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Yanai et al.

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[54] **SYSTEM AND METHOD FOR DISK MAPPING AND DATA RETRIEVAL**

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[*] Notice: This patent is subject to a terminal disclaimer.

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[22] Filed: **May 6, 1997**

Related U.S. Application Data

[60] Continuation of application No. 08/665,607, Jun. 18, 1996, Pat. No. 5,664,144, which is a division of application No. 08/052,039, Apr. 23, 1993, Pat. No. 5,544,347, which is a continuation-in-part of application No. 07/586,796, Sep. 24, 1990, Pat. No. 5,206,939, which is a continuation-in-part of application No. 07/587,247, Sep. 24, 1990, Pat. No. 5,269,011, and application No. 07/587,253, Sep. 24, 1990, Pat. No. 5,335,352.

[51] **Int. Cl.**[6] **G06F 12/08**

[52] **U.S. Cl.** **711/4**; 711/202; 711/112; 711/113

[58] **Field of Search** 711/112, 113, 711/4, 202

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,262,332	4/1981	Bass et al.	711/114
4,310,883	1/1982	Clifton et al.	707/205
4,467,421	8/1984	White	711/118
4,500,954	2/1985	Duke et al.	711/138
4,533,995	8/1985	Christian et al.	711/122
4,533,996	8/1985	Hartung et al.	395/823
4,593,354	6/1986	Ushiro	395/185.01
4,686,620	8/1987	Ng	707/10
4,780,808	10/1988	Moreno et al.	711/4
4,825,406	4/1989	Bean et al.	395/858
4,837,675	6/1989	Bean et al.	395/182.03

(List continued on next page.)

FOREIGN PATENT DOCUMENTS

WO 91/06053	5/1991	WIPO .
WO 91/08536	6/1991	WIPO .
WO 91/08537	6/1991	WIPO .

OTHER PUBLICATIONS

R.D. Tennison, "Compacting Indexed Data," IBM Technical Disclosure Bulletin, vol. 24, No. 7A, Dec. 1981, pp. 3202–3202.

N.K. Ouchi, "System for Blocking Variable–Lenght Records," IBM Technical Disclosure Bulletin, vol. 16, No. 4, Sep. 1973, pp. 1239–1240.

(List continued on next page.)

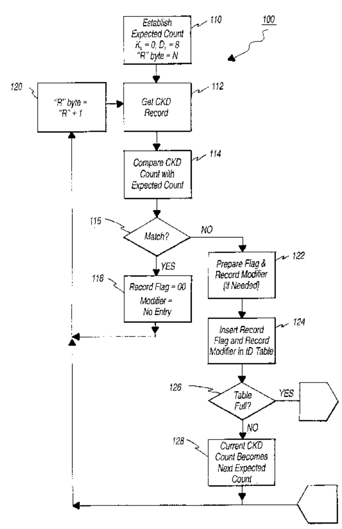
Primary Examiner—Reginald G. Bragdon

Attorney, Agent, or Firm—Arnold White & Durkee

[57] **ABSTRACT**

An apparatus and method for disk mapping and data retrieval includes a data storage medium on which has been stored a plurality of data records. Each record includes at least a record identification portion, for uniquely identifying each record from among the plurality of data records. The apparatus builds a record locator table in high speed semiconductor memory which comprises the unique record identifiers for the records on the storage medium as well as a record locator index generated by the apparatus, which indicates the address of the data record on the storage medium. Data retrieval is facilitated by first searching the record locator table in high speed semiconductor memory for a requested data record. Utilizing the record locator index associated with the reqested data record, the system directly accesses the requested data record on the storage medium thereby minimizing storage medium search time. Also disclosed is an apparatus and method for converting CKD formatted data records to FBA formatted disk drives and for building and compressing the "count" portion of the CKD data formatted record into a record locator table.

83 Claims, 6 Drawing Sheets



U.S. PATENT DOCUMENTS

4,837,680	6/1989	Crockett et al.	395/284
4,862,411	8/1989	Dishon et al.	711/167
4,875,155	10/1989	Iskiyan et al.	711/113
4,914,656	4/1990	Dunphy, Jr. et al.	371/10.2
4,939,598	7/1990	Kulakowski et al.	360/48
4,993,030	2/1991	Krakauer et al.	395/182.04
5,072,378	12/1991	Manka	395/182.04
5,124,987	6/1992	Milligan et al.	395/182.05
5,155,809	10/1992	Baker et al.	395/200.57
5,155,845	10/1992	Beal et al.	395/182.04
5,206,939	4/1993	Yanai et al.	711/4
5,247,638	9/1993	O'Brian et al.	395/888
5,263,145	11/1993	Brady et al.	711/114
5,301,304	4/1994	Menon	395/500
5,414,834	5/1995	Alexander et al.	707/100

OTHER PUBLICATIONS

IBM Publication GA 33–1528–2, Third Edition, "IBM 4321/4331 Processors Compatibility Features," Sep. 1982, pp. 1–1, 1–4, 1–5, 2–1, 2–2, and 2–3.

Patterson et al., "A Case for Redundant Arrays of Inexpensive Disks (RAID)," Report No. UCB/CSD 87/391, Computer Science Division (EECS), University of California, Berkeley, California, Dec. 1987 (pp. 1 to 24).

Patterson et al., "Introduction to Redundant Arrays of Inexpensive Disks (RAID)" Compcon 89 Proceedings, Feb. 27–Mar. 3, 1989, IEEE Computer Society, pp. 112–117.

Ousterhout et al., "Beating the I/O Bottleneck: A Case for Log–Structured File Systems," Operating Systems Review, vol. 23, No. 1, ACM Press, Jan. 1989, pp. 11–28.

Douglis et al., "Log Structured File Systems," Compcon 89 Proceedings, Feb. 27–Mar. 3, 1989, IEEE Computer Society, pp. 124–129.

Jeff Moad, "Relief for Slow Storage Systems," Datamation, Sep. 1, 1990, pp. 25–28.

Storage Technology Corporation's Responses to Plaintiffs Interrogatories No. 4–5, EMC Corp. v. Storage Technology Corp., Civil Action Nos. 94–482, in the United States District Court for the District of Delaware, Jan. 19, 1995, pp. 1–5.

Stipulated Protective Order, EMC Corp. v. Storage Technology Corp., Civil Action No. 94–482, in the United States District Court for the District of Delaware, Oct. 17, 1995, pp. 1–10.

Storage Technology Corporation's Outline of the Issues for the Sep. 7 and 8 Mediation, EMC Corp. v. Storage Technology Corp., Civil Action No. 94–482, in the United States District Court for the District of Delaware, Sep. 2, 1995, pp. 1–10.

Storage Technology Corporation's Third Supplemental Responses to Plaintiff's Interrogatories No. 1–3, EMC Corp. v. Storage Technology Corp., Civil Action No. 94–482, in the United States District Court for the District of Delaware, Oct. 18, 1996. pp. 1–17 & p.

Storage Technology Corporation's Second Supplemental Responses to Plaintiffs Interrogatories No. 1–3, EMC Corp. v. Storage Technology Corp., Civil Action Nos. 94–482, in the United States District Court for the District of Delaware, May 16, 1995, pp. 1–31.

Plaintiff EMC Corporation's Response to Defendant's Third Set of Interrogatories No. 18, Jun. 30, 1995, EMC Corp. v. Storage Technology Corp., Civil Action Nos. 94–482, in the United States District Court for the District of Delaware, pp. 1–10.

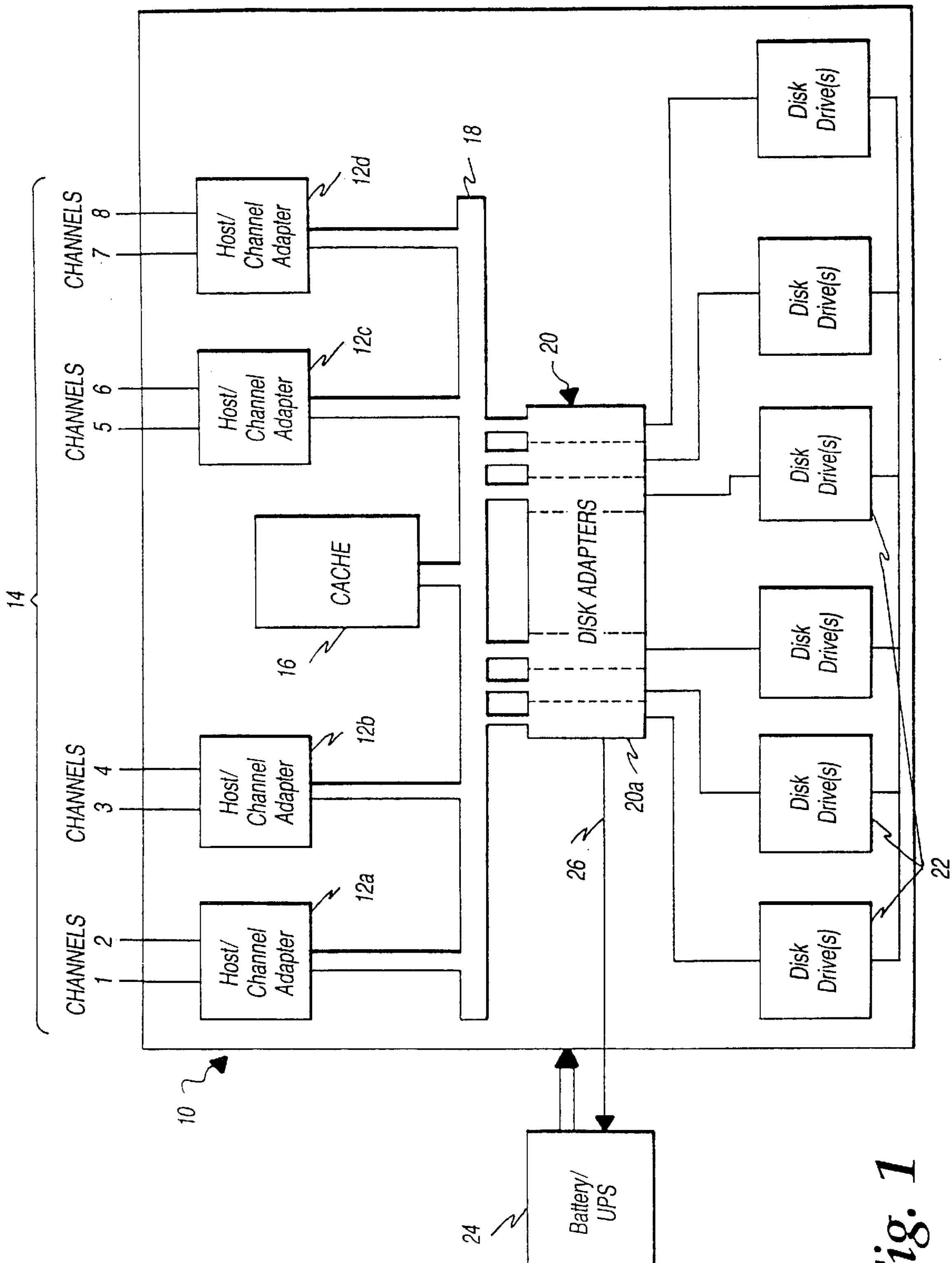
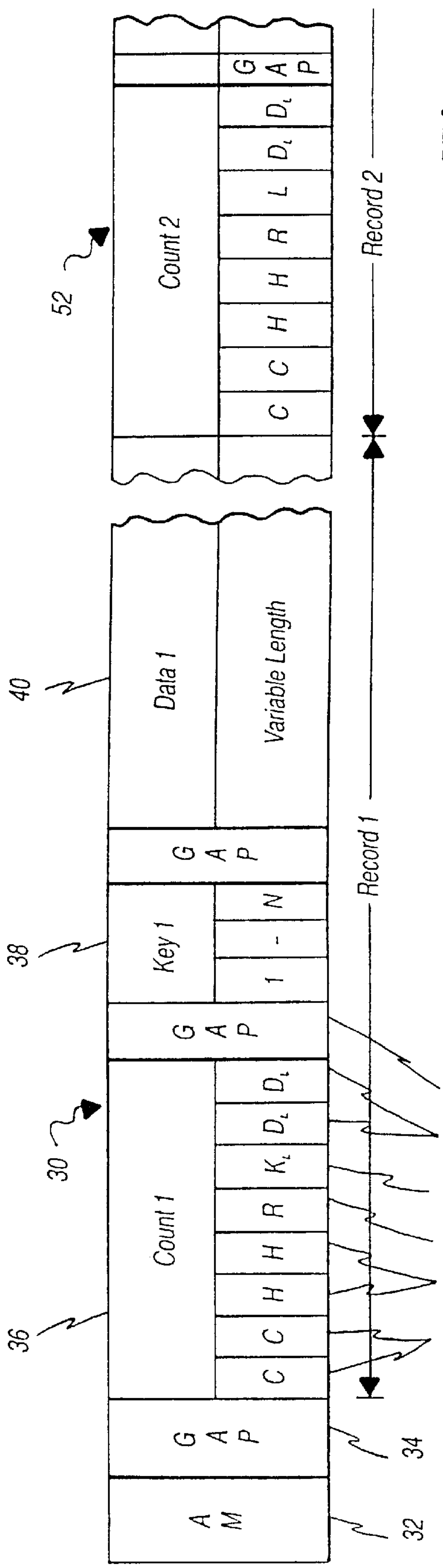
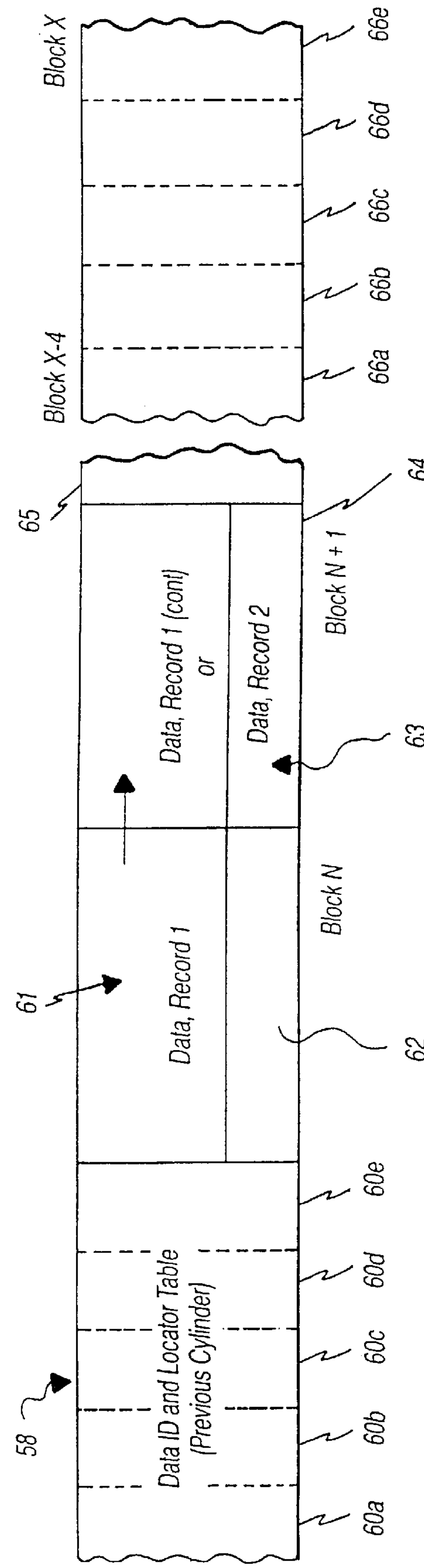

CHANNELS 1 2
CHANNELS 3 4
CHANNELS 5 6
CHANNELS 7 8
14
Host/ Channel Adapter
12a
Host/ Channel Adapter
12b
Host/ Channel Adapter
12c
Host/ Channel Adapter
12d
CACHE
16
18
20
DISK ADAPTERS
20a
26
Disk Drive(s)
22
10
Battery/ UPS
24

Fig. 1



A M
GAP
Count 1
C C H H R K_L D_L D_L
GAP
Key 1
1 - N
GAP
Data 1
Variable Length
Count 2
C C H H R L D_L D_L
GAP
Record 1
Record 2
30
32
34
36
37
38
40
42
44
46
48
50
52

Fig. 2



Data ID and Locator Table (Previous Cylinder)
Data, Record 1
Block N
Data, Record 1 (cont) or Data, Record 2
Block N + 1
Block X-4
Block X
58
60a
60b
60c
60d
60e
61
62
63
64
65
66a
66b
66c
66d
66e

Fig. 3

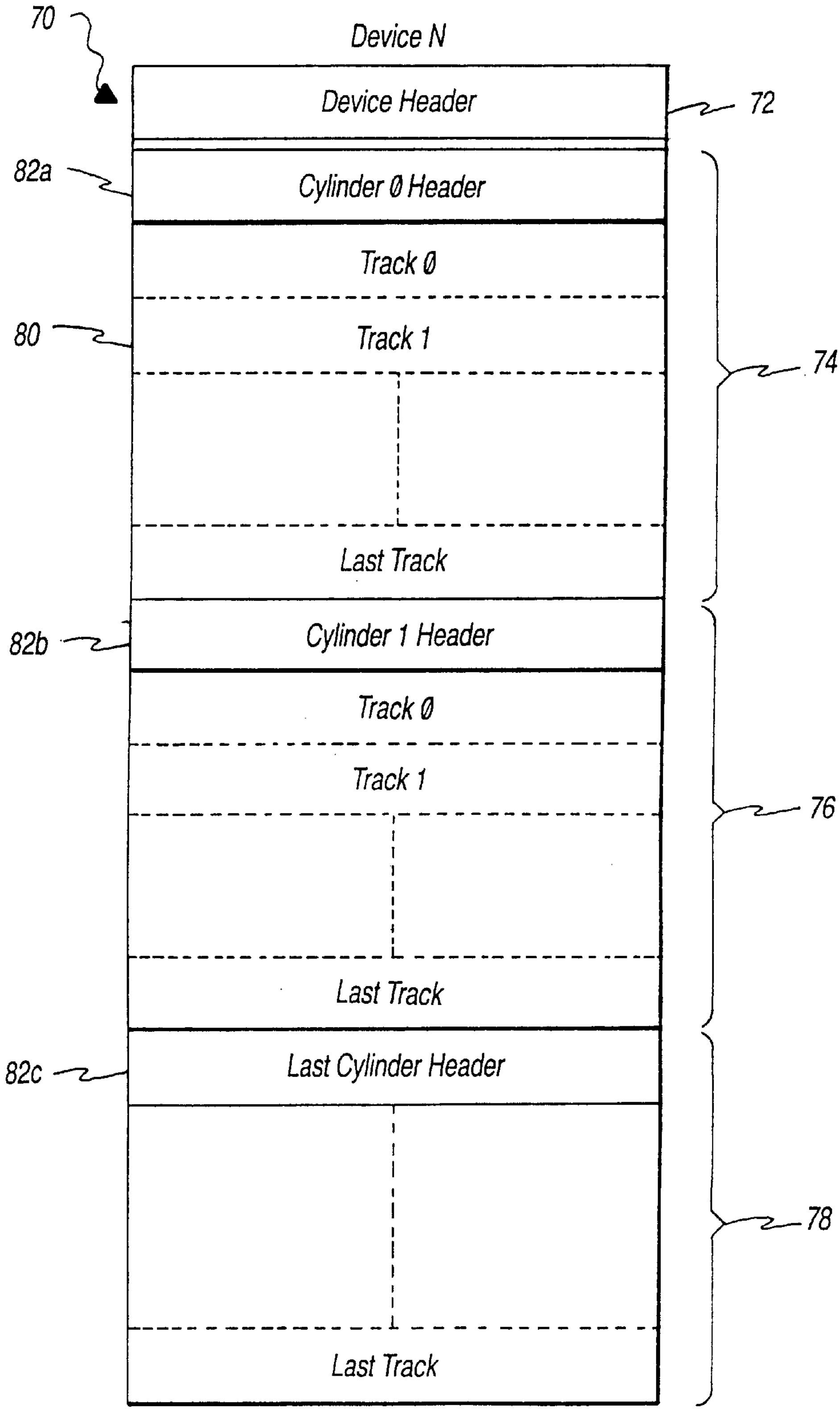

70
Device N
Device Header
72
82a
Cylinder Ø Header
Track Ø
80
Track 1
74
Last Track
82b
Cylinder 1 Header
Track Ø
Track 1
76
Last Track
82c
Last Cylinder Header
78
Last Track

Fig. 4

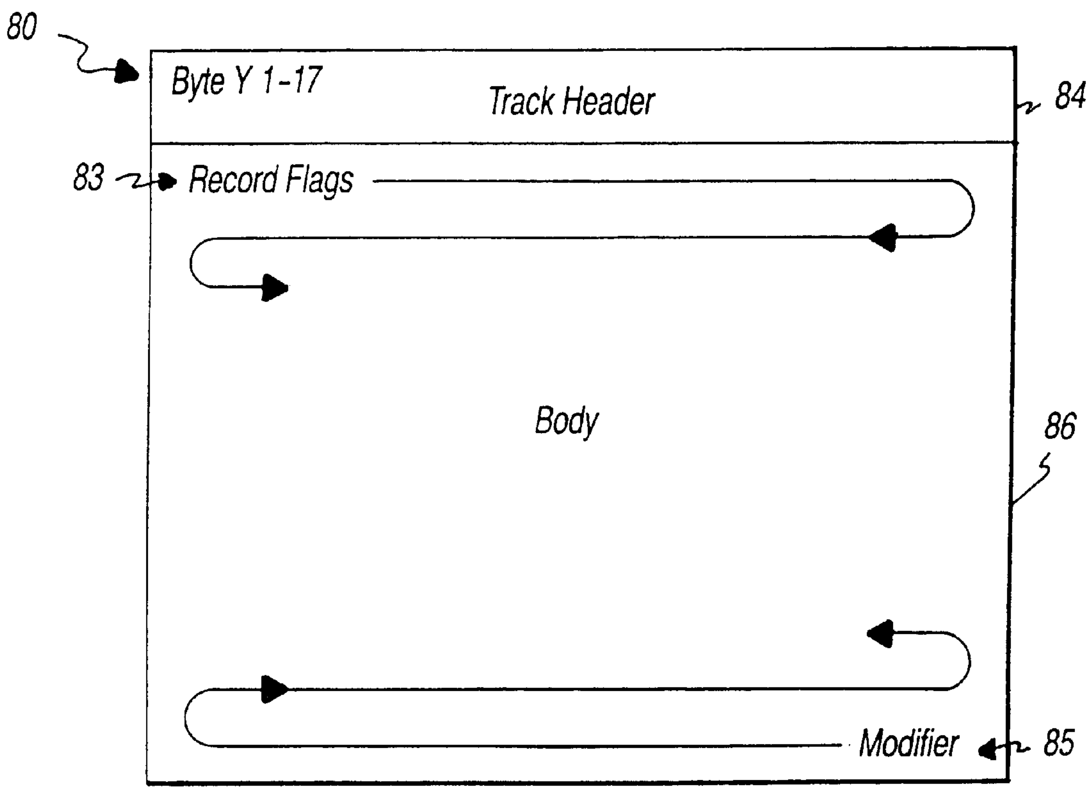
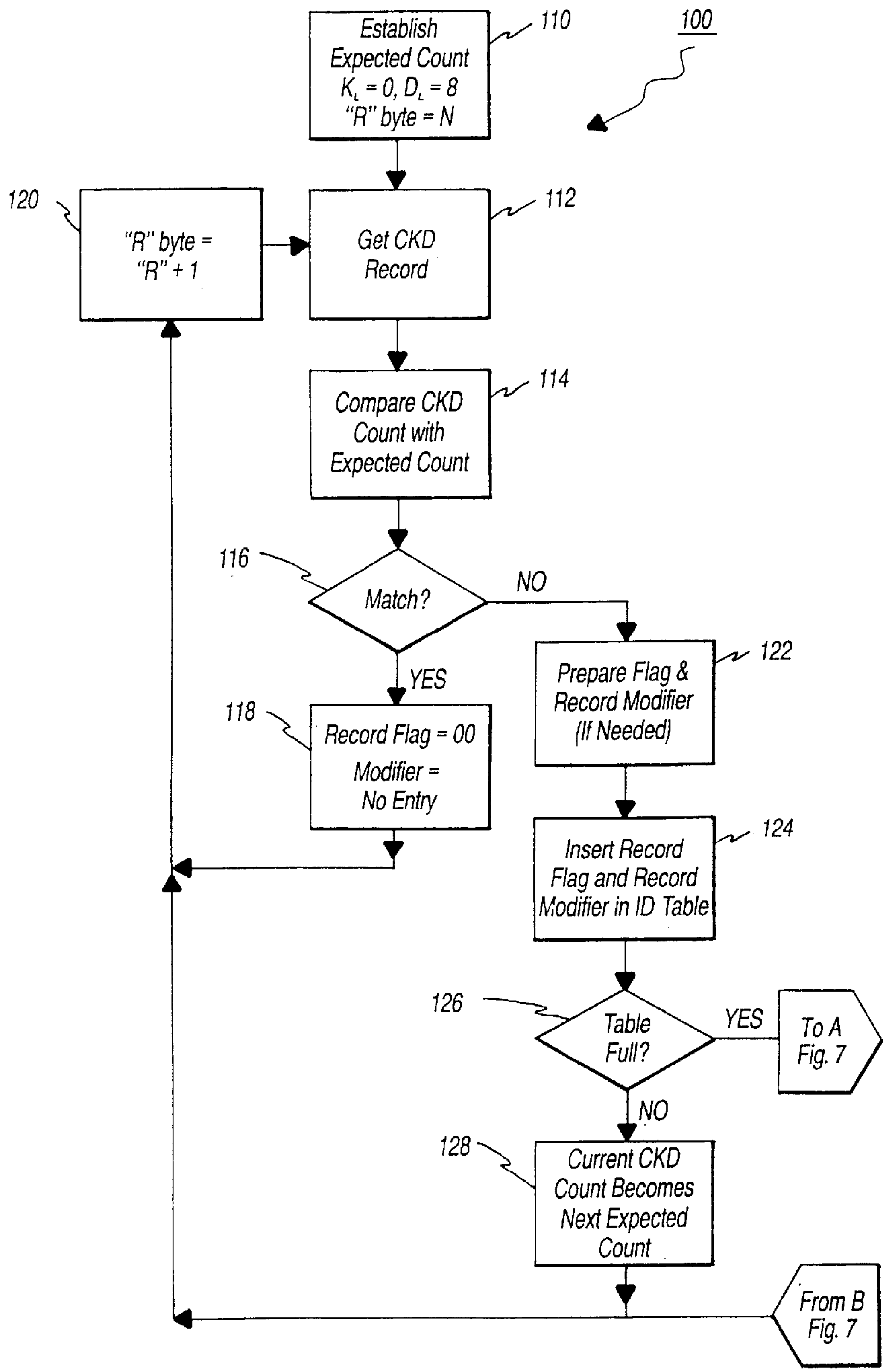

80
Byte Y 1-17
Track Header
84
83
Record Flags
Body
86
Modifier
85

Fig. 5



100
Establish Expected Count $K_L = 0, D_L = 8$ "R" byte = N
110
Get CKD Record
112
"R" byte = "R" + 1
120
Compare CKD Count with Expected Count
114
Match?
116
NO
YES
Record Flag = 00 Modifier = No Entry
118
Prepare Flag & Record Modifier (If Needed)
122
Insert Record Flag and Record Modifier in ID Table
124
Table Full?
126
YES
To A Fig. 7
NO
Current CKD Count Becomes Next Expected Count
128
From B Fig. 7

Fig. 6

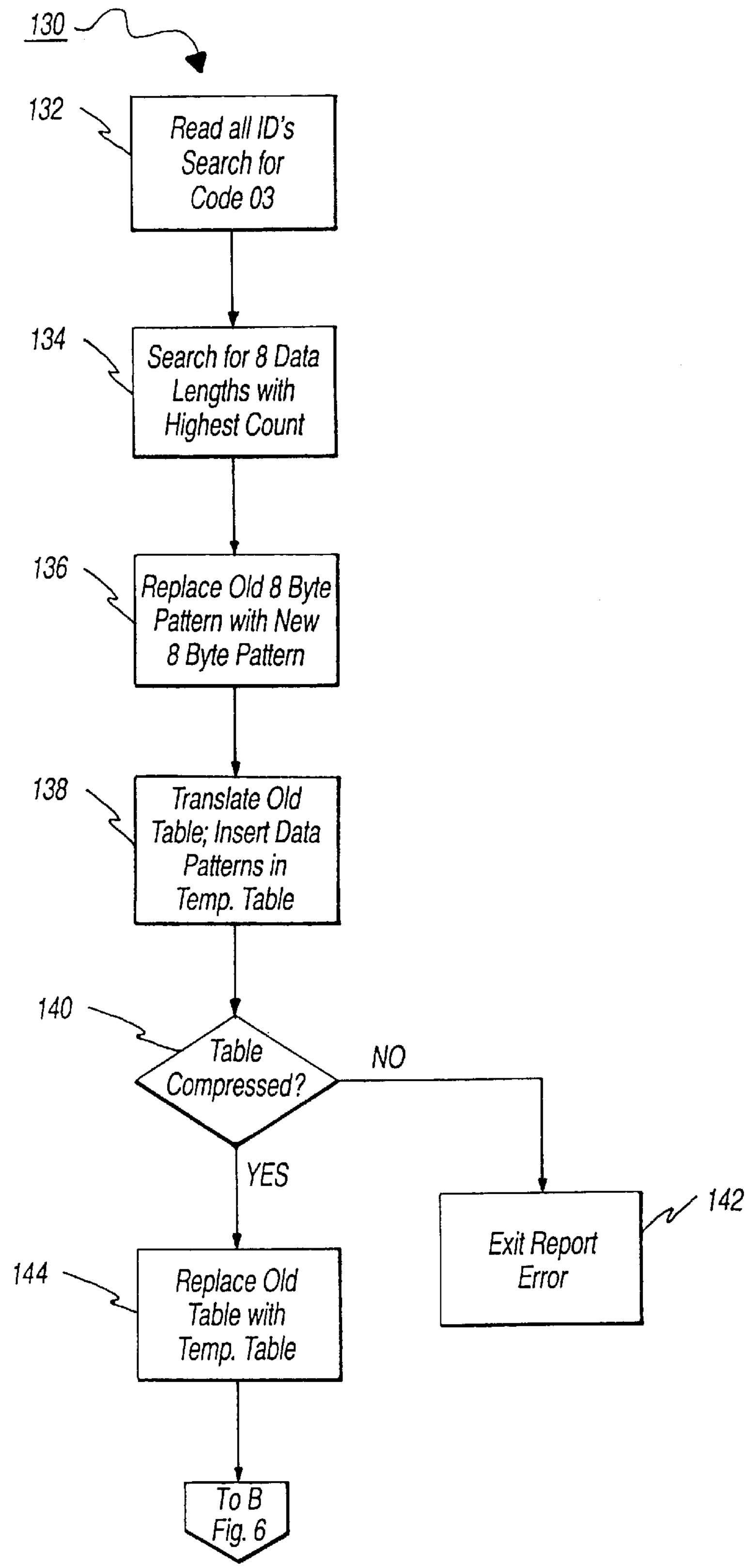

130
132
Read all ID's Search for Code 03
134
Search for 8 Data Lengths with Highest Count
136
Replace Old 8 Byte Pattern with New 8 Byte Pattern
138
Translate Old Table; Insert Data Patterns in Temp. Table
140
Table Compressed?
NO
YES
142
Exit Report Error
144
Replace Old Table with Temp. Table
To B Fig. 6

Fig. 7

SYSTEM AND METHOD FOR DISK MAPPING AND DATA RETRIEVAL

RELATED APPLICATIONS

This application is a continuation of application Ser. No. 08/665,607, filed Jun. 18, 1996 now U.S. Pat. No. 5,664,144 which is a divisional of U.S. patent application Ser. No. 08/052,039 filed Apr. 23, 1993, entitled REMOTE DATA MIRRORING (U.S. Pat. No. 5,544,347 issued Aug. 6, 1996), which is a continuation-in-part of U.S. patent application Ser. Nos. 07/586,796 filed Sep. 24, 1990 entitled SYSTEM AND METHOD FOR DISK MAPPING AND DATA RETRIEVAL (U.S. Pat. No. 5,206,939 issued Apr. 27, 1993); which is a continuation-in-part of Ser. No. 07/587,247 filed Sep. 24, 1990 entitled DYNAMICALLY RECONFIGURABLE DATA STORAGE SYSTEM WITH STORAGE SYSTEM CONTROLLERS SELECTIVELY OPERABLE AS CHANNEL ADAPTERS OR STORAGE DEVICE ADAPTERS (U.S. Pat. Nos. 5,269,011 issued Dec. 7, 1993) and 07/587,253 filed Sep. 24, 1990 entitled RECONFIGURABLE MULTI-FUNCTION DISK CONTROLLER SELECTIVELY OPERABLE AS AN INPUT CHANNEL ADAPTER AND A DATA STORAGE UNIT ADAPTER (U.S. Pat. No. 5,335,352 issued Aug. 2, 1994).

The following disclosure in this application is the disclosure in U.S. patent application Ser. No. 07/586,796 as filed on Sep. 24, 1990 and entitled SYSTEM AND METHOD FOR DISK MAPPING AND DATA RETRIEVAL (U.S. Pat. No. 5,206,939 issued Apr. 27, 1993), which is fully incorporated herein by reference.

FIELD OF THE INVENTION

This invention relates to data storage on disk drives and more particularly, to a method and apparatus for retrieving data records stored on a storage medium utilizing a data record locator index stored in memory.

BACKGROUND OF THE INVENTION

Large disk storage systems like the 3380 and 3390 direct access storage devices (DASD) systems employed with many IBM mainframe computer systems are implemented utilizing many disk drives. These disk drives are specially made to implement a count, key, and data (CKD) record format on the disk drives. Disk drives utilizing the CKD format have a special "address mark" on each track signifying the beginning of a record on the track. After the address mark comes the three part record beginning with the "COUNT" which serves as the record ID and also indicates the lengths of both the optional key and the data portions of the record, followed by the optional "KEY" portion, which in turn is followed by the "DATA" portion of the record.

Although this format gives the system and user some flexibility and freedom in the usage of the disk drive, this flexibility forces the user to use more complicated computer programs for handling and searching data on the disk. Since the disk drive track has no physical position indicator, the disk drive controller has no idea of the data which is positioned under the read/write head at any given instant in time. Thus, before data can be read from or written to the disk drive, a search for the record must be performed by sequentially reading all the record ID's contained in the count field of all the records on a track until a match is found. In such a search, each record is sequentially searched until a matching ID is found. Even if cache memory is used, all the records to be searched must first be read into the cache

before being searched. Since searching for the record takes much longer than actual data transfer, the disk storage system spends a tremendous amount of time searching for data which drastically reduces system performance.

Disk drives employing what is known as a Fixed Block Architecture (FBA) are widely available in small, high capacity packages. These drives, by virtue of their architecture, tend to be of higher performance than drives employing a CKD format. Such FBA drives are available, for example, from Fujitsu as 5.25" drives with 1 gigabyte or greater capacity.

The distinct advantage of utilizing many small disk drives is the ability to form a disk array. Thus a large storage capacity can be provided in a reduced amount of space, and storage redundancy can be provided in a cost effective manner. A serious problem arises, however, when trying to do a "simple" conversion of data from CKD formatted disks to FBA disks. Two schemes for such a conversion have been considered which do not provide an acceptable solution to the conversion problem. The first of such schemes involves placing every field i.e. Count, Key and Data, of the CKD formatted record into a separate block on the FBA disk drive. Although this scheme does not waste valuable disk space when CKD formatted records contain large amounts of data, the "Count" field which is very short (8 bytes) occupies an entire block which is typically at least 512 bytes. For example, a CKD formatted record containing 47 K bytes of data could be converted to 95 blocks of FBA disk, 512 bytes in length. In such a conversion, one block would be used to store the count of the record while 94 blocks (47 K bytes length of data divided 512 bytes of FBA disk block) would be used to store data, for a total of 95 blocks. However, search time for finding the desired record is still a problem since all the records must be sequentially searched.

For records having very short data lengths such as eight bytes, however, one full track, or 94 CKD formatted data records would need 188 blocks on the FBA disk: 94 blocks for the count portion of the records and 94 blocks for the data portion of the records, even though each data record may only occupy 8 bytes of a 512 byte FBA block. Such a scheme may thus waste nearly 50% of the disk space on an FBA disk drive.

The second scheme for converting data from CKD to FBA drives involves starting each CKD record in a separate block and then writing the complete record in sequential blocks. Utilizing such a scheme, the first FBA block will contain the "count" portion of the record as well as the optional key portion and the start of the data portion of the record. This scheme, however, produces serious system performance degradation when data must be written to the disk, since before writing data to the disk, the entire record must first be read into memory, modified, and subsequently written back to the disk drive. Such a loss in system performance is generally unacceptable.

SUMMARY OF THE INVENTION

This invention features an apparatus and method for retrieving one or more requested data records stored on a storage medium by searching for a data record identifier and associated data record locator index stored in high speed semiconductor memory. The apparatus receives one or more data records, each of the data records including at least a record identification portion and a data portion. The apparatus transfers and stores the data records to one or more data storage mediums. As the records are transferred to the data

storage medium, the apparatus of the present invention generates a plurality of record locator indices, each of the record locator indices corresponding to one of the plurality of data records, for uniquely identifying the location of each of the data records stored on the storage medium.

The apparatus further includes high speed semiconductor memory for storing at least the plurality of record locator indices and the associated plurality of record identification portions. Upon receiving a request for one or more data records stored on the storage mediums, the apparatus of the present invention searches the high speed semiconductor memory utilizing the data record identification portion and locates the corresponding record locator index associated with the requested data record. The apparatus then directly retrieves the data record from the storage medium using the record locator index located during the search of semiconductor memory.

In the preferred embodiment, the data records are received in CKD format and stored on an FBA formatted disk drive. The record identification portions and associated record locator indices are combined to form one record locator table stored in one or more blocks of the FBA formatted disk drive and also copied in the high speed semiconductor memory.

A method for retrieving one or more requested data records stored on a storage medium is disclosed utilizing a data record locator index stored in memory and includes the steps of receiving a plurality of data records, each record including at least a record identification portion and the data portion, and transferring and storing the data records to one or more storage mediums. The method also includes generating a plurality of record locator indices, each of which are associated with one of the plurality of data records and uniquely identify the location of the each of the plurality of data records stored on the storage medium. Also included are the steps of storing at least a plurality of record locator indices and the associated plurality of record identification portions in memory. In response to a request for access to one or more of the plurality of data records, the method includes searching the memory, locating one or more data record identification portions and associated record locator indices corresponding to the one or more requested data records, and directly retrieving from the storage medium the requested data records as directed by the record locator indices.

In one embodiment, the method of the present invention includes transforming and encoding CKD formatted data records onto one or more FBA disk drives. Also in the preferred embodiment, the step of storing the data record to one or more storage mediums includes storing the data to one or more directly addressable storage mediums, the step of storing further including the steps of transforming and encoding at least the record identification portion of each of the data records, generating a plurality of record locator indices, and combining the transformed and encoded record locator indices and record identification portions, for forming a record locator table stored in a high speed semiconductor memory.

BRIEF DESCRIPTION OF THE DRAWINGS

These, and other features and advantages of the present invention are described below in the following detailed description and accompanying drawings, in which:

FIG. **1** is a block diagram of a system for disk mapping and data retrieval according to the present invention;

FIG. **2** is a schematic representation of a CKD formatted data record;

FIG. **3** is a schematic representation of several blocks from a fixed block disk drive in which has been inserted the CKD formatted data transformed according to the method of the present invention;

FIG. **4** is a detailed schematic representation of a portion of the data identification and locator table of FIG. **3**;

FIG. **5** is a detailed schematic representation of a portion of the data identification and locator table of FIG. **4**;

FIG. **6** is a flowchart of the method for transforming CKD formatted data into fixed block data including a method for preparing a record identification and locator table; and

FIG. **7** is a flowchart illustrating the method for compressing the length of the record identification and locator table according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

In accordance with the present invention, the disk storage system **10**, FIG. **1**, for disk mapping and data retrieval includes one or more means for receiving write commands and data such as channel adapter boards **12***a*–**12***d*. The channel adapter boards are adapted to receive disk read/write commands and data over a plurality of communication channels such as channels **14** from one or more host computers (not shown) over channels identified respectively as **1**–**8** in FIG. **1**.

The channel adapter boards **12***a*–**12***d* are connected to temporary or cache semiconductor memory storage unit **16** by means of bus **18**. Bus **18** is also connected to one or more disk adapter boards **20** which read and write data to one or more disk drive units **22**.

Each of the disk drive units **22** may include one or more disk drives, depending upon the user's requirements. Also included in the system is one or more uninterruptable power supply (UPS) **24**.

In operation, one or more channel adapter boards **12***a*–**12***d* receive write commands along with the accompanying data over one or more channels **14** from one or more host computers. In the preferred embodiment, the data is received in CKD format. In order to improve system performance, the disk storage system of the present invention does not wait for disk adapters **20** to locate and update the data on the appropriate disk drives but rather, the channel adapter boards store the data in CKD format in temporary semiconductor memory storage unit or cache **16**.

In addition to storing the data that must be written to one or more disk drives **22**, channel adapter boards **12***a*–**12***d* store in the memory, an indication associated with each data record that must be written to disk, indicating to the disk adapters **20** that the associated data record stored in cache must be written to the disk drives. A more detailed description of a disk storage system with write preservation utilizing a write pending indicator is described in U.S application Ser. No. 07/586,254 filed concurrently with the present application and incorporated herein by reference. U.S. application Ser. No. 07/586,254 was continued in U.S. application Ser. No. 156,394 filed Nov. 22, 1993, which issued on Aug. 23, 1994 as U.S. Pat. No. 5,341,493.

In one embodiment, the system and method for disk mapping and data retrieval includes mapping CKD formatted data onto fixed block disk drives. To facilitate understanding of the CKD to FBA data transformation a CKD record **30**, FIG. **2** is shown and described below.

In order for a CKD disk drive to locate the first record on any given track, the disk drive read/write head must search the entire track until it encounters a position indicator called an address mark **32**. Following a short gap **34** in the track, the first record **30** begins. The CKD record is divided into three fields or portions: the record identification portion, called the count, **36** followed by another gap, **37**; the optional key portion **38**; and the data portion **40**.

The count portion of the data record uniquely identifies this record. The count is the portion of the record that a host system requesting access to a given record presents to the disk drive in order to enable the disk drive to search for and locate the record.

The count is comprised of 8 bytes of information. Bytes 0 and 1, as shown at **42**, are used to designate the length of the data, while the third byte, **44**, designates the length of the optional key field. The fourth byte **46**, designates the record number on the track. The fifth and sixth bytes **48**, and the seventh and eighth bytes, designate the head and cylinder numbers respectively, at which the record is located on the device. The second record **52**, is located immediately following the end of the data portion **40** of the first record **30**.

Thus, in accordance with the present invention, a portion of an FBA disk having CKD formatted data stored thereon to retrieve all the data of a given record, as illustrated herein below. Each record identification and locator table is subsequently loaded into the system memory to facilitate and greatly reduce data record searching and data retrieval time.

Shown in greater detail in FIG. **4**, is a data record and identification table **70** according to the present invention for one device such as one disk drive including multiple cylinders. Each cylinder being emulated includes such a table on the drive itself, as well as a corresponding copy in the semiconductor cache memory.

Each device record identification and locator table includes a header portion **72** followed by one or more cylinder portions **74–78**. In turn, each cylinder portion is comprised of a plurality of track portions **80**.

Device header portion **72** of the record locator and identification table includes such information as shown in Table 1 below, including the length of the header, line 1; the starting address of the device scratch memory address, line 2; and the length of the device header including the scratch area, line 3. The header also includes one or more bytes for device flags, line 4.

TABLE 1

DEVICE ID TABLE HEADER BUFFER AND FLAG OFFSETS

1. DV HEADER	SIZE	$1000		LENGTH OF DV HEADER AT THE ID TABLE
2. DV SCRATCH	OFFSET	DV HEADER		DV SCRATCH START ADDRESS
3. DV HEADER LENGTH	SIZE	$10000		LENGTH OF DV HEADER AT THE ID TABLE INCLUDING THE SCRATCH AREA
DV HEADER BUFFERS OFFSETS				
4. DV FLAGS	OFFSET	0		DV TABLE FLAGS
5. DV STATISTICS	OFFSET	4		STATISTICS/RESERVED BYTES
6. DV READ TASK	OFFSET	$40		READ TASK (ONLY ONE)
7. DV SENSE INFO	OFFSET	$60		SENSE INFO FOR THIS DV
8. DV TABLE SELECT BUFFER	OFFSET	$80	$40 BYTES	SELECTION BUFFER FOR THE DEVICE
9. RW COUNT BUFFER	OFFSET	$C0	8 BYTES	R/W COUNT COMMAND DATA BUFFER
10. DV WR PEND FLAGS	OFFSET	$100	$140 BYTES	WR PENDING BIT PER CYLINDER
11. DV WR PEND GROUPS	OFFSET	$240	$20 BYTES	WR PENDING BIT FOR 8 CYLINDERS
12. DV FLAGS SELECT BUFFER	OFFSET	$280	$40 BYTES	SELECTION BUFFER FOR UPDATES
13. DV FMT CHANGED FLAGS	OFFSET	$300	$140 BYTES	FMT CHANGED BIT FOR CYLINDER
14. DV FMT CHANGED GROUPS	OFFSET	$440	$20 BYTES	FMT CHANGED BIT FOR 8 CYLINDERS
15. DV TEMP BLK	OFFSET	$400	$200 BYTES	TEMP BLK FOR RECOVERY
16. TEMP CYL ID SLOT	OFFSET	$600	$A00 BYTES	TEMP ID FOR RECOVERY

is shown in FIG. **3** and includes record identification and locator table **58** including the 5 blocks labeled **60***a*–**60***e*, for the tracks of the previous cylinder which is organized as described below.

The first data record **61** of the next CKD cylinder being emulated and located on the FBA drive begins in block, **62**. If the data portion of the record is longer than the length of the second block **62**, the data portion of the first record will be continued in the next block **64**, and subsequent blocks as necessary to store the data portion of the first record. If the length of the first record **61** is equal to or smaller than block **62**, any remaining unused portion of block **62** will not be used and instead, the data portion of record **2**, **63**, will begin in FBA disk drive block **64**. This process will repeat itself until all of the blocks of a given cylinder being emulated have been copied. Thus, because the data portion of every record begins at the beginning of a block, (i.e. there is never more than one data record per block), once the system computes the address or block in which a requested data record resides, immediate access is possible with little or no disk drive search time. Utilizing the record identification and locator table of the present invention, the system is able to compute the number of fixed length blocks that must be read

Such flags include a write pending flag which is set if one or more records on the device are temporarily stored in cache memory awaiting writing and storing to the disk drive, as well as an in-cache bit indicating that at least one record on the device is located in cache memory to speed up access to the record, line 4. Other bytes of the device header provide various informational, operational, or statistical data to the system.

For example, the write pending group flags shown at line 11 include one bit indicating a write pending on any one record on any of the 64 preselected consecutive cylinders comprising a cylinder group. Similarly, each cylinder has a write pending flag bit in the device header as shown at line 10. The various write pending flags form a "pyramid" or hierarchy of write pending flags which the system may search when no access to records stored on disks is requested for handling write pending requests. Such a hierarchy structure allows the system to inquire level by level within the structure whether any records on the device; any records within a group of cylinders; any records on a given cylinder; any records on a track; and record by record, whether any write pending flags are set or whether any records are located in cache memory. Such information is useful when processing data such as writing data to disk after a power failure as more fully described in U.S. application Ser. No. 07/586,254 filed concurrently herewith and incorporated herein by reference. U.S. application Ser. No. 07/586,254 was continued in U.S. application Ser. No. 156,394 filed Nov. 22, 1993, which issued on Aug. 23, 1994 as U.S. Pat. No. 5,341,493. The "last track" header is a header of a fictitious or non-existent track and serves to indicate that the record locator table was itself modified and must also be written to disk.

A more detailed description of the cylinder header portions **82***a*–**82***c* of the device record identification and locator table **70** of FIG. **4** is shown in Table 2 wherein any given cylinder header includes such information as the length of the cylinder header, line 1; cylinder write pending flags, line 4; the physical address of the cylinder line 6; and the CRC error check byte of the cylinder, line 7.

TABLE 2

CYLINDER ID TABLE HEADER BUFFERS AND FLAGS OFFSETS			
1. CYL_HEADER_LENGTH	SIZE	$AO	LENGTH OF CYL HEADER AT ID TABLE
2. CYL_FLAG	OFFSET	0	CYL FLAGS
3. CYL_FLAG_AUX	OFFSET	1	ADD ON TO THE ABOVE
4. CYL_WR_PEND_FLAGS	OFFSET	2	WR PENDING BIT PER TRACK
5. CYL_STATISTICS	OFFSET	4	STATISTICS/RESERVED BYTES
6. CYL_PH_ADD	OFFSET	16	PH ADD OF CYL
7. CYL_SLOT_CRC	OFFSET	23	CRC OF CYL

Each track entry in the record identification and locator table is shown in greater detail in FIG. **5** and comprises a track header portion **84** and a track body portion **86**. The track header portion **84** includes information as shown in Table 3 below, including a track flag byte, line 1; record-count bytes, line 2,; the track CRC check byte, line 3; track compress patterns line 4; and cache address pointer, line 5.

The body **86**, FIG. **5** of the track portion of the record identification and locator table includes a plurality of record flags **83**, (line 6, Table 3,) beginning at byte **20** and record modifiers **85** (line 7, Table 3) beginning at byte **159** and extending sequentially backward as necessary or until a collision with the record flags **83** occurs.

TABLE 3

ID TABLE TRACK HEADER AND BODY OFFSETS			
1.TRACK_FLAG	OFFSET	0	TRACK FLAGS
2.RECORD_COUNT	OFFSET	1	NUMBER OF RECORDS AT THIS TRACK
3.TRACK_CRC	OFFSET	5	CRC BYTE FOR TRACK
4.COMPRESS_PATTERNS	OFFSET	6	TRACK COMPRESS PATTERNS
5.CACHE_TRACK_POINTER	OFFSET	14	POINTER TO CACHE
6.RECORD_FLAGS	OFFSET	20 → 159	COMMON FLAG POINTER
7.TRACK_TABLE_BODY (MODIFIER)	OFFSET	159 → 20	TRACK BODY
	TRACK COMMON FLAG BITS		
8.DEFECTIVE	BIT	7	DEFECTIVE TRACK
9.ALT	BIT	6	ALTERNATE TRACK
10.EX_TRACK_TABLE	BIT	5	EXTENDED TRACK TABLE SLOT
11.WRT_PEND	BIT	4	WRITE PENDING IN TRACK
12.DIAG_CYL	BIT	3	DIAGNOSTICS CYL ('CE', 'SA')
13.NOT_USED	BIT	2	NOT USED
14.INVALID_ID	BIT	1	ID SLOT DEFECTIVE AND INVALID
15.IN_CACHE	BIT	0	TRACK IN CACHE FLAG
	RECORD FLAGS BITS		
16.COMPRESS_CODE	BITS	0 → 3	COMPRESS ALGO' FOR THIS RECORD
17.KEY_IN_CACHE	BIT	4	KEY FTELD IN CACHE
18.DATA_IN_CACHE	BIT	5	DATA FIELD IN CACHE
19.KEY_W_PEND	BIT	6	KEY FIELD WRITE PENDING
20.DATA_W_PEND	BIT	7	DATA FIELD WRITE PENDING

The track flags shown on line 1 in table 3 are described in detail on lines 8–15 and include such bits indicating a defective track bit, line 8; a write pending bit, line 11; and track in cache bit, line 15. Similarly, the record flag bits of line 6 are shown in greater detail in lines 16–20 including bits comprising the compression algorithm for this record, line 16; key and data fields in cache, lines 17 and 18; and key field and data field write pending bits, lines 19 and 20.

The channel adapters **12***a*–**12***d*, FIG. **1**, receive data and read/write commands from one or more hosts over its respective channels. The data records are provided by the host in CKD format and are stored in cache memory **16** in CKD format. All records stored in cache whether temporarily while awaiting writing to disk, or records which have been read from the disk to be stored in cache for quicker access, are stored in CKD format. When the record is to be written to the disk drive, one of disk adapters **20** reads the data from cache memory over bus **18** and converts the CKD formatted data to the format of the present invention including a record identifier and locator table all of which can be stored in a plurality of fixed blocks before outputting the data over the disk adapters' SCSI interface to one or more of disk drives **22**.

The present method for mapping CKD formatted data into fixed block disk drives is, in part, based on the recognition that under usual conditions, a sequence of CKD formatted records will include the URN portion of the count identifying the record number from among a number of sequentially numbered data records of the same length. Further, the records are generally stored on the same device cylinder and accessed by the same device head. Additionally, the key length will generally be zero or some predetermined generally constant number. Thus, the method for disk mapping **100**, FIG. **6** of the present invention includes establishing the profile of an expected record, step **110**. In the preferred embodiment, the expected record is established with the count CCHH code as the physical cylinder and head identification, as well as the key length (K_1)=0, data length (D_1)=8 and the "R" byte of the count assigned as record number (n)=0. Further, the record flags are set to 00.

During step **112**, the system employing the method of the present invention obtains the first CKD formatted record and compares the CKD record with the previously established expected record at step **114**. At step **116**, a determination is made as to whether or not the CKD formatted record including the "count" and record flags match those of the expected data record. If the CKD formatted record and the expected record match, the method proceeds to step **118** wherein the body of the track portion of the record identification and locator table previously discussed in conjunction with FIG. **5** and table 3 is built. Since the CKD formatted record matched the previously established expected data record, the record flag is set to 00 and no entry is made in the record modifier portion of the track ID cable. Subsequently, the "R" byte for the record number of the next expected data record is incremented by one, step **120**, before returning to the step of obtaining the next CKD formatted data record at step **112**.

If the results of the comparison at step **116** indicate that the CKD formatted record does not match the expected data record, the method proceeds to step **122** wherein a change format code (see Table 5) and record modifier, as required, are prepared. Next, the record format code and, if required, record modifier are inserted into the track identification table, step **124**. If the track ID table is not full as determined at step **126**, processing continues to step **128** wherein the current CKD count becomes the next expected count. Processing then returns to step **120** where the "R" byte is incremented by one before getting the next CKD record at step **112**.

If, as indicated at step **126**, the track identification table is full, meaning that the record flag portion of the ID table has collided with the record modifier portion of the ID table, the method of the instant invention will attempt to compress or shrink the body of the track ID table as shown in flowchart **130**, FIG. **7**. During the compression process of the instant invention, the system and method of the present invention attempt to define from one to eight data lengths which are repeated within this track. Such repeating data lengths are then classified as "patterns" and are thereafter referred to by a pattern "code" in the track header as shown on line 4 of Table 3, thus saving up to 2 bytes in the modifier portion of the track ID table for each repeated data length.

The method of the present invention first reads the ID table, step **132**, searching for ID's with format code 03 for repeating values of data lengths, step **134**. From those repeating values, the system and method of the present invention build a data length pattern table beginning with the data length that is most frequently repeated, and continuing on to find the seven most repeated data lengths and replaces the old 8 byte pattern with the new 8 byte pattern, step **136**.

The method then proceeds to compare the data lengths of all the CKD records of the current track which have previously been read to determine whether or not any of the data lengths match the data patterns loaded in the pattern table, step **138**. If any data lengths match the data patterns in the pattern table, the method proceeds to insert the data pattern code for the data length in a temporary ID table. Thus, the replaced record modifiers which previously contained the changed or modified data lengths are now unnecessary and eliminated, thus compressing or shrinking the size of the record identification and locator table and therefore allowing more room for the system to complete reading the CKD records for a given track. The system verifies at step **140**, that the ID table was in fact compressed. If no ID table compression was achieved, the system reports an error, step **142**. If ID table compression was achieved, the method replaces the old ID table with the temporary ID table with compressed counts, step **144**, before returning to step **120**, FIG. **6**.

Although this count compression routine somewhat reduces system performance, the time to compute repeating data patterns and thus, to compress the "count" information in a record identification and locator table is minimal when compared to the tremendous savings of time which results from the ability to search the record locator table containing the count information in semiconductor memory instead of searching the disk drives for the requested record given the respective access times.

An example of a record identification and locator table for track 0 of a representative disk drive along with decoded information of each record is reproduced below as Table 4. This track identification and record locator table forms part of the device record identification and locator table as discussed previously in conjunction with FIG. **4**. Line 2 of Table 4 corresponds to the track header portion **84**, FIG. **5** of the track identification table also previously discussed in conjunction with table 3. The second byte of the header, the number "5" indicates that there are five records on this track.

TABLE 4

```
1. TRACK NUMBER 0
2. FLAGS/COUNT/H/W/R/S/PAT/CACHE PTR: 00 5 00 00 00 00 0000000000000000 00000000
3. FLAGS          00 01 03 03 01
4. BODY:       0000000000000000 0000000000000000 0000000000000000 0000000000000000
5.             0000000000000000 0000000000000000 0000000000000000 0000000000000000
6.             0000000000000000 0000000000000000 0000000000000000 0000000000000000
7.             0000000000000000 0000000000000000 0000000000000000 000000000000000F
8.             B0E050900418A0
```

					RECORD FLAGS			PHYSICAL ADDRESS			
	REC #	ID CCHHR	KEY LENGTH	DATA LENGTH	WR PEND	IN CACHE	NON STD	BLOCK	TRACK	CACHE	ADD
9.	00	0000000000	00	0008	—	—	00	00000000	02E0		
10.	01	0000000001	04	0018	—	—	01	00000001	04E0		

TABLE 4-continued

11.	02	0000000002	04	0090	—	—	03	00000002	0800
12.	03	0000000003	04	0050	—	—	03	00000003	0B80
13.	04	0000000004	00	0FB0	—	—	01	00000004	0EC0

Line 3 begins the record flag portion of the track identification table and is comprised of five record flags namely, flags: 00; 01; 03; 03; and 01. Each of the record flags is associated with a corresponding record, in ascending order. Thus record flag 00 is associated with data record 0; record flag 01 is associated with data record 1; and record flag 03 is associated with data record 2 and so forth.

A representation of a record modifier portion of the track identification and locator table is shown at lines 4–8 of Table 4. As discussed in conjunction with FIG. **5**, the record modifier portion of the track identification and record locator table is read backwards beginning with the byte, "A0" of line 8.

The track identification and record locator table of Table 4 may be further understood in conjunction with lines 9–13. As shown on line 9, which identifies record 0 of this track, the second, third and fourth columns comprise the original "count" information of the CKD record. It should be noted that this record matches the description of the "expected" record utilized in the example associated with the method of FIG. **6** since the first record on the track is record 0, the key length is 0, and the data length is 8 bytes. Thus, the record locator flag associated with that record, "00" is the first record flag byte encountered on line 3.

Proceeding to line 10, record number 1 on the track has a key length of 04 and a data length of 18 and thus, deviates from the previously established "expected" data record and thus is assigned a record flag of 01.

Various codes which comprise the record flags are reproduced in Table 5 below wherein as shown in line 1, the code 00 means no change to the previously established "expected" record. As shown in line 2 of the table, record flag format 01 indicates that the first byte of the record modifier is the change flag byte, indicating that every bit flagged with a "1" points to the byte in the record identifier that should be replaced by the following bytes in the record modifier. The order of the record identifier is shown in line 7 of table 5 and begins with the key length, followed by data length (high), data length (low) and the first byte of the cylinder.

TABLE 5

RECORD FORMAT CHANGE CODES		
1.	ID FLAG FORMAT CODE 0:	NO CHANGE
2.	ID FLAG FORMAT CODE 1:	1ST BYTE 0F MODIFIER IS THE CHANGE FLAG BYTE
3.		EVERY BIT FLAGGED POINTS TO BYTE IN THE
4.		ID THAT SHOULD BE REPLACED BY THE NEXT INFO BYTES.
5.		NUMBER OF EXTRA INFO BYTES IS THE NUMBER OF '1'S
6.		IN THE 1ST BYTE. THIS CODE IS USED IF WE CAN'T USE ANY OTHER CODE.
7.		$K_L D_{LH} D_{LL}$CHHR
8.	ID FLAG FORMAT CODE 2:	ONE BYTE INFO TO DL L + DL H = 2
9.	ID FLAG FORMAT CODE 3:	ONE BYTE INFO TO DL L + DL H = 0
10.	ID FLAG FORMAT CODE 4:	ONE BYTE INFO TO DL L DL H UNCHANGED
11.	ID FLAG FORMAT CODE 5:	TWO BYTES INFO TO DL
12.	ID FLAG FORMAT CODE 6:	ONE BYTE INFOR TO DL L + DL H = 1
13.	ID FLAG FORMAT CODE 7:	ONE BYTE INFO TO DL L + DL H = PATT FROM ID TABLE HEADER
14.	ID FLAG FORMAT CODE 8:	DL L = PATT #0 FROM ID TABLE HEADER + DL H = 0
15.	ID FLAG FORMAT CODE 9:	DL L = PATT #1 FROM ID TABLE HEADER + DL H = 0
16.	ID FLAG FORMAT CODE A:	DL L = PATT #2 FROM ID TABLE HEADER + DL H = 0
17.	ID FLAG FORMAT CODE B:	DL L = PATT #3 FROM ID TABLE HEADER + DL H = 0
18.	ID FLAG FORMAT CODE C:	DL L = PATT #4 FROM ID TABLE HEADER + DL H = 0
19.	ID FLAG FORMAT CODE D:	DL L = PATT #5 FROM ID TABLE HEADER + DL H = 0
20.	ID FLAG FORMAT CODE E:	DL L = PATT #6 FROM ID TABLE HEADER + DL H = 0
21.	ID FLAG FORMAT CODE F:	DL L = PATT #7 FROM ID TABLE HEADER + DL H = 0

Thus, returning now to line 10 of table 4, the flag code 01 indicates that the first byte of the modifier namely, "A0" indicates the bits that are to be changed in the record identifier. Reading change byte A0 in conjunction with line 7 of Table 5 discloses that the successive bytes in the record modifier will modify the key length and data length (low) of the data record. The record modifier bytes in the track identification table modify the record identifier in reverse order as that shown in line 7 of Table 5 that is, from record number to key length. Thus, the second byte, "18" of the record modifier at line 8 of table 4 indicates that the previously expected data length is to be replaced with a data length (low) of "18", while the next byte of the record modifier, "04" is to replace the previously expected key length. It is in this manner that the system "reconstructs" the count portion of a CKD record from the "encoded" record identification and locator table.

Record number 2, line 11 of Table 4 also has a key length of "04" but the data length changes to "90". Thus, a flag of 03 is entered. The record flag of 03, as shown at line 9, Table 5, indicates that the next sequential byte of information in the record modifier is to be used as the data length (low) and the data length (high) will equal 0. Thus, the next consecutive entry of "90" in the record modifier portion of the track identification table body is accounted for.

Similarly, the next byte of the modifier portion of the track identification table is "50" which is the changed data length of record 3 read in conjunction with a record flag of "03" at line 12 of Table 4.

The final record flag "01" in the record flag portion of this track indicates that the next sequential byte namely, "E0" in the record modifier portion of the table is the changed flag byte pointing to the bytes in the record identifier that are to be changed or modified by the subsequent bytes in the record modifier portion of the table. Code E0 indicates that the key length, data length (high) and data length (low) are to be changed by the three bytes which follow as indicated by line 7, table 5. Thus, byte "B0" of the record modifier is used as the data length (low); byte "0F" is used as the data length (high) byte, and byte 00 modifies the former key length entry.

The building of a record identification and locator table in accordance with the present invention greatly reduces the amount of fixed block disk space required to store the "count" portion of a CKD formatted data record.

An additional example of a track level record identification and locator table is reproduced in table 6 below and is useful in showing an entry in the data pattern table previously described in conjunction with FIG. **7**. Table 6 is a representation of a track identification table for an exemplary track number "D00" and is used for illustrative purposes only.

TABLE 6

1. TRACK NUMBER D00	
2. FLAGS/COUNT/H/W/R/S/PAT/CACHE PTR:	11 81 00 00 00 C7 3E14181500FB9024 03FDE000
3. FLAGS	00A320 28 202020XX XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX
4.	XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX
5.	XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XX
6. BODY:	XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX
7.	XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXXXXX28

	REC #	ID CCHHR	KEY LENGTH	DATA LENGTH	RECORD FLAGS WR PEND	RECORD FLAGS IN CACHE	FORMAT CODE	PHYSICAL ADDRESS BLOCK	TRACK	CACHE	ADD
8.	00	00D0000000	00	0008	—	—	0	00047DB0	02E0		
9.	01	00D0000001	00	0028	D.	D.	3	00047DB1	04E0	03FDE118	
10.	02	00D0000002	00	0028	—	D.	0	00047DB2	0700	03FDE150	
11.	03	00D0000003	00	003E	—	D.	8	00047DB3	0920	03FDE188	
12.	04	00D0000004	00	003E	—	D.	0	00047DB4	0B60	03FDE1D0	
13.	05	00D0000005	00	003E	—	D.	0	00047DB5	0DA0	03FDE218	
14.	06	00D0000006	00	003E	—	D.	0	00047DB6	0FE0	03FDE260	

On line 2 of table 6, the track "header" information is presented including the first byte "11" indicating that on this track, there is at least one record which is in cache; and at least one record which has a write pending, as previously explained in conjunction with Table 3. The second byte of the track header, "81" indicates there are 81 records in this track, while byte 5, "C7" is the CRC byte for this track The next byte of the header, "3E" is the first byte of the data pattern table which extends for 8 bytes ending with "24". In this example, bytes 1–7 of the pattern table are not used, but are merely shown for illustrative purposes only. The last four bytes of the track header, "03 FD E0 00" is the cache beginning memory address at which any records from this track which are stored in cache are located.

Of particular interest in Table 6 is record 03 located at line 11. Since the data length, "3E" of record 3 is a deviation from the previously established data length "28", a record flag of other than 00 is expected, and thus the record flag "08" is entered As can be compared from line 14 of the record flag codes in Table 5, record flag code "08" indicates that the data length (low) of this record identifier is to be loaded with pattern 0, the first pattern from the identification table header and thus, the "3E" pattern from line 2 of Table 6 is used as the data length for record number 3 when the system reconstructs the data record. The record flag, "28" which is shown and underlined on line 3 of table 6 also indicates that the data of this record is stored in cache. The cache address is ascertained by adding up the cache memory starting address (line 2) contained in the header of the track identification table along with the length of any intervening data or key information stored in cache.

Modifications and substitutions of the present invention by one of ordinary skill in the art are considered to be within the scope of the present invention, which is not to be limited except by the claims which follow.

We claim:

1. Apparatus for retrieving a requested variable-length data record stored on at least one fixed block architecture (FBA) formatted storage medium comprising:

means for receiving a plurality of variable-length data records, each of said variable-length data records including at least a record identification portion and a data portion;

means, responsive to said means for receiving, for transforming and storing said plurality of variable-length data records on said at least one FBA formatted storage medium;

means, responsive to said means for transforming and storing, for generating a corresponding plurality of record locator indices, each of said corresponding plurality of record locator indices being associated with one of said plurality of variable-length data records and a corresponding record identification portion, for uniquely identifying the location of each of said plurality of variable-length data records stored on said at least one FBA formatted storage medium;

memory storage means, for storing at least said plurality of record locator indices and the associated record identification portions in a record locator table;

means for requesting access to said requested variable-length data record, and for providing the record identification portion corresponding to said requested variable-length data record;

means, responsive to said means for requesting access, for searching said record locator table stored in said memory storage means, for locating an associated one of said record locator indices corresponding to said requested variable-length data record; and

record retrieval means, responsive to said means for searching, for retrieving from said at least one FBA formatted storage medium said requested variable-length data record as directed by said associated one of said record locator indices corresponding to said requested variable-length data record.

2. The apparatus as claimed in claim **1**, wherein said means for receiving includes means for receiving said plurality of variable-length data records in count-key-data (CKD) format.

3. The apparatus as claimed in claim **1**, wherein said at least one FBA formatted storage medium has a plurality of fixed-length blocks of storage locations, and said means for transforming and storing said plurality of variable-length data records on said at least one FBA formatted storage medium includes means for aligning a beginning of each of said data portions of each of said variable-length data records on a beginning of a respective one of said fixed-length blocks of storage locations.

4. The apparatus as claimed in claim **3**, wherein said associated one of said record locator indices corresponding to said requested variable-length data record specifies the respective one of said fixed-length blocks of storage locations storing a beginning portion of said requested variable-length data record.

5. The apparatus as claimed in claim **4**, wherein said record retrieval means includes means responsive to information in said record locator table for computing a number of the fixed-length blocks of storage locations that are read to retrieve all of the data portion for said requested variable-length data record.

6. The apparatus as claimed in claim **1**, wherein the record identification portion contains a record number portion that usually identifies a record number from among a number of sequentially numbered data records, and wherein the apparatus includes means for determining whether the record number portion of the record identification portion identifies a record number from among a number of sequentially numbered data records.

7. The apparatus as claimed in claim **6**, including means for incrementing a record number for a next expected data record by one.

8. The apparatus as claimed in claim **1**, wherein said record locator table includes a track-level record locator table, and wherein said means for searching said record locator table includes means for computing an address for said requested variable-length data record from length information stored in said track-level record locator table for intervening variable-length data records in a track including said requested variable-length data record, said intervening variable-length data records occurring in the track before said requested variable-length data record.

9. The apparatus as claimed in claim **1**, wherein said memory storage means includes semiconductor memory, said at least one FBA formatted storage medium includes a plurality of FBA formatted disk drives, and said record retrieval means and said means for transforming and storing retrieves and stores at least one variable-length data record in a cache in said semiconductor memory; one of said record locator indices is associated with said at least one variable-length data record and includes means for indicating that the variable-length data record is in cache, and includes a pointer to a memory address of said at least one variable-length data record in cache, and includes means for indicating that the variable-length data record in cache is awaiting writing to said at least one FBA formatted storage medium.

10. The apparatus as claimed in claim **1**, wherein said record retrieval means retrieves the requested variable-length data record from said at least one FBA formatted storage medium with no intervening search of said at least one FBA formatted storage medium.

11. The apparatus as claimed in claim **1**, wherein said at least one FBA formatted storage medium includes an FBA formatted disk drive.

12. The apparatus as claimed in claim **1**, wherein said at least one FBA formatted storage medium includes semiconductor memory.

13. A method for transforming and storing variable-length data records onto at least one fixed block architecture (FBA) formatted storage medium, and for retrieving a requested data record stored on said at least one FBA formatted storage medium, comprising the steps of:

receiving a plurality of variable-length data records, each of said variable-length data records including at least a record identification portion and a data portion;

storing to said at least one FBA formatted storage medium, said plurality of variable-length data records, said step of storing including:

transforming said plurality of variable-length data records to an FBA format, and storing the plurality of data records in the FBA format on said at least one FBA formatted storage medium;

generating a plurality of record locator indices; each of the plurality of record locator indices corresponding to one of the plurality of data records, for uniquely identifying the location of each of the plurality of data records stored on said at least one FBA formatted storage medium;

forming a record locator table including the plurality of the record locator indices and record identification portions; and

storing said record locator table in memory;

searching said record locator table stored in memory, for locating one of the record locator indices corresponding to said requested data record; and

retrieving from said at least one FBA formatted storage medium, said requested data record as directed by said one of the record locator indices corresponding to said requested data record.

14. The method as claimed in claim **13**, wherein said record locator table includes a track-level record locator table, and wherein said searching said record locator table includes computing an address for said requested data record from length information stored in said track-level record locator table for intervening data records in a track including said requested data record, said intervening data records occurring in the track before said requested data record.

15. The method as claimed in claim **13**, wherein said at least one FBA formatted storage medium has fixed-length blocks of storage locations, and said transforming said plurality of variable-length data records to an FBA format includes aligning a beginning of each of said data portions of each of said variable-length data records on a beginning of a respective one of said fixed-length blocks of storage locations.

16. The method as claimed in claim **13**, wherein said requested data record is retrieved from said at least one FBA formatted storage medium with no intervening search of said at least one FBA formatted storage medium.

17. A method for transforming and storing variable-length CKD formatted data records onto one or more fixed block architecture (FBA) disk drives, and for retrieving a requested data record stored on one or more of said fixed block architecture disk drives, comprising the steps of:

receiving a plurality of variable-length CKD formatted data records, each of said variable-length CKD formatted data records including at least a record identification portion and a data portion;

storing to said one or more fixed block architecture (FBA) disk drives, said plurality of variable-length CKD formatted data records, said step of storing including:

transforming said plurality of variable-length CKD formatted data records from a CKD format to an FBA format, and storing the plurality of data records in the FBA format on said one or more FBA disk drives;

generating a plurality of record locator indices; each of the plurality of record locator indices corresponding to one of the plurality of data records, for uniquely identifying the location of each of the plurality of data records stored on said one or more FBA disk drives;

forming a record locator table including the plurality of the record locator indices and record identification portions; and

storing said record locator table in memory;

searching said record locator table stored in memory, for locating one of the record locator indices corresponding to said requested data record; and

retrieving from said one or more FBA disk drives, said requested data record as directed by said one of the record locator indices corresponding to said requested data record.

18. The method as claimed in claim **17**, wherein said record locator table includes a track-level record locator table, and wherein said searching said record locator table includes computing an address for said requested data record from length information stored in said track-level record locator table for intervening data records in a track including said requested data record, said intervening data records occurring in the track before said requested data record.

19. The method as claimed in claim **17**, wherein said FBA disk drives have fixed-length blocks of storage locations, and said transforming said plurality of variable-length data records from a CKD format to an FBA format includes aligning a beginning of each of said data portions of each of said variable-length data records on a beginning of a respective one of said fixed-length blocks of storage locations.

20. The method as claimed in claim **17**, wherein said requested data record is retrieved from said one or more FBA disk drives with no intervening search of said one or more FBA disk drives.

21. Apparatus for retrieving a requested variable-length data record stored on at least one fixed block architecture (FBA) formatted storage medium comprising:

means for receiving a plurality of variable-length data records;

means, responsive to said means for receiving, for transforming and storing said plurality of variable-length data records on said at least one FBA formatted storage medium;

means, responsive to said means for transforming and storing, for generating a corresponding plurality of record locator indices, each of said corresponding plurality of record locator indices being associated with one of said plurality of variable-length data records, for uniquely identifying the location of each of said plurality of variable-length data records stored on said at least one FBA formatted storage medium;

mapping means, for storing at least said plurality of record locator indices in a record locator table, and in response to a request for access to said-requested variable-length data record, for searching said record locator table for obtaining an associated one of said record locator indices corresponding to said requested variable-length data record; and

record retrieval means for retrieving from said at least one FBA formatted storage medium said requested variable-length data record as directed by said associated one of said record locator indices corresponding to said requested variable-length data record.

22. The apparatus as claimed in claim **21**, wherein said at least one FDA formatted storage medium has a plurality of fixed-length blocks of storage locations, and said means for transforming and storing said plurality of variable-length data records on said at least one FBA formatted storage medium includes means for aligning a beginning of a data portion of each of said variable-length data records on a beginning of a respective one of said fixed-length blocks of storage locations.

23. The apparatus as claimed in claims **22**, wherein said associated one of said record locator indices corresponding to said requested variable-length data record specifies the respective one of said fixed-length blocks of storage locations storing a beginning portion of said requested variable-length data record.

24. The apparatus as claimed in claim **22**, wherein said record retrieval means includes means responsive to information in said record locator table for computing a number of the fixed-length blocks of storage locations that are read to retrieve all data for said requested variable-length data record.

25. The apparatus as claimed in claim **21**, wherein said record locator table includes a track-level record locator table, and wherein said mapping means includes means for computing an address for said requested variable-length data record from length information stored in said track-level record locator table for intervening variable-length data records in a track including said requested variable-length data record, said intervening variable-length data records occurring in the track before said requested variable-length data record.

26. A method for transforming and storing variable-length data records onto a fixed block architecture (FBA) formatted storage medium, and for retrieving a requested data record stored on said at least one FBA formatted storage medium, comprising the steps of:

receiving a plurality of variable-length data records; storing to said at least one FBA formatted storage medium, said plurality of variable-length data records, said step of storing including:

transforming said plurality of variable-length data records to an FBA format, and storing the plurality of data records in the FBA format on said at least one FBA formatted storage medium;

generating a plurality of record locator indices; each of the plurality of record locator indices corresponding to one of the plurality of data records, for uniquely identifying the location of each of the plurality of data records stored on said at least one FBA formatted storage medium; and

forming a record locator table including the plurality of the record locator indices;

searching said record locator table, for locating one of the record locator indices corresponding to said requested data record; and retrieving from said at least one FBA formatted storage medium, said requested data record as directed by said one of the record locator indices corresponding to said requested data record.

27. The method as claimed in claim **26**, wherein said record locator table includes a track-level record locator table, and wherein said searching said record locator table includes computing an address for said requested data record from length information stored in said track-level record locator table for intervening data records in a track including said requested data record, said intervening data records occurring in the track before said requested data record.

28. The method as claimed in claim **26**, wherein said at least one FBA formatted storage medium has fixed-length blocks of storage locations, and said transforming said plurality of variable-length data records to an FBA format includes aligning a beginning of a data portion of each of said variable-length data records on a beginning of a respective one of said fixed-length blocks of storage locations.

29. Apparatus for transforming, storing, and mapping variable-length data records on at least one fixed block architecture (FBA) formatted storage medium comprising:

means for receiving a plurality of variable-length data records, each of said variable-length data records including at least a record identification portion and a data portion;

means, responsive to said means for receiving, for transforming and storing said plurality of variable-length data records on said at least one FBA formatted storage medium;

means, responsive to said means for transforming and storing, for generating a corresponding plurality of record locator indices, each of said corresponding plurality of record locator indices being associated with one of said plurality of variable-length data records and a corresponding record identification portion, for uniquely identifying the location of each of said plurality of variable-length data records stored on said at least one FBA formatted storage medium; and

memory storage means, for storing at least said plurality of record locator indices and the associated record identification portions in a record locator table.

30. The apparatus as claimed in claim **29**, wherein said at least one FBA formatted storage medium has a plurality of fixed-length blocks of storage locations, and said means for transforming and storing said plurality of variable-length data records on said at least one FBA formatted storage medium includes means for aligning a beginning of each of said data portions of each of said variable-length data records on a beginning of a respective one of said fixed-length blocks of storage locations.

31. The apparatus as claimed in claim **29**, wherein the record identification portion contains a record number portion that usually identifies a record number from among a number of sequentially numbered data records, and wherein the apparatus includes means for determining whether the record number portion of the record identification portion identifies a record number from among a number of sequentially numbered data records.

32. The apparatus as claimed in claim **31**, including means for incrementing a record number for a next expected data record by one.

33. Apparatus for retrieving data stored on at least one fixed block architecture (FBA) formatted storage medium, said at least one FBA formatted storage medium including a plurality of fixed-length blocks of storage locations, said apparatus comprising:

means for receiving a plurality of variable-length data records, each of said variable-length data records including at least a record identification portion and a data portion;

means, responsive to said means for receiving, for transferring and storing the data portions of said plurality of variable-length data records on said at least one FBA formatted storage medium by aligning a beginning of each of the data portions on a respective one of said fixed-length blocks of storage locations;

means, responsive to said means for transferring and storing, for generating a corresponding plurality of record locator indices, each of said corresponding plurality of record locator indices being associated with one of said plurality of variable-length data records and a corresponding record identification portion, for uniquely identifying the respective one of the fixed-length blocks of storage locations on which is aligned the beginning of the data portion of said one of said plurality of variable-length data records;

memory storage means, for storing at least said plurality of record locator indices and the associated record identification portions in a record locator table;

means for requesting access to a requested variable-length data record, and for providing the record identification portion corresponding to said requested variable-length data record;

means, responsive to said means for requesting access, for searching said record locator table stored in said memory storage means, for locating an associated one of said record locator indices corresponding to said requested variable-length data record; and

record data retrieval means, responsive to said means for searching, for retrieving from said FBA formatted storage medium the data portion of said requested variable-length data record as directed by said associated one of said record locator indices corresponding to said requested variable-length data record.

34. The apparatus as claimed in claim **33**, wherein said at least one FBA formatted storage medium includes rotating disk storage, and said memory storage means includes random access semiconductor memory.

35. The apparatus as claimed in claim **33**, wherein said means for receiving includes means for receiving said plurality of variable-length data records in count-key-data (CKD) format.

36. The apparatus as claimed in claim **33**, wherein said record data retrieval means includes means responsive to information in said record locator table for computing a number of the fixed-length blocks of storage locations that are read to retrieve all of the data portion for said requested variable-length data record.

37. The apparatus as claimed in claim **33**, wherein the record identification portion contains a record number portion that usually identifies a record number from among a number of sequentially numbered data records, and wherein the apparatus includes means for determining whether the record number portion of the record identification portion identifies a record number from among a number of sequentially numbered data records.

38. The apparatus as claimed in claim **37**, including means for incrementing a record number for a next expected data record by one.

39. The apparatus as claimed in claim **33**, wherein said record locator table includes a track-level record locator table, and wherein said means for searching said record locator table includes means for computing an address for said requested variable-length data record using length information stored in said track-level record locator table for intervening variable-length data records in a track including said requested variable-length data record, said intervening variable-length data records occurring in the track before said requested variable-length data record.

40. The apparatus as claimed in claim **33**, which further includes means for storing the record locator indices in a compressed format in the record locator table.

41. The apparatus as claimed in claim **33**, which further includes means for storing the record identification portions in a compressed format in the memory storage means.

42. Apparatus for retrieving data stored on fixed block architecture (FBA) formatted storage medium, the FBA formatted storage medium including a plurality of fixed-length blocks of storage locations, said apparatus comprising:

a data record receiver for receiving a plurality of variable-length data records, each of said variable-length data records including at least a record identification portion and a data portion;

a data record storer, responsive to the data record receiver, for transferring and storing the data portions of said plurality of variable-length data records on said FBA formatted storage medium by aligning a beginning of each of the data portions on a respective one of said fixed-length blocks of storage locations;

a record locator index generator, responsive to said data record storer, for generating a corresponding plurality of record locator indices, each of said corresponding plurality of record locator indices being associated with one of said plurality of variable-length data records and a corresponding record identification portion, for uniquely identifying the respective one of the fixed-length blocks of storage locations on which is aligned the beginning of the data portion of said one of said plurality of variable-length data records;

memory storage, for storing at least said plurality of record locator indices and the associated record identification portions in a record locator table;

a data record access requester, for requesting access to a requested variable-length data record, and for providing the record identification portion corresponding to said requested variable-length data record;

a record locator table searcher, responsive to said data record access requester, for searching said record locator table stored in said memory storage, for locating an associated one of said record locator indices corresponding to said requested variable-length data record; and

a record data retriever, responsive to said record locator table searcher, for retrieving from said FBA formatted storage medium the data portion of said requested variable-length data record as directed by said associated one of said record locator indices corresponding to said requested variable-length data record.

43. The apparatus as claimed in claim **42**, wherein the FBA formatted storage medium is rotating disk storage, and said memory storage is random access semiconductor memory.

44. The apparatus as claimed in claim **42**, wherein said data record receiver is adapted for receiving said plurality of variable-length data records in count-key-data (CKD) format.

45. The apparatus as claimed in claim **42**, wherein said record data retriever is responsive to information in said record locator table for computing a number of the fixed-length blocks of storage locations that are read to retrieve all of the data portion for said requested variable-length data record.

46. The apparatus as claimed in claim **42**, wherein the record identification portion contains a record number portion that usually identifies a record number from among a number of sequentially numbered data records, and wherein the apparatus includes a record number checker for determining whether the record number portion of the record identification portion identifies a record number from among a number of sequentially numbered data records.

47. The apparatus as claimed in claim **46**, which includes a record number counter for incrementing a record number for a next expected data record by one.

48. The apparatus as claimed in claim **42**, wherein said record locator table includes a track-level record locator table, and wherein said record locator table searcher includes an address computer for computing an address for said requested variable-length data record using length information stored in said track-level record locator table for intervening variable-length data records in a track including said requested variable-length data record, said intervening variable-length data records occurring in the track before said requested variable-length data record.

49. The apparatus as claimed in claim **42**, further including a data compressor for compressing and storing the record locator indices in a compressed format in the record locator table.

50. The apparatus as claimed in claim **42**, further including a data compressor for compressing and storing the record identification portions in a compressed format in the memory storage.

51. A method of retrieving data stored on fixed block architecture (FBA) formatted storage medium, the FBA formatted storage medium including a plurality of fixed-length blocks of storage locations, said method including the steps of:

receiving a plurality of variable-length data records, each of said variable-length data records including at least a record identification portion and a data portion;

transferring and storing the data portions of said plurality of variable-length data records on said FBA formatted storage medium by aligning a beginning of each of the data portions on a respective one of said fixed-length blocks of storage locations;

generating a corresponding plurality of record locator indices, each of said corresponding plurality of record locator indices being associated with one of said plurality of variable-length data records and a corresponding record identification portion, for uniquely identifying the respective one of the fixed-length blocks of storage locations on-which is aligned the beginning of the data portion of said one of said plurality of variable-length data records;

storing at least said plurality of record locator indices and the associated record identification portions in a record locator table;

requesting access to a requested variable-length data record, and for providing the record identification portion corresponding to said requested variable-length data record;

searching said record locator table, for locating an associated one of said record locator indices corresponding to said requested variable-length data record; and

retrieving from said FBA formatted storage medium the data portion of said requested variable-length data record as directed by said associated one of said record locator indices corresponding to said requested variable-length data record.

52. The method as claimed in claim **51**, wherein the FBA formatted storage medium is rotating disk storage, and said record locator table is stored in random access semiconductor memory.

53. The method as claimed in claim **51**, which includes receiving said plurality of variable-length data records in count-key-data (CKD) format.

54. The method as claimed in claim **51**, which includes using information in said record locator table for computing a number of the fixed-length blocks of storage locations that are read to retrieve all of the data portion for said requested variable-length data record.

55. The method as claimed in claim **51**, wherein the record identification portion contains a record number portion that usually identifies a record number from among a number of sequentially numbered data records, and wherein the method includes determining whether the record number portion of the record identification portion identifies a record number from among a number of sequentially numbered data records.

56. The method as claimed in claim **55**, which includes incrementing a record number for a next expected data record by one.

57. The method as claimed in claim **51**, wherein said record locator table includes a track-level record locator table, and wherein the method includes searching said record locator table by computing an address for said requested variable-length data record using length information stored in said track-level record locator table for intervening variable-length data records in a track including said requested variable-length data record, said intervening variable-length data records occurring in the track before said requested variable-length data record.

58. The method as claimed in claim **51**, which includes storing the record locator indices in a compressed format in the record locator table.

59. The method as claimed in claim **51**, which includes storing the record identification portions in a compressed format.

60. Apparatus for retrieving data stored on at least one fixed block architecture (FBA) formatted storage medium comprising:

means for receiving a plurality of variable-length data records, each of said variable-length data records including at least a record identification portion and a data portion;

means, responsive to said means for receiving, for transforming and storing at least the data portions of said plurality of variable-length data records on said at least one FBA formatted storage medium;

means, responsive to said means for transforming and storing, for generating a corresponding plurality of record locator indices, each of said corresponding plurality of record locator indices being associated with one of said plurality of variable-length data records and a corresponding record identification portion, for uniquely identifying the location of each of the data portions of said plurality of variable-length data records stored on said at least one FBA formatted storage medium;

memory storage means, for storing at least said plurality of record locator indices in a record locator data structure, the record locator indices being stored at locations different from the locations of the data portions of their associated variable-length data records;

means for requesting access to a requested variable-length data record, and for providing the record identification portion corresponding to said requested variable-length data record;

means, responsive to said means for requesting access, for searching said record locator data structure stored in said memory storage means, for locating an associated one of said record locator indices corresponding to said requested variable-length data record; and

record retrieval means, responsive to said means for searching, for retrieving from said at least one FBA formatted storage medium at least the data portion of said requested variable-length data record as directed by said associated one of said record locator indices corresponding to said requested variable-length data record.

61. The apparatus as claimed in claim **60**, wherein said means for receiving includes means for receiving said plurality of variable-length data records in count-key-data (CKD) format.

62. The apparatus as claimed in claim **60**, which further includes means for compressing a count portion of each variable-length data record to produce a compressed count portion of said each variable-length data record, and wherein the memory storage means includes means for storing the compressed count portion of each variable-length data record in the record locator data structure.

63. The apparatus as claimed in claim **60**, which further includes means for compressing a portion of each variable-length data record to produce a compressed portion of said each variable-length data record, and wherein the memory storage means includes means for storing the compressed portion of said each variable-length data record in the record locator data structure.

64. The apparatus as claimed in claim **63**, wherein the data portion of said each variable-length data record stored in said at least one FBA formatted storage medium is not compressed, and wherein the means for transforming and storing includes means for storing the compressed portion of said each variable-length data record in said at least one FBA formatted storage medium in association with the data portion of said each variable-length data record.

65. The apparatus as claimed in claim **60**, wherein said at least one FBA formatted storage medium has a plurality of fixed-length blocks of storage locations, and said means for transforming and storing said plurality of variable-length data records on said at least one FBA formatted storage medium includes means for aligning a beginning of each of said data portions of each of said variable-length data records on a beginning of a respective one of said fixed-length blocks of storage locations.

66. The apparatus as claimed in claim **60**, wherein the record identification portion contains a record number portion that usually identifies a record number from among a number of sequentially numbered data records, and wherein the apparatus includes means for determining whether the record number portion of the record identification portion identifies a record number from among a number of sequentially numbered data records.

67. The apparatus as claimed in claim **60**, wherein said record retrieval means retrieves at least the data portion of the requested variable-length data record from said at least one FBA formatted storage medium with no intervening search of said at least one FBA formatted storage medium.

68. A method for storing and retrieving data stored on at least one fixed block architecture (FBA) formatted storage medium, said method comprising:

receiving a plurality of variable-length data records, each of said variable-length data records including at least a record identification portion and a data portion;

storing to said at least one FBA formatted storage medium, at least the data portions of said plurality of variable-length data records, said storing including:

transforming at least said data portions of said plurality of variable-length data records to an FBA format, and storing at least said data portions of said plurality of data records in the FBA format on said at least one FBA formatted storage medium;

generating a plurality of record locator indices; each of the plurality of record locator indices corresponding to one of the plurality of data records, for uniquely identifying the location of each of the data portions of said plurality of data records stored on said at least one FBA formatted storage medium;

forming a record locator data structure including the plurality of the record locator indices, the record locator data structure being stored in memory at a location different from the location of the data portions of the plurality of data records stored on said at least one FBA formatted storage medium;

searching said record locator data structure stored in memory, for locating one of the record locator indices corresponding to a requested data record; and

retrieving from said at least one FBA formatted storage medium, at least the data portion of said requested data record as directed by said one of the record locator indices corresponding to said requested data record.

69. The method as claimed in claim **68**, which includes receiving said plurality of variable-length data records in count-key-data (CKD) format.

70. The method as claimed in claim **69**, which further includes compressing a count portion of each variable-length data record to produce a compressed count portion of said each variable-length data record, and storing the compressed count portion of said each variable-length data record in the record locator data structure.

71. The method as claimed in claim **68**, which further includes compressing a portion of each variable-length data record to produce a compressed portion of said each variable-length data record, and storing the compressed portion of said each variable-length data record in the record locator data structure.

72. The method as claimed in claim **71**, wherein the data portion of said each variable-length data record stored in said at least one FBA formatted storage medium is not compressed, and wherein the method includes storing the compressed portion of said each variable-length data record in said at least one FBA formatted storage medium in association with the data portion of said each variable-length data record.

73. The method as claimed in claim **68**, wherein said at least one FBA formatted storage medium has a plurality of fixed-length blocks of storage locations, and wherein said transforming and storing said plurality of variable-length data records on said at-least one FBA formatted storage medium includes aligning a beginning of each of said data portions of each of said variable-length data records on a beginning of a respective one of said fixed-length blocks of storage locations.

74. The method as claimed in claim **68**, wherein the record identification portion contains a record number portion that usually identifies a record number from among a number of sequentially numbered data records, and wherein the method includes determining whether the record number portion of the record identification portion identifies a record number from among a number of sequentially numbered data records.

75. The method as claimed in claim **68**, wherein the data portion of the requested variable-length data record is retrieved from said at least one FBA formatted storage medium with no intervening search of said at least one FBA formatted storage medium.

76. Apparatus for retrieving data stored on at least one fixed block architecture (FBA) formatted storage medium comprising:

a data record receiver, for receiving a plurality of variable-length data records, each of said variable-length data records including at least a record identification portion and a data portion;

a data record storer, responsive to the data record receiver, for transforming and storing at least the data portions of said plurality of variable-length data records on said at least one FBA formatted storage medium;

a record locator index generator, responsive to said data record storer, for generating a corresponding plurality of record locator indices, each of said corresponding plurality of record locator indices being associated with one of said plurality of variable-length data records and a corresponding record identification portion, for uniquely identifying the location of each of the data portions of said plurality of variable-length data records stored on said at least one FBA formatted storage medium;

memory storage, for storing at least said plurality of record locator indices in a record locator data structure, the record locator indices being stored at locations different from the locations of the data portions of their associated variable-length data records;

a record locator index searcher, responsive to a request for at least the data portion of a requested variable-length data record, for searching said record locator data structure stored in said memory storage means, for locating an associated one of said record locator indices corresponding to the requested variable-length data record; and

a data retriever, responsive to said record locator index searcher, for retrieving from said at least one FBA formatted storage medium at least the data portion of said requested variable-length data record as directed by said associated one of said record locator indices corresponding to said requested variable-length data record.

77. The apparatus as claimed in claim **76**, wherein said data receiver is adapted to receive said plurality of variable-length data records in count-key-data (CKD) format.

78. The apparatus as claimed in claim **77**, which includes a data compressor for compressing a count portion of each variable-length data record to produce a compressed count portion of said each variable-length data record, and wherein the compressed count-portion of said each variable-length, data record is stored in the record locator data structure.

79. The apparatus as claimed in claim **76**, which includes a data compressor for compressing a portion of each variable-length data record to produce a compressed portion of said each variable-length data record, and wherein the compressed portion of said each variable-length data record is stored in the record locator data structure.

80. The apparatus as claimed in claim **79**, wherein the data portion of said each variable-length data record stored in said at least one FBA formatted storage medium is not compressed, and wherein the data record storer stores the compressed portion of said each variable-length data record in said at least one FBA formatted storage medium in association with the data portion of said each variable-length data record.

81. The apparatus as claimed in claim **76**, wherein said at least one FBA formatted storage medium has a plurality of fixed-length blocks of storage locations, and the data record storer transforms and stores at least the data portions of said plurality of variable-length data records on said at least one FBA formatted storage medium by aligning a beginning of each of said data portions of each of said variable-length data records on a beginning of a respective one of said fixed-length blocks of storage locations.

82. The apparatus as claimed in claim **76**, wherein the record identification portion contains a record number portion that usually identifies a record number from among a number of sequentially numbered data records, and wherein the data record storer determines whether the record number portion of the record identification portion identifies a record number from among a number of sequentially numbered data records.

83. The apparatus as claimed in claim **76**, wherein said record retrieval means retrieves at least the data portion of the requested variable-length data record from said at least one FBA formatted storage medium with no intervening search of said at least one FBA formatted storage medium.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 5,909,692

DATED : June 1, 1999

INVENTOR(S) : Yanai et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 18, line 16 (claim 22), change "FDA" to --FBA--.

Signed and Sealed this

Nineteenth Day of October, 1999

Attest:

Q. TODD DICKINSON

Attesting Officer

Acting Commissioner of Patents and Trademarks