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Systems

Reference Manual for IBM 3350 Direct Access Storage

IBM

Preface

This publication is intended to familiarize data processing personnel with the characteristics of IBM 3350 Direct Access Storage. The reader should have prior knowledge of direct-access storage devices and concepts.

The publication lists the functional characteristics and describes the record format, capacity, and timing characteristics. A list of all commands executed by the 3350 is included in the Channel Commands section.

Suggested operator instructions are included in the Operator Controls and Indicators section.

The following publications are recommended for detailed information concerning the subjects covered in this manual:

- *IBM System/370 Principles of Operation,* Order No. GA22-7000
- *Reference Manual for IBM 3830 Storage Control Model 2,* Order No. GA26-1617
- *Reference Manual for IBM Integrated Storage Control,* Order No. GA26-1620
- The functional characteristics manual applicable to the parent system. Order numbers for functional characteristics manuals can be found in the *IBM System/360 Bibliography*, Order No. GC20-0360 and *System/370 Bibliography,* Order No. GC20-0001.
- The *Data Processing Glossary,* Order No. GC20-1699, defines terms related to direct-access storage devices.
- Additional information for use when planning a 3350 installation can be found in the *3350/3344 Installation and Conversion Guide,* Order No. GC20-1780.

If IBM 3350s are part of a system which includes the IBM 3850 Mass Storage System, certain attachment restrictions may apply. These restrictions are detailed in the *IBM 3850 MSS Principles of Operation,* Order No. GA32-0029.

Third Edition (April 1977)

This publication replaces and makes the second edition of *Reference Manual for IBM 3350 Direct Access Storage*, Order No. GA26-1638-1, obsolete. The contents of Technical Newsletter GN26-0326 has been incorporated into this edition. Changes or additions are indicated by a vertical bar to the left of the change.

Changes or additions to the specifications contained in this publication are periodically made. Before using this publication in connection with the operation of IBM equipment, contact the local IBM Branch Office for revisions.

Copies of this and other IBM publications can be obtained through IBM Branch Offices.

A form for reader's comments is provided at the back of this publication. If the form has been removed, send your comments to the address below.

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Illustrations

The IBM 3350 Direct Access Storage provides fast-access, large-capacity, high data-rate, low-cost, reliable online data storage. The 3350 can be attached to IBM System/370 Models 135, 138, 145, 148, 155-II, 158, 158-3, 165-II, 168, and 168-3.

The 3350 offers significant cost/performance advantages with increased recording density and a faster data-transfer rate.

The 3350 selective format standard feature allows each drive to operate in one of three modes: 3330-1 compatibility, 3330-11 compatibility, or 3350 native. To the system, a 3350 drive operating in a compatibility mode has the same characteristics as a 3350-1 or 3350-11. The track formats, tracks per cylinder, and number of cylinders functionally match those of the IBM 3330 Model 1 or the IBM 3330 Model 11. Maximum capacity can be obtained by running the string in the 3350 native mode.

The 3350 provides high-performance, large-capacity storage for a wide range of applications such as:

- Data base/data communications
- Inventory and manufacturing control
- Graphic processing
- Time-sharing
- Message switching
- Systems residence
- Other applications requiring direct or sequential processing

HIGHLIGHTS

- Cost per byte: lower than any previous IBM disk storage facility.
- Storage capacity: 200 (3330 compatibility mode) or 317 (native mode) million bytes per drive.
- Data rate: 1198 thousand bytes per second.
- Seek time: an average of 25 milliseconds.
- Latency: 8.4 milliseconds (average).
- Command set: similar to the 3330 with a Read Multiple Count, Key, and Data command.
- Rotational position sensing: standard feature.
- Fixed head models: up to 2.2 million bytes per model with zero seek time.
- Security and privacy: write protection control from operator panel, file protection, and seek verification.
- Alternate controller feature: provides increased data availability.

GENERAL DESCRIPTION

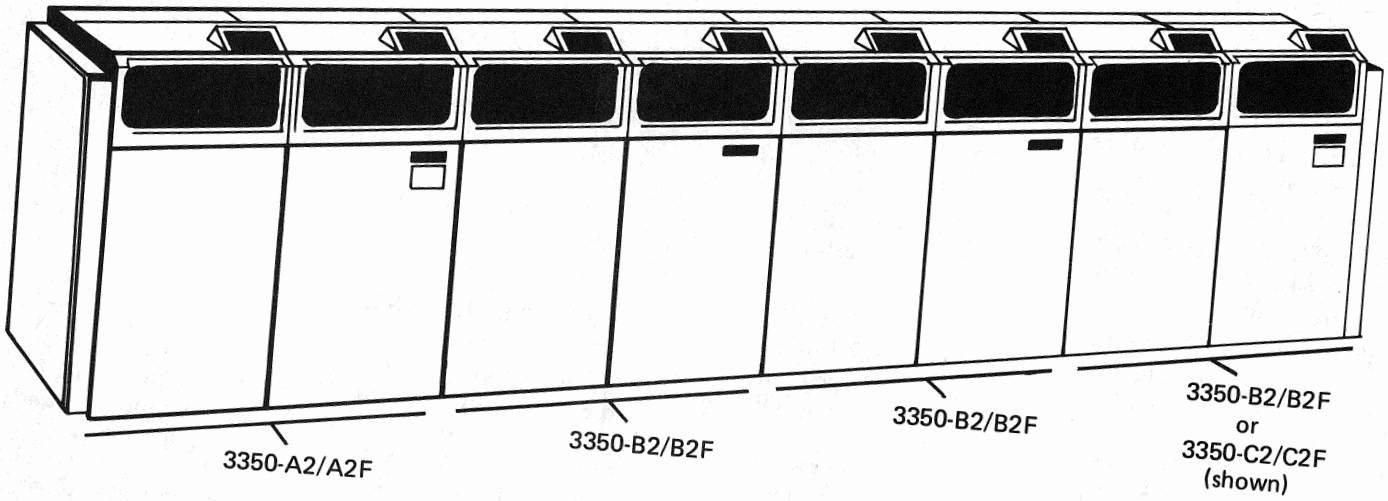
A 3350 Direct Access Storage subsystem consists of from one to four dual-drive disk storage units. Three types of 3350 are available; two with a controller and drives, and one with only the drives. All 3350 units are available in models having fixed head storage. The units use extensions of the technology developed for the IBM 3340 disk storage with improvements that increase storage capacity, data rate, and reliability.

The 3350 uses a sealed Head/Disk Assembly (HDA) with 16 recording surfaces. The HDA is not removable by the user. Fifteen surfaces are used for data storage and one contains servo information for seeking, track following, data clocking, generating the index signal, and indicating the rotational position. In models featuring fixed head storage, data is also stored on the servo surface.

The first unit in each 3350 string must contain a controller (Model A2 or A2F) and dual-drives. The other units (up to three) consist of dual-drives (Model B2 or B2F). Where increased data availability is required, an alternate controller (Model C2 or C2F) can be substituted for the last dual-drive unit. Models A2F, B2F, and C2F provide up to 1.1 million bytes of zero seek time storage per drive under fixed heads. If an Alternate Controller model (C2 or C2F) is selected, a maximum of two B2 or B2F models can be installed between the A2/A2F and C2/C2F controllers.

Each of the eight drives (four dual-drive units) in a storage subsystem can operate in one of three modes: 3350 native, 3330-1 compatibility, or 3330-11 compatibility. This selective format standard feature must be specified for each individual drive at the time of order and can be changed if required.

A functional description of the 3350 models is shown in Figure 1.



IBM 3350-A2/A2F or C2/C2F (controller and two drives)

CONTROLLER (only one controller in a string, A2/A2F or C2/C2F, can be online)

- Interprets and executes commands from the storage control
- Regulates the storage control and disk drive interfaces
- Checks data integrity by error detection and error correction functions
- Controls the writing and interpretation of the track format fields
- Furnishes status and sense information to the storage control
- Performs diagnostic evaluation of the 3350 storage string
- Serializes and deserializes data
- Provides and controls ac power for the entire storage string (A2/A2F only)

DRIVES (A2/A2F, or C2/C2F has two independent drives)

- Responds to commands from the controller
- Positions access mechanism at a physical cylinder
- Selects the read/write head
- Locates a specified sector on a selected track
- Reads or writes data
- Provides safety and service information for evaluation

IBM 3350-B2/B2F (two drives)

- Responds to commands from the controller
- Positions access mechanism at a physical cylinder
- Selects the read/write head
- Locates a specified sector on a selected track
- Reads or writes data
- Provides safety and service information for evaluation

IBM 3350-A2F, B2F, and C2F Models

- Native Mode – provides 1,144 kilobytes of fixed head storage per drive with zero seek time.
- Compatibility Mode – provides 742 kilobytes of fixed head storage per drive with zero seek time.

Figure 1. IBM 3350 Disk Storage

IBM 3350 ATTACHMENT

The 3350 can be attached to the following System/370 systems:

Model	Attachment Device
135 138	3830-2
145 148	Integrated Storage Control (ISC) or 3830-2
155-II	3830-2
158*, 158-3	Integrated Storage Control (ISC) or 3830-2
165-II	3830-2
168, 168-3	Integrated Storage Control (ISC) or 3830-2

*Also 158 submodel 2 (Japan only)

Attachment of IBM 3350s to the systems shown may involve additional requirements.

Attachment to IBM 3850 Mass Storage System

The 3350 DASD can be attached to the 3850 Mass Storage System Staging Adapters as real spindles in native mode; however, the 3350s cannot be used for 3850 staging. A new feature, control store additional, provides additional microprogram storage to permit 3350 storage to be attached to IBM 3830 Model 3 Storage Control and to the 158/168 ISCs that have staging adapters on either one or both paths.

Expanded control store is a prerequisite for the new feature on either the 3830-3 or ISC. Each 3350 string can be made up of Models A2/A2F, B2/B2F, and C2/C2F in their normal configuration sequence. (See Figure 1.)

COMPATIBILITY WITH EXISTING STORAGE

Each 3350 drive is formatted at manufacture into one of three operating modes: 3330-1 compatibility, 3330-11 compatibility, or 3350 native. Operational modes can vary between drives on the same string or unit.

IBM 3330 Model 1 Compatibility Mode

In the 3330-1 compatibility mode, a single 3350 drive contains two logical 3330-1 volumes of data. Each logical 3330-1 volume is equal to an actual 3330-1 volume in capacity and format.

IBM 3330 Model 11 Compatibility Mode

In the 3330-11 compatibility mode, a 3350 drive holds one logical 3330-11 volume of data. Each logical 3330-11 volume is equal to an actual 3330-11 volume in capacity and format.

IBM 3350 Native Mode

In the 3350 native mode, the drive is used as a single logical device with the full capacity of 317,498 kilobytes of storage.

Models and Special Features

The 3350 dual-drive storage units are available in six models and can incorporate the special features described when required.

3350 MODELS

Six 3350 models are available: the A2 (dual-drive storage and controller), the A2F (dual-drive storage with fixed heads and controller), the B2 (dual-drive storage), the B2F (dual-drive storage with fixed heads), the C2 (dual-drive storage and alternate controller), and the C2F (dual-drive storage with fixed heads and alternate controller).

The fixed heads on Models A2F, B2F, and C2F provide up to 1.144 million bytes of zero seek time storage per drive. The fixed head storage capacity takes the place of an equal amount of storage under the moving heads.

When a Model A2F, B2F, or C2F drive is used in the 3330-1 compatibility mode, the fixed head storage is associated with the first of the two logical 3330-1 logical volumes on the drive.

The C2 and C2F alternate controller models permit the user to manually select either the A2/A2F or the C2/C2F as the online controller. The other controller drives then function as a B2/B2F unit. If the online controller requires service, manual switching to the other controller when preceded by a power off on the A2/A2F (by a switch on the C2/C2F) unit allows subsystem availability to be re-established.

When subsystem control has been switched from one controller to the other, outstanding status and drive reservations (if any) are lost. Recovery/restart procedures, required by the controller switchover, must be performed by the user.

Installation of an alternate controller (C2 or C2F) on a 3350 subsystem requires that a primary controller adapter feature be installed on the A2/A2F controller.

The basic 3350 characteristics are shown in Figure 2.

The fixed head storage capacity of Models A2F, B2F, and C2F is:

	3350 Native Mode	3330-1 or 3330-11 Compatibility Mode
Logical Cylinders	1-2	1-3
Tracks	0-29	0-18
Tracks/Logical Cylinder	30	19
Capacity/Drive (bytes)	1,144,140	742,710
Capacity/Unit (bytes)	2,288,288	1,485,420

SPECIAL FEATURES

Three special features are available for the IBM 3350 Direct Access Storage: string switch, remote switch, and primary controller adapter.

String Switch

The string switch feature, available for all controller models, allows a 3350 subsystem to be dynamically shared by two storage controls. The 3350 can be dedicated to a single storage control through use of the Enable/ Disable switch. The string switch feature can be installed on either or both controller units (A2/A2F and C2/C2F) in a string. If the string switch feature is installed on the A2/A2F, it is recommended that a string switch also be installed on the C2/C2F to allow communication with more than one storage control.

REMOTE SWITCH ATTACHMENT

The remote (Enable/Disable) switch allows the string switch to be controlled from the control panel of a System/370 Model 158 or 168 Multiprocessor. The string switch feature is a prerequisite for this feature.

Primary Controller Adapter

The primary controller adapter feature is required on the A2/A2F when a C2/C2F model is used. The adapter permits the selection/deselection of the controller of the A2/A2F unit as the online controller through use of a manual switch on the C2/C2F unit in a 3350 subsystem.

The 3350 storage subsystem uses a sealed, head/disk assembly (HDA) as the storage medium. The recording heads and the carriage are an integral part of the HDA.

All 3350 drives are shipped formatted in the operating mode specified by the customer. If an HDA is to operate in a different mode it can be reformatted with an IBM supplied program.

Characteristic	3350 in 3330-1 Compatibility Mode (2 per drive)	3350 in 3330-11 Compatibility Mode	3350 in Native Mode
Cylinders per drive	404 (plus 7 alternates)	808 (plus 7 alternates)	555 (plus 5 alternates)
Tracks per cylinder	19	19	30
Tracks per drive	7,676 (plus 133 alternates)	15,352 (plus 133 alternates)	16,650 (plus 150 alternates)
Track capacity (bytes)	13,030	13,030	19,069
Cylinder capacity (bytes)	247,570	247,570	572,070
Drive capacity (approx bytes)	100 million (per logical volume)	200 million	317.5 million

Figure 2. Basic 3350 Characteristics

Data Formats

All 3350 drives are initialized at manufacture and shipped with a home address and an eight-byte track descriptor record (R0) written on all tracks. If the data areas become defective during normal use, an IBM utility program is available to flag defective tracks and assign alternates.

DATA GROUPS

The basic information unit stored by the drive is a byte consisting of eight bits (binary digits). A group of bytes separated by a gap is called an area. Areas and gaps are combined to form a record, the basic information unit.

RECORD FORMAT

A record consists of three specific areas: the count area, the key area, and the data area (plus the necessary gaps to separate them). The process of writing an entire record is called formatting.

Count Area

The count area contains the physical address of a data record and defines the size of key and data areas of the record. The count area is written when the record is formatted and is not changed until the record is reformatted.

Key Area

The key area can be used to access data when organized in a keyed sequence. Primarily, it serves as an identifier of the data area that follows. Examples of a key identifier are: a part number, an employee number, or a Social Security number.

After formatting, the key area length is fixed. The contents of the area can be changed as required. If the key area content is changed, the data area (which follows) must also be rewritten.

Data Area

The record's data area contains the information addressed and identified by the count and key areas. This data is organized and arranged by the programmer.

The data area length is defined by the count area. Once formatted, the contents, but not the length, of the data area can be changed without affecting the count and key areas in the record.

TRACK FORMAT

Each track has the same format: a home address, a track descriptor record, and one or more data records. The records, and the areas in the records, are separated by gaps. See Figure 3.

Home Address

Each track contains one home address (HA) defining the physical location of the track (track address) and the track condition. The home address is the first recorded area following the index point.

Special commands are required to read and write in the home address area.

Track Descriptor Record

The track descriptor record is the first record following the home address area. In IBM programming systems, the R0 count area provides the address of an alternate track if the track is defective. If the track is an alternate, the address of the defective track is provided.

Special commands are required to read and write data in the R0 area.

Data Records

One or more data records follow the track descriptor record. The data record format is determined when the count, key, and data areas are originally written. The number of data records per track is determined by the number of bytes in each record and track capacity.

Data records, and track descriptor records, can be formatted with or without keys depending on the programmer's file organization.

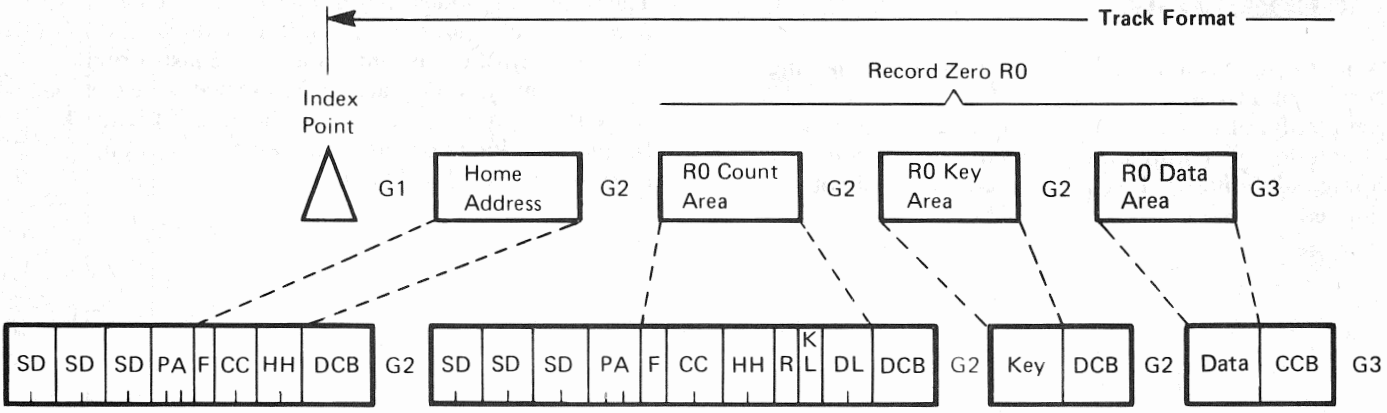
OVERFLOW RECORDS

The record overflow function allows records exceeding the track capacity to be continued on the next track following the HA and R0 areas. These record segments can continue on successive tracks up to the cylinder boundary.

WRITE PADDING

Write padding is a process of filling out the remaining portion of a track with a special pattern following completion of format writing. Padding begins upon completion of writing initiated by a format write command if another format write command is not chained.

The 3350 (all modes) has a format write release feature which under some conditions allows the storage control to disconnect after the last format write command on a track and to service other drives while the original drive pads to the end of the track. In this case, index orientation may be lost upon reconnection to the channel.



INDEX POINT: Indicates the start of all tracks.

G1(gap 1): Separates index and home address.

HOME ADDRESS
Supplies basic track information, one per track following index.

SD (Skip Displacement): Each two bytes give displacement (in bytes) from index to track defect center and displacement of the second defect center from the first defect center, and the third defect center from the second.

Note: *The SD bytes are normally internal conventions involving only the storage control and drive. They are transparent to the using system except: (1) they must be supplied by the system for a Write HA when the drive is in 3350 native mode; (2) the SD bytes, for use in item 1, may be sensed by executing a Sense I/O chained from a successful Read HA.*

PA (Physical Address): Storage control check for address verification.

Note: *The PA bytes are an internal convention involving only the storage control and the drive.*

F (Flag): Defines track condition as follows:

Bit 0	Skip displacement
Bit 1	Unused
Bit 2	Indicates HA area moved for skip displacement
Bits 3 – 5	Unused
Bits 6, 7	Track status
00 =	Normal primary
01 =	Normal alternate
10 =	Defective primary
11 =	Defective alternate

Note: *This HA flag byte is the only flag that is transferred between the using system and the drive.*

CC (Cylinder Number): Specifies the cylinder number under user control.

Native Mode	0-554
3330-1 Mode	0-403
3330-11 Mode	0-807

HH (Head or Track Number): Specifies the head (or track) within the cylinder under user control.

Native Mode	0-29
3330-1 Mode	0-18
3330-11 Mode	0-18

DCB (Detection Code Bytes): Generated by the 3350 controller and used for single error burst detection of ten bits or less.

G2 (Gap 2): Separates home address and record zero count areas.

RECORD ZERO

R0 Count Area

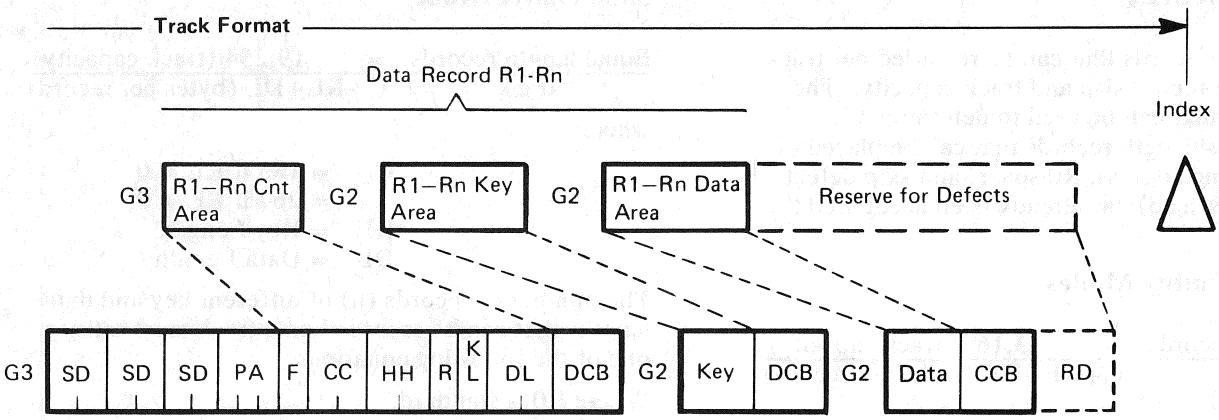
SD: Similar to home address

PA: Same as home address

F (Flag): Defines track condition for overflow records:

Bit 0	Defect in next count field
Bit 1	Defect in this key field
Bit 2	Defect in this data field
Bit 3	Unused
Bit 4	Logical record continues on next track
Bit 5	Unused
Bits 6, 7	Track status
00 =	Normal primary
01 =	Normal alternate
10 =	Defective primary
11 =	Defective alternate

Figure 3. 3350 Track Format



R0 Count Area (continued)

CC: Same as home address

HH: Same as home address

R (Record Number): Normally = 00 for record zero.

KL (Key Length): Specifies length of record key area. If no keys used, value is 00.

DL (Data Length): Specifies length of data area.

DCB: Same as home address

G2 (Gap 2): Separates record zero count and key areas.

R0 Key Area

KEY: Identifies information in data area. For a standard R0, this area is not present.

DCB: Same as home address. Not present with no R0 key area on track.

G2 (Gap 2): Separates record zero key (if used) and data areas.

R0 Data Area

DATA: Contains information identified by count and key (if present) areas. A standard R0 has eight bytes.

CCB (Correction Code Bytes): Detects single error bursts up to ten bits and corrects single error bursts up to four bits.

G3 (Gap 3): Separates all records (except R0) from each other.

DATA RECORDS (R1 – Rn)

R1 – Rn Count Area

SD: Similar to home address

PA: Same as home address

F: Same as record zero

CC: Same as home address

HH: Same as home address

R (Record number): Identifies the number of the record on the track (if specified by the programmer).

KL (Key Length): Defines the length of the record key area (in bytes). If zero, the key area is omitted.

DL (Data Length): Defines the length of the record data area (in bytes).

DCB: Same as home address

G2 (Gap 2): Separates the record areas.

R1 – Rn Key Area

KEY: Used to identify the information placed in the data area. Use is dependent on application and the programmer.

DCB: Same as home address

G2: Separates record areas

R1 – Rn Data Area

DATA: Contains the information identified by the count and key (if present).

DCB: Same as R0 data area

G3: Separates the records on a track.

TRACK CAPACITY

The number of records that can be recorded per track depends on the record size and track capacity. The following formulas can be used to determine the number of equal length records that can be placed on a track. The home address, R0 space, and skip defect allowance (overhead) has already been accounted for.

3330 Compatibility Modes

$$\frac{\text{Equal length records}}{\text{track}} = \frac{13{,}165 \text{ (track capacity)}}{C+KL+DL \text{ (bytes per record)}}$$

where:

C = 135 if KL = 0
= 191 if KL ≠ 0
KL = Key Length
DL = Data Length

Note: *When an end-of-file (EOF) mark is written, the DL in the count area must be zero. The storage control, however, adds a one-byte data area when writing the EOF mark. Programmers working with track balance routines must allow for this byte by subtracting one byte from the track balance remaining. The standard 135-byte overhead allowance should therefore be increased to 136 for each EOF written.*

The number of records (n) of different key and data lengths that can be recorded on a track must satisify one of the following equations.

Where R0 is standard:

$$13{,}165 \geq \sum_{i=1}^{n} (KLi+DLi+C)$$

Where R0 is not standard:

$$13{,}298 \geq [KL(0)+DL(0)+C-10]+\sum_{i=1}^{n} [KLi+DLi+C]$$

3350 Native Mode

$$\frac{\text{Equal length records}}{\text{track}} = \frac{19{,}254 \text{ (track capacity)}}{C+KL+DL \text{ (bytes per record)}}$$

where:

C = 185 if KL = 0
= 267 if KL ≠ 0
KL = Key Length
DL = Data Length

The number of records (n) of different key and data lengths that can be recorded on a track must satisify one of the following equations.

Where R0 is standard:

$$19{,}254 \geq \sum_{i=1}^{n} (KLi+DLi+C)$$

Where R0 is not standard:

$$19{,}442 \geq [KL(0)+DL(0)+C-3]+\sum_{i=1}^{n} [KLi+DLi+C]$$

Figures 4 and 5 give the maximum number of equal length records on a track. The track and cylinder capacity in both number of bytes and number of records is shown. There are two tables, one without keys, and one with keys. For drives being used in compatibility modes, use the capacity tables in the *Reference Manual for IBM 3330 Disk Storage*, Order No. GA26-1615.

Record Length (DL Bytes)	Track Capacity (Records)	Track Capacity (Bytes)	Cylinder Capacity (Records)	Cylinder Capacity (Bytes)
19,069	1	19,069	30	572,070
9,442	2	18,884	60	566,520
6,233	3	18,699	90	560,970
4,628	4	18,512	120	555,360
3,665	5	18,325	150	549,750
3,024	6	18,144	180	544,320
2,565	7	17,955	210	538,650
2,221	8	17,763	240	533,340
1,954	9	17,586	270	527,580
1,740	10	17,400	300	522,000
1,565	11	17,215	330	516,450
1,419	12	17,028	360	510,840
1,296	13	16,848	390	505,440
1,190	14	16,660	420	499,800
1,098	15	16,470	450	494,100
1,018	16	16,288	480	488,640
947	17	16,099	510	482,970
884	18	15,912	540	477,360
828	19	15,732	570	471,960
777	20	15,540	600	466,200
731	21	15,351	630	460,530
690	22	15,180	660	455,400
652	23	14,996	690	449,880
617	24	14,808	720	444,240
585	25	14,625	750	438,750
555	26	14,430	780	432,900
528	27	14,256	810	427,680
502	28	14,056	840	421,680
478	29	13,862	870	415,860
456	30	13,680	900	410,400
436	31	13,516	930	405,480
416	32	13,312	960	399,360
398	33	13,134	990	394,020
381	34	12,954	1,020	388,620
365	35	12,775	1,050	383,250
349	36	12,564	1,080	376,920
335	37	12,395	1,110	371,850
321	38	12,198	1,140	365,940
308	39	12,012	1,170	360,360
296	40	11,840	1,200	355,200
284	41	11,644	1,230	349,320
273	42	11,466	1,260	343,980
262	43	11,266	1,290	337,980
252	44	11,088	1,320	332,640
242	45	10,890	1,350	326,700
233	46	10,718	1,380	321,540
224	47	10,528	1,410	315,840
216	48	10,368	1,440	311,040
207	49	10,143	1,470	304,290
200	50	10,000	1,500	300,000
192	51	9,792	1,530	293,760

Figure 4. Record Capacities, Without Keys (Part 1 of 2)

Record Length (DL Bytes)	Track Capacity		Cylinder Capacity	
	(Records)	(Bytes)	(Records)	(Bytes)
185	52	9,620	1,560	288,600
178	53	9,434	1,590	283,020
171	54	9,234	1,620	277,020
165	55	9,075	1,650	272,250
158	56	8,848	1,680	265,440
152	57	8,664	1,710	259,920
146	58	8,468	1,740	254,040
141	59	8,319	1,770	249,570
135	60	8,100	1,800	243,000
130	61	7,930	1,830	237,900
125	62	7,750	1,860	232,500
120	63	7,560	1,890	226,800
115	64	7,360	1,920	220,800
111	65	7,215	1,950	216,450
106	66	6,996	1,980	209,880
102	67	6,834	2,010	205,020
98	68	6,664	2,040	199,920
94	69	6,486	2,070	194,580
90	70	6,300	2,100	189,000
86	71	6,106	2,130	183,180
82	72	5,904	2,160	177,120
78	73	5,694	2,190	170,820
75	74	5,550	2,220	166,500
71	75	5,325	2,250	159,750
68	76	5,168	2,280	155,040
65	77	5,005	2,310	155,150
61	78	4,758	2,340	142,740
58	79	4,582	2,370	137,460
55	80	4,400	2,400	132,000
52	81	4,212	2,430	126,360
49	82	4,018	2,460	120,540
46	83	3,818	2,490	114,540
44	84	3,696	2,520	110,880
41	85	3,485	2,550	104,550
38	86	3,268	2,580	98,040
36	87	3,132	2,610	93,960
33	88	2,904	2,640	87,120
31	89	2,759	2,670	82,770
28	90	2,520	2,700	75,600
26	91	2,366	2,730	70,980
24	92	2,208	2,760	66,240
22	93	2,046	2,790	61,380
19	94	1,786	2,820	53,580
17	95	1,615	2,850	48,450
15	96	1,440	2,880	43,200
13	97	1,261	2,910	37,830
11	98	1,078	2,940	32,340
9	99	851	2,970	26,730
7	100	700	3,000	21,000
5	101	505	3,030	15,150
3	102	306	3,060	9,180
1	103	103	3,090	3,090

Figure 4. Record Capacities, Without Keys (Part 2 of 2)

Record Length (DL Bytes)	Track Capacity (Records)	Track Capacity (Bytes)	Cylinder Capacity (Records)	Cylinder Capacity (Bytes)
18,987	1	18,987	30	569,610
9,360	2	18,720	60	561,600
6,151	3	18,453	90	553,590
4,546	4	18,184	120	545,520
3,583	5	17,915	150	537,450
2,942	6	17,652	180	529,560
2,483	7	17,381	210	521,430
2,139	8	17,112	240	513,360
1,872	9	16,848	270	505,440
1,658	10	16,580	300	497,400
1,483	11	16,313	330	489,390
1,337	12	16,044	360	481,320
1,214	13	15,782	390	473,460
1,108	14	15,512	420	465,360
1,016	15	15,240	450	457,200
936	16	14,978	480	449,280
865	17	14,705	510	441,150
802	18	14,436	540	433,080
746	19	14,174	570	425,220
695	20	13,900	600	417,000
649	21	13,629	630	408,870
608	22	13,376	660	401,280
570	23	13,110	690	393,300
535	24	12,840	720	385,200
503	25	12,575	750	377,250
473	26	12,298	780	368,940
446	27	12,042	810	361,260
420	28	11,760	840	352,800
396	29	11,484	870	344,520
374	30	11,220	900	336,600
354	31	10,974	930	329,220
334	32	10,638	960	320,640
316	33	10,428	990	312,840
299	34	10,166	1,020	304,980
283	35	9,905	1,050	297,150
267	36	9,612	1,080	288,360
253	37	9,361	1,110	280,830
239	38	9,082	1,140	272,460
226	39	8,914	1,170	264,420
214	40	8,560	1,200	256,800
202	41	8,282	1,230	248,460
191	42	8,022	1,260	240,660
180	43	7,740	1,290	232,200
170	44	7,480	1,320	224,400
160	45	7,200	1,350	216,000
151	46	6,946	1,380	208,380
142	47	6,674	1,410	200,220
134	48	6,432	1,440	192,960
125	49	6,125	1,470	183,750
118	50	5,900	1,500	177,000
110	51	5,610	1,530	168,300

Figure 5. Record Capacities, With Keys (Part 1 of 2)

Record Length (DL Bytes)	Track Capacity		Cylinder Capacity	
	(Records)	(Bytes)	(Records)	(Bytes)
103	52	5,356	1,560	160,680
96	53	5,088	1,590	152,640
89	54	4,806	1,620	144,180
83	55	4,565	1,650	136,950
76	56	4,256	1,680	127,680
70	57	3,990	1,710	119,700
64	58	3,712	1,740	111,360
59	59	3,481	1,770	104,340
53	60	3,180	1,800	95,400
48	61	2,928	1,830	87,840
43	62	2,666	1,860	79,980
38	63	2,394	1,890	71,820
33	64	2,112	1,920	63,360
29	65	1,885	1,950	56,550
24	66	1,584	1,980	47,520
20	67	1,340	2,010	40,200
16	68	1,088	2,040	32,640
12	69	828	2,070	24,840
8	70	560	2,100	16,800
4	71	284	2,130	8,520

Figure 5. Record capacities, With Keys (part 2 of 2)

Input/Output Operations

This section describes the Input/Output operations used with the 3350. Additional information about the central processing unit (CPU) and channel program control of I/O operations is found in *The IBM System/370 Principles of Operation.*

DRIVE MODES

Each 3350 drive can be operated in one of three modes: 3330-1 compatibility, 3330-11 compatibility, or 3350 native. Units are shipped with drives formatted in the mode as specified by the customer. Changes in mode require CE and customer action.

Drive Addresses

The I/O drive address is an 8-bit byte plus a parity bit (Figure 6). The parity bit is discarded after a check is made for odd parity and the remaining eight bits are used to designate the required drive.

Bits 0 and 1 are the storage control address bits. If a non-existent storage control is addressed, condition code 3 is indicated.

On all real 3330, 3340, or 3350 drives operating in either native or 3330-11 mode, there is only one logical volume on a drive. When a 3350 is operating in the 3330-1 mode, there are two logical volumes on a drive.

The bit 2 function depends on the string configuration. If the storage control has no 3350 operating in the 3330-1 compatibility mode attached, bit 2 (together with bits 0 and 1) functions as a storage control address bit.

If any attached 3350 drives are operating in the 3330-1 compatibility mode, bit 2 is used to select the correct logical device on the drive. When bit 2 is off (0), the primary logical device on the drive is addressed. When bit 2 is on (1), the secondary logical device is addressed.

Bits 3 and 4 are the string address. This allows a maximum of four storage strings to be attached to one storage control. Each string (of up to eight physical drives) may contain only 3350s, or only 3330s, or only 3340s (not 3344s); the 3350 strings can be in any combination of compatibility and native mode 3350s.

If bits 3 and 4 address a string that is non-existent, powered off, or disabled by the string switch, condition code 3 is indicated.

Bits 5, 6, and 7 select one of the eight drives on the string. Unit check is returned if the drive is powered down or non-existent. Addresses of the storage controls and string controllers are established by the user and plugged at installation by the CE.

A maximum of 32 physical drives can be addressed through a single storage control. When 3350s are operating in the 3330-1 compatibility mode, 64 logical drive addresses are available. Smaller configurations of 8, 16, or 32 drives can be addressed but require different plugging arrangements by the CE. The smaller addressing configurations require fewer unit control words to be available in the channel.

Valid 3350 Addresses

When any 3350 is operating in 3330-1 compatibility mode there are 36 valid secondary address ranges as shown in Figure 7. The 3350 operates as two 3330-1s and requires two logical addresses per spindle. When a 3350 is not operating in the 3330-1 compatibility mode and 3330s and/or 3340s are attached to the storage control, only primary addresses can be used.

When the 3350s are operating in either 3330-11 compatibility or 3350 native mode, 72 valid address ranges are available for each storage control. These address ranges are shown in Figure 8.

Additional addressing information is found in the applicable storage control reference manual and in the *3350/3344 Installation and Conversion Guide.*

0	1	2*	3*	4*	5	6	7
Storage Control Address		Logical Drive Selection (3330-1 Compatibility Mode only)	String Address (max. 4)		Physical Drive Address (max. 8)		

* When less than 64 addresses are configured, bits 2 through 4 can become part of the storage control address.

Figure 6. Drive Addressing

Primary Addresses	Secondary Addresses	Addresses Required
00-07	20-27	16
00-07, 10-17	20-27, 30-37	32
00-0F	20-2F	32
00-1F	20-3F	64
08-0F	28-2F	16
08-0F, 18-1F	28-2F, 38-3F	32
10-17	30-37	16
10-1F	30-3F	32
18-1F	38-3F	16
40-47	60-67	16
40-47, 50-57	60-67, 70-77	32
40-4F	60-6F	32
40-5F	60-7F	64
48-4F	68-6F	16
48-4F, 58-5F	68-6F, 78-7F	32
50-57	70-77	16
50-5F	70-7F	32
58-5F	78-7F	16
80-87	A0-A7	16
80-87, 90-97	A0-A7, B0-B7	32
80-8F	A0-AF	32
80-9F	A0-BF	64
88-8F	A8-AF	16
88-8F, 98-9F	A8-AF, B8-BF	32
90-97	B0-B7	16
90-9F	B0-BF	32
98-9F	B8-BF	16
C0-C7	E0-E7	16
C0-C7, D0-D7	E0-E7, F0-F7	32
C0-CF	E0-EF	32
C0-DF	E0-FF	64
C8-CF	E8-EF	16
C8-CF, D8-DF	E8-EF, F8-FF	32
D0-D7	F0-F7	16
D0-DF	F0-FF	32
D8-DF	F8-FF	16

Figure 7. Addresses for 3330-1 Compatibility Mode

Address Ranges from 00 to 7F	Addresses Required	Address Ranges from 80 to FF
00-07	8	80-87
00-07, 10-17	16	80-87, 90-97
00-0F	16	80-8F
00-1F	32	80-9F
08-0F	8	88-8F
08-0F, 18-1F	16	88-8F, 98-9F
10-17	8	90-97
10-1F	16	90-9F
18-1F	8	98-9F
20-27	8	A0-A7
20-27, 30-37	16	A0-A7, B0-B7
20-2F	16	A0-AF
20-3F	32	A0-BF
28-2F	8	A8-AF
28-2F, 38-3F	16	A8-AF, B8-BF
30-37	8	B0-B7
30-3F	16	B0-BF
38-3F	8	B8-BF
40-47	8	C0-C7
40-47, 50-57	16	C0-C7, D0-D7
40-4F	16	C0-CF
40-5F	32	C0-DF
48-4F	8	C8-CF
48-4F, 58-5F	16	C8-CF, D8-DF
50-57	8	D0-D7
50-5F	16	D0-DF
58-5F	8	D8-DF
60-67	8	E0-E7
60-67, 70-77	16	E0-E7, F0-F7
60-6F	16	E0-EF
60-7F	32	E0-FF
68-6F	8	E8-EF
68-6F, 78-7F	16	E8-EF, F8-FF
70-77	8	F0-F7
70-7F	16	F0-FF
78-7F	8	F8-FF

Figure 8. Address Ranges for 3350 Native or 3330-11 Compatibility Mode

Seek Addresses

A specific track on a 3350 drive is selected by the seek address together with a Seek command. All seek addresses consist of exactly six bytes. Bytes 0, and 1 are zero, bytes 2 and 3 specify the logical cylinder, and bytes 5 and 6 are the logical head address to be used.

Byte	0	1	2	3	4	5
Function	0	0	C	C	H	H

The cylinder address may require movement by the access mechanism. The head address involves selection of the correct read/write head to cover the required track.

The CCHH part of the count area and home address normally corresponds to bytes 2 through 5 of the seek address. The three physical address (PA) bytes preceding each count area and home address reflect the physical cylinder and head address. The PA bytes, written by the storage control, are used for seek verification.

When the seek address is received by the storage control, it is converted into the physical cylinder and head address and sent to the 3350 for seek operations. The acceptable seek address ranges for the 3350 operating modes are:

Operating Mode	Data Tracks		Alternate Tracks	
	CC	HH	CC	HH
Native	0-554	0-29	555-559	0-29
3330-1	0-403	0-18	404-410	0-18
3330-11	0-807	0-18	808-814	0-18

ACCESS AND DATA TRANSFER

The total time required for access and data transfer consists of seek time (if required), head selection time, latency time, and data transfer time.

Seek Time

Seek time is the time required to move the read/write heads to the correct cylinder. If the heads are at the correct cylinder, the seek time is zero. If a different cylinder is required, a minimum of 10 milliseconds is required for a one cylinder change. The maximum access time is 50 milliseconds, and the average time is 25 milliseconds.

When fixed head models are involved and the required data is in the fixed head cylinders, no seek time is required.

Head Selection Time

The time required to select the required read/write head is negligible.

Latency

The 3350 drives rotate at a nominal speed of 3600 revolutions per minute. The time required for a specific record to reach the read/write heads is a maximum of 16.7 milliseconds. Half a revolution, 8.4 milliseconds (the average delay), is generally used for timing purposes.

All 3350s utilize rotational position sensing. This capability permits the drive to disconnect from the channel during the time required to bring the correct record to the read/write head. Other drives can be used by the channel and storage control during this period.

Data Transfer Rate

The nominal data transfer rate of the 3350 is 1,198,000 bytes per second or 0.835 microseconds per byte.

DATA INTEGRITY AND SECURITY

The 3350 protects data integrity by error detection and error correction. Data security and privacy are provided through use of write protect, seek verification, and file protection.

Write Protect

The write protect function prevents data from being erased or rewritten. A switch in the control panel of each drive causes any write command to be rejected. The switch can be changed when the file is not selected or not busy. When a write command is rejected, the sense information indicates write inhibited (byte 1, bit 6) and command reject (byte 0, bit 0).

Seek Verification

The 3350 track format includes three bytes in each count area and home address that are used for seek verification. When the count area or home address is processed during a read or search operation, the three bytes are compared with the most recent seek address. A non-compare indicates that the access mechanism is not properly positioned. Command retry is used to reposition the access mechanism to the correct track. If command retry is unsuccessful, the operation is ended with unit check and sense information that posts equipment check, permanent error, and seek error indicated in byte 7, message A.

File Protection

The Set File Mask instruction in a chain of channel commands describes the write and seek functions that can be performed. If an inhibited write or seek operation is attempted, a unit check is generated in the status byte followed by command reject in the sense bytes. The various bits in the Set File Mask command are used to indicate which functions are to be inhibited.

A description of the Set File Mask command is given in the 3830-2 and ISC Reference Manuals.

Error Recovery

Error recovery usually involves storage control and system-invoked actions. These recovery actions can vary depending on how and to what system the 3350 is attached.

Recovery actions involving the storage control (ISC or 3830-2) and the attached 3350s are described in three topics: Error Correction Function, Error Condition Table, and Error Recovery Action.

ERROR CORRECTION FUNCTION

The error correction function (ECF) is part of the recovery action procedure. It is used whenever a correctable data check is posted for a data area. The ECF algorithms and the related recovery procedure are described in the storage control reference manuals (3830-2 or ISC).

ERROR CORRECTION TABLE

The error correction table (Figure 9) identifies sense bit configurations set by the storage control in sense bytes 0, 1, and 2. Each of these unique configurations requires a specific recovery action to be invoked by the system.

ERROR RECOVERY ACTION

The 3350 recovery action table (Figure 10) specifies the actions to be taken for each sense byte configuration shown in the error condition table. The recovery action table may specify construct restart channel command words. The instructions for constructing restart CCWs follow.

CCW Restart Construction

If sense byte 1, bit 7 (operation incomplete) is on, an error occurred after data transfer had started. The error recovery procedures can correct the error and continue the operation normally. The recovery action table specifies the restart CCW required, either 1 or 2.

RESTART CCW 1 CONSTRUCTION

1. The command code byte is provided in sense byte 3.
2. The data address is that of the interrupted CCW, plus the count of that CCW, minus the CSW residual count.
3. The flags, except program controlled interrupt (PCI), are those of the interrupted CCW.
4. The count is the residual count in the CSW. If the residual count is zero, use a count of one. If command was a write, the data address should specify a byte having '00'. If command was a read, turn on the skip bit.

RESTART CCW 2 CONSTRUCTION

1. The command code is provided in sense byte 3.
2. The count is constructed as follows:
   a. Fetch the count of the CCW designated by CSW-8, and set a pointer to this CCW.
   b. Subtract the restart displacement from the count obtained in step a. If this result is positive, go to step f; otherwise, go to step c.
   c. Check the chain data flag of the CCW designated by the pointer. If the flag is not set, go to step e; otherwise, go to step d.
   d. Advance the pointer to the next non-TIC CCW in the data chain and add this CCW count to the counts of all previous non-TIC CCWs in the data chain. Return to step b.
   e. Truncation occurred. Set the restart CCW 2 count equal to 1. Go to step 3 and include the skip bit in the restart CCW flags.
   f. Set the Restart CCW 2 count equal to the result of the subtraction in step b. Go to step 3.
3. The flags (except PCI) are those of the CCW designated by the pointer in step 2. The skip bit is also set if step 2e was previously executed.
4. The data address is that of the CCW designated by the pointer in step 2e, plus the count of that CCW, minus the restart CCW count generated in step 2.

   If another operation incomplete or an error during a Read Multiple CKD command occurs while executing the restart CCW, a new restart CCW can be generated from the old restart CCW.

Note: *Be sure to avoid destroying the old restart CCW before generating the new one.*

Error Correction Table

Byte	Bit	Name	General Description	Action	Logged
0	0	Command Reject	Programming error.	2	No
0 1	0 6	Command Reject Write Inhibit	A write command received with the write inhibit switch in the Read position.	1	No
0	1	Intervention Required	Drive offline or not plugged for the address.	3	Yes (See Note.)
0	2	Bus Out Parity	Bus out parity error.	3	Yes
0	3	Equipment Check	Equipment malfunction.	4	Yes
0 1	3 0	Equipment Check Permanent Error	Equipment malfunction, storage control retry exhausted or undesirable.	1	Yes
0	4	Data Check	Data check not correctable with a Read Multiple CKD command.	4	Yes
0 1	4 0	Data Check Permanent Error	Uncorrectable data check, storage control retry exhausted.	1	Yes
0 1	4 7	Data Check Operation Incomplete	Data check in second or subsequent overflow segment but not a data-field correctable error.	6B	No
0 1 2	4 7 1	Data Check Operation Incomplete Correctable	Correctable data check in the data area of an overflow segment, not the last segment.	6	Yes
0 2	4 1	Data Check Correctable	Correctable data check in the data area or data area of the last overflow segment.	5	Yes
0	5	Overrun	Service overrun in second or subsequent overflow segment, during a format write, or a Read Multiple CKD.	4	Yes
0 1	5 0	Overrun Permanent Error	Storage control retry exhausted on a service overrun.	1	Yes
1	1	Invalid Track Format	Track capacity exceeded.	2	No
1	2	End of Cylinder	Cylinder boundary detected during multitrack operation.	8	No
1 1	2 7	End of Cylinder Operation Incomplete	Cylinder boundary detected during overflow operation.	9	No
1	4	No Record Found	Record not found in basic command sequence.	2	No
1	5	File Protect	The seek command or read/search multitrack operation violated the file mask.	10	No
1 1	5 7	File Protect Operation Incomplete	A read or write overflow violated the file mask.	11	No
1	7	Operation Incomplete	After start of data transfer during an overflow operation, either a defective or alternate track condition or a seek error in the second or subsequent segment was found.	7	No
2	3	Environmental Data Present	Statistical usage/error log information is present.	3	Yes

Note: *If sense byte 10, bits 4 and 5 are zero, no recording action is performed.*

Figure 9. Error Correction Table

Recovery Action Table

Action	Explanation
1	Print console error message for operator and/or customer engineer notification, (see Figure 10, part 4).
2	Exit with programming error or unusual condition indication.
3	a. Repeat the operation once. b. If the error condition persists, do action 1.
4	a. Repeat the operation. b. If the error condition persists after 10 retries, do action 1.
5	a. Perform error correction function. b. Examine bit 7 of the file mask (PCI). If off, go to step c. If on, return to user with indication that the data has been corrected. (User is operating in PCI fetch mode and must supply own restart recovery action.) c. Examine the interrupted CCW (CSW-8): If it is a Read Multiple CKD command ('5E'), do action 5B; otherwise, continue with this step. If the user's chain has not been completed, examine the next non-TIC CCW in the user's chain. If bit 3 of this CCW is on (count area), go to step d. If bit 3 is off, do action 5A. **Note:** *If data chaining is indicated in the interrupted CCW, the preceding test must be executed on the first non-TIC CCW past the last CCW in the data chain.* d. Continue the user's chain by executing the following: Seek (see Note # below) Set File Mask (same as original) Read Home Addr (skip bit on) Search Equal ID (CCHHR from sense bytes 8-12) TIC*-8 TIC (CSW) (channel status word)
5A	Continue the user's chain by executing: Seek (see Note # below) Set File Mask (same as original) Read Home Addr (skip bit on) Search Equal ID (CCHHR from sense bytes 8-12) TIC*-8 Read Count (skip bit on) TIC (CSW) (channel status word)
5B	This action is used to restart a Read Multiple CKD data recovery process after a correctable data check has been processed. Reconstruct the Read Multiple CKD as follows: a. Construct Restart CCW 2. b. Set command code to '5E'. Restart the operation through the following chain: Seek (see Note # below) Set File Mask (same as original) Read Home Addr (skip bit on) Search Equal ID (CCHHR from sense bytes 8-12) TIC*-8 Read Mult CKD (from step b) TIC (CSW) (if user's chain has not been completed)

Note #: *Get the cylinder bytes and the high-order head byte from the user, not from the sense bytes. Get the low-order head byte from sense byte 6, bits 3-7.*

Figure 10. Recovery Action Table (Part 1 of 4)

Recovery Action Table (continued)

Action	Explanation
6	a. Perform error correction function. b. Examine bit 7 of the file mask (PCI). If off, go to step c. If on, return to user with indication that the data has been corrected. (User is operating in PCI fetch mode and must supply own restart recovery action.) c. Increment the seek argument by one (see Note # below). d. Construct restart CCW 2. e. Complete the interrupted operation and continue the user's chain (if appropriate) by executing: Seek (argument from step c) Set File Mask (same as original) Set Sector (argument 0) Search ID Equal (record 1) TIC*-8 Restart CCW 2 TIC (CSW) (channel status word) **Note:** *If the modified seek argument is not within the user's extent, IOS must supply the correct seek argument before issuing the Seek. If that is impossible, IOS must do action 2.*
6B	a. Examine bit 7 of the file mask (PCI). If off, go to step b. If on, return to user with indication that data has been corrected. (User is operating in PCI fetch mode and must supply own restart recovery action.) b. Construct restart CCW 2. c. Complete the interrupted operation and continue the user's chain (if appropriate) by executing the following: Seek (see Note # below) Set File Mask (same as original) Set Sector (argument 0) Search ID Equal (record 1) TIC*-8 Restart CCW 2 TIC (CSW) (channel status word) **Note:** *If the modified seek argument is not within the user's extent, IOS must supply the correct seek argument before issuing the Seek. If that is impossible, IOS must do action 2.*

Note #: *Get the cylinder bytes and the high-order head byte from the user, not from the sense bytes. Get the low-order head byte from sense byte 6, bits 3-7.*

Figure 10. Recovery Action Table (Part 2 of 4)

Recovery Action Table (continued)

Action	Explanation
7	a. Construct seek argument (see Note # below). b. Construct restart CCW 1. c. Continue user's chain by executing the following chain: Seek (argument from step a) Set File Mask (same as original) Set Sector (argument 0) Search ID Equal (record 1) TIC*-8 Restart CCW 1 TIC (CSW) (channel status word)
8	a. Increment the cylinder address of the user's seek argument by one. Set the head address to zero. b. Continue the operation by executing the following: Seek (argument from step a) Set File Mask (same as original) Set Sector (argument 0) Read Home Addr (skip bit on) TIC (CSW-8) (channel status word -8) **Note:** *If the modified seek argument is not within the user's extent, IOS must supply the correct seek argument before issuing the Seek. If that is impossible, IOS must do action 2.*
9	a. Increment the cylinder address of the user's seek argument by one. Reset the head address. b. Construct restart CCW 1. c. Complete the interrupted operation and continue the user's chain (if appropriate) by executing the following: Seek (argument from step a) Set File Mask (same as original) Set Sector (argument 0) Search ID Equal (record 1) TIC*-8 Restart CCW 1 TIC (CSW) (channel status word) **Note:** *If the modified seek argument is not within the user's extent, IOS must supply the correct seek argument before issuing the Seek. If that is impossible, IOS must do action 2.*

Note #: *Get the cylinder bytes and high-order head byte from the user, not from the sense bytes. Get the low-order head byte from sense byte 6, bits 3-7.*

Figure 10. Recovery Action Table (Part 3 of 4)

Recovery Action Table (continued)

Action	Explanation
10	a. Determine if the interrupted command is a seek. If yes, go to step b. If not, do action 10A. b. Continue the operation by executing the following: Seek (user's argument, see Note # below) Set File Mask (same as original) Set Sector (argument 0) Read Home Addr (skip bit on) TIC (CSW) (channel status word) **Note:** *If the modified seek argument is not within the user's extent, IOS must supply the correct seek argument before issuing the Seek. If that is impossible, IOS must do action 2.*
10A	a. This is a multitrack operation. Increment the user's seek argument by one (see Note # below). b. Continue the operation by executing the following: Seek (argument from step a) Set File Mask (same as original) Set Sector (argument 0) Read Home Addr (skip bit on) TIC (CSW-8) (channel status word -8) **Note:** *If the modified seek argument is not within the user's extent, IOS must supply the correct seek argument before issuing the Seek. If that is impossible, IOS must do action 2.*
11	a. Increment the user's seek argument by one (see Note # below). b. Construct restart CCW 1. c. Complete the interrupted operation and continue the user's chain (if appropriate) by executing the following: Seek (argument from step a) Set File Mask (same as original) Set Sector (argument 0) Search ID Equal (record 1) TIC*-8 Restart CCW 1 TIC (CSW) (channel status word) **Note:** *If the modified seek argument is not within the user's extent, IOS must supply the correct seek argument before issuing the Seek. If that is impossible, IOS must do action 2.*

Note #: *Get the cylinder bytes and the high-order head byte from the user, not from the sense bytes. Get the low-order head byte from sense byte 6, bits 3-7.*

Figure 10. Recovery Action Table (Part 4 of 4).

The following commands are recognized and executed by the 3350. (See Figures 11 through 16.)

The three diagnostic commands are only used when microdiagnostics from the System/370 are required.

CONTROL COMMANDS

- No Operation
- Recalibrate
- Seek
- Seek Cylinder
- Seek Head
- Space Count
- Set File Mask
- Set Sector
- Restore
- Diagnostic Load
- Diagnostic Write

SEARCH COMMANDS

- Search Home Address Equal
- Search ID Equal
- Search ID High
- Search ID Equal or High
- Search Key Equal
- Search Key High
- Search Key Equal or High

READ COMMANDS

- Read Data
- Read Key and Data
- Read Count, Key, and Data
- Read Record Zero
- Read Count
- Read Home Address
- Read Initial Program Load
- Read Sector
- Read Multiple Count, Key, and Data

SENSE COMMANDS

- Sense I/O Type
- Sense I/O
- Read and Reset Buffered Log
- Diagnostic Sense
- Device Reserve
- Unconditional Reserve
- Device Release

FORMAT WRITE COMMANDS

- Write Home Address
- Write Record Zero
- Erase
- Write Count, Key, and Data
- Write Special Count, Key, and Data

UPDATE WRITE COMMANDS

- Write Data
- Write Key and Data

CONTROL COMMANDS

Command	Code		Function	Data Transferred Across Channel
	Single Track	Multi–track		
No Operation	03		No action. Channel end and device end presented during initial status.	None
Recalibrate	13		Moves the access to cylinder 0 and selects head 0.	None
Seek	07		1. Moves access to cylinder specified by the seek address. 2. Selects the head specified by the seek address.	Six address bytes (0-5). Only bytes 2, 3, and 5 are used for the seek address.
Seek Cylinder	0B			
Seek Head	1B		Selects head specified by the seek address.	Six address bytes. Only five lowest bits of byte 5 are used.
Space Count	0F		When chained from read, search, write, or space count command, locates start of next count area (including R0), spaces over the count area, and ends with channel end and device end in gap before key area. When not chained, searches for index, spaces over G1, HA, G2, and R0 count area. Ends operation in gap following R0 count with channel end and device end.	Three bytes used as KL (one byte) and DL (two bytes) for next command.
Set File Mask	1F		Sets file mask to control operation of write and seek commands.	One byte of file mask data.
Set Sector	23		Used on disconnected command chaining channels to eliminate the need for the channel to maintain connection with the storage control during rotational delay.	One byte that specifies angular track position (0–127).
Restore	17		No action. Zero initial status followed by final status of channel end and device end.	None
Diagnostic Load	53		Transfers the specified 512-byte data block from read only storage to the storage control buffer.	One byte of control information addresses one sector on the read only storage.
Diagnostic Write	73		Transfers and executes inline test from main storage to storage control. A 16-byte error code message is stored in storage control. Message may then be transferred to main storage by a Diagnostic Sense command. (See sense commands.)	Maximum of 512 bytes.

Figure 11. Control Commands

SEARCH COMMANDS

Command	Code		Function	Data Compared
	Single Track	Multi–track		
Search Home Address Equal	39	B9	Locates a home address area selected by the search argument.	Four bytes (CCHH) of HA area from selected drive and track, with CCHH from the system.
Search ID Equal	31	B1	Locates a count area selected by the search argument.	Five bytes (CCHHR) of next count area from selected drive and track, with CCHHR from the system.
Search ID High	51	D1	Locates a count area selected by the search argument. (Locates any ID from the track that is higher than the ID from system.)	Five bytes (CCHHR) of next count area from drive and track with CCHHR from system.
Search ID Equal or High	71	F1	Locates a count area selected by the search argument. (Locates ID from track that is equal to or higher than the ID from system.)	Five bytes (CCHHR) of next count area from drive and track with CCHHR from system.
Search Key Equal	29	A9	Locates a key area selected by the search argument. (The key area compared is from the next record unless chained from a Read Count or Search ID. If chained from a Read Count, the key searched is in the same record.)	Key bytes from selected drive and track with key from system.
Search Key High	49	C9	Locates a key area selected by the search argument. (Same as Search Key Equal except finds any key higher than system key.)	Key bytes from selected drive and track with key from system.
Search Key Equal or High	69	E9	Locates a key area selected by the search argument. (Same as Search Key Equal except key is equal to or higher than system key.)	Key bytes from selected drive and track with key from system.

Figure 12. Search Commands

READ COMMANDS

Command	Code		Function	Data Read
	Single Track	Multi–track		
Read Data	06	86	Transfers data area of record from drive to main storage.	First data area after address marker or data area of record chained from count or key of same record.
Read Key and Data	0E	8E	Transfers key and data areas of record from drive to main storage. If KL = 0, same as Read Data.	First key and data areas after address marker or the key and data areas that were command chained from the count area of the same record.
Read Count, Key, and Data	1E	9E	Transfers count, key, and data areas of record from drive to main storage.	Next record or first record after R0.
Read Record Zero (R0)	16	96	Transfers R0 (count, key, and data) from drive to main storage. If chained from Search HA or Read HA, is executed immediately with no search for index.	Record Zero (R0).
Read Count	12	92	Transfers next count area (8 bytes) from drive to main storage.	Next record count area or first count area after R0.
Read Home Address	1A	9A	Transfers five bytes (FCCHH) to main storage.	Byte 0 = Flag Byte 1 = Cyl Addr Byte 2 = Cyl Addr Byte 3 = 0 Byte 4 = Head Addr
Read Initial Program Load	02		Recalibrates to cylinder 0, head 0, searches for index point, and reads R1 data from drive to main storage. Cannot be preceded by Set File Mask or Space Count in same chain.	First data area after R0 on cylinder 0, head 0.
Read Sector	22		Transfers one angular position byte used by next Set Sector. If chained from a read, write, or search CCW, is position of the record used in the previous CCW. If not chained, is position required to access the last record processed by the drive. Resets orientation information.	One byte of angular position data.
Read Multiple Count, Key, and Data	5E		Transfers remaining records on track to channel. Since number of bytes unknown, CCW count should be larger than the longest track length and SILI bit should be on to suppress incorrect length. Command retry may be affected.	Starts at count field of next record (except R0).

Figure 13. Read Commands

SENSE COMMANDS

Command	Code		Function	Data Transferred Across Channel
	Single Track	Multi–track		
Test I/O	00		Determines status of device on channel. Generated automatically by channel when status information required.	One status byte.
Sense I/O Type	E4		Transfers seven bytes of sense data designating storage control type and drive type. **Note**: *When the Sense I/O is chained from a successful Read HA, the skip displacement information appears in sense bytes 18 through 23.*	7 bytes of storage control and drive identification. (See Note.)
Sense I/O	04		Determines cause of last unit check. Sense data is reset upon transfer.	24 bytes of sense information.
Read and Reset Buffered Log	A4		Supplies usage or error logging data on the addressed drive. Data is reset upon transfer.	24 bytes of usage or error logging data.
Diagnostic Sense	44		Determines type of error(s) found when running diagnostic test (part of Diagnostic Write) or transfers test to system after a Diagnostic Load.	16 bytes of error code message or 512 bytes of test data.
Device Reserve	B4		Reserves addressed device for exclusive use by channel on multichannel interfaces or string switch machines. Cannot follow a Set File Mask or Space Count in same chain. Also transfers 24 sense bytes.	24 sense bytes.
Unconditional Reserve	14		Same as Device Reserve except is routed through alternate path. Resets information in original path and string switch. Used to recover from hardware malfunction.	24 sense bytes.
Device Release	94		Terminates device reservation on multichannel interfaces or string switch machines. Cannot follow a Set File Mask or Space Count in same chain. Also transfers 24 sense bytes.	24 sense bytes.

Figure 14. Sense Commands

FORMAT WRITE COMMANDS

Command	Code		Function	Data Written
	Single Track	Multi–track		
Write Count, Key, and Data	1D		Writes one complete record on the selected cylinder and track. (If file mask violated, sets command reject. Must chain from Write R0, Write CKD, Erase, successful Search ID Equal, or Search Key Equal.)	Count, key, and data areas of next track record. Data area from system; count area, flags, gaps from storage control.
Write Special Count, Key, and Data	01		Same as Write CKD except for flag bit 4 (on) indicating a record overflow segment. (Not used for last segment of overflow record.)	Same as Write CKD.
Erase	11		Same as Write CKD except no information is written in count, key, and data areas. No address marker, sync byte, or ECC bytes are written with this command.	Bytes of zeros.
Write Home Address (HA)	19		In 3330 compatibility modes, writes 5-byte (F CC HH) home address area on selected drive and track. In 3350 native mode, writes 11-byte (SD SD SD F CC HH) home address area on selected drive and track. (If 3350 native mode, must chain from successful Search HA with CCW count = 4 or more if flag bit 6 off.) **Note:** *When the Sense I/O is chained from a successful Read HA, the skip displacement information appears in sense bytes 18 through 23.*	The 5-byte (3330) or 11-byte (3350) home address transferred from system. (See Note.)
Write Record Zero (R0)	15		Writes count, key, and data areas of R0. (Same as Write CKD except must chain from Write HA or successful Search HA.)	Flag byte from HA. CC HH R KL DL DL from system for count area. Key and data from system.

Figure 15. Format Write Commands

UPDATE WRITE COMMANDS

Command	Code		Function	Data Written
	Single Track	Multi–track		
Write Data	05		Changes data area of a record. (If file mask violated, sets command reject. Must chain from successful Search ID Equal or Search Key Equal.)	Data from system. Byte number as specified by DL DL bytes in count.
Write Key and Data	0D		Changes key and data areas of record. (If KL = 0, same as Write Data. If file mask violated, sets command reject. Must chain from successful Search ID.)	Data from system. Byte number as specified by KL DL DL bytes in count area of same record.

Figure 16. Update Write Commands

The status and condition of the 3350 is reported in the sense bytes. There are 24 bytes and seven different formats. Four formats, 1, 4, 5, and 6 describe the 3350. The remaining three formats, 0, 2, and 3 are associated with the storage control.

Only the formats used with the 3350 are explained in this manual. Refer to the following manuals for formats 0, 2, 3, and a detailed description of unit status:

- *Reference Manual for Integrated Storage Control,* Order No. GA26-1620.
- *Reference Manual for 3830 Model 2 Storage Control,* Order No. GA 26-1617.

SENSE BYTE SUMMARY

In all the formats, the first eight bytes, 0 through 7, give high-level information concerning status and condition. Sense byte 7 identifies the format in which the remaining bytes, 8 through 24, are arrayed:

- Bits 0 through 3 indicate the format type for bytes 8 through 24

0	1	2	3	Format
0	0	0	1	1
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6

- Bits 4 through 7 define a message

4	5	6	7	Message
0	0	0	0	0
|	|	|	|	|
|	|	|	|	|
∇	∇	∇	∇	∇
1	1	1	1	F

Each of the formats concerned with the 3350 is summarized in Figures 17 through 26. Figure 22 contains the applicable message for each of the formats. Should the indicated format be 0, 2, or 3, refer to the appropriate storage control manual for interpretation.

SENSE BYTES 0 THROUGH 7 SUMMARY

	Bit 0	1	2	3	4	5	6	7
Byte 0	Command Reject	Interven-tion Required	Channel Bus Out Parity	Equipment Check	Data Check	Overrun	Unused	Unused
Byte 1	Permanent Error	Invalid Track Format	End of Cylinder	Unused	No Record Found	File Protected	Write Inhibited	Operation Incomplete
Byte 2	Unused	Correctable	Alternate Controller Selected	Environ-mental Data Present	Compatibil-ity Mode	Unused	Unused	Unused
Byte 3	Restart Command (provided only when byte 1, bit 7 is on.) '06' = Read operation; '05' = Write operation							
Byte 4	Physical Drive Identification (1 out of 8 coding)							
	0	1	2	3	4	5	6	7
Byte 5	Low-Order Logical Cylinder Address							
	128	64	32	16	8	4	2	1
Byte 6 (See Note.) 3350/3330-11	High-order Logical Cylinder Address (CE) 1024	512	256	Logical Head				
3330-1	(CE) 1024	256	0	16	8	4	2	1
Byte 7	Format (Bits 0 through 3)				Message Code (Bits 4 through 7)			

Note: *When the CE cylinder 1024 (in all models) is addressed, byte 6, bit 0 = 1 and all other cylinder bits in bytes 5 and 6 are zeros.*

Figure 17. Sense Bytes 0 through 7 Summary

3350 SENSE BYTES

SENSE BYTE 0

Bit 0 Command Reject	1. Invalid or uninstalled feature command issued. 2. Invalid command sequence. 3. Invalid or incomplete argument transferred by a control command. 4. Track formatted without home address. 5. Write portion of file mask violated. 6. Write command received for device with Write Protect switch on. Byte 1, bit 6 (write inhibited) also set. 7. Format write attempted on defective track.
Bit 1 Intervention Required	1. Drive addressed not physically attached to system. 2. Drive addressed not ready (HDA not powered-up). 3. Diagnostic Write or Load command issued and microdiagnostic is resident in control storage. 4. Addressed device in CE mode and not available for use.
Bit 2 Bus Out Parity	The storage control has detected a parity error in the data transferred from the channel (not a command reject).
Bit 3 Equipment Check	An unusual hardware condition in the channel, storage control, or drive. (Condition further defined in bytes 7 through 23.)
Bit 4 Data Check	1. A correctable data error detected in information received from a drive. (Byte 2, bit 1 on, and correction data in bytes 15 through 22.) 2. An uncorrectable data error detected in information from a drive. (Condition further defined in byte 7.)
Bit 5 Overrun	1. Storage control received the byte from the drive before the last byte read was accepted by the channel. 2. Data byte was received too late from the channel during a write operation. *The storage control posts overrun only if one of the above conditions occurs more than ten times in CCW chain, in the second or later segment of overflow record, or during a format write operation. Data transmission is stopped when overrun is detected. If a write was in progress, the remaining part of the record is padded with zeros. All data overruns are retried by the storage control except for overruns occurring on second or higher record segments and overruns occurring during format write operations.* *If the overrun exists after command retry is exhausted, byte 1, bit 0 (permanent error) is posted.*
Bit 6,7	Unused -- set to 0.

Figure 18. Sense Byte 0 Description

SENSE BYTE 1

Bit 0 Permanent Error	Storage control retry count exhausted and not successful.
Bit 1 Invalid Track Format	1. An attempt was made to write data exceeding the track capacity. 2. Index was detected in gap following count or key area during read or search operation (programming error).
Bit 2 End of Cylinder	1. A multitrack read or search attempted to go beyond the cylinder boundary. 2. An overflow operation attempted to go past the cylinder boundary. (Byte 1, bit 7, operation incomplete, also set.)
Bit 3	Unused -- set to 0.
Bit 4 No Record Found	1. Two index points sensed in command chain with no intervening read in home address or data area or without a write, sense, or control command. 2. Access position verified before the bit is posted (programming error).
Bit 5 File Protected	File mask violated by: 1. Seek command. 2. Multitrack read or search command. 3. Overflow operation. (Byte 1, bit 7 also on.)
Bit 6 Write Inhibited	An attempt made to write on drive with Read Only switch set on. Byte 0, bit 0, command reject, also set.
Bit 7 Operation Incomplete	One of the following occurred when overflow record was processed: 1. Overflow to a file protected boundary. (Byte 1, bit 5, file protected, also set.) 2. Overflow beyond cylinder boundary. (Byte 1, bit 2, end-of-cylinder, also set.) 3. Correctable data error found in data area - not last segment. (Byte 2, bit 1, correctable, and byte 0, bit 4, data check, also set.) 4. Defective or alternate track found after start of data transfer. 5. Uncorrectable data error found in any area - not first segment. 6. Seek error found in second or later segment. See sense byte 3 for restart command, and bytes 8 through 13 for restart information.

Figure 19. Sense Byte 1 Description

3350 SENSE BYTES

SENSE BYTE 2

Bit 0	Unused -- set to 0.
Bit 1 Correctable	Indicates that data error posted in byte 0, bit 4 is correctable. Bytes 15 through 22 identify error pattern and restart displacement.
Bit 2	Alternate controller selected.
Bit 3 Environmental Data Present	Indicates that bytes 8 through 23 contain either usage, error statistics, or error log information.
Bit 4	If 1, drive is operating in a 3330 compatibility mode. If 0, drive is operating in native mode.
Bits 5–7	Unused -- set to 0.

SENSE BYTE 3

Bits 0–7 Restart Command	When byte 1, bit 7 is set, this byte shows the operation in process at the time of interrupt: 0000 0110 = Read 0000 0101 = Write (Zero when byte 1, bit 7 is off.)

SENSE BYTE 4

Bits 0–7 Physical Drive Identification	This byte identifies the physical drive selected. Bit 0 = drive 0, bit 1 = drive 1, and so on. The bit number is equal to the drive number.

SENSE BYTE 5

Bits 0–7 Low Order Logical Cylinder Address	Identifies low-order eight bits of the current seek argument.								
	Bit	0	1	2	3	4	5	6	7
	Cylinder	128	64	32	16	8	4	2	1

Figure 20. Sense Bytes 2 through 5 Descriptions

SENSE BYTE 6

This byte identifies the logical track address and cylinder used in the current Seek. Bits 0 through 2 indicate the high-order address bit; bits 3 through 7 indicate the logical track.

Bit No.	3350 Native or 3330-11 Compatibility Mode	3330-1 Compatibility Mode
0	CE Cylinder*	CE Cylinder*
1	Cylinder 512	Cylinder 256
2	Cylinder 256	Cylinder 0
3	Logical Head 16	
4	Logical Head 8	
5	Logical Head 4	
6	Logical Head 2	
7	Logical Head 1	

*When CE cylinder 1024 is addressed, bit 0=1 and all other cylinder bits of bytes 5 and 6 = 0. Bits 3 through 7 of byte 6 can address any valid head.

SENSE BYTE 7

Bits 0–3 Format Type	Specifies format of sense bytes 8 through 23 as follows:		
	0000	(Format 0)	Programming/system checks.
	0001	(Format 1)	Device checks.
	0010	(Format 2)	Storage control equipment checks.
	0011	(Format 3)	Storage control checks.
	0100	(Format 4)	ECC uncorrectable data checks.
	0101	(Format 5)	ECC correctable data checks*.
	0110	(Format 6)	Usage/error statistics.
	* Also may be presented on errors which are not ECC correctable but which require restart displacement information.		
Bits 4–7 Message Code	Message code indicating type of error; defined on Format Message page. (See Figure 22.)		

Figure 21. 3350 Sense Bytes 6 and 7 Descriptions

3350 FORMAT MESSAGES (Sense Byte 7)

Message Number	FORMAT 1	FORMAT 4	FORMAT 5
0	No message	HA area data check	Unused
1	Transmit target error	Count area data check	Unused
2	Microprogram detected errors	Key area data check	Unused
3	Transmit difference high error	ECC uncorrectable data checks	ECC correctable data checks*
4	Sync out timing error	No sync byte in HA area	
5	Unexpected drive status at initial selection	No sync byte in count area	
6	Transmit cylinder error (string switch only)	No sync byte in key area	
7	Transmit head error	No sync byte in data area	
8	Transmit difference error	Unused	
9	Unexpected file status during Read IPL or retry	No address mark detection on retry	
A	Seek error		
B	Retry seek incomplete or sector noncompare (with equipment check)		
C	No interrupt from drive		
D	Defect skipping re-orientation check		
E	Device type undetermined at initial selection		
F	Retry orientation check		

* Also may be presented on errors which are not ECC correctable but which require restart displacement information.

Figure 22. Format Messages

FORMAT 1 SENSE BYTE SUMMARY (3350 Equipment Checks)

	Bit 0	1	2	3	4	5	6	7	
Byte 8 Drive Status	Controller Check	Device Interface Check	Drive Check	Read Write Check	Online	HDA Attention	Busy	Seek Cmpl or Search Sector or Pad Cmpl	A
Byte 9 Checks Status	Pad In Progress	Sector Compare Check	Motor At Speed Latched	Air Switch Latched	Write Enable	Fixed Head HDA Installed	Spindle Mode 2 Bit	Spindle Mode 1 Bit	
Byte 10 HDA Sequence Control	Mode Size Check	HDA Sequence Latch 4	HDA Sequence Latch 2	HDA Sequence Latch 1	HDA Timer Chk Latch	HDA Sequence Chk Latch	Unused	Odd Physical Track	
Byte 11 Load Switch Status	Drive Start Switch	Guard-band Pattern	Target Velocity	Track Crossing	Unused	Air Switch	Unused	Motor At Speed	
Byte 12 Read/Write Safety	Multiple Chip Select Check	Capable/ Enable Check	Write Overrun	Index Check	Delta Current Check	Control Check	Write Transition Check	Write Current During Read Chk	
Byte 13* Control Interface Bus Out	Control Interface Bus Out (for message code C).				Expected Drive Status Data valid for message codes 1, 3, 5, 6, 7, 8, and 9.				B
Byte 14* Control Interface Bus In	Control Interface Bus In (at time error was detected). (Valid only for message codes 1, 3, 5, 6, 7, 8, 9, and C.)								B
Byte 15* Control Interface Tag Bus	Control Interface Tag Bus (at time error was detected). (Valid only for message codes 1, 3, 5, 6, 7, 8, 9, and C.)								
Byte 16 Access Status	Access Time Out Check	Overshoot Check	Servo Off Track Check	Rezero Mode Latch	Servo Latch	Linear Mode Latch	Control Latch	Wait Latch	
Byte 17 Controller Checks	VFO Detected Error, 2-bit	VFO Detected Error, 1-bit	SERDES Check	Gap Counter Check	Write Data Check	Monitor Check	ECC Hardware Check	ECC Zeros Detected	
Byte 18 Microprogram Detected Errors	Unused	Unused	Unused	Unused	Coded Error Condition (bits 4 through 7)				D
Byte 19 Status	Set R/W On (see Byte 8)	Reserved	Reserved	Reserved	Head Short Check	Pad Gate Check	3350 Drive	1 (Always On)	
Byte 20 Interface Checks	Control Interface Tag Bus Parity Chk	Control Interface Bus Out Parity Chk	Drive Selection Check	Device Bus In Parity Check	Control Interface Bus In Parity Chk	Write Current Failure	3330 Mode Index Check	Re-orient Counter Check	C
Byte 21 Device Interface Check	Unused	Unused	Unused	Unused	Unused	Unused	Device Bus Out Parity Check	Device Tag Parity Check	C
Bytes 22 and 23	Fault Symptom Code								

* These bytes are also valid for message code 2 when byte 18 equals 1, 3, 5, 6, or E.

Note: **A, B, C,** *and* **D** *refer to bytes on the following page.*

Figure 23. Format 1 Summary

A If busy (bit 6 on), Search Sector is in progress.
If set read/write is on (byte 19, bit 0 = 1), byte 8 is read as follows:

0	1	2	3	4	5	6	7
Controller Checks	Write Current Sense	Drive Check	Read/Write Check	On Line	Pad in Progress	Index Mark	3330 Modes

B With message code A or B (byte 18, bits 4 through 7), bytes 13 and 14 indicate:

0	1	2	3	4	5	6	7
Previous Seek Address (access position before present seek, bytes 5 and 6) Low Physical Cylinder.							
128	64	32	16	8	4	2	1
High Physical Cylinder Address		Physical Head Address					
512	256	32	16	8	4	2	1

C If equipment check is on (byte 0, bit 3) and with message code A indicated in byte 7, bits 4 through 7, bytes 20 and 21 indicate:

0	1	2	3	4	5	6	7
Present Seek Address (low physical cylinder address)							
128	64	32	16	8	4	2	1
High Physical Cylinder Address		Physical Head Address					
512	256	32	16	8	4	2	1

D Microprogram error messages (sense byte 18, bits 4 through 7)

0	Unused	8	Repetitive command overruns on G1 operations.
1	No tag valid on read/write operation.	9	Repetitive command overruns.
2	No normal or check end on read/write or ECC operations.	A	Incorrect drive selected.
3	No response from drive on control operation.	B	Busy missing after seek start was issued.
4	Time out waiting for index.	C	Unused
5	ECC hardware check.	D	Unused
6	Multiple or no controller selected.	E	Always active bit on bus in.
7	Preselection check.	F	Unresetable interrupt.

FORMAT 4 SENSE BYTE SUMMARY (ECC Uncorrectable Data Checks)

	Bit 0	1	2	3	4	5	6	7
Byte 8 Cylinder Address	High-order cylinder byte of the last count area read. (See Note.)							
Byte 9 Cylinder Address	Low-order cylinder byte of the last count area read. (See Note.)							
Byte 10 Head Address	High-order head byte of the last count area read. (See Note.)							
Byte 11 Head Address	Low-order head byte of the last count area read. (See Note.)							
Byte 12 Record Number	Record number of the record in last count area read. (See Note.) Zero if error occurred in home address.							
Byte 13 Sector Number	Sector number of the record in error. (See Note.)							
Byte 22	Fault symptom code.							
Byte 23	Fault symptom code.							

Note: *The information in these bytes is unreliable if the message code in byte 7 is 0 or 4 (error occurred in HA), 1 or 5 (error occurred in count area), or 9 (AM detection failure on retry).*

Figure 24. Format 4 Summary

FORMAT 5 SENSE BYTE SUMMARY (ECC Correctable Data Checks*)

	Bit 0	1	2	3	4	5	6	7
Byte 8 Cylinder Address	High-order cylinder byte of the last count area read. (See Note.)							
Byte 9 Cylinder Address	Low-order cylinder byte of the last count area read. (See Note.)							
Byte 10 Head Address	High-order head byte of the last count area read. (See Note.)							
Byte 11 Head Address	Low-order head byte of the last count area read. (See Note.)							
Byte 12 Record Number	Record number of the record in last count area read. (See Note.)							
Byte 13 Sector Number	Sector number of the record in error.							
Byte 14 Unused	Unused.							
Byte 15 Restart **Byte 16** Displace-ment **Byte 17**	Specifies the number of bytes processed by the storage control to the end of the area in question.							
Byte 18 Error **Byte 19** Displace-ment.	Error displacement location of first byte in error within the data area measured from the end of area.							
Byte 20 Error **Byte 21** Pattern **Byte 22**	Error pattern used for error correction function. (See Error Correction Function.)							
Byte 23 Unused	Unused.							

Note: *The information in bytes 8 through 12 is unreliable if the message code in byte 7 is 0 or 4 (error occurred in HA) or 1 (error occurred in count area).*

* Also may be presented on errors which are not ECC correctable but which require displacement information.

Figure 25. Format 5 Summary

FORMAT 6 SENSE BYTE SUMMARY (Usage and Error Statistics)

	Bit 0	1	2	3	4	5	6	7
Byte 8 - 11 Bytes Read or Searched	These four bytes provide an accumulated count of the number of bytes processed by the storage control in read or search operations. Bytes processed during retry operations are not included in this count. Only key and data area counts are accumulated.							
Byte 12 - 13 Unused	Unused.							
Byte 14 - 15 Retry Data Errors	These two bytes contain the number of initial ECC uncorrectable data errors retried by the storage control.							
Byte 16 - 17 Number of Seeks	These two bytes provide the number of seek commands processed by the storage control.							
Byte 18	Bit 0 set to zero = bytes 20 through 23 contain information for interfaces A and B. Bit 0 set to one = bytes 20 through 23 contain information for interfaces C and D.							
Byte 19 Seek Errors	Total number of seek errors retried by the storage control. (Seek errors found on retry are not included.)							
Byte 20	Command overruns, channel A or C.							
Byte 21	Data overruns, channel A or C.							
Byte 22	Command overruns, channel B or D.							
Byte 23	Data overruns, channel B or D.							

Figure 26. Format 6 Summary

OPERATOR PANEL

Each 3350 unit has two operator panels, one for each drive. The indicators and controls for each operator panel are shown in Figure 27.

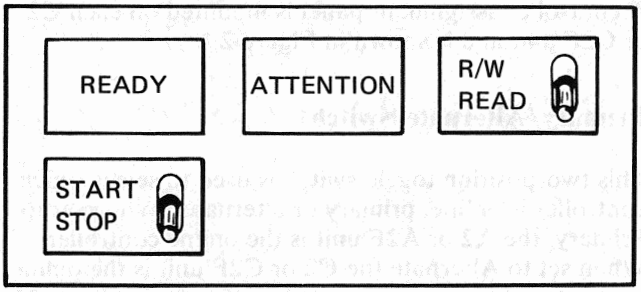


Figure 27. 3350 Operator Panel

Ready Lamp

The Ready lamp turns on when the drive is on, the disk drive speed is up to normal, and the head is on a track.

Attention Pushbutton

When pressed, the Attention pushbutton starts a rezero operation. Rezero moves the heads to cylinder zero, resets the address registers, and signals attention to the controller. On a drive in 3330-1 mode, device end interrupts are generated for both logical devices.

Read, R/W Switch

When in the Read position, no write or erase operation can be performed. If set to R/W, all reading and writing operations are possible. If the switch position is changed during an operation, the condition does not change until the operation is completed.

Start/Stop Switch

The drive Start/Stop toggle switch starts and stops a drive. When set to Start, the brake is released, the disks rotate up to speed, and the heads move to cylinder zero. When set to Stop, the heads retract, the brake engages, and the disks stop. An electrical interlock in the Stop position prevents a stop if the drive is busy.

POWER CONTROL PANEL (A2/A2F)

A power control panel is mounted on the front cover of each A2 or A2F dual-drive unit and is shown in Figure 28.

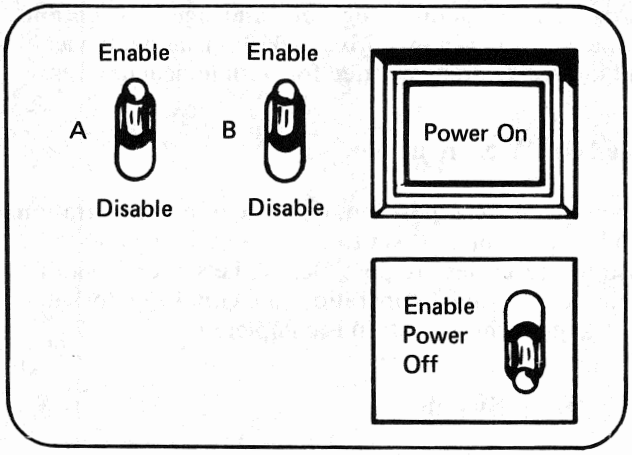


Figure 28. 3350 A2/A2F Power Control Panel

Power On Switch

Pressing the Power On switch allows ac power to be applied to the string if the Power switch is in the Enable position.

Power Switch

ENABLE

With the switch in the Enable position, the string may be powered up by pressing the Power On switch or by a system-controlled power up sequence.

OFF

When the switch is set to Off, the entire string is powered down and string power cannot be restored until the switch is set to Enable.

Power On Indicator

The Power On indicator is on when ac power is applied to the drive as controlled by the Power On/Off switch and the subsystem sequencing.

A and B Enable/Disable Switches

These switches are used to select the active interface in 3350 systems that have the optional string switch feature.

CONTROLLER ASSIGNMENT PANEL (C2/C2F)

A controller assignment panel is mounted on each C2 or C2F unit and is shown in Figure 29.

Primary/Alternate Switch

This two-position toggle switch is used to select which controller is online, primary or alternate. When set to Primary, the A2 or A2F unit is the online controller. When set to Alternate the C2 or C2F unit is the online controller. String power must be off before this switch is changed. During a power up sequence, the online controller is determined by the position of the Primary/Alternate switch.

Primary/Alternate Indicators (C2 or C2F Units)

One of these indicators is on to indicate whether the primary or alternate controller is online.

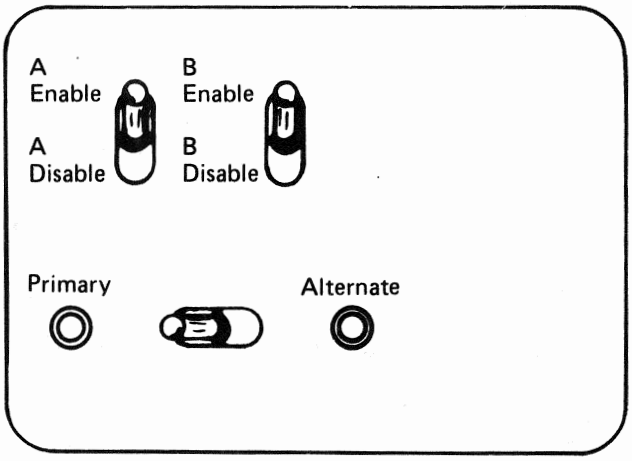


Figure 29. 3350 C2/C2F Controller Assignment Panel

A

B

C

D

E

F

G

H

I

K

L

M

N

O

P

R

S

T

U

W

Numeric

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