

Systems Reference Library

IBM 1401 Data Processing System Operator's Guide

This reference publication describes the operating features and procedures for each of the units of an IBM 1401 system. Several operations that utilize two or more units are also described. One section outlines recommended procedures for restarting after an error condition on the 1402 or 1403.

For operator convenience, the logic of the 1401 system is discussed briefly. This includes addressing, phases of operation, internal checking, and coding structures. For a list of associated publications, see the *IBM 1401 Bibliography*, Form A24-1495.

Major Revision, March 1965

This publication, A24-3144-2, is a major revision of, and obsoletes A24-3144-1 and Technical Newsletter N24-0248.

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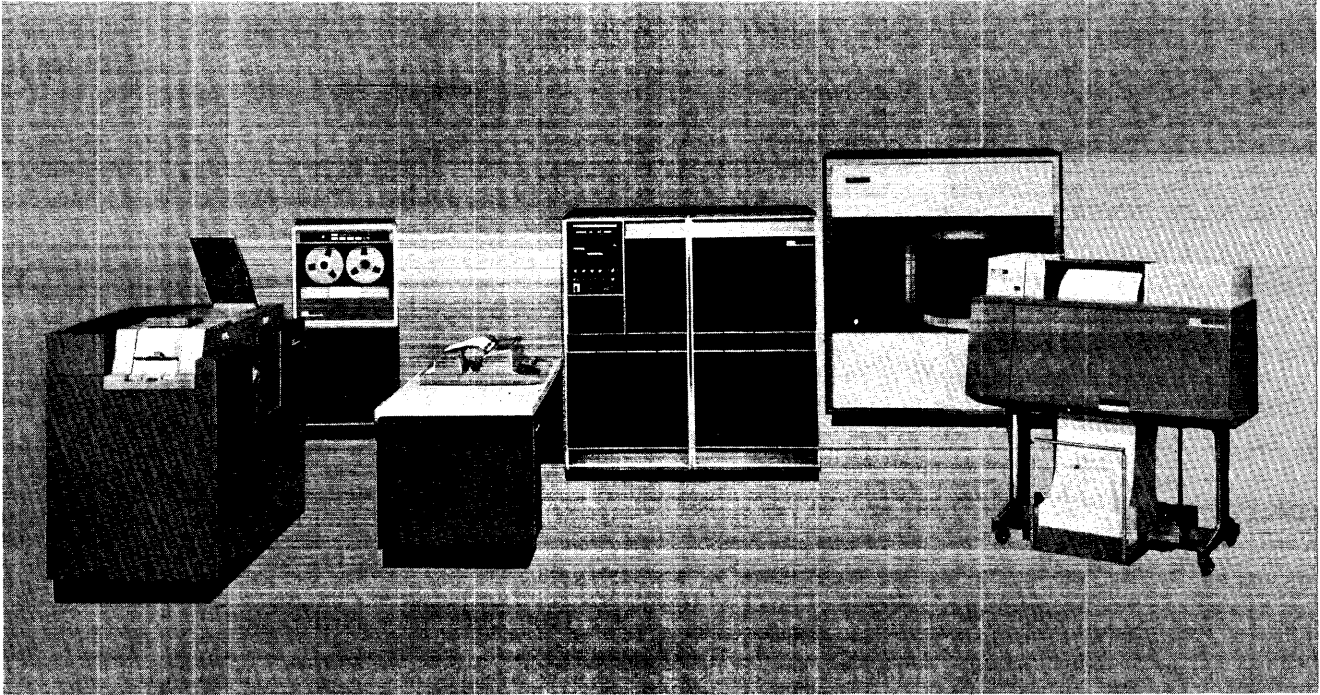


Figure 1. An IBM 1401 Data Processing System

IBM 1401 Data Processing System

Operator's Guide

The IBM 1401 Data Processing System (Figure 1) is an intermediate-size, solid-state, high-speed processing system with the program flexibility of larger systems. A 1401 system may consist of only those components that are required to meet the present needs of a company. Later, as the recordkeeping requirements of the business continue to mount, the system can be expanded to meet the increased burden. The 1401 permits various configurations for processing card records, magnetic tape records, disk records, and character-stored documents.

The 1401 system provides high-speed input/output, arithmetic and logical ability, and the advantages of stored-program techniques. It handles variable-length alphanumerical data and program instructions.

IBM 1401 Data Processing Systems can be considered in three basic concepts: card systems, tape systems, and disk storage systems.

IBM 1401 card systems are planned for procedures involving large volumes of card documents as source data and output, with particular advantage to applications requiring reentry data.

IBM 1401 tape systems are for handling magnetic tape, with all the advantages of compact record handling and storage for high-speed data processing.

IBM 1401 disk storage systems permit rapid random access to large volumes of repetitive data without the necessity of processing large card volumes or sorting tape records.

This guide gives the information needed to operate the basic units of a 1401 system. The features and operating procedures are described. Programming for a 1401 system is described in other publications.

Features and Operations

The features and standard procedures used to operate each of the units of an IBM 1401 Data Processing System are described in this section. In addition, several *system* operations, which utilize two or more units, are discussed at the end of this section.

IBM 1401 Processing Unit

The IBM 1401 Processing Unit (Figure 2) contains the core storage and circuitry that perform the system logic. Storage capacity is 1,400; 2,000; 4,000; 8,000; 12,000; or 16,000 alphanumerical characters of 8-bit core storage. These eight bits consist of six bits for binary-coded decimals, a check bit, and an eighth bit for field definition.

A console (Figure 3) is located on the upper left front of this unit, and serves two functions: it is the primary operator control panel of the computer, and it indicates the status of the system at any time. The console consists of keys, switches, signal lights, and dials for the processing unit and for certain functions of other units in the system. When a key is pressed, it lights to indicate that the function is controlled by the key. During automatic operation, the keys serve as lights to indicate that the corresponding function is in operation.

The console also contains back-lighted display lights that show the bit configuration of data in the system.

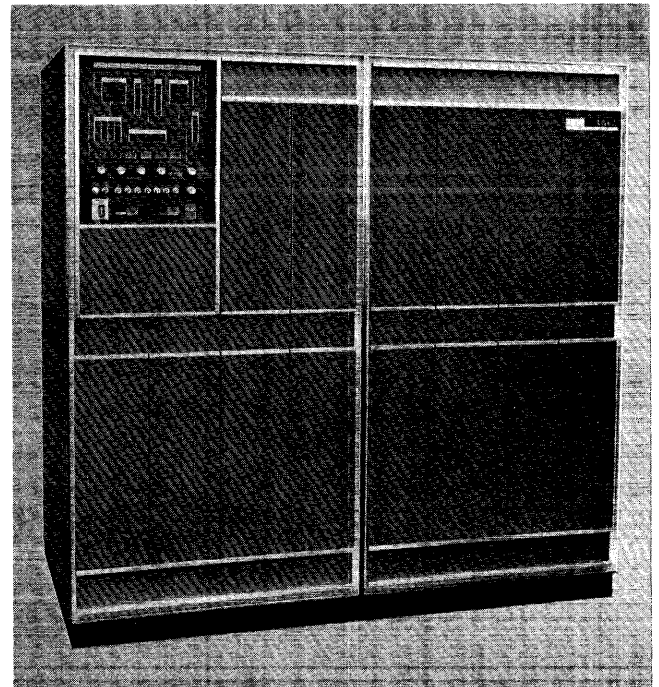


Figure 2. IBM 1401 Processing Unit

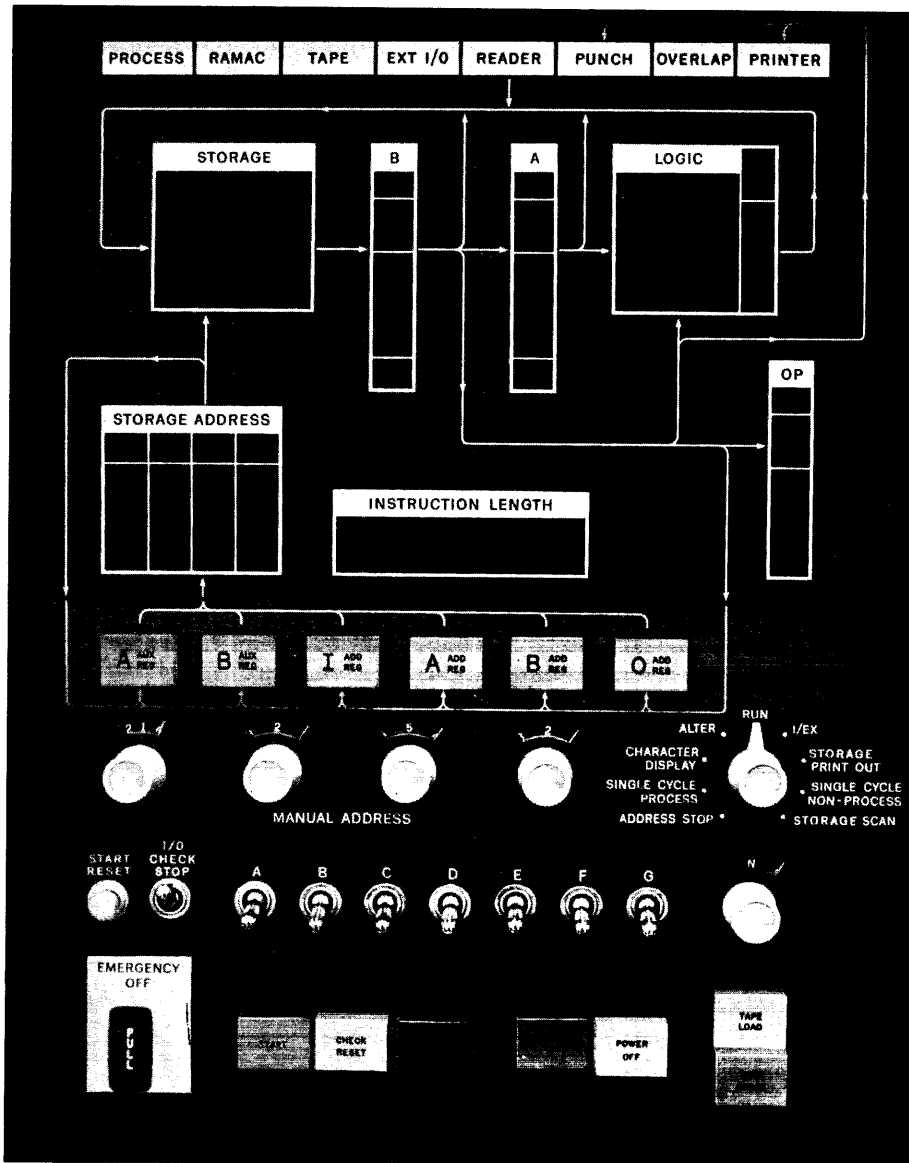


Figure 3. IBM 1401 Console

registers. The bit configuration of each character in each of the machine's logical elements is shown in binary-coded-decimal form (including check-bit and word-mark status). The data can be displayed one character at a time.

The various lights on the console are joined by connecting lines that constitute a data-flow schematic. This can be used by the operator in tracing the path of data through the IBM 1401 Processing Unit.

An auxiliary console panel (see Figure 7) is also located on the 1401 processing unit, below the main console. It permits additional operator control of the system.

In the following descriptions of *Features*, these sections refer to the main console: *Control Keys and Switches, Mode Switch, Registers' Keys and Lights, Logic Lights, Signal Lights*. The last section refers to the *Auxiliary Console Switches*.

Features

Control Keys and Switches (Figure 4)

Power On

This yellow key-switch turns ON the main power supply for the entire system. After it is pressed, the POWER light on the IBM 1402 Card Read-Punch, the PRINT-READY light on the IBM 1403 Printer, and the POWER ON and READY lights on the IBM 1405 Disk Storage should be backlit.

Power Off

This key-switch turns OFF the main power supply for the entire system.

Emergency Off

In an EMERGENCY, pull this switch to disconnect all power distributed within the system. The switch must be manually reset by an IBM customer engineer, before power is restored to the system.

Start

This green key initiates or resumes machine operation after a manual, programmed, or automatic stop. The specific operations performed, when this key is pressed,

are determined by the setting of the 1401 mode switch (see *Mode Switch*):

1. When the switch is set at RUN OR ADDRESS STOP, the START key on *any* unit can be used to start system operation.
2. When the switch is set at SINGLE CYCLE PROCESS, the START key on *any* unit causes the program to advance through one machine cycle.
3. For all other settings of the mode switch, the START key on the 1401 is used to perform the operation specified by the switch.

If an error indication occurs in any unit, the start keys are inoperative until the check reset key for that unit is pressed.

Stop

This red key stops system operation at the completion of the program instruction in process. (In a few program instructions, however, operation may stop at the end of the I-phase. See *IBM 1401 System Logic: Phases of Operation*.) This STOP key can be used interchangeably with the STOP keys on the IBM 1402 Card Read-Punch and the IBM 1403 Printer.

When a programmed halt occurs during processing (Op register displays BA821), this key lights to indicate to the operator that a planned stop, rather than an error condition, has occurred. The light turns OFF when the START key is pressed.

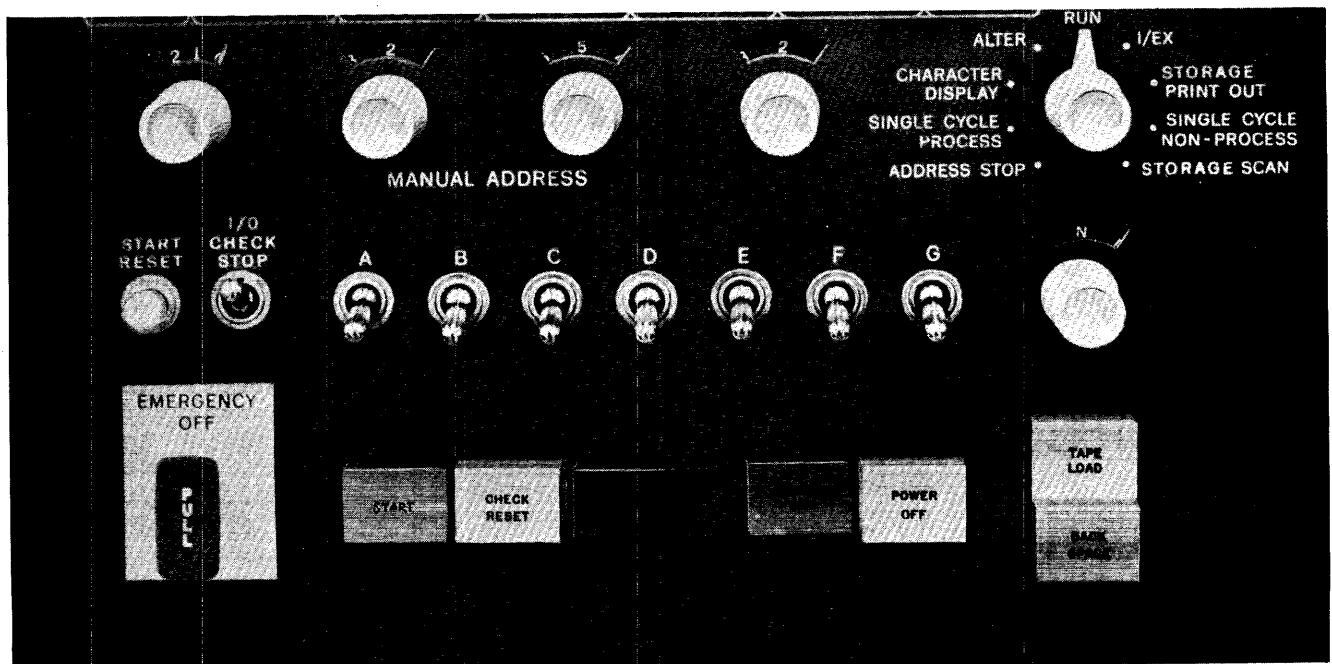


Figure 4. Control Keys and Switches; Mode Switch

Check Reset

If the processor checking circuits detect an error, this key-light turns ON. Following a processing error, this key must be pressed to turn off the PROCESS light and make the START key effective, so that operation can be restarted.

Start Reset

This key resets the system so that the operator can restart system operation. It performs these functions:

1. Turns OFF all signals that were turned ON by the previous operation.
2. Removes the operation code from the Op register.
3. Removes the number from the INSTRUCTION LENGTH register.
4. Turns OFF the OVFL0 light in the LOGIC block.

The START RESET key does *not* affect information in core storage or in the address registers.

Before a new job is started, this key must be pressed to reset the 1401 system.

I/O Check Stop

When this toggle switch is ON (up), system operation stops at the completion of an input or output operation if any one of these errors was detected:

- Hole-count check in the 1402 read feed.
- Hole-count check in the 1402 punch feed.
- Validity check in a 1402 read or punch feed read operation.
- Print check.

If the I/O CHECK STOP switch is OFF (down) and any one of these errors is detected, the error condition is ignored and operation continues. The program would ordinarily have a series of error tests (BRANCH IF READER ERROR, BRANCH IF PUNCH ERROR, and BRANCH IF PRINTER ERROR instructions) which would interrogate the error possibilities and implement appropriate action. For instance, the test for reader error might branch to a subroutine that would check each column for validity. If all characters were valid, a reader check condition would be assumed, and the program would be directed to a specific halt. If a column (or columns) was found to be invalid, the program might be written to automatically insert a corrected character in some cases, and cause a program halt in other cases, depending on what character and column was invalid.

The I/O check stop switch should always be on to take advantage of the built-in checking facilities of the

system, unless appropriate program branch tests are made.

Sense Switches

Seven sense switches are available to control program operation. Switch A is standard in all 1401 card systems, and controls last-card operation. The other six switches (B, C, D, E, F, and G) are standard in 1401 Models C and D, and may be included as special features in all other models.

These toggle switches act as setup switches, and should be set ON or OFF for a job before operation starts. A switch is ON when it is turned up. Sense switch A detects the last card of a run. It can be used to direct programming to a routine that has been prepared specifically for handling operations at the end of the job, such as printing final totals. The setting of the other six switches depends on the programmer, and should be specified in the operator's instructions.

Manual Address

These four dial switches are used to:

- Set up an address to be entered in a storage address register.
- Select a storage location for display or alteration, without disturbing the contents of the address registers.

The address dials are effective only when the mode switch is set at one of these five positions:

1. ALTER
2. CHARACTER DISPLAY
3. ADDRESS STOP
4. STORAGE PRINT-OUT
5. STORAGE SCAN

For operator convenience, the four dials are provided to set up a 5-position actual numerical address that is then coded internally into a 3-position alpha-numerical address. For example, an address of 3146 is converted to A46 (see *IBM 1401 System Logic: Addressing* for the coding of other addresses).

Tape Load

This key is used to load (into core storage) a program that is written on tape.

When TAPE LOAD is pressed, tape unit 1 is automatically selected, and tape data starts loading at address 001 and continues until an interrecord gap is sensed. Then an automatic branch back to 001 occurs, and the instruction beginning in 001 is executed.

Tape Select

During automatic operation, this dial switch is set to N (normal position). To select a particular tape unit for a manual operation, such as backspacing, this switch is set to the number (1-6) that corresponds to the tape unit.

The D (diagnostic) setting of this switch allows characters to be read into core storage just as they appear on the tape (or disk) record, without internally correcting any parity errors. This setting is used to locate the error position when system operation stops because a tape or disk parity error was detected.

Whenever the 1401 is operating in the overlap mode, this switch must be set to the N position, regardless of whether or not a tape unit is used. Setting this switch at any other position causes improper system operation.

Backspace

When the TAPE SELECT switch is set for a specific tape unit (1-6) pressing this yellow key once causes the tape in the selected unit to backspace until an interrecord gap is reached.

Mode Switch

This dial switch (Figure 4) selects any one of the nine modes of machine operation described in the following paragraphs.

Run: When the mode switch is set to RUN, the system is under control of the stored program. This is the normal setting for this switch. All other settings provide for special operations.

Alter: The mode switch is set to ALTER:

- To manually change the address in any of the address registers (see *Altering an Address in an Address Register*)
- To manually change a character in the A- or B-register (see *Altering a Character in the A- or B-Register*)
- To manually change the contents of a storage location (see *Entering a Character in Storage*)
- Before turning the power ON or OFF (see *Turning the System On* and *Turning the System Off*).

I/EX (Instruction/Execution): When the mode switch is set to I/EX, the first time the START key is pressed the machine reads one complete instruction from core storage to the address and character registers, and then stops. This is called the *instruction phase* of the operation.

The next time the start key is pressed, the machine executes the instruction (performs the operation called for by the operation code entered in the Op register during the I-phase). This is called the *execution phase* of the operation.

Repeatedly pressing the start key results in alternate instruction and execution phases.

If a 1407 console operation is performed with the MODE switch set to I/EX, the 1401 does *not* stop between the instruction and the execution phases.

Character Display: This setting of the mode switch is used to display, on the console, a character in core storage. When the START key is pressed, the character at the address selected by the MANUAL ADDRESS dials is shown in the B-register block.

Storage Print Out: This mode of operation permits any 100-character block of storage to be printed. The two high-order MANUAL ADDRESS dials select the desired block of storage. For example, if 12xx is set up and the START key is pressed, the 100 characters in block 1201-1300 are printed in print positions 1-100, on a 1403 Model 1. If a 1403 Model 2, or a 1404, is attached to the system, 132 positions are printed. This consists of the one hundred positions specified by the dials, plus 32 positions of the next hundred block. After the characters are printed, another print cycle occurs automatically and prints 1's on the following line to indicate the word marks associated with the data.

Single Cycle Process: This mode is used primarily in debugging a program. Each time the START key is pressed, the system takes one .0115-millisecond storage cycle, and then stops. The results of that cycle are displayed on the console for operator reference.

The start key must be pressed repeatedly to advance through the instruction (I) and execution (E) phases of one operation. The I-phase requires a minimum of two and a maximum of nine cycles to transfer an instruction from storage to the registers for execution. The number of cycles depends on the length of the instruction.

Each pressing of the start key moves one position of the instruction to the proper register. (The Op register contains the operation code, the A-address register contains the A-address, the B-address register contains the B-address, and the A-register contains the d-modifier.) Then the corresponding register lights display the character, and the INSTRUCTION LENGTH light shows which position of the instruction was transferred. (See *IBM 1401 System Logic: Phases of Operation* for a more detailed description.)

To execute the operation called for by the Op code, the E-phase requires a storage cycle for each character involved in the operation, and two cycles for analyzing

the sign position. For example, if a 2-position number is to be added to a 3-position number, seven cycles are required. However, if an input or output operation (without read or punch release) is executed, all the execute cycles are executed immediately when the start key is pressed.

Continued use of the START key in this mode of operation advances the program, cycle by cycle, through successive instruction and execution phases.

Single Cycle Non-Process: This mode is similar to the single cycle process mode. It is used primarily to observe the results of arithmetic operations, one character at a time, without destroying the original data (in the B-field). The results of the calculation are displayed in the LOGIC block but they are not stored. Therefore, this same calculation must also be made in the RUN mode if the results are valid and required for the completion of the job.

In this mode, data does not enter storage from the A-register or from the logic unit. Data enters storage from the B-register only.

This mode of operation cannot be used for input or output operations.

Address Stop: This setting of the mode switch permits stopping system operation at a specified point in the program. It is commonly used in program testing operations. When the START key is pressed, in this mode of operation, processing continues until the address set up in the MANUAL ADDRESS dials is reached (moved to the storage-address register), and then it stops. Any storage address except the following may be used:

1. The I-address of a reader, punch, or printer instruction.
2. The B-address of a tape, disk, or console inquiry station instruction.

Storage Scan: This mode checks core storage to find any position(s) that contains incorrect parity. With correct parity, a character in storage consists of an *odd* number of bits. With incorrect parity, it has an *even* number of bits (See *IBM 1401 System Logic: Internal Checking* for a more detailed description of parity.) This mode is also used after an error indication on an input or output operation, to locate the particular position that caused the error signal.

With the START key held pressed, checking of storage starts at the address set up in the MANUAL ADDRESS dials, and continues until the error is located. If no error is detected, checking continues as long as the start key is held. For this checking operation, each position of storage is automatically read out to the B-register where it is checked for parity.

When an error is located:

1. The B, STORAGE, and PROCESS lights turn ON.
2. The position (address) of storage that contains the error is shown in the STORAGE ADDRESS display block.
3. The contents (character bits) of the storage position in error are shown in the B-register display block.
4. If the storage scan is performed immediately after a reader check, punch check, or printer check signal, the corresponding input or output unit light (READER, PUNCH, or PRINTER) also turns ON when the error position is detected.

Because scanning stops at the first error, and since more than one error may have occurred when the error signal was given, the START key should again be held down to continue the scanning operation.

If the START key is released at any time, scanning stops. In this case the character displayed in the B-register block is not in error, unless the B light is ON.

Whenever a storage scan operation is performed, the A-register must contain some valid character because, if it does not, operation stops with the PROCESS light ON. Frequently the A-register does not contain a character when power is turned ON. Therefore, if storage is to be scanned for parity errors at that time, a character must first be entered in the A-register by setting the mode switch to ALTER, and then pressing A ADD REG and START.

Registers' Keys and Lights

Registers are used by the 1401 system to process a program stored in core storage (see *IBM 1401 System Logic*). There are various types of registers that are capable of receiving information from core, storing it, and transferring it as directed by control circuits within the system. For operator reference, the condition of these registers at any particular time during processing is reflected by lights and keys on the console (Figure 5).

The 1401 has seven basic registers. Four are *address* registers: I-address, A-address, B-address, and storage address. These contain the address of an instruction character (I-address), of a data character to be operated on (A-address and B-address), and of the storage location affected on each machine cycle (storage address). Three are *single-character* registers: Op register, A-register, and B-register. The Op register contains the operation code. The A-register contains a character from the B-register on each instruction cycle, except the first and last, and on each execution cycle that involves the A-address field. The B-register contains the

character read from core storage on each machine cycle.

Other registers are provided for special operations, such as an O-address register for the processing-overlap special feature, and the A-auxiliary and B-auxiliary registers for the multiply-divide special feature.

I-Add Reg

The yellow I-address register key-light is pressed to display the address in the I-address register. This address is displayed in the STORAGE ADDRESS block, and the key-light turns ON. Pressing this key turns OFF any other register key-light(s) that is lighted.

In an automatic operation, if processing stops at the end of an individual instruction (I) cycle, this key lights and STORAGE ADDRESS shows the address of the last instruction character transferred from core storage to an address register.

A-Add Reg

The yellow A-address register key-light is pressed to display the address in the A-address register. This address is displayed in the STORAGE ADDRESS block, and the key-light turns ON. Pressing this key turns OFF any other key-light(s) that is lighted.

In an automatic operation, if processing stops at the end of an individual execution cycle involving the A-address, this key is lighted and STORAGE ADDRESS shows the address of the last A-field character read out from (or into) core storage.

B-Add Reg

The yellow B-address register key-light is pressed to display the address in the B-address register. This address is displayed in the STORAGE ADDRESS block, and the key-light turns ON. Pressing this key turns OFF any other key-light(s) that is lighted.

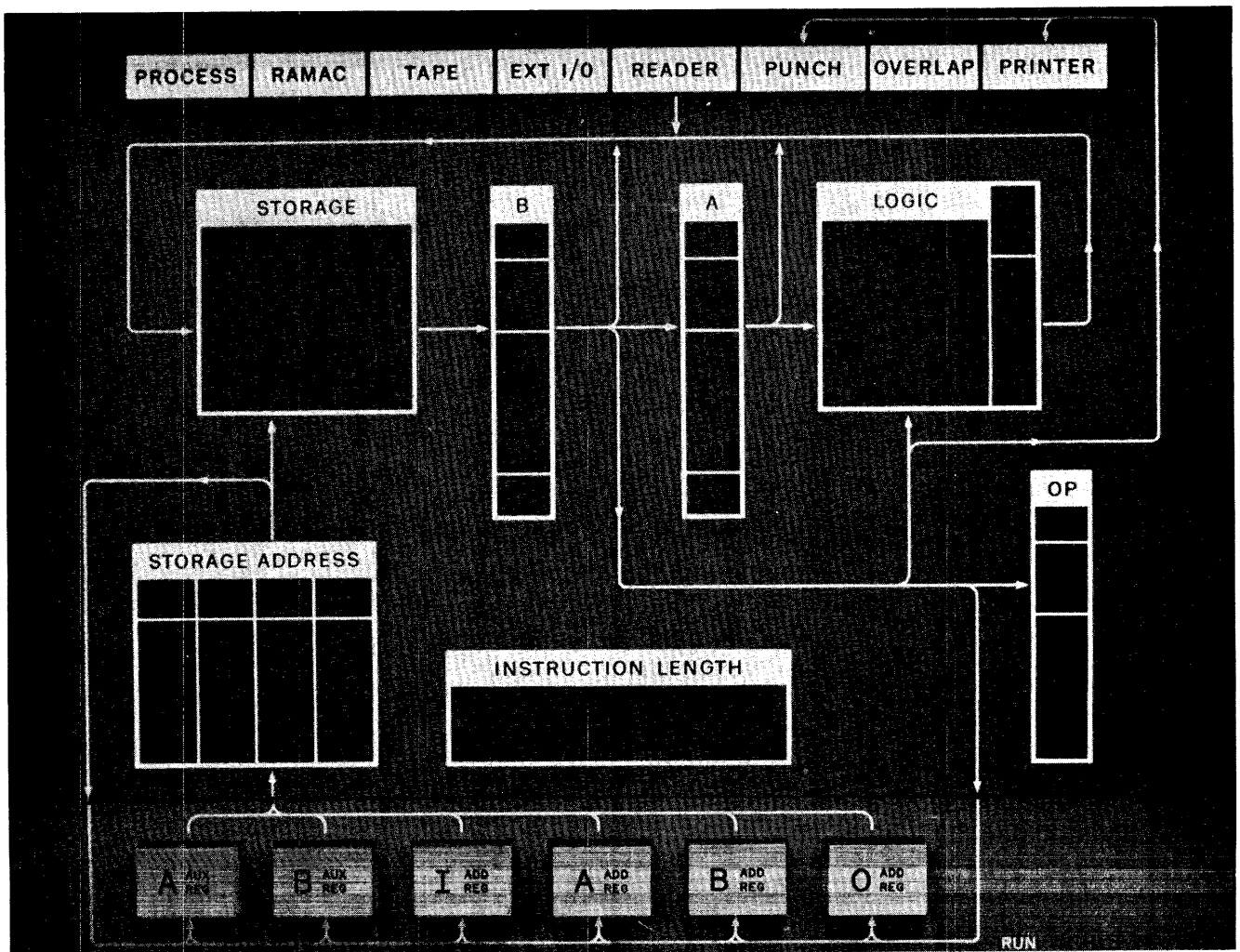


Figure 5. Registers' Keys and Lights, Logic Lights, and Signal Lights

In an automatic operation, if processing stops at the end of an individual execution cycle involving the B-address, this key is lighted and STORAGE ADDRESS shows the address of the last B-field character read out from (or into) core storage.

O-Add Reg

The yellow O-address register key-light is used in conjunction with the processing-overlap special feature. It is pressed to display the address in the O-address register. This address is displayed in the STORAGE ADDRESS block, and the key-light turns ON.

In an automatic operation, if processing stops at the end of an individual cycle involving the overlap feature, this key is lighted and STORAGE ADDRESS shows the address of the last character read out from (or into) core storage in the overlap mode.

The O-address register key-light may turn ON at the same time as any other address register key-lights. Pressing any other key-light turns OFF the O-address register key-light, but pressing this key-light does not turn OFF any other key-light.

A-Aux Reg; B-Aux Reg

The yellow A-auxiliary register and B-auxiliary register key-lights are used in conjunction with the multiply-divide special feature. Either one is pressed to display the address in the corresponding address register. The address is displayed in the STORAGE ADDRESS block, and the key-light turns ON. Pressing either of these keys turns OFF any other key-light that is lighted.

In an automatic operation, if processing stops at the end of a multiply or divide cycle, the corresponding key is lighted and STORAGE ADDRESS shows the address of the last storage position read out from (or into) core storage for the multiplication or division operation.

Storage Address

This block serves two purposes: to indicate an error condition in the storage address register, and to display a core-storage address.

When an error is detected in the storage address register, the words STORAGE ADDRESS are lighted and the address is displayed. This light turns on if:

- A parity or validity error occurs in the storage address register.
- An address is developed that is invalid on the particular system in use (for example, an address of 6500 for a 4,000-position system).

- A wraparound of core storage occurs. This programming error is discovered; indicating that word marks were either missing or incorrectly placed in the data fields being operated on by the instruction. Most instructions require a word mark following the instruction itself, and a word mark in either the A- or B-field. The 4-position CLEAR STORAGE instruction does not give this error when core-storage position 000 is cleared.

If the error is detected during an input or output operation, that operation is completed before the system stops. If it is detected at any other time, system operation stops at the end of the cycle in which the error is detected. The storage-address error signal is turned OFF by pressing the check reset key.

The backlighted numbers in the STORAGE ADDRESS block are used to display an address of core storage. For operator convenience, an address is displayed as a 4-position numerical address, which corresponds to a coded 3-position alphanumerical address in core storage. For example, an address displayed as position 1587 is coded V87 in core storage (see *IBM 1401 System Logic: Addressing*). Each position of the address is displayed in BCD code, with a check bit if required (see *IBM 1401 System Logic: BCD Codes*). The address 1587 would be displayed as shown in Figure 6.

The thousands position of the storage address register is unique in that one set of lights are used to display thousands addresses from 0xxx to 15xxx. If the address being displayed is below 999, the thousands position of the storage address register is blank. If the address being displayed is from 1xxx through 9xxx, this position shows the normal bit configuration for the numerical value of the address position. Addresses in the 10,000 range are represented by lighting the 0 and 8 lamps. The thousands position of addresses above 10,000 are represented by two or more lights. For instance, the 1, 2, and 8 bit lights are on for any address in the 11,000 range, while the 2, 4, and 8 bit lights are on to represent any address in the 14,000 range.

STORAGE ADDRESS			
	C		
		8	
	4		4
			2
1	1		1

Figure 6. Storage Address 1587 Displayed

An address is automatically displayed whenever system operation stops. The address register key-light that is ON indicates which address register the bits represent and, indirectly, the cycle at which the halt occurred. If an error has been detected in the storage address register, STORAGE ADDRESS is lighted to indicate this, and the address displayed can be checked for a parity or validity error. An address may be displayed manually by pressing an address register key (I ADD REG, A ADD REG, B ADD REG, O ADD REG, A AUX REG, or B AUX REG).

OP

Any time system operation stops, the operation code in effect is displayed by the backlighted numbers in the OP block. This is shown in BCD code, with a check bit if required (see *IBM 1401 System Logic: BCD Codes*).

If a parity (*even parity*) or validity error is detected in the operation register, the word OP is lighted. System operation stops at the end of the next storage cycle, a 1 appears in INSTRUCTION LENGTH, and the faulty operation code is displayed. This light is turned OFF by pressing the check reset key.

B

If *even parity* (error condition) is detected in the B-register, the letter B is lighted. System operation stops and the erroneous character is displayed below in BCD code, with its check bit and word mark if present (see *IBM 1401 System Logic*). This light is turned OFF by pressing the check reset key.

A

If *even parity* (error condition) is detected in the A-register, the letter A is lighted. System operation stops and the erroneous character is displayed below in BCD code, with its check bit and word mark if present (see *IBM 1401 System Logic*). This light is turned OFF by pressing the check reset key.

Instruction Length

This block provides the backlighted numbers 1-8 and letters OP. The number displayed in this block tells the length of the instruction being executed, if processing stops during the execution phase of an operation.

If processing stops at the end of an instruction cycle, the number (or letters) indicates the position of the instruction transferred from core storage to a register on that cycle. The OP signal lights if operation stops

at the end of the first instruction cycle. That cycle always transfers the Op code from storage to the Op register. On any other instruction cycle, the lighted number tells the number of the position following the Op code.

Logic Lights

This block (see Figure 5) performs four functions:

1. Signals error conditions. System operation stops and the word LOGIC is lighted if an invalid character is detected by the 1401 *adder*. The system uses the adder for all arithmetic operations. The adder is also used in conjunction with card read and card punch operations, and for a programming function known as *indexing*. If the error is found during an input or output operation, the system stops at the end of the operation. At any other time, the system stops at the end of the cycle in which the error is found. This LOGIC light is turned OFF by pressing the check reset key.
2. Displays invalid character. When system operation stops because an error condition is detected in the adder during an arithmetic or indexing function, the invalid character is displayed at the right in the LOGIC block. This character results, at the end of a storage B-cycle, from an error in one individual addition (out of the series of add cycles that constitute *any* calculation in the 1401). The character is displayed in BCD code (see *IBM 1401 System Logic: BCD Codes*).
3. Indicates an overflow. If an arithmetic overflow condition exists in the machine, the OVFL0 signal is backlighted. This signal is turned OFF by executing a program instruction that tests the error condition, or by pressing the start reset key. If the key is used and then CLEAR STORAGE cards are fed at the beginning of a program, however, the OVFL0 signal turns ON again.
4. Indicates result of a comparison. When programming compares the A- and B-fields of an instruction, the result is indicated to the operator by the signal that is backlighted:

B \neq A Unequal condition

B = A Equal condition

B > A Value of the B-field is greater than the value of the A-field, or the A-field is shorter than the B-field

B < A Value of the B-field is less than the value of the A-field.

The last two signals ($B > A$ and $B < A$) are operative only when the high-low-equal compare special feature is installed.

At the beginning of a programmed compare operation the equal ($B = A$) signal turns ON automatically, and all others turn OFF. The equal signal remains ON until it is turned OFF by an unequal condition ($B \neq A$, $B > A$, or $B < A$).

Signal Lights

The lights at the top of the 1401 console (see Figure 5) represent each type of unit in the 1401 system. A light turns ON to indicate an error condition in the corresponding unit, or to signal the operator that the unit requires attention. Two or more of these lights may be ON at the same time.

Process

This light turns on whenever any error is detected in the IBM 1401 Processing Unit and indicated by another error light on the console. System operation may or may not stop, depending on the setting of the CHECK STOP switch on the auxiliary console and on the type of error condition (see *Check Stop*). This light is turned OFF by pressing the check reset key, if the CHECK STOP switch is ON. If the switch is OFF, this light is turned OFF either by pressing the check reset key or by executing a program instruction that tests the error condition.

At least one other light is *always* ON with the PROCESS light. The lights and their significance are:

- OP — An invalid Op code, or an Op code that contains a parity error, was transferred to the Op register.
- STORAGE ADDRESS — A parity or validity error in the storage address register, an address invalid for the system in use, or a wraparound of core storage occurred. A storage-address error can cause other lights (such as STORAGE, A and/or B) to turn ON.
- LOGIC — The 1401 adder contains an invalid character. If the STORAGE light and the A and/or B light are also ON, the invalid character contains a parity error (even parity).
- A and/or B — A parity error was detected in the corresponding register (A- or B-register).
- STORAGE with A and/or B — A parity error was detected as a character was entering core storage, or as a character was being moved from one storage location to another.

RAMAC®

If an error is detected in the disk unit attached to the system, this light turns ON. It is turned OFF by pressing the start reset key or by executing a subsequent disk storage program instruction. When an IBM 1405 Disk Storage unit is used, a light on that unit indicates the particular error condition that was detected.

When power to the system is turned ON, this RAMAC light turns ON and stays ON until the disk unit is ready to operate. Then it goes OFF automatically.

Tape

If an error occurs during a tape read or write operation, this light turns ON but system operation does not stop. A program instruction can be included to stop operation, if desired. The light turns OFF when any subsequent tape operation is executed by the stored program.

During a manual operation, with the TAPE SELECT switch set to a tape drive number 1-6, the TAPE light is ON.

Ext I/O (External Input/Output)

This light turns ON when one of the external input or output units and/or the direct-data-channel special feature of the 1401 system requires operator attention. The units are:

- IBM 1011 Paper Tape Reader
- IBM 1012 Tape Punch
- IBM 1412 Magnetic Character Reader
- IBM 1418 Optical Character Reader
- IBM 1419 Magnetic Character Reader
- IBM 1428 Alphameric Optical Reader

The light turns OFF automatically when the condition that requires attention is corrected.

Reader

This light turns ON when the attached card reader requires operator attention (empty hopper, full stacker, card jam, clutch failure, hole-count error, or validity error). System operation may or may not stop, depending on the type of condition and the setting of the I/O CHECK STOP switch.

This light turns OFF automatically when the condition is corrected in the card reader (see *Restart Procedures for IBM 1402 and IBM 1403*).

Punch

This light turns ON when the card punch requires operator attention (empty hopper, full stacker, full chip

box, clutch failure, or hole-count error). System operation may or may not stop, depending on the type of condition and the setting of the I/O CHECK STOP switch.

This light turns OFF automatically when the condition is corrected in the card punch (see *Restart Procedures for IBM 1402 and IBM 1403*).

Overlap

This light turns ON when any process error occurs during an overlap cycle. Ordinarily, the PROCESS light is also ON, along with an indication of the type of failure. However, if an A-register check occurs during a tape-overlap cycle, only the OVERLAP light turns ON. This light is turned OFF by pressing the check reset key.

Printer

This light turns ON if an error occurs in the printer or if the printer requires operator attention. System operation may or may not stop after the printer operation, depending on the type of condition and the setting of the I/O CHECK STOP switch.

This light turns OFF automatically when the condition is corrected at the printer (see *Restart Procedures for IBM 1402 and IBM 1403*).

Storage

This light turns ON when a parity error (even parity) is detected in a character as it is read into storage. It is turned OFF by pressing the check reset key.

Auxiliary Console Switches (Figure 7)

Bit Switches

Eight bit switches are used to alter characters in storage. They provide for the 6-bit BCD code (B, A, 8, 4, 2, 1), a word-mark bit (M), and a check bit (C) for odd

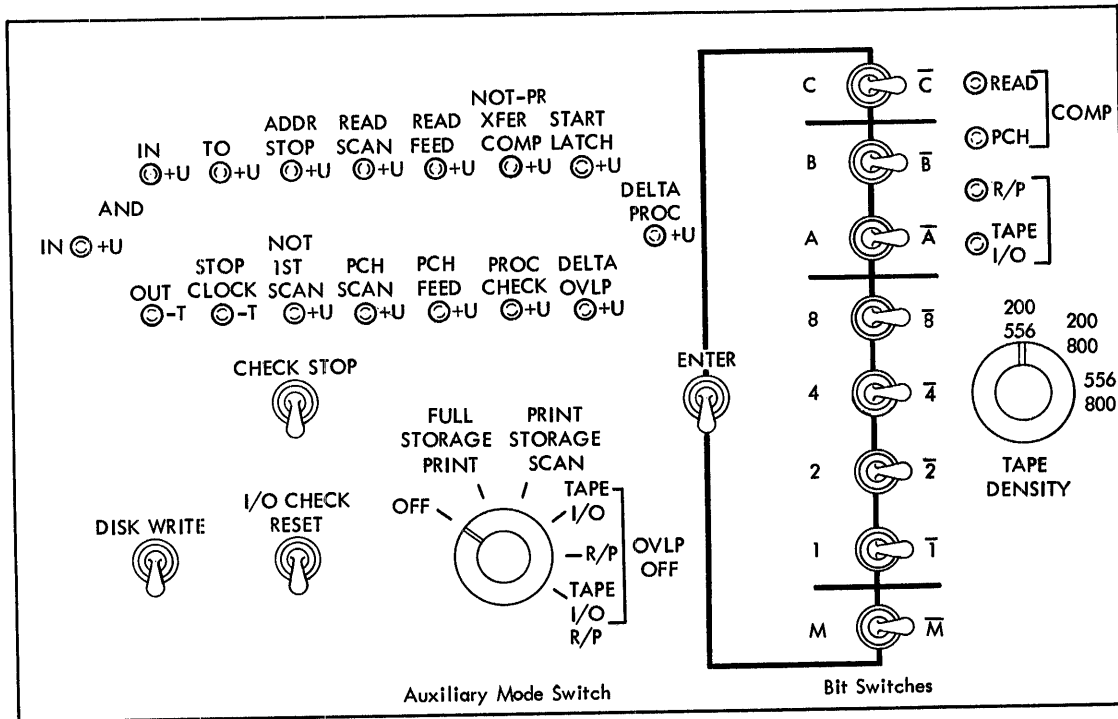


Figure 7. IBM 1401 Auxiliary Console

parity. The switches can be used when the mode switch is set to *ALTER*, and they are effective only when the *ENTER* switch is turned *ON*.

These toggle switches are *ON* when they are set to the left, and they are *OFF* when set to the right. The *OFF* positions are indicated by dashes over the characters. The switches may be set to either position during automatic operation.

Enter

This switch enters, into storage, the character selected by the bit switches that are *ON*. This switch is effective when the mode switch is set to *ALTER*.

This toggle switch is a spring-loaded switch. Raising the switch enters one character in storage. When the switch is released, it returns to its normal position. The character entered in storage is displayed in the *B*-register block on the console. The address of the core location affected is displayed in the *STORAGE ADDRESS* block.

The *ENTER* switch can be used when the mode switch is set to *STORAGE SCAN*, to enter a character in *all* positions of core storage (for example, a check-bit to clear all storage). For this, the *START* key is held down while the enter key is raised and released. Less than 0.2 of a second are required to enter a character in all 16,000 positions of core storage.

Check Stop (Process)

When this switch is turned *ON* (up), system operation stops automatically if a *process* error occurs. When the switch is *OFF*, operation stops *only* for errors detected in the *Op* register, an address register, or an input/output operation. It does not stop for other process errors, such as a logic error or a parity error detected when a character is moved from one storage location to another.

Disk Write

When this switch is *ON* (up), normal disk-storage operations can be performed. When it is turned *OFF*, this switch facilitates testing programs by preventing the writing of test data on permanent records in the disk storage unit attached to the system. Program instructions to *WRITE DISK* or *WRITE DISK WITH WORD MARKS* are *not* executed, but all other disk storage instructions are performed normally. When either of these two instructions is encountered, the switch prevents the transfer of data from core storage to the disk surface. Automatic comparison of the record address in core storage and the address on the disk record is per-

formed, however, and the unequal-address compare signal turns *ON* if an unequal condition occurs.

Regardless of the setting of the *DISK WRITE* switch, a *WRITE DISK CHECK* program instruction must be performed following a write operation. Because the data in core storage has not actually been written on disk when the *DISK WRITE* switch is *OFF*, a read-back-check error indication occurs each time a write-disk-check operation is performed. This can be tested by a program instruction.

I/O Check Reset

This switch resets error conditions detected in an input or output unit when the *I/O CHECK STOP* switch is *OFF*. It is used primarily by IBM customer engineers. However, it can be used with the *I/O CHECK STOP* switch *ON*, to reset *PRINT CHECK* errors.

Auxiliary Mode Switch

This dial switch can be set at any one of six positions:

Off: This is the normal setting. In this position, the switch has no effect on system operation.

Full Storage Print: This position is effective only when the system has more than 4,000 positions of core storage (an IBM 1406 is included in the system). It is used in conjunction with the *MODE* switch on the main console to print the contents of all storage positions. When the *MODE* switch is set to *STORAGE PRINT OUT* and the *START* key is pressed, printing starts with storage position 001 and continues until all positions in storage have been printed. Word marks print as 1's under the corresponding data positions.

If a 1403 Model 1 is attached to the system, storage data is printed out in blocks of 100 characters. If a 1403 Model 2 or a 1404 is attached, a block of 132 characters is printed. However, the last 32 positions printed on each line are repeated at the beginning of the next line of data. For example, core positions 101-132 print at the end of the first line and at the beginning of the second line.

The printing operation can be stopped before all positions are printed, if desired, by pressing the start reset key and then turning the *MODE* switch on the main console to *RUN*.

Print Storage Scan: This position is effective only when the print-storage special feature is installed. It can be used, in conjunction with the *MODE* switch on the main console, to scan both the standard print area in storage (positions 201-332) and the 132 special print-storage positions. When the *MODE* switch is set to

STORAGE SCAN and the START key is pressed, scanning begins at position 201 of storage, and at the first print-storage position. Scanning continues through 132 positions in each area. During this procedure, the contents of the standard print area are displayed in the B-register, and the contents of the special print-storage area are displayed in the A-register.

If an error is found in either register, scanning stops. Otherwise, it stops at position 332. After an error stop, resetting the error indication and pressing the START key continues the scan.

The other three positions of this switch prevent input/output operations from being performed in the overlap mode. They are used primarily by IBM customer engineers:

Tape I/O: This setting prevents magnetic tape or serial input/output operations from being performed in the overlap mode.

R/P (Read/Punch): This setting prevents card operations from being performed in the overlap mode.

Tape I/O R/P: This setting prevents tape, serial input/output, or card operations from being performed in the overlap mode.

Tape Density

This 3-position switch controls the low- and high-density rates of the IBM 729 V Magnetic Tape Units attached to the 1401 system. The three settings are 200-556, 200-800, and 556-800. The tape unit reads or writes characters in one of the densities designated by the switch.

The IBM 729-II, 729-IV, 729-VI and 7330 Magnetic Tape Units operate at either 200 or 556 characters per inch, regardless of the setting of the tape density switch.

Sync Points

The synchronization points, shown in the shaded area, are available to simplify the servicing of the system. These points are only for the use of IBM customer engineers.

Operations

Altering an Address Register

An address in the I-address, A-address, or B-address register can be manually changed by the operator. This permits changing any address of any program instruc-

tion, for a one-time use, without affecting that address stored in core storage.

1. Stop the operation at the appropriate point in the program (see *Stopping at a Predetermined Address*).
2. Set the mode switch to ALTER.
3. Set up the desired address in the MANUAL ADDRESS dials.
4. Press the address register key-light (I ADD REG, A ADD REG, OR B ADD REG) for the register to be altered.
5. Press START.
6. The address register selected in step 4 now contains the new address. Check this address displayed in the STORAGE ADDRESS block to make sure it is set up correctly.
7. Press START RESET, if the operating instructions for this job require it.
8. To resume operation, set the mode switch to RUN and press START. If the I-address register has been altered in this operation, processing will now start with the program instruction stored at that address.

Altering the A- or B-Register

A character in the A-register or in the B-register can be manually changed by the operator for a one-time use. This does not affect the character stored in core storage.

1. Stop the operation at the appropriate point in the program (see *Stopping at a Predetermined Address*).
2. Set the mode switch to ALTER.
3. Be sure the MANUAL ADDRESS dials are set at zero, or at some location outside the range of the stored program. This is necessary because, when the following steps are performed, the character will also enter the core storage location selected by the dials.
4. Turn ON the bit switches (on the auxiliary console) for the BCD coding of the new character. Include the check and word-mark bits, if required.
5. Raise the ENTER switch (on the auxiliary console), and then release it.
6. The B-register now contains the new character. The character is displayed in the B-register block. Check it to make sure it is set up correctly. The letter B should not be lighted. If it is, make sure the character you have set up contains *odd* parity.

To enter a character in the A-register, continue with steps 7 and 8.

7. Press the A-address register key.
8. Press **START**. This moves the character from the B-register to the A-register. Both registers now contain the same character.
9. Since a character enters the A-register via the B-register, the original B-character must be reentered in the B-register (using steps 4-6) if it is to be retained.
10. To resume operation, set the mode switch to **RUN** and press **START**.

Entering a Character into Core Storage

A character may be entered into any position of core storage manually by the operator. If some other character is already stored in that position, it is replaced by the new one. This character may represent data or a position of a program instruction.

1. Stop system operation.
2. Set the mode switch to **ALTER**.
3. Set up the storage address (of the character to be entered) in the **MANUAL ADDRESS** dials.
4. Turn ON the bit switches (on the auxiliary console) for the BCD coding of the new character. Include the check and word-mark bits, if required.
5. Raise the **ENTER** switch (on the auxiliary console), and then release it.
6. The selected location now contains the new character, and the character is displayed in the B-register block. Check this block and the **STORAGE ADDRESS** block, to make sure the correct character has been entered in the correct location. The letter **B** should *not* be lighted. If it is, check the parity of the character you have set up. If the character contains even parity, correct it in the bit switches, press the **CHECK RESET** key to turn OFF the **B** light, and repeat steps 5 and 6. If the character appears to be correct, the **B** light probably indicates that the previous character in the selected location was incorrect. Press the **CHECK RESET** key and repeat steps 5 and 6.
7. The same character can be entered into several storage locations by repeating steps 3, 5, and 6.

Entering the Same Character in All Storage Positions

When you want to enter the same bit configuration in all core-storage positions (for example, to set each

addressable location to C bits), proceed as follows:

1. Press the stop key if the system is not already stopped.
2. Turn the mode switch to **STORAGE SCAN**.
3. Set the bit switches to the required bit configuration.
4. Press and hold the 1401 start key while you raise the enter key and release it.

NOTE: If errors occur, see *Storage Scan* section.

Displaying a Core-Storage Character

A character in any position of core storage may be displayed on the console without disturbing the character in storage.

1. Stop system operation.
2. Set the mode switch to **CHARACTER DISPLAY**.
3. Set up the storage address of the character in the **MANUAL ADDRESS** dials.
4. Press **START**. The character is displayed in the B-register block, and the location selected in step 3 is displayed in **STORAGE ADDRESS**.

Printing Out an Area of Core Storage

For operator reference, information in core storage can be printed out on the printer attached to the system. One hundred storage locations are read out and printed on one line, when a 1403 Model 1 is used. When a 1403 Model 2 or a 1404 is used, 132 positions are printed on one line. After the line of data, a line of I's is printed. They represent the word marks, in core storage, associated with the data just printed.

1. Stop system operation.
2. Set the mode switch to **STORAGE PRINT OUT**.
3. Set up the storage address of the hundreds block in the two high-order **MANUAL ADDRESS** dials. The two low-order dials have no effect on the operation, and it makes no difference where they are set. If 2560 is set up, for example, characters will print from storage locations 2501-2600 (or 2501-2632).
4. Press **START**. One line of information and one line of word-mark I's are printed.

If all of core storage is to be printed, steps 3 and 4 can be repeated for each hundreds block, or the auxiliary mode switch on the auxiliary console can be used by following these steps:

1. Stop system operation.
2. Set the mode switch to **STORAGE PRINT OUT**.

3. Set the auxiliary mode switch to FULL STORAGE PRINT.
4. Press START. Alternate lines of data and word-mark 1's are printed. Printing starts with storage position 001 and continues through all core storage positions. If a 1403 Model 2 or 1404 is used, the last 32 characters in each line of data are the same as the first 32 in the next data line. Each line starts with a storage position numbered a hundred plus one (for example: 0101, 0201, 0301).

Other methods of printing from core storage use a program written specifically for that purpose. A general method for handling such a program is described under *Printing Out Core Storage (Program Control)*.

Stopping at a Predetermined Address

Processing can be stopped at a specified point in the program. This is normally used during program testing to permit the operator to investigate the condition of the various registers and/or of core storage for a particular operation. To effect the stop, the storage address of a position of a program instruction (for example, the Op code) or the storage address of a position of data is used. Processing stops as soon as this address is reached, and before the instruction or data character is read out from storage to a register.

1. Stop system operation.
2. Set the mode switch to ADDRESS STOP.
3. Set up the storage address, at which processing is to stop, in the MANUAL ADDRESS dials.
4. Press START. Processing continues until the address set up in step 3 is moved to the storage address register. Then it stops. Pressing START again repeats the operation.

If a program is loaded with the mode switch set at ADDRESS STOP, the loading operation stops twice at the specified address before the program is processed. It stops when core storage is cleared and when a character is loaded into the specified address.

NOTE: The system does not stop when the address-stop switch is set to a core-storage location containing an input/output Op code, or when the switch is set to a location in the data field of an input/output operation.

Scanning Storage

Core storage can be scanned to find the position(s) that contains incorrect parity (even parity) or a hole-count error. This operation is generally used after a signal indicates that an error has been detected during

an input or output operation. The scan can be started at any specified storage position, and it continues until the error is located.

1. Stop system operation.
2. Set the mode switch to STORAGE SCAN.
3. Set up the storage address, at which scanning is to start, in the MANUAL ADDRESS dials.
4. Hold START pressed. Scanning starts at the address set up in step 3, and stops when the parity error is reached. Refer to the console for the address and character displayed.
5. Correct the character by following these steps:
 - a. Set the mode switch to ALTER.
 - b. Set up the address displayed (step 4), in the MANUAL ADDRESS dials.
 - c. Turn ON the bit switches (on the auxiliary console) for the proper coding of the character.
 - d. Raise the ENTER switch.
6. Check the character displayed in the B-register block to make sure you set it up correctly.
7. Press CHECK RESET.
8. Return the mode switch to STORAGE SCAN.
9. Hold START pressed again, to scan for any other parity errors.
10. To resume operation:
 - a. Alter-in a restart address to start processing at the desired program instruction (see *Altering an Address in an Address Register*).
 - b. Set the mode switch to RUN and press START.

Pointers

1. Pull the EMERGENCY OFF switch only in a *true emergency*, since it must be reset by an IBM customer engineer.
2. The START RESET key must be pressed at the beginning of a new job, before the LOAD key, to clear the system of any signals or codes remaining from a previous job. If any error lights on any unit in the system are ON, they must be turned OFF ahead of pressing START RESET.

NOTE: If the system was stopped for any reason while a multiply or divide operation was in progress, the start reset key does not fully reset the system. The system must be single-cycled through the next I-Op cycle. Then press the start-reset key and proceed with the next job.

3. If you know there are invalid punches in card fields not involved in your processing and you wish to ignore the validity check, turn the I/O CHECK

STOP switch OFF. The invalid punches are still detected and the 1402 VALIDITY light turns ON, but processing continues.

4. Although invalid punched characters can be read into core storage with the I/O CHECK STOP switch OFF, they lose their identity if they are also invalid 1401 characters. For example, if a card column is punched with the digits 1, 3, and 5, only the digit 5 is stored. Digits 1 and 3 are lost. (See IBM 1401 System Logic, BCD Codes for bit combinations.)
5. If last-card routines are planned by the programmer, be sure sense switch A is turned ON before the last card is read by the READ brushes.
6. The MANUAL ADDRESS dials should be set at zero when they are not being used. If they are set at some address, the data in storage at that location may be inadvertently changed or destroyed during an operation performed in the ALTER mode.
7. If the tape select switch is set for a manual operation, be sure to return it to N when that operation is completed and before automatic operation resumes.
8. If a program being tested includes tape operations and the program is not advancing, check the tape select switch to be sure it is set to N.
9. If the program calls for reading cards and no cards are feeding through the 1402, make sure the mode switch is set to RUN. This is the only setting that permits card feeding under program control.
10. To determine if a particular position of core storage contains a group-mark character, display this position on the console. A group-mark character is not printed by the 1403.
11. The STORAGE PRINT OUT setting of the mode switch can be used to great advantage in program testing, because the contents of a block in core storage are printed and can be easily examined by the programmer. A specific storage position can be located by using the IBM Diagramming Template (Form X24-5884), which has a ten-to-the-inch printing scale.
12. If you are going to take a storage printout after a programmed halt, press the START RESET key first to clear the system of any signals or codes set up by the halt condition.
13. If operation stops during a storage print-out, and the STORAGE light is ON, a parity error was detected in the print-out area.
14. These five settings of the mode switch are used primarily for program debugging: I/EX, SINGLE CYCLE PROCESS, SINGLE CYCLE NON-PROCESS, STORAGE PRINT OUT, and ADDRESS STOP.
15. If you want to know the address of the Op code in effect when system operation stops, display the I-address register in STORAGE ADDRESS and subtract the number shown in the INSTRUCTION LENGTH block.
16. When a character is displayed in the LOGIC block, it may be off by a value of one on a single-cycle operation because of the carry latch reset.
17. The most common errors signalled by the OP light are: a blank Op code (C-bit displayed) and a zero Op code (C82-bits displayed).
18. When the PROCESS and STORAGE ADDRESS lights are ON, there will most likely be a MOVE (CB4-bits) or LOAD (B21-bits) Op code displayed under OP, and the A- or B-address register will contain either 0000 or x999 (3999, for example). This is frequently the result of a programming error — that is, no word mark to stop the move or load operation, thus causing a wraparound of core storage.
19. If both the READER and PUNCH lights on the 1401 console are ON, stackers in the card read-punch are probably filled. This is virtually the only time both lights are ON at the same time.
20. The STORAGE light on the 1401 console indicates that a parity error exists *somewhere* in core storage. No information is displayed in the STORAGE block.
21. When using the BIT and ENTER switches to manually enter characters into core storage, release the ENTER switch after *each* character. Do *not* hold ENTER raised while changing the MANUAL ADDRESS dials to enter the same character in two or more positions. This would damage the 1401 circuits.

IBM 1402 Card Read-Punch

The IBM 1402 Card Read-Punch (Figure 8) provides the system with simultaneous punched-card input and output. This unit has two card feeds.

Features

Read Feed

The read feed has a rated reading speed of 800 cards per minute. Actual card speed is governed by the processing performed for each card. The read feed is

equipped with a device for large-capacity loading, called a *file feed*. The file feed device has a capacity of about 3,000 cards. Cards may be placed in either the file feed or the card hopper. The card weight should be placed on top of the cards. To place cards in the card hopper, the joggler gate must be opened (lowered). It must be closed to permit card feeding during automatic operation. To run cards out, this gate must be either closed or held open at approximately a 45° angle. Holding it partially open permits running cards out of the card hopper without feeding cards from the file feed to the hopper.

Cards pass through the read side of the machine 9-edge first, face down. The feed path is from right to left, under two sets of brushes (Figure 9). The read check station reads 80 columns of the card to establish a hole count for checking purposes. The read station also reads the 80 card columns, to verify the hole count and to transfer data into storage.

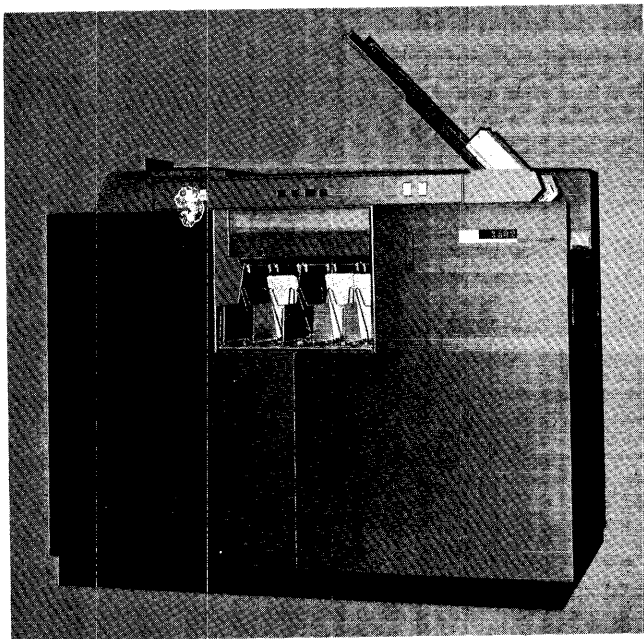


Figure 8. IBM 1402 Card Read-Punch

Punch Feed

The punch feed has a rated speed of 250 cards per minute. The card hopper capacity is 1200 cards. Cards feed 12-edge first, face down. The feed path is from left to right. Cards pass under a *blank* station, a punch station, and a punch check station (Figure 9). The punch station consists of 80 punch magnets for recording information. The punch check station has 80 brushes that read the data punched in the card for a hole-count check. If the punch-feed-read special feature is installed, a set of 80 brushes is positioned at the blank station.

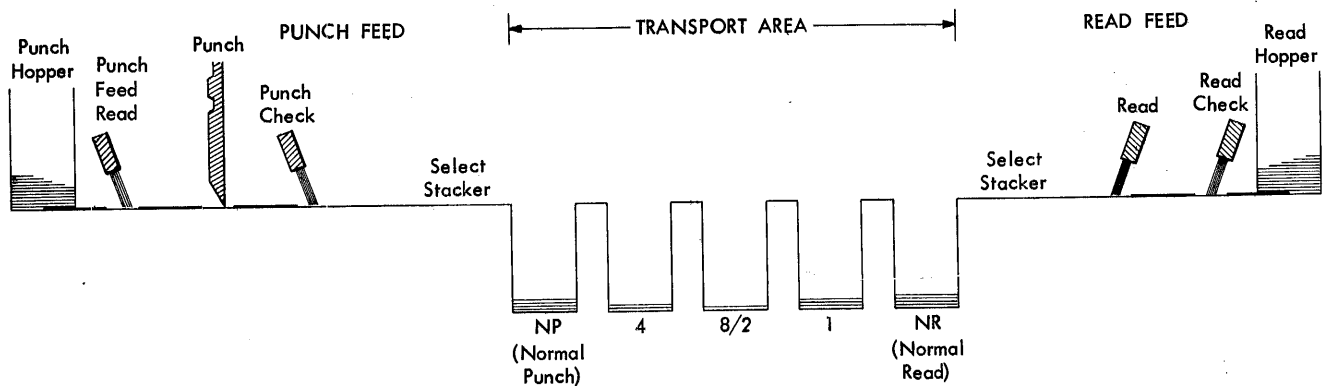


Figure 9. Card Feed Schematic (at End of a Feed Cycle)

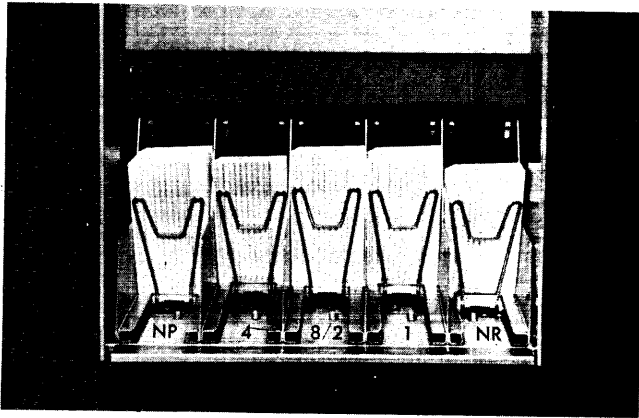


Figure 10. Stackers

Stackers

The IBM 1402 Card Read-Punch has five radial stackers (Figure 10) with a capacity of 1,000 cards each. Cards may be removed from the stackers without stopping card feeding. If a stacker becomes full, operation stops and the stacker light turns ON.

Cards from each feed can be program-directed to three of the five pockets. The cards from the read side go to the NR (normal read) pocket unless program-directed to pocket 1 or pocket 8/2. The cards from the punch side go to the NP (normal punch) pocket unless program-directed to pocket 4 or pocket 8/2. Thus, the center pocket (8/2) can receive cards from either feed.

Switches (Figure 11)

Punch On/Off

This switch controls the *punch* unit of the machine. When it is OFF, the punch is inoperative. When it is ON, the machine operates if all the interlock circuits in the punch are satisfied.

Reader On/Off

This switch controls the *read* unit of the machine. When it is OFF, the read feed is inoperative.

Keys (Figure 11)

Start

This green key is used to initiate machine operation after a manual, programmed, or automatic stop. This START key can be used interchangeably with the START keys on the IBM 1401 Processing Unit and the IBM 1403 Printer.

Stop

This red key is used to stop the system. If a program step is in process, it is completed before operation stops. This STOP key can be used interchangeably with the STOP keys on the IBM 1401 Processing Unit and the IBM 1403 Printer.

Load

This yellow key is used to start loading program instruction cards. Pressing the load key operates the read feed until a card has passed the read station. The I-address register is set to 001, and a word mark is set in address 001. All other word marks in addresses 002 through 080 are removed.

When the card is read at the read station, the program starts and executes the instruction that is punched in the first columns of the card. Continued operation is completely under control of the program cards first, and then of the stored program, and does not require intervention by the operator.

When the punch switch is ON, pressing the load key also starts the punch.

Check Reset

This white key must be pressed to reset any punch or read error indication (PUNCH/READ CHECK, PUNCH/READ STOP, TRANSPORT, VALIDITY), so that the START key can become effective to resume operation.

This key is effective only when the feed unit in error is cleared of cards.

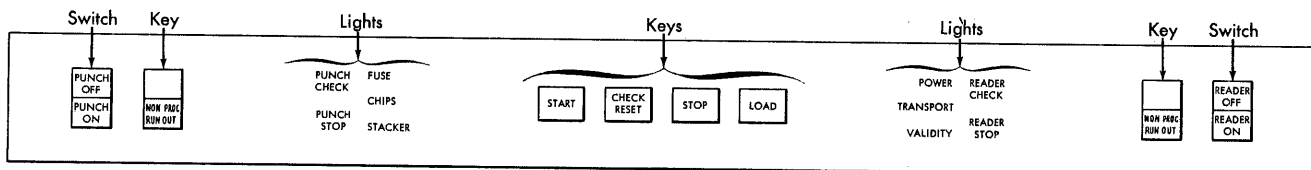


Figure 11. IBM 1402 Keys, Lights, and Switches

Non Proc Run Out

Two nonprocess run-out keys are provided: one for the punch feed, and one for the read feed. These keys are used to clear cards from the corresponding feed. When the *punch-feed* run-out key has been pressed, the last two cards in the normal stacker are not punched, and the third-from-last card has not been checked. This key is operative only when the punch hopper is empty.

When the *read-feed* run-out key has been pressed, the last two cards in the normal stacker have not been processed. This key is operative only when the read hopper is empty. If cards are in the file feed and the juggler gate is closed when this key is pressed, the cards feed to the hopper and one or more may run out to the stacker. Therefore cards should be removed from the file feed before pressing this key. Or, the juggler gate can be held part way open (at about a 45° angle) while the run-out key is pressed. This permits cards to run out, but prevents feeding from the file feed.

The nonprocess run-out keys should be pressed after power is turned ON, and then the 1402 CHECK RESET key must be pressed. This procedure prevents false error signals when cards are run in.

Lights (Figure 11)

Punch Check

This light turns ON if:

- A hole-count error is detected in the punch feed.
- The B-register detects a parity error during a punching operation.
- An incomplete punch operation has occurred (the A-register does not contain an 8-bit and a 2-bit).
- Clutch failure.
- Punch release time is overextended. This is a programming problem. After a program using the Punch Release special feature has been completely checked out, this condition should not occur.

This light can be turned OFF by pressing the 1402 check reset key.

Reader Check

This light turns ON if:

- A hole-count error is detected during card reading.
- An incomplete read operation has occurred (the A-register does not contain an A-bit and a B-bit).

- Clutch failure.
- Read release time is overextended. This is a programming problem. After a program that uses the Read Release special feature has been completely checked out, this condition should not occur.

This light can be turned OFF by pressing the 1402 check reset key, after running cards out of the read feed.

When operation stops and this light is ON, the last card in the stacker has not been processed, and must be re-fed after the error is corrected.

Punch Stop

This light turns ON if any one of these conditions occurs:

- Card-feed failure.
- Card jam.
- Clutch failure.
- The punch nonprocess run-out key is pressed during system operation.

It can be turned OFF by pressing the 1402 check reset key.

When operation stops and *only* this light is ON, cards in the stacker or in the punch feed beyond the PUNCH CHECK brushes have been punched and checked. A card between the PUNCH and PUNCH CHECK stations has not been punched, or it may be incorrectly punched. When the operation is restarted after the error condition is corrected, this card is automatically punched and checked. If other lights are ON with this light the condition of the cards varies (see *Restart Procedures for IBM 1402 and IBM 1403*).

Reader Stop

This light turns ON if any one of these conditions occurs:

- Card-feed failure.
- Card jam.
- Clutch failure.
- The reader nonprocess run-out key is pressed during system operation.

It is turned OFF by pressing the 1402 check reset key after cards are run out of the read feed.

When operation stops and *only* this light is ON (due to a card-feed failure or card jam), cards in the stacker

and in the read feed beyond the READ brushes have been processed. If other lights are ON with this light, the cards probably have not been processed and should be re-fed (see *Restart Procedures for IBM 1402 and IBM 1403* for various conditions).

Fuse

When a fuse in the card read-punch burns out, this light turns ON. The IBM customer engineer should be called to replace the fuse.

Chips

When the chip box is full or not properly positioned, this light turns ON and the machine interlocks. The light turns OFF when the empty chip box is replaced (or properly positioned) in the machine. Operation can be resumed by pressing the START key.

Depending on the position of the cover-interlock override switch, this light is reset differently. If the override switch is on (to allow the machine to run while a cover is open), the chip-box light can be reset by operating either the stop key, stacker-stop switch, jam bar, or the punch on/off switch. If the override switch is off (normal position), this light is reset by any of the preceding means, or by opening any cover.

Stacker

If any of the five stackers becomes full, operation stops and this light signals the operator. When enough cards are removed to allow the stacker guide to return beyond the stacker trip device, this light turns OFF and operation can be resumed by pressing the START key.

Power

When power is supplied to the card read punch, the power light is ON.

Transport

This light turns ON to indicate a card jam in the transport area (see Figure 9). After the card jam is cleared, this light can be turned OFF by pressing the 1402 check reset key. Any cards beyond the READ brushes in the read feed or the PUNCH CHECK brushes in the punch feed were processed, or punched and checked.

Validity

If an invalid character is detected during a read operation, this light turns ON, and operation stops at the end of the read operation. The light can be turned OFF by

pressing the 1402 check reset key. If the invalid punching in the card also causes a parity error, the PROCESS and STORAGE lights on the 1401 console turn ON.

When operation stops and *only* this light is ON, the last card in the stacker has not been processed and must be re-fed after the error is corrected.

When the punch-feed-read special feature is used and a validity error is detected during a read operation in the punch feed, this light turns ON and operation stops at the end of the punch-feed-read operation.

If the I/O CHECK STOP switch on the 1401 console is OFF and a validity error is detected during a read operation, this validity light turns ON but operation does not stop. Validity errors are ignored.

Meter Time, IBM 1402

The meter starts when the first card-read or card-punch instruction is issued to the 1402. The meter stops when cards are run out of both feeds, signifying end-of-job, or when there is a machine halt such as a card jam or unit malfunction, or when a manual halt is initiated with any stop key.

Operations

Interlocks

Several interlocks are built into the 1402. If the machine should stop running for no apparent reason (no error lights displayed, and it is not a last-card condition) and power is still ON, one of the 1402 interlocks may have been opened. In this instance, tap all the covers and doors on the 1402 and pull the sliding door on the top toward you, to make certain the entire 1402 is closed properly. Then press START, and the machine should run properly.

Removing a Read-Feed Card Jam

1. Remove the cards from the read hopper.
2. Slide back the top cover to make the two sets of reading brushes accessible (Figure 12).
3. Remove both sets of brushes and lay them down carefully on their sides. Never pull a card from the throat of the machine with the brushes in the machine. Doing so would probably bend the reading brushes.
4. If you require complete access to the read transport area in order to free the jammed cards, remove the guide plate between the sets of brushes. Pull out the knobs and raise the guide plate from the machine.

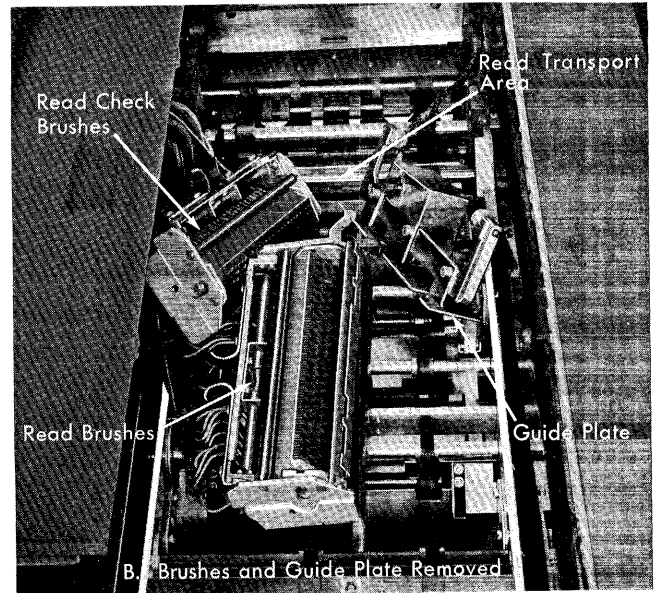
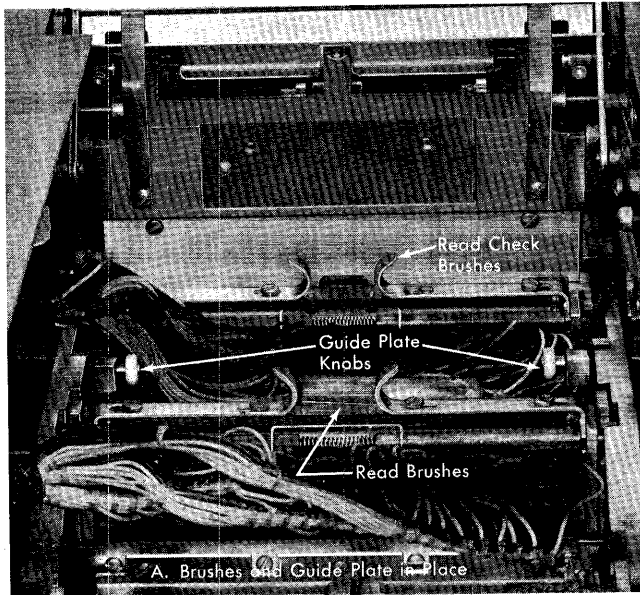


Figure 12. Read Feed

5. Remove all cards, and duplicate any damaged cards.
6. Replace the brushes very carefully. As you reset the brushes, turn the clear plastic timing knob clockwise. This knob is located behind the right front cover.
7. Make certain the brushes are latched firmly in place.
8. The cards that were under the brushes must be re-fed. To determine if any cards from the stackers must be re-fed, investigate the core-storage read area to identify the last card read. You can do this by displaying on the 1401 console a portion of the read area (core-storage positions 001-080), or by printing out the read area (see *Displaying a Character in Core Storage* or *Printing Out an Area of Core Storage*).
9. Before resuming operation, check the 9-edge of the first several cards removed from the read hopper, and duplicate any damaged cards.

Removing a Punch-Feed Card Jam

1. Remove the cards from the punch hopper.
 2. Slide back the top cover to make the punch check brushes accessible (Figure 13).
 3. Remove the brush assembly and lay it down carefully on its side.
4. If the 1402 is equipped with the Punch Feed Read special feature, the punch feed read brushes are made accessible by taking these steps:
 - a. Remove the cover on the left end of the machine.
 - b. Raise the top cover that holds the card joggler.
 - c. Move the latching arm (on the back of the hopper backplate) toward the rear of the machine to unlatch the hopper.
 - d. Pivot the hopper to the left.
 5. Remove the punch feed read brushes.
 6. Remove all cards from the two reading stations.
 7. Replace both sets of brushes carefully. As you re-seat the brushes, rotate the feed rollers by these steps:
 - a. Open the left front cover.
 - b. Push the crank switch down and insert the crank in the crank receptacle. This is located in the center of the topmost pulley (below the left end of the switch-light panel).
 - c. Press down the clutch trip lever located to the left of the crank.
 - d. Turn the crank counterclockwise.
 8. After both sets of brushes are firmly in place, remove the crank, push the crank switch up, and close the covers of the machine.

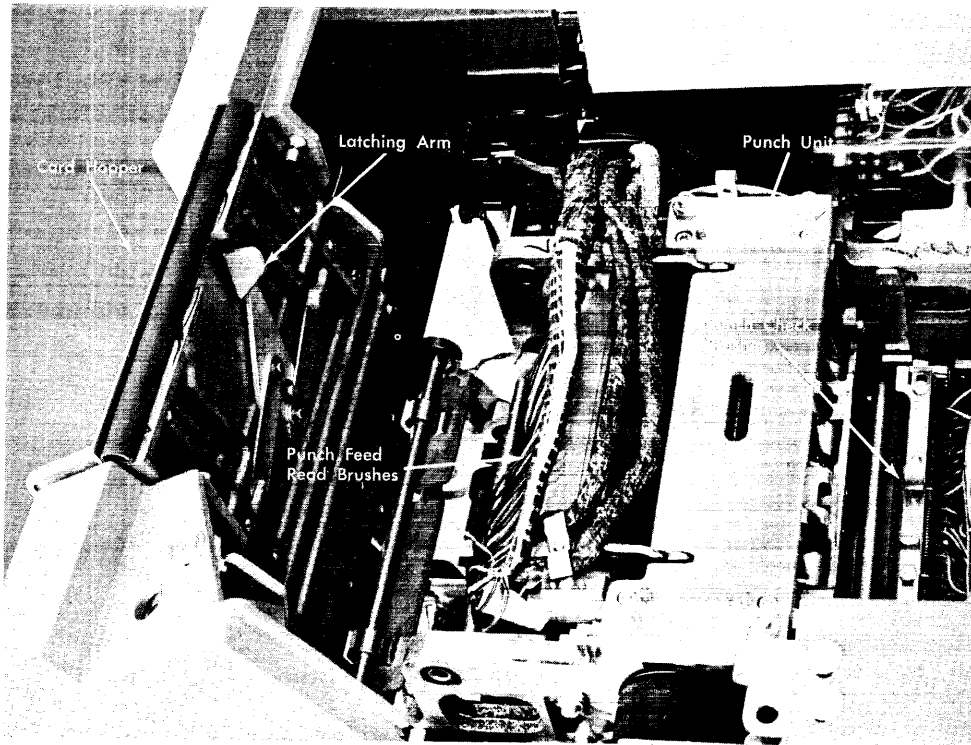


Figure 13. Punch Feed

9. To make a card at the punch dies accessible, face the machine from the rear (Figure 14) and follow these steps:

- a. Open the door at your right.
- b. Remove the plastic chip guide.
- c. Pull the black plastic PULL & TURN handle and turn it clockwise to release the pressure against the die.
- d. Remove the punch die. If the die has two handles, squeeze them together and pull down. If the die has one handle in the center, turn and pull down on the handle.

10. Remove the jammed cards.

11. Return the punch mechanism to operating condition by these steps:

- a. Reinsert the die securely. With a two-handle die be sure the handles return to their original positions when you release them. With a single-handle die, push up and turn the handle.
- b. Turn the black plastic handle counterclockwise and push in, to lock it in place.
- c. Replace the plastic chip guide.
- d. Close the right-hand door.

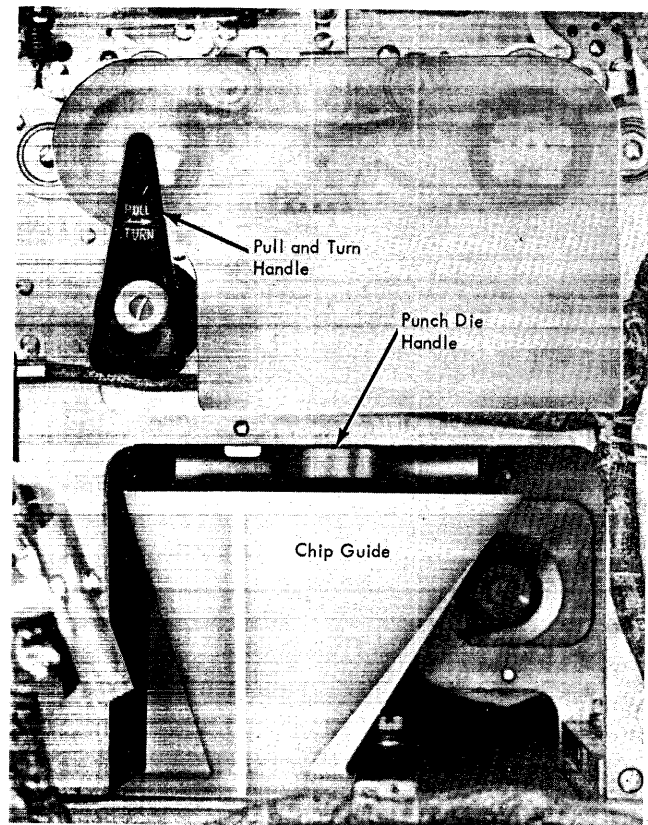


Figure 14. Punch Feed (Rear)

Pointers

1. The jogger gate on the read hopper must always be closed (raised) to feed cards. When it is open, the START and LOAD keys are inoperative and a program instruction to read a card stops system operation.
2. If cards do not feed when the LOAD key is pressed, and the jogger gate is closed, cards may have been left in the read feed from the previous operation. Remove the program cards from the hopper (or file feed) and run the cards out of the feed. Pressing both NON PROC RUN OUT keys before starting any job is a good habit to develop.
3. In some cases, the first card in the file feed may have been positioned so that it will move to the hopper when cards are run out of the read feed, even though the jogger gate is held part way open. It is a good idea, therefore, to place your hand so that you can catch this card as it drops. Grasp the jogger gate with your thumb and extend your hand through the gate.
4. If a card jam occurs, as indicated by the TRANSPORT light, slide back the top cover first to see which feed contains the jammed cards. Then correct this condition.
5. If an abnormal number of READER CHECK or PUNCH CHECK signals occur after a card jam has been removed, make sure that the brush assemblies and/or punch die were replaced properly.
6. When a brush assembly has been removed, always take out all cards from that station before replacing the assembly. If a card were present when the assembly is replaced, the brushes would be damaged.
7. Whenever possible avoid the use of adhesive patches on cards. They cause abnormal wear of the brushes and punches, and they may cause an excessive number of card jams. If it is absolutely necessary to patch a card, apply the patches to the back of the card so that the punches and brushes do not touch the sticky side. Patch only the individual holes that require patching. Do not apply the patching material to an entire field.
8. Handle cards carefully. Replace any damaged or badly warped cards because they may cause card jams. Thoroughly fan and joggle new cards before placing them in the punch hopper.
9. Whenever either NON PROC RUN OUT key has been used, the 1402 CHECK RESET key must be pressed before operation can be restarted.
10. Be sure all cards are completely removed from the punch-feed hopper while the punch-feed NON PROC RUN OUT key is held pressed.
11. If the processing-overlap special feature is installed in the 1401 system and an operation requires card punching, cards should be run out of the punch feed before operation is started. Then the START RESET key on the 1401 console must be pressed (Figure 15).
12. If operation does not restart when a START key is pressed *after cards have been run out of the 1402 punch feed*, the system has been interlocked. This may occur when the processing overlap special feature is installed. It prevents inadvertently altering data in the punch output area on the restart.
If operation was stopped by a programmed halt or by pressing a STOP key (and if cards were run out of the punch feed), operation can be restarted by one of the following procedures:
 - a. When the Op register does *not* contain a PUNCH Op code,
 - press CHECK RESET and START RESET,
 - alter-in a restart address, and
 - press START.
 - b. When the Op register *does* contain a PUNCH Op code, press START twice.

If operation was stopped by a punch error condition (and if cards were run out of the punch feed), operation can be restarted by pressing the START key *twice* in the last step of the normal restart procedures (see *Restart Procedures for IBM 1402 and IBM 1403*).
If operation was stopped by a *read* error condition and if cards were run out of the *punch* feed, pressing START at the end of the normal restart procedure for a read error (see *Restart Procedures for IBM 1402 and IBM 1403*) causes one card to be fed in the read feed. Then operation stops again and these steps must be taken:
 - a. Press CHECK RESET and START RESET.
 - b. Alter-in the address of the Op code displayed in the Op register when the error occurred. If this code specifies an arithmetic operation, the original B-field factor may have been changed by partial execution of the operation before the halt. If so, it must be reset to its original value.
 - c. Press START.
13. When system power is first turned on, press the reader and punch non-process run-out keys. This will prevent first-card-in errors.

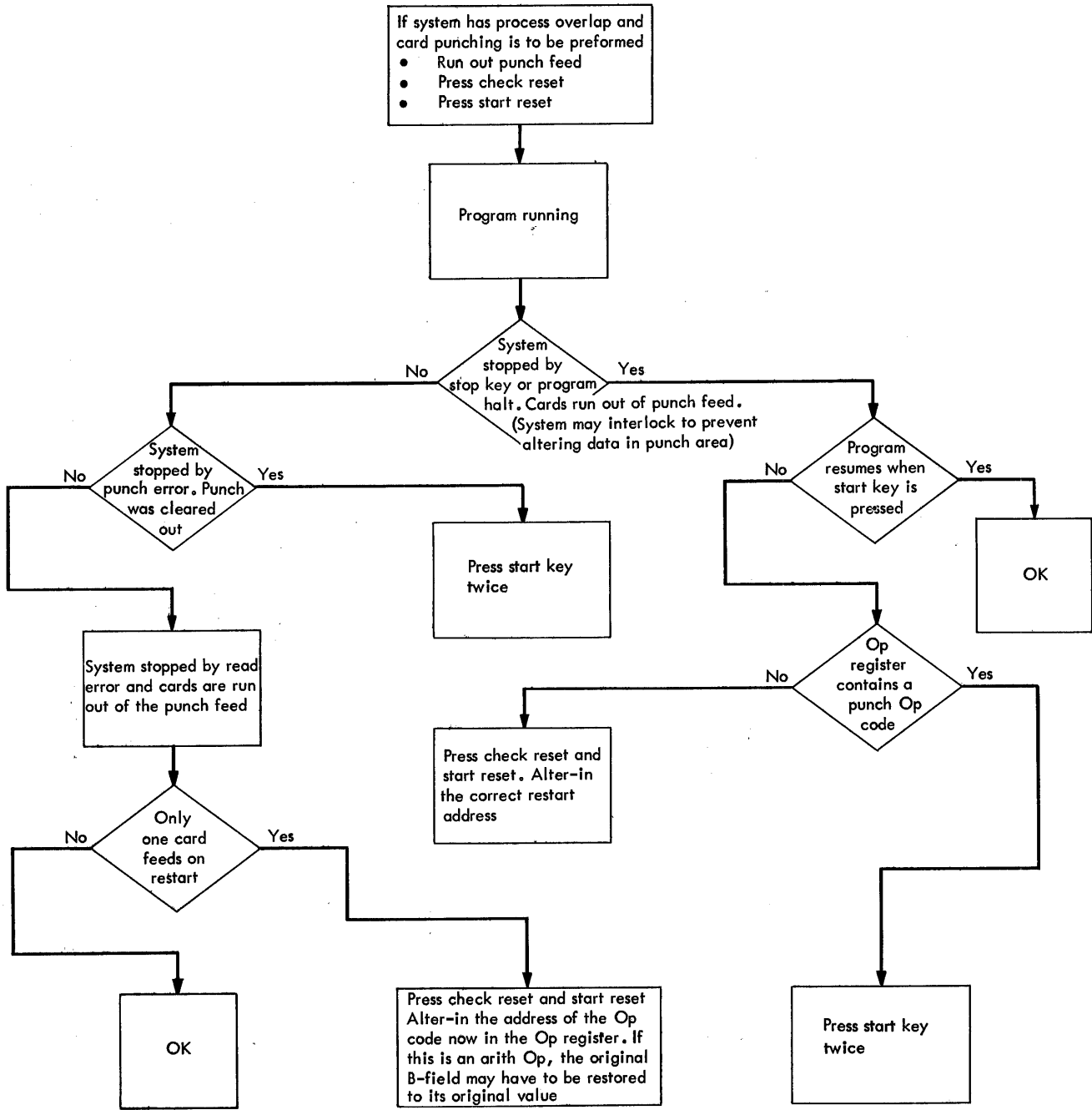


Figure 15. Initial Punch Setup after Error, Processing Overlap Special Feature

The IBM 1403 Printer (Figure 16) is another output medium for the IBM 1401 Data Processing System. Refer to *IBM 1403 Printer*, Form A24-3073, for additional information.

Method of Printing

The alphabetic, numerical, and special characters are assembled in a train or 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.

As each hammer magnet is energized, it is checked against the corresponding position in the print area of core storage to insure that printed output is accurate. Also the machine checks to insure that the character is printed in the correct print position, that only valid characters are printed, and that overprinting within the same line does not occur.

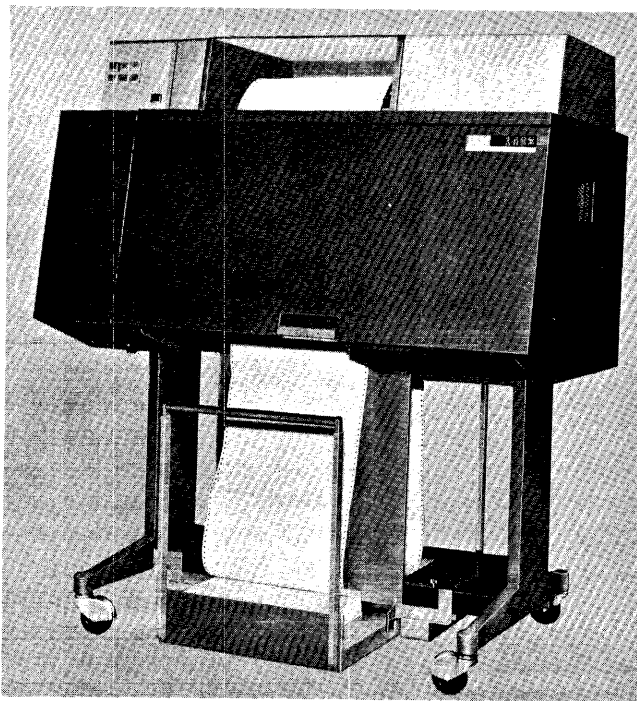


Figure 16. IBM 1403 Printer

Machine Covers

In addition to improving appearance, the covers of the IBM 1403 and other machines have been designed to safeguard personnel against possible injury when in operation. While some hazards such as moving mechanical parts are obvious, others are not. In the latter category are electrical potentials and acoustical noise.

While IBM maintains a rigorous attention to safety on all of its machines, the effectiveness of safeguards is decreased by failure to keep the covers closed when running. IBM cannot be responsible for injury caused under such conditions, but is primarily interested in avoiding any accidents or injuries to personnel.

The frames of all IBM equipment have been made electrically safe by recommended grounding practices, and the covers have been acoustically designed to reduce noise below any possible hearing damage level. Operation with the covers open, however, causes needless exposure to these unseen hazards. Because of this, IBM strongly recommends that all personnel associated with the equipment follow the simple *safety first* procedure of keeping the covers closed whenever the machine is operating. In addition to the safety aspects of this procedure, the visual and aural environment of the installation will be significantly enhanced.

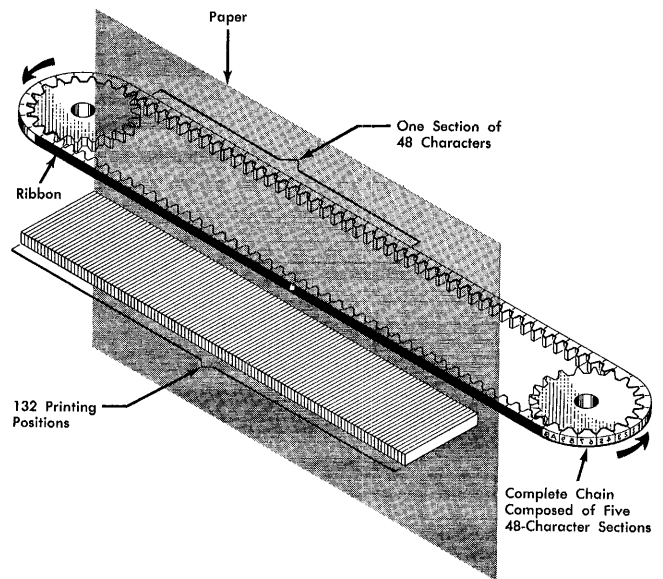


Figure 17. Schematic of Printing Mechanism

Features

Setup Controls

Feed Clutch

The feed clutch (Figure 18) controls the carriage-tape drive and form-feeding mechanism. Forms can be fed automatically when it is set to **DRIVE**. In drive position it is set for either six- or eight-lines-per-inch spacing.

When the feed clutch is set to **NEUTRAL**, automatic form-feeding cannot take place, but the tape-controlled carriage does function under control of the program or a carriage control key.

Paper Advance

This knob positions the form vertically. It should be used only when the feed clutch is disengaged.

Vertical Print Adjustment

This knob is used for fine vertical movement of the print unit within one line space, to obtain accurate registration of the print line. The carriage tape is not

affected by this knob, which is operative with the feed clutch either engaged or disengaged.

Lateral Print Adjustment

With this knob, the print unit can be moved laterally to align the 1403 print positions with the corresponding positions on the form. Before the print unit can be moved, the knob must be rotated slightly, away from the operator. The maximum distance that the unit can be moved is 2.4".

Lateral Print Vernier

This knob permits fine lateral positioning of the print unit for accurate registration of printing.

Right-Hand Tractor Vernier

This knob is used to make fine adjustments in paper tension. The right-hand forms tractors are moved to the right or left, a maximum distance of one-half inch.

Print Density

The 1403 print hammer unit adjusts automatically for different thicknesses of forms. However, to provide a vernier control for print impression, a print-density control-lever is used. When this lever is set at position **A**, printing is dark. At position **E**, printing is light. Between these two settings are intermediate settings. Position **C** is considered the normal setting. This lever moves the type chain closer to, or farther from, the hammer unit.

The setting of this lever must be considered in conjunction with form thickness to determine the setting of the print timing dial.

Print Timing Dial

This dial (Figure 19) should be set to obtain the best printing quality for each run. The setting varies with the thickness of forms being fed and with the setting of the print density. A print-timing dial chart (Figure 20) on the ribbon cover gives the setting for eight different thicknesses combined with five different settings of the print density. For example, if four-part forms with interleaved carbons have a thickness of .015" and the print density lever is set at **C**, the chart specifies that the print timing dial should be set at 17.

Although the density settings vary by 4 in the chart, and the thicknesses by .003", the operator can obtain a finer setting of the timing dial. To do this, start with the number read from the chart and turn the timing

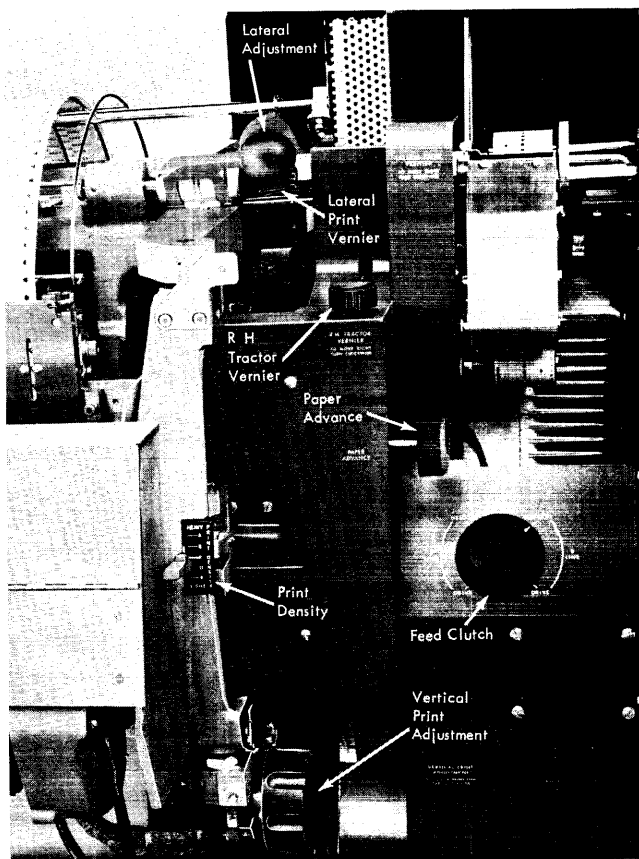


Figure 18. IBM 1403 Setup Controls

dial clockwise until the printing on the *left* side of the form becomes light. Then rotate the dial counter-clockwise until the printing on the *right* side of the form becomes light. The setting that should give the best printing is halfway between the two readings.

Print-Unit Release Lever

Pulling this lever (see Figure 19) toward the operator releases the print mechanism, so it can swing open and permit access to the forms transport area. When closing the print unit, push this lever firmly, as far as it will go, to latch the unit in place.

Forms Tractors

Marginally punched continuous forms are fed by two pairs (upper and lower) of forms tractors (Figure 21). The tractors can be positioned laterally to accept forms of various overall widths between 3½" and 18¾".

The adjustments for the upper and lower tractors are identical, and the tractors must be positioned alike to maintain correct alignment of forms. Each pair of tractors is mounted on a tractor slide bar. The left-hand tractor is locked in place, by a spring-loaded latch, in one of nine notches located one inch apart in the tractor slide bar. The third notch from the left is the best location for most applications.

The first (leftmost) notch is used for forms 5½" to 18¾" wide. When this notch is used the lateral movement of the print unit is limited to .4".

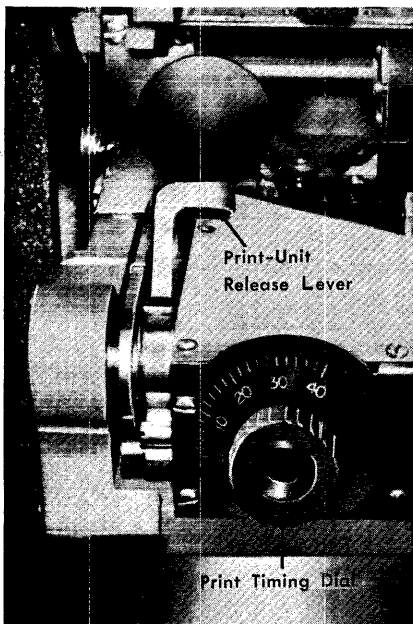


Figure 19. Print Timing Dial and Print-Unit Release Lever

The second notch from the left is used for forms 4½" to 17¾" wide. When this notch is used, the lateral movement of the print unit is limited to 1.4".

The third notch is used for forms from 3½" to 16¾" wide. When this notch, or any notch 4 through 9 is used, full lateral movement of the print unit (2.4") is possible.

The ninth (last) notch can be used for forms from 3½" to 10¾" wide. When this notch is used, the first usable print position is 38.

The right-hand tractor is locked in place, by a spring-loaded pin, in any one of 27 holes located one-half inch apart in the tractor slide bar. After the right-hand tractors are locked in place, a fine adjustment (up to ½") can be made by the right-hand tractor vernier.

Left-Hand Tractor Lock

This spring-loaded lever releases the left-hand tractor so that it can be moved, and it locks the tractor in any one of nine notches in the tractor slide bar.

Right-Hand Tractor Pin Latch

Pulling out this spring-loaded pin permits sliding the right-hand tractor along the tractor slide bar. It is snapped into one of 27 holes to lock the tractor in place.

Ribbon Shield and Print-Line Indicator

This shield prevents the ribbon from smudging the forms as they are printed. It pivots with the print unit when the unit is opened. A lever at the top left end of the shield releases the shield from the print unit. With the print unit open, you can swing this shield back against the forms and use it as a guide for vertical print-line alignment of forms. The top edge of the left and right ends of the shield indicate where the lower edge of the characters will print. Print position is indicated by the ribbon guide bar; thus, it is advisable to

		PRINT TIMING DIAL SETTING							
		FORM THICKNESS							
		003	006	009	012	015	018	021	024
P R I N T I N G	A	21	18	15	12	9	6	3	0
	B	25	22	19	16	13	10	7	4
	C	29	26	23	20	17	14	11	8
	D	33	30	27	24	21	18	15	12
	E	37	34	31	28	25	22	19	16

OBTAIN DIAL SETTING BY MATCHING "FORM THICKNESS" TO "PRINT DENSITY"

Figure 20. Print-Timing Dial Chart

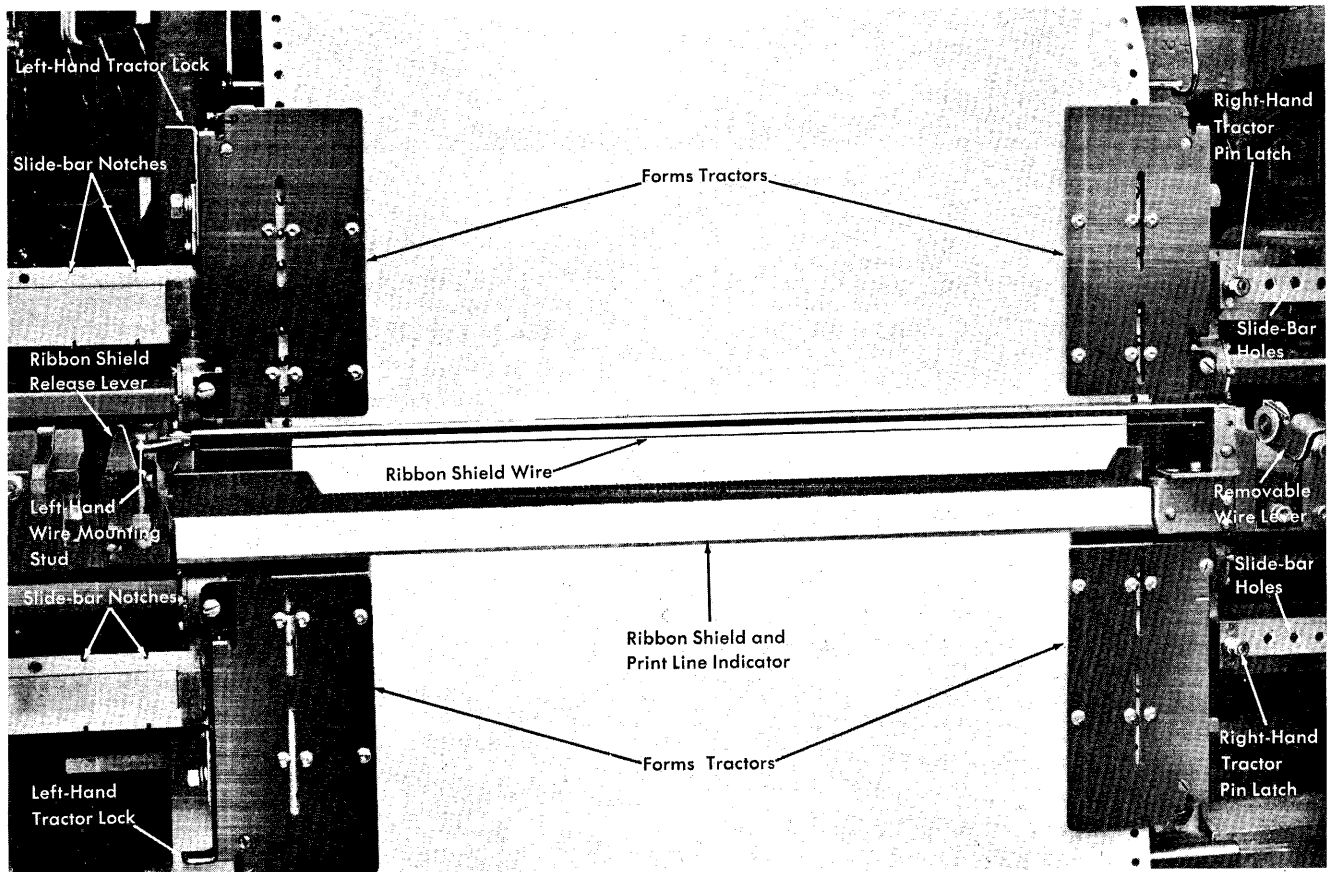


Figure 21. Forms Feeding

use the ribbon guide bar for *all* forms alignment adjustments as outlined in the section titled "Inserting Forms," item 11.

Ribbon Shield Wire

This wire holds forms away from the ribbon to prevent smudging the forms when the machine is idling. When continuous card forms are fed, however, the ribbon shield wire should be removed to prevent bursting the forms.

This procedure should be followed to mount a removable wire: Attach the loop in the end of the wire to the mounting stud on the left-hand ribbon shield casting. Thread the wire through the groove in the back of both the left- and right-hand castings. Insert the forked end of the lever, on the other end of the wire, over the mounting stud on the right-hand ribbon shield casting. Be sure this spring-loaded lever is latched in place. To remove the wire, follow these steps in reverse order.

Acoustical Dampener

The acoustical dampener, a nylon and bronze brush on the print-unit frame, provides a drag on single-part forms to dampen high-frequency vibration of the paper. The brush is hinged so it can be rotated out of the way when special forms are used or when form feeding difficulties are experienced. To prevent damage to single-part forms, rotate the brush away from the paper when the print unit is moved horizontally for alignment.

Paper-Stacking Controls (Figure 22)

Paper Guide

This feature guides forms, which have been printed, to an output-paper cart at the rear of the machine. The guide can be raised or lowered to accommodate forms of various sizes, by sliding the paper-guide control

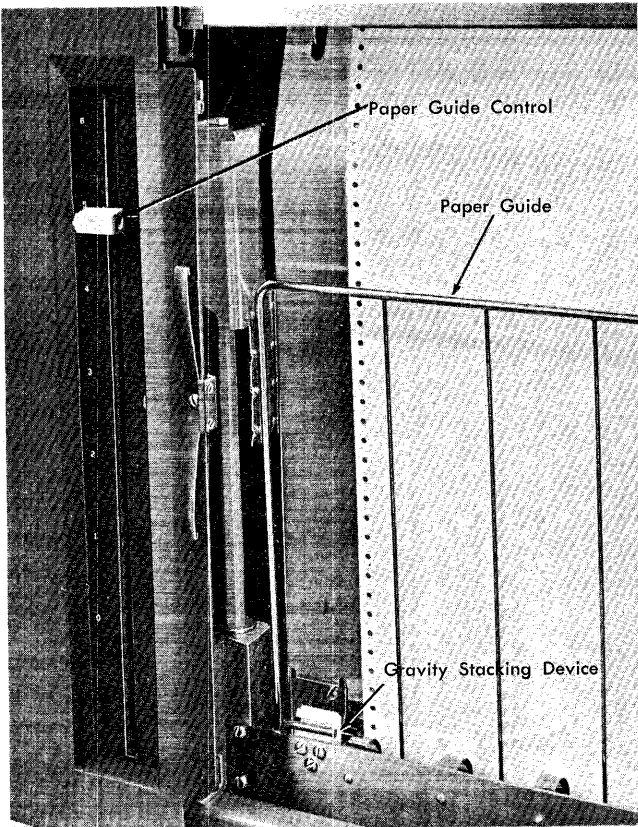


Figure 22. Paper Stacking Controls

lever up or down in its track. A scale (0-6) is printed along this track so that the setup position for a particular form can be recorded in the operator's procedures. For the best stacking operation, this guide should be set as low as possible, allowing enough space for the forms to fanfold into a stack. Thus, the original setting for a run depends on the depth of the forms. As the stack of forms increases, the guide must be moved up.

Gravity Stacking Device

This device permits the selection of either gravity or stacker drive rollers to move forms as they are fed to the output stack. If the gravity stacking bar is locked in its upper position, pressure is not applied to the forms. This setting is used for multiple-part forms to prevent slippage that might occur between forms and carbons if pressure were applied.

If the bar is locked in its lower position, pressure is applied to the forms by the rollers. This is used for single-part forms.

Output-Paper Cart

Forms stack on this cart as they feed from the printer. Two stacker guides should be adjusted for the depth of the forms. Turning the grey plastic knob in the rear center of the platform clockwise brings the guides closer together for short forms. Turning it counterclockwise moves the guides farther apart for longer forms.

Before this cart is inserted or removed from the machine, the adjustable paper guide should be raised to its highest position.

NOTE: Always make sure that both forms carts are electrically grounded. Always stop the system before allowing either forms cart to touch the printer as they are moved into position under the printer. This will avoid process errors and sync checks.

Tape-Controlled Carriage

Continuous forms feed past the print mechanism in the 1403 by line-spacing (single, double, or triple) or by a high-speed movement called *skipping*. Skipping is used to quickly advance a form, without printing, to a particular position, such as a predetermined total line. Skipping is started by program control and stopped by the tape-controlled carriage (Figure 23).

The carriage operation is controlled by holes read in a paper tape that corresponds in length to the depth of one or more forms. The holes are punched in the tape in locations that represent the positions of the form at which skipping must stop. One hole is punched

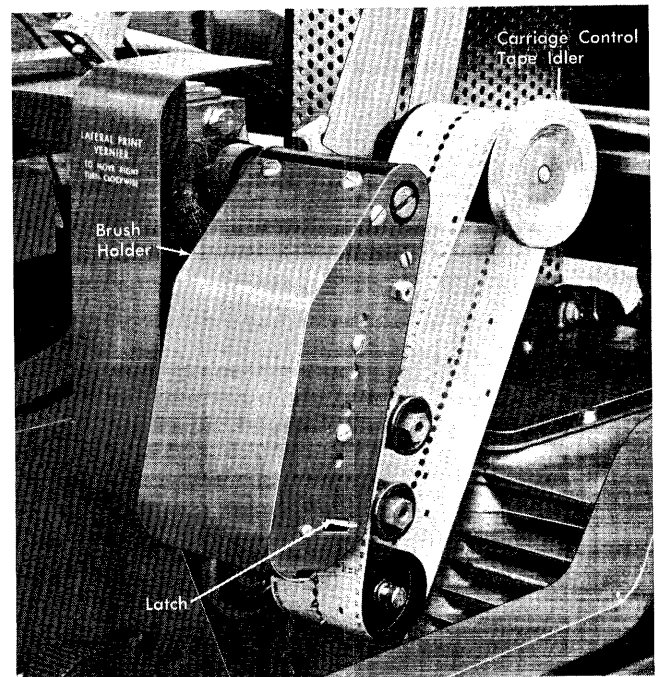


Figure 23. Tape-Controlled Carriage

for each skip-stop. The tape is made into a loop and moves continuously through the carriage, in step with the forms fed past the print unit.

Because skipping to different sections of the form is controlled by the program and by holes punched in the carriage tape, forms can be designed to permit printing in practically any desired arrangement. The carriage can control continuous forms up to 22" in length, with 6-lines-per-inch spacing, or up to 16½" with 8-lines-per-inch spacing. The minimum length is 1". For efficient stacking of forms, the recommended maximum length is 17".

Skipping occurs at a rate of approximately 33" per second in a 1401-A system. In all other 1401 systems a dual-speed carriage is installed, and skipping occurs at a rate of about 75" per second for skips of more than eight lines. Distances of less than eight lines, and the last eight lines in a high-speed skip, are skipped at 33" per second.

In addition to stopping skips started by program control, the carriage control tape can also signal an *overflow* condition. For this, the tape is punched to indicate the last available printing line on a form. When this punch is read, programming can cause a skip to the first line that is to be printed on the next form.

Brush Holder

This unit contains the brushes that read the holes in the carriage tape. It must be latched in place whenever the 1403 is in operation. It is raised by pushing the latch on the right side of the unit toward the front.

Carriage Control-Tape Idler

The carriage tape is looped around this idler. To accommodate tapes of various lengths, the idler can be moved up or down in its track at the left. It should be adjusted so that a small amount of slack is left in the tape.

Turning the locking knob on the right end of the idler counterclockwise releases the idler so that it can be moved in its track. Turning the knob clockwise tightens the idler in place.

Pin-Feed Drive

Carriage tapes are prepunched through the center with round feed holes. With the carriage brush holder raised, the tape can be placed over the pin-feed drive (Figure 23). This drive advances the tape in synchronization with the movement of the forms through the machine.

Reading Brushes (Stop/Slow)

With a dual-speed carriage, two sets of reading brushes (Figure 24) are used to sense holes in the carriage control tape. One set is called the *stop* brushes, the other the *slow* brushes. Seven spaces, as measured by the control tape, separate the two sets. Each set contains twelve brushes to read punches in twelve columns in the carriage tape.

After a skip to a particular position is initiated, it is stopped when the skip-stop punch representing the position is read by the *stop* brushes.

The *slow* brushes are used to change from high-speed to slower-speed skipping. They are positioned ahead of the *stop* brushes. When a skip is initiated and the skip-stop punch is read by the *slow* brushes, skipping slows down, ready to stop when that same punch is read by the *stop* brushes. In a 1401-A system (with a single-speed carriage) only the *stop* brushes are operative.

Contact Rolls

If erratic forms skipping is experienced, check to ensure that there is no build-up of glue, tape, or other foreign material on these rolls.

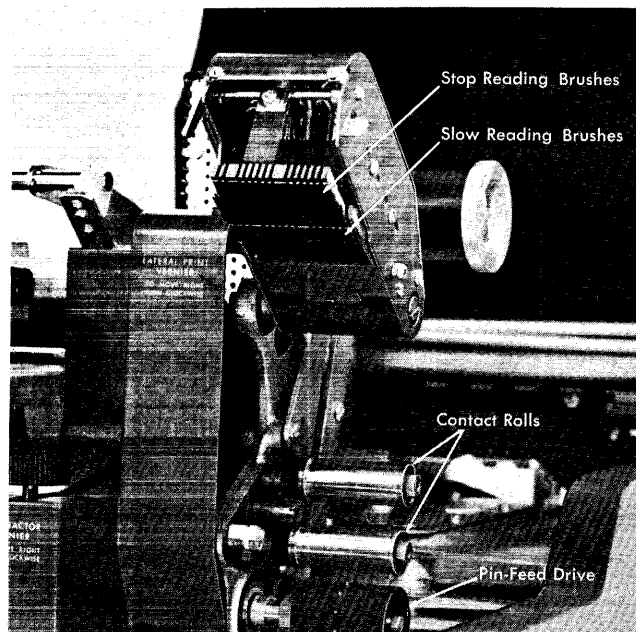


Figure 24. Carriage Brushes

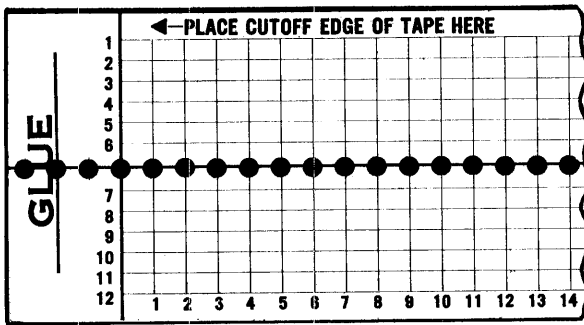


Figure 25. Carriage Control Tape

Control Tape

A maximum of 132 horizontal lines on a control tape (Figure 25) can be used to control one or more forms, although, for convenience, the tape blanks are slightly longer. The horizontal lines are spaced six to the inch for the entire length of the tape. The control tape has twelve vertical lines, called *channels*. Each channel may be punched to control *one* specific skip-stop position on a form (or forms), such as the first printing line or a predetermined total line. If the length of tape used represents two or more forms, the punching in each channel is repeated for the additional forms.

Round holes in the center of the tape are pre-punched for the pin-feed drive that advances the tape in synchronization with the movement of a printed form. The effect is exactly the same as though the skip-stop holes were punched along the edge of each form.

Keys (Figure 26)

Start

This green key starts system operation. There is a duplicate start key at the rear of the printer for operator convenience (Figure 27). These keys can be used interchangeably with the **START** keys on the IBM 1401 Processing Unit and the IBM 1402 Card Read-Punch.

Stop

This red key stops system operation at the completion of the instruction in process. There is also a duplicate stop key at the rear of the machine for operator convenience. These keys can be used interchangeably with the **STOP** keys on the IBM 1401 Processing Unit and the IBM 1402 Card Read-Punch.

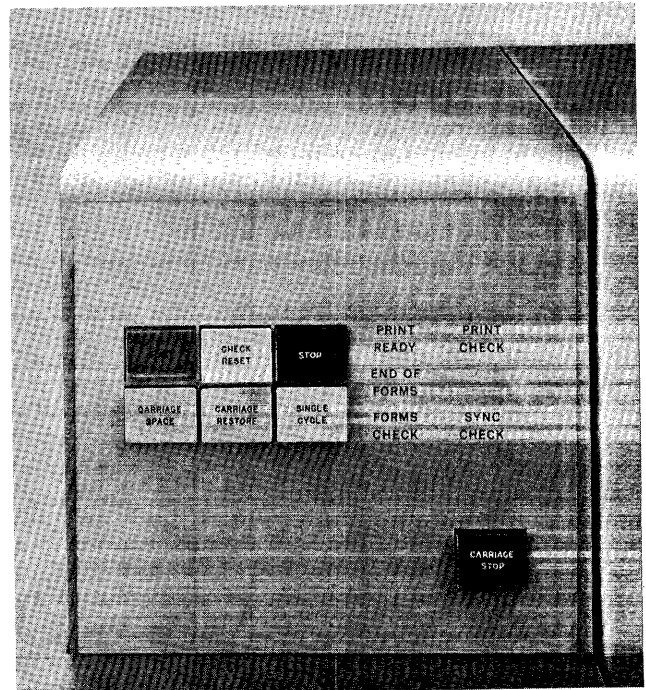


Figure 26. IBM 1403 Operating Keys and Lights

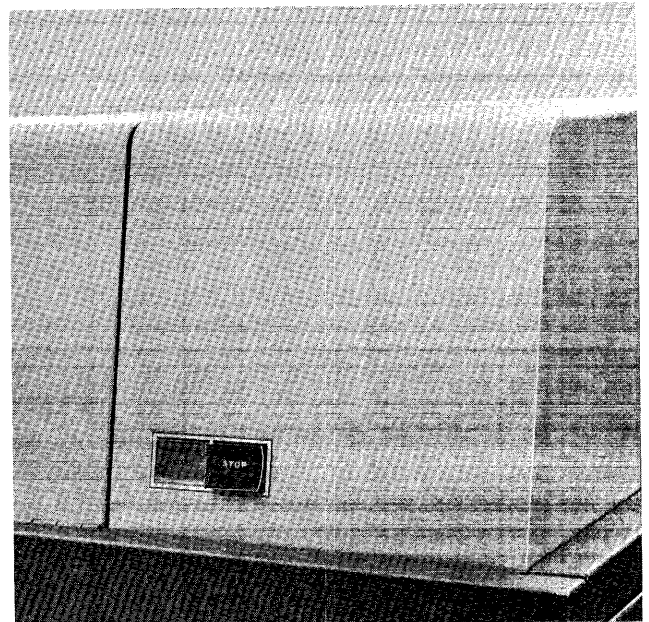


Figure 27. IBM 1403 Keys (Rear)

Carriage Stop

Pressing this red key stops carriage movement immediately and turns on the forms-check light.

Single Cycle

Each pressing of this key initiates the operation of the printer for one print cycle.

If the end-of-forms light is ON, this key can be pressed repeatedly to complete the printing on the present form. When channel 1 of the carriage control tape is read, indicating that the next form (if any) has been fed, this key becomes inoperative.

Check Reset

This key resets a printer error indication. Then pressing a START key resumes operation.

Carriage Space

Each time this key is pressed, the forms and carriage tape advance one space.

Carriage Restore

This key positions the carriage at channel 1 (*home position*). If the carriage feed clutch is disengaged, the forms do not move. If it is engaged, the forms move in synchronization with the tape-controlled carriage. This key is inoperative if either the print unit or the carriage-tape brush holder is open.

Lights (Figure 26)

Print Ready

This light turns ON when the printer is in condition to print. If the print unit is opened, this light turns OFF. The light turns ON again when the print unit is closed and the print chain reaches printing speed.

Print Check

This light turns ON if:

- A print hammer failed to operate, or operated when it should not have.
- Storage positions containing printable data did not have an opportunity to print.
- A printing parity error is detected in a system in which the print-storage special feature is installed. When this feature is not installed, a parity error is detected by the B-register and PRINT CHECK does *not* turn ON.

This light can be turned OFF by pressing the 1403 check reset key.

End of Forms

This light turns ON and the machine stops, when the last form in a stack is fed through the machine, or when a break in forms occurs at either the upper or lower left-hand forms tractor. If an end-of-forms condition occurs during a skip, the skip in process is completed, but printing does not occur.

This light turns OFF when more forms are inserted in the machine, or when the break in the forms is corrected.

Forms Check

This light indicates paper-feed trouble. Any one of these conditions may turn this light ON:

- The forms are off the forms tractors.
- The carriage stop key was pressed.
- Printer adjustments that required opening the forms tractors were made.

It can be turned OFF by pressing the 1403 check reset key.

Sync Check

This light turns ON if the print chain was out of synchronization with the printer circuitry in the 1401 at any time during the print operation.

This light can be turned OFF by pressing the 1403 check reset key. The timing is corrected automatically.

Indicator Panel Lights (Figure 28)

Gate Inlk

This light is ON when the print unit is not locked in position.

Brush Inlk

This light is ON if the carriage tape brushes are not latched in position for operation.

Shift Inlk

If the feed clutch is not set at DRIVE, or NEUTRAL, this light is ON.

Ther Inlk

If the thermal interlock light is ON, a thermal unit has indicated excessive heat. The IBM Customer Engineering Department should be notified.

HS Start

If the high-speed start light is ON, a high-speed skip has been initiated.

LS Start

If the low-speed start light is ON, either a low-speed skip or line spacing has been initiated.

HS Stop

The high-speed stop light turns ON to indicate that high-speed skipping is to be stopped.

LS Stop

The low-speed stop light turns ON to indicate that a low-speed skip-stop has been initiated. It is also ON whenever the carriage is not in motion.

Meter Time, IBM 1403

The printer meter will record time if the processing unit meter is recording and a print instruction has been issued. The printer meter can be stopped manually by pressing and releasing the space key or restore key.

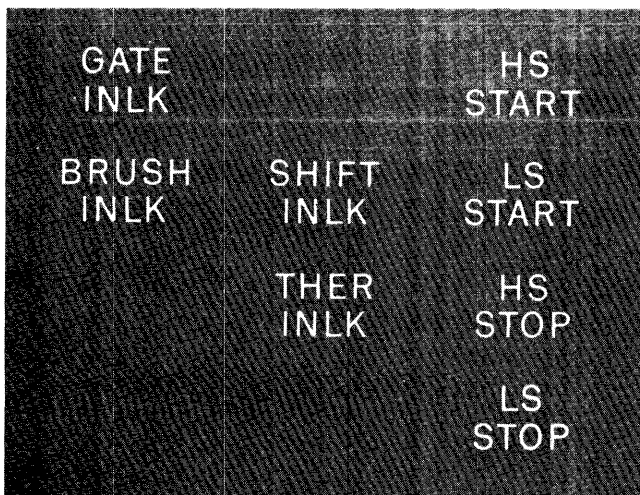


Figure 28. IBM 1403 Indicator Panel

Operations

Preparing a Carriage Tape

The punching of a carriage tape for a particular form should be planned by first marking the tape in the positions in which the holes are to be punched.

Marking the Tape for Punching

1. Lay the tape next to the left edge of the form, with the top line (immediately under the *glue* portion) even with the top edge of the form.
2. Mark tape channel 1 on the line that corresponds to the first printing line on the form.
3. Mark one tape channel for each of the other skip stops required. The tape should never be punched in more than one channel on the same line. Also, holes in the same channel should be no closer than eight lines apart.
4. If an overflow signal is required, mark channel 9 or 12 for the last printing line on the form.
5. Repeat steps 2-4 for as many additional forms as will fit in the 132 line spaces usable on the tape. With the tape thus controlling several forms in one revolution through the carriage, the life of the tape is increased.
6. Mark the tape for cutting on the line corresponding to the bottom edge of the last form. The cut edge should be at least four lines from the last hole punched in the tape, because about the last half inch of the tape overlaps the *glue* section when the two ends are spliced.

If it is necessary to punch a hole lower than four lines from the bottom of the form, place the tape so that the top line of the tape is four lines lower than the top edge of the form, and then mark the channels. To compensate for this, cut the tape four lines lower than the bottom edge of the last form.

Although the control tape is lined for *six* lines-per-inch spacing, it can be used to control *eight* lines-per-inch spacing. Each $\frac{1}{8}$ " line on the tape represents each $\frac{1}{8}$ " line on the form. Therefore, in planning a tape for an 8-lines-per-inch document, the operator counts to each corresponding position on the form and on the tape, rather than aligning the tape next to the form. Since a maximum of 132 tape lines can be used, one or more forms totalling 22 inches in length can be planned with 6 lines-per-inch spacing, or forms totalling 16 $\frac{1}{2}$ " in length can be planned with 8 lines-per-inch spacing.

Punching the Tape

A small compact punch (Figure 29) is provided for punching the tape:

1. Insert the tape in the punch. Position the horizontal line to be punched over the guide line on the base of the punch, and place the center feed holes over the pins that project from the base.
2. Move the indicator slide until it points to the channel to be punched.
3. Press the top of the punch, at the back. This cuts a rectangular hole at the intersection of the vertical (channel) and horizontal lines.
4. Repeat steps 1-3 for each mark on the tape.
5. Cut the tape on the line marked for the bottom edge of the last form.
6. Loop the tape and glue the bottom end to the top section, marked *glue*. Be sure that the bottom edge lines up with the first line, and that the center feed holes coincide.

Inserting a Carriage Tape

1. Raise the front cover of the printer to gain access to the tape-controlled carriage.
2. Turn the feed clutch to NEUTRAL (see Figure 18).
3. Raise the carriage brush holder by pushing the latch, on the side of the holder, toward the front.
4. Holding the tape loop so that the printed captions can be read, place the tape over the pin-feed drive (see Figure 24) so that the pins engage the center drive holes. The line numbers on the tape must face the right end of the 1403.

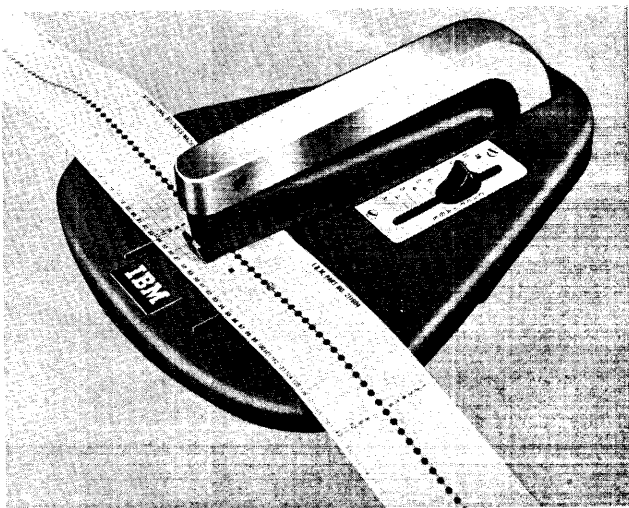


Figure 29. Carriage-Tape Punch

5. Loop the tape around the adjustable carriage-control-tape idler (see Figure 23).
6. Remove the excess slack from the tape by loosening the locking knob on the idler and sliding the idler in its track. Tighten the knob when the desired tension is reached. The tape should be just tight enough so that it gives slightly when the top and bottom portions of the loop are pressed together. If it fits too tightly, the pin-feed holes may be damaged.
7. Press the brush holder down until it latches, and close the printer cover.
8. Press the carriage restore key to bring the tape to its home position (channel 1). The carriage is ready to operate (when the feed clutch is set to DRIVE).

Inserting Forms

1. Raise the front cover of the printer to gain access to the print unit and forms area.
2. Turn the feed clutch to NEUTRAL (see Figure 18).
3. Unlock and swing back the print unit by pulling the print-unit release lever (Figure 30) toward you.
4. Set both the left-hand forms tractors (see Figure 21) slightly to the left of the first printing position. Pull the tractor lock up (or down) and slide the tractor until it latches in the appropriate notch.
5. Open the left-hand tractor covers, and place the forms over the pins. Close the covers.
6. Open both right-hand tractor covers.
7. Move the right-hand tractors to the desired location to line up the right side of the forms. Pull out the tractor pin latch, and slide the tractor until the pin snaps into the appropriate position.
8. Place the forms over the tractor feed pins and close the tractor covers.

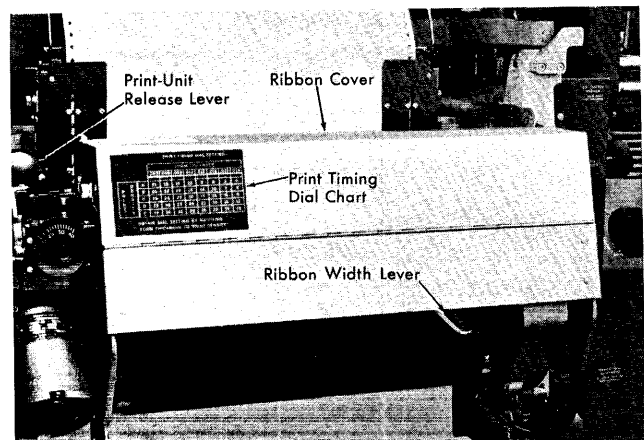


Figure 30. IBM 1403 (Front Cover Open)

9. Tighten the tension on the form, using the **R H TRACTOR VERNIER**.
10. Close and lock the print unit in place. Be sure to push the print-unit release lever as far as it will go.
11. To position the forms for printing, turn the paper advance knob and the vertical vernier until the block, line, or area on which the first line of print is to occur is just visible above the top surface of the ribbon guide bar. Align the desired hammer position to the form by means of the lateral-print-alignment lever and its vernier, while observing the relationship of the markings on the ribbon guide bar to the form. The printed characters will appear between the bar markings. Now, turn the paper-advance knob backwards three line spaces if in 6-line neutral or four line spaces if in 8-line neutral. (*Note: On 1403 Model 3 printers only, turn the paper-advance knob backwards four line spaces if in 6-line neutral, or five line spaces if in 8-line neutral.*) The forms are now in position for printing.

On all models of the 1403, the top surface of the extreme left and right ends of the plastic ribbon shield may be used for vertical forms alignment when the ribbon shield is unlatched from the print unit and swung in against the forms. (See *Ribbon Shield and Print-Line Indicator* section.)
12. Restore the carriage tape to the first printing position by pressing the carriage restore button.
13. Set the feed clutch at **DRIVE**. Set it for either six or eight lines-per-inch, depending on the form to be printed.
14. Close the front cover of the printer.
15. Position the paper supply on the input-paper cart so that the forms feed straight up into the machine.

Inserting Additional Forms on an End-of-Forms Condition

The last form fed through the machine may be detected during a skip from one form to another, or while skipping or spacing within a form. If it is detected during a form-to-form skip, the skip is completed but printing does not occur and these steps should be taken:

1. Insert the new forms on the forms tractors (see *Inserting Forms*), aligning the top of the new form with the bottom of the last form. This positions the new form for printing on the skipped-to line.

If the form-to-form skip moved the last form beyond the upper forms tractors, determine (from your procedure write-up) the line on the form to which the skip was directed. Insert the new forms, positioning the skipped-to line for printing.

Inserting the new forms turns **OFF** the end-of-forms light. This makes the single cycle key operative again.

2. Make any slight adjustments that may be necessary for accurate registration by using the vertical-print adjustment and/or the lateral-print vernier knobs.
3. Press the single cycle key. Printing occurs on the skipped-to line. Press this key repeatedly to print on the first form until it reaches the upper forms tractors.

If the form spans both the upper and lower forms tractors when it is inserted (step 1), this step and step 4 are omitted.

4. Insert the new form on the upper forms tractor.
5. Press a **START** key to resume operation.

If the end-of-forms condition is detected while skipping or spacing within a form:

1. Print the rest of that form, using the single cycle key.
2. When the skip (or space) to the next form occurs, follow the same procedure as described in the preceding five steps.

Changing Ribbons

Ribbons are available in widths of 11" and 14". The ribbon-width lever (Figure 30) adjusts the ribbon-feed mechanism to accommodate one width or the other.

Removing a Ribbon

1. Turn off the power by pressing the **POWER OFF** key on the 1401 console.
2. Lift up the front cover of the printer.
3. Swing the print unit out by pulling the print-unit release lever toward you.
4. Open the ribbon cover (Figure 31).

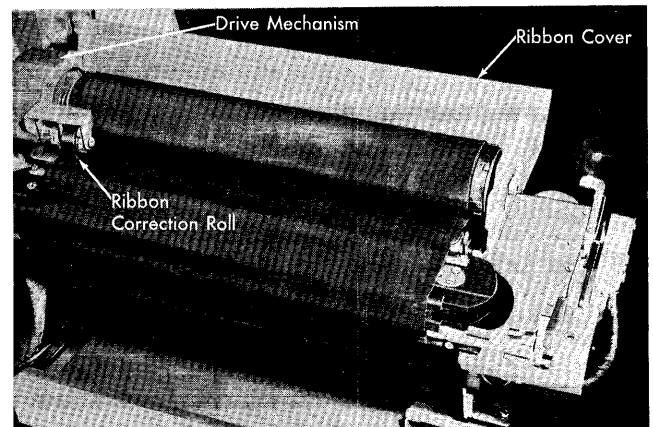


Figure 31. Ribbon Mechanism

5. Unlatch the ribbon shield, and swing it against the form.
6. Push the top ribbon roll toward the hinged side of the print unit (drive end), lift out the other end of the ribbon roll, and remove the roll from the drive mechanism.
7. Slip the ribbon out from under the ribbon correction roll, which may be lifted to free the ribbon.
8. Remove the bottom roll by following the same procedure as described in step 6 for the top roll.

Installing a Ribbon

A new ribbon is fastened on two spools with most of the ribbon on one of them. To install the ribbon, follow these steps:

1. Install the full ribbon roll in the *lower* position by following, in reverse order, the procedure described in *Removing a Ribbon*, step 6. To lock the roll firmly in place in the drive end, position the roll so that the two notches in the end of the spool coincide with two pins in the socket.
2. Wind ribbon onto the empty spool until the ribbon-reversing bar is on the spool. This is a metal strip that is permanently fastened to the ribbon. It reverses the direction of the ribbon when all the usable ribbon is on one spool. Therefore the ribbon-reversing *bar* must always be positioned between the ribbon-reversing *lever* and the spool (Figure 32).
3. Route the ribbon between the print chain and the ribbon shield, and slide it under the ribbon-correction roll.
4. Install the empty spool in the upper position by following, in reverse order, the procedure described in *Removing a Ribbon*, step 6.
5. Take up any slack in the ribbon by manually turning the upper ribbon roll.

Cleaning the Print Chain

When the 1403 print chain requires cleaning, call the IBM customer engineer to perform this function.

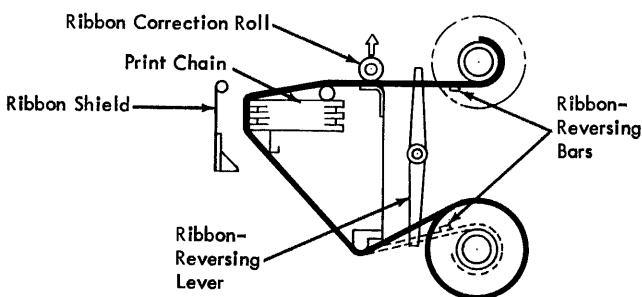


Figure 32. Schematic of Ribbon Mechanism

Selective Tape List (Changing from Forms to Tapes)

1. Move the continuous-forms cart out of the way.
2. Place the multilister stacker on the two mounting brackets.
3. Tighten the screws holding the stacker retaining plates in each of the mounting brackets on the top of both ends of the multilister stacker.
4. Install the multilister stacker assembly directly below the conventional-forms stacker.
5. Plug the electrical connector in the receptacle on the multilister assembly.
6. Move the forms tractors all the way to each side so that they will not interfere with the tapes.
7. Remove the clip-on paper guide assembly from the upper tractor bar.
8. Install the front tape guide by pushing the snap-on clips located on both sides of the plate, so that the guide fits firmly on the lower tractor bars.
9. Swing the print unit closed and latch it with the print unit release lever.
10. Unlatch the paper-storage cover from the paper-storage unit rail.
11. Unlock the tape-spool tray by pulling the locking pin toward you, and slide the assembly to the left until it locks in position.

Selective Tape List (Changing from Tapes to Forms)

To change from selective tape lister mode back to continuous forms mode of operation, these steps should be followed:

1. Disengage the locking pin located on the left side of the tape-spool tray by pulling it toward you, and slide the glide-mounted assembly to the extreme right until it locks in position.
2. Replace the paper-storage cover by lifting the right end up until it can be latched on the paper-storage unit rail.
3. Swing out the print unit by pulling the print-lever release toward you.
4. Remove the front tape guide plate by pulling the snap-off clips located on both sides of the plate and attached to the lower tractor bars. Lift plate upward until the rollers are disengaged from the upper tractor bar.
5. Assemble the clip-on paper guide assembly to the upper tractor bar and locate according to the desired form to be processed.
6. Reposition the tractors to accommodate the width of the desired form to be processed.

NOTE: The tape-advancing mechanisms that move the tapes are permanently mounted. They do not interfere with conventional form-feeding operations.

7. Remove the multilister stacker assembly in the rear of machine directly below the conventional forms stacker assembly by:
 - a. Unplug the 3-wire, 5A, 250V connector on the lower middle right end of the multilister stacker assembly.
 - b. Loosen the screws holding the stacker retaining plates in each of the mounting brackets on the top of both ends of the multilister stacker.
 - c. Lift the multilister stacker up and toward you so the square stacker retaining plates clear the holes in the two mounting brackets.
8. Replace the conventional forms cart.

Interchangeable Cartridge Installation

To install an interchangeable cartridge, these steps should be followed:

1. Lift up cartridge by handles and carefully place over positioning pins.
2. Press brake button on cover adjacent to print-unit release lever to lock gearing mechanism. Rotate chain with other hand until cartridge drops into position.
3. Slowly press handles to lock cartridge in place; do not force handles. Repeat the procedure if the handles fail to lock down or if the chain does not rotate after print unit is latched.
4. Replace ribbon on upper spool.
5. Close ribbon cover and print unit.

NOTE: To install numeric cartridge, proceed as just outlined; this automatically selects the numeric mode of operation.

Interchangeable Cartridge Removal

To remove an interchangeable cartridge, these steps should be followed:

1. Swing out print unit by pulling the print-unit release lever toward you.
2. Open ribbon cover.
3. Unlatch the ribbon shield and swing it against the form.
4. Push the top ribbon roll toward the hinged side of the print unit, lift out the other end of the ribbon roll, and remove the roll from the drive mechanism.
5. Slip the ribbon out from under the ribbon correction roll, which may be lifted to free the ribbon.

NOTE: The preceding steps may be eliminated by referring to steps 1 through 7 of *Changing Ribbons*.

6. Lift up on cartridge latch handles to unlatch cartridge. Raise the cartridge straight up with the handles to clear the cartridge positioning pins.

Pointers

1. If many errors are signalled by the **FORMS CHECK** light, the input-paper cart may not be positioned correctly.

Move it so that the forms feed straight up to the forms tractors. This is especially important for thick forms.

2. Be sure the paper cart is grounded against the machine to reduce the static electricity generated by paper as it feeds into the machine. If it is not properly grounded, the **SYNC CHECK** light may turn **ON** intermittently.
3. To start forms stacking properly, guide the leading edge of the first form into the stacking gate at the rear of the machine.
4. If all printing occurs on the same line, the feed clutch was left in **NEUTRAL**. Set it to **DRIVE**.
5. Be sure the feed clutch is set correctly for the forms to be printed: at 6 or 8 lines-per-inch spacing. If less than the proper amount of printing appears on a form, the clutch is probably set at 8 lines-per-inch but should be set at 6 lines-per-inch. Conversely, if more printing than expected appears on a form, the clutch is probably set at 6 instead of 8 lines-per-inch.
6. If the carriage does not restore to the home position when the carriage restore key is pressed, make sure that the carriage tape is properly positioned over the pin-feed drive and that the brush holder is latched in place.
7. If a forms runaway occurs and the carriage stop key does not stop it, tear off the forms below the forms tractors. Notify the IBM customer engineer.
8. A forms runaway is generally caused by initiating a skip for which no skip-stop punch in the carriage tape is read to stop the skipping. Check to see that the correct carriage tape is installed and that it is not torn.

Any one of these errors can also cause a forms runaway:

- control tape reversed in the carriage (inserted with printing away from the operator).
- two or more skip-stop punches in the same line of the tape.
- program error.

9. If the single cycle key is pressed during system operation, the operation stops at the end of the next print cycle. Avoid the possibility of a sync check by pressing the stop key before pressing the single-cycle key. Press a **START** key to resume operation.
10. If the print unit or carriage brush holder was opened and closed again during system operation, printing will not occur when the next print instruction is given. Press a **START** key to resume operation.
11. If the feed clutch is turned to **NEUTRAL** and back to **DRIVE** during system operation, printing will not occur when the next print instruction is given. Press a **START** key to resume operation.
12. When inserting new forms on an end-of-forms condition, do *not* restore the carriage if the skip-to line is at any position other than the first printing line on the form. Restoring the carriage at this time could get the forms, carriage tape, and program out-of-step.
13. Any time the carriage stop key has been pressed, check the carriage tape to see that the proper tape is correctly mounted and has not been damaged.

The IBM 1404 Printer, Model 2 (Figure 33), is another output medium for the IBM 1401 Data Processing System, and is available for Models B, C, E, and F. It is a combination printer, capable of processing either cut-card forms or continuous forms. The 1404 retains all the basic features of the IBM 1403 Printer — tape-controlled carriage, printing unit, and continuous forms carriage, and incorporates a newly designed card feeding mechanism. Under the control of the 1401 stored program and the tape-controlled carriage, this unit can print on continuous forms at a rated speed of 600 lines per minute; or it can print on card documents at a maximum rate of 800 cards per minute.

Simply by positioning a movable print unit before the card feeding mechanism and pushing a switch, an operator can change from continuous forms feeding to card document feeding. Conveniently located controls, hoppers, and stackers, all accessible from the front, permit easy operation.

The 1404 can process cards of many sizes, ranging from a single 51-column card to an 80-column card with an 80-column stub. It can also process any two cards that range in size from 51 to 80 columns at one time. As many as 25 lines of data, either from 1401 core storage, or from the card itself, can be printed on a card.

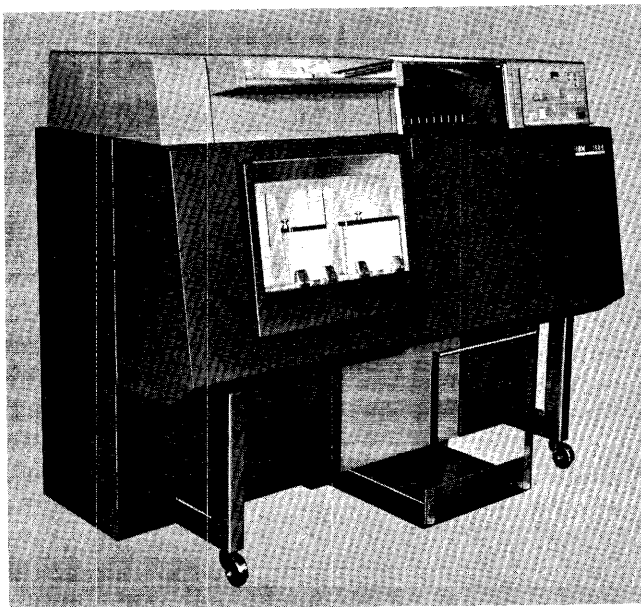


Figure 33. IBM 1404 Printer

Many businesses, in a variety of industry classifications, need accuracy and speed in printing on such card documents as checks, earnings statements, premium notices, bills, and proxy notices. The 1404 provides this accuracy and speed, and is flexible enough to be quickly converted for applications requiring continuous forms printing.

Functional Characteristics

The right-hand side of the printer contains the continuous-forms feed mechanism. The card document feeding mechanism is at the left. The print unit, consisting of the type chain, motor, ribbon, and hammers, can be moved laterally and positioned in front of either feed mechanism to print on continuous forms or cards. Also see *IBM 1403 Printer* section for functions and operations which are common between the 1403 and 1404.

Continuous Forms Feed

To print on continuous forms, the print unit is positioned on the right-hand side. In this instance, the operation of the printer, print unit, and carriage are the same as for the IBM 1403 Printer (see *IBM 1401 Data Processing System Reference Manual*, Form A24-1403).

Card Document Feed

The card-feeding mechanism consists of two sets of card levers and feed rolls that can be set to operate as one, or as two separate card channels. The large, single, card hopper (Figure 34), located at the front of the printer, can also be set up to accommodate one, or two separate card stacks. The hopper has a capacity of 1,200 standard IBM cards, or 900 IBM-stock postcards. The two throats can be adjusted easily to accommodate either type of card.

Depending on the particular application, one or two cards can be processed at one time, and both cards feed either 9- or 12-edge first. The application also determines the setting of a *channel select rotary switch* located on the console. This switch controls the card-lever circuitry (left or right channel) and sets up the proper 1401 reading circuits (for the *read-compare* feature).

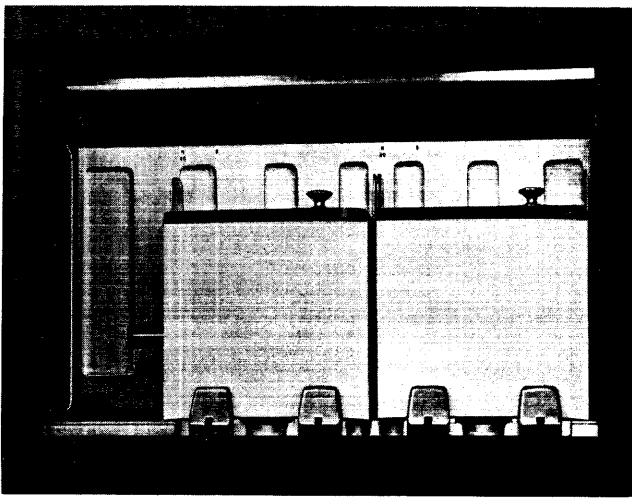


Figure 34. Card Feed Hopper

Card Forms

The card document feeding mechanism can feed IBM cards of either standard or postcard stock, and it can feed one or two cards at a time. If the printer is to process single cards, they can vary in width from 51-column cards to 80-column cards with 80-column stubs.

If the printer is to process two cards at a time, 51- to 80-column cards can be processed in either card channel.

Setting the Hoppers

The nature of the card printing operation determines how the four hopper side plates are set. There are two (left and right) side plates for each channel, and two settings for each *left* side plate.

N (Normal) Setting

This setting is used when 66- to 80-column cards are being processed in the left channel. A groove in the guide support shaft is the location of the *N* setting of the left side plate. An aligning hole in the side plate block aids in locating this groove, into which a knurled thumbscrew is tightened (Figure 35).

The right-hand side plate of the left channel is also set by a knurled thumbscrew. It should be set so that there is slight clearance between the end of the card and the side plate.

If the read-compare feature is installed, this *N* setting for the left channel permits card columns 1-80 to be read by left read-compare brushes 1-80.

For 2-card operations, or when only the right-hand channel is used, the left side plate of the right-hand channel is set at its *N* position. The right-hand side plate, again, is set according to the size of the cards being processed.

If the read-compare feature is installed, this *N* setting for the right-hand channel permits card columns 1-80 to be read by right read-compare brushes 1-80.

For operations that involve cards wider than the standard 80-column card, the left channel side plates are unused and moved out of the way to the extreme left of the guide support shaft. In this instance, the left side plate of the right-hand channel is moved to the *N* setting of the left channel, and the right-hand side plate is adjusted according to the width of the forms.

S (Short Card) Setting

This setting is used when 51- to 65-column cards are being processed in the left channel. Adjusting the left-channel hopper plates parallels the procedure described for the *N* (normal) setting.

If the read-compare feature is installed, this *S* setting for the left channel permits columns 1-65 to be read by left read-compare brushes 16-80.

For operations involving the simultaneous feeding of two short cards, or when using only the right-hand channel for short cards, the left side plate of the right-hand channel is set at its *S* position. The right-hand side plate is set according to the width of the forms.

If the read-compare feature is installed, this *S* setting for the right-hand channel permits columns 1-65 to be read by right read-compare brushes 16-80.

Adjusting the Throat

The two card throats can be adjusted by the operator to feed either IBM standard or postcard stock. If a card with a stub must pass through both throats, adjust them both.

To adjust a throat, first loosen a wing nut at the back of the hopper (Figure 36). Then set the calibrated adjusting screw to the desired dimension. Each line represents a one-thousandth of an inch opening. For standard IBM cards, set the opening at 10 thousandths; for postcard stock, set it at 12 thousandths. After making the adjustment, tighten the wing nut to lock the throat at the desired opening.

NOTE: When adjusting the throat from any setting to a *higher* setting turn the adjusting screw clockwise to the higher setting. When adjusting from any setting to a *lower* setting, turn the adjusting screw clockwise, almost a full turn, to the lower setting.

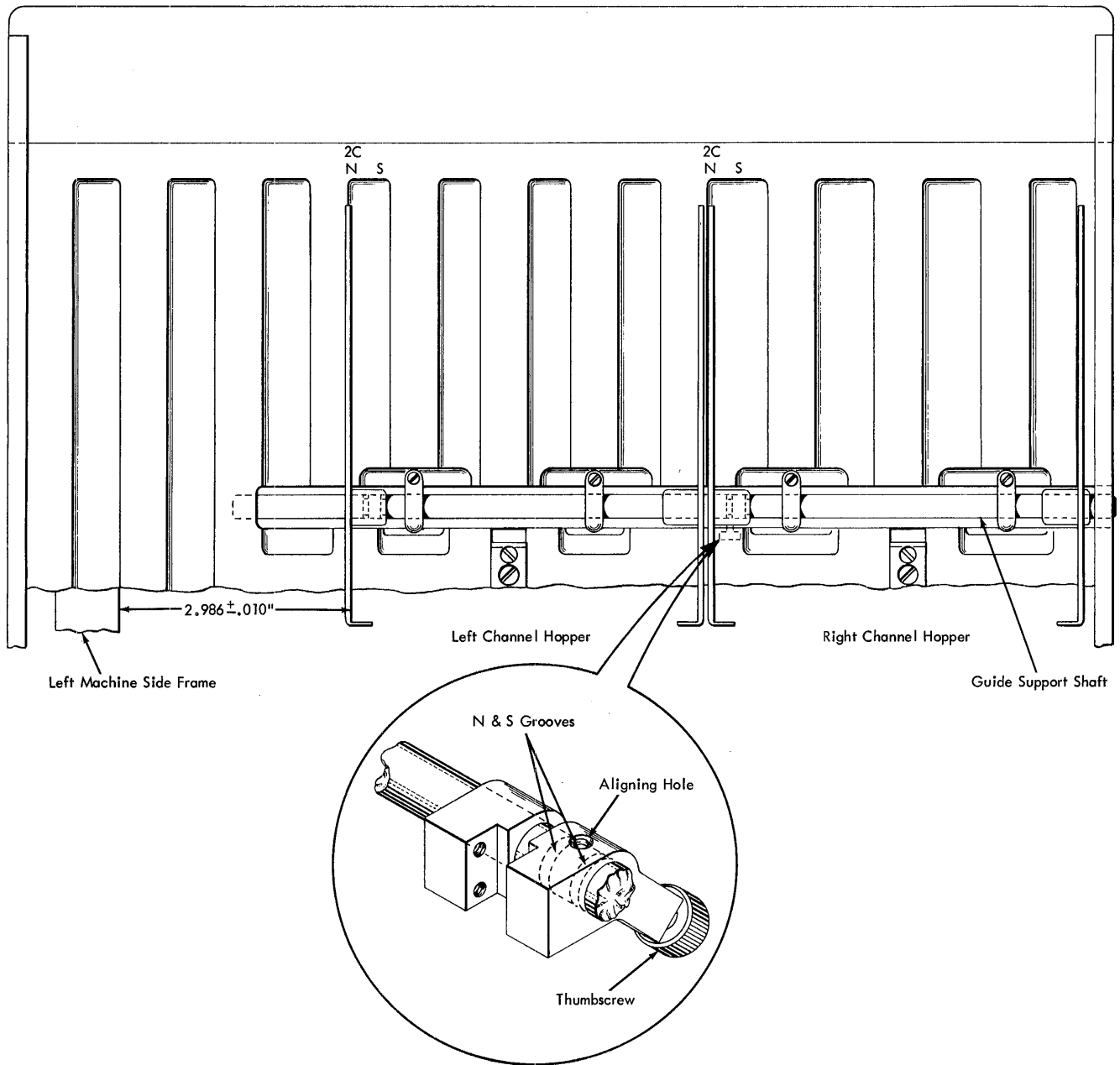


Figure 35. Hopper Side Plate Adjusting Mechanism

Card Feeding

In the IBM 1404 Printer, card feeding is under the control of the tape-controlled carriage and the 1401 stored program. Cards are fed from the hopper(s), past the read-compare brushes (special feature) to a point just ahead of the print station. Under the control of the carriage tape, the cards are then advanced to the first printing line. The program determines how many lines print on each card. After the printing operation, the cards are ejected into the stacker, located on the top

of the machine. Figure 37 is a side-view schematic of the card transport mechanism.

NOTE: Cards are stacked in reverse of the order in which they are loaded into the hopper.

The card transport mechanism facilitates the recovery of cards, regardless of their location in the card path. To gain access to the card path:

1. release, and swing-open the hopper mechanism to the left

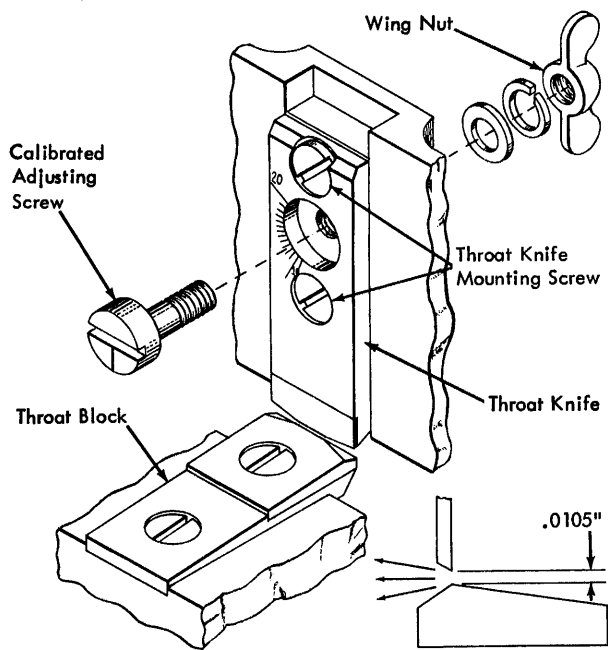


Figure 36. Throat Adjusting Mechanism

2. release, and swing the print chain and ribbon mechanism to the right
3. release, and swing-up the roller frame

If the read-compare feature is installed, the read-compare brush blocks are mounted on the roller frame.

Print Unit

For printing card documents, the print unit is positioned on the left side of the 1404 and the card-feed switch on the printer console is turned ON.

Lateral Movement

To move the print unit laterally, unlock it by raising the *translator knob*; the same knob is used to move the unit to the left (Figure 38). Re-lock the print unit after moving it to the desired lateral position. (Fine lateral adjustments can be made easily by using the lateral print vernier knob.)

To establish a reference point, consider that the left side plate of each hopper is set at the *N* setting. Then the *leftmost* lateral position of the print unit permits print position 1 to print 1/4 inch from the left edge of a left-channel card, and print position 78 prints 1/4 inch from the left edge of a right-channel card. See Figure 39.

The *rightmost* lateral position of the print unit is 2.4 inches to the right of the leftmost position just described. When the print unit is set to its rightmost

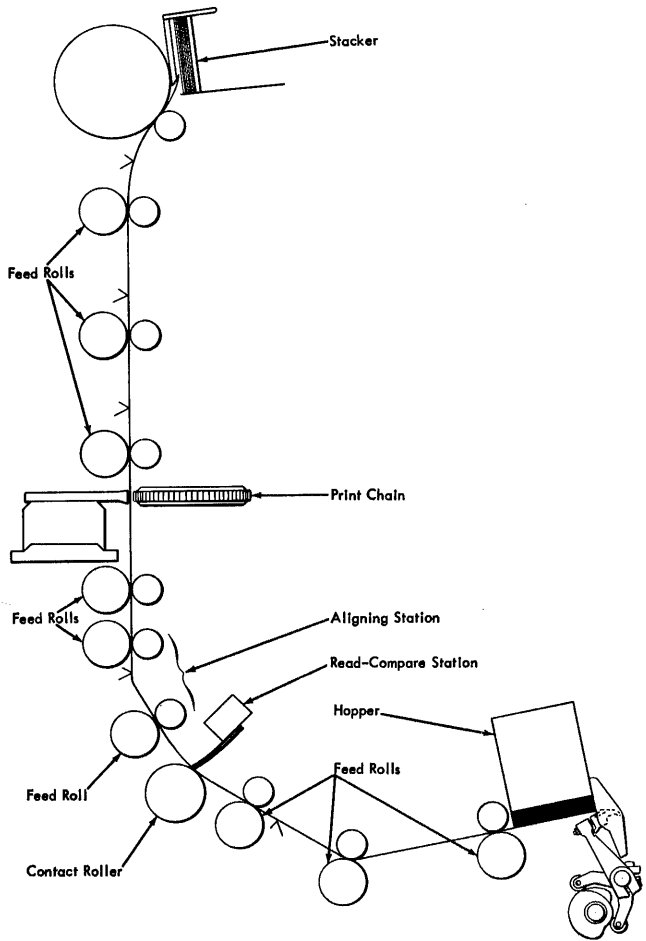


Figure 37. IBM 1404 Card Transport Schematic

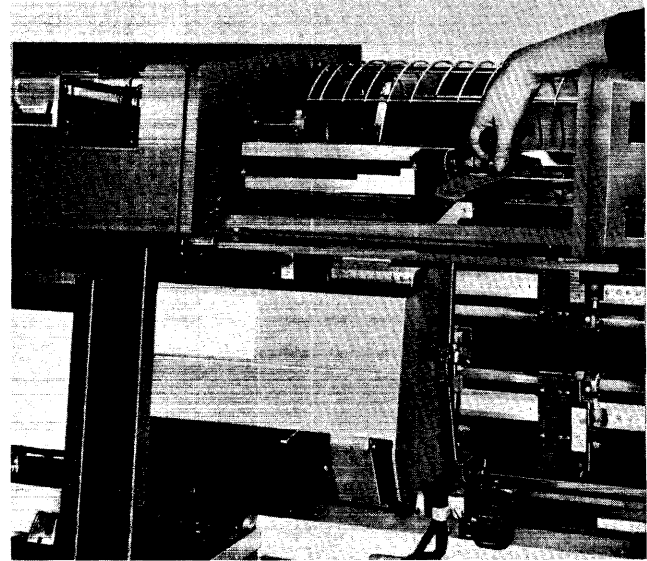


Figure 38. Moving the Print Unit

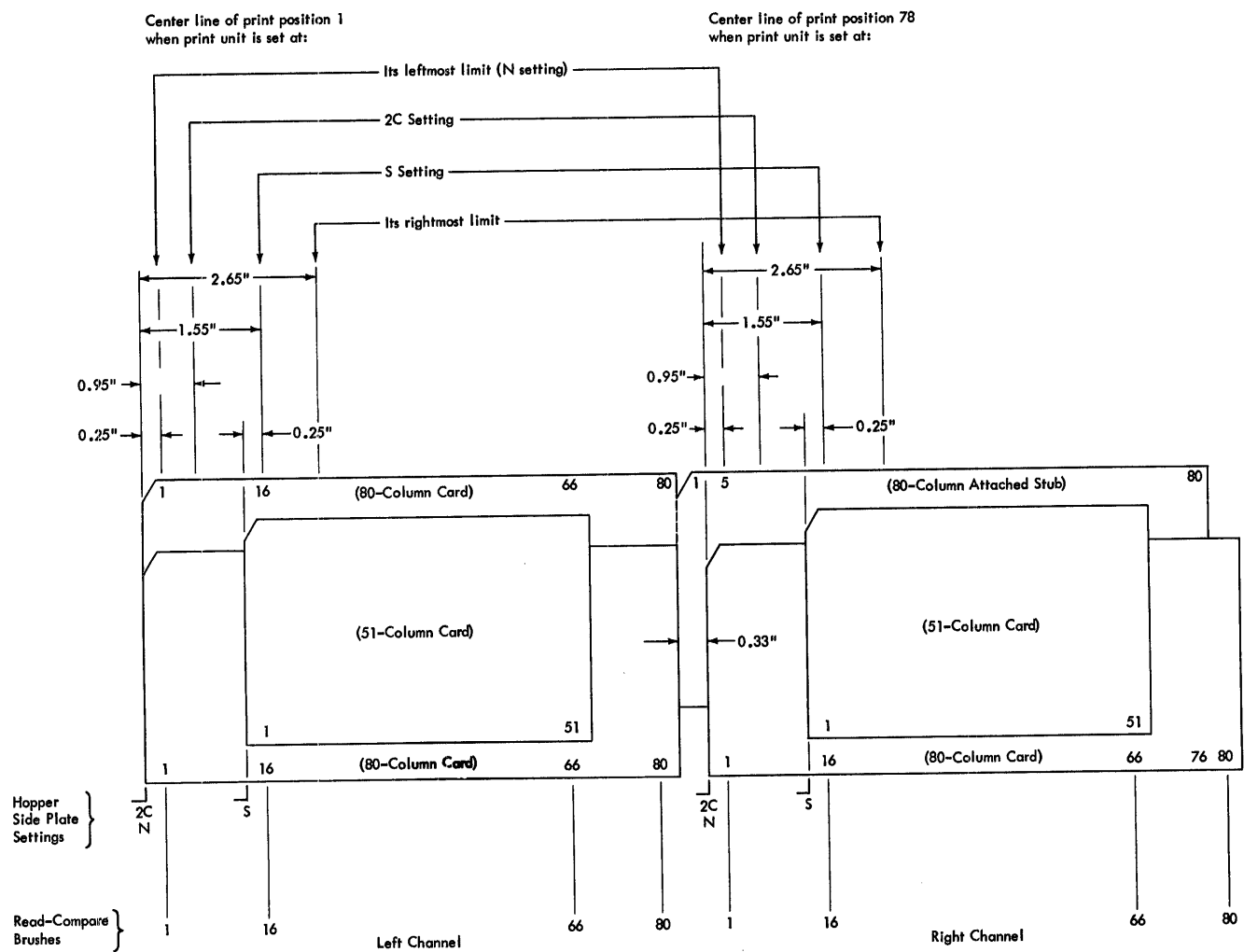


Figure 39. Hopper Side Plate and Print Unit Relationship

Limit of lateral movement, print position 1 prints 2.65 inches from the left edge of a left-channel card.

Any print-unit setting within these two limits can be used when printing card documents, regardless of the setting of the hopper side plates.

Print Alignment, Continuous Forms

The following procedure is used to align continuous forms in the 1404 printer.

1. There is no need to unlatch the ribbon shield from the T-casting.
2. Open the T-casting and insert the forms in the forms tractors.

3. Set the 6-8 line clutch control to either neutral position.
4. Turn the paper-advance knob until the area to be printed is just visible above the ribbon-guide bar.
5. Position the printing mechanism horizontally with the alignment lever and its vernier adjustment so that the markings on the ribbon-guide bar match the intended print position.
6. Turn the paper-advance knob *backwards* three line spaces for 6-line printing, or four line spaces for 8-line printing.
7. Press the restore key.
8. Turn the 6-8 line clutch to the appropriate 6- or 8-line position. The forms are now correctly positioned to receive the first line of print.

Print-Unit Indicator Settings

There is an indicator, fixed to the card-feed frame and located just below the translator knob, that can be used in conjunction with a decal on the printer frame. The indicator and decal help the user determine the lateral position in which he locks the print unit. They do not, however, limit or restrict the movement of the print unit.

N (Normal) Setting

When the print unit is moved laterally so that the *N* is positioned under the indicator, print position 1 prints $\frac{1}{4}$ inch from the left edge of a card in the left channel when the left hopper side plate is set at *N*. (See Figure 39.) Note that this setting of the print unit corresponds to the leftmost lateral position of the print unit, previously described. At this *N* setting, there are 71 print positions on an 80-column card in the left channel.

When the left side plate of the right channel is also set at *N*, there is a lateral space of 0.326 inches between two 80-column cards. Thus, four print positions in this particular case are unusable. These four would be positions 72-75 when two 80-column cards are printed side-by-side and the print unit is set at *N*.

NOTE: The desired printing format dictates whether to use certain other printing positions. If an *identical printing format* were desired for both left- and right-channel 80-column cards, then print positions 76 and 77, for example, would not be used. The reason is that print position 1 prints no less than $\frac{1}{4}$ inch from the left edge of the left-channel card; therefore, observing the same $\frac{1}{4}$ -inch margin on right-channel cards prevents print positions 76 or 77 from being used in this application. Furthermore, because right-channel cards are limited to print positions 78 to 132 (55 positions), the left-channel card must be limited to print positions 1 to 55 (55 positions). Thus, the desired printing format determines which of the available printing positions are to be used.

S (Short Card) Setting

When the print unit is set at *S*, print position 1 prints $\frac{1}{4}$ inch from the left edge of a left-channel 51- or 60-column card (left side plate set at *S*). Similarly, the 78th print position is $\frac{1}{4}$ inch from the left edge of a right-channel 51- or 60-column card.

2C (Two Card) Setting

When the print unit is set at 2C, print position 1 prints approximately one inch from the left edge of a left-channel 80-column card (left side plate set at *N*). Similarly, print position 132 prints approximately one inch from the right edge of a right-channel 80-column card. Print positions 65-68 align with the lateral space between two 80-column cards; therefore, these four print positions are unusable in this case.

Printing Characteristics

Printing on continuous forms in the 1404 is performed at the same speeds, and under the same conditions as in the IBM 1403 Printer. Printing is based on a 100 ms cycle. During this cycle, the system is interlocked for 84 ms (alphamerical printing), and processing can take place during the last 16 ms. Forms movement for one line requires 20 ms of this basic cycle.

Printing on card documents occurs on the top surface of each card as they appear in the hopper. With 8-lines-per-inch spacing, a maximum of 25 lines can be printed on one side of a card. With 6-lines-per-inch spacing, a maximum of 19 lines can be printed on one side (see Figure 40).

When printing on the first line of each card, and spacing at 6 lines per inch, the maximum output is 400 cards per minute for each card channel. If printing occurs at 8 lines per inch, this is reduced to 369 cards per minute.

Method of Printing

As in the IBM 1403 Printer, the method of printing in the 1404 is through the use of a continuous type chain traveling in a horizontal plane. Any one of 48 different characters can be printed as it is positioned opposite a magnet-driven hammer. These 48 different characters include: 26 alphabetic, 10 numerical, and 12 special characters (&, ., □, —, \$, *, /, %, #, @, ≠ in special character arrangement A or B). The standard number of print positions is 132.

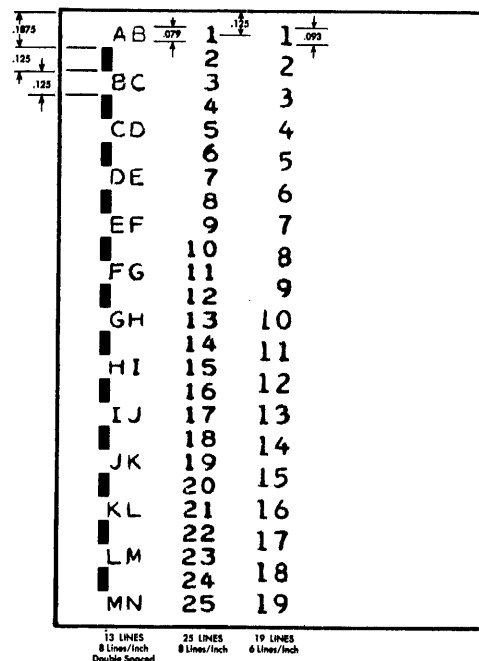


Figure 40. Three Spacing Formats

As each character is printed, it is checked against the corresponding position in the print area of core storage. The machine also checks to insure that each character is printed in the correct print position, that only valid characters are printed, and that overprinting does not occur.

Improved Ribbon

An improved ribbon, featuring a lighter-density ink, is available and is recommended for use on the IBM 1404.

Tape-Controlled Carriage

The tape-controlled carriage, in conjunction with the 1401 program, controls the feeding, spacing, and skipping of both continuous forms and card forms. The carriage is controlled by a punched paper tape that corresponds in length to the length of one or more forms. Holes punched in the tape can stop a form when it reaches any pre-determined printing line.

Line spacing of either 6 or 8 lines per inch is standard. At 6 lines per inch, spacing is performed at a minimum speed of 38 inches per second, and high-speed skipping occurs at a minimum of 85 inches per second. Skips of less than 8 lines occur at a minimum of 38 inches per second. Skips that are 8 lines or more in length occur at high speed, except for either the last 5 or 8 lines, as follows:

- When the print unit is positioned on the left side (printing on cut cards), the last 5 lines of a high-speed skip are skipped at 38 inches per second.
- When the print unit is positioned on the right side (printing on forms), the last 8 lines of a high-speed skip are skipped at 38 inches per second.

The punched paper tape controls skipping to pre-determined lines. In the tape there are 12 channels, two of which (9 or 12) can be interrogated for overflow.

When printing on card forms, a skip to channel 1 impulse causes a new card to be fed, the card at the aligning station to be moved into the correct printing position, and the card in the printing station to be ejected to the stacker. The *channel 1* punch in the tape determines the *first printing line* of the card.

Preparing the Carriage Control Tape

As with an IBM 1403 carriage control tape, these two general rules apply:

1. Never punch more than one tape channel on the same line.

2. Never punch holes in the same channel closer than 8 lines apart.

Most of the information pertaining to the control tape for the IBM 1403 applies to the IBM 1404. The following additional information pertains to tapes used when printing cut-card forms.

Starting at the line-1 end of the tape, mark the locations of the tape punches for a printed card form. It is usually desirable to repeat this set of punches as many times as the usable length of the tape (22 inches) allows. However, the interval between repeated sets of these punches varies, depending on the print position (on the card) of the first line to be printed and also on the number of lines per inch (6 or 8). Here is how to determine the number of lines from a 1-punch to the next 1-punch:

At 6 lines-per-inch spacing: $20 + F$

At 8 lines-per-inch spacing: $27 + F$

F represents the *line number* on the card of the first line to be printed. It ranges from 1 to 19 at 6 lines-per-inch, and from 1 to 25 at 8 lines-per-inch.

For example, suppose the first line is to be printed on line 1 of the card and that spacing is to be 6 lines-per-inch. Then, by the first formula ($20 + F$, or 21 lines), the second 1-punch must be located 21 lines from the first 1-punch.

If the user places his first 1-punch in *tape* line number 9 and his spacing is 8 lines-per-inch and the location of his first line to be printed is card line number 1 (Figure 41), then he should punch 1's also in tape lines 37, 65, 93, etc.

IBM 1404 Printer Console

The IBM 1404 Printer console (Figure 42) is located in the upper right-hand section of the printer. It contains the keys, switches, and indicator lights that control the

Card Line Number of First Line to be Printed (F)	Number of Lines from a 1-Punch to the Next 1-Punch	
	6 Lines Per Inch (20 + F)	8 Lines Per Inch (27 + F)
1	21	28
6	26	33
11	31	38
19	39	46
25	--	52

Figure 41. Some Intervals Between Repeated Sets of Carriage Tape Punches

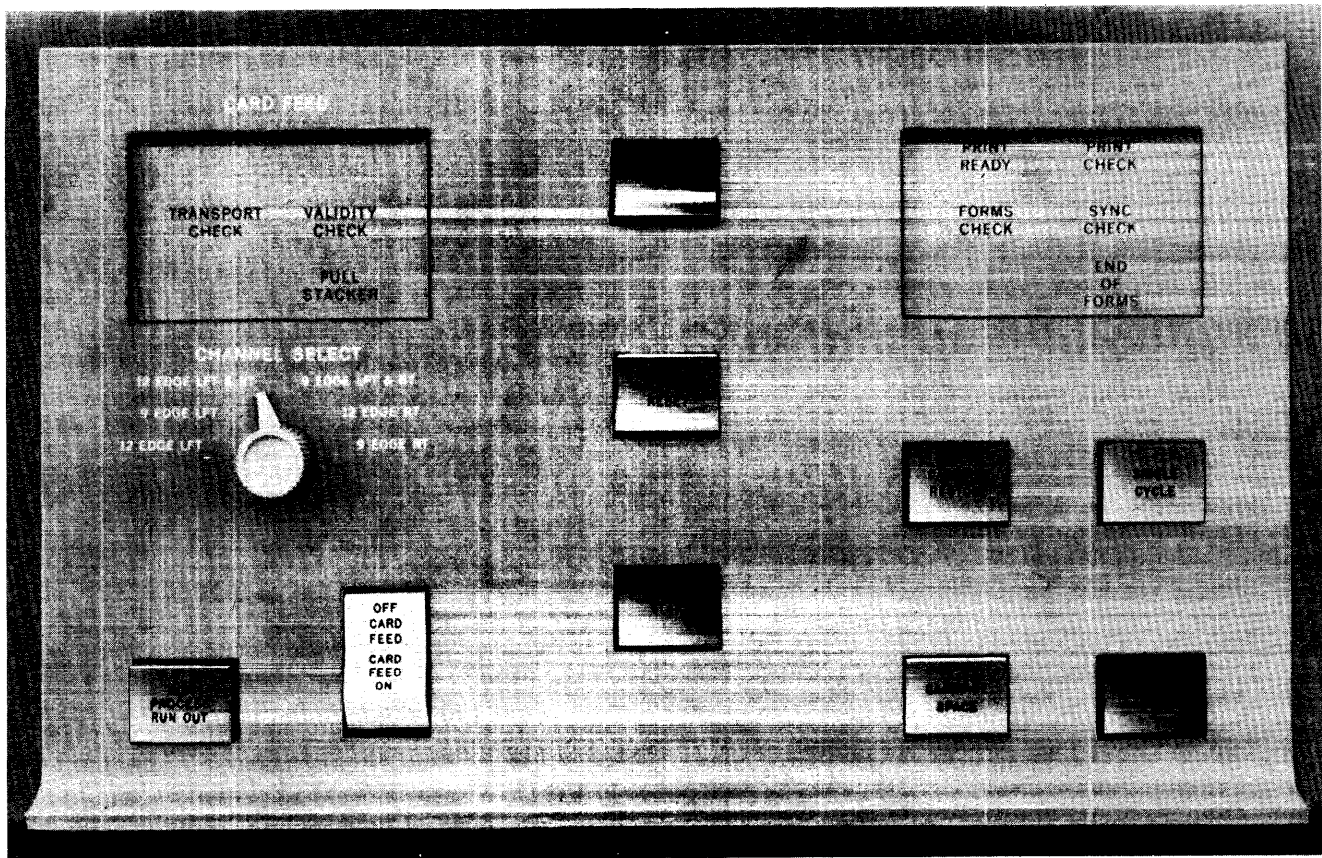


Figure 42. IBM 1404 Console

operation of the tape-controlled carriage, as well as both feeding mechanisms.

Check Reset Key

Pressing this key resets all printer error indicators. The program can be restarted by pressing the start key.

Carriage Space Key

Each time this key is pressed, the form advances one space. This key is operative only when the print unit is positioned on the right side (for printing continuous forms).

Single Cycle Key

Pressing this key once operates the 1404 for one print cycle. If the end-of-form light is on, pressing this key causes printing until channel 1 in the carriage tape is sensed. This key is operative only when the print unit is positioned on the right side (for printing continuous forms).

Carriage Stop Key

If the carriage is in motion, pressing this key stops it. To resume operation, the check reset key must be pressed. Do not press this key while feeding cards in the 1404.

Print Ready Light

This light turns ON when the printer is in operating condition.

Print Check Light

This light turns ON to indicate a print error.

Forms Check Light

This light turns on to indicate paper feed trouble in the forms tractor. The light goes out when corrective action is taken, and the check-reset key is pressed.

Sync Check Light

This light turns ON to indicate that the chain was not in synchronism with the printer comparing unit during a particular print cycle. The printer stops at the end of that print cycle so that the printed line can be inspected for errors. Pressing the check reset key resets the error condition, and turns out the light. Chain speed is automatically corrected.

End-of-Forms Light

This light turns ON, and the printer stops to indicate an end-of-forms condition.

Stop Key

This key is used to stop the system. It is not effective until the instruction being executed is completed. Similar stop keys are provided on each of the other units in the system. Another stop key on the 1404 is located at the rear of the machine, inside the door covering the forms-stacker area.

Carriage Restore Key

Pressing this key positions the carriage at channel 1 (*home position*). If the carriage feed clutch is disengaged, forms do not move. If it is engaged, the forms move in synchronization with the control tape. This key is operative only when the print unit is positioned on the right side (for printing continuous forms).

Start Key

This key is used to start the machine after a manual, programmed, or automatic stop. Similar start keys are provided on each of the other units in the system. Another start key on the 1404 is located at the rear of the machine, inside the door covering the forms-stacker area.

Card Feed Controls

These lights, keys, and switches are located on the left side of the console panel, and control the card-document feed.

Transport Check Light

This light turns ON to indicate a card jam or misfeed. Before restarting the operation, correct the condition, and press the non-process runout key. This turns off the light. If all the cards are removed from the 1404, pressing the start reset key on the IBM 1401 Console also turns off this light.

Validity Check Light

If the read-compare feature is installed, an invalid card code read by the read-compare brushes turns this light ON. An invalid card code does not automatically stop 1401 system operation. (See *Branch if Indicator On instruction*.)

Full Stacker Light

A full stacker in either card-feed channel turns this light ON.

Channel Select Switch

This rotary switch can be set at any one of 6 positions. The switch setting depends on whether or not both card channels are to be used, and whether cards are to be fed 9- or 12-edge first. If only one channel is used, the card levers in the unused channel are inoperative. If the read-compare feature is installed, the setting of the switch determines whether the 1401 read circuits read 9- or 12-edge first.

Non-Process Run-Out Key

This key must be used if the transport check light goes on. After both card hoppers have been emptied, this key ejects all cards from the printer channels.

NOTE: To resume program operation after using this key, press the IBM 1401 Console *start reset* key.

Card Feed Switch

When the print unit is positioned on the left side, turning the card feed switch ON makes the card-feeding mechanism operative.

Meter Time, IBM 1404

The 1404 meter records time if the CPU meter is recording and:

- The first print instruction has been issued while running a continuous-forms job.
- The first card has been fed while running a card-stock job. If a normal meter stop occurs with cards in the feed, meter recording resumes with the first subsequent print instruction.

The 1404 printer meter can be stopped manually by:

- Pressing and releasing the space key or the restore key.
- Running cards out of the card feed.
- The occurrence of a transport check (jam).

Once the 1404 meter has been started, it will stop and start under control of any start and stop keys regardless of the CPU program function, provided none of the 1404 stop conditions just listed occur.

Read-Compare Special Feature

As a special feature for the IBM 1404 Printer, 30 card columns can be read from the card feed channels. With this feature, 80 read-compare brushes are provided for each card channel. A control panel is also provided to select the reading of any 30 of the 160 available positions. The control panel (Figure 43) is located on the left side of the 1404. It is accessible after opening the left side door. Four control-panel hubs

(two LEFT BRUSH SET-UP and two RIGHT BRUSH SET-UP—see Figure 43) are for customer engineering use.

Storage locations 334 to 363 are assigned as a read-in area for the data read by the read-compare brushes. Storage position 333 is used for internal programming.

Comparison of data from the card with data in storage is accomplished by using the normal 1401 COMPARE instruction (C AAA BBB). This instruction compares data in the assigned read-in area (from the comparing brushes) with data in any other core-storage area.

Split wiring from reading brushes to storage entries is permitted provided that only one set of card columns is punched in each card.

When reading is not required, the read-compare brushes should be raised from the contact rollers.

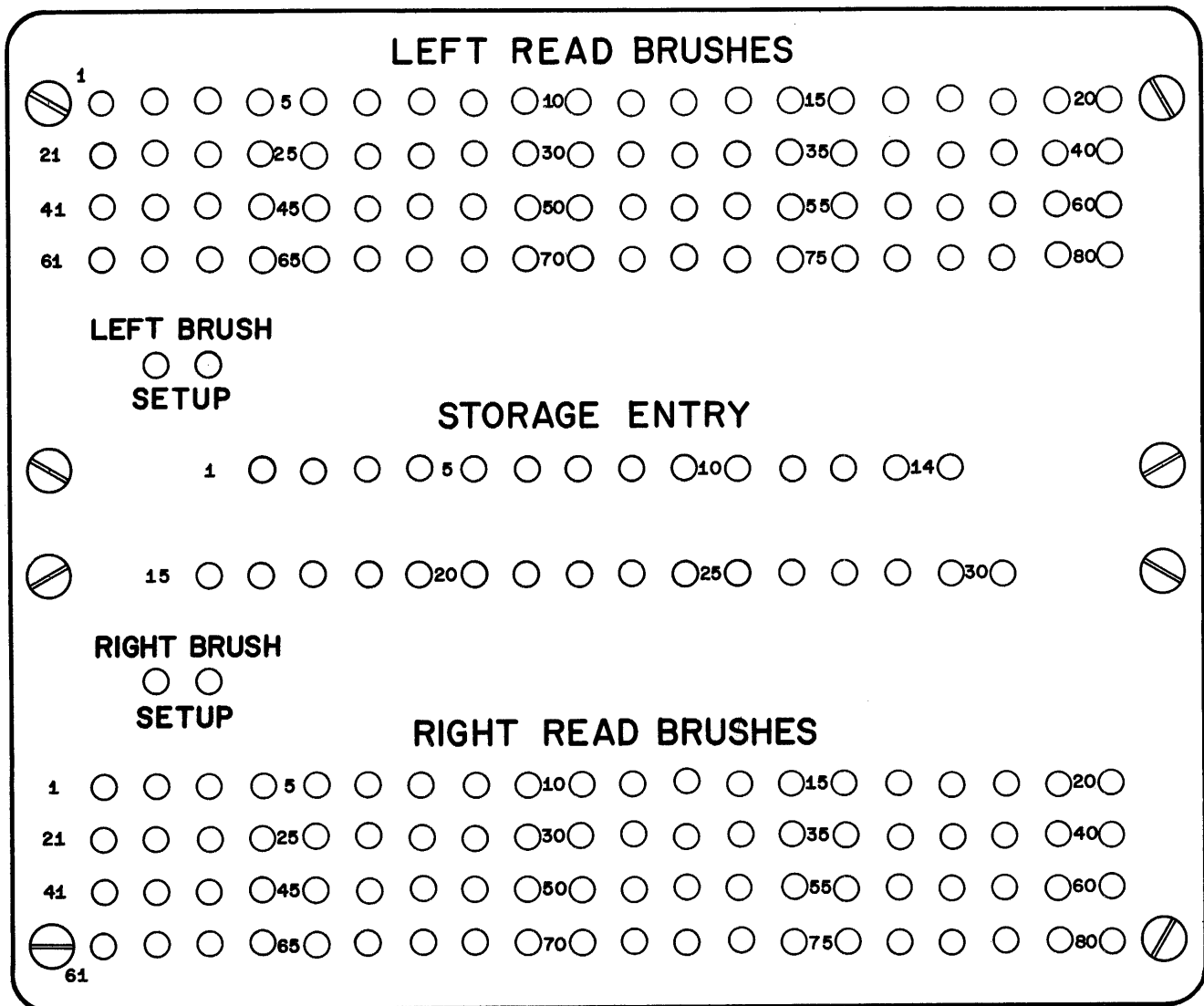


Figure 43. IBM 1404 Read-Compare Control Panel

Normal Run-In Procedure

Every IBM 1404 program written for use on an IBM 1401 system must position the first card at the print station before executing the first print instruction.

Figures 44 and 45 show diagrams of two 1404 programs. Each program is to read each card, compare the card's control number with that of a card- or a tapefile record, and print one line of data from the card or the tape record. One of the programs (see Figure 44) uses an F 1 instruction in the program loop that represents the main line of the program. The other program (see Figure 45) uses an F A instruction in its loop. Using the F A instruction can save 20 ms of time, as was previously mentioned.

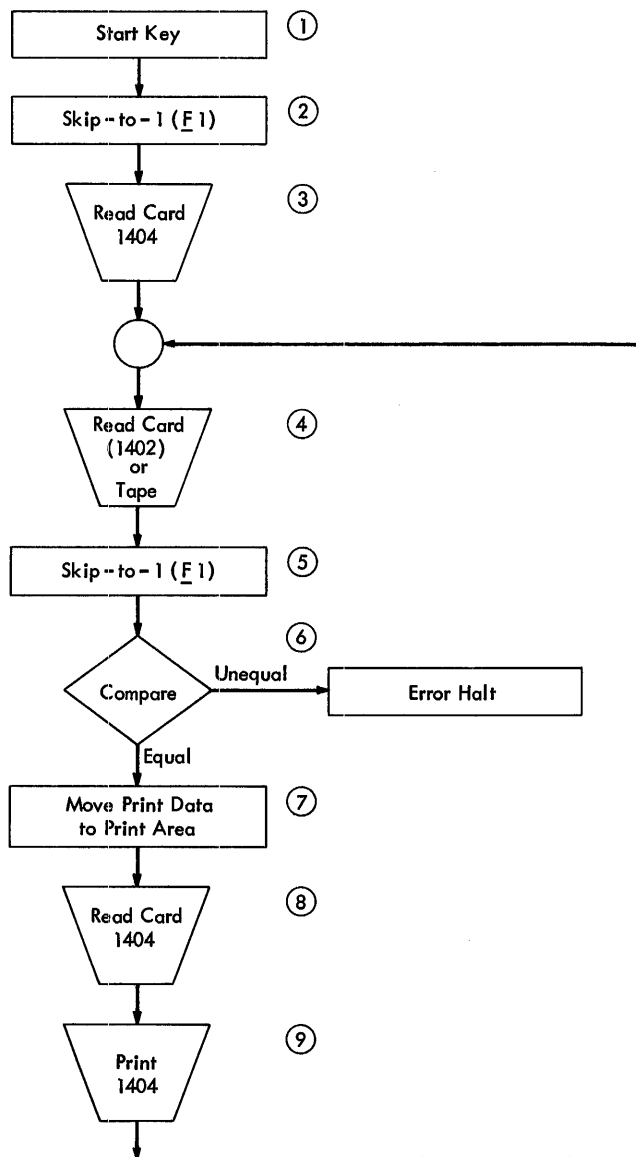
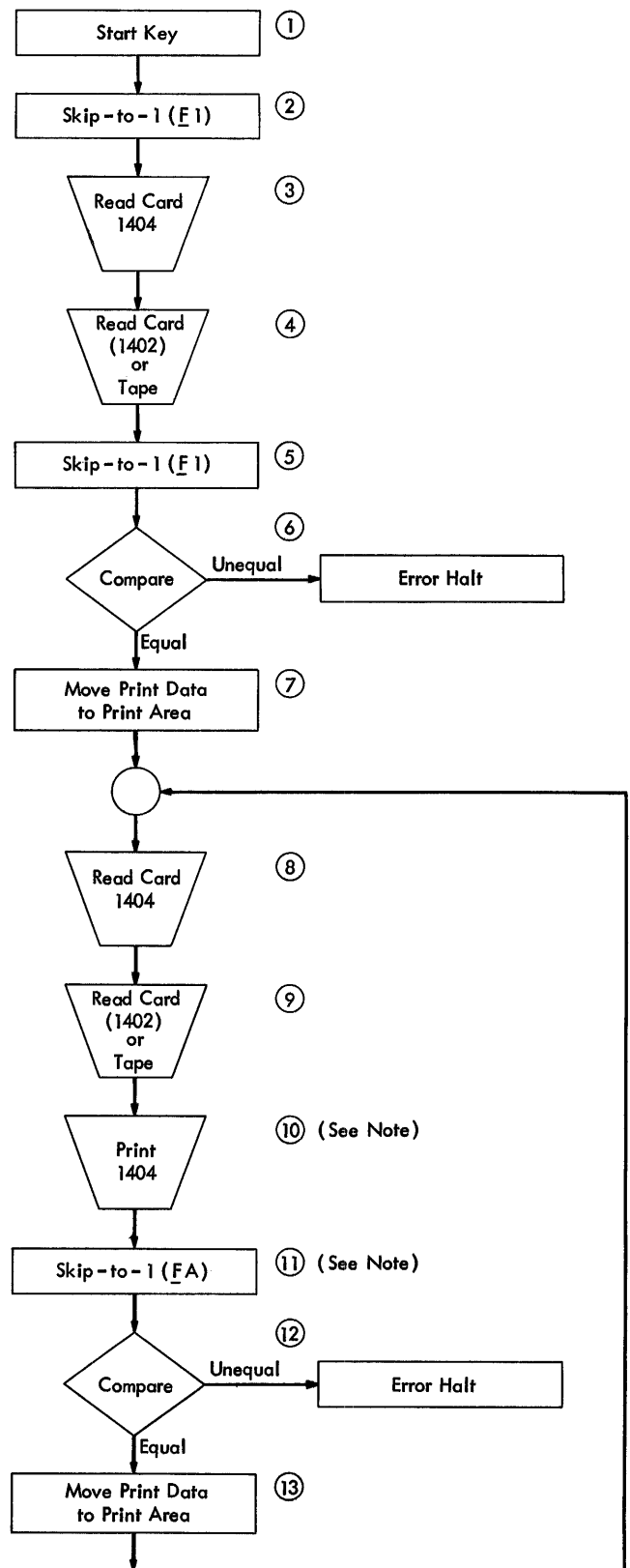


Figure 44. Program Using Immediate Skip F1



NOTE: In the program, the FA instruction must precede the print instruction. The order of execution, however, is as shown here.

Figure 45. Program Using Delayed Skip FA

Referring to Figures 44 and 45, note the action in each case on the run-in. Pressing the 1404 start key (block 1) provides the first card-feed cycle automatically. This positions the first card just ahead of the read-compare station (see Figure 37). To position the first card at the print station requires two programmed F 1 instructions. In Figures 44 and 45, the first F 1 instruction (2) feeds the first card past the read-compare brushes, where the 1404 read instruction (3) reads the card. The second F 1 instruction (5) is necessary to feed the first card to the print station. An important point to note is this: on the run-in the required actions that affect card movement are pressing the 1404 start key and the execution of two F 1 instructions.

Normal Run-Out Procedure

When processing cut-card forms without reading them, follow this procedure on the run-out.

1. If both card hoppers are being used and the system stopped because cards ran out of one hopper, remove the remaining cards from the other hopper.
2. Press the 1404 start key. The 1401 system executes two complete sets of *programmed* instructions and three additional automatic *non-programmed* carriage cycles. These carriage cycles eject the remaining cards into the stacker.

When processing cut-card forms that are being *read*, follow this procedure on the run-out.

1. Same as preceding step 1.
2. This step can vary, depending on the user's choice.
 - If he has written a *last-card* routine that uses one of the sense switches, B-G, set that switch ON and press the start key on either the IBM 1401 Console or the IBM 1404. This completes the processing of the last two cards and ejects them into the stacker.
 - If the user did not write a last-card routine, place one blank card in the hopper (or in each hopper if both are used). Press the 1404 start key once. The 1404 will stop when the hopper empties. Press the 1404 start key once more. The 1401 system processes the last punched card, feeds the blank card, and stops with a read operation code in the operation register. Press the non-process run out key to pass the blank card through the 1404 feed and into the stacker.
 - If the user did not write a last-card routine, place three blank cards in the hopper (or in each hopper if both are used). Press the 1404 start key.

The 1404 feeds the blank cards, processes the last *file* card (including printing), and stops when the hopper empties. After the hopper becomes empty, press the non-process run out key to pass the three blank cards through the feed and into the stacker.

Transport-Check Condition

If a transport-check condition should occur, the user must clear the feed path of cards. Frequently, cards in the feed path can be cleared out by pressing the non-process run out key (which will also reset the transport-check light). If, however, the cards in the feed path must be manually removed, use this procedure:

1. Open the divided front cover by swinging open the left and the right portions.
2. Release and swing the hopper mechanism to the left.
3. Release and swing the print chain and ribbon mechanism to the right.
4. Release and swing up the roller frame.

NOTE: The read-compare brushes, if installed, are mounted on the roller frame.
5. Press the non-process run out key to reset the transport-check light.

A visual inspection of the last few cards that were either run out by the non-process run out key or removed manually will indicate the point in the input file where processing must be resumed. Be sure to check the printing on the last few cards in the stacker, if the machine stops because of a transport-check condition.

Because of the flexibility of the IBM 1404 Printer used with an IBM 1401 system, restart procedures can vary among applications. Some applications might require a restart procedure as simple as this: determine the last card correctly printed, then put the cards that follow it back in the feed hopper and resume operation as indicated under *Normal Run-In Procedure*. Other applications, however, might dictate a restart procedure much more complex. It might include branching to a core address that contains the first instruction of a programmed *restart routine*. Such a routine might backspace tape, re-read a tape record and compare the control field in the card with that of the tape record. This would ensure that the input cards and the information to be printed are again in step prior to resuming the processing of the input file.

IBM 1445 Printer Model 1

The IBM 1445 Printer, Model 1 (Figure 46), provides either conventional or Magnetic Ink Character Recognition (MICR) printed output for the 1401 system. The 1445 printer has a rated speed of 190 lines per minute with the standard 56-character set, which includes 42 alphameric characters and 14 E-13B characters specified by the American Banking Association (A.B.A.).

Special character sets, available for the 1445 printer, vary the printing speed from 120 lines per minute to 600 lines per minute. The actual printing speed obtainable for a particular job or application depends, in part, upon the total number of lines to be printed, the amount of processing required for each line that is printed, the character set used, and the printer.

The standard number of positions that can be printed on one line on the 1445 printer is 113. The characters are printed eight characters to the inch on the 1445.

The IBM 1445 Printer is equipped with a standard typebar containing 56 characters: 14 E-13B characters and 42 alphameric characters. Other character sets are also available for the 1445.

The vertical spacing can be manually adjusted for six or eight lines to the inch on the 1445 printer. The vertical line spacing is performed by a tape-controlled carriage directed by the stored program in the processing unit. The sequence and arrangement of data on a line of printing is also controlled by the stored program.

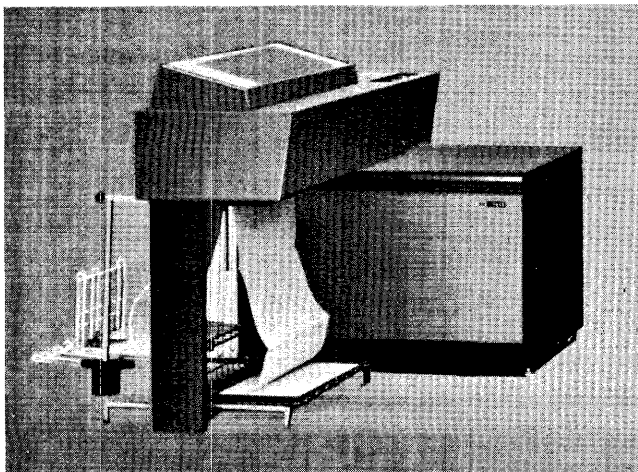


Figure 46. IBM 1445 Printer

Method of Printing

Alphabetic, numeric, and special characters are located on a bar (Figure 47) that travels back and forth in a horizontal plane. To print, a magnet releases a spring-loaded hammer at the proper time so the desired character is pressed against the ribbon and paper.

A line to be printed should be assembled in core storage in exactly the same manner in which it must appear as output. Before a character is printed, a comparison is made of the character in the print area to the corresponding character in the core storage position to ensure the accuracy of the printed output.

Tape-Controlled Carriage

The carriage is tape controlled (Figure 48) and advances the form as directed by the stored program. The vertical spacing is manually set by the operator for either six or eight lines to the inch. The carriage can be single, double, or triple spaced. These operations are planned in the program when spacing operations are required. If no spacing instruction is pending, the carriage single spaces after printing on the IBM 1445, Model 1.

The carriage instructions give flexibility to the spacing operations by providing linespacing and forms skipping on an immediate or delayed basis. The instructions are used with the control tape which is arranged to identify the format of the form being used.

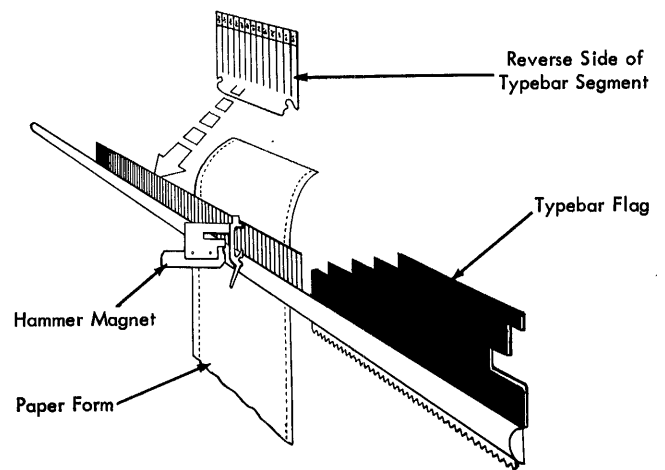


Figure 47. Printing Schematic

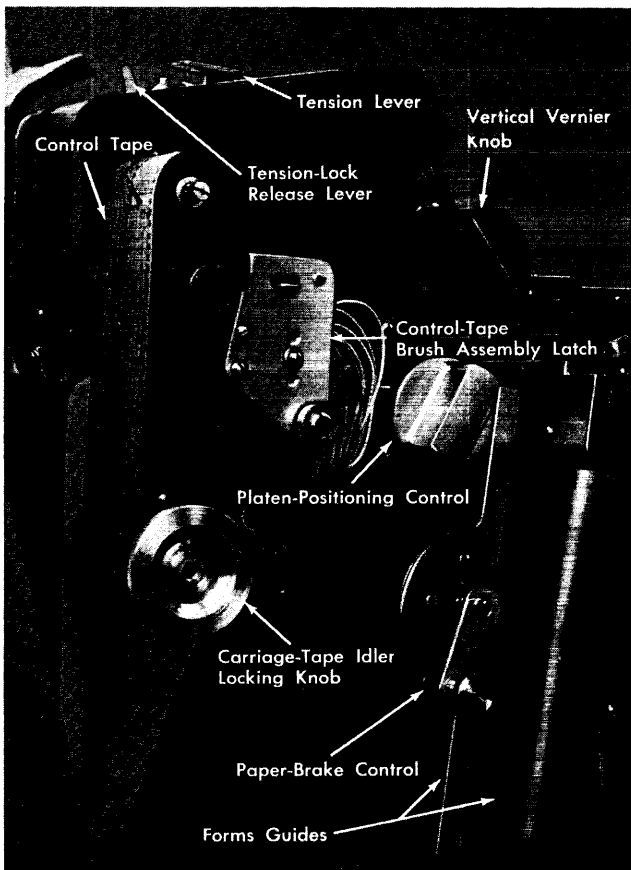


Figure 48. Tape-Controlled Carriage

An immediate skip requires 60 ms for the first linespace and 10 ms for each additional linespace. The maximum time for an immediate triple space operation is 80 ms. A delayed space operation of not more than one space is executed as part of a following print cycle without extending the normal print cycle time.

Sensing a punch in the control tape in channels 9 or 12 during a carriage operation sets an indicator.

The indicator can be tested by the appropriate branch-if-indicator-on instruction. The indicator is reset by executing the appropriate branch-if-indicator-on instruction or by sensing a punch in channel 1 of the control tape.

The carriage is equipped with several adjustments that must be set to ensure proper form feeding (Figure 48):

1. An adjustable paper brake is provided for setting the proper tension on the forms.
2. The form-thickness adjustment is for setting the proper clearance between the platen and the typebar to ensure optimum printing quality on forms of different thickness.

Forms

The forms used on the IBM 1445 Printer must be designed for use with a tractor feed (Figure 49). Therefore, the forms must be continuous with marginal punching on both sides. There is no provision made for pressure feeding of documents. The maximum paper width recommended is 16¾ inches and the minimum is 4 inches. For more detail on forms specifications refer to *IBM 1403 and 1443 Printers: Form Design Considerations*, Form A24-3041.

Printer Keys, Lights, and Switches (Figure 50)

Start Key

Pressing the start key places the IBM 1445 Printer in a ready status if the following conditions are met:

- AC power on
- DC power on

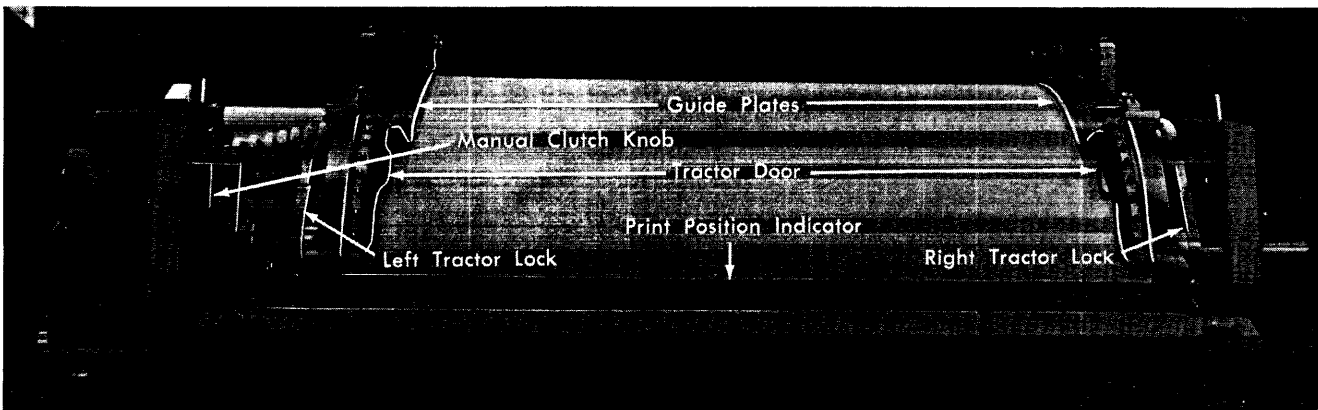


Figure 49. Tractor Feed

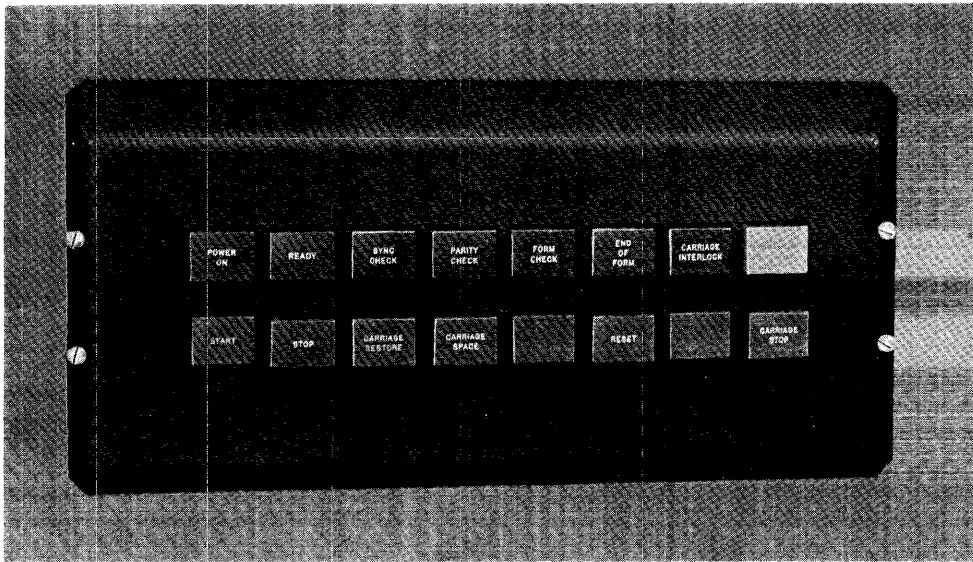


Figure 50. Control Keys

Form guide plates closed
 Typebar in position
 Carriage brush assembly closed
 6-8 linespace drive mechanism cover closed
 End-of-form switch closed
 No error condition.
 Paper-guide latch completely positioned to the right
 Upper ribbon and print-line indicator handle in operating position, fully seated on the stop
 Platen positioning control adjusted correctly
 Ribbon check light off.

Pressing this key with the end-of-form light on causes the printer to operate under the control of the system until a channel-1 punch is sensed in the carriage tape. This operation repeats each time the start key is pressed. Therefore, if no form is in the carriage, data is printed on the platen.

Stop Key

Pressing this key removes the printer from ready status. The rest of the system is not affected unless the program selects the printer when the ready status has been interrupted. If this occurs, the system will be interlocked until the printer is placed in a ready condition.

Power-On Switch

This switch, located on the control panel for the printer, controls the power supply to the printer. Pressing this switch turns the power on.

Power-Off Switch

This is located on the control panel for the printer. It controls the power supply when the printer is used with a 1401. Pressing this switch turns the power off.

Ribbon Check Light

This light comes on when the magnetic-ink ribbon is empty. While this light is on, the 1445 cannot be started until the magnetic-ink ribbon spool is replaced with a full spool. When the ribbon condition is corrected, pressing the reset-check key extinguishes the ribbon check light.

The upper ribbon guide and print-line indicator handle also turn this light on if the handle is not fully restored to operating position against its stop.

Reset Key

Pressing the reset key resets all the check indicators associated with the printer. This key is effective only when the printer is in a ready status.

Power-On Light

This light indicates when dc power is applied to the printer control circuits.

Ready Light

This light indicates that the printer has been conditioned by the operator to accept instructions from the system. It is turned off when the stop key is pressed, when an error is detected, or when the printer runs out of forms and a 1 is sensed in the carriage tape.

Parity Check Light

This light is turned on when a parity error is detected by the error check circuits. It is turned off by the check-reset key on the console, by the machine-reset key on the printer, or when the parity error indicator is program tested with a branch-if-indicator-on instruction B (I) (with the I/O check stop switch off).

Sync Check Light

This light turns on when the typebar is out of synchronism with the printer. When this occurs, the printer is removed from ready status. The light is turned off by pressing the machine-reset key on the printer.

Form Check Light

This light comes on when the form guide plates are not in operating position on the paper. On the 1445 the paper-guide latch and platen positioning control also affect this light.

Carriage Interlock

This light comes on when the tape-brush assembly is not closed or the cover over the 6-8 linespace drive mechanism is open.

End-of-Form Light

This light comes on when approximately four inches of the last form is left to be printed. However, the printer continues to operate until the carriage tape advances to a channel-1 punch which removes the printer from the ready status. If the start key is pressed, the machine will restart and continue to operate until the next channel 1 is sensed in the carriage tape. If the carriage tape is not punched in channel 1, the printer continues to operate.

Carriage Stop Key

Pressing this key stops the carriage operation. This key *should not* be used to stop the printer operation.

Carriage Space Key

Pressing this key causes the form to advance one space. The ready light *must be off* for this key to operate.

Clutch Knob

The manual-clutch knob controls the carriage-tape drive and the form-feeding mechanism. The clutch knob has two settings, *OUT* and *IN*. The *OUT* position disengages the feed clutch so that the form does not move with the carriage drive. The *IN* position engages the clutch so that the form is moved in synchronization with the carriage tape.

Carriage Restore Key

Pressing this key positions the carriage at channel 1. If the manual clutch knob is set to *OUT*, the form does not move. If it is set to *IN*, the form moves in synchronization with the control tape. The ready light *must be off* for this key to operate.

Typebar Switch

This switch, mounted under the top cover and near the typebar drive (Figure 51), has three positions: *ON*, *OFF*, and *TYPEBAR REMOVAL*. The *OFF* position turns off the ribbon and typebar motors and de-energizes the solenoid in the typebar drive unit. For safety, use this position if the ribbon is to be replaced without removing the typebar. The *TYPEBAR REMOVAL* position turns off the ribbon and typebar motors but leaves the

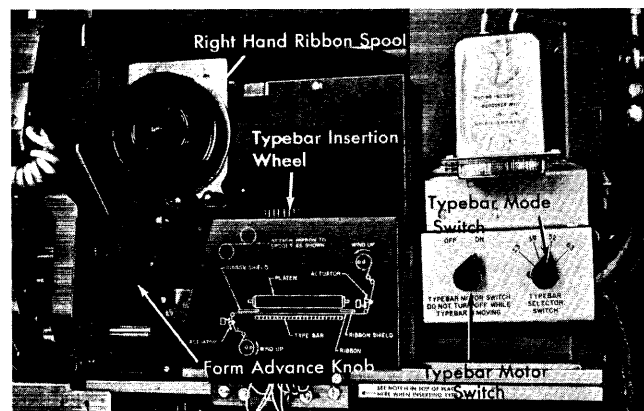


Figure 51. Printer Right-Hand Controls

solenoid energized to permit easy operation of the typebar drive handwheel. Use this position when removing or installing a typebar.

Do not turn this switch to OFF or to TYPEBAR REMOVAL while the typebar is in motion.

Meter Time, IBM 1445

The 1445 meter starts when the first print instruction is issued to the printer. It can be stopped manually by pressing and releasing the space key or the restore key.

Carriage Control Tape

The control tape (Figure 52) has 12 columnar positions indicated by vertical lines. These positions are called *channels*. Holes can be punched in each channel throughout the length of the tape. A maximum of 132 lines can be used to control a form, although, for convenience, the control tapes are slightly longer. Horizontal lines are spaced six to the inch for the entire length of the tape. Round holes in the center of the tape are prepunched for the pin-feed drive that advances the tape in synchronism with the movement of

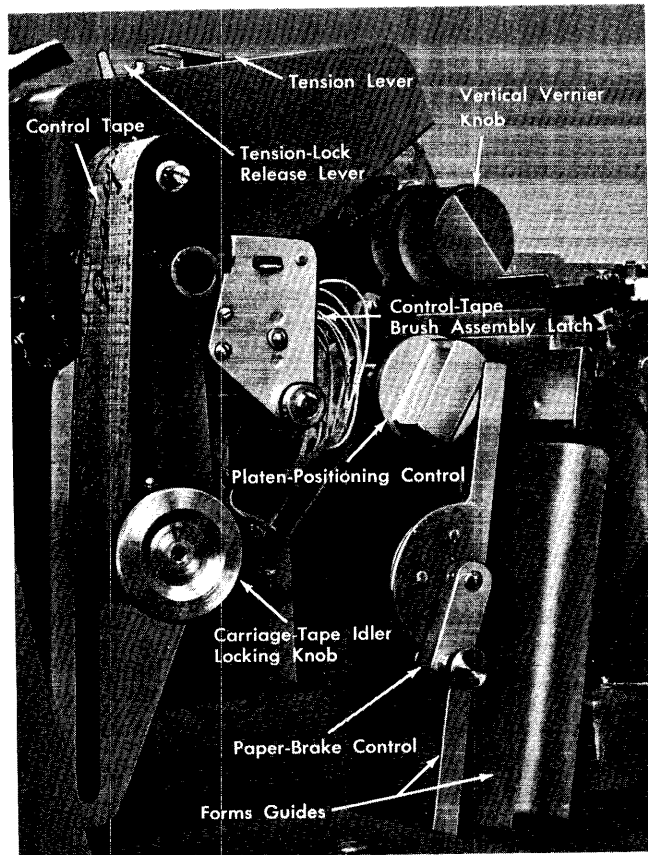


Figure 52. Printer Left-Hand Controls

the printed form through the carriage. The effect is exactly the same as though the control holes were punched along the edge of each form.

Punching the Carriage Control Tape

A compact punch (Figure 53) is used for punching the tape. The tape is first marked in the channels in which the holes are to be punched. This can be done easily by laying the tape beside the left edge of the form it is to control, with the top line (immediately under the glue portion) even with the top edge of the form. Mark the first channel on the line that corresponds to the first printing line of the form. Mark the additional channels for each of the other skip stops and for the overflow signal (channel-9 or -12 punch) required for the form.

The marking for one form should be repeated as many times as the usable length of the tape (22 inches) allows. With the tape controlling several forms in one revolution through the sensing mechanism, the life of the tape is increased. Finally, the line corresponding to the bottom edge of the last form should be marked for cutting after the tape is punched.

The tape is inserted in the punch by placing the line to be punched over a guide line on the base of the punch, and placing the center feed holes of the tape over the pins projecting from the base. Then turn the dial until the arrow points at the number of the channel to be punched. Pressing on the top of the punch, toward the back, cuts a rectangular hole at the intersection of the vertical and horizontal lines in the required channel of the tape.

The tape should never be punched in more than one channel on the same line. After the tape is punched, cut it and loop it into a belt. Glue the bottom end to

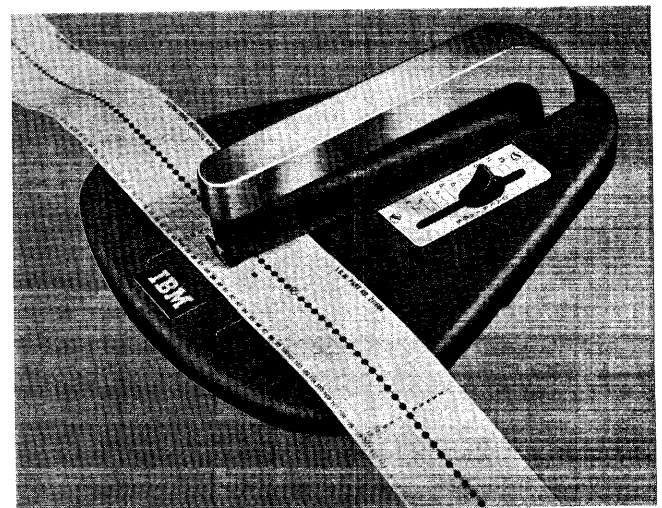


Figure 53. Carriage Tape Punch

the top section, marked *glue*, with the bottom line coinciding with the first line. Before the tape is glued, use an ink eraser to remove the glaze on the tape; if this is not done, the tape ends can come apart. The center feed holes should coincide when the two ends of the tape are glued together.

The last hole punched in the tape should be at least four lines from the cut edge, because approximately the last half inch of the tape overlaps the glued section when the two ends are spliced. If it is necessary to punch a hole lower than four lines from the bottom of the form, the tape should be placed with the top line (immediately under the glued portion) four lines lower than the top edge of the form, before making the channels. To compensate for the loss, the tape should then be cut four lines lower than the bottom of the edge of the form.

8 Lines-per-Inch Spacing

The control tape for 8 lines-per-inch spacing is punched as it would be for normal 6 lines-per-inch spacing. Each line on the tape always equals one line on the form, regardless of whether the latter is 6 or 8 lines per inch. In measuring a control tape for a document printed 8 lines to the inch on the form, every $\frac{1}{8}$ inch on the form represents one line on the tape.

Conditions to Consider When Punching a Carriage Tape

1. A channel-1 punch is required in the carriage tape for each form as the location of the first body line of printing.
2. A channel-9 or -12 punch in the carriage tape is used to indicate an overflow position of a form.

The buffered 1445 will operate as follows:

If a branch on channel 9 or 12 occurs immediately before printing, the last line on the form is printed one line above the channel-9 or -12 punch location in the carriage tape.

If a branch on channel 9 or 12 occurs during a carriage busy, the last line printed on the form is one line above the channel-9 or -12 punch location in the carriage tape.

If a branch on channel 9 or 12 occurs immediately after printing, the last line of printing corresponds to the channel-9 or -12 punch location in the carriage tape.

3. On an unbuffered 1445, a branch on channel 9 or 12 always interlocks the system. The last line of printing on the form is printed one line above the channel-9 or -12 punch location in the carriage tape.

Inserting Control Tape in Carriage

1. Raise the counterbalanced cover of the printer to gain access to the tape reading mechanism.
2. Turn the feed-clutch knob to disengage the clutch.
3. Raise the brushes by lifting the latch located on the side of the brush holder.
4. Place one end of the tape loop, held so that the printed captions can be read, over the pin-feed drive wheel so that the pins engage the center drive holes.
5. Place the opposite end of the loop around the adjustable carriage-control tape idler.
6. Remove the excess slack from the tape by loosening the locking knob on the idler and moving the idler in its track. Tighten the knob when the desired tension is reached. The tape should be just tight enough so that it gives slightly when the middle portions of the loop are pressed together. If it fits too tightly, damage can occur to the pin-feed holes.
7. Press the brushes into operating position until they latch, when the tape is in position.
8. Press the carriage restore key to bring the tape to its home position, and, with the forms located at the first print line, turn the feed-clutch knob back to the engaged position. The carriage is ready to operate.
9. Close the top cover and press the start key to place the printer in ready status.

IBM 1445 Printer Special Features

Selective Character Set

This feature provides the controls that are necessary to allow the 1445 printer to use other than the standard 56-character set. This feature is required for the two additional character sets: 14 and 42. Speeds for the two special character sets are:

42-character bar (Alphameric Type) 240 lpm

14-character bar (Standard Numeric Type) 525 lpm

Print Storage

This feature is required only when the 1445 is attached to a IBM 1401 Data Processing system. After the completion of the transfer, normal program execution is resumed while the printer writes a line from print storage. This increases the processing time by 290 ms when using the standard 56-character typebar. Normally, the processor is interlocked during a write-a-line operation.

Operating Pointers

Consider the following points when setting up or operating the IBM 1445 Printer:

Paper Brake

This control is located on the left side of the lower form guide (see Figure 52). It maintains a horizontal print line. It has six positions: 0 to 5. Turn the adjusting control clockwise to increase the amount of drag exerted on the form by the brake fingers. Excessive pressure results in tearing the forms. Too little pressure can result in a wavy line of printing or in unequal spacing.

When forms are inserted into the lower forms guide, the brake fingers must be retracted fully by turning the control (see Figure 52) as far as possible and locking it.

Typebar Insertion Wheel

This wheel is located on the right side of the carriage and on the upper rear of the typebar drive unit (see Figure 51). Manually rotating the wheel positions the typebar. Use it when inserting or removing a typebar in the printer. With the power on and the typebar switch set to the removal position to energize the typebar solenoid, the typebar can be removed or replaced. Then turn the typebar insertion wheel until the notch on the typebar flag of the 39-, 52-, or 63-character typebar is aligned properly to the decal.

The aligning notch on the 13-character typebar flag is the right edge of the upper section of the flag. This can be used as a reference when inserting the 13-character typebar into operating position. Be careful to avoid damage to the typebar.

When a typebar has been changed, press the printer reset key before the start key to prevent a sync-check indication.

Form Thickness Adjustment

The platen can be adjusted toward or away from the typebar by the platen positioning knob to compensate for the number of carbon copies used.

The adjustment is made through a knob and detent combination below the left end of the carriage (see Figure 52). Control setting 3 is the standard position for the average one-part form of regular weight paper. For increasing thickness the knob should be turned counterclockwise.

Sixteen positions are provided by the control. To insert a new form, the control should be turned fully counterclockwise then readjusted before printing is started.

Manual Clutch

After forms have been advanced manually and the manual clutch has been engaged, the form-advance knob should be rotated back and forth slightly to ensure that the detent has seated. Also check the forms to see that they are taut. If these conditions are met, the first and second lines of printing are even after the form has been manually shifted.

Ribbon Replacement

It is easier to replace the ribbon with the typebar removed. This prevents the possibility of machine damage due to the ribbon being inserted between the type fingers accidentally. Similar damage can be caused if ribbons are used after they have worn through or frayed.

Installing Magnetic Ink Ribbon

This procedure describes the method of installing a magnetic ink ribbon on the IBM 1445 Printer.

1. Pull the upper ribbon support and print-line indicator handle to the front of the machine to permit clearance for the ribbon to be placed into the ribbon roll supports. When this handle is in the open position, the form-check light is on.
2. Retract the platen by turning the platen positioning control knob to the rear (counterclockwise) for maximum clearance between the platen and the typebar.
3. Release the paper brake control by moving it down past zero.
4. Release the form guide by pulling the latch to the left to the limit of travel. This latch is located on the left side of the paper guide near the top. The handle is free swinging and hangs downward. This latch also has an interlock switch which operates the form-check light.
5. To gain more clearance between the form guide position, push the left end of the form guide to the rear of the machine until it latches against the magnetic latch. This latch will hold the form guide open for maximum clearance.
6. Remove the magnetic ink ribbon from the shipping carton and hold the ribbon so that the full spool is on the top with the shiny side toward the operator. Unroll enough of the ribbon to permit the empty spool to be under the base of the printer so that the ribbon between the two spools can be fed between the guides from the left side of the machine.

The magnetic ink ribbon operates in front of the form guide and in back of the typebar. By moving the ribbon slowly toward the right of the machine, the upper ribbon spool can be placed in the upper ribbon support mounting. After the upper spool is in place, position the lower spool on the left ribbon spool support (spring loaded) for the lower mounting. By pushing the spool to the left on the left ribbon spool support, clearance is made for the spool to be placed in position on the right spool support. When the lower ribbon spool is in position on the lower supports, rotate the spool so that the drive spool support on the right engages the notches on the spool. When the drive spool support is properly engaged, a clicking of the ratchet can be heard as the spool is rotated manually.

7. After the ribbon is mounted, pull the form guide free of the magnetic latch so that it is returned to its normal position.
8. Engage the form-guide latch located on the upper left end of the form guide by pushing the latch firmly to the right. This latch also operates an interlock switch which turns on the form-check light.
9. Restore the platen to the normal printing position by turning the platen positioning knob clockwise. The position of the platen is determined by the form being used and the print quality. When the platen positioning knob is fully retracted, this also is interlocked and turns on the form-check light.
10. Restore the upper ribbon support and print-line indicator to its operating position by moving the handle toward the platen to the fixed stop. This is also interlocked by a switch which operates the form-check light.
11. Set the form brake to apply the proper tension on the paper so that the paper will not rub on the magnetic ink ribbon and the printing alignment is evenly spaced as the paper moves through the machine.
12. Remove the slack from the ribbon which is left after the upper ribbon support and print-line indicator has been placed in position by manually turning the lower ribbon spool until the upper ribbon spool begins to turn. This operation puts the proper tension on the magnetic ink ribbon.
13. The end-of-ribbon condition is sensed when the ribbon moves to a point indicated by a piece of foil. This is sensed and the end-of-ribbon light comes on. When this light is on, the machine cannot be restarted until the ribbon is replaced and the reset key is operated to turn off the end-of-ribbon light.
14. Conditions that must be rechecked if the form-check light stays on:
 - a. Form guide plates located above the form tractor doors
 - b. Platen positioning control
 - c. Form-guide latch
 - d. Upper ribbon support and print-line indicator handle.

IBM 729 and IBM 7330 Magnetic Tape Units

Magnetic tape units in an IBM 1401 system function as both input and output devices. Tape is a principal medium for storing files of data for processing, and it also serves as storage for intermediate results of computations. Besides being used to store data, tape can be used to store program steps, thus setting up a *library* or file of procedures.

Reading from or writing on tape is performed in a tape unit, under control of the processing unit. The IBM 1401 can use any of four models of the IBM 729 Magnetic Tape Unit (Models II, IV, V, or VI), or an IBM 7330 Magnetic Tape Unit (Figures 54 and 55).

As many as six tape units can be attached to the system. All tape units in the system must be the same model, unless the tape-intermix special feature is installed. This feature makes it possible to have any of the units, in any combination, connected to the 1401 system at one time.

The various tape units are similar in general appearance and operation. They differ primarily in the speed

at which the tape is moved past the read-write head, and in the quantity of data recorded per inch of tape (density). The rate of speed is expressed in inches per second, and the density rate is expressed in characters per inch (cpi).

All models of the IBM 729 and the IBM 7330 have dual density. That is, they can read or write at either a high-density or low-density rate. This is controlled by a key (729) or switch (7330) on the tape unit. The number of characters recorded in high or low density varies with the model of the tape unit. These rates, and the rates of speed, are summarized in Figure 56.

On the IBM 729, Model V, the density rate can be further affected by the 800 cpi special feature and TAPE DENSITY switch on the 1401 auxiliary console. This switch is used to select pairs of densities: 200/556, 200/800, or 556/800. Then the high or low density selected on the tape unit operates in conjunction with the pair selected on the console.

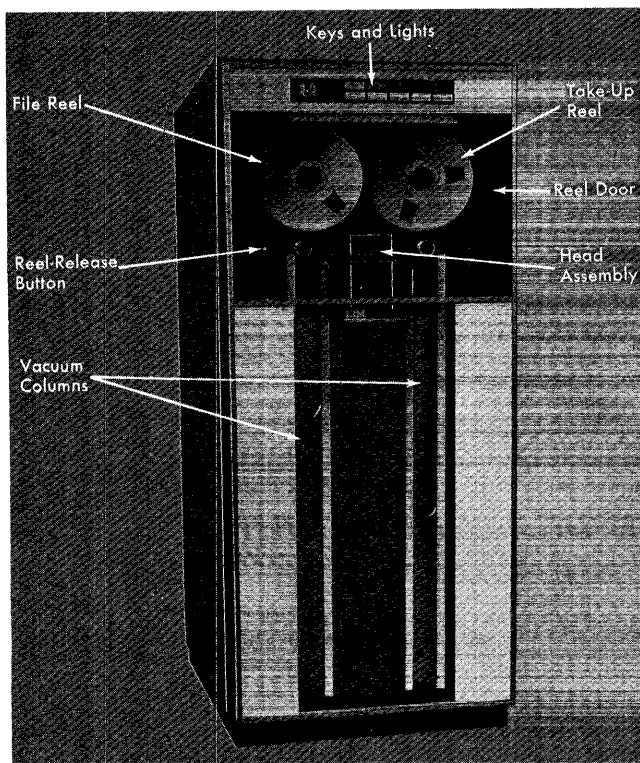


Figure 54. IBM 729 Magnetic Tape Unit

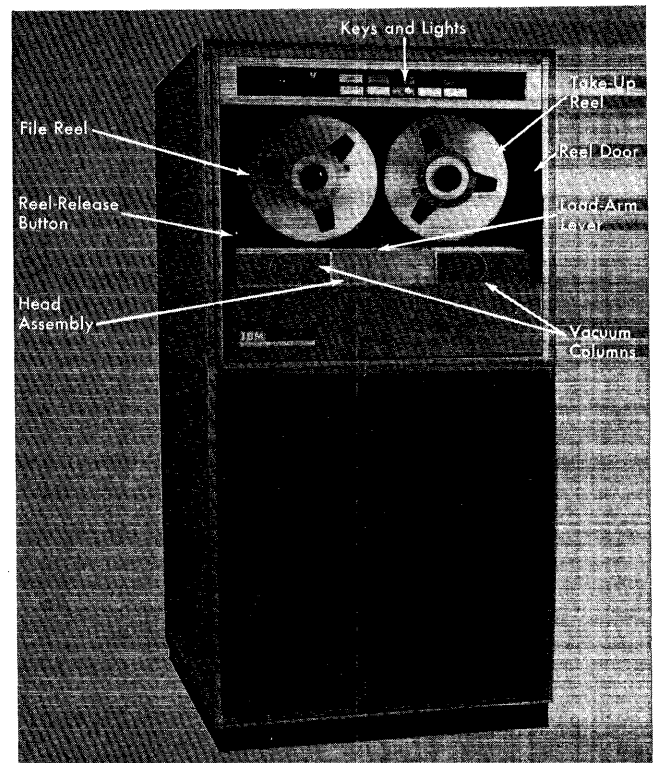


Figure 55. IBM 7330 Magnetic Tape Unit

OPERATING CHARACTERISTICS	7291I	7291V	729V*	729V1	7330
Density (Characters per Inch)	Low→ 200 or High→ 556	200 or 556	200 556 or 800	200 or 556	200 or 556
Tape Speed (Inches per Second)	75	112.5	75	112.5	36
Interrecord Gap Size (Inches)	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$
Character Rate (Characters per second)	Low Den→ 15,000 or High Den→ 41,667	22,500 or 62,500	15,000 41,667 or 60,000	22,500 or 62,500	7,200 or 20,016
High-Speed Rewind (Minutes)	1.2	.9	1.2	.9	2.2
Regular Rewind (Inches per Second)	75	112.5	75	112.5	36
* Density and Character Rate affected by Tape Density Switch on 1401 Auxiliary Console.					

Figure 56. Tape-Unit Characteristics

Tape Records

Magnetic tape is made of plastic material, coated with a metallic oxide. It can be 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 "written" on the tape. The magnetic spots, representing information written on the tape, remain unchanged unless they are written over. Any write operation destroys the previous recording. Thus, a reel of tape can be used for permanent storage of data, or it can be used again and again for temporary storage.

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

In the 1401 system, characters are recorded on tape in binary-coded decimal (BCD) code, the same code as used in core storage. (See *IBM 1401 System Logic: BCD Codes* for this coding pattern.) Data is stored sequentially and forms tape records. These records are not restricted to a fixed number of characters, but may be of any practical size, within the limits of a working area assigned in the computer. This feature permits writing all information pertinent to an item in a single continuous data record. As much information as is needed can be conveniently included in its most compact form.

Records, or blocks of records, are separated on tape by an *interrecord gap* (IRG) — a length of blank tape about $\frac{3}{4}$ " long. During writing, the gap is automatically produced at the end of a record or block of records. Reading of the record block begins with the first character after a gap, and continues without interruption until the next gap is reached. A single record or block of records is, therefore, defined or marked by an interrecord gap before and after the data.

An interrecord gap, followed by a special single-character record known as a *tape mark*, is used to mark the end of a file of information. One or more files of data may be written on one reel of tape.

Tape may be backspaced under computer control. In this case, tape motion reverses until the previous interrecord gap is reached. This feature provides for rereading or rewriting a record or block of data when an error condition is detected.

If an error condition is detected during operation, the machine can be instructed to backspace and try again to correct the error. If an error cannot be corrected automatically by rewriting or skipping tape, instructions may stop the machine and indicate to the operator where the failure occurred so that appropriate action may be taken.

If an error has developed in storage, however, no rewriting operation can correct the condition. In this case, the machine is usually instructed to stop so that some manual correction to the record can be made. When this is not feasible, the error record may be written by an output unit for later correction.

Tape Markers

Magnetic tape must have some blank space at the beginning and end of the reel to allow threading through the feed mechanism of the tape unit. Reflective markers are placed on the tape (Figure 57) to enable the magnetic tape unit to sense the beginning and the end of the usable portion of tape. Photoelectric cells in the tape unit recognize a marker as either a *load-point* marker (where *reading* or *writing* is to begin) or an *end-of-reel* marker (where *writing* is to stop). The tape unit does not recognize the end-of-reel marker when *reading* tape. Instead, the tape mark written on the tape signals an end-of-reel condition.

The markers are small pieces of transparent plastic with a thin film of aluminum on one side. Pressure-sensitive adhesive covers the aluminum film. The markers are fastened manually to the shiny (uncoated) side of the tape. New reels of tape obtained from IBM have these markers in position, but they may be placed by the operator if a different location is required.

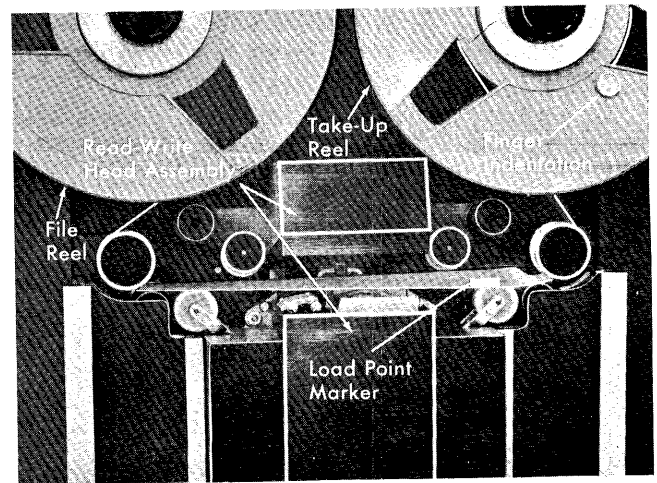
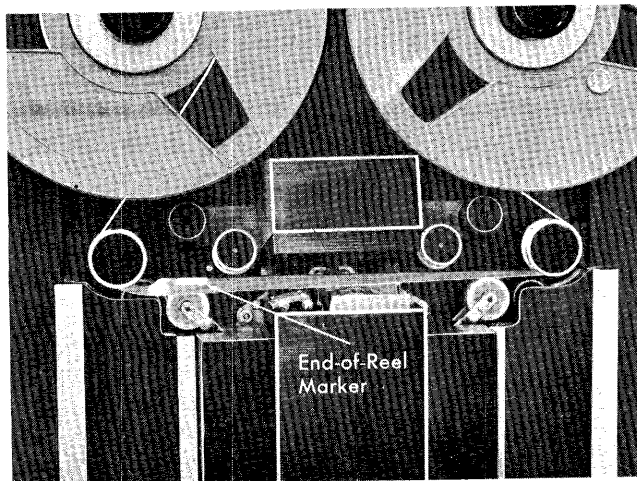


Figure 57. IBM 729 Tape Path

The markers should be placed carefully on the tape. They should be properly aligned and pressed tightly onto the tape with the *back* of a fingernail. It is best to do this while the tape is mounted in a tape unit to reduce the collection of dust on the unrolled portion of tape. If it must be done away from the machine, the unrolled end should be kept off the floor and away from dust.

Load-Point Marker

At least 10 feet of tape must be allowed between the beginning of the reel and the load-point marker, as a leader for threading the tape in the tape unit. More than ten feet may be allowed by placing the marker at any desired distance from the beginning of the reel. To indicate the load point, the marker must be placed parallel to and not more than $\frac{1}{2}$ " from the edge of the tape nearest the operator, when the reel is mounted.

End-of-Reel Marker

About 14 feet of tape are usually reserved between the end-of-reel marker and the end of the tape. This space includes at least ten feet of leader and enough tape to hold a record of 9600 characters after the end-of-reel marker is sensed. New reels can be supplied with this marker placed wherever desired to accommodate checkpoint records from different systems. The marker must be placed parallel to and no more than $\frac{1}{2}$ " from the edge of the tape away from the operator, when the reel is mounted.

Features

Tape Reels

Tape reels are made of a plastic material and have a $10\frac{1}{2}$ " diameter. A reel can hold 2400 feet of tape, or it can be used with a minimum of 50 feet. A full reel weighs about four pounds and can contain data equivalent to that in 200,000 fully punched 80-column cards (at 556 characters per inch, discounting interrecord gaps. A 2,400-foot reel can contain approximately 13 million characters, assuming records 2,000 characters in length, written at 556 characters per inch.)

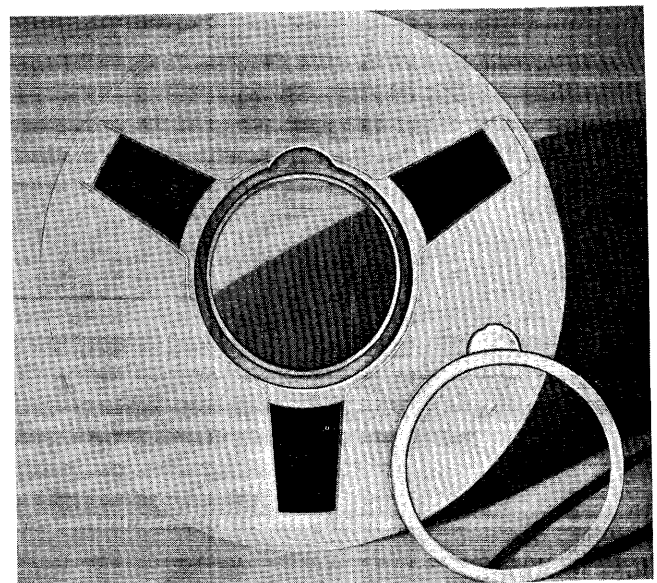


Figure 58. Tape Reel and File Protect Ring

Each reel is equipped with a *file-protection* ring (Figure 58) that can be used to safeguard data written on the tape. This is a red plastic ring that fits in a groove in the back (machine side) of the reel. When the ring is removed, data *cannot* be written on the tape—*no ring, no write*—but the tape-data can be read for processing. Thus, the tape is protected from accidental writing, which would erase previous file records. When the ring is inserted, data can be either written on or read from the tape.

Any tape operation requires two tape reels. A *file* reel, containing tape to be read or written, is mounted on the left-hand hub in the tape unit. An empty *take-up* reel is mounted on the right-hand hub. In a setup operation, the lead end of the tape is threaded through the tape unit onto the take-up reel. Then during any read or write operation, the tape unwinds from the file reel and winds onto the take-up reel. Both reels move in a clockwise direction. Since the tape records are in reverse order on the take-up reel at the completion of a job, tape is normally rewound to the file reel. During the rewind, both reels move in a counterclockwise direction.

The tape reels turn automatically as needed to wind the tape, when the tape unit is under program control. Under manual control, the operator can turn the tape reels by key (such as LOAD REWIND) or by hand. To turn a reel by hand, the operator uses the finger indentation in the reel, and must unlatch the reel by pressing the reel-release button.

Reel-Release Button

This white button (see Figures 54 and 55) is located below the left-hand tape reel, and is accessible when the reel door is open. It must be held pressed to turn either tape reel by hand.

NOTE OF CAUTION: The effect of the 7330 file-protect ring will be lost if the reel-release button is pressed after the tape unit is loaded and in ready status.

Reel Door

This glass door covers the tape reels and read-write head assembly. An interlock prevents any automatic or key-controlled operation when this door is open. In addition, the door should never be opened when the READY light is ON or during a load, rewind, or unload operation. With the door open during any of these operations, the tape could become damaged.

Read/Write Head Assembly

The read/write head assembly is between the two tape reels. As tape passes from one reel to the other it feeds through this assembly, with the shiny side of the tape up. The magnetically coated side is down.

The assembly is built in two sections. The lower section is stationary, and the upper section pivots up (open) and down (closed). When the assembly is open, the operator can thread or remove the tape. When the assembly is closed, the tape is held in contact with the read/write head, which is located in the lower section. This is the mechanism that actually reads data from tape or writes data on tape, when the tape unit is under automatic control and a READ or WRITE program instruction is executed. The read/write head is known as a *two-gap* head. Writing on tape is performed at the first gap that the tape passes. At the second gap, tape characters are read. This reading occurs on a READ program instruction, or for checking purposes on a WRITE instruction.

In the IBM 729, the assembly is closed by pressing the LOAD REWIND key. It is opened by pressing the UNLOAD key, or by executing a REWIND TAPE AND UNLOAD program instruction. The head assembly must be open before the operator opens the reel door to make any manual adjustment.

In the IBM 7330, the assembly is closed manually by pivoting the load-arm lever to a vertical position. It can be opened manually by pivoting the load-arm lever to the right. When the tape is not rewound to the load point, the head assembly can be opened by pressing HIGH SPD REWIND or by executing a REWIND TAPE AND UNLOAD program instruction.

Load-Arm Lever (7330)

When this lever (see Figure 55) is manually pivoted to the left, to a vertical position, it closes the head assembly and seats the load arm for tape feeding. When it is pivoted to the right, it opens the head assembly and raises the load arm. Tape can then be threaded through, or removed from, the tape unit.

Vacuum Columns

During automatic operation, tape passes through two vacuum columns, as it is fed from one reel to the other. One column is located on each side of the read/write head assembly. In the 729, the columns are vertical. In the 7330, they are horizontal.

The tape forms a loop in each column. These loops act as cushions for the sudden start and stop motion of the tape past the read/write head. Tape moves past the read/write head spasmodically under program control, but the tape reels do not necessarily turn at the same time. Vacuum-actuated switches in the columns permit each reel to rotate independently. The file reel feeds tape when the loop in the left-hand column reaches a prescribed minimum length. The take-up reel

winds tape when the loop in the right-hand column reaches a point near the bottom (729) or right end (7330) of the column.

In the IBM 729, tape is loaded into the columns by pressing the LOAD REWIND key. It is removed from the columns by pressing the UNLOAD key or by executing a REWIND TAPE AND UNLOAD program instruction. The tape must be removed from the columns before the operator opens the reel door to perform any manual operation.

In the IBM 7330, tape is loaded manually by the operator (see *Loading Tape in the IBM 7330*), and it can be removed manually. If the tape is not rewound to the load point, it can be removed by pressing HIGH SPD REWIND or by executing a REWIND TAPE AND UNLOAD program instruction.

Address Selection Dial

This dial (Figure 59) assigns a number to the tape unit, to associate the unit with the tape-drive number specified in the stored program. Because a maximum of six tape units can be attached to the system, this dial may be set at any number 1-6. If some other number (7, 8, 9, 0, or blank) is selected, the tape unit cannot be used by the stored program. When two or more tape units are used in the same job, each unit must be assigned a different number.

A dial setting should never be changed while a tape operation is in process. This applies to *any* unit, regardless of whether or not that particular unit is assigned to the job in process.

Keys and Switches

The corresponding keys on the IBM 729 and on the IBM 7330 (Figure 59) perform generally the same functions. Wherever there is a difference, the applicable tape unit is specified in the following sections.

Load Rewind (729)

This key rewinds tape onto the file reel to its starting point (*load point*). It is used at two main times in any tape operation:

1. At the beginning of a job, to position the tape for reading or writing the first record.
2. At the completion of a job, to rewind all tape onto the file reel ready for unloading.

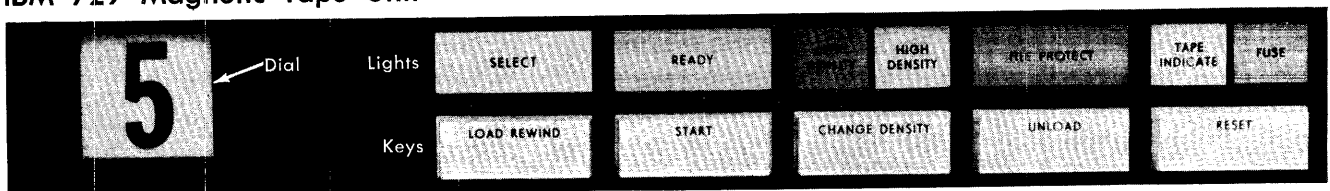
The LOAD REWIND key is effective only when the reel door is closed and the READY light is OFF.

When tape is properly mounted in the tape unit at the beginning of a job, pressing this key:

1. Lowers (loads) tape into the vacuum columns.
2. Closes the head assembly.
3. Moves tape to the left (rewind direction) until the load-point reflective marker is sensed. If the tape was mounted with the marker erroneously positioned to the left of the head assembly, the tape will unwind from the take-up reel.

When a job is completed, pressing this key rewinds tape from the take-up reel to the file reel until the load-point reflective marker is sensed. For this operation a

IBM 729 Magnetic Tape Unit



IBM 7330 Magnetic Tape Unit

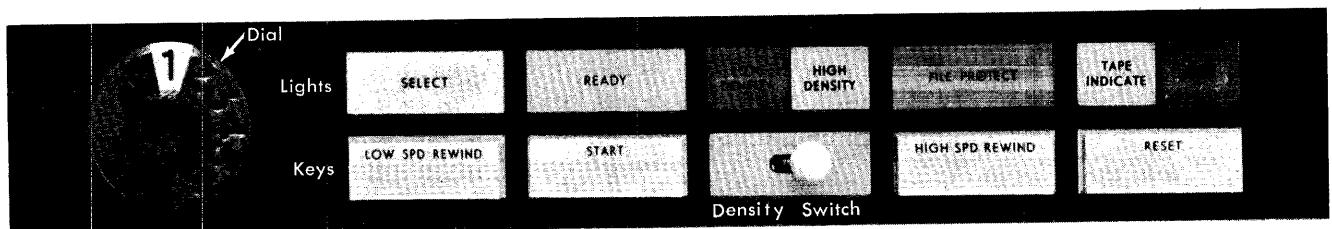


Figure 59. IBM 729 and IBM 7330: Keys, Lights and Switches

low-speed rewind is initiated if the take-up reel contains less than one-half inch of tape (less than 450 feet). If the take-up reel contains more than one-half inch of tape, however, a high-speed rewind (an average of 500 inches per second) is initiated. In a high-speed rewind, tape is automatically removed from the vacuum columns, the head assembly is opened, and tape is rewound at high speed until less than one-eighth inch of tape remains on the take-up reel. This measurement is controlled by a light-beam and photocell mechanism in the tape unit. After the high-speed rewind, tape is automatically lowered into the columns, the head assembly is closed, and a low-speed rewind continues until the marker is sensed.

Whenever this key has been pressed, the reel door must remain closed until the rewind operation is completed. If it were opened, the tape could be broken or damaged.

Low Spd Rewind (7330)

This key is used for two main functions:

1. To position the tape at its *load* point (starting point) for reading or writing the first tape record. When tape has been loaded in the vacuum columns, pressing this key rewinds the tape onto the file reel at low-speed (in-column) until the load-point reflection marker is sensed. If the tape was loaded with the marker erroneously positioned to the left of the head assembly, the tape will unwind from the take-up reel.
2. To rewind tape onto the file reel at the completion of a job, ready for unloading. Tape rewinds at low-speed until the load-point reflective marker is sensed.

The LOW SPD REWIND key is effective only when:

- The reel door is closed,
- The READY light is OFF,
- Tape is in the vacuum columns, and
- The head assembly is closed.

Whenever this key has been pressed, the reel door must remain closed until the rewind operation is completed. If it were opened, the tape could be broken or damaged.

Start

This key readies the tape unit for automatic operation, and turns ON the READY light. It is effective only when:

- The reel door is closed,
- Tape is loaded in the vacuum columns, and

- Tape is not in the process of loading or rewinding to the load point. If START is pressed during a rewind operation, the READY light turns ON when rewinding is completed.

Pressing this key makes all other keys, except RESET, inoperative.

Change Density (729)

Pressing this key changes the density rate of the tape unit from its previous setting (from low to high, or from high to low). The density rate in effect is indicated by the LOW DENSITY or HIGH DENSITY light, and must agree with the density rate of the tape being processed. This key is effective only when the READY light is OFF.

Density Switch (7330)

This toggle switch sets the tape operation for low density (left) or for high density (right), and the corresponding density light turns ON. The setting must agree with the density rate of the tape being processed. This switch is effective only when the READY light is OFF.

Unload (729)

This key performs these three functions:

1. Opens the head assembly.
2. Removes the tape from the vacuum columns regardless of the distribution of tape on the two reels. If the tape has not been rewound to the file reel, the LOAD REWIND key should be pressed before UNLOAD.
3. Turns OFF the TAPE INDICATE light, if it is ON.

It is effective only when the reel door is closed and the READY light is OFF.

High Spd Rewind (7330)

This key:

1. Removes the tape from the vacuum columns.
2. Opens the head assembly.
3. Rewinds tape onto the file reel at high speed until the reflective marker is detected.
4. Turns OFF the TAPE INDICATE light, if it is ON.

It is effective only when:

- The reel door is closed,
- The READY light is OFF, and
- The tape is not rewound to the load point.

Whenever this key has been pressed, the reel door must remain closed until the unload and rewind operations are completed. If it were opened, the tape could be broken or damaged.

Reset

This key changes the tape unit from automatic to manual control (making the other keys operative), and turns OFF the READY light.

On a 729, this key also stops any machine operation in process, except unload or rewind. Once started, an unload operation is always completed. If a high-speed rewind is in process when RESET is pressed, rewinding shifts to low speed. If a low-speed rewind is in process, RESET stops the operation.

On a 7330, this key stops any operation in process. However, to avoid possible damage to the tape, do not press this key during a high-speed rewind.

Lights

The corresponding lights on the IBM 729 and on the IBM 7330 (Figure 59) indicate generally the same conditions. Wherever there is a difference, the applicable tape unit is specified in the following sections.

Select

When the tape unit is under automatic control (READY light ON), the yellow SELECT light turns ON whenever processing selects this unit for a tape operation. This is determined by the execution of a tape program instruction that contains the number of this unit (as set up in the address selection dial).

Ready

This light indicates that the tape unit is ready for automatic operation. It is turned ON by pressing the START key (see *Keys and Switch: Start* for the setup required for starting).

When READY is lighted, all keys except RESET are inoperative. This light is turned OFF, and the tape unit is placed under manual control, by pressing the RESET key.

The reel door should never be opened when the READY light is ON.

Low Density/High Density

These lights indicate the density rate (low or high) in which the tape unit is operating. This must agree with the density rate on the tape being processed.

On the 729, HIGH DENSITY turns ON when power is initially turned ON in the system. The density rate can

be changed to low by pressing the CHANGE DENSITY key. The red LOW DENSITY light turns ON. Each time this key is pressed (with the READY light OFF) the density rate is switched from its previous setting.

On the 7330, the red LOW DENSITY light is ON if the density switch is set to the left. The HIGH DENSITY light is ON if the switch is set to the right.

File Protect

When this light is ON, it indicates that tape in this unit can be read but *not* written on, because a tape reel *without* a file-protection ring has been mounted. This light also turns ON when no file reel is mounted, when a load, rewind, or unload operation is in process, or when the machine is under manual control (READY light OFF).

This light turns OFF when a tape reel that has a file-protection ring is mounted and in process. This tape can be either read or written. (See *Reel Release Button*.)

Tape Indicate

This light is turned ON by:

- Sensing the end-of-reel reflective marker during a tape-writing operation.
- Reading a tape mark during a tape-reading operation.

This light is turned OFF by pressing UNLOAD (729) or HIGH SPD REWIND (7330), or by executing a REWIND TAPE AND UNLOAD OR BRANCH IF END OF REEL program instruction.

Fuse

This red light turns ON whenever a fuse or circuit breaker in the tape unit is open. The IBM customer engineer should be called to correct this condition.

Meter Switch, IBM 729 and IBM 7330

If the use-meter switch is not set to ON or the tape unit is not ready before an instruction calls on this unit, the system interlocks and the processing unit use-meter continues to run.

Meter Time, IBM 729 and IBM 7330

The time meters on 729 and 7330 magnetic tape units start when the first tape operation affecting the particular tape unit is issued. The meter stops when the tape unit receives and completes a rewind unload command. The meter can be stopped by manually unloading the unit, or by pressing and releasing the reset key. (See *Meter Switch, IBM 729 and IBM 7330*.)

Operations

Loading Tape in the IBM 729

1. Determine whether the file reel should or should not have the file-protection ring.
2. Mount the file reel on the left-hand mounting hub. Push the reel firmly against the stop on the hub. Push near the center of the reel (*not* at the outer edge) to avoid possible damage to the tape.
3. Tighten the hub knob securely. The hub contains a rubber rim that grips the reel. Do not use excessive force, however, because that might strip the threads.
4. Place an empty reel (take-up reel) on the right-hand mounting hub, and tighten the hub knob securely.
5. While pressing the reel-release button, rotate the file reel clockwise to unroll about four feet of tape.
6. Thread the tape (Figure 60):
 - a. Over and around the left-hand roller,
 - b. Through the head assembly, and
 - c. Under and around the right-hand roller.

As the tape passes through the head assembly, the shiny side of the tape should be up.

7. Place an opening in the take-up reel at "one o'clock." Thread the tape on the reel in a clockwise direction until the end is at this opening.
8. While pressing the reel-release button with your left hand, hold the tape-end against the hub with the index finger of your right hand and rotate the take-up reel clockwise until one or two loops of tape are wound onto the reel.

Align the tape carefully on the reel to prevent damage to the edge on the first few turns.
9. Withdraw your index finger, and use the finger indentation on the tape reel to continue spinning the reel. Do not hold the cut-out area of the reel because this can nick or curl the edge of the tape. Turn the reel until tape is wound for at least two turns beyond the load-point reflective marker.

If you are reusing tape that is already mounted but has been unloaded, start with this step. Wind about three turns onto the take-up reel to prevent the lead end of the tape from coming off the take-up reel when LOAD REWIND is pressed (in step 11).
10. Close the reel door.
11. Press LOAD REWIND. This loads tape into the vacuum columns, closes the head assembly, and re-winds tape to the load point.

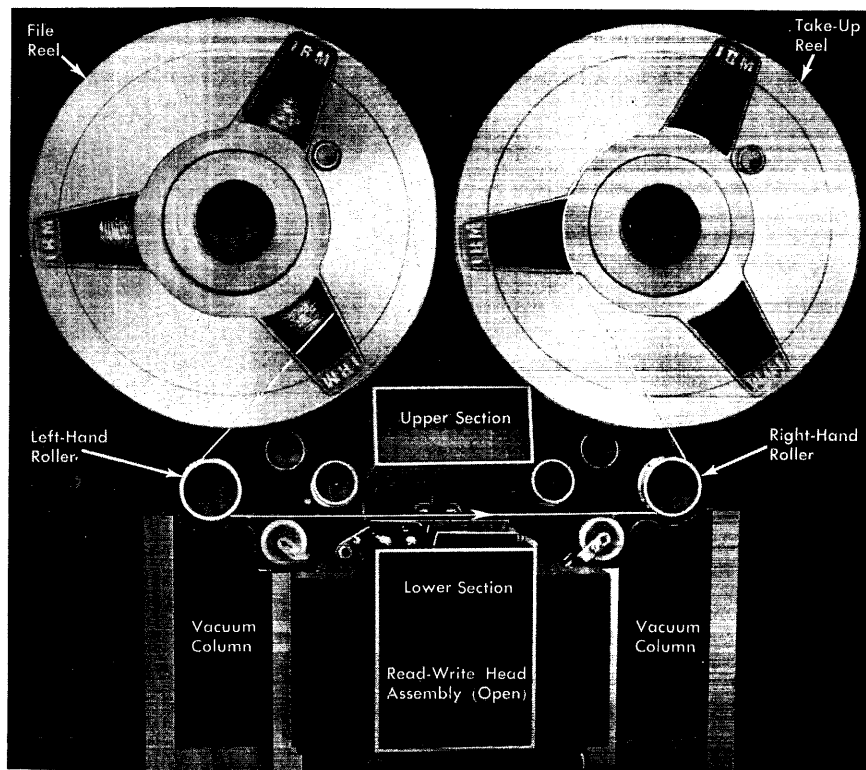


Figure 60. IBM 729 Tape Threading

If the lead end of the tape comes off the take-up reel, it may be that the end was not held securely against the hub or the reflective marker was not wound onto the take-up reel. Press RESET and UNLOAD, and repeat steps 6-11.

12. Set the address selection dial to the number specified in your operating instructions.
13. Press START. This places the tape unit under automatic control, and turns the READY light ON. Check the FILE PROTECT light. If the file-protection ring has been removed from the file reel, this light should be ON. If it is not, notify the IBM customer engineer.

Loading Tape in the IBM 7330

1. Determine whether the file reel should or should not have the file-protection ring.
2. Mount the file reel on the left-hand mounting hub. Push the reel firmly against the stop on the hub. Push near the center of the reel (*not* at the outer edge) to avoid possible damage to the tape.
3. Tighten the hub knob securely. The hub contains a rubber rim that grips the reel. Do not use excessive force, however, because that might strip the threads.
4. Place an empty reel (take-up reel) on the right-hand mounting hub and tighten the hub knob securely.
5. While pressing the reel-release button, rotate the file reel clockwise to unroll about two feet of tape.
6. Open the head-assembly cover.
7. Thread the tape as shown in the illustration on the inside of the head-assembly cover and in Figure 61:
 - a. Around the right side of the left-column idler,
 - b. Around the end of the load arm,

- c. Through the head assembly and over the right-hand tape guide,
- d. Between the feed and stop rollers and the rocker arm,
- e. Under and around the idler, and
- f. Around the left side of the right-column idler.

As the tape passes through the head assembly, the shiny side of the tape should be up.

8. Place an opening in the take-up reel at "one o'clock." Thread the tape on the reel in a clockwise direction until the end is at this opening. (See Figure 60 for an illustration of winding tape on reels.)
9. While pressing the reel-release button with your left hand, hold the tape end against the hub with the index finger of your right hand and rotate the take-up reel clockwise until one or two loops of tape are wound onto the reel.

Align the tape carefully on the reel to prevent damage to the edge on the first few turns.
10. Withdraw your index finger, and use the finger indentation on the tape reel to continue spinning the reel. Do not hold the cut-out area of the reel because this can nick or curl the edge of the tape. Turn the reel until tape is wound for at least two turns beyond the load-point reflective marker.

If you are reusing tape that is already mounted but has been unloaded, start with this step. Wind about three turns onto the take-up reel to prevent the lead end of the tape from coming off the take-up reel when LOW SPD REWIND is pressed (in step 15).
11. While pressing the reel-release button, lower the load arm by moving the load-arm lever to the left.
12. Release the reel-release button for a few seconds to allow a vacuum to build up in the vacuum columns.

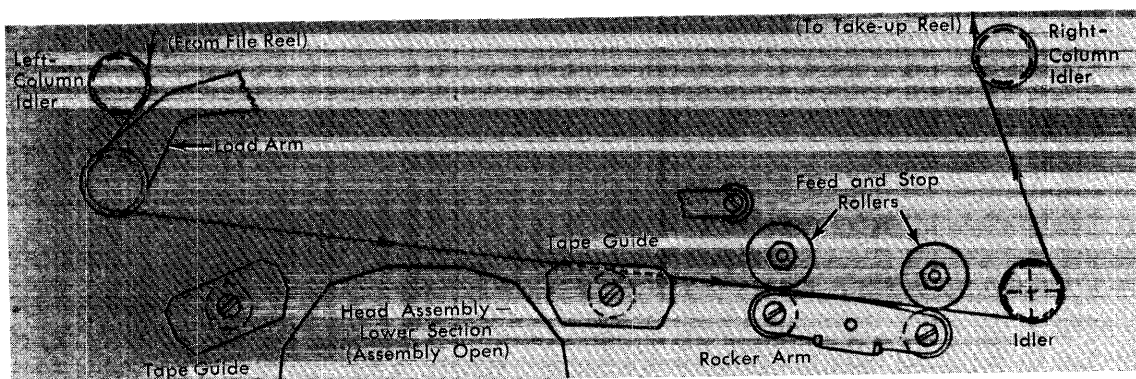


Figure 61. IBM 7330 Tape-Threading

13. Load tape by pressing the reel-release button, and rotating the left-hand reel clockwise and the right-hand reel counterclockwise. The vacuum pulls the tape loops into the columns.
14. Close the head-assembly cover and the reel door.
15. Press **LOW SPD REWIND**. This rewinds tape to the load point. If the lead end of the tape comes off the take-up reel, it may be that the end was not held securely against the hub or the reflective marker was not wound onto the take-up reel. Press **RESET** and **HIGH SPD REWIND**, and repeat steps 6-15.
16. Set the address selection dial to the number specified in your operating instructions.
17. Press **START**. This places the tape unit under automatic control, and turns the **READY** light **ON**. Check the **FILE PROTECT** light. If the file-protection ring has been removed from the file reel, this light should be **ON**. If it is not, notify the **IBM** customer engineer.

Removing the File Reel

Before the file reel of tape can be removed from the tape unit, the tape must be rewound and unloaded from the vacuum columns and reading mechanism. These functions can be performed automatically by program instruction or manually by key depression. For a completely manual operation, follow the steps outlined below. When the rewind and unload are performed automatically, start with step 4 to remove the file reel.

1. Press **RESET** to change the unit from automatic to manual control. This turns the **READY** light **OFF**.
2. On the 729, press **LOAD REWIND** to rewind the tape onto the file reel. When the load-point marker is sensed and rewinding stops, press **UNLOAD** to remove tape from the vacuum columns and to open the head assembly.
3. On the 7330, press **HIGH SPD REWIND** to open the head assembly, remove the tape from the vacuum columns, and rewind it onto the file reel. If the tape is already rewound to the load point, manually open the head assembly by pivoting the load-arm lever to the right, and remove the tape from the columns.
4. Open the reel door.
5. While pressing the reel-release button, rotate the file reel counterclockwise to wind the remainder of the tape onto the file reel. Use the finger indentation on the reel to turn the reel.
6. Loosen the hub knob and remove the file reel. If resistance is encountered, exert pressure from the

rear of the reel. Place your hands as near the center of the reel as possible to avoid pinching the edges together and possibly damaging the tape. Never rock a reel by grasping it at the outer edge.

Protecting Tape from Foreign Particles

Magnetic tape requires careful handling to protect it from foreign particles. If particles accumulate between the tape and the read-write head of the tape unit, they can significantly reduce the effective intensity of reading and writing impulses. The following procedures should be observed to reduce the possibility of tape read-write errors caused by dust and dirt:

1. Keep each reel of tape in a dustproof container when it is not in use on a tape unit. When a reel of tape is to be used, take it directly from its container. When a reel of tape is removed from a tape unit, immediately replace it in a container. While a reel of tape is on a tape unit, keep the container closed tightly to minimize the accumulation of dust in the container.
2. Store tape-reel containers in a cabinet elevated from the floor and away from paper and cards, which may be sources of dust. This should minimize the transfer of dust from the outside of the container to the reel during loading or unloading operations.
3. Do not use the top of a tape unit as a work area. Placing things on the tape unit exposes them to heat and dust from the blowers in the unit, and may interfere with the cooling of the unit.
4. To label a reel of tape externally for identification, use a material that can be removed without leaving a residue. Adhesive stickers that can be applied and removed easily are most satisfactory. Never use an eraser to alter the identification on a label.
5. Place reflective markers (indicating the load point and the physical end of a tape) on tapes with care. Trouble may result if the tape is soiled or damaged in this process. If possible, apply the reflective markers while the tape is mounted in a tape unit. If the markers are applied while the tape is away from a tape unit, keep the unrolled end of the tape off the floor and away from dusty areas.
6. Inspect the tape-reel containers periodically. To remove any accumulated dust, wash the containers with a regular household detergent.
7. Clean Mylar* tape by wiping it gently with a clean, lint-free cloth moistened with an **IBM**-recommended tape transport cleaner. This cleaner must never be used on **IBM** heavy duty (HD) magnetic tape, how-

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

ever. HD magnetic tape can be cleaned by wiping with a dry cloth only. Do not use carbon tetrachloride or IBM cleaning fluid for cleaning any magnetic tape.

8. The regularity with which tape drives must be cleaned depends on the amount of usage they receive. Generally speaking, if tape drives are heavily used, they should be cleaned once each eight-hour shift and before each long sort. The most important parts to clean are: the read-write head, the bases of the vacuum columns, and the hard rubber rollers (capstans) that move in and out as the tape is loaded and unloaded. The other metal, plastic, and hard rubber rollers (both stationary and moving) should be cleaned regularly.

The IBM 729 vacuum columns are opened by sliding the column latches down and out toward you. They are latched by folding the latch in toward the column, and sliding the latch upward. Be sure that the column is securely latched after cleaning.

The IBM 7330 vacuum columns are opened by pulling the top of the column down toward you. The column nearest the front tape unit door is spring loaded to ensure that it is closed before the front tape unit door is closed.

Protecting Tape from Nicks and Kinks

To read and write information properly on magnetic tape, the edges of the tape must be free from nicks and kinks. Information is recorded on magnetic tape to within 24-thousandths-of-an-inch of the edges of the tape.

To protect the tape:

1. Handle tape reels near the center of the reel. If resistance is encountered in removing a reel from a tape unit, exert pressure on the back of the reel with the hands as near the center of the reel as possible. Never rock a reel by grasping it near the outer edge because this could pinch the edges together and damage the outer turns of the tape.
 2. Always avoid pinching the reels, or contacting the exposed edge of the turns of tape.
 3. When loading a reel of tape, observe these precautions:
 - a. Push the reel firmly against the stops on the mounting hub to insure proper alignment. If the reel is not properly aligned, it may fail to feed the tape smoothly, and read or write errors may occur. Also, during rewind, the tape will not wind correctly, and edges of the tape will be exposed.
 - b. Tighten the hub securely. If you do not, the reel can wobble during read-write operations and may eventually fall off the tape unit. A loose tape reel that falls off the drive during a high-speed rewind will ruin the tape and very likely crack the plastic reel as well. Do not, however, use excessive force when tightening the hub, because this might strip the threads over a period of time.
 - c. Be careful not to fold or wrinkle the end of the tape on the take-up reel, because this probably would cause the tape to wind unevenly on the take-up reel.
4. If a tape that has been unloaded is to be reused, wind about three turns on the take-up reel. This prevents the lead end of the tape from coming off the take-up reel when the tape is reloaded and the tape drive is searching for the load-point reflective marker.
 5. Before opening the reel door to demount the tape, allow the tape drive mechanism to complete the unloading sequence.
 6. Before storing tape reels, place sponge rubber grommets or plastic strips on the reel to prevent the free end of the tape from unwinding in the container. Do *not* use adhesive-type tapes (such as cellophane or masking tape) for this purpose because, when removed, they leave a sticky residue on the magnetic tape.
 7. Smoking should not be permitted in the machine room. Under no circumstances should a person who is smoking handle tape, attend the tape units, or work in the tape storage area. Ashes can contaminate tape, and live ashes can produce permanent damage if they touch the surface of the tape.
 8. When the file-protection ring is required, be sure it is inserted properly. If it is not, the reel may wobble and cause the tape to wind unevenly, thus damaging the edges.

When removing the ring, do so carefully. Never, under any circumstances, demount the tape reel from the tape unit to remove the ring while tape is loaded in the vacuum columns.
 9. If a reel of tape is dropped, the reel may be broken or bent. Bending, however, is less likely, because a strain sufficient to bend a reel usually breaks it. Inspect the reel immediately. Breaking or bending of the reel can usually be found by visual inspection. In addition, check the reel for bending by mounting it on the hub of a tape unit. If the reel has been bent or broken, it must not be used again. The tape itself

may be serviceable or it may be crimped and/or soiled.

- If there is no evidence of crimping or other tape damage, and the reel is undamaged, thoroughly clean both the reel and the unwound portion of tape.

- If the tape appears undamaged but the reel is damaged, clean the unwound portion of tape, and wind the tape onto a good reel by following these steps:

When the data on this tape does not have to be saved, do steps a-g:

- a. Position the reflective marker about 14 feet from the end of the tape.
- b. Remove the take-up reel.
- c. Mount the damaged reel backwards (file-protection ring facing outward) on the take-up hub.
- d. Mount an empty reel on the file (left) hub.
- e. Thread the tape onto the empty reel and load the tape. Press the rewind key.
- f. The tape will go into a high-speed rewind, and when the rewind is completed, the tape will be properly wound onto a good reel.
- g. Demount the reel from the file hub, destroy the reel on the take-up hub, and mount a good reel on the take-up hub.

When the data on the tape must be saved, do steps b-f, and continue with these steps:

- h. Remove the good reel from the file hub and mount it backwards on the take-up hub.
- i. Place an empty reel on the file hub.
- j. Thread the tape onto the empty reel and load the tape. Press the rewind key.
- k. The tape will go into a high-speed rewind and, when the rewind is completed, the tape will be wound properly on the reel on the file hub.

- If the reel and a portion of the tape are damaged, the undamaged portion of the tape may be salvaged. When the tape does *not* contain data that must be saved, cut off the damaged portion and wind the tape onto a good reel by performing steps a-g.

- When crimped tape contains essential data, thoroughly clean the tape and attempt to reconstruct this data by performing a tape-to-printer operation. Then write the data onto a new tape. If reconstruction fails, the tape records must be rewritten from the original source material.

Storing Magnetic Tape

The following conditions for long-term storage of IBM magnetic tape are recommended:

	<i>Relative Humidity</i>	<i>Temperature</i>
Heavy Duty tape	20%-80%	40°-120° F

Tape that has been exposed to other conditions should be reconditioned to the operating environment of the machine room for a length of time equal to the time it was outside the recommended conditions (to a maximum reconditioning period of 24 hours). Reels of tape should always be stored vertically in their plastic containers when not in use. Stored tapes must also be kept out of a strong magnetic field area.

Any time tape-loaded reels are shipped, they should be placed in their plastic containers and sealed in a plastic bag. Additional protection should be provided by packing in stiff cardboard shipping cartons.

Pointers

1. Be sure each tape drive unit in use is set up with a different selection number.
2. Tape units not in use must always be set at some number other than those in use.
3. Never change the address selection number of *any* unit, in use or not, while a tape operation is in process.
4. Never turn the power OFF when tape is loaded in the vacuum columns and the head assembly is closed in the IBM 729. Opening the assembly to remove tape requires power, and tape may be damaged if power is turned ON with tape in the columns. Extraneous noise may be recorded on the tape when power is reapplied.
5. If a power failure occurs when tape is loaded in the vacuum columns of an IBM 729, have an IBM customer engineer remove the tape from the head assembly and columns before power is restored.
6. When the HIGH SPD REWIND key on the IBM 7330 has been pressed, do not press the RESET key or open the reel door until rewinding is completed. This could place undesirable tension on the tape and damage the tape. If an emergency forces you to do so, take these steps.
 - a. Press the reel-release button and wind at least 200 feet of tape from the file reel onto the take-up reel.
 - b. Close the reel door.
 - c. Resume the high-speed rewinding.

7. Never open the reel door when tape is in the vacuum columns and/or the head assembly is closed in the IBM 729.
8. If the stored program requires read and/or write tape operations and processing does not appear to be advancing, check to see that all required tape drive numbers are properly dialed and that the READY lights on those units are ON.
9. If the stored program calls for a write operation (A42-bits displayed in the A-register) and the FILE PROTECT light is ON, operation stops. A reel without the file-protection ring has been mounted. Make sure the address selection numbers have been dialed correctly on the tape units in use. If they have, unload the tape and demount the tape reel. Mount the correct reel that contains the file-protection ring, load the tape, and restart.
10. At the completion of a tape-writing operation, pull out the file-protection ring as soon as you demount the tape reel.
11. Make absolutely sure that data on a reel of tape is no longer active and may be destroyed, before you insert the file-protection ring in the reel. Carelessness can destroy valuable records.
12. In the 7330, be sure the head assembly is open before power is turned ON.

IBM 7340 Hypertape Drive Model 2

The IBM 7340 Hypertape Drive, Model 2, (Figure 62), when used with the IBM 1401 Data Processing System, makes it possible to read and write magnetic tape at speeds of 34,000 alphameric characters a second, and 68,000 numeric characters a second. The speed of 68,000 numeric characters a second is possible by packing two consecutive digits on tape as one 8-bit character. (If the data is both alphameric and numeric, the speed ranges from 34,000 to 68,000 characters a second.)

As many as four hypertape drives can be connected to a 1401 system through the IBM 7641 Hypertape Control and the serial I/O adapter feature. IBM 729 and 7330 Magnetic-Tape Units and 7340 Hypertape Drives, Model 2, can be connected to the same system for off-line conversion of existing tape libraries to hypertape for large-scale system use. Data is transmitted to and from the processing unit in 6 or 7-bit plus odd parity Binary Coded Decimal (BCD). The 7641 control unit contains a 6/8/6 converter, however, so tape can be written or read in the packed mode. Two check bits are provided on hypertape so all single-bit and most double-bit errors can be corrected.

A highly reliable method of bit recording on hypertape is called IBM Phase Encoding. With this method, each bit (either a one or zero), is recorded by a one-cycle wave form. The wave form used to write ones is positive and opposite in direction or phase to the negative wave form used to write zeros.

When tape is read, the sensing and decoding of a bit depends on the phase or direction of the recorded signal rather than on only the magnetic strength of the signal. Therefore, the possibility of losing a weak signal is lessened by using IBM phase encoding.

The 1-inch-wide tape used with the hypertape drive is packaged in a tape cartridge. The tape cartridge eliminates manual threading and results in rapid loading and unloading. After the cartridge is inserted, the load operation is automatic and is accomplished in less than 15 seconds.

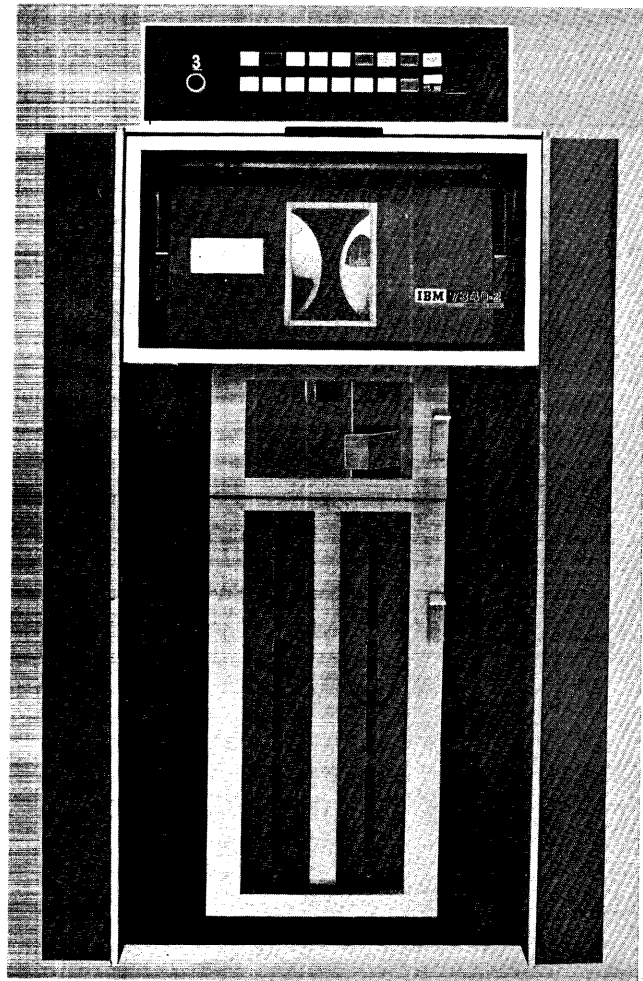


Figure 62. IBM 7340 Hypertape Drive Model 2

The dust resistant cartridge reduces contamination of the tape and prevents possible tape damage through handling. Also, the cartridge makes possible an unload operation without a rewind operation at any point in the file.

Machine Features

Cartridge

The IBM 7340 Hypertape Drive, Model 2, uses a cartridge primarily to minimize tape load and unload time, unload without rewinding, and protect the tape from damage caused by tape handling and from contamination by foreign particles.

The cartridge (Figure 63) is approximately 17 inches long, 10 inches high, and two inches wide. Containing both the supply reel and the take-up reel, its combined weight is less than eight and one-half pounds. The supply reel holds 1,800 feet of tape.

The cartridge has a handle on the top edge. The bottom of the cartridge is such that it will stand upright. They should be stored upright (not stacked horizontally, one upon the other). A window in the front permits visual inspection of the reels.

The cartridge has three labeling areas, one on each end and one on the front. The end labeling areas provide an identification area for use in storing the cartridges. The front labeling area is visible when the cartridge is in use in the machine.

Tape-Reel Replacement

The front cover of the cartridge is removable for reel replacement. It is secured to the cartridge by two latches. To remove it:

1. Lay the cartridge down with the window facing upward and the handle away from you.
2. Insert the cartridge wrench in the right-hand latch and rotate about one-eighth turn toward the top of the cartridge. (Pressure must be applied to the wrench, while rotating it, to overcome spring tension.)

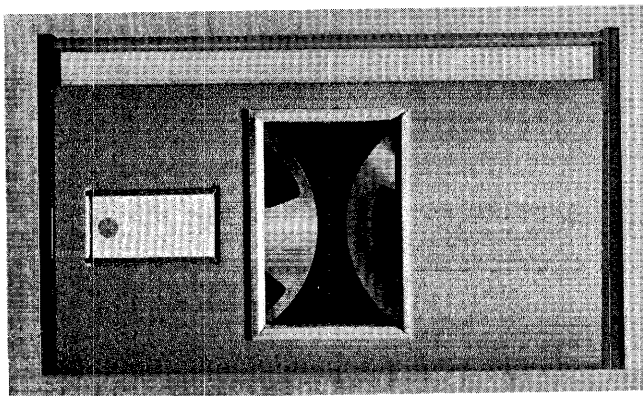


Figure 63. Cartridge

3. Insert the wrench in the left-hand latch and rotate toward the top of the cartridge in the same manner as Step 2.
4. The cover is now free to be removed.
5. Each of the reels is held by a tension spring (the tension spring is held by a retaining screw). Loosen the head screw, with the same wrench used to release the latches, until the tension spring is free to move aside.
6. The reel is now free to be removed.
7. Reverse this procedure for replacement of the reel and cover.

File Protection

The cartridge can be file-protected (writing prevented). File protection is under control of a mechanical slide in the upper middle portion of the back of the cartridge (Figure 64). The right end of the slide is red and is visible when the cartridge is file-protected.

The cartridge is placed in file-protect status manually with the cartridge out of the machine. To file-protect the cartridge:

Take the cartridge out of the machine, place it on the cover, and press the aluminum plunger with the eraser end of a pencil or similar object. This permits the slide to move toward the plunger. The red portion of the indicator will now be exposed.

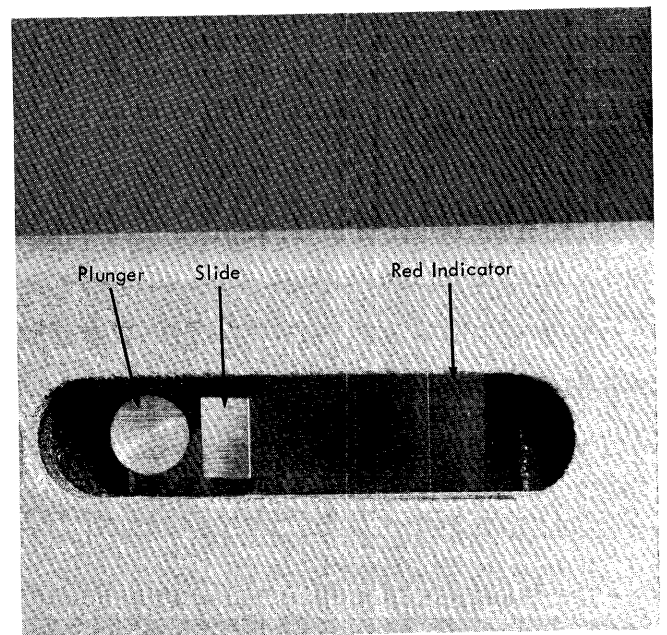


Figure 64. Cartridge File-Protect Device

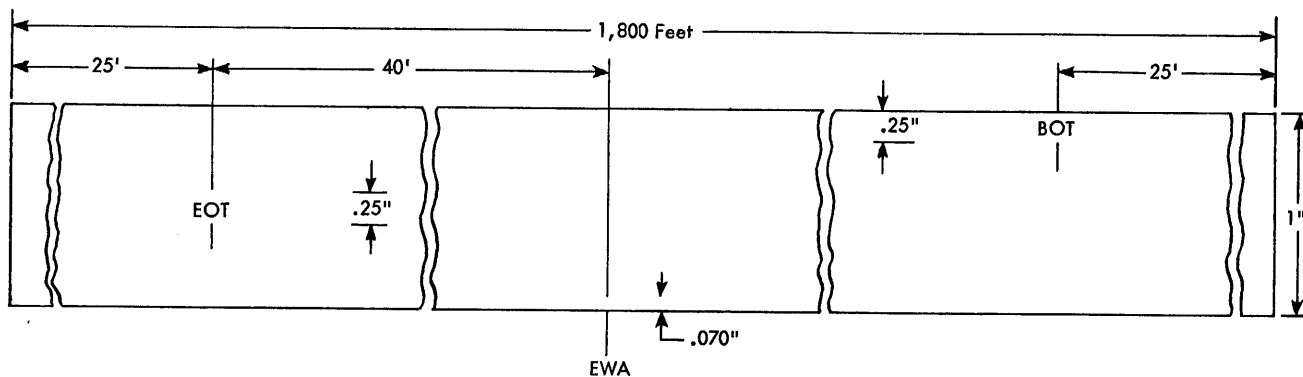


Figure 65. Tape Markers

The file-protect light is on whenever the loaded cartridge is file-protected.

The file-protect status can only be reset *manually*. With the cartridge out of the machine, move the slide away from the plunger until a click is heard. The red indicator will no longer be visible, and writing on tape is now possible.

Tape Markers

There are three tape markers on each reel of tape used by the hypertape drive. These markers indicate various conditions, which are sent to the processing unit for proper attention.

Two of these markers, beginning of tape (BOT) and end of tape (EOT), define the writing area of tape. The third marker, end warning area (EWA), informs the operator that writing is taking place within a specific distance from the EOT. The markers with their sizes and locations are shown in Figure 65.

Beginning-of-Tape (BOT)

This marker is located at the inner edge of tape (edge nearest machine), about 25 feet from the beginning of the tape. Sensing this marker stops all machine operations involving backward tape motion and interlocks the machine to prevent any further backward motion beyond this point.

End-of-Tape (EOT)

This marker prevents any forward motion of tape beyond this point. It is midway from the edges of the tape, 25 feet from the end of the tape.

End Warning Area (EWA)

This marker informs the operator that writing is taking place in an area that is within 40 feet of the end of the tape. It is 40 feet from the EOT marker (65 feet from

the end of the tape), at the outer edge of the tape (edge nearest operator). When this marker is sensed, the EWA indicator is turned on, and the indication is sent to the computer for appropriate action (at the end of each WRITE instruction other than WTM).

IBM 7340 Hypertape Drive Keys, Lights, and Switches

The keys, lights, switches, and indicators are located in a unit attached to the top of the unit (Figure 66).

Address Switch

This switch assigns a number, from zero to three and blank, to the tape unit, to identify it to the stored program. This number is displayed and changes as the address switch is changed.

Select Light

This light is on when the address switch is properly positioned and the tape unit is addressed by the computer.

Start Key

Pressing this key makes the unit available to the computer and turns on the ready light.

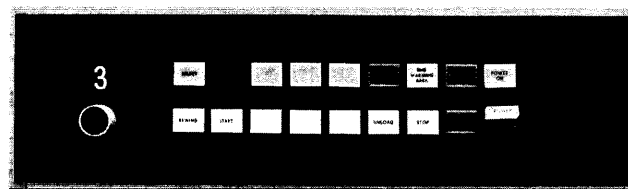


Figure 66. IBM 7340 Model 2 Control and Lights

Ready Light

This light is on when the start key has been pressed, and the unit is under computer control. Any of the tape-unit mechanical check signals turn off the ready light. If the light fails to turn on, a mechanical check is indicated. If unloaded, press the stop key; if loaded, follow *unload key* procedure.

Stop Key

Pressing the stop key removes the unit from computer control. If the ready light is turned off, any operation in process is stopped and some mechanical check conditions are reset. In the latter case, the machine must be unloaded and loaded again to restore the unit to ready status.

File-Protect Light

This light is on when the loaded cartridge is in file-protect status.

End Warning Area Light

This light is on when the end warning area mark is sensed, and remains on while the end warning area of tape is being processed.

Unload Key

If the unit is not in ready status and is loaded, pressing this key initiates a tape unload operation. In case of a mechanical check, press the stop key and the unload key simultaneously.

Rewind Key

This key initiates a rewind operation if the unit is loaded and not in ready status. If the rewind operation is interrupted, and you want to position the tape for reading or writing again, either press the rewind key again or unload and reload the unit.

Power On/Off Switch

This switch turns unit power on and off. Usually this switch is on, and power comes on when the system power switch is turned on.

Power On Light

This light is on when power is on.

Change Cartridge Indicator

This indicator is on when a cartridge is in an unloaded position.

Fuse Indicator

This indicator is on when a fuse has blown in the IBM 7340.

Meter Switch, IBM 7340

If the use-meter switch is not set to ON before an instruction calls on this unit, the system interlocks and the following comments and procedures apply:

Meter Time, IBM 7340

The meter starts when the 7340 is first addressed, and stops when the unit receives and executes a rewind-unload or unload instruction. The meter can also be stopped by manually unloading the unit.

IBM 7641 Keys, Lights, and Switches

The keys, lights, and switches for the hypertape control unit are located on the front of the unit (Figure 67).

Main-Line Power Switch

This switch controls power for the control unit and the drive unit.

Power-On Light

This light is on when power is on.

Tape Record Format Switch

This is a 3-position manual switch that permits the operator to select one of three modes of operation: (Program control will take precedent over this switch setting.)

1. Unpacked Mode. In this mode, tape is recorded on six or seven tracks plus two check tracks. (Track 1 is used for word marks if L Op code is used.)
2. Packed Mode. In this mode, two consecutive non-zoned BCD characters are translated into one eight-

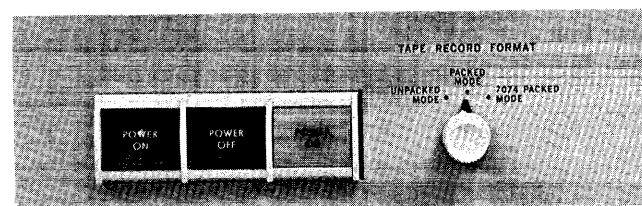


Figure 67. IBM 7641 Controls and Lights

bit character. This increases the characters per second from 34,000 to 68,000.

3. 7074 Packed Mode. In this mode, two non-zoned BCD characters are translated into one 8-bit character. When writing tape in either the unpacked mode or the 7074 packed mode, a change of mode character (DELTA-1, 2, 4, 8, B bits) must be inserted between alphabetic and numeric data when data changes from alphabetic to numeric or vice versa. If the first characters to be written on tape are numeric, they must be preceded by a change of mode character.

NOTE: When reading tape that has been prepared on the IBM 7074, DELTA characters *will not* be transferred to core storage in the packed mode. They will be transferred in the unpacked mode.

Load Operation

Cartridges greatly facilitate loading tape in the IBM 7340 Hypertape Drive, Model 2. To load tape:

1. Raise the top cover. This lowers the front window and exposes the cartridge receiver.
2. Place the cartridge at 90 degrees to the receiver, with the bottom of the cartridge side bars resting in the receiver (Figure 68).
3. Apply gentle pressure to hold the cartridge in contact with the receiver, and raise the cartridge to a vertical position.

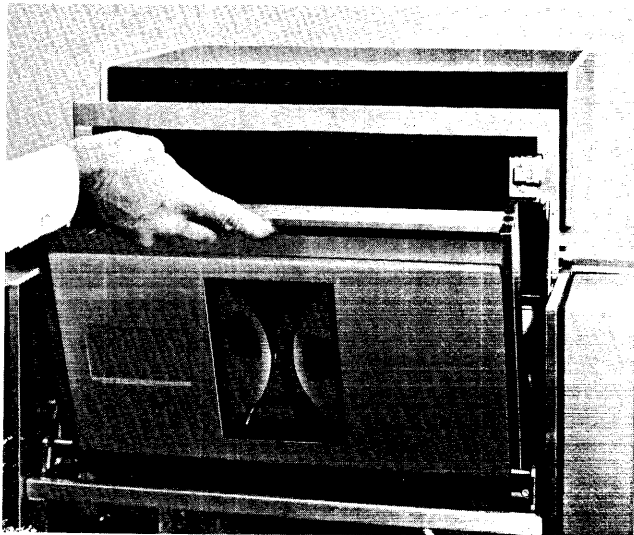


Figure 68. Mounting a Cartridge

4. Lower the top cover. This raises the front window and puts the cartridge in a ready-to-load position.

The rest of the load operation is automatic. The receiver and cartridge move backward so that the tape reels engage the reel hubs, tape lowers into the columns, and the head moves into position. The load operation takes place in less than 15 seconds.

Unload Operation

The cartridge cannot be removed from the hypertape drive unless it is first unloaded (Figure 69). The unload operation results from:

Program-controlled unload: if the unit is in ready status.

Pressing the unload key: if the unit is not in ready status.

The unload sequence is:

1. Press the stop key (if the ready light is on).
2. Press the unload key.
3. The head moves out of the column to the unload position.
4. The right reel rotates to take up the tape from the columns.
5. After tape is out of both columns, the cartridge moves away from the reel drive hubs.

Unload takes place in less than 15 seconds.

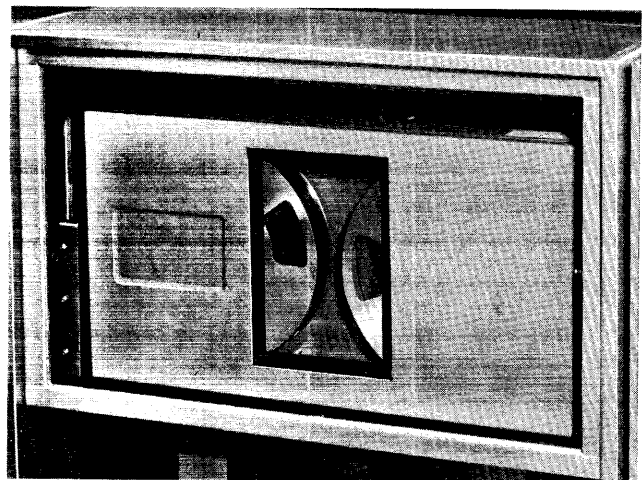


Figure 69. Cartridge in Unloaded Position

IBM 1311 Disk Storage Drive

The IBM 1311 Disk Storage Drive (Figure 70) provides a fast, efficient means of disk storage for any system to which it is attached. Each drive is capable of storing 2 to 2.98 million alphabetical characters.

There are five models of the IBM 1311 Disk Storage Drive. Various combinations of these models are used on the systems that can attach the 1311.

IBM 1311 Model 2

The 1311, Model 2, is the disk-storage drive used when more drives than the master are required on the 1401 system. The Model 2 drives are attached to a system through the master drive, and a maximum of four Model 2 drives can be attached.

IBM 1311 Model 4

The 1311, Model 4, is the required first drive when 1311's are attached to the IBM 1401 Data Processing System. This model is the master drive on the system and contains the power supply and the controlling circuitry, lights and switches that control it, and the other 1311's attached to that system. Only one Model 4 can

be attached to the system and four additional units, Model 2, for a maximum of five disk-storage drives on a 1401 system.

Information is stored on small, removable disk packs. This concept of removable disk packs means that only those records required for a particular application need be used. Data records for other applications can be removed from the system and stored.

The IBM 1311 Disk Storage Drive and the portable disk pack allow the user to select the number of disk drives (maximum of 5) needed on the system at any one time and to place only the required disk records on the drives. Any number of disk packs are available for data storage. The number of disk packs needed by the user depends on his disk-storage requirements.

The disk pack is a precision device, designed to meet the extremely close tolerances required for high-speed reading and writing on the IBM 1311 Disk Storage Drive. When the disk pack is not on a disk-storage drive, it is inside its protective cover (Figure 71). The disk pack and its cover combine to make a rugged, sealed container. Because the disk pack is a precision instrument, it should be handled with care. Every effort should be made to keep dust and foreign matter away from the disk surfaces. (The dust could become wedged between the disk surface and the read/write heads, causing permanent damage to the head and the disk.)

The disk drives used in combination with the IBM 1401 Data Processing System expand the input/output abilities of the system and provide the user with a flexible, low-cost, in-line data processing system.



Figure 70. IBM 1311 Disk Storage Drive

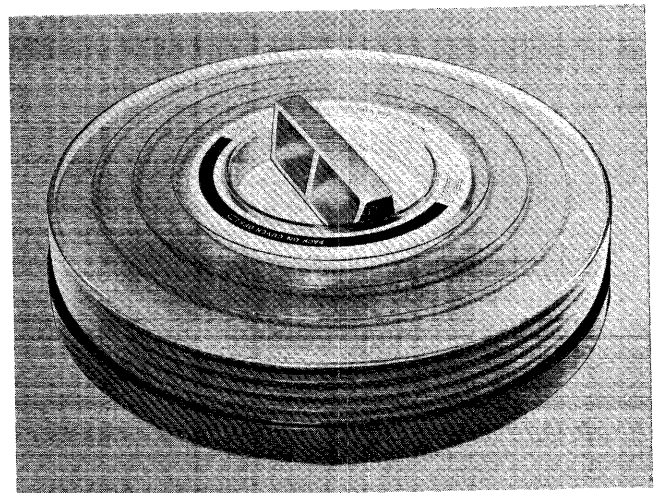


Figure 71. IBM 1311 Disk Storage Drive Disk Pack

Storage Capacity

The IBM 1440 Data Processing System can have as many as five IBM 1311 Disk Storage Drives attached to it. Each drive has its own independent access mechanism consisting of ten read/write heads. All drives can be used by a single program in much the same way a tape system uses tape units for storing master and active input and output files. The 1311 supplies only the access and drive mechanisms; the disk records are separate.

Independent portable disk packs are used with the 1311 drive. Each disk pack has six magnetic disks, 14 inches in diameter, providing ten surfaces for recording data. The pack is easily removed (nominal change time of two minutes).

The packs are interchangeable with other IBM 1311 drives. This means that the philosophy of tape libraries can now be applied to magnetic-disk storage. A library of disk packs can be set up, and when needed, the

packs necessary for an operation can be placed on the disk-storage drives for system use.

Each disk pack has a storage capacity of 2 million alphanumeric characters when records are written in the sector mode, or 2.98 million when the data is written in the track-record mode. With five disk drives attached to a system, from 10 to approximately 15 million alphanumeric characters of data are available for system use.

Access Assembly

The access assembly on each IBM 1311 has 10 read/write heads attached to it (Figure 72).

The read/write heads move horizontally across the tracks on the disk during a seek operation. Vertical movement of the access mechanism is not necessary, because there is a head for each disk surface. Because each disk surface has its own read/write head, it is not necessary to perform a seek operation if the sought record is in the same vertical plane (cylinder) as the record previously operated upon.

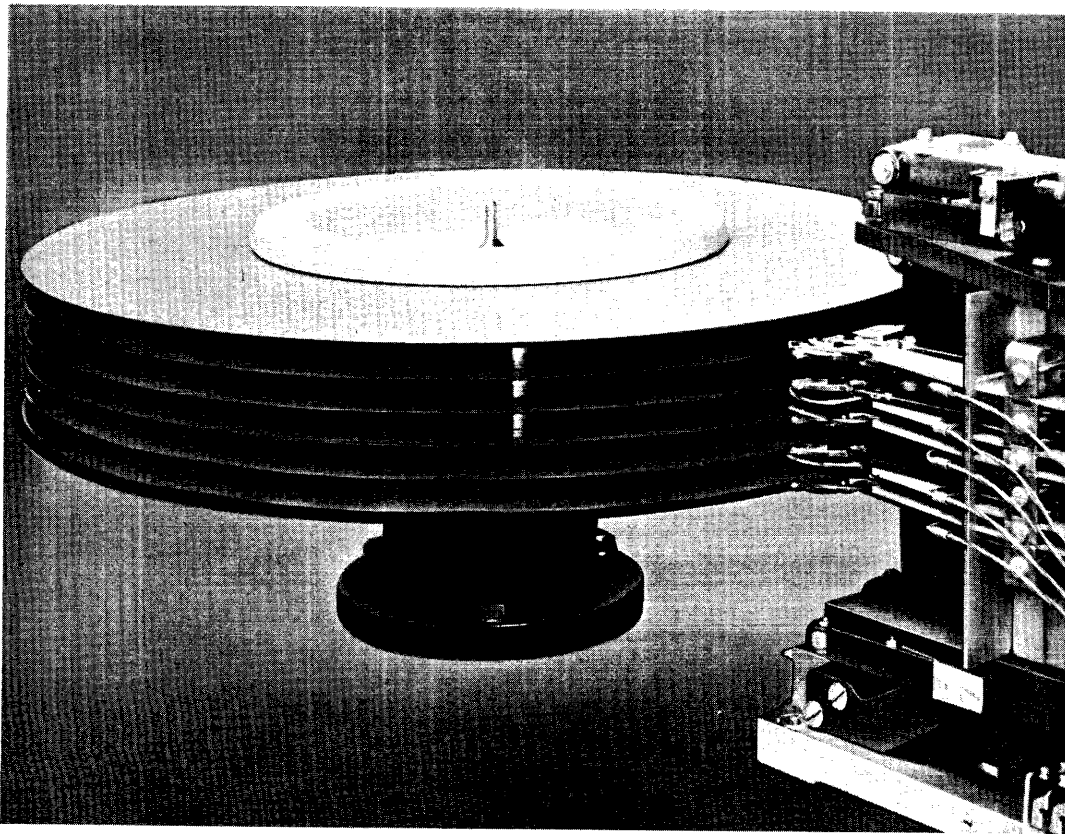


Figure 72. Access Assembly

IBM 1311 Operating and Handling Procedures

Receiving the Disk Pack

The disk pack is shipped in a container that can withstand normal freight handling abuse. However, if the container shows shipping damage, an IBM customer engineer should be consulted before using the disk pack on the IBM 1311 Disk Storage Drive. This eliminates the possibility of damage to the drive and the disk pack.

The original shipping container can be retained and reused for any subsequent shipping of the disk pack. An additional supply of shipping containers can be obtained through your local IBM representative.

Storage Requirements

Disk packs should be stored in the data processing room in enclosed metal cabinets or fire-resistant containers. A separate room can be used to store duplicate master records or other vital data. If such a room is used, it should be constructed of fire-resistant material and contain appropriate fire prevention equipment.

The ideal environment for storage of disk packs is the same environment as the computer room (60°-90°, 10%-80%). If the pack is removed from this environment it should be conditioned to the operating environmental conditions for two hours. The conditioning time is required to assure correct track registration and data recording and retrieval. Storage of the pack in the computer room eliminates the conditioning requirement.

The disk pack should be stored in a clean, enclosed, metal cabinet that is elevated from the floor and protected from sources of dust and dirt such as paper, cards, etc. This precaution minimizes transfer of dust to the disk-storage drive during loading operations and provides additional protection in case of fire. Disk packs should never be stored in direct sunlight, stacked one on top of another, or stored on edge.

A 2-piece cover provides a positive dust seal and maximum pack protection during the time the disk pack is removed from the machine. The top of the cover is used as a mounting tool or handle which permits the operator to secure the disk pack to the disk drive.

The cover of the disk pack is made of polystyrene material. This type of plastic provides a strong protective cover which, with normal care, will protect the disk pack throughout its life. However, if the disk pack is dropped, the cover may chip or crack, as it absorbs the impact of the fall. (See *1311 Operating Procedures*.)

Like many other modern high-quality plastics, the cover of the disk pack may ignite if it is exposed to

continuous intense heat. The ignition point is 475° Fahrenheit, and if the cover burns it will release carbon monoxide gas, chlorine compounds, and intense smoke.

Machine Room Housekeeping

The read/write heads of the IBM 1311 Disk Storage Drive "float" over the surfaces of the disk pack on a thin "film" of air molecules — a film so thin, that it is measured in millionths of an inch. Some types of dust or dirt on the disk surfaces can cause permanent damage to the disk surface and the read/write heads. An air-filtering system in the 1311 purifies the air that surrounds the disks when the 1311 is in operation. Prevent foreign particles from entering the 1311 while disk packs are being placed on or removed from the system; dirt or dust should be kept to a minimum in the environment of the machine room.

Good housekeeping practices should always prevail in the machine room. It should receive daily attention with a vacuum, wet mop or similar device. Cleaning implements that raise dust (such as brooms and feather dusters) should be avoided. Steel wool or metal abrasives *should never* be used for buffing the floor. Waxes or other top dressings that may flake should, if used at all, be lightly applied.

Disk Pack Handling

For additional protection against dust, the air from the room is filtered before entering a disk-storage drive unit. Therefore, the cover of the disk-storage drive must always be kept closed, whether a disk pack is installed or not, to prevent dust from bypassing the filters.

If the disk pack receives a sharp impact, such as being dropped or falling from a shelf or table, it must not be placed on a disk-storage drive until it has been inspected by an IBM customer engineer. Such a pack, if mounted on the drive, can further damage the pack and the machine.

The disk pack assembly is specifically designed to prevent removal of the cover when the pack is not on the disk-storage drive. *The disk pack should never be handled without its cover.*

Care must be exercised in installing the disk pack. If the hub of the disk-storage drive receives a sharp impact from the disk pack, the contour of the hub and/or the pack drum can be altered and cause misalignment of the disk surfaces to the read/write heads.

Foreign objects must never be placed between the disks nor where they can fall or be pushed against the disk surfaces.

Disk packs that contain useful information must never be exposed to an intense magnetic field. (Technically, an intensity greater than 50 oersteds may cause loss of information. The IBM physical planning engineer may be consulted if high-intensity fields are suspected.)

Avoid smoking while handling a disk pack. Ashes can contaminate the disks. It is also recommended that smoking be prohibited in the computer room.

Disk Pack Labeling

Only the disk-pack center trim shield is labeled, never the cover. The transparent cover enables the disk pack label to be read with the cover on. Labeling the disk pack only, precludes the possibility of placing a labeled cover on the wrong pack, which could result in the alteration or loss of pertinent data.

Disk packs should be labeled with a material that can be removed without leaving a residue. Adhesive stickers that can be applied and removed easily are satisfactory. *Never use an eraser to alter the identification on a label.* Erasing creates foreign particles that can interfere with the proper spacing between the read/write heads and the disks. These foreign particles may be too small to detect with the human eye.

Operating Procedures

When the cover is locked onto the pack, the disk pack can be carried by the handle on the cover.

The following instructions should be used when installing or removing the disk pack:

Installation

Care should be taken when placing the disk pack on the disk-storage drive. The close tolerance between the disk pack and the shroud on the drive that surrounds it, has been designed to protect the disk pack when it is installed on the 1311. Nevertheless, care should be exercised while loading and unloading the pack so that the pack is protected from unnecessary abuse.

To install the disk pack on the disk-storage drive, use the bottom cover knob to unscrew and remove the bottom cover from the disk pack. Place the disk pack on the 1311 drive spindle. Turn the top cover clockwise (as indicated by the *on* arrows) until it comes to a full stop. Even though the cover might become disengaged before the full stop point is reached, the cover should continue to be turned to ensure the activation of the *pack on* safety switch. The *pack on* safety switch

must be activated before the 1311 can be started. The top cover can then be removed, leaving the disk pack locked on the spindle.

While the disk pack is on the drive, the top and bottom covers should be reassembled and stored in a designated storage area.

Removal

After pressing the stop key, wait until the disk pack has stopped before proceeding. *The disk-storage drive cover should never be opened until after the pack has come to a complete stop.*

The disk pack is removed from the 1311 by replacing the top cover over the top of the pack, engaging the cover pins, and turning the cover counterclockwise (as indicated by the *off* arrows) for two full turns. The cover has then been securely fastened to the disk pack so that both the pack and the top cover can be removed from the spindle of the 1311 as a unit. The bottom cover must then be immediately attached to create a positive dust seal.

Shipping Procedures

When a disk pack is being shipped from one location to another location, certain precautions should be followed:

1. The pack must be tightly secured in its 2-piece cover. This cover presents a positive dust seal and therefore it is not necessary to use a plastic bag around the pack.
2. In order to properly protect the disk pack from shock, it should be shipped or transported in the proper IBM shipping container. If the original shipping container has become worn or damaged, another can be obtained through the local IBM office. Any questions regarding packaging of the disk pack for shipment can be answered by the local IBM representative.
3. The disk pack must be protected from excessive radiation such as X-ray, and from the effects of electromagnetic fields which are present near building electrical power distribution centers.
4. If, after a disk pack has been received, the shipping container shows damage, an IBM customer engineer should be consulted before using the disk pack on the IBM 1311 Disk Storage Drive. This eliminates the possibility of damage to the machine and the disk pack.
5. When a disk pack is removed from a container, it should be dusted before it is taken into the machine room for its conditioning period.

The 1311 was designed so that the removable packs would be transportable. If the preceding suggestions are followed and reasonable care is used in handling, shipping the disk pack should not present any unusual hazards in data processing. No warranty of safety of data or pack, however, is expressed or implied by IBM.

IBM 1311 Disk-Storage Drive Keys and Lights

Start-Stop Key-Light

Pressing this key supplies the power to the disk drive and establishes the unit in ready condition (Figure 73). The key light is turned on.

Pressing this key again retracts the access mechanism to the home position and removes the power from the drive. With the unit in this state, disk-pack replacement can be accomplished without affecting the operation of the system or other drives under control of the attached system program.

Write Address Key-Light

This key is located on the master disk drive (number 0) and controls the write disk address mode for all disk drives. Write operations in the address mode can be performed only when this key-light is pressed and the light is on. The WRITE DISK SECTOR and the WRITE DISK TRACK RECORD instructions (without addresses) cannot be performed if the light is ON.

When this key-light is OFF, *write with address* operations cannot be performed. Read operations can be performed with or without addresses, regardless of the setting of this key-light.

If the write operation called for by the stored program does not agree with the key-light setting, the instruction is terminated and a program testable indicator is set.

Module Ready Light

This light is ON when the IBM 1311 is ready for use by the attached system.

The IBM 1311 is in ready state when the following conditions have been fulfilled:

- The disk pack is rotating up to speed
- The access mechanism is extended in to the disk pack
- The read-write heads are loaded.

This light is OFF when the power is removed from the drive. If it is OFF, processing continues until the stored program addresses this particular drive; then the instruction terminates and a program testable indicator is set.

Pack-On Light

This light comes ON when the disk pack is properly installed on the disk storage drive and the spindle is tightened. The dust cover should not be removed from the disk pack until this light is ON.

Select Lock Light

This light (disk-storage drive 0 only) comes ON to signal that the disk drives on the system are inoperable and customer engineering assistance is needed.

Compare-Disable Switch (CE)

This switch is located inside the master drive (number 0). It is to be used only by the customer engineer. It is a pull-out-type switch and is restored to normal position when the rear gate is closed after the switch has been used.

When the switch is pulled out, the sector address-compare during the address mode of track read operation is disabled. This permits the reading of track information when an unequal address compare error prevents reading from the record.

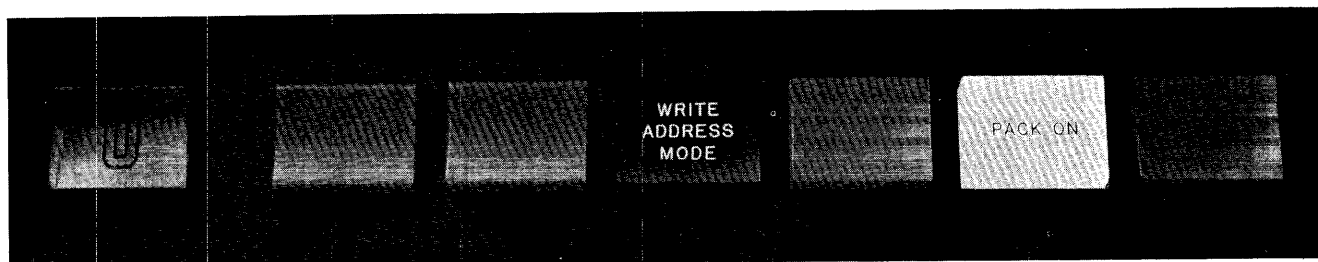


Figure 73. IBM 1311 Control Keys and Lights (Master Unit)

Meter Switch, IBM 1311

If the use-meter switch is not set to ON before an instruction calls on this unit, the following comments and procedures apply:

- The unit will be in the *not ready* status. The system can test for *not ready* and will operate but will not recognize the 1311.
- The master drive's meter switch must be on to allow operation of any additional 1311 unit.
- To restart, stop the system, turn meter switch on, start program over, and restart the job.

Meter Time, IBM 1311

Disk-drive meter time is recorded when the processing unit is running, unless the 1311 meter control switch is turned off. Meter recording can be stopped by turning the meter switch off.

IBM 1405 Disk Storage

The IBM 1405 Disk Storage unit (Figure 74) provides large-capacity storage for data, and functions as an input/output unit in the IBM 1401 system. Data is read from or written on the faces of magnetic disks, under control of the processing unit.

In addition to providing increased storage capacity, magnetic-disk storage units permit the processing of data on a random basis. Because any record is addressable, the IBM 1401 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. It eliminates the necessity of accumulating transactions of a like kind (batching) before entering them. Transactions can be entered as they occur, regardless of sequence. In less than a second, the 1401 program can seek a record, update it, and return the updated record to the storage unit. Also, the 1401 can process other data within core storage while the access mechanism searches for a record.

Disk storage also permits the storage of subroutines in order to conserve core-storage locations for *working space*. For instance, if there are five different subroutines in a program, only the number of core-storage locations required for the longest subroutine need be reserved for all five. Then, when program conditions dictate, a subroutine can be sought in the disk storage unit, brought to the reserved area in the processing unit, executed, and returned to the 1405.

The IBM 1405 Disk Storage unit is available in two models. Model 1 is a 25-disk unit. On each disk there are 200 tracks, each capable of containing ten 200-character records. The total capacity of this model is 10 million alphabetic and/or numerical characters.

Model 2 has twice the capacity of the Model 1. It has 50 disks, each capable of containing ten 200-character records on each of 200 tracks. The total capacity of the Model 2 is 20 million alphabetic and/or numerical characters.

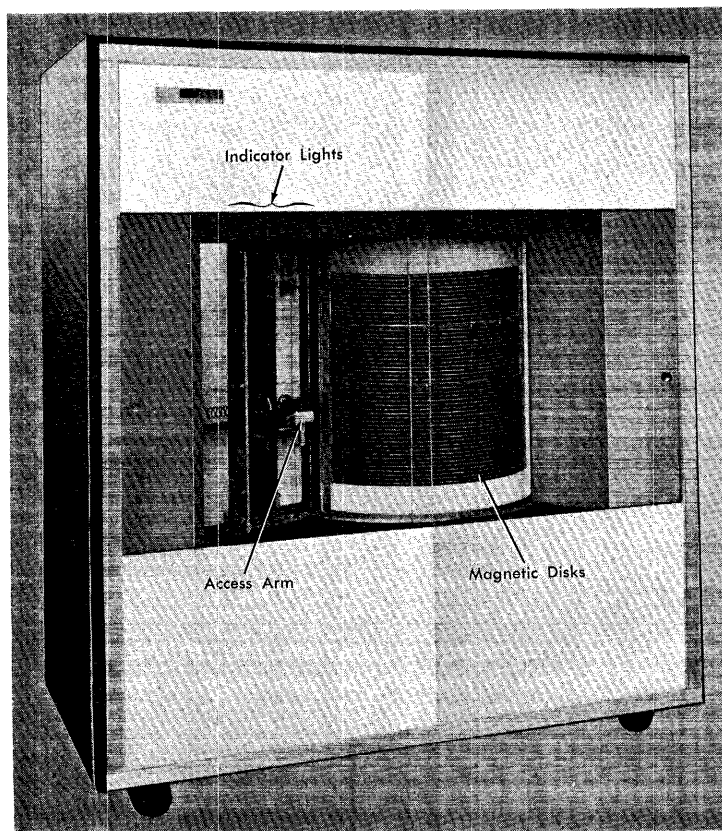


Figure 74. IBM 1405 Disk Storage Model 2

Features

Magnetic Disks

Magnetic disks are thin metal disks, two feet in diameter, 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 1200 rpm.

Information is recorded on disks in the form of magnetized spots located in concentric tracks on each disk surface. The records remain unchanged, and they can be read from disk as often as desired. A write operation, however, destroys the previous data and stores new data. Thus, the magnetic disks can be used repeatedly.

Data is recorded on disk in BCD code (binary-coded-decimal), the same code as used in core storage. (See *IBM 1401 System Logic: BCD Codes* for this coding pattern.) To ensure the accuracy of recorded data, a parity check is made whenever data is transferred to or from disk storage.

Each 200-character record on disk has an indelible seven-digit record *address*. The addresses are arranged sequentially in ascending order from the bottom to the top of the disk storage unit. The record address of the first record in the outside track of the bottom disk is x0000000. The address of the last record in the inside track of the top disk is x999990. (The x in the record address refers to the access arm to be used and is not part of the seven-digit indelible address.)

Data is read from or recorded on disk at the rate of 22,500 characters per second. Minimum access time is 100 milliseconds. Maximum access time is 800 milliseconds for Model 2, and 700 for Model 1. Access time is the time required to locate (seek) a particular disk track. Read, write, and write disk check operations can be performed on a disk record without having to re-seek, if no other seek operation intervenes.

Access Arm

The IBM 1405 has one standard access arm located at the side of the stack of disks. A second arm is available as a special feature. The access arm is fork-shaped and has two read/write heads that read and record data. One read/write head is for the top surface, and the other is for the bottom surface of the same disk (Figure 75). The arm can move to any desired track on any disk, under control of the stored program. During a seek operation, the access mechanism moves vertically to seek the disk, and horizontally to seek the track.

To execute a read, write, or write disk check instruction, the access arm must have been previously directed to the proper track location by a seek instruction.

Lights

A backlighted panel of indicator lights (Figure 76) is located to the left of the disk pack for operator reference.

Power

When power is supplied to the system, this light turns ON.

Ready

This light turns ON when the 1405 is conditioned for use in the 1401 system. If it goes OFF, either low air pressure, a power supply failure, or improper functioning of the reading or writing circuits has occurred. When this light goes OFF, the RAMAC light on the 1401 console turns ON. Then, processing stops when the stored program addresses the disk storage unit.

Parity

If a parity error is detected as characters are read from or written on a disk record, this light and the 1401 RAMAC light turn ON, but system operation does not stop. A program instruction can be included to stop operation, if desired. The lights are turned OFF by pressing the start reset key on the 1401 console, by executing a program instruction that tests the error condition, or by executing a subsequent disk-storage instruction (except SEEK DISK).

Acc 0, Acc 1, Acc 2

If the standard access arm has been placed in an inoperable condition by a logic safety circuit or by an IBM customer engineer, the ACC 0 (ACCESS 0) light and the 1401 RAMAC light turn ON but system operation does not stop. A program instruction can be included to stop operation, if desired. The lights are turned OFF by pressing the start reset key on the 1401 console or by executing a subsequent disk-storage instruction.

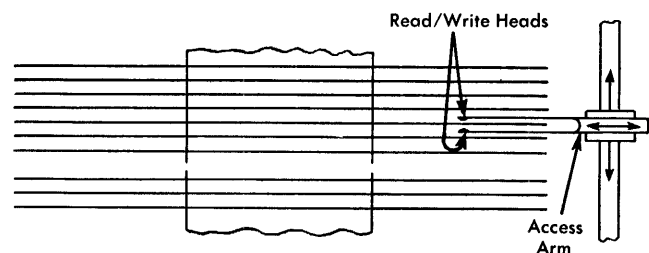


Figure 75. Access Arm

POWER	ACC 0	RECORD	LENGTH
READY	ACC 1	ADDRESS	COMPARE
PARITY	ACC 2	ADDRESS	INVALID

Figure 76. IBM 1405 Indicator Lights

The ACC 1 light corresponds to the additional-access arm (special feature), when that is installed, and it functions the same as ACC 0. The ACC 2 light has no function when the 1405 is attached to the 1401 system. It is used in the IBM 1410 system.

Record Length

If a wrong-length record is detected when reading from or writing on disk, this light and the 1401 RAMAC light turn ON but system operation does not stop. A program instruction can be included to stop operation, if desired. The lights are turned OFF by pressing the start reset key on the 1401 console or by executing a subsequent disk-storage instruction (except SEEK DISK).

Address Compare

In a disk operation, if the record address in storage is not the same as the record address on disk, this ADDRESS COMPARE light and the 1401 RAMAC light turn ON but system operation does not stop. A program instruction can be included to stop operation, if desired. The lights are turned OFF by pressing the start reset key on the 1401 console or by executing a subsequent disk-storage instruction (except SEEK DISK).

Address Invalid

If a disk-storage instruction for an address that is not in the system is processed by the 1401, this light and the 1401 RAMAC light turn ON but system operation does not stop. For example, this might be an address for the larger-capacity IBM 1405, Model 2, when Model 1 is installed.

A program instruction can be included to stop operation, if desired. These lights are turned OFF by pressing the start reset key on the 1401 console or by executing a subsequent disk storage operation (except SEEK DISK).

Meter Switch, IBM 1405

If the meter switch is not set to ON before the first programmed instruction calls on this unit, the system interlocks and the following comments and procedures apply:

- Stop the system, turn the meter switch ON, press the start reset key, and restart at the program step that initiated the operation that could not be completed.

Meter Time, IBM 1405

The 1405 meter records when the processing unit is operating. The meter-time recording can be stopped by turning the meter switch off.

IBM 1407 Console Inquiry Station

The IBM 1407 Console Inquiry Station (Figure 77) provides the operator with direct access to data or programs stored in the IBM 1401 Data Processing System. It can be installed with any 1401 system except a Model A system.

The inquiry station consists of controlling circuitry and a modified IBM electric typewriter, standard model B, with a pin-feed platen and a 12" carriage. Typing can be performed manually by the operator, using a 64-character keyboard, or automatically by program control. Six control keys (see Figure 81) to the right of the keyboard allow the operator to specify the type of operation that is to be performed.

Three basic functions can be performed by the 1407.

1. Automatic processing of a program can be interrupted to obtain specific data from core or disk storage. This is especially valuable when a 1401 disk storage system is used. For example, an account record or a stock-status record stored on disk can be requested by the operator and made available in a short time, even though a program is being processed. Thus, management can, at a moment's notice, request information from the 1401 system and have an answer almost instantaneously.
2. Data or programs in core storage can be altered or examined by the operator. This function is performed in the alter mode of operation. The operator selects the starting address for inserting or reading information from core storage by using the manual

This function requires preplanning by the programmer, and the storage of *inquiry routines*. When the operator wishes to request information, he presses the REQUEST/ENTER control key. Then as soon as the program in process checks and finds that this key has been pressed, the system signals the operator by turning ON the ENTER light. The operator can type any one of a series of *preplanned* inquiries and enter it in core storage. The stored inquiry routine processes the inquiry and automatically types the reply on the 1407. The length of the message is predetermined by the programmer. After the reply, automatic processing is resumed.

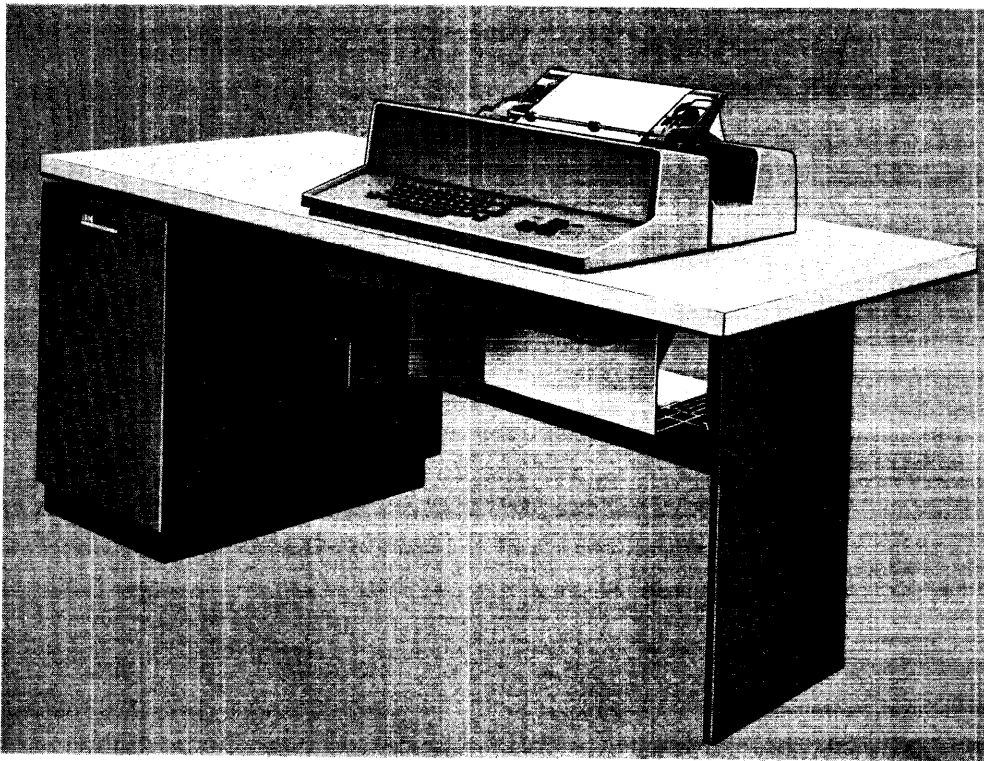


Figure 77. IBM 1407 Console Inquiry Station

address dials on the 1401, and he signals the end of the transmission by pressing the CLEAR control key on the 1407.

3. The 1407 can be used as an additional printer for the 1401 system. It is frequently used to type *exception* records while regular reports are printed on the 1403.

Features

Keyboard

The 64-character keyboard (Figure 78) has keys for typing letters, digits, and 28 special characters. The alphabetic characters are always typed as uppercase letters, without the use of a shift key. The shift key is used for certain special characters that are located in the usual uppercase locations. The keyboard can be used for manual typing when either the ENTER light or the ALTER DATA light is ON. At all other times the keyboard is locked.

The carriage return and backspace keys perform the functions named, as on any typewriter keyboard. The operation of other functional keys and levers are described in the following sections.

Impression Control Lever

This lever (located below the impression indicator) can be moved forward and backward to change the amount of force with which the typebars strike the paper. The higher the number set in the indicator, the harder the typebars strike. To determine the correct setting for each type of work, use the comma and period as a test, adjusting the impression so that they print distinctly but not heavily. As a general rule, use a high setting for multiple carbon copies.

Margin Release

To type beyond the right- or left-hand margin stop, press the MARGIN RELEASE key once, and continue typing.

Margin Set

The MARGIN SET key is used to position the left- and right-hand margin stops. To reset either margin stop:

1. Move the carriage to the present margin stop position.
2. Hold the margin set key down, and move the carriage to the new location.
3. Release the margin set key. The margin stop is repositioned.

Carriage Controls (Figure 79)

Line Position Reset

When this lever is in its normal forward position, regular line spacing is in effect. When it is pushed back, it locks out standard line spacing and provides a free-rolling platen. The LINE POSITION RESET lever makes it possible to print above or below the line (double underscore, subscript, superscript, exponent) and then continue with regular line spacing. For this operation, follow these steps: push back the reset lever, roll the platen to the desired place, type, and return the reset lever to its forward position. Regular spacing, from the original line, is resumed when the carriage return key is pressed or the platen knob is turned.

Line Space

To select single, double, or triple line spacing, move the line-space lever to the position labeled 1, 2, or 3.

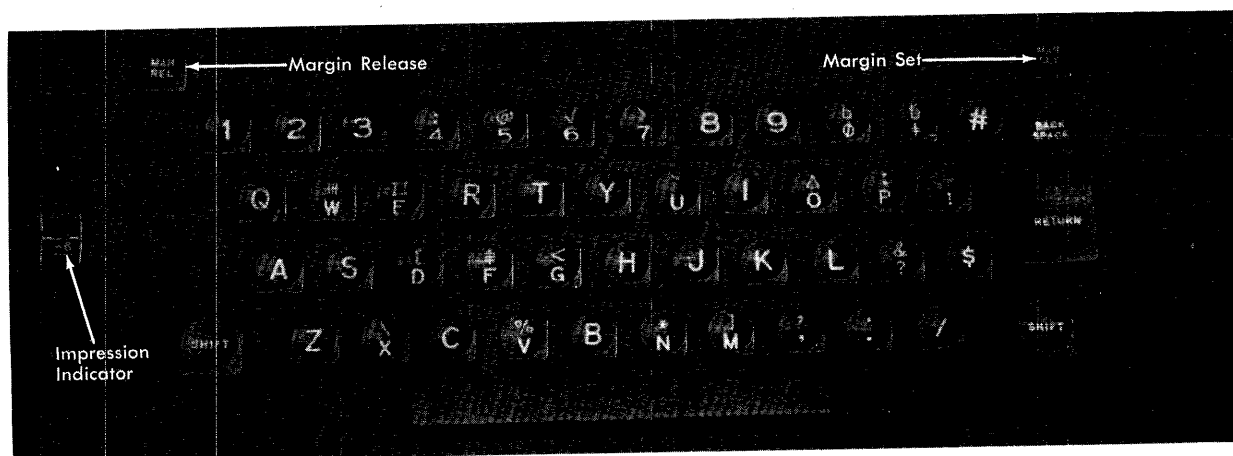


Figure 78. IBM 1407 Keyboard

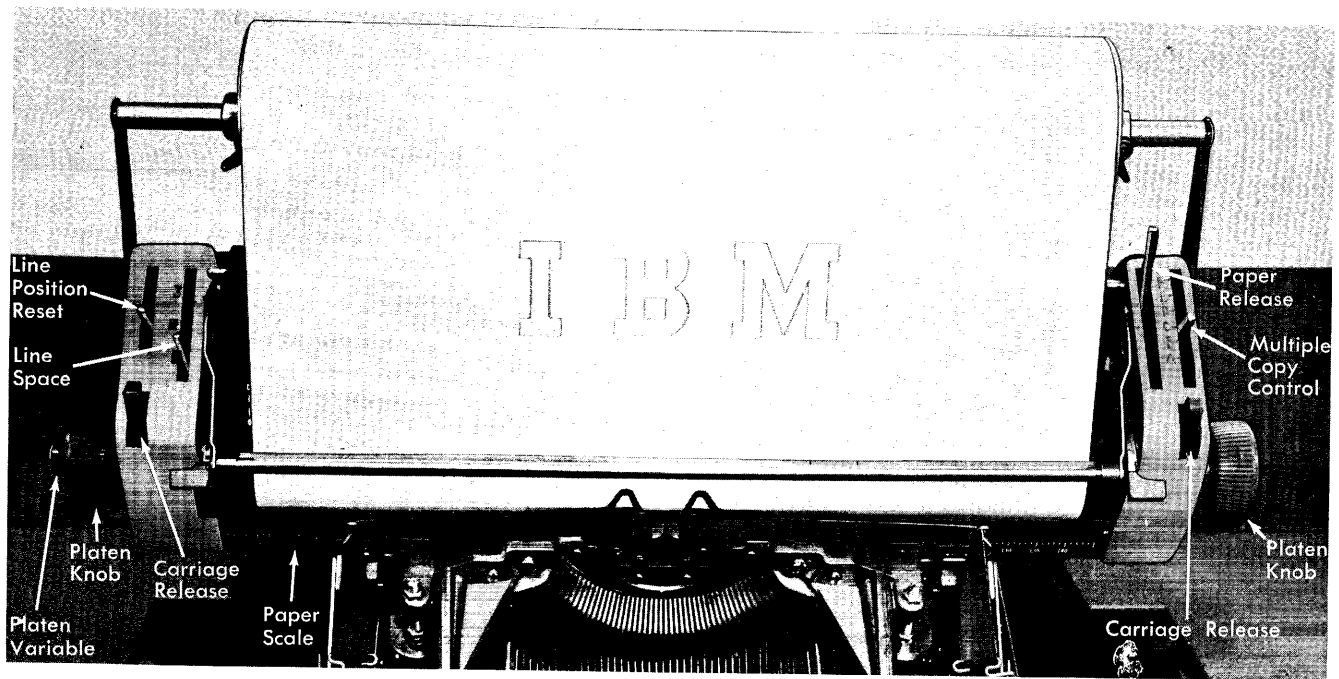


Figure 79. IBM 1407 Carriage Controls

Carriage Release

To move the carriage to the left by hand, press either the left- or the right-hand carriage release lever. (As the left margin is approached, the air-cushioning action that quiets the electric carriage return will be felt.)

Platen Knob

The platen knob is used to turn the platen forward or backward by hand.

Platen Variable

When the platen variable button is held in, the platen knob turns the platen smoothly, without line spacing. It should be used to locate a printed line for corrections or additions, when a previously typed page is reinserted.

Paper Scale

This scale indicates the position of the carriage, and assists in setting margin and tab stops accurately.

Paper Release

This lever frees the paper for manual positioning and removal.

Multiple-Copy Control

This lever moves the platen backward or forward to compensate for the thickness of paper or for multiple copies. With proper positioning of the platen, the typebars strike the paper evenly. The weight of paper and carbon paper used is an important factor in determining the correct setting. Normally, the multiple-copy control lever should be set at A when one to four copies are typed. As a general rule, the lever should be moved back one position for every three extra copies (after the first four).

Check this lever to make sure it is set properly if, at any time, the typebars fail to print when the motor and console typewriter are operating.

Pin-Feed Platen

A pin-feed platen is standard on the IBM 1407 Console Inquiry Station. It maintains proper registration and alignment of continuous forms that are 9 $\frac{3}{8}$ " wide, hole-to-hole. The writing line is 8 $\frac{1}{2}$ " wide.

The platen is available in three degrees of hardness: hard, medium, and soft. A hard platen should be used whenever forms with five or more parts are to be typed, but it should never be used with less than a five-part form.

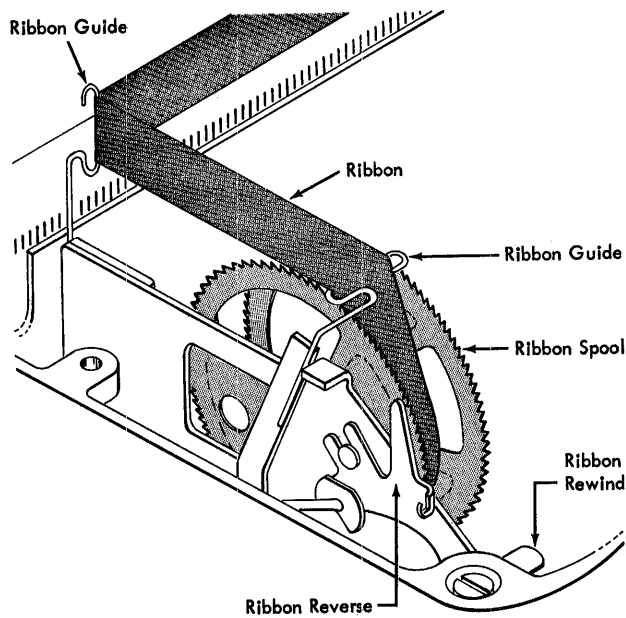


Figure 80. IBM 1407 Ribbon Controls

Ribbon Controls (Figure 80)

Ribbon Reverse

The direction in which the ribbon moves from one spool to the other is automatically reversed when all the usable portion of the ribbon has been wound onto one spool. However, the direction can be reversed manually at any time by pressing down a RIBBON REVERSE lever (next to a ribbon spool). When ribbon is winding onto a spool this lever is up. The lever must be pushed down to reverse the operation and wind from that spool onto the other one.

Ribbon Rewind

When the RIBBON REWIND lever is held down, the ribbon winds automatically from one spool to the other. This lever can be locked down by pushing down and back.

IBM 1407 Control Keys and Lights (Figure 81)

Request/Enter

This key is used to interrupt a program in process so that information can be requested from core or disk storage. It may be pressed at any time when the 1401 system is in the *run mode*. Pressing this key-light turns ON the REQUEST light, and sets an internal indicator for

the program to check. When the program tests the indicator and finds that this key has been pressed:

- Processing stops so that an inquiry can be handled.
- The REQUEST light turns OFF.
- The ENTER light turns ON.
- The keyboard is unlocked so that the operator can key-in an inquiry.

This ENTER light also turns ON when the 1401 is in the *alter mode* and when the ALTER DATA key on the 1407 is pressed to enter characters from the 1407 keyboard.

The ENTER light turns OFF when either the RESPOND/TYPEOUT key or the CLEAR key is pressed.

Form

This red FORM key-light turns ON and typing stops immediately when an end-of-forms condition occurs in the 1407. This key can then be held pressed to complete the typing on the form in the carriage, if desired.

After a new supply of forms is inserted, this key must be pressed to reset the end-of-forms condition, turn OFF the FORM light, and resume operation.

Alter Data

This yellow ALTER DATA key-light turns ON whenever the mode switch on the 1401 console is set to ALTER. When the 1401 system is in the alter mode, characters can be read from core storage and typed on the 1407 by use of the RESPOND/TYPEOUT key, or they can be entered into core storage from the 1407 keyboard. Before characters are entered, a core-storage starting address must be set up in the manual address dials

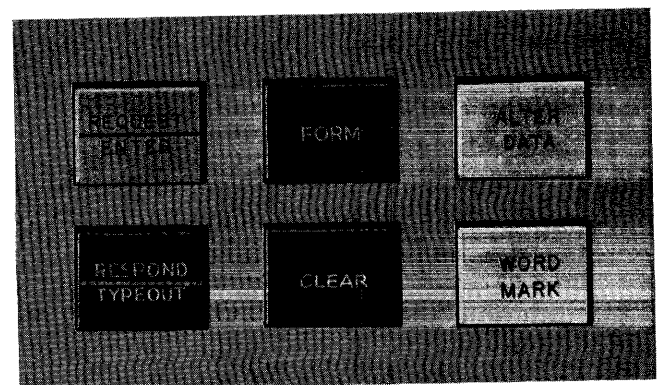


Figure 81. IBM 1407 Control Keys and Lights

on the 1401 console and this lighted ALTER DATA key must be pressed. Pressing this key causes:

- The keyboard to unlock,
- The ENTER light to turn ON,
- The 1401 to be signalled that characters will be altered-in from the 1407.

Respond/Typeout

This green key may be pressed when the system is in either the run mode or the alter mode. In the *run mode*, it is used in conjunction with the processing of an inquiry. After a program has been interrupted and an inquiry has been keyed-in (see *Request/Enter* key-light), pressing this RESPOND/TYPEOUT key causes:

- A carriage return.
- The keyboard to be locked.
- The ENTER light to turn OFF.
- A group-mark with word-mark to enter core storage immediately after the keyed inquiry.
- The 1401 system to handle the inquiry.

After the inquiry is processed, the response is automatically typed on the 1407 from 1401 core storage. When typing starts, the RESPOND/TYPEOUT light turns ON.

In the *alter mode* (ALTER DATA key-light ON), this RESPOND/TYPEOUT key is used to type out data read from a selected location of core storage. This key is pressed after a core-storage starting address has been set up in the manual address dials on the 1401 console. When typing starts, this key-light turns ON.

The RESPOND/TYPEOUT light turns OFF when the CLEAR key is pressed or when program-controlled typing is completed.

Clear

The red CLEAR key-light is operative in either the run mode or the alter mode. In the *run mode* of operation, it is used in conjunction with the keying of an inquiry. If the operator makes a typing error, he can press this CLEAR key to set up the system for re-keying the same inquiry. This causes:

- A carriage return.
- The keyboard to be locked.
- The ENTER light to turn OFF.
- An internal indicator to be set ON.
- Processing to be resumed. The program can test the indicator. When it finds that the CLEAR key has been pressed, the system can be readied for a re-keying

of the inquiry. Then the keyboard is unlocked, and the ENTER light turns ON again to signal the operator that he can start typing.

This key can also be used, in the run mode, to stop the typing of the response to an inquiry. Pressing the key during this type-out causes:

- Typing to stop.
- A carriage return.
- The RESPOND/TYPEOUT light to turn OFF.
- An internal indicator to be set ON.
- Processing to be resumed.

The CLEAR key-light functions as a signal light during an inquiry operation in the run mode. The light turns ON, and the keyboard locks, if a group-mark with word-mark is sensed in 1401 core storage before the operator finishes keying-in the inquiry.

In the *alter mode* of operation (ALTER DATA key-light ON) this CLEAR key must be used to terminate either an alter-in or read-out operation. For an alter-in operation, the operator presses this key when he finishes typing. This causes a carriage return and locks the keyboard. For a read-out operation, the operator presses this key when the portion of storage that he wishes to examine has been typed out. This stops the typing and causes a carriage return. Unlike operations in the run mode, pressing the CLEAR key in the alter mode does not set the internal indicators.

Word Mark

This yellow key is pressed to enter a word mark (into 1401 core storage) with the next character that is keyed-in. Word marks can be entered when characters are altered-in (alter mode of operation), or when programming provides for word marks in an inquiry operation in the run mode. For operator reference, characters entered with word marks are typed in red on the 1407.

Meter Switch, IBM 1407

If the use-meter switch is not set to ON before an instruction calls on this unit, the system interlocks and the following comments and procedures apply:

- Stop the system, turn the meter switch on, press start reset, and restart the program at the instruction that initiated the operation that could not be completed.

Meter Time, IBM 1407

The meter starts when the 1407 is first called upon by the program.

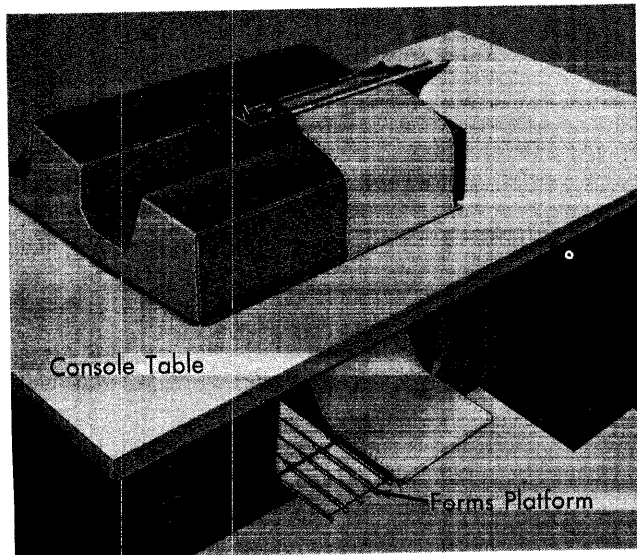


Figure 82. Continuous-Forms Feeding

Operations

Inserting Forms

Either roll paper or continuous forms can be fed in the 1407 typewriter. A roll of paper is mounted on a rod above and in back of the platen (see Figure 84). To insert continuous forms (Figure 82), follow these steps:

1. Place the stack of forms on the forms platform at the rear of the 1407. For the best form-feeding operation, place the forms so that they line up with the typewriter carriage when it is positioned at the right-hand margin stop. This allows the forms to align directly behind the carriage at the time it line spaces.

2. Feed the forms, from the stack, up through the slot in the console table at the back of the typewriter.
3. Insert the first form in the typewriter carriage.

After forms are printed, they stack on the console table in back of the typewriter.

Changing Ribbons

1. Open the cover over the typebars by grasping the cover at the center and pulling it up and toward you.
2. Wind all the used ribbon onto one spool by pressing the ribbon rewind lever (Figure 83). When all the usable portion is on the spool, winding stops automatically and the ribbon-reverse lever next to the full spool goes down.
3. While holding back the ribbon guide located over the spool, pull out the small knob at the center of the spool (on the side toward the typebars) and remove the spool.
4. Loosen the end of the ribbon from the empty spool. Pull the ribbon from the ribbon guides, and discard the used ribbon and spool.
5. Insert a spool of new ribbon, while holding back the ribbon guide over the spool. The spool must be held so that the teeth at the top of the spool point toward the platen. Be sure the spool is properly mounted on the hub and that the knob is in place at the center of the spool.
6. If the ribbon-reverse lever next to the full spool is up, press it down.

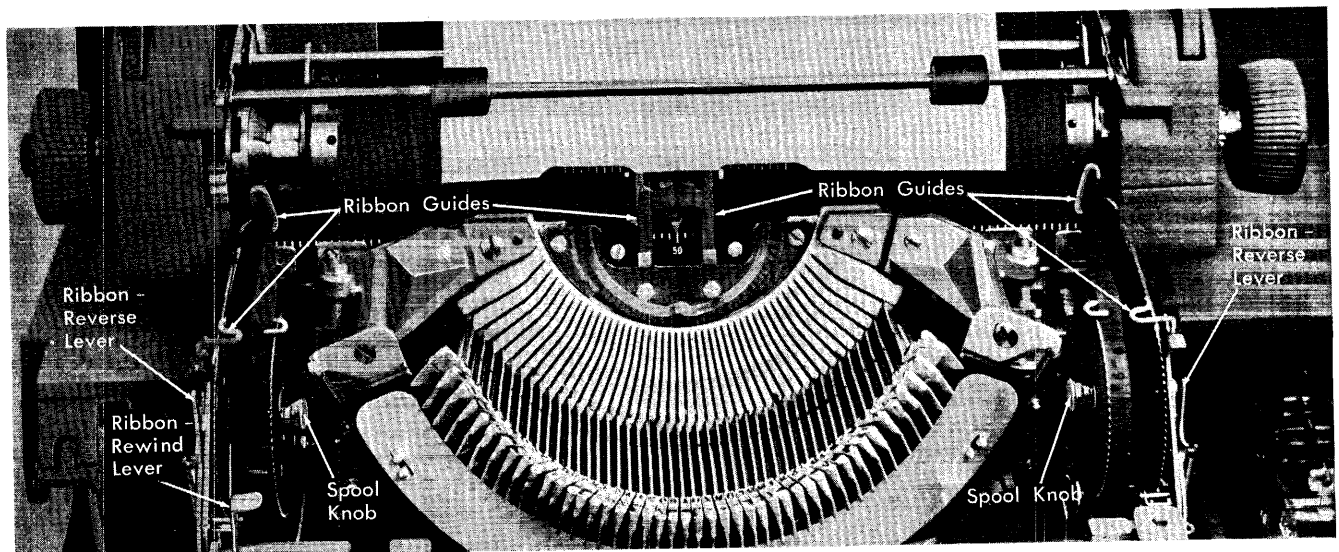


Figure 83. Ribbon Threading

7. Feed the ribbon through the six ribbon guides and hook it onto the empty spool. Be sure the ribbon is positioned so that the red portion is the *lower* half as the ribbon feeds in front of the platen.
8. Close the cover, pressing it lightly until it snaps shut.

Changing Platens

1. Center the carriage.
2. Raise the paper bail, rod, and left- and right-hand carriage end covers (Figure 84).
3. Push back and lift up the left- and right-hand platen latches.
4. Lift out the platen.
5. Insert the new platen, positioning it so that the groove in the right end of the platen shaft centers over the carriage end plate.
6. Lock the platen into position by moving the platen latches forward and down.
7. Close the carriage end covers, pressing them lightly until they snap shut.
8. Lower the rod and paper bail.

Processing an Inquiry (with Programmed Interrupt)

If a program in process contains instructions that provide for its being interrupted, operation (in the run mode) can be stopped and an inquiry can be keyed-in and processed. An inquiry routine must have been stored in core storage.

To handle an inquiry, follow these steps:

1. Press the REQUEST/ENTER key. The REQUEST light and an internal indicator turn ON. When the program tests and finds that this indicator is ON, and

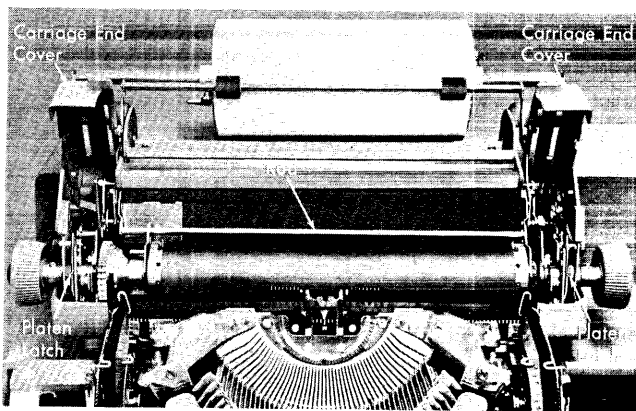


Figure 84. Platen Removal

when the 1401 is ready to accept the inquiry from the 1407, the REQUEST light turns OFF and the ENTER light on the 1407 turns ON. (The internal indicator turns OFF.)

2. Type the inquiry on the 1407 keyboard. This *must* be one of a group of *preplanned* questions. If programming has provided for reading-in word marks, press the WORD MARK key immediately before each character with which a word mark must be associated.
3. If an error occurs during typing, press the CLEAR key. This turns OFF the ENTER light and locks the keyboard temporarily. When the 1401 is ready to receive a re-keyed question, the ENTER light turns ON again and the keyboard is unlocked. Re-key the question starting from the beginning.
4. After typing the inquiry, press the RESPOND/TYPOUT key. This causes the 1401 system to start processing the inquiry.
5. When the processing is completed, the response is typed automatically on the 1407. During this typing, the RESPOND/TYPOUT light is ON. After the response has been typed, this light turns OFF and automatic processing is resumed. If typing should be stopped and automatic processing resumed before the complete response has been typed, press the CLEAR key.

Processing an Inquiry (with Manual Interrupt)

If a program in process does not provide programmed interruption to process an inquiry, the operator must stop operation and transfer to the inquiry routine. The inquiry routine must have been previously stored in core storage. After the inquiry has been handled, the operator must transfer back to the program, if processing is to be resumed. The function allows the operator to decide, on the basis of the response to the inquiry, whether or not processing should continue.

One method of stopping an operation to process an inquiry uses a list of addresses at which the program can readily be interrupted. These addresses are planned by the programmer and listed in the operating instructions. To stop automatic processing at one of these addresses and to handle an inquiry, follow these steps:

1. Press STOP on the 1401 console and note the I-address displayed in STORAGE ADDRESS.
2. Pick the next higher address from the list of addresses in the operating instructions, and set up the system to stop at this address:
 - a. Set the 1401 mode switch to ADDRESS STOP.
 - b. Set up the address in the MANUAL ADDRESS dials.
 - c. Press START.

3. When processing stops at this address, alter into the I-address register the high-order storage address of the inquiry routine:
 - a. Set the 1401 mode switch to ALTER.
 - b. Set up the address in the MANUAL ADDRESS dials.
 - c. Press I ADD REG and START on the 1401 console.
4. Set the mode switch to RUN and press START RESET on the 1401.
5. Press REQUEST/ENTER on the 1407 and START on the 1401. The REQUEST light turns ON.
6. The 1401 system starts processing the inquiry routine. When the system is ready to receive a keyed inquiry, the REQUEST light turns OFF, and the ENTER light on the 1407 turns ON.
7. Type the inquiry on the 1407 keyboard. This *must* be one of a group of *preplanned* questions. If the inquiry routine has provided for reading-in word marks, press the WORD MARK key immediately before each character with which a word mark must be associated.
8. After completely keying the inquiry, press the RESPOND/TYPOUT key. This causes the 1401 system to start processing the keyed-in inquiry.
9. When the processing is completed, the response is typed automatically on the 1407. During this typing the RESPOND/TYPOUT light is ON. If typing should be stopped before the complete response has been typed, press the CLEAR key.
10. Examine the message and proceed according to the directions in the operating instructions. If a return to the original program is required, alter-in the I-address originally selected from the list of stopping addresses (step 2), set the mode switch to RUN, and press START. If a branch to a different address is required, alter-in that address and start processing.

Entering Information into Core Storage (Alter Mode)

Data or program instructions can be entered into a selected area of 1401 core storage from the 1407 keyboard by following these steps:

1. Alter into the B-address register the high-order address of the core-storage area that is to receive the keyed information:
 - a. Set the 1401 mode switch to ALTER.
 - b. Set up the address in the MANUAL ADDRESS dials.
 - c. Press B ADD REG and START on the 1401 console.
 - d. Press START RESET on the 1401 console.
2. Press the lighted ALTER DATA key on the 1407.
3. Type the desired information. As the characters enter core storage, word marks are cleared from these positions, if any had previously been stored. If a word mark is to be entered with any character at this time, press the WORD MARK key before typing that character.
4. After all the information has been keyed-in, press the CLEAR key.

Reading Information out of Core Storage (Alter Mode)

Information can be read out from a selected area of core storage and typed on the 1407 by following these steps:

1. Alter into the B-address register the high-order address of the core-storage area that is to be read out:
 - a. Set the mode switch to ALTER.
 - b. Set up the address in the MANUAL ADDRESS dials.
 - c. Press B ADD REG and START on the 1401 console.
 - d. Press START RESET on the 1401 console.
2. Press RESPOND/TYPOUT on the 1407. This key-light turns ON and typing starts. Each character that has a word mark is typed in red, and each blank position is indicated by the letter *b*.
3. When all the required information has been typed, press the CLEAR key.

IBM 1447 Console Model 3

The IBM 1447 Console, Model 3 (Figure 85), provides the 1401 system user with a fast means of communication. All the advantages of the IBM 1407 Console Inquiry Station, plus the increased printout speed of 14.8 characters per second, provides the console operator with an efficient and time-saving method of inquiry and reply.

Before the 1447, Model 3, can be attached to a 1401 system, the IBM 1409 Console Auxiliary (Figure 86) and the 1409 adapter special feature must be installed.

The indicator and operator panels are located on the 1401 processing unit. Several additional keys and lights, located on the printer keyboard, are used during I/O printer operations.

IBM 1447 Keys, Lights and Switches

Proceed Light

The proceed light glows when the console I/O printer is selected to operate.

Check Light

The check light glows when the inquiry-clear indicator is turned on.

Reset Key

The reset key is used with the type key, on a 1447 Model 3 having buffer storage. The reset key is not required on the unbuffered model.

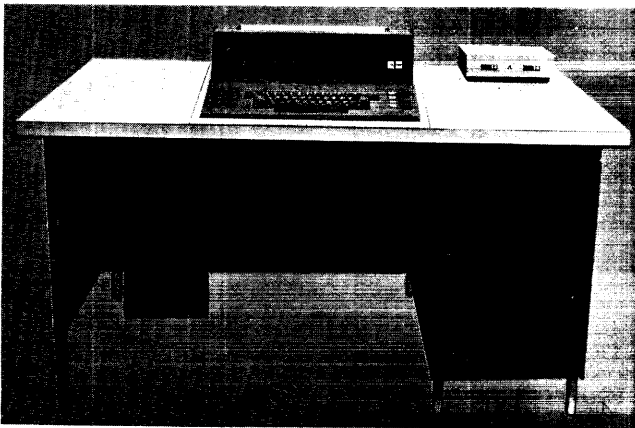


Figure 85. IBM 1447 Console Model 3

Alter Type-In Key

When the CPU mode switch is set to ALTER, this key must be pressed to allow storage entry of keyboard information. Characters enter storage starting at the address indicated by the B-storage address register.

Type Stop Key

This key is used to terminate a character-display type-out operation.

Type Key

During *manual* operation, the type key initiates a storage type-out operation, beginning with the address indicated by the CPU B-storage address register. The CPU mode switch must be in alter mode.

During *programmed* operation, the type key is used to perform the following functions.

Buffer: The type key initiates request to the buffer. CPU selection of the 1447 permits keyboard entry

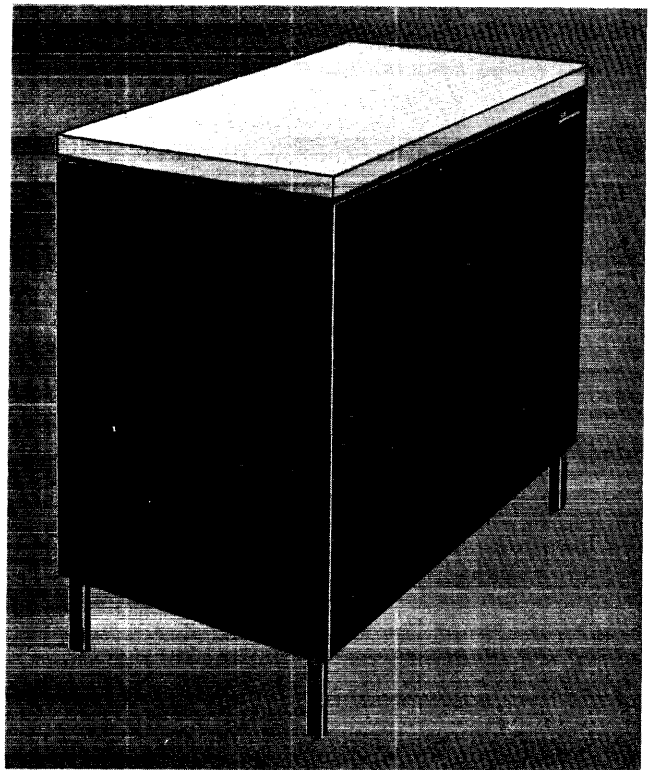


Figure 86. IBM 1409 Console Auxiliary

into the buffer. Press the release key to turn on the inquiry-request (Q) latch.

Buffer and Polling: The type key initiates a request to the buffer. Subsequent CPU selection of the 1447 being polled allows keyboard information to enter buffer storage.

Unbuffered: The type key turns on the inquiry-request (Q) latch. CPU selection (by a branch on Q and a read Op) allows the operator to enter information from the keyboard.

Unbuffered and Polling: This initiates the turn-on of the Q-latch when the 1447 is polled.

IBM 1401 Mode Switch

When a 1447 is attached (through an IBM 1409 Console Auxiliary) to the 1401 system, the I/EX position of the 1401 mode switch is affected as follows: When performing a programmed type operation, the system will stop at the end of the *next* I-phase instead of the end of the I- or E-phase of the *type* operation.

Meter Switch, IBM 1447

If the use-meter switch is not set to ON before an instruction calls on this unit, the system interlocks and the following comments and procedures apply:

- Stop the system, turn the meter switch on, press start reset, and restart the program at the instruction that initiated the operation that could not be completed.

Meter Time, IBM 1447

The meter starts when the first instruction is issued involving the 1447.

Console I/O Printer

The console I/O printer combines a keyboard of 64 characters 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 reaches the right-hand margin, an automatic carrier-return and line-feed operation is executed. Printing is suspended during this operation and during any tabulation operation. This printer can print up to 130

characters per line without the pin-feed platen, and up to 128 characters per line with the pin-feed platen feature (10 characters per inch).

The printing of either ten or twelve 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 then can be manually altered with a double-space setting, resulting in either three-instead-of-six or four-instead-of-eight lines per inch.

Printer Forms

The console I/O printer can:

1. Print on cut forms
2. Feed and stack continuous pin-feed forms
3. Feed continuous-roll single-thickness paper.

With the pin-feed special feature installed, form width (pin to pin) can be 6, 7½, 8, 9, 10, 10¾, 11¼, 11½ or 13¾ inches. The form width must be specified for each pin-feed platen.

The maximum form width is 15 inches. The maximum length of a printer line is 13 inches.

When using continuous forms, the forms are placed on the forms platform. The form is then inserted in a slot between the console printer and the table, and then inserted in the console printer.

The printed forms are stacked on the portion of the console inquiry station table behind the console printer.

Keyboard

The console I/O printer keyboard (Figure 87) is not mechanically connected to the printer mechanism. Seven keys on the keyboard are function keys initiating space, cancel, release, carrier return and line feed, tab, shift, and shift lock.

Some of these function keys also transmit specific characters when they are pressed. The function keys and the characters they transmit are:

Function Key	Character	BCD Coding
Space	no character	C
Carrier Return		
Line Feed	]	C B 8 4 1
Tabulate	[	A B 8 4 1

Functional-Control Characters

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. The characters designated as functional-control characters and the printing functions they initiate are:

Character	BCD Coding	Printer Function
blank	C	Space
] [	C B 8 4 1	Carrier Return Line Feed
[]	A B 8 4 1	Tabulate

These characters can be printed when they are transmitted in the load mode, but the printer function is *not* executed.

Five keys on the 1447 keyboard offer a choice of two special characters each (Figure 87). The 1447 is equipped with two interchangeable print elements, one containing print-arrangement A and the other print-arrangement H. The operator can change the print element to provide the special-character printing required by the program. Internal coding is not affected when the print element is changed.

Word-Mark Key

When the period (.) key is pressed in upper shift, a word mark (inverted circumflex) is printed. Transmission of the word mark with its associated character depends upon the operation being performed.

Cancel Key

The cancel key is used to inform the system that the message should be disregarded. The key operation:

1. Sets the INQUIRY-CLEAR (*) latch ON in the system.
2. Turns on the red type light on the console.

3. Inserts a C-bit in core storage.
4. Initiates a carrier-return and line-feed operation.
5. Disconnects the printer from the system.

Release Key

The release key is used to end a printer-to-system operation. When in normal shift status, the key operation:

1. Inserts a group-mark with word-mark in core storage.
2. Initiates a carrier-return and line-feed operation.
3. Disconnects the printer from the system.

(When the release key is pressed during an alter operation, the group-mark with word-mark is not sent to the system.)

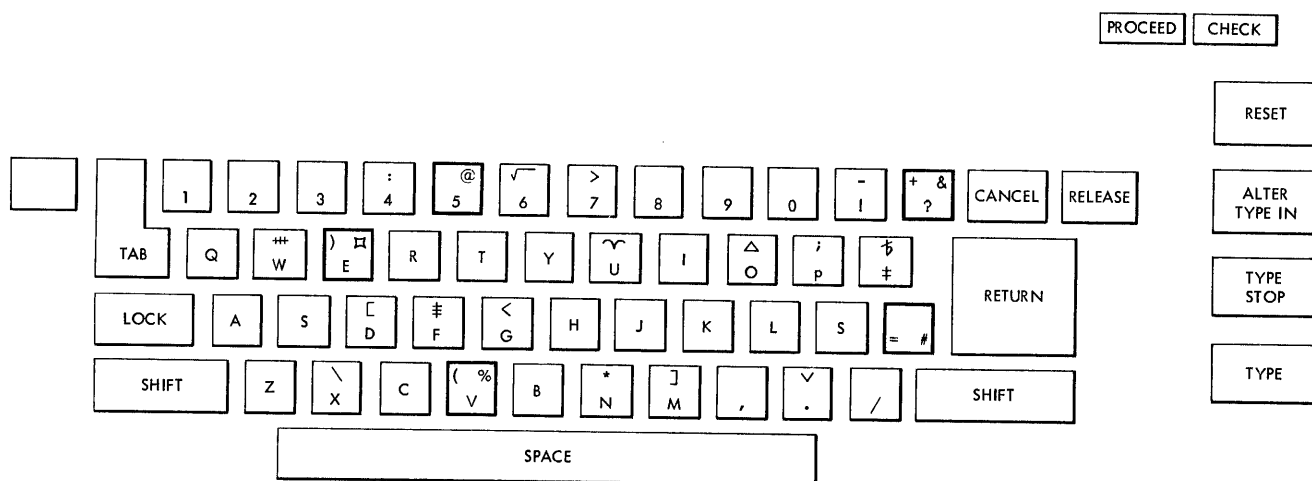
Shift and Shift-Lock Keys

The shift and shift-lock keys are used to enter uppercase characters. The shift status must be restored to normal (lower case) before the release key is pressed.

Console I/O Printer Keys and Levers

Tab Control (Clear and Set)

To clear tab settings, tab to each stop and press the CLR (or top) of the tab control (Figure 88). To set a tab stop, position the carriage to the desired point on the writing line and press the SET (or bottom) of the tab control.



NOTE: Characters on left side of key are the H arrangement; characters on right side of key are the A arrangement.

Figure 87. Console Printer Keyboard

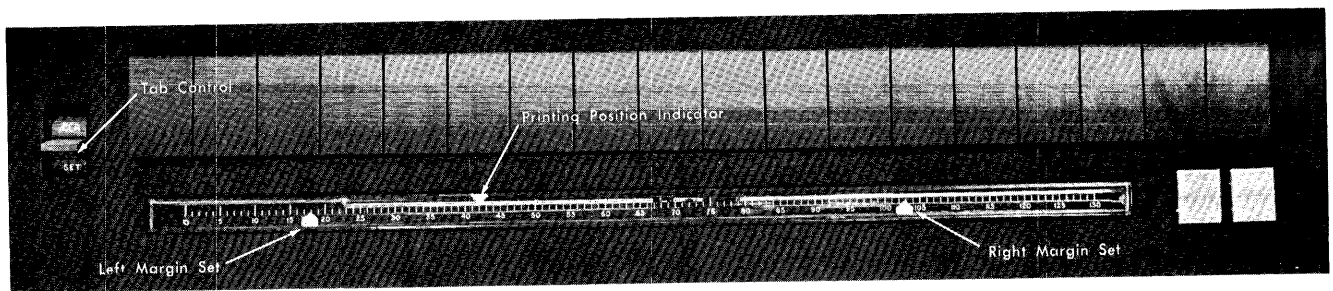


Figure 88. Margin Stops

Margin Stop

The margin stops limit the length of the line to be typed. To set the margin stops:

1. Lift the I/O printer cover.
2. Space until the position indicator is at desired location of new margin.
3. Push the margin stop toward the typewriter, and align the red mark on the margin stop with the typing position indicator.

To set the left margin stop, push in the left margin stop and slide it to the desired position on the margin guide.

Multiple-Copy Control Lever

To compensate for additional copies, move the multiple-copy control lever toward the rear of the printer (Figure 89). This adjusts the platen so that the printing element will strike squarely on the form. Paper weight and number of copies will determine the setting of

this control. Normally, set the multiple-copy control lever on the second marking for one original with three carbon copies, and on the third marking for one original with five carbon copies.

Line-Space Lever

This lever controls the line-space movement of the platen (Figure 8). The line-space lever can be set for either single or double space.

Paper-Release Lever

Move the paper-release lever (Figure 89) forward to position or remove forms.

Platen Variable

This control, operated by pressing in on the left end of the platen, allows the platen to rotate freely. The platen variable is useful after reinserting a page for correction or addition.

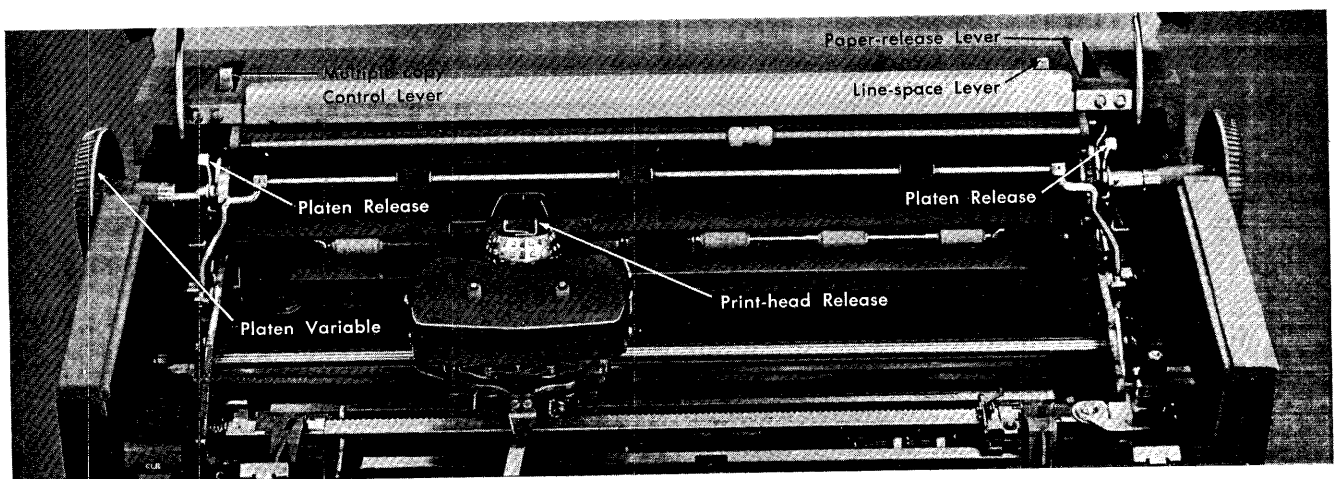


Figure 89. Impression and Form Controls

Ribbon and Platen Procedures

Platen Removal and Replacement (Figure 89)

1. Move the paper-release lever forward.
2. Move the paper bail forward.
3. Lift the cover.
4. Press the platen spring and lift the platen.

The feed rolls are now accessible. Clean the platen, feed rolls and bail rolls periodically to assure proper paper feeding and to prevent roll marking. There is no need to remove the metal deflector.

To replace the platen, position it with the ratchet teeth to your right. Center the end plate in the groove in the platen shaft, and press down until it clicks into place.

Ribbon Reversal

Open the top cover of the console printer by grasping the center of the cover and pulling up and away from the printer. To close the cover, lower it and press lightly. The cover will snap shut.

Reverse the ribbon direction by moving the ribbon-reverse lever (Figure 90) to the opposite side of the ribbon cartridge.

Ribbon Installation (Figure 90)

1. Open the cover over the print element.
2. Position the carrier near the center of the carrier rod.
3. Shift the ribbon-change lever to the right, and raise the ribbon guide.
4. Lift the ribbon cartridge vertically off the carrier ribbon posts.

5. Ease the ribbon through the slots in the ribbon guides.
6. Insert a pencil in the cartridge hole, and turn the cartridge in the direction of the arrow. Rewind any excess ribbon.
7. Hold the new ribbon cartridge with the exposed length of ribbon toward the platen.
8. Slide the ribbon down through the slots in the ribbon guides.
9. Position the cartridge on the cartridge posts, and press down firmly.
10. Rewind any excess ribbon by turning either cartridge post in the direction of the arrow.
11. Move the ribbon-change lever to the left to lower the ribbon guide into the typing position.

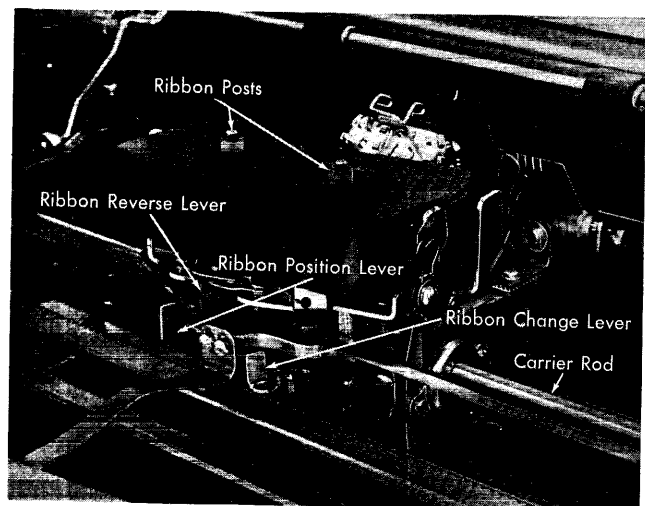


Figure 90. Console Printer Ribbon

IBM 1009 Data Transmission Unit

The IBM 1009 Data Transmission Unit (Figure 91) provides an economical combination of data processing and data transmission. This Tele-processing unit permits high-speed, 2-way communication between two IBM 1401 Data Processing Systems, two 1410 Data Processing Systems, a 1401 system and a 1410 system, or between a 1401 or 1410 system and an IBM 7701 Magnetic Tape Transmission Terminal.

The IBM 1009 Data Transmission Unit controls the movement of data, a character at a time, from the storage area of a processing system, and the transmission of this data to another system over toll or leased wire circuits. With this unit, commercial and scientific data can be transmitted at up to 300 characters per second. This data can be sent short distances between local plants, or long distances across the country — all under stored program control.

Console Panel

Indicator lights and functional keys and switches are located on the console panel (Figure 92) on the top portion of the IBM 1009 Data Transmission Unit. They

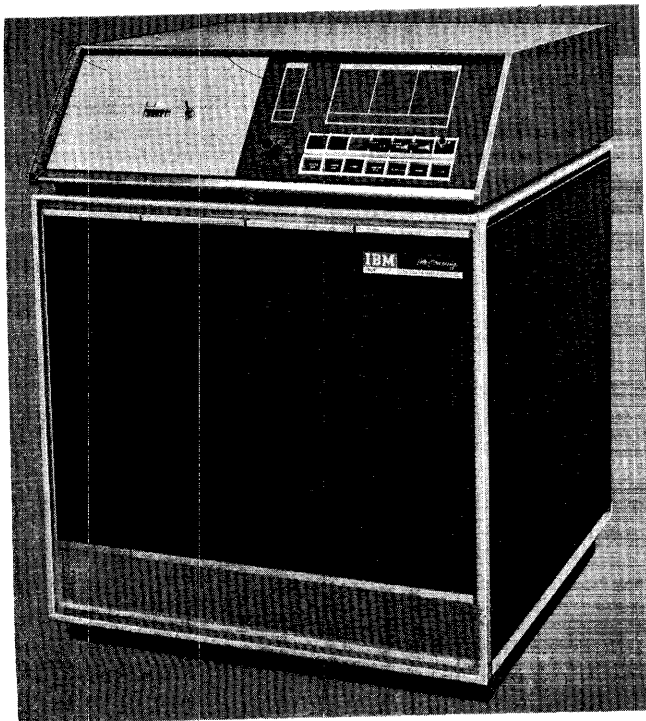


Figure 91. IBM 1009 Data Transmission Unit

are used by the terminal attendant in operating the 1009 during either a transmitting or receiving operation.

Indicator Lights

Power

This light indicates that the power was turned on by pressing the power-on key. It goes off when the power is turned off.

Ready

This light is on when there is a line for data transmission established between two IBM 1009 Data Transmission Units, and the two units are in synchronism. The test-normal switch on both 1009's must be set at NORMAL. Also, the data key on both telephones must be operated, and both connected data processing systems must have power on.

Run

When the 1009 is in an operative status (after the 1009 start key is pressed, and before the attached system starts data transmission), the run light is on. It stays on while the 1009 is in operation. The run light goes out under any of these conditions:

1. The stop key is pressed.
2. The power-off key is pressed.
3. The end-of-file light comes on.
4. The telephone light comes on.
5. An error condition causes the alarm to sound (see *Audible Alarm*).

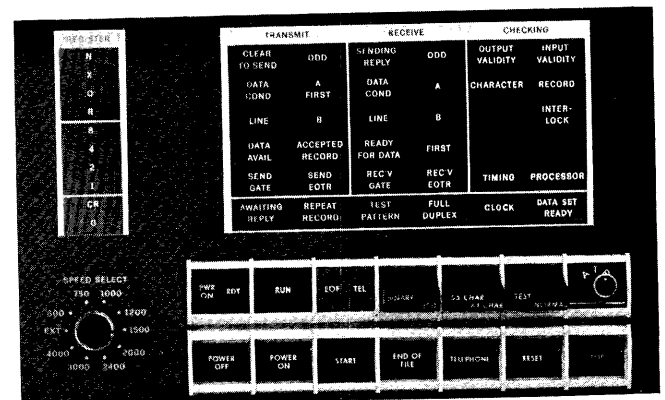


Figure 92. IBM 1009 Console Panel

End-of-File

When either attendant presses the end-of-file key of the 1009, the end-of-file light on the other 1009 is turned on, and the alarm sounds. The signal is returned immediately to the originating 1009, causing the EOF light to come on, and the alarm to sound. Pressing the stop key on each 1009 turns these signals off.

Telephone

If a line for data transmission is established, and either terminal attendant presses the telephone key of the 1009; the TEL light turns on, and an alarm sounds on the other 1009 console. The signal is returned immediately to the originating 1009, causing the TEL light to come on, and the alarm to sound. Pressing the stop key on each 1009 turns these signals off.

Other Console Lights

These are the lights in the upper section of the 1009 console. They are used primarily by the IBM customer engineer for diagnostic purposes.

Clear to Send

This light is under control of the communications-company data set. It indicates that transmission can take place.

Data Cond (Transmit)

This light indicates that the message is being transmitted.

Line (Transmit)

This light indicates that the data set is receiving information from the 1009.

Data Avail

This light indicates that a message is ready for transmission.

Awaiting Reply

This light indicates that the transmitting 1009 is waiting for an accepted record, or a repeat-record indication from the receiving 1009.

Odd (Transmit)

This light is on during the transmission of every other message.

Accepted Record

This light indicates that a correct message transmission acknowledgment was transmitted from the receiving 1009.

Send EOTR

This light indicates the end of each message.

Repeat Record

This light indicates that an incorrect message transmission acknowledgement was transmitted from the receiving 1009.

Sending Reply

This light indicates that the end of the message was detected and the receiving 1009 is ready to send a message transmission acknowledgement to the transmitting 1009.

Data Cond (Receive)

This light indicates that the message is being received.

Line (Receive)

This light indicates that the 1009 is receiving information from the data set.

Ready for Data

This light indicates that the receiving 1009 is ready to receive data.

Test Pattern

This light indicates that the test-normal switch on the other 1009 is set to TEST and is sending test signals.

Odd (Receive)

This light is on during the reception of every other message.

Rec'v EOTR

This light indicates the end of each message.

Full Duplex

This light indicates that the 1009 is conditioned for full duplex (four-wire) communications facilities.

Output Validity

This light indicates

1. that the data processing system has received an invalid character (even parity), or
2. that the data processing system has failed to receive a character from the 1009, or
3. the loss of a message between 1009's.

Character

This light indicates that the receiving 1009 has received an invalid character or an invalid parity check character.

Timing

This light indicates that the two 1009's are out of synchronism. This condition is also indicated by the audible alarm if the 1009 is operative or in the RUN status.

Input Validity

This light indicates that two or three consecutive error messages have been detected. If the third message is correct, the light is turned off; if the following message is also incorrect, the light is turned off by pressing the 1009 start key, and transmission continues.

Record

This light indicates that a message was lost in the transmission between 1009's.

Interlock

This light indicates:

1. that the 1009 is in a receive-run condition, and the attached system is operating under transmit program control, or
2. that the 1009 is in a transmit-run condition and the attached system is operating under receive program control, or
3. that the stored program has addressed the 1009 for some reason, but the 1009 is not in RUN condition, and is unable to respond.

Processor

This light indicates:

1. that the transmitting 1009 has not received the next character from the attached system within the three-second interval that follows the transmission of the preceding character, or
2. that the system has not started the transmission of the next message within the three-second interval that follows the previous message acknowledgement, or
3. that the system was not ready to accept the character available from the 1009, or
4. that the system did not generate a message transmission acknowledgement within the three-second interval that follows the end-of-message indication.

Data Set Ready

This light indicates that the data key on the telephone has been operated.

Keys

Power-On

Pressing this key turns on the power in the 1009. Because the power goes on immediately, it is not necessary to hold the key down.

Power-Off

Pressing this key turns off the power in the 1009.

Start

If the IBM data processing system and the IBM 1009 Data Transmission Unit have been conditioned to transmit or receive, the terminal attendant presses the start key on the 1009. This causes the run light to come on.

End-of-File

When all messages of a group have been transmitted, the attendant at the sending station presses the stop key and then the end-of-file key. This signals the attendant at the receiving station by turning on the end-of-file light and the audible alarm on the receiving 1009. Pressing the stop key on the receiving unit turns off both signals.

The transmitting station end-of-file light also turns on and the audible alarm sounds. Pressing the stop key at each terminal turns off both signals.

Telephone

If a line for data transmission has been established and either terminal attendant wants to talk to the other, he presses the telephone key. This allows the message being transmitted to be completed. The telephone key signals the other station by turning on the telephone light and causing the alarm to sound. Pressing the stop key on the 1009 being signaled, turns off both signals.

Reset

If both the reset key and the stop key are pressed simultaneously, or if the reset key is pressed following the operation of the stop key; an immediate stop in transmission is effected.

Stop

This key is pressed to stop either the transmit or the receive function. If it is pressed while a message is being transmitted or received, the function will stop when the message is complete. If both the stop key and the reset key are pressed simultaneously, an *immediate* stop is effected. If both keys are pressed simultaneously during the transmission of a message, that message will be sent again. Also, a stop key operation turns off:

1. the end-of-file light and the associated audible alarm
2. the telephone light and the associated audible alarm
3. the audible alarm caused by the three successive errors in the transmission of the same record
4. the audible alarm caused by one 1009 getting out of synchronization with the other.

Switches

BCD/Binary

This switch specifies the coding of blank characters for data transmission. Both 1009 switch settings must be the same. When set to BCD, the character set is 55 characters (IBM 705 character set). When set to BINARY, the character set is 64 characters (IBM 1401-1410 character set).

Test-Normal

When this switch is set at TEST, test signals are sent to the remote terminal. The 1009 that receives the test signals acknowledges it by turning on the test-pattern light located in the upper portion of the console panel.

When the test-normal switch is set at NORMAL, the 1009 can execute its normal transmit and receive functions.

Transmit-Receive

This switch sets the mode of operation. If the 1009 is to work in conjunction with an IBM data processing system as a transmitting station, this switch is set at TRANSMIT. If the 1009 is to work with an IBM data processing system as a receiving station, the switch is set at RECEIVE.

Speed-Selector Switch

This switch determines the transmission speed of the IBM 1009. The speed must be compatible with the communication-channel terminal equipment used with the 1009. The setting of this switch on the receiving 1009 must agree with the switch setting on the transmitting 1009.

The 1009 operates in half-duplex or full-duplex mode using the fixed-speed settings of the speed-selector switch.

The following list shows some of the speed-selection settings, and the associated character rates.

600—600 bits (75 characters) per second.

1200 — 1200 bits (150 characters) per second.

Ext—up to 2400 bits (300 characters) per second.

At this setting, transmission speed is determined strictly by the frequency of the data set.

Meter Switch, IBM 1009

If the use-meter switch is not on when the first instruction calls on the 1009, the ready and run lights will not come on. Depending on the program, the system can branch on Transfer 1 and loop, or print out a message that the 1009 is not ready.

To restart the system and functions of the 1009 if the 1009 meter switch was not on:

- Stop the system, turn the meter switch on, press the 1009 start key, and restart the program step that initiated the 1009 function that could not be completed.

Meter Time, IBM 1009

The usage meter on the 1009 records time when all of the following conditions are satisfied.

- The 1009 power is on.
- The 1009 is in *normal operate* mode (on CE panel).
- The 1009 is in character phase (connected by telephone line to another *line speed* device).
- The 1009 is in run condition.
- The 3-second alarm is off, or if it is on, the processing unit meter is recording time (buffered machines only).

Refer to *IBM 1009 Data Transmission Unit*, Form A24-1039, for further information.

Audible Alarm

The audible alarm is a loudspeaker designed to signal the terminal attendant under these conditions:

1. When the transmitting-station attendant presses the end-of-file key, the audible alarm and the end-of-file light of the receiving 1009 turn on. Pressing the stop key on the receiving 1009 turns both signals off.
2. When one terminal attendant presses the telephone key, the audible alarm and the telephone light turn on in the 1009 being called. Pressing the stop key of the 1009 being called turns both signals off.
3. Errors in three successive transmissions of the same message cause the alarm to sound in the transmitting and/or receiving 1009. Pressing the 1009 stop key turns the associated alarm off.
4. If one 1009 gets out of synchronization with the other, the alarm sounds at both terminals. Pressing the stop key on each 1009 turns the alarm off.
5. If the 1009 is in a RECEIVE-RUN condition and the attached system is operating under a transmit program, the alarm sounds. The alarm turns off when the transmit-receive switch is set to the correct setting and the 1009 start key is operated.
6. If the 1009 is in a TRANSMIT-RUN condition and the attached system is operating under a receive program, the alarm sounds. The alarm turns off when the transmit-receive switch is set to the correct setting, and the 1009 start key is operated.
7. If the program addresses the 1009 for any reason and the 1009 is not in a RUN condition, the alarm sounds. The alarm turns off when the RUN condition is established in the 1009.
8. If the receiving data processing system, operating under the control of a receive program, fails to take a character from the receiving 1009; the alarm sounds. Pressing the stop key on the 1009 turns the alarm off.
9. If the transmitting 1009 has not received the next character within the three-second interval that follows the transmission of the preceding character, the alarm sounds.
10. If the transmitting system has not started the transmission of the next message within the three-second interval that follows the previous message acknowledgement, the alarm sounds.
11. If the receiving system did not generate a message transmission acknowledgement within the three-second interval that follows the end-of-message indication, the alarm sounds.

Operating Principles

Before data is sent, the terminal attendants should complete certain housekeeping operations, such as loading the transmit and receive programs, loading the data to be sent, and readying the data processing system and the 1009. The completion of operations such as these before the scheduled time of transmission or reception of data minimizes any delays after making the connection for data transmission.

Making the Connection

Any terminal attendant can establish a line for data transmission by dialing the telephone number of another terminal. If the call is routed through operators, advise them that the call is to be a data transmission call, and that the transmission should not be monitored. Monitoring will degrade the transmission. The transmitting equipment is ready to transmit if:

1. The transmit program has been loaded in the data processing unit.
2. The input (card or magnetic tape) equipment is ready.
3. The 1009 is in a ready condition (power on, BINARY/BCD switch set to desired mode, test-normal switch set to NORMAL, transmit-receive switch set to TRANSMIT).

When the telephone rings at the terminal being called, the attendant answers the telephone and tells the caller whether or not the equipment is ready to accept data. The receiving equipment is ready to receive if:

1. The receive program has been loaded in the data processing system.
2. The output (card or magnetic tape) facilities are ready.
3. The 1009 is in a ready condition (power on, BINARY/BCD switch set to the desired mode, test-normal switch set to NORMAL, transmit-receive switch set to RECEIVE).

If the equipment is ready, each terminal attendant presses the data key on his telephone and cradles the telephone handset. When the ready light on the 1009 glows, each terminal attendant presses the start button on the 1009 console. When the run light glows, he presses the start button on the 1401 to begin the transmission of data.

Ending the Operation

When the last record has been sent and received correctly,

1. The attendant at the transmitting terminal:
 - a. presses the end-of-file key on the 1009 to turn on the EOF light and the audible alarm on the receiving 1009.
 - b. presses the stop key to turn off the EOF light and the audible alarm on the transmitting 1009.
 - c. presses the TALK key on the telephone to disconnect the line for data transmission.
2. The attendant at the receiving terminal:
 - a. presses the stop key on the 1009 to turn off the EOF light and audible alarm.
 - b. presses the TALK key on the telephone to disconnect the line for data transmission.
3. After pressing the TALK key, both terminal attendants should listen for a dial tone to be sure the line is disconnected.

Operator Calls

If the attendant at either terminal wants to talk to the attendant at the other terminal, he presses the telephone key on the IBM 1009 Data Transmission Unit. The TEL light and audible alarm signal the attendant at the remote terminal. If a message is being transmitted when the telephone key is pressed, that message will be completed before the 1009 stops.

When the 1009 stops,

1. The attendant being called:
 - a. presses the stop key on the 1009 to turn off the TEL light and the audible alarm.
 - b. presses the TALK key on the telephone.
 - c. picks up the telephone receiver, and answers the call.
2. The calling attendant:
 - a. presses the TALK key on the telephone.
 - b. picks up the telephone receiver, and begins the conversation.

When the conversation is ended,

1. The attendant called:
 - a. presses the data key on the telephone.
 - b. cradles the telephone receiver so that the transmission of data can continue.
2. The calling attendant:
 - a. presses the data key on the telephone.
 - b. cradles the telephone receiver so that the transmission of data can continue.
 - c. presses the start key on the 1009 to resume data transmission.

IBM 1009 Error Conditions and Checking Procedures

Figure 93 shows the various error conditions that can occur during a transmit or receive operation with the 1009.

Terminal	Signals*	Type Error	Recommended Procedure
Transmitting Terminal	Audible alarm Processor light	The processor has failed to initiate a new message, or, in transmitting a message, has failed to continue to transfer characters to the 1009.	Investigate the processor console lights to determine the cause of interruption, and take corrective action.
	Audible alarm Interlock light	The 1009 is not in a transmit-run condition.	If the system is a 1401, press the start-reset key on the 1401. If the 1009 is attached through an IBM 1414-4, the start-reset function is automatic. Set the 1009 transmit/receive switch to TRANSMIT. Press the 1009 start key. Restart the processor program according to the procedure set up for that program.
	Audible alarm Input Validity light	Three consecutive error messages have been transmitted.	Press the 1009 start key.
Receiving Terminal	Audible alarm Processor light	The processor has failed to generate acknowledgement of a message transmission within the 3-second interval following an end-of-message indication.	Investigate the processor console lights to determine the cause of delay, and take corrective action.
	Audible alarm Interlock light	The 1009 is not in a receive-run condition.	Press the start-reset key on the 1401. Set the transmit-receive switch to receive. Press the 1009 start key. Restart the processor program according to the procedure set up for that program.
	Audible alarm Input Validity light	Three consecutive error messages have been detected.	Press the 1009 start key.
	Audible alarm Processor light Output Validity light	The processor failed to accept one or more characters from the 1009.	Investigate the processor console lights to determine the cause of interruption, and take corrective action.
	Audible alarm Output Validity light Input Validity light Record light	A message has been lost between the transmitting and receiving terminals. This procedure is also followed at the transmitting terminal.	Press the TEL key. When the TEL light comes on, press the TALK button on the telephone handset, lift the receiver, and begin conversation with the transmitting terminal. Tell the attendant there of the possibility of a lost message. After determining the restart procedure, transmission can be resumed.** { Press the DATA button on the telephone. Press the 1009 start key.
Transmitting or Receiving Terminal	Audible alarm Timing light	The two terminal subsets are out of synchronism. This is usually caused by random line noises or by a poor line connection.	This type of error should be self-correcting. If trouble persists, re-establish the line for data transmission.
*Only those lights useful in depicting errors are mentioned. Other lights may or may not be on.			
**One or more messages may have been lost. Transmission may have to be restarted at a batch point, or some other suitable method may be used.			

Figure 93. Table of Common Errors and Recommended Checking Procedures

IBM 1231 Optical Mark Page Reader

The IBM optical mark page readers read positional marks made by an ordinary lead pencil on paper documents. The positional marks are converted into a machine-usable form by the 1231 and entered directly into a data processing system.

Features

Documents are read in the 1231 at a maximum rate of 2,000 sheets per hour. The 1231 throughput depends on computer programming, the feed mode (continuous or on-demand), and the method of grouping the data on the data sheet. (When identification data and detail data are interspersed and read into 1231 storage, more program steps are needed to separate the data in the computer.)

The 1231 (Figure 94), therefore, acts as an on-line input device to data processing systems, such as, IBM 1401, IBM 1440, and IBM 1460.

The 1231 is a fully-buffered machine that operates at an average document cycle of 1.8 seconds (1800 ms) in continuous feed mode. Variations in data-sheet feeding can cause a document cycle of as few as 1,772 ms. Because a maximum time of 7.2 ms can be used for transferring the buffered information from the 1231 to the

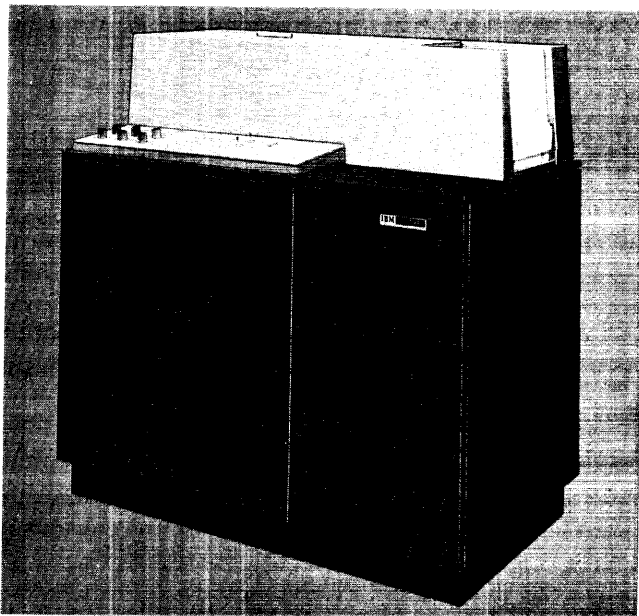


Figure 94. IBM 1231 Optical Mark Page Reader

computer, 1,765 ms of each document cycle can be used for computer processing. Thus, 1231 subroutines can be inserted into routines of other applications. For example, an IBM 1403 Printer could print up to 18 lines between 1231 feed instructions.

Optical mark page readers are ideally suited for applications such as: order entry, payroll, accounts payable, inventory control, sales analysis, and general ledger work.

By means of stored program controls, the IBM 1231 and the IBM 1232 can:

- Control specific data to be stored.
- Control data that is to be repetitively punched into cards.
- Identify the end of a field.

A 1231 can be programmed to recognize each part (field) of a data sheet on an individual basis. Each field can then be checked for the various conditions under which a document can be selected.

A master mark special feature provides group identification when several data sheets are to be processed as a group.

Data Sheet

The document used as input to the optical mark page readers is an 8½" x 11" sheet of paper called a *data sheet*. The data sheet contains a maximum of 1,000 mark positions. The mark positions are arranged in as many as 50 rows, each row containing a maximum of twenty mark positions.

Each row is divided into two groups of ten mark positions each. The ten mark positions are called *words*. Each word is divided into two groups of five mark positions called *segments*. Consequently, each data sheet can have a maximum of 50 rows, 100 words, and 200 segments. A data sheet normally contains five rows per inch, but may have less.

Timing marks are printed along the right-hand edge of each data sheet. These marks are used to synchronize the motion of the document with the various units of the reader. Each word on the data sheet has an associated timing mark.

Words within each row of the data sheet are divided into two groups: odd-numbered words and even-num-

bered words. Odd words are on the left, even words on the right. The timing mark for an odd-numbered word is .636" above the mark positions of the word; the timing mark for an even-numbered word is .536" above the mark positions of the word.

Data Sheet Terminology

Timing Mark: Rectangular marks preprinted on the data sheet in non-reflective ink. The timing mark is used to synchronize the motion of the document with the various units of the 1231. Timing marks are located on the right-hand side of the data sheet (Figure 95).

Mark Positions: Areas printed in reflective ink that designate where marks are to be placed. A non-reflective mark in this area is read as a word or bit.

Words: Ten mark positions of a row. Words on the left half of the data sheet are odd words; words on the right half of the data sheet are even words.

Segments: Mark positions 0 through 4, or 5 through 9 of any word.

Non-Reflective Inks: A type of ink that is sensed by the 1231. Usually, timing marks are the only non-reflective printing on the data sheet. The recommended non-reflective ink is black. See *Ink Requirements*.

Reflective Inks: A type of ink not sensed by the 1231. Reflective inks are used for headings, data sheet instructions, mark position outlines and any other data that is not to be read.

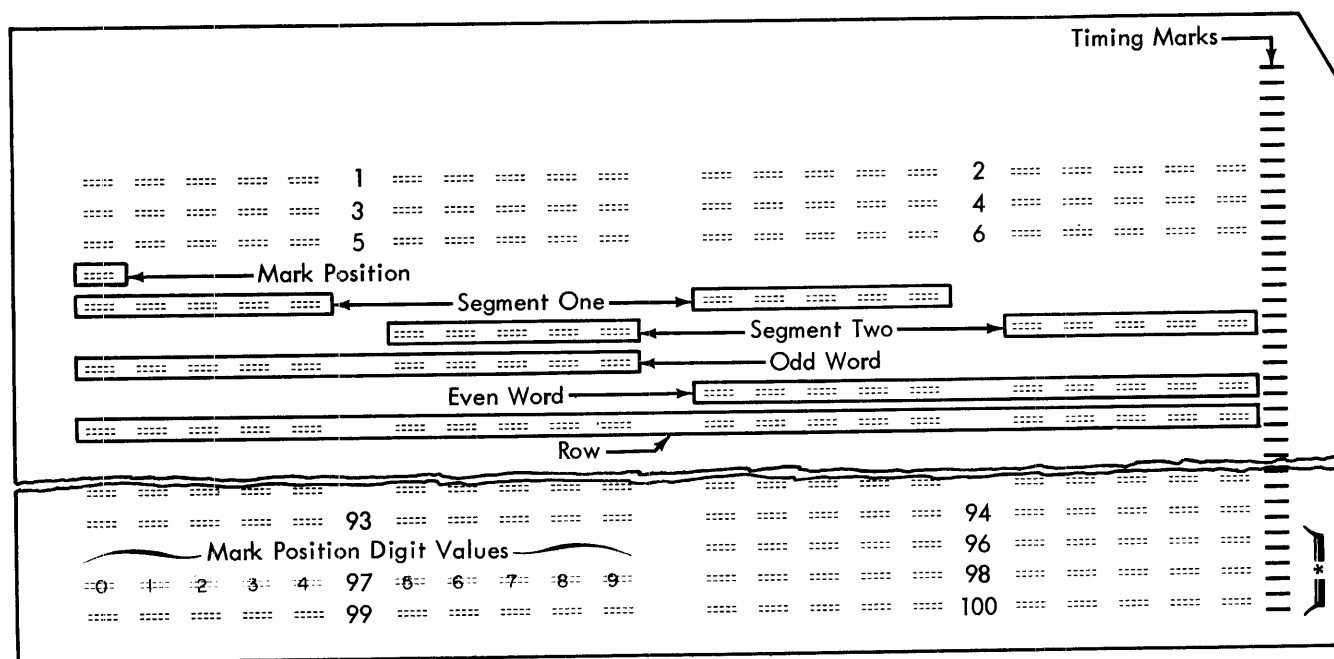
Marking the Data Sheet

Marks that are to be read by an IBM 1231 must be dark enough for positive machine-reading, yet erase easily and completely. For these reasons, a number 2 pencil is recommended.

Marks made with a number 1 pencil, or an IBM ELECTROGRAPHIC® pencil, are difficult to erase; even after an erasure is made, a residue remains that could be read as a mark by the machine.

Erasures should always be made carefully and completely. Any incomplete erasure could be read as a mark.

When response positions are marked, the mark should be made the full length of the mark position, and should fill at least two-thirds of the space between the top and bottom of the guide lines. A mark that extends no more than 1/16" past the ends of the response position is acceptable in all but the last even-word position (next to the timing marks). In this position, a mark must not extend beyond the right end of the guide lines or it could be read as a timing mark. This would result in erroneous reading of the rest of the data sheet.



* These six control timing marks are used for counter read out controls in the IBM 1230.

Figure 95. Data Sheet Format

IBM 1231 Principles of Operation

The IBM optical mark page reader uses sonic delay lines for storing controls and data. Controls are marked on the regular data sheet and entered into storage during the program load cycle. This data sheet is referred to as a program control sheet.

As data sheets are read, data is stored in the delay lines according to instructions from the program control sheet. Each word or segment to be stored must be programmed for entry into storage.

When a data sheet passes under the photo-electric read head, each word or segment is tested (according to preset switch settings) for conditions, such as; no-mark, multi-mark, or other-than-one. Any word or segment that does not pass the requirements of these switch settings causes the data sheet to be routed to the select stacker.

Storage data is available for readout to the data processing system.

Document Path

The data sheet begins its movement through the optical mark page reader when it is fed from the hopper. The document then passes under a read head; is transported through the transport area, past a selection station, and on into one of the two gravity stackers (Figure 96).

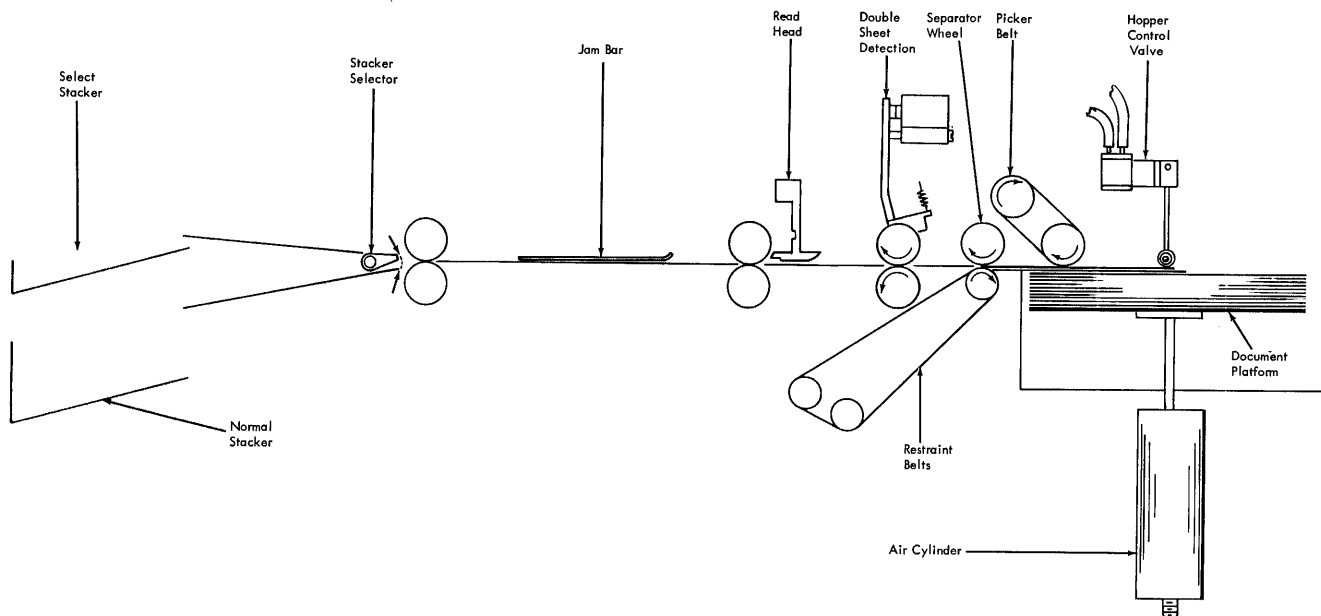


Figure 96. IBM 1231 Document Path

Feed Hopper

Data sheets are placed in the hopper (Figure 97) with the side to be read facing up; the top edge of the data sheet positioned to feed first. Data sheets feed from the top of the stack. The platform on which the documents are held raises automatically to maintain proper feeding. Whenever documents are added to the hopper, document feeding must be discontinued and the platform lowered to accommodate the additional supply of documents. If the stop key is pressed or any emergency stop switch activity occurs, the document platform drops immediately. The stop key stops only the feeding of the documents. An emergency stop (jam, misfeed, timing mark check, etc.) halts the feed rolls, as well as document feeding.

The capacity of the hopper is approximately 600 documents. When documents are processed at the rate of 2,000 per hour, the hopper capacity is great enough for 18 minutes of continuous operation without operator attention. If feeding is attempted and for some reason, such as an empty hopper, a document is not fed within five seconds, the entire feed unit stops operating and the hopper platform drops.

Feed and Transport Mechanism

The feed unit of an optical mark page reader contains a set of four picker belts, two restraint belts, and a separator roll. The transport area contains the feed rolls. As the feed rolls move a document through the

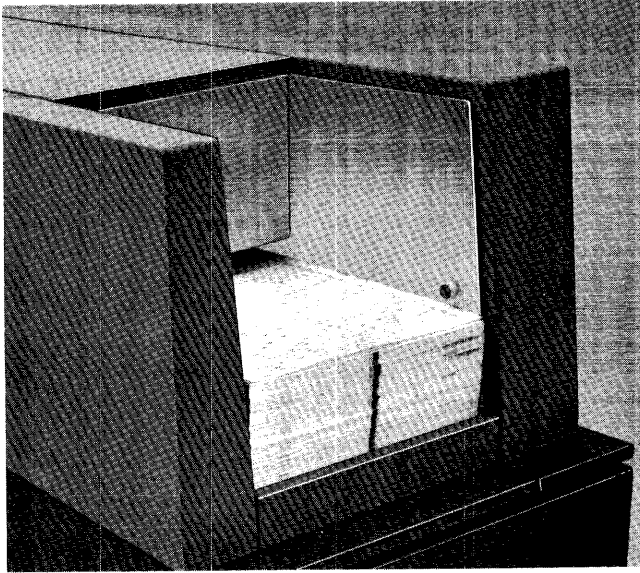


Figure 97. Feed Hopper

transport area, the document passes a selector station and moves on into either the normal or select stacker.

A pressing of the reset key brings documents up to the feeding level and starts feed roll and restraint belt activity. When the start key is pressed, picker belt and drive roll activity starts. Picker belts and the separator roll are operated by the picker belt clutch. The picker belts ride on top of the stack of documents in the hopper, and move documents into the separator station.

At the separator station, a drive roller acts upon the top document to move it forward, while restraint belts move the balance of the documents backward. This creates a shearing action, causing separation of documents. The top document feeds, and the lower documents are restrained. The restraint belts move at a slower speed and have a lesser effect on documents than the drive roller. Therefore, whenever both the drive roller and the restraint belts act upon the same document, the document continues to move forward.

The first set of feed rolls is located about one and one-half inches ahead of the leading edges of the documents in the hopper. A document sensing device, just under the first top roll, senses the presence of documents. As documents pass, they are recognized by this sensing device, causing the picker belts and drive roll to stop. When the trailing edge of the document passes the sensing device, circuits are activated which cause another feed cycle. Consequently, if the feed mode switch is set for continuous feeding, documents feed approximately one and one-half inches apart.

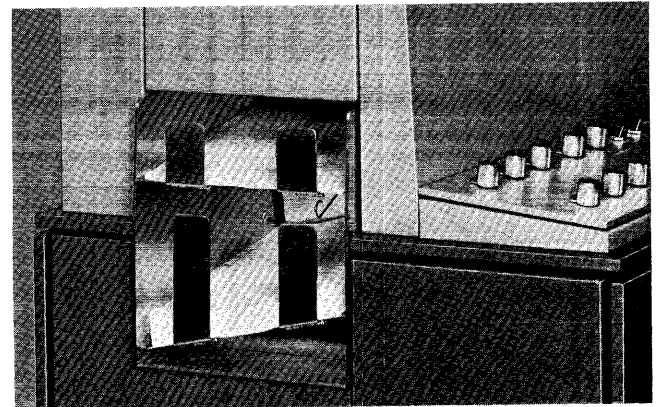


Figure 98. Stacker

All documents pass the read station as they move through the transport mechanism. By the time the leading edge of a document has reached the drive rolls just ahead of the selector station, all reading has been completed. Drive rolls beyond the read station accelerate the document to ensure proper stacking.

Selector Station and Stackers

An optical mark page reader has two stackers, *normal* and *select*, into which it can direct documents (Figure 98). The normal stacker holds about 600 documents. The select stacker, which is just above the normal stacker, holds about 50 documents. Both stackers are equipped with full-stacker switches that stop document feeding when either stacker is filled.

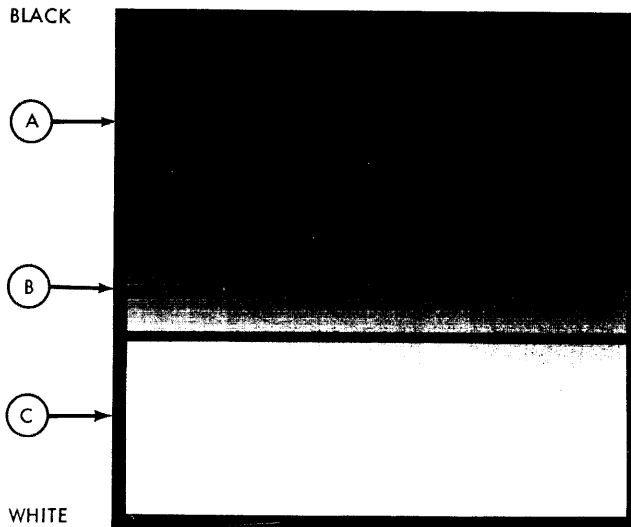
As soon as a document passes the read station, the reader examines its logic and machine controls to determine into which stacker the document will be directed. Documents always enter the normal stacker unless controlled to enter the select stacker. If a document is to be selected, a selector guide in the selector station deflects the document into the select stacker.

The processing unit can also control the direction of a document into the select stacker. After the document has been read, the processing unit has 50 ms in which to analyze the data and give the select instruction.

Mark Recognition and Discrimination

During the reading of data sheets, the optical mark page readers categorize marks according to their degree of light reflectance (Figure 99). A mark falls into one of the following categories:

1. Good
2. Poor
3. Uncertain



A: Good Mark
 B: Light Mark or Poor Erasure
 C: Poor Mark or Good Erasure (Marks in this area are not read)

Figure 99. Mark Reflectance Relationship

A good mark is recognized as a positive indication of a mark; a poor mark (or good erasure) is not recognized as a mark, and an uncertain mark (light mark or poor erasure) is one whose light reflectance level comes somewhere in between a good mark and a poor mark, but cannot be positively identified as either. The reading or rejection of uncertainties can be customer-controlled.

Three read-mode switches, each associated with a set of field-checking switches, allow operator-control of mark discrimination on a field-by-field basis. Documents containing uncertainties can be selected for a visual check if desired.

Each of the three read-mode switches has four settings: SING RESP (single response); MULT RESP (multiple response); SING RESP SEL UNC (single response select uncertainties), and MULT RESP SEL UNC (multiple response select uncertainties).

The setting of each read-mode switch affects mark discrimination (Figure 99) as follows:

1. SING RESP:
 - a. Marks in area A are accepted.
 - b. Marks in area B that are not accompanied by a mark in area A of the same word or segment are accepted.*
 - c. Marks in area B that are accompanied by a mark or marks in area A of the same word or segment are not accepted.*

2. SING RESP SEL UNC:
 - a. Marks in area A are accepted.
 - b. Marks in area B that are not accompanied by a mark in area A of the same word or segment cause the data sheet to be selected.*
 - c. Marks in area B that are accompanied by a mark in area A of the same word or segment are not accepted as marks.*
3. MULT RESP:
 - a. Marks in area A are accepted.
 - b. Marks in area B are accepted.
4. MULT RESP SEL UNC:
 - a. Marks in area A are accepted.
 - b. Marks in area B cause the document to be selected.

Whenever a data sheet is selected by the 1231, storage is cleared and data from that data sheet is not transferred to the computer. However, in the 1232, the information is transferred to the IBM 534 Card Punch and a card is punched. The word or segment in which the uncertainty is detected is transferred to the card punch as a blank character, and the 11-punch in column 81 is inhibited.

IBM 1231 Data Flow

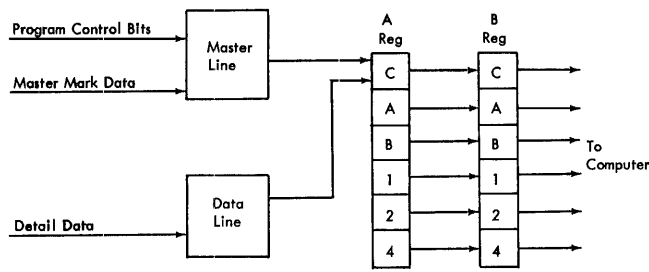
Before the 1231 can act as an input device to a data processing system, the controls for the internal functions must be loaded and switches must be set to establish the conditions required for the particular run.

Two storage devices (sonic delay lines) are used to store and control the data as it is read from the data sheets. One of these storage devices, the *master* line, is used to store all the controls from the program control sheet and, if the 1231 is equipped with the master mark special feature, master-mark data and controls associated with master-mark data are also stored.

The other storage line, the *data* line, is used to store information from the data sheet. As the data sheet is read, the two storage lines work concurrently and in synchronism. The master line, which contains the program instructions, determines which information from the data sheet is to be retained.

The following sequence is used for entering data into a fully equipped 1231, and for making this information available to the processing system (Figure 100):

*The number of mark positions included in any one mark discrimination test is determined by the setting (SEGMENT or WORD) of the check-length switch.



IBM 1231 Data Flow

Figure 100. IBM 1231 Data Flow

1. Line mark and word mark bits are generated by internal circuitry to establish the starting point of the data on the delay lines. These bits go into the master line.
2. Program control bits are loaded into the 1231 from the program control sheet, and go into the master line.
3. Master-mark information (if master mark special feature is installed and being used) is entered into the first ten positions of the master line.
4. Detail data reads into positions 12 through 111 of the data line.
5. A READ instruction from the processing unit causes the data (master and detail) from the master line and the data line to read out in sequence into the A register. The master data from positions 1 through 10 of the master line reads out first, followed by positions 12 through 111 of the data line.

The master and data lines read into the A register one segment at a time. Data is transferred from the A register to the B register between segments. While

data is transferring from the B register to the processing system, the A register is receiving data from the next segment in storage. As data is transferred from the delay lines to the A register, each character is checked for odd-parity.

IBM 1231 Message Format

Each word transferred from the 1231 to the computer reads into two adjacent positions of computer storage. Words are transferred one segment at a time; each segment entering one computer storage position. Words with marks in positions 0, 1, 2, 3, or 4 transfer to the computer as A, B, 1, 2, or 4 bits. Combinations of these bits make up a valid character. Similarly, marks in positions 5, 6, 7, 8, or 9 transfer to the computer as A, B, 1, 2, or 4 bits. Any or all of the marking positions on the data sheet may contain marks, and the data will be transferred to the computer as a valid combination of bits. Data is read by the 1231 from left to right, top to bottom, a row at a time. Information from a data sheet is stored in the following sequence:

1. Segment one of the first word programmed to read.
2. Segment two of the first word.
3. Segment one of the second word programmed to read.
4. Segment two of the second word.

If only one segment of any word is programmed to read, only one position of computer storage is used.

IBM 1231 Controls

The operator's console (Figure 101) on the optical mark page reader contains the keys, lights and switches necessary for setup and operation.

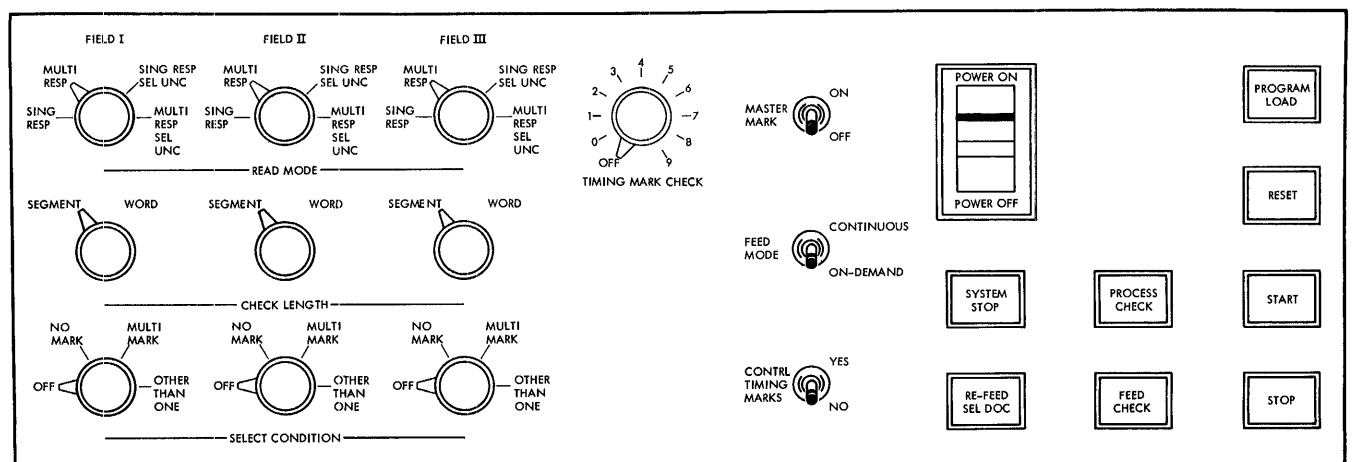


Figure 101. IBM 1231 Operator's Console

Keys and Switches

Start Key

Pressing the start key feeds the first data sheet and establishes continuous running conditions with two exceptions: (1) If the feed mode switch on the 1231 is set to CONTINUOUS, the feed circuits are interlocked with the program of the processing system and will not feed the first sheet until the processing system is placed in an operating status, and (2) if the reader is in a load program cycle, the program control sheet feeds and the control bits are stored.

Stop Key

Pressing the stop key halts document feeding and lowers the hopper plate to facilitate the loading of more data sheets.

Reset Key

Pressing the reset key raises the hopper to the feed position and resets the electronic circuitry. Check or error conditions should be corrected before pressing the reset key.

Program Load Key

Pressing the program load key clears the delay line storage of previously-stored data, and conditions the machine for program loading. This key is lighted during the program load cycle.

Master Mark Switch

The master mark switch is active only on machines equipped with the master mark special feature. This switch controls the capability of the optical mark page reader to recognize a master mark on the right edge of the data sheet. When this switch is on, the recognition of a master mark causes the data in the first ten positions of storage to be cleared and new master-mark data to be accepted.

Feed-Mode Switch

The feed mode switch has two settings: CONTINUOUS and ON-DEMAND. When the switch is set to CONTINUOUS, documents feed continuously. This setting requires the processing unit program to give a read instruction within 150 ms after buffer full in the 1231. This will occur once every 1.8 seconds (1,800 ms). When the switch is set to ON-DEMAND, feeding is controlled from

the system program. The next document will not feed until the contents of the delay line (from previous document) is transferred to the computer.

Check-Length Switch

Three check-length switches are located on the operator's panel; one for each of three sets of switches associated with fields. These switches have two settings: SEGMENT and WORD. The setting defines the length of the item as it will be checked for each field. The SEGMENT setting will check the five positions of a segment; the WORD setting will check all ten positions of a word.

Select-Condition Switches

Each of the three select switches has four settings: OFF, NO MARK, MULTI-MARK, and OTHER-THAN-ONE. Each switch is associated with a check length switch and one of the three fields. The settings represent the conditions in a given field under which a document will be directed to the select stacker.

Read-Mode Switches

These three switches, each associated with a set of field-checking switches, determine the conditions of mark discrimination. Each read mode switch has four settings: SINGLE RESPONSE, MULTIPLE RESPONSE, SINGLE RESPONSE-SELECT UNCERTAINTIES, and MULTIPLE RESPONSE-SELECT UNCERTAINTIES. See *Mark Recognition and Discrimination* in this publication for a detailed description of each switch setting.

Control-Timing-Marks Switch

This switch enables the 1231 to eliminate the 75ms delay associated with the timing-mark-checking feature. The switch has two settings, YES and NO. YES is used when the documents to be processed have the six, extra, control-timing marks needed for 1231 operation. NO is used when no control timing marks are on the documents; the 75ms delay is eliminated.

Timing-Mark-Check Switch

This switch is an 11-position rotary switch with settings numbered 0 through 9 and OFF. The switch is preset by the operator to match the units-position count of timing marks on the data sheets to be processed. For example; if there were 106 timing marks on a document to be processed, the switch would be set at 6.

Lights

Start Key Light

The start key, when lit, indicates that the machine is in a ready state. The light goes off when the start key is pressed, and the light remains off until the machine is again conditioned to the ready state.

Feed Check Light

This light indicates a sheet jam, a misfeed, a double-sheet feed, a full stacker, or an empty hopper. These conditions cause the machine to stop, and the condition must be corrected before the light can be turned off by pressing the reset key.

Process Check Light

This light indicates the following conditions:

1. A parity error in storage logic.
2. The count of data-sheet timing marks is not in agreement with the setting of the timing-mark switch.
3. Failure of processing unit to take data from the B-register before the A-register loaded new data into it. See *1231 Data Flow*.
4. A logic or delay line failure when:
 - a. No control bits are loaded into the master line during the reading of a program control sheet.
 - b. No data bits are loaded during the reading of a data sheet. (Blanks normally load a C bit.)

System Stopped Light

This light is turned on whenever the processing system is stopped while connected to the 1231.

Refeed Sel Doc Light

This light comes on whenever one or more of the following conditions occurs (the last document in the select stacker must be reprocessed):

1. A multi-mark is detected during the reading of the master-mark document.
2. An uncertainty is detected during the reading of the program control sheet.
3. An uncertainty, without an accompanying dark mark, is detected during the reading of the master-mark sheet.
4. A READ instruction during continuous mode operation is received too late.
5. A process check occurs and a new sheet has started to feed (1231 in continuous feed mode only).

CE Test Switch, IBM 1231

If this switch is not set to ON-LINE before the first instruction calls on this unit, the system will interlock.

Meter Time, IBM 1231

The meter starts when the first read instruction is received by the 1231, and runs until the hopper empties and the hopper platform drops.

IBM 1231 Operating Procedures

When properly implemented, the optical mark page readers provide economical and reliable conversion of source data into a machine-usable form. However, to achieve the best level of performance, reasonable controls should be used in the following areas:

1. Documents should be stored under controlled conditions of temperature and humidity.
2. Documents should be handled carefully to minimize mutilation.
3. When documents are being marked, proper procedures should be followed. Marks should be made with a black, lead pencil, and should completely fill the mark position. (A number 2 pencil is recommended.) Erasures should be made carefully and completely.
4. Prior to processing documents, the machine should be properly set up.
5. Test documents should be run and checked for correct results. Selected documents should be analyzed to determine the reason for selection.

IBM 1231 Setup

A fully-loaded 1231 is set up according to the following procedure:

1. Turn the main line switch to **POWER ON**.
2. Set the feed mode switch to either **CONTINUOUS** or **ON-DEMAND**.
3. Set the timing mark check switch to the units position count of the timing marks on the detail data sheet. This number should agree with the count of the marks on the program-control sheet. When master-mark sheets are processed, they are not checked for a timing mark count.
4. Set the control timing marks switch to **YES** or **NO**, depending on whether or not 1231 processable documents are being read.
5. Set the master-mark switch to either **ON** or **OFF**, depending upon the application.
6. Set the field-checking switches to their proper settings. The check-length switches should be set to either **WORD** or **SEGMENT**; the select condition switches should be set to **OFF**, **NO-MARK**, or **OTHER-THAN-ONE**; the read mode switch should be set to **SING RESP**, **MULT RESP**, **SING RESP SEL UNC** or **MULT RESP SEL UNC**. See Figure 101.

7. Joggle the data sheets and place them in the hopper face up, top edge to the left; and place the program-control sheet on top. If the master-mark feature is used, place the master-mark sheet for the first group on top of the first group. The documents must be well-joggled, prior to insertion in the hopper, to keep the edges even and to ensure straight feeding.
8. Press **PROGRAM LOAD** to clear storage.
9. Press **RESET** to raise the hopper to feeding position. The front hopper side plate is operator-adjustable. This plate should keep the documents against the rear hopper side plate without binding. To check for binds, depress the hopper platform about $\frac{1}{2}$ inch. The platform should return to normal operating height without hesitation.
10. Press **START**. This will feed the program-control sheet and the machine will stop.
11. Press **START**. Sheets will feed immediately when the feed mode switch is set to **CONTINUOUS** and the system is not in a *halt* condition. If the system is in a *halt* condition, the start key on the system must be pressed before feeding will start.

When the feed-mode switch is set at **ON-DEMAND**, pressing the start key causes one data sheet to feed. Further feeding of documents is under control of the computer-programmed **READ** instruction; as soon as the buffer has been read out, the next data sheet is fed automatically.

Restart Procedures

Generally, if a condition occurs which causes the 1231 hopper to lower, caution must be exercised in restoring operation. *When the machine is in a stopped condition, pressing of RESET in the 1231 will destroy data in the optical mark page reader's storage.* This will prevent transfer of a complete data sheet to the computer.

Pressing of the stop key on the 1231 causes the machine to complete the processing of the data sheet being read (or just read), then causes the hopper platform to lower. To return the hopper platform to proper feeding level, the reset key must be pressed. *Any time that RESET is pressed to raise the hopper platform, care must be exercised to ensure that the last document read has been completely processed.* This is accomplished by placing the receiving unit (the processing unit) in operating condition, and allowing the unit to complete the processing before pressing the reset key on the optical mark page reader.

Operator procedures for various stop conditions are:

<i>Indication</i>	<i>Cause</i>	<i>Restart Procedure</i>	<i>Indication</i>	<i>Cause</i>	<i>Restart Procedure</i>
Feed Check Light	Document Misfeed	<ol style="list-style-type: none"> 1. Press STOP. 2. Clear document (if necessary). 3. Place document(s) to be reprocessed on top of documents in hopper. If jammed document had passed read head it need not be reprocessed. 4. Press RESET. 5. Press START 	System Stopped Light	Processing Unit is in a <i>halt</i> condition	<p>If the processing unit halt condition is not caused by the 1231, no 1231 action is required. If operating in <i>continuous</i> feed mode and if REFEED SEL DOC is also lit, the last document read must be reprocessed. In this case:</p> <ol style="list-style-type: none"> 1. Press STOP. 2. Remove the top document from the select stacker and place it on top of the documents in the hopper. 3. Press RESET. 4. Press START.
Feed Check Light	Empty 1231 hopper	<ol style="list-style-type: none"> 1. Refill hopper. 2. Press RESET. 3. Press START. 	Process Check Light (1231)	Parity error detected. The error may be caused by a slow-starting clock in the computer, a timing-mark check, or a failure of data to load into 1231 storage.	<ol style="list-style-type: none"> 1. Place last data sheet in normal stacker back on top of documents in hopper. 2. Press RESET. If PROCESS CHECK does not turn out, the program control sheet must be reloaded and the procedure under <i>1231 Set-up</i> must be followed. 3. Press START.
Feed Check Light	Full Stacker 1231	<ol style="list-style-type: none"> 1. Empty stacker. 2. Press RESET. 3. Press START. 			
Feed Check Light	More than one data sheet fed	<ol style="list-style-type: none"> 1. Press RESET and STOP. Hold both keys pressed until double-feed documents have been completely run out. 2. Place documents to be reprocessed on top of documents in 1231 hopper. 3. Press RESET to raise hopper platform. 4. Press START. 	Process Check Light (1231) With Refeed Sel Doc Light	Parity error detected too late to stop the signal to feed the next document.	Similar to procedure under <i>Process Check Light 1231</i> except that two documents are reprocessed; one from the normal stacker and one from the select stacker.

IBM 1285 Optical Reader

The IBM 1285 Optical Reader, Model 1 (Figure 102), serves as an input device for IBM 1401, 1440, 1460, and System/360 Model 30 Data Processing Systems. The 1285 reads printed paper tapes such as those produced on cash registers and adding machines. Using advanced optical-recognition techniques to read directly from the source document of many business transactions, the 1285 eliminates the time, expense, and errors inherent in a system that requires information to be manually punched into cards before being entered into the system.

Features

The ability to bring the flexibility of stored-program processing all the way to the source document means corresponding flexibility in the types of data that can be handled. In most applications, each entry consists of two types of data. The first is descriptive, consisting of an identifying field such as an item or invoice number. The second type is quantitative, indicating the count or amount associated with the descriptive field.

These individual entries are then frequently grouped under a higher level of descriptive information, such as an account number. When this is the case, a total line can be printed for the quantitative field. Even

higher levels of groupings can be present, indicating such information as teller number or department and then, above this level, a field indicating the specific branch office or store that provided the tape.

These higher levels of descriptive or *control* fields are not necessarily read from the tape. A keyboard provides means for the operator to enter such control data for a specific group of tapes.

The steps taken to process the information, from the initial reading of the tape to the final reports or bills printed from the updated files, are also widely diverse. The steps taken depend on many factors such as the specific job, the size of the data processing system, and the type of file-storage media (that is: card, magnetic tape, magnetic disk). A typical sequence of steps is as follows:

1. Read the printed tape, and write magnetic tape records consisting of entries in certain control groups. (This magnetic tape is called the *detail tape*.)
2. Process the detail tape with an audit program (see *Reject Correction*).
3. Sort the detail tape into the same sequence as the master tape.
4. Process the detail tape against the master-file tape to produce the desired output.

Two or three of these steps often can be performed in one system run. In fact, in some cases that do not require sorting (input is either in same sequence as the master file, or the master file is processed in random sequence) the entire job can be performed in one run.

Character Recognition

The IBM 1285 Optical Reader, Model 1, uses a new character-recognition technique with an *electronic flying spot scanner*. The principal component of this reading mechanism is a cathode ray tube. An electronic beam in this tube scans the document through a scan window and, in a 3-step operation, generates signals that allow the interpretation of the character. The three steps in this scan operation are:

1. Locating the print line.
2. Determining the position of a character, and defining its upper, lower, left, and right extremes. This is called the *normalizing scan*.



Figure 102. IBM 1285 Optical Reader

3. Scanning the character to determine the presence of predetermined characteristics relative to the above extremes. This is called the *recognition scan*.

Locating the Print Line

A portion of the printed tape is exposed to the scanner through a window. As the tape moves across the window, either during the initial load or between subsequent frames, the scanner detects the first line of print that enters the window and tracks it as it moves to the top of the window. When that first line reaches the top of the window, the transport mechanism stops. The low-order or right-hand print position is the one scanned to position the tape during the transport operation.

Once the tape is positioned to read a line, it remains stationary until all lines in the window are read. The number of lines in the window at a given setting (referred to as a *frame*) varies, depending on vertical line spacing. In practice, this is usually a fixed number with constant spacing between lines and, therefore, a constant number of lines in a frame. However, there is no maximum limit to the space that can be left between lines except as determined by the allowable roll size, and there is no requirement that constant spacing be maintained.

When the scanner is searching for the first line of a new frame, the paper continues to be transported until the scanner detects a low-order character and tracks it to the top of the window. The line is then read, from low-order to high-order (right to left) for its full length. After reading a line, the scanner moves down the low-order print position, searching for another line. If there is another line in the window, it is read at the next read command. If not, the transport is started to bring in a new frame.

Normalizing Scan

The first step in reading a character is to normalize (determine exactly the position of the character, by defining its upper, lower, left, and right extremes). Scanning starts with a search pattern that "looks" for a character on the tape. The flying spot sweeps the tape in an area determined by the position of the low-order character in the line. As the flying spot scans a character, voltages are stored that correspond to the top, bottom, left, and right extremes of the character. At this point, the normalizing pattern is stopped, and signals are generated in the beam-control logic to cause the spot to begin the recognition scan.

Recognition Scan

With the voltages stored by the normalizing operation, the flying spot is made to perform a series of scans

that have a precise relationship to the physical dimensions of the character. The number of scans and the exact path of each scan depends on which character font is being read.

Each time the spot crosses a segment of the character, a signal is sent to the recognition-logic circuitry of the 1285. Each character in the set can be uniquely defined by the logical combination of these crossover points.

A read operation is completed without a reject indication when one and only one character logic statement is satisfied for each character in the line. In the event that either no statement or more than one statement is satisfied by a character (after an automatic rescan), it is considered a reject and handled as determined by the setting of the correction mode switch.

Reject Correction

A key on the operator's panel selects one of two procedures to follow in the event of a rejected character. When in the off-line mode of reject correction, the 1285 automatically inserts the special character @ (C-8-4-bits) in place of a rejected character. When the read operation is completed, an indicator is set that can direct the program to a correction routine or to a routine that flags the line for correction during a subsequent processing run. There are various ways of programming a reject-correction routine. The method used depends on several factors concerning the specific application. Common techniques for performing reject correction include the use of special check codes for descriptive fields and frequent total lines (or subtotals) for quantitative fields. These can be used by the routine to regenerate the rejected character.

When in the on-line mode of reject correction, the 1285 automatically stops and displays the rejected character on the cathode-ray tube (CRT) display unit as it appears on the tape. The operator examines the character and either corrects or rejects it. If the operator recognizes the character, he presses the corresponding key on the keyboard and then presses the enter key. The read operation is then completed. If the operator does not recognize the displayed character he can press the reject key and then the enter key to replace the reject character with the reject symbol (@). The read operation is then completed.

Reject Line Marker

Anytime that a reject symbol (@) is inserted in place of an unreadable character, the tape moves until the line containing the character is at the top line position in the window. The tape is then marked by a dot about

$\frac{1}{8}$ " in diameter. This dot is on the printed side of the tape, near the edge, on the line containing the rejected character. The dot is plainly visible to an operator for off-line correction (key punching) purposes.

The tape is not marked when a character is corrected by the operator at the keyboard. However, an instruction is provided that makes it possible to mark a line under program control as well as the automatic marking of all lines with rejected characters. For example, if a program-produced total did not agree with a total line read from the tape, that line could be moved to the top of the window and marked for subsequent inspection.

Input Document Considerations

Readable Character Fonts

The reading technique employed in the IBM 1285 Optical Reader, Model 1, makes it possible to recognize more than one type style. Every 1285 contains the circuitry required to read the IBM 1428 type font. As a special feature the logic and control circuitry can be expanded to read the numeric optical-recognition font developed by the National Cash Register Company (NCR). This facility is an advantage of cathode ray tube scanning and the solid logic technology used by the 1285. The IBM 1428 font and the NCR font cannot be intermixed.

The IBM 1285 Optical Reader Model 1 can accept input from various printing devices. Some existing printers require no modification to produce acceptable tapes. Others require only that the typewheels be changed to a character style or font that is recognized by the 1285.

IBM 1428 Character Font

Every IBM 1285 can recognize the character set shown in Figure 103 when printed in the character font used with the IBM 1428 Alphameric Optical Reader. The

```

1 2 3 4 5 6 7 8 . 9 0 T
1 2 3 4 5 6 7 8 . 9 0 N
1 2 3 4 5 6 7 8 . 9 0 C
1 2 3 4 5 6 7 8 . 9 0 S
1 2 3 4 5 6 7 8 . 9 0 Z
1 2 3 4 5 6 7 8 . 9 0 X
1 2 3 4 5 6 7 8 . 9 0 /

```

Figure 103. IBM 1428 Character Font

character centerline dimensions of this type style are .060" in width, .090" in height, and the characters are spaced ten or fewer per inch.

The setting of the numeric format switch specifies that the character in the low-order print position is either always numeric or always alphabetic. In the alphabetic mode, if an alphabetic character is not used, then a special symbol (\neq) must be printed in the low-order position. This character, though recognized, is not read into core storage. It is used by the reader to define the location of a print line. In the numeric mode, one of the digits 0-9 must appear in the low-order position.

Note. When alphabetic characters are intermixed with the symbol, the second character in the print line (the first numeric character) will be either:

1. In the core-storage position specified by the B-address, if the first character is \neq .
2. In core-storage position B-1, if the first character is alphabetic.

NCR Optical Character Recognition Font

Printing devices already equipped with the optical character recognition font developed by the National Cash Register Company (NCR) can be used to produce input to the IBM 1285 Optical Reader. With the optional font special feature, the 1285 can read the character set shown in Figure 104. The centerline dimensions of this font are .030" to .060" in width, .129" in height, and the characters are horizontally spaced ten or fewer per inch.

The character set recognizable in the NCR font consists of the digits 0 through 9, and six special symbols including the alternate styles of the single-print-position integers 10 and 11. The reference mark normally used in the low-order print position should be removed from the printing device. If printed, these reference marks must be blanked using the format-blank knobs.

The NCR font cannot be intermixed with any other font. There are no restrictions as to where in the print line the NCR special symbols can be used.

```

1 2 3 4 5 6 7 8 . 9 0 Y
1 2 3 4 5 6 7 8 . 9 0 H
1 2 3 4 5 6 7 8 . 9 0 J
1 2 3 4 5 6 7 8 . 9 0 B
1 2 3 4 5 6 7 8 . 9 0 H
1 2 3 4 5 6 7 8 . 9 0 P

```

Printed by permission of National Cash Register Company.

Figure 104. NCR Optical Character Recognition Font

Commas and Decimals

All decimal points and commas must be no larger than .030" in their printed horizontal dimension, and .040" in their vertical dimension. A space of .020" must exist between every part of any two adjacent characters, decimals, or commas. The decimal defined in the NCR font is small enough (.015" diameter) to be satisfactory. However, when the IBM 1428 font is used, decimals and commas must be smaller than those defined for the font (.020" wide and .045" high).

Size of Roll

The 1285 can read printed paper rolls with the following dimensions:

Width: 1 $\frac{3}{8}$ " to 3 $\frac{1}{2}$ " (roll width must be uniform within .015").

Length: 36" to 200'

Outside diameter: 4 $\frac{1}{2}$ " maximum

Center hole diameter: $\frac{1}{2}$ " minimum

Paper

The paper used must meet the following requirements:

Basis weight: 10 to 20 pound (weight of 500 17" x 22" sheets).

Thickness: .0020" to .0045".

Reflectance: The paper must be white enough to reflect at least 55% as much light as would be reflected from a surface of magnesium oxide (commonly used as a standard of whiteness). Marks or imperfections are allowed as long as they do not cause the reflectance from a .006" diameter area to vary more than 15% from the background reflectance of the paper. These percentages are given as those allowable when measured by using the 1285 reading system.

Print Quality

The quality of printing produced by devices that prepare rolls for the 1285 depends on:

1. The adjustment and maintenance condition of the printer.
2. The condition of the ribbon.
3. The paper used.

The operator of the printing device must be able to recognize when his output is approaching marginal quality, and must take immediate steps to correct it. The correction usually means simply changing the ribbon. Selection of the proper ribbon is an essential factor in obtaining satisfactory print quality. The selection should be based on the quality of the base fabric and the type and quantity of ink.

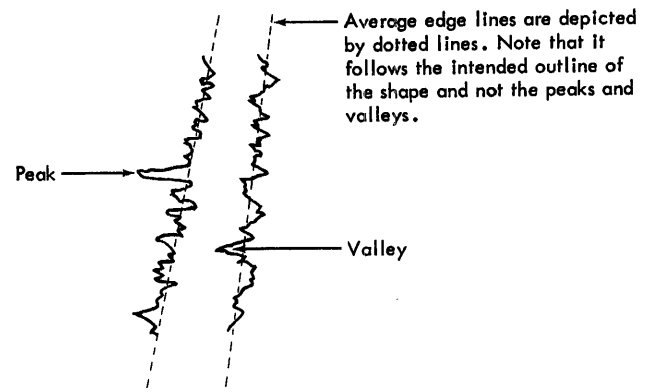


Figure 105. Average Edge

Character-Stroke Width

When viewed through a magnifier, the character stroke of ribbon printing appears ragged and lacks sharpness of edge definition. The stroke-width requirements outlined in this section are given as the distances between *average edges* of character strokes. The average edge of a character stroke is defined as an imaginary line drawn through the *peaks* and *valleys* of the printed edge. This is illustrated in Figure 105. This average-edge line averages out the peaks and valleys (within certain limitations given in this section) to show the intended shape of the character. In fact, although imaginary, this average-edge line is closely analogous to the line actually read by the 1285, in that it does actually see and ignore extraneous bulges and voids on the edge of a character (again, within the limitations given in this section). The direction of the line at a given point is determined by the average peaks and valleys along a .025" increment of the character stroke. If the width of a line is relatively uniform, then the average edges representing each side of the line are parallel. If the line appears tapered, then the average-edge lines are tapered and not parallel.

Based on this definition, the minimum and maximum dimensions in Figure 106 are:

A—Average stroke width: .008"-.020".

B—Maximum height of peaks in excess of average width: .008".

This applies to two peaks directly opposite each other on the two edges of a stroke.

C—Minimum depth of valleys less than average width: .008". This applies to two valleys directly opposite each other on the two edges of a stroke. D is an exception to this allowance.

D—Minimum *actual* width of a stroke at a point: .006".

E—Minimum distance between *actual* edges of different strokes: .004".

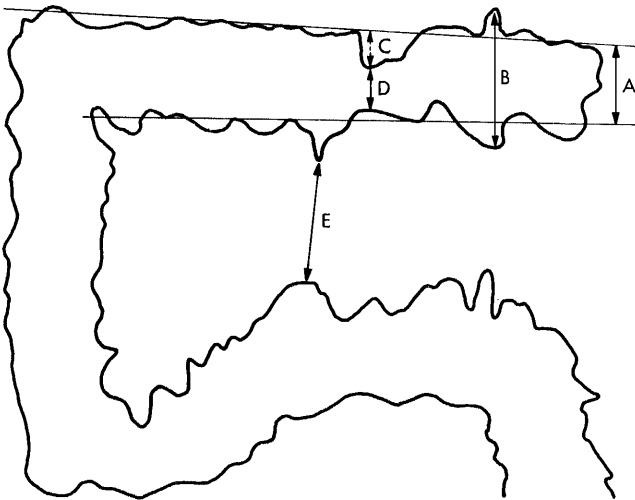


Figure 106. Stroke Width

Reflectance

The light reflected from a printed character must be less than 50% as much as that reflected from the surrounding background paper. This reflectance must not vary more than 20% in .025" increments of stroke length. These percentages are given as those allowable when measured by using the 1285 reading system.

Ink: Voids and Splatter

Voids (blank areas within a printed character stroke) are allowed to the extent that they do not violate the character-reflectance requirements. Extraneous ink spots cause no problem as long as they are at least .004" from a character edge and small enough to fit the requirements of background paper reflectance.

Print Registration

The reading band for a printed line is established relative to the character in the low-order print position. With this character as center, the band extends across the tape in a line perpendicular to the right edge. The height of the reading band for a specific character font is equal to the character height of the font plus 40%. All characters in the line must be entirely within this band. Character skew (the angle between the vertical center-line of a character and the right edge of the paper) must not exceed two degrees.

Print Format

The scan technique in the 1285 allows considerable flexibility of print format. However, certain limiting conditions must be met regarding the position of printed lines, spacing, and the use of special characters.

Printing Position

Distance from End of Tape. There must be at least 10' but not more than 24' of unprinted tape at either end of the roll.

Distance from Edge of Tape. No part of a character may be within .1" of either edge of the tape. The entire low-order character in a line to be read must be within .3" of the right edge of the tape. If a line is not to be read, the low-order character must be at least .5" from the edge.

Character Spacing

There must be at least .020" between every part of two adjacent characters. There must not be more than ten characters per inch. A blank space of .200" or greater (about two character widths) between two characters in a print line is always transferred into core storage as a single blank character (C-bit). A space of .150" or less is never interpreted as a blank.

Line Spacing

Printed lines must be separated by a continuous, clear band at least .050" high. There is no maximum limit to the space that can be left between lines.

Blanked Fields

A single vertical strip can be blanked out of the scan area by using the two format-blank knobs on the display panel. The strip can be anywhere on the tape. At least one blank character position must separate characters that are to be read from those within the blanked vertical strip.

Splices

The 1285 can read paper rolls up to 200 feet long. For maximum efficiency, short rolls should be spliced together to form a continuous tape as close to 200 feet long as possible. This minimizes the number of times the reader must be stopped for a new roll. Those rolls that require header information are not spliced to the end of another tape since header information can be keyed in only when a tape is initially loaded.

Splices must meet the following specifications:

1. Splices must be butt splices (not overlapped) and there may be no more than .025" between the paper ends.
2. Splicing tape must be pressure sensitive, transparent tape. It is used only on one side of the paper.

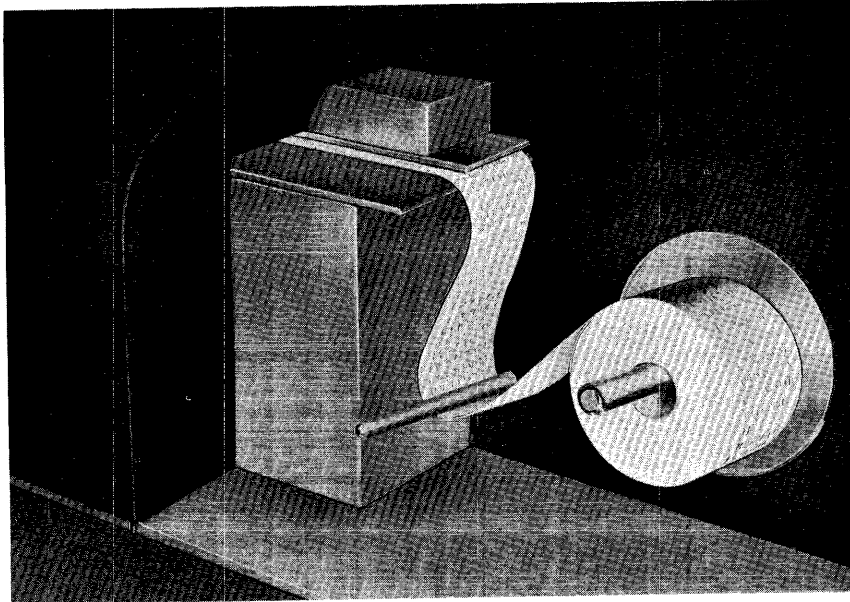


Figure 107. IBM 1285 Supply Spindle

3. The splicing tape must be within .250" of each edge and must not extend beyond the edge.
4. Total thickness of the splice must not exceed .010."
5. Two tapes that are spliced together must be the same width and their edges must be in alignment within .032" in 12 inches.
6. No part of a printed character can occur within 4" of any part of a splice, including the splicing tape.

Mechanical Characteristics

The printed paper is transported from the supply spindle across the scan window by a flat, high-friction belt. Small holes in the belt and a vacuum chamber below the scan station enable atmospheric pressure to keep the paper tight against the belt.

The supply spindle can accommodate a maximum tape length of about 200 feet. The diameter of the input roll (Figure 107) should not be more than 4½ inches. After passing the scan window, the paper is wound into a tight, easily handled roll by the powered take-up spindle (Figure 108).

Loading the Journal Tape

The 1285 is designed for quick, easy loading of the journal tape. A self-threading mechanism enables an operator to load a new tape in about ten seconds. To load a tape, follow these steps:

1. Close the tape guides at the take-up spindle.

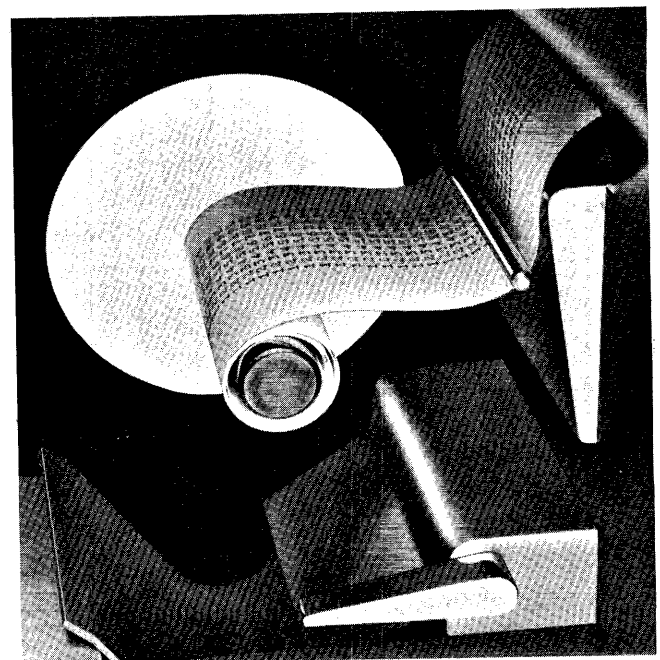


Figure 108. Take-Up Spindle

2. Place the tape on the input (right-hand) spindle so that the print face is up when the paper is extended to the transport area.
3. Insert the end of the tape approximately two inches into the opening of the transport area.
4. Press the Load key.

The tape is caught by the first powered feed roller and fed through the transport mechanism. Two spring-loaded guides direct the paper around the take-up spindle. A vacuum holds the tape to the spindle. After two turns of the tape around the spindle, the guides withdraw.

NOTE: The tape-threading process may not be completed until after several read instructions, depending on the length of tape preceding the first print line. The initial loading operation moves the tape to this first line. The threading process is complete when the tape is drawn around the take-up spindle and the guides withdraw.

IBM 1285 Operating Keys and Lights

Figure 109 illustrates the operating controls next to the keyboard.

Reader On Key

Pressing this key turns on the dc power throughout the reader, and starts the scanning mechanism.

Reader Off Key

Pressing this key turns the dc power off in the reader. Wait at least five seconds after turning this switch off

before turning the master power switch off. (The master power switch is under the operator's table on the front panel.)

Reset Key

This key is used to reset the transport-check indicator.

Off-Line Correction Key

This illuminated key is set or reset when pressed. When lit, the reject symbol @ is automatically substituted for unrecognizable characters. When off, unrecognizable characters are displayed on the CRT unit for operator correction.

Numeric Format Key

This illuminated key is set or reset when pressed. It is used only when reading the IBM 1428 character font. When lit, the 1285 is set to read tapes with only numeric characters in the low-order print position. When off, the low-order character in each line in the 1428 font must be either an alphabetic or the special symbol \neq .

Optional Font Key

This illuminated key is present if the machine has the optional-font special feature. It is set or reset when pressed. When off, the reader is set to read the standard IBM 1428 character font. When on, it is set to read the optional font.

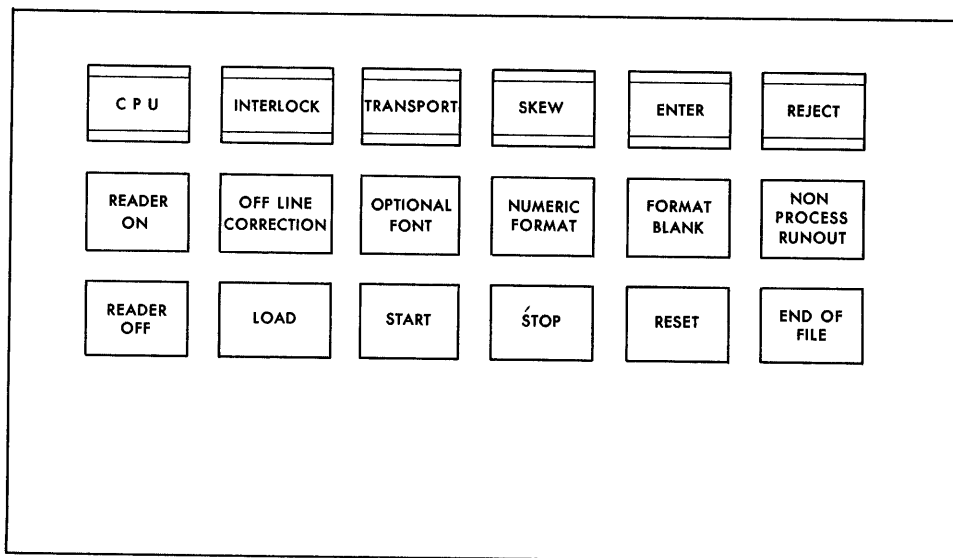


Figure 109. IBM 1285 Control Keys and Lights

Format Blank Key

This illuminated key is set or reset when pressed. When lit, the format blank feature is in operation. When off, the format blank feature is not in operation, regardless of the setting of the format blank knobs on the display panel.

Load Key

With the **READER ON** light on, pressing this key causes the transport mechanism to feed a tape onto the output spindle and position the first print line at the top of the scan window. When the tape is successfully loaded, the reader-ready indicator is turned on, the **ENTER** light is turned on, and the first print line is displayed in the display tube.

Start Key

With the **ENTER** light on, pressing this key turns the ready-to-read-a-line indicator on, and allows the program to read from the tape.

Stop Key

Pressing this key stops the reader (at the completion of the read operation, if there is one in process) and displays the next print line.

Non-Process Run-Out Key

When pressed, this key turns the reader-ready indicator off and feeds tape through the transport mechanism. The tape is not read and the end-of-file indicator is not turned on by the end of the tape.

End-of-File Key

Pressing this key runs the trailing end of the tape through the transport mechanism, and turns the end-of-file indicator on.

CPU Light

This light turns on whenever the central processing unit is stopped.

Interlock Light

This light turns on if any of the interlocks are not closed. The start key is inoperative as long as this light is on.

Transport Light

This light turns on and the reader-ready indicator is turned off if any condition occurs in the transport

mechanism that requires operator intervention. When the end of the tape is sensed, this light comes on, signalling the operator to press the end-of-file key.

Skew Light

This light turns on, the error indicator is turned on and the ready-to-read-a-line indicator is turned off, if a character is detected that overlaps one of the format-blank margins. The print line is displayed, allowing the operator to adjust the format blank knob to correct the margins.

Enter Light

This light turns on when the tape is loaded, and remains on until the start key is pressed. It indicates header information can be entered from the keyboard.

Reject Light

This light comes on each time a reject character is displayed in the display tube. It turns off when the character is keyed in with the enter key on the keyboard.

IBM 1285 Keyboard

The keyboard is shown in Figure 110. It is used for two distinct functions:

1. Keying in header information before beginning to read a roll.
2. Keying in characters when on-line reject correction is performed.

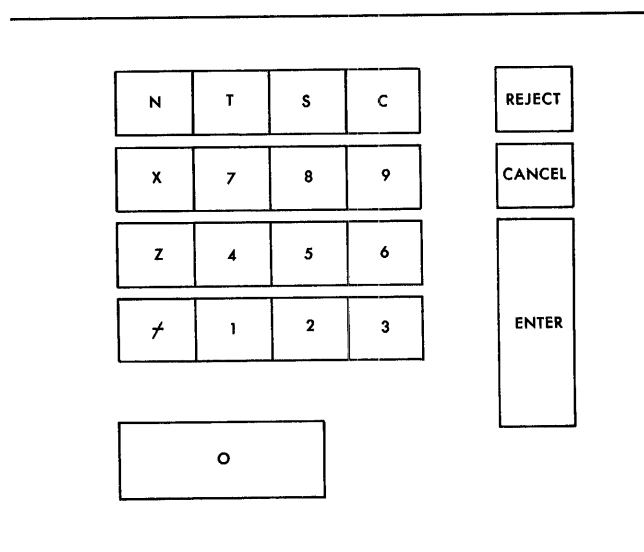


Figure 110. IBM 1285 Keyboard

The keyboard includes keys for each of the ten digits and the six special characters. In addition to these, the following keys are provided.

Reject Key

Pressing this key (then the enter key) enters a reject symbol (@) in core storage in place of the rejected character.

Cancel Key

If the wrong key is pressed, the character can be cleared by pressing this key instead of the enter key. The correct character can then be keyed in.

Enter Key

All characters entered from the keyboard are transferred only after pressing this key. This includes header information as well as rejected characters. If the reader displays a mark as a rejected character, the cancel key, followed by the enter key, is used to resume reading without entering any character or reject symbol. Either a character key, the reject key, or the cancel key must be pressed for the enter key to be effective.

IBM 1285 Display Panel

Figure 111 illustrates the display panel above the read area on the 1285. The display tube is used to:

1. Display a full print line, after pressing the load key or the stop key. This facilitates alignment of the scan area when the position and format knobs are used.
2. Display rejected characters when performing on-line reject correction.

There are five knobs under the display tube. This section describes the function of each.

Intensity

This knob increases or decreases the intensity of the display tube.

Focus

This knob focuses the display tube.

Position

This knob positions the displayed character or line in the display tube.

Format A and Format B

These knobs are used when it is necessary to blank out a vertical strip on the tape. The strip being blanked can be seen in the display tube when displaying a full line. The format-A knob establishes the left edge of the vertical strip. The format-B knob adjusts the right edge.

Meter Switch, IBM 1285

If the use-meter switch is not set to ON before an instruction calls on this unit, the system interlocks.

Meter Time, IBM 1285

The meter starts when the first program instruction selects the 1285.

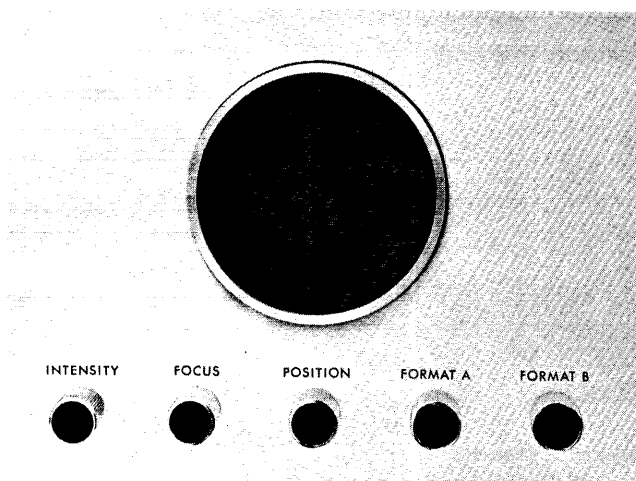


Figure 111. Display Panel

Also refer to the sections of this manual concerning the I/O units attached to your system.

Turning the System On

1. Set the 1401 mode switch to **ALTER**. When the power is turned ON with the mode switch at this setting:
 - a. Information in core storage is retained.
 - b. A series of relays is used to prevent blown fuses. If power is turned ON repeatedly with the mode switch set at **RUN**, some fuses will eventually be blown (especially in the 1403).
2. Hold the **POWER ON** key pressed until the lights on the console flicker. Then release it. Processing may start immediately, unless the system includes an **IBM 1405 Disk Storage**, which requires about two minutes warm-up time.

The blowers in the 1401 and 1403 start operating, and these lights should be ON:

 - **POWER ON 1402**
 - **PRINT READY ON 1403**
 - **POWER ON and READY ON 1405**
3. If the power does not come ON after steps 1 and 2, the **EMERGENCY OFF** switch has probably been pulled. Call an **IBM customer engineer** to reset it.
4. Turn the mode switch to **RUN** to permit processing.

Turning the System Off

1. Run any cards out of the 1402, by pressing both **NON PROC RUN OUT** keys, and then press **CHECK RESET** on the 1402.
2. Set the 1401 mode switch to **ALTER**. When the power is turned OFF with the mode switch at this setting:
 - a. Information is retained in core storage until the power is turned ON again.
 - b. A series of relays is used to prevent blown fuses. If power is turned OFF repeatedly with the mode switch left at **RUN**, some fuses will eventually be blown (especially in the 1403).
3. Unload tape from all tape units that were used.
4. Press **POWER OFF** on the 1401 console. This turns OFF the main power supply for the entire system.

Loading a Program from Cards

After power has been turned ON for the system, set up the various units of the system as follows:

1. Set the switches on the 1401 console.
 - a. Mode switch to **RUN**.
 - b. The **I/O CHECK STOP** switch ON (up), unless input/output checking is to be performed by programming and the operating instructions specify that the switch is to be set OFF.
 - c. Sense switches as specified in the operating instructions. Sense switch A must be set ON (up) if last-card detection is required by the program.
 - d. Tape select switch to **N** (normal).
2. Set the switches on the 1401 auxiliary console.
 - a. The **CHECK STOP** switch ON (up), unless the operating instructions specify that it is to be set OFF.
 - b. Auxiliary mode switch OFF.
 - c. The **DISK WRITE** switch ON (up) when data is to be written on disk records. If data must not be written on disk, set this switch OFF. This setting is used primarily in debugging operations when good records must not be destroyed.
 - d. The **TAPE DENSITY** switch as specified in the operating instructions, if an **IBM 729-V Magnetic Tape Unit** is used.
3. Check the 1403.
 - a. The **PRINT READY** light should be ON.
 - b. If any other lights are ON, press **CHECK RESET** on the 1403. If any lights remain ON, follow the procedure required for the particular light (see *IBM 1403 Printer: Lights*).
 - c. Insert the proper forms and carriage tape.
 - d. Press **CARRIAGE RESTORE** and engage the carriage.
4. If tape records are to be processed, set up the tape unit(s).
 - a. Mount the tapes and set the address selection dials as specified in the operating instructions.
 - b. Check the density lights to make sure each tape unit is set for the density specified in the operating instructions. If the density setting must be changed, press **CHANGE DENSITY** on the 729, or turn the density switch on the 7330.

- c. Check the FILE PROTECT lights. They should be ON when records are to be read from tape, and OFF when records are to be written on tape. If this is not the case, demount the tape reel and check the file-protection ring.
 - d. Press RESET, LOAD REWIND on the 729 (or low SPD REWIND on the 7330), and START on each tape unit. The READY light should be ON.
5. Set up the 1402.
- a. The POWER light should be ON.
 - b. Press both READER ON and PUNCH ON.
 - c. Press both NON PROC RUN OUT keys.
 - d. Press CHECK RESET on the 1402.
 - e. If any error-indication lights are ON, follow the procedure required to turn OFF the particular light (see *IBM 1402 Card Read-Punch: Lights*).
 - f. If cards are to be punched, place blank cards in the punch-feed hopper (face down, 12-edge first).
 - g. Place the program cards, followed by data cards if any, in the reader file feed (face down, 9-edge first). If the card deck is small enough to permit it, place the deck directly in the card hopper.
6. Press CHECK RESET and START RESET on the 1401 console.
7. Press CHECK RESET and LOAD on the 1402. The program is loaded, and processing of data starts automatically.
8. If a STOP key is pressed at any time while the program is being loaded, press START (not LOAD) to continue the loading operation.

Loading a Program from Tape

After power has been turned ON for the system, set up the various units of the system as follows:

1. Set the switches on the 1401 console.
 - a. Mode switch to RUN.
 - b. The I/O CHECK STOP switch ON (up), unless input/output checking is to be performed by programming and the operating instructions specify that the switch is to be set OFF.
 - c. Sense switches as specified in the operating instructions. Sense switch A must be set ON (up) if last-card detection is required by the program.
 - d. Tape select switch to N (normal).
2. Set the switches on the 1401 auxiliary console.
 - a. The CHECK STOP switch ON (up), unless the operating instructions specify that it is to be set OFF.
3. Check the 1403.
 - a. The PRINT READY light should be ON.
 - b. If any other lights are ON, press CHECK RESET on the 1403. If any lights remain ON, follow the procedure required for the particular light (see *IBM 1403 Printer: Lights*).
 - c. Insert the proper forms and carriage tape.
 - d. Press CARRIAGE RESTORE and engage the carriage.
4. If cards are to be processed, set up the 1402.
 - a. The POWER light should be ON.
 - b. Press READER ON and PUNCH ON.
 - c. Press both NON PROC RUN OUT keys.
 - d. Press CHECK RESET on the 1402.
 - e. If any error-indication lights are ON, follow the procedure required to turn OFF the particular light (see *IBM 1402 Card Read-Punch: Lights*).
 - f. If cards are to be punched, place blank cards in the punch-feed hopper (face down, 12-edge first).
 - g. If cards are to be read, place them in the reader file feed (face down, 9-edge first).
5. Set up the tape unit(s).
 - a. Mount the program tape, and set the address selection dial of that unit to 1.
 - b. Mount any other tapes that are required, and set the address selection dials as specified in the operating instructions.
 - c. Check the density lights to make sure each tape unit is set for the density specified in the operating instructions. If the density setting must be changed, press CHANGE DENSITY on the 729, or turn the density switch on the 7330.
 - d. Check the FILE PROTECT lights. They should be ON when records are to be read from tape, and OFF when records are to be written on tape. If this is not the case, demount the tape reel and check the file-protection ring.
 - e. Press RESET, LOAD REWIND on the 729 (or LOW SPD REWIND on the 7330), and START on each tape unit. The READY light should be ON.

6. Press **START RESET** and **TAPE LOAD** on the 1401 console. The program is loaded, and processing of data starts automatically.
7. If a **STOP** key is pressed at any time while the program is being loaded, press **START** (not **TAPE LOAD**) to continue the loading operation.

Printing Out Core Storage (Program Control)

Portions of core storage can be printed out by using switches on the 1401 console and auxiliary console (see *IBM 1401 Processing Unit: Printing Out an Area of Core Storage*), or by using a program written specifically for that purpose. The type of listing and the exact method for taking a core-storage print-out vary with the particular program that is used. However, the print-out programs usually provide a labeled list for easy reference, and they generally require these operations:

1. Use the 1401 switches to print the first 200 positions, because the print-out program requires these positions.
 - a. Set the 1401 mode switch to **STORAGE PRINT OUT**.
 - b. Set the 1401 auxiliary mode switch **OFF**.
 - c. Set up storage address **V00xx** in the **MANUAL ADDRESS** dials.
 - d. Press **START**. The first 100 positions are printed.

- e. Set up storage address **01xx** in the **MANUAL ADDRESS** dials.
 - f. Press **START**. The second 100 positions are printed.
2. Set the mode switch to **RUN**.
 3. Refer to the operating instructions for the program, and set the sense switches to regulate the number of positions to be printed.
 4. Load the print-out program (see *System Operations: Loading a Program from Cards*).
 5. When printing stops, press the reader **NON PROC RUN OUT** and **CHECK RESET** keys on the 1402.

Backspacing Tape

Tape in any magnetic tape unit can be backspaced to the previous interrecord gap (IRG) by following this procedure:

1. Stop systems operation.
2. Set the tape select switch on the 1401 console to the number of the tape unit concerned.
3. Press the **BACKSPACE** key on the 1401 console *once*.
4. Set the tape select switch to **N**.
5. Alter-in a restart address, if specified in the operating instructions. (See *IBM 1401 Processing Unit: Altering an Address in an Address Register*.)
6. Press **START**.

Restart Procedures

This section describes procedures that can be followed if processing stops and a light(s) on the card read-punch or printer indicates an error condition in that unit.

Card Read-Punch

An error detected in a card in the *read feed* turns ON the READER CHECK, READER STOP, and/or VALIDITY light, depending on the type of error.

An error detected in a card in the *punch feed* turns ON the PUNCH CHECK and/or PUNCH STOP light, depending on the type of error. If the punch-feed-read special feature is installed and a punch-feed-read operation has occurred, the procedure for restarting after either a PUNCH CHECK or PUNCH STOP signal differs from the restart procedure without this feature. Both procedures are described in the section for each light. If the punch-feed-read special feature is installed and an error is detected at that station, the VALIDITY light turns ON.

Reader Check Light

When *only* this light is ON, the last card in the NR stacker caused the error signal and has not been processed. It should be re-fed.

1. Remove cards from the read-feed hopper.
2. Run out the two cards in the read feed, while holding the juggler gate open at about a 45° angle (to prevent feeding cards from the file feed).
3. Press the CHECK RESET key on the 1402 to reset error indicators in the reader-punch. If the process-check light is also on, press the CHECK RESET key on the 1401 also.
4. Remove the last three cards from the NR stacker.
5. Check the first card (of the three removed) and correct it, if necessary. If a hole-count error occurred, a storage-scan operation can be used to determine the position in error (see *Scanning Storage*).
6. Place the three cards in the read-feed hopper, and replace the cards removed from the hopper in step 1.
7. Press START to resume operation.

Reader Stop Light

When *only* this light is ON, all cards in the stackers have been processed, and none should be re-fed. Also, in the case of a card jam, any cards in the read feed past the read station have been processed.

1. Remove cards from the read-feed hopper.
2. Remove any jammed cards from the read feed.
3. Run out any undamaged cards, while holding the juggler gate open at approximately a 45° angle (to prevent feeding cards from the file feed).
4. Press CHECK RESET on the 1402.
5. Duplicate any damaged cards.
6. Place in the read-feed hopper any cards that were in the read feed between the read check and read stations, and replace the cards removed from the hopper in step 1.
7. Press START to resume operation.

If *any other* light is ON with the READER STOP light, the last card in the NR stacker caused the error signal and has not been processed. It must be re-fed. (In the case of a card jam between the read station and the stacker, however, the cards must be examined to determine the last card correctly processed. All following cards must be re-fed.)

1. Remove cards from the read-feed hopper.
2. Remove any jammed cards from the read feed.
3. Run out any undamaged cards, while holding the juggler gate open at approximately a 45° angle (to prevent feeding cards from the file feed).
4. Press CHECK RESET on the 1402.
5. Duplicate any damaged cards.
6. Replace cards in the read-feed hopper in this order:
 - a. The last card stacked in the NR pocket.
 - b. The cards removed or run out from the read feed, in their original order.
 - c. The cards removed from the hopper.
7. Press START to resume operation.

Validity Light

When this light is ON and a feed cycle has occurred in the *read* feed, the last card in the NR stacker contains an invalid character. The last card has not been processed. To correct and refeed the error card, follow the procedure described for an error indicated by the **READER CHECK** light (except for the storage scan operation mentioned in step 5).

Punch Feed Read

When *only* the **VALIDITY** light is ON and a punch-feed-read operation (special feature) has occurred in the *punch* feed, the card just read at the punch feed read station contains an invalid character.

1. Remove cards from the punch-feed hopper.
2. Run out the three cards in the punch feed.
3. Press **CHECK RESET** on the 1402.
4. Remove the last three cards from the NP stacker.
5. Visually check the first of these three cards. It had been punched *but not checked* when the error occurred. Replace this card in the stacker (after correcting it, if necessary).
6. Correct the validity error in the second card (the error card).
7. Place the second and third cards in the punch-feed hopper, and replace the cards removed from the hopper (in step 1).
8. Press **START RESET** on the 1401 console.
9. Alter-in a restart address, to start processing at the program instruction that had previously caused the second card to be read by the punch-feed read brushes. (See *Altering an Address in an Address Register*.)
10. Set the mode switch to **RUN** and press **START** to resume operation.

If both the **VALIDITY** and **PUNCH CHECK** lights are ON, two or more error conditions have been detected in the punch feed. Follow the restart procedure described for an error indicated by the **PUNCH CHECK** light with a punch-feed-read operation. Correct the invalid character in the card just read by the punch-feed read brushes (third card removed from the NP stacker in step 4 of the following *Punch Check Light* procedure).

Punch Check Light

If this light is ON, the error signal was caused by the last card in the NP stacker or by the card just punched. If the punch-feed-read special feature is not installed,

follow these steps to correct the error and resume operations:

1. Remove cards from the punch-feed hopper.
2. Run out the three cards in the punch feed.
3. Remove the last four cards from the NP stacker.
4. Visually check the first of these four cards, and correct it if necessary.
5. The second card was punched but not checked. Discard it, because the same data is repunched on the run-in cycle when operation is restarted.

If the B-light on the 1401 console is ON (indicating a B-register parity error), perform a storage scan operation starting at position 101 to determine and correct the position (101-180) that contains the parity error. (See *Scanning Storage*.) Note the I-address for restarting after the scan.

6. The third and fourth cards are blank.
7. Replace the cards removed from the punch-feed hopper (in step 1).
8. To resume operation, press the 1402 check reset key and press **START**. The last punch cycle repeats and information in the punch storage area is repunched.

Punch Feed Read

When the **PUNCH CHECK** light is ON and a punch-feed-read operation (special feature) has occurred, the last card in the NP stacker and the following cards should be reprocessed. Follow these steps to correct the error and resume operation:

1. Remove cards from the punch-feed hopper.
2. Run out the three cards in the punch feed.
3. Press **CHECK RESET** on the 1402.
4. Remove the last four cards from the NP stacker.
5. Duplicate the *prepunched* data in the first two cards, into two blank cards.

If the B-light on the 1401 console is ON (indicating a B-register parity error), perform a storage scan operation starting at position 101 to determine and correct the position (101-180) that contains the parity error. (See *Scanning Storage*.) Note the I-address for restarting after the scan.

6. Place the two duplicated cards and the third and fourth cards in the punch-feed hopper. Replace the cards removed from the hopper in step 1.
7. Press **START RESET** on the 1401 console.
8. Alter-in a restart address (see *Altering an Address in an Address Register*) to start processing at the program instruction that had previously caused the

first card to be read by the punch feed read brushes. (Reconstruct internal data, if necessary.)

9. Set the mode switch to RUN and press START to resume operation.

Punch Stop Light

When *only* this light is ON (and the punch-feed-read special feature is *not* installed), all cards in the stackers have been punched and checked. Also, in the case of a card jam, any cards in the punch feed past the punch check station have been punched and checked: The card between the punch and punch check stations may not have been punched correctly. This data is automatically repunched when operation is restarted.

1. Remove cards from the punch-feed hopper.
2. Remove any jammed cards from the punch feed, and run out any undamaged cards.
3. Press CHECK RESET on the 1402.
4. Discard the last card punched, because the data will be repunched.
5. Duplicate any damaged cards.
6. Replace the cards removed from the punch-feed hopper in step 1.
7. Press START to resume operation.

If *any other* light is ON with the PUNCH STOP light, visually check the last card in the NP stacker and correct it if necessary. In the case of a card jam between the punch check station and the stacker, check the last card read by the punch check brushes and correct it if necessary. To resume operation after clearing any card jams, follow the procedure described for an error indicated by the PUNCH CHECK light.

Punch Feed Read

When *only* the PUNCH STOP light is ON and a punch-feed-read operation (special feature) has occurred, all cards in the punch feed between the hopper and the punch check station should be reprocessed. The cards in the stackers and the cards, if any, between the punch check station and the stackers have been punched and checked. Follow these steps to restart the operation:

1. Remove cards from the punch-feed hopper.
2. Remove any jammed cards from the punch feed, and run out any undamaged cards.
3. Press CHECK RESET on the 1402.
4. Duplicate, into a blank card(s), the *prepunched* data in the card (or cards, in the case of a card jam) that was between the punch and punch-check

stations when operation stopped. This card was punched but not checked, and it must be reprocessed.

5. Place the duplicated card(s) and all following cards removed from the punch feed (between the hopper and the punch station) in the punch-feed hopper in their original sequence (after duplicating damaged cards, if any).
6. Replace the cards removed from the hopper (in step 1).
7. Press START RESET on the 1401 console.
8. Alter-in a restart address (see *Altering an Address in an Address Register*) to start processing at the program instruction that had previously caused the first card (duplicated in step 4) to be read by the punch-feed read brushes. (Reconstruct internal data, if necessary.)
9. Set the mode switch to RUN and press START to resume operation.

If *any other* light is ON with the PUNCH STOP light and a punch-feed-read operation has occurred, two or more error conditions have been detected in the punch feed. To resume operation after clearing any card jams, follow the procedure described for an error indicated by the PUNCH CHECK light with a punch-feed-read operation. If cards have jammed between the punch check station and the stacker, the last card read by the punch check brushes should be the first card reprocessed. Duplicate the *prepunched* data in that card into a blank card. Also duplicate, into blank cards, the *prepunched* data in all following cards that have passed the punch station. Place the duplicated cards, and the following cards that were removed from the punch feed, in the punch-feed hopper in their original sequence.

Printer

Various conditions of continuous forms in the IBM 1403 Printer (such as an end-of-forms condition, or forms that have separated or come off the forms tractors) turn ON the END OF FORMS OR FORMS CHECK light (see *IBM 1403 Printer: Lights*). After the forms are properly repositioned, the 1403 check reset key must be pressed to turn OFF the light.

An error condition in a 1403 printing operation turns ON the SYNC CHECK OR PRINT CHECK light, depending on the type of error. The SYNC CHECK light turns ON if the print chain is out of synchronism with the printer circuitry in the 1401 at any time during the print operation. The timing is corrected automatically, and this error light can be turned OFF by pressing the 1403 check reset key.

Print Check Light

When this light is ON (and the print-storage special feature is *not* installed), a printing error was detected as the last line was printed. Follow this procedure to locate the error:

1. Press CHECK RESET on the 1403 or I/O CHECK RESET on the 1401 auxiliary console.
2. Perform a storage scan operation (starting at position 201) to determine the print position(s) containing the printing error. (See *Scanning Storage*.)
3. When scanning stops at an error position, make a note of the address displayed in STORAGE ADDRESS and the character displayed in the B-register block.
4. Check the printed line to determine whether the character was printed correctly.
5. Repeat the scan operation (steps 2-4) until *all* print positions (201-332) are checked.
6. If all positions were printed correctly:
 - a. Press CHECK RESET on the 1403 or I/O CHECK RESET on the 1401 auxiliary console.
 - b. Press START RESET on the 1401 console.
 - c. Set the mode switch so that processing will stop after the next line prints. For this, set the switch to ADDRESS STOP and set up the proper stop address (See *Stopping at a Predetermined Address*), or set the switch to I/EX and cycle through the next print operation.
 - d. Check this printed line in the error positions found (in steps 2-5) for the previous line. This is necessary because the errors signaled for the previous line may have been detected *after* the printing occurred and, in some cases, the same condition is not signaled a second time. If this line is correct, and no further error was detected, set the mode switch to RUN and press START. If this line contains errors, call the IBM customer engineer.
7. If any of the positions (step 5) were printed incorrectly, try printing this same line of data again:
 - a. Press CHECK RESET on the 1403 or I/O CHECK RESET on the 1401 auxiliary console.
 - b. Press START RESET on the 1401 console.
 - c. Set up the I-address of this same print instruction.
 - d. Set the mode switch to I/EX and press START twice.
 - e. Check the printing. If it is correct, set the mode switch to RUN and press START. If it is not correct, call the IBM customer engineer.

Print Storage

If the print-storage special feature is installed, either a printing error or a parity error was detected when the 1403 PRINT CHECK light is ON. A parity error may have been detected when data was transferred from main storage positions 201-332 to the special *print storage* positions, or when the data in print storage was printed. Follow this procedure to locate the error and correct it if possible:

1. Check the B-register light. If it is ON, a parity error was detected *while data was serially transferring from storage positions 201-332 to print storage*. The address displayed in STORAGE ADDRESS is the storage position (201-332) that contains the error. The character displayed in the B-register block shows the incorrect parity.
 - a. Enter the correct character.
 - b. Alter-in the I-address of the print instruction.
 - c. Press CHECK RESET and START RESET on the 1401 console.
 - d. Press CHECK RESET on the 1403 or I/O CHECK RESET on the 1401 auxiliary console.
 - e. Set the mode switch to RUN and press START to resume operation.
2. If the B-register light is *not* ON, either a printing or parity error was detected *when the data in print storage was printed*. Perform the following storage scan operation to check the *print storage* positions:
 - a. Set the mode switch on the 1401 console to STORAGE SCAN.
 - b. Set the auxiliary mode switch on the 1401 auxiliary console to PRINT STORAGE SCAN.
 - c. Press CHECK RESET on the 1403 or I/O CHECK RESET on the 1401 auxiliary console.
 - d. Hold START pressed until the error position is located. Scanning automatically starts in position 201 and in the first position of print storage. When the error is located, PRINT CHECK turns ON again.
3. When scanning stops at the error position, check the character displayed in the A-register block to determine if it contains correct parity. The A-register contains the character that is in *print storage*.
4. Press I/O CHECK RESET to turn OFF the PRINT CHECK light, which turned ON again in step 2d.
5. If the A-register *does* contain a parity error, note the address displayed in STORAGE ADDRESS. This is the address of main storage (201-332) that corresponds to the special print storage position that contains the parity error. Visually compare the printed

line with the main storage positions 201-332 to determine if the printed data is still in main storage.
If it is:

- a. Scan the remainder of the special print storage positions.
- b. Note all parity errors.
- c. Alter-in the I-address of the print instruction.
- d. Press CHECK RESET and START RESET on the 1401 console.
- e. Press CHECK RESET on the 1403 or I/O CHECK RESET on the 1401 auxiliary console.
- f. Set the mode switch to RUN and press START to print the line again and resume operation.

If the printed data *is not* the same as that now in storage positions 201-332, other processing has occurred, which may have affected totals, switches, and other controls. The program should generally be restarted from the beginning, or from a logical

restart point such as the beginning of a major control group or the beginning of a printed page.

6. If the A-register *does not* contain a parity error when scanning stops (step 2d), a *printing* error occurred. To locate the error, follow a procedure similar to that outlined for the PRINT CHECK light when the print-storage special feature is not installed:
 - a. Scan the entire print storage area, checking the character displayed in the A-register each time scanning stops.
 - b. If all positions printed correctly, press START RESET and set the system to stop after the next line prints. For this, use the ADDRESS STOP or I/EX setting of the mode switch. Check the printed line in the error positions indicated for the previous line. If this line is correct, continue processing.
 - c. If any positions printed incorrectly, call an IBM customer engineer.

The IBM 1401 Data Processing System reads data, processes it to obtain desired results, and makes these results available for future use. The data can be obtained through various types of input components, such as a card reader, magnetic tape unit, or disk storage (Figure 112). It is processed in a central processing unit, and the results are supplied to the user through output components. The results can be punched, printed, or written on magnetic tape or disk.

The 1401 system controls the input, processing, and output of data by executing a series of instructions at high speed. Such a series of instructions designed to solve a specific problem is known as a *program*. Because this program is located in core storage when it is

controlling operations, it is referred to as a *stored program*.

The 1401 normally executes program instructions sequentially, but sometimes it is necessary to skip over a particular group of instructions or otherwise change the sequence of operations. Branch instructions are provided in the system to make it possible to take the next instruction from another area of the stored program. This feature also makes it possible to repeat an instruction, or group of instructions, as often as desired. To control the sequence of program-step execution, conditions that arise during the processing of data are tested at various points in the program. For example, a test can be made for a plus or minus condition, or for the presence of a particular code in a detail card.

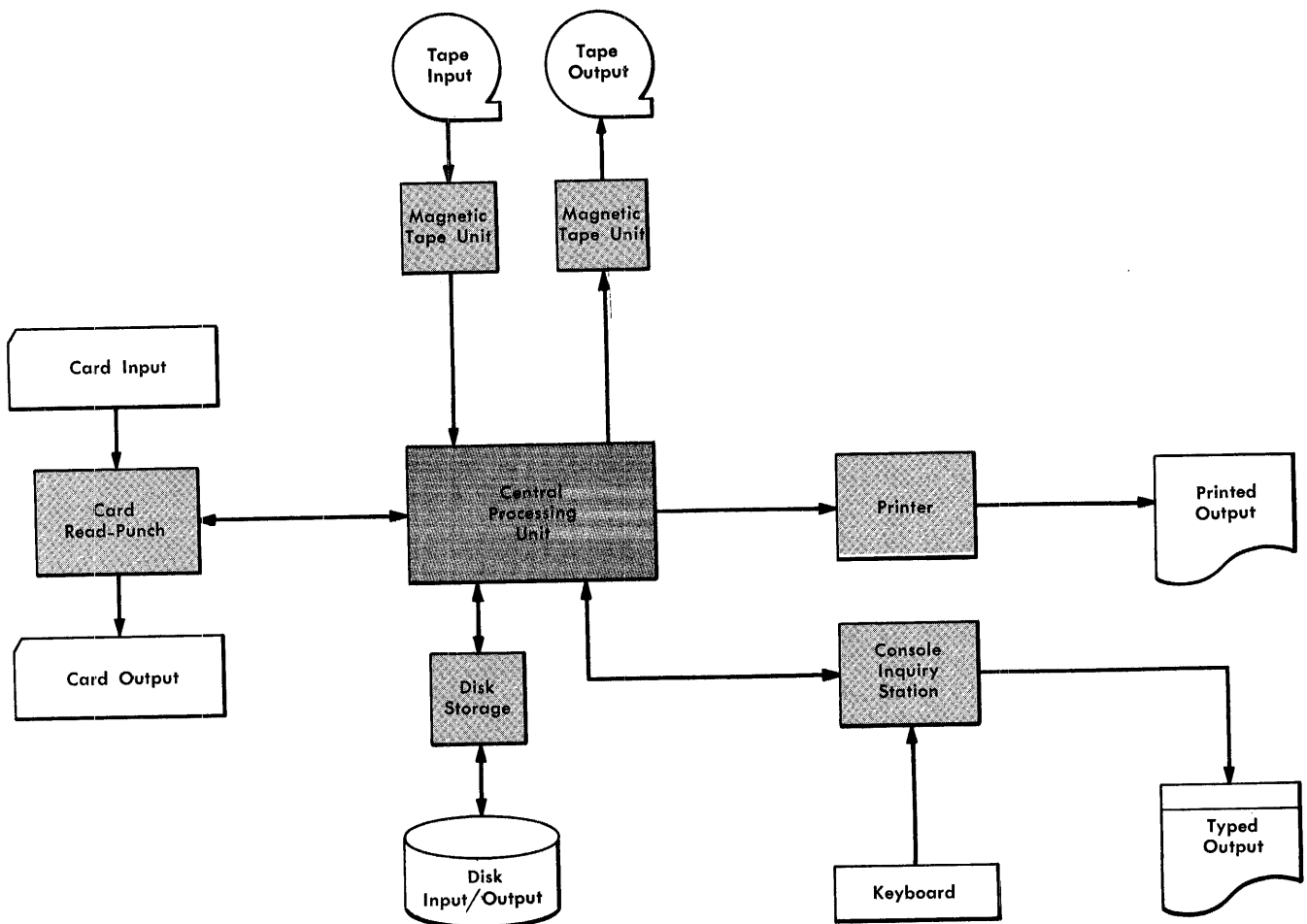


Figure 112. Schematic of Input/Output Components

Variable Word Length

Stored programming involves the concept of *words*. A 1401 word can be a single character, or a group of characters that represent a complete unit of information. Because IBM 1401 words are not limited to a specific number of storage positions, and because each position of core storage is numbered and addressable, each word occupies only the number of core-storage locations actually needed for that program instruction or data field.

The use of variable-length instructions and data requires a method of indicating the actual length of each instruction and/or data-word. This identification is provided in core storage by a *word mark*, which is an extra *bit* (see *BCD Codes*) associated with the high-order character of a word.

The word mark serves several functions:

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

Word marks are generally shown in publications by a line under each character that has an associated word mark.

Stored Program Instructions

All machine functions are started by the program instructions in 1401 core storage. Because the 1401 uses the variable-word-length concept, the length of an instruction can vary, depending on the operation to be performed. Figure 113 shows examples of the six combinations possible in variable-length instructions.

A 1401 instruction always contains an operation code and may contain addresses and/or a d-character, in this format:

Op Code *A-Address or I-Address* *B-Address* *d-Character*
X XXX XXX X

NUMBER OF POSITION	OPERATION	INSTRUCTION FORMAT
1	No Operation	Op Code <u>N</u>
2	Select Stacker	Op Code d-Character <u>K</u> 2
4	Unconditional Branch	Op Code I-Address B 400
5	Write Mark Tape	Op Code I-Address d-Character <u>U</u> %U2 M
7	Add	Op Code A-Address B-Address <u>A</u> 075 423
8	Write Tape	Op Code A-Address B-Address d-Character <u>L</u> %U1 731 W

Figure 113. Examples of Instruction Formats

Op Code. The operation code 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 (the first of two possible fields in core storage to be affected by the operation), or it can select a special unit or feature (such as tape unit, disk-storage unit, or IBM 1419 Magnetic Character Reader).

I-Address (Instruction Address). This is a three-character storage address. Instructions that cause program-branching use the I-address to specify the location of the next instruction to be executed if a branch occurs.

B-Address. This is a 3-character storage address that identifies the B-field (the second field in core storage to be affected by the operation). 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, numerical, or special character, positioned as the last character of an instruction.

Sample Instruction

Op Code *A-Address* *B-Address*
A 542 560

This is an example of a 7-position ADD instruction. The operation code A causes the field whose units position is in storage location 542 to add to the field whose units position is in location 560. This operation continues until a word mark in 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.

Addressing

The 1401 core storage unit stores both the program instructions and the data to be processed. Each position in storage can be addressed. That is, each individual instruction or data field can be read:

- An instruction — to tell the system what function to perform.
- A data-field — to be processed (for example, to be added to another field, or moved to another location).

An *instruction* in core storage is addressed by the location of its high-order position, which contains the operation code. The machine reads the instruction from left to right until it senses the high-order position of the next instruction. The high-order position is identified by a word mark that is set by the program when the instruction cards are loaded. In contrast, a *data field* is addressed by its units position and read from right to left until a word mark is sensed in its own high-order position.

An example of stored instruction and data fields (Figure 114) illustrates this addressing. The instruction stored in core storage positions 400-406 is read starting with position 400. The reading stops when the word mark in position 407 is read. This ADD instruction specifies that the data in the A-field (address 542) is to be added to the data in the B-field (address 560). To perform the addition, the A-field is read starting with position 542, and the B-field starting with position 560. The word mark in position 536 defines the high-order position of the 7-position A-field, and the word mark in position 553 identifies the high-order position of the 8-position B-field. The amount 0,025,347 is added to 04,601,231. After the operation is completed, the B-field contains 04,626,578.

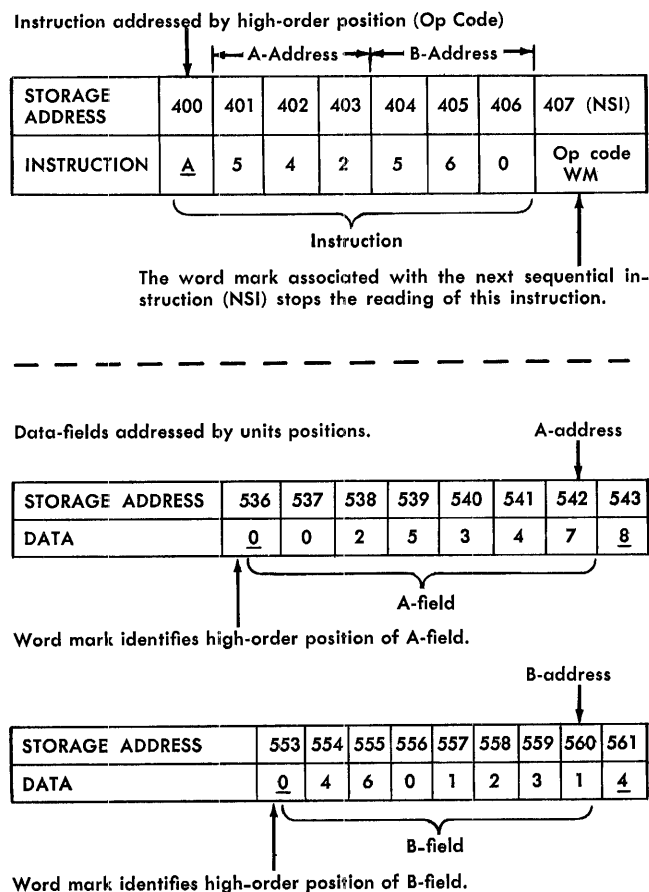


Figure 114. Examples of Instruction and Data Addressing

Input/Output Storage Assignments

Certain areas of core storage are reserved for use by input/output devices. In most cases, the assigned storage positions correspond to card columns or print positions. The reserved storage positions are:

Storage Positions	Reserved for	Correspond to
001-080	Card-read input area	80 card columns
101-180	Card-Punch output area	80 card columns
201-300 (or 332)	Printer output area	100 (or 132) print positions
334-363	Card-read input area for IBM 1404 Printer (special feature)	30 card columns

All other storage positions, except 000 and 100, can be used for processing or instructions. If the read-compare special feature for the IBM 1404 Printer is installed, location 333 is used for internal programming.

Whenever the reserved areas are not being used as specified, they can be used for other storage operations.

Address Coding Structure

Core storage units for 1401 systems are available in any of six sizes. These sizes (1,400; 2,000; 4,000; 8,000; 12,000; and 16,000) indicate the number of characters that each size can accommodate. Each character-position is numbered and addressable. For example, in a 1,400-position unit the positions are numbered with addresses 0000-1399; in a 16,000-position unit the positions are numbered with addresses 00000-15999.

When these address locations are used as part of a program instruction (referred to as *A-address* and *B-address*, *A-operand* and *B-operand*, or *A-field* and *B-field*), they occupy a major portion of the area required to store the instruction. To reduce, as much as possible, the amount of storage required for an entire program, each address is converted to a 3-character machine-language code (Figure 115).

1. Addresses 00000-00999 use the digits 000-999.
2. Addresses 01000-03999 are coded by including a bit(s) with the *hundreds* position of the address. An A-bit (zero zone) is used for addresses 01000-01999, a B-bit (11-zone) for addresses 02000-02999, and AB-bits (12-zone) for addresses 03000-03999 (see the first column of Figure 115). The tens and units positions of the 3-character machine-language code are the same as those in the 4-character core-storage address.
3. Addresses 04000 and above are coded by bits over the *units* position, as well as the bits over the *hundreds* position. All addresses 04000-07999 contain an A-bit over the units position. The hundreds positions of these addresses follow the pattern described

	ADDRESSES 0000-3999		ADDRESSES 4000-7999 A-Bit (0-Zone) over Units Position		ADDRESSES 8000-11999 B-Bit (11-Zone) over Units Position		ADDRESSES 12000-15999 AB-Bits (12-Zone) over Units Position	
	Addresses	Codes	Addresses	Codes	Addresses	Codes	Addresses	Codes
	0000-0099	000-099	4000-4099	00 † -09Z	8000-8099	00I-09R	12000-12099	00? -09I
	0100-0199	100-199	4100-4199	10 † -19Z	8100-8199	10I-19R	12100-12199	10? -19I
	0200-0299	200-299	4200-4299	20 † -29Z	8200-8299	20I-29R	12200-12299	20? -29I
	0300-0399	300-399	4300-4399	30 † -39Z	8300-8399	30I-39R	12300-12399	30? -39I
	0400-0499	400-499	4400-4499	40 † -49Z	8400-8499	40I-49R	12400-12499	40? -49I
	0500-0599	500-599	4500-4599	50 † -59Z	8500-8599	50I-59R	12500-12599	50? -59I
	0600-0699	600-699	4600-4699	60 † -69Z	8600-8699	60I-69R	12600-12699	60? -69I
	0700-0799	700-799	4700-4799	70 † -79Z	8700-8799	70I-79R	12700-12799	70? -79I
	0800-0899	800-899	4800-4899	80 † -89Z	8800-8899	80I-89R	12800-12899	80? -89I
	0900-0999	900-999	4900-4999	90 † -99Z	8900-8999	90I-99R	12900-12999	90? -99I
A-Bit (0-Zone) over Hundreds Position	1000-1099	† 00- † 99	5000-5099	† 0 † - † 9Z	9000-9099	† 0I- † 9R	13000-13099	† 0? - † 9I
	1100-1199	/00-/99	5100-5199	/0 † -/9Z	9100-9199	/0I-/9R	13100-13199	/0?-/9I
	1200-1299	S00-S99	5200-5299	S0 † -S9Z	9200-9299	S0I-S9R	13200-13299	S0?-S9I
	1300-1399	T00-T99	5300-5399	T0 † -T9Z	9300-9399	T0I-T9R	13300-13399	T0?-T9I
	1400-1499	U00-U99	5400-5499	U0 † -U9Z	9400-9499	U0I-U9R	13400-13499	U0?-U9I
	1500-1599	V00-V99	5500-5599	V0 † -V9Z	9500-9599	V0I-V9R	13500-13599	V0?-V9I
	1600-1699	W00-W99	5600-5699	W0 † -W9Z	9600-9699	W0I-W9R	13600-13699	W0?-W9I
	1700-1799	X00-X99	5700-5799	X0 † -X9Z	9700-9799	X0I-X9R	13700-13799	X0?-X9I
	1800-1899	Y00-Y99	5800-5899	Y0 † -Y9Z	9800-9899	Y0I-Y9R	13800-13899	Y0?-Y9I
	1900-1999	Z00-Z99	5900-5999	Z0 † -Z9Z	9900-9999	Z0I-Z9R	13900-13999	Z0?-Z9I
B-Bit (11-Zone) over Hundreds Position	2000-2099	I00-I99	6000-6099	I0 † -I9Z	10000-10099	I0I-I9R	14000-14099	I0?-I9I
	2100-2199	J00-J99	6100-6199	J0 † -J9Z	10100-10199	J0I-J9R	14100-14199	J0?-J9I
	2200-2299	K00-K99	6200-6299	K0 † -K9Z	10200-10299	K0I-K9R	14200-14299	K0?-K9I
	2300-2399	L00-L99	6300-6399	L0 † -L9Z	10300-10399	L0I-L9R	14300-14399	L0?-L9I
	2400-2499	M00-M99	6400-6499	M0 † -M9Z	10400-10499	M0I-M9R	14400-14499	M0?-M9I
	2500-2599	N00-N99	6500-6599	N0 † -N9Z	10500-10599	N0I-N9R	14500-14599	N0?-N9I
	2600-2699	O00-O99	6600-6699	O0 † -O9Z	10600-10699	O0I-O9R	14600-14699	O0?-O9I
	2700-2799	P00-P99	6700-6799	P0 † -P9Z	10700-10799	P0I-P9R	14700-14799	P0?-P9I
	2800-2899	Q00-Q99	6800-6899	Q0 † -Q9Z	10800-10899	Q0I-Q9R	14800-14899	Q0?-Q9I
	2900-2999	R00-R99	6900-6999	R0 † -R9Z	10900-10999	R0I-R9R	14900-14999	R0?-R9I
AB-Bits (12-Zone) over Hundreds Position	3000-3099	?00-?99	7000-7099	?0 † -?9Z	11000-11099	?0I-?9R	15000-15099	?0?-?9I
	3100-3199	A00-A99	7100-7199	A0 † -A9Z	11100-11199	A0I-A9R	15100-15199	A0?-A9I
	3200-3299	B00-B99	7200-7299	B0 † -B9Z	11200-11299	B0I-B9R	15200-15299	B0?-B9I
	3300-3399	C00-C99	7300-7399	C0 † -C9Z	11300-11399	C0I-C9R	15300-15399	C0?-C9I
	3400-3499	D00-D99	7400-7499	D0 † -D9Z	11400-11499	D0I-D9R	15400-15499	D0?-D9I
	3500-3599	E00-E99	7500-7599	E0 † -E9Z	11500-11599	E0I-E9R	15500-15599	E0?-E9I
	3600-3699	F00-F99	7600-7699	F0 † -F9Z	11600-11699	F0I-F9R	15600-15699	F0?-F9I
	3700-3799	G00-G99	7700-7799	G0 † -G9Z	11700-11799	G0I-G9R	15700-15799	G0?-G9I
	3800-3899	H00-H99	7800-7899	H0 † -H9Z	11800-11899	H0I-H9R	15800-15899	H0?-H9I
	3900-3999	I00-I99	7900-7999	I0 † -I9Z	11900-11999	I0I-I9R	15900-15999	I0?-I9I
	Units Position:		Units Position:		Units Position:		Units Position:	
	Address Digit	Code	Address Digit	Code	Address Digit	Code	Address Digit	Code
	0	†	0	I	0	?	0	?
	1	/	1	J	1	A	1	A
	2	S	2	K	2	B	2	B
	3	T	3	L	3	C	3	C
	4	U	4	M	4	D	4	D
	5	V	5	N	5	E	5	E
	6	W	6	O	6	F	6	F
	7	X	7	P	7	G	7	G
	8	Y	8	Q	8	H	8	H
	9	Z	9	R	9	I	9	I

Figure 115. Machine Language Codes for Core-Storage Addresses

in items 1 and 2, in order to distinguish between 04000-04999 (no bit), 05000-05999 (A-bit), 06000-06999 (B-bit), and 07000-07999 (AB-bits). For example, address 5346 contains an A-bit over the units position (between 04000 and 07999) and an A-bit over the hundreds position (the second thousands group within the range). It is thus coded T4W (T = 3 + A-bit and W = 6 + A-bit).

All addresses 08000-11999 contain a B-bit over the units position, and all addresses 12000-15999 contain AB-bits over the units position. In each range, the hundreds position is coded to distinguish the thousands group, as described above.

In every case the tens position of the 3-character machine-language code is the same as the tens position of the 4- or 5-character core-storage address. When the indexing special feature is used to modify an address, however, the particular register used is indicated by a bit over the tens position of the machine-language code. Index register 1 is indicated by an A-bit, index register 2 by a B-bit, and index register 3 by AB-bits. Thus, if address 5346 (machine-language code T4W) is modified by index register 3, the code is TDW.

Phases of Operation

The 1401 system processes input data to produce the desired output results by proceeding through the series of stored program instructions, one by one. Each instruction must first be interpreted, and then its function performed, or executed. Thus, each instruction requires two phases of operation. Interpreting the instruction is accomplished during the first phase, known as the *instruction* phase or I-phase. Performing the operation called for by the Op code portion of the instruction is accomplished during the second phase, known as the *execution* phase or E-phase. Each phase of operation consists of several storage cycles. The length of each cycle is .0115 milliseconds.

Registers

To handle both phases of operation, the 1401 system uses *registers*, which are devices capable of receiving an individual instruction from core storage, recognizing the operation to be performed, and identifying the data position to be processed, as directed by control circuits. For these operations, seven registers (Figure 116) are

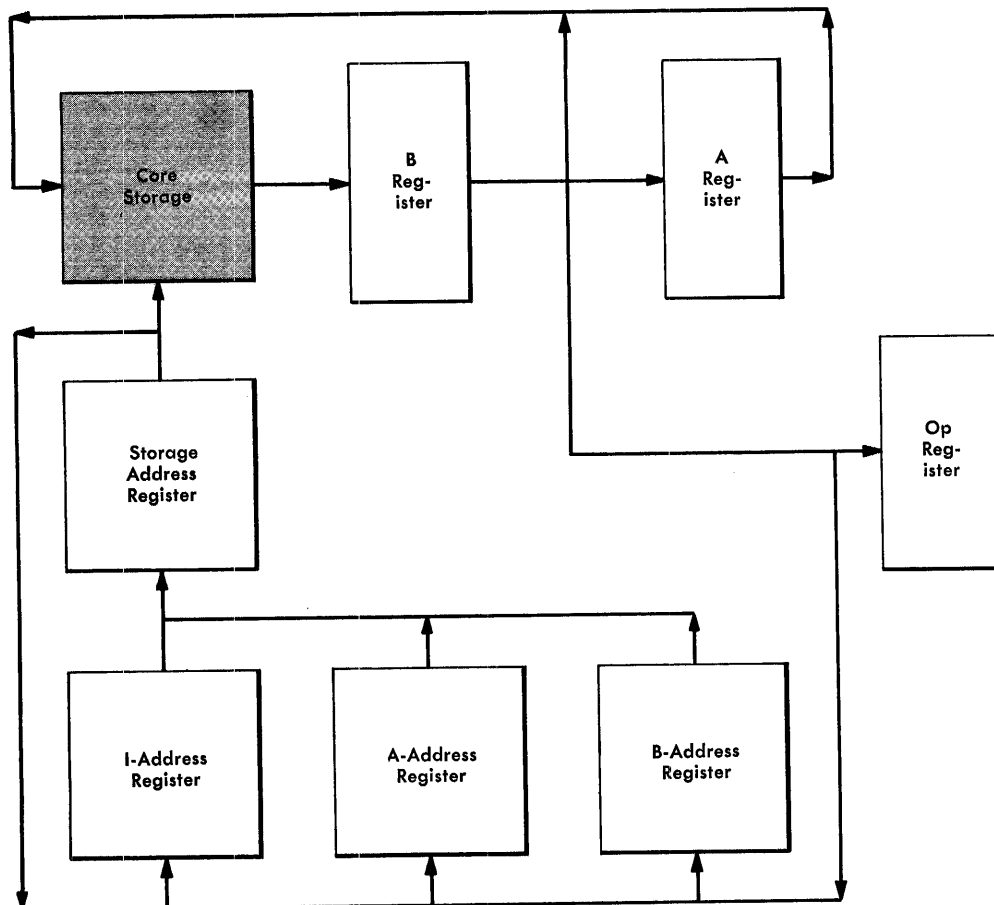


Figure 116. Address and Single-Character Registers

available. Each performs its own unique function. Four are 3-position address registers and three are single-character registers. The four address registers are:

I-address. During the execution phase of an operation, this register contains the storage location (address) of the high-order position of the next sequential instruction. During the instruction phase, it contains the address of the individual instruction character that is transferring from core storage to a register (an address register or a single-character register). Thus, this I-address register controls program sequence.

A-address. Normally contains a storage address of data for the A-field portion of a stored-program instruction.

B-address. Normally contains a storage address of data for the B-field portion of a stored-program instruction.

Storage Address. Contains the address of the storage location that is being read out (or in) on any particular storage cycle.

The A-address, B-address, and storage address registers control the transfer of data from one storage location to another.

The three character registers are single-position registers:

Op. Stores the operation code of the instruction in process for the duration of the operation.

B. Contains the character that is being read out from core storage. This register is reset, and another character is read in, on every storage cycle.

A. During the execution of an operation, the A-register receives a character from the B-register on each storage cycle that involves the A-address. During the instruction phase, the A-register receives a character from the B-register on each storage cycle except the first and last.

I-Phase

During the I-phase of operation for an instruction, the entire instruction reads out of core storage and transfers into the proper registers. At the same time it also transfers back into its original location in core storage for later use.

The I-phase requires from two to nine storage cycles called I-cycles. The exact number of cycles taken depends on the length of the instruction (see Figure 113). One cycle is required for each character in the instruc-

tion, plus one cycle to determine the end of the instruction by sensing the word mark in the first position of the following instruction.

Figure 117 shows, schematically, the operation performed on each I-cycle for an instruction. It illustrates the transfer of a 7-position instruction, character-by-character, to the various registers. Eight cycles are required. Although the address registers contain 3-character address codes, 4 characters are shown in this schematic because the STORAGE ADDRESS lights on the console display 4-digit addresses. The operation is described briefly in the following paragraphs.

When one instruction has been completed and processing is ready for the next instruction, the first I-cycle (I-Op) occurs. At this time the address of the first position of the instruction (Op code) is transferred from the I-address register to the storage address register. This causes the operation code to transfer from storage to the B-register, to the Op-register, and back to storage. The address in the I-address register and in the storage address register is increased by one. Both registers now contain the address of the first instruction character following the Op code.

On the second I-cycle (I-1), the character transfers to the B-register, to the A-register, to the hundreds position of both the A-address and B-address registers, and back to core storage. This procedure continues until the A-address portion of the instruction is completely transferred to the A-address register.

Then each character is transferred to the B-register, the A-register, the B-address register, and back to core storage. It is not transferred to the A-address register. This continues until the B-address is completely transferred to the B-address register (see *Cycles I-4, I-5, and I-6*). Whenever a d-character is part of the instruction, it is retained in the A-register.

When a character with a word mark transfers to the B-register, it is recognized as the first position of the next instruction. This indicates the end of the I-phase, and signals the system to start the execution (E-phase) of the instruction.

E-Phase

During the E-phase of operation for an instruction, the operation specified by the Op code is performed using the data fields and/or locations specified by the A-address and/or B-address portions of the instruction.

The number of cycles required for the E-phase varies, depending on the number of characters in the A- and B-fields. If the operation code indicates that data is to be processed from both the A- and B-fields (for example, adding field A to field B), a character is read alternately from each field. First a character is

CYCLE	OPERATION	Instruction Location									
		A	5	6	7	T	1	2	S		
		197	198	199	200	201	202	203	204		
I-Op	The operation code enters the B-register and the Op register. Because this is the first I-cycle, the A-register is undisturbed.	I-Address Register 0|1|9|7		B-Register A		A-Register ?		Cycle 1			
		Op Register A		A-Address Register ??|??|?		B-Address Register ??|??|?					
I-1	The A-address register is reset to blanks during the first part of the cycle for all instructions. The B-address register is reset to blanks during the first part of the cycle for all operations except Move, Load, Store A- and Store B-address Register operation. During the I-1 cycle, the second instruction character (first character of the A-address) enters the hundreds positions of the A- and B-address registers, and the A-register by the way of the B-register.	I-Address Register 0|1|9|8		B-Register 5		A-Register 5		Cycle 2			
		Op Register A		A-Address Register 0|5|b|b		B-Address Register 0|5|b|b					
I-2	The third character of the instruction enters the tens position of the A- and B-address registers, and the A-register through the B-register.	I-Address Register 0|1|9|9		B-Register 6		A-Register 6		Cycle 3			
		Op Register A		A-Address Register 0|5|6|b		B-Address Register 0|5|6|b					
I-3	The fourth instruction character enters the units position of the A- and B-address registers, and the A-register through the B-register.	I-Address Register 0|2|0|0		B-Register 7		A-Register 7		Cycle 4			
		Op Register A		A-Address Register 0|5|6|7		B-Address Register 0|5|6|7					
I-4	The B-address register is reset at the beginning of this cycle. The fifth instruction character (first character of the B-address) enters the hundreds position of the B-address register, and the A-register through the B-register. (The letter "T" is in the B-address register but "13" is displayed on the console.)	I-Address Register 0|2|0|1		B-Register T		A-Register T		Cycle 5			
		Op Register A		A-Address Register 0|5|6|7		B-Address Register 1|3|b|b					
I-5	The sixth instruction character goes to the tens position of the B-address register, and the A-register through the B-register.	I-Address Register 0|2|0|2		B-Register 1		A-Register 1		Cycle 6			
		Op Register A		A-Address Register 0|5|6|7		B-Address Register 1|3|1|b					
I-6	The seventh character of the instruction (last character of the B-address) enters the units position of the B-address register and the A-register through the B-register.	I-Address Register 0|2|0|3		B-Register 2		A-Register 2		Cycle 7			
		Op Register A		A-Address Register 0|5|6|7		B-Address Register 1|3|1|2					
I-7	The first character of the next instruction enters the B-register only. Because this is the last I-cycle for this instruction, the A-register and the Op register, the A- and B-address registers are undisturbed. The detection of a word mark associated with this character signals the machine that this is the Op code for the next instruction. The loading operations stops, and the instruction that was just loaded is executed. Note that the I-address register contains the address of the high-order position of the next sequential instruction.	I-Address Register 0|2|0|4		B-Register S		A-Register 2		Cycle 8			
		Op Register A		A-Address Register 0|5|6|7		B-Address Register 1|3|1|2					

Figure 117. Schematic of I-Cycles to Transfer a 7-Character Instruction

read from the A-field (address specified by the A-address register). Then a character is read from the B-field (address specified by the B-address register).

Each cycle in which an A-field character is addressed is called an *A-cycle*, and each cycle in which a B-field character is addressed is called a *B-cycle*. Because data fields are read from the low-order to the high-order position of the field, the address in the A-address or B-address register is decreased by one on each A-cycle or B-cycle, respectively.

When two data fields are processed and a word mark in the high-order position of one of the fields is sensed in the B-register, the E-phase of operation ends and processing is ready for the next instruction. Some operations stop only when the B-field word mark is sensed, some only when the A-field word mark is sensed, and some when a word mark is sensed in either field.

Internal Checking

Advanced circuit design is built into the 1401 to assure accurate results. Self-checking within components of the system consists of *parity*, *validity*, and/or *hole-count* checks.

Parity Checking

The IBM 1401 checks data and/or instruction characters in various registers, and at various times during processing, for *odd-bit* configurations. Each character handled by the processing unit must consist of an *odd* number of bits. For this, a *check bit* is included, when necessary, with the 6-bit BCD code (binary-coded-decimal) used by the 1401 for all characters (see *BCD Codes*). The check bit is added to any character that would otherwise have an even number of bits. For example, the character P has a BCD code of B421. The check bit is added to give this character an odd number of bits (C B421).

If the character has a word mark associated with it, the word-mark bit is included in the test for odd-bit parity. Thus, if the character P has a word mark, the check bit is *not* added because the bit configuration is already *odd* (WM B421).

Whenever a parity error (*even* parity) is detected, a console light turns ON to indicate the place where the error occurred.

Validity Checking

A bit configuration that does not comprise a valid data or instruction character causes a validity-error signal

in the system component in which the error is detected. For example, a validity check is performed on each character as it is read into the 1401 from the card reader. An invalid character (such as punches 1-2-5 in a card column) can be transferred to core storage, but the validity-check circuits on the 1402 can detect it and cause processing to stop. The validity light on the card read-punch turns on to indicate the error. Similarly, in the 1401 processing unit an invalid Op code or an invalid address can cause processing to stop. An invalid address is detected by one of the following checks:

Checking for an Address Outside the System Core-Storage Capacity. For example, an address of 5600 specified for a system with 4,000 positions of core storage is an invalid address. For this purpose the system checks the units and hundreds positions of each address to determine whether the address is beyond the system capacity.

Index Checking. This is performed during an indexing operation to ensure that modification of an address does not give an address in excess of installed core-storage capacity. If it does, the modified address is invalid.

Wraparound Checking. *Wraparound* describes the process of modifying the low-order position of core storage by -1 , or the high-order position of core storage by $+1$. If a wraparound is detected at any time other than during a CLEAR, STORAGE SCAN, or STORAGE PRINT OUT operation, an error is signaled and operation stops.

An accumulator field positioned in the last few available core-storage locations (such as units position of the field in 3999) will cause a wraparound error, if an arithmetic function involving recommentation is performed.

Hole-Count Check

Reliability is further assured in the 1401 system by the *hole-count* checking feature of the IBM 1402 Card Read-Punch. With this feature, the total number of holes read in each column of a card at the read-check station is compared with the total number of holes read from the same column of the same card as it passes the read station.

Hole-count checking is also performed in the punch-feed side. A count of the total number of holes punched in each column of the card at the punch station is retained internally for one punch-feed cycle. Another column-by-column hole count is taken as this same card passes the punch-check station, and the two counts are compared.

If a hole-count error (unequal comparison) occurs in either the read or punch feed, system operation stops, and a signal light on the 1402 indicates the feed in which the error occurred. If the error occurred in the read feed, the operator can determine where the error occurred by setting the 1401 mode switch to STORAGE SCAN and pressing the start key. The scan stops at the storage address of the column in error.

BCD Codes

In the punched card area of data processing, characters are represented by a *card code* that is punched in the cards and used by the various IBM unit-record machines. In the computer area of data processing the basic card coding remains the same but a faster, more flexible, machine language is used for internal processing.

Just as each digit, letter of the alphabet, or special character is coded into a card as a punched hole, or a combination of punched holes, it is coded in the core-storage unit as a pattern of magnetized cores. The internal code used in the IBM 1401 Data Processing System is called *binary coded decimal* (BCD). All data and instructions are translated into this code as they are stored. No matter how information is introduced into the system (from punched cards, magnetic tape, or other input sources), the BCD code is used in all data flow and processing from that point on, until it is either translated into printed output as reports are written or converted to punched card code for card output. Converting input data to the 1401 internal code, and subsequently reconvertng, is completely automatic.

The binary-coded-decimal (BCD) code is a *6-bit code*. The term *bit* is derived from the first letter of the word *binary* and the last two letters of the word *digit*. Each character is coded by a combination of bits identified as B, A, 8, 4, 2, and 1 (Figure 118). For example, the digit 3 is represented by a 1-bit and a 2-bit, the digit 6 by a 4-bit and a 2-bit. Thus each digit 0-9 is coded by one or more of the numerical bits numbered 8, 4, 2, and 1. The A- and B-bits (zone bits) are used in conjunction with bits 8, 4, 2, and 1 to code letters. For example, the letter A is represented by the combination of a B-bit, an A-bit, and a 1-bit. Combinations of bits that are not used for digits or letters represent special characters.

The 1401 core-storage unit (Figure 119), which uses this BCD code, is composed of a number of tiny rings

(cores) that are made of magnetic material and joined by multiple wires. The cores can be easily magnetized and, unless deliberately changed, retain their magnetism indefinitely. They are magnetized by sending an electrical impulse through one of the connecting wires. The direction of the current determines the *polarity*, or magnetic state, of the core. Reversing the current changes the magnetic state (Figure 120). Consequently, the two states can be used to represent 1 or 0, plus or minus, yes or no, or ON or OFF conditions. The first condition (1, plus, yes, or ON) in any of the pairs of representations indicates that a *bit* is present. The other condition is referred to as a *no-bit* condition. For 1401 system purposes, this is the basis of the binary system of storing information in BCD code.

Cores in the core storage unit are strung on screens of wires, called *planes*. The unit contains several planes that are *stacked* so that each addressable core storage position is represented by all the cores at the intersection of the same two wires in each plane. (Figure 121). An imaginary vertical line could be drawn through the cores for a storage position. When a character is stored, the core in each plane for that storage position is magnetized positively if a bit is present (represented schematically by a 1), or negatively for a no-bit condition (represented schematically by a 0).

To conform to the BCD character coding, six planes are required: two for the zone portion (A- and B-bits) and four for the numerical portion (8-, 4-, 2-, and 1-bits) of characters. In addition, one plane is used for the check-bit position of characters. The check bit is included with the BCD coding of any character that would otherwise have an even number of bits. This provides all characters with the *odd* parity that the 1401 system requires for correct operation.

Another plane is for word-mark bits. This bit is used with the high-order position of any instruction or data field for field definition. Whenever a word-mark bit is associated with a character, it is included in the count for odd-bit parity, and thus affects the inclusion of the check bit.

To illustrate the use of the seven planes to store a BCD character, the letter J is placed in storage (Figure 121). The BCD coding for the letter J is composed of a B-bit and a 1-bit. Since this is an even number of bits, a check bit is included to obtain *odd* parity. Thus the BCD code for the letter J is represented by the binary configuration 1 10 0001, reading from top to bottom in the core-stack position in which J is stored.

Figure 118. Character Code Chart (in Collating Sequence)

CHARACTER	DEFINITION/ NOTE	PRINT † ARRANGEMENT		** CARD CODE	BCD CODE	OPERATION WHEN USED AS OP CODE	CHARACTER	DEFINITION/ NOTE	PRINT † ARRANGEMENT		** CARD CODE	BCD CODE	OPERATION WHEN USED AS OP CODE
		A	H						A	H			
BLANK													
.	.	.	.	12-3-8	B A 8 2 1	Halt	G		G	G	12-7	B A 4 2 1	
□	□ )	□	)	12-4-8	C B A 8 4	Clear Word Mark	H	2	H	H	12-8	B A 8	Store B-Address Register
[				12-5-8	B A 8 4 1		I		I	I	12-9	C B A 8 1	
<	Less Than			12-6-8	B A 8 4 2		I	(Minus Zero)	—	—	11-0	B 8 2	Zero and Subtract
≡	Group Mark / 1			12-7-8	C B A 8 4 2 1		J		J	J	11-1	C B 1	
&		&	+	12	C B A		K		K	K	11-2	C B 2	Select Stacker (Card)
\$		\$	\$	11-3-8	C B 8 2 1		L		L	L	11-3	B 2 1	Load Characters to Word Mark
*		*	*	11-4-8	B 8 4		M		M	M	11-4	C B 4	Move Characters to Word Mark
]				11-5-8	C B 8 4 1		N		N	N	11-5	B 4 1	No Operation
;				11-6-8	C B 8 4 2		O		O	O	11-6	B 4 2	
Δ	Delta (Mode Change)			11-7-8	B 8 4 2 1		P	2	P	P	11-7	C B 4 2 1	Move Characters to Record or Group Mark
—		—	—	11	B		Q	2	Q	Q	11-8	C B 8	Store A-Address Register
/		/	/	0-1	C A 1	Clear Storage	R		R	R	11-9	B 8 1	
,		,	,	0-3-8	C A 8 2 1	Set Word Mark	+	Record Mark	+	+	0-2-8	A 8 2	
%	2	%	(	0-4-8	A 8 4	Divide	S		S	S	0-2	C A 2	Subtract
Y	Word Separator			0-5-8	C A 8 4 1		T		T	T	0-3	A 2 1	
\	Left Oblique			0-6-8	C A 8 4 2		U		U	U	0-4	C A 4	Control Unit (Tape)
≡	Tape Segment Mark			0-7-8	A 8 4 2 1		V		V	V	0-5	A 4 1	Branch if Word Mark and/or Zone
≡	3	≡	≡		A		W	2	W	W	0-6	A 4 2	Branch if Bit Equal
#	4	#	=	3-8	8 2 1	Modify Address	X	2	X	X	0-7	C A 4 2 1	Move and Insert Zeros
@	2	@	'	4-8	C 8 4	Multiply	Y		Y	Y	0-8	C A 8	Move Zone (Bits)
:				5-8	8 4 1		Z		Z	Z	0-9	A 8 1	Move Characters and Suppress Zeros
>	Greater Than			6-8	8 4 2		0		0	0	0	C 8 2	
√	Tape Mark			7-8	C 8 4 2 1		1		1	1	1	1	Read a Card
?	(Plus Zero)	&	&	12-0	C B A 8 2	Zero and Add	2		2	2	2	2	Write a Line
A		A	A	12-1	B A 1	Add	3		3	3	3	C 2 1	Write and Read
B		B	B	12-2	B A 2	Branch	4		4	4	4	4	Punch a Card
C		C	C	12-3	C B A 2 1	Compare	5		5	5	5	C 4 1	Read and Punch
D		D	D	12-4	B A 4	Move Numerical (Bits)	6		6	6	6	C 4 2	Write and Punch
E		E	E	12-5	C B A 4 1	Move Characters and Edit	7		7	7	7	4 2 1	Write, Read, and Punch
F		F	F	12-6	C B A 4 2	Control Carriage (Printer)	8	2	8	8	8	8	Start Read Feed
							9	2	9	9	9	C 8 1	Start Punch Feed

† Print arrangement H is required for both FORTRAN and COBOL Programming Systems. Otherwise, arrangement A is recommended. Other printing arrangements (B-K) are available.

** The 1401 does not accept the 8-9 portion of 402 MLP codes. Nor does it generate 402 MLP codes for punching.

1 If specified, this code can be made compatible with 705 Group Mark Code (12-5-8).

2 This character can be used as an Op code if the associated special feature is installed.

3 The A-bit coding for this character (Substitute Blank) must be program-generated in the 1401 (it cannot be read from a card; it can be punched as a zero). It is used in conjunction with the C-bit to indicate a blank position on tape that was written in even-bit parity.

4 This character can be used as an Op code in systems with more than 4,000 positions of core storage.

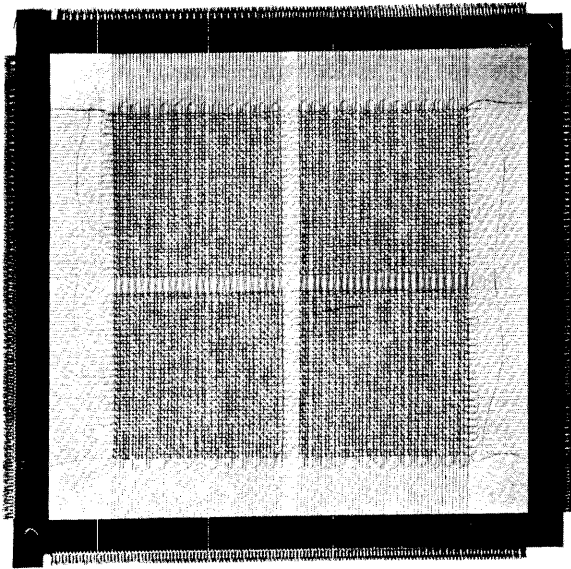


Figure 119. Magnetic Core Storage Unit

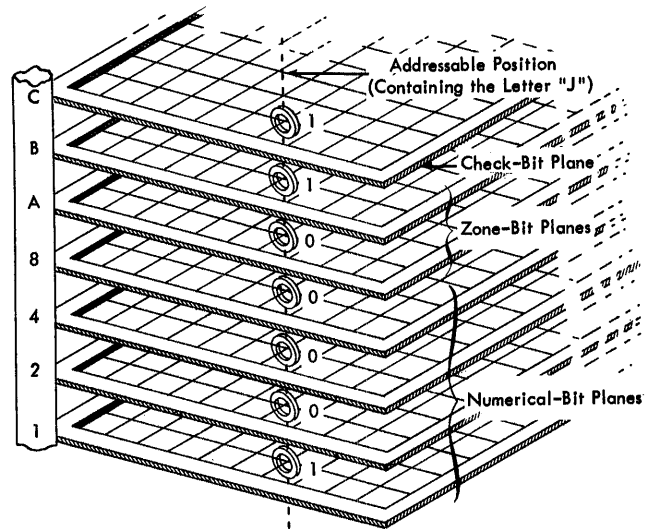
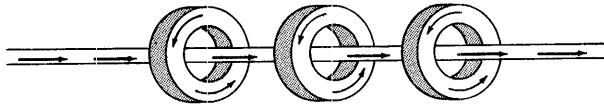


Figure 121. Schematic of Core Storage

Condition: 1, Plus, Yes, or On



Condition: 0, Minus, No, or Off

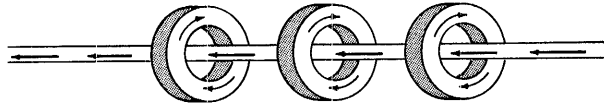


Figure 120. Polarity of Magnetic Cores

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