GENERAL INFORMATION MANUAL
dp/f-5022
DISCfILE™ STORAGE SYSTEM

data products corporation

GIM 501

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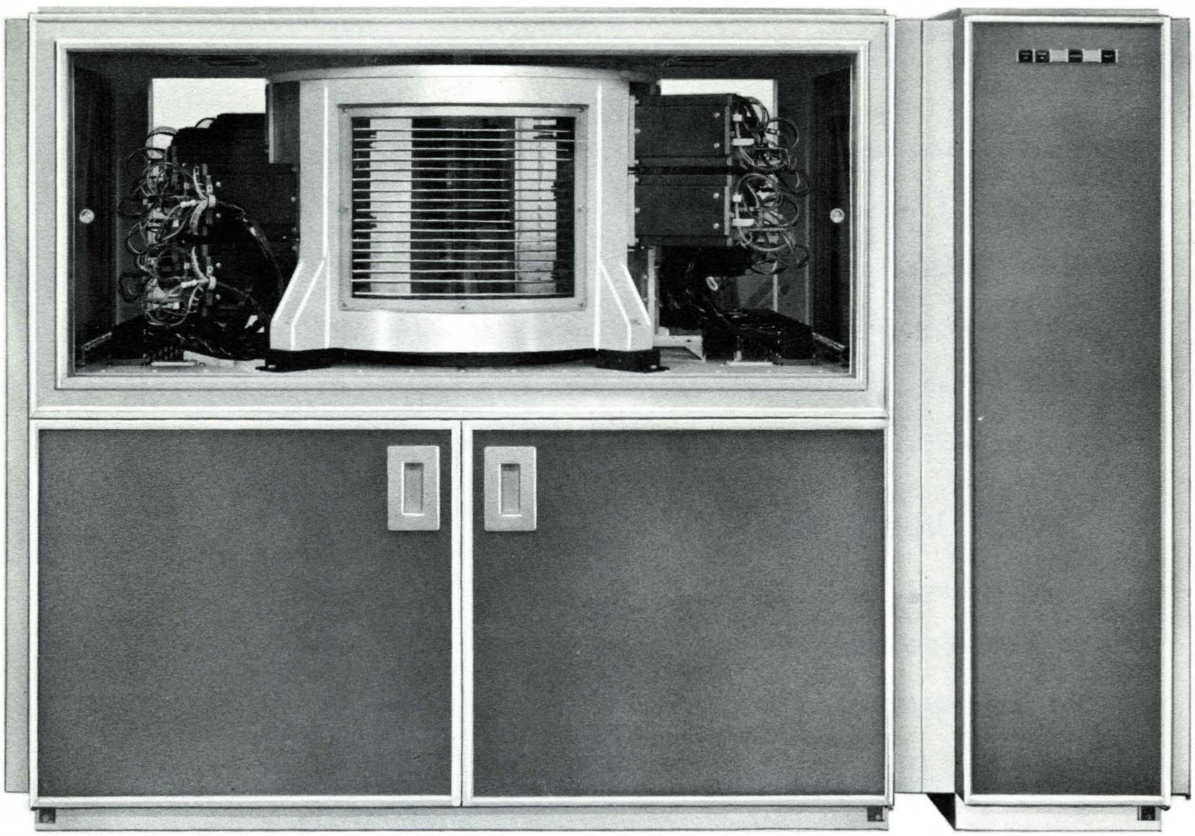
contents



dp/f-5022 DISCfILE System consisting of a DISCfILE Unit and Logic Unit

description

introduction

The dp/f-5022 DISCfILE storage system provides an economical and versatile form of random-access mass memory for use where large storage capacity and high transfer rates are desirable.

The capabilities of the system are such that they provide the principal storage for files, programs, subroutines, assembly and compiler routines, and a voluminous working storage area.

The dp/f-5022 system is logically similar to, and uses many of the same sub-assemblies as, the dp/f-5020, 5024, and 5025. The use of similar sub-assemblies ensures the same high reliability and low maintenance which has been proved in operational use of the DISCfILE systems.

summary of characteristics

A dp/f-5022 DISCfILE storage system comprises a logic unit and from one to four DISCfILE units. The storage capacity of a DISCfILE unit is a function of the format which is employed. If one of the more common formats is selected, the net useful storage capacity per unit is more than 200 million data bits, or up to 860 million data bits per system. The capacity per unit exceeds 32 million alphanumeric characters, or 50 million decimal digits.

Data is stored upon 16 oxide coated non-inflammable magnesium-alloy storage discs. The data is stored on 512 circular tracks on each disc, 256 on the top surface and another 256 on the bottom. These tracks are accessed by eight magnetic heads which are carried on a forked arm which is positioned rapidly and precisely by an independent magnetic digital positioner.

The use of the independent positioners provides significant advantages to the user. Computational speeds are increased and the system does not exhibit the restrictions imposed on programming by single access mechanisms.

The simplicity of the DISCfILE interface allows the system to be readily incorporated into a data processing system. This also allows the on line capacity to be easily extended beyond 860 million bits by using additional systems with one data processor.

significant advantages

- Rapid access to data
- High transfer rates
- High reliability
- Guaranteed freedom from bad spots
- Low cost of basic system
- Additional storage when needed can be added at low cost per bit
- Entire files and entire program libraries can be stored reliably and are readily accessible
- Supplements internal memory for large computations
- Simplifies multi-programming and program scheduling
- Write-lockout and write monitoring
- Low maintenance requirements
- Customer selection of record length
- Record identification addresses written off-line and completely protected from accidental erasure
- Continuous automatic checking of write data

the DISCfILE T.M.

Figure I illustrates the relationship between discs, heads and positioners. The discs are mounted on a vertical spindle and rotate within a cast metal shroud. Each disc

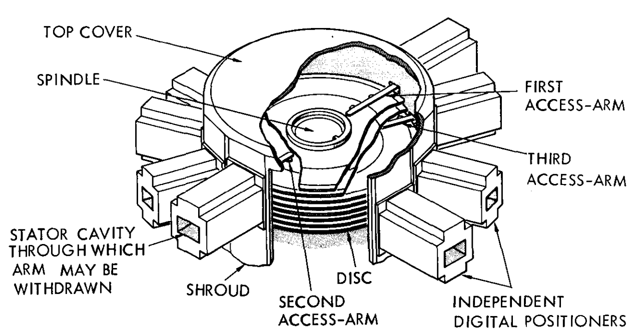


FIGURE I PICTORIAL VIEW OF SHROUD, DISCS, ARMS AND POSITIONERS

is accessed by eight heads housed in four head pads on a forked arm. These are moved by digital positioners which are bolted directly onto the shroud.

The arm and heads can be withdrawn through the positioner stator for maintenance and may be reinserted without adjustment since the precision is built into the stator which remains with the shroud. The shroud, arms and discs have the same temperature coefficient so that thermal changes do not affect the precision of the equipment.

The physical interface consists of fourteen twisted pairs that carry pulses, and three twisted pairs that carry relay signals. The same interface is used regardless of the size or capacity of the system.

It is possible to prevent erasure of data or writing on any selected disc by a Write-Lockout system. Sixteen switches, one for each disc, are housed inside a locked panel within each DISCfILE unit. When a switch is operated it prevents writing or erasure from taking place on the associated disc.

The write current flowing through the selected write head is examined, using an echo technique to ensure that current flows through the write head in the proper direction at writing time.

the discs

The discs, which are 31 inches in diameter, are precision ground and lapped to a surface finish of a few millionths of an inch. The material employed has a high internal loss characteristic which damps out vibration and reduces resonance effects.

The discs are coated with a thin but precisely controlled layer of magnetic material. This is machined to a fine surface finish after the coating is applied.

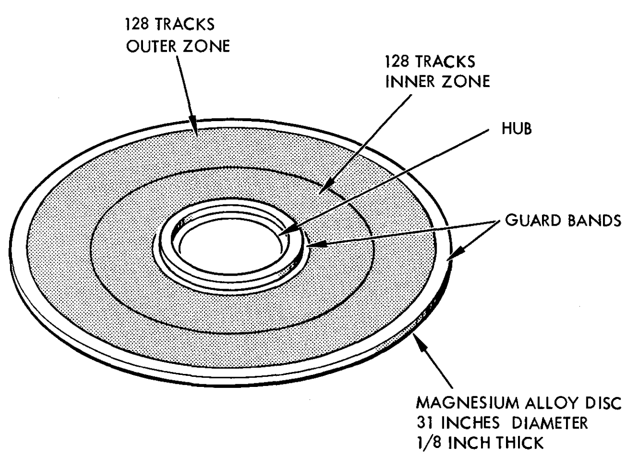


FIGURE II MAGNETICALLY COATED DISC

The magnetic material is a finely divided high-coercivity ferrite powder which is bonded together and to the disc by a tough thermosetting plastic. After finishing, each disc is inspected and tested to ensure that it contains no areas which could cause or might lead to "bad spots" in service.

A typical disc is illustrated in Figure II. The data is stored on each surface of the disc in two zones of 128 data tracks each. These tracks are spaced 0.037 inch apart center to center. The nominal recording density is 600 bits per inch, using a phase-modulated recording technique. The outer zone contains 34,840 bits while the inner zone contains 20,904 bits. The discs rotate at a nominal rate of 1200 rpm (1000 rpm for 50 cps machines).

the flying heads

A simplified diagram of the flying head pad is shown in Figure III . There are two "flying" surfaces joined together by a light but rigid bridge. Each surface contains an erase gap and a read/write gap. The erase gap erases a track width of 0.040 inch; the read/write gap writes a track width of 0.025 inch. The two gaps are separated by 0.062 inch. The difference in width between the erase track and the read/write track ensures that complete erasure is accomplished in the track area before writing. Each surface is crowned to a precision measured in millionths of an inch. To preserve this precision against service wear, the surface is coated with a layer of crystalline aluminum oxide, in the hard form of synthetic sapphire.

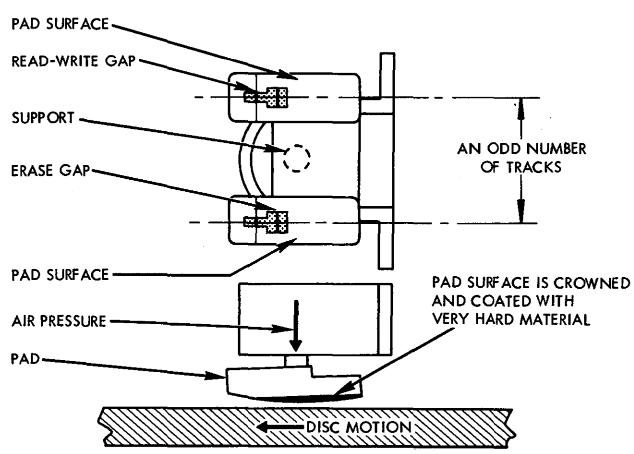


FIGURE III VIEWS OF PAD STRUCTURE

A "flying head" does not fly in the normal aerodynamic sense of that word. Correctly, it is a slider air-bearing which is held away from the disc by the thin but resilient boundary layer of air which rotates with the disc. This layer acts like a spring of stiffness exceeding 5,000 pounds per inch forcing the head away from the surface of the disc. Typical head pad characteristics are shown in Figure IV.

It is necessary to force the head against the air layer to produce an air-bearing effect. If a normal spring provided this force, then the force would change if the relative distance between the head supporting arm and the disc varied. In order to provide a constant force,

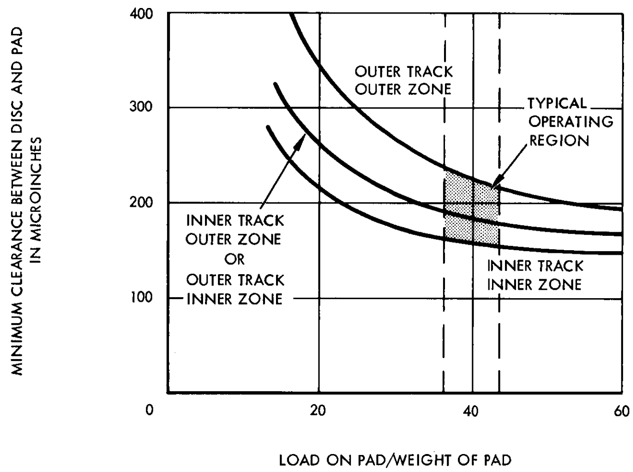


FIGURE IV THE CHARACTERISTICS OF THE HEAD PAD

compressed air and a "piston" are used instead of a spring. A light return spring retracts the heads when the air pressure is removed, and provides "fail-safe" characteristics should the air supply fail. This use of air pressure allows the relative distance between the arm supporting the head and the disc surface to vary by ±0.025 inch without affecting the clearance between the disc and the head pad.

the digital positioner

Figure V illustrates the principal parts in a digital positioner. The positioner must move the access arm rapidly, precisely, and with minimum acceleration and deceleration. It is a modern adaptation of an early type of d.c. motor, turned inside out, so that the armature becomes the stator, and is then cut and flattened into a linear form. The principal components are two wound steel stator assemblies, a permanent magnet armature mounted

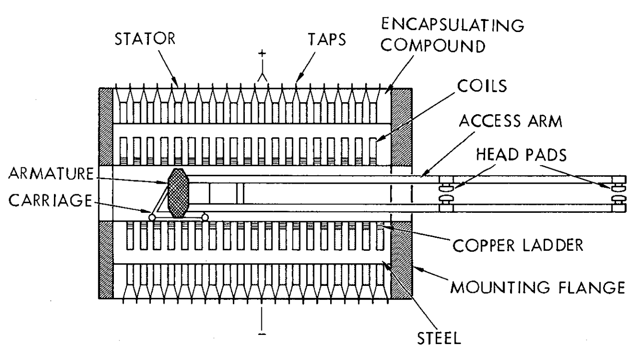


FIGURE V THE DIGITAL POSITIONER

on a carriage running on rails, and a forked arm, carrying the head pads, which is also attached to the carriage.

In order to position the armatures, taps are selected on the stator by means of reed relays. A static magnetic field is set up which causes the armature to move to the selected position. The configuration of the elements is such that no matter where the armature is initially, it is always forced towards the selected position and then held there by a strong magnetic field. Only one set of taps is selected for a given position, since the armature is repelled by all the unselected taps and attracted only by the selected taps.

Each of the selectable 64 positions is, in effect, a magnetic "notch". These magnetic "notches" cannot get dirty or become worn as would a mechanical detent. Moreover, the precision of location of the notches cannot change because this is set permanently during the manufacturing process. The notches, at their widest point, are only twenty thousandths of an inch, and the restoring force, within the notch, is equivalent to a spring of one hundred pounds per inch stiffness.

The digital positioner limits and controls the accelerations and oscillations which occur as the positioner reaches the desired position. This function is performed by the combination of the permanent-magnet armature and a copper damping ladder. This represents a simple and reliable form of viscous damping which produces a "soft" stop.

One of the most important features of the design is the manner in which the access arms and heads can be withdrawn through the stator. This simplifies maintenance and minimizes the possibility of damaging or misadjusting the equipment when the heads are removed for cleaning.

address organization

Data is written into or read from the file in records or groups of records. The required record is identified by specifying the physical position at which the record commences. This is known as the address.

The address structure is illustrated in Figure VI. The complete address is broken up into a number of fields. The disc field is used to select one of 64 discs. The first two digits select one of four disc units while the last four select a specific disc in that unit.

The group of tracks which can be accessed by switching between the heads on an arm are known as a "position". The position field selects one of 64 positions associated with the addressed positioner.

Each track is divided into a number of equal sectors (20 for the outer zone, and 12 for the inner zone). The record field specifies both the sector and track which is required within the position. A track pair of 32 sectors is the standard dp/f-5022 configuration. At the customers option* the system is also supplied with a track pair of 16 or 8.

*All options specified in this manual are available at a reasonable cost.

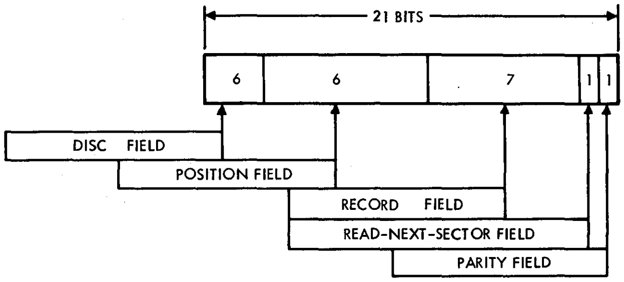


FIGURE VI THE ADDRESS FIELDS

Records commence at a predetermined position within the sector. No sector may contain more than one record, although a data record may occupy more than one sector.

The remaining bits within the address perform two special functions. The read-next-sector field is used to command the equipment to utilize only those bits in the record field which select a particular head and, thus, a particular track. Then, whichever sector is available first is selected. The parity field is used to check the transfer of the address from the computer.

To achieve the most efficient use of the DISCfILE, it is important to understand its structure. The relationship between tracks, heads, positions, positioners and disc units within a system is shown in Table I.

ELEMENTS	NUMBER OF ELEMENTS IN A			
	Position	Disc	DISCfILE	System
Tracks	8	512	8192	32,768
Heads	8	8	128	512
Positions	1	64	1024	4096
Positioners		1	16	64
DISCfILE			1	4

TABLE I Organization of System

When a new record is selected, the access time depends upon the location of the new record relative to the old. Switching between heads at any position is effectively instantaneous. If only the record field is changed there will be a latency delay unless the new record can be chosen to follow the old.

If the new address introduces a change to the disc and/or position fields, a positioning delay will occur. A disc and/or position field change also necessitates switching and confirmation procedures which introduce time delays.

factors affecting access-time

There is no single factor which defines the "speed" of a random-access mass-storage device. In some applications the latency and transfer rates dominate the situation. In others positioning-time is all important. Generally, the application must be analyzed to obtain an accurate estimate of the time that will be taken for an operation. Figure VII shows the normal definition of access-time.

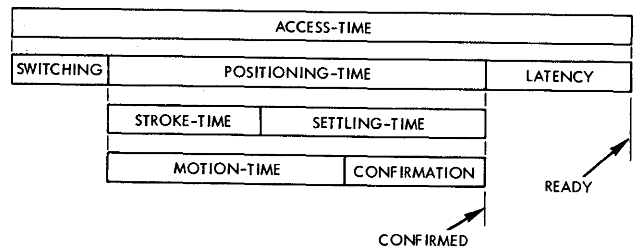


FIGURE VII COMPONENTS OF ACCESS TIME

latency

Table II shows the relationship between line frequency, transfer rate for the inner and outer zones, and average latency. The rotation speed is fixed by the choice of line frequency. The table also shows the nominal time interval occupied by each bit of information.

LINE FREQUENCY CPS	TRANSFER RATE (KILOBITS/SECOND)		BIT-TIME (MICROSECONDS)		AVERAGE LATENCY (MILLISECS.)
	Outer Zone	Inner Zone	Outer Zone	Inner Zone	
60	697	418	1.4	2.4	26
50	580	348	1.7	2.9	31

TABLE II Normal or average rates and times affected by line frequency

switching times

If a disc and/or position field is changed, the average switching time will be 26 milliseconds. During operation it will vary between 20 and 30 milliseconds. This switching time involves removing power from the previously addressed positioner and reapplying power for the new address. The switching time may be reduced significantly when the computer anticipates a change in disc and/or position. The computer may clear positioner power and accomplish other routines while the DISCfILE is powering off. The computer may then return to the file and select a new address. This reduces the switching time for the new address to seven milliseconds.

The head switching time (including read amplifier recovery time) is 100 microseconds. In practice, this time is unimportant because it is so much shorter than the various electromechanical times which occur. The reading amplifier recovery time after writing averages 75 microseconds.

The logic unit remains connected to the selected DISCfILE at all times. However, the logic unit is disconnected from the computer unless it is receiving an address or record data is being transferred.

positioning time

Figure VIII illustrates the positioning time for various motions. This includes the confirmation time, but not the initial switching delay.

Confirmation ensures that the head is accurately settled over the track before reading or writing can commence. The normal process of confirmation in the dp/f-5022 system is to read the address in each header on the selected track in turn. When each of the addresses has been read continuously without error for a nominal 39 milliseconds, confirmation is complete.

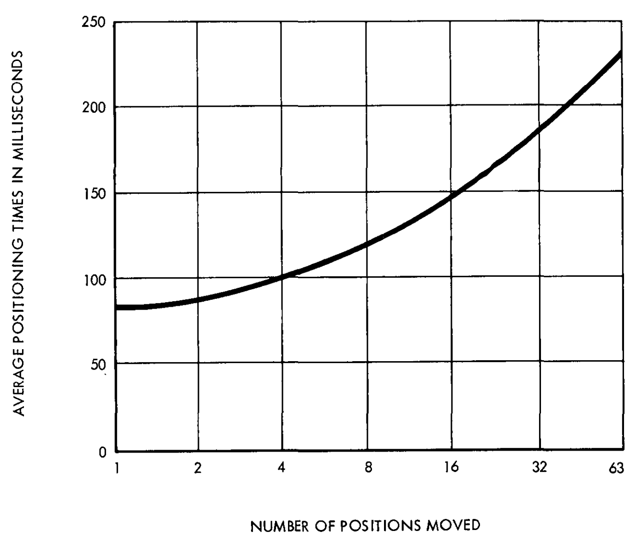


FIGURE VIII TYPICAL POSITIONING TIMES INCLUDING CONFIRMATION

Table III illustrates some typical average access times, including all possible delays. Further values may be computed by using Figure VIII and taking switching delays and latency into account.

NUMBER OF STEPS	60CPS	50CPS
One	135	140
Eight	170	175
Random-Average	205	210
Full-Stroke	285	290

TABLE III Typical access-times in milliseconds including all delays and latency

operating rate

Positioning and other times define the characteristics of the electromechanical components, but they do not define the operating rate of the complete storage unit. This is affected to a major extent by the logical organization of the system, and by the way in which the data is ordered and structured.

The operating rate of any electromechanical storage unit depends on how the data is accessed. In general, the highest rates are achieved when the data is accessed sequentially. The lowest normal rates occur when the access is totally random.

During actual computation the rate is somewhere between the highest and lowest values. This is because, while it is difficult to program for sequential access, the data is always ordered to some extent.

The user can influence the actual operating rate very considerably by the way in which he allocates and utilizes the storage volume. In the DISCfILE, substantial improvements can be achieved by this means without introducing the complexity of optimum, minimum-latency, or sequential-access programming.

file of data

In most applications the typical file of data occupies a small fraction of the total storage capacity of the DISCfILE. Even when an unusually large file is encountered, it is normally simple to divide it up into a number of relatively separable sub-files. Each small file or sub-file is assigned its own well defined region within the storage volume.

The random-access characteristics of modern mass-memories makes it possible to process several files at the same time. However, it is still a common practice to process one at a time. Under these circumstances access is confined to the selected region for long periods of time, and the operating rate can be increased by choosing a minimum access-time "shape" for the region.

In multifile processing, access is confined to a few selected regions, but these may be anywhere within the storage volume. In disc file systems which do not employ independent positioners, this can lead to frequent long-stroke motions and a serious reduction of operating rates.

The dp/f-5022 system uses independent positioners. In multifile 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 positioner is required to provide access to two or more files which may be processed at the same time.

If the above condition is met there are no long-stroke motions and the operating rate can be as high as if a single file only were processed. It is advisable, of course, to employ as nearly the optimum "shape" as is possible for each of the files.

the shape of a file

Approximately 32,000 alphanumeric characters can be stored in the eight tracks at each position. This is more than four thousand words in most computers. If access can be confined to a position, the average access-time is the latency of 26 milliseconds*.

There are sixteen positioners and access arms in each DISCfILE unit. If the new position had been previously selected so that no motion is required, the average access-time in switching from one positioner to any other is approximately 90 milliseconds. This includes 26 milliseconds latency. Consequently, at any time, there is a "cylinder" of more than 500,000 characters available with an average access-time of 90 milliseconds.

If a new access causes motion of a positioner, the access-time will depend on how far the selected positioner must move. Table III shows some typical access-times involving motion.

Table IV illustrates the random-average access-time within files of data of various sizes. In each case two very simple "shapes" have been chosen. The "shape" is defined by the number of positioners and the maximum number of steps or positions per positioner. The shape in the left hand columns is that normally used if only one file at a time is processed. The right hand columns illustrate a shape which is convenient for multifile processing.

APPROXIMATE SIZE OF FILE IN ALPHANUMERIC CHARACTERS	SHAPE OF FILE			
	16 POSITIONERS		4 POSITIONERS	
	Positions	Access-Time Millisecs.	Positions	Access-Time Millisecs.
500,000	1	90	4	125
1,000,000	2	115	8	135
2,000,000	4	125	16	148
4,000,000	8	135	32	160
8,000,000	16	148	64	205

TABLE IV Typical random-average access-times to data files of different sizes and shapes (including all delays and 60cps latency)

It should be noted that in all cases the times given are random-average access-times. If the access to the data within the file is ordered, times shorter than these will be experienced during actual computation.

*This time should be increased by 5 milliseconds for 50cps operation.

capacity and format

sectors

Data is written into or read from the DISCfILE as records. Usually each record is allocated to a sector. The physical length of the sector varies as the radius of the track, but the data storage is the same for all tracks, because only the innermost track is written at the maximum density.

A control track carries sector marks that indicate where a sector ends and another sector begins. These are used to time and control reading and writing. The control tracks are pre-recorded and three spare sets of tracks are provided. The standard format is a track pair of 32 (see Table V). At customer option, the system may also be supplied with track pairs of 16 or 8 sectors.

The 16 sectoring arrangement is shown in Figure IX. The outer zone tracks are divided into ten equal parts and the inner zone into six. This yields sixteen sectors per pair of tracks, or 64 sectors per position.

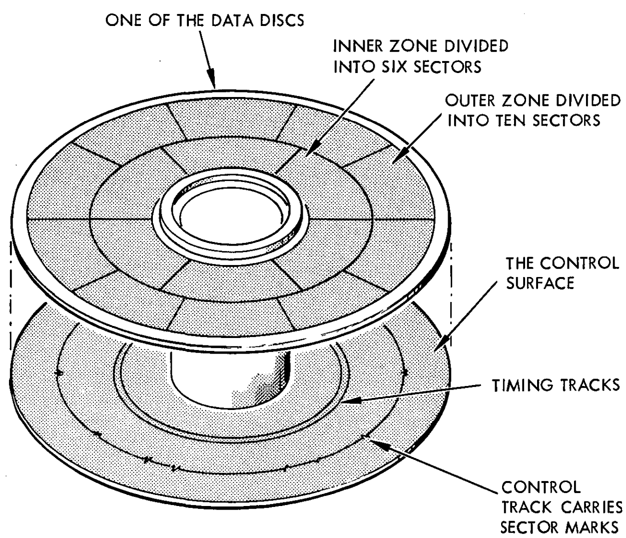


FIGURE IX SECTORING

Each sector contains a header as well as a record. In addition, there are gaps before the header, and between the header and the record to accommodate mechanical tolerances, including the physical difference between the erase gap and the read/write gap.

The header consists of a synchronizing pattern followed by 19 bits of header address. This address is written off-line from the test panel or may be written remotely by the computer. It identifies the disc, position and record fields of each sector. The header does not contain the two most significant bits of the disc field. These bits are used initially to select one of four disc units. In addition, the read-next-sector and parity fields are not used; these fields are written with ZERO bits in the header to accommodate the logic. The address is followed by a gap and then a second synchronizing pattern which is written in front of the record.

The address of a particular sector is written in the header of the previous sector. The computer is thereby warned one sector ahead that the desired record is approaching. This address is then checked with the desired sector 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 error-free characteristics of the DISCfILE.

the 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. The effect of this is illustrated in Figure X.

If a large number of sectors are used, the storage capacity may be reduced unreasonably. If there are few, it places demands upon the internal storage of the computer because the records are long. It also tends to reduce computation speeds because latency is involved in finding the beginning of the sector and then in finding the item of data within the sector. This is illustrated by the lower curve in Figure X. Usually either 16 or 32 sectors per track-pair are found to be a reasonable compromise between speed and capacity requirements.

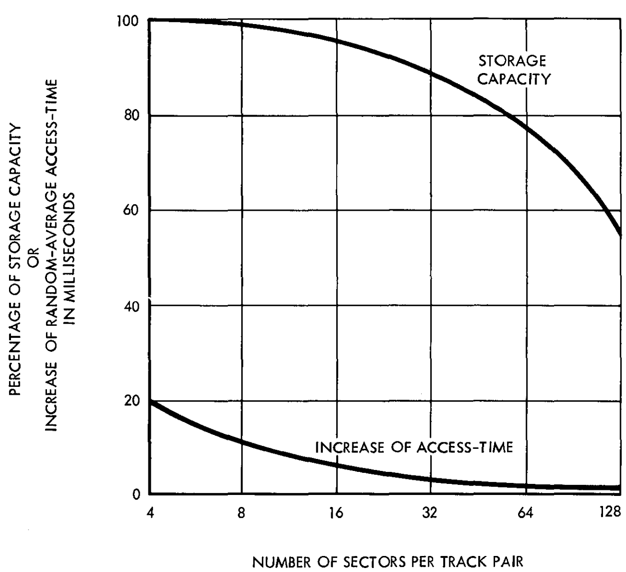


FIGURE X EFFECT OF SECTORING UPON STORAGE CAPACITY AND ACCESS TIME

storage capacity

The storage capacity in terms of records is shown in Table V and, as bits of stored data, in Table VI. The capacity in alphanumeric characters or decimal digits can be computed from these tables. It is a common practice to add a parity checking bit to each character or to each pair of decimal digits. However, the reliability of the DISCfILE makes this degree of redundancy unnecessary. A parity bit for every 20 to 30 data bits is sufficient.

RECORDS PER	SECTORS PER TRACK PAIR		
	8	16	32
Inner Track	3	6	12
Outer Track	5	10	20
Position	32	64	128
Disc	2048	4096	8192
DISCfILE	32,768	65,536	131,072
System(up to)	131,072	262,144	524,288

TABLE V Storage capacity in terms of records

BITS PER	SECTORS PER TRACK PAIR		
	8	16	32
Record	6774	3290	1548
Track Pair	54,192	52,640	49,536
Position (thousands)	217	211	198
Disc (thousands)	13,873	13,476	12,681
DISCfILE (thousands)	221,970	215,613	202,899
System (thousands) (up to)	887,881	862,453	811,597

TABLE VI Storage capacity in terms of bits of data

Table VII illustrates typical storage capacities in terms of characters and digits with allowance for parity checking.

ALPHANUMERIC CHARACTERS PER	SECTORS PER TRACK PAIR		
	8	16	32
Record	982	525	248
Position	34,624	33,600	31,744
DISCfILE (millions)	37.1	32.8	32.5
DECIMAL DIGITS PER			
Record	1692	787	372
Position	54,144	50,368	47,616
DISCfILE (millions)	55.4	51.6	48.8

TABLE VII Storage capacity in terms of alphanumeric characters and decimal digits (assuming one parity bit per 24 data bits)

system operation

This section deals primarily with the use of the dp/f-5022 DISCfILE system in data processing applications. The system is such that it can be installed and programmed initially in its simplest form, but can be expanded later to provide increased capacity.

system interface

The system interface is illustrated in Figure XI. All signal wires except relay lines between the logic unit and the data processor employ pulse communication via pulse transformers at both input and output. It has been found that this technique provides a convenient means of communicating with most computer interfaces. There are 14 pairs of pulse wires and three pairs of relay wires which connect the system to the data processor.

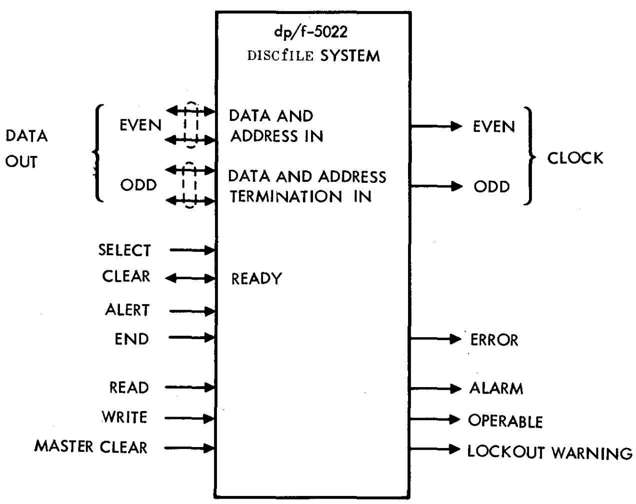


FIGURE XI THE SYSTEM INTERFACE

Record and address data are transmitted to and from the system on four pairs of wires. The pairs are used two at a time so that one pair is pulsed for a ONE and the other for a ZERO. Four pairs are used altogether so that alternative bits may be transmitted on different wires to reduce data transmission frequencies.

Associated with the data wires are two pairs of clock wires. These are pulsed alternately to indicate when even and odd bits of data are to be transmitted from the data processor to the DISCfILE. The functions of other signals are summarized on this page.

input signals

SELECT

Connects system to data processor
Clears all error indications

ADDRESS TERMINATION

Initiates seek
Disconnects system from data processor

ALERT

Reconnects system to data processor

END

Terminates command
Disconnects system from data processor

CLEAR

Removes power from positioner

READ

Commands file to read a record

WRITE

Commands file to write a record

MASTER CLEAR

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

output signals

READY

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

ERROR

Indicates that a data or sequence error has been detected

ALARM

An environmental alarm condition exists or the DISCfILE is in test mode

OPERABLE

Interlocks are set and the equipment is operational

LOCKOUT WARNING

Indicates that data processor has addressed a locked-out disc

the normal signal sequence

The normal signal sequence is illustrated in Figure XII. A SELECT signal is sent to the system and this is followed by the ADDRESS transmitted on the data wires. Next, an ADDRESS TERMINATION signal disconnects the system from the computer. The DISCfILE then starts to seek the addressed record.

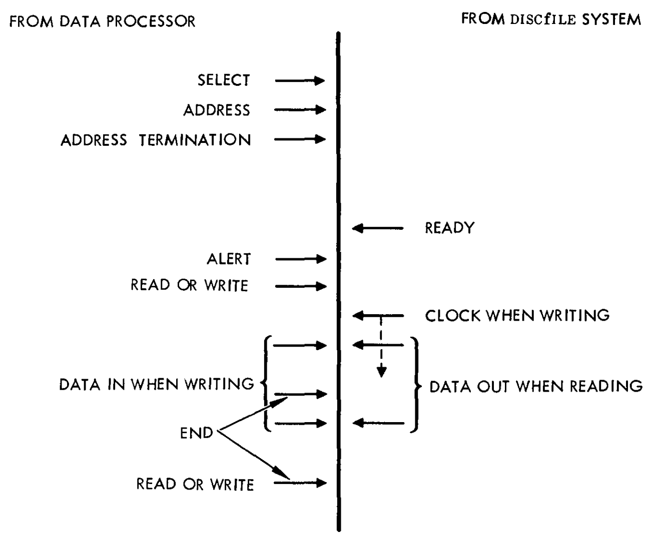


FIGURE XII THE NORMAL SIGNAL SEQUENCE

One sector time before the specified record, the READY signal is emitted. When the data processor desires to operate on the addressed record, it should emit an ALERT followed by either a READ or a WRITE command. If the command is to read, data is emitted on the data wires. If the command is to write, then clock pulses are emitted and the data processor must transmit one bit of data for each clock pulse.

Transfer of data either in or out of the DISCfILE can be terminated by sending an END signal. The equipment can be commanded to continue to read or to write by sending a READ signal after reading or a WRITE signal after writing. A READ signal sent after writing will cause the equipment to read from the addressed sector when it next appears under the heads. By this means, read-after-write checks can be performed. However, the presence of write echo minimizes this need.

the operations in the DISCfILE

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

In the dp/f-5022, seek is never issued as a command but is inherent in an address specifying a new storage location. Since the operation can be lengthy, the disc unit is always disconnected from the data processor during seek. For this reason a "reconnect" command is required. This is performed by ALERT.

The DISCfILE may also be "reconnected" during a seek operation by a new SELECT followed by a new address. This seek interrupt feature allows the data processor to "change its mind" anytime up to ALERT.

The selected record is read or written by sending READ or WRITE after the ALERT. A guard slot is provided at the end of each record during which the data processor must inform the DISCfILE whether it desires to terminate or to continue the operation. The operation can be continued into the next sector by sending another READ or WRITE. This process may be continued if desired until all the data in all the tracks of a position has been transferred. Switching from track to track within a position is automatic and essentially instantaneous. The operation is terminated by sending an END.

the states of the system

The logic unit and the selected DISCfILE unit are always in one of three logical states. These are illustrated in Figure XIII and are the address-state, the seek-state, and the action-state.

A SELECT connects the system to the data processor and initiates the address-state. During this state an address is transmitted to the logic unit. The address-state is terminated by ADDRESS TERMINATION.

The address-state is followed by the seek-state, during which a new record is sought. If the operation does not involve a position change, the seek-state exists for the latency time. If motion is required, then the duration of the state is increased by positioning time. The seek-state is terminated by READY.

The READY signal sets the system into the action-state. Most of the major operations occur while the unit is in this state.

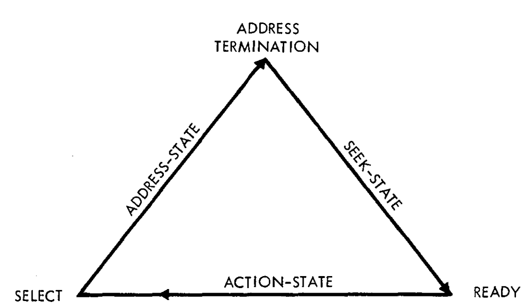


FIGURE XIII THE STATES OF THE SYSTEM

the address state

The timing diagram of the address-state is shown in Figure XIV. The state is initiated when the data processor sends SELECT to the system. Approximately ten microseconds later (no sooner than 5 microseconds), it should transmit the address serially to the system. The address can be transmitted at any frequency up to a maximum of 750,000 pulses per second.

The data processor commands the DISCfILE system to disconnect from it by sending an ADDRESS TERMINATION signal. If it is desired to command a read-next-sector mode, that field in the address should contain a ONE. In this mode, the DISCfILE will terminate the seek-state by emitting a READY pulse as soon as the addressed track is confirmed.

When a position change has been requested, the computer may "change its mind" and send a new address. The new address will be obeyed if SELECT, the new address, and ADDRESS TERMINATION are all received, in proper sequence.

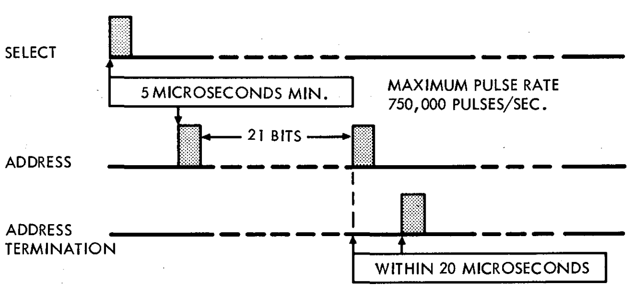


FIGURE XIV TIMING DIAGRAM OF ADDRESS-STATE

the seek state

When the address termination pulse is properly received, the DISCfILE enters the seek-state. The seek-state will be terminated by the emission of READY. The duration of the seek-state is primarily dependent upon whether or not the new address differs from the previous one, the distance the positioner must travel to reach the addressed position, and the state of the read-next-sector field.

The seek-state may be interrupted at any time by a new SELECT followed by an address and ADDRESS TERMINATION. The time required for the DISCfILE to reach the new address depends on whether the positioner is in motion when the SELECT is received. When the new SELECT arrives before the positioner is set in motion, the DISCfILE immediately starts to operate on the new address. If a SELECT is received after the positioner is set in motion, there is a delay before the new address is operated upon. This delay is dependent upon the time the DISCfILE has spent operating upon the old address but shall not exceed a nominal 250 milliseconds. This delay is required to ensure that power is not removed from the positioner while it is moving.

the action state

The timing diagram of the action-state is shown in Figure XV. The READY pulse initiates the state, and END terminates it.

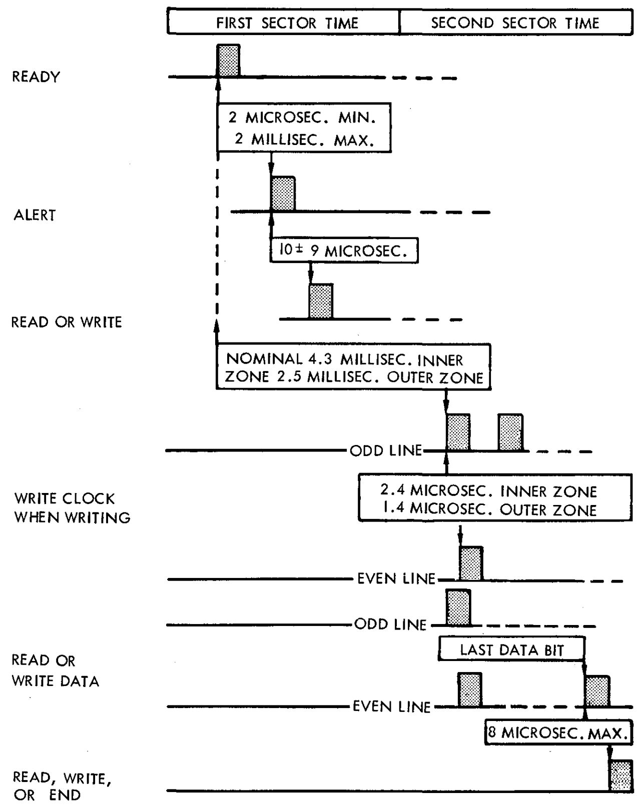


FIGURE XV ACTION-STATE TIMING DIAGRAM

When a READY is emitted, it must be followed by an ALERT in order to read or write. If an ALERT is not sent to the unit within the defined time limits, then one will not be accepted until one revolution later when the next READY is emitted. A READY is emitted at every sector in the read-next-sector mode. Table VIII lists sector times for various formats.

Once an ALERT has been accepted by the unit, no further READY signals are emitted. The ALERT must be followed by either a READ or WRITE pulse.

When writing is commanded, the file emits clock pulses, and each of these should be responded to by transmitting one bit of data back to the file. When reading is commanded, then record data is transmitted to the data processor.

LINE FREQUENCY AND ZONE	SECTORS PER TRACK PAIR		
	8	16	32
60CPS			
Outer Zone	10.4	5.2	2.6
Inner Zone	17.3	8.7	4.3
50CPS			
Outer Zone	12.6	6.2	3.1
Inner Zone	21.0	10.4	5.2

TABLE VIII Sector-times in milliseconds

The reading or writing action is terminated by sending an END pulse. The END pulse must be received not later than 8 microseconds after the end of the record. One bit of data may be read or one clock pulse may be transmitted from the file after an END pulse.

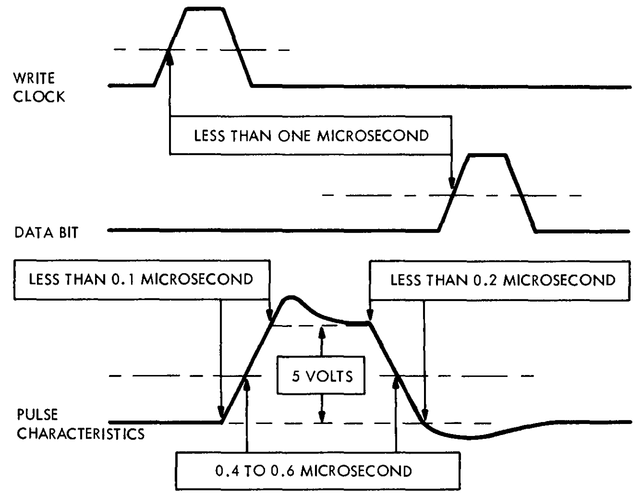


FIGURE XVI CLOCK AND DATA CHARACTERISTICS

reading and writing

Reading may be initiated only when the system is in the action-state. A READ signal is transmitted to the unit in the sector before which reading will take place. The READ condition is cleared at the end of the record, and another READ must be transmitted during the provided guard slot if it is desired to read in the next sector.

The data transmission is in the form of pulses on two sets of "twisted pair" data wires. Each set is pulsed alternately to transmit odd and even bits of data. One pair of each set is for a ONE, and the other pair for a ZERO, so that there is a pulse emitted for every storage bit position in the sector. When the computer has received sufficient data, it may disregard any further reading signals; however, it cannot properly terminate the flow of data unless it sends an END. This signal terminates the action completely. The file can be reconnected only by sending a new SELECT followed by an address.

The WRITE signal is transmitted under the same conditions as READ. The CLOCK is transmitted to the computer when writing should take place. The odd and even clock lines are pulsed alternately. One bit of data should be supplied over the corresponding pair for every clock pulse that is transmitted. The clock pulses will continue until the end of the record unless an END is sent to the system. If an END is not sent, each clock pulse must be responded to in order to fill the sector.

Figure XVI illustrates the maximum delay which is permitted between the transmission of a clock pulse from the DISCfILE system and the receipt of a data pulse at the system interface. This diagram also illustrates the general characteristics of the pulses which are employed. The peak amplitude of the pulse should not exceed seven volts, while the lowest point of the "shoulder" of the pulse should not fall below four volts.

the error-detection system

The system and its interface has been designed to combine simplicity of operation with the maximum possible flexibility. This introduces the possibility that the computer could send signals, or sequences of signals, which might introduce an error or be otherwise invalid. The error-detection system is intended to monitor invalid conditions. Any error condition is immediately cleared by a new SELECT signal from the data processor.

Error-protection has been achieved by taking the following steps in the design of the DISCfILE unit and the logic unit:

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

address checks

A check is made to determine that the correct number of address bits have been transmitted and that 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 600 milliseconds, an ERROR pulse is emitted. In addition, if the selected record cannot be located by 120 milliseconds after the track is confirmed, an ERROR pulse is emitted.

clock checks

The integrity of the timing clocks from the control track are continuously monitored. These clocks are checked to ensure that no pulses are missing and the frequency of the clock corresponds to the zone (inner or outer) currently addressed. An invalid condition results in an ERROR pulse.

data checks

During a write operation, a check is made to ensure that a bit is returned to the unit within the correct time after each clock pulse is transmitted. The current in the selected head is also checked bit by bit while writing; this is a simple form of echo-check. During a read operation, the data bits are checked to ensure that no bits are missing. An ERROR pulse is emitted if a data bit is found to be missing.

maintenance and lock-out switches

If any maintenance switch is operated or if an impending alarm condition is detected, an ALARM is supplied to the computer. When a hazardous alarm condition exists, the OPERABLE signal is terminated.

A set of sixteen switches is provided on a panel in the DISCfILE unit behind a door which can be locked by a key. Each switch corresponds to one of the data discs. When a switch is operated, it is impossible to write or to erase on that disc. Should the computer address a locked-out disc, a LOCKOUT WARNING is issued.

This feature is of particular importance in maintaining file security. Data which is valuable can be stored on locked discs and cannot be changed or erased by mistake.

general characteristics

power

A single DISCfILE system requires 4.5 kw, three-phase, wye connected a. c. power. Each additional DISCfILE requires 3.5 kw. The DISCfILE operates from 208 volts ± 10% and from 60 cps ±1 cps line frequency. At customer option, the system can also operate from 380 or 415 volts ±10% source and a 50 cps ±1 cps line frequency.

Illuminated push buttons control and indicate the status of the system. With multiple files, the power switching is sequenced to avoid excessive line transients which might occur if all files were started at the same time.

physical characteristics

Both the DISCfILE and the Logic Unit are 64 inches (163 cm) high and just under 36 inches (90 cm) wide. A DISCfILE and a Logic Unit together is 87 inches (220 cm) long and weighs 3,020 lbs (1,370 kg.). An additional DISCfILE unit is 69 inches (175 cm) long and weighs 2,575 lbs (1,170 kg.).

Approximately 30 inches (75 cm) should be left above and on all sides of the unit for maintenance access. Power and signal wiring enter the unit from below and sufficient space is allowed under the unit for surface floor wiring. Cooling air enters through filters at the ends and top of the unit.

All visible metallic frames are anodized aluminum. The remaining surfaces are either glass or removable panels.

environment

The DISCfILE should be operated in an air temperature of between 60°F and 85°F (15°C and 30°C) and relative humidity of 20% to 80%. The elevation of the installation should not exceed 6,500 feet (2,000 meters). The equipment should be installed and operated in the moderately clean environment normally associated with electronic data processing equipment operation.

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).

final tests

The equipment is functionally tested to ensure that its specified performance is achieved. It then undergoes a reliability check. During this check there must be no unrecoverable errors, and recoverable errors must be less than one per billion data bits transferred to or from the DISCfILE.

Computation conditions are simulated by varying the data and by reading or writing and selecting tracks on a random basis. About ten thousand million bits are transferred, and each positioner is moved 65,000 times. Normally, during this test, there are less than five recoverable errors.

reliability

Provided that proper scheduled maintenance is performed the equipment should exhibit error rates far lower than those specified in the reliability check, and it should operate for at least three years before major overhaul is required. There should also be no errors due to failure of the magnetic recording medium (bad spots) for the warrantable lifetime of the equipment.

Quality control and inspection are of major importance in the manufacture of the DISCfILE. The long-term reliability and freedom from error is assured by rigid inspection and control of all materials, components, and processes at every stage of manufacture. All the critical parts of the DISCfILE are manufactured and tested in ultra-clean rooms. Each part is inspected and tested by sensitive and precise optical, mechanical, and electrical equipment.

maintenance

Preventive maintenance procedures may easily be performed by operating personnel and consume a minimum of time. Access to the unit is convenient, and little obstruction is encountered in obtaining access to any internal part. The heads and armatures are removed through the positioner stators for cleaning; the circuit modules are hinged.

A complete maintenance panel is provided. This panel can be used for off-line marginal checking and monitoring of the performance of the equipment. The panel includes indicators which denote the nature of any error condition when such a condition exists. The panel may also be used for writing headers off-line when desired. Recommended scheduled maintenance for each DISCfILE unit is one hour per week, plus two hours per one hundred operating hours. Unscheduled maintenance is unlikely to exceed an average of two hours per month.

system expansion

The dp/f-5022 system is normally supplied with one logic unit and one DISCfILE unit. The system may be expanded to increase total capacity by adding up to three additional DISCfILE units. A switching module, mounted in one of the DISCfILE units, is required to accommodate multi-file operation.

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