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## **IBM 5444 Disk Storage Drive, IBM 5440 Disk Cartridge: Component Descriptions**

This publication describes the IBM 5444 Disk Storage Drive Models 1, 2, and 3, and the IBM 5440 Disk Cartridge. The 5444 Disk Storage Drive is a direct access disk file that provides data storage for small computer systems. The 5440 Disk Cartridge is a removable disk cartridge that is used on the 5444.

The manual contains the following information:

1. The way in which the 5444 communicates with the system to which it is attached. As an example, details are given of the track format that is employed by one using system, the IBM System/3.
2. The operations that are performed by the 5444.
3. Timing details and storage capacity.
4. A summary of handling procedures for the 5440. These procedures are amplified in Product Reference Literature *IBM 5440 Handling Procedures*, Order No. GA26-1598.

The manual is intended as a reference aid for programmers, systems engineers, and those persons concerned with the operation of the 5444 in conjunction with the using system. The reader should have a good understanding of the principles of data processing, of programming concepts, and of the system to which the 5444 is attached.

## Preface

The IBM 5444 Disk Storage Drive Model 1, 2, or 3 is controlled completely by the system to which it is attached. The machine communicates with its using system through a control unit that forms part of the using system. The three models of 5444 Disk Storage Drive provide a wide range of on-line storage capacities; all models use the removable IBM 5440 Disk Cartridge to provide virtually unlimited off-line storage capacity.

This manual is intended as a reference aid for programmers, systems engineers, and others concerned with the operation of the machine in conjunction with its using system. The reader should have a good understanding of the principles of data processing, of programming concepts, and of the using system. The manual is divided into the following sections:

1. "Introduction". This section describes the 5444, its models, and its attachment to a system.
2. "Machine Description".
3. "Principles of Operation". This section describes all machine operations and the way in which the 5444 communicates with its using system.
4. "Data Organization". This section describes the organization of data and gives details of the track format that is used on the 5444 when it is attached to the IBM System/3.
5. "Timing".
6. "Disk Cartridge Handling Procedures". This section summarizes handling procedures for the 5440. The procedures are dealt with fully in Product Reference Literature *IBM 5440 Handling Procedures*, Order No. GA26-1598. Abbreviations, a glossary of terms, and an index conclude the manual.

For ease of understanding, the 5444 Model 2 is described. Where appropriate, the differences among the models are given.

*First Edition (August, 1970)*

Changes are periodically made to the information herein; before using this publication in connection with the operation of IBM equipment, refer to the latest SRL Newsletter, for the editions that are applicable and current.

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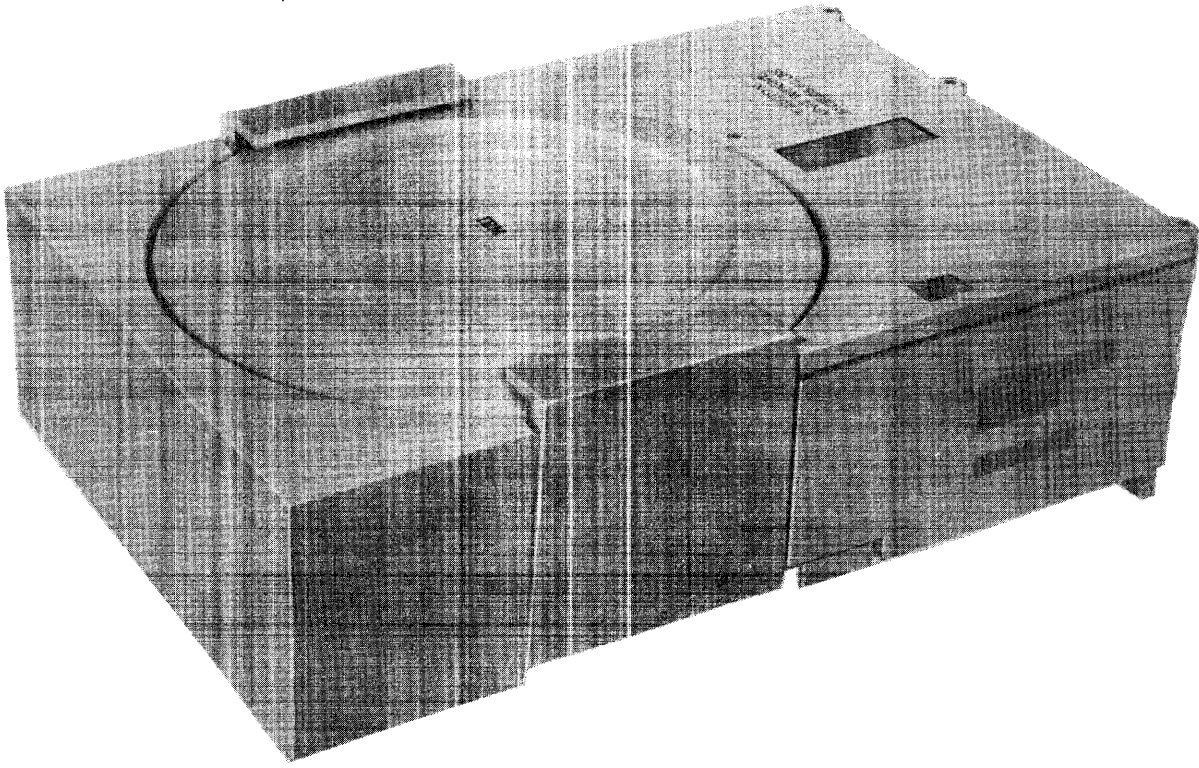
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Frontispiece. IBM 5444 Disk Storage Drive [07948]

The IBM 5444 Disk Storage Drive (see Frontispiece) is a direct-access storage unit that provides data storage for small computer systems. The unit is designed to be mounted within the frame of the using system.

The 5444 Disk Storage Drive provides:

- Up to 4.92 million 8-bit bytes of on-line data storage.
- Virtually unlimited off-line data storage.
- An average access time of 269 milliseconds.
- A data transfer rate of 199,000 bytes per second.
- 24,576 bytes of data available at a single access.
- A choice of three models.

A flat rotating disk, coated on both sides with a magnetic recording material, provides the storage medium that is used in the 5444. The 5444 normally contains two of these disks (one fixed and one removable) that are driven by a common spindle, the removable disk being mounted in an IBM 5440 Disk Cartridge above the fixed disk; this arrangement provides, on one unit, the functional capabilities that are normally associated with multiple disk drives. Data is written onto, and read from, both recording surfaces of the disks by read/write heads.

The 5440 Disk Cartridge can be quickly and easily removed from the 5444, thus providing virtually unlimited off-line storage. Cartridges can be interchanged between the various models of 5444.

## MODELS OF 5444

The three models of the 5444 are as follows:

*5444 Model 1:* This model is provided with a fixed disk and a removable disk. Data is stored on 100 bands or *tracks* of information on each of the four recording surfaces; the total storage capacity is nominally 2.46 million bytes (4.92 million packed-decimal digits). The average access time is 153 milliseconds for 33 tracks. (The average access time is defined as the access time for one third of the total number of tracks available.)

*5444 Model 2:* This model is provided with a fixed disk and a removable disk. Data is stored on 200 tracks on each of the four recording surfaces; the total storage capacity is nominally 4.92 million bytes (9.84 million packed-decimal digits). The average access time is 269 milliseconds for 67 tracks.

*5444 Model 3:* This model is provided with a removable disk only. Data is stored on 200 tracks on each recording surface; the total storage capacity is nominally 2.46 million bytes (4.92 million packed-decimal digits). The average access time is 269 milliseconds for 67 tracks.

Figure 1 summarizes the characteristics of the models.

The 5444 Model 3 can only be used as an addition to Model 2. The total nominal storage capacity of the two models is then 7.37 million bytes (14.74 million packed-decimal digits).

In each model of the 5444, three extra tracks (*alternate tracks*) are available on each recording surface. These tracks are used for the storage of data from defective tracks, if permitted by the system program.

For simplicity, the 5444 Model 2 is described in this manual, but differences among the three models are stated where appropriate.

## ATTACHMENT OF 5444 TO SYSTEM

The 5444 is controlled completely by the using system to which it is attached. No operator console is provided on the machine. The 5444 and the central processing unit of the system communicate through a file control unit (FCU) in the system (Figure 2). The machine operations of moving the read/write heads to a particular track, reading data from that track, or writing data onto that track, are controlled by command signals from the FCU. The 5444 contains appropriate circuits that enable it to respond to these command signals.

Information is transferred between the FCU and the 5444 one bit at a time, that is, serial-by-bit.

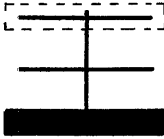
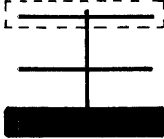
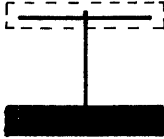
Machine	Disk Arrangement	Number of Recording Surfaces in Model	Number of Recording Tracks per Surface	Total Nominal Storage Capacity	
				Bytes	Packed Decimal Digits
5444 Model 1		4	100	2.46 million	4.92 million
5444 Model 2		4	200	4.92 million	9.84 million
5444 Model 3		2	200	2.46 million	4.92 million

Figure 1. Characteristics of Models of 5444 [07949]

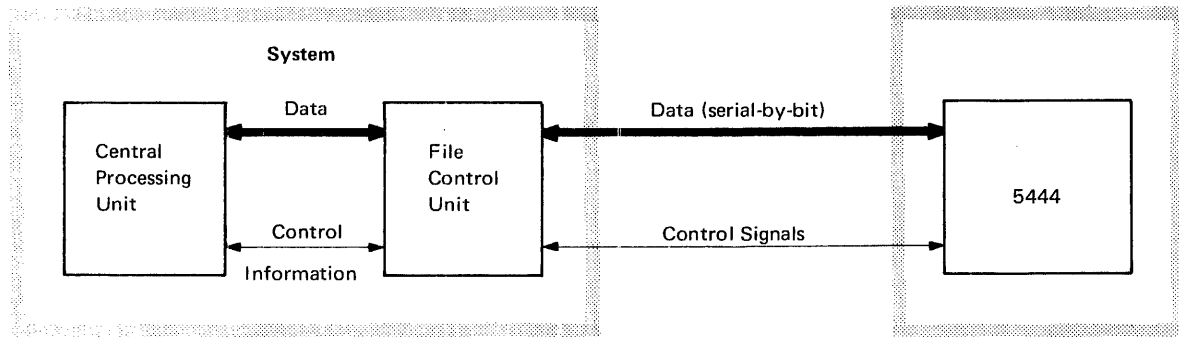


Figure 2. Attachment of 5444 to System [07950]

The 5444 Models 1 and 2 each contain two 14-in. (35,6 cm) diameter magnetic recording disks that are mounted on a common drive spindle. The lower disk is fixed and the upper disk is removable in a disk cartridge. The Model 3 contains a removable disk but no fixed disk. A drive mechanism rotates the disk(s) at a constant speed of 1,500 rpm (40 ms per revolution).

Information is stored on each side of a disk on 100 tracks (Model 1) and 200 tracks (Models 2 and 3). This information is written onto the tracks or read from the tracks by read/write heads — one head for each recording surface.

The read/write heads are attached to an access mechanism that moves them radially across the disk surfaces. The track location to which the heads are moved is defined in the command signals from the FCU of the using system.

The 5444 contains access control circuits and read/write circuits that enable it to respond to the command signals from the FCU.

The 5444 contains no power supplies. These are obtained from the using system, through the FCU.

#### FIXED DISK

The fixed (lower) disk is permanently mounted in an enclosure at the base of the drive spindle. A cover protects the disk from damage and contamination when the (upper) disk cartridge is removed from the 5444.

#### IBM 5440 DISK CARTRIDGE

The removable (upper) disk is permanently enclosed in the 5440 Disk Cartridge (Figure 3) to protect the recording surfaces from damage and contamination; the surrounding top cover and protective cover of the disk cartridge form a top cover assembly (Figure 4). When the cartridge is not installed, the top cover assembly fits into a bottom cover to provide safe and contamination-free off-line storage. The top and bottom parts of the disk cartridge are held together by magnets in the bottom cover.

The disk cartridge is 15 in. (38,1 cm) in diameter, 2.4 in. (6,1 cm) high, and weighs 5-1/2 lb (2,5 kg). Cartridges for customer use have a blue top cover.

When placed in the 5444, the disk cartridge locates on a cone at the top of the drive spindle. A magnetic chuck clamps the cartridge to the spindle; both disks (Models 1 and 2) therefore rotate at the same speed. To prevent the bottom cover becoming dirty while the disk cartridge is installed, the cover is inverted and stored over the top cover, and is locked in position by two clamp arms (Figure 5). The

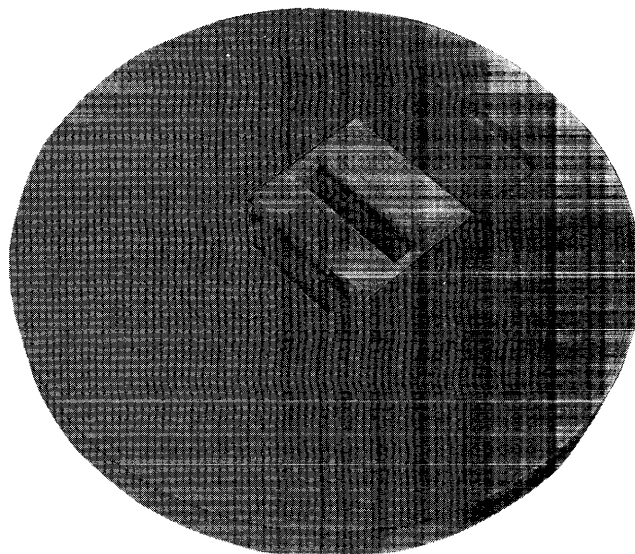


Figure 3. IBM 5440 Disk Cartridge [07951]

carrying handle operates a release mechanism for removing the top cover assembly from the 5444 and from the bottom cover.

The disk cartridge is easily removed from the 5444 and replaced with another cartridge. The cartridge provides, therefore, an off-line data storage that is limited only by the quantity of cartridges available to the customer.

The same version of the disk cartridge is used for all models of the 5444, and cartridges may be interchanged between models. However, because the Model 1 operates over 100 tracks only, any data that has been recorded on tracks above track 100 by a Model 2 or 3 cannot be read by a Model 1. The storage capacities of the disk cartridge, when fitted to the various models of 5444, are given in Figure 6.

Disk cartridge handling procedures are given later in this manual.

#### ACCESS MECHANISM

The access mechanism moves the read/write heads to the track location that is defined by the FCU. The heads (Figure 7) are attached by support arms to a carriage that slides back and forth to move the heads across the disk surfaces.

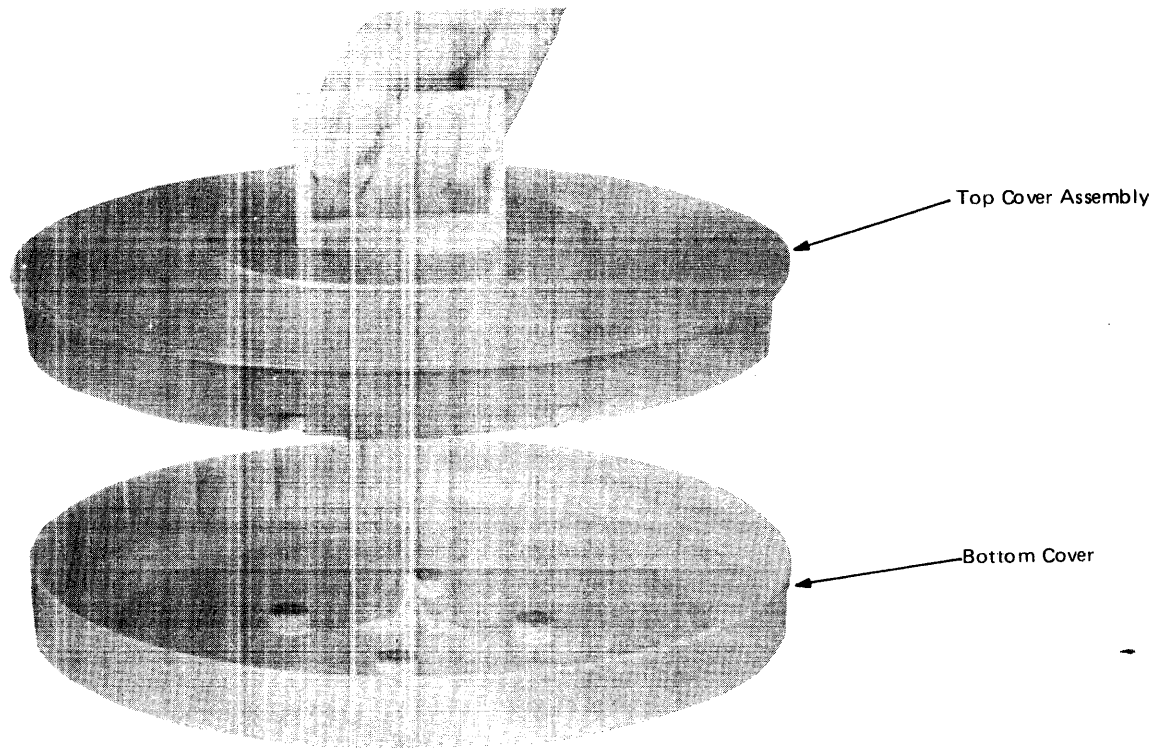


Figure 4. Disk Cartridge Separated [07952]

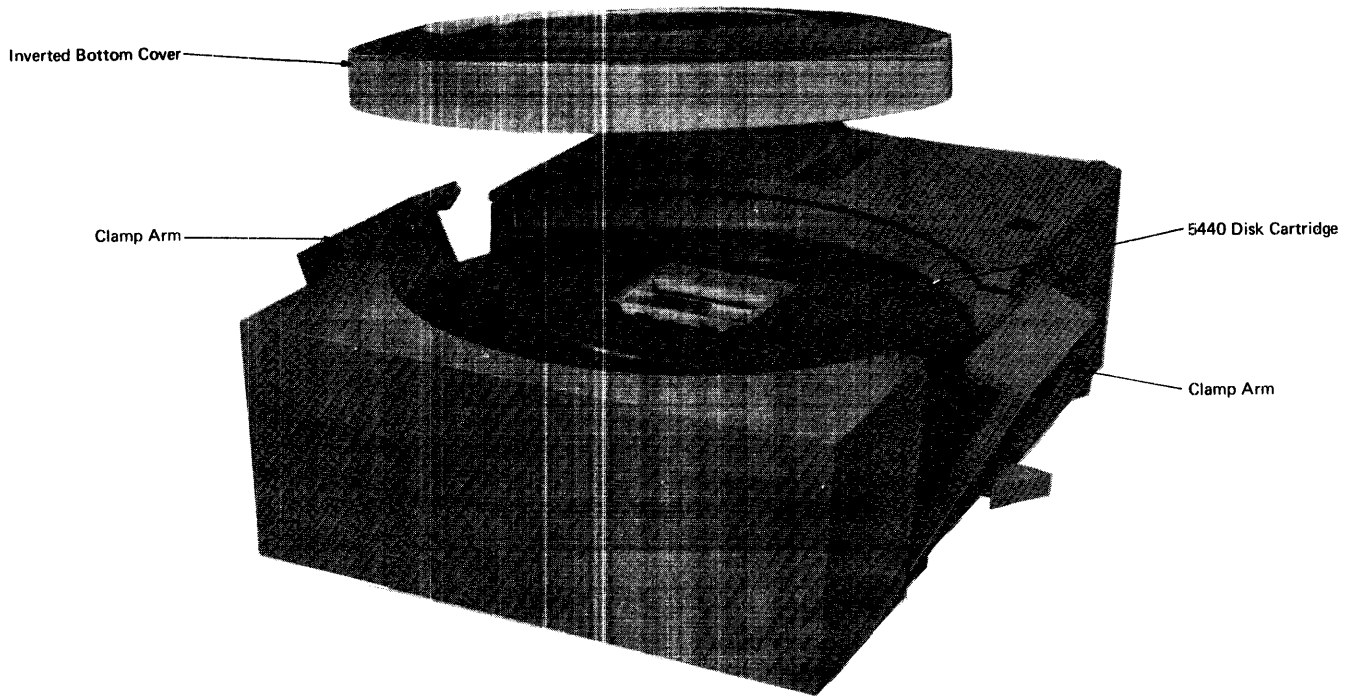


Figure 5. Disk Cartridge Positioned in 5444 [07953]



Used on Model of 5444	Recording Tracks per Surface of Disk in Disk Cartridge	Maximum Nominal Storage Capacity of Disk Cartridge	
		Bytes	Packed Decimal Digits
1	100	1.23 million	2.46 million
2 and 3	200	2.46 million	4.92 million

Figure 6. Disk Cartridge Characteristics [07954]

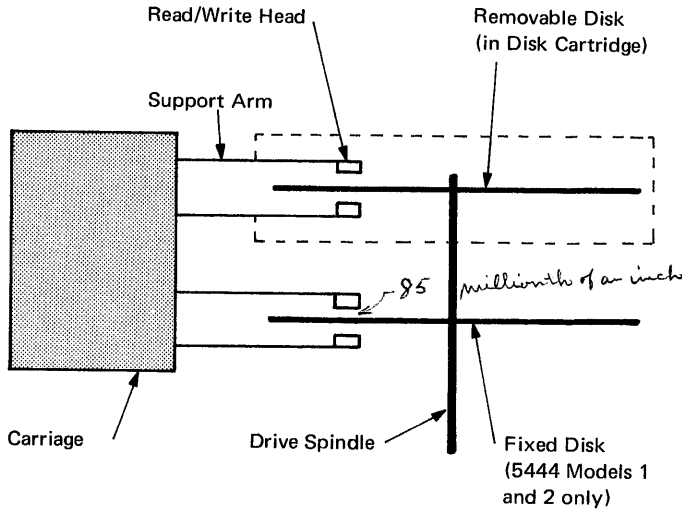


Figure 7. Arrangement of Disks and Read/Write Heads [07955]

When the 5444 is switched on, the mechanism automatically moves the read/write heads to the *home* position (track 000) — that is, the position in which the heads are nearest the disk edge. The heads remain at the home position until an access command is received from the FCU.

When an access command is received, the mechanism moves all the read/write heads together horizontally from the home position towards the disk center until the required track location is reached. Four tracks (in a 5444 Model 2, for example) are therefore available for recording purposes at each access position; thus, when the uppermost head is

positioned over track 025, the other three heads are also positioned at track 025 of their respective disk surfaces. Subsequent access commands cause the read/write heads to move to new track locations.

Details of the time that is taken for the access mechanism to move the read/write heads from one track location to another are given later in the manual under “Access Time”.

When the 5444 is switched off, the access mechanism automatically retracts the read/write heads away from the disks. When the heads are in this position, the disk cartridge may be removed.

### READ/WRITE HEADS

One read/write head is used for each recording surface. When the 5444 is running, the heads float on a thin film of air, just clear of the surface of the rotating disks; the heads do not touch the disk surfaces.

### CONTAMINATION CONTROL

To avoid interference between the read/write heads and the disk surfaces, dust and dirt particles must be excluded from the 5444 and from the disk cartridge. The following techniques achieve, as near as possible, a dust-free atmosphere:

1. A cleaning brush sweeps dust particles from each disk surface during the start sequence.
2. When the 5444 is operating, the disks run in a closed air-circulation system, so that no air enters or leaves the system. A filter in the circulation system removes any dust particles.
3. Contamination-free off-line storage is provided for the disk in the disk cartridge (see “Disk Cartridge”).

### MACHINE SAFETY AND DATA PROTECTION

The 5444 contains safety devices to control both the start and stop procedures and the various machine operations. These devices include interlocks to prevent the operator gaining access to the 5444 while it is operating and to prevent the 5444 starting while the operator has access to it.

The 5444 also contains safety circuits to protect recorded data. These circuits ensure that read and write operations take place only when it is safe for them to do so, and that recorded information is not lost accidentally.

# Principles of Operation

## COMMUNICATION WITH SYSTEM

No operator console is provided on the 5444. The operations that are performed by the 5444 are controlled completely by the system to which it is attached, through command signals from the FCU. These operations are:

1. Start sequence.
2. Moving the read/write heads to a particular track, as specified by the FCU.
3. Read and write operations at that track.
4. Stop sequence.

The lines of communication between the 5444 and the FCU (Figure 8) are as follows:

*Read/write data lines:* These lines carry, from the FCU, the data that is to be written onto the disks. The lines also carry, to the FCU, the data that has been read from the disks.

*Read/write control lines:* These lines, from the FCU, control both the selection of disks and heads, and the read/write operations.

*Access control lines:* These lines, from the FCU, control the movement of the read/write heads to a track that is specified by the FCU.

*Status lines:* These lines send machine status information to the FCU to indicate the readiness of the 5444 to respond to access and read/write control signals.

*Start/stop line:* This line controls the start and stop sequences of the 5444. The line is operated by the start/stop switch on the system console.

*Power lines:* These lines, from the FCU, provide the power supplies to the 5444.

## OPERATIONS

### Start Sequence

The start sequence is controlled by a signal on the start/stop line from the FCU. Once started, the sequence proceeds automatically, taking approximately one minute to complete. Before the sequence can begin, the following conditions must be satisfied:

1. The 5444 must be secured in position within the system frame to prevent start-up whenever the operator can gain access to the machine. For example, if the 5444 is mounted in a drawer in the frame, this drawer must be closed.

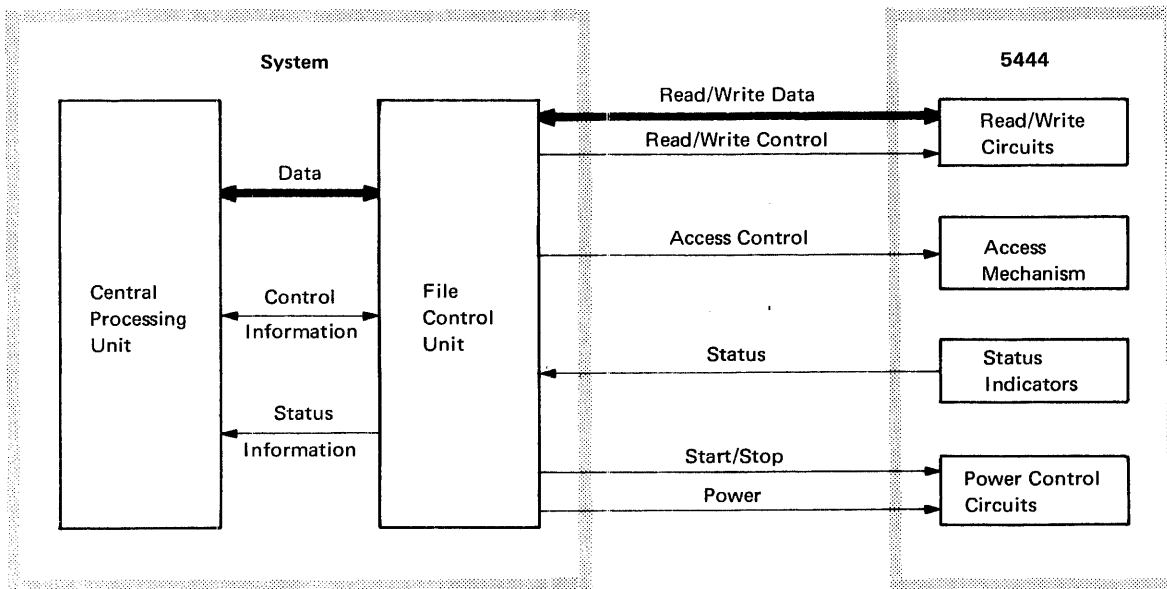


Figure 8. Data Flow and Control [07956]

2. The disk cartridge must be held in position on the 5444 by the two clamp arms. These arms operate two interlocks that prevent start-up if the disk cartridge is not clamped in position.
3. The system power supplies must be switched on.

The start sequence begins when the start/stop line is activated. During the sequence, cleaning brushes sweep the disk surfaces to remove dust particles. At the end of the sequence, the disks are rotating at the nominal speed of 1,500 rpm and the read/write heads are positioned at the home position (track 000), near the disk edge.

The 5444 is now ready to perform access and read/write operations as commanded by the signals from the FCU. The ready condition of the 5444 is indicated to the FCU on one of the status lines.

### **Access Operations**

Access operations are controlled by commands from the FCU that enter the 5444 on the access control lines. Access operations cannot take place unless the 5444 has indicated (to the FCU) that it is ready to respond to these commands.

When an access command is received by the 5444, the access mechanism moves forwards or backwards as required, thus carrying the read/write heads across the disk surfaces. During the movement, the 5444 transmits a pulse to the FCU (over the status lines) for each track that is crossed by the read/write heads. The FCU counts these pulses and, when the correct number of tracks has been crossed, removes the access command. The access mechanism stops, with the heads positioned at the required track. Read/write operations can now be performed.

Forward and reverse operations are similar in control and execution. The operations can start from, and end at, any of the tracks within the normal recording area. The maximum access time for a movement of one track is 39 milliseconds. Details of other access times are given later in the manual under "Access Time".

### **Read/Write Operations**

Read/write operations are accomplished using read/write heads — one for each recording surface. The operations can only take place when the 5444 has indicated (to the FCU) that it is safe to proceed. Read/write operations are controlled by command signals from the FCU that enter the 5444 on the read/write control lines.

Each read/write head contains windings that allow it to be used both for reading information from a disk surface or for writing information onto a disk surface.

To perform a read or write operation, the appropriate disk and head are first defined by the read/write control lines. The head is then selected for either a read operation or a write operation, as required.

During a read operation, signals are read off the selected track by the selected head. The signals are then amplified before being transmitted to the FCU over a read/write data line. During a write operation, data that is to be recorded is fed to the 5444 from the FCU through one of the read/write data lines. The data is then fed to the selected read/write head and is recorded on the selected track.

### *Write Checking*

To obtain the best performance from the 5444, the program should be able to repeat those commands that show a unit-check error. These errors are often due to temporary conditions that are not present in subsequent retries.

A write operation that does not write correctly because of temporary or intermittent conditions can be detected by the immediate issuing of a read command. In this way, any such "soft" write error can be corrected while the data is still available in the system main storage. If this write-checking procedure is not carried out, the soft write error may become a "hard" error that can be corrected only by reconstruction or adjustment.

In IBM programming systems, the use of write checking is optional ("verify" option). Before deciding not to write check, however, the programmer should assess the system downtime, together with the time taken to recover from a hard error, against the time that may be consumed in write checking.

### **Stop Sequence**

The stop sequence is controlled by the start/stop line from the FCU. Once started, the sequence proceeds automatically, taking approximately half a minute to complete.

The sequence begins when the start/stop signal is dropped. Access and read/write operations are stopped, the read/write heads are retracted off the disks, and the disks slow down. When the disks have stopped rotating, the 5444 can be opened to remove the disk cartridge.

# Data Organization

The track format that is used in the 5444, for the organization of data, is written by the system to which the machine is attached. This section describes, as an example, the format that is determined by attachment of the 5444 to an IBM System/3.

## CYLINDER CONCEPT

The read/write heads, being attached to the carriage, move

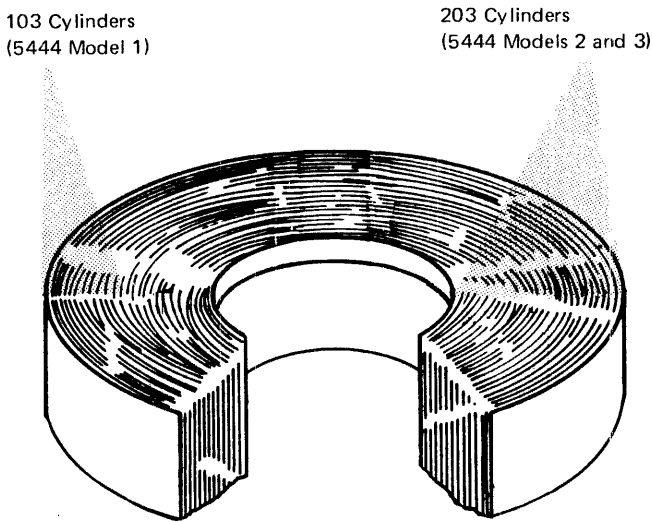


Figure 9. Cylinder Concept [07957]

across the disk surfaces together. At every access position, therefore, two tracks (one on each surface) are available on each disk for recording purposes; these tracks can be considered as forming a "cylinder" of information. Each disk thus contains 100 (5444 Model 1) or 200 (Models 2 and 3) concentric cylinders of information (and three alternate cylinders) as shown in Figure 9.

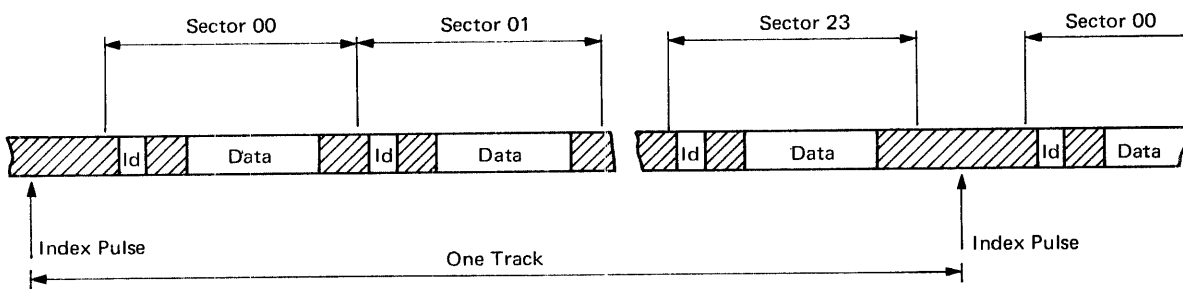
The cylinders are numbered 000 through 102 (Model 1) or 202 (Models 2 and 3), cylinder 000 being the outermost. Cylinders 001, 002, and 003 contain the alternate tracks for storage of data from defective tracks (see "Alternate Track Assignment").

To select a particular track on the 5444, the appropriate disk is first selected. The location of the specific track is then defined by the cylinder number and head number.

## TRACK FORMAT

Each track is divided into 24 equal-length sectors (Figure 10). Any given data record is identified by the cylinder number, head number, and sector number that correspond to that record. The same track format is used for all tracks on the 5444.

Each sector contains an identifier field and a data field. (These fields are described later under "Sector Format".) Sectors, identifier fields, and data fields are separated by gaps. These gaps contain no data; their length varies according to their location within the track. Gaps are determined by the using system both to allow for mechanical tolerances



Key

: Gap

Id: Identifier Field

Data: Data Field

*Track 004, 005, 006 and 071 through 075 are factory created. They are used for alignment.*

Figure 10. Track Format [07462A]

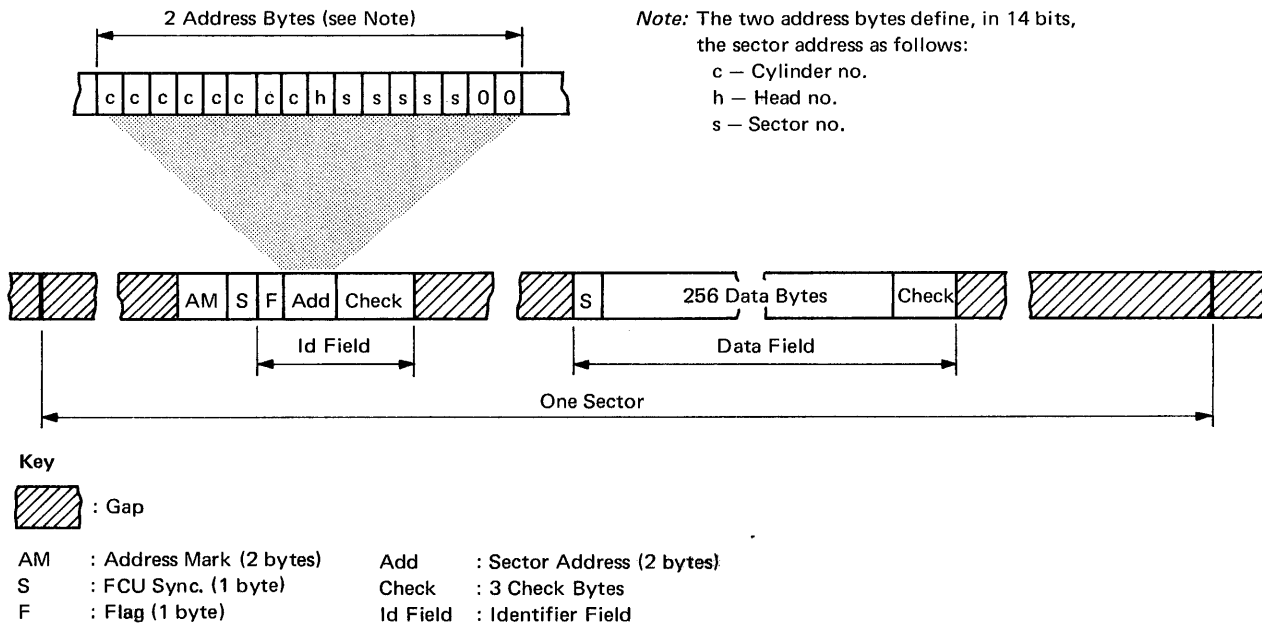


Figure 11. Sector Format [07463A]

and to meet synchronization requirements of the read/write circuits.

An index pulse indicates the start of each track (see Figure 10) and aligns the start of tracks on a cylinder on any one disk; a separate index pulse is used for each disk. These pulses are derived from transducers that monitor the rotation of the two disks, and are passed on a status line to the FCU.

Note: Figure 10 shows an index pulse at the beginning of a track. However, only one index pulse is used per disk, and this pulse is present all the time that the 5444 is in operation. The pulse is not dependent on any read/write operations taking place.

Because the top disk is removable and is not keyed to the drive spindle, there is no specific phase relationship between the index pulses for the two disks; phasing is completely random.

### SECTOR FORMAT

Each sector contains an identifier field and a data field (Figure 11). The identifier field contains the physical address of the sector, and the data field contains the stored data. The start of each sector is denoted by an address mark, which consists of two bytes of specially recorded information that are uniquely identifiable.

The identifier field contains a flag byte, two address bytes, and three check bytes. The flag byte indicates the condition of the track (see "Flag Byte"). The address bytes contain the sector address as a binary number of 14 bits (see

Note: The two address bytes define, in 14 bits, the sector address as follows:  
 c — Cylinder no.  
 h — Head no.  
 s — Sector no.

Figure 11). The check bytes are generated by the FCU to verify the identifier field (see "Check Bytes").

The data field contains one FCU synchronizing (sync) byte, 256 data bytes, and three check bytes. The FCU sync byte contains a fixed bit pattern to synchronize the read/write circuits of the 5444 with the FCU. The content of the data bytes is not restricted, except that unused parts of the field should be filled with any valid bit pattern. The check bytes verify the data field (see "Check Bytes").

### Flag Byte

The flag byte in the identifier field indicates either that the track is a normal data track, or that the entire track is not used because of a defect, or that the track is an alternate for a defective track. Normally, all eight bits of the flag byte are set to zero when the sector address is first written. The bit significance is given in Figure 12.

The flag byte in each sector on a track is generated by the FCU as each sector is written. Bits 6 and 7 are duplicated into every sector flag byte that is written on the track.

Flag Byte Bit	Setting	Function
0 through 5	Always 0	(Not used)
6	0	Indicates operative track
	1	Indicates defective track
7	0	Indicates primary track
	1	Indicates alternate track

Figure 12. Significance of Flag Byte Bits [07958]

### Alternate Track Assignment

When a track is found to be defective, an alternate track is assigned. On the *defective* track, the address of the alternate track is written into the identifier field of every sector. On the *alternate* track, the address of the defective track is written into the identifier field of every sector.

When an access operation is performed to a defective track, the flag byte indicates that the track is defective. The address of the alternate track is given in the identifier field. The read/write heads then move to the new track address, where the address of the original (defective) track is given in the identifier field. As far as the FCU is affected, the read/write heads are now positioned at the correct track address, as defined in the access instruction.

*Note:* Alternate tracks are assigned one track at a time.

Facilities in the system automatically ensure that the proper exit procedure and return procedure to the original location are made if a data operation overlaps.

### Check Bytes

Check bytes verify the information that is stored in the

fields to which they are appended. In the 5444, data is stored into, and retrieved from, fields containing multiple bytes. The storage capacity is more effectively used by associating check bits (in check bytes) with each field, rather than with each byte.

When data is transferred from the system to the 5444, the FCU computes three check bytes that are placed at the end of each field. The check bytes are arithmetically coded from information to be placed in the associated field. Subsequently, when the field is read from the disk, the FCU recomputes the check information and compares it with the check bytes that have been read from the associated field. Because the check bytes are at the end of each field, the check is not completed until the entire field has been read.

### SUMMARY OF STORAGE CAPACITIES

Figure 13 summarizes the data storage capacities for the various models of the 5444. Storage capacities are given per sector, track, cylinder, recording surface, and disk, together with total capacities.

Model of 5444	Bytes per Sector	Bytes per Track	Bytes per Cylinder	Bytes per Recording Surface	Bytes per Disk	Total Storage Capacity (Bytes)	
						Actual	Nominal
1	256	6144	12,288	614,400	1,228,800	2,457,600	2,460,000
2	256	6144	12,288	122,880	2,457,600	4,915,200	4,920,000
3	256	6144	12,288	122,880	2,457,600	2,457,600	2,460,000

Figure 13. Data Storage Capacities [07959]

Timing estimates for disk storage operations depend on the following three factors:

1. Access time.
2. Rotational delay.
3. Data transfer rate.

A negligible delay occurs in switching from one read/write head to another at the same cylinder location, or in switching from a read operation to a write operation (or vice versa) at the same sector address. Because the 5444 contains one read/write head for each disk surface, no vertical movement of the access mechanism takes place.

**ACCESS TIME**

Access time is the time taken for the access mechanism to move the read/write heads from one cylinder location to another. The time is measured from the receipt of an access command, up to (and including) the settling of the heads after an access movement.

Figure 14 shows the maximum access time (in either the forward or reverse direction) for the number of cylinders that the access mechanism crosses.

The more important access times for the three models of 5444 are given in Figure 15. These times are as follows:

1. The access time for a one-cylinder movement.
2. The average access time for random movements, that is, the time taken for the access mechanism to cross one-third of the total number of cylinders that are available on each model.

3. The maximum access time, that is, the time taken for the access mechanism to cross the maximum number of cylinders available on each model.

**ROTATIONAL DELAY**

When the read/write heads are positioned at a cylinder location, a search operation is performed to find a specific sector. The search is started on the track that is to be read by the selected head. One revolution of the disks takes 40 ms (1,500 rpm); thus the read/write head may be at the required sector, or it may be up to 40 ms away from that sector, when the search begins. A rotational delay therefore occurs that may vary between 0 ms and 40 ms.

For a large number of different search operations, the average rotational delay in finding a sector on a particular track is 20 ms, that is, one-half of the revolution time. A multitrack search through a particular cylinder takes place at the rate of 40 ms per track, no rotational time is lost while switching from head to head.

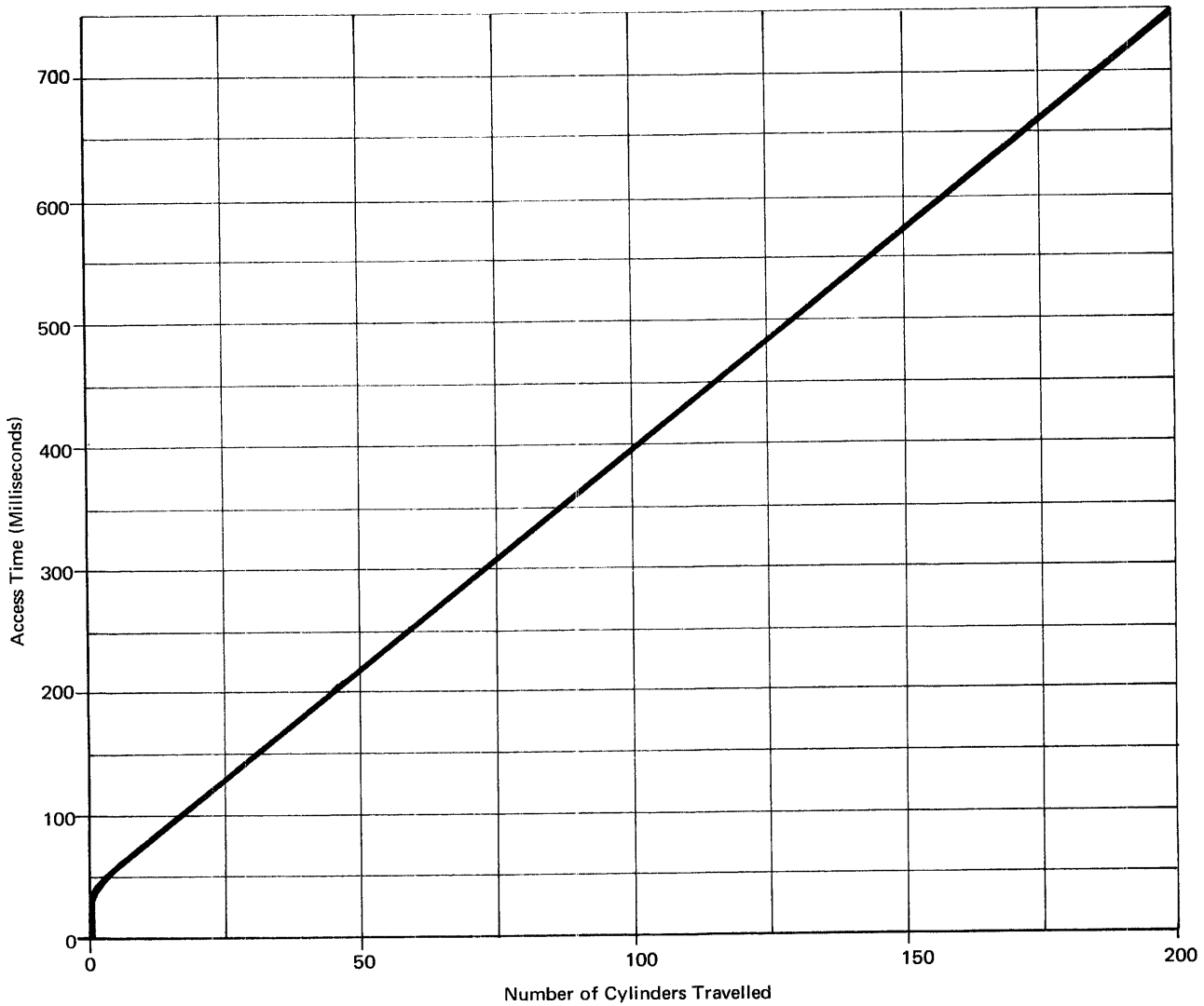
**DATA TRANSFER RATE**

The data transfer rate is the speed at which data is transferred between the 5444 and the FCU. The nominal data transfer rate for the 5444 is 199,000 bytes per second.

In one revolution of the disks, 24 sectors are "processed" in 40 ms. One sector, therefore, is processed in 1.67 ms. During this 1.67 ms, the sector identifier field is read and a read or write operation is performed on the data field.

*The disks are constructed from light alloy. They are 14 in diam. 0.05 in. thick coated approx. 0.0001 in (0.003 mm) thick of epoxy bonded magnetic iron oxide on both surfaces.*

*The usable surface is 2 in wide for track 000 to 202. Track 202 is at 4.5 in radius and 0.01 in apart from next track. (Track 000 is at 0 in radius)*



For a one-cylinder access:  
Maximum access time = 39 ms

For an access of more than one cylinder:  
Maximum access time in milliseconds =  $39.9 + (3.55 \times \text{number of cylinders travelled})$

Figure 14. Maximum Access Times – Graph [07960]

Model	Access Time for 1 Cylinder	Average Access Time	Maximum Access Time
1	39 ms	153 ms for 33 cylinders	391 ms for 99 cylinders
2 or 3	39 ms	269 ms for 67 cylinders	746 ms for 199 cylinders

Figure 15. Access Times for Models of 5444 [07961]



This section contains a summary of handling procedures for the disk cartridge. Detailed information is given in Product Reference Literature *IBM 5440 Handling Procedures*, Order No. GA26-1598.

### GENERAL PRECAUTIONS

Disk cartridges are precision devices that require careful handling so that vital information is not destroyed. The following general precautions are recommended for maintaining the quality and life of the disk cartridge:

1. Do not remove the cartridge top cover assembly from the bottom cover, except when installing the cartridge on the 5444. When the top cover assembly is removed, do not place it on a surface where the disk can be damaged or contaminated.
2. Do not drop the cartridge, and do not place it where it can be knocked down or where it can receive any sharp impact.
3. Do not touch the disk surfaces with the hands, pencils, or any other objects.
4. Do not spill beverages on the cartridge. Keep them away from the 5444 and away from cartridge storage areas.
5. Do not expose the cartridge to intense magnetic fields. Consult the IBM installation-planning engineer if exposure to high-intensity magnetic fields is suspected.
6. Do not smoke while handling the cartridge, or while near the 5444.
7. If damage to the cartridge or to the 5444 is suspected, do not install the cartridge. Notify the local IBM branch office.
8. Before installing the cartridge, ensure that it is at machine room temperature. This condition can be achieved by leaving the cartridge in the machine room for at least two hours.
9. Keep cartridge covers free from dust and dirt. Clean them with a soft lint-free cloth or tissue before installing the cartridge.
10. When installing a cartridge, take care to avoid damaging either the disk or the drive spindle. Any damage may alter the alignment between the disk surfaces and the read/write heads, causing further serious damage.

### RECEIVING AND SHIPPING

Each disk cartridge is protected in transit by a container that can withstand normal shipping usage.

When the disk cartridge is received, carefully examine the container and cartridge for signs of shipping damage. If the condition of both is acceptable, remove the cartridge and store it. Keep the container; it may be required later. If the container or cartridge shows any sign of damage, do not use the cartridge. Retain the damaged container and cartridge in the "as received" condition, and immediately notify the local IBM branch office.

For shipping purposes, always use the special IBM shipping container. If the original container is lost or damaged, order a new container from the local IBM branch office. For the best shipping results:

1. Place the disk cartridge in its polyethylene bag.
2. Pack securely in the shipping container.

Consult the local IBM branch office for any queries concerning shipping procedures.

### CARRYING

Carry the disk cartridge either horizontally or vertically. To carry it horizontally, use its handle. To carry it vertically, place the fingers in the handle recess and grip the beveled edge on the bottom cover with the thumb.

When carrying more than one disk cartridge, stack them on top of each other. Do not, however, carry more than *five* cartridges at a time.

### LABELING

Use the top surface of the disk cartridge as a labeling surface. Cartridge identification may be written onto the surface with a pen or marker that does not leave a residue; *do not use a lead pencil*. Use isopropyl alcohol to remove markings.

Alternatively, adhesive-backed labels may be attached to the top surface for identification purposes. Observe the following precautions:

1. Use adhesive-backed labels that do not work loose, but that can be applied and removed easily without leaving a residue.
2. To write on the labels, use a pen or marker that does not leave a residue. *Do not use a lead pencil*.
3. Write on the label *before* it is applied to the cartridge. Attach the label onto the cartridge before the cartridge is installed on a drive.
4. Use a new label if changes to the label information are necessary. Never use an eraser to alter the identification on a label. Rubber or paper particles could contaminate the cartridge.

## INSTALLATION

### CAUTION

Any damage that is caused to the disk cartridge or drive spindle during installation of the cartridge may alter the alignment between the disks and the read/write heads, causing further serious damage.

Before installing the disk cartridge, inspect the top and bottom covers; remove any dust and dirt. Ensure that the cartridge is at machine room temperature.

To install the disk cartridge, proceed as follows:

1. Open the two clamp arms on the 5444.
2. With the cartridge handle horizontal, use the thumb to push the gray sliding knob against its spring.
3. Raise the handle and lift the cartridge clear of the bottom cover.
4. Align the keyways on the cartridge top cover with the keys on the 5444 structure and place the cartridge in the machine. Take care not to damage the disk or the drive spindle. Make sure that the cartridge seats down correctly onto the spindle.
5. Push the cartridge handle down so that it lies flat within its recess.
6. Invert the bottom cover and store it on the cartridge.
7. Clamp the bottom cover in position with the two clamp arms. (The drive cannot operate until the clamp arms are closed.)

## REMOVAL

*Note:* To prevent accidents to the operator or machine, the clamp arms on the 5444 cannot be opened until the disks have stopped rotating and the read/write heads have retracted away from the disks.

1. Open the two clamp arms.
2. Remove the inverted bottom cover.
3. Using the thumb, push the sliding knob on the disk cartridge handle against its spring.

4. Raise the handle and lift the cartridge carefully from the 5444.
5. Place the cartridge into the bottom cover *immediately*.

### CAUTION

Do not rest the disk cartridge on any surface where the disk can be damaged or contaminated.

6. Push the handle down so that it lies flat within its recess.
7. If a new cartridge is not to be installed immediately, protect the 5444 to keep out dust and dirt.

## STORAGE REQUIREMENTS

For long-term storage, store disk cartridges in their shipping containers. The atmospheric requirements for long-term storage are as follows:

Temperature:  $-40^{\circ}\text{F}$  to  $+150^{\circ}\text{F}$  ( $-40^{\circ}\text{C}$  to  $+66^{\circ}\text{C}$ )  
Relative humidity: 8% to 80%.

For cartridges that are in constant use, store in the following manner:

1. Store in a machine room environment:  
Temperature:  $60^{\circ}\text{F}$  to  $100^{\circ}\text{F}$  ( $15,6^{\circ}\text{C}$  to  $37,8^{\circ}\text{C}$ )  
Relative humidity: 8% to 80%.
2. If cartridges must be stored in a different environment, allow two hours for adjustment to machine room temperature before use.
3. Store in a clean, dust-free metal cabinet or similar fire-resistant container.
4. Do not store in direct sunlight.
5. Store cartridges on edge in racks, or stacked one on top of another. Do not stack more than *five* cartridges on top of each other.
6. Do not store cartridges where they can be exposed to intense magnetic fields.
7. For vital information, store a duplicate set of records in another location.

**ABBREVIATIONS**

cm	Centimeter
FCU	File Control Unit
in.	Inch
Kg	Kilogram
lb	Pound
ms	Millisecond
rpm	Revolutions per Minute
Sync	Synchronizing

**GLOSSARY OF TERMS**

*Access Time:* The time taken for the read/write heads to move from one cylinder location to another.

*Address Mark:* Two bytes of unique information that indicate the start of a sector.

*Average Access Time:* The time taken for the read/write heads to move across one-third of the total number of cylinders available.

*Byte:* A sequence of eight adjacent bits.

*Check Bytes:* Bytes that are appended to the data and identifier fields and used for verifying the information contained in these fields.

*Data Field:* That part of a sector containing the stored information.

*Data Transfer Rate:* The rate at which data is transferred between the 5444 and its control unit.

*Direct Access Storage:* A type of storage where information is stored or retrieved directly, without prior sequential searching.

*Flag Byte:* A byte, in the identifier field, that indicates track condition.

*Identifier Field:* That part of a sector containing the physical address of the sector.

*Index Pulse:* A pulse that is used to indicate the start of each track on a disk.

*Off-Line:* The status of a 5444 when it is *not* under direct control of the system to which it is attached.

*On-Line:* The status of a 5444 when it *is* under direct control of the system to which it is attached.

*Serial-by-bit (Data Transfer):* The transfer of data one bit at a time (serially).

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Component Descriptions

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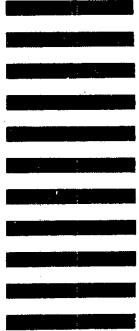
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