X1215/16 (ABOVE SERIAL NUMBER 2000)

Cartridge Disk Drive Unit

Vol. III: Theory

PHILIPS Data Systems

This section deals with theory of the CDD block diagrams (figure 3-1 and 3-2) are referred to when explaining the actions during operation.
The relationship between the main blocks of the CDD and the interfacing principles employed for communication between the Control Unit and the CDD are described in detail.
The functions are described in conjunction with the logic diagrams present in Volume IV.

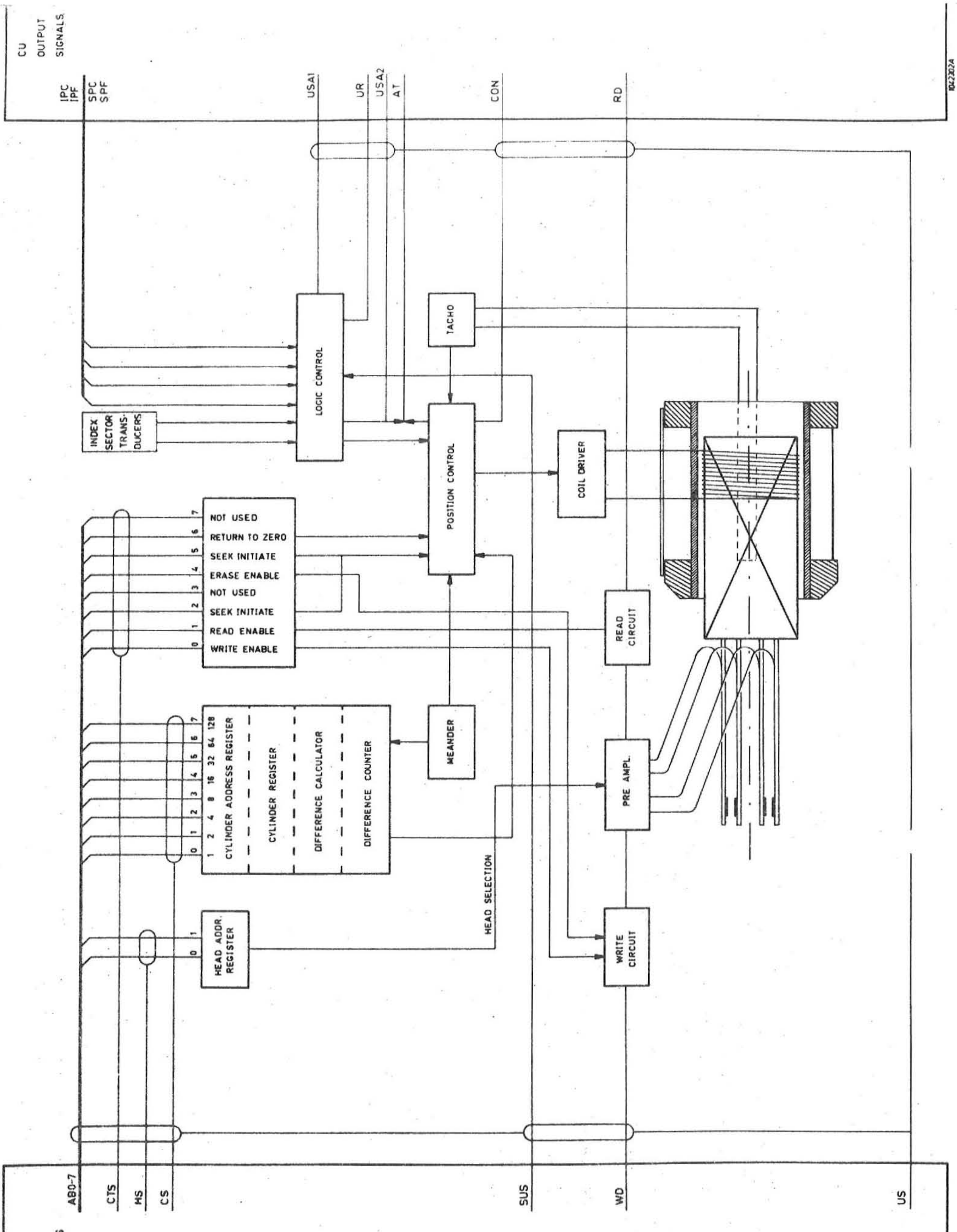


FIGURE 3-1 OVERALL BLOCK DIAGRAM

After the power has been switched on and the starting procedure initiated, some time elapses before the Cartridge Disk Drive (CDD) is ready. When the CDD is ready, the interface signal UR (Unit Ready) is made active. At such time, the Control Unit can select the CDD by means of the interface line US, (Unit Select). The Cylinder Select signal CS, together with the Address Bus lines AB0 through AB7 indicate the required cylinder address. The signal CTS (Control Select), together with signals AB2, AB5 or AB6 can initiate a seek action.

After the seek is finished, the interface signal CON (on-cylinder) is raised, indicating the heads are positioned on the selected cylinder.
At this juncture, a head is selected by the tag line HS (Head Selected), together with the interface bus lines AB0 and AB1. When the head has been selected, signal CTS is raised again, together with the interface lines AB0 and AB1, or AB4 to start data processing.

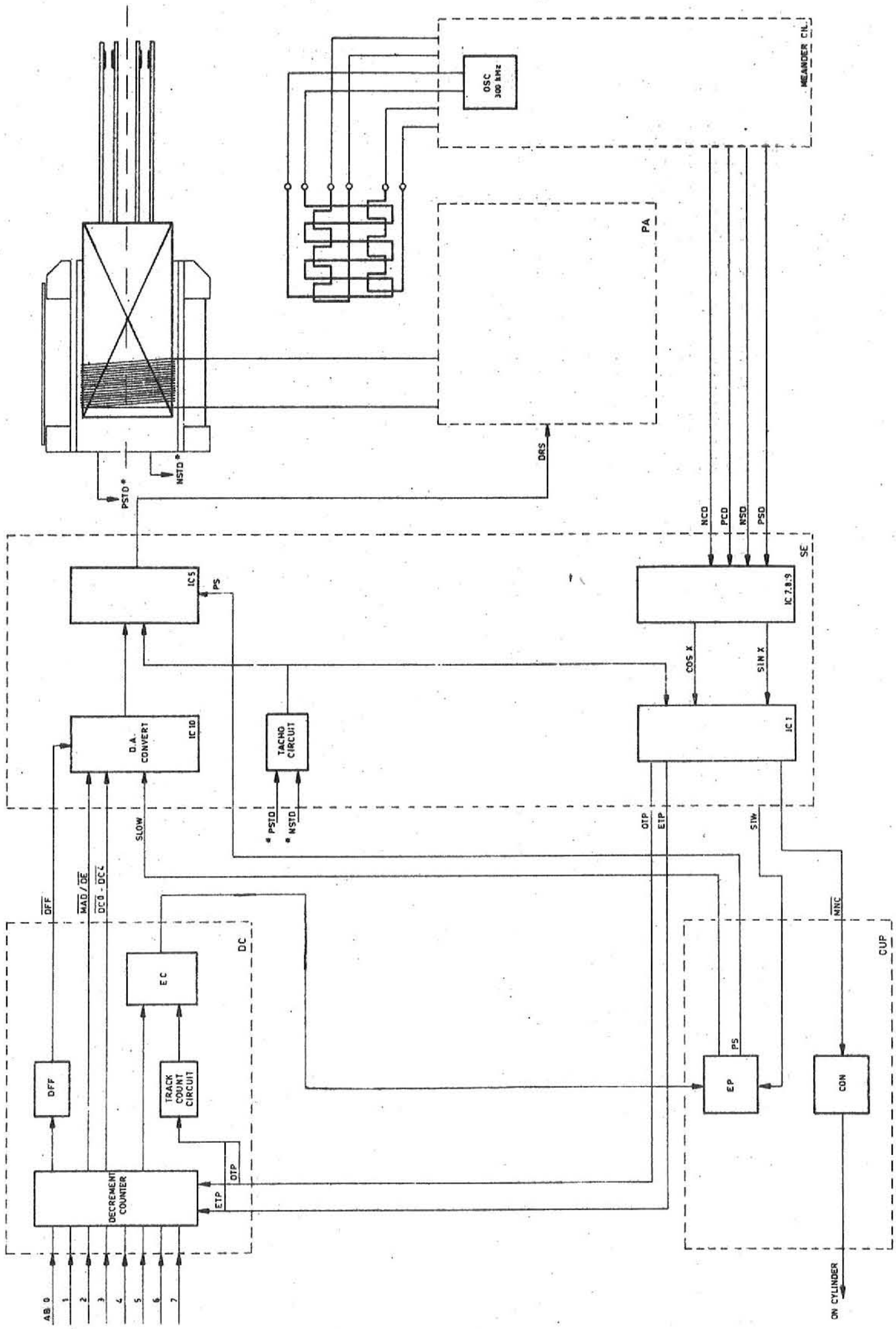


Figure 3-2 POSITION BLOCK DIAGRAM

Section 2 of this volume dealt mainly with the interface dialogue.
A more detailed description of the result of the dialogue is described here.

When the Cylinder Select command is received, the Cylinder Address register is compared with the Cylinder Register containing the last cylinder address. The result is stored either normally or inverted and sent to the Difference Counter.
Inversion only takes place if the direction of the seek is reverse.
The coil driver is activated via the Position Control logic and electronics. The current through the coil will move the head across the track until the Difference Counter has reached its pre-selected count. This count down is realised by the Meander circuit which gives a pulse for each track passed to step the Difference Counter.

Thirty-one or less cylinders before the selected cylinder the movement becomes controlled by the Difference Counter. The current is reversed and deceleration of the positioner ensues, following a pre-selected curve. The moment the count is reached, half a cylinder before the selected cylinder, the positioner is fully decelerated by a maximum current pulse. The control of the positioner changes from the Velocity mode to the Positioning mode, moving the heads to the track centre.
At this juncture, the interface signal CON is raised, enabling read or write actions to be performed.
The logic-control-block monitors all actions, detecting error or unsafe conditions.

Index pulses of the fixed disk are used to check the disk speed.
Other functions of the index and sector pulses are beyond the scope of this manual. All input and output interface signals (except the index and sector pulses), signal AT (Attention) and SUS (Set Unsafe) are gated with the selection signal US (Unit Select).

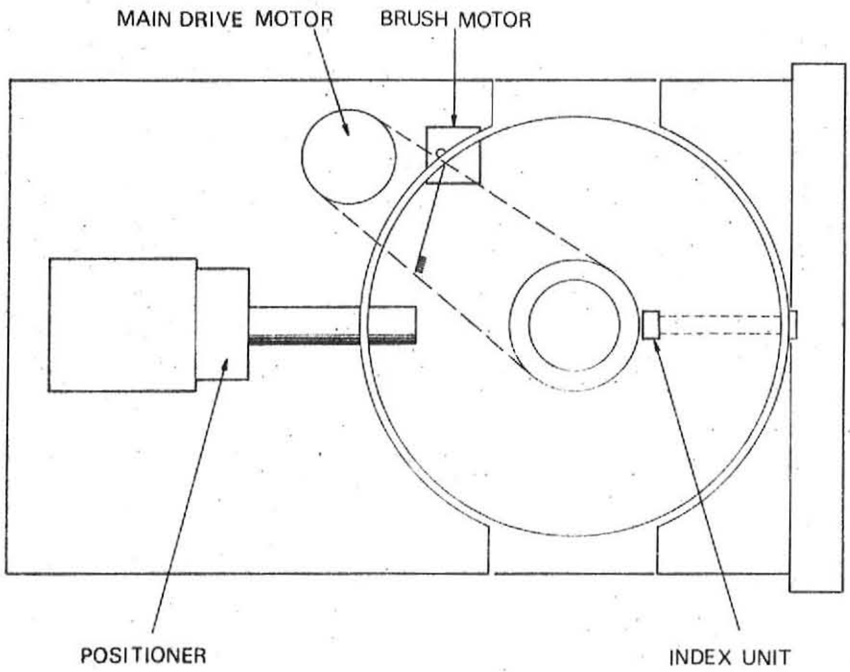


Figure 3-3 PRINCIPLE COMPONENTS

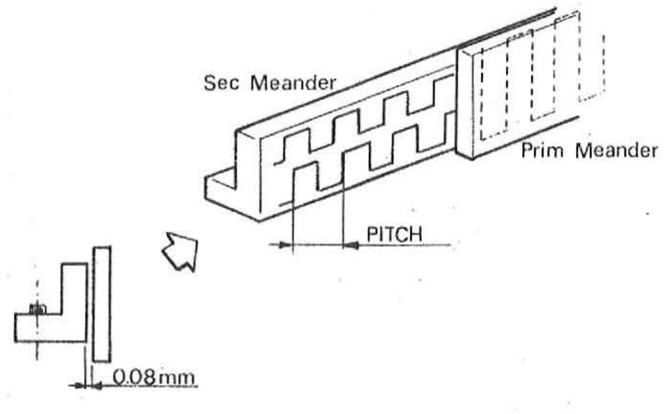


Figure 3-4 MEANDER TRACK PITCH

In the description of a normal Power-on and Start cycle a number of main blocks present in the cartridge disk drive are described.

4.1 MAIN DRIVE MOTOR

If a cartridge is placed on the disk drive and the unit started, the asynchronous main drive motor is started. A belt drives the spindle on wich the cartridge is placed. The fixed disk is kept in position at the lower part of the spindle and centre, if properly fixed, while the cartridge is mounted on top of the spindle.
Within sixty seconds of starting the main drive motor the cartridge will be revolving at its'nominal speed of 2400 rpm.

4.2 BRUSH MOTOR

2.5 seconds after the main drive motor is started, a timing signal activates a small low speed motor (about 300 rpm). This motor is geared down so that 3 revolutions of the motor occur during the remaining 20 seconds whilst four brushes sweep over the four surfaces during the Claining cycle.

4.3. INDEX/SECTOR TRANSDUCERS

For the fixed disk as well as for the cartridge a magnetic transducer is present which detects the slots in the index/sector ring of the cartridge and the index/sector of the fixed disk.
The latter ring is fixed to the spindle. In the electronics the detection of slots is transformed into logic pulses.

4.4. POSITIONER

Providing that the correct speed has been attained by the spindle, the unit starts the first seek so that the positioner moves inwards.
The positioner is one of the critical parts of the disk drive, and is balanced out to overcome vibrations and incorrect loading of the heads. The positioner incorporates a coil, a speed tranducer a prime meander circuit and the heads.
By sending a current through the voice coil in one direction, the carriage is moved in that direction.
When reversing the current the carriage movement is reversed.

4.5 SPEED TRANDUCER

The speed tranducer consists of a magnet fixed on the position arm, moving through the centre of a coil which is fastened in the positioner house.
The voltage induced in the coil is directly related to the speed of the positioner arm. This voltage is used to control the speed.

4.6 DISPLACEMENT PICK-UP SYSTEM

For measuring the displacement of the carriage a "meander system" is applied.
The meander consits of 2 printed cards. One card is mounted on the carriage and contains a coil which is printed in meander form on the card. This one is called the primary meander.
The other card is fixed on the base plate and contains two coils, which are printed, also in meander form. These are called the secondary meander A and B.

When the positioner moves, the prime meander passes the second meander. The pitch of the meander tracks is twice the track distance (figure 3-4). Alle tree meander circuits have voltages with a frequency of 300 kHz. The secondary meander voltages become modulated by the movement resulting in, after demodulation, a sine-wave and a cosine wave. These signals are sent to the positioner control and track count circuits.

4.7 TRACK ZERO INDICATOR

The track zero indicator is an opto- electronic device which is mounted on the base plate. When a "flag" which is mounted on the carriage passes the indicator, the logic output of the indicator is inverted. The output signal of the indicator, in combination with some other logic signals determines the position of track 000.

General

Several Cartridge Disk Drives may be connected to one Control Unit.
Each unit is selected by the interface signal Unit Select (US), and is connected to the Control Unit with an asymetrical cable, or with a coax-cable (2L00).
The principle of the interface is the so called "STAR TYPE".

5.1. LOGIC LEVELS

The "0" logic level shall be between 0V and + 0.8V
The "1" logic level shall be greater than + 2.4V (nominal +4.5V)
A signal with an inversion bar $(\overline{X})$ is active for a logic "0".
A signal without an inversion bar (X) is active for a logic "1".

5.2 INPUT SIGNALS

The interface input signals of the disk drive unit are:

a) Unit Select (USL)
b) Three tagline signals: Cylinder select (CS)
Control select (CTS)
Head select (HS)
c) Eight Address & Busline (AB0-AB7)
d) Set Unit Unsafe (SUS)
e) Write Data (WRDA)

5.2.1 Unit Select signal

With the Unit Select signal a certain disk drive can be selected.

5.2.2. Tagline and Address Busline

Although in principle data can be written on an arbitrary place of the disk surface, the data normally written on fictive concentric circles namend tracks.
The pitch of these tracks is determined by the meander system.
The CDD has a maximum of 204 tracks per disk surface. (408 for the X1216)
The normal procedure is that the control unit, by combination of tag line and address & busline signals, indicates on which track the heads should be, then selects one of the four heads and, when the heads are settled on the right place, gives write or read commands.
Figures 3-6 and 3-7 show how the various combinations of tagline signals and address & busline signals are interpreted by the disk drive unit

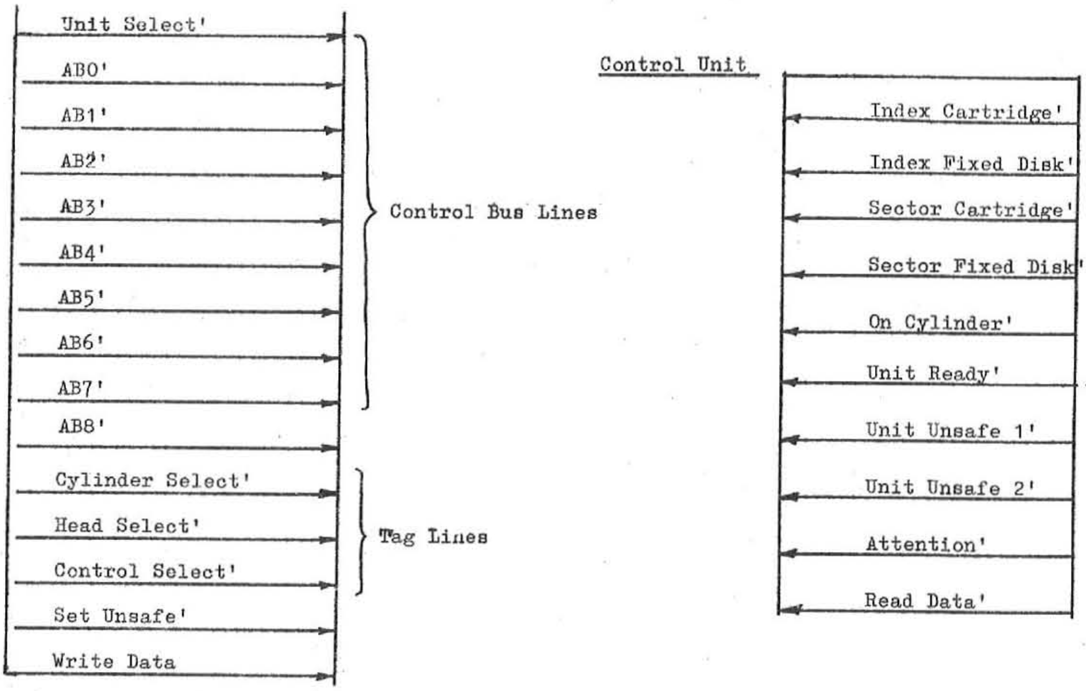


Figure 3-5 I/O INTERFACE

	Cylinder select signal active	Head select signal active	Control select signal active
Add. & Busline AB0 active	1	0/1	Write enable
" AB1 "	2	2/3	Read enable
" AB2 "	4	Not used	Seek initiate
" AB3 "	8	Not used	Reset unsafe
" AB4 "	16	Not used	Erase enable
" AB5 "	32	Not used	Seek initiate
" AB6 "	64	Not used	Return to zero
" AB7 "	128	Not used	Not used
" AB8 "	256	Not used	Not used

Figure 3-6 Tag and Control Bus Lines

Add. & Busline AB0	Add. & Busline AB1	Head Select signal	Selected Read nr.	Corresponding Disk surface	
Not active	Not active	Active	0	upper	cartridge
Active	Not active	Active	1	lower	
Not active	Active	Active	2	upper	fixed disk
Active	Active	Active	3	lower	

Figure 3-7 Head selection

Remark: The combination of Address & Busline signals and the Cylinder Select signal indicates the new track to which the haeds should go.

Example
A seek to cylinder 50 is executed and a read enable command is given for the lower head of the cartridge.

Cyl. Select

Head Select

Control Select

AB 0

AB 1

AB 4

AB 5

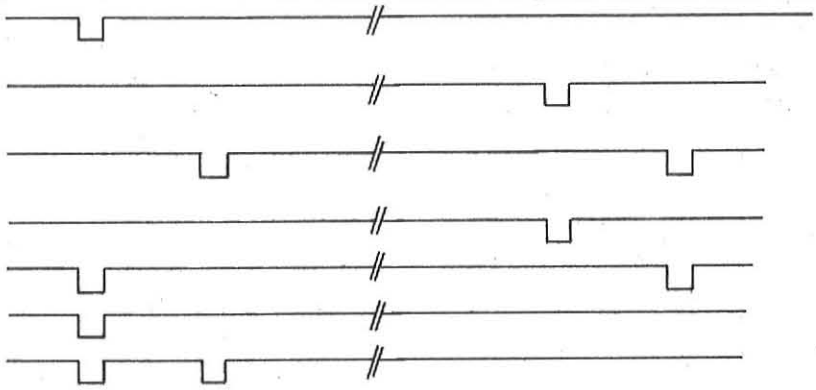


Figure 3-8 Seek to cylinder 50

logics.
An example explains the use of these lines clearly (Fig 3-8)

5.2.3 Set Unit unsafe.

This command can be given by the Control Unit in case of power failure of the Control Unit.
The CDD turns to the unsafe 2 mode, which means that the heads are retracted and the write electronics are disabled so that no damage either to Disk Drive Unit or data can occur.

5.2.4 Write Data

The write data signal consists of serialized data to be written on a disk surface.
Fig. 3.9 shows a write data signal.

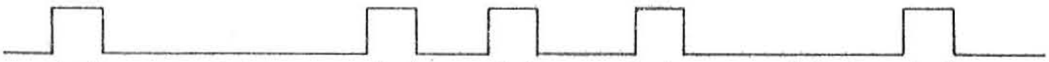


Figure 3-9

a) Duration of both clock and data pulse (if present) - 100 nsec
b) Time between a clock and data pulse - 100 nsec
c) Duration of a bit cell - 400 nsec
A bit cell is the area between the beginning of a clock pulse and the beginning of the next clock pulse.

5.3 OUTPUT SIGNALS

The output interface signals of the disk drive unit are:

a) Index Signal Cartridge (IPC)
b) Index Signal Fixed Disk (IPF)
c) Sector Signal Cartridge (SPC)
d) Sector Signal Fixed Disk (SPF)
e) On Cylinder (CON)
f) Unit Ready (UR)
g) Unit Unsafe 1 (USA1)
h) Unit Unsafe 2 (USA2)
i) Attention (AT)
j) Read Data (RDDA)

5.3.1 Index Pulse Cartridge Fixed Disk.

Once per revolution, an index pulse becomes active at the moment the index slot passes the index and sector transducer.
This pulse provides the physical beginning of each track and is not gated with the unit select signal.

5.3.2. Sector Pulse Cartridge (Fixed Disk)

Each time a sector slot passes the index and sector transducer, the beginning of a new sector is signalled.
With the aid of sector pulses a track can be divided into pieces.
This signal is not gated with the Unit Select signal.

Note: There is no relation between the index/sector signals of the cartridge and the index/sector signals of the fixed disk.

5.3.3 Unit Ready signal

The activation of this signal indicates that the CDD is ready to operate, that is to say it is ready to receive instructions and to transmit such output signals as are not gated.
This signal becomes active when:
- a cartridge has been inserted,
- the disk has attained a speed of 2400 rpm, nominal,
- when the heads are loaded for the first time, and the drive is completing the first seek.
The signal is deactivated when the operator stops the driver.

5.3.4 On Cylinder

This signal, when active, indicates that the heads are positioned and the seek operation is finished. The unit can accept read/write or another seek command.

5.3.5 Unit unSAfe 1

This signal becomes active when the positioner drifts away from the correct track position. In this situation the unsafe 1 procedure is entered and the following series of actions are carried out:
- write protection is set,
- the heads are returned to track 000,
- the unsafe 1 signal is set,
- when the heads are at track 000 an Attention signal is sent.
The Unsafe 1 signal can be reset by issuing a Return To Zero command or, by using a Reset Unsafe command (optional).

5.3.6 Unit UnSafe 2

When the Unit unsafe 2 signal becomes active it indicates that an unsafe procedure has been carried out as result of one or more of the following conditions occuring in the CDD:

1) there is write current but no erase current,
2) there is erase current but no write current,
3) there is write and/or erase enable when the heads are not on cylinder,
4) there is write and/or erase enable at the same time as there is read enable,
5) there is alternating write current in only one half of a head coil,
6) more than one head is selected,
7) the heads pass the minus 001 track position, traveling in the retracting direction, without the CDD stopping,
8) the speed of rotation of the disk is incorrect,
9) an emergency brake is applied as a result of one of the following conditions:
   a. the positioner speed exceeds a specified maximum,
   b, the seek time is too long,
   c, mains power is not present,
   d, D.C. voltages + 12V, - 12V and + 5V are not present,
   e, the Set Unsafe signal is active.

The above listed conditions cause the Set Unsafe 2 procedure to be entered if they persist for a period in excess of the following times:

conditions 1 and 2: 60 usec
all other conditions: 0,1 usec.

The unsafe 2 procedure involves, in the sequence given, the actions shown below:

- the Unsafe 1 signal is set
- write protect is set after maximal 150 usec.
- positioner, if moving, is slowed down
- heads are returned to the retracted position.

The setting of the Unsafe 2 signal results in the setting of the Attention signal.
The Unsafe 2 signal may be reset only by stopping and restarting the Disk Drive Unit.

5.3.7 ATtention.

The activation of the Attention signal will indicate to the Control Unit that a change of positioner status has occured within the Disk Drive Unit. The signal is activated in three situations, these being:

1. When a seek operation has been completed, including a seek to zero,
2. when the Unsafe 1 signal is activated,
3. when the Unsafe 2 signal is activated.

The Attention signal will remain active until the operator switches off the Disk Drive Unit or until either a read enable command is given or a seek is initiated. A seek is initiated when:

- a seek command is given,
- a return to zero command is given,
- an unsafe 1 condition exists,
- an unsafe 2 condition exists.

The Attention signal is not gated by the Unit Select signal.

5.3.8 Read DAta

The Read Data line is used to transmit recovered read data from the Disk Drive Unit to the Control Unit. The data consists of a stream of serialised bits.

6.1 SERVO SYSTEM

The servo system is used to position the heads at required cylinder and to maintain this position. Functional parts of the system are:

1. the voice-coil.
2. The Power Amplifier (PA).
3. The Servo Electronic
4. the meanders
5. the speed transducer
6. the track zero indicator
7. the logic control

In this Servo System two different control loops give the possibility of directing the heads and maintaining them in position.

1. The speed servo loop.
   Is active during a seek and moves the heads in the neighbourhood of the end position resulting in a low the end position resulting in a low final speed.
2. The position servo loop.
   Is active when the heads are naer the desired cylinder to locate and maintain them in this position.

6.2 VELOCITY AND ACCELERATION

When re-positioning over 64 tracks or less mainly acceleration and deceleration forces are used. The friction force will be ignored in order to position over any distance in the shortest possible time. In the first part of the movement a maximum acceleration is needed, in the second part a maximum deceleration is needed.

The velocity curve is as follows.

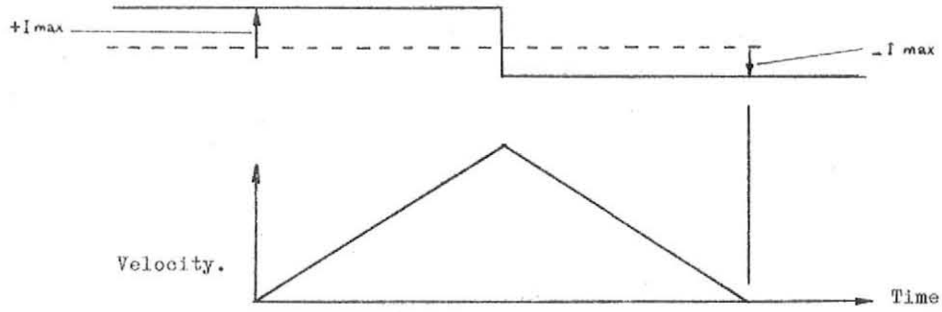


Figure 3-10

When the movement will be more than 64 tracks a flat top is made in the velocity curve, during this period there is no dissipation in the voice coil. A slight increase in the random access time results from this measure.

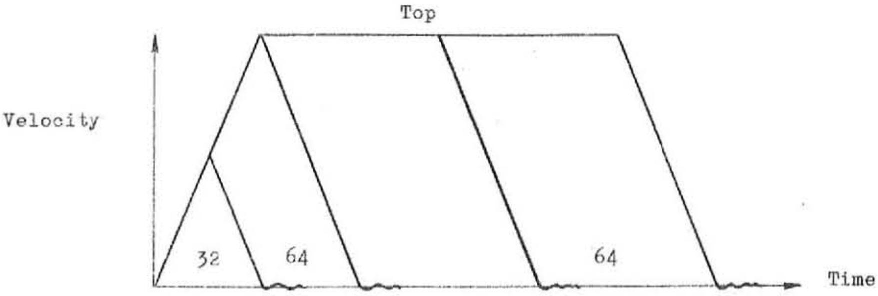


Figure 3-11

The flat top is made in suc a way that with a maximum count, usually 200 cylinders to travel, the maximum velocity will be reached within the first 32 cylinders.

6.3 MEANDER SYSTEM

The meander system consists of two printed cards (figure 3-12)

1. Primary, which is mounted on the carrige and c ntains one coil in a meander form.
2. Secondary, fixed on the base plate and containing two meander forms A and B on the card.
   The meander forms A and B are shifted half the track pitch from each other.

When the carriage moves the primary meander passes along the secondary meander.
The pitch of the meander "t" is twice the track distance. The clearance between the meanders 0.08 mm. The primary meander is fed with a 300 khz. sine wave voltage. In the secondary A and B meanders the induced sine wave is amplitude modulated. The amplitude on the position of the primary with respect to the secondary meander.

Throughout, the amplitude depends on the cylinder positioning. The output voltages are demodulated into the signals sin X and cos X on the meander card.

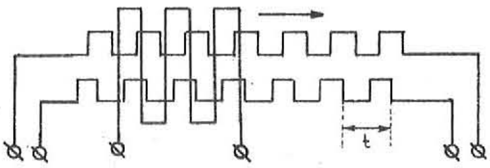


Figure 3-12

6.4 VOICE-COIL SYSTEM

The required acceleration and decelaration forces are generated with a voice-coil system. The voice-coil is mounted on the carriage and is rectangular in form.
The short voice-coil can move in a long magnetic field.
Depending on the direction of the current through the voice-coil it is accelerated or decelerated.

The current through the voice-coil is determined by the Power Amplifier by means of a feedback system.
The Power Amplifier consists of two parts:
a)The Power Amplifier card which is mounted in the electronic cage.
b)A power stage, driven by the Power Amplifier card in turn driving the voice-coil.
  The transistors of the power stage are mounted on heatsinks at the rear of the disk unit.
The Power Amplifier card obtains its input from form card SE.

6.5 SERVO OPERATIONS

To generate a required speed.
The number of cylinders which have to be passed during a seek is stored in the Difference Counter, DCO-DC7.
During the seek this counter is decremented by one each time a track is passed, this is done by the count pulses derived from the SINX and COSX meander signals.
The 5 least significant bits of the DC counter, DCO - DC4, are connected to a digital / analoque concerter, which converts the contents of DCO - DC4 into an analoque value. DCO - DC4 are only active if the contents of DC is less than 32, in other cases the output of DA is set to maximum by the signal $\overline{\text{MAD}}$.

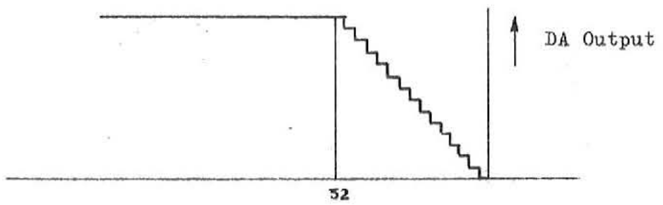


Figure 3-13

The D/A conventer output voltage represents the required speed of the positioner as a function of the position. (When the contents of the difference counter is greater than 32 the voltage will be increased by an extra voltage produced by the signal DE/(MAD).

Figure 3-15 shows that the speed may be high if the distance is far from the final position and, when the final position is approached the required speed decreases. (V is added to shorten the positioning times over long distances).

The non-linear form of the "deceleration curve" is determined by the requirement that the deceleration must be constant during the deceleration of the positioner.

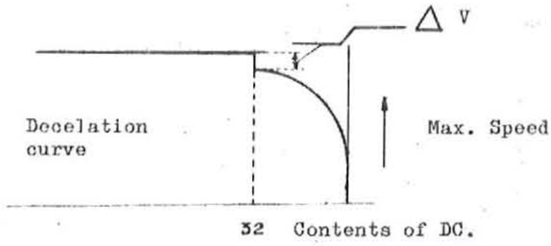


Figure 3-14

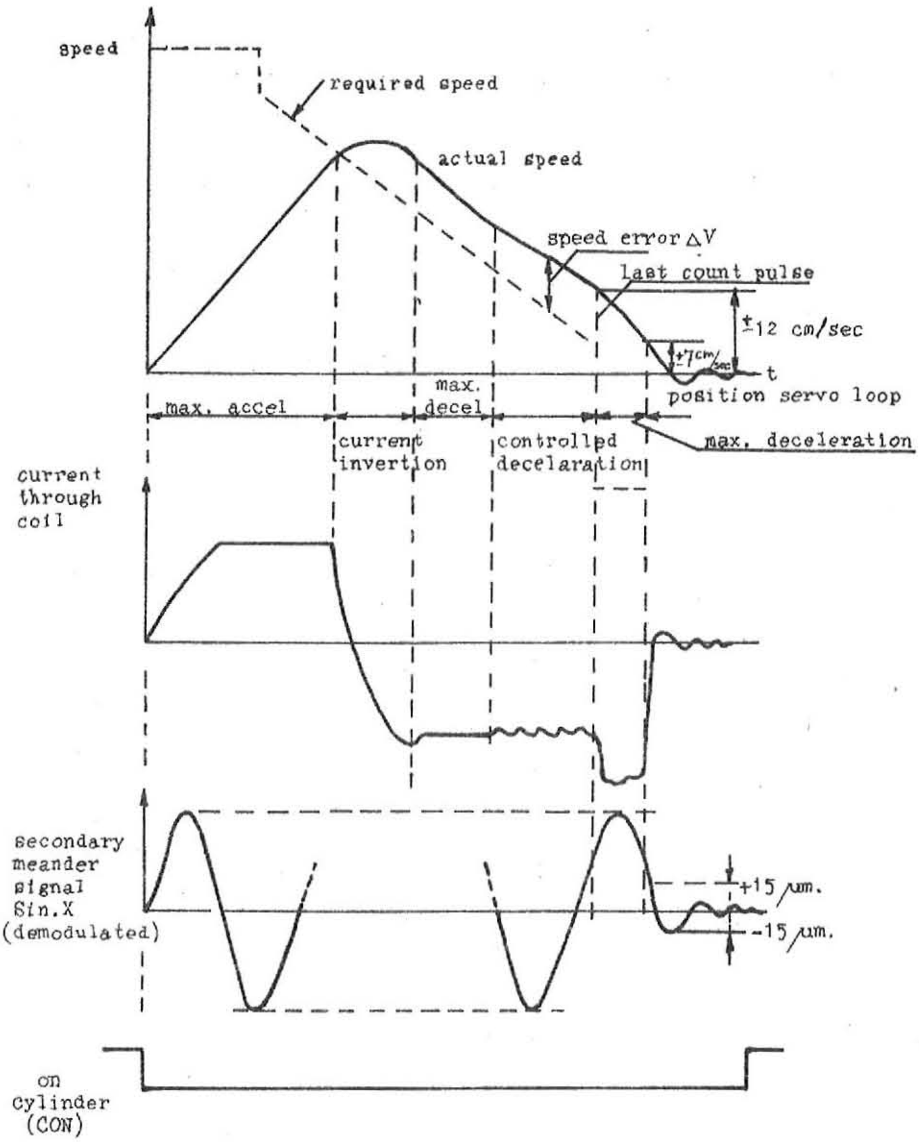


Figure 3-15 VELOCITY DIAGRAM

The actual speed is compared with the required speed. The actual speed is measured by the speed transducer. The difference in voltage between actual speed and required speed drives the Power Amplifier.
As the servo system is a closed (feedback) system, the servo system ensures that the difference between actual speed and required speed is as small as possible.

Actions during a seek.

1. The speed servo loop will be switched with the signal PS.

2. The big difference between the required speed and the actual speed causes maximum acceleration of the positioner.

3. When the actual speed equals the required speed the current is inverted in the case of a seek of less than 64 tracks.
   In the case of a seek over more than 64 tracks the voice-coil current will be approximately 0 during the flat top of part the velocity curve. Thirty two tracks before the required position the current is inverted.

4. The time necessary to invert the voice-coil current is relatively high so, after inversion of the current, the required speed will already have decreased slightly. Therefore, the positioner will have maximum deceleration for a short time; until the required speed is reached.

5. After the required speed is reached the deceleration will be controlled by the required speed.

6. At the moment that the last count pulse OTP or ETP appears, half track distance before the final position, the actual speed will be approximately 12 cm/sec., independent of the distance covered.

7. A short period of maximum deceleration will follow, produced by the signal MAD.

8. When the actual speed is less than 7 cm/sec., indicated by the signal SIW, the signal PS will activate the position servo loop.

9. The exact position of the heads with respect to the track centre is indicated by the SINX signal.

10. The voltage level indicating the distance from the track centre is proportional to the distance change, and is fed to the servo system.

11. The servo system locates the positioner on the track centre. When it is settled within 10 µm. of this centre after some delay (1.5msec) the "On Cylinder" signal appears.

6.6 POSITION SERVO LOOP

The position servo loop is initiated less than half a track before the desired cylinder.
Half a track before the desired cylinder maximum deceleration of the positioner is produced by the signal MAD. When the speed has fallen to a certain level the signal SIW sets and causes the servo system to enter the position servo loop.
In the position servo loop the distance between the momentary position and the track centre is measured and converted into a voltage (SINX).
This voltage is fed to the power amplifier which, in turn, drives the positioner to the track centre.
Because this would result in an undamped vibration around the track centre a differentiating circuit is added to provide the necessary damping.

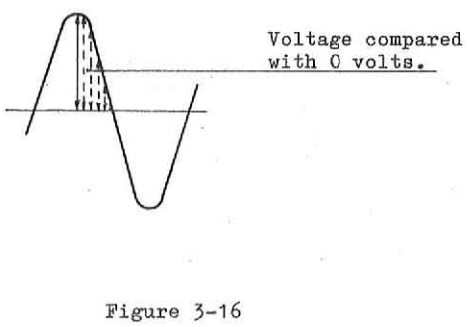


Figure 3-16

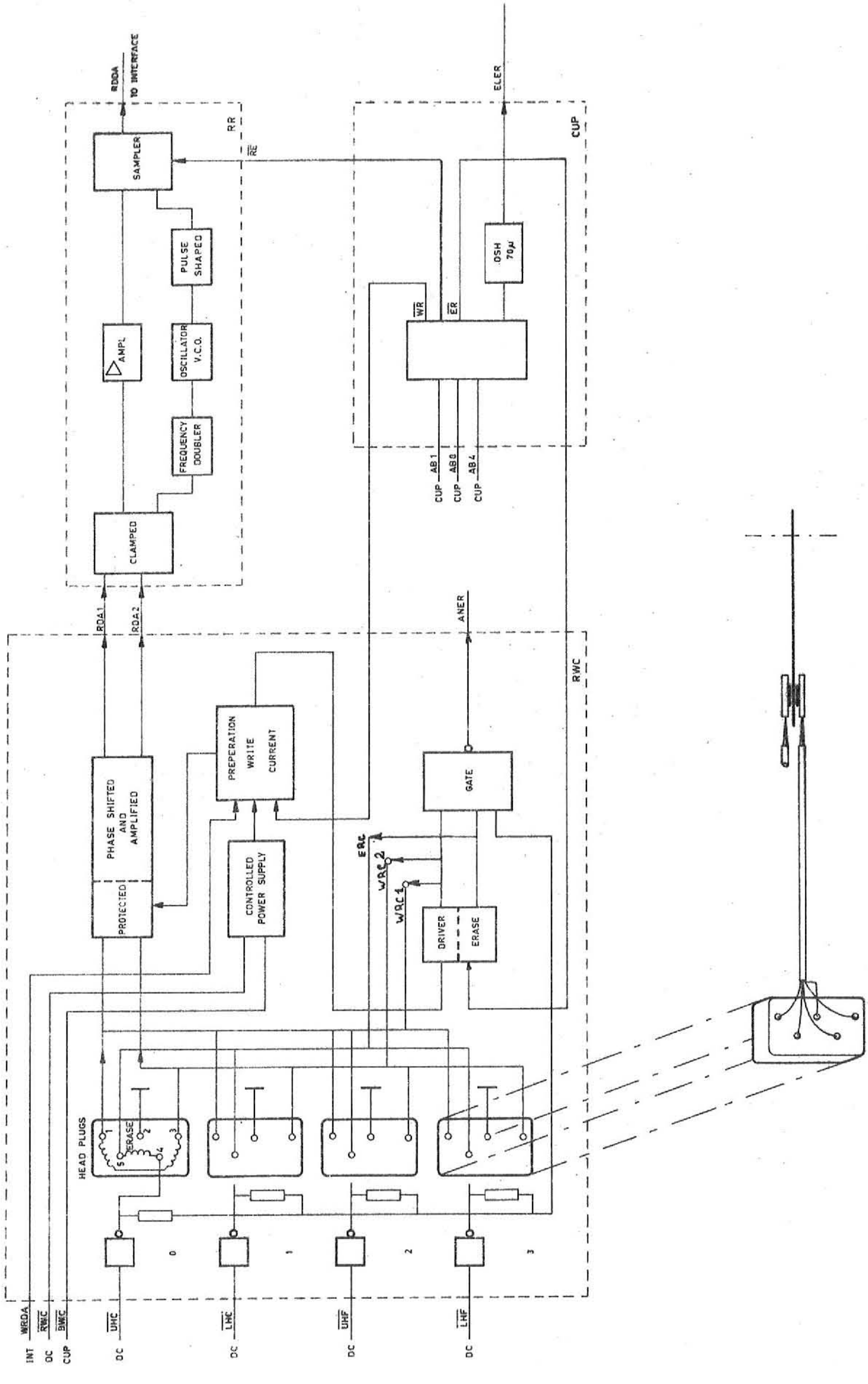


Figure 3-17 READ/WRITE

6.7 ADDITIONAL CONTROL SIGNALS

To reverse the direction of movement the output of the DA converter is inverted by the signal $\overline{DFF}$ (Direction of Force Forward).

For special seeks (return to zero, reverse to retracted) the DA convertor is kept on a low level by the signal SLOW.
The positioner then moves with a speed of 10 cm/sec.

Because the displacement voltage is a sine wave as a function of the position, signal SINX has to be inverted if the positioner is located on an odd numbered track. In that case the logic signal SPE (Select Positive Edge) is inactive.

6.8 WINDOW FUNCTIONS

The servo electronics issues several logic signals according to the analogue situation.
These functions are performed by windows and comparators.
A window is looking at the absolute value of its' input voltage and delivers a logic signal when the input voltage exceeds a certain level, called the threshold level.

A comparator only looks at the sign of the input voltage. When the input is positive it delivers a logic "0" and when the input is negative it delivers a logic "1".

Window signals are:

- SIW (Speed In Window), sent to the control logic which, in turn, gives PS. The threshold levels are set to equal a speed of approximately 7 cm/sec.
- ETP (Analoque signal SINX in window). Threshold levels indicate a displacement of approximately 15 μm.
- OTP (Analoque signal COSX in window). Threshold levels indicate a displacement of approximately 15 μm.
- $\overline{MNC}$ (Mechanical on Cylinder). The speed voltage is amplified and applied on a very small window indicating a speed 1.2 cm/sec.
  The displacement voltage is applied to small window indicating 10 μm. (approximately).
  The outputs of both windows are combined in such a way that $\overline{MNC}$ is active when both speed and displacement are in their windows.

6.9 RECORDING PRINCIPLES

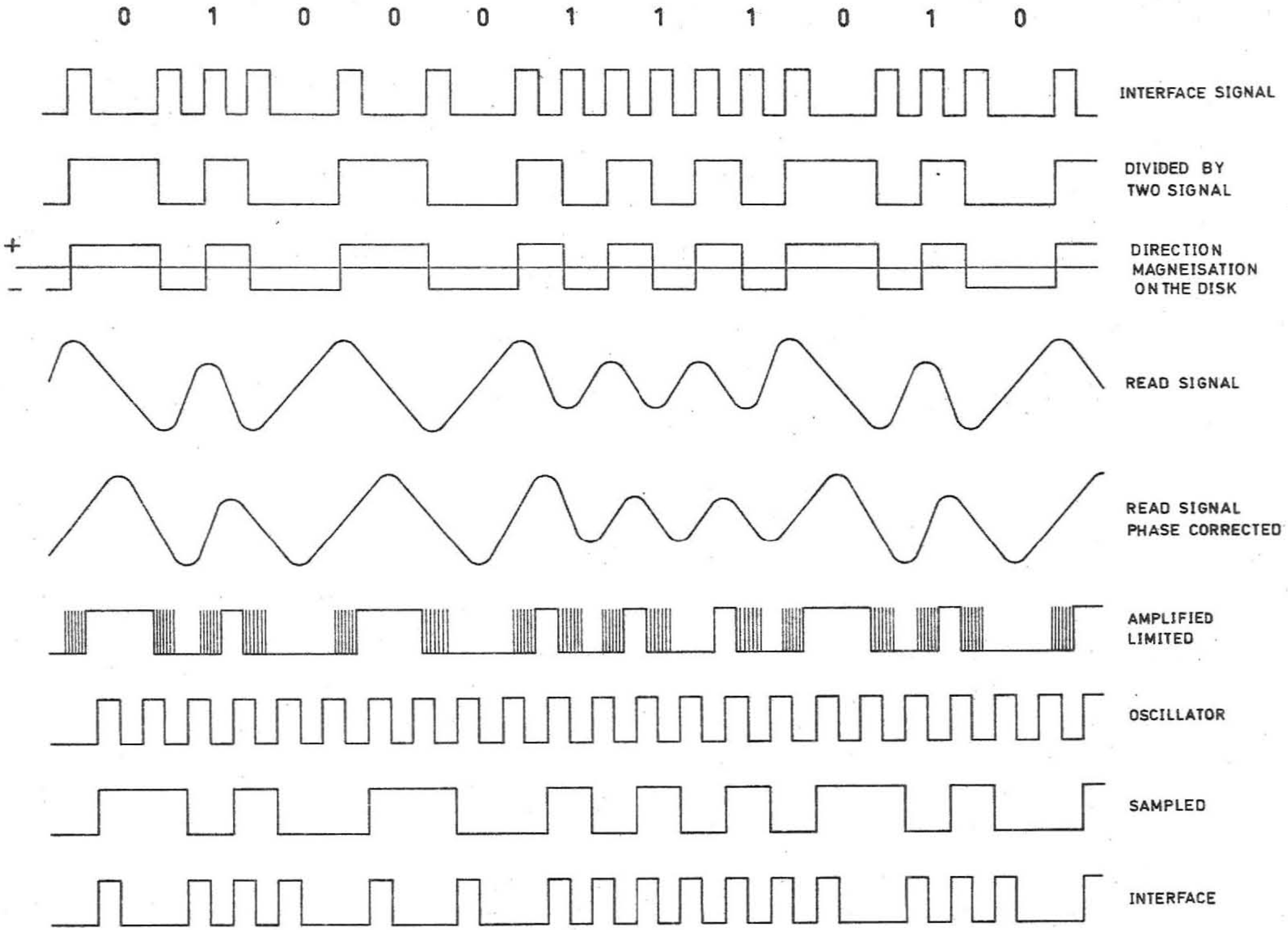
The change of the magnetic field in the head from one direction to the other produces the directional field changes on the magnetic disk. The current through the coil will never stay zero while writing is taking place, but is always maximum one way or the other ('non return to zero' principle). A binary 'one' is identified by two pulses in a bit cell period and a binary 'zero' by one pulse during a bit cell period (one magnetic change on the surface). The frequency for recording a 'zero' is 1.25 Mhz. and for a 'one' it is 2.5 Mhz.

6.10 WRITE OPERATIONS (Figures 3-17 and 3-18)

Information can be written on the disk by sending a current through one or the other half of the read/write coil of the selected head.
Because of this current the magnectic coating of the disk is magnetised on that particular place in one or the other direction, depending on which half of the head coil the current is flowing in.
The written track is narrowed by an erase gap to prevent track overlap.
Before writing can be initiated one of the heads must be selected.
By activating the interface signals ABO and CTS, the signal WR (write enable) becomes active. By activating the signals AB4 and CTS, the signal ER (erase enable) becomes active. Because the erase gap is physically behind the read/write gap, there is, for proper operation, some delay between the activating and deactivating of the signals WR and ER.
When the signal WR is active, information can be written on the disk.
This information, on the interface line, consists of clock pulses and data pulses, which, in the disk drive unit, are "divided by two".
The "divided by two" signal is written on the disk: One logic state of the signal corresponds with the current through one half of the head coil, the other logic state corresponds with the current through the other half of the head coil. See also figure 3-18.
Fig. 3-27 shows a flow diagram of head selection and write operation.

When writing on tracks 128-203, (256-406), the write current is reduced because of the higher density of flux reversals on the inner tracks. The logic signal RWC (reduce write current) activates this reduction.

Figure 3-18 WRITING/READING/RECOVERING

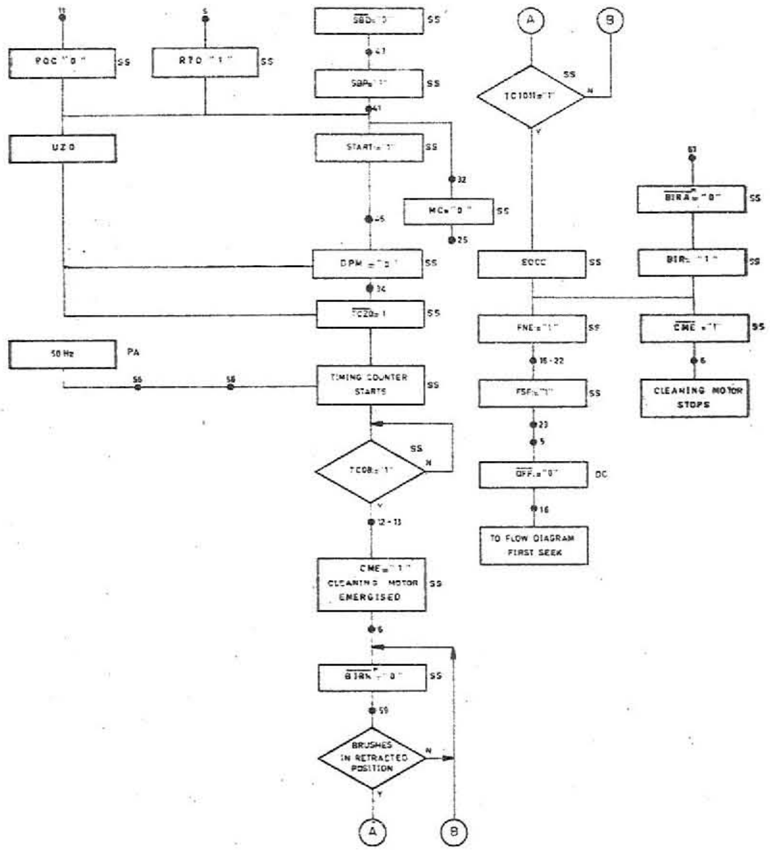


6.11 READ OPERATION (Figures 3-17 and 3-18)

The same head coil is used for writing, and reading.
When reading, every reversal of magnetic flux direction induces a voltage in the read/write coil. In the read pre-amplifier a 90° phase-shift of the head signal takes place. In this way zero-crossings of the signal correspond with magnetic flux reversals, and peak detection can be adopted. Before phase-shifting the head signal is amplified (150 x). After phase-shifting the signal is amplified another 100 times. The signal is then sent to the Read Recovery card and limited.
Realising that mechanical actions are involved, a circuit is incorporated to stabilise the jittering pulses received from the head.
An oscillator circuit of twice the highest received frequency (2.5 MHz) used to sample the incoming pulses in the following way.
The oscillator circuit consists of a frequency doubler, and a resonant circuit tuned for a frequency of approximately 5 MHz. The frequency doubled input pulse, initiates, via a transistor, the resonant circuit. The output of the voltage controlled oscillator circuit is amplified and mixed with the input data signal for sampling.
The sampled data pulse has the frequency of the input signal and the stability of the oscillator circuit used.
A one-shot with a pulse-width of 100 ns, generates a pulse on any data transition for the required interface signal RDDA (Bit Cell configuration).

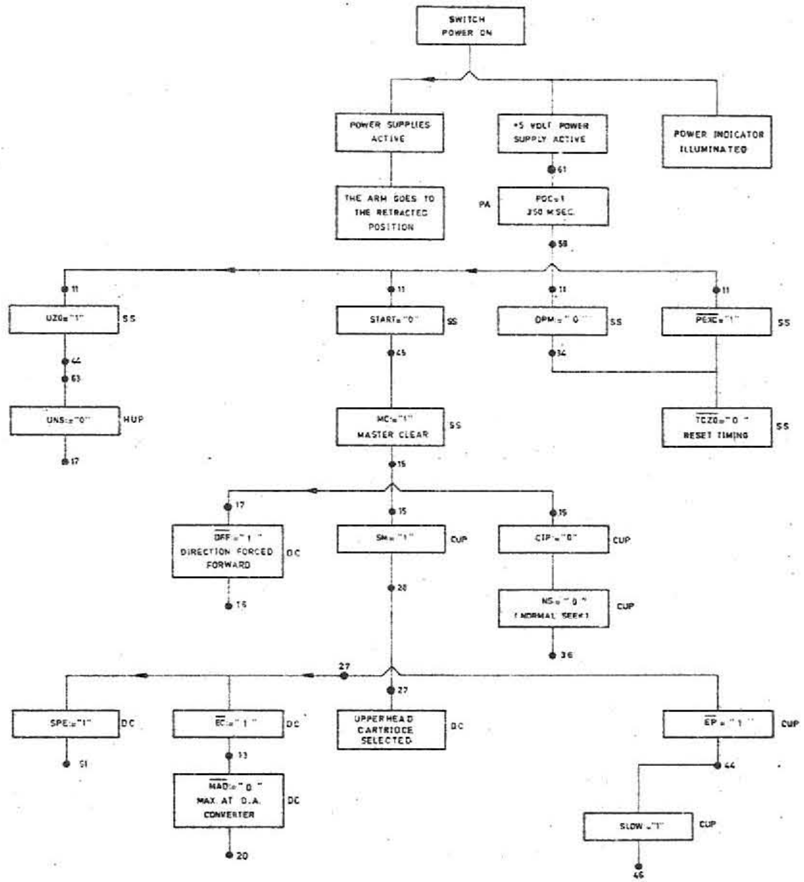
6.12 READ/WRITE PROTECTION

As the storing of data on the disks is very important checks are incorporated in the read/write electronics to ensure the proper operation of the read/write actions. As soon as a check becomes active, the write channel is blocked.
The write channel is blocked when
a) There is write current and no erase current during more than 60 µsec.
b) There is erase current and no write current during more than 60 µsec.
c) More than one head is selected.
d) Read and write enable or erase enable at the same time.
e) Alternating write current in only one half of a head coil.
f) Read enable, write enable or erase when the positioner is moving.



START

Figure 3-20



POWER ON

Figure 3-19

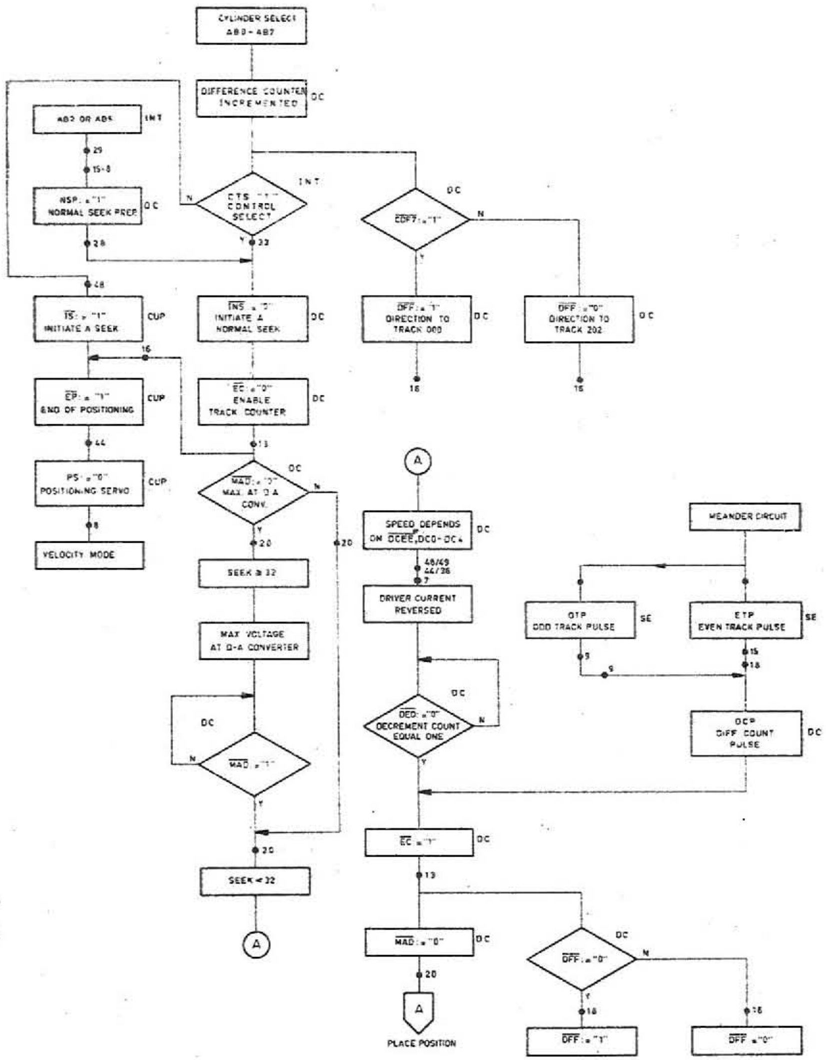
The following paragraphs describe in detail the logic operation of each of the functional elements. The descriptions are generally divided into different parts, reflecting the primary functions. The functional diagrams in Volume IV should be used in conjunction with this section.

7.1 POWER ON (Figure 3-19)

By switching the Power button at the rear of the disc-unit, the power-indicator will light, the positioner goes to the retracted position and the power supply becomes active.
When the power supply is active, the signal POC (Power On Clear) is "1" for more than 60 ms. This signal resets the flip-flops UNS (Unsafe), EPM (Energise Pack Motor) and Start. The relay which connects the electronic brake to the main drive motor is energised as well as the lock magnet which holds one of the clamps and the positioner block magnet. The signal POC sets the flip-flop PEXC (Preparation Exchange of the Cartridge).
POC resets the flip-flop UNS (Unsafe report flip-flop) by way of UZO and the flip-flop START by way of SZO and produces the signal MC (Master Clear) which has the function of clearing the unit. It resets the flip-flop DFF (Direction of Force Forward) and the flip-flop CIP (Cartridge In Pack) which resets the flip-flop NS (Normal Seek). The signal MC sets the flip-flop SM (Slow Motion) and the SPE (Select Positive Edge) becomes a '1'. Also, the flip-flop EC (Enable Count) is reset and the signal $\overline{\text{MAD}}$ (Maximum at DA converter) becomes a '0'. The flip-flop EP (End of Position) is reset by the signal SM which sets the signal SLOW to a "1".
The Head Selection register flip-flops H0 and H1 are reset by signal SM, which means that the upper head of the cartridge is selected.

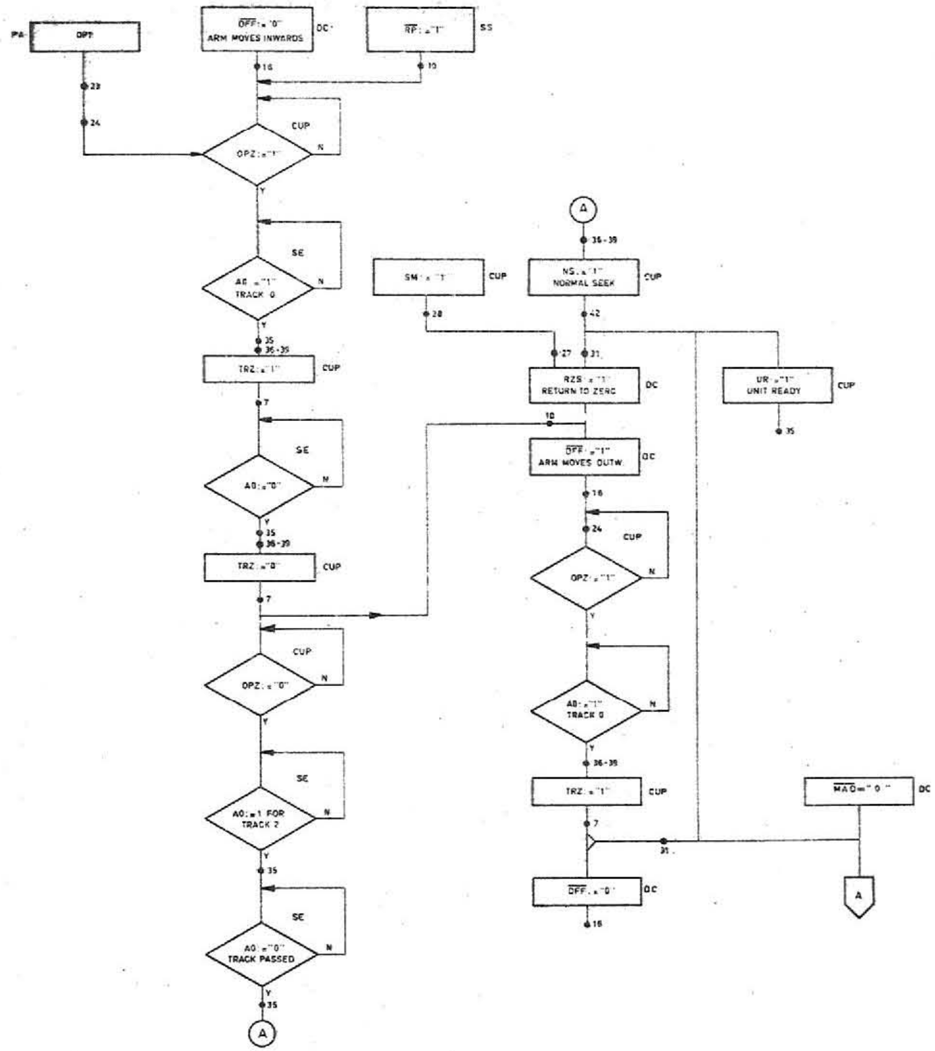
7.2 START (Figure 3-20)

Two micro-switches ensure that the X1215 cannot be started when a cartridge is not present or when the cartridge loading sequence has been incorrectly implemented, and to check that the two clamps are closed.
They are connected in parallel to, effectively, form an OR gate. The logic checks that these switches are closed before permitting the X1215 to be started.
When one or two of these switches are open, the signal RTO (Ready To Operate) is not produced and the flip-flops Start and Unsafe cannot be set.
When the cartridge is correctly loaded, the micro-switches are closed and signal RTO is active to remove the block on the start circuit.
By operation of the Start/Stop button on the Operators' panel, the signal SBP (Start/Stop Button Pressed) becomes a '1'. The flip-flop START is set and the signal MC (Master Clear) is removed.
The $\overline{\text{POC}}$ (Power On Clear) signal reset the flip-flop DPM (De-Energise Pack Motor) to start the pack motor. The signal TCZO is removed to allow the Timing Counter (TC) to function by the 50Hz signal.
The Timing Counter is stepped by each clock pulse input. The counter starts with TC0 and steps through TC08 (2.5 sec.).
When the Timing Counter reaches stage 8 (TC08 is a '1'), the flip-flop CME (Cleaning Motor Energised) is set which will start the brush motor. The brushes go inside the pack and open a micro-switch which is connected on the brush arm. The signal BIRN (Cleaning Brush In Retracted Not Active) becomes a '0'. While the Timing Counter is being stepped to stage 11 (TC1011 is a '1'), the brushes move in and out of the pack in a cleaning action several times. Each cleaning action operates the micro-switch, effecting the signals BIRN and BIRA. When TC1011 is a '1' (after 30 sec.), it sets the D-type flip-flop EOCC (End of Cleaning Cycle). Some time later the signal $\overline{\text{BIRA}}$ (Brushes in Retracted position) becomes a '0'. The signals EOCC and BIR both being a '1' removes signal CME which stops the cleaning motor. When the signal $\overline{\text{TC1112}}$ (after 60 sec.) becomes '0', the signal ESSC (End of Start/Stop Cycle) becomes a '1' and the D-type flip-flop PEXC (Preparation Exchange of Cartridge) is reset and signal $\overline{\text{PEXC}}$ sets the flip-flop FNE (First Seek Normal End) and the signal FSF (First Seek Forward) becomes a '1' which activates the positioning by inhibiting the signal RET.
The signal FSF sets the flip-flop DFF (Direction Forced Forwards).



NORMAL SEEK

Figure 3-22



FIRST SEEK

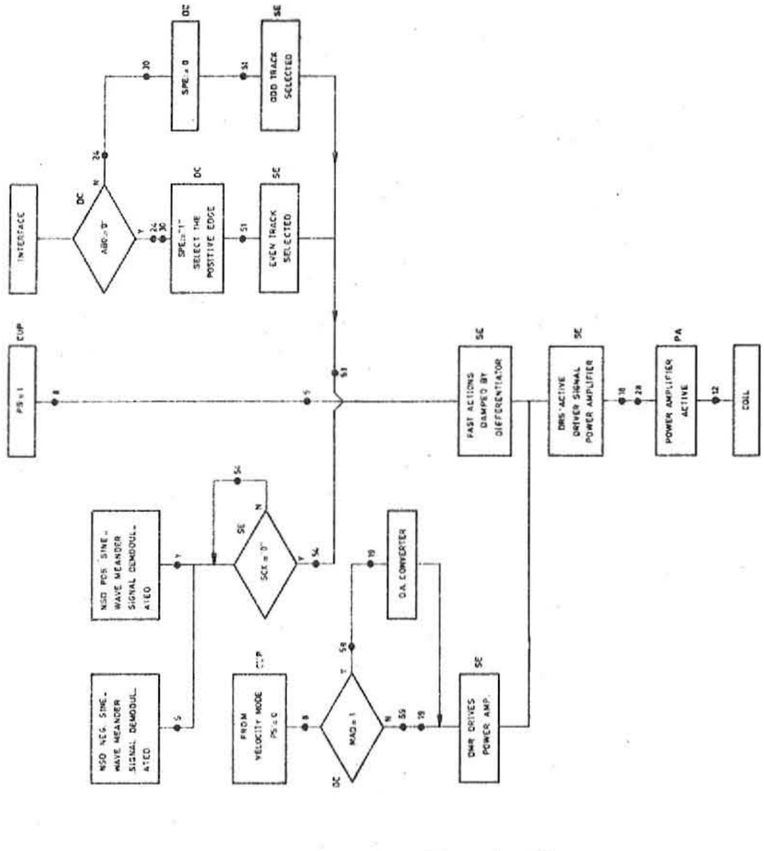
Figure 3-21

7.3 FIRST SEEK (Figure 3-21)

At the end of the start procedure, the flip-flop DFF (Direction Forced Forward) is set and the positioner moves towards the discs. When the heads reach the vicinity of track zero, the signal OPZ (Optical Zero) becomes a '1'. When the heads are positioned over track zero, the signal AO (Area Around Even Track) becomes a '1' and the signal TRZ (Track Zero) is a '1'. The heads continue to move and the signal AO becomes a '0', making signal TRZ a '0'. The signal OPZ becomes a '0' because the heads have moved away from track zero. When the heads reach track $1\frac{1}{2}$, the signal AO becomes a '1' and when track $2\frac{1}{2}$ is passed, the signal becomes a '0'. With signals AO and OPZ both '0' th signal NS (Normal Seek) becomes a '1'. The signal SM (Slow Motion), which is still a '1' (see Power-on), and signal NS produce signal RZS (Return to Zero Seek) which resets the flip-flop DFF. The heads start moving in the opposite direction and the signal OPZ becomes a '1' again. Also, signal AO becomes a '1' when the heads reach track $\frac{1}{2}$ and makes signal TRZ a '1'. Because the signal NS is still a '1' and the signal TCZ (Track Centre Zero) is a '1' and the flip-flop DFF is set again. The rest of the seek is discussed in the Position Mode description in this volume.

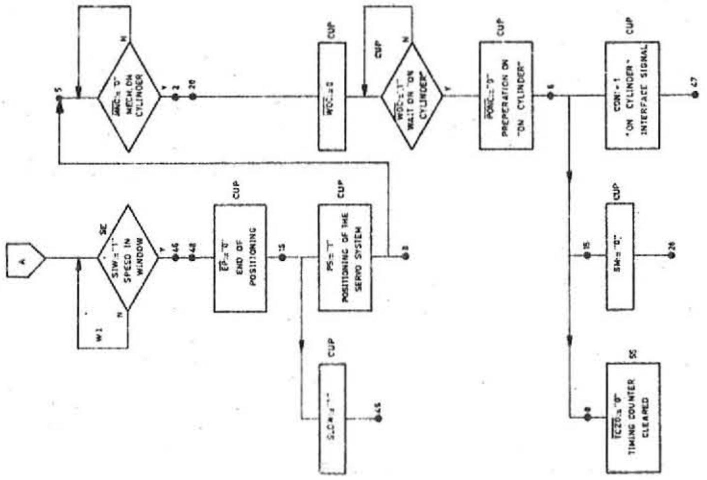
7.4 NORMAL SEEK (Figure 3-22)

The interface signals AB0 through AB7 fill a counter with the contents of the new address. This address with the old address which is present in a second counter. The output of an adder indicates the number of tracks that the positioner has to move. When the number is positive, the flip-flop DFF (Direction Forced Forward) is set and the heads will move inside the pack. When the number is negative, the flip-flop DFF is reset and the movement is in the opposite direction. The number of tracks required to be moved by the positioner is placed in a synchronous up/down counter.
When the positioner starts moving, the counter receives a DCP (Decrement Pulse) pulse from the meander (see Meander sections) each time the positioner moves over a track. When the counter has received the same number of pulses as the contents of the counter, then the output of the counter, signal DEO (Decrement Counter equal one) is produced. This indicates that the positioner is within half a track distance of the required track.
The movement of the positioner is initiated by the interface signal AB2, together with the signal CTS (Control Select Command). This signal AB2 makes signal NSP a '1' (Normal Seek Preparation). The leading edge of signal CTS produces signal IS (Initiate a Seek) to reset flip-flop EP (End of Position). The signal PS becomes a '0' (Positioning Servo) which indicates that the positioner is now in the Velocity mode. Also, during the CTS pulse, the signal INS (Initiate a Normal Seek) becomes a '1' and this will set the flip-flop EC (Enable Count). The signal $\overline{\text{MAD}}$ (Maximum at DA conterter) is either a '0' or a '1', depending on the output of the synchronous up/down counter. When the output of the counter is less than 32 (the positioner has to move less than 32 tracks), the signal $\overline{\text{MAD}}$ is a '1'. When the output of the counter is equal or greater than 32, the signal $\overline{\text{MAD}}$ is a '0'.
While $\overline{\text{MAD}}$ is "0" the positioner accelerates or moves at maximum speed. The moment that signal $\overline{\text{MAD}}$ becomes '1', the speed reduces and is dependent on the signals DC0 through DC4 (the 5 least significant bits of the outputs of the up/down counter), together with signal $\overline{\text{DCEE}}$. When the positioner has arrived at the selected track, the outputs of the counter make signal DEO a '1' and, on the leading edge of the last DCP pulse, the flip-flop EC is reset. The signal EC either sets or resets the flip-flop DFF which depends on the state of the flip-flop DFF when triggered. The signal $\overline{\text{MAD}}$ becomes a '0'.
The rest of the seek is described in the Position Mode section in this volume.



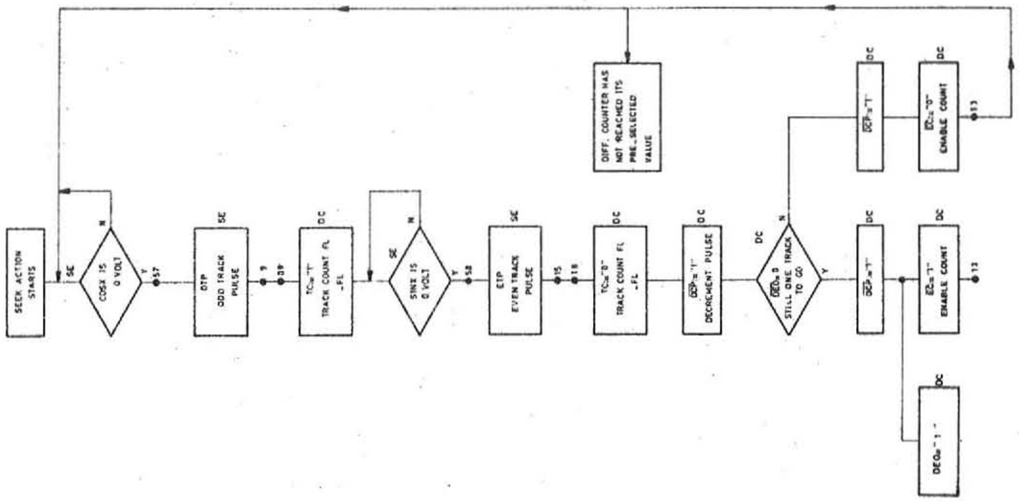
POSITIONING MODE

Figure 3-25



PLACE POSITIONING

Figure 3-24



TRACK COUNT OPERATION

Figure 3-23

7.5 TRACK COUNT OPERATION (Figure 3-23)

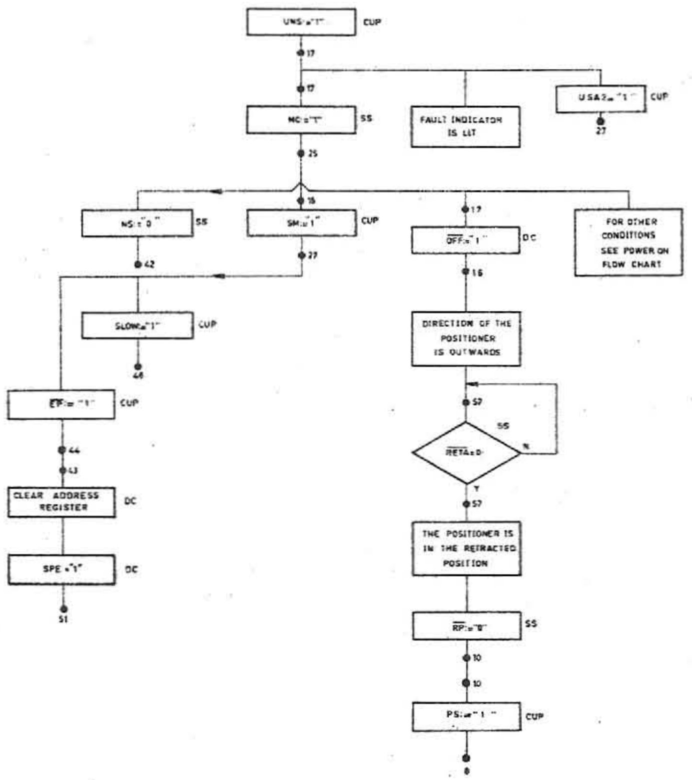
When the positioner moves over the tracks the meander produces the signals, COSX SINX. OTP (Odd Track Pulse) and AO (Area around even track). Also the signals SINX ETP, (Even Track Pulse) and A12 are produced. The flip-flop TC produces a DCP (Decrement Pulse). These DCP pulses decrement the count in the up/down counter each time the pulse is raised.
Providing the positioner has not reached the selected track the up/down counter receives a DCP pulse for every track. Also, the output signal DEO (Difference counter Equals One) is a "0" and the flip-flop EC (Enable Count) stays set. The moment the positioner reaches the selected track the signal DEO becomes a "1" and, on the leading edge of the DCP pulse, flip-flop EC is reset. The flip-flop EP (End of Position) is set and the signal PS (Position Servo) becomes a "1".

7.6 PLACE POSITIONING (Figure 3-24)

Due to the signal $\overline{\text{MAD}}$ (Maximum At DA Converter) being active fpr a short duration, the speed of the arm will decrease and when the speed decreases sufficiently, it comes within a pre-selected value (window); a tachometer monitors the speed. The output of the tachometer WSIW (Window Speed In Window) produces signal SIW (Speed In Window). When the speed is at the pre-selected value, signal SIW becomes logical '1' and sets the flip-flop EP (End of Positioning). The signals SLOW and PS (Place Positioning Servo) becomes a '1' to change the control from Velocity Mode to Positioning Mode.
Another window signal MNC (Mechanical on Cylinder), together with signal EP are used to produce signal WOC.
The one-shot WOC (Wait on On Cylinder) is used to delay (because of mechanical transients) the control circuit which indicates that the head has arrived at the selected cylinder.
When the delay has expired, the signal PONC (Preparation On Cylinder) becomes a '1' and signal CON becomes a '1'. Also, signal TCZO (Reset Timing Counter) becomes a '0' and SM (Slow Motion) is reset.

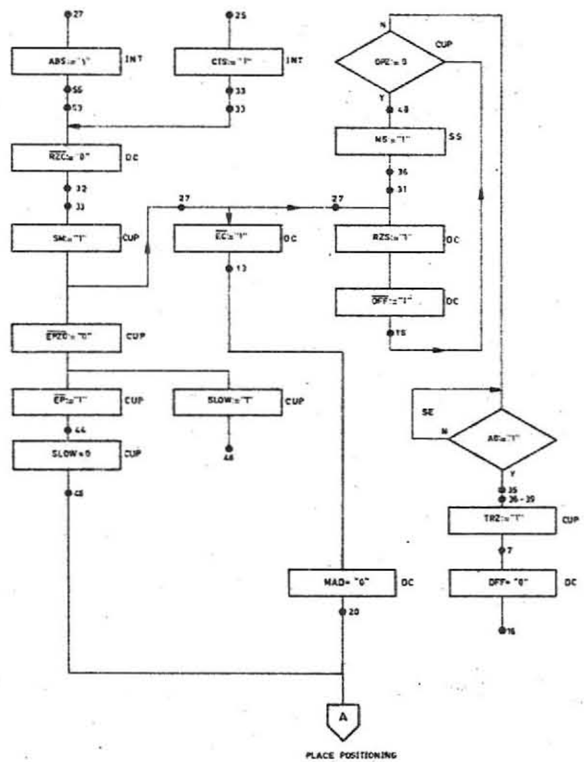
POSITIONING MODE (Figure 3-25)

Depending on the least significant bit of the address bus lines (AB0) selection of an even or odd track is realised. Signal SPE (Selection of a Positive Edge) determines whether the positive-going or negative-going edge of the received sine-wave signal is used. If the signal SPE is a logical "!" no inversion of the sine-wave signal is needed.
The sum of position signal (SINX) and differentiated position signal is supplied to an electronic swtich circuit. One switch is open when signal PS (Positioning Servo System) is a logic "!" (Positioning Mode). If the switch is closed (PS = "0") the other is opened (Velocity Mode) and the signal DMR (Difference between Momentary and Required speed)controls the positioning of the heads. Both switches (selection of velocity mode or positioning mode) are connected together and the output provides the input to an operational amplifier.
The output of this amplifier is the signal DRS (Driver Signal) which activates the power amplifier to send a proportional current through the positioning coil.
For more detailed information about the differentiator, electronic switch and operational amplifier refer to Volume 5.



GO TO RETRACTED POSITION SEEK (UNSAFE 2)

Figure 3-27



RETURN TO ZERO SEEK

Figure 3-26

7.7 RETURN TO ZERO SEEK (Figure 3-26)

Upon receipt of the interface signals CTS (Control Select) and AB6 (Return to Zero Seek) the signal $\overline{\text{RZC}}$ (Return to Zero Command) becomes a "0" to set the flip-flop SM (Slow Motion). The signal NS (Normal Seek) is a "1". The signal RZS (Return to Zero Seek) becomes a "1" due to the signals NS and SM. The signal RZS and signal SR (Slow Reverse to track zero), a result of the signal TRZ (Track Zero), reset the flip-flop DFF (direction of Force Forward) and the direction of movement of the positioner is reverse.
Also the signal MAD becomes a "1" when signal EC (Enable Count) becomes a "0". If, after some time, optical zero is detected and later signal AO is produced; then the signal TRZ becomes a "1". The signal TRZ together with the signal RZS produces the signal DFFZ1 to set the flip-flop DFF. The signals NS and TRZ produce signal REPS (Reset End of Position flip-flop during a Slow Seek). The signals REPS and SM produce signal $\overline{\text{EPZO}}$ (End of Position Reset Signal) to reset flip-flop EP. Together signal $\overline{\text{EPZO}}$ and the reset output of flip-flop EP set signal SLOW to a logical "0". The rest of this seek is described in the Place Positioning Mode, see section 7.6 of this volume.

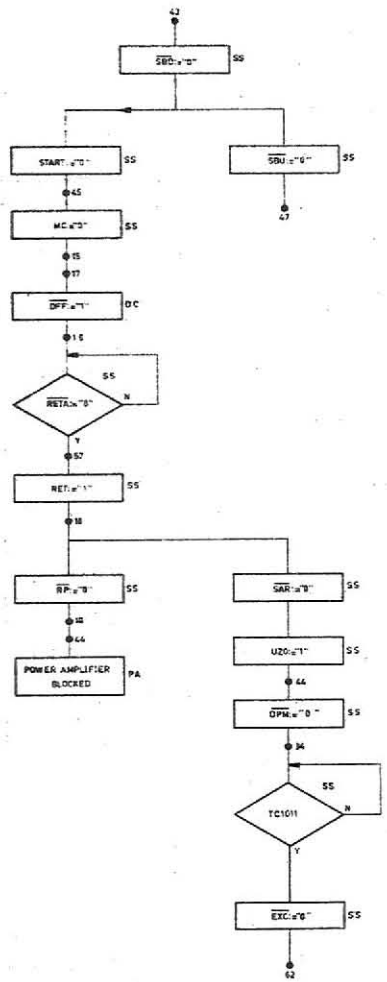
7.8 GO TO RETRACTED POSITION SEEK (Figure 3-27)

If 'unit unsafe 2' is made active, a fault condition is signalled (see Table 5.3.6 of this volume). The fault indicator on the Operator's panel is lit, and the master clear signal MC is produced with the following results:

a) The D-type flip-flop CIP (Carriage In Pack) is reset which resets the flip-flop NS (Normal Seek).

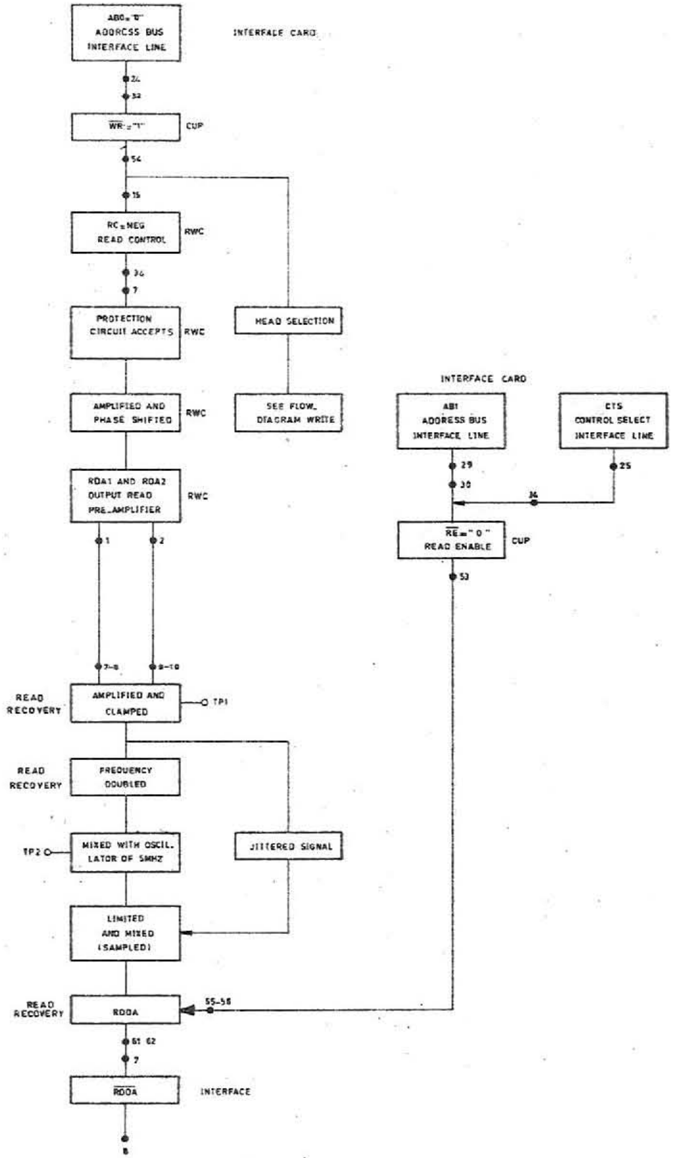
b) The output of the NAND-gate SM becomes a '1' with the result that signal EPZO is produced to reset flip-flop EP (End of Position). Signal EPZD, the inverted value of the reset output of flip-flop EP, clears the address register, resulting in emptying the Address register. This can be checked by measuring signal SPE (='1'), the inverted value of bit zero.

c) Another result of the master clear signal is that the flip-flop DFF is reset. The reset output moves the positioner outwards. When the arm has reached the retracted position, the micro-switch is operated and signal RETA is produced. The output of the retracted position flip-flop RET, in the first instance, produces signal RP (Retracted Position) which results in signal PS being produced. Signal RP also blocks the input to the power amplifier. The unit unsafe signal UNS, produces the interface signal USA2 (Unit Unsafe 2) and the interface signal AT (Attention).



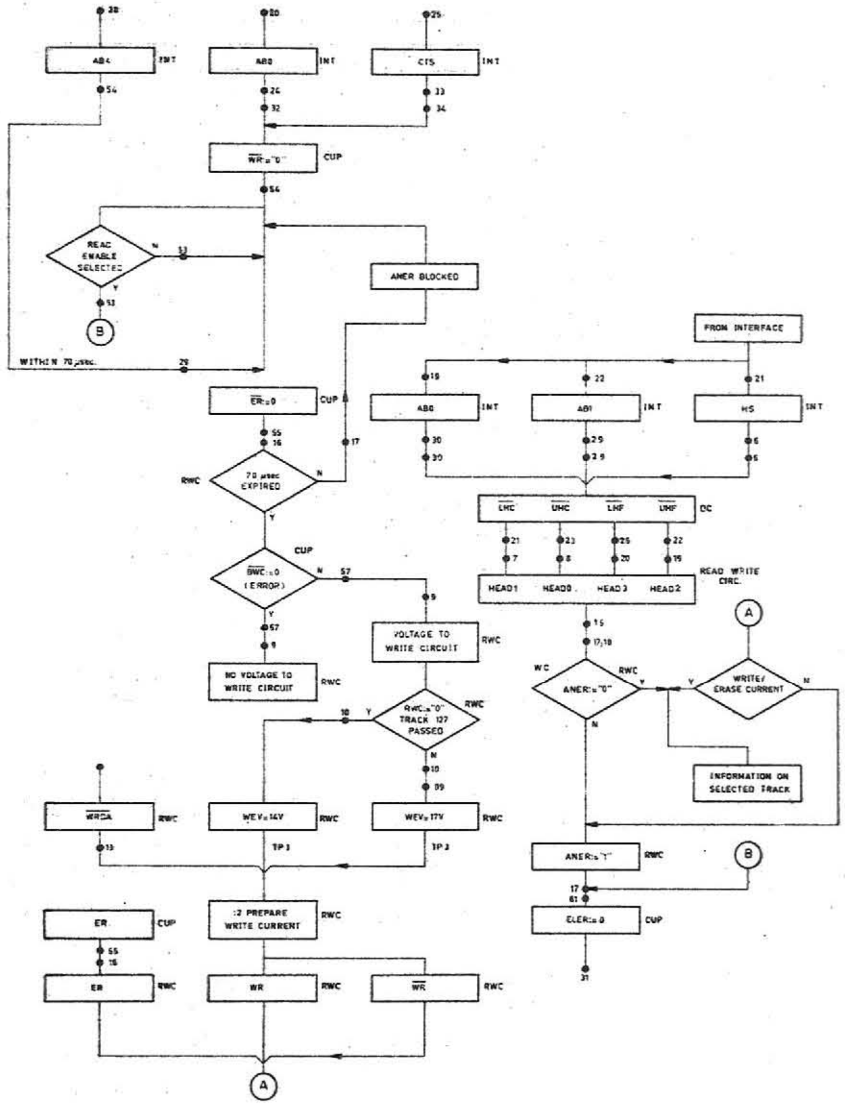
STOP

Figure 3-20



READ

Figure 3-29



WRITE HEAD SELECTION

Figure 3-28

7.9 WRITING (Figure 3-28)

Before writing can be initiated, one of the heads must be selected (signals HS, ABO and AB1, see figure 3-27).
The interface lines CTS (Control Select), ABO (Write Enable) and AB4 (Erase Enable) are preparation signals for signals WR (Write Enable) and ER (Erase Enable). From the Control Unit the selection signals are received (erase enable signal must come within 70 μs after the write enable signal). During this time of 70 μs, signal ANER (Analogue Error) is blocked so that the unit does not react. The time lapse is necessary because of the time relationship between the write and erase gaps at full disc speed (erase head situated 'behind' the read/write head). If the read enable signal is present during the writing an electronic error is raised (signal ELER). If no fault is detected, signals UNS (Unit Unsafe) and RER (Recoverable Error) are not active, and signal BWC (Block Write Current) is not produced so that a voltage is supplied to the write circuit. The current through the read/write head is controlled because when the bit density of the track becomes greater, from cylinder 127 onwards to cylinder 203, the write current must reduce. This is done by the signal RWC (Reduce Write Current) reducing the supply voltage from 17 Volts to 14 Volts.
Operation of the write circuit is now possible and the data to be written on the track (serial information) is received. A 'divide by two' circuit produces edges from the bit cell pulses so that magnetisation changes are written on the track.
Two checks are incorporated. The first check determines the co-existance of the write and erase current (the erase and the write currents are 55 mA and 85 mA respectively from cylinder 000 to cylinder 128, and 43 mA and 67 mA respectively from cylinder 128 to the final cylinder). The other checks the selection of more than one head.
If more than one head is selected, signal ANER (Analogue Error) is selected.
If the checks are found to be correct (signal ANER is not raised so that signal stays logical '0'), the information is written to the track.

7.11 READING (Figure 3-29)

When reading, signals CTS (Control Select) together with AB1 (Read Enable) are required ($\overline{RE}$ = '0'). If signal ABO (Write Enable) or AB4 (Erase Enable) is also present, a fault condition occurs. If the write enable signal WR is not present, the read circuit is allowed to be operative by activating the signal RC (Read Control). The protection circuit, using a diode-resistor network situated on the Read Pre-Amplifier card, will conduct.
Before reading is initiated, the head is selected by the signal HS (Head Select), together with the signals ABO and AB1. The read signal from the head is amplified (200 X), phase-shifted, then amplified (100 X) again. The signal is then sent to the Read Recovery Card where it is amplified to such an extent that the peaks are flattened. Realising that mechanical actions are involved, a circuit is incorporated to stabilise the jittering pulses received from the head. An oscillator circuit of double the highest received frequency (2.5 MHz) is used the sample the incoming pulses in the following way.
The oscillator circuit consists of a frequency doubler, a one-shot and a resonant circuit tuned for a frequency of approximately 5 MHz. The one-shot, shaping the frequency doubled input pulse, initiates, via a transistor, the resonant circuit. Each time the one-shot produces a pulse, the resonant circuit is triggered. The output of the oscillator circuit is amplified and mixed with the input signal; this is called sampling. The sampled pulse has the frequency of the input signal and the stability of the oscillator circuit used.
A one-shot with a pulse-width of 100 ns, together with a frequency doubler are used to produce the required interface signal RDDA (Bit Cell configuration).

7.12 STOP (figure 3-30)

To stop the unit, the Start/Stop button must be pressed. This action results in the resetting of the Start flip-flop on the leading edge of signal SBP.
The signal MC (Master Clear) becoming a logical '1', resets the flip-flop DFF.
The positioner arm moves outwards, passing optical zero, until it reaches the retracted position. The signal RET becomes a '1' by the micro-swtich and two actions now take place.
The first action results in signal SAR being produced to raise signal UZO. The pack motor flip-flop EPM will be reset if the 50 Hz pulse is present, resulting in DPM = '0'. The drive motor will then stop. If now TC1011 becomes a logical '1' the PEXC flip-flop (Preparation Exchange Cartridge) will be set, and now the cartridge can be exchanged.
The second action results in the retracted position signal RP being raised so that the Power Amplifier input is blocked keeping the arm in the retracted position.

8.1 POWER SUPPLY (figure 4-16)

The mains voltage, which is normally 220 VAC, single phase, is connected with a transformer in the disc drive unit via a mains filter, a switch and a fuse.
The switch and the fuse are situated on the rear of the disc unit, the transformer is situated below the base plate in the rear of the disc unit.
The drive motor for the spindle and the motor for the cleaning mechanism are connected to the primary side of the transformer.
The transformer has been designed in such a way that, when a different mains voltage is required, the disc unit can be easily adapted to this voltage, by changing one connection on the primary side of the transformer.
A temperature safety has been built into the transformer.
The secondary side of the transformer delivers six voltages.

a) One voltage is used to make a DC voltage of + 24 V.
b) One voltage is used to make a DC voltage of + 12 V.
c) One voltage is used to make a DC voltage of + 5 V.
d) One voltage is used to make a DC voltage of - 12 V.

The voltages mentioned in a till d are stabilized. The stabilisation is done on a power supply card which is attached to the rear of the disc drive unit. The necessary series transistors are mounted on heatsinks which are mounted on the rear of the unit.

e) One voltage is used to feed the stabilisation circuit of the + 5 Volts supply.
f) The last voltage delivers after rectifying and smoothing a + 35 Volts voltage. These voltages are not stabilized and are fed from a winding with a centre tap.

Finally, on the primary side of the transformer, there is a voltage which, after rectifying, is used to brake the drive motor for the spindle electrically.

8.2 POWER SUPPLY CARD (figure 4-15)

The power supply card carries the following circuits:

a) A +5 Volts supply (protected by a 4A. fuse)
b) A +24 Volts circuit (protected by a 1.2A fuse)
c) A +12 Volts circuit (protected by a 1A fuse)
d) A -12 Volts circuit (protected by a 1A fuse)

Each circuit is basically the same, comprising a voltage regulator, transistor controlled by an integrated circuit.
Fluctuations of the output voltage are sensed, amplified and then fed to the voltage regulator transistor.
If the output voltage becomes too low the value of the internal resistor of the regulator transistor decreases.
If the voltage increases the value of the internal resistor of the regulator transistor increases.
The voltage drop across the transistor alters accordingly, regulating the output voltage.
The +5 Volts supply employs a thyristor protection circuit. If the voltage becomes too high the output voltage is short circuited to earth.