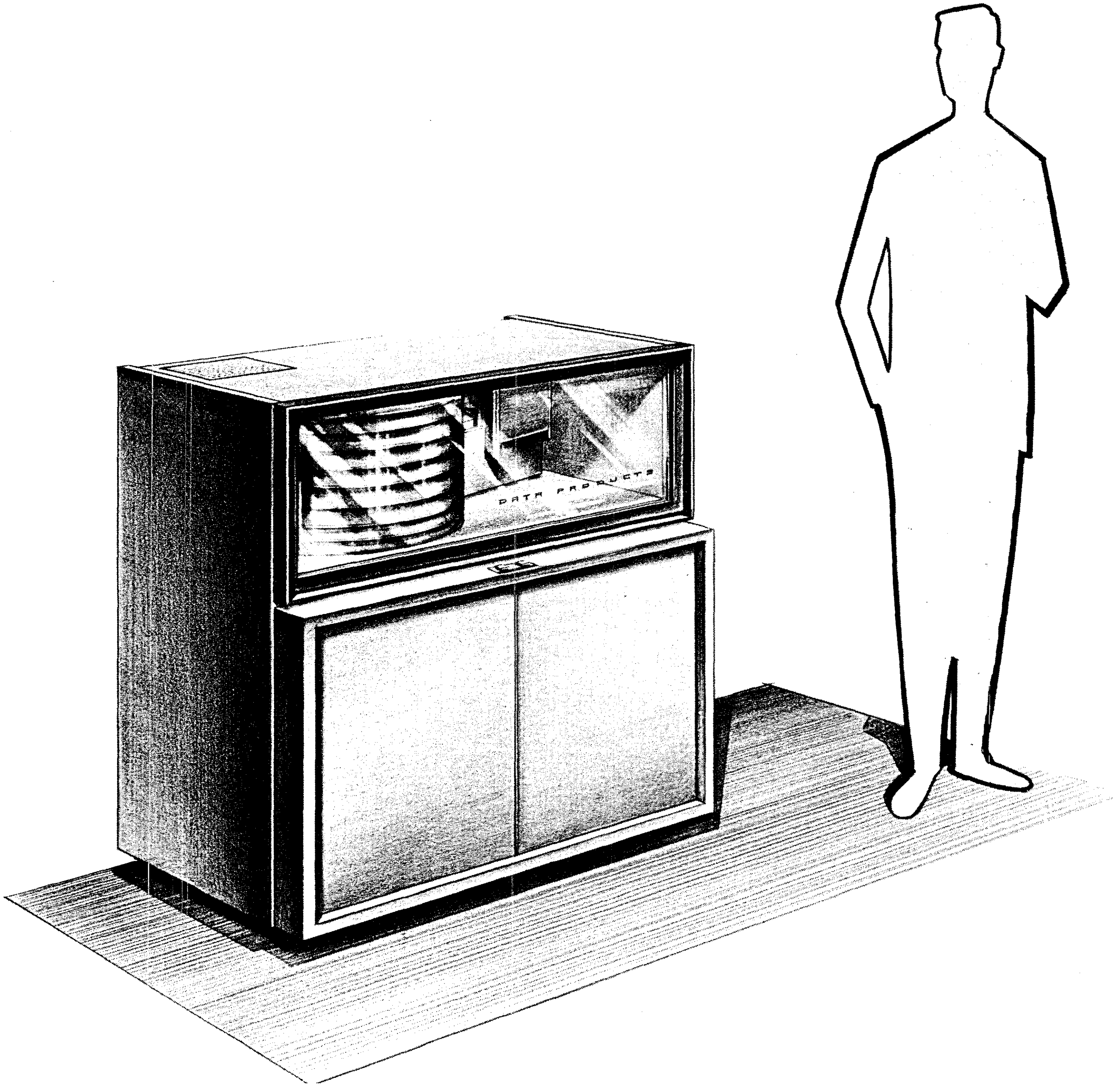
# GENERAL INFORMATION MANUAL

*data products corporation*

*dp/f-5100* DISCfILE *storage systems*


DATA PRODUCTS

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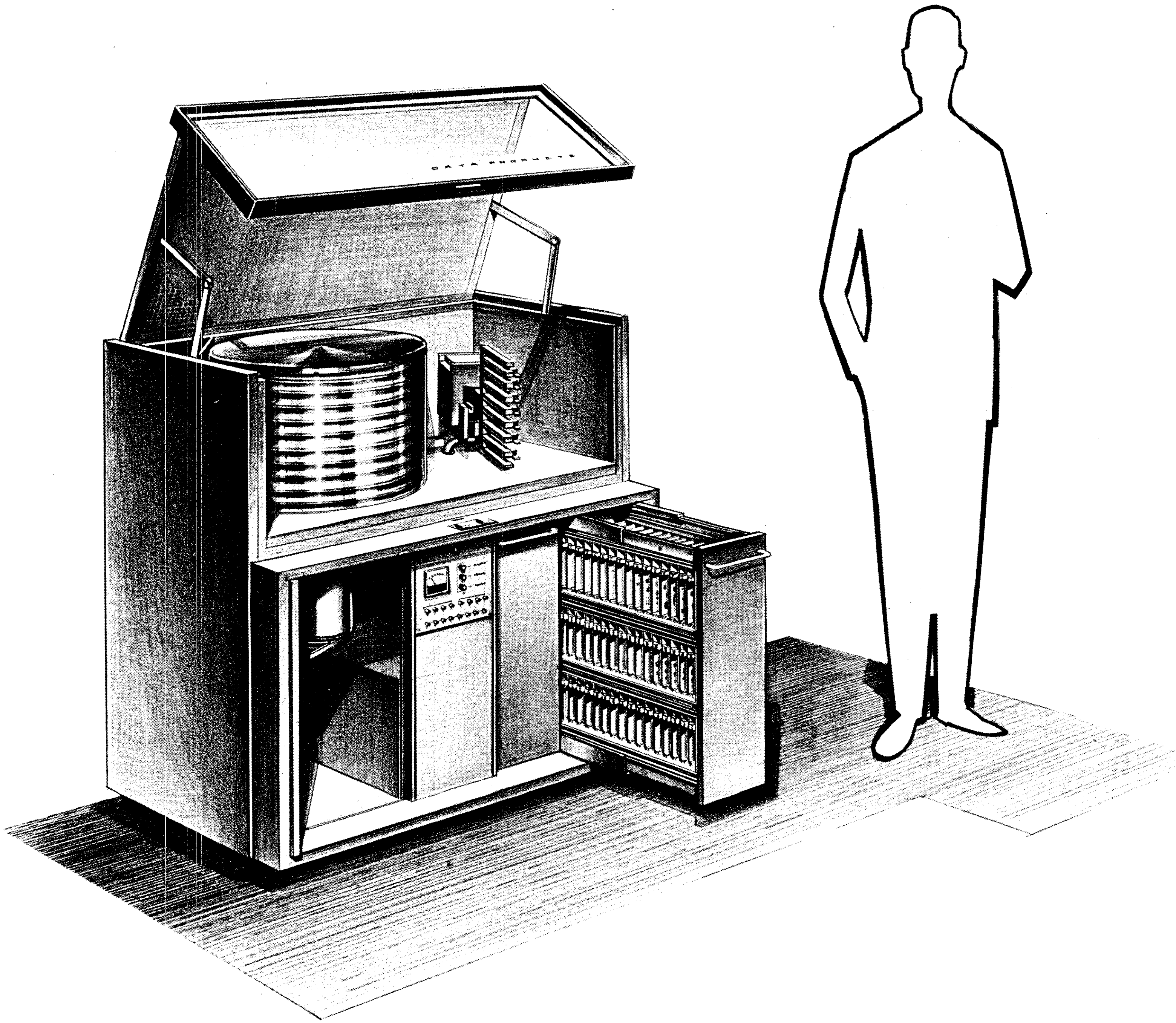
DATA PRODUCTS

# DESCRIPTION

## INTRODUCTION

The dp/f-5100 DISCfILE* storage systems provide an economical and versatile form of mass random-access memory for use where moderate storage capacity and 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-5100 systems are logically similar to and use many of the same subassemblies as the larger dp/f-5020 and dp/f-5030 DISCfILE systems. The interface is such that a dp/f-5100 system can supplement or be used in place of one of the larger systems. The use of the same subassemblies assures both spares interchangeability and the same high-reliability and low-maintenance which has been proven in operational use of the larger capacity DISCfILES.

### Summary of Characteristics

A dp/f-5100 DISCfILE storage system contains a dp/f-5102 DISCfILE control unit and from one to four dp/f-5101 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 storage capacity per unit is between 40 million and 45 million bits. The system can be expanded up to a maximum capacity of 180 million bits. Commonly, either alphanumeric characters or decimal digits are stored together with some form of parity checking. Making a suitable allowance for parity checking, the capacity per unit exceeds six million alphanumeric characters, or ten million decimal digits. The capacity per system is up to four times these amounts.

Data is stored upon eight oxide coated non-inflammable magnesium alloy storage discs which are 24 inches in diameter. The discs rotate at 1500 rpm and the data stored on circular tracks is accessed by 16 flying head pads carried on a comb. The heads and comb move together and are positioned rapidly and precisely by a single magnetic digital linear positioner.

Systems which include more than one DISCfile unit have multiple seek characteristics. This makes it possible to be positioning in some units while reading or writing in another. Under these circumstances the delay due to positioning can be reduced so that it has a negligible effect upon computing time. In any case, the positioning time is relatively short. For one-step, the total time required is between 100 and 125 milliseconds. The random average positioning time is less than 225 milliseconds.

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## SIGNIFICANT ADVANTAGES

- Low cost of basic system.
- Additional storage can be added when it is needed at low cost-per-bit.
- Multiple-seek capability.
- Entire files can be stored in readily accessible form.
- In scientific applications entire program libraries can be stored reliably and are readily accessible.
- Supplements internal memory for large computations.
- Simplifies multiprogramming and program scheduling.
- Customer selection of record length.
- Record identification addressing selected by customer and written under computer control.
- Rotation speed may be reduced to match computer capability.

### Multiple Systems

It is possible to increase the capacity beyond the 180 million bit limit of a single DISCfILE system by employing several systems with one data processor. The system interface has been designed to facilitate this, in that most of the signals may be fed in common to all systems.

## THE DISCfILE

The design concepts and all the critical subassemblies are identical with those used in the larger DISCfILES. The principal changes are as follows:

Smaller discs have been employed. This makes it possible to obtain lower transfer rates without increasing latency. It also makes it possible to record all the data at the same frequency.

A single linear-positioner and a comb has been employed. This increases the amount of data stored at each position, this permitting large data transfer without access delays.

The control unit and system interface has been simplified. This makes the unit more suitable for use in systems which have a simple command structure. The unit can perform all the functions which are available in the larger DISCfILES, but, to do this, a greater share of the burden is placed upon the computing system.

A simple form of multiple seek has been included. This is not as versatile or powerful as that available in the dp/f-5025 and dp/f-5035. However, it is simple to use, and to program, and provides a very significant speed advantage over systems which do not employ multiple-seek.

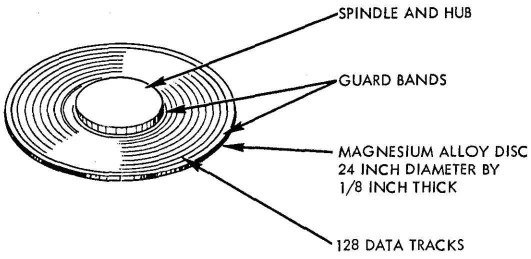


FIGURE I. MAGNETICALLY COATED DISC

## The Discs

The discs are precision ground and lapped to a few millionths of an inch finish. The material employed is a high quality, non-inflammable magnesium alloy. This has a high internal loss characteristic which damps out vibration rapidly and thereby prevents any form of resonance.

The discs are coated with a thin but precisely controlled layer of magnetic material. This is also machined to restore the same finish as the disc had before coating. The magnetic material is a very finely divided high-coercivity ferrite powder. It is bonded together and to the disc by an extremely hard and tough thermosetting plastic. This material can be used because with a rigid metal disc it does not need to be flexible and can be cured at a high temperature.

The discs are inspected and tested with great care to ensure that they contain no areas which cause "bad spots" or are likely to introduce "bad spots" in service. This technique has been highly successful and no "bad spot" has ever developed in operational service.

A typical disc is illustrated in Figure I. Each surface of the disc is used to store 128 data tracks, which are spaced apart on 0.0375 inch centers. The nominal recording density is 600 bits per inch, using a phase-modulated recording technique. The absolute maximum number of bits which can be stored in a single track is 23,600.

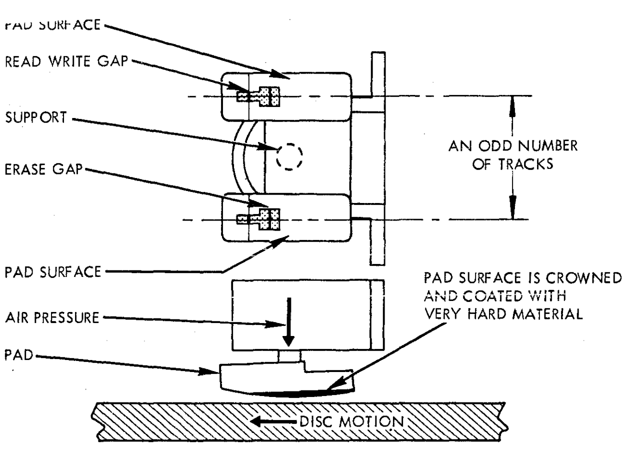


FIGURE II. VIEWS OF PAD STRUCTURE

## The Flying Heads

A diagrammatic representation of a flying head pad is given in Figure II. There are, in fact, two "flying" surfaces joined together by a light but rigid bridge. Each part of the pad contains an erase head and a read-write head. The erase gap is wider than the read-write gap.

Figure III is a diagrammatic representation of the discs, the heads and the comb. There are eight data discs accessed on each side by a head pad. Consequently, there are 32 erase and 32 read-write heads in the system.

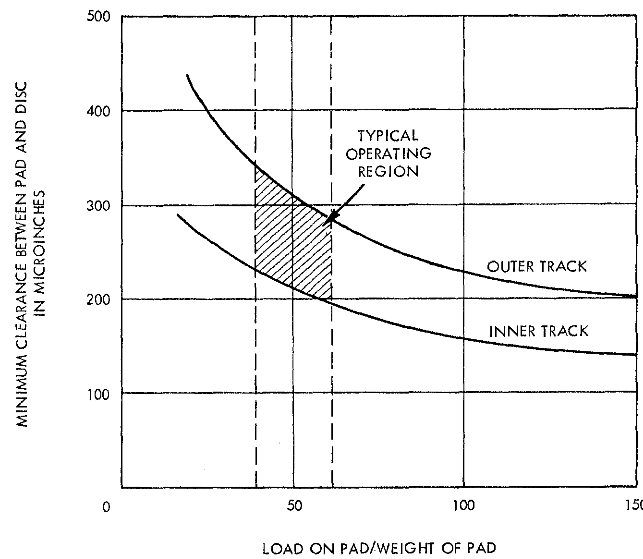


FIGURE IV. THE CHARACTERISTICS OF A FLYING HEAD PAD

A "flying head" does not "fly" in the normal aerodynamic sense of the word. Correctly, it is a slider air-bearing which is held away from the disc by the thin but very tough layer of air which rotates with the disc. This layer is so "hard" that it is equivalent to a spring of stiffness 8,000 pounds per inch, tending to force the head away from the disc. The characteristics of a typical head pad are shown in Figure IV.

The head must be forced against the air-layer by some type of spring. If a normal spring were employed the force that it exerted would be a function of the relative distance between the head supporting arm and the disc. To overcome this difficulty compressed air and a "piston" is used to provide the force. A light return spring is provided to retract the heads when the air pressure is removed. This also provides most desirable "fail-safe" characteristics. The technique of providing the force by air pressure is so effective that the relative distance between the arm supporting the head and the disc can vary by $\pm 0.060$ inch without changing the clearance between the disc and the pad.

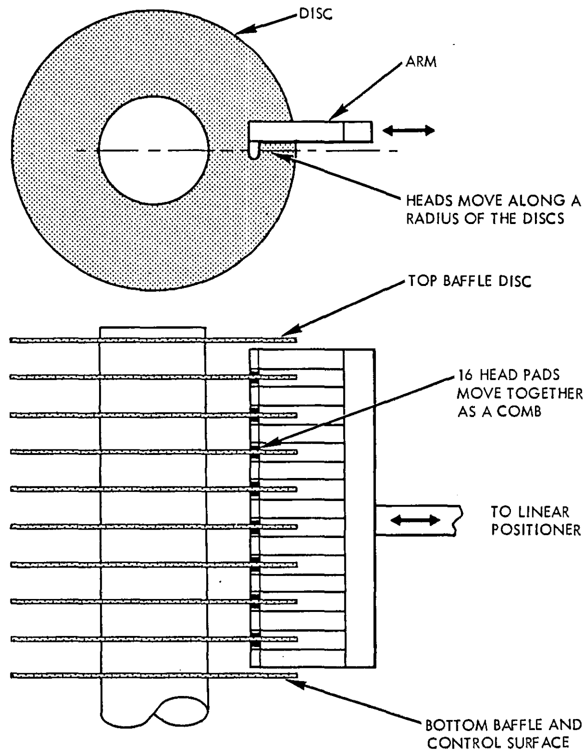


FIGURE III. ARRANGEMENT OF DISCS AND HEAD PADS

The face of the pad is coated with a layer of crystalline aluminum oxide. This is applied in a form which is so hard that it is effectively synthetic sapphire. The principal reason for using this is that the face is curved or "crowned" to a precision measured in millionths of an inch. This can be achieved and held with wear in service only if a very hard material is used.

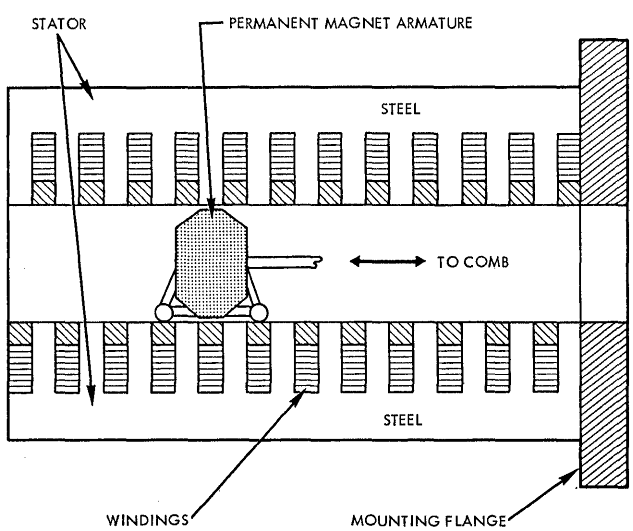


FIGURE V. THE MAGNETIC LINEAR-POSITIONER

The Linear-Positioner

A simplified and diagrammatic representation of the linear-positioner is shown in Figure V. The actual unit contains many more poles and winding slots.

To position the armature, taps are selected on the upper and lower portions of the stator. This sets up a static magnetic field which causes the armature to move to, and to locate itself accurately at, the selected position. The field does not change, nor is it necessary to change taps as would be the case in a more conventional motor.

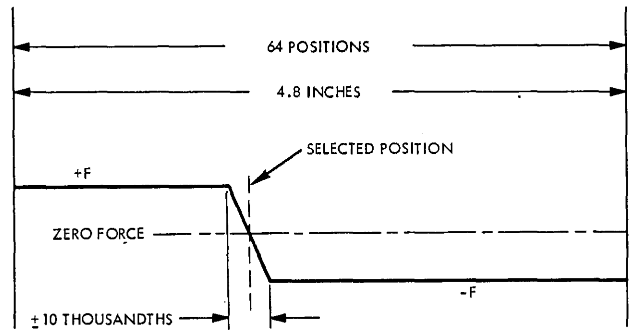


FIGURE VI. POSITIONER FORCE CURVE

A diagram illustrating the force acting upon the armature, as a result of the field, is given in Figure VI. This force tends to make the armature move towards the selected position. It is uniform except in a region which is very close to that which is selected. In this region the force is equivalent to a very strong spring "attached" to the precise point at which the armature should settle. The stiffness of this "spring" is in excess of 100 pounds per inch.

The linear-positioner generates a force which moves the armature to the correct position and then locates it there with a precision and stiffness which is equivalent to a mechanical rack. However, the "notch" is a magnetic field and cannot get dirty or wear or otherwise get out of adjustment.

The linear-positioner has the further property that it is simple to introduce and to control damping. This leads to very smooth starting or stopping. This is beneficial in that it does not introduce undue shock or vibration into the equipment. It is most important in that by this means it is possible to ensure that the highest acceleration frequency component applied to the head pad structure is much less than its frequency of response. This effectively removes any possibility of "head crashes" due to the positioning action.

## MULTIPLE-SEEK

One data channel and control unit is used with up to four DISCfILE units in each system. This makes it possible to add additional storage to the system without modification of hardware or programs. In the dp/f-5100 DISCfILE systems speed is increased at the same time as capacity. This is achieved by employing "multiple-seek".

Each DISCfILE unit stores the portion of the address which defines the position. This makes it possible for a DISCfILE unit to seek a new position without being connected to the control unit. For this reason several DISCfILES can seek at the same time. It also makes it possible to hold the last position in a unit so that it is possible to return to a previously accessed record without any delay except latency.

### The Use of Multiple-Seek

The random-average positioning time or access-time is always quoted as one of the operational parameters of the system.

The slowest operation that can be performed in any random-access mass-memory system is to seek sectors whose addresses have been chosen at random. This rarely occurs because a queue of the desired addresses is used to perform the search on a less-than-random basis.

The random-average access time of a system with one DISCfILE is about 250 milliseconds. This drops to 170 milliseconds if two units are used. It drops still further to 130 for three and less than 110 milliseconds for four files. These figures are based on using a queue which is only as long as the number of DISCfILE units in use. Longer queues and more sophisticated programming will yield higher speeds.

A common operation is to gather data from two areas of a storage unit and to store the processed results in a third. If a single positioner is used in a large system, the computer must have great internal storage capacity and the heads must move frequently.

With a multiple positioner system, it is usually possible to arrange that the areas are accessed by different positioners so that they move rarely and time is saved by not incurring the positioning delays. Most merging and sorting operations have these characteristics and yield very significant speed gains, while making it possible to utilize moderate internal storage capacity.

There are many business applications where the computation involves access to associated records which are located in different areas of the file. An example of this is the delivery of parts from a supplier. This initiates changes to the purchase order, inventory and accounting files. Usually it is not possible to complete the changes as a result of one access to each record. It is preferable to read each of the selected records, modify them, and then store the modified data.

In the above situation a non-multiple-seek system would position five times. In a multiple-seek system three accesses are required which all take place together so that the average positioning time is little more than that of one access.

In this system the total time required would average 390 milliseconds. A single-positioner system, having the same characteristics, would take over one second. It would have to be nearly five times as fast as the multiple-seek system to do the same job in the same time.

## THE ADDRESS ORGANIZATION

Data is written into or read from the file in records or groups of records. Each record occupies a "sector" of a track. A record location is defined by address containing a unique track and sector.

The track is identified by selecting a head and a position. The heads are arranged in four "cylinders" of eight heads in each. Switching between heads within a cylinder is effectively instantaneous, but a small delay is introduced in switching from cylinder to cylinder. The relationship between tracks, heads, cylinders, positions and DISCfILES within a system is shown in Table I.

The complete address consists of a number of "fields". To achieve the most efficient use of the DISCfILE, it is important to understand and utilize the field structure. The number of bits per field and their relative position in the address is shown in Figure VII.

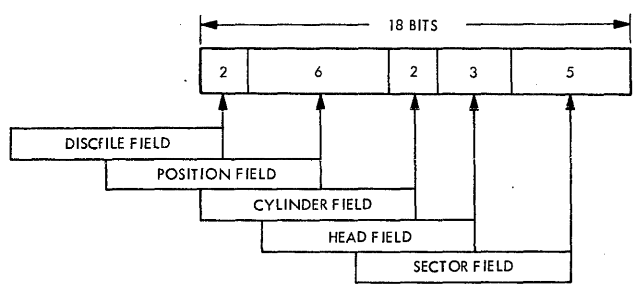


FIGURE VII. ADDRESS FIELDS

When a new record is selected the access-time depends on the location of the new record relative to the old. If the new address does not introduce a change to the position field, the access-time is largely dependent upon the rotational latency delay.

If any field is changed, there will be a delay due to latency unless the new sector can be chosen to follow the old. If the head field is changed there is no additional delay. A cylinder field change introduces a small delay.

If either a DISCfILE field or a position field is changed it is not possible to program for minimal latency. However, a DISCfILE field change introduces no additional delay. A change to the position field always introduces a positioning delay.

| UNITS | NUMBER OF UNITS IN A | | | | |
|---|---|---|---|---|---|
| | DISC | CYLINDER | POSITION | DISCFILE | SYSTEM (up to) |
| TRACKS | 256 | 8 | 32 | 2048 | 8192 |
| HEADS | 4 | 8 | 32 | 32 | 128 |
| CYLINDERS | | | 4 | 256 | 1024 |
| POSITIONS | | | | 64 | 256 |
| DISCFILES | | | | | 4 |

TABLE I ORGANIZATION OF DATA

| NOMINAL ROTATION SPEED REVS. PER MIN. | NOMINAL TRANSFER RATE KILOBITS PER SEC. | NOMINAL AVERAGE LATENCY MILLISECONDS |
|---|---|---|
| 1500 | 600 | 20 |
| 1200 | 480 | 25 |
| 1000 | 400 | 30 |

TABLE II TRANSFER RATE AND LATENCY

| OPERATION | | TIME |
|---|---|---|
| CHANGE | SAME | |
| DISCFILES | SYSTEM | 5 microseconds |
| HEADS | CYLINDER | 10 microseconds |
| CYLINDERS | POSITION | 7 milliseconds |
| POSITION ADDRESS | | 27 milliseconds |
| POSITION | | See Figure IX |

TABLE III TIME TAKEN TO EXECUTE A COMMAND AFTER A NEW ADDRESS HAS BEEN RECEIVED

## FACTORS AFFECTING SPEED

There is no single factor which defines the "speed" of a mass random-access storage device. In some applications the latency and transfer rates dominate the situation. In others positioning-time is all important. In general, the application must be analysed if it is desired to obtain an accurate estimate of the time that will be taken.

In programming for the use of DISCfILES it is very desirable that estimates of operating time should be made. The DISCfILE is easier to program than a sequential device such as a tape unit, but the speed of operation is still dependent upon how well the file is used.

### Rotation

Table II shows the relationship between rotation speed, transfer rate, and average latency. The unit is normally supplied to operate at 1500 rpm, but one of the lower speeds can be selected if a lower transfer rate is desirable.

### Switching Delays

The typical switching delays are illustrated in Table III. The time listed against "position address" is the time required for the unit to accept a new position field. The actual positioning time commences at the end of this time. This delay can be reduced to seven milliseconds by releasing the DISCfILE under program control at the end of a previous access.

It should be recognized that the DISCfILE control unit engages the computer only when it is receiving an address or data, or when it is transmitting data. However, the control unit must remain connected to the selected DISCfILE until the switching delay is complete.

### Positioning Time

Figure VIII illustrates the normal definition of positioning time. In practice the initial switching delay is often included as part of the positioning time. This figure also illustrates other component times which are commonly in use.

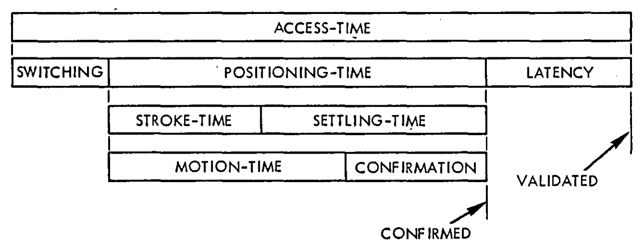


FIGURE VIII. COMPONENTS OF ACCESS TIME

The process of confirmation in the dp/f-5100 systems is to read the headers in each sector accurately for a period of 50 milliseconds. Confirmation ensures that the head is accurately settled over the track before reading or writing can commence.

The process of validation starts after confirmation. This is a final check that the head is on the correct track and is just coming to the selected sector.

Table IV illustrates some typical average access times including all possible delays. Further values may be

| NUMBER OF STEPS | 1500 RPM | 1200 RPM | 1000 RPM |
|---|---|---|---|
| ONE | 145 | 150 | 155 |
| EIGHT | 210 | 215 | 220 |
| RANDOM AVERAGE | 255 | 260 | 265 |
| FULL-STROKE | 365 | 370 | 375 |

TABLE IV TYPICAL AVERAGE ACCESS TIMES IN MILLISECONDS INCLUDING ALL DELAYS

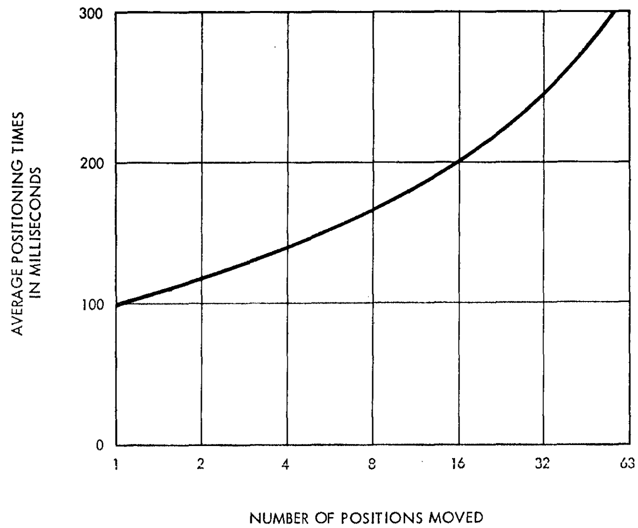


FIGURE IX. TYPICAL POSITIONING TIMES INCLUDING CONFIRMATION

computed by using Figure IX and taking switching delays and latency into account.

Figure IX illustrates the positioning time for various motions. This includes the confirmation time, but not the initial delay. It should be noted that the number of steps have been shown in a logarithmic form because this corresponds approximately to the frequency with which the various steps occur in normal computation.

## Cylinder Mode

The amount of data stored in each cylinder is equivalent to 4,000 words or more of core storage. Each position contains at least 16,000 words.

In many data processing applications it is possible to order the data or queue the inquiries so that many inquiries fall within a cylinder or position. In scientific computations it is a very common practice to transfer 4,000 words or more as a large block.

The practice of taking advantage of the fast access within the cylinder or position is defined as a "cylinder mode" of operation.

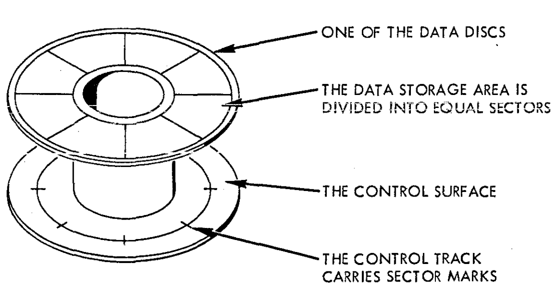


FIGURE X. SECTORING

# CAPACITY AND FORMAT

## Sectors

Data is written into or read from a random-access memory as records. In the DISCfILE each record is written in a sector. The length of the record can be less than the capacity of a sector, but it cannot be greater.

A typical sectoring arrangement is shown in Figure X. All the tracks are divided up into eight equal parts. The physical length of the sector varies as the radius of the track, but the data storage is the same in all cases because only the innermost track is written at the maximum density. The control track carries sector marks which indicate where each sector ends. These are used to time and control reading and writing in the sectors.

Five different sets of control tracks are provided in the dp/f-5101 DISCfILE unit. They permit the selection of 8, 10, 16, 25 or 32 sectors per track.

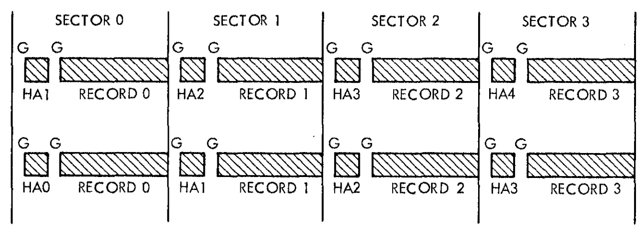


FIGURE XI. METHODS OF ARRANGING THE HEADERS AND RECORDS WITHIN THE SECTORS

## Headers and Records

Each sector contains a header and record. This is illustrated in Figure XI. Each header contains two gaps (G) which are used partly as safety zones and partly to accommodate the distance between the erase and read-write gaps.

The header also contains the header address (HA). This is 16 bits in length because the DISCfILE field is not recorded in the header. The position, cylinder, and head fields define the particular track in which the sector is located. The remaining five bits identify the particular record.

The header addresses are written under computer control. At that time any suitable arrangement of the sector field may be chosen.

There are two common methods of relating the header address to the record. The first is illustrated at the top of Figure XI. In this method the address of the record is written in the header address of the previous sector. When this method is employed the computer is warned one sector ahead that the desired record is approaching.

The other method is illustrated on the second line. In this case the header address is in the same sector as its record and the computer must respond rapidly. The dp/f-5100 systems can employ either method.

### The Effects of Sectoring

The header in each sector occupies space on the track. Consequently, 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 XII.

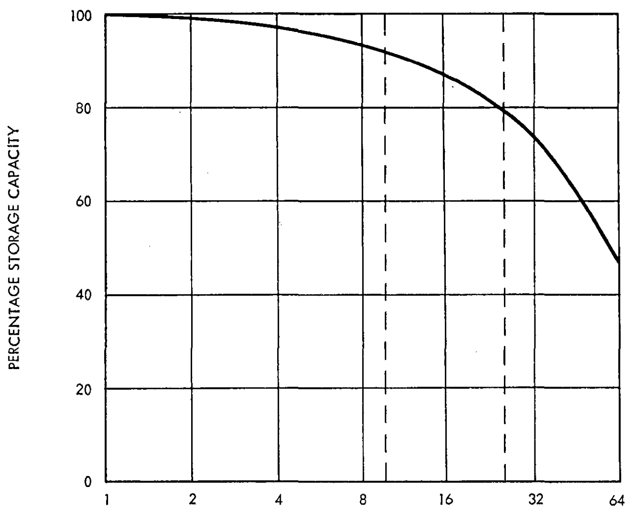


FIGURE XII. EFFECT ON STORAGE CAPACITY OF SECTORING

If a very large number of sectors is used, the storage capacity is reduced unreasonably. If very few are used this usually places heavy 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. Time is also lost in transferring unnecessary data within the system.

Commonly between eight and sixteen sectors are found to be a reasonable compromise between speed and capacity requirements. The 25 and 32 sector configurations have been included for the convenience of those who wish to use the file as an electronic analog of a punched card system.

### Storage Capacity

The storage capacity in terms of the number of records is shown in Table V. The capacity, as bits of stored data, is shown in Table VI.

The storage capacity in terms of alphanumeric characters or decimal digits can be computed from the previous tables. With this type of format, it is a common practice to add a parity checking bit to each character or pair of decimal digits.

DISCfILES are sufficiently reliable to make this degree of redundancy unnecessary. A parity bit for every 20 to 30 data bits is usually more than adequate. Table VII illustrates the storage capacity in terms of characters and digits on the basis of one parity bit for every 24 data bits.

| RECORDS PER | SECTORS PER TRACK | | | | |
|---|---|---|---|---|---|
| | 8 | 10 | 16 | 25 | 32 |
| CYLINDER | 64 | 80 | 128 | 200 | 256 |
| POSITION | 256 | 320 | 512 | 800 | 1,024 |
| DISCfILE | 16,384 | 20,480 | 32,768 | 51,200 | 65,536 |
| SYSTEM (up to) | 65,536 | 81,920 | 131,072 | 204,800 | 262,144 |

TABLE V STORAGE CAPACITY IN TERMS OF RECORDS

| KILOBITS PER | SECTORS PER TRACK | | | | |
|---|---|---|---|---|---|
| | 8 | 10 | 16 | 25 | 32 |
| RECORD | 2750 bits | 2160 bits | 1275 bits | 750 bits | 540 bits |
| CYLINDER | 176 | 172.8 | 163.2 | 147.2 | 138.2 |
| POSITION | 704 | 691.2 | 652.8 | 588.8 | 553 |
| DISCfILE | 45,056 | 44,237 | 41,779 | 37,683 | 35,289 |
| SYSTEM (up to) | 180,224 | 176,947 | 167,117 | 150,733 | 141,158 |

TABLE VI STORAGE CAPACITY IN TERMS OF BITS OF DATA

| ALPHANUMERIC CHARACTERS PER | SECTORS PER TRACK | | | | |
|---|---|---|---|---|---|
| | 8 | 10 | 16 | 25 | 32 |
| RECORD | 440 | 344 | 204 | 120 | 84 |
| DISCfILE (millions) | 7.2 | 7.0 | 6.7 | 6.1 | 5.5 |
| DECIMAL DIGITS PER | | | | | |
| RECORD | 660 | 276 | 306 | 180 | 126 |
| DISCfILE (millions) | 10.8 | 10.6 | 10.0 | 9.2 | 8.3 |

TABLE VII STORAGE CAPACITY IN TERMS OF ALPHANUMERIC CHARACTERS AND DECIMAL DIGITS WITH ALLOWANCE FOR PARITY CHECKING

## THE SYSTEM INTERFACE

All wires between the control unit and the data processor employ pulse communication via pulse transformers at both input and output. Consequently, particular voltage levels or polarities are not critical in communicating with the system.

The system interface is illustrated in Figure XIII. This is the interface of the dp/f-5102 DISCfILE control unit which communicates with the data processing system.

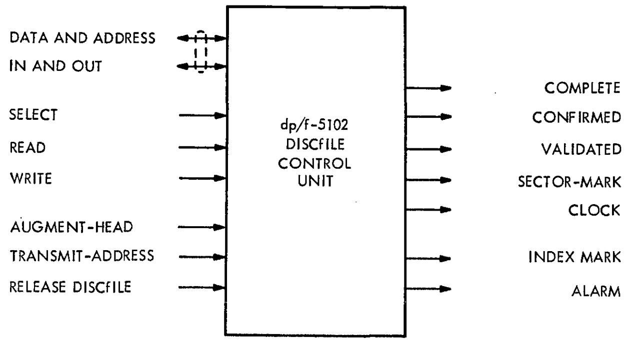


FIGURE XIII. THE SYSTEM INTERFACE

### The Data Channel

Data and addresses are transmitted both to and from the system on a pair of wires. One wire is pulsed to represent a ONE and the other for a ZERO.

### The Basic Input Signals

A SELECT signal is sent to indicate that a new address will be transmitted. The READ and WRITE signals initiate either reading or writing.

### The Basic Output Signals

The COMPLETE signal indicates that the control unit has accepted a new address and where this involves a change to a position or cylinder field, it has transferred the new address to the appropriate DISCfILE unit. Where a change is involved, the COMPLETE will be transmitted from 7 to 27 milliseconds after the SELECT pulse, depending upon the nature of the change. Where no change or only an electronic change is involved, the COMPLETE will be transmitted a few microseconds after the address has been received. A new SELECT may be sent to the system any time after a COMPLETE signal.

The CONFIRMED signal indicates that the positioner has settled onto the selected track and that reading or writing may be commanded. The VALIDATED signal is emitted whenever a match occurs between the address and the header address. It indicates that the desired record is about to pass under the selected head.

The SECTOR-MARK signal indicates when the previous sector has finished and also provides a time reference. The CLOCK is used to regulate the transmission of the address and the data from the computer to the DISCfILE system. One pulse is provided for each bit of data to be transmitted.

### Other Input Signals

Three additional signals can be sent to the system to command features which are available on an optional basis.

AUGMENT-HEAD is a means whereby the head field can be increased by ONE without transmitting a new address. This makes it possible to take advantage of the high switching rates in the head field region. This feature is used when it is desired to transfer a number of tracks of data without interruption.

A TRANSMIT-ADDRESS signal causes the system to transmit the next header address which is encountered on the selected track. It permits the computer to sense the present position of the file or to check for itself that the correct track has been selected.

A RELEASE-DISCfILE signal will remove power from the positioner in the selected file. It is used as a time-saving device in multiple-seek operation.

### Other Output Signals

Two additional signals are generated by the system. They are provided for the convenience of the user, but he may elect not to utilize them during normal computation.

The INDEX-MARK is normally used only when headers are written. It provides a spacial reference within the system.

The ALARM signal indicates that the error-prevention system has detected an alarm condition. The nature of the signal which created the alarm can be determined from the time at which the ALARM signal was transmitted.

### The DISCfILE Unit Interface

Normally this interface is internal to the system. It is of importance if a DISCfILE unit is used without the control unit. This interface is necessarily a more complex one than the system interface, and is described in detail in a later section.

# *OPERATIONAL CHARACTERISTICS OF THE* DISCfILE *SYSTEM*

This section deals primarily with the use of dp/f-5100 DISCfILE systems 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 and to utilize more sophisticated programming techniques. For this reason the largest capacity and most versatile system has been described.

## THE OPERATIONS IN THE DISCfILE

DISCfILES are 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 a few microseconds to a few hundred milliseconds.

The simplest operation is to read from or write into a specified record. The first step is to connect the DISCfILE system to the computer (SELECT). Then an address is specified. Next, by a combination of mechanical motion and switching, a specified track is selected. Finally, the desired record moves under the head and reading or writing is performed. Only two commands are needed in such a system. They specify either read or write at address "n".

It is usually found more convenient to control the DISCfILE by using three commands. One specifies "go to address n" and the others read or write. With a command structure of this type it is possible to read or write into a number of records on the same track without re-specifying the address. It is also possible to read a record and then after one rotation time, to write into it without sending a new address.

The command "go to address n" is defined as SEEK. It is never actually issued as a command but is implied by the transmission of a SELECT followed by an address which specifies a new storage location.

In practice it is undesirable to allow the DISCfILE to remain connected to the computer while a SEEK operation takes place. Therefore, the computer is always disconnected after the address is transmitted and reconnected just prior to reading or writing. This is the function of the VALIDATED signal which warns the computer that the desired record is about to pass under the selected head.

A similar situation exists in a multiple-seek system. It is rather simple to store the six bits of the position field in each DISCfILE unit so that if a SEEK involves a new position the control unit can be disconnected from the DISCfILE unit. This permits the control unit to engage other DISCfILE units while the one that was originally selected moves to a new position.

At a later time it will be necessary to reconnect the control unit to the DISCfILE unit. It would be possible to employ a "connect" command for this purpose but it would still be necessary to specify to which DISCfILE unit the control unit should be connected.

A more simple technique is to employ a SELECT and the same address as was specified in the original SEEK. This re-establishes the original status without requiring a special command. The last address and status of each DISCfILE unit can be "remembered" by the computer by reserving four internal storage locations for the purpose. The operation of sending a SELECT followed by the same address as was specified when the DISCfILE unit was last accessed is known as CONNECT.

The AUGMENT-HEAD operation is used to switch from one head to the next higher in sequence without requiring a new address. It is used when it is desired to read or write continuously in all the records in a number of adjacent tracks. It makes it possible to move to the next record in the next track without loss of time.

The TRANSMIT-ADDRESS and RELEASE-DISCfILE operations are usually employed when a track and head have already been selected in order to perform a reading or writing operation. If a DISCfILE unit is accessed in order to perform one of these operations, a CONNECT is invariably employed rather than a SEEK.

The TRANSMIT-ADDRESS causes the DISCfILE to send the next header address to the computer. Normally when a SEEK involves a position change, a delay of approximately 20 milliseconds occurs while the energy stored in the linear positioner is dissipated. This delay can be avoided by using the RELEASE-DISCfILE signal, so that the control unit can operate with another DISCfILE unit while the delay occurs.

## THE STATES OF THE SYSTEM

The control unit and the selected DISCfILE unit are always in one of four well defined logical states. These are illustrated in Figure XIV.

A SELECT connects the system to the computer and initiates the "address-state". During this state an address is transmitted to the control unit. The DISCfILE, head and sectorfields are stored in the control unit. The position and cylinder fields are transferred to the selected DISCfILE unit where they are stored electromechanically. The address-state is terminated by the COMPLETE signal.

Logically the address state is followed by the "seek-state". During this state the positioner moves to a new position. If the operation does not involve a position change, the seek-state "exists" for only a fraction of a microsecond.

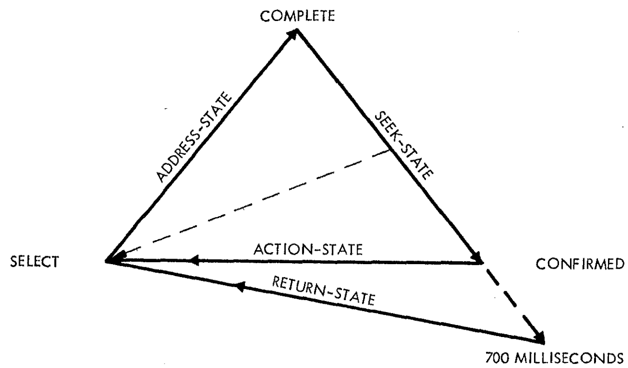


FIGURE XIV THE STATES OF THE SYSTEM

The CONFIRMED signal sets the system into the "action-state". All the major operations, other than SEEK and CONNECT, occur while the unit is in this state.

If the seek-state is terminated by the time delay, the system is set into the "return-state". This makes it possible to return the system to the normal sequence of states. This state is also employed for entering the control sequence when the unit is first switched on. It is also utilized during the operation of writing headers.

The seek-state is normally terminated by a CONFIRMED pulse. Rarely there occur certain invalid or error conditions which can prevent confirmation taking place. In this event the seek-state is terminated unconditionally when 700 milliseconds have elapsed.

### The Address-State

A timing diagram of the address-state is shown in Figure XV. The state is initiated when the computer sends a SELECT pulse to the system.

Approximately ten microseconds later the system will transmit the first of 18 clock pulses to the computer. One bit of the address should be transmitted to the system as each clock pulse is received. The computer may disconnect from the system when the last bit of the address has been transmitted.

If the operation is to be a CONNECT, or if the cylinder and position fields are not changed, the COMPLETE pulse will be emitted shortly after the last bit of address was received.

If the address introduces a position change the COMPLETE will be delayed 27 milliseconds. If, on the other hand, a RELEASE-DISCfILE signal was sent to the selected unit, more than 20 milliseconds before the SELECT, the delay will be seven milliseconds. If the address introduces a cylinder change, but not a position change, the delay is seven milliseconds.

Once the system has received a SELECT, it will emit the 18 clock pulses and will receive the corresponding 18 address bits. It will not accept or emit any other signals until the COMPLETE is emitted.

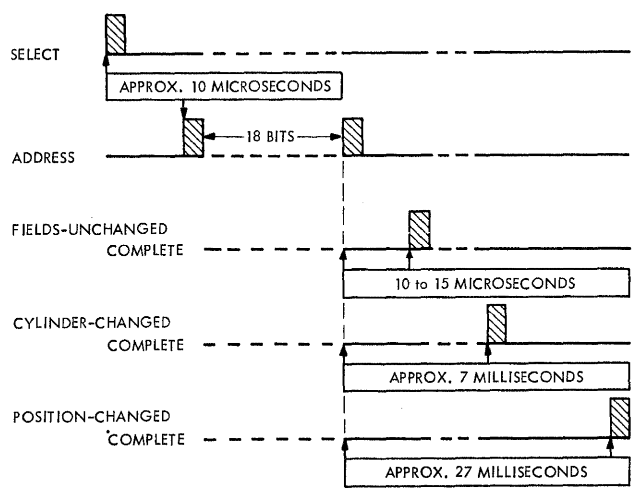


FIGURE XV TIMING DIAGRAM OF ADDRESS-STATE

### The Seek-State

A timing diagram of the seek-state is shown in Figure XVI. The state is initiated by a COMPLETE and terminated by a CONFIRMED pulse.

If the selected position was already confirmed when the SELECT was transmitted, and no position change was requested, the CONFIRMED pulse will be emitted at the same time as the COMPLETE.

If the operation is a SEEK and the position field is changed, the delay before CONFIRMED is transmitted will be the positioning time. This is indicated on the last line of the diagram. This situation will exist only if the control unit is left connected to the selected DISCfILE.

The control unit can be disconnected while the positioner moves to its new position, by sending a SELECT pulse. When it is reconnected by means of a CONNECT there will be a minimum delay of 50 milliseconds before the CONFIRMED pulse will be emitted. The delay will exceed 50 milliseconds if the control unit was disconnected from the selected DISCfILE for an insufficient time.

When the system is in the seek-state it will accept only a SELECT pulse and will emit no signals until the state is terminated.

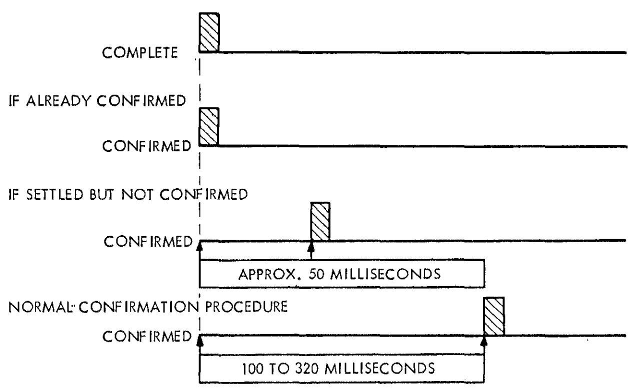


FIGURE XVI TIMING DIAGRAM OF SEEK-STATE

## The Action-State

A timing diagram of the action-state is shown in Figure XVII. The CONFIRMED pulse initiates the state and a SELECT terminates it, but neither of them have any significant influence upon the timing within the state. The diagram is for a rotation speed of 1500 rpm.

When the action-state is established the system will emit SECTOR-MARK and INDEX-MARK pulses. It will also emit VALIDATED each time that a coincidence occurs between the address which was sent to the system and the header address. It will also accept signals on all the incoming lines.

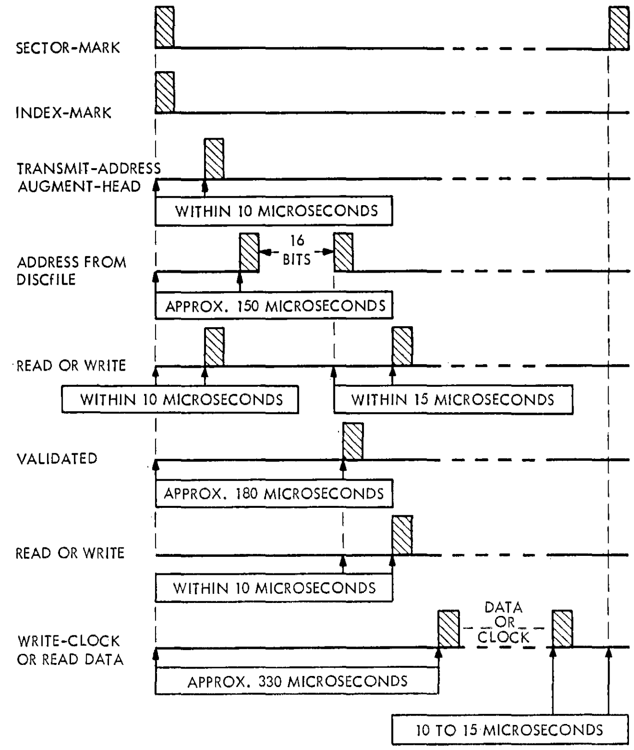


FIGURE XVII TIMING DIAGRAM OF ACTION-STATE

The TRANSMIT-ADDRESS or the AUGMENT-HEAD signal will be accepted only during a ten microsecond period following each SECTOR-MARK. The header address is transmitted to the computer approximately 150 microseconds after the TRANSMIT-ADDRESS signal.

The READ and WRITE signals are mutually interlocked so that neither can follow the other in the same sector. They are accepted by the unit within ten microseconds after a SECTOR-MARK or a VALIDATED. They are also accepted within 15 microseconds after the last bit of a header address is transmitted to the computer.

The data transmitted from the DISCfILE during READ and the CLOCK during WRITE are both emitted during the same period of time within the sector. In both cases transmission is terminated just ahead of the SECTOR-MARK.

Once a READ, or WRITE, or TRANSMIT-ADDRESS is received the system will not accept any other control signals. This situation will continue until the next SECTOR-MARK in the case of a READ or WRITE. It will continue until the last bit of the address is transmitted in the case of a TRANSMIT-ADDRESS.

## Reading and Writing

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

The data transmission is in the form of pulses on the data and address wires. One wire is pulsed for a ONE and the other 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 but it cannot terminate the flow of data.

If the header address for the record is placed in the previous sector, it is usually most convenient to use the next SECTOR-MARK as the signal which initiates the transmission of the READ. If, on the other hand, the header address is in the same record, the VALIDATED pulse can be used to initiate the transmission of READ. The time interval after the transmitted address is provided to serve a similar purpose in the event that the customer wishes to perform his own validation.

When the header address in the previous sector is employed, it is often useful to send a TRANSMIT-ADDRESS at the same time as the READ. The computer then receives the address of the next record about 150 microseconds before it receives data. In this period of time it is usually possible to check that reading is, in fact, commencing at the correct record.

If the AUGMENT-HEAD is transmitted at the same time as READ, then the reading will be performed in the next sector in the track under the next highest head position. It is possible to combine AUGMENT-HEAD with the WRITE signal to perform a similar function. It is generally considered inadvisable to do this because an additional degree of checking should be used when writing.

The WRITE signal is transmitted under the same conditions and at the same time as the READ. The CLOCK is transmitted to the computer when writing should take place. One bit of data should be returned for every clock pulse that is transmitted. The CLOCK pulses will continue until the end of the sector. The record to be written is usually less than the number of clock pulses which are transmitted. The remaining bit positions must be filled out with ZEROS. If it is desired to disconnect the computer after the record has been transmitted, it is usually simple to add a circuit which switches the clock pulses into the ZERO data line until the next SECTOR-MARK is received.

If data is written incorrectly it causes great inconvenience. For this reason special precautions are advisable when a WRITE operation is to take place

If possible the header addresses in the previous sector and in the sector in which writing will occur should be checked. A simple way to do this is to send the header address for the previous sector and wait for a VALIDATED. When this is received the header address in the sector in which writing will occur should be transmitted. The next VALIDATED is then used to initiate the WRITE signal.

When a number of records are written in sequence the TRANSMIT-ADDRESS may be employed to determine that the correct record has been accessed. The WRITE pulse should then be transmitted in the allocated time interval.

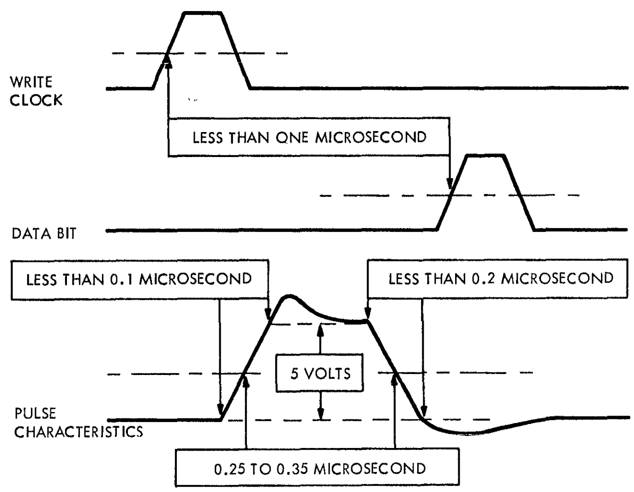


FIGURE XVIII CLOCK AND DATA CHARACTERISTICS

Figure XVIII illustrates the maximum delay which is permitted between the transmission of a clock pulse from the DISCFILE system and the receipt of a data or address 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 and the lowest point of the "top" of the pulse should not fall below four volts.

## The Return-State

The return-state is initiated when the timer determines that the seek-state has existed continuously for 700 milliseconds. A pulse is emitted on the ALARM line to warn the computer that an unusual situation has occurred. At the same time the state is defined by the emission of

SECTOR and INDEX MARKS without a CONFIRMED signal preceding them.

The return-state is cleared by the next SELECT pulse. At this time the system will accept a SEEK without the usual restriction that the action-state must exist before a position change is requested.

The system will also accept a TRANSMIT-ADDRESS while it is in the return-state. No other pulses will be accepted or emitted.

## THE ERROR-PREVENTION SYSTEM

The system and its interface have been designed to combine simplicity of operation with the maximum possible flexibility. This introduces the possibility that the computer could send to the system signals or sequences of signals which might introduce an error or be otherwise invalid. The error-protection system is intended to provide a reasonable degree of protection against invalid conditions.

Error-protection has been achieved by taking the following steps in the design of the DISCfILE unit and the control 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.
- When a signal is blocked, a pulse is emitted on the ALARM line. This indicates that an ALARM condition exists. Since the pulse is in response to the signal it is also known which signal caused the ALARM.
- Other checks are made within the unit and signals are transmitted to the computer if an invalid condition is detected.

### Data Checks

A check is made to ensure that a data or address bit is returned to the unit within the correct time after each clock pulse is transmitted. An ALARM pulse is emitted every time that a data or address bit is not detected.

### Address Checks

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

When the last address bit has been transmitted to the unit a check is made to ensure that the DISCfILE field specifies an operating DISCfILE unit. If it does not, the address is blocked from entering the system and an ALARM pulse is transmitted at COMPLETE time.

The unit will act upon a SEEK which specifies a position change only if the selected DISCfILE unit was in the action-state or the return-state when the SELECT is transmitted. If it was not, an alarm is sent at COMPLETE time.

If, for any reason, it is not possible to select and settle on the correct track during a SEEK, the CONFIRMED pulse will not be emitted. After the seek-state has existed for 700 milliseconds an ALARM pulse will be emitted and the system will enter the return-state.

### Maintenance Switches

If any maintenance switch is left in the test or maintenance condition, or if a DISCfILE unit is otherwise determined to be inoperable, it is impossible to select that unit. The error condition will be detected and an ALARM transmitted when attempts are made to address the unit during normal operation.

## WRITING HEADERS

The operation of writing headers is usually performed only when the DISCfILE is originally put into operation. A switch on the control unit is operated to permit this function. All normal functions can then be performed except AUGMENT-HEAD and RELEASE-DISCfILE.

The 700 milliseconds delay is used instead of the normal confirmation procedure to ensure that the positioner has more than adequate time to settle onto the track. When a new position is commanded, it should never be more than eight positions away from the previous position.

During this operation a WRITE can be commanded only during the ten microseconds interval after a SECTOR-MARK. CLOCK pulses will be sent to the computer at the address time, but not during the normal writing time. The new header will be written and all data in the rest of the sector will be erased.

After a new set of headers have been written, it is advisable to return the unit to normal operation. A check should then be made that headers can be read correctly when a SEEK has commenced from the track on each side of the track in which the header is being tested. This should be repeated, starting eight tracks away and at the extremes of the positioner motion.

# *THE* DISCfILE *UNIT*

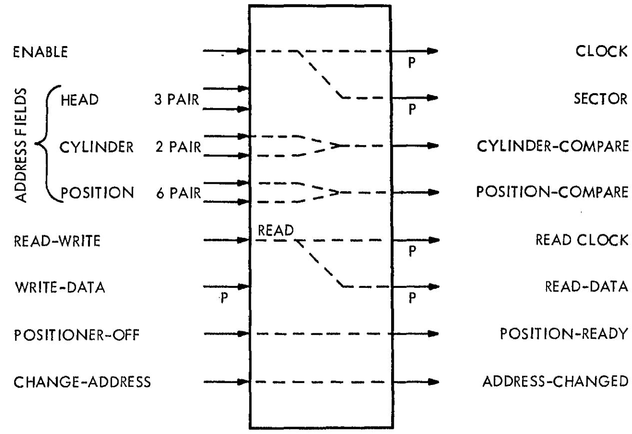


FIGURE XIX. THE dp/f-5101 DISCfILE UNIT INTERFACE

This section summarizes the interface characteristics of the dp/f-5101 DISCfILE unit. This contains the storage discs, heads, linear-positioner, power supplies and those circuits directly associated with operation of these elements. Normally it is part of a dp/f-5100 DISCfILE system.

## THE INTERFACE

Figure XIX illustrates the DISCfILE unit interface. An output signal is always the result of a previous input signal. This relationship is indicated by the broken lines on the figure.

The unit is selected by the ENABLE line. In the absence of this signal the other input signals are ignored and the output signals are gated off. In a multi-unit system there is an ENABLE for each DISCfILE and all other signals are fed on a common 34 wire bus.

The lines marked "P" are pulsed lines similar to those described in Figure XVIII. The remaining lines employ d.c. levels. A nominal six volts is the active state and zero is inactive. The address lines require $\pm 7$ mA, the other input lines -3 mA, and the output drivers will deliver $\pm 10$ mA. The transition time between levels should be less than one microsecond.

## OPERATING SIGNALS

An ENABLE is accepted and the output lines gated-on only when the heads are landed and the maintenance switches are in the operate position. The first CLOCK pulse is emitted within five microseconds after an ENABLE. It should be used by the control unit to determine that the selected DISCfILE is operable.

The CLOCK is a short pulse at the beginning of every bit time. SECTOR is signalled by four pulses, one bit time apart. The index-mark is on the same line but is eight pulses long.

The cylinder and position fields are stored by self-holding contacts on the dry reed switching arrays. Additional contacts set up the field comparators. The position and cylinder fields of the incoming address are always compared with the stored address. A match activates one or both of the COMPARE lines within five microseconds after an address change.

If the position fields do not compare, the POSITIONER-OFF line should be activated, provided that the positioner is not still in motion. This signal removes power from the positioner. The POSITION-READY is emitted in about 20 milliseconds when the current has decayed to zero.

CHANGE-ADDRESS should be sent either when POSITION-READY is received, or if the position fields compare and the cylinder fields do not. After about seven milliseconds the reeds are storing the new address and an ADDRESS-CHANGED is emitted. At this point the heads have been switched, but the positioner has just started to move. The new position must be confirmed before reading or writing data.

The control unit may disconnect after POSITIONER-OFF. It must be connected without changing the address between CHANGE-ADDRESS and ADDRESS-CHANGED. The position fields are compared at the latter time and if they do not compare POSITION-READY is re-activated and power is not applied to the positioner.

POSITIONER-OFF must be longer than five microseconds but may finish at POSITION-READY. This is terminated by CHANGE-ADDRESS, which should be from 1/2 to 1000 microseconds long. ADDRESS-CHANGED is two microseconds in duration.

The WRITE-DATA consists of a clock pulse for each bit which is to be written, plus another pulse at the mid-point of the bit-time for each ONE. When writing there should be a delay of 60 bits, then 30 ZEROS, then one ONE, and then the information. The delay starts with the end of the header address when writing data, and with SECTOR for headers.

When reading, everything is read and the control unit must gate out the undesired signals. A pulse is emitted on the READ-DATA line at the midpoint of the bit-time for each ONE.

The READ-WRITE line should normally be in the read state. It should be in the write state by one bit-time before WRITE - DATA starts and remain for three bits afterwards.

# GENERAL CONSIDERATIONS

This section applies to a single dp/f-5101 DISCfILE unit. In a system, the dp/f-5102 Control Unit is housed in one of the DISCfILE units.

## POWER

The unit should be supplied with 2.5 KVA, single phase a.c. at 230 volts $\pm$10%. Nominal voltages of 115 or 250 can be supplied. The frequency is either 50 or 60 cps $\pm$1 cps.

Power to each section of the unit may be switched selectively from the maintenance panel. Normal operation is controlled by two illuminated push-buttons.

When the unit is OFF, but power is supplied, the power push-button glows green. This changes to red when power is ON.

When the disc speed and air pressure are correct, the heads push-button glows blue and power is applied to the circuits. When the heads are landed, the color changes to amber. The heads are retracted if the disc speed or air pressure falls below tolerable limits.

## PHYSICAL CHARACTERISTICS

The unit is 42 inches (107 cms) wide, 31 inches (79 cms) deep, and 43 inches (110 cms) high. The table surface is 29 inches (74 cms) high. It weighs less than 1300 lbs. (600 kg).

Three feet (one meter) should be left above and in front of the unit for maintenance access. No access is needed to either the sides or the back.

Power and signal wiring enter the unit from beneath on the left. Three inches is allowed under the unit for surface floor wiring. Cooling air enters through the top at the back. The unit can be modified to accept air from a duct behind the back.

The frame round the glass panel and the visible internal metallic parts, such as the main supporting plate, are gunmetal anodized. The remaining surfaces are painted steel.

## ENVIRONMENT

The air temperature should be between 60°F and 85°F (15°C to 30°C). Relative humidity should be 20% to 80%. The elevation should be below 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.

During storage or shipment the unit should be sealed to prevent excessive penetration of dust, dirt or moisture. Apart from this, it can withstand any humidity and temperatures between -20°F and 150°F (-30°C to 65°C).

## FINAL TESTS

The equipment is functionally tested to ensure that its specified performance is achieved. It then undergoes a reliability check during which no maintenance is permitted. There must be no unrecoverable errors, and recoverable errors must be less than one per 100,000,000 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. Over 5,000,000,000 bits are transferred and the positioner moves 65,000 times.

## RELIABILITY

Provided that proper scheduled maintenance is performed the equipment should exhibit error rates far lower than those specified in the reliability check, and 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 life of the equipment.

Quality control and inspection are of major importance in the manufacture of DISCfILES. 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, using sensitive and precise optical and electrical equipment.

## MAINTENANCE

Maintenance problems are reduced by the small number of different circuit cards, components, and special tools which are required. Access is from the front. The heads swing out over the table surface and are cleaned without disconnecting them. The circuit modules roll out and are adjacent to the maintenance panel.

Recommended scheduled maintenance is 30 minutes per week, plus one hour per 100 operating hours. Unscheduled maintenance is unlikely to exceed an average of one hour per month.