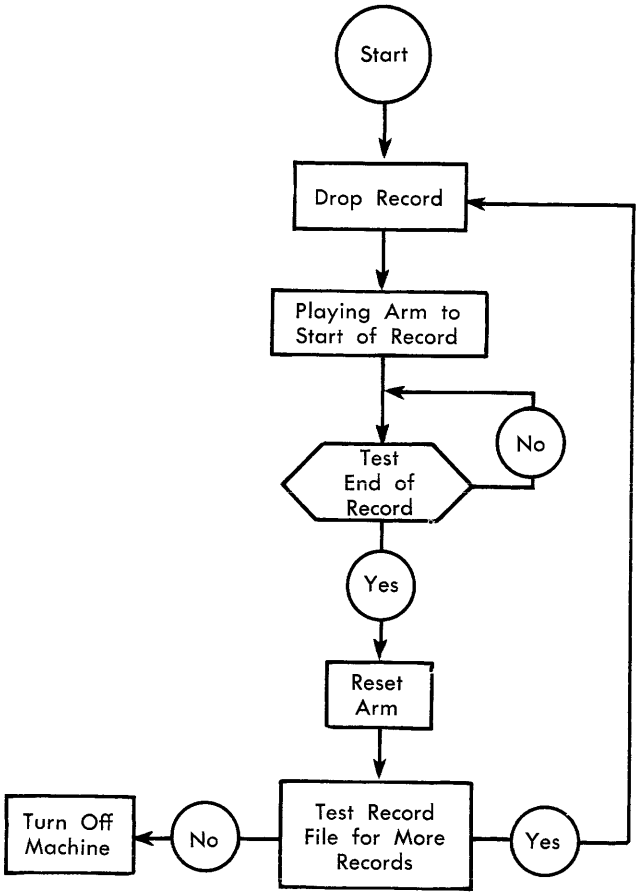

Figure 2. Block Diagram of a Program

next record in sequence drops into place; the playing arm returns to the starting position on the new record; the record plays; and so on, until all the records have been played once, without any need for intervention or assistance by anyone. This series of actions is called a *program* (Figure 2).

In data processing systems, the program is more complex. It controls the entire flow of data in and out of various processing units. If, for instance, original data is punched into cards, the program controls the reading of this data, its transport to various processing areas for addition, subtraction, multiplication, division, modification, classification, recording, and any other kind of action to which data can be subjected.

A data processing system is a group of various interconnected mechanical and electronic components. A system of this kind must be able to handle and complete such a program. The concept of *stored programming* provides this flexibility and efficiency.

In punched-card data processing, the wires in the control panel actually comprise the program of instructions. The requirements of the procedure are studied carefully, and then the proper wires are placed in the control panel. The entire program can be changed by removing one control panel and replacing it with another for a different procedure. The factors limiting the extent to which unit-record equipment can handle the program are the number of program steps that can be provided within the physical confines of the control panel, and the number of control panels that can be conveniently utilized.

Stored-program data processing systems use a similar, but much more flexible, concept. All the instructions needed to complete a procedure are written in the form of program steps. These program steps are made available to the machine by various methods, the most common of which is punched cards. The data processing system stores these program steps in some kind of storage medium.

Thus, when a procedure is to begin, the program is *loaded* into the system (Figure 3), and the entire procedure can be performed from beginning to end. The IBM 1460 Data Processing System makes use of four kinds of storage: magnetic-core storage, magnetic-tape storage, magnetic-disk storage, and the already familiar punched-card storage.

Magnetic-Core Storage

All configurations of the IBM 1460 Data Processing System use magnetic-core storage for storing instructions and data.

The magnetic-core storage unit is composed of a number of tiny rings made of magnetic material. Several electric wires are passed through each of these rings, and each ring is magnetized.

Every magnetic field has *polarity*. This can be demonstrated by the common phenomenon of two horseshoe-shaped magnets, which attract each other firmly when turned one way, and repel each other just as firmly when turned the other way. Similarly, each magnetic core possesses a magnetic field. The polarity

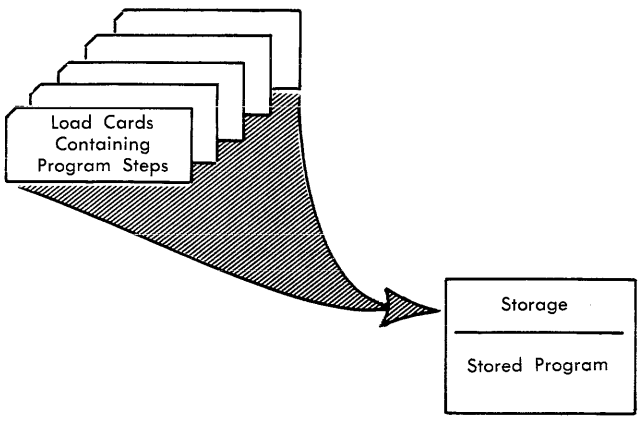

Figure 3. Stored Program

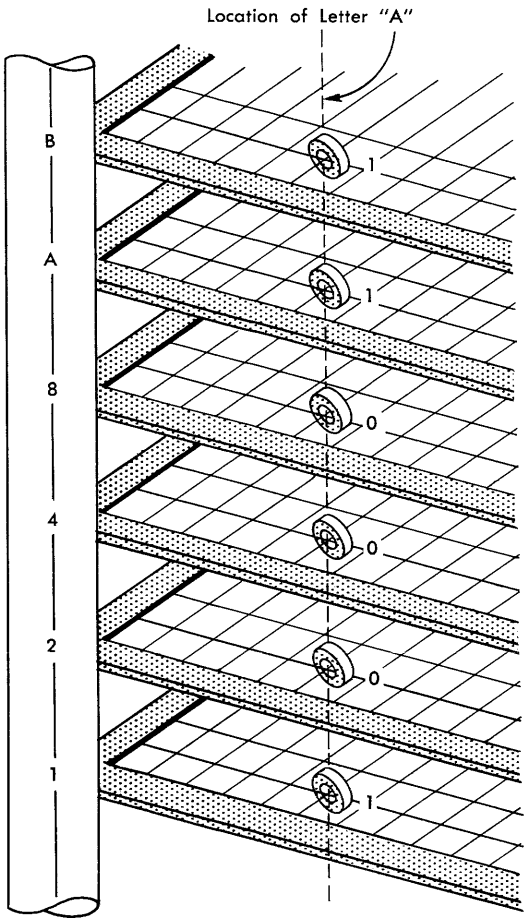

Figure 4. The Letter A Represented in Magnetic-Core Storage

of this field is determined by whether a *bit* or a *no-bit* of information is stored. A core magnetized in one direction contains a bit of information. When the polarity is reversed, the core contains a no-bit of information. These two conditions are represented schematically by bit values of 1 (representing a bit) and 0 (representing a no-bit). All data in core storage is instantly available, and in the IBM 1460, the core-storage units have been specifically designed for high utility by making each location of core storage *addressable.* Thus, a program step can designate the exact cores needed for that step.

Each location of core storage consists of a number of *planes* or levels of magnetic cores. Various combinations of bits designate digits, letters, and special characters (Figure 4). Notice that the planes are stacked, and the cores representing a single character (in this case the letter *A*) are all at the intersection of the same two wires in each plane.

The physical make-up of each core-storage location and its associated circuitry make it possible for the IBM 1460 to modify instructions and process data directly in the storage area. (This is called *add-to-storage* logic.)

The design, construction, and circuitry of the core-storage unit in the 1460 system make it possible for this compact but extremely powerful storage unit to do as much as or more than storage units of greater size.

Magnetic-Tape Storage

Magnetic tape is made of plastic material, coated with a metallic oxide. It has the property of being easily magnetized in tiny spots, so that patterns of these magnetized spots are codes for digits, alphabetic characters, and special characters.

Data can be read from a variety of sources and put on the tape. The magnetic spots representing the information that has been stored on the tape remain until they are either erased or written over.

Because magnetic data can be kept permanently, magnetic tape is an ideal storage medium for a large volume of information. The reels of tape are removable from the system, and can be filed (Figure 5). They can also be transported, and used in other systems.

Data stored on the magnetic tape is read sequentially. The data processing system can search the tape to find the data to be used. Storing program steps on magnetic tape is a common method of collecting a *library* or file of programs.

Another great advantage of magnetic-tape storage is that a reel of tape produced as output of a procedure can be removed from the data processing system. With this tape, reports can be written with an independent unit, while the data processing system proceeds with the next program.

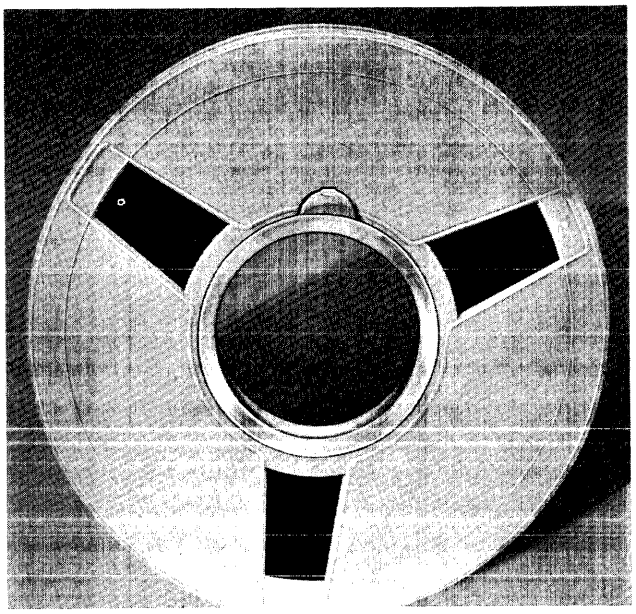

Figure 5. Reel of Magnetic Tape

Magnetic-Disk Storage

Magnetic disks are thin metal disks that are coated on both sides with a ferrous oxide recording material. These disks are mounted on a vertical shaft, and are separated from one another. As the shaft revolves, it spins the disks at a constant speed.

Information is recorded on disks in the form of magnetized spots located in concentric tracks on each recording surface.

The magnetic disk can be used repeatedly. Each time new information is stored on a track, it erases the data formerly stored there. Records can be read from disks as often as desired until they are written over or erased.

In addition to providing increased storage capacity, magnetic-disk files permit the processing of data on a random basis. Because any record on any track is addressable, the IBM 1441 Processing Unit has access to any record in the disk-storage unit. This random accessibility is the key to the in-line approach to data processing. Transactions can be entered as they occur — regardless of sequence. The 1460 can process other data within core storage while the access mechanism searches for a record.

Language

In the punched-card area of data processing, the language of the machine is the holes in the card. As data processing needs increase, the basic card-language remains the hole in the card. But in the transition from unit-record systems to data processing systems, another faster, more flexible machine-language emerges.

Just as each digit, letter, or special character is coded into the card as a punched hole or a combination of holes, it is coded into magnetic storage as patterns of magnetized spots.

Obviously, many different code patterns can be set up. The internal code used in the IBM 1460 Data Processing System is called *Binary Coded Decimal.* All data and instructions are translated into this code as they are stored. No matter how information is introduced into the system, the binary-coded-decimal representation is used in all data flow and processing from that point on, until it is translated into printed output when reports and documents are written or converted to card code for punching. Converting input data to the 1460 internal code, and subsequent reconverting, is completely automatic.

Processing

Processing is the manipulation of data from the time it is introduced to the system as input until the desired results are ready for output. The following functions are performed in the processing unit.

Logic

The logic function of any kind of data processing system is the ability to execute program steps; but even more, the ability to evaluate conditions and select alternative program steps on the basis of those conditions.

In unit-record equipment, an example of this logic is selector-controlled operations based on an X-punch or No X-punch, or based on a positive or negative value, or perhaps based on a comparison of control numbers in a given card field.

Similarly, the logic functions of the 1460 system controls comparisons, branching (alternative decisions similar in concept to selector-controlled procedures), move and load operations (transfer of data or instructions), and the general ability to perform a complicated set of program steps with necessary variations.

Arithmetic

The IBM 1441 Processing Unit can add, subtract, multiply, and divide. Multiplication and division can be accomplished in any 1460 system, by programmed subroutines. When the extent of the calculations might otherwise limit the operation, a special multiply-divide feature is available.

Editing

As the term implies, *editing* adds significance to output data by punctuating and inserting special characters and symbols. The IBM 1460 has a unique ability to perform this function, automatically, with simple program instructions.

Checking

Advanced circuit design with extremely reliable components is built into the 1460 system to provide assurance of accurate results. Self-checking within the machine is separated into three categories: *parity, validity,* and *hole count.*

Solid-State Circuitry

Transistorization of 1460 components is another significant design characteristic. In addition to providing a lower cost system, the use of transistors increases reliability, while decreasing maintenance requirements (Figure 6). Other advantages are carefully controlled space requirements, heat dissipation, and power requirements.

The physical arrangement of the system components offers a less tanglible, but equally important, benefit in greater operating efficiency, because the components requiring operator attention can be situated for

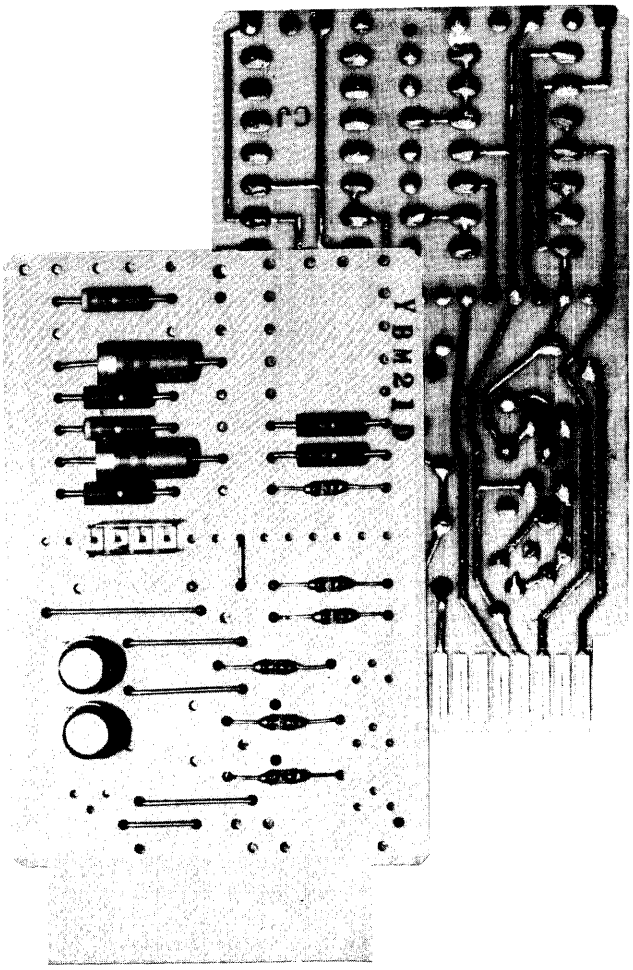

Figure 6. Transistor Cards

accessibility and convenience. The controls and arithmetic components are consolidated into a single set of modular cabinets.

Thus far, only the most obvious advantages offered by the 1460 have been given. As the system components and features are described in greater detail, further advantages become evident. Power and economy of the 1460 are not derived from any single characteristic or component, but from the many considerations that led to the design of a balanced system in which every component can operate at its optimum rate.

Advanced Design

Advanced systems design of the IBM 1460 permits use of the machine as a complete, independent accounting system. It can also perform low-cost, direct input and output, and auxiliary tape operations for large-scale data processing systems.

The entire system is operated by the stored program. Timesaving features, such as the powerful editing function and the elimination of control panels, provide increased flexibility for application development. The capacity to use magnetic-tape data means economy in recording, transporting, and storing large volumes of information in compact form; and the availability of magnetic-disk storage permits in-line processing in addition to providing increased storage capacity.

IBM 1460 Used with Other IBM Systems

On-Line Operation

The IBM 1460 Data Processing System can be attached to an IBM 1401, or an IBM 1440, or another IBM 1460 Data Processing System.

Off-Line Operation

The IBM 1460 has additional flexibility when it is used with tape-oriented configurations of large-scale, general-purpose IBM data processing systems. For example, the 1460 can produce, edit, sort, print, punch, and further manipulate tape data used by the IBM 7070 and 7080. This allows more time for the operations that are more efficient and practical for each system.

IBM Scientific Data Processing Systems

The column binary feature enables the 1460 to process card and tape data recorded in binary form. This ability makes the 1460 especially useful as an auxiliary system for the IBM 704, IBM 709, and IBM 7090 Data Processing Systems.

Card-Oriented System

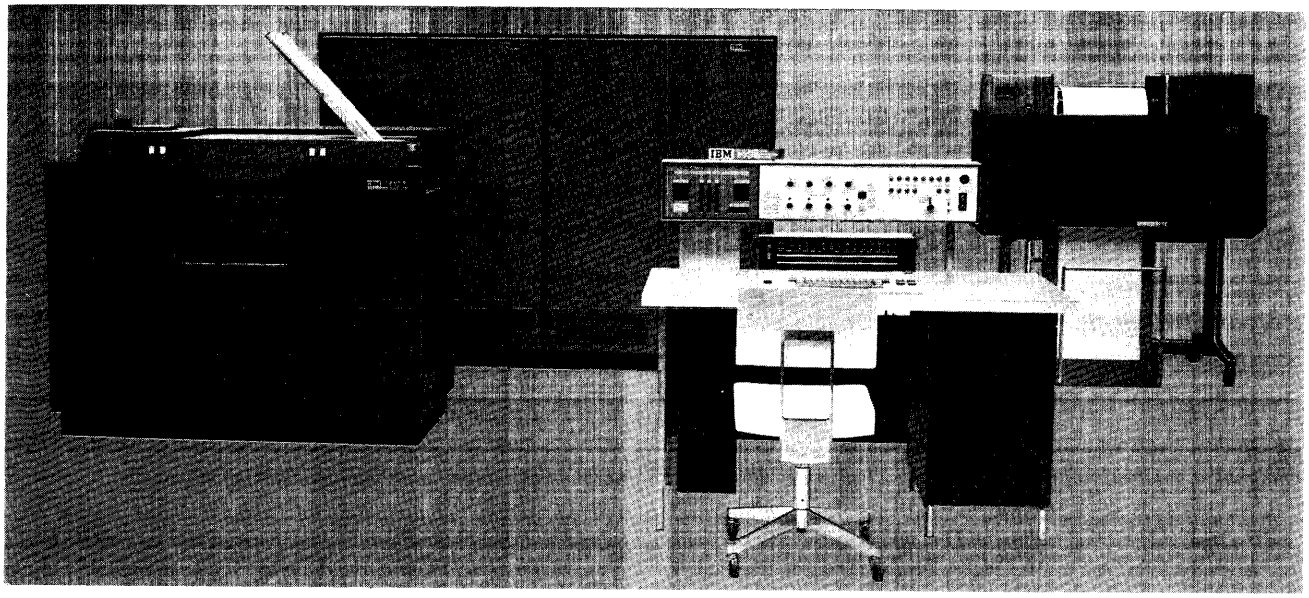

Figure 7. Card-Oriented 1460 System

The IBM 1460 card-oriented system (Figure 7) is completely transistorized, and utilizes the modern technique of stored-program control. This system can perform all basic functions (such as: reading, printing, comparing, adding, subtracting, editing) and variations of these functions.

The IBM 1460 incorporates an advanced design of many outstanding features of existing equipment, for improved programming and operating efficiency:

1. Core storage provides instant access to information and the stored program. Every position can accommodate either an alphabetic or numeric character, and is individually addressable. Character time is .006 millisecond.
2. Variable word length permits a maximum utilization of the storage facility.
3. High-speed printing increases output efficiency.
4. High-speed reading and punching offer faster input and output and permit easy integration of the 1460 into existing accounting machine procedures.
5. Editing completes the preparation of information for printed output.

Physical Features

The physical features of the units that make up the card-oriented system are compact and of modern design. The units are mobile to permit an operating arrangement that is both convenient and efficient. The IBM 1460 Data Processing System in its card configuration is composed of five interrelated units:

IBM 1441 Processing Unit, Model B
IBM 1461 Input-Output Control, Model 1
IBM 1447 Console, Model 1, 2, or 4
IBM 1402 Card Read-Punch, Model 3
IBM 1403 Printer, Model 2.

System Data Flow

The IBM 1402 Card Read-Punch and the IBM 1403 Printer are two of the input and output units for the IBM 1460 Data Processing System (Figure 8). IBM

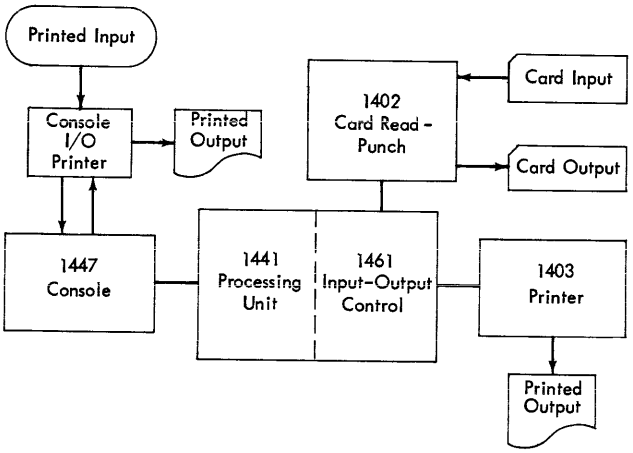

Figure 8. Card-Oriented 1460 System Schematic

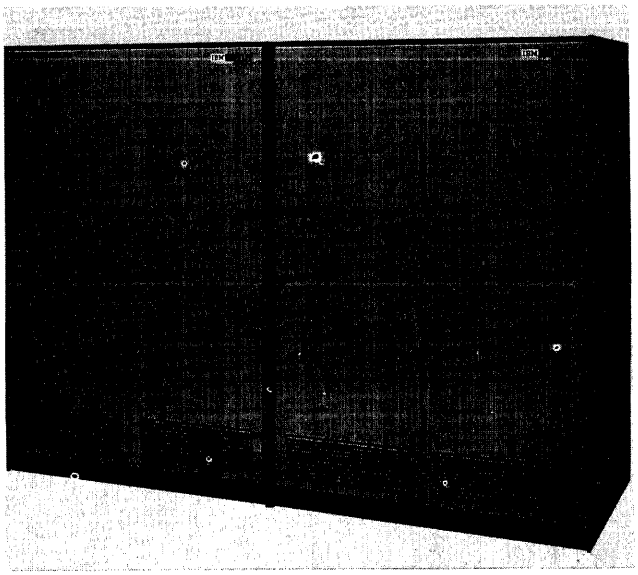

Figure 9. IBM 1441 Processing Unit and IBM 1461 Input/Output Control

1402 and 1403 data passes through the IBM 1461 Input/Output Control unit.

The arithmetic and logical functions of the system are performed in the IBM 1441 Processing Unit.

An IBM 1447 Console (Model 2 or 4) is also considered an input/output unit because these two models have a console I/O printer associated with them. (The 1447, Model 1, does not have printed input and output capabilities.) The console is directly connected to the IBM 1441 Processing Unit.

IBM 1441 Processing Unit

The processing unit (Figure 9) contains the magnetic-core storage unit to perform all the machine logic. Alphabetic and numeric characters are represented in storage by an 8-bit code. The eight bits consist of six bits for alphameric binary code, a seventh bit for checking, and an eighth bit for field definition.

Three areas of storage are reserved for input and output data. In the first, 80 storage positions receive 80 columns of card information from the card reader. Another 80 positions are reserved for assembly of data to be punched. The third area is reserved for the assembly of 132 characters of printer information. However, when these areas are not being used as specified, they can be used for other purposes.

Each of the storage positions is identified by a 3-character address. The first 1000 positions of storage have the addresses 000-999. The remaining storage positions need an alphabetic or special character in the hundreds position of the address (Figure 10).

The IBM 1441 Processing Unit stores the program instructions and the data. It employs a *variable word-length concept*, and each position is addressable.

CODED ADDRESSES IN STORAGE

Actual Addresses		*3-Character Addresses*
000 to 999	No zone bits	000 to 999
1000 to 1099	A-bit, using 0-zone	+00 to +99
1100 to 1199		/00 to /99
1200 to 1299		S00 to S99
1300 to 1399		T00 to T99
1400 to 1499		U00 to U99
1500 to 1599		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	B-bit, using 11-zone	$\bar{0}$00 to $\bar{0}$99
2100 to 2199		J00 to J99
2200 to 2299		K00 to K99
2300 to 2399		L00 to L99
2400 to 2499		M00 to M99
2500 to 2599		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	A-B-bit, using 12-zone	$\overset{+}{0}$00 to $\overset{+}{0}$99
3100 to 3199		A00 to A99
3200 to 3299		B00 to B99
3300 to 3399		C00 to C99
3400 to 3499		D00 to D99
3500 to 3599		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 10. Storage Address Codes

Stored programming involves the concept of *words*. A word is a single character, or group of characters, that represents a complete unit of information. One of the most important characteristics of the IBM 1460 Data Processing System is this variable word-length principle, in which words are not limited to any predetermined number of character positions in the storage unit.

Each word occupies only that number of character

positions actually needed for each specific instruction, or for the specific data involved. This facility contributes to the high efficiency of the core-storage unit.

The same stored-program instructions are used so that programs written for a 1401 system can be run on a 1460 system without any change or modification to the program if the same input/output units are used. The programmer may want to re-evaluate the placement of the input/output commands and change any timing loops to take full advantage of the faster character-transfer cycle, but these are the only changes necessary. (If a 1412 or 1419 is involved, the timing loops must be changed.)

Speed

The IBM 1401 Processing Unit has a character-transfer cycle of .008 ms compared to a character-transfer cycle of .0115 ms on the IBM 1401 Processing Unit. This cycle time improvement provides significant reductions in instruction execution time when 1401 programs are run on a 1460 system.

For example, a move operation that takes 332 ms to transfer 10 characters from one location to another location in a 1401 system requires only 168 ms on a 1460 system.

Program Run-Time Savings

Program run-time savings of up to 50% can be realized when existing 1401 programs are run on a 1460 system. The most significant program run-time savings are realized when the programs run are predominantly dependent upon internal-processing speeds. Programs already restricted by input/output unit speed are still restricted, but some program run-time savings can be realized during those portions of the program that are not involved with the input/output units.

Test runs of specific 1401 programs on a 1460 system have shown these program run-time improvements:

- A sort program of 15,000 records resulted in savings of 30%.
- A merge program of 27,000 records resulted in savings of 38%.
- A Fortran program assembly resulted in savings of 26%.
- A Fortran program resulted in savings of 40%.

Additional Features

The 1441 has several standard features that were considered special features on the 1401.

High-Low-Equal Alphamerical Compare. This feature causes the compare instruction to store the results of a comparison in indicators that can be tested for high, low, or equal conditions.

This feature provides speed and flexibility in tape-sorting operations. A control number in storage can be used to determine the sequence of records that have been read from tape.

Move Record. This feature is an instruction that makes it possible to move two or more fields that comprise a complete record in storage, disregarding word marks within the record. The operation causes the record to be moved serial-by-character from left to right, until a record mark or group-mark with a word-mark is sensed in core storage. This feature increases program efficiency, because only one instruction is needed to move several sequential fields.

IBM 1461 Input/Output Control, Models 1, 2, and 3

Model 1 of the 1461 (see Figure 9) contains the circuitry necessary for controlling data transmission between the IBM 1441 Processing Unit and the IBM 1402 Card Read-Punch and the IBM 1403 Printer.

Model 2 of the 1461 is required when IBM 729 Magnetic Tape Units are attached to a 1460 system and it provides the controlling circuitry necessary for the proper operation of the 729 tape units.

Model 3 of the 1461 is required when IBM 7330 Magnetic Tape Units are attached to a 1460 system and it provides the controlling circuitry necessary for the proper operation of the 7330 tape units.

Additional Features

The 1461 has two standard features that are special features on the 1401.

Print Control, Additional. This feature controls the additional 32 print positions of the IBM 1403 Printer, Model 2, attached to the system.

Space Suppression. This feature provides program control for space suppression on the printer attached to the system.

IBM 1447 Console Model 1

The IBM 1447 Console, Model 1 (Figure 11), containing operating keys, lights, and switches, is designed to give the operator external control for setting up and checking system operation. Several features facilitate program testing.

The left side of the console panel shows the data as it moves from one system component to another (address registers, character registers, and storage addresses).

Special lights indicate operating conditions of the processing and disk units, the card read-punch, and the printer. If certain errors are detected while the system is running, a red light on the console comes on to show which unit requires attention.

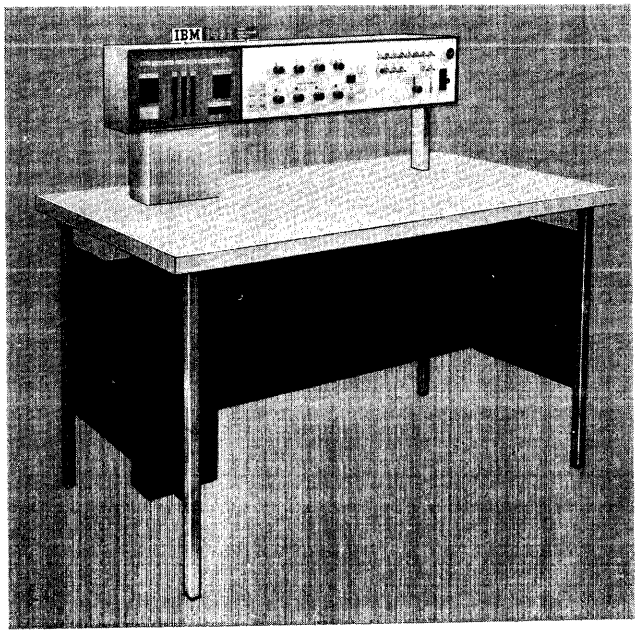

Figure 11. IBM 1447 Console, Model 1

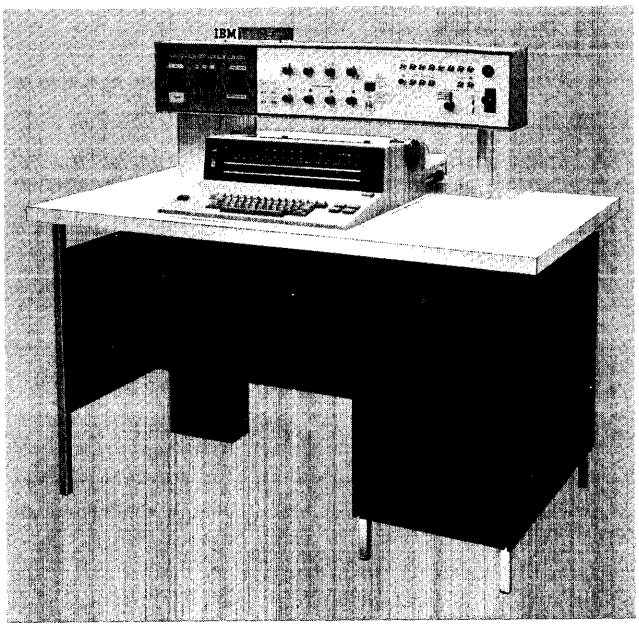

Figure 12. IBM 1447, Model 2, Inquiry Unit

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 on the console. A special switch disconnects 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 execution of the program at a predetermined point. This provides an opportunity to bypass program steps that have already proved accurate and to stop at instruction areas that need to be examined step by step.

For a detailed description of the operating keys, lights, and switches, see *IBM 1447 Console*, Form A24-3031.

IBM 1447, Model 2, Inquiry Unit

The IBM 1447, Model 2, Inquiry Unit (Figure 12) is the input/output printer and keyboard with the controlling circuitry. This unit is used to alter and correct data and programs in storage. It can also be used under program control to print such data as exceptions, or a log of all operations, or as a local inquiry station to obtain records at random from disk storage.

The maximum writing line is 13 inches with the character spacing of either 10 or 12 characters to the inch, as specified. The line spacing can be specified for either six or eight lines to the inch.

The IBM 1447, Model 1, is a prerequisite for Model 2.

Inquiry I/O Printer

The inquiry I/O printer combines a keyboard of 64 characters (designated by the A or H Standard Interchange Code) and a pin-feed platen (special feature) with the advantages of a carriageless printer. The single printing element moves horizontally when printing, no longer subjecting forms to horizontal carriage movement. This printing method results in an output rate of 14.8 characters per second.

Margins, tab stops, and ribbon shift (color) are set manually by the operator. When the printing element moves to within 12 character positions (approximately) of the right-hand margin, a bell sounds. When the printing element reaches the right-hand margin, an automatic carriage return and line-feed operation is executed. Printing is suspended during this operation and during any tabulation operation.

Besides being able to print 64 characters, the console printer can execute various printer functions when the specific functional control characters are sent from the system in the move mode.

These characters can be printed when they are transmitted in the load mode.

The printing of either 10 or 12 characters per inch must be specified by the customer. Vertical spacing of six or eight lines per inch must also be specified by the customer. This vertical spacing can then be manually altered with a double-space setting, resulting in either three instead of six or four instead of eight lines per inch.

IBM 1447, Model 4, Inquiry Unit with Controls for a 1448

The IBM 1447, Model 4, Inquiry Unit with controls for an IBM 1448 Transmission Control Unit is the printer, keyboard, and keys and lights for control of the 1448. The Model 1 and Model 4 combine the functions of a console, and inquiry station, and control for the IBM 1448 Transmission Control Unit.

The IBM 1447, Model 1, is a prerequisite for the Model 4.

IBM 1402 Card Read-Punch, Model 3

The IBM 1402 Card Read-Punch, Model 3 (Figure 13), used with the 1460 system operates exactly the same as the 1402 used on a 1401 system, and provides the card-oriented 1460 system with simultaneous punched-card input and output. This unit has two card feeds. The read section has a rated reading speed of 800 cards per minute. Actual card speed realized is governed by the program routine for each particular run. The read feed is equipped with a device for large-capacity loading, called a *file feed*. With the file-feed device, the read feed can be loaded with as many as 3,000 cards, which reduces operator-attendance requirements.

The 51-column read feed (special feature), interchangeable with the standard 80-column feed, allows the processing of stub cards, thus increasing the flexibility of the IBM 1460 Data Processing System.

The cards feed through the read side of the machine 9-edge first, face down. The feed path is from right to left, passing two sets of brushes (Figure 14). The *read check* station reads 80 columns of the card to establish

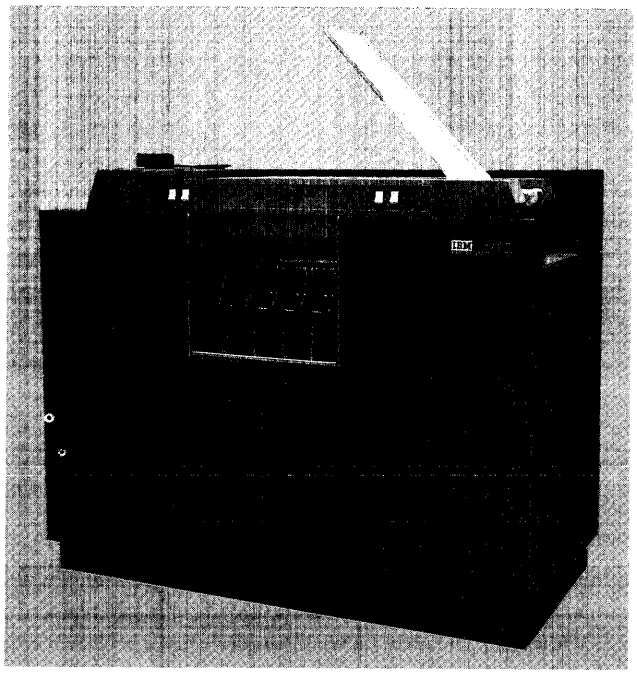

Figure 13. IBM 1402 Card Read-Punch, Model 3

a hole count for checking purposes. The *read* station also reads the 80 columns, proves the hole count, and directs the data into storage. At the end of the card-transport path, three stackers are available to receive the cards. The *normal read* stacker is the stacker closest to the read hopper and is used unless the cards are program-directed to stackers 1 or 2.

The punch section has a rated speed of 250 cards per minute. The card hopper capacity is 2100 cards. The cards feed 12-edge first, face down. The feed path is left to right, passing a blank station, a punching station, and a reading station (see Figure 14). The punching station consists of 80 punches for recording information. The punch-reading station counts all the holes in all 80 columns of the card, for punch checking. At the end of the card transport path on the punch side, three stackers are available to receive the cards. The *normal punch* stacker is used unless the cards are program-directed to stacker 4 or 8. With the addition of punch feed read (special feature), the source card

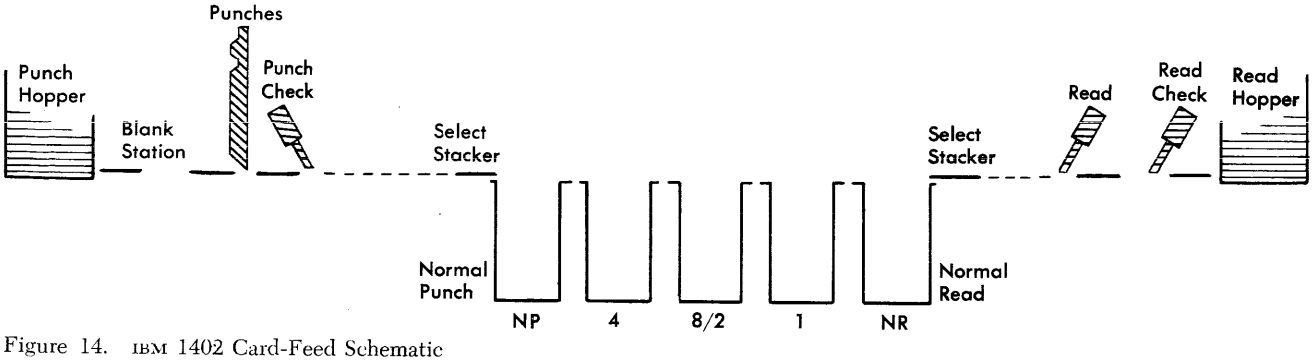

Figure 14. IBM 1402 Card-Feed Schematic

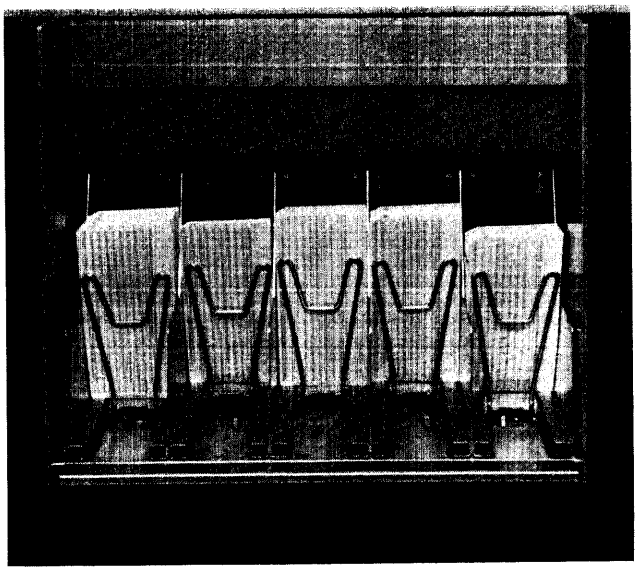

Figure 15. Radial Stackers

can be read in the punch side, and output data can be punched into the same source card.

All these stackers are of the radial type (Figure 15) with a capacity of 1000 cards each. Cards can be removed from the stackers without stopping the machine. Two stackers are assigned exclusively to the reader and two are assigned exclusively to the punch. The center or *common stacker* (8/2 stacker) can be used by either unit.

Both feeds are equipped with jam-detection devices and with misfeeding detection. A card jam or a misfeed in either the read or punch feed causes the system to stop, and a console light glows, indicating which feed caused the stop.

There is no electrical or mechanical coupling between the read and punch units. Therefore, any information from the read side must be entered into storage and read out of storage to the punch unit, for operations equivalent to reproducing or gangpunching.

Additional Features

Early Card-Read. The early card-read special feature is a standard feature on the 1402, Model 3. This feature minimizes the decrease in card-reading speed that is caused by lengthy processing routines.

IBM 1403 Printer

The IBM 1403 Printer (Figure 16) is another output medium for a card-oriented 1460 system. Either the 1403, Model 2, or the 1403, Model 3, can be attached.

Both models of the 1403 have a printing capacity of 132 printing positions. Horizontal spacing is ten characters to the inch. Vertical spacing of six or eight lines to the inch can be manually selected by the operator. The dual-speed tape-controlled carriage skips the first eight lines of any skip at a speed of 33 inches per second. The remaining lines are skipped at a speed of 75 inches per second.

Each printing position can print 48 different characters, and the printing format is controlled by the system's stored program.

As each character is printed, checking circuits are set up to ensure that the character printed is correct. Checks are also made to ensure that only valid characters are printed and that overprinting does not occur. If an error is detected, the machine stops, and the associated check light comes on.

The IBM 1403 Printer has special features that increase operating efficiency. Mobile forms stands allow blank forms to be loaded and wheeled to the printer and completed forms to be wheeled away. This reduces paper handling and job setup time. Forms insertion is simplified by operator control levers and keys.

The basic differences between the Model 2 and Model 3 1403 are speed and method of printing. The Model 2 has a rated speed of 600 lines per minute; the Model 3 has a rated speed of 1,100 lines per minute.

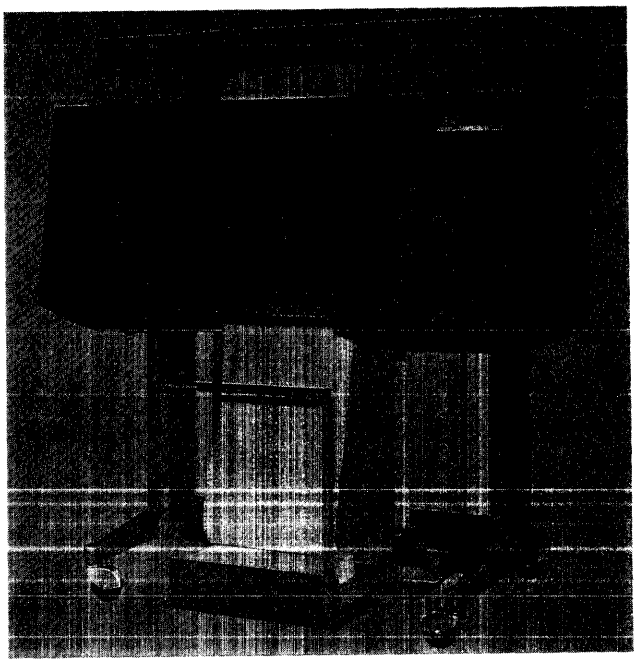

Figure 16. IBM 1403 Printer

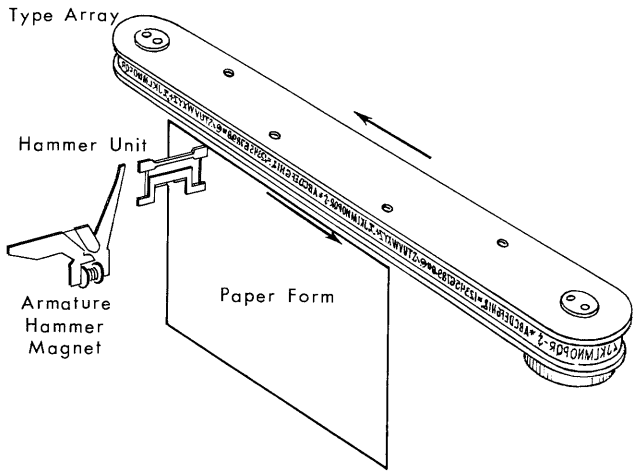

Figure 17. Schematic of Printing Mechanism

Model 2 Method of Printing

The alphabetic, numeric, and special characters are assembled in a chain (Figure 17). As the chain travels in a horizontal plane, each character is printed as it is positioned opposite a magnet-driven hammer that presses the form against the chain.

Model 3 Method of Printing

The 1403, Model 3, uses the same printing setup as the Models 1 and 2, but the print chain is redesigned for the Model 3. Instead of having the type attached to a connecting band, it is restrained on a track to ensure greater accuracy at higher operating speed.

Checking

The IBM 1460 Data Processing System contains many important design factors to ensure maximum efficiency and reliability. The self-checking features built into the 1460 system are designed to ensure a high degree of error detection.

Parity Check

The odd-number bit configuration is used for the parity check. The proper number of bits for any given character is known as parity for that character. A word mark that appears with a character is included in the check for an odd number of bits.

When information is moved within the system, a parity check is performed to test the presence of an odd number of bits for each character being moved.

Validity Check

A validity check is performed on all information when it is read into storage from the card reader, to ensure that all characters are valid. If any invalid characters are detected, the machine stops and the associated check light comes on.

Four types of *address validity checking* are performed by the processing unit. Although each of the four checks has a specific function, each check ensures that all addresses used in a program are within the core-storage capacity of the system.

Hole-Count Check

The hole-count feature compares the total number of punches read in a card column at the first reading station, with the total number of punches in the same card column at the second reading station. The hole-count feature is also effective with the punch side to compare the total number of holes set up for punching in a column, with the number of holes punched in the card column. If the result of the hole-count comparison is unequal, in either case, the system stops, and check lights indicate the unit involved.

Word Mark

The use of the variable-length instruction and data format requires a method of determining the instruction and data-word length. This identification is provided by a *word mark.*

The word mark serves several functions:

1. It indicates the beginning of an instruction.
2. It defines the size of a data word.
3. It signals the end of execution of an instruction.

NOTE: Word marks are illustrated in this discussion by underlining each character that has an associated word mark.

Stored-Program Instructions

All arithmetic and logical functions are performed by the instructions retained in storage. One form of an instruction consists of an operation code followed by two 3-character addresses. The 2-address instruction is required to move data from one location to another, to perform arithmetic operations of addition or subtraction, to compare two fields, or to edit.

Because the 1460 system uses a variable word-length concept, the length of an instruction can vary from one to eight characters.

Instruction Format

Op Code	*A- or I-address*	*B-address*	*d-character*
x	xxx	xxx	x

Mnemonic

This is the mnemonic operation code used by the (SPS or) Autocoder processor program(s) to designate the actual machine operation code.

Op Code

This is always a single character that defines the basic operation to be performed. A word mark is always associated with the operation code position of an instruction.

A-Address

This always consists of three characters. It can identify the units position of the A-field, or it can be used to select a special unit or feature such as tape unit or column-binary feature.

I-Address

Instructions that can cause program branches use the I-address to specify the location of the next instruction to be executed if a branch occurs.

B-Address

This is a three-character storage address that identifies the B-field. It usually addresses the units position of the B-field, but in some operations (such as tape read and write) it specifies the high-order position of a record-storage area.

d-Character

The d-character is used to modify an operation code. It is a single alphabetic, numeric, or special character, positioned as the last character of an instruction.

Instruction Example

Op Code	*A- or I-address*	*B-address*
A	072	423

This is an ADD instruction. The operation code A causes the field whose units position is in storage location 072 to be added to the field whose units position is in location 423. This operation continues until a word mark for the high-order position of field B (which must have a defining word mark) is sensed. The word mark stops the operation being performed and causes the program to advance to the next instruction. If field A is shorter than field B, it must also have a defining word mark.

As stated before, not all instructions have the 2-address form. Others consist of only one address, or no address. This concept results in what is known as *variable-length instructions.*

Examples of the six combinations possible in variable-length instructions are shown in Figure 18.

Addressing

The 1460 processes data by following a series of stored instructions. The storage unit stores both the instructions and the data. Each position in storage can be addressed. The high-order position of a field in storage is identified by an associated *word mark.*

An *instruction* in core storage is addressed by the location of its high-order position. The machine reads the instruction from left to right until it senses the word mark associated with the next instruction. The final instruction in the program must have a word mark set at the right of the low-order position. The high-order character is the operation code, with an associated word mark that is set by the program when the instruction cards are loaded. In contrast, a *data word* is read from right to left until a word mark is sensed with its own high-order position. In addressing a data word, we specify its units position.

NUMBER OF POSITIONS	OPERATION	INSTRUCTION FORMAT
1	READ A CARD	OP code: 1
2	SELECT STACKER	Op code: K; d-character: 2
4	BRANCH	Op code: B; I-address: 400
5	BRANCH IF INDICATOR ON	Op code: B; I-address: 625; d-character: /
7	ADD	Op code: A; A-address: 072; B-address: 423
8	BRANCH IF CHARACTER EQUAL	Op code: B; I-address: 650; B-address: 080; d-character: 4

Figure 18. Instruction Formats

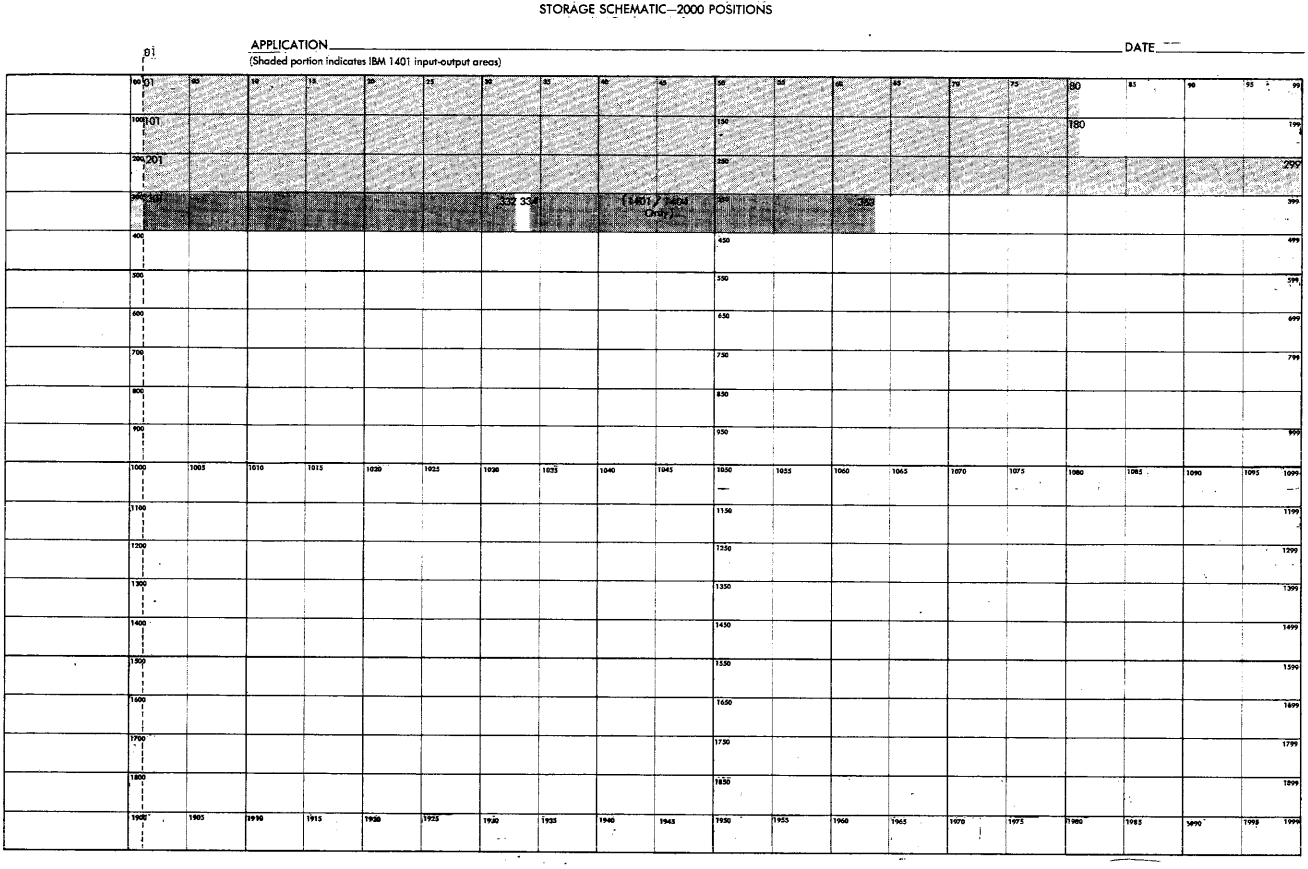

Figure 19. Storage Layout

Input/Output Storage Assignments

Certain areas of storage are reserved for use by input/output devices (Figure 19). In most cases, the assignments are such that a correlation is achieved between input/output columns and/or print positions. The storage location assignments are:

001 through 080	card input
101 through 180	card output
201 through 300 (or 332)	print output
334 through 363	IBM 1404 input (special feature)

Except for locations 000 and 100, the areas isolated by these storage assignments can be used for normal processing or instructions.

Address Registers

Four address registers are incorporated in the IBM 1441 Processing Unit. The storage-address register specifies the core-storage location that will be involved in a particular storage cycle. The I-, A-, and B-address registers furnish the storage-address register with the proper address according to the cycle being executed.

Chaining Instructions

In some programs, it becomes possible to perform a series of operations on several fields that are in sequence in storage. Some of the basic operations, such as add, subtract, move, and load, have the ability to be *chained* so that less time is required to perform the operations, and space is saved in storing instructions. Here is 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 700 850
A 695 845
A 690 840
A 685 835
```

At the completion of the first instruction, the A-address register contains 695 and the B-address register contains 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, thus using .480 milliseconds (ms). Also, 28 storage positions are required to store these instructions.

By taking advantage of the fact that A- and B-address registers contain the necessary information to perform the next instruction, this same sequence of operations can be executed:

```
A 700 850
A
A
A
```

Connecting instructions together in this manner is called chaining. 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 .372 milliseconds to execute. Only ten storage positions are required to store these chained instructions.

The ability to chain a series of instructions is not dependent on the use of the same operation code. Chained instructions may have various Op codes. The requirement is that the A-fields to be operated on must be in sequence, and the B-fields must be in sequence.

Example:
```
A 900 850
M
A
M
```

For example, assume that the data fields are each ten characters long:

The ten characters at location 900 were added to 850.
The ten characters at location 890 were moved to 840.
The ten characters at location 880 were added to 830.
The ten characters at location 870 were moved to 820.

Loading Instructions

Before the 1460 can start processing, program instructions must be put into the system. This is accomplished by means of a loading routine.

Instructions are placed in the machine by the use of load cards or program tapes. Several different types of load cards condition the 1460 to accept information for processing. They cause word marks to be set at specific storage locations, and load a series of instructions that allow the cards containing the actual program instructions to be stored in their correct locations.

Operation Codes

General descriptions of the operation codes for the IBM 1460 are presented here. Detailed descriptions of all Op codes and instructions are found in these publications:

- *System Operation Reference Manual,* Form A24-3067
- *Miscellaneous Input-Output Instructions,* Form A24-3068
- *Tape Input-Output Instructions,* Form A24-3069
- *Disk Storage Input-Output Instructions,* Form A24-3070

Arithmetic Operation Codes

Add and subtract, and the special multiply and divide operation codes, perform the arithmetic operations. Because the operations are performed within core storage, no accumulators or counters are necessary. Thus, the capacity for arithmetic functions is not limited by a predetermined number of counter positions.

Logic Operation Codes

The decision-making ability of the IBM 1460 Data Processing System is based on the logic operation codes. As a result of testing for conditions that can arise during processing, the program can be directed to predetermine sets of instructions, or subroutines.

For example, test the unequal compare indicator to determine if it is on. If it is off, continue the program with the next sequential instruction. If the indicator is on, transfer the program to location 568 for the next instruction.

Op Code	*I-address*	*d-character*
B	568	/ (BRANCH IF INDICATOR ON)

Move and Load Operation Codes

The move and load operation codes provide program control over the rearrangement of data in storage and also the transfer of data from an input device into storage.

MOVE instruction transfers data only; LOAD instruction transfers data and associated word marks.

Miscellaneous Operation Codes

These codes perform operations such as selecting stackers, setting and clearing word marks, comparing, and controlling the forms carriage.

Input/Output Operation Codes

Input/output operation codes control reading and punching data cards, and printing reports. Branching instructions are provided to transfer the program automatically at the completion of a function. More than one function can be initiated by a single instruction.

For example, to cause the 1460 system to read card data into core storage and then transfer the program, write this instruction:

Op Code	*I-address*
1	495 (READ CARD)

After the card has been read, the program continues with the instruction at storage location 495.

Editing

Editing in the IBM 1460 Data Processing System is automatic control of zero suppression, insertion of identifying symbols, and punctuation of an output field. This function can be performed with two simple instructions. One single EDIT instruction can cause all desired commas, decimals, dollar signs, asterisks, credit

	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 20. Editing Operation

symbols, and minus signs to be inserted automatically in a numeric field. Also, unwanted zeros to the left of significant digits are suppressed (Figure 20).

In editing, two fields are needed: the data field, and a control field. The control field indicates how the data is to be edited. It specifies the location of commas, decimals, conditional CR and minus symbols, and indicates where zero suppression is to occur.

The control word is divided into two parts: the body (used for punctuating the A-field) and the status portion (contains the sign symbols and asterisks). Printing sign symbols is, in part, controlled by the sign of the A-field.

To edit a field, a LOAD instruction loads the control word in the output area (B-field); the EDIT instruction moves the data in the A-field to the output area, and performs the editing function.

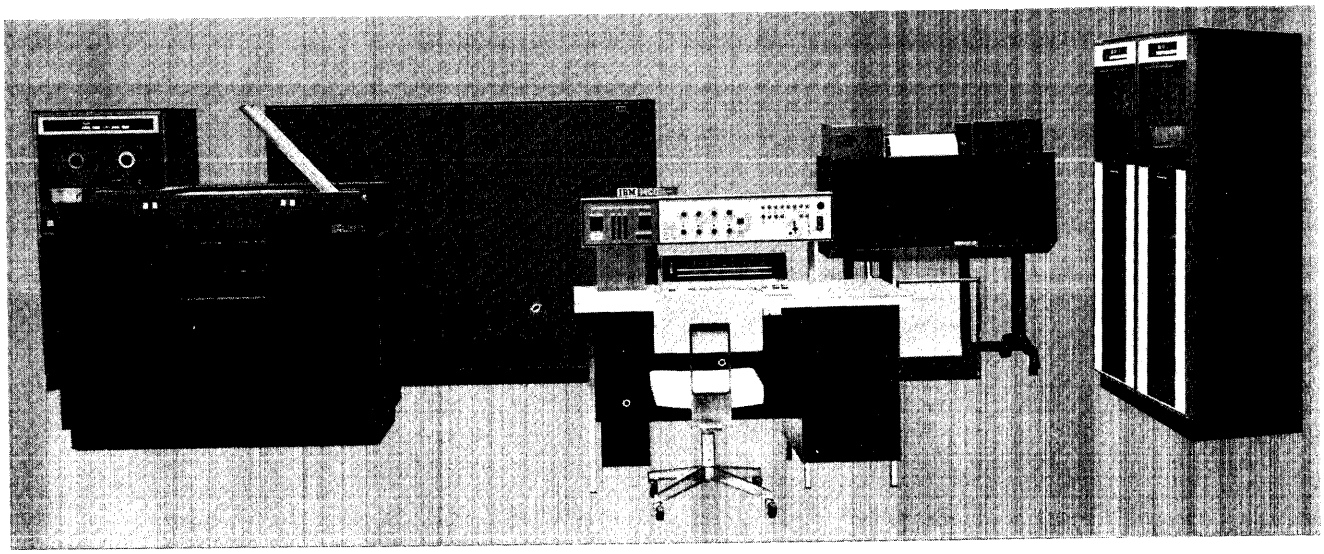

Figure 21. Tape-Oriented 1460 System

A card-oriented 1460 system can be expanded to a magnetic-tape-oriented system (Figure 21). The tape-oriented system can be used alone as a complete data processing system. It can also be used as auxiliary equipment for intermediate and large-scale systems, providing economical off-line tape editing and printing.

As many as six magnetic tape units can be connected to the IBM 1460 Data Processing System, providing low-cost, full scale, punched-card, and magnetic-tape input and output operations.

The logic, arithmetic, editing, and tape instructions of the tape system can be used to perform the primary functions:

Magnetic tape to printer
Punched cards to magnetic tape
Magnetic tape to punched cards
Punched cards to printer
Tape sorting and merging

System Data Flow

The magnetic-tape-oriented 1460 has the same data flow as the card-oriented system, plus the input from an attached tape unit into the system, and output from the system to an attached tape unit (Figure 22).

Magnetic Tape Units

A tape-oriented 1460 system can use IBM 729-II, 729-IV, 729-V, 729-VI, or the 7330 Magnetic Tape Units. A maximum total of six magnetic tape units can be attached to a 1460 system. The system can have the 800-character-per-inch feature, which allows the attachment of IBM 729-V or 729-VI Magnetic Tape Units to the system. Thus, magnetic tapes varying in character rates from 7,200 characters per second to 90,000 characters per second can be used on the same 1460 system.

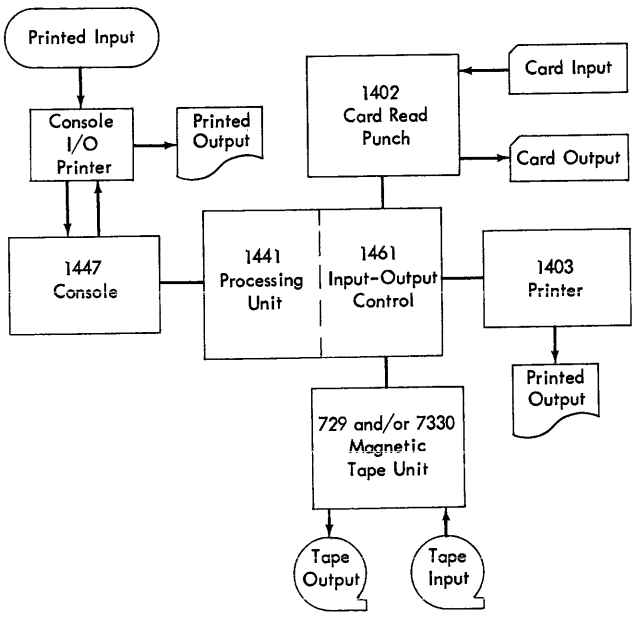

Figure 22. Tape-Oriented 1460 System Schematic

The faster internal character rate of the 1460 allows the attachment of IBM 729-VI Magnetic Tape Units to the system. When operating at 800 characters per inch, the 729-VI has a character rate of .011 ms. The reading of a 1,000-character tape record, using 729-VI tape units at 800 characters per inch, interlocks the IBM 1441 Processing Unit for 17.7 ms, as opposed to 22.7 ms for a Model C or D 1401 equipped with 729-IV tape units. Substantial savings in run-time are available to the user of the 1460 system when the 729-VI is attached to the system.

Magnetic Tape

An important feature in economical processing of business data is compact storage. A magnetic-tape reel (10½ inches in diameter) contains 2,400 feet – sufficient tape to record as many as 14 million characters. Tape reels can be stored or transported easily from one installation to another. Also, magnetic-tape records have gained wide acceptance as legal documents.

The magnetic-tape recording code used with the IBM 1460 is the same binary-coded-decimal code used with other IBM data processing systems. This compatibility permits interchanging tapes between installations that employ different IBM systems. The tape itself is a ribbon, ½-inch wide, coated with a magnetic oxide material.

Four models (II, IV, V, and VI) of the IBM 729 Magnetic Tape Unit (Figure 23) can be used with the IBM 1460. All models have duel density; that is, they can write and read either high-density or low-density magnetic tape. Models II and IV can read and write at

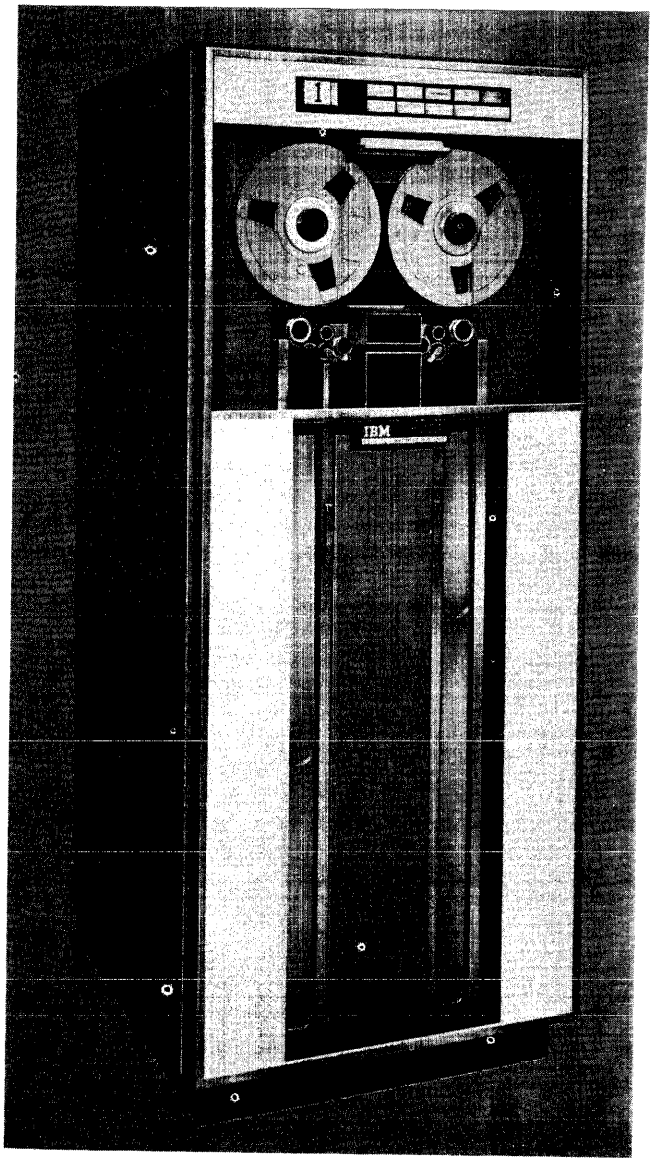

Figure 23. IBM 729 Magnetic Tape Unit

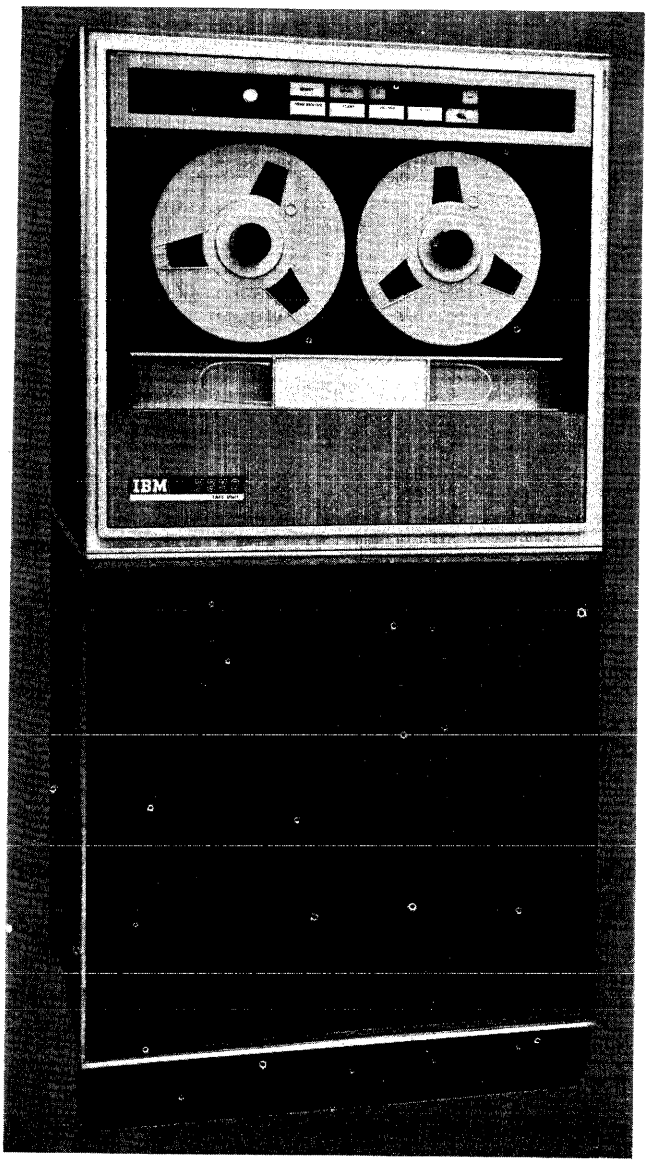

Figure 24. IBM 7330 Magnetic Tape Unit

either 200 characters per inch or at 556 characters per inch. Models V and VI can read and write at 200, 556, or at 800 characters per inch. Higher-density tapes provide a significant storage advantage in that fewer reels are required for a given volume of data.

In addition to the dual-density feature, all models use a ¾-inch inter-record gap, and BCD character representation.

The IBM 7330 Magnetic Tape Unit (Figure 24) can be used advantageously in cases where the volume of information is too cumbersome for efficient unit-record processing, and where the tape processing speed is not the major consideration. It has the dual-density feature, the ¾-inch inter-record gap, and the BCD character representation that permit the 7330 to process tapes used in IBM 727 and 729 Magnetic Tape Units, and in the IBM 7701 and 7702 Magnetic Tape Transmission Terminals.

The primary difference between the 7330 and the 729 is processing speed. Figure 25 shows a comparison of the five tape unit models available for use with the IBM 1460 Data Processing System.

Tape Checking

The IBM 729 and 7330 achieve increased reliability through two new features: the *two-gap head*, and *dual-level sensing*. The first of these, the two-gap head, makes it possible to verify automatically the validity of recorded information at the time it is written. The relative position of the read and write gaps is such that a character recorded by the write gap passes the corresponding read gap almost instantaneously. Thus, as each character of a record is written, it is read and a parity check applied.

If an error is detected, the stored program receives a signal, and a corrective action can be taken. With the two-gap head, a parity check is detected when the character is written.

The ability of the two-gap head to read tape in reading and writing operations makes it possible to check these operations by dual-level sensing.

A critical analysis is made of the signal strength of the recorded information. On the basis of this analysis, recorded information is accepted if its signal strength meets fixed standards. If the signal strength does not meet these standards, an error is indicated.

Operating Characteristics	729 II/V	729 IV/VI	7330
Density Characters per Inch (CPI)	200, 556 or 800*	200, 556 or 800*	200 or 556
Tape Speed, inches per Second	75	112.5	36
Inter-Record Gap (IRG) Size, Inches	3/4	3/4	3/4
Character Rate, Characters per Second	15,000, 41,667 or 60,000**	22,500, 62,500 or 90,000**	7,200 or 20,016
High-Speed Rewind Minutes	1.2	.9	2.2
Regular Rewind, Inches per Second	75	112.5	36

Notes: * 800 CPI for 729 V and VI only.
** 60,000 for 729 V at 800 CPI; 90,000 for 729 VI at 800 CPI.

Figure 25. Comparison of IBM 729 and 7330 Magnetic Tape Unit Characteristics

Tape Instructions

When tape units are part of the IBM 1460 Data Processing System, they must be controlled by special tape instructions.

Instruction Format

Op Code	*A-address*	*B-address*	*d-character*
x	%xx	xxx	x

Op Code

Signifies the operation code.

A-Address

%xx always appears in the A portion of a regular tape instruction. The % sign signals that a tape unit is to be selected. The second character can be either U or B depending on whether the tape being read or written is in even- or odd-bit parity. The third digit specifies the number of the particular tape unit involved.

B-Address

Specifies the location in core storage of the high-order position of a tape record.

d-Character

Represents the actual operation (read or write).

Instruction Example

M(%U2)(419)R. Read the record from tape unit 2 to core storage in a read tape operation. The high-order tape-record character is moved to location 419, the next character is moved to location 420, etc., until transmission is stopped by an inter-record-gap in the tape record, or a group-mark with word-mark in core storage.

Disk-Storage-Oriented System

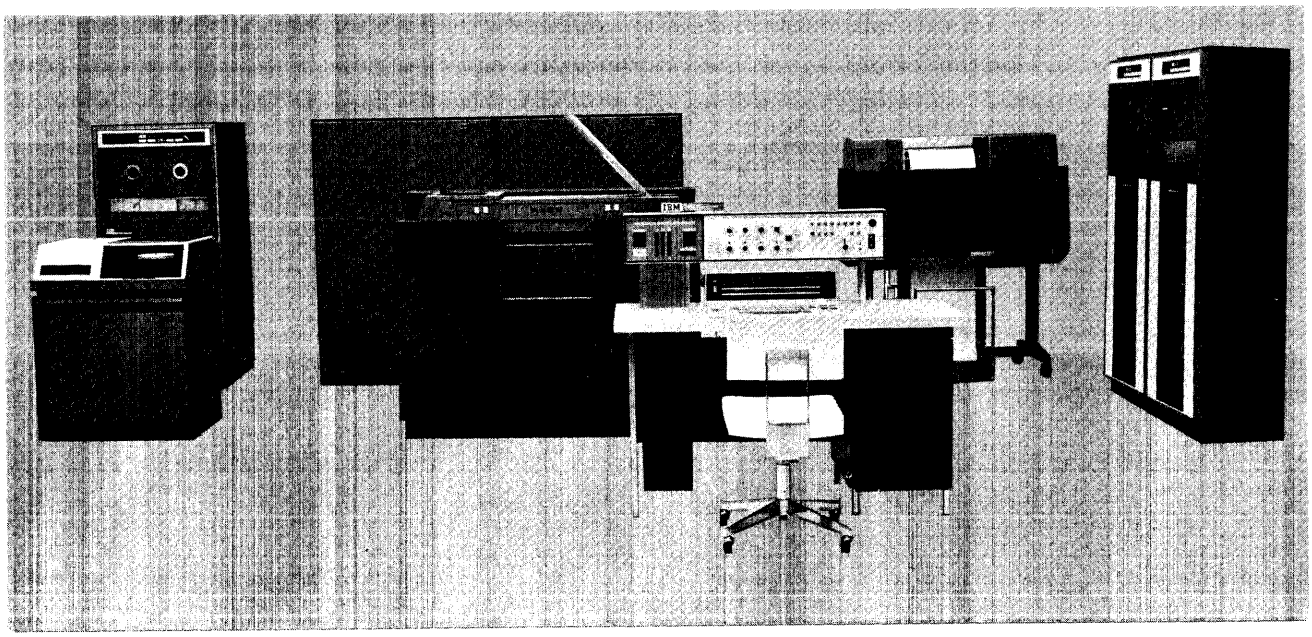

Figure 26. Disk-Storage-Oriented 1460 System

A card-oriented system or a tape-oriented system can be expanded to form a disk-storage-oriented 1460 system (Figure 26).

System Data Flow

The disk-storage-oriented 1460 has the same data flow as the card-oriented/tape-oriented system, plus the input from an attached 1311 into the system, and output from the system to an attached 1311 (Figure 27).

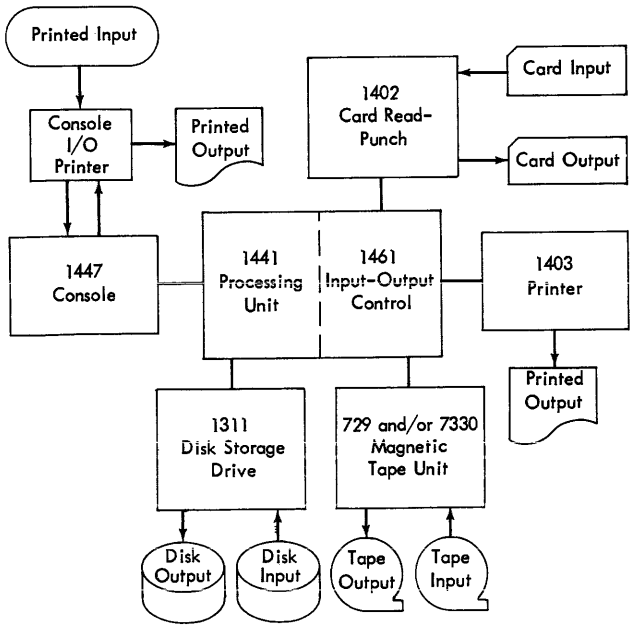

Figure 27. Disk-Storage-Oriented 1460 System Schematic

IBM 1311 Disk Storage Drive

Up to five IBM 1311 Disk Storage Drives can be attached to a 1460 system. The first disk storage drive attached to the system must be a Model 1 (Figure 28). Additional drives are Model 2's.

Figure 28. IBM 1311 Disk Storage Drive, Model 1

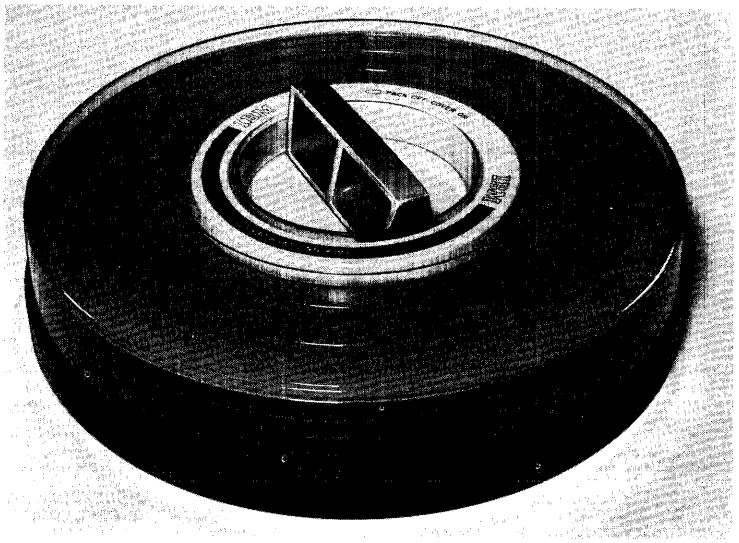

Figure 29. IBM 1311 Disk Storage Drive Disk Pack

IBM 1311 disk storage consists of small disk packs on which information is stored. When recording or reading the information, a disk pack (Figure 29) is mounted on an IBM 1311 Disk Storage Drive. A disk pack is easily removed by the operator for storage. Thus, when processing is completed for a file of records on a disk pack, that pack can be removed, stored, and another pack mounted. Disk packs can be changed in about two minutes per drive.

With the maximum of five IBM 1311 Disk Storage Drives installed on a system, the system user can place as many as 10 million characters of disk-stored information on line at one time (approximately 15 million if he uses the track-record special feature). The library concept of removable disk packs, however, frees him from any limits of disk-storage capacity. A user's storage requirements determine the number of disk packs he need maintain.

The 1311 rotates the installed disk packs at a speed of 1,500 rpm, and the read-write positioning is performed by a 5-arm, comb-like access assembly. Each access arm contains two read-write heads, which can read or write on ten tracks at one setting of the access assembly. These ten tracks can be considered a *cylinder*. The only motion required of the access assembly is horizontal motion, to locate the proper cylinder for any record on the disk pack. There are 100 cylinder positions for the access assembly. The average access time for disk records is 250 ms. When the *direct seek* special feature is installed, the average access time is 150 ms.

Disk Pack

A disk pack can store 2 million characters of information. The unique feature of a disk pack is that it can be removed from an IBM 1311 Disk Storage Drive in less than one minute, stored on a shelf while other disk packs are being processed, and returned to the system whenever it is needed. When more than one IBM 1311 Disk Storage Drive is installed on the system, the disk packs are interchangeable between the various disk drives.

A disk pack, in its protective container, is 4 inches high, 14 inches in diameter, and weighs less than 10 pounds.

Disk-Storage Addressing

A 6-digit sector address precedes each addressable 100-character location in a disk pack. These numeric addresses are sequential throughout the pack. For example, the addresses of the outer cylinder of the first pack on a system are 000000-000199. The addresses of the second cylinder of the same pack are 000200-000399, and so on. The addresses of the last (inner) cylinder of the first pack are 019,800-019,999. When a 1401 system uses five disk drives, the range of addresses is 000000-099,999.

Disk Instructions

When disk-storage units are part of the IBM 1460 Data Processing System, they must be controlled by special instructions.

Instruction Format

Op Code	*A-address*	*B-address*	*d-character*
M/L	% Fx	xxx	R/W

Op Code

This is always a single character that defines the basic operation to be performed. M represents a move operation, and L a load operation.

A-Address

%Fx signals that a disk operation is to be performed. The actual operation is determined by the digit in the x-position.

B-Address

This is the high-order position in core storage of the 10-digit disk-control field. A data area in core storage, of sufficient size to contain the data being read into or out of disk storage, must follow the 10-digit field. The data area must be followed by a group-mark with a word-mark.

d-Character

This character determines whether the disk operation is a read or a write operation.

IBM 1301 Disk Storage, Models 11, 12, 21, and 22

The IBM 1301 Disk Storage, Models 11, 12, 21, and 22 (Figure 30), provides the 1460 system with the advantages of large-capacity random-access storage. As many as five IBM 1301 modules can be attached to a 1460 system. Each one of the 1301 models has at least one module (800 addressable sectors). Model 11 is a master unit and contains one module. The Model 11 must be the unit attached to the 1460 system when only one module is required. Model 21 is a 1-module additional unit.

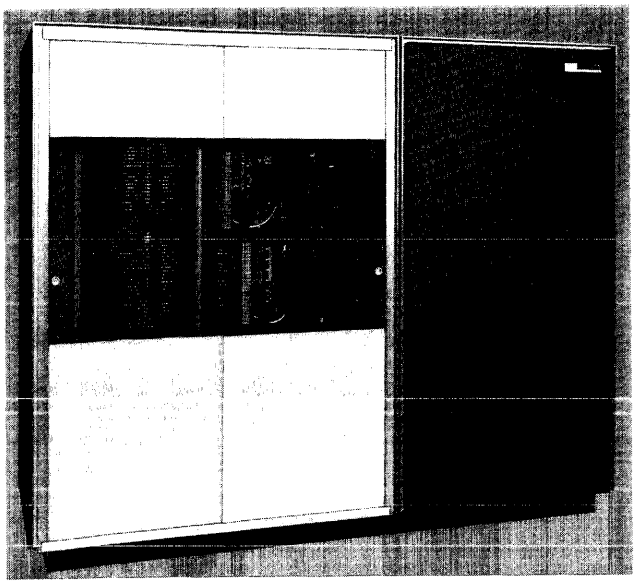

Figure 30. IBM 1301 Disk Storage, Model 12

Model 12 is a master model and contains two modules, and Model 22 is the additional unit containing two modules. For disk-storage capacities of over 20 million characters, the 1301 Model 12 must be installed on the system when either Model 21, 22, or both are added. The total capacity cannot exceed five modules.

Disk Organization

Each 1301 module is a disk array of 20 data disks mounted on a rotating vertical shaft. Each disk is coated on both surfaces with a magnetic recording material. The data is recorded as magnetized spots on these surfaces.

Access Assembly

The access-assembly mechanism is a group of access arms arranged like the teeth of a comb. The entire access assembly moves horizontally between the disks (no vertical movement is involved) to any one of the possible 250 data-track positions on each disk surface. These data tracks are arranged in concentric circles. Each of these 250 data-track positions are accessible for reading and writing by positioning the read-write heads between the disks. Two read-write heads are located on each access arm. When in position, one head services the bottom surface of the disk directly above it, and the other head services the top surface of the disk below it.

Disk-Storage Organization

Each one of 40 disk surfaces is divided into tracks and and sectors. Each disk surface contains 250 tracks, and each track is subdivided into 20 sectors per track. The capacity of a sector depends on the mode in which the writing is executed. Sectors written in the load mode contain 90 data characters. Sectors written in the move mode contain 100 data characters. With a 90-character sector, the character capacity of a 1301 disk storage unit is 18 million characters; with a 100-character sector, the character capacity is 20 million characters.

If the track-record special feature is unused, the maximum character capacity of a 1301 storage unit is 25.43 million characters.

Cylinder Concept

The multiple-head access assembly brings about a new concept of disk-storage record organization. The 40

read-write heads of the access assembly are at any one time located in the same relative position on each of the parallel records. Thus, 40 tracks in the same vertical plane are available with one seek operation. This vertical plane can be considered a cylinder of 40 tracks (800 sectors) of data available for system use. Because each disk has 250 tracks per surface, and each track position is part of a separate cylinder, a 1301 disk array has 250 cylinders.

No further access-assembly mechanism motion is needed to position the read-write heads in that cylinder. Instead, only electronic head switching is used to select the particular track in that cylinder.

Disk-Storage Addressing

A 6-digit sector address precedes each addressable location in the disk-storage unit. These numeric addresses are normally sequential within track, cylinder, and disk module. If a system used five modules (disk arrays), the sector addresses continue in this sequence from disk array to any disk array. For more detailed information see IBM *1301 Disk Storage*, Form A24-3157.

Special Features

When application coverage or processing conditions require more program flexibility and faster program execution, special features can be added to an IBM 1460 Data Processing System.

Each special feature contributes to the efficiency of the total system by providing one or more of these advantages:

1. system compatibility between the IBM 1460 and other IBM data processing systems
2. increased speed
3. simplified programming
4. additional system capacity
5. simplified system organization

Most of the special features available on Models A-F of the IBM 1401 are also available on the 1460 system. The units and the features on these units are as follows.

IBM 1441 Processing Unit, Model B

Bit Test

This feature is a BRANCH instruction that causes the character located at the B-address to be compared, bit by bit, with the d-character. If any bit in the character located at the B-address matches any bit in the d-character, the program branches to the specified I-address (WM and C-bits are not compared).

Console (1447, Model 2 or 4) Attachment

This special feature provides for the attachment of a console input/output printer to the 1460 system.

Direct Data Channel

This special feature provides for the attachment of the following data processing systems through their serial I/O adapters: 1401-1401; 1401-1440; 1401-1460; 1440-1440; 1440-1460; 1460-1460.

Direct Seek

This feature allows the 1311 access assembly to be positioned directly at a new setting without first returning to the home position.

Disk-Storage Control

This feature provides the controlling circuitry necessary for the proper operation of any IBM 1311 Disk Storage Drives attached to the system.

Expanded Disk-Storage Control

This feature provides the additional controlling circuitry necessary for the proper operation of any IBM 1301 Disk Storage unit attached to the system. If only IBM 1301's are being used, both disk-storage control and expanded disk-storage control must be installed on the IBM 1441 Processing Unit.

Expanded Print Edit

This feature provides additional editing capacity when printed documents contain fields that require special punctuation including asterisk protection, floating dollar sign, decimal control, and sign control left.

Asterisk Protection

In applications such as check-writing, it is often necessary to have asterisks appear at the left of significant digits, to prevent alteration of figures and amounts. The asterisk-protection feature causes multiple asterisks to be printed as specified by an asterisk written at the left of the zero-suppression code in the edit control word.

Floating Dollar Sign

When a control word is written with the $ at the left of the zero-suppression code, a dollar sign is inserted in the position at the left of the first significant digit in a printed amount field. By using this method of punctuation, amount fields used in records, such as checks and bills, cannot be easily altered because there is no space between the dollar sign and the first significant digit.

Sign Control Left

Whenever CR or minus symbols must be printed at the left of a negative field, the sign-control-left feature is used. The appropriate negative sign is written in the high-order position of the control word. The sign of the field being edited is examined, and the CR or minus sign is inserted whenever the amount is negative.

Decimal Control

This feature ensures that decimal points print only when there are significant digits in the field being edited.

Indexing and Store Address Register

Indexing

In 1460 programming, many problems require that the same operations be performed repetitively with a change only in the A- or B-address. Modifying these addresses each time a repetitive operation is performed requires several program steps, plus additional storage locations which must be set aside for this use.

Three index locations are provided in the IBM 1441 Processing Unit, Model B, to modify addresses automatically. This means that fewer instructions are needed, which, in turn, means that additional storage space is made available. This provides for faster execution of a program, and an over-all simplification of programming effort.

Store Address Register

This feature makes it possible to store the contents of the A- and B-address registers after any operation. It is particularly useful when fields or records of variable length are being processed, or when a method of linking a main routine with a subroutine is desired. For example, the address of the next sequential instruction is stored in the B-address register after a program branch to the I-address occurs. If the first instruction of the subroutine stores the contents of the B-address registed in the last step of the subroutine (unconditional branch instruction), the program will branch back to the next instruction in the main routine after the subroutine has been executed.

Multiply-Divide

The multiply-divide special feature greatly increases processing speed and conserves storage space in cases where applications require a significant amount of calculating.

Scan Disk

Scan disk provides an automatic rapid search of 1311 and/or 1301 (Models 11, 12, 21, 22) disk information for a specific identifier or condition within the data itself.

Seek Overlap Adapter

This feature is required when the seek overlap feature is installed on the IBM 1311 Disk Storage Drives attached to a 1460 system. This feature provides some of the circuitry necessary for proper operation of the seek-overlap feature.

Serial Input/Output Adapter

This special feature is required to attach these components to a 1460 system:

IBM 1009 Data Transmission Unit, Model 1
IBM 1011 Paper-Tape Reader, Model 1
IBM 1012 Tape Punch, Model 1
IBM 1412 Magnetic Character Reader, Model 1
IBM 1418 Optical Character Reader, Model 1 or 2
IBM 1419 Magnetic Character Reader, Model 1
IBM 1428 Alphanumeric Optical Reader, Model 1 or 2
Direct Data Channel

The same adapter accommodates the eight units, but only one can be attached at a time.

Track Record

This feature provides the ability to write and read one record per track under the control of the program. The 1311 track is comprised of one sector address in 7-bit mode plus 2,980 seven-bit characters (move mode) or 2,682 eight-bit characters (load mode). The 1301 track is comprised of one sector address in 7-bit mode plus 2,543 seven-bit characters (move mode) or 2,261 eight-bit characters (load mode).

Transmission Control Unit Attachment

This feature is required when the IBM 1448 Transmission Control Unit is attached to the IBM 1441 Processing Unit.

Translate

The translate special feature provides the data processing system with the capability of fast, flexible translation of codes to and from the code of the system.

This feature uses stored-program instructions to initiate the code translation and subsequent record movement. One translate instruction translates a complete record, moving left to right as it replaces each record character with a character from a translate table in core storage until a group-mark with a word-mark is detected in the field being translated.

IBM 1461 Input/Output Control, Models 1, 2, 3

Adapter, 51-Column Feed

This feature is required when the 51-column interchangeable read feed special feature is installed on the IBM 1402 Card Read-Punch, Model 3, and it provides the controlling circuitry necessary for the proper operation of the interchangeable read feed.

Binary Transfer

This feature makes it possible to process cards and magnetic-tape data recorded in column-binary form. This provides compatibility between the IBM 1460 and

IBM scientific data processing systems, such as the IBM 704, IBM 709, and the IBM 7090.

Auxiliary operations that can be performed for large-scale binary systems are:

1. Card-to-tape
2. Tape-to-card
3. Card-to-card
4. Tape-to-tape
5. Card-to-printer
6. Tape-to-printer
7. Tape sorting, editing, and merging
8. File maintenance.

Compressed Tape (Models 2 and 3)

With this special feature, the 1460 can read compressed tape prepared by the IBM 7070, and it can expand it within storage to enable the 1460 stored program to process it. A compressed tape record is written by the 7070 by means of the WRITE-WITH-ZERO-ELIMINATION instruction. With this operation, as many as five high-order zeros from each numeric word in storage are not recorded on tape, thus saving tape capacity and read-write time (alphabetic data is not compressed).

Numerical Print Control

This feature is required when the numerical print special feature is installed on the IBM 1403 Printer, Model 2, and it provides checking circuitry necessary for proper operation of the numerical print feature.

Print Storage

This feature provides 132 non-addressable extra positions of core storage that are used as temporary storage for data to be printed, and releases nearly all of the normal interlock during print time. After the transfer to print storage is complete, the 1460 is free to perform other operations because actual printing involves only the print storage area and the IBM 1403 Printer, Model 2. Thus, available processing time is greatly increased for applications characterized by high printing requirements.

Printer Adapter — 1403, Model 3

This feature provides the circuitry necessary for attaching and controlling an IBM 1403 Printer, Model 3, on a 1460 system.

Printer Control Adapter — Second Printer

This feature provides the circuitry necessary to attach the first IBM 1462 Printer Control Unit and its associated 1403 Printer to the 1460 system.

Processing Overlap

By permitting the 1460 system to process data while conducting input or output operations, this feature provides full use of high-speed processing and input/output capabilities. With this feature, the system continues to compute, while the I/O unit prepares to send or receive data and continues to compute between character transfers.

Actually, processing is interrupted so that input or output cycles can be taken. A character can be read, written, punched, transmitted, or received between processing cycles. Thus, job time is reduced through increased efficiency. The time saved varies only with the specific application, but also with the input/output requirements of the program.

The input/output units that can make use of this feature are:

1. IBM 729-II Magnetic Tape Unit
2. IBM 1011 Paper Tape Reader, Model 1
3. IBM 1402 Card Read-Punch, Model 3
4. IBM 1419 Magnetic Character Reader, Model 1
5. IBM 7330 Magnetic Tape Unit.

NOTE: When an IBM 1448 Transmission Control Unit is installed on the system and the unit is being used, the processing overlap feature cannot be employed.

Punch-Feed Read Control

This feature is required when the punch-feed-read special feature is installed on the IBM 1402 Card-Read-Punch, Model 3, and it provides the controlling circuitry necessary for proper operation of the punch-feed read feature.

Read-Punch Release

During reading and punching operations in a standard 1460, there is a 21-millisecond read-start-time interlock, and a 37-millisecond punch-start-time interlock, during each complete read or punch cycle. The read-punch-release feature provides two operation codes that are used to release the read and punch start time interlocks, and make extra time available for processing during read and punch cycles.

Selective-Tape-Listing Control

This feature is required when the selective-tape- listing special feature is installed on the IBM 1403 Printer, Models 2 or 3, and it provides the controlling circuitry necessary for proper operation of the selective-tape-listing feature.

Tape Attachment/Intermix (Model 2 Only)

This feature makes it possible to have up to six IBM 729-II, or 729-IV, or 729-V, or 729-VI, or 7330 Magnetic Tape Units connected to the same 1460 system.

IBM 1447 Console, Models 1, 2, or 4

Model 1 has a control section with power and operator controls. An indicator panel shows the status and contents of the various machine registers and storage controls.

A Model 2 is a Model 1 with the inquiry printer and keyboard added to combine the functions of a console and an inquiry station.

A Model 4 is a Model 1 with the inquiry printer, keyboard, and keys and lights for the control of an IBM 1448 Transmission Control Unit combined to function as a console, an inquiry station, and control for the 1448.

The features for altering the Model 1 to a Model 2 or 4 can be attached or removed whichever the case may be.

Attachment, 1051 Model 1

This feature provides the circuitry necessary for attaching an IBM 1051 Control Unit, Model 1, to the IBM 1447 Console.

Buffer Feature

This feature provides a 210-character buffer for the inquiry channel.

Pin-Feed Platen

A pin-feed platen is available for the 1447 in a choice of nine widths. The pin-to-pin widths are: 6, 7½, 8, 9, 10, 10⅛, 11¼, 11½, and 13⅛ inches. The maximum printing line for the 13⅛-inch platen is 126 characters (10 characters per inch).

Remote Terminal Attachment

This feature provides the circuitry for attaching up to twenty-four 1050 systems via a single half-duplex line from the locally-installed IBM 1051 Control Unit, Model 1.

Sense Switches

Six sense switches can be included on the IBM 1447 Console. The manual toggle switches that control them are located on the console. Switch A is used to control last-card operations. Six additional sense switches (B, C, D, E. F, and G) are used for external control over the course of the stored program.

IBM 1402 Card Read-Punch, Model 3

51-Column Interchangeable Read Feed

The interchangeable 51-column read feed (including file feed) permits feeding either 51-column cards or standard 80-column cards in the read feed of the IBM 1402 Card Read-Punch, Model 3.

The 51-column card is commonly used for charge sales slips, postal money-order forms, installment payments, inventory cards, and many other applications.

Using an interchangeable feed allows direct entry to the data processing system from the stub card. This eliminates the need for reproducing 51-column cards into standard 80-column cards.

Punch-Feed Read

This special feature provides the ability to punch output data into the same card from which the input data was read. The punch feed in the IBM 1402 Card Read-Punch, Model 3, is modified by adding a set of 80 reading brushes one station ahead of the punch station (Figure 31). The card at the punch-feed read station is read while the card ahead of it is being punched. The information read from the punch-feed read brushes enters into 1441 core-storage addresses 001-080 in the same manner as information read in the read feed. A validity and a columnar hole-count check is made on each column that is read from the punch-feed read brushes.

The punching operation for punch-feed read is the same as in the basic 1460 (storage positions 101-180). A hole-count check is also made at the punch check brushes.

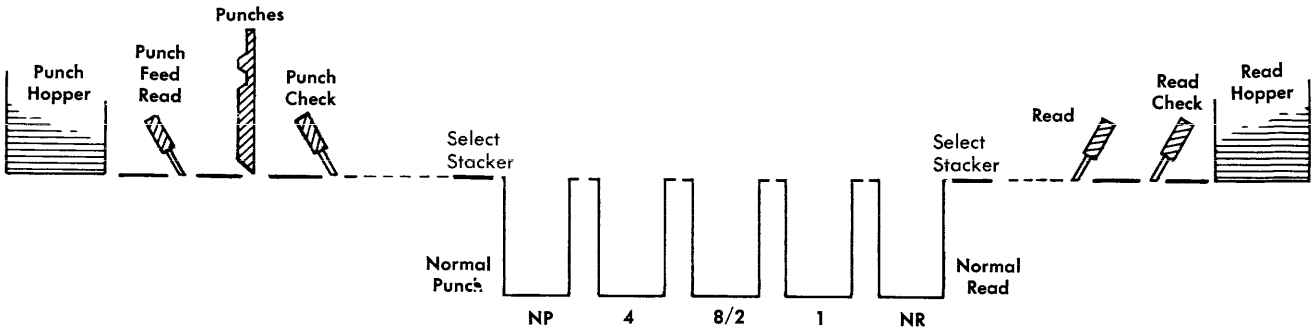

Figure 31. Punch-Feed-Read Schematic

IBM 1403 Printer

Auxiliary-Ribbon-Feeding Feature (Model 2)

The auxiliary-ribbon-feeding feature is recommended for satisfactory utilization of polyester film ribbon and can also be used for conventional fabric ribbons. This feature and the polyester film ribbon are recommended when the IBM 1403 is used to prepare paper documents heavier than 24-pound stock for optical-character recognition on the IBM 1418 Optical Character Reader or IBM 1428 Alphameric Optical Reader.

Interchangeable-Chain-Cartridge Adapter (Model 2)

Many scientific and commercial applications require distinctive type styles for particular printing jobs. This special feature for the IBM 1403 Printer, Model 2, allows chain cartridges to be interchanged.

With this feature, an operator can insert an interchangeable chain cartridge with a different type font, type style, or special character arrangement.

Numerical-Print Feature (Model 2)

This special feature for the IBM 1403 Printer, Model 2, is designed for those businesses with certain 1401 applications that require no alphabetic printing. With this feature, the time required to produce numeric reports can be reduced by as much as fifty per cent.

By changing the chain cartridge in the 1403, Model 2, the system's user can switch from the alphameric to the numeric mode. The numeric chain is composed of 15 character sets, with 16 characters (0 through 9 $. , * - □) in each set. In the numeric mode, the 1403 can print 1,285 lines per minute – more than twice as fast as in the alphameric mode.

Selective-Tape-Listing Feature (Models 2 and 3)

This special feature increases the use of the IBM 1403 Printer, Models 2 and 3, in applications (primarily banking) requiring adding-machine tape listings. Combinations up to eight 1½-inch tapes or four 3$\frac{1}{16}$-inch (double-width) tapes can be accommodated on the 1403. The permanently-mounted tape-advancing mechanism does not interfere with normal form-feeding operations.

IBM 1311 Disk Storage Drive

Seek-Overlap Feature

This special feature provides the 1460 with the ability to overlap a 1311 read or write operation with seek operations on the other attached disk-storage drives.

The attachment of other units expands the capabilities of the IBM 1460 Data Processing System. TELEPROCESSING® units speed direct communication between installations. Banking equipment permits rapid introduction of data directly from source documents. Other units make the 1460 more productive by increasing input or output speeds, expanding capabilities, or by simplifying manual chores.

For detailed information on these units, see the appropriate publications listed in IBM *1401/1460 Bibliography*, Form A24-1495.

IBM 1009 Data Transmission Unit

The 1009 (Figure 32) permits high-speed 2-way communication between two IBM 1460 Data Processing Systems, between a 1460 and an IBM 7701 Magnetic Tape Transmission Terminal, between a 1460 and an IBM 7702 Magnetic Tape Transmission Terminal, or between a 1460 and an IBM 1013 Card Transmission Terminal.

With this unit, a 1460 system can transmit at speeds up to 300 characters per second over toll or leased communications-company lines. This information can be sent short distances between local plants, or long distances across the country — all under stored-program control.

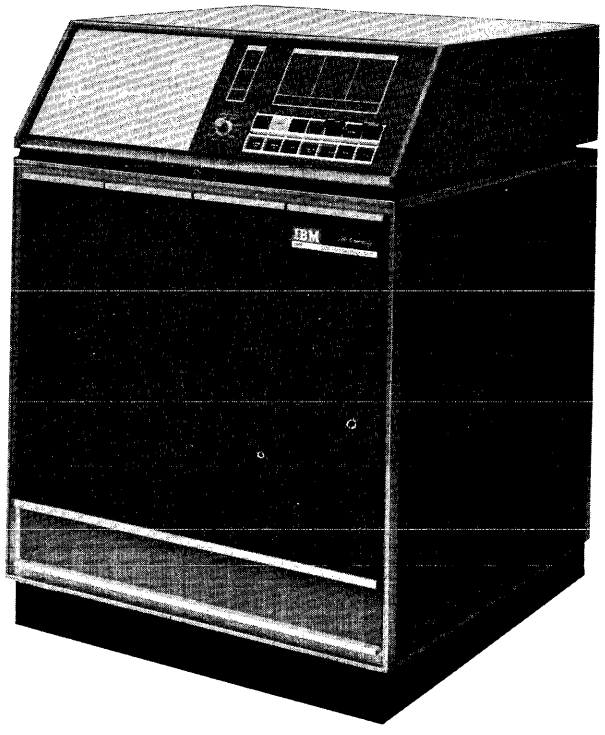

Figure 32. IBM 1009 Data Transmission Unit

IBM 1011 Paper Tape Reader

Many decentralized accounting procedures require that source data be sent from remote locations to a central data processing location. Because of its utility and economy, punched paper tape is an ideal medium for data transmission.

The IBM 1011 Paper Tape Reader (Figure 33) permits the 1460 to accept, as input, data punched in either 5-track or 8-track paper tape.

IBM 1012 Tape Punch

In many applications, punched tape is used to send processed data from a 1460 installation. The IBM 1012

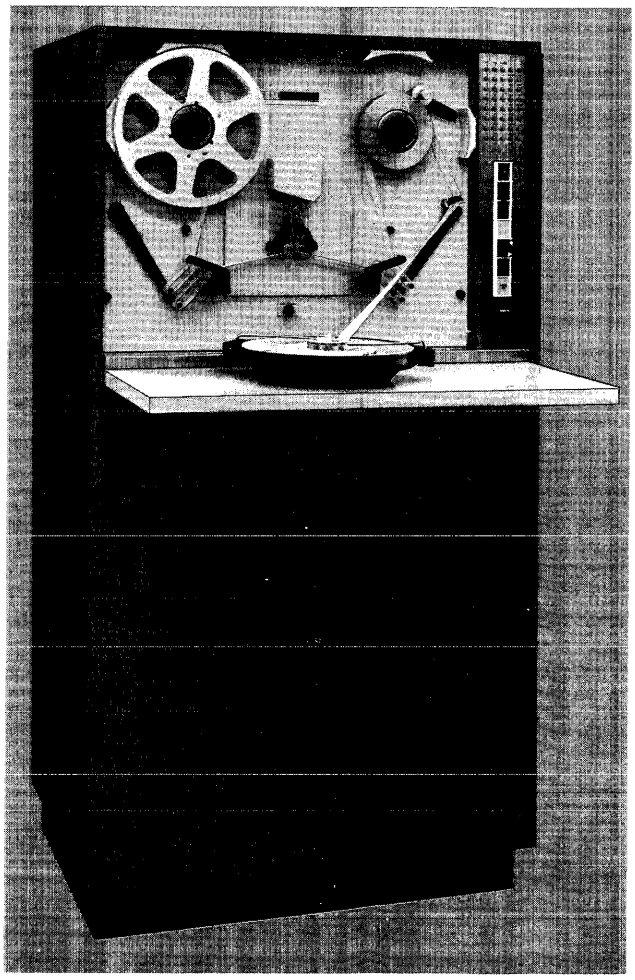

Figure 33. IBM 1011 Paper Tape Reader

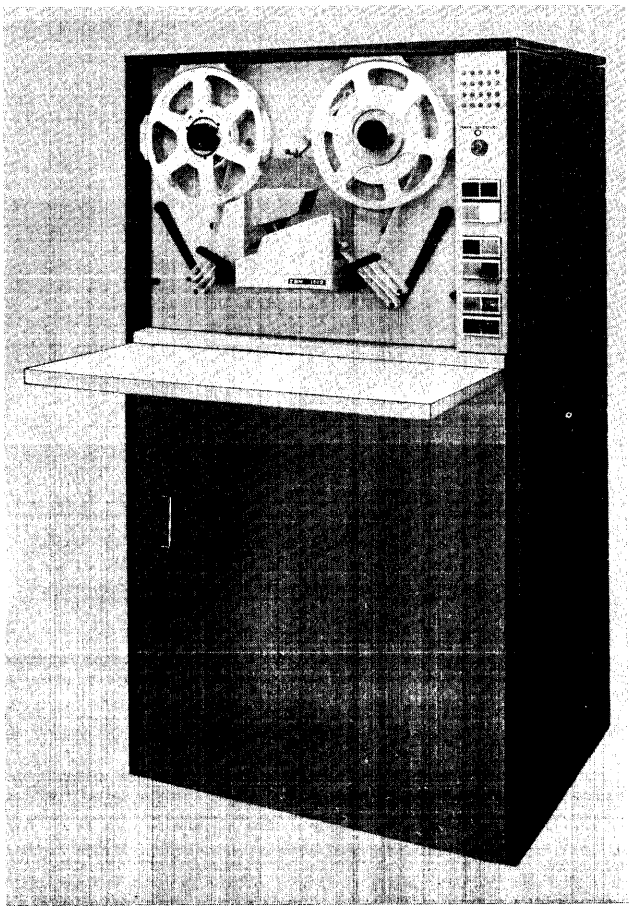

Figure 34. IBM 1012 Tape Punch

Tape Punch (Figure 34) provides the 1460 with the ability to transfer data directly from core storage to either 5-, 6-, 7-, or 8-track paper tape or to Mylar* tape.

IBM 1412 and 1419 Magnetic Character Readers

When they are attached to a 1460 system, the 1412 or 1419 (Figure 35) permit fast and direct entry of banking transactions into core storage. Data, in the form of magnetically inscribed characters, is read from documents and transferred into core storage for processing. During this time, the documents are selected into stackers specified by the 1460 stored program.

IBM 1418 Optical Character Reader

Numeric data on printed card or paper documents can be read optically into 1460 core storage with the

*Trademark of E. I. du Pont de Nemours Company, Inc.

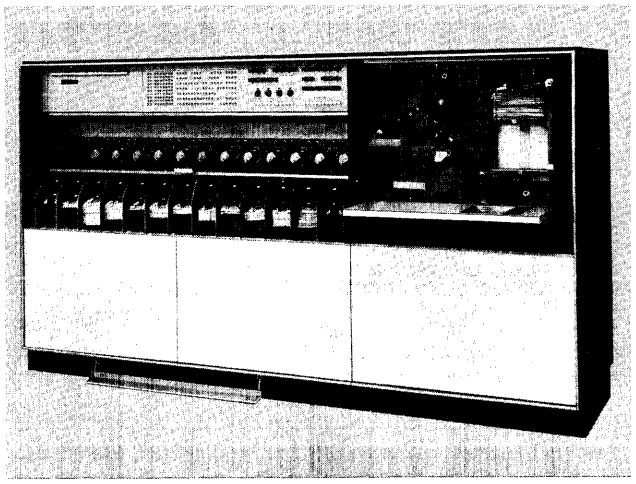

Figure 35. IBM 1419 Magnetic Character Reader

IBM 1418 Optical Character Reader. Model 1, with three stackers, can select the documents according to class, or general category; Model 2 (Figure 36), with thirteen stackers, in addition to sorting by class, can sort each document numerically. Model 3, which is similar in appearance and operation to the Model 1, has a broader range of document-handling capabilities. The Model 3 is particularly adaptable to cash-accounting applications where a small stub is customarily returned with a payment.

In many instances, because of its ability to read characters directly from a document, the 1418 eliminates other preparation of data for use in the system. It allows all functions necessary for processing data, from the source document to the final report, to be performed in one operation.

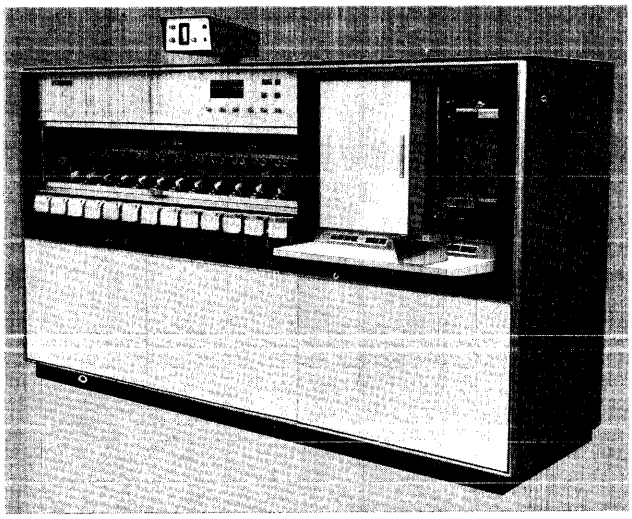

Figure 36. IBM 1418 Optical Character Reader, Model 2

IBM 1428 Alphameric Optical Reader

The IBM 1428 (Figure 37) can be connected, through a serial input/output adapter, to an IBM 1460 system. When connected to a 1460, the 1428 supplies high-speed alphameric input to the data processing system from printed documents of various sizes. Thus, the 1428 provides for direct entry into the 1460 system of data from such documents as insurance premium notices, charge sales invoices, operations and route slips, payroll and dividend checks, and mail orders.

The IBM 1428, Model 1, is equipped with three sorter pockets. The Model 2 is equipped with 13 pockets. The Model 3, which is similar to the Model 1 in appearance and operation, can handle documents of a broader size range. It is particularly adaptable to handling small stub-size documents such as those returned with a payment in many cash-accounting applications. The IBM 1428, Model 2, can also be used off-line as an optical sorter.

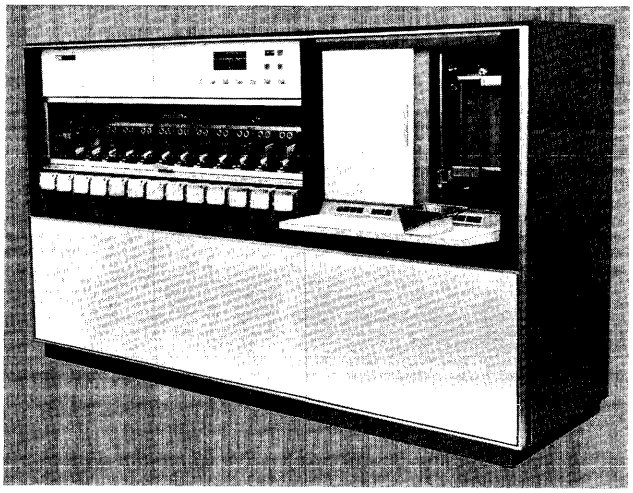

Figure 37. IBM 1428 Alphameric Optical Reader, Model 2

IBM 1448 Transmission Control Unit

The IBM 1448 Transmission Control Unit (Figure 38) is used to control data transfers between the IBM 357 and 1030 Data Collection Systems and/or IBM 1050 and 1060 Data Communication Systems and an IBM 1460 Data Processing System.

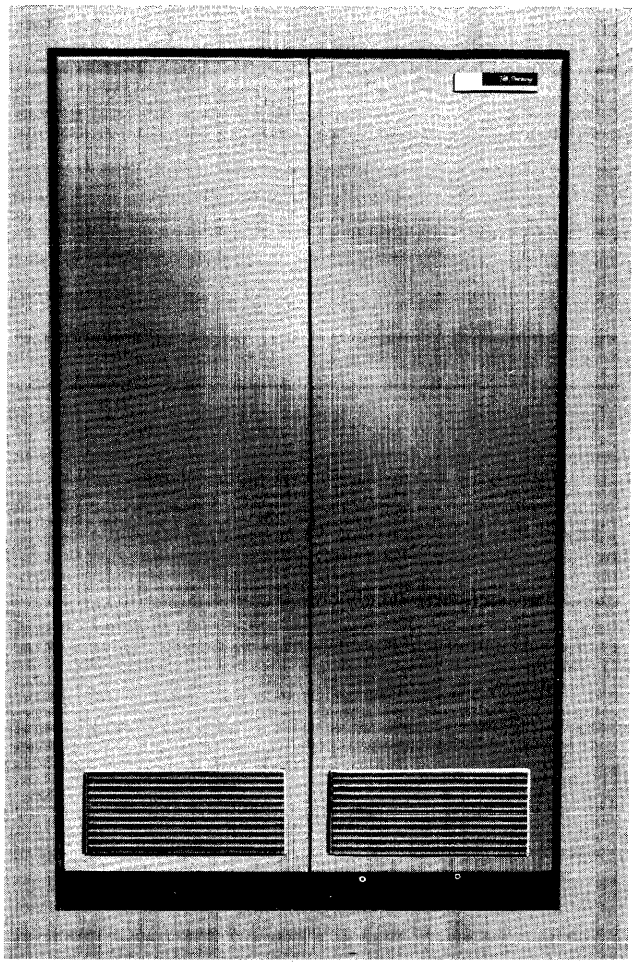

Figure 38. IBM 1448 Transmission Control Unit

This section contains a description of the generalized programs and automatic programming systems that IBM provides users of the IBM 1460 Data Processing Systems.

It should be noted that most of the programs are 1401 programs. However, they are all applicable for use with the IBM 1460 system, except for portions of the programs that utilize the IBM RAMAC® 1405.

Consideration should be given to the type of system and configuration the user is interested in when reading the descriptions in this publication, the abstracts, or the actual program publications. For example, if reference is made to the IBM 1401 Processing Unit, and the reader has an IBM 1460 system, he should consider this reference to mean the processing unit with his particular system configuration.

Figure 39 gives the minimum 1460 system requirements for the various programs.

Symbolic Programs

The 1401 Symbolic Programming System (SPS) and 1401 Autocoder are the basic symbolic programming aids for IBM 1401 Data Processing Systems. Each consists of a set of language specifications and a processor program. The language is used to write the source program, and the processor program translates the symbolic language program (the *source* program) into the actual machine language program (*object* program).

Symbolic Languages

Both the Autocoder and SPS languages permit the programmer to define areas, write instructions, and exercise some control over the execution of the processor program by writing symbolic statements. These statements are written using mnemonic operation codes and the symbolic names with which the programmer names data, instructions, and work area. For example, a symbolic instruction to add the data in a field called WHTAX to the data in a field called TOTDED would be written A WHTAX TOTDED in symbolic language.

Area Definition (Declarative Operations)

The area-definition entries are used to assign sections of storage for fixed data (constants) that will be needed during processing, to set aside work areas, and to assign symbolic names to data and devices used in the program. Area-definition statements are examined by the processor program during assembly of the object program. Some produce *constants* (cards that are loaded with the object program), but none produce instructions to be executed in the object program.

Instruction (Imperative Operations)

The instruction entries state symbolically the procedure to be taken during execution of the object program. They are actual commands to the object machine such as ADD, SUBTRACT, READ, and PUNCH.

Processor Control Operations

These are special instructions given by the programmer to the processor program. They exercise such control as: where to begin assigning storage for the object program where the program ends, and how much storage is available in the object machine. Processor control statements are never executed as instructions in the object program. They are used only during object-program assembly.

Symbolic Programming System (SPS)

The SPS is essentially a one-for-one coding system in which one symbolic statement is written for each instruction that appears in the object program. Two versions of the SPS are available. SPS-1 operates on a 1401 with a minimum of 1,400 positions of core storage, but it can assemble programs for any object-machine with as many as 4,000 positions of core storage. SPS-2 can assemble programs for any 1401 system (1,400 to 16,000 positions of core storage), but must assemble the program in a 1401 system with at least 4,000 positions of core storage.

An SPS source program must be coded on the 1401 Symbolic Programming System Coding Sheet, Form X24-1152. This coding sheet is designed for fixed-form coding. (A special area is reserved for each item to be contained in an SPS statement.)

Autocoder

The 1401 Autocoder is a more powerful symbolic programming system for the IBM 1401 Data Processing System. This system provides a macro facility that permits the user to call out standard sets of instructions

Program Name	Minimum Storage Capacity	Minimum Tape Units	1402 Card Read Punch	1403 Printer	1311 Disk Storage	Additional Features
SPS-1	8000	--	x	x	--	--
SPS-2	8000	--	x	x	--	--
Autocoder	8000	4	x	x	--	Indexing & Store Address Registors
Autocoder (1311)	8000	--	x	x	x	--
Input/Output Control System	8000	4	x	x	--	Indexing & Store Address Registers
Input/Output Control System (1311)	8000	--	x	x	x	--
FORTRAN	8000	--	x		--	Indexing & Store Address Registors Multiply - Divide
COBOL 4K	8000	4	x	x	--	Indexing & Store Address Registors Sense Switches Multiply - Divide*
COBOL 12-16K version	1200	4	x	x	--	Indexing & Store Address Registors Sense Switches Multiply - Divide
Report Program Generator	8000	--	x	--	--	1403, Magnetic Tape and 1311 as required by application. 1403 required for assembly phase.
FARGO	8000	--	x	x	--	--
Sort 1	8000	4	x	x	--	--
Sort 2	8000	4	x	x	--	Indexing & Store Address Registers
Sort 6	8000	--	x	x	x	Magnetic tape unit if required by application.
Merge 2	8000	3	x	x	--	Indexing & Store Address Registors
File Organization System (1311)	8000	--	x	x	x	--
Card Utility Programs	8000	--	x	x	--	--
Tape Utility Program	8000	1	x	x	--	Bit Test (optional) Binary Transfer (optional)
Multiply Tape Utility	8000	1	x	x	--	Indexing & Store Address Registors Bit Test (optional) Binary Transfer (optional) Read Punch Release Sense Switches
Disk Utility Programs (1311)	8000	--	x	x	x	--
1009 Utility Program	8000	1 ← or →	x	--	--	SIOA (1009) Sense Switches
Auto Test	8000	1	x	x	--	Indexing & Store Address Registors Sense Switches
1460-1448 IOCS	8000	--	x	x	x	Indexing & Store Address Registors 1448 Transmission Control Unit
1401/1440/1460	8000	--	x	x	x	Indexing & Store Address Registors SIOA, DDC

* If required by source program usage

Figure 39. Minimum System Requirements

(routines) from a library stored on magnetic tape. It also permits him to code *literals* (actual data to be operated on during processing) directly in the instructions that use them, thus simplifying the area-definition part of the source program.

The 1401 Autocoder system can be used to assemble programs for all IBM 1401 Data Processing Systems except 1401/1311 systems.

An Autocoder source program, like SPS, is written on a special coding sheet. Autocoder statements, however, are written in free-form. (The operand fields are not divided into special areas as they are in SPS.)

Autocoder for IBM 1401/1311

This program can be used to assemble programs for all IBM 1401 Data Processing Systems equipped with IBM 1311 disk storage. The program is similar in function to the 1401 Autocoder program. The library routines of 1401/1311 Autocoder are stored in disk storage, however, rather than on magnetic tape. The machine-language object program produced as output can be contained either in punched cards or on magnetic disks.

IBM 1440 Autocoder — IBM 1401 Processor Programming System

This 1401 program produces a 1440 machine-language program. The input to the 1401 is an IBM 1440 symbolic source program, consisting of 1440 Autocoder-language statements. Thus, IBM 1440 programs can be assembled on a 1401 system.

Common Business-Oriented Language (Cobol)

This programming system permits programmers to use terms related to the problem to be solved rather than to the machine and machine language used to solve the problem. Thus, the language is common to all programmers regardless of the system. The 1401 Cobol processor takes the Cobol statements punched in cards from a Cobol Program Sheet and translates the statements into Autocoder language. The 1401 Autocoder processor translates Cobol output into actual machine language.

Two Cobol programs are available. They are 1401 Cobol 4K and 1401 Cobol (12K-16K). Both programs can process source programs written for a 1401 system with as many as 16,000 core-storage position. In addition to different minimum machine requirements (see Figure 39) for these programs, there are other minor differences. The 4K Cobol program offers some advantages over 12K-16K Cobol in improved diagnostics, greater efficiency of object programs, and more extensive implementation of the Cobol language.

Fortran

The 1401 *Fortran* (*For*mula *Tran*slation) is an automatic coding system for the IBM 1401. Fortran language, which is applicable to most other IBM data processing systems as well as the 1401, enables the user to express problems in a symbolic source language similar to the language of mathematics. This similarity allows users of the 1401 to prepare their problems for the computer, even though the users may not be trained as programmers. Fortran is designed primarily for use in scientific and technical fields where most problems are stated in mathematical form.

Using as input source programs written in Fortran language, the Fortran program (processor) produces object programs in IBM 1401 machine language. The user has the option of executing the object program immediately or punching it into cards for future use.

A 1401 user with a magnetic-tape unit can take advantage of the faster tape-reading operation. He does this by using the option provided by Fortran to generate a Fortran processor on magnetic tape.

Report Program Generator (RPG)

The RPG is a special program designed to create report-writing object programs from report specifications given by the user.

Instead of writing a specific program for a report, the user states his problem in RPG language. The RPG processor program interprets these specifications and generates an object program that uses source data from punched-card, magnetic-tape, or 1405 disk-storage files. Output from the RPG-produced programs can be printed reports, punched cards, or magnetic tape.

The reports produced by programs generated by the RPG range from a simple listing of items from the input file to complex reports that incorporate editing and calculating the input data. Included are such functions as printing various kinds of lines (heading lines, detail lines, total lines initiated by control-field changes, and offset total lines); crossfooting; and summary punching. Exception records can be produced with the reports.

Report Program Generator for IBM 1401/1311

The RPG for IBM 1401/1311 systems creates report programs with a minimum of time and effort. The user writes a set of specifications stating the characteristics of the input data from which the report is to be made and the characteristics of the desired report. These specifications are punched into cards, which become input to the RPG. The specifications are processed and a report program in symbolic language is generated. This symbolic program becomes input to the IBM 1401/1311 Autocoder processor, which pro-

duces the report program in machine language. The machine-language program, when supplied with input data and executed, produces the output report in any combination of three forms; printed, punched card, and either magnetic tape or 1311 disk storage.

The input file from which the data for the report is taken may consist of data records that are contained in punched cards, on magnetic tape, or in 1311 disk storage.

1401 Automatic Report Generating Operation (Fargo)

This report generating program is designed to yield printed reports according to the user's specifications as recorded on Fargo coding sheets (Phases 1, 2, 3, and 4) and punched in control cards. Detail data cards to be processed follow directly behind the combined Fargo program decks and control cards without intermediate operations. Report processing begins immediately after loading the program.

This programming system is designed primarily for IBM 1401 card systems having a minimum of 4,000 positions of core storage.

Input/Output Control System (IOCS)

The 1401 IOCS eliminates the need for detailed programming of standard input and output operations. It is included as part of the 1401 Autocoder system, and provides additional control, record-definition statements, and macro instructions. With these entries, the user can specify the input and output devices and the contents of file records. The library routines for reading and writing, blocking and deblocking, file labeling, and error checking are furnished as part of the Autocoder processor and can be extracted by using the IOCS macro instructions.

The Autocoder processor tailors the IOCS routines to fit the particular requirements, specified by the programmer, for each job. The Autocoder processor produces the minimum number of instructions needed by interpreting the detailed information the programmer supplies in the control entries.

Although IOCS is used primarily for magnetic-tape files, IOCS macro instructions can also be used for unit-record files (input and output files) from, and to, the IBM 1402 Card Read-Punch and the IBM 1403 Printer.

Input/Output Control System (IOCS) for IBM 1401/1311

Like the 1401 IOCS program, the 1401/1311 IOCS program eliminates detailed user programming of input/output operations. In addition to the types of files for which 1401 IOCS is applicable (that is, card, printer, and magnetic-tape files), 1401/1311 IOCS can also be used for IBM 1311 disk-storage files.

Direct-Data-Channel Input/Output Control System (DDC IOCS) for IBM 1401/1440/1460

Direct transfer of data between a 1401 system and a 1440, a 1460, or another 1401 system can be accomplished by using the direct data channel feature. Applications of such direct data transfer include (1) multi-processing of data, (2) internal processing on one system, and peripheral operations on the other system, and (3) the processing of data from multiple remote terminals.

The 1401/1440/1460 DDC IOCS program provides concise, efficient, pretested routines to perform these functions: program detection of *read request* or *write request* by either of the two interconnected systems, error detection and correction, system-to-system read-write, output scheduling, coordination with other IOCS programs, and scheduling of the user's DDC (direct data channel) routine for each system.

Input/Output Control System for IBM 1460-1448

IOCS for the IBM 1460-1448 supplements Autocoder for the IBM 1401 and IOCS for the IBM 1401. Additional macro instructions and descriptive entries are provided that allow the IBM 1460 to be used with the IBM 1448 and a maximum of 40 low-speed, half-duplex, multipoint transmission lines.

IOCS for the 1460-1448 is assembled on a 1460 system, using Autocoder for the IBM 1401-1311. Machine requirements for running an object program depend upon over-all system configuration. If a second system, connected by direct data channel to the 1460, is used many of the functions of the 1460 can be performed by the other system. Processing in the 1460 can then be confined to control of the 1448. Otherwise, core-storage and I/O requirements for the 1460 are determined by both the 1448 and over-all program needs.

Card-System Programs

IBM provides a number of utility programs, subroutines, and program error-detection aids for user of IBM 1401 card systems. They are:

Utility Programs

Clear Storage

This program clears all storage positions to blanks and sets a word mark in location 001.

Card Loader

This program enables the user to load instructions and constants into the machine prior to loading and running a program. The instructions and constants must be in machine language and must be punched with one instruction or constant per card.

Print Storage

This program enables the user to print out the contents of selected portions of core storage, as specified in a control card.

Punch Storage

This program enables the user to punch the contents of selected portions of storage into cards. The resulting card output is in the form of a self-loading deck that can be loaded into storage by the card-loader utility program.

Punch-List-Sequence Check

This program punches, prints, or sequence-checks information from an input program deck, the format of which conforms to that specified for the card-loader program. Any combination of these three operations can be performed simultaneously by the punch-list-sequence-check program.

Subroutines

Multiply-I

This subroutine multiplies two numbers, each having a maximum of ten digits. A maximum of 20 digits and a sign can be obtained as a product. The important feature of this subroutine is its use of a minimum of storage space.

Multiply-II

This subroutine multiplies two numbers, each having a maximum of nine digits. A maximum of 18 digits and a sign can be obtained as a product. The important feature of this subroutine is economy in time, whereas multiply-I features economy in storage space.

Divide

This subroutine uses repetitive subtraction to perform division. The length of the divisor, dividend, and quotient may range from 1 to 20 digits.

Dozens-to-Units Conversion

This subroutine converts dozens, and fractions of dozens, to units.

Units-to-Dozens Conversion

This subroutine converts units to dozens and fractions of dozens.

Program Error-Detection Aids

Insert Halts

This program inserts halt instructions in an object program at specified places to permit manual inspection of the contents of core storage.

Insert Linkages to Fixed Print Storage

This program inserts into desired sections of an object program linkages to a routine that prints out the contents of storage between specified limits. This print area can be specified only once for the object program.

Insert Linkages to Selective Print Storage

This program performs the same function as the preceding program, except that the limits of storage to be printed can be varied for a single object program.

Remove Linkages

This program removes from an object program those linkages previously inserted to aid in detecting program errors.

Disk Utility Programs (IBM 1311)

Nine disk utility programs assist users of the IBM 1401 equipped with IBM 1311 disk storage in the operation of their installations. By means of these programs, certain frequently required operations (such as loading or unloading disk files from cards, and printing out areas of disk storage for program-testing purposes) can be performed without programming effort on the part of the user. Each program includes a label-checking routine. A brief description of each program follows.

Disk Label Program

This program can write the label track, delete the label track and restore the normal sector addresses, enter labels, delete labels, change specified fields within labels, print labels, and punch labels in the RDLIN-card format. The RDLIN card contains the label in-

formation in the format required by the label-checking routines of IBM 1401 programs that process IBM 1311 disk files.

Clear Disk Storage

This program clears specified portions of disk packs by filling these areas with blanks or any other valid 1401 character. It can write sequential addresses referenced to any disk drive, or wirte the same addresses that were on the pack.

Disk-to-Tape

This program writes the contents of specified areas of disk storage on magnetic tape in the format used by the tape-to-disk program.

Tape-to-Disk

With this program the user can reload areas of disk storage previously written on magnetic tape by the disk-to-tape program. He can reload all of the data or selected portions of it.

Disk-to-Card

This program punches the contents of specified areas of disk storage into cards in the format used by the card-to-disk program.

Card-to-Disk

This program reloads into disk storage the data that was punched into cards by the disk-to-card program.

Copy Disk

This program can write data and addresses from specified areas of a disk pack either to another pack located on a second drive, or to another area of the same pack. When copying onto a second pack, the program can write the information either in the same position on the second pack relative to that of the source pack, or in a different relative position. In all cases when the information is written in a different relative position, disk addresses (if written) are adjusted to be valid for the new location.

Print Disk

This program prints the contents of specified areas of disk storage on the IBM 1403 Printer.

Disk-Record-Load

Addresses, single records, parts of records, or entire tracks can be loaded into disk storage from cards, by using this program.

Tape System Utility Programs

The four utility programs for IBM 1401 tape systems perform functions otherwise handled by off-line IBM card-to-tape, tape-to-card, and tape-to-printer equipment. The tape utility programs perform additional functions that cannot be performed by auxiliary or off-line equipment.

Card-to-Tape

This program prepares single tape records from single card records in either the BCD or column-binary mode. It also has the following capabilities, unavailable in auxiliary or off-line equipment: input records can consist of more than one card; output records can be blocked on tape; variable-length input fields can be selected for output on tape; an exception procedure enables certain input records to be treated differently from the usual routine; input records and cards within input records can be sequence-checked prior to output.

Tape-to-Card

With this program the user can prepare card records in either the BCD or column-binary mode from single tape records. The program also has the following capabilities, unavailable in auxiliary or off-line equipment: input tape records can be blocked; variable-length tape records can be accommodated; output records can consist of more than one card; input fields can be selected for output in specified card fields; an exception procedure enables certain input records to be bypassed, printed, stacker-selected, or printed and punched; input records can be sequence-checked prior to output.

Tape-to-Printer

This program prints single or blocked variable-length input records. It also has the following capabilities, unavailable in auxiliary or off-line equipment: multiple-file printing and selective-file printing; input fields can be selected for printing and can have editing and zero suppression; an exception procedure enables input records to be bypassed or treated in a manner differing from ordinary routine; various types of forms-control spacing can be specified; input records can be sequence-checked prior to printing.

Multiple Utility Program

This program permits any one, two, or all three of the tape utility programs (card-to-tape, tape-to-card, and tape-to-printer) to be executed concurrently. Operation of this program is under sense-switch control. Some of the additional features of the individual tape utility programs are not available in this combined-operation program.

Tape Reading and Writing Subroutines

Three individual programs are provided: read, write, and read/write. They are distributed in symbolic (SPS) form to facilitate incorporation into any program written in SPS or Autocoder language. Standard error-checking and record-recovery procedures are used in the programs.

IBM 1012 Tape Punch Routines

These routines relieve the user of detailed instruction coding for these IBM 1012 functions pertaining to 5- or 8-track tape: tape punching, error checking, automatic error correction, end-of-record processing, and end-of-reel processing. The routines, as written, are to be incorporated in the Autocoder system library and can be inserted in any program assembled by Autocoder. Two macro instructions (PTAPE and CTAPE), when used in the symbolic source program, cause the 1401 Autocoder or the 1401/1311 Autocoder processor to insert the appropriate routines in the user's object program.

IBM 1401-1009 Utility Program

This utility program makes a 1401-1009 system operational with a minimum of 1401 programming effort. The program can be used at any installation that has an IBM 1401 Data Processing System communicating (by means of an IBM 1009 Data Transmission Unit and communications-company line facilities) with another 1401-1009 installation, an IBM 1410-1009 installation, or an IBM 7701 Magnetic Tape Transmission Terminal. The program performs card-to-card, card-to-tape, tape-to-card, and tape-to-tape transmission as desired by the user.

Sort-1

Sort-1 is a generalized, 2-way-merge sorting program for IBM 1401 systems with a minimum of 4,000 core-storage postions and four magnetic tape units. It is considered a *generalized* sort program because it is capable of modifying itself according to specifications provided by the user in control cards.

Sort-1 can sort fixed-length magnetic-tape records (either single or blocked) into an ordered sequence of records. The control data of each record can be located in more than one place in the record and can be of different sizes for different files. The input records can be in any order. They can be contained on from one to 99 reels; however, there must be no more input records than will fit on one output reel.

The Sort-1 program consists of two phases. Phase-1 reads into core storage a number of input records, sorts them internally, and writes the short sequences on alternate output tapes. Phase-2 performs a 2-way merge, using four tape units: two for input and two for output. The last pass of phase-2 writes the entire sorted file on one tape reel. A fifth tape unit, if available, can be used to store unreadable records and records larger or smaller in length than specified in the control cards. If a fifth tape is not provided, this information is punched into cards.

Sort-2 and Merge-2

Sort-2 and Merge-2 are generalized programs that utilize increased storage capacity and the advanced-programming features to provide faster tape sorting and merging on the IBM 1401 tape systems with a minimum of 8,000 core-storage positions.

Sort-2 and Merge-2 are two separate programs. Sort-2 sorts fixed-length tape records (either single or blocked) using either 2- or 3-way merging, depending upon whether four or six magnetic tape units are available. The increased number of storage positions enables Sort-2 to accommodate longer tape records and to perform sorting and merging faster than Sort-1.

Merge-2 combines tape files that have been sorted by the Sort-2 program. Sort-2 and Merge-2 can be used with each other, or they can be used as independent programs.

Sort-6

Sort-6 consists of a set of generalized sorting routines. They are incorporated in the 1401/1311 Autocoder system library. The user supplies to the 1401/1311 Autocoder processor a description of the kind of sort program that he wants. The Autocoder then generates a sort program conforming to his general specifications.

This program is a generalized one that can be used for many sorting applications. Prior to each sorting run, the user must modify the generalized program (by using the appropriate control cards) to suit his particular input file and to specify certain processing options. Sort-6 provides automatic input and output label-checking options. The program operates on IBM 1401 systems equipped with an IBM 1311 Disk Storage Drive.

Sort-6 can sort blocked or unblocked fixed-length data records contained in cards, on magnetic tape, or

in disk storage. The sorted output can be written on magnetic tape or in disk storage, in either ascending or descending sequence.

Sort-7 and Merge-7

Sort-7 and Merge-7 are generalized programs that sort and merge magnetic-tape files. The programs provide automatic label-checking operations for IBM 1401 standard header and trailer labels. Exits permit the user to insert his own label-checking routines for non-standard header and trailer labels.

Sort-7 can sort tape records into either ascending or descending sequence. It sorts fixed-length or variable-length records that are blocked or unblocked. The last phase of Sort-7 produces a single sequential file.

Merge-7, a single-pass program, can combine as many as five tape files into a single sequential-tape file. It can also sequence-check or reblock a single tape file.

Sort-7 and Merge-7, although they are separate programs, can be used to complement each other. Thus, each reel of a file can be sorted by Sort-7, and the resulting sorted reels can be merged by Merge-7.

File-Organization Programs (IBM 1311)

Two sets of disk file organization programs are provided to aid users in establishing and maintaining their data files in IBM 1311 disk storage. These programs are of the *generative* type. That is, the user supplies a set of parameters for his particular application. From these parameters, the IBM 1401-1311 Autocoder program, using the file-organization routines, generates a file-organization *object* program that is appropriate for the application.

One set of file-organization routines is designed for random files, and the other, for control-sequential files.

Random Programs

These programs are:

- Two-pass load program for master records
- Additions program for master records
- Loading and additions program for trailer records
- Programs for deleting and tagging master and trailer records
- Unload program for reorganizing master and trailer files.

Control-Sequential Programs

These programs are:

- Load program
- Additions program
- Programs for deleting and tagging records
- Reorganization program

Autotest

Autotest is a testing program that allows a user to make maximum use of machine time while testing Autocoder, SPS, and Fargo programs. Autotest provides the ability to stack programs, and to produce complete operating instructions and a core storage print-out for every object program.

In addition to these functions, the user may select any combination of the optional features provided by Autotest to obtain an efficient and thoroughly documented test of all object programs. These optional features include:

1. a tape file generator
2. a RAMAC® (1405) file generator (not applicable for 1460 operation)
3. a RAMAC (1405) file trace routine (not applicable for 1460 operation)
4. Automatic patching – the ability to automatically patch the object program without reassembling or manually calculating patching addresses.
5. a snapshot feature that prints out the contents of a selected area of core storage following the execution of any instruction in the program being tested.
6. a listing, identified by program, can be obtained for all output cards.

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