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GENERAL INFORMATION MANUAL

MODELS 5045-360
326
325

DISCfILE® STORAGE SYSTEMS

data products corporation

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GENERAL INFORMATION MANUAL

MODEL 5045

DISCfILE® STORAGE SYSTEM

contents

The Model 5045 DISCfILE System

general description

introduction

The Model 5045 DISCfILE® Systems are designed to satisfy major computer systems requirements for a compatible, low-cost-per-bit, random access, mass memory. The Model 5045 features the field-proven reliability exhibited by the DISCfILE line of disc memories with access to over **three times** the storage capacity. A variety of convenient interfaces and a very flexible format ensure compatibility with current and future data processing systems.

There are several configurations available, each of which is defined by a unique interface. The Model 5045 may be supplied with an interface compatible with any of the DISCfILE Systems currently installed. In addition, this system may be supplied with an interface compatible with the Data Products Corporation new DATASTAK ™ System. This design philosophy permits current and future users to incorporate the larger capacity module in their systems while utilizing existing software and hardware.

The Model 5045 utilizes similar storage media and access mechanisms as used in previous DISCfILE models. Increased capacity is attained by doubling the number of discs and recording data at a higher density. The use of **microminiature logic** and **electronic switching** provides higher reliability in addition to improved access times.

The basic storage module incorporates two separate and independent access channels, each capable of accessing any one of 32 discs. This **dual-channel** feature permits two independent computers to simultaneously access the system or a single computer to double its throughput. Alternatively, the system may communicate through a single data channel, and utilize the two access channels to time-share seek operations. This **multiple-seek** feature nearly halves the average time required to obtain data.

The Model 5045 is capable of recording fixed or variable length records. The fixed record length capability allows this system to be easily incorporated into systems currently utilizing DISCfILE units. The ability to record variable length records ensures compatibility with major data processing systems now utilizing this format. The variable length record capability results in format as well as interface compatibility with the DATASTAK Systems. This provides the customer with the unique ability of incorporating removable disc pack systems with very large capacity on-line systems without modifying programs.

The system incorporates the write lockout feature available in all DISCfILE models. Any one or combination of discs may be manually locked out. Critical data is thereby protected from erasure or writing and preserved for reading only.

system configurations

There are three basic system configurations, referred to as the Models 5045-360, 325 and 326. All three versions utilize the same basic storage module.

The **Model 5045-360** incorporates the popular variable word length capability and is the version which is compatible with the DATASTAK Systems. The 360 configuration exhibits the inherent dual-channel capability.

The **Model 5045-326** is interface and format compatible with the Model 5022, 5024 and 5026 Systems. The 326 version utilizes a single data channel but has the multiple-seek capability. This system exhibits much lower access times than those normally associated with single-access devices. The Model 5045-326 is supplied with an additional module in order to provide the same pulse interface as the Model 5022, 5024 and 5026 Systems. This module, referred to as the logic unit, processes input addresses, controls system data formatting and conducts extensive error checking normally performed by a controller in the 360 and 325 versions of the 5045.

The **Model 5045-325** is interface and format compatible with the Model 5025 Systems. Thus, the 325 configuration offers dual access over independent channels to a data file equal to three Model 5025 modules.

disc unit organization

Figure I shows the physical relationship between discs, heads and positioners. The 32 data discs are mounted on a vertical spindle. Each disc is accessed by eight heads housed in four head pads on a forked arm. The arm is driven by a digital positioner which is bolted directly onto the shroud.

Data is stored on both surfaces of each disc in two zones of 256 data tracks each. Four heads access the inner zone and four heads access the outer zone. The eight tracks that are accessed at each positioner location are referred to as a position. Table I summarizes the relationship between tracks, heads, positions and positioners.

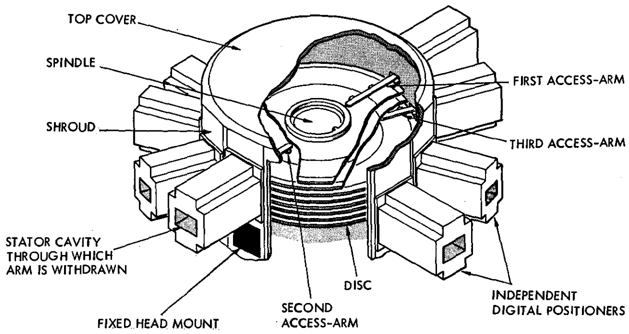

FIGURE I PHYSICAL ORGANIZATION OF DISCS AND POSITIONERS

ELEMENTS	NUMBER OF ELEMENTS IN A		
	Position	Disc	DISCfILE
Tracks	8	512	16,384
Heads	8	8	256
Positions	1	64	2048
Positioners	—	1	32

TABLE I RELATIONSHIPS AMONG SYSTEM ELEMENTS

storage capacity

The Model 5045 has a total storage capacity of over 764 million bits. The system offers the option* of almost 4.5 million additional bits for very fast access by means of fixed heads. An extra data disc is supplied when the fixed head option is exercised.

Immediate customer applications may not demand the entire available capacity. A system may then be supplied with less than the full complement of discs to a minimum of eight. Discs may then be added in the field to satisfy expanding on-line storage requirements.

The precise number of bits available for record data is dependent upon the formatting used and the length of the recorded records. The capacities for various record lengths are summarized for each version of the Model 5045 in the corresponding sections of this document.

transfer rates

Transfer rates are a function of the system clock frequency and the disc rotational speed. A control disc contains a permanently recorded clock track. This track is used to generate two clock frequencies, defining the rates for the inner and outer zone. During an inner zone operation 31,112 clocks per disc revolution are supplied. During an outer zone operation 62,224 clocks per revolution are supplied. The discs rotate at a nominal speed of 1200 rpm (1000 rpm for 50 cps). Table II lists the transfer rates and bit-to-bit timing for 60 and 50 cps operation.

*Prices for options will be supplied upon request.

LINE FREQUENCY CPS	TRANSFER RATE (KILOBITS/SEC)		BIT TIME (MICROSECS)	
	Outer Zone	Inner Zone	Outer Zone	Inner Zone
60	1197	600	0.84	1.67
50	998	500	1.0	2.0

TABLE II AVERAGE TRANSFER RATES AND BIT TIMING

factors affecting access time

There are several factors affecting the access times to data in a random-access, mass-storage device. The significance of each factor and, in turn, the overall speed of the device, depends to a large extent on the particular application. The application must be analyzed to obtain an accurate estimate of the time required to perform any single operation or series of operations. Figure II illustrates the components of access time. The components which are relevant to applications considerations are switching time, motion time, confirmation time and latency.

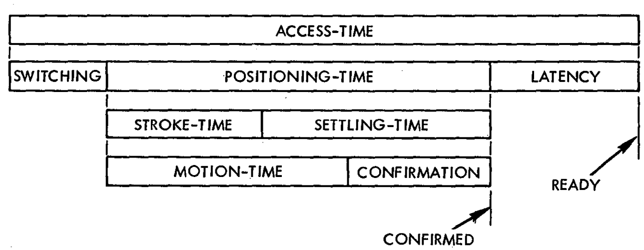

FIGURE II COMPONENTS OF ACCESS TIME

switching times

Switching time is experienced when a new disc and/or position address is supplied to a channel. This is the time required to remove power from the previously addressed positioner and switch to the new positioner and/or position. Positioner power switching time averages 16 milliseconds.

This delay may be significantly reduced when the data processor can anticipate a change in disc and/or position. The data processor may then instruct the channel to clear positioner power and perform other routines while power is being removed. When the data processor returns, only six milliseconds is required to switch to a new positioner.

No delay is involved when switching between heads in a position. Head switching time (including read amplifier recovery time) is a nominal 100 microseconds. This time is unimportant since it is so much shorter than the various electromechanical times which occur. The read circuit recovery time, after writing, averages 75 microseconds.

motion time

Motion time is required whenever a new disc and/or position is selected. This is defined as the time from application of positioner power to the time that the confirmation procedure can begin. Motion time is dependent upon the length of the stroke required to reach the new position. Figure III illustrates the average motion times for various stroke lengths. The motion time for any stroke length shall not exceed 225 milliseconds.

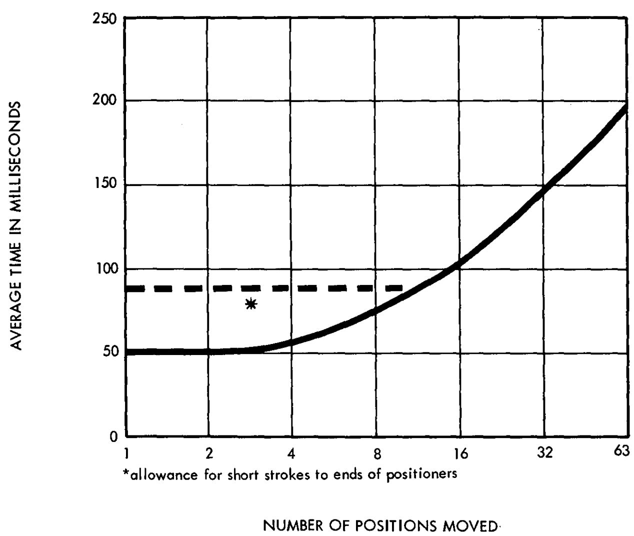

FIGURE III TYPICAL MOTION TIMES

It should be noted that the motion time curve is a function of the number of positions moved and does not directly indicate the speed of the memory. Even when the data processor is randomly addressing data that is distributed throughout the disc module (i.e., using all 64 positions), the average number of positions moved is only on the order of 21. This results in a random average motion time of approximately 115 milliseconds.

In addition, the dual-channel capability of the Model 5045 significantly reduces the effects of motion times on total access times. In the 360 and 325 versions, the two access channels double the throughput available in similar single channel devices. In the 326 configuration, the multiple-seek capability eliminates the effect of motion times when accessing within most files of data.

confirmation time

Confirmation time is required to ensure the final settling of the positioner over the addressed track. The confirmation procedure is performed by reading and checking a contiguous number of headers from the track. When contiguous headers have been read and checked for a nominal 39 milliseconds, confirmation is complete.

latency

Latency is the time required, after the positioner has settled, to locate the addressed record. Latency is a function of record length and the rotational speed of the disc, but will average 26 milliseconds in a 60 cps device (31 milliseconds for 50 cps operation).

operating rate

Positioning time and other delays define the characteristics of the electromechanical components, but they do not define the operating rate of the system. The operating rate of any electromechanical storage device to some degree depends upon how the data is ordered and accessed. In any case, the dual-channel or multiple-seek capability inherently increases the speed of the system.

In general, the highest rates are achieved when the data is accessed sequentially. The lowest rates occur when the access is totally random. While it is difficult to program for sequential access, data is always ordered to some extent. Thus, during actual computation, the rate is somewhere between the highest and the lowest values.

The user can substantially influence the actual operating rate by the manner in which he allocates and utilizes the storage volume. In a file system, significant improvements can be achieved by this means without introducing the complexity of optimum, minimum-latency, or sequential-access programming.

A typical file of data usually occupies a small fraction of the total storage area. Even when an unusually large data file is encountered, it is normally simple to divide it into a number of relatively small subfiles.

Operating rates may then be significantly increased by selecting a minimum access "shape" for each data file. The shape is defined by the number of positioners and the maximum number of positions required to access the data. Since positioning time is the largest variable of access time, each data file can be assigned to a storage area encompassing the minimum number of positions per positioner.

Thus, a data file equal to one-quarter of the DISCfILE capacity can be stored in a minimum access "cylinder" of 16 positions of the 32 positioners. The use of independent positioners allows the data file to be relegated to different areas on each disc, without sacrificing access times. This greatly increases programming flexibility, since related data does not have to be confined to strict cylindrical patterns or to any one "corner" of the storage area.

effects of ordering data

There are several ways in which data can be ordered to optimize the dual-channel or multiple-seek capabilities of the system. Two techniques which are generally useful are:

1) Look at the computation taking place and establish likely areas where frequent access is needed. Related data is then placed in a field so that the bulk of the accesses occur in narrow regions of the file.

2) Provide a short queue by observing the accesses and making them in a reasonable order.

The highest rate of access is achieved if no positioner motion takes place. More than 45,000 eight-bit bytes can be accessed by the eight tracks at a single position, with an access time which is a function of latency only. When two channels are used, more than 90,000 bytes can be accessed with an average access time, based on an average latency, of 26 milliseconds.

The next higher rate of access is achieved if no motion time is required, but only switching between positioners. In this case, the average access time to any record in a file of more than 1,400,000 bytes, when using one channel, is 81 milliseconds (including average latency of 26 milliseconds). If both channels are used independently to access data from a file of this size, the average access time is reduced to 40.5 milliseconds.

If a new access causes motion of a positioner, the access time to any single record depends on how far the selected positioner must move. Table III shows some typical access times to records when motion is required.

NUMBER OF STEPS	60CPS (MILLISECS.)*	50CPS (MILLISECS.)*
One	131	136
Eight	156	161
Random-Average	195	200
Full-Stroke	275	280

*Includes all delays and latency

TABLE III TYPICAL ACCESS TIMES USING SINGLE CHANNEL

These are average times required to access single records utilizing a single channel. The inherent dual-channel or multiple-seek capability of the 5045 Systems dramatically decreases the average access times for actual computations.

dual-channel operation

The 360 and 325 configurations have dual-channel capability. Simplified switching and resultant higher reliability is attained by dividing the storage area into four groups, referred to as groups A, B, C and D. The 32 positioners (numbered 0 through 31 from the top down) are alternately assigned to each group (i.e., positioners 0, 4, 8, etc. to group A; 1, 5, 9, etc. to group B; 2, 6, 10, etc. to group C; and 3, 7, 11, etc. to group D).

The only restriction on dual-channel operation is that both channels cannot access two positioners in the same group simultaneously. When a disc address conflict occurs, the system simply notifies the data processor of the busy condition. The channel may then proceed to another positioner or wait for the busy positioner to be released. This restriction results in no penalties when performing large dumps, since most data files can then be assigned to sequential positioners throughout a cylinder. In addition, most data files (up to 11,500,000 eight-bit bytes) can be distributed among the four groups (e.g., positioners 0 through 3) and randomly accessed with minimum probability of conflict.

In multi-file processing, it is usually possible to foresee which files may be processed together. The regions for the files can then be allocated such that no one group is accessed by both channels simultaneously. Even when data must be distributed randomly among the four groups, a very minimum queue is required to prevent conflicts.

Figure IV illustrates the relationship between the components of access time for the two channels. Table IV lists typical average random-access times for data files of various shapes and sizes.

As seen in Table IV, over 20 transfers per second can be attained when accessing randomly within a data file of 1,400,000 eight-bit bytes. In a data file 64 times as large (92,000,000 eight-bit bytes), 10 single accesses per second can still be accomplished in a random mode.

APPROXIMATE SIZE OF FILE IN EIGHT-BIT BYTES	SHAPE OF FILE			
	32 POSITIONERS		8 POSITIONERS	
	Positions	Access Time Millisecs.*	Positions	Access Time Millisecs.*
1,400,000	1	40.5	4	66
2,800,000	2	53	8	66
5,700,000	4	66	16	71
11,500,000	8	66	32	81
23,000,000	16	71	64	98
46,000,000	32	81	—	—
92,000,000	64	98	—	—

*Includes all delays and latency

TABLE IV TYPICAL AVERAGE RANDOM ACCESS TIMES FOR DUAL CHANNEL OPERATION

Random or semi-random accesses ease the problems of programming in almost all types of computation. For example, in large transfers or dumps where the amount of data may vary from 500 to 45,000 bytes, high transfer rates are very important. However, short access times are also necessary to locate an area into which a dump can take place, and then to locate the area from which the new data is transferred. The dual-channel capability of the 5045 optimizes this type of routine, since it allows dumping and filling to occur simultaneously.

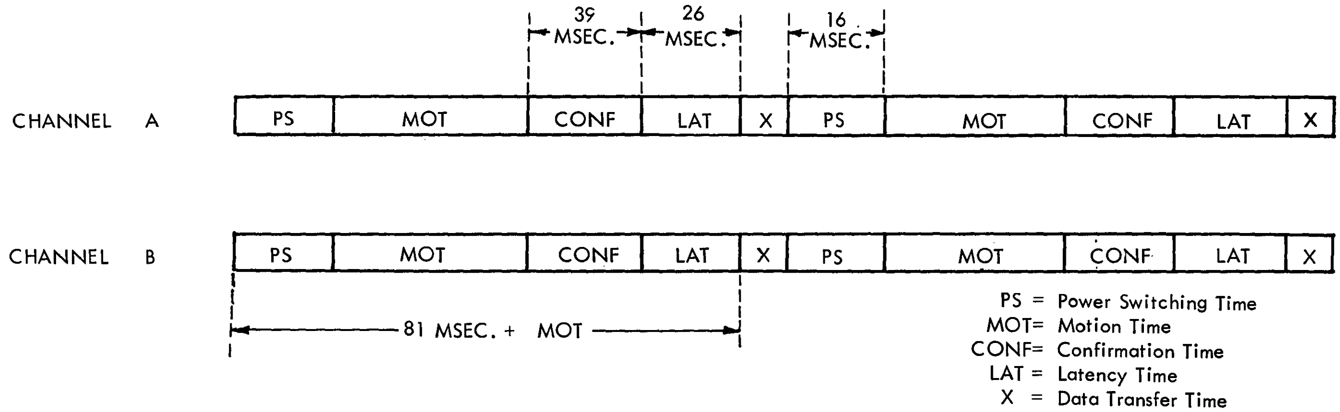

FIGURE IV ACCESS TIME COMPONENTS USING DUAL CHANNEL

The availability of two channels allows two computers to access the system independently. Either computer may be reading or writing without concern for what the other is doing. The 5045 is ideal for those applications requiring a secondary storage accessible by two computers or for input-output buffering between multiplex communications channels and the main computer. The utilization of both channels by a single computer doubles system throughput, providing many more accesses per second than normally available with a mass, random-access memory.

multiple-seek operation

The 5045-326 System has multiple-seek capability. The 326 configuration incorporates a logic unit which controls both access channels in the disc unit. The access channels in the 326 system are referred to as seek channel A and seek channel B. The logic unit must be connected to the addressed seek channel during switching, confirmation and latency times or when reading or writing. However, during motion time, the positioner is under control of the seek channel and the logic unit can disconnect and proceed to the other channel.

Figure V illustrates the relationship between the components of access time for the two seek channels. Table V lists typical random access times for data files of various shapes and sizes during multiple-seek operation.

In the 326 configuration, the logic unit actuates a positioner by transferring a new address to the selected channel. This transfer occurs as soon as power is removed from the previously addressed positioner. The logic unit may disconnect from the channel immediately after transferring the address. As seen in Figure V, switching between seek channels requires an average of five milliseconds. The 326 version thus exhibits a total average switching time of 15 milliseconds.

It can be seen that the effect of motion time can be eliminated as long as the switching, confirmation and latency times for one seek channel overlap the motion time for a positioner previously actuated in the other seek channel. Since the sum of the switching, confirmation and latency times averages 80 milliseconds, all motion times requiring less than 80 milliseconds are effectively eliminated by the multiple-seek feature.

The average access time within any data file up to

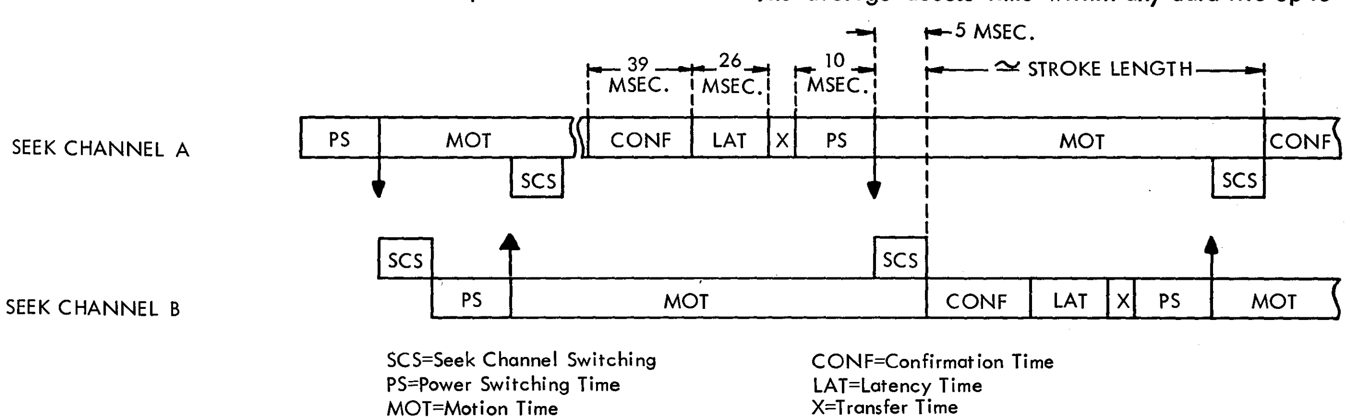

FIGURE V ACCESS TIME COMPONENTS USING MULTIPLE SEEK

APPROXIMATE SIZE OF FILE IN EIGHT-BIT BYTES	SHAPE OF FILE			
	32 POSITIONERS		8 POSITIONERS	
	Positions	Access Time* Msec.	Positions	Access Time* Msec.
1,400,000	1	80	4	80
2,800,000	2	80	8	80
5,700,000	4	80	16	80
11,500,000	8	80	32	80
23,000,000	16	80	64	115
46,000,000	32	80	—	—
92,000,000	64	115	—	—

*These times include all delays and latency

TABLE V TYPICAL AVERAGE RANDOM ACCESS TIMES FOR MULTIPLE SEEK OPERATION

46,000,000 bytes is 80 milliseconds. For files in the order of 92,000,000 bytes, motion time becomes significant. However, even when the data must be randomly accessed throughout the storage area of the entire disc unit, the average random access time to any one record is only 115 milliseconds. When large data transfers occur, the effective access times are further reduced since the transfer time would also overlap motion time in the alternate channel.

The 5045-326 system offers a dual confirmation option. The system can be supplied with confirmation logic contained in both channels of the disc unit. This eliminates the need for time sharing the logic unit for the confirmation procedures. Confirmation in both channels may then be performed simultaneously and the logic unit need only be tied to the channel for switching and latency times.

The dual confirmation option, in conjunction with the multiple-seek capability of the 326, results in operating speeds equivalent to those exhibited by dual-channel configurations, as listed in Table IV.

model 5045-360

The Model 5045-360 employs the variable record length format and current-mode interface compatible with Data Products DATASTAK Systems. This allows the same basic controller design and software to be used with either system or simultaneously with both systems.

system operation

track organization

To achieve maximum compatibility with the DATASTAK system, the tracks in the 5045-360 may be arranged so that all contain the same amount of data. Since the outer zone tracks normally store twice the number of bits as the inner zone, the outer zone is functionally divided into two zones as shown in Figure VI.

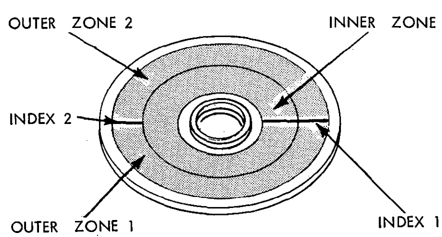

FIGURE VI DATA TRACK ORGANIZATION

Organizing outer zone tracks in this way provides for accessing 12 data tracks at each position. The beginning of each track in the inner zone and outer zone 1 is indicated by the INDEX 1 pulse; the beginning-of-track reference for outer zone 2 tracks is the INDEX 2 pulse. In applications where equal-length tracks are not important, the INDEX 2 pulse is not used.

interface

Each access channel has a separate independent interface. The basic interface signals employed in the system include the minimum number required to access a position, select a head, and read or write data in the selected track. A signal is also provided in the basic interface for indicating system status. In addition, optional signals may be included to satisfy individual customer requirements. The access channel interface is illustrated in Figure VII.

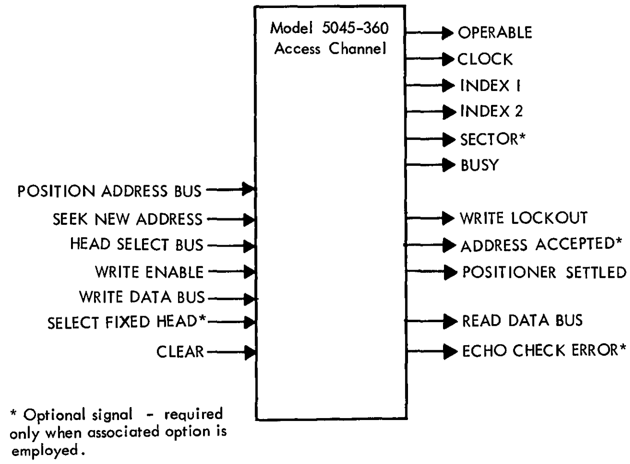

FIGURE VII MODEL 5045-360, CHANNEL INTERFACE

input signal functions

POSITION ADDRESS BUS (eleven lines, levels)

Used for transmission of disc and position address. Five most significant bits address disc; six bits address position.

SEEK NEW ADDRESS (one line, pulse)

Commands system to seek disc and position address currently on address lines.

HEAD SELECT BUS (four lines, levels)

Transmits address for one of eight heads on selected positioner.

WRITE ENABLE (one line, level)

When active, commands system to write data in selected track.
When inactive and a head is selected, instructs system to read data from selected track.

WRITE DATA BUS (two lines, pulses)

Pulsed to transfer write data. ONES and ZEROS are on separate lines.

*SELECT FIXED HEAD (one line, level)

Commands system to select fixed-head track identified by address on POSITION ADDRESS and HEAD SELECT BUSES.

CLEAR (one line, pulse)

Removes power from positioner and clears address from channel.

output signal functions

OPERABLE (one line, level)

Indicates system is in a state of operational readiness.

CLOCK (one line, pulse)

Transmits basic timing pulses to data processor. Clock frequency agrees with selected head. When no head is selected, outer zone clock is transmitted.

INDEX 1 (one line, pulse)

Pulsed to indicate beginning-of-track reference for inner zone or outer zone 1.

INDEX 2 (one line, pulse)

Pulsed to indicate beginning-of-track reference for tracks in outer zone 2.

*SECTOR (one line, pulse)

When using fixed record length option, pulsed to indicate beginning of each sector. Inner zone sector marks are sent when an inner zone head is selected; outer zone sector marks are sent when an outer zone head is selected or when no head is selected.

BUSY (one line, level)

Activated when addressed disc is in group currently being accessed by the other access channel.

*ADDRESS ACCEPTED (one line, level)

Active level indicates new address has been accepted by system, and position address signals may be removed.

POSITIONER SETTLED (one line, level)

Activated to indicate positioner is settled at addressed position.

WRITE LOCKOUT (one line, level)

Activated to indicate that writing and erasure is locked out on currently addressed disc.

READ DATA BUS (two lines, pulses)

Pulsed to transfer read data, with ONES and ZEROS on separate lines. When the echo check option is employed, this bus also returns data generated at output of write amplifier to the data processor.

*ECHO CHECK ERROR (one line, pulse)

Pulsed to indicate bad comparison between write data bit supplied to system and bit supplied to head.

signal characteristics

The standard interface uses current levels and current pulses. Optional circuits are available for voltage modes. The current is supplied from a positive voltage and is referenced at a nominal +6 volts for the transmitter and a +1 volt for the receiver. Simplified circuit diagrams of the transmitter and receiver are shown in Figure VIII.

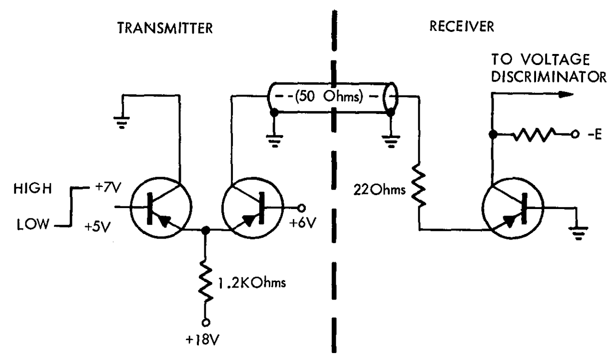

FIGURE VIII CURRENT MODE INTERFACE LOGIC

There are two standard current states. The LOW state is the quiescent state for pulses and is represented by less than two milliamperes. The HIGH or active pulse state is represented by 9 ± 2 milliamperes. Transitions between the states should occur between 10 and 100 nanoseconds. A pulse should remain at the high state for more than 20 nanoseconds and should remain above the 50% level for between 80 and 200 nanoseconds.

signal sequence

The system is energized by a manually operated switch on the disc unit. (If desired, a signal may be added to the interface to provide a remote power-on function.) When power sequencing is complete and the discs are rotating at the proper speed, OPERABLE is supplied to the data processor. This signal is maintained as long as the system is energized and operating conditions are normal. Should a malfunction occur which prevents normal operation, the OPERABLE signal is removed.

To access a record, the data processor places the disc and position address of that record on the POSITION ADDRESS BUS and then forwards the SEEK NEW ADDRESS pulse. This signal commands the file system to begin seeking the new address. In the basic system, the address signals must be maintained constant for a minimum period of 20 milliseconds to allow time for clearing the previous address and accepting the new address.

Two options are available to allow the data processor to disconnect within a much shorter time. An optional ADDRESS ACCEPTED signal may be added to the interface to notify the data processor when the address has been accepted. This level is generated within 10 milliseconds nominal after SEEK NEW ADDRESS and maintained until a new seek operation is initiated or a CLEAR command is received. Also available as an option is an input buffer register for address storage. When this register is used, the SEEK NEW ADDRESS pulse strobes the address into the register, and the data processor may disconnect immediately after the SEEK NEW ADDRESS pulse is transmitted.

A seek operation for a different address may be initiated at any time. After the previous address has been accepted, this is accomplished by merely placing the new address on the POSITION ADDRESS BUS and forwarding a SEEK NEW ADDRESS pulse. To initiate a new seek operation before the previous address has been accepted, the data processor must forward a CLEAR before the SEEK NEW ADDRESS pulse.

If a disc is addressed in the group currently being accessed by the other control channel, the file system notifies the data processor with an active level on the BUSY line. In response to BUSY, the data processor may initiate a seek operation for a different address, or may wait until the other control channel releases its address.

In the 5045-360, confirmation (i.e., the operation of determining that the positioner has settled at the addressed position) is performed automatically within the system. Upon completion of the confirmation procedure, the system notifies the data processor by supplying POSITIONER SETTLED. The data processor may then reconnect to the system when ready to transfer data.

Addresses and control information must be initially recorded at the beginning of each inner zone track and at the beginning of each of the two artificially formatted "tracks" in the outer zone. When writing such information, the data processor monitors the INDEX 1 or INDEX 2 pulse to determine the beginning of the track, then counts pulses on the CLOCK line to locate the precise area for writing.

When ready to transfer data, the data processor places the binary address of the desired head on the HEAD SELECT BUS, while holding WRITE ENABLE inactive. Under these conditions, data is read from the track associated with the selected head and supplied to the data processor over the READ DATA BUS. If an outer zone head is selected, the data processor should examine read data from only that portion of the track containing the desired records; that is, if the desired data is stored in outer zone 1, read data should be monitored only between the INDEX 1 and INDEX 2 pulses; if the desired data is stored in outer zone 2, read data should be monitored only between the INDEX 2 and INDEX 1 pulses.

To write data, the data processor first selects a head and reads addresses until the desired record area is located. The system is instructed to write by supplying an active WRITE ENABLE level, and gating information to be written over the WRITE DATA BUS in response to pulses on the CLOCK line. When the echo check option is employed, signals developed from the write current are returned to the data processor over the READ DATA BUS. An alternative option provides for echo checking write data within the disc unit. When this option is employed, the file system forwards the ECHO CHECK ERROR pulse to the data processor if a write data error is detected.

When an access has been completed and another seek is not immediately required, the data processor may clear the previous address from the channel by forwarding the CLEAR pulse. This releases the addressed disc for accessing by the other access channel.

The SELECT FIXED HEAD signal is required only for systems employing the optional fixed data heads. When a fixed head access is required, the data processor forwards the SELECT FIXED HEAD signal together with an address on the POSITION ADDRESS and HEAD SELECT BUSES. The file system uses SELECT FIXED HEAD and the information on the address buses to select a head on the fixed head disc. As long as the SELECT FIXED HEAD level is active, all data transfer commands will be executed on the addressed fixed head track.

format considerations

The Model 5045-360 offers a wide range of format capability. The basic system design permits the data processor to vary the length and number of records on each track, in this way attaining maximum efficiency in storage area utilization. The fixed sectoring option provides for recording fixed-length records in areas marked by SECTOR pulses supplied by the file system, thus simplifying software and controller design.

variable record length format

When employing the variable record length format, the data processor marks the beginning of each record area by recording a special address mark character immediately before the address identifying the record. The address mark is unique and easy-to-recognize because it is written at one-half the clock frequency.

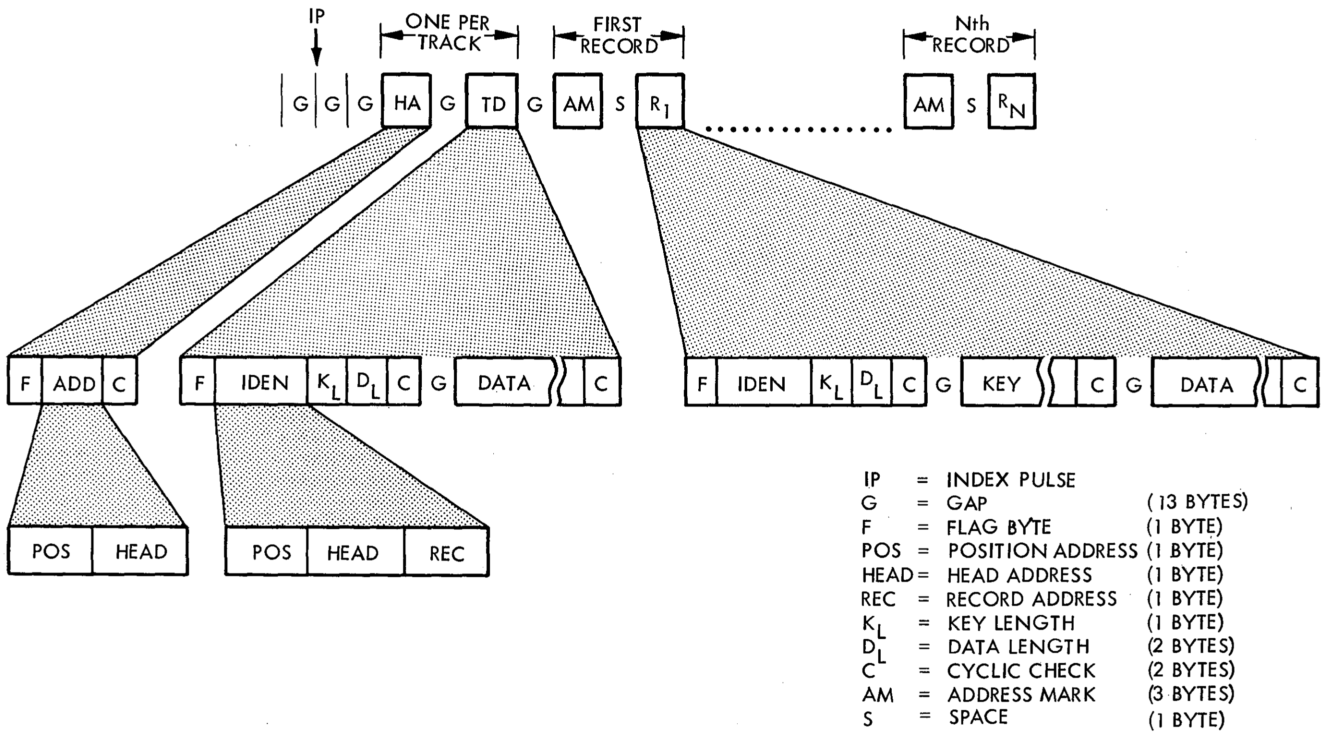

FIGURE IX TYPICAL VARIABLE LENGTH RECORD FORMAT

Figure IX illustrates a typical format for variable length records. The illustrated format includes all groups of control information normally required on the track. The number of information groups used and the length of each group is dependent upon the particular application.

The track contains three general types of information referred to as the home address (HA), track descriptor (TD) record, and the variable length records (R_1 through R_N). Contained in each variable length record are an address mark, a header, a key area (optional), and a data area. The header contains the address and other pertinent information about the record. The key area, an optional data area, may be used to identify the content of the data record. This provides for content search within a file of data.

Gaps are required between groups on the track to accommodate the read/write-to-erase gap distance, to provide for data synchronization, and to allow for displacement between the read/write head and INDEX mark. The gap width required in the 5045-360 is equal to 13 bytes. However, this may be altered to the length used in the DATASTAK in order to increase compatibility with that system.

A single home address and a single track descriptor record is written at the beginning of each track. The number of variable length records written is determined by the data processor. The following format description utilizes the 8-bit byte as the basic data unit.

the home address

The home address defines the location of the track and is written two gap widths after the INDEX pulse (IP). The home address contains a flag byte, a position and track address and two check bytes.

The flag byte indicates the integrity of the track recording area and the home address identifies the position and track. The check bytes are an arithmetic function of the preceding information in the home address and are used for data checking.

the track descriptor record

The track descriptor record is used to specify an alternate track in the event that the associated track is defective. Since it always follows the home address, the track descriptor record is not preceded by an address mark.

The track descriptor record consists of a header and data area and has a format similar to the variable length records. (Variable length records may also contain a key area, but this is normally not included in the track descriptor record.) The similar format results in logic simplicity when buffering and processing the records.

The length of the data portion of the record is dependent upon the amount of information required to specify an alternate address.

the variable length record

The variable length record contains a header area, key area (if desired) and a data area. The header begins with a flag byte which is identical to the flag byte in the home address. The identifier portion specifies the position, track and record number. The key length and data length areas specify the number of bytes in the key and data portions of the record. The header area is appended by two check bytes.

The variable length key and data areas are each preceded by the appropriate gap to allow for reading or writing either area independent of the other. Cyclic check bytes are appended to each area for checking when reading.

fixed length record option

The capability of writing fixed length records is inherent in the mechanization of the variable length record formatting. However, the user may prefer that the record length be controlled within the file system, thereby eliminating some formatting logic in the controller.

The fixed record length option is mechanized by supplying sector marks to the interface from an additional track on the control disc. The sector marks are equally spaced about the circumference of the track; the number of sector marks recorded is at the option of the customer and is dependent upon the desired record length.

When utilizing the sector marks, the data processor writes a header at the beginning of each sector. This header identifies the cylinder, track and record number. The headers are then used to locate the desired record for writing and reading data.

Each header and data record must be preceded by a gap to accommodate mechanical tolerances and by a synchronizing pattern to facilitate reading.

storage capacity

In the 5045-360 system, the control disc clock track fixes the maximum number of bytes which can be written on each inner zone track at 3889, and the maximum number of bytes for each outer zone track at twice that number, or 7778. Dividing each outer zone track into two separate tracks as described in the paragraph covering Track Organization, therefore, provides for 12 tracks per position, with each track containing 3889 bytes. However, the entire 3889 bytes are not directly addressable as data because of the format control information and the synchronizing and tolerance gaps which are associated with each record. To determine addressable storage capacity, it is necessary to consider the maximum bytes available per track, the length of the records to be stored, and the record format.

variable length record capacity

The variable length record track format illustrated in Figure IX specifies the type and length of control information on the track, and the number and length of gaps associated with that information.

The home address and the gaps required before and after the index pulse consume a total of 44 bytes. The track descriptor record and the gap preceding that record require a minimum of 22 bytes. The maximum available storage per track is therefore equal to 3823 bytes (3889 - 66).

Each record written on the track also requires space for synchronizing gaps, the header used to identify the record, and cyclic check bytes. This space totals 56 bytes, if a key area is contained in the record, or 41 bytes if the key area is not used. The total number of bytes in a variable length record may be expressed as follows:

$$41 + C + (KA + DA)$$

Where: KA = bytes in key area
DA = bytes in data area
$C = 15$ if $KA \neq 0$
$C = 0$ if $KA = 0$

When only a single record is written per track (following the track descriptor record) and $KA = 0$, the equation for maximum bytes in the data area is:

$$3823 = 41 + C + (KA + DA)$$
$$3782 = DA$$

When multiple equal-length records are written on a track, track storage capacity in terms of records is as follows:

$$N \text{ (records)} = \frac{3823}{41 + C + (KA + DA)}$$

Therefore, if $KA = 10$ and $DA = 200$, then

$$N = \frac{3823}{41 + 15 + 10 + 200}$$

$$N = 14$$

For a number of equal-length records (N) per track, maximum bytes (B_R) available for key and data areas in each record may be expressed as:

$$B_R = \frac{3823 - N(41 + C)}{N}$$

Table VI lists the number of records available using different sectoring arrangements and the corresponding capacities in terms of data bits. Table VII lists capacities in terms of 8-bit bytes utilizing the above formulas; i.e., the figures reflect actual data capacity excluding all control information, gaps and any required cyclic check information.

RECORDS PER	RECORDS PER TRACK			
	1	4	8	16
Position	12	48	96	192
Disc	768	3072	6144	12,288
DISCfILE	24,576	98,304	196,608	393,216
BITS PER				
Record	30,272	7334	3511	1599
Track	30,272	29,336	28,088	25,584
Position (10^3)	363.3	352.0	337.1	307.0
Disc (10^3)	23,249	22,530	21,572	19,649
DISCfILE (10^6)	744.0	721.0	690.3	628.8

TABLE VI CAPACITY IN RECORDS AND BITS

BYTES PER	RECORDS PER TRACK			
	1	4	8	16
Record	3782	914	436	197
Track	3782	3656	3488	3152
Position	45,384	43,872	41,856	37,824
Disc (10^3)	2905	2808	2679	2421
DISCfILE (10^6)	92.9	89.8	85.7	77.5

TABLE VII CAPACITY IN 8-BIT BYTES

Table VIII lists capacities in terms of four-bit decimal digits. This table is computed on the same basis as Table VIII with two packed-decimal digits per byte. Table IX lists capacities in terms of six-bit alphanumeric characters. These figures include one parity bit for every four characters.

DECIMAL DIGITS PER	RECORDS PER TRACK			
	1	4	8	16
Record	7564	1829	873	395
Track	7564	7316	6984	6320
Position	90,768	87,792	83,808	75,840
Disc (10^3)	5809	5619	5364	4854
DISCfILE (10^6)	185.9	179.8	171.6	155.3

TABLE VIII CAPACITY IN 4-BIT DECIMAL DIGITS

ALPHANUMERIC CHARACTERS PER	RECORDS PER TRACK			
	1	4	8	16
Record	4843	1173	561	256
Track	4843	4692	4488	4096
Position	58,116	56,304	53,856	49,152
Disc (10^3)	3719	3603	3447	3146
DISCfILE (10^6)	119.0	115.3	110.3	100.7

TABLE IX CAPACITY IN 6-BIT ALPHANUMERIC CHARACTERS

fixed length record capacity

Just as with the variable record length format, addressable storage capacity, when using the optional fixed sectoring, is dependent upon the address bytes and check bytes recorded on each track, and the required tolerance gaps.

A gap of four bytes is required between the end of a record and the following sector mark, and a gap of 17 bytes is required between the sector mark and the beginning of the address header. These gaps allow for mechanical tolerances between the sector marks recorded on the control disc and the read/write heads on the positioner arm, and for the spacing between the read/write and erase gaps on each head.

The address header and associated cyclic check bytes total 6 bytes, and a gap of 13 bytes is required between the end of header and beginning of data. Thus, there are a total of 40 address and control bytes required in each sector. Assuming the same track arrangement (12 equal-length tracks per position) discussed under variable length record capacity, storage capacity for each track is determined as follows:

B_T (bytes/track) = 3889 - 40N

Where N = number of records per track

model 5045-326

The Model 5045-326 utilizes the same pulse-type interface and is compatible with the 5022, 5024 and 5026 DISCfILE Systems. This version allows the user to incorporate the larger capacity module into data processing systems utilizing existing hardware and software.

record format

In the 326 configuration, the number of records per track is at the option of the customer. Usually, each record is allocated to a sector. The physical length of a sector in each zone varies with the radius of the track. Data storage is the same for all tracks in a given zone since only the innermost track is written at the maximum density.

A control track contains sector marks which indicate where each sector ends and another sector begins. These are used to reference the timing and control of reading and writing. Table X summarizes the capacity in terms of records for typical sector formats. The table is referenced to a track pair which is the total number of sectors in one outer zone track and one inner zone track. The system can be supplied with any sector configuration resulting in a track pair of 48 or less. This results in records of 1616 bits or over, which encompass the record lengths required by current data processing applications.

RECORDS PER	SECTORS PER TRACK PAIR			
	12	24	25	48
Inner Track	4	8	9	16
Outer Track	8	16	16	32
Position	48	96	100	192
Disc	3072	6144	6,400	12,288
DISCfILE	98,304	196,608	204,800	393,216

TABLE X STORAGE CAPACITY IN TERMS OF RECORDS

Each sector contains a header followed by a record. There are gaps before the header and between the header and the record to accommodate mechanical tolerances, including the physical displacement between the erase and read/write gaps.

The header is preceded by a synchronizing pattern which is used by the logic to identify the beginning of the header. The header is written off-line from the logic unit test panel or may be written remotely from the computer. It identifies the disc, position and record fields of each sector. The operate-next-sector and parity fields are not used in the header. These fields are ZERO bits in the header. These bits ensure that the header and the input address are of the same length when compared. The header is followed by a gap and then a second synchronizing pattern which is written in front of the record.

The header of a particular sector is always written in the header space of the preceding sector. The computer is thereby warned one sector ahead that the desired record is approaching. After the correct track is confirmed, the desired record must be validated before reading or writing. Record validation is performed by comparing each header from the confirmed track with the stored address. When a match is found, the desired address is incremented by one and another match must take place with the header of the desired sector. This double check contributes significantly to the reliable writing characteristics of the system.

effects of sectoring

Since the header in each sector occupies space on the track, the amount of data which can be stored on a track is reduced as the number of sectors per track is increased. If a large number of sectors are used, the storage capacity may be reduced unreasonably. If few sectors are used, it places demands upon the internal storage of the computer because the records are long. It also reduces computation speeds because latency is involved in finding the item of data within the track. Between 12 and 48 sectors per track-pair are a reasonable compromise between speed and capacity requirements.

address organization

The address is transferred to the logic unit in the order shown in Figure X, with the least significant bit (LSB) first. The parity field is used by the system to check

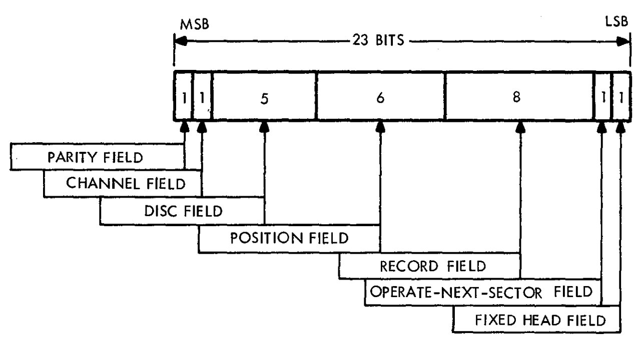

FIGURE X THE ADDRESS FIELDS

that the address is properly transferred.

The channel field is used to select one of two channels (A or B). The disc field is then used to select one of a maximum of 32 discs available to the channel. The position and record fields define the desired position, track and record for a movable positioner.

The operate-next-sector field is used to command the system to use only those address bits which define the desired track. The system then operates in the initial sector available after the track is confirmed.

The fixed head field, when required, instructs the channel to select one of the fixed head tracks for reading or writing. When a fixed head is addressed, the position field is used to select a track and the record field defines the desired sector.

capacity

The specific capacities for the 326 vary somewhat from those for the 360 variable record length system. This is due to the difference in the number of bits required for header information and gaps when using fixed sectors.

Tables XI, XII and XIII summarize capacities for various sectoring in terms of data bits, characters and bytes, respectively. Tables XII and XIII include adequate allowance for required parity checking.

BITS PER	SECTORS PER TRACK PAIR			
	12	24	25	48
Record	7450	3570	3300	1616
Track pair	89,400	85,680	82,500	77,568
Position (thousands)	358	343	330	310
Disc (thousands)	22,886	21,934	21,120	19,857
DISCfILE (10^6)	732.4	701.9	675.8	635.4

TABLE XI STORAGE CAPACITY IN TERMS OF BITS OF DATA

ALPHANUMERIC CHARACTERS PER	SECTORS PER TRACK PAIR			
	12	24	25	48
Record	1192	571	528	256
Position	56,736	54,816	52,800	49,152
DISCfILE (millions)	117.2	112.6	108.1	100.7
4 BIT DECIMAL CHARACTER PER				
Record	1858	889	821	400
Position	89,184	85,344	82,100	76,800
DISCfILE (millions)	182.6	174.8	168.1	157.3

TABLE XII STORAGE CAPACITY IN TERMS OF CHARACTERS

BYTES PER	SECTORS PER TRACK PAIR			
	12	24	25	48
Record	929	444	410	200
Track Pair	11,172	10,656	10,250	9,600
Position	44,688	42,624	41,000	38,400
Disc (10^3)	2,860	2,728	2,624	2,458
DISCfILE (10^6)	91.5	87.3	84.0	78,5

TABLE XIII STORAGE CAPACITY IN TERMS OF BYTES

system interface

The system interface is illustrated in Figure XI. It will be noted that the interface contains all the signal functions used in the 5022, 5024 and 5026 systems. Many of the functions indicated in Figure XI are not used in the 5022 Model. These functions are primarily used to implement the multiple-seek function and can therefore be ignored. The following discussion assumes that the programmer is utilizing all available signal functions.

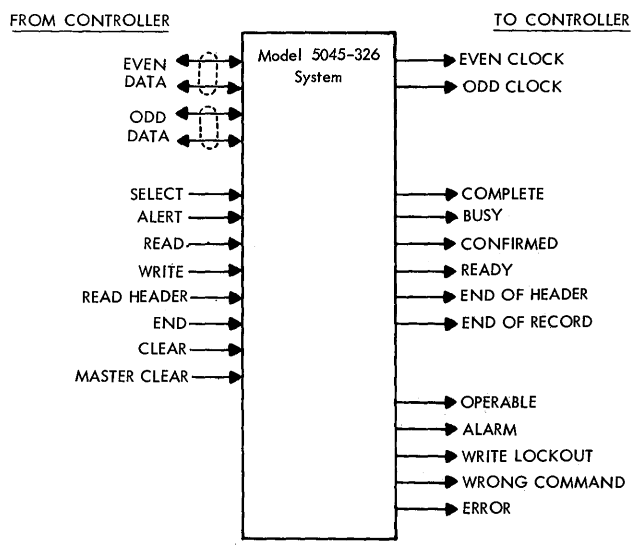

FIGURE XI MODEL 5045-326 INTERFACE

Command and data signals are transmitted over 22 lines of twisted-pair wires. There are three additional twisted-pair lines for relay control signals. All lines, with the exception of the relay signals, employ pulse communication at both input and output.

Write and read data are transmitted over two complementary pairs of data lines. The two pairs are used to reduce transmission frequencies. Each odd bit (first, third, etc.) is transferred over the odd data pair while each even bit (second, fourth, etc.) is transferred over the even data pair. Each pair comprises two lines; one for data ONES and one for data ZEROS. When the computer commands a read header operation, the system presents the next address header over the data lines.

The input address is transferred to the system over the even pair of lines. The address is followed by the ADDRESS TERMINATION bit which is transmitted over the ODD DATA ONE line. The address may be transmitted at any frequency between 100 cps and 750 kc.

Two clock lines (odd and even) are associated with the data lines. These lines are pulsed alternately to indicate when even and odd bits of data must be supplied by the data processor. The functions of the remaining signals are summarized below:

input signals

SELECT

Connects system to data processor for addressing
Clears all error indications

ADDRESS TERMINATION

Initiates seek in selected seek channel
Disconnects system from data processor

ALERT

Reconnects system to data processor for reading or writing

READ HEADER

Commands system to read the next address header

READ

Commands system to read a record

WRITE

Commands system to write a record

END

Terminates read, write or read header operation
Disconnects system from data processor

CLEAR

Removes power from positioner

MASTER CLEAR

Removes power from previously selected head positioner, clears all logic and clears error indicators

output signals

OPERABLE

Indicates that all interlocks are set and the equipment is operational

BUSY

Indicates addressed disc is one of group controlled by other channel

COMPLETE

Indicates system has accepted a new address

CONFIRMED

Indicates that addressed channel has settled on track

READY

Indicates addressed channel is prepared to be alerted for a read or write operation

END OF HEADER

When reading headers, indicates that last header bit is transferred
When reading or writing data, provides time reference for beginning of reading or writing

END OF RECORD

Indicates that the last data bit is being read or written

WRITE LOCKOUT WARNING

Indicates that a locked-out disc is selected

ERROR

Indicates that data or sequence error has been detected

WRONG COMMAND

Indicates an illegal SELECT pulse or an attempt to write on a locked-out disc

ALARM

Indicates that an environmental alarm condition exists

interface characteristics

Communication between the controller and logic unit is by means of 0.5 microsecond pulses. The peak amplitude of the pulse should not rise above 7 volts while the lowest point of the pulse "shoulder" should not fall below 4 volts. The controller must respond to a write clock with a write data bit between 0 and 0.5 microsecond, trailing edge to trailing edge, as measured at the logic unit interface.

interface philosophy

The DISCfILE is similar to direct-access storage devices in that the storage locations are identified and accessed by means of addresses. It differs in that the access time can vary from microseconds to a few hundred milliseconds. As a result, the command "seek" or "go to address" is separated from the command READ or WRITE.

In the 326, seek is never issued as a command but is inherent in a new address. Since the operation can be lengthy, the system is always disconnected from the data processor while seeking takes place. It is important for the data processor to know just how far the seek operation has progressed.

Initially, the logic unit must switch to the proper seek channel, if necessary, and transfer the address to the disc unit. When this is done, the logic unit generates COMPLETE. This signal is especially significant in multiple-seek operation, since the data processor may now begin to seek in another seek channel.

A signal is required to indicate that the seek channel is prepared to receive an operate command. This is performed by READY. In addition, a signal is required to indicate that the data processor is prepared to issue an operate command. This is performed by ALERT.

Latency is involved when the data processor seeks a specific record on a track. Latency can be avoided by using the operate-next-sector mode. The file will then emit READY as soon as the selected track is confirmed. This mode is useful when searching for, or transferring whole tracks or groups of tracks.

READ HEADER is useful in conjunction with the operate-next-sector mode since the data processor receives the address of the first header to appear on the confirmed track. This may be used by the data processor to determine which core location to store the data when reading or to withdraw the data when writing. The READ HEADER command is also useful when the data processor wishes to remain connected to the file while maintaining the original address in the logic unit.

the signal sequence

The normal signal sequence for accessing a single record is shown in Figure XII. A SELECT signal is sent to the system followed by the address transmitted on the even data wires. After transmission of the address information, an ADDRESS TERMINATION pulse is sent. This pulse disconnects the data processor from the system. The complete address is stored in the logic unit where it is checked for parity and correct length.

When the new address has been accepted by the selected seek channel, a COMPLETE signal is transmitted. If the new address does not involve a change in disc or position, the CONFIRMED signal is emitted with COMPLETE. When a change in disc and/or position is requested, the seek channel must direct the selected positioner to the addressed position.

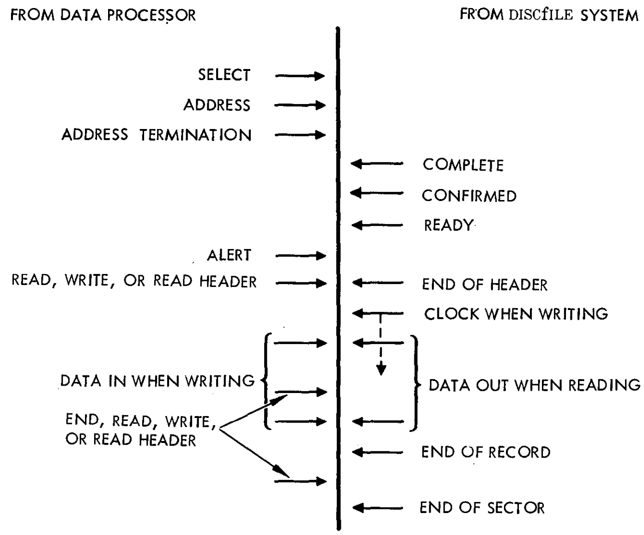

FIGURE XII THE NORMAL SIGNAL SEQUENCE

The CONFIRMED pulse is then generated after the positioner has settled. Settling is ensured when the address stored in the logic unit agrees with a predetermined number of headers read from the selected track. The READY signal, which is emitted one sector time before the specified record, defines the end of the seek operation.

When the data processor has received a READY, it may emit an ALERT followed by a READ HEADER, READ, or WRITE command. When READ HEADER is sent, the system forwards the address header from the next sector to the data processor. The last header bit will be indicated by END OF HEADER. If the command is READ, record data from the next sector is emitted on the data lines. If the command is WRITE, the system waits until the area reserved for data is located under the head. Clock pulses are then emitted and these are gated back to the data channel as ONES or ZEROS over the appropriate line, supplying one bit of data for each clock pulse.

The last bit of each record is indicated by the END OF RECORD pulse, unless record transfer is interrupted by a new command. Transfer of data either into or out of the system is terminated by sending an END signal. The END signal or a new operate command may be sent any time during the record or during a guard slot provided after END OF RECORD. The END OF RECORD signal must be responded to by either an END, READ HEADER, READ or WRITE.

The system is commanded to continue reading or writing by sending a new READ or WRITE command. The file will then perform the appropriate read or write operation in the next sector. This process may be continued if desired until all data on all tracks of the selected position has been transferred.

Read-after-write checks can be performed by emitting the proper END followed by a SELECT and the initial address. The data processor may them command a READ in response to the READY that will occur in the sector preceding the one just written. The data processor may also check write data by using READ HEADER and operate-next-sector. The READ HEADER command, emitted in each sector, places the file in the continue mode and headers are continuously read from the track. The operate-next-sector mode allows the data processor to perform record validation using the header information. The computer can then emit a READ in the sector preceding the desired one.

states of the system

The 5045-326 logic unit is always in one of four logical states. As shown in Figure XIII, these are the quiescent state, the address state, the seek state and the action state.

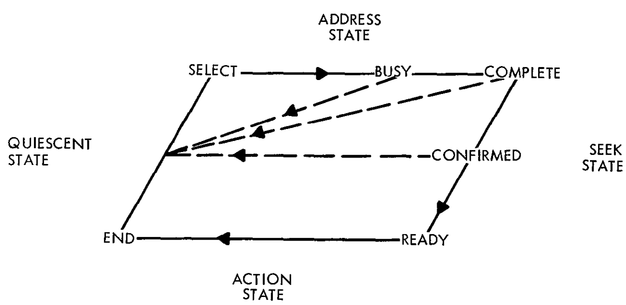

FIGURE XIII STATES OF THE SYSTEM

When the system is not accepting an address, seeking a track, or operating on a command, it is in the quiescent state. In this state the system is disconnected from the data processor.

A SELECT signal connects the system to the data processor and initiates the address state. During this state, the address is transferred to and accepted by a seek channel. The duration of the address state is dependent upon the extent of switching required to access the addressed disc. The address state may be interrupted by BUSY, but is normally terminated by COMPLETE.

COMPLETE initiates the seek state. The duration of the seek state is dependent upon the positioning time, if any, required to access a track. The seek state may be interrupted by a new SELECT command from the data processor. This is the procedure when utilizing multiple seek. The seek state terminates after the track is confirmed and a READY is emitted.

The READY signal sets the system into the action-state during which all reading and writing of data occurs. The duration of the action state depends upon the interval before the data processor decides to initiate action and upon the number of sectors which are read from or written into. The action state is terminated by END.

logic/disc unit interface

The response by the system to computer commands is dependent upon the current state of the system. The state of the system also determines the current status of the Logic/Disc Unit interface. The mechanization of the Logic/Disc Unit interface is of particular importance for multiple-seek applications. The relationship between the status of the data processor interface and the disc unit interface is illustrated in Figure XIV. The shaded portions indicate when the corresponding interface is connected to the logic unit.

The data processor is connected to the logic unit by SELECT and disconnected by ADDRESS TERMINATION. The data processor is then free to perform other routines while the system processes and seeks the address. This is the normal procedure in single seek channel systems such as the 5022.

During the address state, the logic unit switches to the addressed seek channel. Only after the seek channel is selected and supplied with an address, can it be disconnected. This is why no commands are accepted by the system between SELECT and COMPLETE.

COMPLETE indicates that power is applied to the positioner and that it is moving toward the addressed track. In an operation using one seek channel, the logic unit will remain connected and will ensure the settling of the positioner by performing track confirmation. However, with multiple-seek, the logic unit is instructed to disconnect from the seek channel and initiate an operation in a second seek channel. This may be done after COMPLETE.

Though the logic unit is relieved of the motion time required to reach a track during multiple-seek, it must be reconnected with the seek channel to confirm. This is accomplished by the data processor issuing a SELECT with the original address. The logic unit will then confirm the addressed track, locate the correct sector, and issue READY. When all desired data is transferred from that position, the data processor may proceed to the other seek channel.

the address state

A timing diagram for the address state is shown in Figure XV. Approximately ten microseconds after emitting SELECT, the data processor begins to transfer the address, bit serially, to the logic unit. When the operate-next sector mode is desired, that field in the address should be a ONE. The ADDRESS TERMINATION should follow the last bit of the address within 20 microseconds.

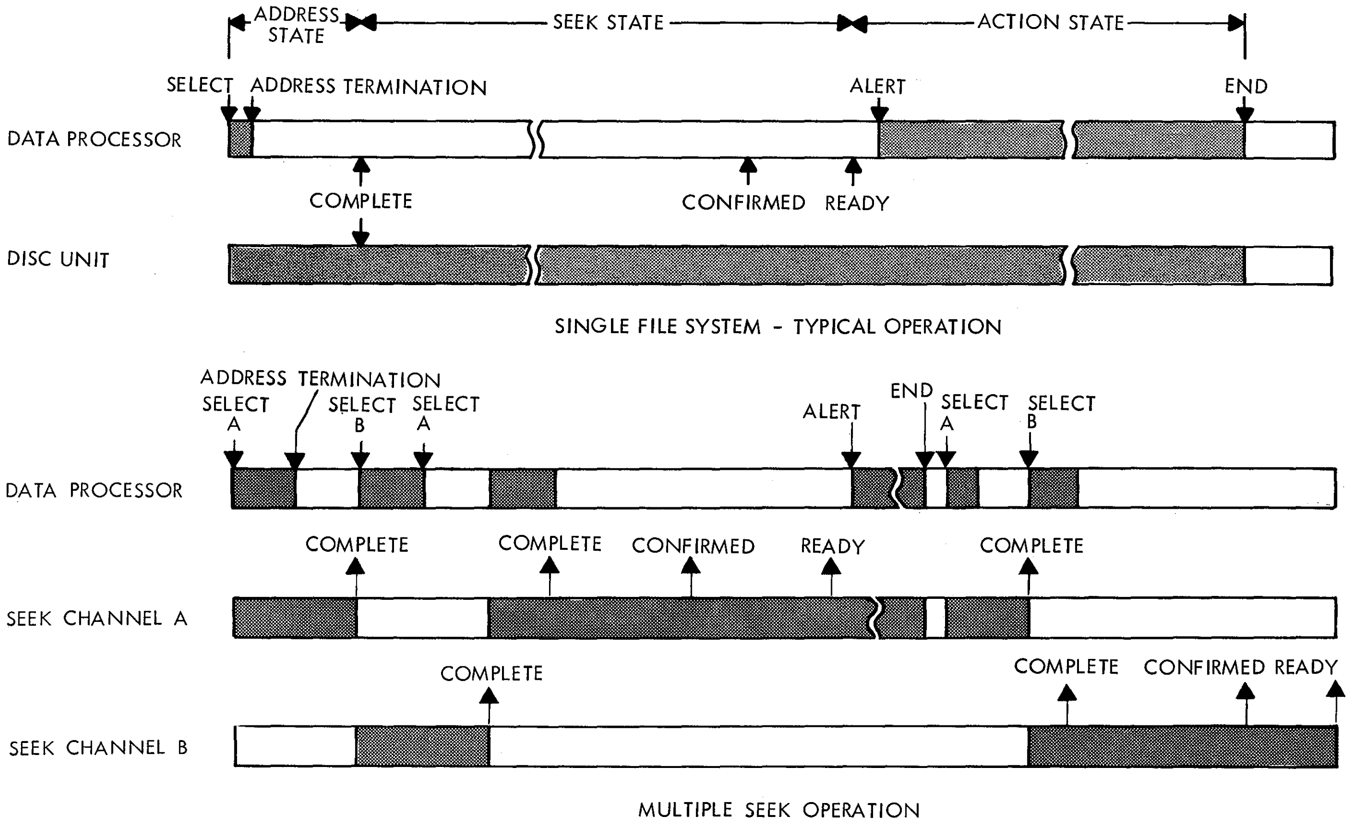

FIGURE XIV SINGLE AND MULTIPLE SEEK OPERATION

When the new address requests a position which is already selected, the COMPLETE signal will be emitted within 5 microseconds after ADDRESS TERMINATION. If, on the other hand, a disc and/or position change is requested, there will be a delay of 10 milliseconds nominal before COMPLETE. The delay is the time required to remove power from a positioner. Five additional milliseconds are required to switch between seek channels, if required.

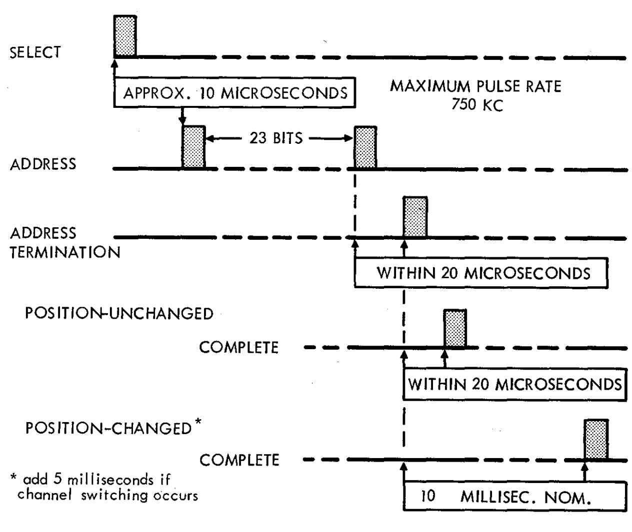

FIGURE XV ADDRESS STATE TIMING DIAGRAM

When the data processor attempts to select a disc that is being operated upon by the other seek channel, a BUSY is generated. The data processor may then wait for the busy disc to be released, in which case COMPLETE is returned immediately after release. Alternatively, the data processor may decide to select another disc.

When addressing fixed heads, the COMPLETE signal will be developed within 5 microseconds after ADDRESS TERMINATION.

the seek state

A timing diagram for the seek state is shown in Figure XVI. This state is initiated with COMPLETE. The COMPLETE signal informs the data processor that the selected seek channel has accepted the address and that it may proceed to select the other seek channel.

The interval between COMPLETE and CONFIRMED is the time required for the positioner to reach and settle down to the addressed position. Once settling is ensured by the confirmation procedure, the positioner is CONFIRMED and remains so unless it is cleared. The positioner can only be cleared by addressing a new disc and/or position in the same seek channel or by issuing a clear pulse.

When the new address selects a position currently in the confirmed state, CONFIRMED is issued with COMPLETE. When a disc and/or position change occurs, motion and confirmation times are required to locate the new position.

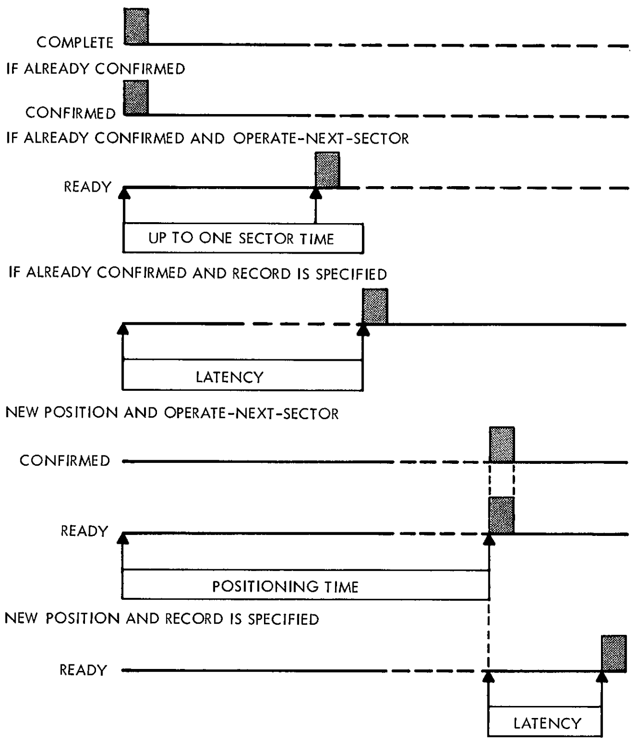

FIGURE XVI SEEK STATE TIMING DIAGRAM

The concurrence or non-concurrence of CONFIRMED and COMPLETE are useful to the programmer. By testing for CONFIRMED at this time, he may determine whether he can begin to operate in the selected track or whether he should perform other routines while any required positioning is accomplished.

When the data processor returns to a seek channel, for which a seek has been initiated, it must address the same disc and position. The system will then perform track confirmation and issue the CONFIRMED signal. The data processor may not change the disc and/or position address between COMPLETE and CONFIRMED. Any attempt to do so results in WRONG COMMAND.

When the operate-next-sector mode is used, the READY signal is emitted concurrently with or up to one sector time after CONFIRMED; otherwise READY is emitted up to one disc revolution time (dependent upon the latency delay) after CONFIRMED.

the action state

A timing diagram of the action state is shown in Figure XVII. The READY pulse initiates the state, and the END pulse terminates it. READY is emitted in the sector immediately preceding the sector in which reading or writing will be performed. When the data processor desires to operate in the next sector, it must respond to READY with ALERT followed by one of the operate commands (i.e., READ HEADER, READ or WRITE).

When the data processor does not respond with ALERT and the system is not in the operate-next-sector mode, READY is generated once each disc revolution. When in the operate-next-sector mode, READY is generated once each sector time until ALERT arrives.

A new SELECT will be accepted any time during the action state before ALERT. Once ALERT is received, no further READY signals will be generated and no SELECT will be permitted until the operation is terminated by END.

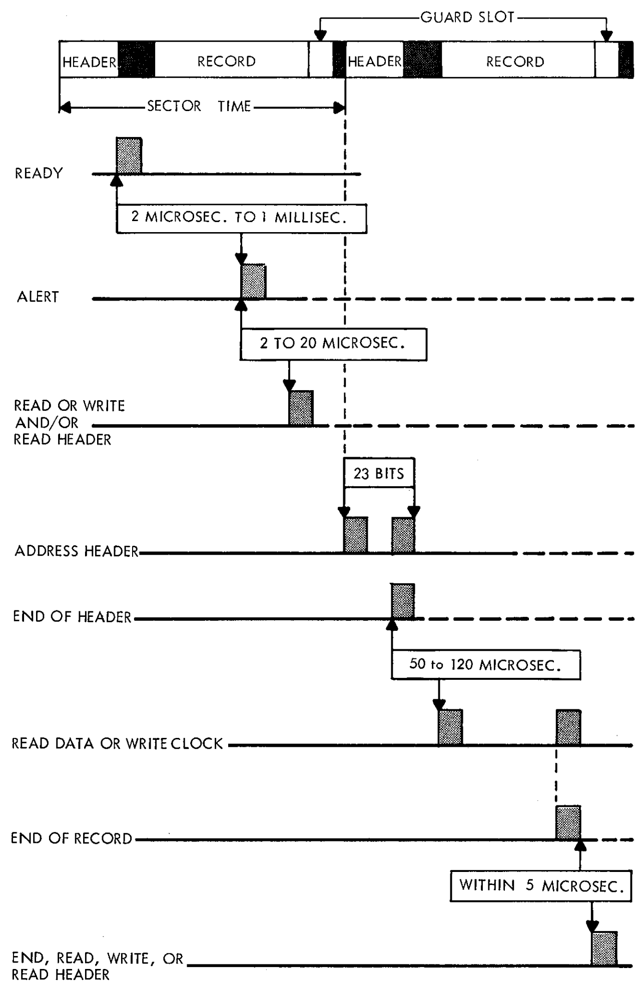

FIGURE XVII ACTION STATE TIMING DIAGRAM

Any one of the READ HEADER, READ or WRITE commands may follow ALERT. In addition, READ HEADER may be combined with either READ or WRITE. It is not permissible to command both a READ and a WRITE operation for the same sector.

When a READ HEADER pulse is sent to the system, the next address header appearing under the head is transmitted to the data processor over the data lines. The system will emit an END OF HEADER pulse, informing the data processor that the last header bit has been transferred. When writing is commanded, the system begins emitting clock pulses when the record portion of the sector is located under the head. Each clock pulse issued must be responded to by the data processor transmitting one bit of data. When reading is commanded, the system transmits record data to the data processor.

The reading or writing action may be ended any time during the record by sending an END signal or a new operate command. The system emits an END OF RECORD pulse only when the data processor reads or writes a complete record. An END OF RECORD pulse must be responded to by an END, READ HEADER, READ or WRITE.

A combination of the operate-next-sector and the continue mode is useful when transferring a block of data between the system and the data processor. The READ HEADER command may then be used to determine which sector the first record will be written or read. The address headers may be used to identify which core location will be used to store or supply the first record.

reading and writing

Reading can begin only when the system is in the action state. A READ signal is transmitted from the data processor to the logic unit in the sector time preceding the sector in which reading is to take place. The read operation is cleared at the end of the record. Another READ must be transmitted if it is desired to read in the following sector.

When the data processor has received all the data it requires, further data signals may be disregarded; however, it cannot end the flow of data until it sends an END signal or a new operate command. The END signal terminates the reading action completely. The file can then be reconnected only by a new SELECT followed by an address.

The WRITE signal is transmitted under the same conditions as a READ signal. The clock pulses are transmitted to the data processor to indicate when data bits are to be written. One bit of data should be supplied to the system for every clock pulse. These clock pulses will continue until the end of the record unless the data processor sends an END signal or a new operate command. Each clock pulse must be responded to with a data bit. When the data processor writes a short record, the system automatically pads the remainder of the record with ZEROS.

dual confirmation option

At customer option, the confirmation logic may be incorporated into each of the two channels in the drive unit. This results in no changes in the interface. The dual-confirmation capability simply relieves the logic unit from performing the confirmation procedure. This effectively eliminates confirmation time from access time considerations when multiple-seeking within most files of data. The 326 configuration can then exhibit average access times equivalent to those experienced in the dual-channel configuration.

error detection

The system continually monitors the input address and the interface command sequence. Each input address is checked for parity and length. The interface sequence is checked to ensure that no signals are accepted that might cause invalid conditions.

The following design features contribute to the low error characteristics of the system:

- Where possible, operations have been designed to be fail safe.
- The system transmits signals to the data processor only when the system state makes it valid for the data processor to respond to the signals.
- If a signal is received from the data processor during a wrong state, or at a wrong time during the state, it is blocked from entering the system.
- Stringent checks are made within the unit and the data processor is notified if any invalid condition is detected.

address checks

A check is made to determine that the correct number of address bits have been transmitted and that address parity is correct.

If, for any reason, it is not possible to select and settle on the correct track during a seek, the READY pulse will not be emitted. After the seek-state has existed for 400 milliseconds, an ERROR pulse is emitted. In addition, if the selected record cannot be located within 120 milliseconds after the track is confirmed, an ERROR pulse is emitted.

interface command checks

The system checks to ensure that an END or operate command is received during or just after a record is read or written. The absence of a proper signal results in an ERROR pulse.

In addition, a WRONG COMMAND pulse is emitted whenever a SELECT signal arrives at an improper time or when writing is attempted on a locked-out disc. This function is particularly useful when testing and debugging a program.

maintenance

Switches and indicators are provided in the logic unit to simulate logic sequences and to observe the results thereof. Switches in the disc unit allow the operator to sequence up the unit manually. The operation of any test switch in the logic unit or disc unit terminates the OPERABLE signal. Any data currently written on the discs is thoroughly protected during test.

model 5045-325

The Model 5045-325 provides a compatible, very large capacity storage module, which may be incorporated into those data processing systems currently utilizing 5025 modules.

The 325 version is designed to use the same record format and has the same capacity as the 536 configuration described in the preceding section. When using a 5045-325, data formatting is under control of the data processor. The record length is at the option of the user and is determined by the number of sector marks contained on the permanently recorded control track.

system interface

The disc unit interface is illustrated in Figure XVIII. One set of the signals in the figure are required for each channel. Most data and control signals are the direct result of input signals. This relationship is indicated by the broken lines in Figure XVIII.

The DISC AND POSITION ADDRESS BUSES are logic levels used to select the desired disc and position.

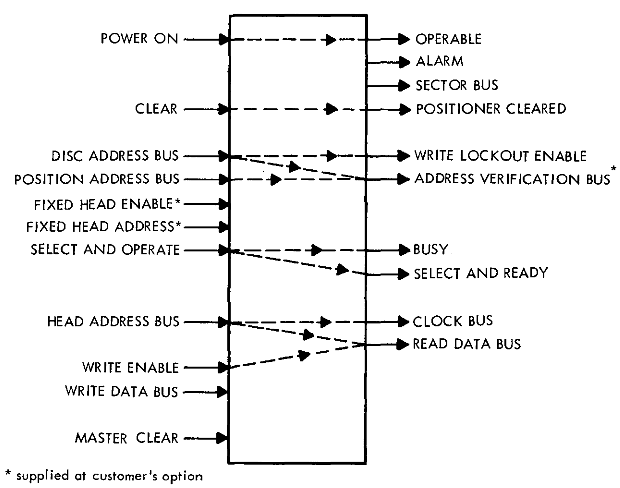

FIGURE XVIII THE DISC UNIT INTERFACE

The disc address is sent over five twisted pairs while the position address is sent over six twisted pairs. These levels are representative of the binary coded address information stored in the controller and will be decoded in the file. The HEAD ADDRESS BUS contains eight lines, one of which is enabled to select the desired head.

The ADDRESS VERIFICATION BUS, when used, comprises eleven twisted pairs. This bus supplies logic levels which are representative of the disc and position addresses currently stored by the channel.

When using fixed heads, four additional address inputs and one additional enable are required. The FIXED HEAD ENABLE instructs the associated channel to use the proper input lines to select a fixed head. The four FIXED HEAD ADDRESS bits are used to select one of twelve sets of fixed heads. The HEAD ADDRESS BUS is then used to select one of the eight fixed heads within the set.

The SECTOR BUS transfers coded characters derived from the sector control track which indicate the start of the track and the beginning of each sector within the track. The CLOCK BUS forwards the basic timing information from the file control track to the controller. The clock information consists of two lines; each line containing a continuous train of pulses 180° out of phase with the other. The frequency of the pulses is dependent upon the head and, in turn, the zone currently selected.

The WRITE DATA BUS and READ DATA BUS each contain two lines. One line is pulsed for a ONE and the other line is pulsed for a ZERO. The WRITE DATA is in response to the pulses on the CLOCK BUS. The functions of the remaining control and status signals are summarized below.

input signals

POWER ON

Instructs the file to sequence up to an operational state.

CLEAR

Removes power from positioner.

SELECT AND OPERATE

Instructs the channel to store a new address and seek the corresponding disc and position.

WRITE ENABLE

When active, commands channel to write data.
When inactive, allows channel to read data or headers.

MASTER CLEAR

Removes power from positioner and clears all logic.

output signals

OPERABLE

Indicates that the file is sequenced up and operational.

ALARM

Indicates that an environmental alarm condition exists.

WRITE LOCKOUT ENABLE

Indicates that controller channel is addressing a locked-out disc.

BUSY

Indicates that controller channel is addressing a busy disc.

SELECT AND READY

Indicates that power is applied to addressed positioner.

signal characteristics

Logic levels and pulses are referenced to 100 feet of coaxial cable properly terminated into 75 ohms. All pulses are 0.3 microsecond, ±20% at the 50% amplitude point, with rise and fall times 0.1 microsecond maximum between the 10% and 90% points. When writing, the controller must respond to each clock pulse within 0.4 to 1.0 microsecond as measured at the system interface.

signal sequence

An operation is initiated by the controller sending a SELECT AND OPERATE with a new DISC AND POSITION ADDRESS. The controller may initially instruct the file to CLEAR. This signal is useful when the controller channel knows that a change in disc and/or position is imminent, and desires to operate on another file while positioner power is being removed. The controller may then return to the cleared channel, saving the power off time.

Should the addressed disc be controlled by the other channel, the file notifies the controller with BUSY. The controller may then proceed to a different disc or may simply wait for the busy disc to be released.

When the new address is stored and power is applied to the selected positioner, the file generates SELECT AND READY. The controller may now start the track confirmation sequence.

The controller enables one of the eight heads on the selected positioner by supplying an active level on one of the HEAD ADDRESS BUS lines. This head enable, besides defining the desired track, also indicates the zone in which the operation will occur. As long as the WRITE ENABLE remains inactive, the head enable allows the channel to begin reading. The CLOCK BUS responds with timing pulses of the proper frequency. The file then proceeds to process headers from the selected track while the controller utilizes the SECTOR and CLOCK BUSES to locate the headers.

The controller must count a number of clocks after the sector mark to locate the approximate area in which the header is written. The controller must then search for the preamble of three ZEROS and the sync bit ONE which precedes each header.

The file will process data under the head as long as a head is enabled. When the track confirmation and track verification procedures are performed, the controller may proceed to read or write a record or group of records.

When a read operation is desired, the controller simply maintains the active level on the HEAD ADDRESS BUS line. The SECTOR and CLOCK BUSES are then used to locate and process the desired record. When the controller desires to write, it must first locate the area reserved for the record. This is done by counting a specified number of clocks after the final header bit. The controller then presents the WRITE ENABLE and the file will write the data received over the WRITE DATA BUS.

At customer option, the controller may be supplied with "echo check" data. When writing, the file will automatically return each write data bit over the READ DATA BUS. These bits may be used by the controller for checking.

general characteristics

data storage technique

The basic techniques used in storing and transferring data in the 5045 DISCfILE system are field-proven in over 160 DISCfILE installations throughout the world. Improvements in the discs, flying heads and electronics have made possible a significant increase in recorded bit density, while maintaining the same low error rates exhibited by other systems in the DISCfILE series.

the discs

The discs used for data storage are 31 inches in diameter and are composed of a non-inflammable magnesium alloy. The high internal loss characteristic of this material damps out vibration and reduces resonance effects.

Disc surfaces are precision-ground and lapped to a surface accuracy of a few millionths of an inch. The surfaces are then coated with a thin precisely controlled layer of a finely divided high-coercivity ferrite powder. This material is bonded together and to the disc surface with a tough thermo-setting plastic and machined to a fine surface finish. After finishing, each disc is separately inspected and tested to ensure that it contains no areas which might lead to bad spots in service.

the flying heads

The flying heads used in the system are housed in head pads and mounted on the positioner arm. A simplified diagram of a head pad is illustrated in Figure XIX. The

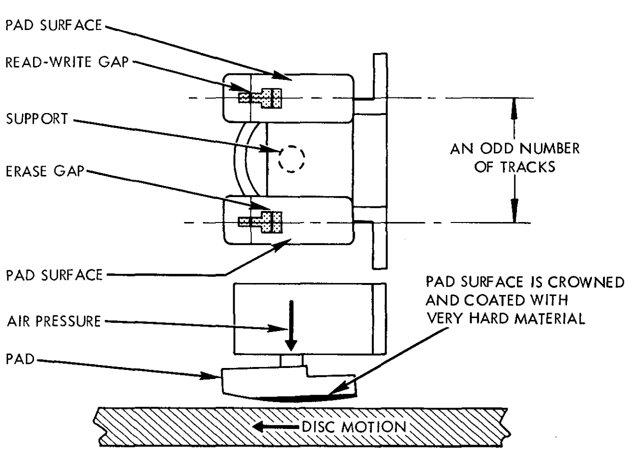

FIGURE XIX VIEWS OF PAD STRUCTURE

head pad consists of two "flying" surfaces joined together by a light but rigid bridge. Each surface contains a read/write gap and an erase gap, with the erase gap made somewhat wider than the read/write gap to allow for complete erasure before writing. Data is recorded at a nominal density of 1000 bits per inch.

The head pads "fly" on a self-generated slider air bearing which is created by forcing the head against the thin resilient layer of air which rotates with the disc. Compressed air is used to provide a constant force on the head, and a light spring retracts the heads when air pressure is removed.

the digital positioner

Figure XX is a simplified diagram of the digital positioner. The positioner moves the access arm rapidly

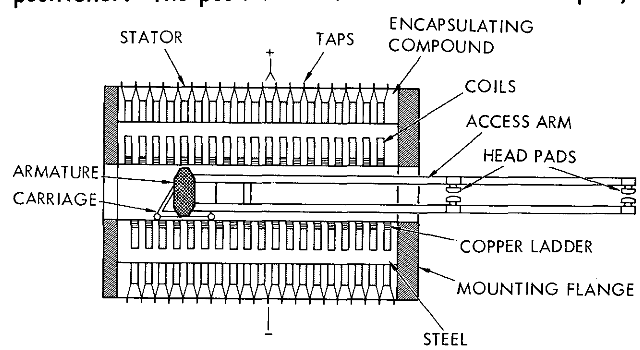

FIGURE XX THE DIGITAL POSITIONER

and precisely, with minimum acceleration and deceleration, along a radius of the disc. Its principal components are two steel stator assemblies, and a permanent magnet armature mounted on a carriage running on rails between the stators. A forked arm which carries the head pads is attached to the armature carriage.

Wound on the stator assemblies is a continuous coil of fine wire. There are 64 sets of taps along the coil which are brought out to external connections on the stator assemblies. To position the armature a strong d.c. current is passed through the coil from one of the sets of taps. The resultant magnetic field forces the armature to the position determined by the selected taps. A copper ladder interacts with the field of the armature permanent magnet to produce a simple form of viscous damping. This limits oscillations about the selected position.

the electronics

Each disc unit contains the required electronics to write and read data and to respond to data processor commands. The electronic circuits are mounted on compact printed circuit boards and all solid state elements are silicon. The majority of the circuits utilize integrated components. The proprietary read/write circuits are not yet available in the integrated form.

Each board incorporates a "ground plane" which mates with redundant ground plane shielding in the mounting module. This arrangement results in virtually complete freedom from radiation interference problems. All critical circuit test points are conveniently accessible by means of lugs located at the front of the board. Each circuit board measures 3-7/8 inches by 2-3/8 inches and mounts to the module by means of a 45 pin connector.

The low level amplifier stages are predominantly differential pair amplifiers with heavy feedback which provides very high common mode noise rejection. The logic circuits provide high-speed current steering. The typical board contains four flip-flops or seven NOR gates.

lockout switches

A set of 32 switches is provided in each disc unit for the write lockout function. Operation of these switches prevents erasure or writing on any one or combination of discs.

When the fixed head option is desired, an additional switch is provided for locking out the disc accessed by the fixed heads.

This write lockout feature is of particular importance in maintaining file security. Critical data may be stored on a disc and may not be inadvertently erased or altered.

system physical description

The Model 5045 DISCfILE system, in its 360 and 325 configurations is contained in a single module referred to as a disc unit. In the 5045-326 configuration, a control module called a logic unit is added to the system. Both units are constructed on simple steel frames and all external panels are either hinged or removable. Incorporated into the construction is a minimum of anodized aluminum trim. Other relevant physical characteristics of the units are listed below.

Disc Unit

Weight	3450 lbs (1565 kg)
Height	70 in. (178 cm)
Depth	36-1/2 in. (92 cm)
Width	68-1/8 in. (173 cm)

Logic Unit

Weight	440 lbs (200 kg)
Height	63-3/8 in. (161 cm)
Depth	35-1/4 in. (90 cm)
Width	18-1/4 in. (46 cm)

Approximately 30 in. (76 cm) clearance should be provided above and on all sides of the system for maintenance access. Power and signal wiring enter the units from below; sufficient clearance is provided at the base for surface floor wiring. Blowers included in the disc unit draw cooling air in through a 5-micron filter system at the top of the unit and exhaust it at the bottom.

The compressed air required for the flying heads may be supplied from a compressor included with the system or from the facility compressed air supply. The compressor is mounted externally to the disc unit and includes the required power cable and hose. When the facility air supply is used, 10 micron filtered dry air at between 40 and 180 psi and 12 cfm must be provided.

power requirements

The 5045 DISCfILE system requires 6.5 kw, 3-phase power. When the system includes a logic unit, an additional 750 watts is required. A system may be supplied to operate from any one of 208, 384, or 415 volts ± 10%, and from either 50 ± 1 or 60 ± 1 cps line frequency.

The DISCfILE should be operated in an air temperature of between 60°F and 85°F (15°C and 30°C) and a relative humidity of 20% to 80%. The equipment should be installed and operated in the moderately clean environment normally associated with electronic data processing operations. During storage or shipment the unit should be sealed to prevent excessive penetration of dust, dirt or moisture. The unit may be shipped or stored at any temperature between -20°F and 150°F (-30°C and 65°C).

reliability

Quality control is of major importance in the manufacture of disc memories. Long-term reliability and extremely low error rates are assured by rigid inspection and control of all materials, components and processes at every stage of manufacture. All the critical parts of the system are manufactured and tested in ultra-clean rooms. Each part is inspected and tested by sensitive and precise optical and electrical devices.

Each major assembly is thoroughly tested when integrated with the system. The system then undergoes a lengthy reliability test before shipment. Field computation conditions are simulated by randomizing data patterns and addresses. During this test about 200 billion bits are transferred and each positioner is moved about 40,000 times. Normally, less than 20 recoverable errors occur.

The equipment should exhibit error rates for lower than those specified in the reliability check, provided that proper scheduled maintenance is performed. The system should operate for at least three years before major overhaul is required.

maintenance

The system is designed to be easily maintained by operating personnel. Access to the file is convenient and little obstruction is encountered in reaching any internal part. Modules are hinged when necessary. No mechanical adjustments are required and the few electronic adjustments need to be checked only about every three months.

Recommended scheduled maintenance for each Disc Unit is one hour per week, plus two hours for each one hundred operating hours. Unscheduled maintenance is unlikely to exceed an average of two hours per month.

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