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## **IBM 2321 Data Cell Drive**

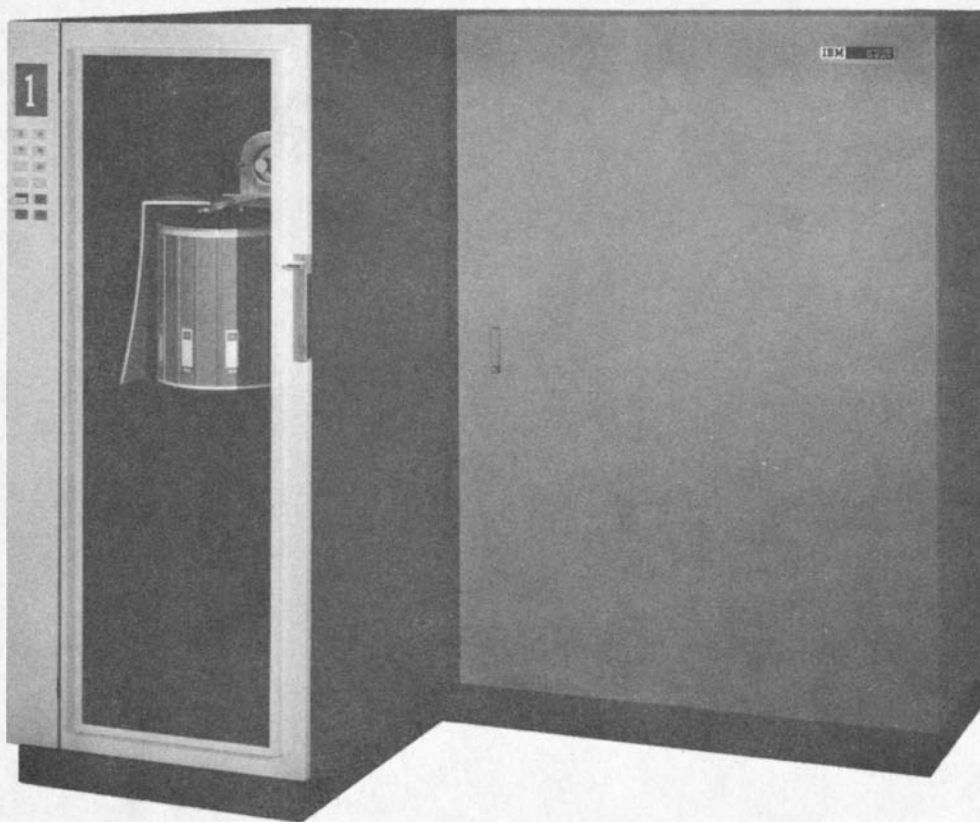
This manual contains information that describes the operating features and components of the IBM 2321.



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IBM 2321 Data Cell Drive

## INTRODUCTION

Significant advancements have been made in random access memory development since the IBM 350 Disk Storage was announced in 1956. These include the double density 350, the 1405, the 1301, the 1302, and the IBM 1311 with the innovation of removable and interchangeable random access storage media. A further advancement in this field has been made with the announcement of the IBM 2321 Data Cell Drive, Models 1 and 2. Model 1 is designed for use with the 2841 Storage Control; Model 2 is designed for use with the 7631 File Control Unit.

The IBM Data Cell Drive economically extends on-line random access capability to a volume of data beyond that of present storage units. To accomplish this, each IBM 2321, Model 1 offers 400 million 8-bit bytes (800 million packed decimal digits) of on-line data in removable and interchangeable increments of 40 million 8-bit bytes (80 million packed decimal digits) each. With the open-ended storage capacity made possible by the removability feature, plus multiple Data Cell Drive usage, data processing requirements for billions of characters can now be met.

## DESCRIPTION

The IBM 2321 as a random access storage unit is capable of storing data on, and retrieving data from, magnetic strips under the direction of a storage control unit.

From a circular array of 10 cells with 20-sub-cells each, a rotary positioning system positions a selected subcell of ten strips beneath an access station. At this station a selected strip is first withdrawn from the subcell, then rotated past a read/write head element for data transfer, and finally returned to its original location in the subcell.

Physically, the components are arranged in a mechanical section and an electronic section (Figure 1). These sections are two separate self-contained frames, provided to facilitate shipment and installation. When the frames are attached, the machine dimensions are as illustrated in Figure 1.

The machine is designed to operate on 208v/230v AC 3-phase 60-cycle power. Consult the System's Installation — Physical Planning Manual for detailed physical planning considerations.

The mechanical section contains the following principal components:

Operator's Panel — to indicate the 2321 status and provide for operator intervention.  
Data Cell Array — containing the magnetic strips in 10 removable cells of 200 strips each.

Cell Drive — to rotate the Data Cell Array to one of 200 discrete positions.

Selection Mechanism — to select one of ten strips in a subcell.

Drum Drive — to transport a selected magnetic strip to and from a subcell.

Read/Write Head — to provide for magnetic recording on 100 tracks from a 20-element head block that can be addressed to any one of five discrete positions. On the 2321 Model 2, two of these head elements are reserved for record formatting purposes.

Hydraulic Power Supply — to supply hydraulic power to the cell drive.

Pneumatic Supply — to supply filtered air to the selection mechanism, and the drum drive.

The electronic section contains the following principal components:

Motion Controls — to control the cell drive, selection mechanism, drum drive, and read/write head block positioning.

Recording Electronics — to control data transfer to and from the read/write elements.

Power Sequence Panel — to control power distribution within the Data Cell Drive in an established sequence.

Electronic Power Supply — to furnish various voltages required for the electronic and power sequencing circuitry.

Customer Engineering Panel — to provide a means for the Customer Engineer to simulate



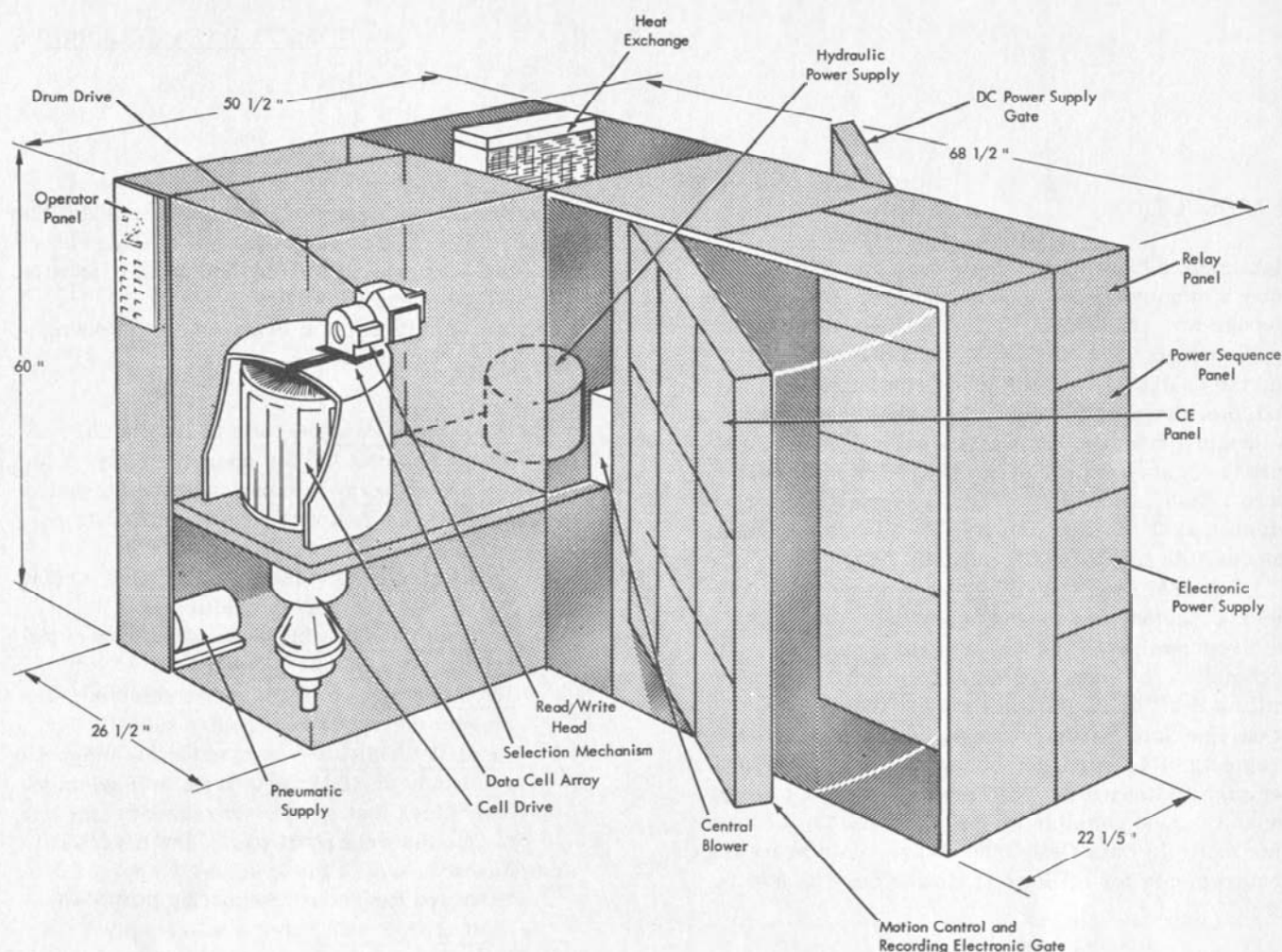


Figure 1. Component Layout

Data Cell Drive instructions.

Central Blower — to provide cooling air for Data Cell Drive components.

#### Data Cell Array

The storage medium used in the 2321 is a 0.005"  $\times$  2-1/4"  $\times$  13" strip having an iron-oxide coating on one side for magnetic recording and an anti-static coating of carbon on the other side. A set of ten strips is contained in a subcell. Each strip has a pair of coding tabs used to identify its position in the subcell. Twenty subcells are housed in a Data Cell; ten Data Cells are attached around the periphery of a spindle to form a Data Cell array (Figure 1).

Each Data Cell is physically removable and interchangeable with any Data Cell in any 2321 Data

Cell Drive. To facilitate Data Cell removal and to protect the magnetic strips during handling, a combination handle-cover is provided. A covered Data Cell with 200 strips weighs approximately 3 pounds. Safety interlocks are provided to prevent 2321 operation when a Data Cell is either not replaced, improperly replaced, or replaced without removing the handle-cover. For 2321 operations requiring less than a full complement of ten Data Cells, ballast cells are used to dynamically balance the rotating array.

The IBM 2321, Model 1 provides 100 addressable recording tracks on each magnetic strip. The 2321, Model 2 provides 90 addressable recording tracks plus ten format tracks for each strip. A logical extension of the established track capacity provides the incremented storage capacities for the various modes of operation as listed in Table 1.

Table 1. IBM 2321 Capacity (Expressed in Bytes)

	MODEL 1 Capacity		MODEL 2 Capacity	
	8-Bit Alpha- numeric Mode	Packed Decimal Digit Mode	Move Mode (6-Bit)	Load Mode (8-Bit)
Track	2,000	4,000	2,800	2,086
Cylinder <i>20 Tracks</i>	40,000	80,000	50,400	37,548
Strip <i>1000 Tracks 50 cylinders</i>	200,000	400,000	252,000	187,740
Subcell <i>500 cylinders 1000 tracks</i>	2,000,000	4,000,000	2,520,000	1,877,400
Data Cell	40,000,000	80,000,000	50,400,000	37,548,000
Full Array	400,000,000	800,000,000	504,000,000	375,480,000

### Cell Drive

The cell drive is an electrohydraulic servomechanism that bidirectionally rotates the circular array of ten Data Cells to one of two hundred discrete subcell positions.

Data Cell positioning is initiated by a Seek instruction. With all safety interlock satisfied, a decoded cell address causes the electrohydraulic servomechanism to rotate the cell array placing the subcell containing the addressed strip beneath the access station. A check on the position is made by a subcell position detector which signals the electronic control unit that a subcell is within operable range of the access station.

### Access Station

After the addressed subcell is properly positioned beneath the access station, the addressed strip is selected from a subcell of ten and placed on a revolving drum. It is then rotated past the read/write head for data transfer. The strip is returned to its original subcell location by a restore function. (See Seek.) The major components of the access station are the selection mechanism, drum drive, and read/write head.

### Selection Mechanism

The selection mechanism includes the mechanical components for the selection of a magnetic strip from a positioned subcell. With the cells positioned by the cell drive, a selected strip is exposed when the adjacent strips are parted by the separation fingers.

### Drum Drive

The drum drive is an electromechanical device that drives the drum in either a clockwise (forward) direction or a counterclockwise (reverse) direction. When the drum is at its home position, the drum shaft is mechanically latched. With the adjacent strips parted, the selected strip is picked up by the pick-up head which is attached to the revolving drum. Gliding on a film of air acting as an aerodynamic bearing, the selected strip is rotated past a read/write head in a clockwise direction. During the restore cycle, the rotational direction of the drum is reversed and the strip is returned to its original subcell location.

### Read/Write Head Block

The read/write head block contains 20 magnetic elements. It can be positioned to one of five discrete positions thus providing for the 100 recording tracks per strip. The head block is positioned, during access time, as determined by the address in the Seek instruction. (Seek is described under OPERATION.)

### Access Time

Access time is defined as the length of time required to place a selected strip in a data transfer position. Average access time under varying conditions is listed in Table 2.

### Data Utility Time

The time involved with an operation after a strip is placed in the data transfer position is called data

Table 2. Average Access Time

Conditions	Time/Number of Subcell Moves			
	0 Subcell	1 Subcell	50 Subcell	100 Subcell
When only Read/Write element selection is required	100 $\mu$ sec			
When only Read/Write head Block motion is required	95 ms			
When No Strip is on the Drum	175 ms	250 ms	350 ms	400 ms
When a previously Address Strip is on the Drum	375 ms	450 ms	550 ms	600 ms

utility time. Data utility time is determined from data organization, the programed operations, and the following 2321 parameters:

Drum period = 50 ms  
Data time = 41.8 ms

Drum period is defined as the time required for the drum to make one complete revolution. Data time is defined as the time required for the entire track to pass the read/write head.

Re-access time = 8.2 ms

Re-access time is defined as the time required for the gap between the leading and trailing ends of a strip to pass the read/write head. Re-access time can be used for electronic switching of the read/write elements.

#### Addressing

The physical location of an individual recording track is determined by considering the following areas:

Data Cell Drive  
Data Cell  
Subcell  
Strip  
Cylinder  
Read/Write Head Element

When a record is addressed, the location of each of the areas just listed is compared against

the new address. From this comparison, the necessary electronic and electromechanical action required to place the addressed record in the data transfer position is determined. For example, assume that the new record address is in a different IBM Data Cell Drive than the previously addressed record and that the remaining portions of the address also differ. The new address causes the following to occur:

1. The newly addressed Data Cell Drive is selected.
2. The cell array is rotated to the selected subcell.
3. The 20-element read/write head block is positioned.
4. The selection mechanism and the drum drive are activated to select and transport the selected strip to the drum.
5. The specific read/write head element is electronically selected.

When the new address is the same as the old address in a specific area, no electromechanical action is required for that area. For example, if the only difference between a new and old address is the selection of an adjacent track within the same cylinder position, the only action would be the electronic selection of the proper read/write head element, providing the strip was not restored in the interim.

The address format depends upon the using system. Consult the specific using system's reference manual for addressing details.

#### OPERATOR CONTROLS

##### Keys, Switches, and Lights

The operator's console on the Data Cell Drive contains five indicator lights and four manual controls. The indicator lights provide the machine operator with the following information.

AC Power On — indicates that primary AC power is applied to the IBM 2321.

Drive Operative — indicates that the 2321 is capable of performing normal operations as instructed by the storage control unit.

Drive Ready — indicates that the 2321 is ready to perform normal operations.

Home — indicates that the access station is in a latched condition.

Drive Select — indicates that the storage control unit is communicating with the 2321.



The manual push buttons and switch enable the operator to control the following functions.

Restart — this push button allows the restart of the 2321 in the event of certain inoperative conditions, such as a momentary interrupt in power.

Restore — this push button allows a strip restore operation, and is operative only if the 2321 Drive Ready indicator is on and the Drive Select indicator is off.

Reset — this push button allows the reset of 2321 logic in the event of an improper status condition. All motion and timing logic is reset without affecting the drive register condition. This reset will not establish a Drive Operative status.

### Data Cell Replacement

To facilitate Data Cell replacement by the operator, four devices are provided.

1. Entry door with interlock: The entry door permits access to the Data Cell array. An interlocking switch is provided for operator safety. When the door is open, all machine controlled motion is inhibited.
2. Data Cell location indicator: The Data Cell location indicator identifies, by number, the Data Cell located in the replacement position. It also indicates the number of the Data Cell positioned under the access station.
3. Manual by-pass valve: The manual by-pass valve allows an operator to manually rotate the array to place any desired Data Cell in the replacement position. The valve is mechanically interlocked with the access station and is closed automatically with the closing of the entry door.
4. Data Cell mount interlock: An interlock switch is provided to prevent 2321 operation unless the switch is properly closed by either a Data Cell or a ballast cell.

The following procedure should be followed when replacing Data Cells.

1. Check the indicator lights.  
AC Power should be on.  
Drive Operative should be on.  
Drive Ready should be on.  
Home should be on.  
Drive Select should be off.

2. Open the entry door. The Drive Ready indicator should extinguish.
3. Check the Data Cell location indicator to determine the physical position of the desired Data Cell.
4. Open the manual by-pass valve and rotate the array (in either direction) to place the desired Data Cell in the replacement position.
5. Place a Data Cell cover on the desired Data Cell. This action engages all mechanical and electrical interlocks and allows the Data Cell to be removed from the machine.

NOTE: New Data Cells, replacement Data Cells, or ballast cells must be inserted in place of removed cells. When the Data Cell cover is removed from a properly inserted cell, the mechanical and electrical interlocks are disconnected.

6. Close the entry door.
7. Check the indicator lights for the following pattern:  
AC Power on.  
Drive Operative on.  
Drive Ready on.  
Home on.  
Drive Select off.

### OPERATION

The 2321 performs three basic functions: (1) transports the recording medium, (2) magnetically records on the recording medium, and (3) reads back the magnetically recorded information. These three functions, individually instructed to occur via the storage control unit, are exercised by three basic Data Cell Drive operations: (1) Seek, (2) Read and (3) Write. The instruction format used for each operation is determined by the using system.

#### Seek

A Seek instruction instructs the 2321 to initiate all functions necessary to place the addressed tracks in the proper position for a subsequent Read/Write operation. During the time the Seek operation is being performed, the Drive Ready indicator on the 2321 console is extinguished. As soon as the Seek operation is completed, the Drive Ready indicator is turned on.

## Restore

To protect the flexible magnetic strips from unnecessary wear, an automatic restore operation is initiated 400 ms after the completion of a Data Cell instruction when there are no intervening instructions. (The IBM 2321 Model 1 is also capable of responding to a restore instruction from the using system.) A Seek instruction serves to restore the previously selected strip when the Seek instruction addresses a new strip.

During the time the restore operation is being performed, the Drive Ready indicator on the 2321 console is extinguished. Following the satisfactory completion of the restore operation, the Drive Ready indicator is turned on.

## Write

A Write instruction instructs the 2321 to activate the proper write head element in preparation for magnetically recording (writing) the write signals received from the storage control unit. Data previously recorded is erased when new data is written in its place. All write operations are preceded by an address compare function. (See Read.) Refer to the specific using system's reference manual for techniques of writing data and addresses.

All write operations should be followed by a Write Check operation to verify that the write data was properly recorded. Errors encountered while writing can normally be corrected in ten or less rewrite attempts. When this is unsuccessful, an alternate track for the data should be assigned.

## Read

A read operation instructs the 2321 to activate the proper read element in preparation for reading the previously recorded information from the selected record.

Prior to transmitting record data to the storage control unit and hence to the processor, an address compare function is normally initiated as a safety factor.

Address comparison is accomplished by the storage control unit as it scans the read data signals for the address data. Data organization on the recording medium is determined by the storage control unit.

The 20 read elements of the read/write head block allow successive read operations of 20 data tracks, Model 1 (18 data tracks Model 2), without time loss because of mechanical motion. The time required to select and condition a read element is 100 microseconds ( $\mu$  secs.) The 8.2 ms of re-access time, as previously defined, can be used for head addressing to allow successive data tracks within the same cylinder to be read.

Errors encountered during a read operation can normally be corrected in 100 or less reread attempts. When this is unsuccessful it is usually necessary to initiate a data recovery procedure. For proper implementation of audit trails and data reconstruction procedures, refer to the manual Disk Storage Concepts (Form F20-8161).



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