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Systems

Reference Manual for IBM 3830 Storage Control Model 1 and IBM 3330 Disk Storage

IBM

Preface

The IBM 3830 Storage Control and IBM 3330 Disk Storage form a large capacity, high speed, direct access, storage subsystem for general purpose data storage and system residence. Attached to the central processing unit (CPU) through a block multiplexer channel, the subsystem operates under direct program control of the CPU.

For experienced programmers, this manual provides readily accessible reference material about channel command words, sense bytes, track format, track capacities, and error recovery.

Less experienced programmers will find sufficient information to create channel programs to best use the standard and special features of the 3830/3330 data storage subsystem.

This manual is organized into the following major subjects:

- INTRODUCTION – describes the basic units and lists highlights and functions. Also includes record and track formats, and means for error correction. Record and track capacities for various record lengths are listed together with the track capacity formulas used to calculate these capacities.
- INPUT/OUTPUT – describes operation between the channel and the Storage Control.
- CHANNEL COMMANDS – lists each command and describes its use.
- STANDARD FEATURES – describes multitrack operation, command retry, rotational position sensing (with formula for calculating sector positions), and other standard features.
- SPECIAL FEATURES – describes two channel switch, two channel switch additional, and write inhibit operations.
- ERROR RECOVERY PROCEDURES – explains the error correction function and lists error recovery techniques for various failures that may occur. The failures and recovery methods are listed in tables.
- OPERATING INSTRUCTIONS – a description of switches, indicators, and procedures for disk pack unloading and loading.
- CONSOLE MESSAGE ANALYSIS – a console error message is illustrated and each area is explained. A complete summary of sense byte information is included.

Programmers should be familiar with the information contained in *IBM System/360 Principles of Operation,* order No. GA22-6821, and *IBM System/370 Principles of Operation,* Order No. GA22-7000. Operators should be familiar with the material presented in the system summary for their system. Order numbers for system summary and other related publications can be found in *IBM System/360 and System/370 Bibliography,* Order No. GA22-6822.

For definitions of terms used in connection with direct access storage devices, see *Data Processing Glossary,* Order No. GC20-1699.

Sixth Edition (November 1976)

This is a major revision that replaces and makes Order No. GA26-1592-4 obsolete. Changes or additions to the specifications contained in this publication are periodically being made. Before using this publication in connection with the operation of IBM equipment, contact the local IBM Branch Office for revisions.

Changes to the text or illustrations are indicated by a vertical line to the left of the change.

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 manual. The reader's comment form requires no postage and your comments are invited. If the form has been removed, send your comments to the address below.

This manual was prepared by the IBM General Products Division, Technical Publications, Department G26, San Jose, California 95193.

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Introduction

The IBM 3830 Storage Control and the IBM 3330 Disk Storage combine to provide high capacity direct access storage for medium-to-large scale IBM computers. When attached to a block multiplexer channel, each storage facility provides fast access to as many as 800,000,000 bytes of online storage.

Standard data checking and retry features increase the system reliability and availability for batch processing and data base applications.

The 3830/3330 storage facility can be attached to the IBM 2880 Block Multiplexer Channel or to system channels with equivalent characteristics.

3830/3330 HIGHLIGHTS

- 30 milliseconds average access time.
- Online storage capacity of 200 million to 800 million bytes in 100 million byte increments.
- Data rate of 806,000 bytes per second.
- Average rotational delay of 8.4 milliseconds.
- Rotational position sensing permits channel disconnection during rotational delay.
- Multiple requesting enables multiple channel programs to be simultaneously active on a single facility.
- Command retry enables the facility to recover from most storage control and disk storage errors without use of error recovery programs.
- Error correction circuitry in the 3830 detects and corrects error bursts of up to 11 bits.
- Powered drawers and front pack loading.
- Interchangeable address plugs permit online servicing of one 3330 drive while processing continues on other 3330 drives.

GENERAL DESCRIPTION

The 3830/3330 facility, consisting of an IBM 3830 Storage Control and from one to four IBM 3330 Disk Storage units, is attached to an IBM 2880 Block Multiplexer Channel or to integrated system channels with block multiplexing capability.

Two models of the 3330 are available: 3330 Model 1, containing two independent disk drives; 3330 Model 2, containing one disk drive. Each drive contains an IBM 3336 Disk Pack providing up to 100 million bytes of storage. On mixed strings of 3330 models, the single physical address of a Model 2 drive is the higher of the two available. For example: a Model 2 drive in the fourth position has an address of H.

Wherever possible the 3830/3330 facility is program-compatible with other IBM direct access storage devices. Major compatibility areas are the data format, channel commands, and permissible instruction sequences. Additional commands are provided for new features and increased serviceability. File scan commands (standard on the IBM 2314 Direct Access Storage Facility) are not used with the 3830/3330.

Removable address plugs permit the logical device addresses of the drives to be changed. An additional service plug permits customer engineer servicing from the CE panel.

A usage meter is provided for the 3830 Storage Control. There are no usage meters on the 3330 Disk Storage units.

The functions of each unit in a basic system configuration are shown in Figure 1.

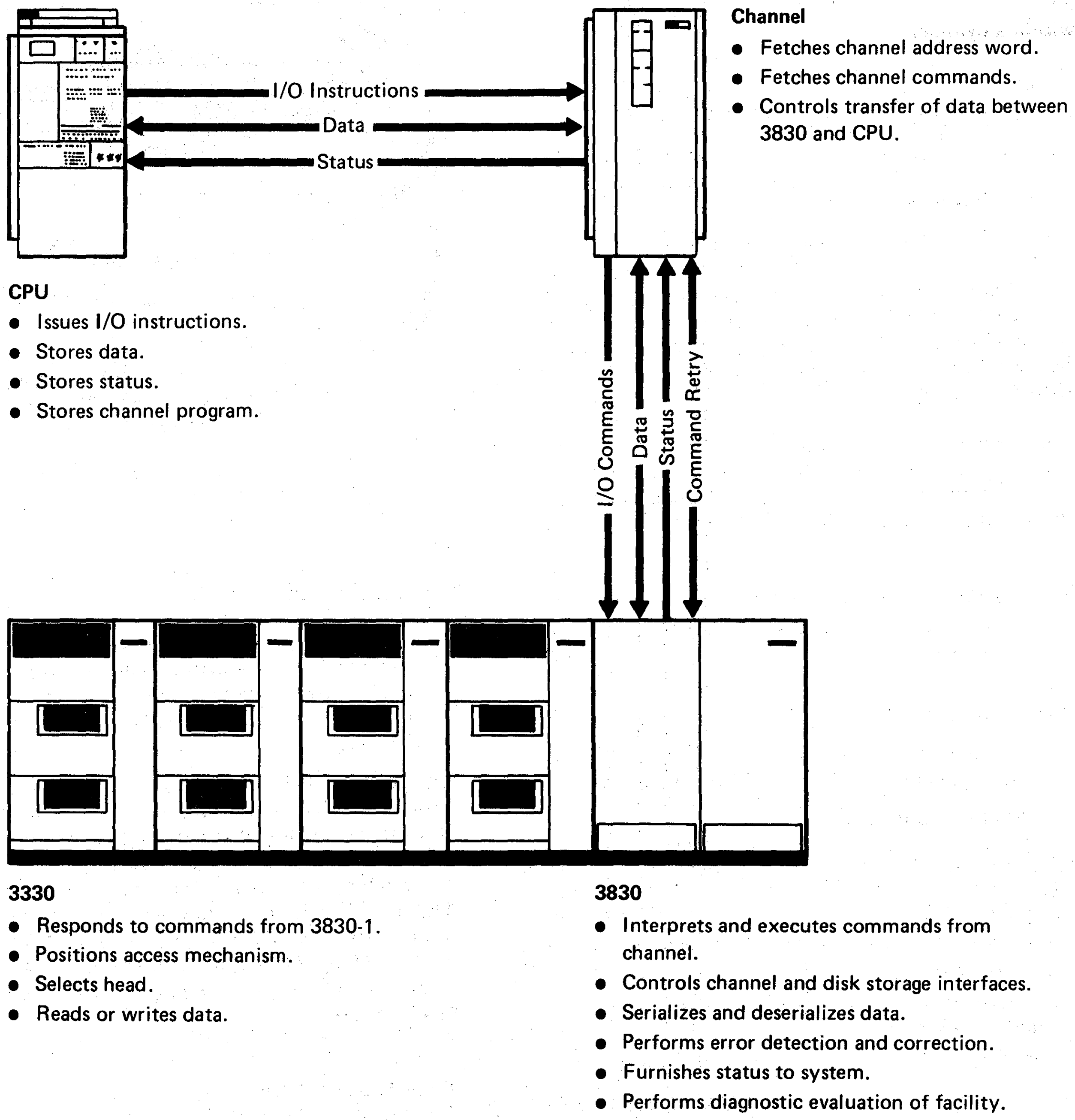
Standard Features

The following standard features are included in all 3830/3330 facilities.

Rotational Position Sensing (RPS): Allows the channel and storage control to be released during most of the record search time. This increases channel and storage control availability for other operations.

Multiple Requesting: Allows up to eight channel programs (one per drive) to be simultaneously active.

Command Retry: A channel-storage control procedure which, under certain conditions, causes a command to be retried without an I/O interrupt. This procedure is initiated by the storage control and used to recover from correctable errors.



Channel

- Fetches channel address word.
- Fetches channel commands.
- Controls transfer of data between 3830 and CPU.

CPU

- Issues I/O instructions.
- Stores data.
- Stores status.
- Stores channel program.

3330

- Responds to commands from 3830-1.
- Positions access mechanism.
- Selects head.
- Reads or writes data.

3830

- Interprets and executes commands from channel.
- Controls channel and disk storage interfaces.
- Serializes and deserializes data.
- Performs error detection and correction.
- Furnishes status to system.
- Performs diagnostic evaluation of facility.

Figure 1. Functional Description

Record Overflow: Provides a means for processing logical records which exceed the track boundaries within a cylinder.

Usage/Error Recording: The storage control maintains a statistical data record of usage and error information for each drive.

Special Features

Special features are optional at extra cost.

Two Channel Switch: A special feature enabling two channels to share the storage control and drives. (The switch allows individual drives to be reserved, using the Reserve/Release commands, for the exclusive use of either channel.)

Two Channel Switch Additional: With the two channel switch installed, this special feature enables four channels to share the storage control and drives. The storage control can be reserved exclusively for any channel.

Write Inhibit: The write inhibit special feature provides the means for protecting packs from being rewritten or erased.

Speed and Capacity

- Average access times:

One cylinder	10 milliseconds
Average number of cylinders	30 milliseconds
Maximum number of cylinders	55 milliseconds

- Data rate: 806 thousand bytes per second
- Rotational delay: (a minimum of 250 microseconds required for channel connection)

Minimum	0 milliseconds
Average	8.4 milliseconds
Maximum	16.7 milliseconds

- Cylinders per pack: 411 (including 7 alternates)
- Tracks per cylinder: 19
- Tracks per pack: 7,809 (including 133 alternates)
- Capacity:

Per track	13,030 bytes
Per cylinder	247,570 bytes
Per pack	100,000,000 bytes

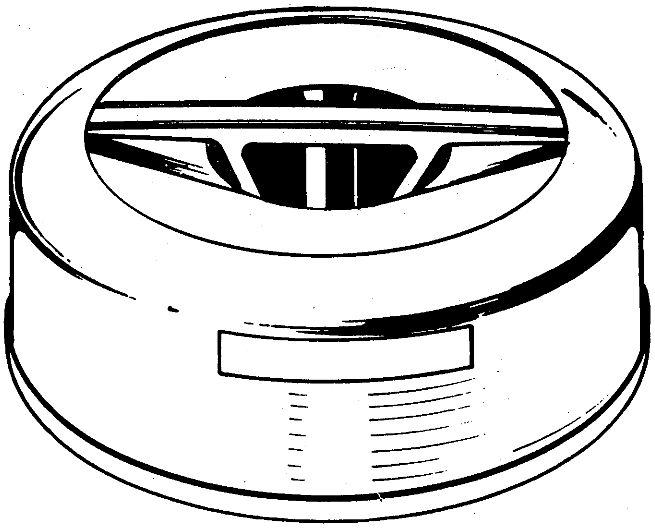


Figure 2. IBM 3336 Disk Pack

IBM 3336 DISK PACK

The IBM 3330 Disk Storage uses the IBM 3336 Disk Pack (Figure 2) as a storage medium. The pack is removable and interchangeable so information written on one 3330 drive can be read and updated by another 3330 drive.

The compact 3336 Disk Pack weighs about 20 pounds. Protective disks on the top and bottom of the disk stack minimize any physical damage that might result from mishandling. The disk pack is stored in a two-piece cover to prevent dust accumulation and damage. The bottom section includes a shock-absorbing bumper strip for additional protection. Additional pack handling information is found in *IBM Disk Pack and Cartridge Handling Procedures,* Order No. GA26-5756.

Pack Initialization

All 3336 packs are initialized at the factory with a home address and an eight-byte track descriptor (record 0) written on all tracks. Any defective track is flagged and an alternate track assigned.

Available IBM utility programs (IBCDASDI, IEHDASR, and IEHATLAS) flag defective tracks and assign alternates if the packs data areas become defective during normal operations.

IBM utility programs (IBCDASDI and IEHDASDR) are available to write the label, Volume Table of Contents (VTOC), and Initial Program Load (IPL) records. These programs also determine the number of flagged tracks for the VTOC entry.

Formats

RECORD FORMAT

The basic unit of information recorded on a 3830/3330 is a byte which consists of eight bits. A group of bytes separated by a special gap is an area. Areas are combined to make a record, the logical unit of information. One or more records are written on a track together with information used by the 3830 Storage Control.

A record consists of three areas: count, key (optional), and data. The significance of the bytes in these areas is shown in Figure 3.

Count Area

The count area contains the location of a data record on a specific track, and defines the size of the key and data areas in that record. The count area is written when the record is formatted and is not changed unless the record is reformatted.

Key Area

Use of the key area depends on the programmer. When used, the key area contains the primary identification of the data area in the record. This identification could be a social security number, part number, employee number, or any other unique identification.

Key area length is defined by the KL byte in the count area. If the KL byte is zero, the key area and following gap are omitted from the record.

Once formatted, the key area contents, but not the length, can be changed. If the key area is changed, the data area of the record must also be rewritten.

Data Area

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

The data area length is defined by the DL bytes in the count area. If the DL bytes are zero, an end-of-file record is written (see End-of-File).

Once formatted, the data area contents, but not its length, can be changed. The data area contents can be changed without affecting any other area in the record.

TRACK FORMAT

All tracks are formatted beginning at index and ending at the following index. Each track has the same basic format: home address, record 0 (track descriptor), and one or more data records. The records, and the areas in the records, are separated by gaps.

Home Address

Each track contains one home address which defines the track location (track address) and condition. Home address is the first recorded area following index and is separated from index by a G1 gap (see Figure 3).

Special commands are used for writing and reading the home address: Write HA and Read HA. The home addresses are normally written at the factory.

Record 0 (Track Descriptor)

Record 0 (R0) is always the first record following the home address area. Although R0 can be used as a normal data record, it is usually reserved by the operating system to store track information.

In IBM programming systems, the count area CCHH bytes of a defective track provide the address of the alternate track. If the track is an alternate, the CCHH bytes contain the address of the defective track. (The 3830 Storage Control uses this information for internal error recovery procedures.) No key area is specified in the KL byte. An eight-byte data area stores the number of track records contained on the track and the number of bytes remaining on the track.

Special commands, Write R0 and Read R0, are used for writing and reading record 0. These track descriptor records are normally formatted when the pack is manufactured.

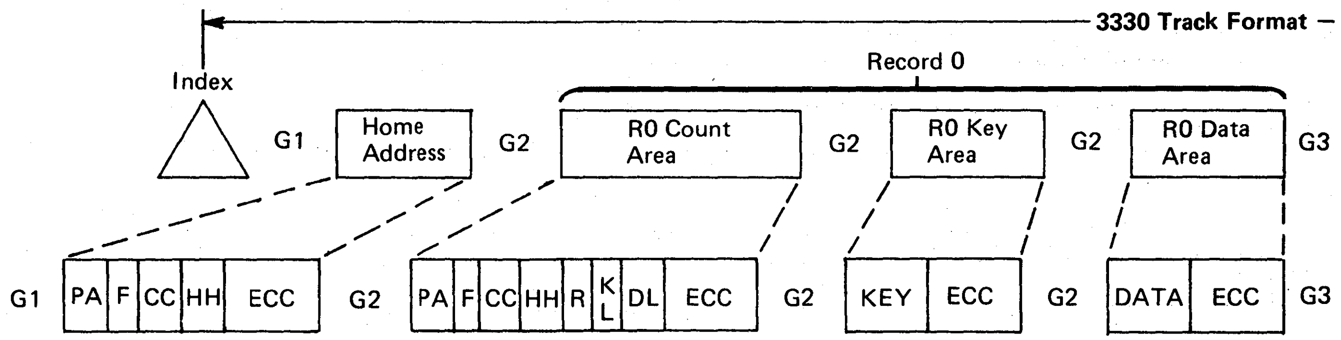
Data Records

One or more data records may follow record 0 on a track. The IBM 3330 uses self-formatting records with the count area specifying the record format and length. The record format is determined when the count, key, and data areas are originally written by a Format Write command (see Channel Commands). The record format is not changed until the entire record is rewritten by another Format Write command.

Data records and R0s can be formatted with or without keys. The file organization generally determines whether keys are used. If a sequential file is always processed sequentially, there is no reason to format with keys. If there is an appreciable amount of nonsequential processing, the records should be formatted with keys for faster access.

Gaps

Gaps are written by the storage control to separate records and areas within the records. Gaps usually include a unique combination of bits and recording areas to maintain orientation and synchronization between the storage control and the disk storage. Gaps are neither accessible to, nor under the control of the using system.



INDEX POINT: indicates the start of all tracks.

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

HOME ADDRESS

Supplies basic track information, one home address per track following index.

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

F (Flag): Defines track condition as follows:

Bits 0–4	Unused, should be zeros.
Bit 5	When on, indicates a CE pack (must be zero for customer packs).
Bits 6, 7	Track Status
00	Normal Primary
01	Normal Alternate
10	Defective Primary
11	Defective Alternate

CC (Cylinder Number): Specifies the cylinder number (from 0 to 410).

HH (Head Number): Specifies the read/write head within the selected cylinder (from 0 to 18).

ECC (Error Correction Code): Generated by the storage control for error detection and correction.

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

Figure 3. Record and Track Format

RECORD ZERO

R0 Count Area

PA: Same as Home Address.

F (Flag): Defines track condition as follows:

Bits 0–5:	Unused, should be zeros.
Bits 6, 7	Track Status
00	Normal Primary
01	Normal Alternate
10	Defective Primary
11	Defective Alternate

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.

ECC (Error Correction Code): Same as Home Address.

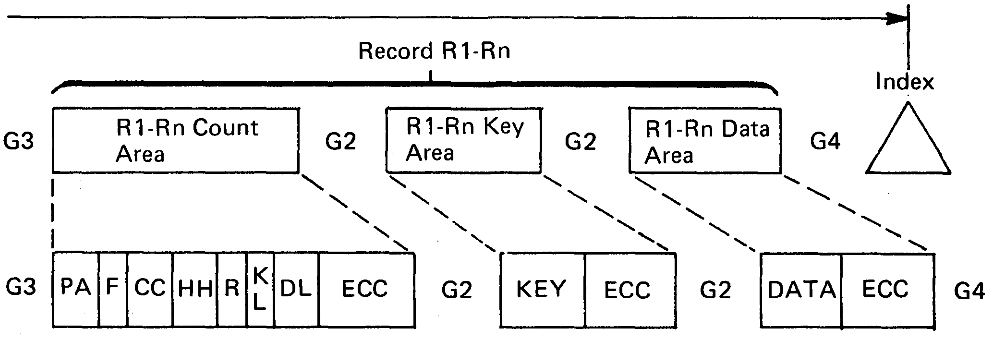
G2 (Gap 2): Separates record zero key (if used) and data areas.

R0 Key Area

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

ECC (Error Correction Code): 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.)

ECC (Error Correction Code): Detects single error bursts up to 22 bits and corrects single error bursts up to 11 bits.

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

DATA RECORDS (R1 – Rn)

R1 – Rn Count Area

PA: Same as Home Address.

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

Bits 0–3:	Unused, should be zeros.
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

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.

ECC: 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.

ECC: Same as Home Address.

G2: Separates record areas.

R1 – Rn Data Area

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

ECC: Same as R0 Data Area.

G2: Separates the records on a track.

G4: Writes zeros from the end of the last data field to index.

Track Capacity and Error Detection

TRACK CAPACITY

The number of records that can be recorded on a track depends on the record size. The following equation has allowances for the home address and standard R0 area.

The number of equal length records per track =

$$\frac{13{,}165 \text{ (track capacity)}}{135+C+KL+DL \text{ (bytes/record)}}$$

where:

$$\begin{aligned} C\text{(overhead/record)} &= 0 \text{ if } KL = 0 \\ &= 56 \text{ if } KL \neq 0 \\ KL &= \text{key length} \\ DL &= \text{data length} \end{aligned}$$

The number of records *(n)* of different key and data lengths that can be recorded on a track must satisfy the following equation (the standard R0 is already accounted for):

$$13{,}165 - \sum_{i=1}^{n} (135 + C + KLi + DLi) \geq 0$$

$$\begin{aligned} \text{Where } C &= 0 \text{ if } KL = 0 \\ &= 56 \text{ if } KL \neq 0 \end{aligned}$$

The tables shown in Figures 4 and 5 give maximum sizes of *n* equal-length records on a track where *n* is all possible values. Track, cylinder, and data pack capacities are given in both the number of bytes and the number of records.

There are tables for records without keys and for records with keys. In both tables, overhead for home address and standard R0 (KL=0, DL=8) is already accounted for.

ERROR DETECTION AND CORRECTION

Data errors are detected and corrected by two automatic recovery systems as well as optional checks that can be incorporated by the programmer.

CPU Parity

To ensure accurate data transmission through the channel between the CPU and the storage control, odd parity is maintained. This means that each 8-bit byte is checked before being transmitted and an additional bit is added to the byte. If the total number of ones in the byte is even, the extra bit is a one; and if the total number of ones is odd, a zero bit is added. This results in all bytes (eight bits plus a parity bit) having an odd number of ones.

As each byte is received it is checked for odd parity by the storage control. Should a byte have an even number of ones, an error is signaled and the byte is retransmitted. After the parity check is complete, the parity bit is removed from the byte.

Error Correction Code

After removing the parity bit, the storage control computes the error correction code bytes which are added to each recorded area on the drive. The seven correction code bytes are used for both error detection and correction.

When the data is read from the disk to the channel, each area is checked by the storage control and the error correction code (ECC) bytes are recalculated. The storage control ECC corrects single bursts of 11 bits or less.

If correctable or uncorrectable data errors are found in the home address, count, or key areas, the storage control starts the correction process by using command retry (See Command Retry). If a correctable data error in a data area is found, error correction is made by the system error recovery procedures (see Error Recovery Procedures).

The ECC bytes are removed and parity bits are attached by the storage control before the data is transferred to the channel.

Data Integrity

Unless corrected immediately, soft write errors cause hard read errors when the data is read. Therefore, where data integrity is required, the program should incorporate verification steps. The record can then be rewritten and verified before the original data is destroyed by the program.

Either of two verification methods may be used: full readback check, or correction code check.

FULL READBACK CHECK

All of the data just written is read back into main storage and compared, byte-for-byte, with the original information.

CORRECTION CODE CHECK

A read operation is made with the skip bit on. This causes the storage control to check the validity of the record using the error correction code bytes.

Capacities With Keys							
Bytes Per Record (KL+DL)		Records Per				Bytes Per Pack (KL+DL)	
Minimum	Maximum	Track	Cylinder	Pack	8 Drives	Minimum	Maximum
2	2	68	1292	521968	4175744	1043936	1043936
3	5	67	1273	514292	4114336	1542876	2571460
6	8	66	1254	506616	4052928	3039696	4052928
9	11	65	1235	498940	3991520	4490460	5488340
12	14	64	1216	491264	3930112	5895168	6877696
15	17	63	1197	483588	3868704	7253820	8220996
18	21	62	1178	475912	3807296	8566416	9994152
22	24	61	1159	468236	3745888	10301192	11237664
25	28	60	1140	460560	3684480	11514000	12895680
29	32	59	1121	452884	3623072	13133636	14492288
33	35	58	1102	445208	3561664	14691864	15582280
36	39	57	1083	437532	3500256	15751152	17063748
40	44	56	1064	429856	3438848	17194240	18913664
45	48	55	1045	422180	3377440	18998100	20264640
49	52	54	1026	414504	3316032	20310696	21554208
53	57	53	1007	406828	3254624	21561884	23189196
58	62	52	988	399152	3193216	23150816	24747424
63	67	51	969	391476	3131808	24662988	26228892
68	72	50	950	383800	3070400	26098400	27633600
73	77	49	931	376124	3008992	27457052	28961548
78	83	48	912	368448	2947584	28738944	30581184
84	89	47	893	360772	2886176	30304848	32108708
90	95	46	874	353096	2824768	31778640	33544120
96	101	45	855	345420	2763360	33160320	34887420
102	108	44	836	337744	2701952	34449888	36476352
109	115	43	817	330068	2640544	35977412	37957820
116	122	42	798	322392	2579136	37397472	39331824
123	130	41	779	314716	2517728	38710068	40913080
131	138	40	760	307040	2456320	40222240	42371520
139	146	39	741	299364	2394912	41611596	43707144
147	155	38	722	291688	2333504	42878136	45211640
156	164	37	703	284012	2272096	44305872	46577968
165	174	36	684	276336	2210688	45595440	48082464
175	185	35	665	268660	2149280	47015500	49702100
186	196	34	646	260984	2087872	48543024	51152864
197	207	33	627	253308	2026464	49901676	52434756
208	220	32	608	245632	1965056	51091456	54039040
221	233	31	589	237956	1903648	52588276	55443748
234	247	30	570	230280	1842240	53885520	56879160
248	262	29	551	222604	1780832	55205792	58322248
263	279	28	532	214928	1719424	56526064	59964912
280	296	27	513	207252	1658016	58030560	61346592
297	315	26	494	199576	1596608	59274072	62866440
316	335	25	475	191900	1535200	60640400	64286500
336	357	24	456	184224	1473792	61899264	65767968
358	381	23	437	176548	1412384	63204184	67264788
382	407	22	418	168872	1350976	64509104	68730904
408	435	21	399	161196	1289568	65767968	70120260
436	467	20	380	153520	1228160	66934720	71693840
468	501	19	361	145844	1166752	68254992	73067844
502	540	18	342	138168	1105344	69360336	74610720
541	583	17	323	130492	1043936	70596172	76076836
584	631	16	304	122816	982528	71724544	77496896
632	686	15	285	115140	921120	72768480	78986040
687	749	14	266	107464	859712	73827768	80490536
750	821	13	247	99788	798304	74841000	81925948
822	906	12	228	92112	736896	75716064	83453472
907	1005	11	209	84436	675488	76583452	84858180
1006	1125	10	190	76760	614080	77220560	86355000
1126	1271	9	171	69084	552672	77788584	87805764
1272	1454	8	152	61408	491264	78110976	89287232
1455	1689	7	133	53732	429856	78180060	90753348
1690	2003	6	114	46056	368448	77834640	92250168
2004	2442	5	95	38380	307040	76913520	93723960
2443	3100	4	76	30704	245632	75009872	95182400
3101	4197	3	57	23028	184224	71409828	96648516
4198	6391	2	38	15352	122816	64447696	98114632
6392	12974	1	19	7676	61408	49064992	99588424

Figure 4. Record and Track Capacities With Keys.

Capacities Without Keys							
Bytes Per Record (KL+DL)		Records Per				Bytes Per Pack (KL+DL)	
Minimum	Maximum	Track	Cylinder	Pack	8 Drives	Minimum	Maximum
1	2	96	1824	736896	5895163	736896	1473792
3	3	95	1805	729220	5833760	2187660	2187660
4	5	94	1786	721544	5772352	2886176	3607720
6	6	93	1767	713868	5710944	4283208	4283208
7	8	92	1748	706192	5649536	4943344	5649536
9	9	91	1729	698516	5588128	6286644	6286644
10	11	90	1710	690840	5526720	6908400	7599240
12	12	89	1691	683164	5465312	8197968	8197968
13	14	88	1672	675488	5403904	8781344	9456832
15	16	87	1653	667812	5342496	10017180	10684992
17	18	86	1634	660136	5281088	11222312	11882448
19	19	85	1615	652460	5219680	12396740	12396740
20	21	84	1596	644784	5158272	12895680	13540464
22	23	83	1577	637108	5096864	14016376	14653484
24	25	82	1558	629432	5035456	15106368	15735800
26	27	81	1539	621756	4974048	16165656	16787412
28	29	80	1520	614080	4912640	17194240	17808320
30	31	79	1501	606404	4851232	18192120	18798524
32	33	78	1482	598728	4789824	19159296	19758024
34	35	77	1463	591052	4728416	20095768	20686820
36	38	76	1444	583376	4667008	21001536	22168288
39	40	75	1425	575700	4605600	22452300	23028000
41	42	74	1406	568024	4544192	23288984	23857008
43	45	73	1387	560348	4482784	24094964	25215660
46	47	72	1368	552672	4421376	25422912	25975584
48	50	71	1349	544996	4359968	26159808	27249800
51	53	70	1330	537320	4298560	27403320	28477960
54	55	69	1311	529644	4237152	28600776	29130420
56	58	68	1292	521968	4175744	29230208	30274144
59	61	67	1273	514292	4114336	30343228	31371812
62	64	66	1254	506616	4052928	31410192	32423424
65	67	65	1235	498940	3991520	32431100	33428980
68	70	64	1216	491264	3930112	33405952	34388480
71	73	63	1197	483588	3868704	34334748	35301924
74	77	62	1178	475912	3807296	35217488	36645224
78	80	61	1159	468236	3745888	36522408	37458880
81	84	60	1140	460560	3684480	37305360	38687040
85	88	59	1121	452884	3623072	38495140	39853792
89	91	58	1102	445208	3561664	39623512	40513928
92	95	57	1083	437532	3500256	40252944	41565540
96	100	56	1064	429856	3438848	41266176	42985600
101	104	55	1045	422180	3377440	42640180	43906720
105	108	54	1026	414504	3316032	43522920	44766432
109	113	53	1007	406828	3254624	44344252	45971564
114	118	52	988	399152	3193216	45503328	47099936
119	123	51	969	391476	3131808	46585644	48151548
124	128	50	950	383800	3070400	47591200	49126400
129	133	49	931	376124	3008992	48519996	50024492
134	139	48	912	368448	2947584	49372032	51214272
140	145	47	893	360772	2886176	50508080	52311940
146	151	46	874	353096	2824768	51552016	53317496
152	157	45	855	345420	2763360	52503840	54230940
158	164	44	836	337744	2701952	53363552	55390016
165	171	43	817	330068	2640544	54461220	56441628
172	178	42	798	322392	2579136	55451424	57385776
179	186	41	779	314716	2517728	56334164	58537176
187	194	40	760	307040	2456320	57416480	59565760
195	202	39	741	299364	2394912	58375980	60471528
203	211	38	722	291688	2333504	59212664	61546168
212	220	37	703	284012	2272096	60210544	62482640
221	230	36	684	276336	2210688	61070256	63557280
231	241	35	665	268660	2149280	62060460	64747060
242	252	34	646	260984	2087872	63158128	65767968
253	263	33	627	253308	2026464	64086924	66620004

Figure 5. Record and Track Capacities Without Keys (Part 1).

Capacities Without Keys							
Bytes Per Record (KL+DL)		Records Per				Bytes Per Pack (KL+DL)	
Minimum	Maximum	Track	Cylinder	Pack	8 Drives	Minimum	Maximum
264	276	32	608	245632	1965056	64846848	67794432
277	289	31	589	237956	1903648	65913812	68769284
290	303	30	570	230280	1842240	66781200	69774840
304	318	29	551	222604	1780832	67671616	70788072
319	335	28	532	214928	1719424	68562032	72000880
336	352	27	513	207252	1658016	69636672	72952704
353	371	26	494	199576	1596608	70450328	74042696
372	391	25	475	191900	1535200	71386800	75032900
392	413	24	456	184224	1473792	72215808	76084512
414	437	23	437	176548	1412384	73090872	77151476
438	463	22	418	168872	1350976	73965936	78187736
464	491	21	399	161196	1289568	74794944	79147236
492	523	20	380	153520	1228160	75531840	80290960
524	557	19	361	145844	1166752	76422256	81235108
558	596	18	342	138168	1105344	77097744	82348128
597	639	17	323	130492	1043936	77903724	83384388
640	687	16	304	122816	982528	78602240	84374592
688	742	15	285	115140	921120	79216320	85433880
743	805	14	266	107464	859712	79845752	86508520
806	877	13	247	99788	798304	80429128	87514076
878	962	12	228	92112	736896	80874336	88611744
963	1061	11	209	84436	675488	81311868	89586596
1062	1181	10	190	76760	614080	81519120	90653560
1182	1327	9	171	69084	552672	81657288	91674468
1328	1510	8	152	61408	491264	81549824	92726080
1511	1745	7	133	53732	429856	81189052	93762340
1746	2059	6	114	46056	368448	80413776	94829304
2060	2498	5	95	38380	307040	79062800	95873240
2499	3156	4	76	30704	245632	76729296	96901824
3157	4253	3	57	23028	184224	72699396	97938084
4254	6447	2	38	15352	122816	65307408	98974344
6448	13030	1	19	7676	61408	49494848	100018280

Figure.5. Record and Track Capacities Without Keys (Part 2).

Input/Output Operations

An input/output operation usually transfers data between the central processing unit (CPU) main storage and an I/O device. An I/O operation is started by a programmed instruction that references a channel command address. The storage control receives the command from the channel, decodes it, and starts the I/O device.

GENERAL DESCRIPTION

Operations requiring logical and arithmetical decisions are performed with the CPU in the problem state. For I/O operations, the CPU must be in the supervisor state.

The CPU is changed from problem to supervisor state when a supervisor call instruction (program initiated) is executed or when an I/O interrupt (device initiated) occurs. The system status that existed at the time of the change is stored in the program status word (see Program Status Word) so the program can be resumed after the interrupt has been serviced.

Supervisor State

When in the supervisor state the CPU can execute the following instructions:

- Start I/O — This starts an I/O operation if the addressed channel, storage control, and disk storage device are available.
- Start I/O Fast Release — This instruction starts an I/O operation if the addressed channel is available. If the storage control and disk drive are not available, an I/O interrupt is returned to indicate an unavailable condition.
- Halt I/O — The channel operation in progress is stopped, and the storage control is disconnected from the channel.
- Halt Device — This terminates the operation at the storage control but does not interfere with other channel I/O operations. This instruction should be used on IBM Block Multiplexer channels instead of Halt I/O.
- Test I/O — The condition code in the program status word (PSW) is set to indicate the condition of the channel, sub-channel, storage control, and device.

The I/O instruction format is shown in Figure 6.

Byte 0	1	2		3
Operation Code		B1	D1	

Byte 0	Bits 0–7	Operation Code
Byte 1	Bits 0–6	Not Used
	Bit 7	On for Start I/O Fast Release or Halt Device.
Byte 2	Bits 0–2	Base address register location (B1) in CPU. Only the low-order 24 bits of the 32 bit register are used.
	Bits 3–7	Displacement (D1). B1 and D1 are added together.
Byte 3	Bits 0–7	Base address register location identifies device addressed by the instruction.

After summing, the last two bytes of the instruction indicate:

Byte 2	Bits 0–3	Must be zero.
	Bits 4–7	Channel address.
Byte 3	Bits 0–4	Storage control address.
	Bits 5–7	Device address.

Figure 6. I/O Instruction Format

CHANNEL OPERATION

The channel directly controls the I/O devices and storage controls. Depending on the System/370 model involved, there may be a single channel or several channels used in I/O operations.

After the channel has received and executed the I/O instruction, the channel selects and governs the storage control and drive that is addressed by the instruction. Reserved CPU main storage locations contain information and instructions that direct the channel in completing the operation. A pointer to this data is contained in the channel address word (CAW).

Channel Address Word

After the channel receives a Start I/O or Start I/O Fast Release, it fetches the channel address word. The channel address word (CAW) is a 4-byte word located at CPU main storage address 72 (decimal). It points to the first channel command word (CCW) in a chain of commands. The first half byte of the CAW contains a protection key, and the last three bytes contain the CCW address. The protection key is used by the channel to ensure that the user's data transfer operations are placed in the CPU main storage locations assigned to that user by the system control program.

The channel fetches the CAW, which must have been placed at address 72 before the I/O instruction is issued. The CAW format is shown in Figure 7.

Byte 0	1	2	3
Key 0000	Command Address		

Byte 0;	Bits 0–3	Storage Protection Key (must match storage key).
	Bits 4–7	Always zero.
Byte 1;	Bits 0–7	Command address, location of first CCW in CPU main storage.
Byte 2;	Bits 0–7	
Byte 3;	Bits 0–7	

Figure 7. Channel Address Word (CAW)

Channel Command Word

The channel fetches the first channel command word (CCW) from the address specified by the CAW. The CCW indicates the operation to be done, the CPU main storage addresses to be used, and the action to be taken on completion.

After receiving the CCW, the channel selects the device specified by sending the address to all attached storage control units. If the indicated device is available, the command code from the CCW is sent to the storage control which returns an initial status byte to the channel. Should the channel, storage control, or drive be already in use, a busy signal is sent to the CPU which will retry the command a short time later.

The channel execution sequence for each CCW is at the channel/storage control interface. The CCW format is shown in Figure 8.

CCW Functions

The channel command word consists of eight bytes.

BYTE 0

The first byte contains the command code (see Channel Commands). This byte specifies the operation to be performed. The two low-order bits, or when these bits are 00, the four low-order bits of the command code identify the operation to the channel. The channel recognizes the operations of Write, Control, Read, Sense, or Transfer in Channel. Commands that start I/O operations transfer all eight bits to the storage control.

BYTES 1, 2, and 3

These specify the address of the area for operations involving data transfer.

BYTE 4

The flag byte is used for command modifying instructions. These bits are discussed in greater detail as follows:

Bit 0 Chain Data Flag: When set to one this bit specifies that the data is chained. The data rate of the device and system to which it is attached can limit the use of this bit.

Bit 1 Chain Command Flag: This bit indicates that the commands are chained. It causes the operation specified by the command code in the next CCW to be started on normal completion of the current operation. This bit cannot be used when bit 0 (chain data) is on.

Bit 2 Suppress Length Indicator (SLI) Flag: Bit 2 is used to suppress an incorrect length indication except when the CCW count is not exhausted, channel end is present, and data chaining is indicated. The SLI bit should be on for Restore, Recalibrate, No-op, and some Space Count commands.

Bit 3 Skip Flag: When set to one, the skip bit specifies the suppression of a transfer of information to the main storage during a Read or Sense Operation. The data is checked just as if it were to be stored.

Bit 4 Program Control Interrupt Flag: This bit causes the channel to generate an interrupt when the CCW is fetched.

Byte 0	1	2	3	4	5	6	7
Command Code	Data Address			Flags 000	Not Used	Count	

Byte 0	Bits 0–7	Command Code
Byte 1	Bits 0–7	Data Address
Byte 2	Bits 0–7	
Byte 3	Bits 0–7	
Byte 4	Bit 0	Chain Data
	Bit 1	Chain Command
Byte 4	Bit 2	Suppress Length Indicator (SLI)
	Bit 3	Skip Flag
	Bit 4	Program Control Interrupt
	Bit 5–7	Always zero except for TIC (Transfer In Channel)
Byte 5	Bits 0–7	Not Used
Byte 6	Bits 0–7	Count
Byte 7	Bits 0–7	

Figure 8. Channel Command Word

Bits 5-7: Not used. These bits are always set to zero except when a TIC command is used, see Transfer-in-Channel command.

BYTE 5

Not used.

BYTES 6 and 7

Specify the number of byte locations in the main storage area designated by the data address.

Channel Status Word

The channel status word (CSW) for each chain of commands is placed in CPU main storage starting at location 64 (decimal). The CSW informs the CPU program of the I/O device status or condition.

Status information is presented twice, at the start of an operation and at its end, for all commands except certain Seek commands that require access motion and for Set Sector commands. Seek commands present their status when the command is received, at the start of the access motion and following completion of the operation. Seek and Seek Cylinder commands present initial status, channel end (after seek address transfer), and device end after the access mechanism is positioned. The Set Sector command presents initial status, channel end (after the sector number is transferred), and device end (when the angular position is reached).

The CSW ending status is posted following completion of an operation. Should an operation be ended before completion, the bits in the status word indicate the reason for its ending.

The CSW, stored at location 64, remains unchanged until a later interruption or a new I/O instruction is processed. The channel status word format is shown in Figure 9.

Status Presentation

INITIAL STATUS

The initial status byte is zero for Test I/O and all non-immediate (data transferring) commands except when:

- The storage control is busy.
- A status condition is pending. (See Pending Status.)
- A unit check occurred.
- Initial status indicated command retry. (See Command Retry.)

Immediate commands (no data transfer) present channel end and device end for initial status.

ENDING STATUS

For most commands, the normal ending status presented is channel end and device end. The exceptions are noted in the individual command descriptions (see Channel Commands).

If an error occurred during the operation, unit check is posted along with channel end and device end.

PENDING STATUS

A pending status condition may exist for either the storage control or the disk storage drive.

Storage Control: Pending status for the storage control causes it to appear busy for all drives except the one with the existing status condition. If the storage control is not busy, it will request service to clear the pending status. The status is cleared when presented to, and accepted by, the channel.

The storage control has a pending status when:

- A disconnect was sent after a command but before channel end was accepted.
- Busy, channel end, or unit check status was stacked (not accepted) by the channel.
- The Test I/O response of zero was stacked by the channel.
- Storage control busy was sent to the channel.
- Unit check (error) was found in an operation after device end was cleared.
- Device end for a Set Sector command was stacked by the channel.

Disk Drive: Pending status for a drive causes the storage control to request service if neither the storage control nor drive is busy. The status is cleared when presented to, and accepted by, the channel.

The drive has pending status when:

- Channel end appears alone.
- Busy status is presented.
- The drive changes from not ready to ready.

CONTINGENT CONNECTION

A contingent connection exists in the storage control after the channel accepts a status byte with unit check. During the contingent connection state, the storage control appears busy to all other addresses except the one with the unit check.

The connection lasts until:

- A command (not Test I/O or No-Op) receives an initial status byte of zero for the storage control and drive address that generated the unit check.
- A selective or system reset occurs.

CSW Functions

The initial CSW is returned by the channel when a device is ready for data transmission. The ending CSW is used to finish the CCW chain.

CSW is built by the channel from the device conditions and then placed into main storage at address 64 (decimal). This causes an input/output interrupt which is analyzed by the I/O Supervisor program.

The CSW consists of eight 8-bit bytes. The first four bytes (0-3) contain the protection key and the address of the next command is the CCW chain. Byte 4 gives the condition of the device just used and is analyzed in detail below. Byte 5 indicates the channel conditions, and the last two bytes contain the residual count from the last CCW executed.

BYTE 4 — DEVICE STATUS

Byte 4 is particularly important because the bits, singly and in combination, signal the condition of both the device and the storage control to the channel and the CPU. The bits in byte 4 are discussed in greater detail as follows:

Bit 0 – Attention: Not used by the 3830.

Bit 1 – Status Modifier: The status modifier is set whenever a Search High, Search Equal, or a Search High or Equal command has been successfully executed. When this bit and the busy bit are both set, the storage control is busy. When bit 1 and unit check are both set, an unusual condition in the last operation requires a retry of the last channel command.

The status modifier when combined with unit check, channel end, and device end, indicates that the storage control and drive are prepared for command retry.

Bit 2 – Control Unit End: Control unit end is set if a busy (bit 3) condition was previously indicated and the busy condition is no longer valid. The storage control busy was indicated by bits 1 and 3 both being set. The drive address associated with the control unit end is the lowest non-busy drive on the highest numbered string even though the drive addressed may not exist.

Byte 0	1	2	3	4	5	6	7
Key 0000	CCW Address			Device Status	Channel Status	Residual Count	

Byte 0	Bits 0–3	Protection Key (storage protection for chain of operations)
	Bits 4–7	Not used -- always zero
Byte 1	Bits 0–7	Command Address, an address eight bytes higher than the last CCW used.
Byte 2	Bits 0–7	
Byte 3	Bits 0–7	
Byte 4	Device Status	
	Bit 0	Attention, not used by 3830
	Bit 1	Status Modifier
	Bit 2	Control Unit End
	Bit 3	Busy
	Bit 4	Channel End
	Bit 5	Device End
	Bit 6	Unit Check
	Bit 7	Unit Exception
Byte 5	Channel Status	
	Bit 0	Program-controlled Interrupt
	Bit 1	Incorrect Length
	Bit 2	Program Check
	Bit 3	Protection Check
	Bit 4	Channel Data Check
	Bit 5	Channel Control Check
	Bit 6	Interface Control Check
	Bit 7	Chaining Check
Byte 6	Bits 0–7	The residual count from the last CCW used.
Byte 7	Bits 0–7	

Figure 9. Channel Status Word

Bit 3 – Busy: The busy bit indicates that the addressed device is busy; when combined with status modifier, the storage control is busy. Busy can be combined with bit 2 (control unit end) and the CPU should then reissue the Start I/O command.

Bit 4 – Channel End: Channel end is set at the end of each command. This informs the CPU that the last command has been executed and the storage control is ready for the next command.

Bit 5 – Device End: Device end is set when the device addressed is available for subsequent use. Device end and channel end are returned to the CPU on completion of all commands that do not require access motion.

Bit 6 – Unit Check: Unit check is set when an unusual or error condition is detected. When combined with status modifier, it indicates that command retry is requested.

Channel end and device end are always presented with unit check (bit 6) when a command retry is not requested. A system interrupt then occurs and the sense bytes provide detailed information about the unusual condition.

Bit 7 – Unit Exception: Unit exception (bit 7) indicates that an end-of-file was detected during a Read IPL, Read R0, Read CKD, Read KD, Read D, Write KD, or Write Data operation. Bit 7 is not set for Read Count, Write CKD, Search Key, or Search ID commands. The unit exception is the result of a data length of zero. The key area, if any, is transferred by the command.

Program Status Word

As soon as an interrupt occurs, all current status information and an identification of the interrupt cause is put into a program status word (PSW). This "old" PSW is stored at a fixed location in the CPU. The control program then fetches a "new" PSW from a different location. Loading the new PSW causes the CPU to branch to a new instruction sequence and service the interrupt.

After the causes of the interrupt have been cleared, an instruction restores the "old" PSW as the current PSW and the system is returned to the pre-interrupt status then the interrupted routine continues.

The program status word format is shown in Figure 10.

Command Chaining

The storage control and drive combination can execute a series of channel commands from a single Start I/O instruction. This operation is called command chaining and is started by activating byte 4 bit 1 in the CCW.

When the channel senses byte 4 bit 1 on during a command, it automatically fetches the next CCW on completion of the command. The I/O operation is then executed after device end has been sent to the channel. Completion of the current CCW does not cause an I/O interrupt, and the count (indicating the amount of transferred data) is not available to the program.

Byte 0	1	2	3	4	5	6	7
System Mask	Key 0MWP	Interrupt Code		I C L C Mask	Instruction Address		

Byte 0;	Bit 0	Channel 0 Mask	System Mask
	Bit 1	Channel 1 Mask	
	Bit 2	Channel 2 Mask	
	Bit 3	Channel 3 Mask	
	Bit 4	Channel 4 Mask	
	Bit 5	Channel 5 Mask	
	Bit 6	Channel 6 Mask	
	Bit 7	External Mask	
Byte 1;	Bits 0–3	Protection Key	
	Bit 4	Must be zero for System/370 (0)	
	Bit 5	Machine check mark (M)	
	Bit 6	Wait state (W)	
	Bit 7	Problem state (P)	

Byte 2;	Bits 0–7	Interrupt Code	
Byte 3;	Bits 0–7		
Byte 4;	Bits 0,1	Instruction Length Code (ILC)	
	Bits 2,3	Condition Code (CC)	
	Bit 4	Fixed-point overflow mask	Program Mask
	Bit 5	Decimal overflow mask	
	Bit 6	Exponent underflow mask	
	Bit 7	Significance mask	
Byte 5;	Bits 0–7	Instruction Address	
Byte 6,	Bits 0–7		
Byte 7;	Bits 0–7		

Figure 10. Program Status Word (PSW)

Command chaining is normally used in all channel programs. The command chaining functions are executed during the time the gaps between record areas are passing the read/write heads.

Command chaining sequence restrictions are covered on the individual Channel Command pages.

Data Chaining

The data transferred between the CPU storage and a drive may be chained. This permits blocks of data to be transferred when it is stored in non-adjacent CPU storage locations.

Data chaining may be used to rearrange the information as it is transferred between the CPU and the drive. The process may also be combined with the skip flag bit so the program can place selected parts of a block of data into CPU storage.

When data chaining is specified (byte 4 bit 0 is on), the channel fetches a new CCW specifying a new storage location on completion of data transfer for the current channel command. Unless the command code specifies Transfer-In-Channel (TIC), the new CCW command code is ignored.

Data chaining occurs immediately after the last byte of data designated by the current CCW has been transferred to CPU main storage or accepted by the drive. If both data chaining and command chaining are indicated by the CCW, data chaining takes precedence and command chaining is ignored.

Note: *Data chaining capabilities are dependent on several variable factors including system type, I/O configuration, channel loading and so on. Because of these dependencies, read or write data chaining within record areas may cause unpredictable overruns or chaining errors. If these conditions are found or suspected, consult your IBM representative.*

Branching in Channel Programs

The next CCW in a chain of channel commands is normally taken from an address eight locations higher than the address of the current CCW. This sequence can be modified in either of two ways 1780

1. If command chaining is specified in a Search command, and execution of the command results in a status modifier bit (search satisfied), the channel fetches the next CCW from a CPU main storage address sixteen positions higher than the current channel command.
2. The Transfer-In-Channel command (TIC) may be used to modify the sequence of a chain of commands. The data address part of the TIC CCW specifies the main storage location of the next channel command word. Therefore, the next CCW may be fetched from any valid CPU main storage location.

These methods for modifying the sequence of a CCW chain provide for branching capabilities within a channel program.

Unit Selection and Device Addressing

The I/O addresses of the storage control and drive are indicated by an eight bit binary number in an I/O instruction. These addresses consist of two parts; the storage control address (determined by the customer when the unit is installed) in the five high-order bits and the disk drive address (determined by the logical address plugs) specified in the three low-order bits (see Figure 11).

The storage control accepts any drive address from 000 through 111. If the specified drive is either not attached or offline, the operation is terminated with unit check status. Multiple responses to an address (caused by duplicate logical address plugs or hardware failures) also stops the operation with a unit check status.

Note: *The addressing options provided in the storage control together with addressing options provided by external switches can cause problems in drive identification. For example, the same drive could be called 1A1, 2B1, 3C1, and 4C1 by system messages. This can be avoided by having the interfaces wired identically when the CE installs the system. The addresses in the example shown would then be 1A1, 2A1, 3A1, and 4A1.*

0	1	2	3	4	5	6	7
Storage Control Address					Drive Address		

Figure 11. Address Byte

BLOCK MULTIPLEXING

With block multiplexing, the storage control can disconnect from the channel following a channel end (without device end) even when the commands are chained. This disconnection reduces the number of CPU interrupts required to permit the overlap of channel data transfer when device mechanical motion is needed.

Block multiplexing allows channel commands involving physical movement to be included in command chains without tying-up the channel for the duration of the delay. The storage control retains the disconnected CCW chain control information for each of the drives in the string. In effect, the string can execute up to eight chains on a time-shared basis.

The control unit also allows disconnection during command retry procedures that require subsystem reorientation.

CONTROL COMMANDS

Control commands do not involve a transfer of data records between the storage control and main storage. However, in certain operations control bytes are transferred from main storage to the storage control. These bytes allow the operation to take place and are parity checked during transfer.

SEARCH COMMANDS

During the execution of Search commands, the channel operates in write mode while the disk storage operates in read mode. The storage control compares the data coming from main storage against that coming from the drive. When the search requirement has been satisified (for example, compared equal, high, etc.) the storage control returns a status modifier bit with channel end and device end. This bit causes the channel to skip the next CCW in the chain and fetch the next command from a storage location 16 positions higher than the current CCW.

Each Search command operates on one record at a time. To search another record, the command must be reissued. This is normally done by chaining a TIC command to the search command, as follows 1780

```
Search Key Equal
TIC*-8
Read Data
```

If the search is unsuccessful, the TIC command following the search command causes the search to be repeated. When a search is successful, the status modifier causes the TIC command to be skipped and the Read Data command is executed.

At the end of every field searched, data validity is verified by the correction code bytes following the searched field. After the correction code check, the appropriate ending status is generated and presented to the channel.

If a data overrun or data check is detected, the storage control attempts recovery through use of command retry. If command retry is unsuccessful, channel end, device end, and unit check status are presented.

READ COMMANDS

A read command transfers information from disk storage to the central processing unit. Read commands may operate in either single track or multitrack mode.

> **Note:** *Read IPL and Read Sector do not operate in multitrack mode.*

On all read commands, the storage control checks the validity of each record area as it is transferred from the disk storage to the storage control. After the error correction code bytes have been examined and data validity is established, the storage control sends an ending status byte of channel end and device end to the channel.

If a data overrun or data check is detected, the storage control normally attempts recovery through use of command retry. If command retry is unsuccessful or not used, channel end, device end and unit check are presented to the channel.

WRITE COMMANDS

Formatting Write Commands

Formatting write commands initialize tracks and records, and establish the length of the areas within each record. Error correction code bytes are calculated and written after each record area.

The formatting write commands are:

- Write Home Address. (See Note in Write HA Channel Command description).
- Write R0. (See Note in Write R0 Channel Command description).
- Write Count, Key, and Data.
- Write Special Count, Key, and Data.
- Erase.

The command prerequisites and file mask settings for these commands are exact; any violation prevents command execution.

Format write commands may be chained if each satisfies the chaining requirements. After the last write format command in a chain has been completed, the storage control erases the remaining portion of the track.

If a command (other than a format write command) is chained from a format write command, it is executed after the track has been erased. If the command is a control command, the storage control uses command retry to free the channel while the track is erased. If a new command chain is attempted before the end of the track is reached, a short control unit busy sequence (busy and status modifier bits) is presented to the channel. In this case, a control unit end signal is generated at the end of the track.

Update Write Commands

Update (non-formatting) Write commands are used to update existing records and must operate on previously formatted tracks. Error correction code bytes are calculated and written after each key and/or data area in the record.

The update Write commands are:

- Write Data.
- Write Key and Data.

Should a data overrun occur during an update write operation (excluding the second and subsequent segments of an overflow record), the storage control attempts recovery with command retry. If the retry is unsuccessful, channel end, device end, and unit check status are presented to the channel.

SENSE/TEST I/O COMMANDS

These commands are used to determine the status of the IBM 3830/3330 facility and identify the specific errors or unusual conditions that have occurred.

Since the Test I/O "command" is not the result of the channel executing a CCW, its operation is explained at this time instead of with the other channel commands. A Test I/O command (command code 0000 0000) is not written by the programmer. A command code of all zeros is considered invalid and causes a program check.

The Test I/O command is automatically generated by the channel when the channel requires status information or is the result of processing a Test I/O instruction. In either case, it appears to the storage control as a command byte of all zeros and is treated as an immediate command. Test I/O requests the storage control to send all outstanding status information to the channel and normally presents an all-zero status byte. Stacked or pending status (if any) is presented in initial status.

CHANNEL COMMAND SUMMARY

The channel commands, command codes, and command description page numbers are shown in Figure 12.

COMMAND	COMMAND CODE				
	Multitrack OFF		Multitrack ON		
	Hex	Binary	Hex	Binary	Page
CONTROL					
No Operation	03	0000 0011			22
Recalibrate	13	0001 0011			23
Seek	07	0000 0111			24
Seek Cylinder	0B	0000 1011			25
Seek Head	1B	0001 1011			26
Space Count	0F	0000 1111			27
Set File Mask	1F	0001 1111			28
Set Sector	23	0010 0011			29
Restore	17	0001 0111			30
Transfer in Channel	x8*	xxxx 1000			31
Diagnostic Load	53	0101 0011			32
Diagnostic Write	73	0111 0011			33
SEARCH					
Home Address Equal	39	0011 1001	B9	1011 1001	34
Identifier ID Equal	31	0011 0001	B1	1011 0001	35
Identifier ID High	51	0101 0001	D1	1101 0001	36
Identifier ID Equal or High	71	0111 0001	F1	1111 0001	37
Key Equal	29	0010 1001	A9	1010 1001	38
Key High	49	0100 1001	C9	1100 1001	39
Key Equal or High	69	0110 1001	E9	1110 1001	40
READ					
Home Address	1A	0001 1010	9A	1001 1010	41
Count	12	0001 0010	92	1001 0010	42
Record Zero (R0)	16	0001 0110	96	1001 0110	43
Data	06	0000 0110	86	1000 0110	44
Key and Data	0E	0000 1110	8E	1000 1110	45
Count, Key, and Data	1E	0001 1110	9E	1001 1110	46
Initial Program Load (IPL)	02	0000 0010			47
Sector	22	0010 0010			48
SENSE					
Input/Output (I/O)	04	0000 0100			49
Read and Reset Buffered Log	A4	1010 0100			50
Device Reserve	B4	1011 0100			51
Device Release	94	1001 0100			52
Read Diagnostic Status 1	44	0100 0100			53
WRITE					
Home Address	19	0001 1001			54
Record Zero (R0)	15	0001 0101			55
Erase	11	0001 0001			56
Count, Key, and Data	1D	0001 1101			57
Special Count, Key, and Data	01	0000 0001			58
Data	05	0000 0101			59
Key and Data	0D	0000 1101			60

* x; not significant (addresses should not exceed storage capacity).

Use of command codes other than shown presents unit check in initial status. A subsequent Sense operation indicates command reject.

Figure 12. Channel Command Summary

CHANNEL COMMANDS

NO-OP

Byte 0	**1**	**2**	**3**	**4**		**5**	**6**	**7**
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary 0000 0011 Hex 03	Not checked for validity; should not exceed addressing capacity.			SLI flag (bit 2) should be on			Must be non-zero; zero count causes a program check.	
Chaining and Special Requirements: See following description.								

NO-OP, an immediate command; causes no action at addressed device.

CHANNEL END is presented in initial status.

DEVICE END is presented in initial status.

INDISCRIMINATE USAGE must be avoided; a No-op resets orientation information and causes all or parts of records to be skipped.

> **EXAMPLE:** a No-op between Read Count and Read Data reads the following record's data.
>
> **EXAMPLE:** a No-op between a command that reads the data field of record n-1 and a command that must process the count area of record n may skip record n and process the count area of record n+1.

NO-OP CCW count field must not be zero.

SLI FLAG must be on to avoid incorrect length indication.

ZERO COUNT will set the program check bit (byte 5, bit 2) in the CSW.

RECALIBRATE

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary 0001 0011 Hex 13	Not checked for validity, should not exceed addressing capacity.			SLI flag (bit 2) should be on			Must be non-zero; zero count causes a program check.	
Chaining and Special Requirements: If used, Set File Mask must allow Seek commands.								

RECALIBRATE causes addressed drive to seek to cylinder zero, head zero.

INITIAL STATUS byte normally zero, not processed as an immediate command.

CHANNEL END presented in ending status.

DEVICE END presented when drive positions the access mechanism to cylinder zero, head zero.

FILE MASK must be set to allow Seek commands.

SLI BIT must be on in Recalibrate CCW to avoid incorrect length indication.

SEEK

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary 0000 0111 Hex 07	Specifies CPU main storage location of the seek address.			Used at the discretion of the programmer.			Six	
Chaining and Special Requirements: If used, Set File Mask must allow Seek commands.								

SEEK transfers the six-byte seek address from channel to storage control.

INITIAL STATUS normally zero.

STORAGE CONTROL selects drive, moves access mechanism to proper cylinder, and selects proper head.

ACCESS MOTION, if any, initiated after seek address transfer.

CCW COUNT > SIX: transfers six bytes of address information.

CCW COUNT < SIX: Seek is not executed. Unit check, channel end, and device end are presented in ending status.

VALID SEEK ADDRESS checked by storage control:

Bytes 0, 1, and 4 must be zero.
Bytes 2 and 3 must not exceed 410 (decimal).
Byte 5 must not exceed 18 (decimal).

INVALID SEEK ADDRESS: Seek not executed. Unit check, channel end, and device end are presented. A subsequent Sense command indicates command reject.

PARITY ERROR detected in seek address transfer: command not executed; unit check, channel end, and device end presented. A subsequent Sense command indicates bus-out parity error.

COMMAND EXECUTION does not require preceding CCW.

FILE MASK must allow Seeks or unit check is presented in initial status.

CHANNEL END presented after seek address transfer.

DEVICE END presented with channel end if no movement; with movement, presented after access mechanism is positioned.

Note: *Several successive seeks, without an intervening data read or write, may cause a seek incomplete condition in the storage control. The storage control uses its internal error recovery procedures to correct the failure. If it cannot correct the failure, unit check with equipment check and permanent error is posted in the sense bytes.*

SEEK CYLINDER

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0000 1011** Hex **0B**	Specifies the CPU main storage location of the seek address.			Used at the discretion of the programmer.			Six	
Chaining and Special Requirements: If used, Set File Mask must allow Seek commands.								

SEEK CYLINDER transfers the six-byte seek address from channel to storage control (same as Seek command).

INITIAL STATUS normally zero.

STORAGE CONTROL selects drive, moves access mechanism to proper cylinder, and selects proper head.

ACCESS MOTION, if any, initiated after seek address transfer.

CCW COUNT > SIX: transfers six bytes of address information.

CCW COUNT < SIX: Seek Cylinder not executed. Unit check, channel end, and device end presented.

VALID SEEK ADDRESS checked by storage control:

Bytes 0, 1, and 4 must be zero.
Bytes 2 and 3 must not exceed 410 (decimal).
Byte 5 must not exceed 18 (decimal).

INVALID SEEK ADDRESS: Seek not executed. Unit check, channel end, and device end are presented. A subsequent Sense command indicates command reject.

PARITY ERROR detected in seek address transfer: command not executed; unit check, channel end, and device end presented. A subsequent Sense command indicates bus-out parity error.

COMMAND EXECUTION does not require preceding CCW.

FILE MASK must allow Seek Cylinder or unit check is presented in initial status.

CHANNEL END presented after seek address transfer.

DEVICE END presented with channel end if no movement; with movement, presented after access mechanism is positioned.

Note: *Several successive seeks, without an intervening data read or write, may cause a seek incomplete condition in the storage control. The storage control uses its internal error recovery procedures to correct the failure. If it cannot correct the failure, unit check with equipment check and permanent error is posted in the sense bytes.*

SEEK HEAD

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary 0001 1011 Hex **1B**	Specifies the CPU main storage location of the seek address.			Used at the discretion of the programmer.			Six	
Chaining and Special Requirements: If used, Set File Mask must allow Seek commands.								

SEEK HEAD transfers the six-byte seek address from channel to storage control.

INITIAL STATUS normally zero.

STORAGE CONTROL selects drive and proper head.

CCW COUNT > SIX: transfers six bytes of address information.

CCW COUNT < SIX: Seek Head not executed. Unit check, channel end, and device end are presented.

VALID SEEK ADDRESS required, but only head address (byte-6) is used (cylinder address is ignored):

Bytes 0, 1, and 4 must be zero.
Bytes 2 and 3 must not exceed 410 (decimal).
Byte 5 must not exceed 18 (decimal).

INVALID SEEK ADDRESS: Seek Head not executed. Unit check, channel end, and device end are presented. A subsequent Sense command indicates command reject.

PARITY ERROR detected in seek address transfer: command not executed; unit check, channel end, and device end presented. A subsequent Sense command indicates bus-out parity error.

COMMAND EXECUTION does not require preceding CCW.

FILE MASK must allow Seek Head or unit check is presented in initial status.

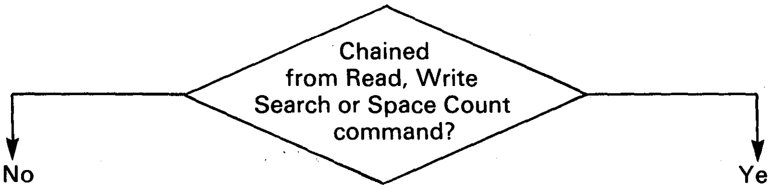
CHANNEL END/DEVICE END presented after seek address transfer.

PACE COUNT

3yte 0	1	2	3	4		5	6	7
Command Code	Data Address			Flags	000	Not Used	Count	
3inary 0000 1111 Hex 0F	Specifies CPU main storage location of the key and data lengths of the record to be recovered.			Used at the discretion of the programmer.			Three	

Chaining and Special Requirements: 1. Cannot be chained from a Format Write or Erase command.
2. Cannot be followed by a Write, Erase, Read IPL, or Set File Mask command in the same chain.

SPACE COUNT bypasses a defective count area to allow data recovery in key and/or data areas following the defective area.



1. Searches for index.
2. Clocks through gap 1, home address and gap 2.
3. Spaces over R0 count area.
4. Receives key and data length transfer from channel.
5. Sets end-of-count-area internal orientation state indicator.
6. Presents channel end and device end to channel.

Using the above:

a. Space Count followed by Read Key and Data recovers or bypasses bad R0 count area.
b. Space Count followed by Read CKD reads R1.

1. Orients at start of next count area.
2. Spaces over the count area.
3. Receives key and data length transfer from channel.
4. Set end-of-count-area internal orientation state indicator.
5. Presents channel end and device end to channel.

Using the above:
Command chain (a) may be used to recover key and data areas of record n (n≠0). Command chain (b) used to recover record n+1.

(a)	Set Sector Search ID (record n-1) TIC*-8 Space Count Read KD	(b)	Set Sector Search ID (record n-1) TIC*-8 Space Count Read CKD

DATA TRANSFERRED FROM CHANNEL used by storage control as key length (first byte) and data length (last two bytes) of record to be recovered.

CCW COUNT > THREE: three bytes are transferred.

CCW COUNT < THREE: the specified number of bytes is transferred.

NO BYTES TRANSFERRED: storage control uses zero. Read Data and Read KD commands will receive unit exception status, Read CKD commands may detect data checks.

INVALID TRACK FORMAT presented if index detected before command execution is complete.

SET FILE MASK

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0001 1111** Hex **1F**	Specifies CPU main storage location of the mask byte.			Used at the discretion of the programmer.			One	

Chaining and Special Requirements:

1. Only one Set File Mask permitted in a CCW chain.
2. Should not be used in the same CCW chain with a Space Count command.

SET FILE MASK sets the write and seek masks which protect the data and defines the command retry-PCI interaction.

Bit 0	Bit 1	Function	Bit 3	Bit 4	Function	Bit 5	Function	Bit 7	Function
0	0	Inhibit Write Home Address and Write R0.	0	0	Permit all Seek commands.	0	Inhibit Diagnostic Write commands.	0	Not PCI fetch mode.
0	1	Inhibit all Write commands.	0	1	Permit Seek Cylinder and Seek Head.	1	Permit Diagnostic Write commands.	1	PCI fetch mode. (The storage control presents unit check if command retry is used to recover from ECC uncorrectable errors.
1	0	Inhibit all Format Write commands.	1	0	Permit Seek Head.				
1	1	Permit all Write commands.	1	1	Inhibit all Seek commands and head switching.				

Bits 2 and 6 must be zero, or unit check, channel end, and device end are presented in initial status.

COMMAND EXECUTION allowed only once in CCW chain, more than one Set File Mask causes unit check in initial status.

COMMAND REJECT indicated by subsequent Sense command,

FILE MASK RESET to zeros at end of CCW chain.

WRITE COMMANDS violating file mask are not executed:

UNIT CHECK is presented in initial status,

COMMAND REJECT is indicated by subsequent Sense command.

SEEK COMMANDS violating file mask are not executed:

UNIT CHECK presented in initial status,

FILE PROTECTED indicated by subsequent Sense command (end-of-cylinder not set).

MULTITRACK/OVERFLOW operations violating file mask presents unit check and file protect.

CHANNEL END/DEVICE END presented to channel after transfer of mask byte.

SYSTEM OR SELECTIVE RESET resets file mask to zeros.

START I/O following a reset without Set File Mask in CCW permits Seek and Write commands (except Write HA and Write R0).

DIAGNOSTIC WRITE violating file mask not executed and unit check is presented.

SET SECTOR

Byte 0	**1**	**2**	**3**	**4**		**5**	**6**	**7**
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary 0010 0011 Hex 23	Specifies CPU main storage location of the desired sector.			Used at the discretion of the programmer.			One	
Chaining and Special Requirements: None.								

SET SECTOR (used on block multiplexer channels) allows the storage control to disconnect during rotational delay.

COMMAND EXECUTION transfers a sector number (0 – 127) from CPU storage to the storage control.

ANGULAR POSITIONS checked for validity by the storage control.

VALID ARGUMENT* (0-127):

1. Storage control presents channel end and disconnects.
2. Device end signaled when angular position reached and channel reconnects.
3. If no reconnection, storage control attempts reconnection on following revolutions.

ZERO ARGUMENT: Storage control attempts reconnection just before index.

ARGUMENT > 127 < 255: Channel end, device end, and unit check presented in ending status. Command reject indicated in a subsequent Sense command.

ARGUMENT = 255:

1. Command treated as a No-op.
2. Channel end/device end presented in ending status.
3. Track orientation is destroyed.

*All valid arguments, except for 255, are adjusted to compensate for channel reselection delay.

Programming Note:

1. The Set Sector command does not guarantee record orientation. The Search commands must still be used for this function.

2. Indiscriminate use of Set Sector with multitrack search may result in missing the desired record. A Set Sector 0, Read HA, and Search M/T sequence will avoid this problem.

RESTORE

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary 0001 0111 Hex 17	Not checked for validity so must not exceed addressing capacity.			SLI flag (bit 2) should be on			Not zero. Zero causes a program check.	
Chaining and Special Requirements: None.								

RESTORE is primarily used for compatibility with other IBM Direct Access Storage Devices and causes no action to be performed.

INITIAL STATUS normally zero.

CHANNEL END/DEVICE END immediately follows initial status.

SLI BIT must be on in the Restore CCW to avoid incorrect length indication.

TRANSFER IN CHANNEL (TIC)

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **xxxx 1000** Hex **x8** x = ignored	Specifies CPU main storage location for the next CCW.			Ignored			Ignored	
Chaining and Special Requirements: 1. Cannot be first CCW designated by channel address word. 2. One TIC command cannot transfer directly to another.								

TRANSFER IN CHANNEL (TIC) provides chaining capabilities for CCWs not located in adjacent CPU main storage locations.

TIC DATA ADDRESS FIELD specifies next CCW to be fetched.

COMMAND EXECUTION does not initiate I/O operations or signal I/O device.

PROGRAM CHECK SIGNAL is generated when chaining requirements are not met or an invalid address is specified. (TIC CCW data address area does not specify a double word boundary.)

ERROR DETECTION ends the chaining operations.

Note: *TIC is the only CCW that allows a zero count, an incorrect length indication cannot occur since flags and count are ignored.*

ASSEMBLER LANGUAGE notation TIC*-8 indicates an unconditional branch to the TIC storage address (*) minus a count of eight. TIC*-16 indicates an unconditional branch to the TIC storage address (*) minus a count of sixteen.

DIAGNOSTIC LOAD

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary 0101 0011 Hex 53	Specifies CPU main storage location of control byte.			Used at the discretion of the programmer.			One	
Chaining and Special Requirements: None.								

DIAGNOSTIC LOAD transfers a 512 byte block of data from the storage control read-only storage to the storage control buffer. The transferred data block is a functional microprogram diagnostic test.

INITIAL STATUS normally zero.

CONTROL BYTE specifying diagnostic microprogram ID number transferred from CPU main storage to storage control.

ROS* TRACK ADDRESS (0-31) specified in bits 0-4.

ROS* SECTOR NUMBER (0-7) specified in bits 5-7.

* ROS refers to the Read Only Storage device attachment to the storage control, not to a drive.

VALID CONTROL BYTE presents channel end in ending status.

STORAGE CONTROL disconnects from channel and transfers diagnostic test to buffer.

COMMAND EXECUTION allows any drive address to be used with the storage control address.

READ DIAGNOSTIC STATUS 1 command transfers the diagnostic test from storage control buffer to CPU main storage.

DATA TRANSFER COMPLETE causes storage control to present channel end and device end.

Caution: This command is intended for maintenance purposes only. Any use other than that provided by IBM diagnostic programs may yield unpredictable results.

DIAGNOSTIC WRITE

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary 0111 0011 Hex 73	Specifies CPU main storage location of diagnostic test.			Used at the discretion of the programmer.			512	
Chaining and Special Requirements: Set File Mask must allow Diagnostic Write command (bit 5 = 1).								

DIAGNOSTIC WRITE transfers a 512 byte diagnostic test from CPU main storage to the storage control.

INITIAL STATUS normally zero.

DATA TRANSFER COMPLETE: test execution begins.

TEST COMPLETE: 16 byte error code message is stored in the storage control buffer.

COMPATIBILITY VERIFIED by storage control by comparing a key in the test against the engineering level of the microprogram.

> **INVALID COMPARISON** ends command; channel end, device end, and unit check presented in ending status.

CCW COUNT > 512: only 512 bytes transferred.

CCW COUNT < 512: only the specified number of bytes transferred, command terminated, channel end, device end, and unit check presented in ending status.

ERROR CODE MESSAGE (16 bytes) transferred from storage control buffer to CPU main storage by a following Read Diagnostic Status 1 (Diagnostic Sense) command.

CHANNEL END/DEVICE END presented after transfer of diagnostic test to the storage control and test completion.

Caution: This command is intended for maintenance purposes only. Any use other than that provided by IBM diagnostic programs may yield unpredictable results.

SEARCH HOME ADDRESS EQUAL

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0011 1001** Hex **39** M/T Binary **1011 1001** Hex **B9**	Specifies main storage location of a cylinder number (CC) and head number (HH).			Used at the discretion of the programmer.			Four	
Chaining and Special Requirements: None.								

SEARCH HOME ADDRESS EQUAL causes storage control to search for index.

INITIAL STATUS normally zero.

CYLINDER AND HEAD NUMBERS from CPU main storage and the track home address area are compared by storage control after index is detected.

FLAG BYTE not transferred or compared during command execution.

COMPARISON EQUAL: channel end, device end, and status modifier presented to channel.

COMPARISON NOT EQUAL: channel end, and device end presented to channel.

CCW COUNT > FOUR: only first four bytes used.

CHANNEL END/DEVICE END presented to terminate the command.

STATUS MODIFIER presented if comparison was equal.

CCW COUNT < FOUR: comparison of main storage and track data continues until CCW count is zero.

CHANNEL END/DEVICE END presented when home address and ECC bytes are read and checked.

STATUS MODIFIER presented if search is satisfied on a short field.

MULTITRACK NOT USED: search confined to one track; continues (as long as channel repeats command) until search condition satisfied or two index points detected.

CHANNEL END/DEVICE END/UNIT CHECK presented to channel after second index found or parity error detected.

MULTITRACK USED: causes search to continue (as long as channel repeats command); head number automatically increments at index until search is satisfied or end-of-cylinder is reached.

CHANNEL END/DEVICE END/UNIT CHECK presented to channel when end-of-cylinder is reached or parity error detected.

SEARCH ID EQUAL

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0011 0001** Hex **31** M/T Binary **1011 0001** Hex **B1**	Specifies main storage location of a five-byte record identifier (CC HH R).			Used at the discretion of the programmer.			Five	
Chaining and Special Requirements: None.								

SEARCH ID EQUAL compares the CPU main storage ID and the count area ID. ID to be compared is next ID on track (including R0).

INITIAL STATUS normally zero.

COMPARISON EQUAL: channel end, device end, and status modifier presented to channel.

COMPARISON NOT EQUAL: channel end and device end presented to the channel.

CCW COUNT > FIVE: only first five bytes used.

CHANNEL END/DEVICE END presented to terminate command.

STATUS MODIFIER presented if comparison was equal.

CCW COUNT < FIVE: comparison of main storage and track data continues until CCW= zero.

CHANNEL END/DEVICE END presented to channel when ID and ECC bytes read and checked.

STATUS MODIFIER presented if search satisfied on the short count.

MULTITRACK NOT USED: search confined to one track; continues (as long as channel repeats command) until search condition satisfied or two index points are sensed.

CHANNEL END/DEVICE END/UNIT CHECK presented to channel when second index sensed or a parity error is found.

MULTITRACK USED: search continues (as long as channel repeats command); head number automatically increments at index until search condition satisfied or end-of-cylinder reached.

CHANNEL END/DEVICE END/UNIT CHECK presented to channel at end-of-cylinder.

SEARCH ID HIGH

<table>
<tr><th>Byte 0</th><th>1</th><th>2</th><th>3</th><th colspan="2">4</th><th>5</th><th>6</th><th>7</th></tr>
<tr><td><b>Command Code</b></td><td colspan="3"><b>Data Address</b></td><td><b>Flags</b></td><td><b>000</b></td><td><b>Not Used</b></td><td colspan="2"><b>Count</b></td></tr>
<tr><td>Binary
0101 0001
Hex 51
M/T Binary
1101 0001
Hex D1</td><td colspan="3">Specifies main storage location of a five-byte record identifier (CC HH R).</td><td colspan="2">Used at the discretion of the programmer.</td><td></td><td colspan="2">Five</td></tr>
<tr><td colspan="9"><b>Chaining and Special Requirements:</b> None.</td></tr>
</table>

SEARCH ID HIGH compares the CPU main storage ID and the disk drive count area ID. ID to be compared is next ID on track (including R0).

INITIAL STATUS normally zero.

COMPARISON HIGH: channel end, device end, and status modifier presented to channel. ID on drive is higher than ID in main storage.

COMPARISON NOT HIGH: channel end and device end presented to channel.

CCW COUNT > FIVE: only first five bytes used.

CHANNEL END/DEVICE END presented to terminate command.

STATUS MODIFIER presented if comparison was equal.

CCW COUNT < FIVE: comparison of main storage and track data continues until CCW = zero.

CHANNEL END/DEVICE END presented to channel when ID and ECC bytes read and checked.

STATUS MODIFIER presented if search is satisfied on the short count.

MULTITRACK NOT USED: search confined to single track, continues (as long as channel repeats command) until search condition satisfied or two index points are sensed.

CHANNEL END/DEVICE END/UNIT CHECK presented when second index sensed or parity error is found.

MULTITRACK USED: search continues (as long as channel repeats command); head number automatically increments at index until search condition is satisfied or end-of-cylinder reached.

CHANNEL END/DEVICE END/UNIT CHECK presented to channel at end-of-cylinder or if parity error found.

SEARCH ID EQUAL OR HIGH

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0111 0001** Hex **71** M/T Binary **1111 0001** Hex **F1**	Specifies main storage location of five-byte record identifier (CC HH R).			Used at the discretion of the programmer.			Five	
Chaining and Special Requirements: None.								

SEARCH ID EQUAL OR HIGH compares the CPU main storage ID and the disk drive count area ID. ID to be compared is next ID on the track (including R0).

INITIAL STATUS normally zero.

COMPARISON EQUAL OR HIGH: channel end, device end, and status modifier presented to the channel. ID on drive is equal to or higher than ID in main storage.

COMPARISON NOT EQUAL OR HIGH: channel end and device end presented to the channel.

CCW COUNT > FIVE: only first five bytes used.

CHANNEL END/DEVICE END presented to terminate command.

STATUS MODIFIER presented if comparison was equal.

CCW COUNT < FIVE: comparison of main storage and track data continues until CCW = zero.

CHANNEL END/DEVICE END presented to channel when ID and ECC bytes read and checked.

STATUS MODIFIER presented if search is satisfied on the short count.

MULTITRACK NOT USED: search confined to one track; continues (as long as channel repeats command) until search condition satisfied or two index points are sensed.

CHANNEL END/DEVICE END/UNIT CHECK presented to channel when second index sensed or a parity error is found.

MULTITRACK USED: search continues (as long as channel repeats command); head number automatically increments at index until search condition satisfied or end-of-cylinder reached.

CHANNEL END/DEVICE END/UNIT CHECK presented to channel at end-of-cylinder.

SEARCH KEY EQUAL

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0010 1001** Hex **29** M/T Binary **1010 1001** Hex **A9**	Specifies main storage locations to which key is compared.			Used at the discretion of the programmer.			Equal to length of the argument.	
Chaining and Special Requirements: When command chained from Search ID or Read Count, key is in same record as ID or count. Search Key Equal bypasses R0 unless chained from Search ID command which searched R0 ID.								

SEARCH KEY EQUAL compares main storage key to key area read from track. Key to be compared is next key on track (excluding R0).

INITIAL STATUS normally zero.

COMPARISON EQUAL: channel end, device end, and status modifier presented to channel.

COMPARISON NOT EQUAL OR NO KEY: channel end and device end presented to channel.

CCW COUNT > KL: search operation completed when key area is read.

CHANNEL END/DEVICE END terminates command.

STATUS MODIFIER presented if comparison was equal.

CCW COUNT < KL: track and main storage data compare continues until CCW count is zero.

CHANNEL END/DEVICE END presented after key area and following ECC bytes are read and checked.

STATUS MODIFIER presented if search satisfied on the short count.

MULTITRACK NOT USED: search confined to one track; continues (as long as channel repeats command) until search condition satisfied or two index points are sensed.

CHANNEL END/DEVICE END/UNIT CHECK presented to channel when second index sensed or a parity error is detected.

MULTITRACK USED: search continues (as long as channel repeats command); head number automatically increments at index until search condition satisfied or end-of-cylinder reached.

CHANNEL END/DEVICE END/UNIT CHECK presented to channel at end-of-cylinder.

COMMAND EXECUTION on record with zero KL does not set status modifier. If followed by a chained Read Data, the data area read is from next record.

SEARCH KEY HIGH

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0100 1001** Hex **49** M/T Binary **1100 1001** Hex **C9**	Specifies main storage location to which key is compared.			Used at the discretion of the programmer.			Equal to length of the argument.	
Chaining and Special Requirements: When command chained from Search ID or Read Count, key is in same record as ID or count. Search Key High bypasses R0 unless chained from Search ID command which searched R0 ID.								

SEARCH KEY HIGH compares main storage key to key area read from track. Key to be compared is next key on track (excluding R0).

INITIAL STATUS normally zero.

COMPARISON HIGH: channel end/device end/status modifier presented to channel. Key on drive is higher than main storage argument.

COMPARISON NOT HIGH: channel end/device end presented to channel.

CCW COUNT > KL: search operation completed when key area is read.

CHANNEL END/DEVICE END terminates command.

STATUS MODIFIER presented if comparison was equal.

CCW COUNT < KL: track and main storage data comparison continues until CCW count = 0.

CHANNEL END/DEVICE END presented after key area and ECC bytes read and checked.

STATUS MODIFIER presented if search satisfied on the short count.

MULTITRACK NOT USED: search confined to one track; continues (as long as channel repeats command) until search condition satisfied or two index points are sensed.

CHANNEL END/DEVICE END/UNIT CHECK presented to channel when second index sensed or a parity error is detected.

MULTITRACK USED search continues (as long as channel repeats command); head number automatically increments at index until search condition satisfied or end-of-cylinder reached.

CHANNEL END/DEVICE END/UNIT CHECK presented to channel at end-of-cylinder.

COMMAND EXECUTION ON RECORD with zero KL does not set status modifier. If followed by a chained Read Data, the data area read is from the next record.

SEARCH KEY EQUAL OR HIGH

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0110 1001** Hex **69** M/T Binary **1110 1001** Hex **E9**	Specifies main storage location to which key is compared.			Used at the discretion of the programmer.			Equal to length of the argument.	
Chaining and Special Requirements: When command chained from Search ID or Read Count, key is in same record as ID or count. Search Key Equal or High bypasses R0 unless chained from Search ID command which searched R0 ID.								

SEARCH KEY EQUAL OR HIGH compares main storage key to key area read from track. Key to be compared is next key on track (excluding R0).

INITIAL STATUS normally zero.

COMPARISON EQUAL OR HIGH: channel end/device end/status modifier presented to channel. Key on drive equal to or higher than main storage argument.

COMPARISON NOT EQUAL OR HIGH: channel end/device end presented to channel.

CCW COUNT > KL: search operation completed when key area is read.

CHANNEL END/DEVICE END terminates command.

STATUS MODIFIER presented if comparison was equal.

CCW COUNT < KL: track and main storage data comparison continues until CCW count = 0.

CHANNEL END/DEVICE END presented after key area and ECC bytes read and checked.

STATUS MODIFIER presented if search satisfied on the short count.

MULTITRACK NOT USED: search confined to one track; continues (as long as channel repeats command) until search condition satisfied or two index points are detected.

CHANNEL END/DEVICE END/UNIT CHECK presented to channel when second index or a parity error is detected.

MULTITRACK USED search continues (as long as channel repeats command); head number automatically increments at index until search condition satisfied or end-of-cylinder reached.

CHANNEL END/DEVICE END/UNIT CHECK presented to channel at end-of-cylinder.

COMMAND EXECUTION ON RECORD with zero KL does not set status modifier. If followed by a chained Read Data, the data area read is from the next record.

READ HOME ADDRESS

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0001 1010** Hex **1A** M/T Binary **1001 1010** Hex **9A**	Specifies main storage location where home address is to be stored.			Used at the discretion of the programmer.			Five	
Chaining and Special Requirements: None.								

READ HOME ADDRESS transfers the F CC HH bytes of the home address to main storage.

INITIAL STATUS normally zero.

DATA VALIDITY verified by ECC bytes following the area.

DATA OVERRUN/DATA CHECK if detected, storage control attempts recovery by command retry.

COMMAND RETRY, if unsuccessful, unit check presented to the channel.

PARITY BIT added to each byte before transfer to the channel.

CHANNEL END/DEVICE END presented to channel after home address ECC check.

READ COUNT

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0001 0010** Hex **12** M/T Binary **1001 0010** Hex **92**	Specifies main storage location where first byte of count data is to be transferred.			Used at the discretion of the programmer.			Eight	
Chaining and Special Requirements: None.								

READ COUNT transfers the eight bytes (CC HH R KL DL DL) of the next count area on the track (excluding R0) from disk storage to main storage.

INITIAL STATUS normally zero.

DATA VALIDITY verified by ECC bytes following the count area.

DATA OVERRUN/DATA CHECK if detected, storage control attempts recovery by command retry.

COMMAND RETRY, if unsuccessful, unit check presented to the channel.

PARITY BIT added to each byte before transfer to the channel.

CHANNEL END/DEVICE END presented to channel after ECC check.

READ RECORD 0 (Track Descriptor Record)

Byte 0	**1**	**2**	**3**	**4**		**5**	**6**	**7**
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0001 0110** Hex **16** M/T Binary **1001 0110** Hex **96**	Specifies main storage location where first byte of R0 count data is to be transferred.			Used at the discretion of the programmer.		–	Specifies number of count, key, and data bytes to be read.	
Chaining and Special Requirements: None.								

READ R0 transfers count, key, and data areas of R0 from drive to the channel.

INITIAL STATUS normally zero.

DATA VALIDITY verified by ECC bytes following each area.

DATA OVERRUN/DATA CHECK if detected, storage control attempts recovery by command retry.

> **Note:** *If a correctable data error (error burst of 11 bits or less) is found in the data area, the correctable bit is set, and the error pattern and error displacement is signaled to the channel so ERP can correct the error.*
>
> **COMMAND RETRY,** if unsuccessful, unit check presented to the channel at the end of the area where the error occurred.

PARITY BIT added to each byte before transfer to the channel.

STORAGE CONTROL searches for index, clocks through gap 1, home address, and gap 2.

DATA TRANSFER of the R0 count area is initiated by the storage control.

COMMAND EXECUTION accomplished immediately if Read R0 is chained from a Search HA or Read HA command; with these commands, storage control does not search for index.

CHANNEL END/DEVICE END presented to channel at completion of ECC check of data area.

READ DATA

<table>
<tr><td>Byte 0</td><td>1</td><td>2</td><td>3</td><td colspan="2">4</td><td>5</td><td>6</td><td>7</td></tr>
<tr><td>Command Code</td><td colspan="3">Data Address</td><td>Flags</td><td>000</td><td>Not Used</td><td colspan="2">Count</td></tr>
<tr><td>Binary
0000 0110
Hex 06
M/T Binary
1000 0110
Hex 86</td><td colspan="3">Specifies main storage location where first data byte is to be transferred.</td><td colspan="2">Used at the discretion of the programmer.</td><td></td><td colspan="2">Specifies number of bytes to be read.</td></tr>
<tr><td colspan="9"><b>Chaining and Special Requirements:</b> None.</td></tr>
</table>

READ DATA transfers the data area of a record from drive to CPU main storage. The data read is:

1. Data area of record read by Search ID or Search Key from which Read Data is chained.
2. Data area of record read by Read Count from which Read Data is chained.
3. Data area of record following next count area on the track (excluding R0).

INITIAL STATUS normally zero.

DATA VALIDITY verified by ECC bytes following each area.

DATA OVERRUN/DATA CHECK, if detected, storage control attempts recovery by command retry.

Note: *If a correctable data error (error burst of 11 bits or less) is detected in the data area, unit check is sent to the channel so ERP can correct the error.*

COMMAND RETRY, if unsuccessful, unit check presented to the channel.

PARITY BIT added to each byte before transfer to channel.

CHANNEL END/DEVICE END presented to channel following ECC check of data area.

READ KEY AND DATA

Byte 0	1	2	3	4		5	6	7
Command Code	Data Address			Flags	000	Not Used	Count	
Binary **0000 1110** Hex **0E** M/T Binary **1000 1110** Hex **8E**	Specifies main storage location where first byte of key data is to be transferred.			Used at the discretion of the programmer.			Specifies the number of key and data area bytes to be read.	
Chaining and Special Requirements: None.								

READ KEY AND DATA transfers key and data areas of record from drive to main storage. The key and data areas are:

1. Key and data area of record read by Search ID from which Read KD is chained.
2. Key and data areas of record read by Read Count from which Read KD is chained.
3. Key and data areas of record following next count area on track (excluding R0).

INITIAL STATUS normally zero.

DATA VALIDITY verified by ECC following each area.

DATA OVERRUN/DATA CHECK, if detected, storage control attempts recovery by command retry.

Note: *If a correctable data error (error burst of 11 bits or less) is detected in the data area, unit check is sent to the channel so ERP can correct the error.*

COMMAND RETRY, if unsuccessful, sends unit check to channel at the end of the area where error occurred.

KEY LENGTH = ZERO: command same as a Read Data command.

PARITY BIT added to each byte before transfer to channel.

CHANNEL END/DEVICE END presented to channel following ECC check of data area.

READ COUNT, KEY, AND DATA

Byte 0	**1**	**2**	**3**	**4**		**5**	**6**	**7**
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0001 1110** Hex **1E** M/T Binary **1001 1110** Hex **9E**	Specifies main storage location where first byte of count data is to be transferred.			Used at the discretion of the programmer.			Specifies the number of count, key, and data bytes to be read.	
Chaining and Special Requirements: None.								

READ COUNT, KEY, AND DATA transfers the next record on the track from the drive to CPU main storage (excluding R0).

INITIAL STATUS normally zero.

DATA VALIDITY verified by ECC bytes following each area.

DATA OVERRUN/DATA CHECK, if detected, storage control attempts recovery by command retry.

Note: *If a correctable data error (error burst of 11 bits or less) is detected in the data area, unit check is sent to the channel so ERP can correct the error.*

COMMAND RETRY, if unsuccessful, signals unit check to the channel at the end of the error where the error occurred.

PARITY BIT is added to each byte before transfer to channel.

CHANNEL END/DEVICE END signaled to channel following ECC check of data area.

EAD IPL

yte 0	1	2	3	4		5	6	7
ommand ode	Data Address			Flags	000	Not Used	Count	
inary 000 0010 ex 02	Specifies main storage location where first byte of data is to be transferred.			Used at the discretion of the programmer.			Specifies number of bytes to be transferred.	
haining and Special Requirements: Must not be preceded by a Set File Mask in the same chain.								

EAD INITIAL PROGRAM LOAD causes storage control to seek to cylinder 0, head 0 of selected drive and search for dex.

ATA AREA READ, following index, is first record after R0.

OMMAND NORMALLY INITIATED by entering DASD address in Load Unit switches and pressing console IPL key.

NITIAL STATUS normally zero.

ATA VALIDITY verified by ECC bytes following data area.

ATA OVERRUN/DATA CHECK, if detected, storage control attempts recovery by command retry.

ote: *If a correctable data error (error burst of 11 bits or less) is detected in the data area, unit check sent to the channel so RP can correct the error.*

COMMAND RETRY, if unsuccessful, presents unit check to the channel.

PARITY BIT added to each byte before transfer to channel.

CHANNEL END/DEVICE END signaled to channel following ECC check

READ SECTOR

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary 0010 0010 Hex 22	Specifies main storage location where sector number is to be stored.			Used at the discretion of the programmer.			One	
Chaining and Special Requirements: None.								

READ SECTOR transfers one byte of data from storage control to main storage.

INITIAL STATUS normally zero.

BYTE TRANSFERRED contains sector number required to access the last record processed.

Note: *If a Set Sector command was last executed, this byte will be the value in Set Sector minus 3. If the last record processed was an overflow record, the angular position is that of the last segment.*

COMMAND EXECUTION resets storage control orientation information.

CHANNEL END/DEVICE END presented after sector number is transferred.

SENSE I/O

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary 0000 0100 Hex 04	Specifies main storage location where bytes are to be transferred.			Used at the discretion of the programmer.			Twenty-four	
Chaining and Special Requirements: None.								

SENSE I/O transfers 24 bytes of sense information from storage control to the channel, then resets to zero.

INITIAL STATUS normally zero.

SENSE I/O DESCRIBES:

UNIT CHECK STATUS

CURRENT STATUS of the device that performed operation.

SYSTEM ERROR RECOVERY information.

UNIT CHECK should always be followed by a Sense I/O, whether or not the sense information is used; otherwise, expected future interrupts may not occur and some I/O access paths may be unavailable.

CONTINGENT CONNECTION in storage control makes all other drive addresses busy after channel accepts unit check, and they remain busy until terminated by command (not Test I/O or No-op) with zero status byte, system reset, or selective reset.

CHANNEL END/DEVICE END presented after sense bytes are transferred.

See Sense Bytes for a description of the sense information concerning the 3830/3330 operations.

READ AND RESET BUFFERED LOG

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **1010 0100** Hex **A4**	Specifies main storage location of first error byte or usage data.			Used at the discretion of the programmer.			Twenty-four	
Chaining and Special Requirements: None.								

READ AND RESET BUFFERED LOG transfers 24 bytes of usage or error information from storage control to the channel.

INITIAL STATUS normally zero.

USAGE OR ERROR INFORMATION, generated and available when their respective counters overflow, applies to storage control addressed by Start I/O and the drive identified in sense byte 4.

COUNTERS reset after data transfer.

CCW COUNT > 24: only 24 bytes transferred.

CCW COUNT < 24: the number of bytes specified are transferred.

CHANNEL END/DEVICE END presented after data transfer.

See Statistical Usage/Error Recording for more information.

DEVICE RESERVE

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **1011 0100** Hex **B4**	Specifies main storage location where sense bytes are to be transferred.			Used at the discretion of the programmer.			Twenty-four	
Chaining and Special Requirements: Valid only for multichannel interfaces. Must not be preceded by a Set File Mask in same chain.								

DEVICE RESERVE command includes all Sense I/O functions and reserves the addressed drive for the channel issuing the command.

INITIAL STATUS normally zero.

RESERVATION MAINTAINED until either a Device Release or a system reset is performed by the channel.

SENSE INFORMATION (24 bytes) transferred to the channel.

NORMAL BUSY CONDITIONS cause a command reject; busy bit set in the CSW.

ABNORMAL FILE STATUS conditions (file unsafe, offline, etc.) do not halt execution.

CHANNEL END/DEVICE END presented after sense byte transfer.

UNIT CHECK, causing command rejection, presented if:

1. Multichannel interface not installed on storage control.
2. Set File Mask precedes command in same chain.
3. Space Count precedes command in the same chain.

CONTINGENT CONNECTION in storage control makes all other drive addresses busy after channel accepts unit check, and they remain busy until terminated by command (not Test I/O or No-op) with zero status byte, system reset, or selective reset.

DEVICE RELEASE

Byte 0	1	2	3	4		5	6	7
Command Code	Data Address			Flags	000	Not Used	Count	
Binary 1001 0100 Hex 94	Specifies main storage location where sense bytes are to be transferred.			Used at the discretion of the programmer.			Twenty-four	
Chaining and Special Requirements: Valid only for multichannel interfaces. Must not be preceded by Set File Mask in the same chain.								

DEVICE RELEASE terminates reservation of the addressed drive.

INITIAL STATUS normally zero.

SENSE I/O command functions are performed by a Device Release; 24 bytes of sense information are transferred to the channel.

NORMAL BUSY conditions cause command rejections; busy bit set in the CSW.

ABNORMAL FILE status conditions (file unsafe, offline, etc.) do not halt execution.

CHANNEL END/DEVICE END presented after sense bytes transferred.

UNIT CHECK, causing command rejection, presented if:

1. Multichannel interface not installed on storage control.
2. Set File Mask precedes command in the same chain.
3. Space Count precedes command in the same chain.

READ DIAGNOSTIC STATUS 1 (Diagnostic Sense)

<table>
<tr><td>Byte 0</td><td>1</td><td>2</td><td>3</td><td colspan="2">4</td><td>5</td><td>6</td><td>7</td></tr>
<tr><td>Command Code</td><td colspan="3">Data Address</td><td>Flags</td><td>000</td><td>Not Used</td><td colspan="2">Count</td></tr>
<tr><td>Binary
0100 0100
Hex 44</td><td colspan="3">Specifies main storage location where data accumulated during previous Diagnostic Load or Diagnostic Write is to be stored.</td><td colspan="2">Used at the discretion of the programmer.</td><td></td><td colspan="2">16 or 512</td></tr>
<tr><td colspan="9">Chaining and Special Requirements: Must follow Diagnostic Write or Diagnostic Load command.</td></tr>
</table>

READ DIAGNOSTIC STATUS 1 performs one of two functions:

FOLLOWING A DIAGNOSTIC WRITE:

ERROR CODE MESSAGE (16 bytes) transferred from storage control to channel; the information accumulated during the previous command.

CCW COUNT FIELD should specify 16 bytes or less (if count is smaller).

CHANNEL END/DEVICE END presented after transfer.

FOLLOWING A DIAGNOSTIC LOAD:

DIAGNOSTIC TEST (512 bytes) transferred from storage control to channel; the information accumulated during the previous command.

CCW COUNT FIELD should specify 512 bytes, if less, unit check presented.

CHANNEL END/DEVICE END presented after data transfer.

INITIAL STATUS normally zero.

DIAGNOSTIC WRITE OR DIAGNOSTIC LOAD must precede the command, otherwise, 16 bytes of data are transferred from storage control area which normally contains error message.

CHANNEL END/DEVICE END presented after data transfer.

Caution: This command is intended for maintenance purposes only. Any other use than that provided by IBM diagnostic programs may yield unpredictable results.

WRITE HOME ADDRESS

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary 0001 1001 Hex 19	Specifies main storage location of home address bytes (F CC HH).			Used at the discretion of the programmer.			Five	
Chaining and Special Requirements: Must be preceded by a Set File Mask permitting Write Home Address commands.								

WRITE HOME ADDRESS establishes track identity, a requirement for data operations on that track.

INITIAL STATUS normally zero.

STORAGE CONTROL orients on index, writes gap 1, home address, and ECC bytes.

FLAG BYTE transferred from main storage, bit 5 must be zero.

CCW COUNT < FIVE, storage control records zeros until five bytes are written.

CCW COUNT > FIVE, only first five bytes are written.

CHAINING REQUIREMENTS must be met; otherwise, unit check presented in initial status.

CHANNEL END/DEVICE END presented after ECC bytes are written.

Note: *Home address is normally prewritten by the disk manufacturer. The use of this command should be limited to identifying defective tracks and assigning alternate tracks. Utility programs are available to perform this function.*

WRITE RECORD 0 (R0)

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary 0001 0101 Hex 15	Specifies main storage location of R0 count, key, and data bytes.			Used at the discretion of the programmer.			Total number of bytes in R0 count, key, and data areas.	
Chaining and Special Requirements: Must be chained from a successful Write HA or Search HA Equal command.								

WRITE R0 causes specified data in main storage to be written on selected drive in the area following home address.

INITIAL STATUS normally zero.

COUNT AREA made up of first eight bytes from main storage.

Note: *The flag byte is generated by the storage control; the remaining data is written in the key and data areas as specified by the KL and DL bytes in the count area.*

ERROR CORRECTION CODE BYTES written by storage control following each record area.

CCW COUNT AREA specifies number of bytes (8 + KL + DL) to be transferred from main storage to the drive.

CCW COUNT < 8 + KL + DL: storage control writes zeros in remainder of record.

CHAINING REQUIREMENTS must be met; otherwise, unit check presented in initial status.

CHANNEL END/DEVICE END signaled after ECC bytes written for data area.

Note: *Record zero is normally written on the disk pack by the manufacturer. The use of this command should be limited to identifying defective tracks and assigning alternate tracks. Alternate and defective tracks are identified in the R0 count area instead of the normal CC HH bytes. Utility programs are available to perform these functions. Proper operation with IBM supported operating systems require an eight-byte field in R0.*

ERASE

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0001 0001** Hex **11**	Specifies main storage location where count, key, and data areas of the record are located.			Used at the discretion of the programmer.			Number of bytes in count, key, and data areas of the record.	
Chaining and Special Requirements: Must be chained from Write R0, Write CKD, Search ID Equal, or Search Key Equal (Search commands must compare equal on all bytes). Read Data or Read Key and Data may be inserted between Search and Erase commands.								

ERASE write zeros in count, key, and data areas on selected drive.

INITIAL STATUS normally zero.

CHANNEL END/DEVICE END signaled following data area; remaining track padded with zeros.

ERASED RECORD and all records following on track are unrecoverable.

CHAINING REQUIREMENTS must be met; otherwise, unit check presented in initial status.

FORMAT WRITE command must not be chained from an Erase command.

WRITE COUNT, KEY, AND DATA

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0001 1101** Hex **1D**	Specifies main storage location where count, key, and data bytes of record are located.			Used at the discretion of the programmer.			Total number of bytes in count, key, and data areas.	
Chaining and Special Requirements: Must be chained from Write R0, Write CKD, Search ID Equal, or Search Key Equal (Search commands must compare equal on all bytes). Read Data or Read Key and Data may be inserted between Search and Write CKD commands.								

WRITE COUNT, KEY, AND DATA causes specified data in main storage to be written on selected drive.

INITIAL STATUS normally zero.

COUNT AREA made up of first eight bytes from main storage.

Note: *The flag byte is generated by the storage control; the remaining data is written in the key and data areas as specified by the KL and DL bytes in the count area.*

ERROR CORRECTION CODE BYTES written by the storage control following each record area.

CCW COUNT FIELD specifies number of bytes (8 + KL + DL) to be transferred from main storage to the drive.

CCW COUNT < 8 + KL + DL: storage control writes zeros for remainder of record.

CHAINING REQUIREMENTS must be met; otherwise, unit check presented in initial status.

UNIT CHECK (command reject) presented if Write CKD attempted after Write R0 on a defective track.

CHANNEL END/DEVICE END signaled to channel after ECC bytes written after data area.

WRITE SPECIAL COUNT, KEY, AND DATA

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0000 0001** Hex **01**	Specifies main storage location where count, key and data areas of the record are located.			Used at the discretion of the programmer.			Number of bytes in the count, key, and data areas of the record.	
Chaining and Special Requirements: Must be chained from Write R0, Write CKD, Search ID Equal, or Search Key Equal (Search commands must compare equal on all bytes). Read Data or Read Key and Data may be inserted between Search and Write Special CKD commands.								

WRITE SPECIAL COUNT, KEY, AND DATA formats a segment of an overflow record; the last segment is written by a normal Write CKD command.

INITIAL STATUS normally zero.

COUNT AREA made up of first eight bytes from main storage.

> **FLAG BYTE** contains a 1 in bit 4; generated and written by storage control; this bit indicates that another part of the record is located on the next track.

ERROR CORRECTION CODE BYTES written by storage control following each record area.

CCW COUNT FIELD specifies number of bytes (8 + KL + DL) to be transferred from main storage to the drive.

CCW COUNT < 8 + KL + DL: storage control writes zeros in remainder of record.

CHAINING REQUIREMENTS must be met; otherwise, unit check presented in initial status.

> **UNIT CHECK** (command reject) presented if Write Special CKD attempted after Write R0 on a defective track.

CHANNEL END/DEVICE END signaled to channel after ECC bytes written for data area.

WRITE DATA

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary 0000 0101 Hex 05	Specifies main storage location of data used to update record.			Used at the discretion of the programmer.			Number of data bytes to be written.	
Chaining and Special Requirements: Must be chained from a Search ID Equal or Search Key Equal command (Search commands must compare equal on all bytes).								

WRITE DATA performs normal record updating after track formatting.

INITIAL STATUS normally zero.

COMMAND EXECUTION causes specified data in main storage to be written into data area of selected record.

NUMBER OF BYTES WRITTEN:

1. Specified in count area of the Write Data CCW.
2. May be less than data length specified in formatted record.

ERROR CORRECTION CODE BYTES written by storage control following data area.

CCW COUNT < COUNT AREA DL: Storage control writes zeros in remaining data area; writes ECC bytes and sends channel end and device end to channel.

CCW COUNT > COUNT AREA DL: Storage control writes only number of bytes indicated in the count area DL, then adds ECC bytes.

CHAINING REQUIREMENTS must be met; otherwise, unit check presented in initial status.

CHANNEL END/DEVICE END sent to channel after ECC bytes written following data area.

WRITE KEY AND DATA

<table>
<tr><th>Byte 0</th><th>1</th><th>2</th><th>3</th><th colspan="2">4</th><th>5</th><th>6</th><th>7</th></tr>
<tr><td><b>Command Code</b></td><td colspan="3"><b>Data Address</b></td><td><b>Flags</b></td><td><b>000</b></td><td><b>Not Used</b></td><td colspan="2"><b>Count</b></td></tr>
<tr><td>Binary
<b>0000 1101</b>
Hex <b>0D</b></td><td colspan="3">Specifies main storage location of the data to be used for record update.</td><td colspan="2">Used at the discretion of the programmer.</td><td></td><td colspan="2">Number of key and data bytes to be written.</td></tr>
<tr><td colspan="9"><b>Chaining and Special Requirements:</b> Must be chained from a Search ID Equal command which must compare equal on all bytes of the searched field.</td></tr>
</table>

WRITE KEY AND DATA used for record updating after track formatting.

INITIAL STATUS normally zero.

COMMAND EXECUTION causes data from main storage to be written in key and data area of selected record.

NUMBER OF BYTES WRITTEN:

1. Specified in count field of Write Key and Data command.
2. May be less than key and data length specified in formatting record.

ERROR CORRECTION CODE BYTES written by storage control following each area.

CCW COUNT < KL/DL BYTE COUNT: Storage control writes zeros in remaining areas, adds ECC bytes, and sends channel end and device end to channel.

CCW COUNT > KL/DL BYTE COUNT: channel end and device end are sent to channel after indicated number of bytes are written and ECC bytes added.

CHAINING REQUIREMENTS must be met; otherwise, unit check presented in initial status.

CHANNEL END/DEVICE END presented after ECC bytes are written for data area.

Note: *If KL = 0, command is same as Write Data.*

The following channel programs are typical examples of how CCWs are arranged to format, read, and write records on the 3830/3330 facility. These examples do not include the CPU program used to start the channel program.

Unless otherwise noted, all numbers are hexadecimal.

TRACK FORMATTING

Example: Format track 6A on head 08 with records R1, R2, and R3 for customer records. Assume that R0 has a key length (KL) of zero and a data length (DL) of eight bytes, and that R1, R2, and R3 have a key length of six bytes and a data length of 0064 (100 decimal) bytes.

The channel program is:

Seek
Set File Mask
Set Sector
Search ID Equal (R0)
TIC*-8
Write CKD
Write CKD
Write CKD

Analyzing the commands:

SEEK

Command	Data Address	Flags	000	Count
0000 0111 '07'	03E8 = 00 00 00 6A 00 08 C C H H	01000	000	0006

Comments: The Seek command positions the access at the required cylinder and selects the proper head. All seek commands transfer six bytes of data from main storage to the storage control (count = 6). The first two seek address bytes are always 0s, the cylinder number (6A) is specified in the third and fourth bytes, and bytes five and six indicate the required head (00 08 at 03EC and 03ED).

SET FILE MASK

Command	Data Address	Flags	000	Count
0001 1111 '1F'	03EE = C0	01000	000	0001

Comments: The Set File Mask command specifies the types of operations that can be performed in this channel program. The mask byte in this case (1100 0000 at address 03EE) permits all Write and Seek commands. The mask is reset to zero at the beginning of each command chain.

SET SECTOR

Command	Data Address	Flags	000	Count
0010 0011 '23'	1390 = 00	01000	000	0001

Comments: Execution of a Set Sector command with an argument at zero, orients the track to index. During the time that the storage control is waiting for index, the channel is available to perform other operations on other drives.

SEARCH ID EQUAL

Command	Data Address	Flags	000	Count
0011 0001 '31'	03EF = 00 6A 00 08 01	01000	000	0005

Comments: The Search ID Equal command causes the first ID found on the track to be compared with the argument. All unequal comparisons of IDs cause the 3830 to signal channel end and device end to the channel so the TIC command (back to Search ID Equal) is executed. When an equal comparison is found (ID of record 0) the 3830 signals channel end, device end, and status modifier to the channel. The status modifier causes the next command (TIC) to be skipped and the first Write CKD command is executed.

TRANSFER IN CHANNEL (TIC)

Command	Data Address	Flags	000	Count
xxxx 1000 'x8'	Address of last command	xxxxx	xxx	xxxx

Comments: TIC*-8 branches back to last command address.
x = positions ignored.

WRITE CKD

Command	Data Address	Flags	000	Count
0001 1101 '1D'	R1 C C H H R KL DL DL 0BB8 = 00 6A 00 08 01 06 00 64	01100	000	0008
	R2 0FA0 = 00 6A 00 08 02 06 00 64	01100	000	0008
	R3 1388 = 00 6A 00 08 03 06 00 64	00100	000	0008

Comments: Execution of the Write CKD commands causes a count area, key area (if not zero), and the data area with the length specified by the DL bytes, to be written on the disk.

The main storage locations specified in the data address are coded with the cylinder number, head number, record number, key length, and data length of each record. Since the KL = 6, a key area of six bytes is created. The data length specified is 0064 (100 decimal) bytes. Although the CCW byte count is only eight, and the channel byte count goes to zero after eight bytes are written, the storage control is committed to write a key area six bytes long and a data area 100 bytes long. Therefore, the storage control inserts zeros in the applicable track positions until the byte count reaches zero.

The difference in the channel byte count and the storage control byte count will cause an incorrect length indication, so the SLI flag (byte 4, bit 2) is set in the CCWs.

In this example, six bytes of zeros are recorded in the key area and followed by the ECC bytes, a gap, 100 bytes of 0s, and more ECC bytes. The data that replaces the zeros can be recorded in the key and data areas at a later time with the following CCW sequence:

Set Sector
Search ID Equal (R1)
TIC*-8
Write KD
Search ID Equal (R2)
etc.

UPDATE PAYROLL RECORD

Example: Update Frank Smith's record. Assume: the disk is organized by key areas; each key area contains an employee number; Frank Smith's number is 656151; this number is located in cylinder 0C, head 04; the key areas are six bytes long and the data areas 64 (100 decimal) bytes long.

The channel program is:

Seek
Search Key Equal
TIC*-8
Write Data

Analyzing the commands:

SEEK

Command	Data Address	Flags	000	Count
0000 0111 '07'	03E8 = 00 00 00 0C 00 04 C C H H	01000	000	0006

Comments: As explained in the first example, the Seek command transfers the track address to the storage control, moves the access mechanism, and selects the specified head.

SEARCH KEY EQUAL

Command	Data Address	Flags	000	Count
0010 1001 '29'	07D0 = F6 F5 F6 F1 F5 F1 (employee number)	01000	000	0006

Comments: After locating the correct cylinder and track, Frank Smith's record must be found. Since the disk is organized by keys, a Search Key Equal is executed. This causes the storage control to search the key area of the next record on the track. If the key is not equal to Smith's number, (main storage locations 07D0 to 07D5) the storage control signals channel end and device end to the channel and the TIC (return to Search Key Equal) is executed. This continues until the correct record is found. The storage control then sends channel end, device end, and status modifier to the channel. The status modifier bit in the status byte causes the channel to skip the next command (TIC) and execute the Write Data command.

TRANSFER IN CHANNEL (TIC)

Command	Data Address	Flags	000	Count
xxxx 1000 'x8'	Address of last command	xxxxx	xxx	xxxx

Comments: TIC*-8 branches back to last command address.
x = positions ignored.

WRITE DATA

Command	Data Address	Flags	000	Count
0000 0101 '05'	0BB8 = xx xx xx to 0C1C (data to update record)	00000	000	0064

Comments: The Write Data command transfers the data to update Frank Smith's payroll record from main storage locations 0BB8 to 0C1C to the disk.

If Frank Smith's payroll record had not been in cylinder 0C, head 04, the program would loop between the Search Key Equal and the TIC until every key on the track had been searched. The storage control would then signal unit check to the channel. A later Sense I/O command would indicate no record found.

The data just written could be verified by chaining the following CCWs to the Write Data command:

Read Sector	(store sector address)
Set Sector	(locate sector)
Search Key Equal	(locate record)
TIC*-8	
Read Data	(verify data)

READ INSURANCE POLICY NUMBER

Example: Find and read Joe Brown's insurance policy number. Assume: The disk is organized by ID (no keys); Joe Brown's employee number is 12341; The data length of each record is 00AA (170 decimal) bytes; His policy number is in the data area; The data set begins on cylinder 0A, track 00.

The record capacity chart shows that forty-three 170 byte records can be written on the track. Since the disk is organized by IDs (Joe Brown's = 12341), the track and record location can be found by dividing the ID by the number of records per track. In this case:

12341/43 = 287 (add 1 to the remainder to establish the address)

Thus Joe Brown's ID is 287 tracks from the beginning of the data set. There is no remainder so the first record on the track will be Joe Brown's.

he CC HH R for the Seek command is then determined by converting the 287 tracks to cylinders and adding the results to e beginning of the data set.

	Cylinder	Track	Record	C	C	H	H	R
tarting Address	10	00	0	00	0A	00	00	00
isplacement*	15	02	1	00	0F	00	02	01
esult:	25	02	1	00	19	00	02	01

= Determined by dividing 287 by 19.

he channel program is:

Seek
Search ID Equal
TIC*-8
Read Data

EEK

Command	Data Address	Flags	000	Count
0000 0111 '07'	03E8 = 00 00 00 19 00 02 C C H H	01000	000	0006

omments: The Seek command is executed to place the access mechanism at cylinder 19 (25 decimal) and select head 02.

EARCH ID EQUAL

Command	Data Address	Flags	000	Count
0011 0001 '31'	05DC = 00 19 00 02 01 C C H H R	01000	000	0005

Comments: The Search ID Equal causes the first ID found on the track to be compared with Joe Brown's ID. All unequal comparisons of IDs cause the storage control to signal channel end and device end to the channel. The TIC (back to Search ID Equal) is then executed. When an equal compare is found (ID of record 1) the storage control signals channel end, device end, and status modifier to the channel. Status modifier causes the next command (TIC) to be skipped and the Read Data command is executed.

TRANSFER IN CHANNEL (TIC)

Command	Data Address	Flags	000	Count
xxxx 1000 'x8'	Address of last command	xxxxx	xxx	xxxx

Comments: TIC*-8 branches back to last command address.
x = positions ignored

READ DATA

Command	Data Address	Flags	000	Count
0000 0110 '06'	0BB8 = xx xx xx to 0C62 (insurance policy number)	00000	000	00AA

Comments: Execution of the Read Data command causes the data area, containing Joe Brown's insurance policy number, to be read into main storage at locations 0BB8 to 0C62.

Standard Features

Standard features are included with all 3830/3330 facilities. Some features were used on earlier systems and some are new.

MULTITRACK (M/T) OPERATION

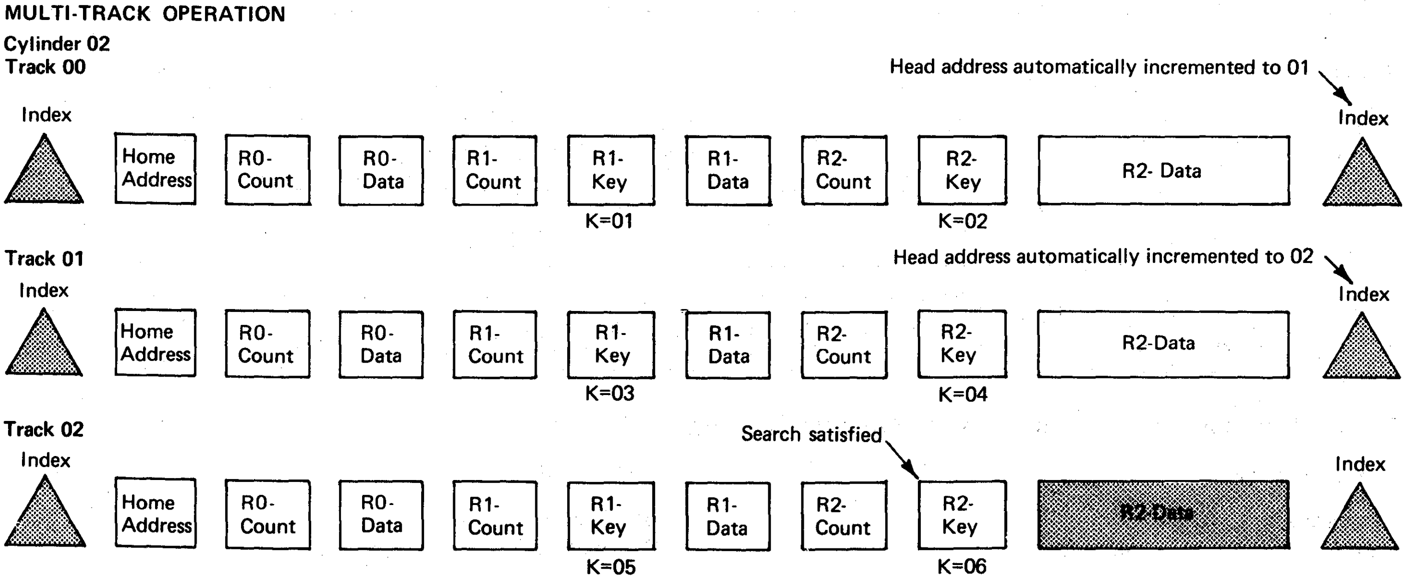
Multitrack (multiple track) operation allows a Search command to check consecutive tracks until a specified area is found. On all Search (and most Read) commands, the storage control can automatically select the next sequential head in the cylinder. If the command code bit 0 is on (1) and the command data transfer has not started, the next sequential head is selected at index. This eliminates the need for Seak Head commands in a chain of Read or Search commands.

The M/T bit must be used with care. A starting point should be indicated before the M/T bit is used. If a multitrack search is started without a Read HA or Read R0, the required record may have passed the head before the search is started. The head sequencing would continue on the next track and so on to the end of the cylinder without finding a comparison.

A Set Sector command with a value of zero might precede the multitrack command. Head switching could again occur before the record is reached. Correct use of a multitrack command is shown in Figure 13.

Multitrack operations are not used on Read IPL, Read Sector, or Read Diagnostic Status 1 commands. The Channel Command pages include the M/T code when multitrack operations can be used.

Note: *If the head switching operation crosses a file-protected boundary or exceeds the cylinder limit, channel end, device end, and unit check are presented to the channel.*



Channel program using multitrack search.

Object:

Update John Doe's payroll record.

Assume:

The disk is organized by keys, and the physical address of the record is unknown.

Set File Mask	(allow Write and Seek commands)
Seek	(cylinder 02, head 00)
Read HA	(make sure all records are read)
Search Key Equal	(M/T bit on, argument = 06)
TIC*-8	
Write Data	(updates shaded area)

Figure 13. Multitrack Operation

RECORD OVERFLOW

The record overflow feature allows records that exceed the capacity of a track to be continued on the next available track within the cylinder. Each part of an overflow record is called a segment. Each segment contains count, key (optional), and data areas. The key and data lengths specified by KL and DL in each count area apply only to the record segment, not the entire record. Since the only significant key area is in the first segment, the remaining segments seldom have key areas.

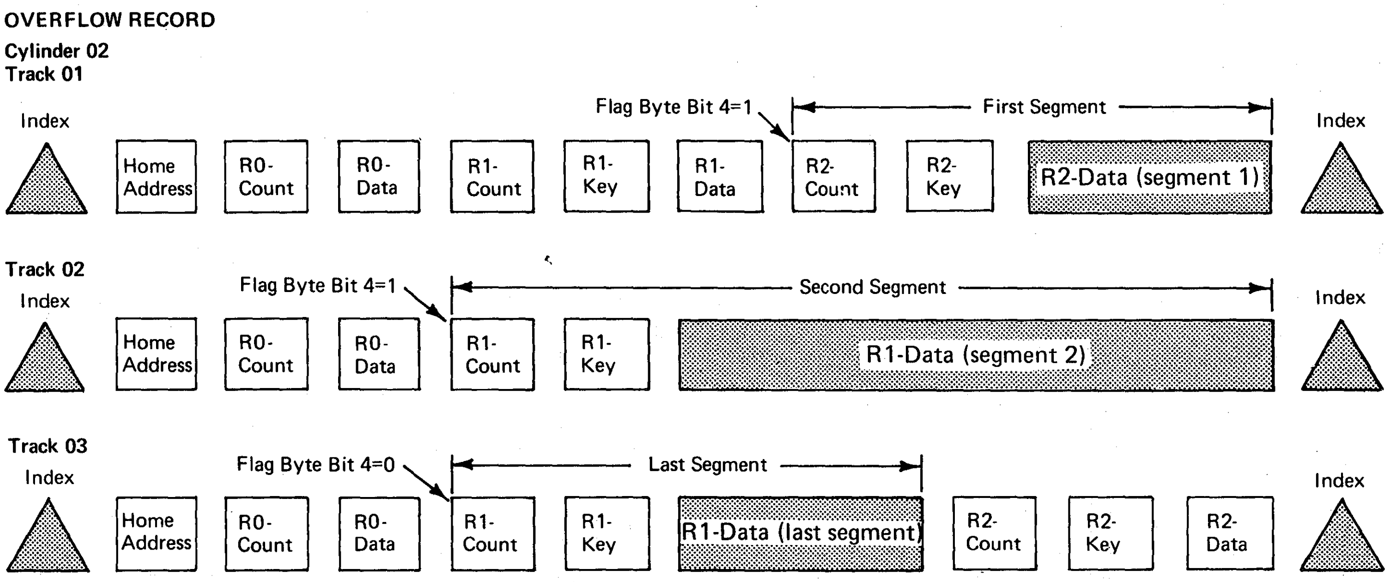
Overflow Record Formatting

All overflow records (except the last segment) are formatted by the Write Special Count, Key and Data command. The last segment uses a normal Write CKD command. An example of an overflow record is shown in Figure 14.

In the Write Special CKD command, bit 4 is on in the flag byte for the record segment being written. This bit, identifying an overflow segment, indicates to subsequent record processing commands in the chain that the record continues on the next track.

All head switching must be done by the formatting program. (See Figure 14.) Head switching will not occur in violation of the file mask, past the end-of-cylinder, or to a defective or alternate track.

Except for the first, all record segments must be written immediately following R0, and all segments but the last must be the last physical record on their tracks.



Typical channel programs for formatting, updating, and reading overflow records.

FORMATTING:

Set Sector	
Search ID R1	(track 1)
TIC*-8	
Write Special CKD	(segment 1)
Seek Head	(next track)
Search ID R0	(track 2)
TIC*-8	
Write Special CKD	(segment 2)
Seek Head	(next track)
Search ID R0	(track 3)
TIC*-8	
Write CKD	(last segment)

UPDATING:

Set Sector	
Search ID R2	(segment 1)
TIC*-8	
Write Data	(updates shaded areas)

READING:

Set Sector	
Search ID R2	(segment 1)
TIC*-8	
Read Data	(reads shaded areas)

Figure 14. Overflow Record

Overflow Record Processing

Overflow records can be read or updated with the following commands:

- Read Count, Key and Data
- Read Key and Data
- Read Data
- Write Key and Data
- Write Data

When any of the above commands are used to process an overflow record, the operation will not terminate at the end of a record segment when the segment is flagged with bit four (on) in the flag byte. Instead, the head address is incremented by 1 at index and the operation continues in the data area of record one on the next track. If this record segment is also flagged with bit four (on) in the flag byte, the operation continues on the next track. When a segment is found that is not flagged, the operation terminates at the end of the data area. The net effect of this procedure is that the data areas of all the record segments appear as a single logical data area.

Should a data overrun occur during the first segment, the storage control attempts recovery through use of command retry. If a data overrun occurs during an operation involving the second (or subsequent) segments, unit check is signaled at the end of the associated segment.

If a data check or bus-out parity error occurs, unit check is signaled at the end of the associated area.

Note: *Note: If a Write operation was in progress, unit check is signaled at the end of the record segment.*

If the CCW count is less than the number of bytes in the logical record, the operation continues to the end of the logical record before presenting ending status.

Spacing over overflow records does not occur automatically. The channel program must be written so that the entire logical record is spaced over, not just the first segment. For example, in the sequence:

Set Sector
Search ID (first segment)
TIC*-8
Read CKD (multitrack)

the Read CKD does NOT read the next logical record on the cylinder. It commences reading the overflow record at the count field of the second segment.

The sequence:

Set Sector
Search ID (first segment)
TIC*-8
Read Key and Data (skip and SLI flags on)
Read CKD (multitrack)

reads the count, key, and data of the next logical record.

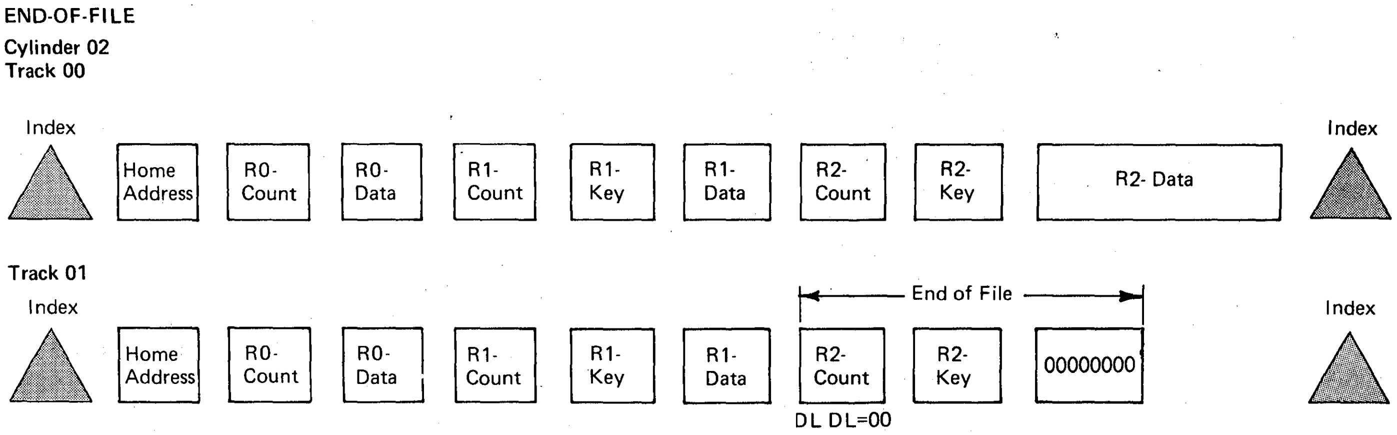
Multitrack operations should not be confused with overflow record operations. Head switching, when processing overflow records, occurs regardless of whether the M/T bit is on or off.

END-OF-FILE

An end-of-file record is used to define the end of a logical group of records and is written by executing a Write CKD command with the DL bytes in the count area set to zero. When a Write CKD with a data length of zero is executed, the storage control writes a data area of one byte of zeros which is followed by the ECC bytes, see Figure 15.

The KL byte in the count area can be either zero or non-zero. If KL is zero, the end-of-file record contains only the contents of the count and data areas. If the KL is not zero, the key area is written as specified by the KL byte.

Unit exception status is generated if a zero data length is found and no data from the data area is sent to the channel. A Read R0, Read CKD, or Read KD transfers the key area (if any) to the channel. The unit exception is generated during execution of Read IPL, Read R0, Read CKD, Read KD, Read Data, Write KD, and Write Data commands.



Set File Mask (allow Seek and Write Commands)
Seek (cylinder 02, head 00)
Write Home Address
Write R0
Write CKD R1
Write CKD R2

Seek Head (cylinder 02, head 01)
Write Home Address
Write R0
Write CKD R1
Write CKD R2 (data length = 00)

Figure 15. End of File

ROTATIONAL POSITION SENSING

Rotational position sensing reduces the time required for the channel to search for a record. This feature lets a Search command be started just before the required record comes under the read/write head.

Rotational position sensing is accomplished by dividing the storage disks into sectors. The tracks in each cylinder are divided into 128 equally spaced sectors and each track record has a sector location as well as a record address. Although not physically indicated on the tracks, the sector location is stored at the beginning of all Read, Write, and Search commands. When chained to a Read, Write, or Search CCW, the Read Sector command provides the sector location required to access the record that was processed by the previous command. A later Set Sector command fetches the sector location from CPU main storage and repositions the track at that record. This type of operation is particularly useful in Write verification and sequential disk processing operations, see Figure 16.

The sector location of a record is determined by the length of all records that are ahead of it and its sequential position on the track. The sector location can be calculated with the following formula. IBM access methods that support the 3330 calculate the correct sector number.

If:	n	=	Record number of required record
	S(n)	=	Sector number
	KL	=	Key length (in bytes)
	DL	=	Data length (in bytes)

Then:

$n = 0$: $S(n) = 0$
$n = 1$: $S(n) = 128/13440\ (237)$

$$n > 1 : S(n) = \frac{128}{13440}\left[237 + \sum_{i=n}^{n-1} (135 + KL_i + DL_i + C)\right]$$

where:

$C = 0$ if KL_i is zero.
$C = 56$ if KL_i is not zero.

A standard R0 key area (KL = 0, DL = 8) is assumed.

The following example shows some of the advantages of using rotational position sensing to locate and retrieve records.

Without RPS

Channel program 1.

Command	Channel and Storage Control Status
Seek	Available as soon as the storage control accepts the seek address.

Channel program 2.

Command	Channel and Storage Control Status
Search ID Equal	Busy (average 12.5 ms on the 2314)
TIC*-8	
Read Data	Busy

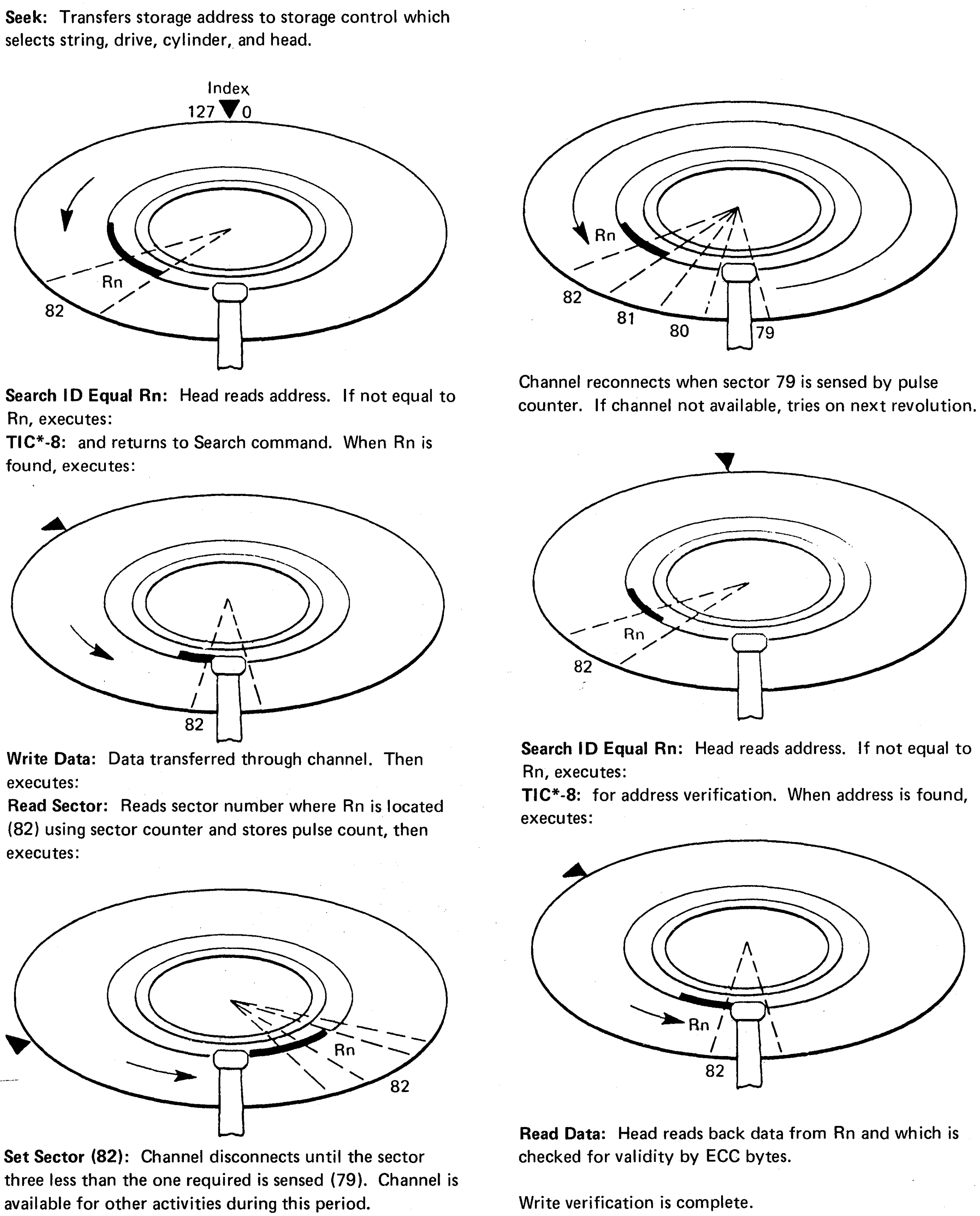
With RPS

When the sector address is known or can be calculated, the following channel program can be used.

Command	Channel and Storage Control Status
Seek	Available during access movement.
Set Sector	Available until sector is located.
Search ID Equal	Busy (average 250 μs on the 3330).
TIC*-8	Normally the first ID read is that of the required record and the TIC is not executed.
Read Data	Busy

Notice that with RPS only one channel program is required to locate the record and transfer the data. This eliminates a Seek I/O interrupt and the I/O processing required to schedule a data transfer channel program.

The channel and disk storage are available during access motion and rotational positioning. This allows Seek and Set Sector operations to be overlapped with other I/O operations on the storage control and channel.



Seek: Transfers storage address to storage control which selects string, drive, cylinder, and head.

Search ID Equal Rn: Head reads address. If not equal to Rn, executes:

TIC*-8: and returns to Search command. When Rn is found, executes:

Write Data: Data transferred through channel. Then executes:

Read Sector: Reads sector number where Rn is located (82) using sector counter and stores pulse count, then executes:

Set Sector (82): Channel disconnects until the sector three less than the one required is sensed (79). Channel is available for other activities during this period.

Channel reconnects when sector 79 is sensed by pulse counter. If channel not available, tries on next revolution.

Search ID Equal Rn: Head reads address. If not equal to Rn, executes:

TIC*-8: for address verification. When address is found, executes:

Read Data: Head reads back data from Rn and which is checked for validity by ECC bytes.

Write verification is complete.

Figure 16. Use of Rotational Position Sensing

MULTIPLE REQUESTING

Block multiplexer channels with rotational position sensing allow the storage facility to disconnect from the channel during mechanical delays caused by arm positioning Seek or Set Sector commands. Reconnection is attempted just before the access mechanism is at the desired track or when the specified rotational position has been reached.

During the time the channel and storage control are disconnected, the CPU is free to start I/O operations on other drives attached to the storage control even though the disconnected channel program is incomplete. This allows separate channel programs to be operating on each drive attached to the storage control.

The storage control stores the Set File Mask, Seek, or Set Sector arguments required to complete the disconnected command chains.

COMMAND RETRY

Command retry is a channel/storage control procedure that automatically retries a channel command without interrupting the control program so no CSW is stored. When a command is improperly executed, the storage control signals the channel with a special combination of status bits (channel or device end, status modifier, and unit check). In response, the channel reissues the command for retry.

Command retry is used:

1. To recover from correctable data errors (11 bits or less) occurring during a Search or Read operation on a home address, count, or key area.

   During a Search or Read operation, the new address, count, or key read from the disk is placed in a storage control buffer. If a correctable data error occurs, the storage control corrects the data in the buffer and requests the channel to reissue the command which caused the error. The storage control disconnects and frees the channel while the record is being reoriented. When the failing command is re-executed, the corrected data in the buffer is used instead of the actual data from the track.

2. When an uncorrectable data error (longer than 11 bits) is found in any record position during a Read or Search operation.

   The failing command is reissued by the storage control. If retry is successful, the channel program continues normally. If retry is not successful, the operation is retried again.

   After any retry, if the error becomes correctable, the procedure described in 1 (above) is used. If the error remains uncorrectable, the operation is ended and the program is interrupted.

3. When a Seek access error is detected.

   The storage control retries the command and attempts to position the access mechanism correctly.

4. When an alternate or defective track is found before data transfer begins.

   The storage control determines the alternate or defective track location (from R0 on the track), initiates a Seek to this track, orients on index, and reissues the command.

5. When a command overrun (or late command chaining) occurs because of interference by another channel or the CPU.

   The storage control initiates a retry of the late command.

6. When a data overrun occurs except: when the data overrun occurs during a record overflow operation in the second or subsequent segments; or the data overrun occurs during a Format Write.

Conditions Following Command Retry

Command retry execution may cause certain conditions to be detected by the initiating program:

1. A CCW containing a PCI may, if retried because of command retry, cause multiple PCI interruptions.
2. A channel program consisting of a single, unchained CCW specifying an immediate command may cause a condition code of a zero rather than a one to be set. This condition code setting occurs if the storage control signals command retry at the time that initial status is presented. The channel program then causes a later interrupt upon completion of the operation.
3. If an early stop to the channel program execution occurs during a command retry, the residual count and command address in the CSW may not necessarily indicate the amount of main storage used.
4. If a CCW used in an operation is changed before that operation has been successfully completed, the results are unpredictable.

STATISTICAL USAGE AND ERROR RECORDING

The storage control keeps a statistical data record of usage and error information for each logical device in the storage facility The usage information provides an accumulated count of the total number of access motions and the total number of data bytes read.

The error information provides an accumulated count of the total number of seek errors, correctable data errors, and uncorrectable data errors recovered by the command retry procedure. Also included is the total number of command and data overrun conditions retried by the storage control.

Any time that the number of errors reaches a preset level, or the number of seeks or the number of data bytes processed reaches the preset level, the storage control generates a unit check signal. The unit check is presented to the channel when the next Start I/O instruction is addressed to the storage control.

The sense information associated with the unit check consists of: environmental data present, sense byte 2, bit 3; and usage and error statistics, sense byte 7. The usage and error information is reset after being transferred to the channel by the Sense I/O command.

The Read and Reset Buffered Log command is used to retrieve the usage and error information after a pack change or at the end of a shift.

A system reset will reset the usage and error statistics for only those devices which have a pack change device end outstanding.

STORAGE CONTROL DIAGNOSTICS

To provide maximum availability, the storage control can execute diagnostic tests on a drive concurrent with normal system operations on the other drives. This capability permits the customer engineer to diagnose and repair most drive failures while the subsystem continues to operate the other attached drives. The storage control provides a transient block of 512 bytes (128 words) of storage for temporary residence of a specified diagnostic test.

The transient area is loaded by the system under control of the On-Line Test Executive Program (OLTEP). A special command (Diagnostic Write) loads a selected test into the storage control and instructs it to execute the test. This loading and execution may also be done from the CE panel.

After the test, error message information or test results are transferred to CPU main storage by a Read Diagnostic Status 1 command. If the CE panel is used, the results are displayed on the panel indicators.

STORAGE CONTROL USAGE METER

If the Enable/Disable switch is set to Enable when a power-up sequence occurs, meter time is logged as long as the CPU meter is recording or until the usage meter and storage control are disabled from the channel.

The usage meter and storage control are disabled when all of the following conditions exist simultaneously:

- The Enable/Disable switch is set to Disable.
- The CPU is in a stop or wait state.
- Command chaining is not in effect.
- No channel is selected by the storage control channel selection switches (see Special Features).
- The storage control is not performing an operation.
- There is no pending status (see Pending Status).

The usage meter can then be enabled when:

- The CPU is in the stop or wait state.
- The Enable/Disable switch is at Enable.

Special Features

TWO CHANNEL SWITCH AND TWO CHANNEL SWITCH ADDITIONAL

The two channel switch special feature allows the storage control to be shared by two channels. The combination of two special features, two channel switch and two channel switch additional, permits the storage control to be shared by four channels. The channels may be attached to either the same or different central processing units.

With appropriate programming or operator action, the individual drives attached to the storage control may be reserved for the exclusive use of any of the channels. Channel switching and device reservation are controlled by the channel program.

Two special commands are used with these features, Device Reserve and Device Release. Reservation of a device is made by executing the Device Reserve command. This same device reservation is ended by a Device Release command. Sense data is transferred to the channel when either command is executed.

Channel Enable/Disable Toggle Switches

Channel access is determined by up to four toggle switches on the 3830 storage control. The four channels are identified as A, B, C, and D. Each toggle switch can be set to either Enable or Disable. When all four switches are in the Enable position, any one of the four channels can select the storage control. Should more than one channel attempt to connect at the same time, tie-breaking logic selects one of the channels. If a switch is placed in the Disable position, the channel identified by the switch can not select the 3830.

Once the storage control has been selected by a channel, it remains connected until ending status has been presented. At that time the storage control becomes available to all other enabled channels unless:

- The ending status byte includes device end to indicate chaining.
- Chaining is indicated without device end and the channel does not disconnect.
- Chaining is indicated in the ending status byte, the channel disconnects, and the storage control becomes busy for: an error recovery procedure; execution of a Diagnostic Load or Write CCW; or completion of a Format Write operation.
- Chaining is indicated and a Format Write is in progress.
- The last status byte was part of a channel initiated signal sequence and was stacked by the channel.
- A contingent connection is established.
- Ending status associated with an interface disconnect has not been accepted by the channel.

Device Status

The Multitag switch on the 3830 storage control panel determines how the device end generated by the drive is presented to the channel. The switch has two positions, Multitag and Off.

In the Multitag position, the device end (going from not-ready to ready) status is presented to each enabled channel. This status condition must be accepted by each individual enabled channel before the channel can use the device.

When the switch is in the Off position, the device end status is presented to one channel, the first channel to accept the status byte. The device then becomes available to all enabled channels for use as required.

A device has a "tagged" status when a Device Reserve command is issued by one specific channel. The device remains committed exclusively to that channel until a Device Release command is issued by that channel. An attempt at device connection by any other channel will result in a busy status condition. The storage control attempts to present device end after the busy condition has ended. The address byte used with this status byte is the same as that used with the busy status byte.

Addressing

The base address (five high-order bits) of the storage control on one channel is independent of the base address on the other channels. However, the three low-order address bits for any attached device must be the same on all channels.

Resets

A system reset may be initiated by any channel at any time. It resets all reservations and status conditions stored in the storage control for the channel, ends all block multiplex command chains in progress on the channel, and resets all device interrupts not involving the other channels. Reservations, status, and device interrupts for the other channels, as well as block multiplex chains in progress on the other channels, are not affected.

If a channel initiates a system reset while the selection switch is connected to the other channels, a machine reset is performed when the channel select switch goes to neutral. A selective reset has no effect on device reservations or status.

WRITE INHIBIT

The write inhibit special feature provides the means for protecting data disk packs from being rewritten or erased. This protection is controlled by the operator and is independent from the system control programs.

A toggle switch, one for each drive, is mounted on the operator panel. When in the down (READ) position, writing or erasing is not permitted. In the up (R/W) position, both read and write operations are allowed. The position of the switch is posted in the storage control.

With the write inhibit feature installed, the storage control checks the switch position before executing any Write command. If the switch is set to READ, the Write command is rejected and the storage control presents a unit check to the channel. The sense information posted consists of command reject (byte 0, bit 0) and write inhibited (byte 1, bit 6).

Error Recovery Procedures

The error correction table (Figure 17) identifies all unique configurations of sense bits in sense bytes 0, 1, and 2 that are posted by the storage control. The table details the specific recovery action to be taken for each of these configurations. The recovery action table (Figure 18) specifies the procedure to be followed for recovery from the error.

ERROR CORRECTION FUNCTION

The device recovery action tables use an error correction function as one step in data error recovery. This function is used when the storage control posts the data check and correctable sense bits in the sense information. These bits are posted if a correctable data error is found in any data area.

Correctable data errors in the home address, count, and key areas are corrected internally by the storage control using command retry. Data check and correctable sense bits are not posted nor do these errors cause a system interrupt.

When the correctable and data check sense bits are included in the sense information, sense bytes 18 through 22 provide the error pattern and displacement.

Error correction is done by aligning the error pattern provided in sense bytes 20 through 22 with the erroneous data in main storage, and comparing the patterns through use of an exclusive OR.

The data error location in CPU main storage is found by using the displacement information from the sense bytes and the counts provided in the interrupted CCW chain. The storage control shows the error location in relation to the first error byte transferred in the operation where the error was discovered.

The displacement between the first byte transferred and the first error byte is found by subtracting the error displacement in sense bytes 18 and 19 from the restart displacement found in sense bytes 15 through 17. The result gives the forward error displacement and is used with the count specified in the interrupt CCW to locate the erroneous data in main storage.

If data chaining was used in the operation that posted the correctable error, the forward displacement may reference data from the second (or subsequent) CCW in the data chain.

Before applying the error correction function, determine whether any error bytes were not transferred because the skip bit was on, a short count in the CCW, or if the error bytes are not in adjacent main storage locations because of data chaining between CCWs.

- If any of the error bytes are in data specified by a CCW with the skip bit on, the error correction function cannot be used for the bytes that were not transferred to main storage
- If any of the error bytes are in data not transferred to main storage because of a short CCW count, the error correction function cannot be used for the bytes that were not transferred to main storage.
- If no short CCW count is found and bit 7 of sense byte 23 indicates channel truncation, the error correction function cannot be applied correctly.
- If the error pattern scans non-adjacent main storage boundaries because of data chaining, the error correction function must be selectively applied to the separated storage locations.
- If the error displacment in sense bytes 18 and 19 is less than 3, the error is partially or totally contained in the error correction code bytes. The error pattern in sense bytes 20 through 22 is then constructed as follows:
  1. If the error displacement is zero, the error pattern must be set to zero by the error recovery programs (ERPs).
  2. If the error displacement is one, the two low-order error pattern bytes (bytes 21 and 22) must be set to zero by the ERP. The high-order bytes contain the correction syndrome.
  3. If the error displacement is two, the low-order pattern byte must be set to zero by the ERPs. The high-order bytes contain the correction syndrome.

  Note: *Case 1 also occurs if the error is totally contained in the gap byte that immediately precedes the data area.*

3330 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 Write Inhibit switch in the READ position.	1	No
0	1	Intervention Required	Drive offline or not plugged for the address.	3	No
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 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	No
0 2	4 1	Data Check Correctable	Correctable data check in the data area or data area of the last overflow segment.	5	No
0	5	Overrun	Service overrun in second or subsequent overflow segment or during a format write.	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 Protected	The Seek command or read/search multitrack operation violated the file mask.	10	No
1 1	5 7	File Protected 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

Figure 17. Error Correction Table

3330 Recovery Action Table

Action	Explanation
1	Print console error message for operator and/or customer engineer notification. (See Figure 21.)
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. If user's chain is not complete, examine next non-TIC command in chain. If bit 3 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 preceeding 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* Set File Mask (same as original) Read Home Address (skip bit on) Search Equal ID (CCHHR from sense bytes 8-12) TIC*-8 TIC (channel status word)
5A	Continue the user's chain by executing: Seek* Set File Mask (same as original) Read Home Address (skip bit on) Search Equal ID (CCHHR from sense bytes 8-12) TIC*-8 Read Count (skip bit on) TIC (channel status word)
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.* d. Construct restart CCW 2. e. Complete the interrupted operation and continue the user's chain (if appropriate) by executing: Seek* (increment seek argument by one) Set File Mask (same as original) Set Sector (argument 0) Search ID Equal (record 1) TIC*-8 Restart CCW 2 TIC (channel status word) **Note;** *If the modified seek argument is not within the user's extent, then IOS must supply the correct seek argument before issuing the Seek. If that is impossible, then IOS must do action 2.*

* Cylinder bytes and high order head byte obtained from user. Low order head byte obtained from bits 3-7 of sense byte 6.

Figure 18. Recovery Action Table (Part 1 of 3).

3330 Recovery Action Table (continued)

Action	Explanation
6B	a. Examine bit 7 of the file mask (PCI). If off, go to step c. If on, return to user with indication that data has been corrected. (User is operating in PCI fetch mode and must suply 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* Set File Mask (same as original) Set Sector (argument 0) Search ID Equal (record 1) TIC*-8 Restart CCW 2 TIC (channel status word)
7	a. Construct seek argument.* b. Construct restart CCW 1. c. Continue user's chain by executing the following: Seek* (increment seek argument by one) Set File Mask (same as original) Set Sector (argument 0) Search ID Equal (record 1) TIC*-8 Restart CCW 1 TIC (channel status word)
8	a. Increment the cylinder address of the user's seek argument by one. Reset the head address. b. Continue the operation by executing the following: Seek (argument from step a) Set File Mask (same as original) TIC (channel status word -8) **Note**: *If the modified seek argument is not within the user's extent, then IOS must supply the correct seek argument before issuing the Seek. If that is impossible, then 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 (channel status word) **Note**: *If the modified seek argument is not within the user's extent, then IOS must supply the correct seek argument before issuing the Seek. If that is impossible, then IOS must do action 2.*

** Cylinder bytes and high order head byte obtained from user. Low order head byte from bits 3 through 7 of sense byte 6.*

Figure 18. Recovery Action Table (Part 2 of 3).

3330 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) Set File Mask (same as original) TIC (channel status word) **Note:** *If seek argument is not within the user's extent, then IOS must supply the correct seek argument before issuing the Seek. If that is impossible, then IOS must do action 2.*
10A	a. This is a multitrack operation. Increment the user's seek argument by one. b. Continue the operation by executing the following: Seek (argument from step a) Set File Mask (same as original) TIC (channel status word -8) **Note:** *If the modified seek argument is not within the user's extent, then IOS must supply the correct seek argument before issuing the Seek. If that is impossible, then IOS must do action 2.*
11	a. Increment the user's seek argument by one. 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 (channel status word) **Note:** *If the modified seek argument is not within the user's extent, then IOS must supply the correct seek argument before issuing the Seek. If that is impossible, then IOS must do action 2.*

Figure 18. Recovery Action Table (Part 3 of 3).

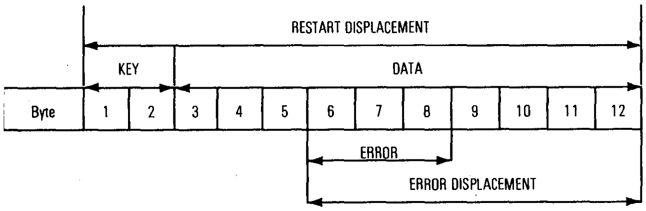
Error Correction Example

To clarify the correction procedure, examine the following:

Assume: Key length = 2 bytes
Data length = 10 bytes

The CSW-8 points to CCW 1 in the following chain:

CCW	Commands	Address	Count	Flags
1	Read KD	A	2	Data chaining
2	TIC	CCW3	--	---
3	--	B	4	data chain, skip
4	--	C	1	suppress incorrect length



Suppose the error affected bytes 6, 7, and 8 as follows:

Byte 6 – – – – – – x x
Byte 7 x x x – – – – –
Byte 8 x – – – – – – –

where — is the correct bit
where (x) is the incorrect bit

This condition generates a restart displacement of 12 and an error displacement of 7. The error pattern would be generated as follows:

Pattern byte 1 (Sense byte 20) 0000 0011
Pattern byte 2 (Sense byte 21) 1110 0000
Pattern byte 3 (Sense byte 22) 1000 0000

Applying the error correction algorithm, as previously described, results in the following system recovery action.

1. Pattern byte 1 could not be applied to data byte six as this byte was not transferred to main storage because of the skip flag in CCW 3.
2. Pattern byte 2 would be exclusively ORed with location B where data byte 7 resides.
3. Pattern byte 3 would not be applied to data byte 8 since this byte was not transferred to main storage because of the short count in CCW 4.

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. The construction process details follow.

RESTART CCW 1 CONSTRUCTION

1. Get command code byte from sense byte 3.
2. Data address equals interrupted CCW address plus the CCW count, minus CSW residual count.
3. Use interrupted CCW flags except for PCI flag.
4. Use CSW residual for count. If zero, use one. If command was a Write, specify a byte having '00'. If command was a Read, turn on the skip bit.

RESTART CCW 2 CONSTRUCTION

1. Get command code from sense byte 3.
2. Construct count as follows:
   a. Get CCW count shown by CSW-8 and set a pointer to this CCW.
   b. Subtract restart displacement from count in (a). If positive, skip to step f; otherwise, continue.
   c. Check chain data flag of the CCW designated by the pointer. If flag not set, skip to step e; otherwise, continue.
   d. Advance pointer to next non-TIC CCW in data chain. Add this CCW count to count or all previous non-TIC CCWs in the chain. Return to step b.
   e. Truncation occurred. Set restart CCW 2 count to 1. Skip to step 3 and include skip bit in restart CCW flags.
   f. Set restart CCW 2 count to step b result. Go to step 3.
3. Flags (except PCI) are same as those of CCW designated by pointer in step 2. Skip bit also set if step 2e was executed.
4. Data address equals that of CCW designated by pointer in step 2, plus the count of the CCW minus restart CCW count from step 2.

   If another operation incomplete occurs, a new restart CCW can be generated. return to step 2 but don't destroy old restart CCW before generating a new one.

DISK PACK LOADING

1. Place the START/STOP switch on the 3330 operator panel in the STOP position.
2. Place the OPEN/CLOSE switch on the 3330 operator panel in the OPEN position.
3. Remove the bottom cover of the disk pack by pressing the two handles on the bottom cover together.
4. Place the disk pack (in its top cover) on the drive spindle.
5. Turn the top cover in a clockwise direction until it comes to a full stop.
6. Lift the top cover from the disk pack.
7. Place the OPEN/CLOSE switch in the CLOSE position.
8. Place the START/STOP switch in the START position to return the drive to normal operation.
9. Reassemble the top and bottom covers.

With the pack identification label facing forward, place the reassembled cover in the recessed "well" on top of the 3330. The cover for the pack in the upper drive should be placed in the well on the left, and the cover for the pack in the lower drive in the well on the right. When stored in this manner, the pack identification is over the logical address plug associated with the drive in which the pack is mounted.

Do not store disk packs on top of the disk drives.

DISK PACK UNLOADING

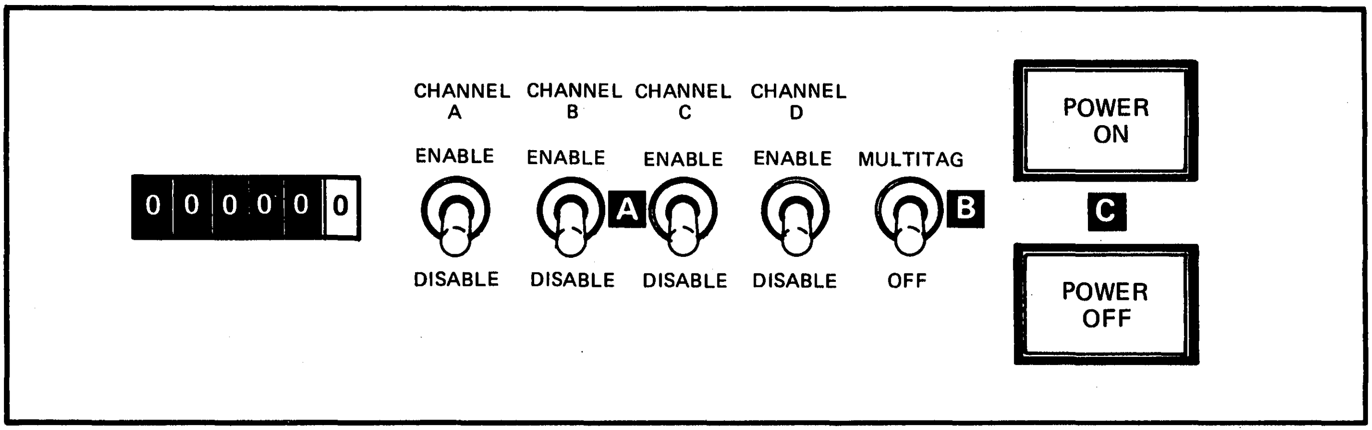
1. Place the START/STOP switch on the 3330 operator panel in the STOP position.
2. Place the OPEN/CLOSE switch on the 3330 operator panel in the OPEN position.
3. Place the top cover on the disk pack and turn the cover in a counter-clockwise direction for two full turns.
4. Lift the top cover, now containing the disk pack, from the spindle.
5. Immediately attach the bottom cover.
6. Unless another pack is being loaded, place the OPEN/CLOSE switch in the CLOSE position.
7. Store the removed disk pack in a clean cabinet or on a clean shelf.

DRIVE ADDRESS CHANGING

To change the address of a drive:

1. Make sure that the program controlling the 3830 is in a wait state, or that the existing conditions allow removal of the logical address plug.
2. Remove the logical address plug from the affected 3330 operator panel and perform any necessary pack changes.
3. Place the desired address plug in the socket on the operator panel.

The drive is now ready to resume normal (or CE) operation.



A

Toggle switch that must be in the Enable position before the 3830 Storage Control is available to the channel. If the two channel switch feature (and possibly the two channel switch additional feature) is installed, a separate switch is provided for each channel.

B

Toggle switch that determines how the device end generated by the drive, in a not-ready-to-ready sequence, is presented to the channel.

Multitag Position: A drive is made available to a channel after it clears the device end generated by the drive in a not-ready-to-ready sequence. Before any other channel can use the drive, it must also accept the not-ready-to-ready sequence device end.

Off Position: A drive is made available to all channels after one of the channels clears the device end generated by the drive in a not-ready-to-ready sequence.

C

Power Off: A momentary pushbutton that can be used to remove ac power from the 3330 facility.

If system power is on when the pushbutton is pressed, ac power is removed from the 3330 facility. If system power is turned off later, then on, ac power is reapplied to the 3330 facility; operation of the Power On pushbutton is not required.

Power On: A momentary pushbutton that can be used to reverse the effect of the Power Off switch. If system power is on, and the Power Off switch is pressed to remove ac power from the 3330 facility, then pressing the Power On switch will restore ac power to the 3330 facility.

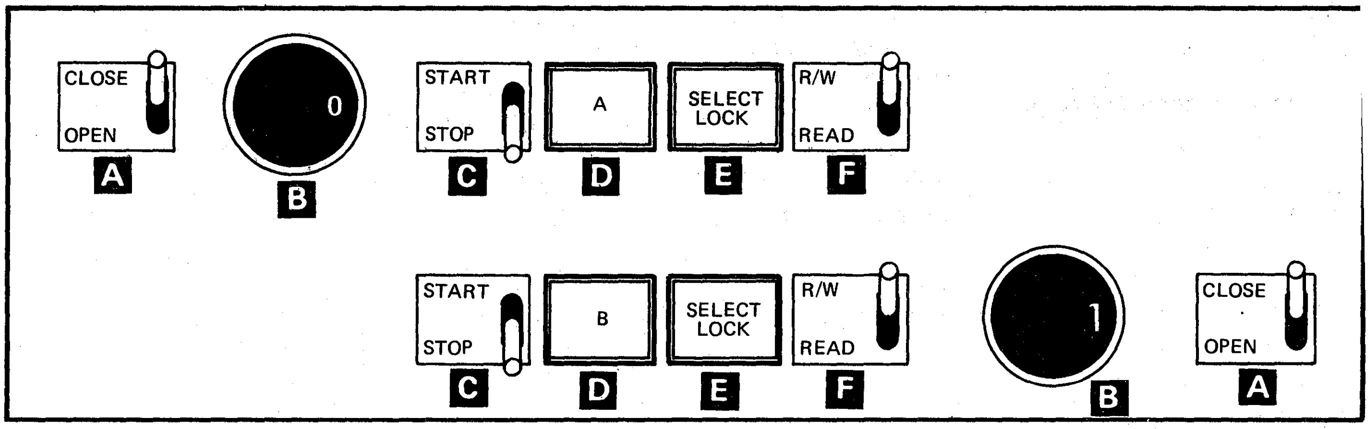
Whenever system power is brought up, ac power is applied to the 3330 facility, regardless of what was previously done to the two pushbuttons.

See 'Storage Control Usage Meter' for usage meter operation.

Figure 19. 3830 Storage Control Panel

3330 DISK STORAGE PANEL

There is one operator panel for each pair of disk drives attached to the 3330 facility. This panel contains switches and indicators associated with the individual drives.



A Opens and closes the drawer of one disk drive to permit operator access.

B A logical address plug with one unique address (0 through 7) must be inserted in the socket associated with each drive. The plugs are interchangeable among drives; simply remove the plug and insert the desired one in its place.

C Starts or stops one disk drive. When the switch is on START, the drive motor starts, a brush cycle is taken, and the read/write heads load. When the switch is on STOP, the heads unload and the drive motor stops.

D **Ready Indicator:** On when the drive is running, track following, and ready for use.

E This indicator comes on if a red/write malfunction occurs in the drive.

F **Write Inhibit:** In READ position, only read operations can be performed on the disk.

Note: *Upper elements are for upper drive and lower elements are for lower drive.*

Figure 20. 3330 Disk Storage Panel

When an error has been detected, the system console prints an error message. This message explains the error, identifies the device, and gives other pertinent information about the error.

The error message follows a specific format. All messages are subject to the following:

- The end of each field, except the last, is marked by a comma.
- Sometimes data fields are omitted, but consecutive commas indicate that a field is missing.
- Each line is printed in the basic format, but may contain different data fields.

The contents of some error messages is shown in Figure 21.

ERROR MESSAGE ANALYSIS

Field 1 is the channel/unit address (CUA). Check that this field refers to a 3830/3330 installed on the system. Three characters are used.

Field 2 contains the error description and can use up to twelve characters. The errors associated with the 3830/3330 are described in Error Descriptions.

Field 3 has the two hex digit code of the last channel command that was executed.

Field 4 is the channel status word. The first two digits are the unit status and the last two digits are the channel status.

Field 5 contains the sense bytes printed by hex digit pairs. This field can vary in length.

Field 6 is the seek address, six bytes in the form: 00 CC HH (each byte uses two hex digits).

Field 7 is the serial number of the storage disk pack mounted on the drive, six digits.

Field 8 is the job name, eight digits.

ERROR DESCRIPTIONS

After the error has been identified as a 3830/3330 error (from field 1), read the error description from field 2 and follow the instructions.

INTV REQD (INTERVENTION REQUIRED) This is a one-line message with the device specified in field 1.

CMND REJ (COMMAND REJECT) This two-line message contains the hex digits of sense byte 7 in field 5.

OVERRUN This two-line message points to further details in the sense bytes of field 5.

EQUP CHECK (EQUIPMENT CHECK) A two-line message. The symptom code is the four hex digits of sense bytes 22 and 23 at the end of field 5.

WRITE INHIB (WRITE INHIBITED) Check that the write inhibit switch on the drive operator panel is set to R/W.

DATA CHECK This two-line message is written for permanent, ECC-uncorrectable read errors described in sense byte format 4. Check the EREP history printouts and look for an invalid track format indication for the disk pack and seek address. If this condition is recorded, suspect a programming problem with a count area too large for the track (writing into index).

Make sure that the error is not due to a disk pack surface defect by moving the pack to another drive. If a surface defect is suspected, use the ATLAS or DASDI/DASDR utilitites to attempt data recovery and assign an alternate track for the one that is defective.

The symptom code will be found in sense bytes 22 and 23 at the end of field 5 in the form of four hex digits.

INTERFACE CONTROL CHECK This is an abnormal condition and no error message is produced.

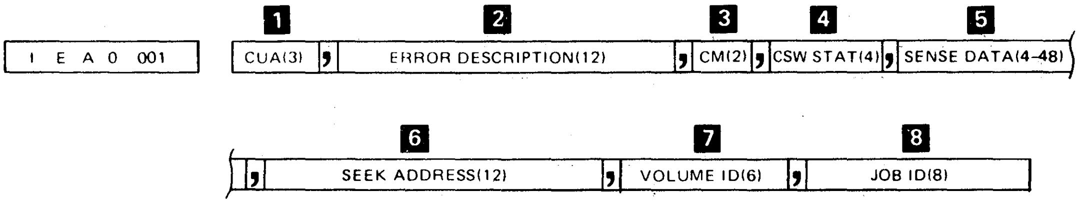


Figure 21. Console Error Message Format

Sense Data

The status and condition of the 3330 and 3830 are reported by the sense bytes. Twenty-four bytes of sense data are available and seven different formats are used. The first eight bytes (0 through 7) are the same for all formats. The remaining sixteen bytes contain different information depending on the format used. Formats 1, 4, 5, and 6 describe the disk storage condition; and formats 0, 2, and 3 are used for the storage control condition.

SENSE BYTE SUMMARY

In all formats the first eight bytes (0 through 7) contain high-level sense and error condition data. Sense byte 7 identifies the format of the remaining sixteen bytes. The first four bits of byte 7 indicate the format (in binary notation) and the last four bits (in binary) define a message if one is appropriate.

Each of the formats is summarized on the following pages. Figure 26 contains the applicable messages for each of the formats.

SENSE BYTE 0 through 7 SUMMARY

	Bit 0	1	2	3	4	5	6	7
Byte 0	Command Reject	Intervention Required	Channel Bus Out Parity	Equipment Check	Data Check	Overrun	Not Used	Not Used
Byte 1	Permanent Error	Invalid Track Format	End of Cylinder	Not Used	No Record Found	File Protected	Write Inhibited	Operation Incomplete
Byte 2	Not Used	Correctable	Not Used	Environmental Data Present	Not Used	Not Used	Not Used	Not Used
Byte 3 Restart	Restart Command (provided only when byte 1, bit 7 is on.) '06' = Read operation; '05' = Write operation							
Byte 4 Physical Identification	Storage Control Identification		Physical Drive Identification 111000 = A 101010 = C 011100 = E 001110 = G 110001 = B 100011 = D 010101 = F 000111 = H					
Byte 5 Cylinder Address	Low-order Logical Cylinder Address							
	128	64	32	16	8	4	2	1
Byte 6 Head Address	Reverse	Cylinder High Addr.	Difference High Addr.	Head Address				
		256	256	16	8	4	2	1
Byte 7 Format/ Message	Format (bits 0 -- 3 hex)				Message Code (bits 4 -- 7 hex)			

Figure 22. Sense Byte 0 through 7 Summary.

3830/3330 SENSE BYTES

SENSE BYTE 0

Bit 0 Command Reject	1. Invalid command code. 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. Improper alternate or defective track pointer. 7. Write command issued with Write Inhibit switch in READ position (byte 1, bit 6 also on).
Bit 1 Intervention Required	1. Drive addressed not attached to system. 2. Drive addressed not ready. 3. Diagnostic Write or Load command issued and microdiagnostic is resident in control storage.
Bit 2 Bus Out Parity	The storage control has detected a parity error in the data transferred from the channel.
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 defined in sense byte 7.)
Bit 5 Overrun	1. Storage control received byte from drive before last byte read was accepted by channel. 2. Data byte received too late from channel during write operation. *The storage control posts overrun only if condition occurs: (1) more than ten times in CCW chain, (2) in second or later segments of overflow record, or (3) during format write operation.* *Overrun detection stops data transmission. When writing, remaining part of record area is padded out with 0s. All data overruns are retried by storage control except for: overruns occurring on second or later record segments; overruns occurring during format write operations.* *If overrun exists after retry is exhausted, byte 1 bit 0 (permanent error) is posted.*
Bit 6,7	Not used -- set to 0.

Figure 23. Sense Byte 0 Description

3830/3330 SENSE BYTES

SENSE BYTE 1

Bit 0 Permanent Error	1. Storage control retry attempted and not successful. 2. A drive unsafe condition detected and retry should not be attempted.
Bit 1 Invalid Track Format	An attempt was made to write data exceeding the track capacity.
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	Not used -- 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. 2. Two index points sensed in command chain with no intervening write, sense, or control command.
Bit 5 File Protected	File mask violated by: 1. Seek command. 2. Multitrack read or search. 3. Overflow operation. (Byte 1, bit 7 also on.)
Bit 6 Write Inhibited	An attempt made to write on drive with Write Inhibit switch set to READ. (Byte 0, bit 0 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 also set.) 2. Overflow beyond cylinder boundary. (Byte 1, bit 2 also set.) 3. Correctable data error found in data area - not last segment. (Byte 2, bit 1 also set.) 4. Correctable data error found in home address or count area - not first segment. 5. Uncorrectable data error found in any area - not first segment. 6. Defective or alternate track found after start of data transfer. 7. Seek error found in second or later segment. See sense byte 3 for Restart command and bytes 8 through 13 for restart information.

Figure 24. Sense Byte 1 Description

3830/3330 SENSE BYTES

SENSE BYTE 2

Bit 0	Not used -- set to 0.
Bit 1 Correctable	Indicates that data error posted in byte 0, bit 4 is correctable. Bytes 18 through 22 identify error pattern and displacement.
Bit 2	Not used -- set to 0.
Bit 3 Environmental Data Present	Indicates that bytes 8 through 23 contain either usage or error statistics for error log information. Byte 7 indicates format for bytes 8 through 23.
Bits 4–7	Not used -- 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

SENSE BYTE 4

Bits 0,1	Storage control physical identification
Bits 2–7 Drive Identitification	Physical address of each drive: 111000 = A 101010 = C 011100 = E 001110 = G 110001 = B 100011 = D 010101 = F 000111 = H

SENSE BYTE 5

Bits 0–7 Cylinder-low	Identifies the low-order cylinder address of latest seek argument from channel.

SENSE BYTE 6

Bit 0 Reverse	Last seek (excluding retries) was in reverse direction (toward track 00).
Bit 1 Cylinder-High	High-order bit of cylinder address in sense byte 5 (binary 256).
Bit 2 Difference	High-order bit of difference count in sense byte 16, format 1 (binary 256).
Bits 3–7 Head Address	Head address of last seek (except retries). Head address is updated during multitrack and overflow operations. **Note**: *If an alternate track condition is found and operation incomplete is posted during an overflow operation, byte 6 is set to the head address of the defective track plus 1. This information is used by the ERPs to construct the seek argument to continue the operation.*

Figure 25. Sense Bytes 2 through 6 Descriptions.

3830/3330 FORMAT MESSAGES (Sense Byte 7)

	FORMAT				
Message Number	0	1	2	4	5
0	No Message	No Message	No Message	Uncorrectable HA Area	Correctable HA Area
1	Invalid Command	Set Target Error	ECC P1 or P3 Non-compare	Uncorrectable Count Area	Correctable Count Area
2	Invalid Sequence	Not Used	ECC P2 Non-compare	Uncorrectable Key Area	Correctable Key Area
3	CCW Count Short	No Drive Write Gate		Uncorrectable Data Area	Correctable Data Area
4	Data Value Incorrect	No Write Current Sense		No Sync Byte in HA Area	
5	Invalid Diagnostic Write	Not Used		No Sync Byte in Count Area	
6	Channel Halted Retry	Transmit Cylinder Error		No Sync Byte in Key Area	
7	Incorrect Retry CCW from Channel	Transmit Head Error		No Sync Byte in Data Area	
8	23FD Not Ready	Transmit Difference Error		Not Used	
9	23FD Seek Check	Unexpected File Status		No Address Mark Detection on Retry	
A	23FD Read Check	Seek Error			
B	Track Pointer Incorrect	Retry Seek Incomplete			
C	SERDES Error, no ST4s	No Interrupt from Drive			
D	Diagnostic Write Code Mismatch	Not Used			
E	Control Storage Busy	Not Used			
F	Retry Byte Count or Sector Wrong	Not Used			

Figure 26. Format Messages.

FORMAT 1 SENSE BYTE SUMMARY (3330 Equipment Checks)

	Bit 0	1	2	3	4	5	6	7
Byte 8 Module Status	Index Error	Offset Active	Seek Incomplete	Seek Complete	Online	Attention	Busy	Record Ready
Byte 9 Monitor Mode	Not Used	Diagnostic 4	Diagnostic 2	Diagnostic 1	Not Used	Mode 4	Mode 2	Mode 1
Byte 10 Monitor State	8	7	6	5	4	3	2	1
Byte 11 Check Status	CE Program Stop	Not Used	Not Used	Not Used	CUDI Bus Out Parity	Monitor Check	Not Used	Drive Command Reject
Byte 12 Safety	Data Safety	Servo Safety	Not Used	Not Used	Power On Reset	Not Used	Not Heads Loaded	Even Latch
Byte 13 CUDI Bus Out	CUDI Bus Out (TA register) Expected Data Expected data for messages 1,6,7,8,9; otherwise TA register.							
Byte 14 CUDI Bus In	CUDI Bus In (ND register) Received Data Drive status for message 9 or ND register.							
Byte 15 CUDI Tag Bus	CUDI Tag Bus (TD register). Contents of TD register.							
Byte 21 CUDI Check	Drive Selection Error	Tag Invalid	Device Check	TA Register Check	CUDI Register Check	TD Register Check	Not Used	Not Used

Figure 27. Format 1 Summary.

FORMAT 2 SENSE BYTE SUMMARY (3830 Equipment Checks)

	Bit 0	1	2	3	4	5	6	7
Byte 8 Control Errors	Channel Buffer Parity	Channel A (or C) Check	Channel B (or D) Check	Data Transfer Error	SERDES, CUDI, ECC See bytes 9, 10, and 21.	PLO Check	Sector Count Check	Multi-connect C or D
Byte 9 SERDES Errors	CUDI Error (See Byte 21)	Write Parity Check	Read Parity Check	Bit Ring Check	Write Compensation Check	ECC Error (See Byte 10)	Missing PLO Pulses	VFO Phase
Byte 10 ECC Errors	No Input Data Received	P0 or Write Error	P1 or P3 Error	P2 Error	Not Used	Not Used	Not Used	Not Used
Byte 13 TA Register Contents								
Byte 14 ND Register Contents								
Byte 15 TD Register Contents								
Byte 21 CUDI Errors	Drive Selection Error	Tag Invalid	Device Error	TA Register Check	CUDI Register Check	TD Register Check	Not Used	Not Used

Figure 28. Format 2 Summary.

FORMAT 3 SENSE BYTE SUMMARY (3830 Control Checks)

	Bit 0	1	2	3	4	5	6	7
Byte 8 Failing Instruction Address	High-order address byte of control storage word addressed when error was detected.							
Byte 9 Failing Instruction Address	Low-order address byte of control storage word addressed when error was detected.							
Byte 10 Error Latches Bit 0=1	1	Clock	CA Decode Even	CA Decode Odd	CB Decode Even	CB Decode Odd	Branch Status	Special Operation
Bit 0=0	0	Clock	CS Decode	0	A Register	B Register	ALU	23FD Parity
Byte 11 Byte 10, Bit 0=1	Not Used	Storage Read Multiple 0/2	Storage ECC Multiple 1/3	Not Used	Cycle Control	CD Decode	Not Used	Not Used
Byte 10, Bit 0=0	Storage Address Bus 1–7	Storage Address Bus 8–13	Storage Write Bus 0/2	Storage Write Bus 1/3	Address Bus 1–13 Low	Address Bus 1–13 High	23FD Not Ready	0
Byte 12 Storage Error Pattern	Identifies the failing bits of a control storage cycle.							
Byte 13 TC Register Contents	Contents of the TC Register after unsolicited selective reset. Register is reset if selective reset is in response to disconnect in from storage control.							
Byte 14 TG Register Contents	Contents of the TG Register after unsolicited selective reset. Register is reset if selective reset is in response to disconnect in from storage control.							
Bytes 15–23 Not Used								

Figure 29. Format 3 Summary.

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 seek address.							
Byte 9 Cylinder Address	Low-order cylinder byte of the last seek address.							
Byte 10 Head Address	High-order head byte of the last seek address.							
Byte 11 Head Address	Low-order head byte of the last seek address.							
Byte 12 Record Number	Record number of the record in error							
Byte 13 Sector Number	Sector number of the record in error.							
Byte 14 Offset	Amount of offset used to recover from the error.							
Byte 15 Retries	Number of retries required to recover from the error.							
Byte 16 Drive Identification	Storage Control Identification (Bits 0–1)		Disk drive identify where error occurred. A = 111000 B = 110001 C = 101010 D = 100011 E = 011100 F = 010101 G = 001110 H = 000111					
Bytes 17–23 Not Used								

Figure 30. 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 seek address.							
Byte 9 Cylinder Address	Low-order cylinder byte of the last seek address.							
Byte 10 Head Address	High-order head byte of the last seek address.							
Byte 11 Head Address	Low-order head byte of the last seek address.							
Byte 12 Record Number	Record number of the record in error.							
Byte 13 Sector Number	Sector number of the record in error.							
Byte 14 Access Offset	Amount of offset used to recover from the error.							
Byte 15 Restart **Byte 16** Displace- **Byte 17** ment.	Specifies the number of bytes processed by the storage control to the end of the data area in error.							
Byte 18 Error **Byte 19** Displacement	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								Channel Truncation

Figure 31. Format 5 Summary.

FORMAT 6 SENSE BYTE SUMMARY (Usage and Error Statistics)

	Bit 0	1	2	3	4	5	6	7
Byte 8 Bytes **Byte 9** Read **Byte 10** or **Byte 11** 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 Correctable **Byte 13** Data Errors.	These two bytes provide an accumulated count for all areas of the number of ECC data errors found by the storage control.							
Byte 14 Retry **Byte 15** Data Errors.	These two bytes contain the number of initial ECC uncorrectable data errors sucessfully retried.							
Byte 16 Number of **Byte 17** Seeks.	These two bytes provide the number of Seek commands processed by the channel.							
Byte 18 Interface Designation	If bit 0 = 0, bytes 20 through 23 pertain to interfaces A and B. If bit 0 = 1, bytes 20 through 23 pertain to 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 32. Format 6 Summary.

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