HEWLETT hp PACKARD

7900A DISC DRIVE

SERVICE TRAINING MANUAL

HEWLETT hp PACKARD

7900A DISC DRIVE

SERVICE TRAINING MANUAL
(HP STOCK NO. 07900-90022)

NOTICE

The information contained in this manual is for training purposes only. Consult the Hewlett-Packard documentation supplied with the system for current information.

PRINTED IN U.S.A.

JAN 1972

HEWLETT hp PACKARD

7900A DISC DRIVE

SERVICE TRAINING MANUAL
(HP STOCK NO. 07900-90022)

NOTICE

The information contained in this manual is for training purposes only. Consult the Hewlett-Packard documentation supplied with the system for current information.

PRINTED IN U.S.A.

JAN 1972

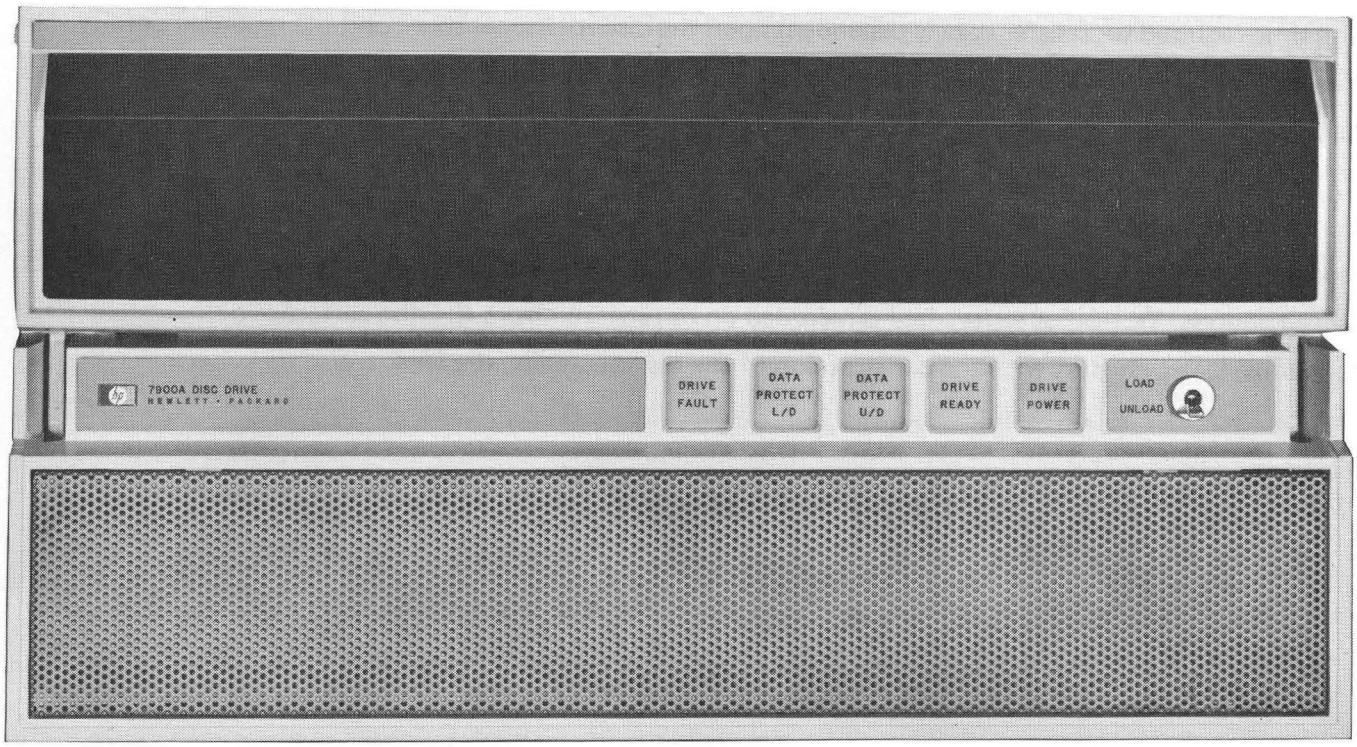
TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

SECTION I

7900A

DISC DRIVE



INTRODUCTION

The moving head disc drive is a random access storage device. From the users standpoint, the important factors are:

1. Storage capacity
2. Time to reach any given address
3. Time to transfer the data to or from the disc

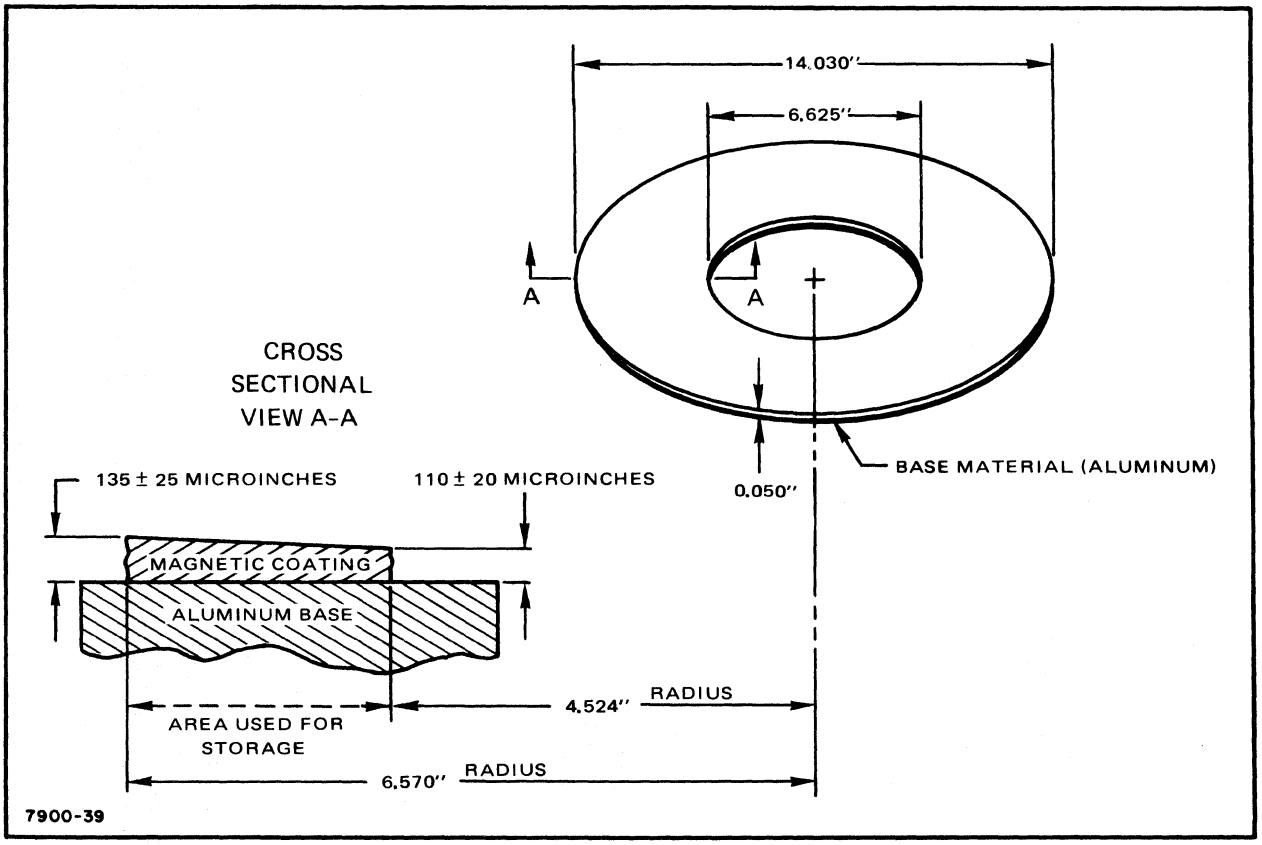
The storage capacity is determined by the number of recording surfaces, the recording density and the number of cylinders to be recorded. The HP 7900 disc drive is capable of storing 4,915,200 bytes of data on a total of four recording surfaces (two fixed and two removable).

The time to reach a given track address is dependent upon many factors within the drive.

The time required to transfer data is dependent upon the disc rotational speed and the recorded density. The transfer rate of the 7900A is 312K bytes per second or 2.5M data bits per second. Data is transferred in serial fashion.

From the standpoint of the controller the disc performs three basic functions: Read, Write and Seek to a record. To seek to a record, the controller must provide the drive with a cylinder address, a sector address and a head address. To read or write, data is recorded on or retrieved from the disc surface. To understand these functions, let's first start with the construction of the storage media; the Disc.

STORAGE MEDIA

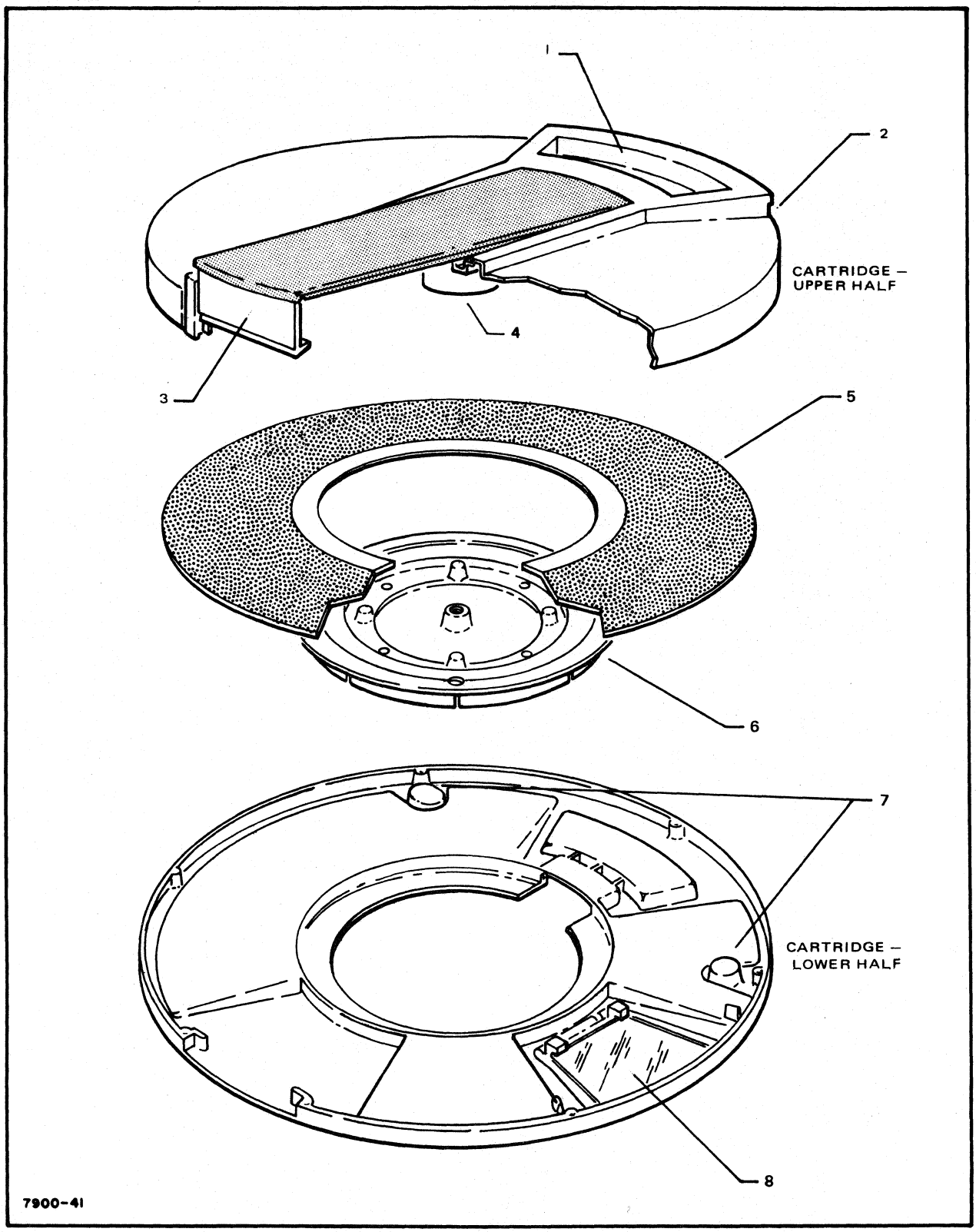


The medium of storage in a disc drive is a thin layer of magnetic material. This magnetic material (ferromagnetic iron oxide) is bonded to both sides of an aluminum disc. Ferromagnetic iron oxide is used because:

1. Its properties do not limit the effective recording bit density.
2. It is relatively stable with respect to temperatures up to 500° C.
3. Most engineering and manufacturing problems have been solved.

The oxide particles are cigar shaped and critically size controlled. This control and effective methods of coating allow high resolution and less de-magnetization during write operations.

DISC CARTRIDGE CONSTRUCTION



DISC CARTRIDGE CONSTRUCTION (CONT)

1. HANDLE - A moulded insert provided for handling the disc cartridge.

2. NAME SLOT - A slot wherein an identification label can be inserted.

3. ACCESS DOOR - Prevents intrusion of dust particles when closed; allows heads to enter and cooling air to leave when open. The door is automatically opened when the disc cartridge is inserted into the disc drive receiver, and closed on removal.

4. HUB HOLDDOWN - A spring-loaded hub at bottom center of the door. When the door is closed, the spring pushes the disc toward the bottom half of the cartridge, thereby securing the disc to the cartridge.

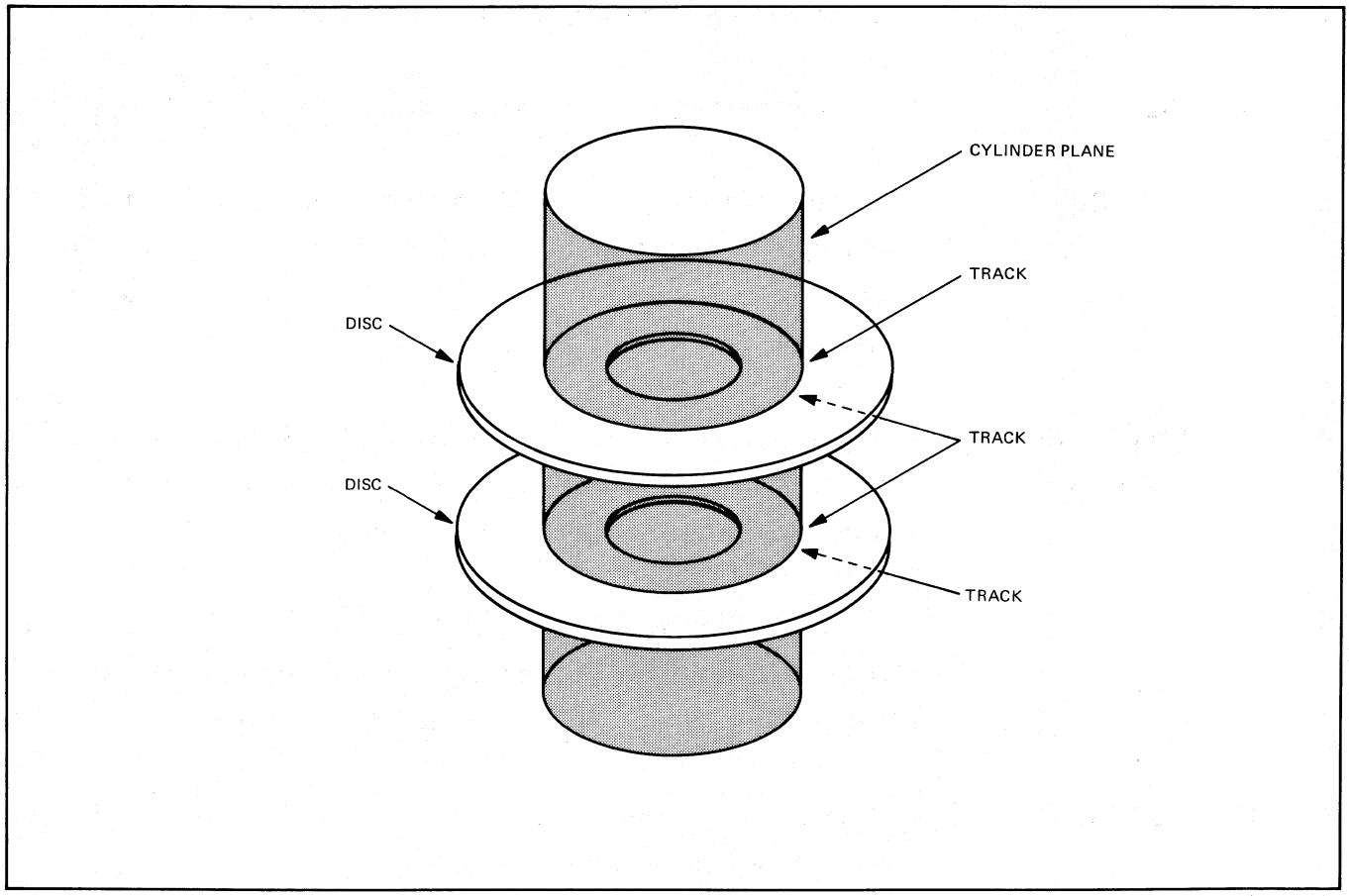
5. DISC - A 14-inch-diameter 0.050-inch-thick aluminum disc with a magnetic coating on both sides. It is the medium for data storage. The disc is connected to and dynamically balanced with the head assembly.

6. HUB ASSEMBLY - Connects disc to spindle (magnetically). Slots in a skirt on the outer edge of the hub are used to generate timing signals and sector address information.

7. LOCATING RECESSES - Two recesses on the bottom surface of the cartridge. When the cartridge is inserted into the disc drive receiver, the cartridge is precisely located in relation to the spindle when these recesses seat onto matching pins within the drive.

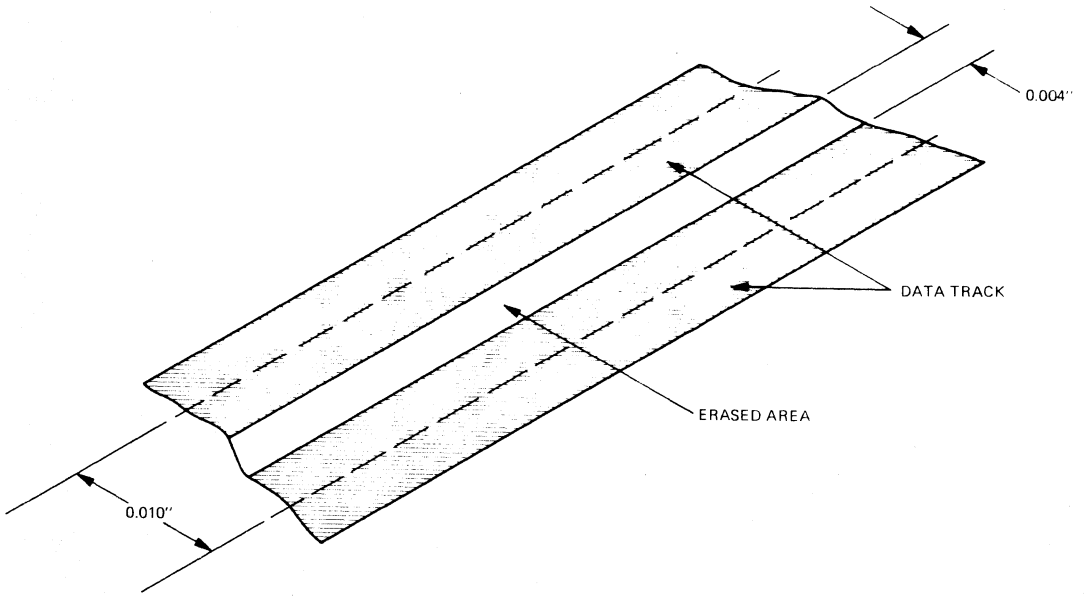
8. AIR INTAKE - Allows air for cooling and cleansing to enter the disc cartridge. It is automatically opened as the cartridge is inserted into the drive, and closed upon removal.

DISC FORMAT

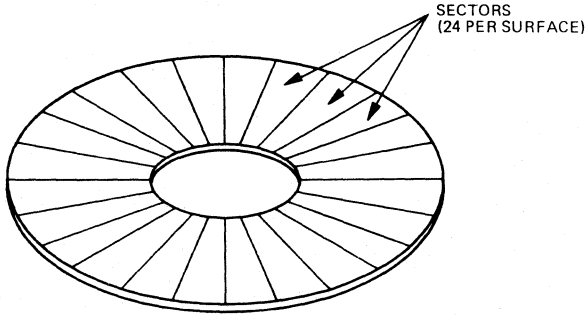


The access mechanism or carriage moves four read/write heads simultaneously. The carriage moves forward or reverse to access any of 203 unique positions called cylinders. Each cylinder extends on a plane through all discs and intersects all recording surfaces. Each intersection of a recording surface is called a "Track". Consequently, each recording surface is divided into 203 separate tracks. These tracks are spaced 0.010" from center to center with 0.004" between data. The tracks are divided into 24 equal individually addressable parts called sectors.

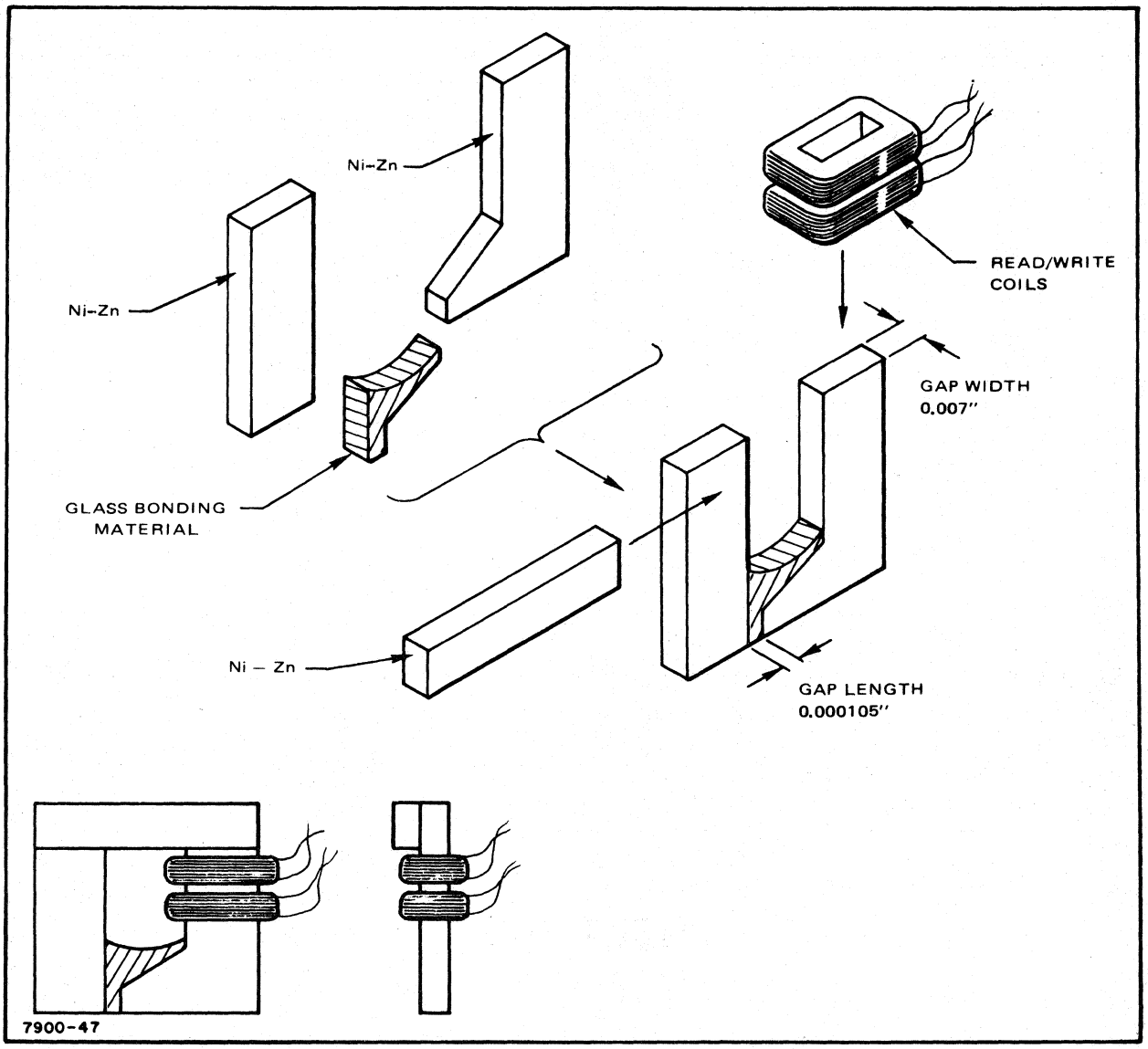
TRACK SEPARATION



SECTORS

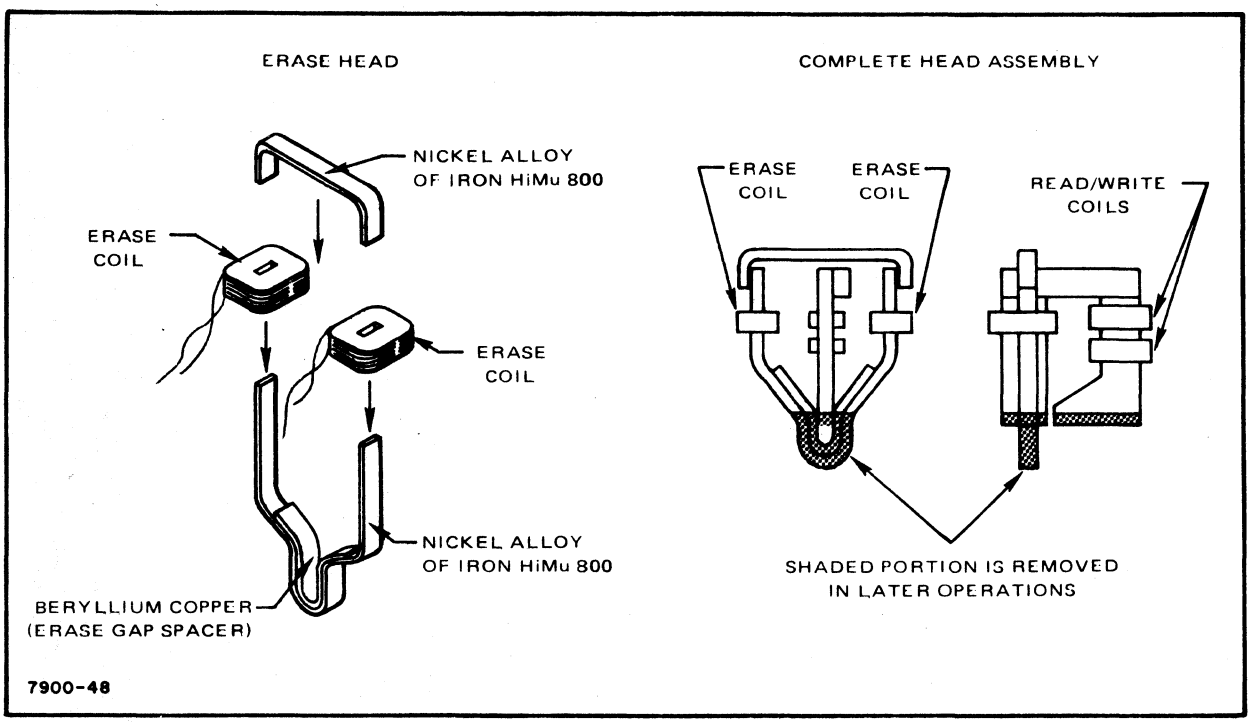


READ/WRITE HEAD CONSTRUCTION



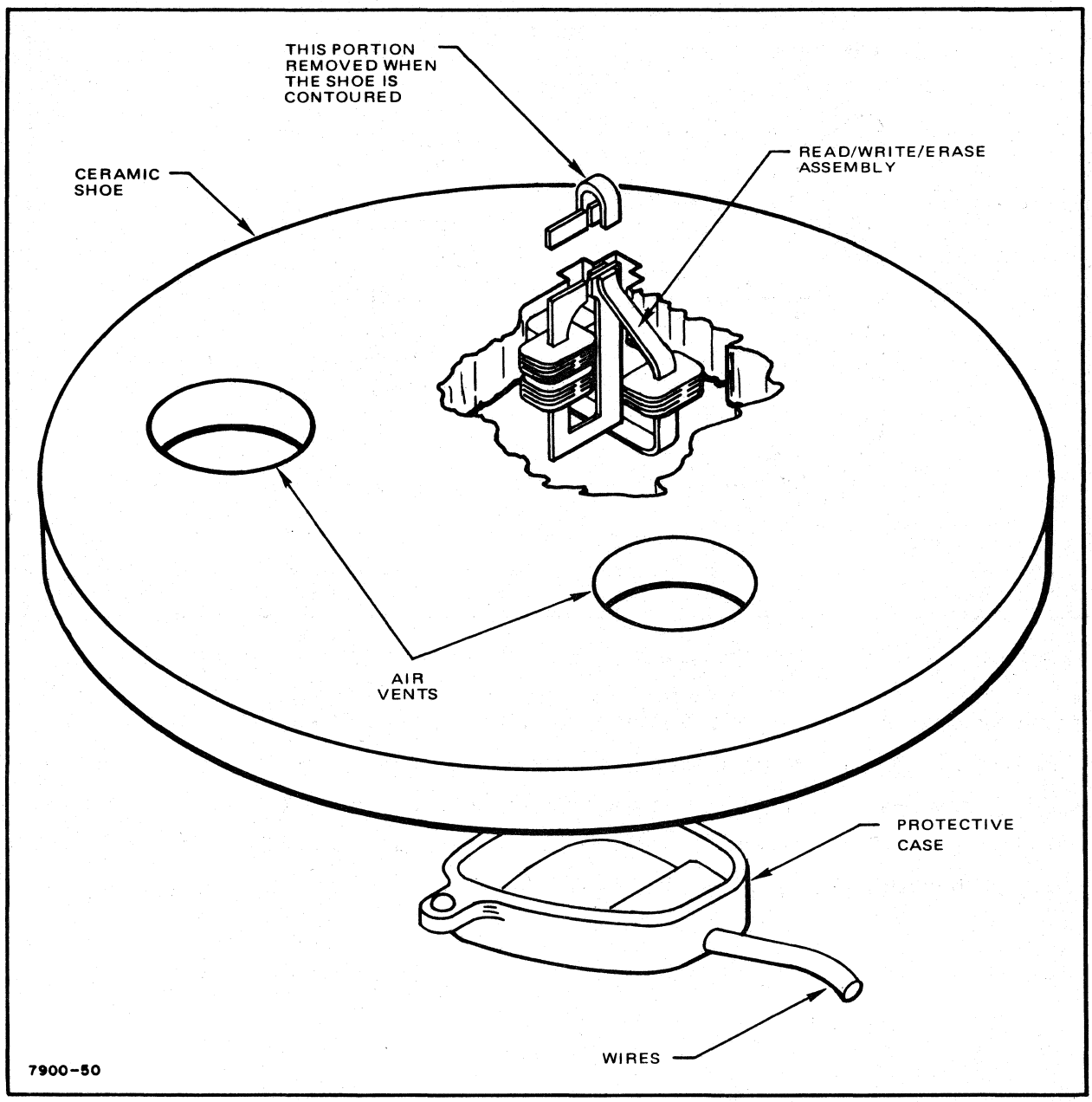
There are two basic parts to the read/write/erase head assembly. The read/write portion of the assembly generates write data flux or detects read data flux. Its construction is shown above. The magnetic flux path is formed of three pieces of nickel-zinc ferrite (Ni-Zn). During the manufacturing process, the first two pieces are "glued" together with a glass bonding material. This is the easiest way to form a uniform gap of 105 microinches, the most critical part of the head assembly. The glass prevents the ferrite material in the neighborhood of the gap from chipping during later processing of the head. The next step is to install two coils of wire on the piece of ferrite with the "foot". Three leads are brought out of the coils, and their electrical configuration is shown later. The last step is to clamp the remaining piece of ferrite in place and glue it. The three-piece construction allows good control of the gap size and easy insertion of the read/write coils.

ERASE HEAD CONSTRUCTION



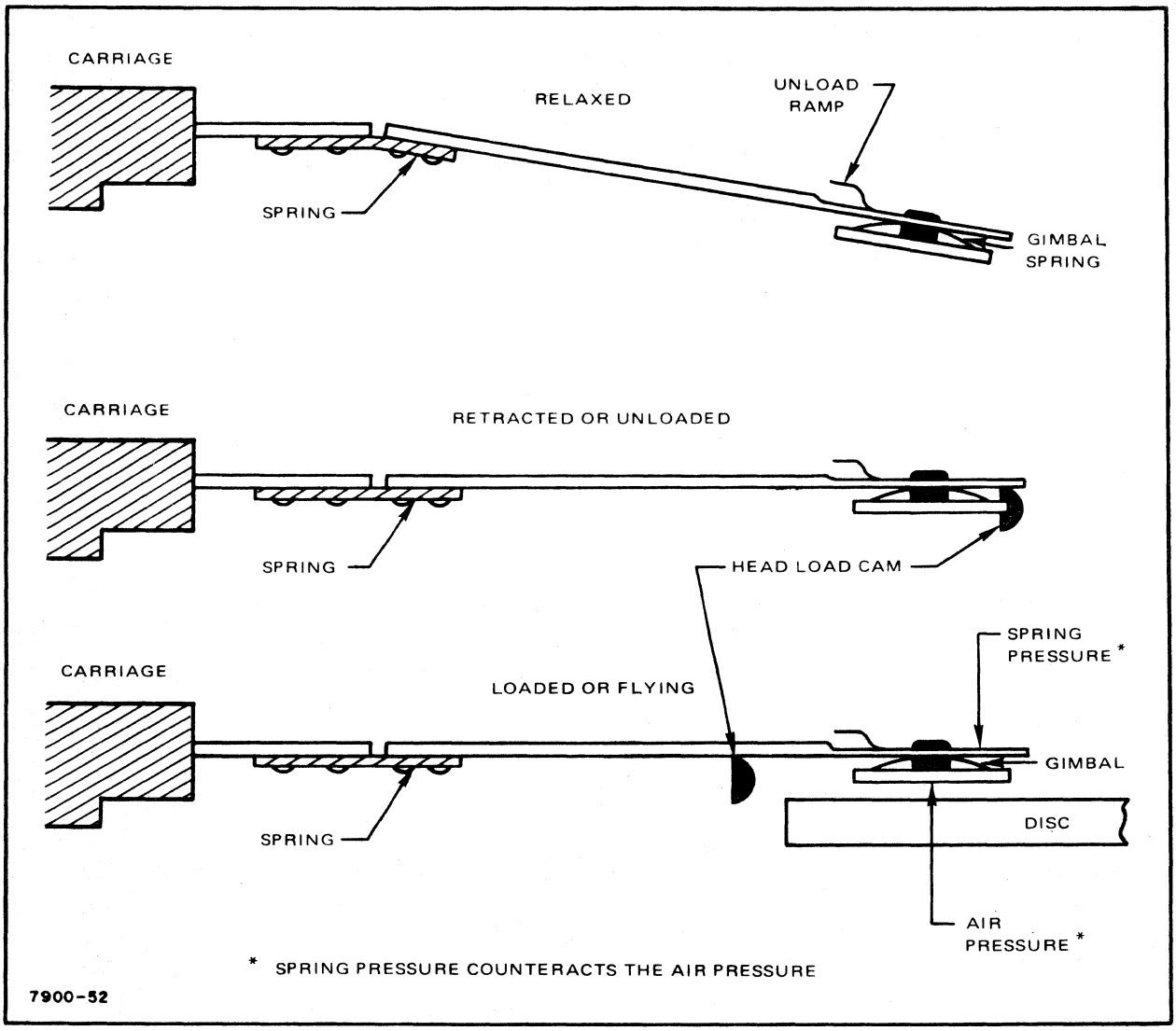
The components of the erase part of the head assembly are shown in the left part of the figure above. The lower u-shaped assembly, of beryllium copper and nickel alloy of iron, clamps with a spring-like action onto the read/write head assembly. The beryllium copper produces an erase gap of 800 microinches on each side of the read/write head. The erase coils are placed on the erase head, and the nickel alloy cap is glued to complete the erase flux path. The two-piece construction allows easy formation of the erase gap and erase coils.

SHOE ASSEMBLY



The Read/Write/Erase assembly is then mounted and glued into a ceramic show. The shoe is then contoured and polished to provide an aerodynamic surface which is used to fly the head above the rotating disc surface.

HEAD SUPPORT

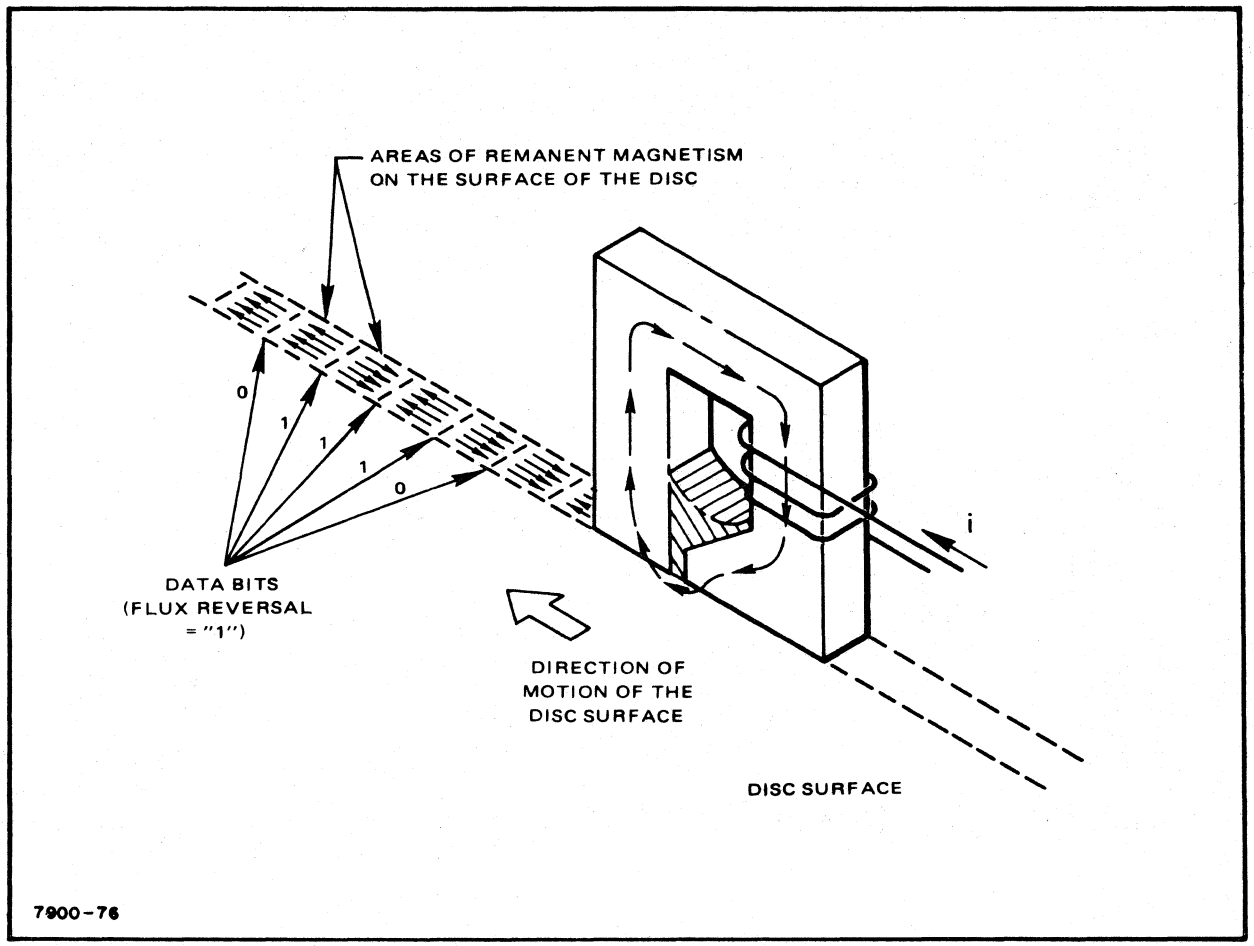


A layer of moving air caused by rotating the disc is used to support the head over the disc surface. The aerodynamic characteristics of the shoe tend to force the head away from the surface while spring tension on the arm counteracts, causing the head to fly at the desired height.

The shoe is connected to a tension arm by gimbles. This type connection allows the show to incline freely in any direction.

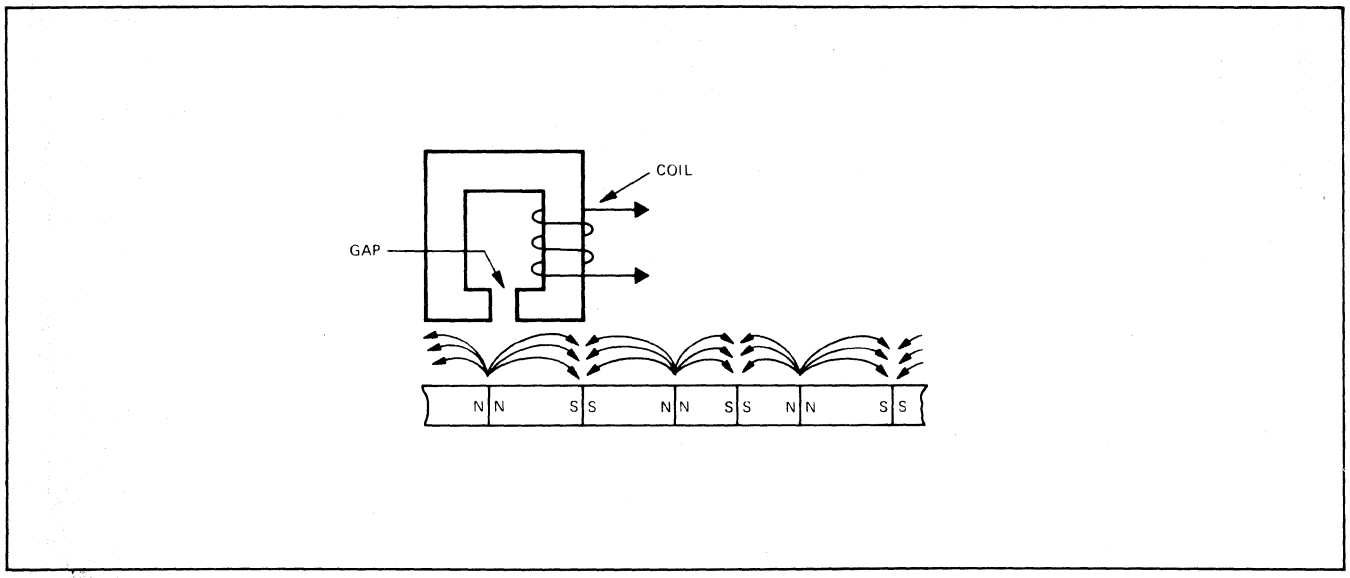
Two air relief holes in the ceramic shoe allow some air pressure to escape. This is used to accurately determine the flying attitude and height of the head.

WRITE DATA



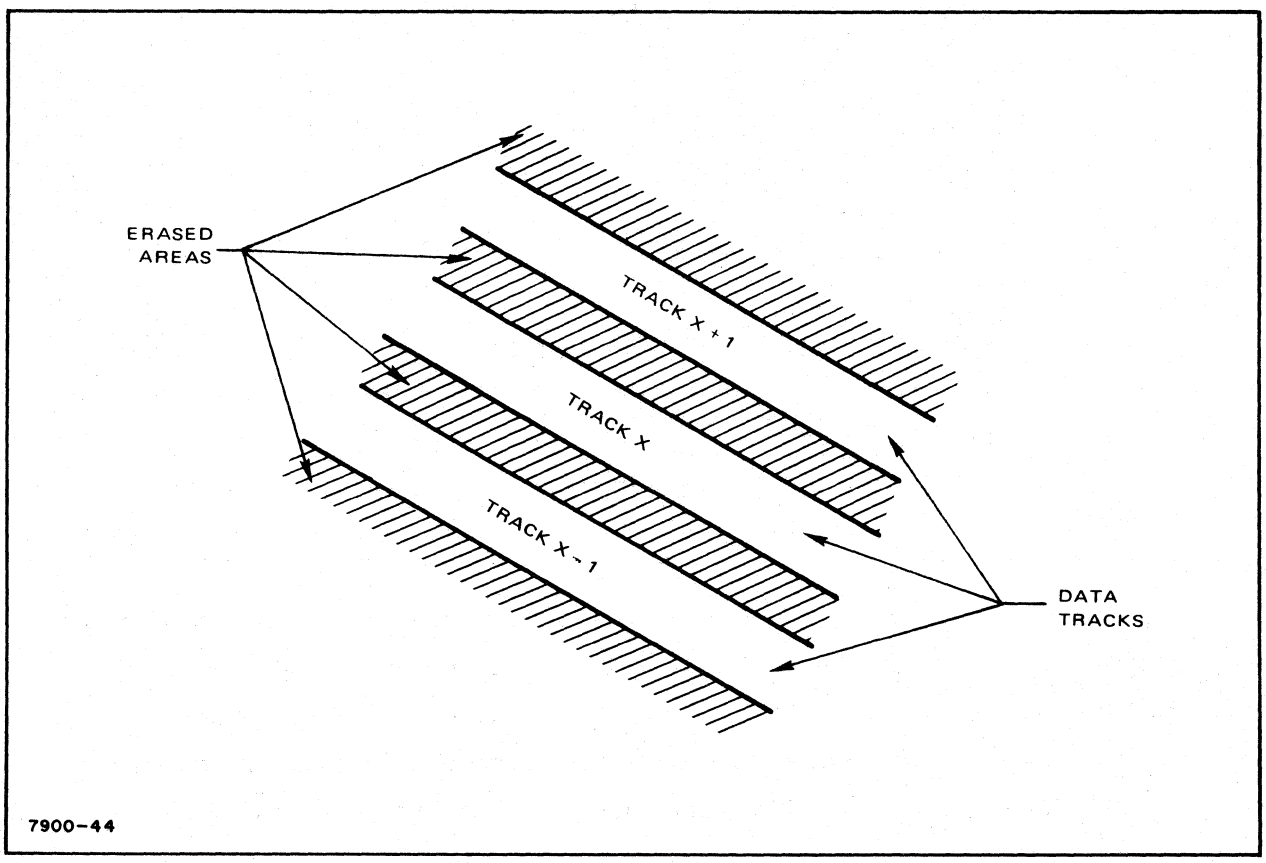
The picture above depicts the write process. A current in the write coil causes magnetic flux to flow in one direction in the head. At the gap, the flux arcs or fringes, causing the field to penetrate and magnetize the disc surface. When the current in the coil is reversed, the flux in the head also reverses. Data bits are represented by presence ("1") or absence ("0") of a flux reversal at the proper time. Between flux reversals the flow of flux is a given direction magnetizes the small part of the surface of the disc which rotates under the head. The size of these magnets range from 200 to 700 microinches long (5 to 17 microns). The length of time required to write a bit is 200 nanoseconds. This time per bit is constant because the write data transfer rate is controlled by a crystal-controlled oscillator.

READ DATA



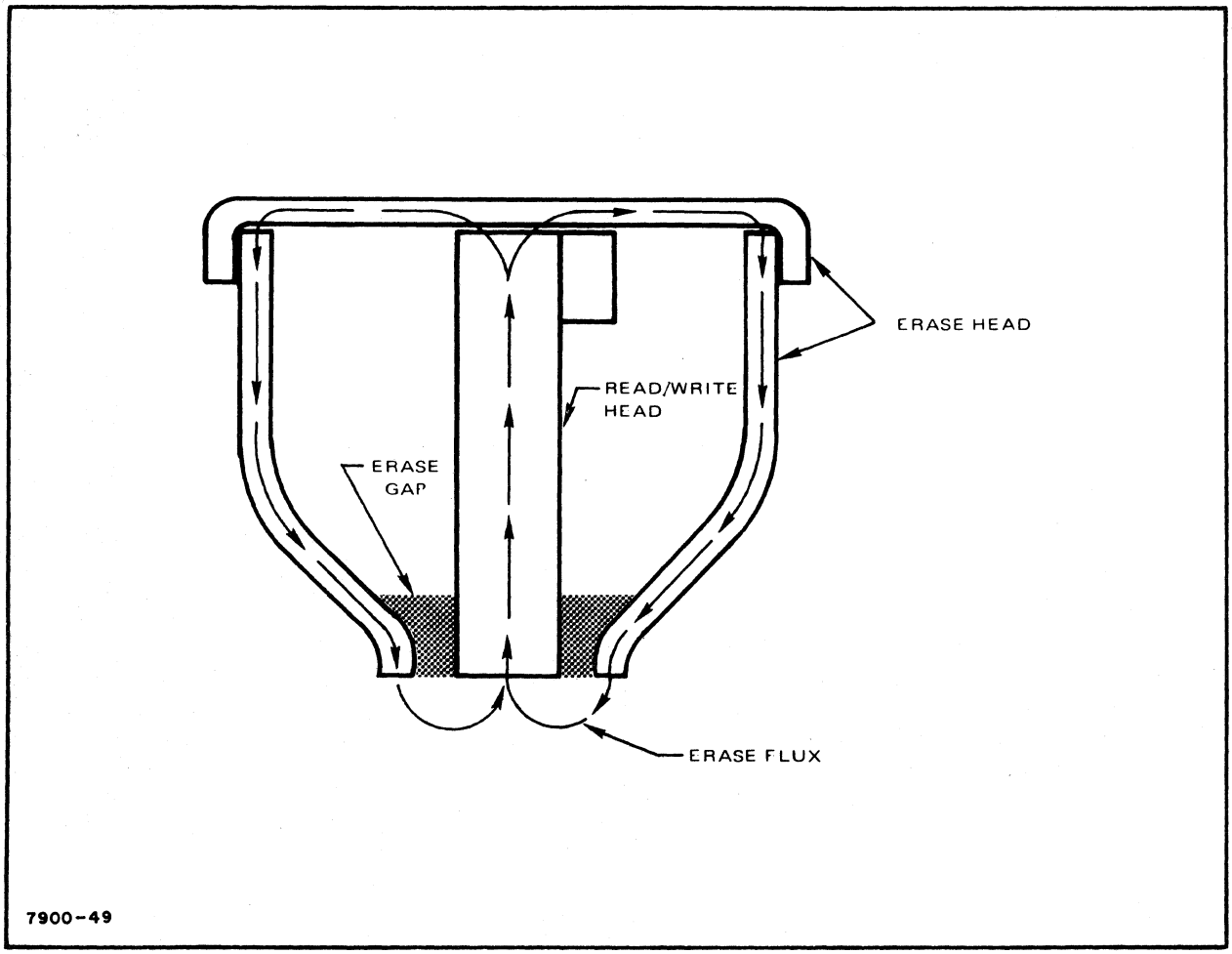
The write process generates small magnetized areas in the surface coating of the disc. These small areas act like bar magnets generating flux. Each bit (clock or data) is represented by a complete reversal of magnetic flux. Consequently, there is a concentration of opposing flux at the point of reversal or end of individual bar magnets. As the read/write gap passes over the recorded data, a change in fringing flux from the disc surface is sensed by the head. This flux change induces a minute voltage pulse in the coil which is amplified and used by the read electronics.

ERASING



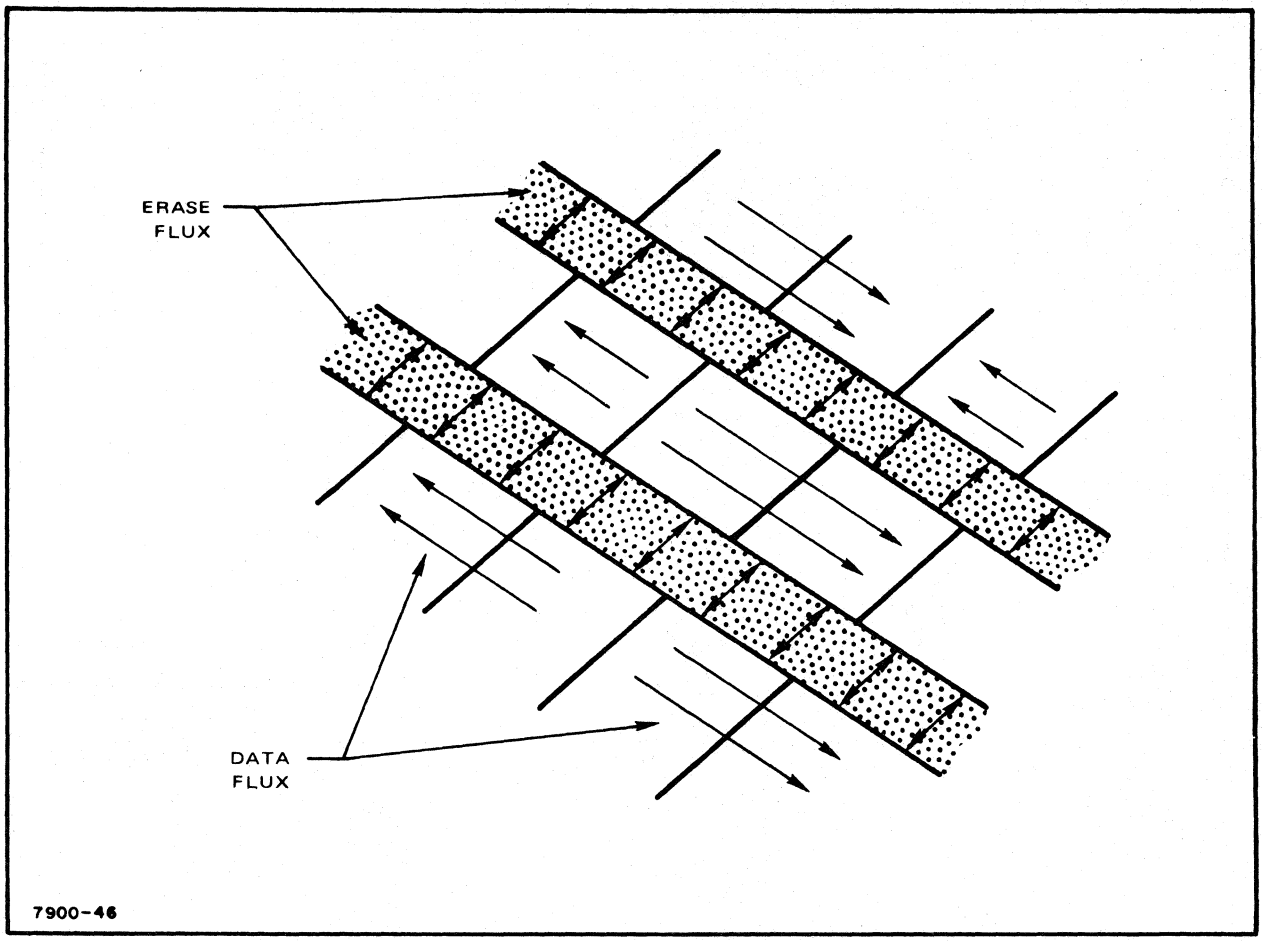
In order to make maximum use of the disc surface, the head is made very small. This means that discrete positions of the head (called tracks) can be very closely spaced. The problem then arises of positioning the head over the same exact point on a given track. To allow some positioning tolerance, the area between data tracks is erased. The erasing process is accomplished when data is written on the disc. This guarantees that signals on adjacent tracks will not interfere with reading the desired track.

ERASE FLUX



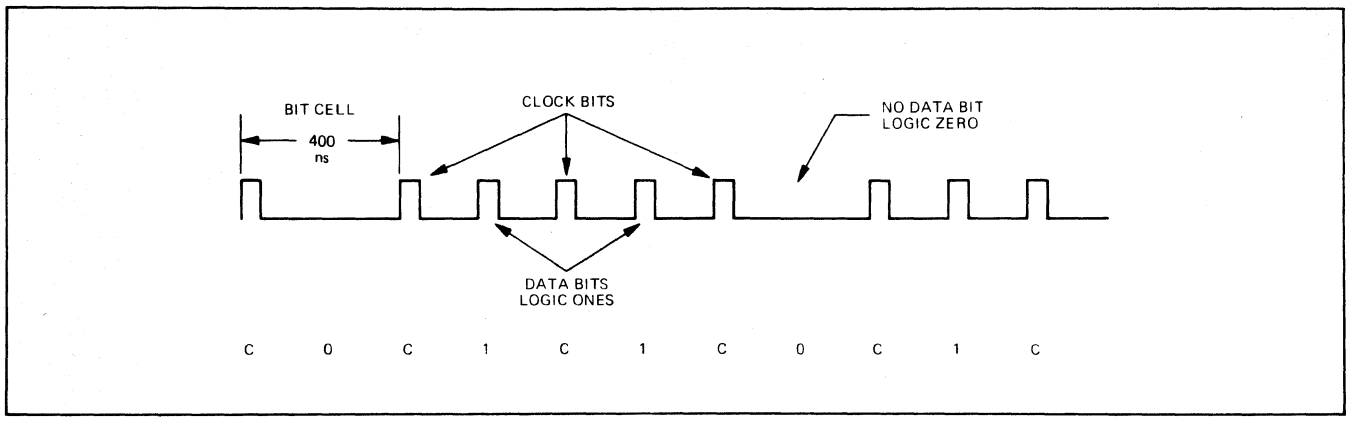
The erase head "straddles" the read/write head. As the figure shows, the read/write head is part of the path for erase flux. The resulting erase magnetization of the disc surface is perpendicular to the direction of data magnetization. The placement of the erase gaps with respect to the write gap is such that erasing occurs after writing.

STRADDLE ERASE



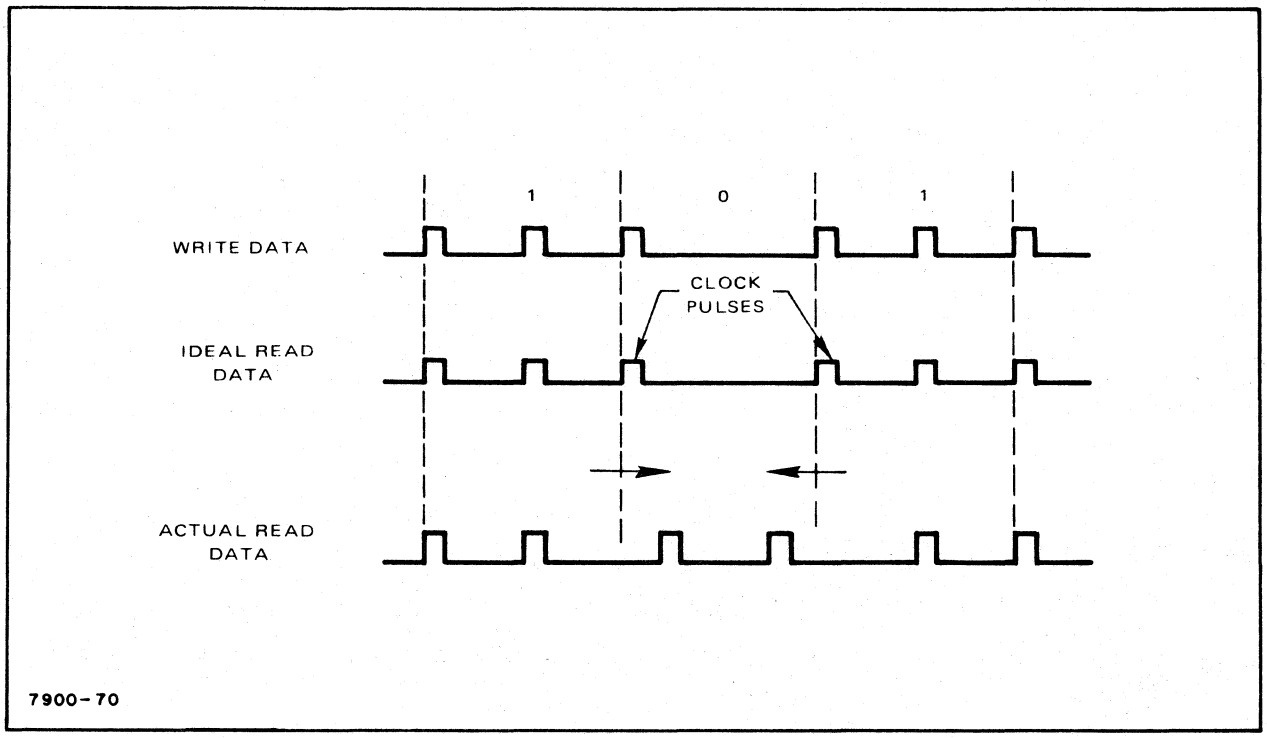
Current state-of-the-art disc drives, including the HP 7900A, use the straddle erase technique. The results of this are illustrated above. The direction of erase magnetization on the surface of the disc is perpendicular to the direction of data magnetization. The erase flux will not affect the data flux, even if the head is not centered on the data track.

SERIAL DATA TRANSFER



Data transfer to or from a disc is accomplished in serial fashion. That is, one BIT at a time as opposed to parallel data, which transfers 8 bits (one byte) at a time. To accomplish this transfer, data is "clocked" in a "bit cell". Clock bits are present every 400 n-seconds. A bit between the clock bits represents a logic 1 and the absence of a bit represents a logic zero. Consequently, an all one record is twice the density (twice the number of flux reversals) as an all zeros record.

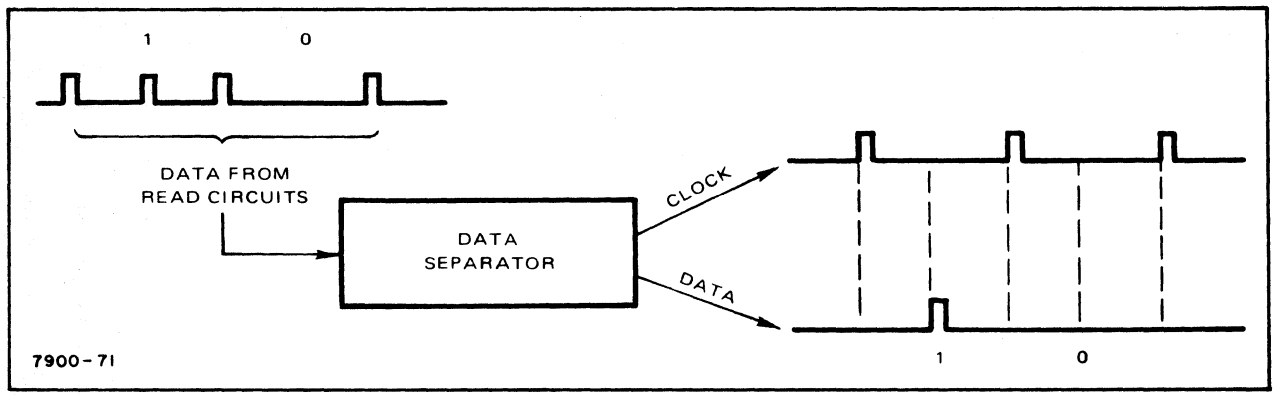
PULSE CROWDING



For obvious economic reasons, the maximum potential storage on the drive must be obtained. To achieve this objective, the data rate is made as high as possible. As a result, the output voltage pulse from one flux reversal is not completely through before the next flux reversal causes another voltage pulse. The dimensions of the read head and its spacing from the surface are such that more than one flux reversal is affecting the head at the same time. The end result of this is a shift in time of some of the recovered pulses with respect to where they should occur. This effect is called "Pulse Crowding", "Bit Shift" or "Peak Shift".

The worst case data pattern where this effect occurs is shown above. As the figure shows, the clock pulses shift in time. The amount of shift can be as high as 10% for each of the clock pulses.

DATA SEPARATION

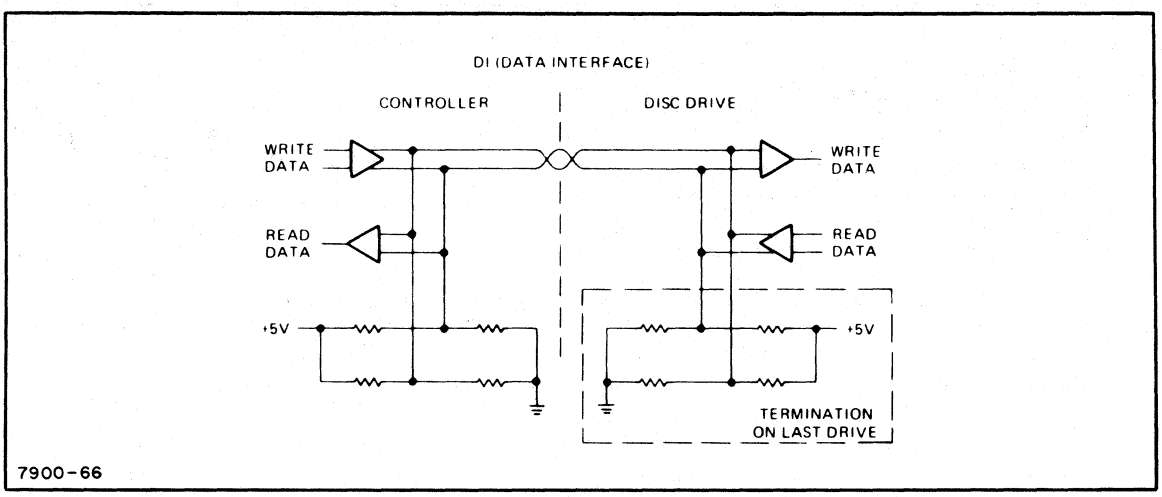


The function of data separation is shown above. Data from the read circuits is a combination of data bits and data recovery clock bits. The data separation must synchronize with the clock pulses and use this synchronization to extract the data. The HP 7900A does not have a data separator within the drive.

Synchronization occurs at the beginning of each sector where a special preamble section was written for this purpose. The first part of the preamble consists of nothing but clock bits, i.e., the data bits are all zero. Once the separator is synchronized with the clock pulses, the major sources of data errors are pulse crowding, rpm data shift, and random electrical noise. The most common error is the pickup of a "1" data bit where a "0" was expected.

Data recovery in the 7900A is based on the fact that the position of the data pulses in time shifts very little. Reliable data recovery is possible because the data separator synchronizes with the average of several clock pulses. One type of circuit which accomplished this is called a phase-locked-loop. With this approach it is possible for clock pulses to shift position in time or to be lost altogether, and the data will still be recovered.

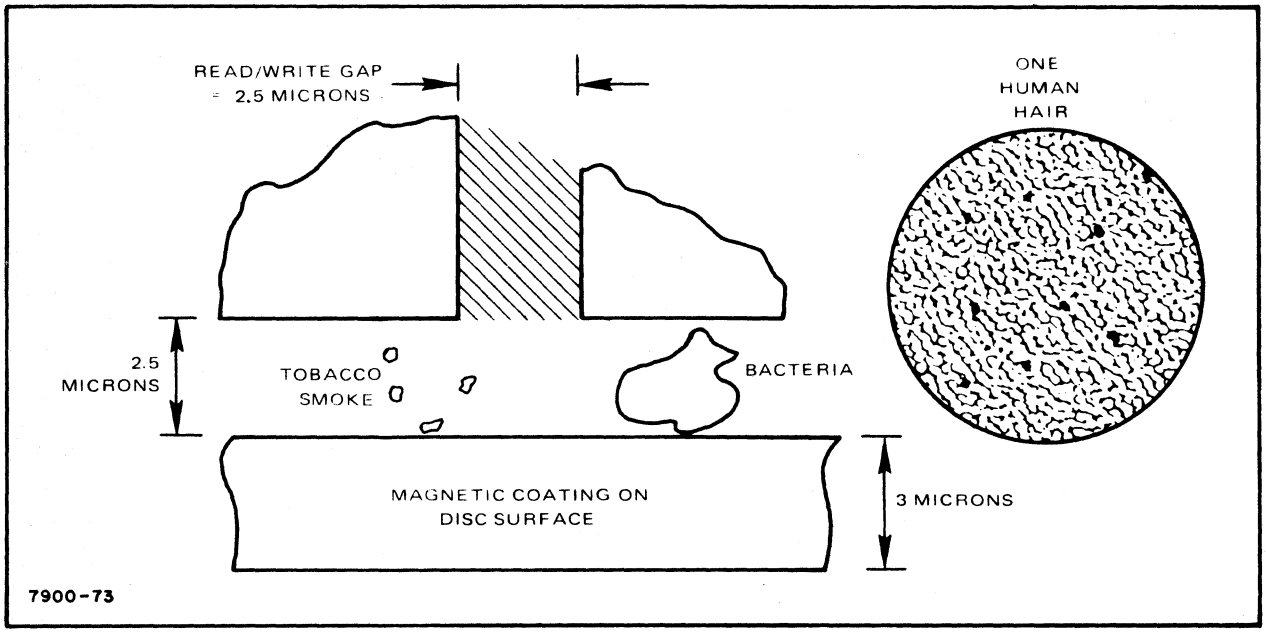
DATA LINE DRIVERS AND RECEIVERS



The data line is the most critical of all the lines between controller and disc drive. The signal transmitted over this line has a minimum frequency of 2.5 MHz and a maximum frequency of 5.0 MHz. This high data rate makes the data line especially sensitive to ground noise, power supply noise, capacitive coupling from adjacent signal lines, and any other sources of electrical disturbance. The use of a differential line driver-receiver reduces the sensitivity to noise. Neither one of the two wires is grounded, and noise appearing on one line will also appear on the other line; but the difference signal between the lines remains unaffected.

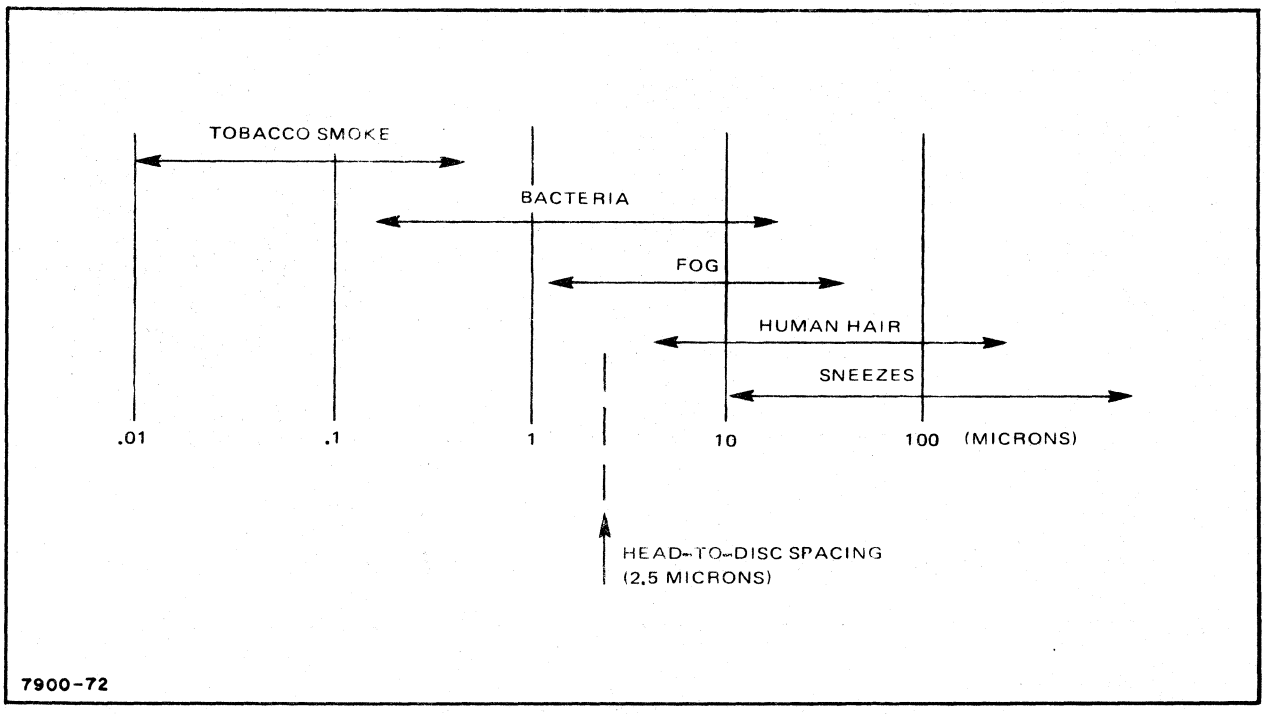
A single pair of lines is shared for both read data and write data. This reduces the number of lines required in the interface cable. Up to four discs can be connected to the data line at once, although only one of the disc drives can send or receive data at a given time.

PARTICLES IN ACTION



The drawing above shows the critical elements involved in the read/write processes - the read/write gap, the head to disc spacing, and the thickness of the surface coating of the disc. The head to surface spacing is an average, and, in fact, the minimum spacing due to surface irregularities of both head and disc may be as small as 1 micron. If a particle were hard enough and of the right size, it could scratch either the disc or the head. Even if not hard enough to scratch, it may be large enough to increase the head to disc spacing, thereby causing a data error. Because of potential damage or data loss the cleanliness of the air within the drive is critical to long-term, error free disc use.

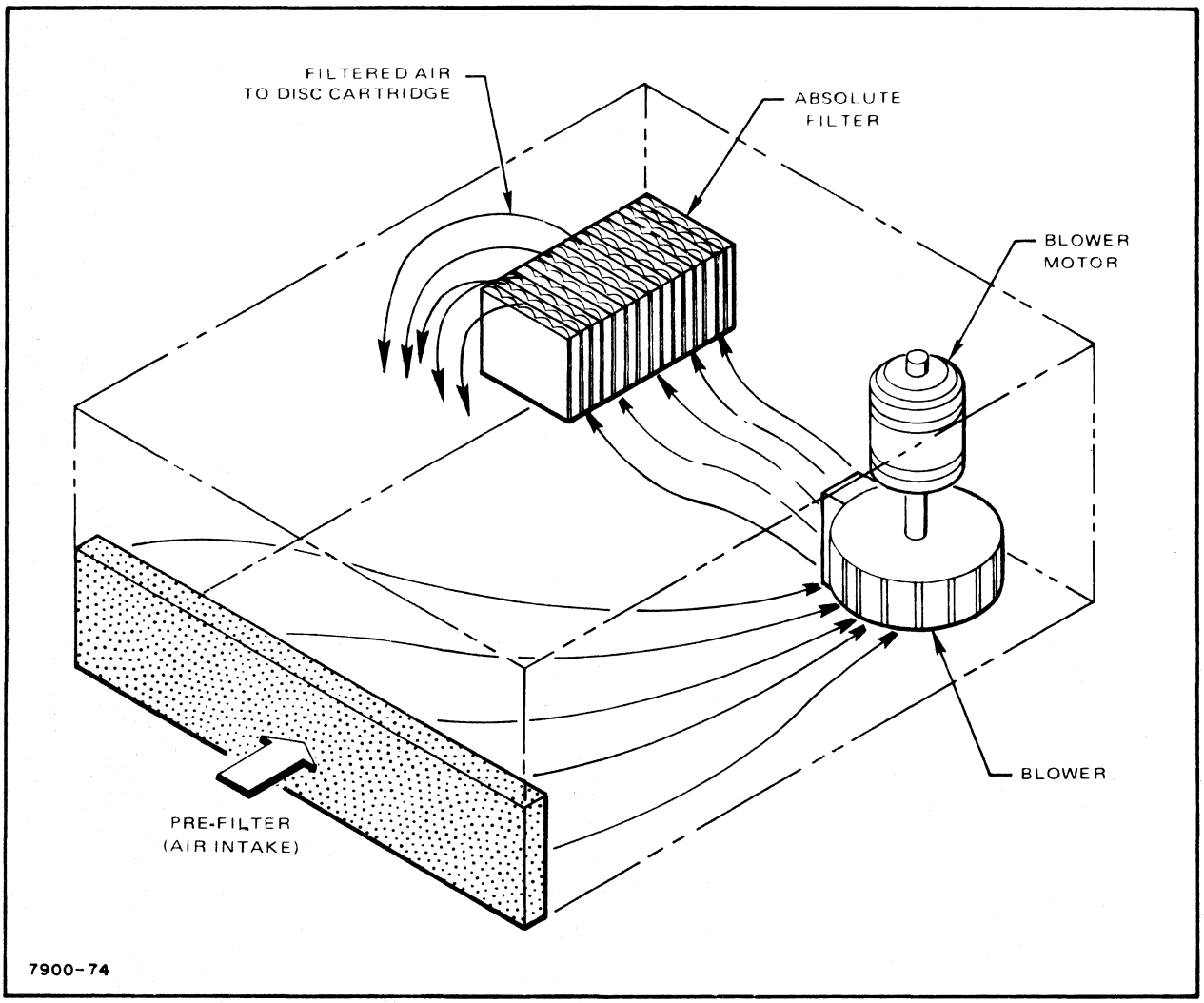
PARTICLE SIZES



There are particles in the air in almost every environment. The chart above shows the range of particle size which can be found. Note that the head to disc spacing is 2.5 microns.

The chart above compares particles on the basis of their respective radii.

HP 7900A AIR FILTRATION SYSTEM



Previous pages have shown the importance of filtering the air which cools and cleans the disc cartridge. Equally important are the details of the implementation.

1. The air should be filtered as much as possible. In this respect the HP 7900A actually has two filters. The pre-filter catches any large particles and an absolute filter to catch small particles.

2. There must be no sources of particles between the absolute filter and the entrance to the disc cartridge. For instance, if the fan pulled air through the filter, then the fan itself would be a source of particles between the filter and the disc.

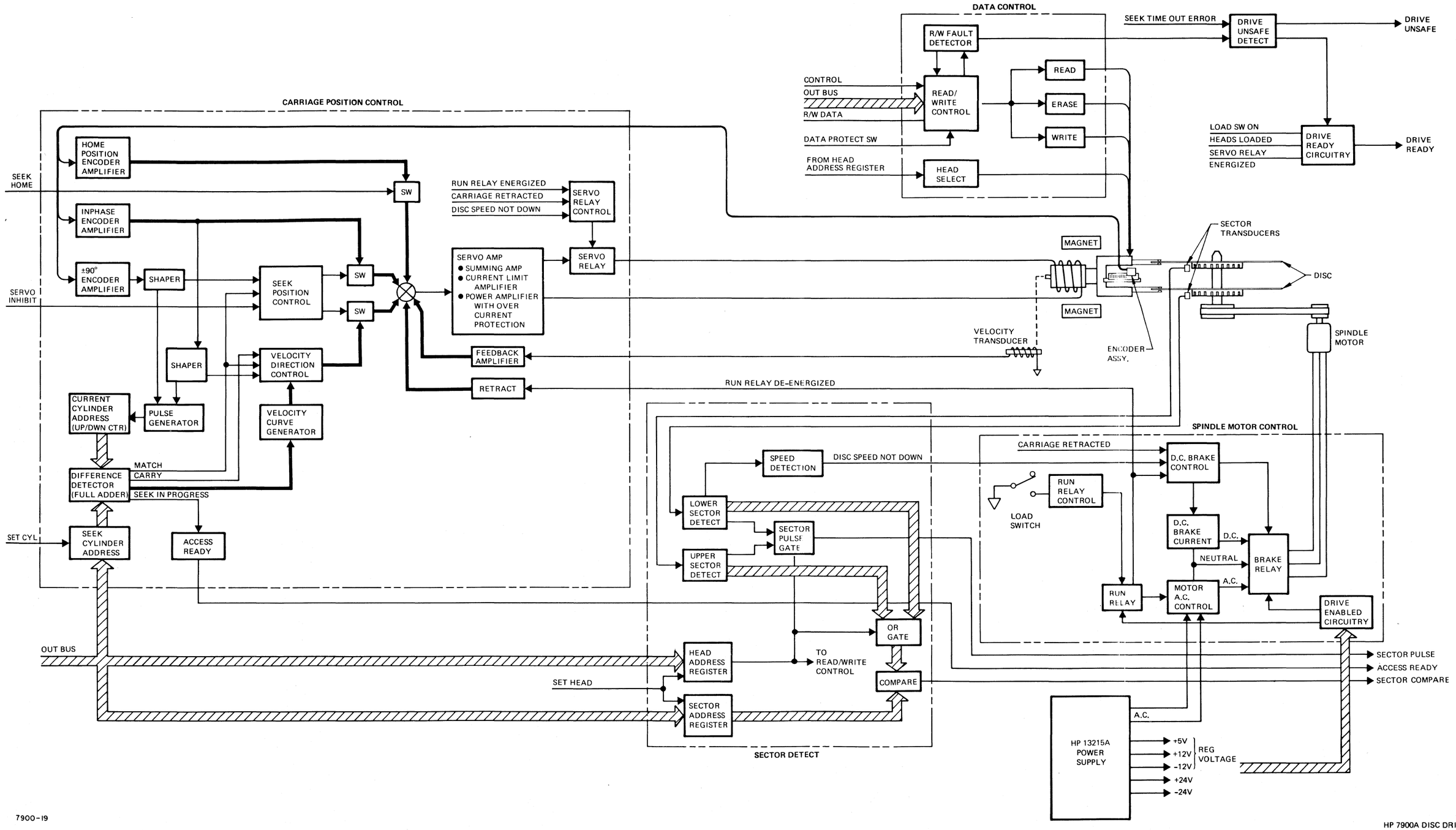
HP 7900A AIR FILTRATION SYSTEM (CONT)

3. The air flow through the filter must be adequate to ensure efficient operation.

   The efficiency of a filter is tested with particles of a given size in air flowing at a specified rate of flow. If the air flow rate is too small, then particles can migrate through the filter, reducing efficiency. If the air flow is quite large, the particles will impace the filter, causing damage to the filter and allowing particles through.

   After the air is thoroughly filtered, it is injected into the fixed disc cavity and the removable cartridge. This tends to purge the critical areas of any foreign material as well as maintaining a high pressure to reject any material that may be airborne.

SECTION II


DATA CONTROL
SEEK TIME OUT ERROR
DRIVE UNSAFE DETECT
DRIVE UNSAFE
R/W FAULT DETECTOR
CONTROL
OUT BUS
R/W DATA
READ/ WRITE CONTROL
READ
ERASE
WRITE
DATA PROTECT SW
FROM HEAD ADDRESS REGISTER
HEAD SELECT
LOAD SW ON
HEADS LOADED
SERVO RELAY ENERGIZED
DRIVE READY CIRCUITRY
DRIVE READY
CARRIAGE POSITION CONTROL
HOME POSITION ENCODER AMPLIFIER
SEEK HOME
SW
INPHASE ENCODER AMPLIFIER
±90° ENCODER AMPLIFIER
SHAPER
SERVO INHIBIT
SEEK POSITION CONTROL
SW
SW
RUN RELAY ENERGIZED
CARRIAGE RETRACTED
DISC SPEED NOT DOWN
SERVO RELAY CONTROL
SERVO AMP
● SUMMING AMP
● CURRENT LIMIT AMPLIFIER
● POWER AMPLIFIER WITH OVER CURRENT PROTECTION
SERVO RELAY
MAGNET
SECTOR TRANSDUCERS
DISC
MAGNET
VELOCITY TRANSDUCER
ENCODER ASSY.
SPINDLE MOTOR
SHAPER
VELOCITY DIRECTION CONTROL
FEEDBACK AMPLIFIER
RETRACT
RUN RELAY DE-ENERGIZED
CURRENT CYLINDER ADDRESS (UP/DWN CTR)
PULSE GENERATOR
VELOCITY CURVE GENERATOR
SPINDLE MOTOR CONTROL
CARRIAGE RETRACTED
D.C. BRAKE CONTROL
MATCH
CARRY
DIFFERENCE DETECTOR (FULL ADDER)
SEEK IN PROGRESS
SPEED DETECTION
DISC SPEED NOT DOWN
RUN RELAY CONTROL
LOAD SWITCH
LOWER SECTOR DETECT
SECTOR PULSE GATE
D.C. BRAKE CURRENT
D.C.
NEUTRAL
A.C.
BRAKE RELAY
SET CYL
SEEK CYLINDER ADDRESS
ACCESS READY
UPPER SECTOR DETECT
RUN RELAY
MOTOR A.C. CONTROL
DRIVE ENABLED CIRCUITRY
OR GATE
OUT BUS
HEAD ADDRESS REGISTER
TO READ/WRITE CONTROL
SET HEAD
COMPARE
SECTOR ADDRESS REGISTER
SECTOR PULSE
ACCESS READY
SECTOR COMPARE
SECTOR DETECT
A.C.
HP 13215A POWER SUPPLY
+5V
+12V
-12V
REG VOLTAGE
+24V
-24V

7900-19

7900A DISC DRIVE

The 7900A moving head disc drive is basically comprised of:

1. A spindle motor to rotate the disc, and spindle motor control circuits.
2. A carriage to move the heads, and carriage position controls.
3. A sector detection method to provide disc rotational position information.
4. A data control section used to write and read data.

1. The discs are attached to a spindle-shaft and bearing assembly and are rotated between read/write heads (one head for each disc surface) by means of a pulley, belt, and spindle motor. The spindle motor control circuitry controls the application of power to the spindle motor -- ac power for starting the motor, dc power for stopping the motor, and removal of power when changing disc cartridges or when the drive is otherwise not ready for use.

2. The read/write head assemblies are attached to the carriage assembly. Location of a head over a track is accomplished by positioning the carriage assembly across the radius of the disc surface. There are 203 cylinders, i.e., unique positions of the carriage assembly. That part of the carriage assembly which distinguishes one cylinder from the next is the encoder assembly. One portion of the encoder detects a reference point, called the home position, which is labeled cylinder 00. The remainder of the encoder generates a very accurate carriage positioning signal. This signal is used to move the head to the exact center of the desired cylinder. It is also used to update the current address register whenever the heads move from one cylinder to the next.

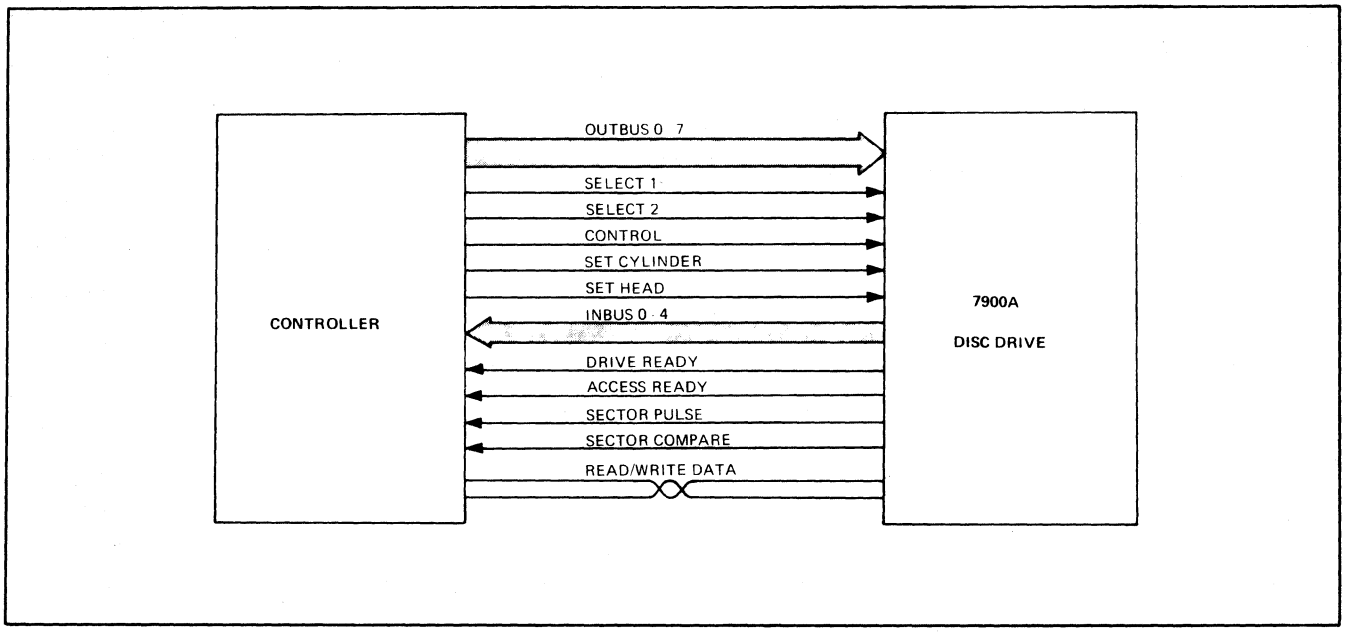
   That part of the carriage responsible for moving the entire assembly consists of a coil of wire free to move within a magnetic field. In essence, the coil and the permanent magnet assembly form a linear motor which moves the carriage assembly, just as a voice coil moves the diaphragm in a loud speaker. Because precise control of carriage velocity is necessary for accurate positioning, a velocity transducer is attached to the carriage, whose signal is used by the carriage position control circuitry.

3. Attached to the bottom of each disc is a short, thin-walled skirt with slots cut in it. This slotted skirt, together with a photocell assembly for detecting the slots, are used for detecting disc rotational disc position. If radial lines were drawn through the slots, the disc would be divided into 24 equal pie-shaped segments. The area of the disc which passes beneath a read/write head from one radial line to the next is called a SECTOR. The sectors are numbered from 00 to 23. The disc controller sends the desired sector address to the disc drive, and the sector detect circuitry compares the desired address with the actual position of the disc. This comparison signal is part of the dynamic status sent to the controller and is used for data transfer timing.

7900A DISC DRIVE (CONT)

4. Data storage and retrieval is accomplished by using a electromagnetic read/write head suspended over the surface of the disc. The spring action of the head supporting arm forces the head toward the surface. The air pressure created by the rotating disc forces the head away from the disc. The two forces cancel each other when the head is suspended at the proper height for reading and writing. The controller selects one of the four heads at the same time that it selects the starting sector. The addressed head will read and write data from a "track", which is that part of the disc which passes under the head during a complete revolution of the disc.

GENERAL INTERFACE CHARACTERISTICS



Operation of the 7900A Disc Drive is the responsibility of a controller. The controller resides logically between the CPU and the disc drive. Its function is to receive commands from the CPU and translate them into a form that the disc drive can use. Communication between the controller and disc drive is accomplished over outbus lines (8), inbus lines (5), status information lines, select lines, data lines, and drive control lines.

OUTBUS AND CONTROL

Outbus lines are multiplexed by using controlling identification lines. The identification lines carry a strobe or clock pulse to identify the desired function. The controlling lines are:

1. SET CYLINDER - When true indicates that the desired cylinder address is present on outbus lines 0 thru 7.

   If Access Ready is true at this time a seek operation is initiated. If Access Ready is false, the Seek Check latch is set and the appropriate status is presented to the controller.

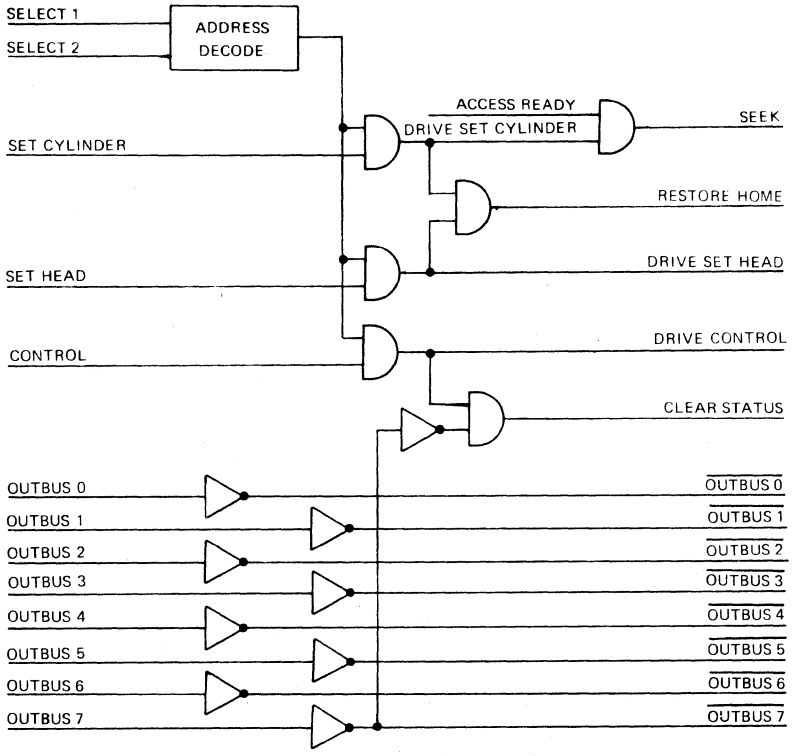
2. SET HEAD - When true indicates that the desired head and sector address is present on the outbus lines.

3. CONTROL - Enables the desired memory function (Read, Write or Erase) as specified with outbus 0 through 2. If control is set true along with outbus 7, the attention status latch is cleared. Control must remain active throughout the entire memory function.

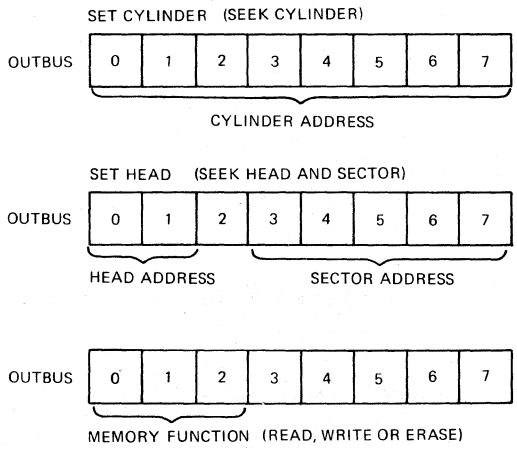
4. SELECT 1 and 2 - Indicate the logical unit address of the unit to be accessed.

The RESTORE HOME function is performed by activating SET HEAD and SET CYLINDER simultaneously.

OUTBUS RECEIVING



OUTBUS MULTIPLEXING



INBUS AND CONTROL

Some inbus lines (from the drive to the controller) are multiplexed. The multiplexing is accomplished by requesting status with selected outbus lines. The multiplexed status lines are inbus 0 through 3.

Activating outbus 7 enables drive condition status (first status, seek check, surface disabled, and override protect status.) Activating outbus 6 enables attention status on the appropriate drive address line. If outbus 7 is activated in coincidence with control, clear status is generated to reset the attention latch.

Nine status lines are available to the disc controller to report the condition of the drive. These status lines are:

1. FIRST STATUS - Initiated by Drive Ready, Reset by Outbus 7.

2. ATTENTION - Set when a seek operation is completed. Presented to the controller on the inbus line corresponding to the Drive Address.

3. SEEK CHECK - Indicates that an illegal address (head, sector, or cylinder) has been sent to the drive or indicates that a seek was attempted while another seek was in progress.

4. SURFACE DISABLED - Indicates that the selected disc is disabled for writing.

5. S1 - Used to override the software protect (PCI) bit. Refer to the 13210A Controller Manual.

6. DRIVE UNSAFE - Indicates that a read/write fault condition occurred or that a seek operation has failed to complete within 850 m seconds.

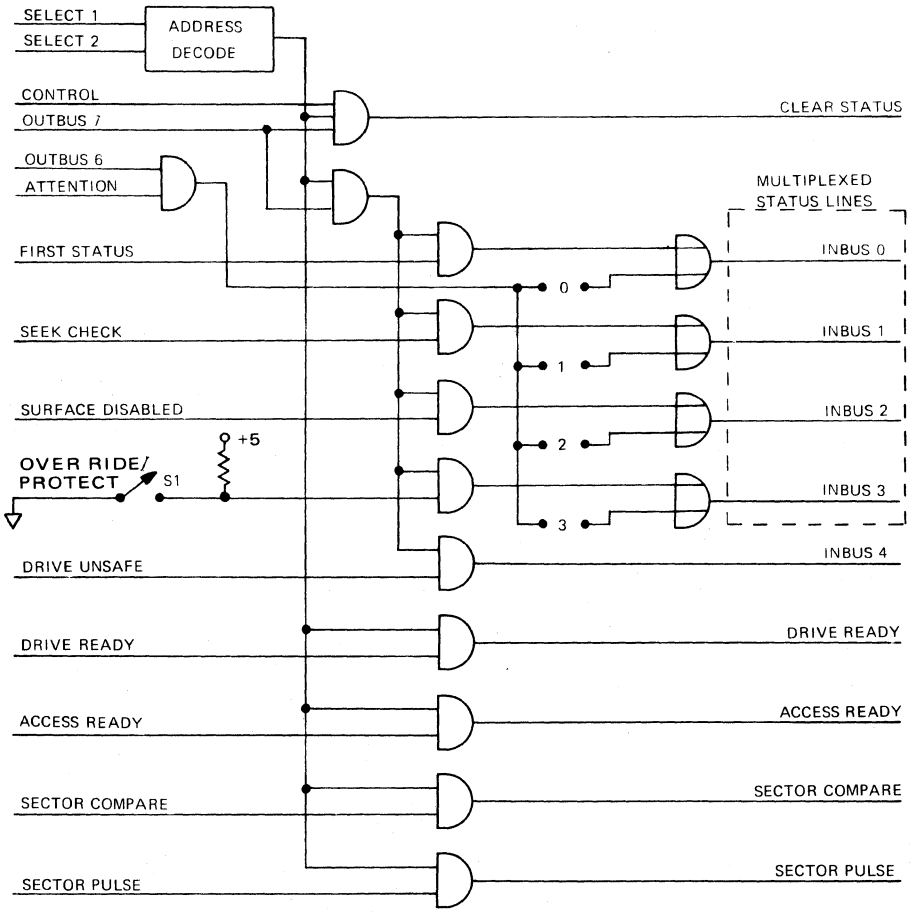
7. DRIVE READY - Indicates that the drive is loaded and ready for use.

8. ACCESS READY - Indicates that the drive is ready and no seek operation is in progress.

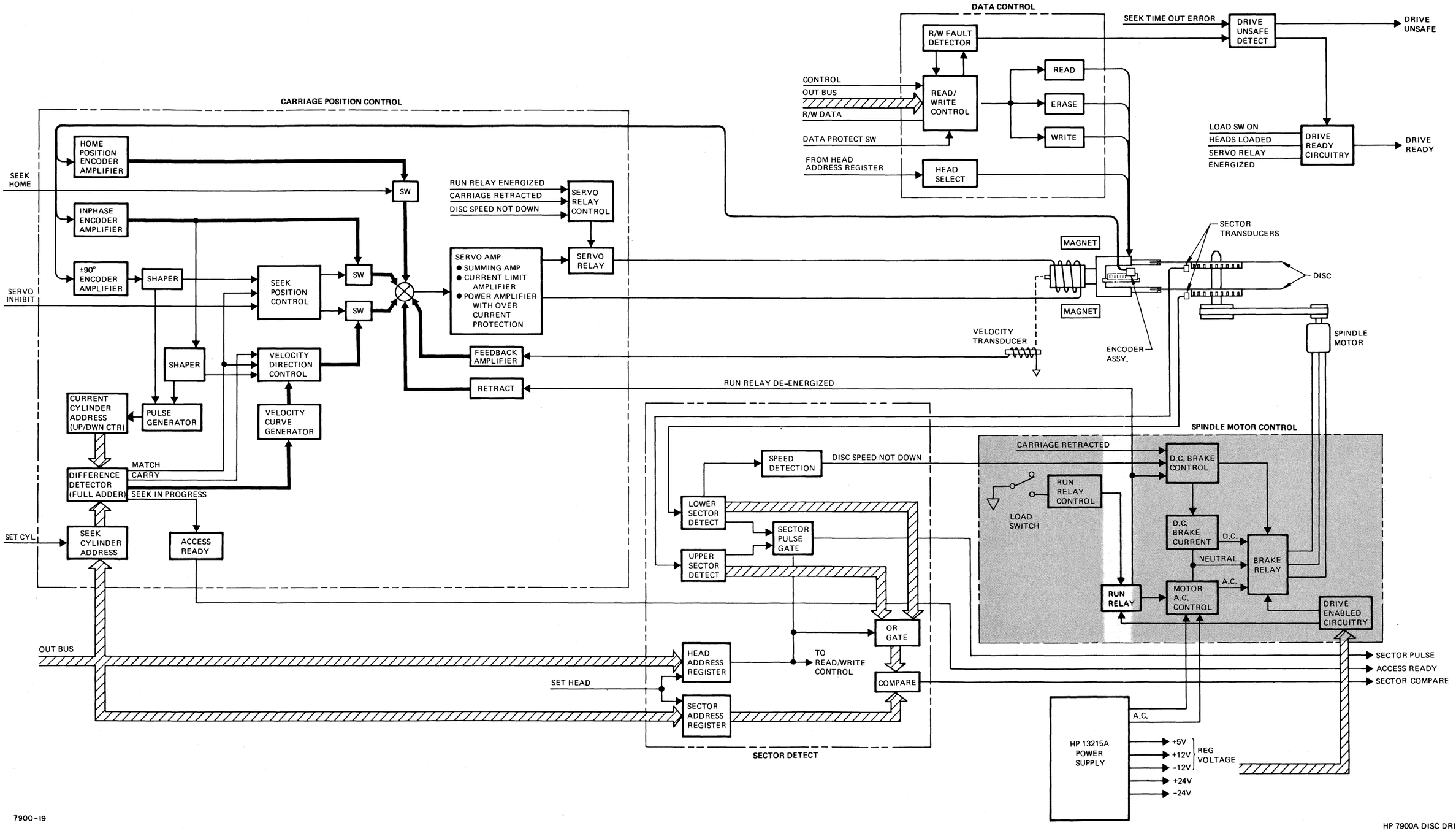
9. SECTOR COMPARE - Becomes true when the selected sector is under the head.

10. SECTOR PULSE - A 17 μsec pulse at the beginning of each sector.

INBUS STATUS



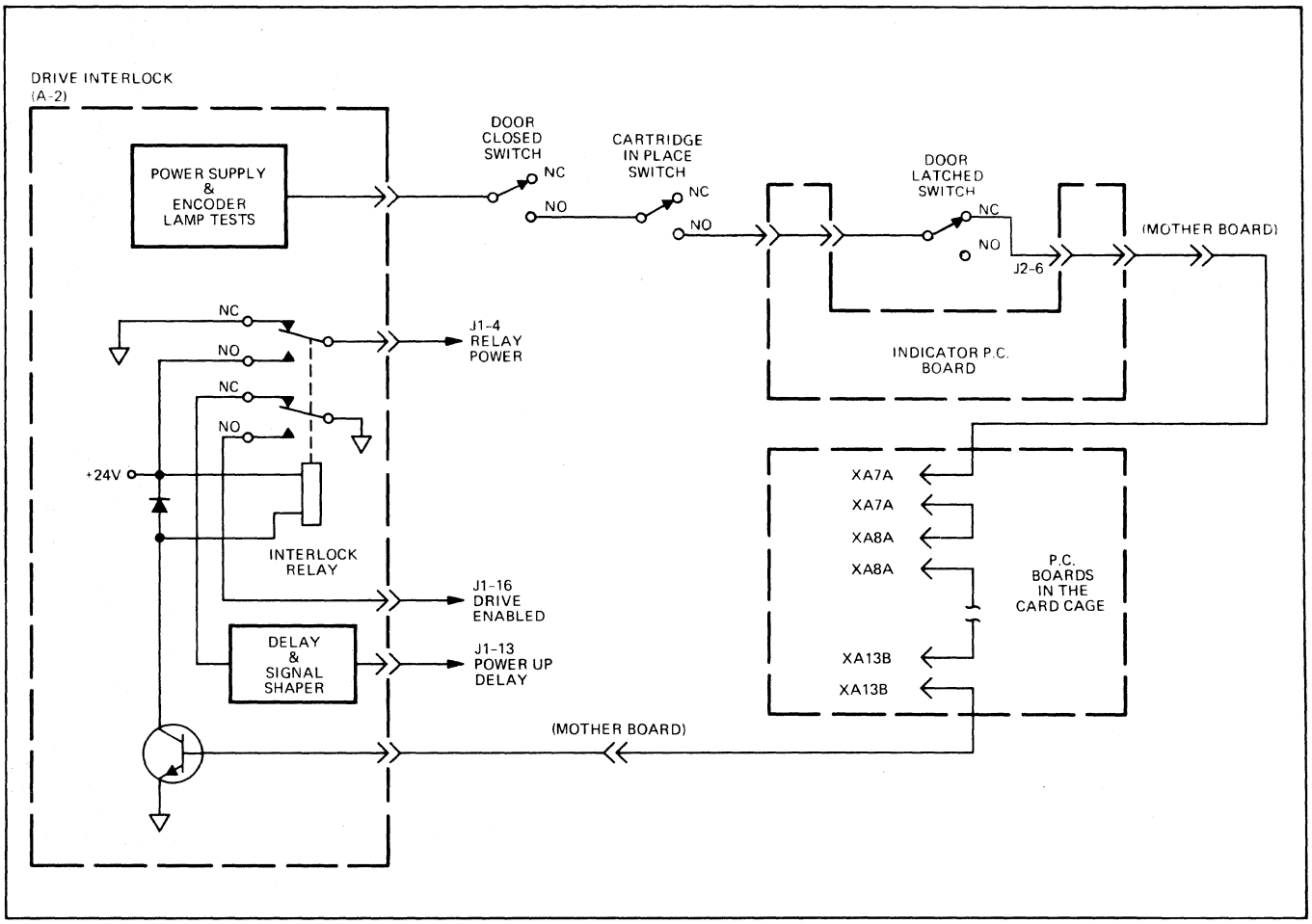
SECTION III



7900-19

HP 7900A DISC DRIVE

DRIVE ENABLE CIRCUITRY



The purpose of the drive enable circuitry is to provide a safety interlock system. To satisfy the interlock system, the following conditions must be met:

1. All power supply voltages must be present.
2. There must be current in the encoder lamp.
3. The front door must be closed.
4. A cartridge must be installed and in place.
5. The door must be properly latched.
6. All PC boards must be properly installed in the drive.

When these requirements are met the Drive Enable Relay is energized. Energizing this relay:

1. Provides Relay Coil Power for the "Run Relay", the "Servo Relay", and the "Brake Relay".
2. Provides "Drive Enabled" for the Control Circuitry.
3. Generates an initial "Power up Delay" pulse which is used as an initial reset.

SPINDLE MOTOR CONTROL

The spindle motor control logic determines when and what power is applied to the spindle motor. This may be no power (off), to AC to make the motor run, or DC to make the motor brake.

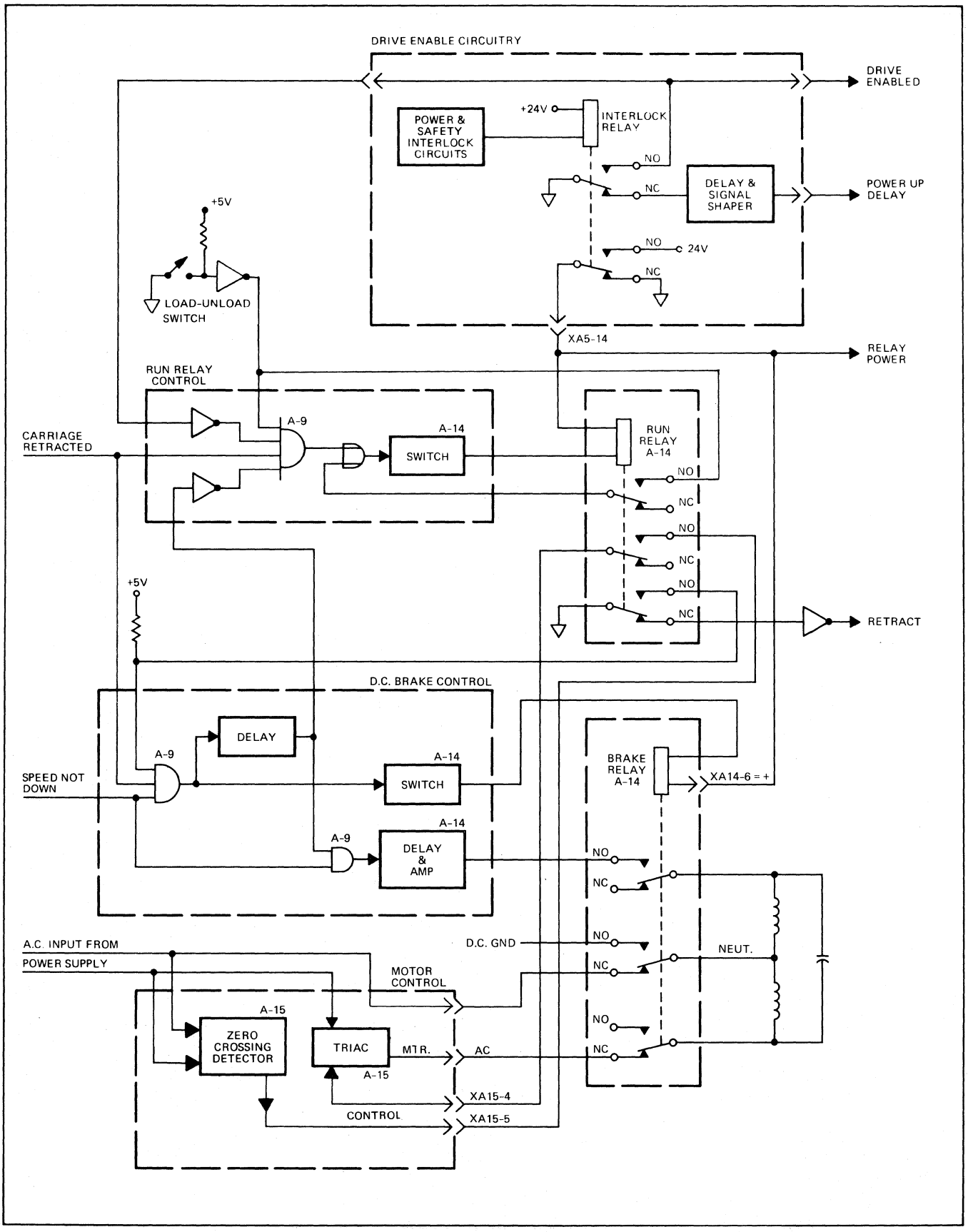
To make the spindle motor run requires that the "Load-Unload" switch be set to "Load", that the Drive Enable Circuitry is satisfied, that the carriage is fully retracted, and that the DC brake circuitry is disabled. When these conditions are met, the Run Relay closes providing a complete circuit for the Motor AC Control circuit. This circuit in turn gates AC power to the spindle motor.

The purpose of the Motor AC Control is to minimize RF interference caused by switching AC power to the motor. The circuit uses a Triac which is controlled by a Zero Crossing Detector to gate motor AC input.

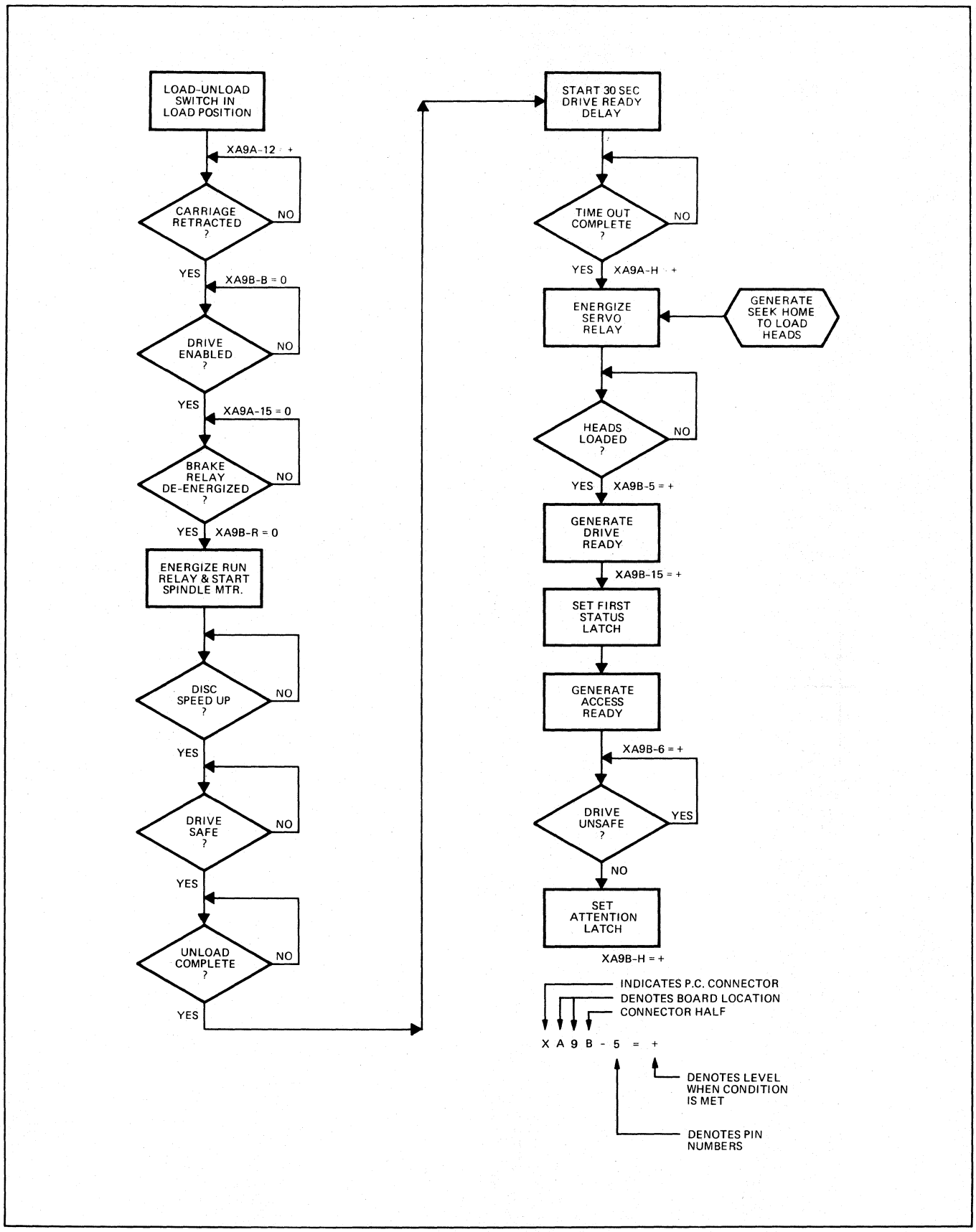
Once the Run Relay is energized, it will remain energized until the Load-Unload switch is set to Unload or the drive enable status is negated. When one of these conditions is met, the Run Relay is de-energized and the Motor AC Control removes AC power from the spindle motor. De-energizing the Run Relay also generates a Retract command for the carriage servo. After the carriage is fully retracted, the brake control circuitry energizes the Brake Relay which transfers the motor to the DC Brake Current Circuit. After a short delay (which allows the relay contacts time to settle) the DC brake circuit is enabled causing the spindle motor to stop. When the Speed Sense Circuit indicates that the spindle has stopped, the DC brake current is removed, and after another short delay the Brake Relay is de-energized and the motor voltage supply path is switched to the AC circuit.

If the Load-Unload switch is set to Load while the motor is braking, the spin-down sequence will continue until the spindle has completely stopped.

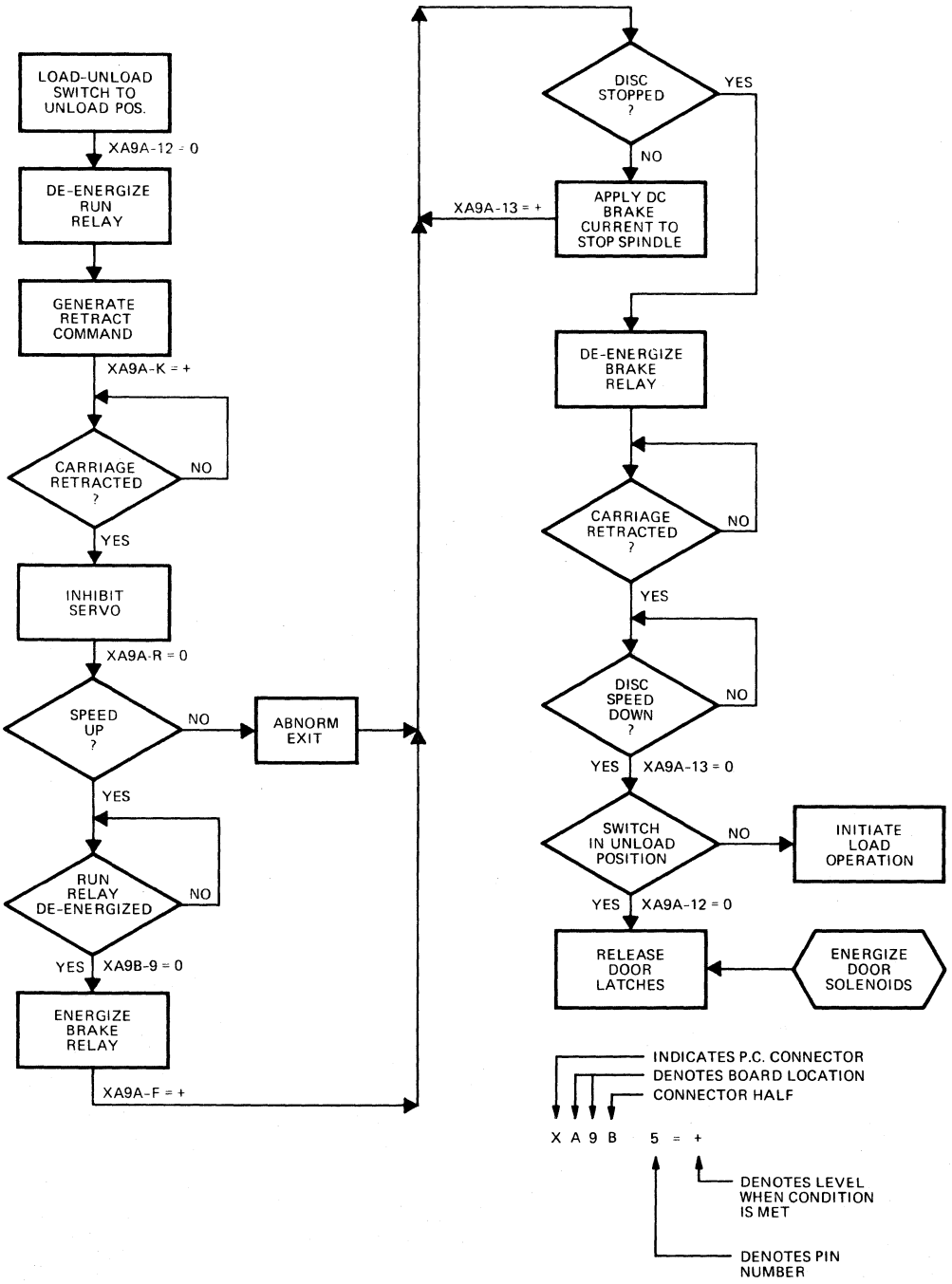
SPINDLE MOTOR CONTROL



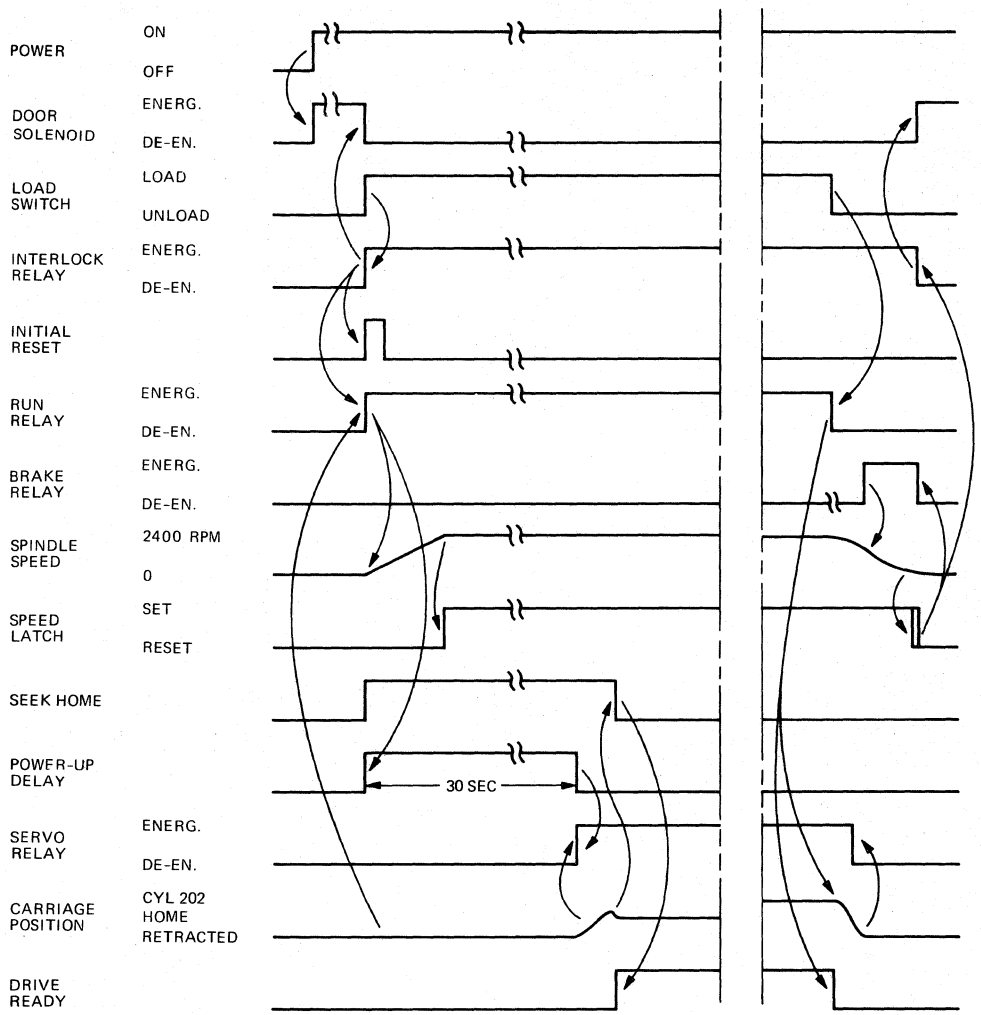
LOAD OPERATION



UNLOAD OPERATION



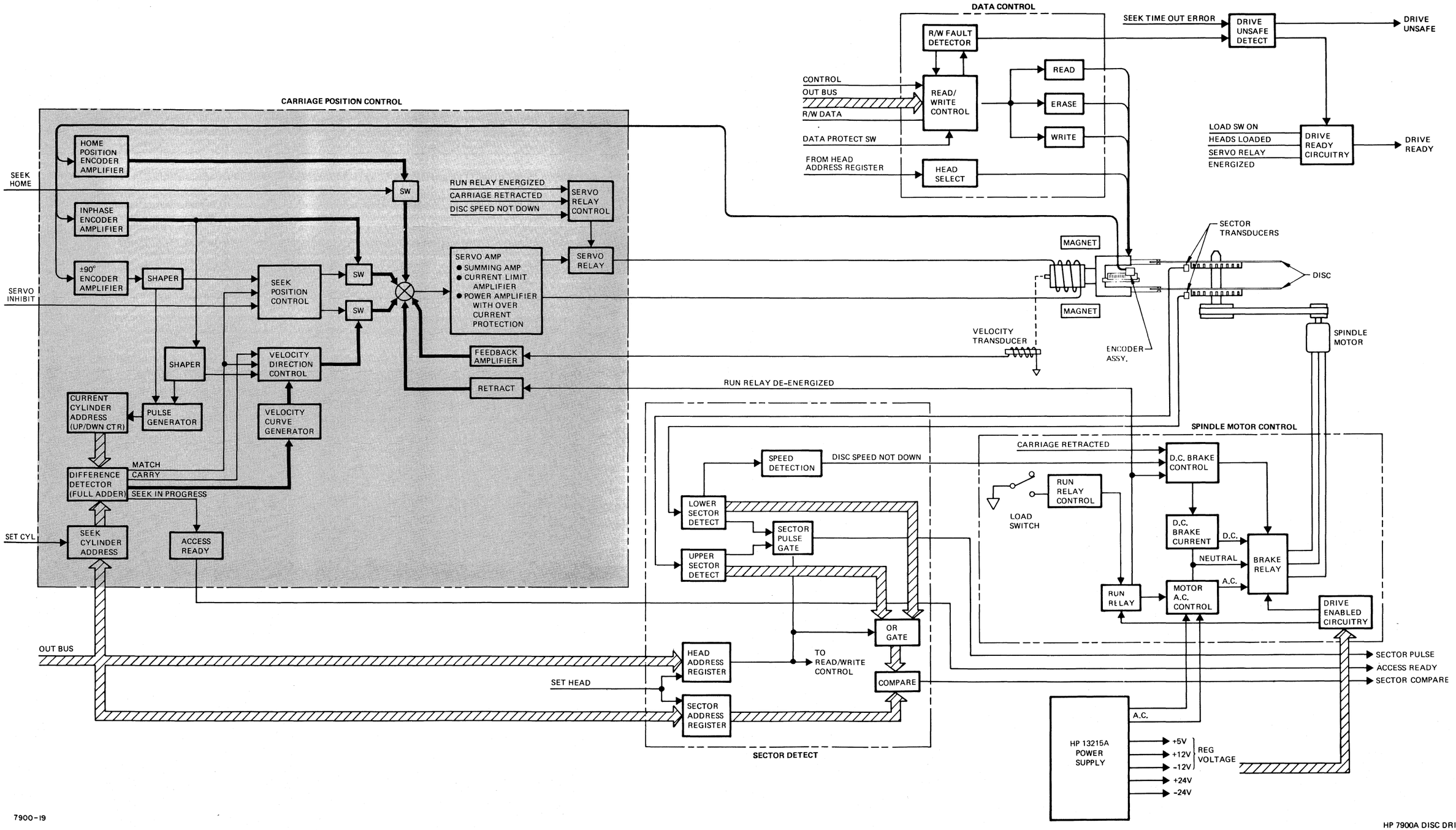
LOAD/UNLOAD TIMING



NOTE: The arrows point from the source signal to the result signal, i.e. Power "ON" initiates door solenoid "ENERGIZED".

Interlock relay "ENERGIZED" causes the door solenoid to "DE-ENERGIZE".

SECTION IV



7900-19

HP 7900A DISC DRIVE

CARRIAGE OPERATION

The carriage position control portion of the 7900A Disc encompasses two major areas of the drive. The position Control, which determines the direction and velocity of a carriage move; and the Servo Amplifier, which actually provides drive current to the linear motor.

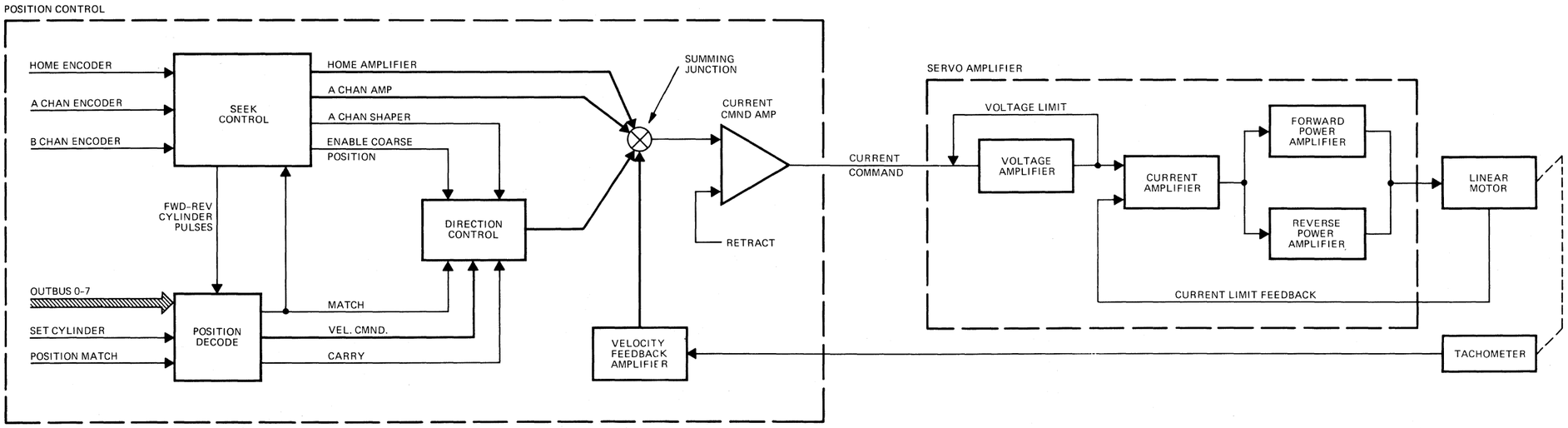
The position decode circuitry receives a new cylinder address and a seek command. The circuitry compares the seek address with the present carriage address and generates a velocity command signal that is a function of the distance to be moved. The correct polarity signal, determined by the direction of the move, is gated into the summing junction. The difference between the commanded velocity and the actual velocity (determined by the Tachometer) is amplified and used to control the current in the linear motor.

Speed controlling feedback is provided by a velocity transducer (or tachometer) that senses the carriage speed. The output of the Velocity Feedback Amplifier is proportional to the speed and direction of the carriage motion.

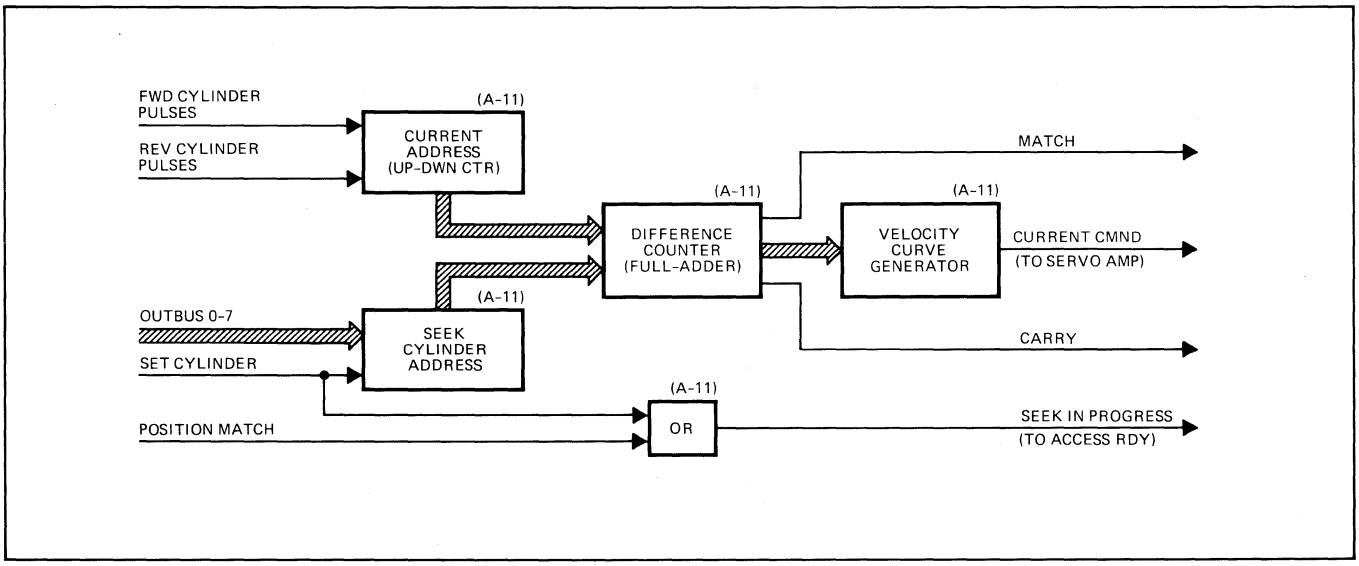
The servo amplifier controls the current to the linear motor, which in turn positions the carriage at the desired location.

The Velocity Command is received and amplified by a Voltage Amplifier. This output drives the Current Amplifier which provides drive current to the appropriate Power Amplifier. Current through the linear motor is sensed and presented to the current amplifier as Current Limiting Feedback.

CARRIAGE CONTROL



SEEK CONTROL

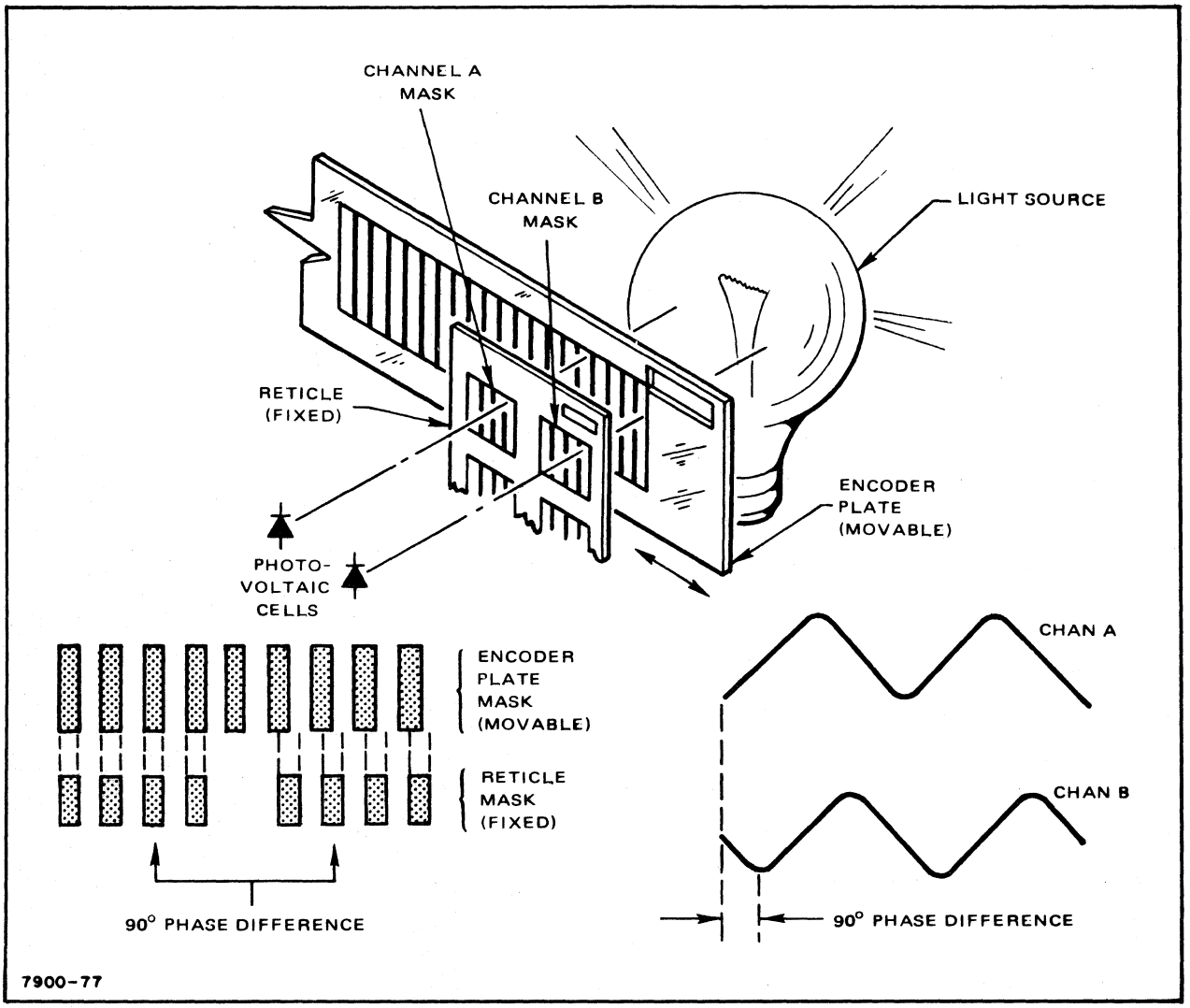


When a SEEK command is issued to the drive, the desired cylinder address is placed on the outbus lines 0 through 7 and clocked into the "Seek Cylinder Address" register by SET CYLINDER. The ones compliment of the current address is added to the desired address and the difference value is presented to a velocity curve generator. The current address is stored in an 8 bit up-down counter that uses forward-reverse cylinder pulses to alter the cylinder location counter. Thus, the current address register always contains the actual carriage position.

When an address difference is detected, "ACCESS READY" is negated, "MATCH" is negated, and if the seek is to be forward, "CARRY" is activated. If the seek is reverse (toward cylinder 00), carry is inactive.

The difference value presented to the velocity curve generator is a binary value relative to the distance between the present carriage position and the desired position. The velocity curve generator then converts this binary value to an analog voltage relative to the distance the carriage is away from its destination. This voltage will be sent to the Servo Amplifier where it commands the carriage to move at some velocity; fast when it is far away (<63 tracks = maximum speed), and progressively slower as it approaches its destination.

CARRIAGE POSITION DETECTION



Carriage position detection is accomplished by means of an optical encoder. The encoder provides two channels of position information which are separated in time by 90°. The information is detected by sensing a value of light from a fixed source through a reticle and encoder plate. A third channel of information is used to sense CYLINDER ZERO or HOME POSITION.

The Encoder Plate (mounted on the carriage) is etched such that there is a "MASK BAR" for each track and that the "BAR" separation exactly represents the 0.010" track to track separation. The reticle is etched such that there is a 1/4" track separation between the A Channel and B Channel "MASK BARS". Thus, the relative outputs are separated by 1/4 of a track width.

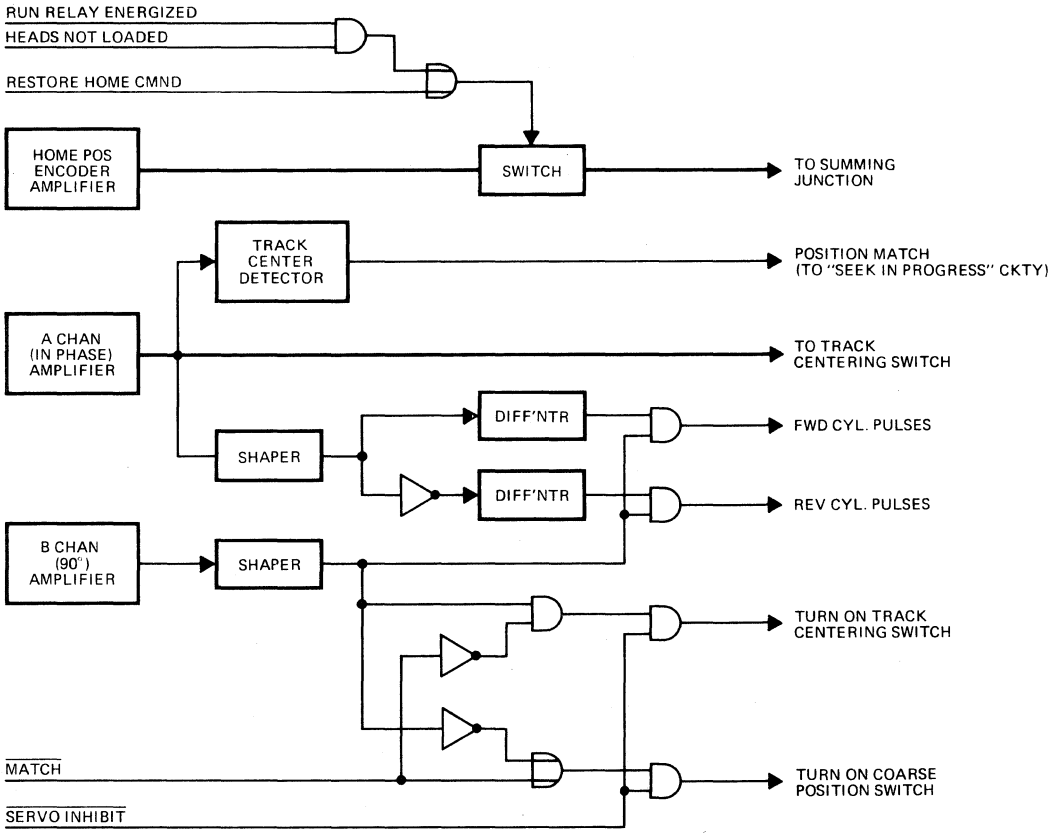
CARRIAGE POSITION CONTROL

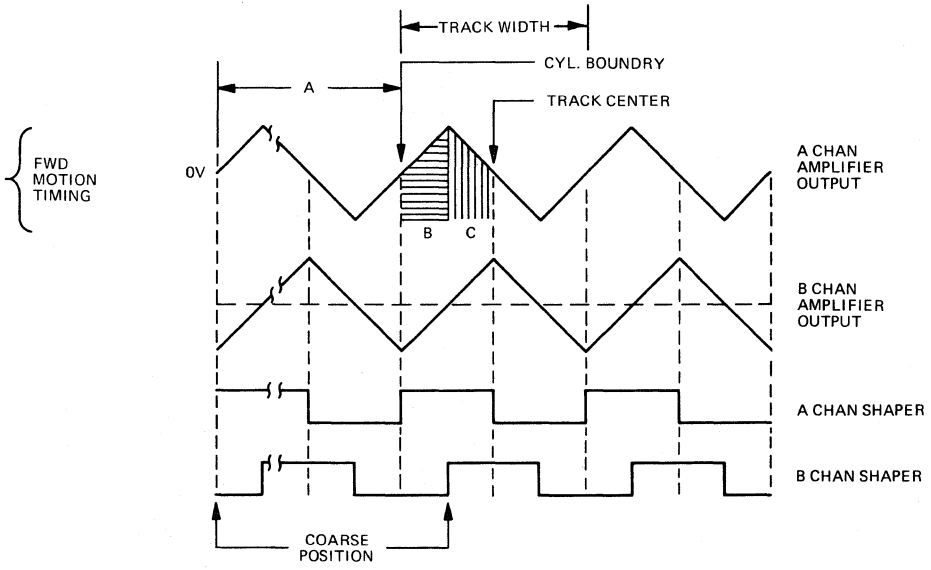
The SEEK POSITION CONTROL circuitry determines which motion command is presented to the summing junction and subsequently to the Servo Amplifier to drive the carriage. There are two methods of initiating a seek operation from the controller: a "Seek Command" or a "Restore Home Command." The "Home Position Encoder" is used to initially position the heads at cylinder 00 by performing a Seek Home in the forward direction; and is used to restore the carriage to the home position to reinitialize the Current Address Register.

Performing a SEEK command and moving the carriage requires using the encoder A and B channels for positioning. Coarse positioning (see timing diagram) controls the carriage from the time the new cylinder address if placed in the cylinder address register (negates "Match") until the heads come within 1/4 track (.0025 inches) of the desired cylinder center. The controlling signals during the coarse positioning are "MATCH" and the B channel shaper output. When "MATCH" is negated, the Coarse Position switch is gated on, and a velocity command is sent to the Servo Amplifier. After the carriage has reached the destination cylinder boundary, "MATCH" is set "ON" and the coarse position switch is held on by the B channel shaper. When the carriage has traveled 1/4 on the way into the desired cylinder, the COARSE POSITION switch is negated and the TRACK CENTERING switch is gated on by "MATCH" and the B channel shaper. At this point, the A channel amplifier is used as the velocity command. Thus, the carriage is centered by servoing on the 0 volt point of the "In Phase" (A Channel) Encoder amplifier.

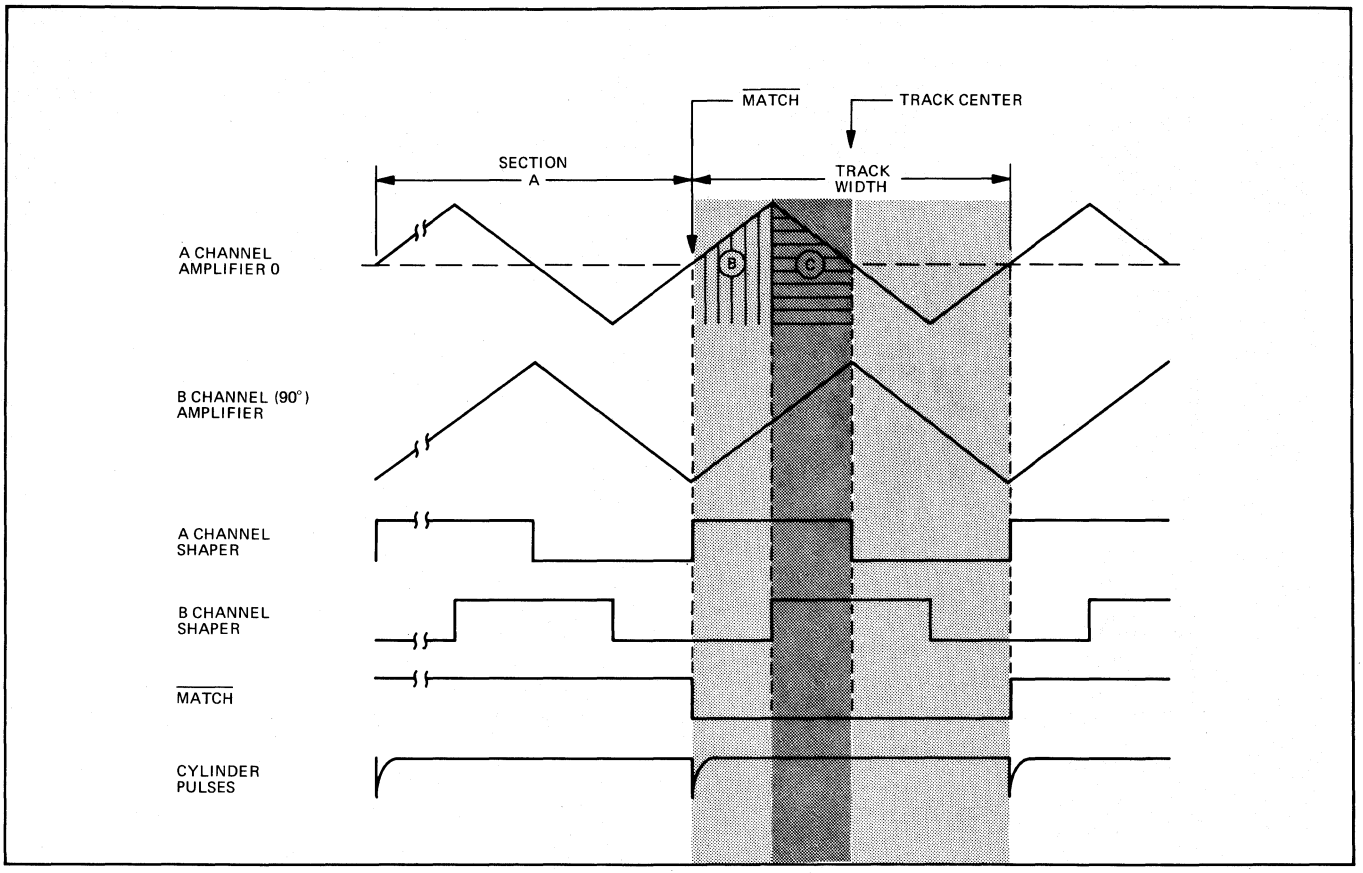
The Track Center Detector is used to sense when the carriage is at track center. Significant (approximately 250 μinch) deviation from track center will be detected by the Track Center Detector which will negate Cylinder "MATCH" which in turn negates ACCESS READY. This prevents inadvertent destruction of data on adjacent tracks in the event of any malfunction or external force which moves the head off the center of the cylinder. Writing on that portion of a track between the cylinder boundary and the track center is also prevented. As the carriage moves toward its destination, the "A Channel Encoder" output is shaped. This signal is then presented to two differentiators. One receives the true signal and the other the inverted signal. The appropriate differentiator output is then gated with the B Channel shaper to produce forward/reverse cylinder pulses used to update the "Current Address Register".

CARRIAGE POSITION CONTROL





ENCODER TIMING (FORWARD SEEK)

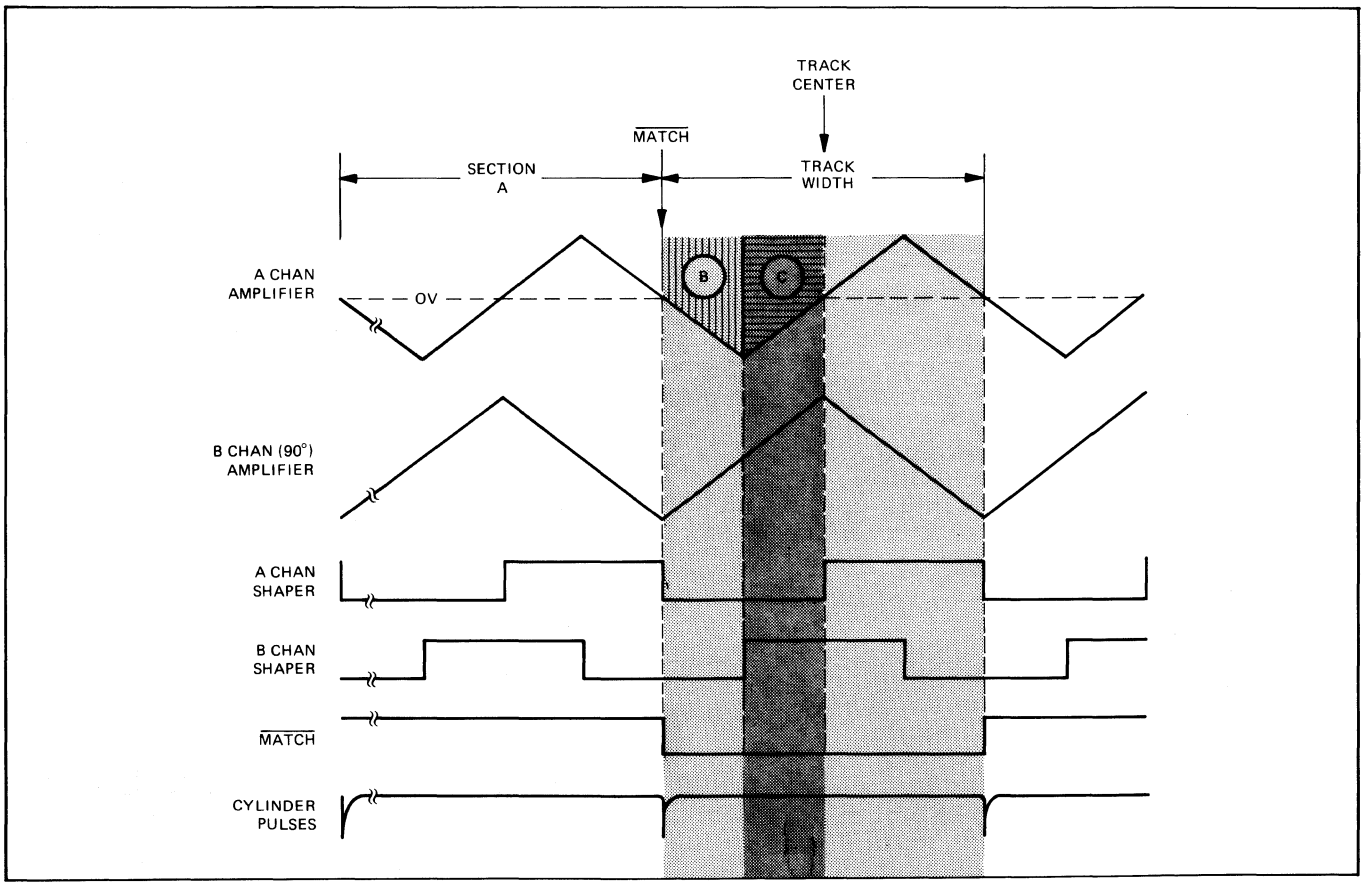


Section A - Controlled by "MATCH" being false. Velocity command is supplied by the "Velocity CMND Generator".

Section B - Controlled by the "B Channel" (90°) pulse shaper output being low. Velocity command is supplied by the "Velocity CMND Generator".

Section C - Controlled by "MATCH" being true and "B Channel" shaper output being high. Velocity command supplied by the "A Channel" Encoder amplifier. The carriage is centered by the "A Channel" encoder amplifier output zero crossing.

ENCODER TIMING (REVERSE SEEK)

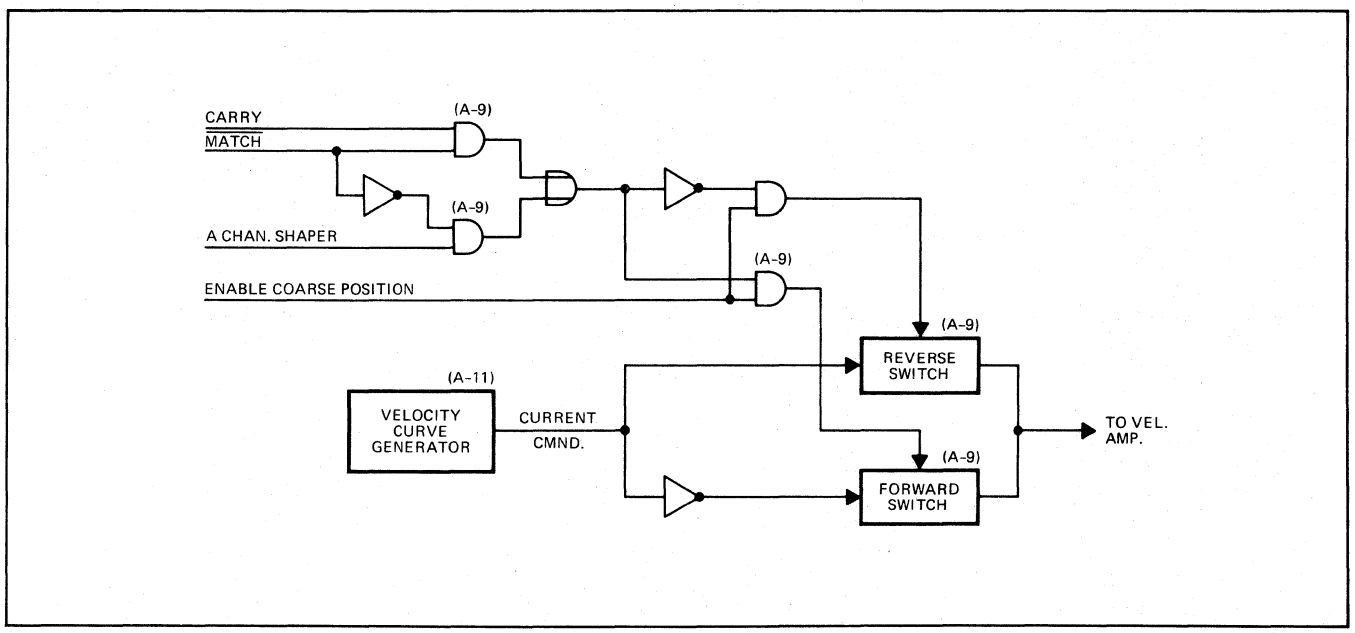


Section A - Controlled by "MATCH" being false. Velocity command is supplied by the "Velocity CMND Generator".

Section B - - Controlled by the "B Channel" (90°) pulse shaper output being low. Velocity command supplied by the "Velocity CMND Generator".

Section C - Controlled by "MATCH" being true and "B Channel" shaper output being high. Velocity command supplied by the "A Channel" Encoder amplifier. The carriage is centered by the "A Channel" Encoder amplifier output zero crossing.

CARRIAGE DIRECTION CONTROL



The Direction Control circuitry is used to gate the proper polarity velocity command to the Servo Amplifier.

The analog velocity command from the Velocity Curve Generator is fed to the Forward and Reverse switches. However, the signal presented to the Forward Switch is inverted to provide the proper polarity to cause the carriage to move forward.

If ENABLE COARSE POSITION is true, either the Reverse or Forward Switch is turned on. During a seek operation, the "Carry" bit from the Difference Counter determines which direction switch is used until "MATCH" occurs. If the 'CARRY" bit = 1, the seek is forward; if "CARRY" bit = 0, the seek is reverse. After "MATCH" occurs, the A channel shaper output controls the direction switches. Once the carriage is within 1/4 track width of the desired track center, "ENABLE COARSE POSITION" is negated and the "Servo Amplifier" is controlled by the A channel Encoder Amplifier.

NOTES

CURRENT COMMAND AMPLIFIER

The current command amplifier produces a signal proportional to the difference between the commanded velocity and the actual carriage velocity. Inputs to the summing junction and subsequently to the current amplifier are:

1. HOME CHANNEL ENCODER AMPLIFIER - used to seek home at initial load or as a result of the "Restore Home" command.

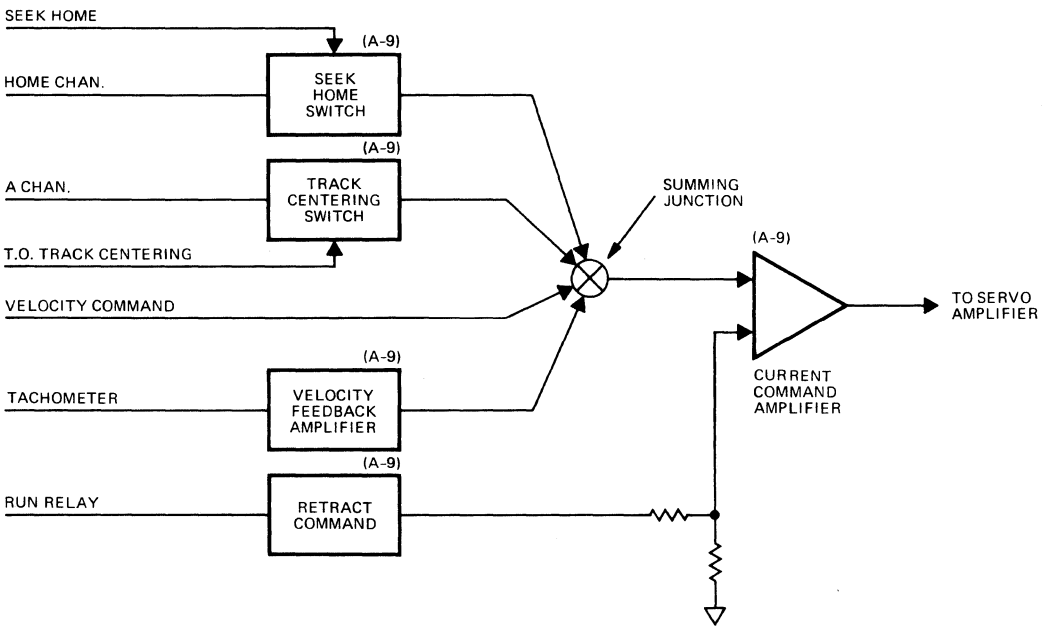
2. CHANNEL A ENCODER AMPLIFIER - used to locate the carriage at the precise center of the desired cylinder.

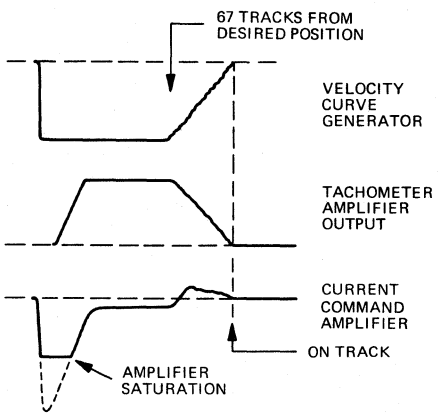
3. VELOCITY COMMAND - signal from the velocity curve generator used to command carriage motion curing a seek operation.

4. VELOCITY FEEDBACK - the amplifier output of the mechanically connected velocity transducer (tachometer), — used to sense actual carriage speed and direction.

5. RETRACT COMMAND - generated as a result of de-energizing the run relay.

During coarse positioning, the output of the CURRENT COMMAND AMPLIFIER is the amplified algebraic sum of the velocity command and the velocity feedback. During a seek operation, the velocity command initially saturates the amplifier until the carriage accelerates to the commanded velocity. Termination of the seek operation is accomplished by controlling the velocity command and decelerating the carriage at a uniform rate.


SEEK HOME
(A-9)
SEEK HOME SWITCH
HOME CHAN.
(A-9)
TRACK CENTERING SWITCH
A CHAN.
T.O. TRACK CENTERING
SUMMING JUNCTION
(A-9)
TO SERVO AMPLIFIER
VELOCITY COMMAND
CURRENT COMMAND AMPLIFIER
(A-9)
VELOCITY FEEDBACK AMPLIFIER
TACHOMETER
(A-9)
RETRACT COMMAND
RUN RELAY


67 TRACKS FROM DESIRED POSITION
VELOCITY CURVE GENERATOR
TACHOMETER AMPLIFIER OUTPUT
CURRENT COMMAND AMPLIFIER
ON TRACK
AMPLIFIER SATURATION

SERVO AMPLIFIER

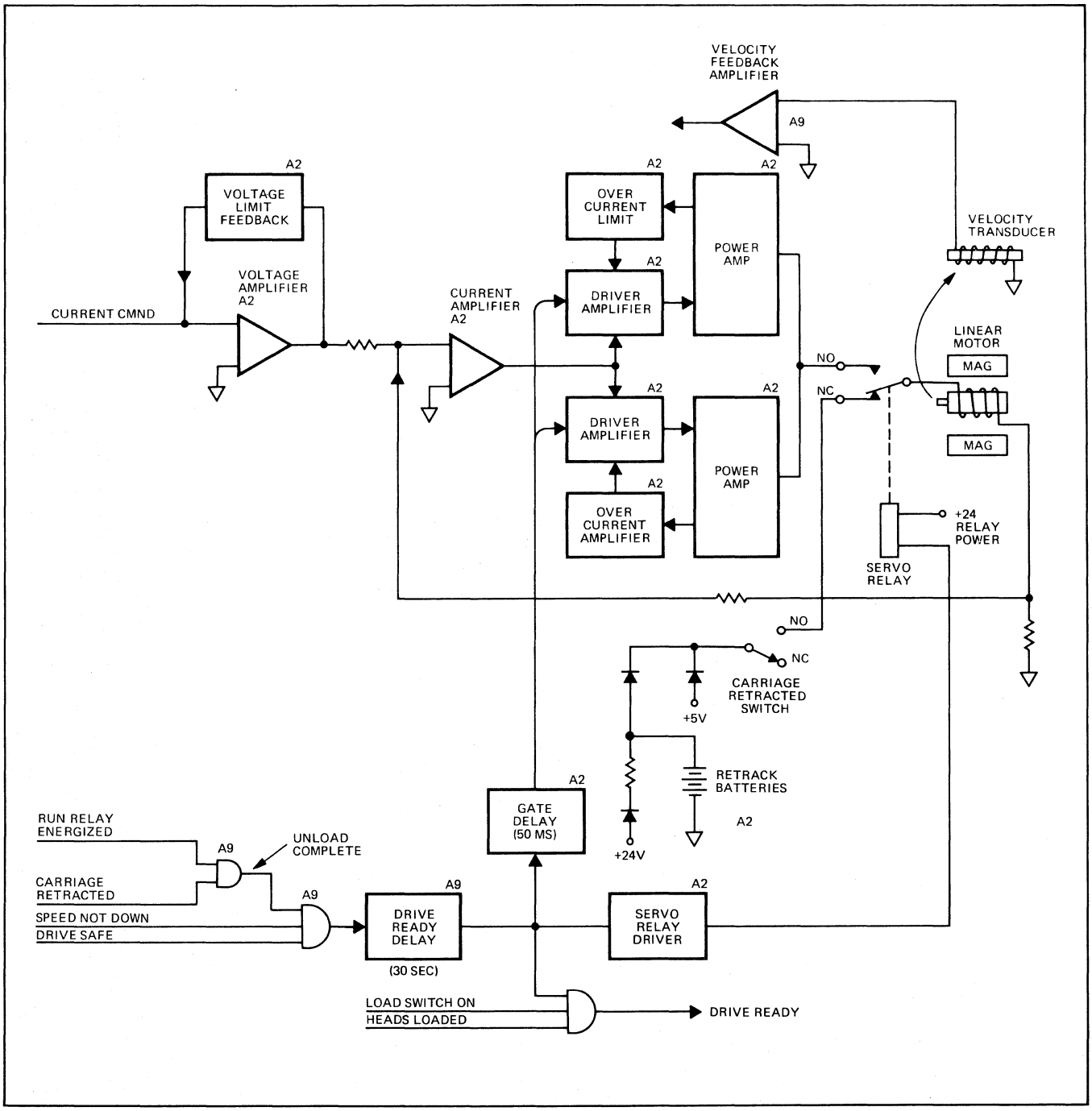
The Current Command is received by a voltage amplifier operating at a fixed gain. The output is clamped to a DC level to limit the current to the power amplifier. A current amplifier compares the voltage amplifier output with the voltage developed across the current sense resistor. The algebraic difference between these voltages is then amplified and fed to two driver amplifiers. One (depending on the polarity) will proportionally drive the appropriate power amplifier (provided the gate delay has enabled the driver amplifiers).

Gate delay is initiated by bringing the disc up to speed and timing out an initial 30 second drive ready delay. The purpose of this delay is to purge the drive of foreign material by allowing air flow but holding the heads unloaded. At the end of the drive ready delay, the servo relay is energized and the 50 ms gate delay is timed out to allow for relay settle time. When these conditions are met, the power amplifier is permitted to drive the linear motor. Current through the motor is limited to 13.5 AMPS. This is accomplished by sensing motor current with a resistor in series with the motor. An over-current limit circuit senses the power amplifier output current and limits the driver amplifier to prevent motor current from exceeding maximum safe limits under malfunction conditions.

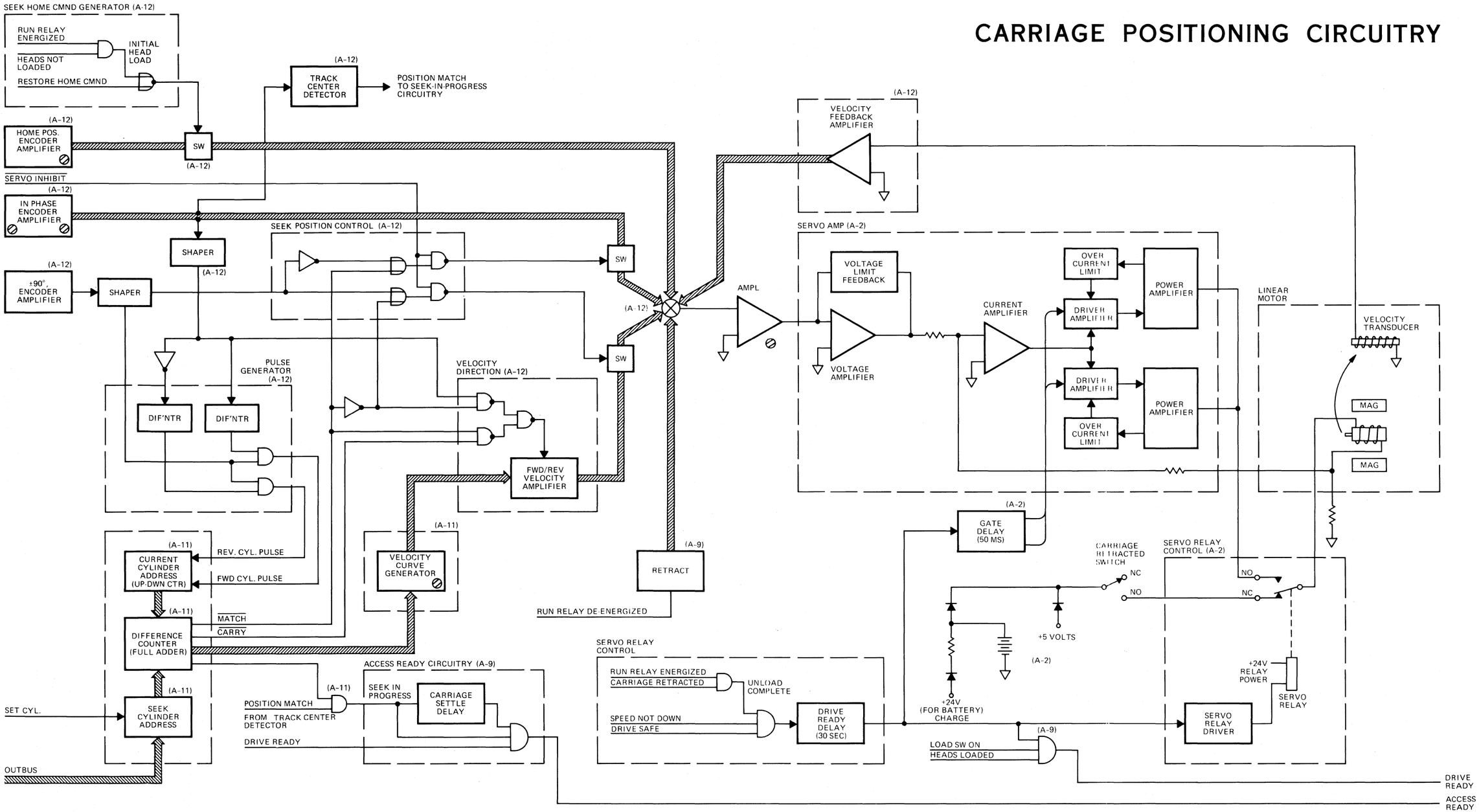
The velocity transducer produces an output that is proportional to the speed and direction of the carriage motion. The coil is mounted in the center of the motor and the magnet is attached to the carriage assembly. Consequently, as the carriage is moved, a voltage is induced into the coil whose magnitude and polarity is proportional to the velocity and direction of movement.

When the drive is unloaded or a drive fault condition occurs, the servo relay is de-energized. When this happens, the linear motor coil is switched to the 5 volt supply and the "Retract Batteries" through the Carriage Retracted switch. This causes the carriage to fully retract until the "Carriage Retracted" switch is transferred. During "drive fault retract" condition with power up, battery charge is conserved by decoupline the batteries from the +5 volt supply. This is accomplished by the diodes in series with the +5 volt supply and the battery pack.

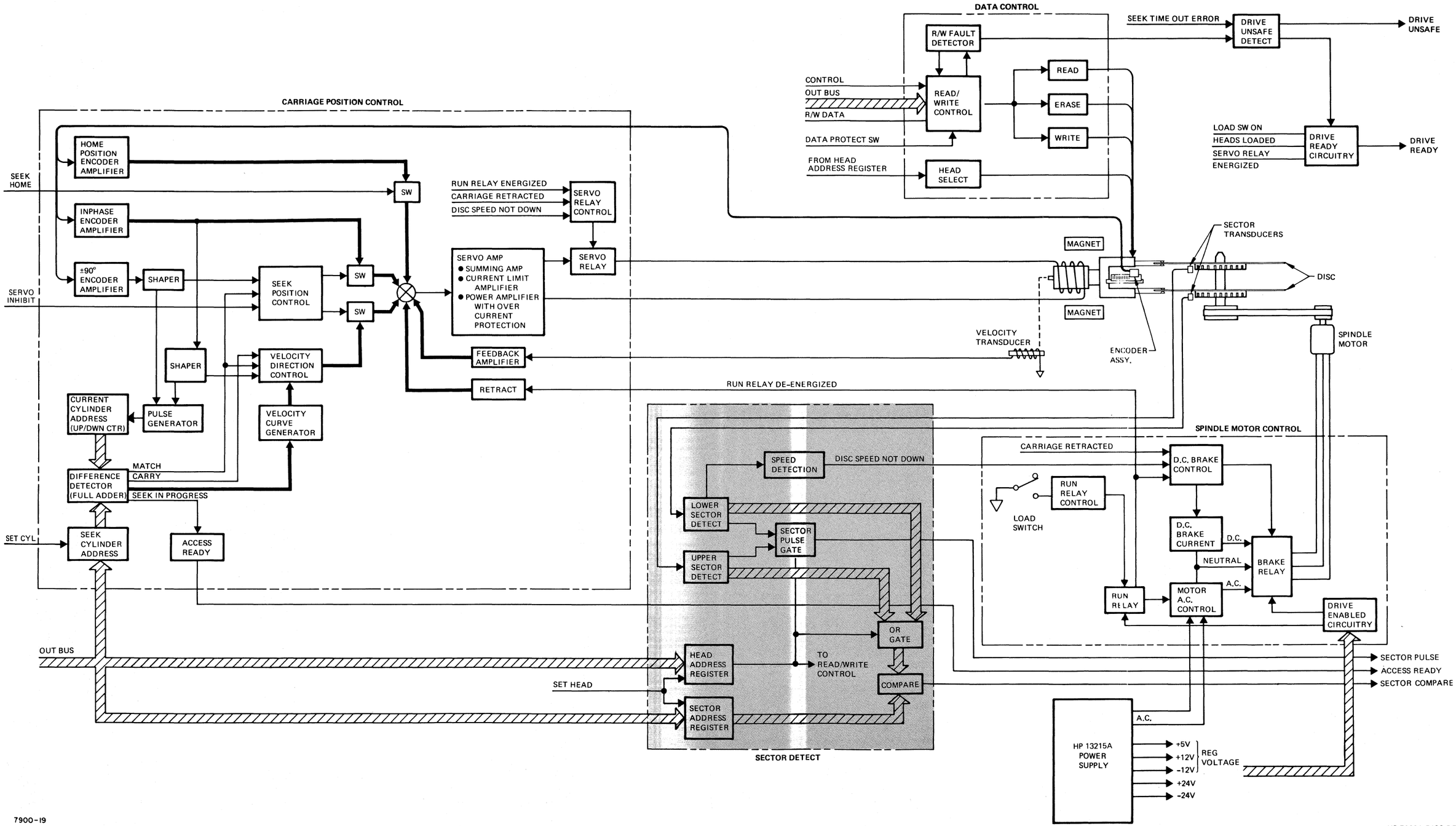
SERVO AMPLIFIER



CARRIAGE POSITIONING CIRCUITRY



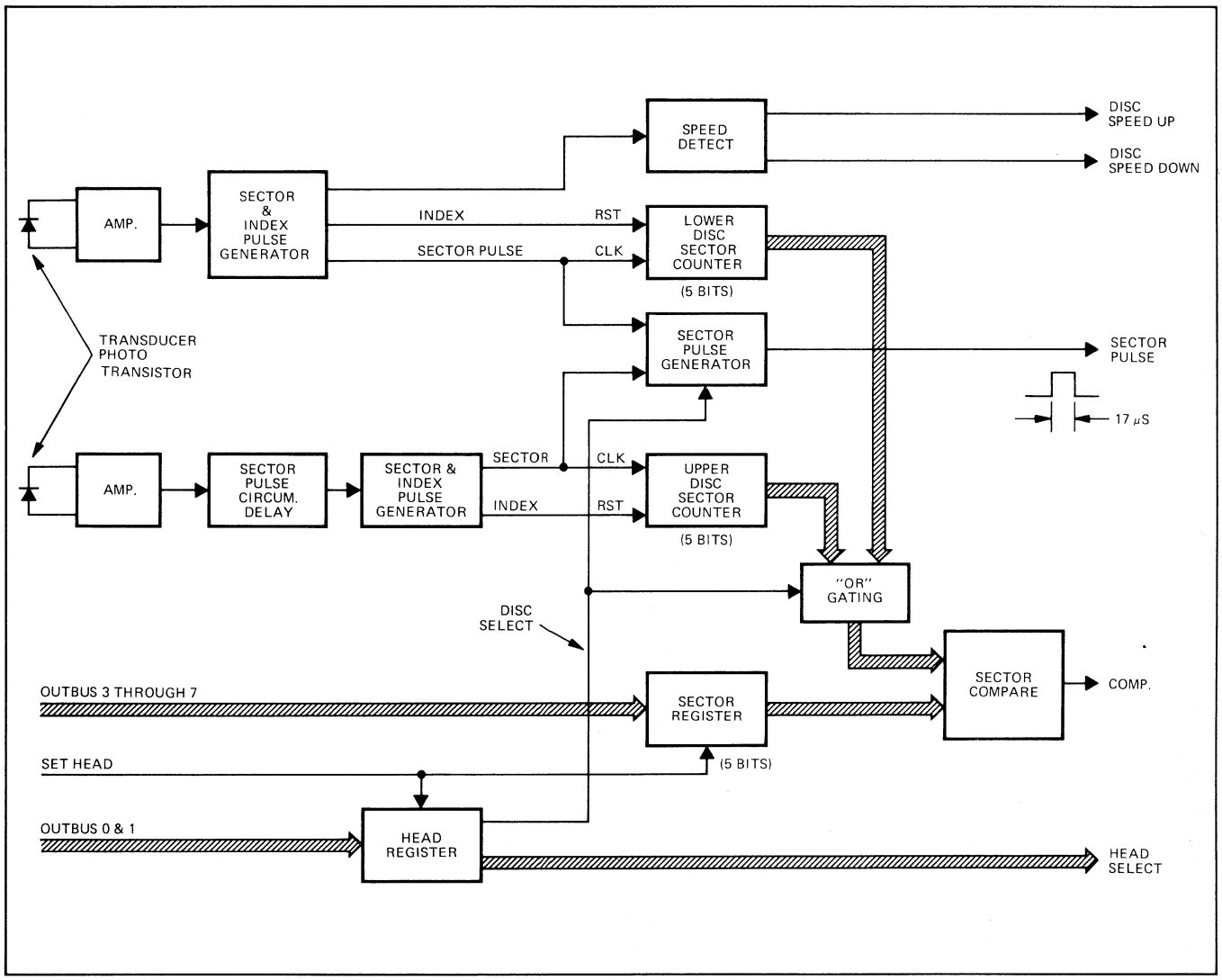
SECTION V



7900-19

HP 7900A DISC DRIVE

SECTOR DETECT



There are two functions performed by the SECTOR DETECT portion of the drive. One function is rotational speed detection and the other is rotational position detection. The same mechanical elements are involved in both functions.

A sector transducer supporting a light source and photocell on opposite sides of a slotted skirt provide electrical impulses corresponding to "Sector Slots" in the skirt. The skirt is divided into 24 equal parts, each representing a sector. An index slot is positioned about 1/4 sector after the "Zero" sector slot and is used as a reference point for numbering the sectors. Each revolution produces 24 sector pulses and an index pulse.

The pulses from the lower (fixed disc) sector transducer are amplified, shaped and presented to the lower Sector Counter, Sector Pulse Generator and to a Speed Detector. The Speed Detector senses two rotational

SECTOR DETECT (CONT)

velocity thresholds. One threshold indicates that disc speed is above 80% of nominal. The other speed threshold is about 0.2% of nominal or virtually stopped. The 80% detector uses a pair of flip-flops controlled by a retriggerable one-shot which is clocked by the sector pulses. Two consecutive pulses with spacing less than 80% of the nominal period establish the "Disc Speed Up" condition. The "Disc Speed Down" circuit uses a retriggerable one-shot with a time-out period of approximately 1.1 seconds.

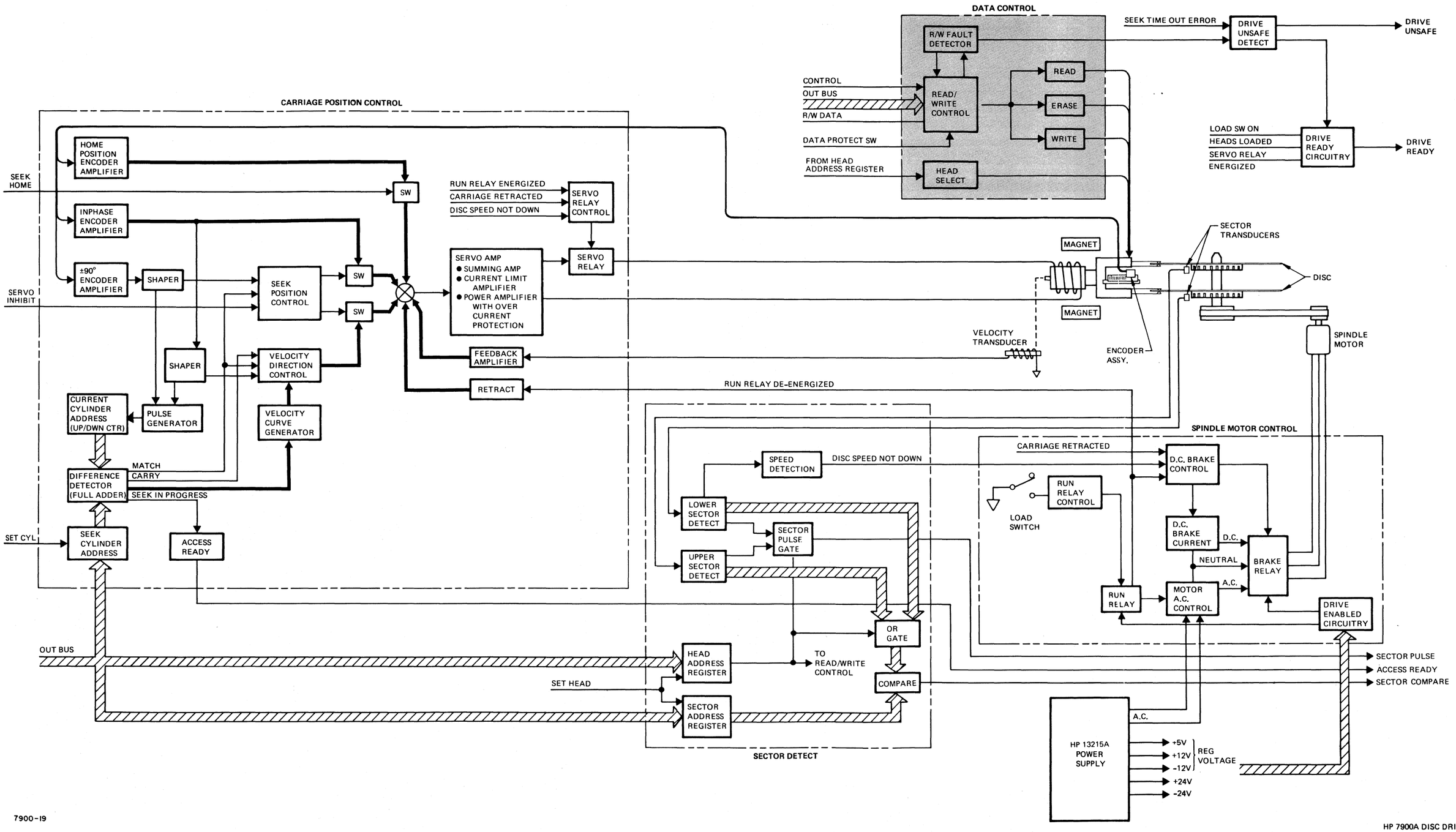
The sector pulses from the upper sector transducer are amplified and fed to a sector delay circuit. This circuit is used to electrically compensate for mechanical (physical) location of the sector transducer with respect to the read/write head gap. This compensation is required to allow cartridge interchangeability between disc drives. The result is a sector pulse representing the exact same physical position on each drive. Output from the delay circuit is fed to the Upper Sector Counter and the Sector Pulse Generator.

The Sector Pulse Generator receives pulses from the upper or lower disc depending on which head is selected. A one-shot then produces a 17 μsec "SECTOR PULSE" for controller use.

The pulses presented to the Sector Counters clock a "Divide by 24" counter. The corresponding index pulse is used as a reference for a zero starting point. The appropriate 5 output lines from the upper or lower sector counter (selected by the Head/Sector address register) is gated to the Sector Compare logic. The Sector Counter output is then compared to the Sector Address Register output. When the two match, a "SECTOR COMPARE" signal is produced and remains true during the entire sector.

The outbus lines (except outbus 2) are used to provide the head and sector address. "Set Head and Sector" is used to clock the addresses into the appropriate register. Outbus 0 is used to select the disc (upper or lower) while outbus 1 is decoded to select the head (upper or lower). Outbus lines 3 through 7 carry the desired sector address. Outbus 2 is unused in selecting a head and sector.

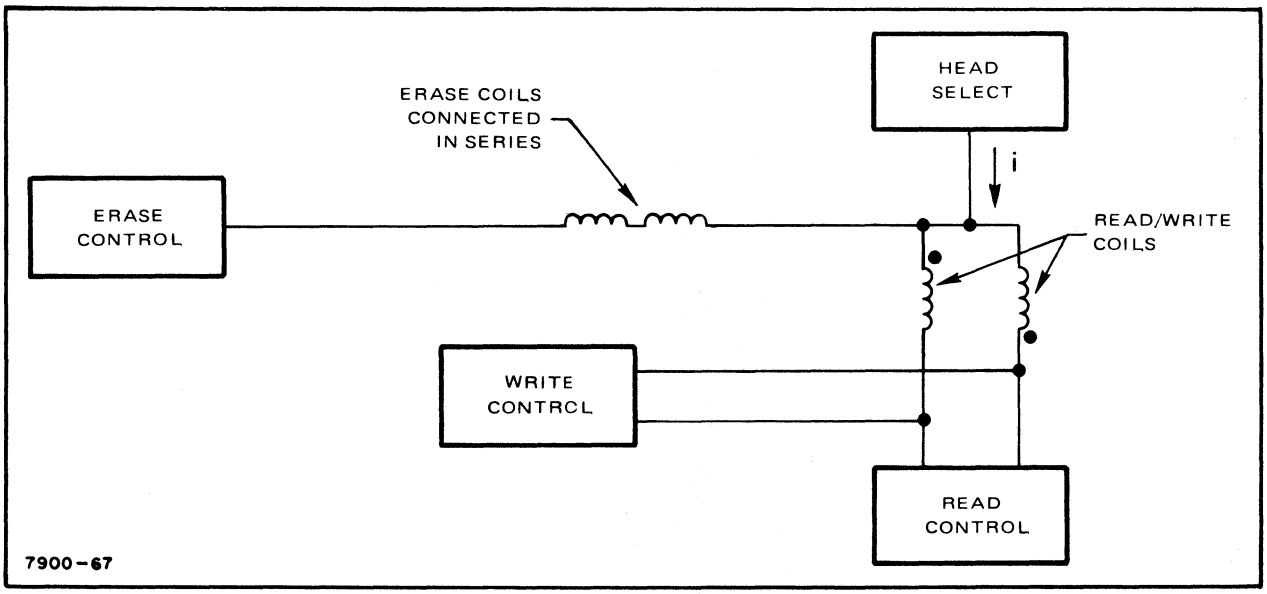
SECTION VI



7900-19

HP 7900A DISC DRIVE

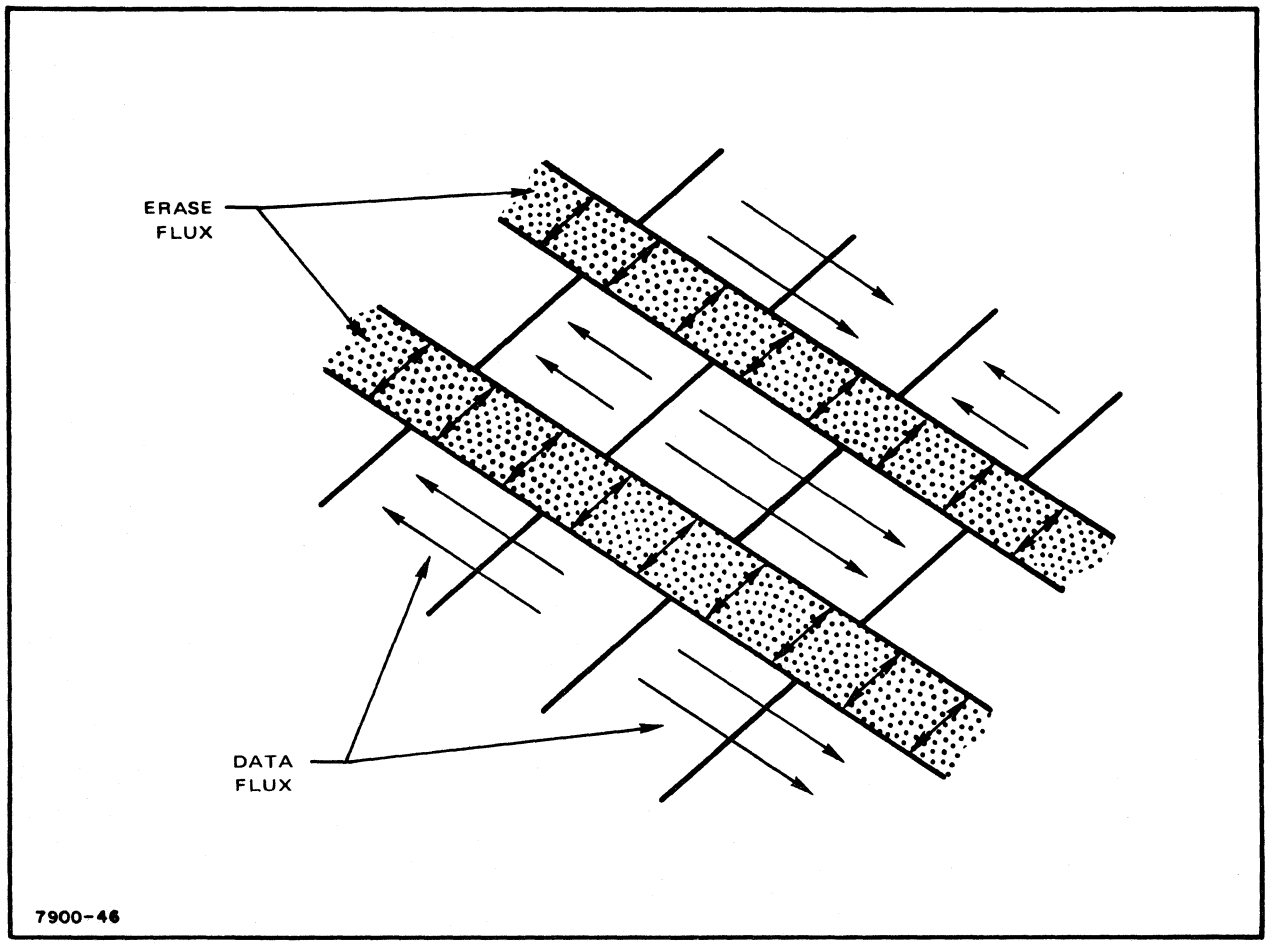
DATA CONTROL



The central element in the DATA CONTROL section of the disc drive is the head assembly. There is one head for each disc surface, each of which consists of an erase element and a read/write element mounted in a ceramic shoe. The shoe is contoured to fly over the disc surface supported by a cushion of moving air. The coils in the head assembly are electrically connected as shown.

The read/write coils are wound on a ferrite core and polarized such that the select current node acts as the center tap of a single coil. These coils are used for both reading and writing by detecting or producing magnetic flux across a gap in the ferrite core.

STRADDLE ERASE



The erase element coil is wound on a strap that straddles the ferrite head and is used to produce a straddle erase flux. This erase strap is comprised of two gaps, one on either side and slightly behind the read/write gap. The erase gaps apply a constant DC magnetic field to erase the edges of the data track during write operation. This provides an erased band between data tracks which prevents the head from seeing read data from adjacent tracks in case of minute registration errors between head and data tracks.

READ/WRITE CONTROL

The read/write control and erase sections of the DATA CONTROL circuitry receives read and write commands on outbus lines 0, 1 and 2. These commands are gated with "Control". A write operation requires that the selected surface be unprotected before Write Enable or Erase is enabled.

Both the Read and Write data pass between the Read/Write Control Board and the External Controller via a single pair of transmission lines. The lines are resistively terminated at the end drive on a Terminator Board which is installed in the multi-unit (daisy chain) connector.

A read operation is executed by activating Outbus 1 and Control, selecting a head and having no Read/Write Unsafe condition existing. A write operation is initiated by activating Outbus 0 (Write), Outbus 2 (Erase), Control, selecting a head, having no Read/Write Unsafe condition existing and not having the selected surface protected.

When a Read Command is initiated, Read Gate enables serial read data to be sent to the transmission lines. This read data is retrieved from the selected surface by the head and gated to the preamp through at F.E.T. by write enable not being active. The output of the preamp is an analog signal with varying amplitude and varying frequency. Each "Peak" of the signal represents a data or clock bit. This signal is passed through a low pass filter to a differentiator. The differentiator output is an analog signal representative of the input. However, each "zero crossing" now represents a data or clock bit. The signal is then fed to a Zero Crossing Detector that changes it to NRZI information which, in turn, is passed through a pulse generator and sent to the controller as Serial Read Data. It is a function of the external controller to separate the clock and data bits.

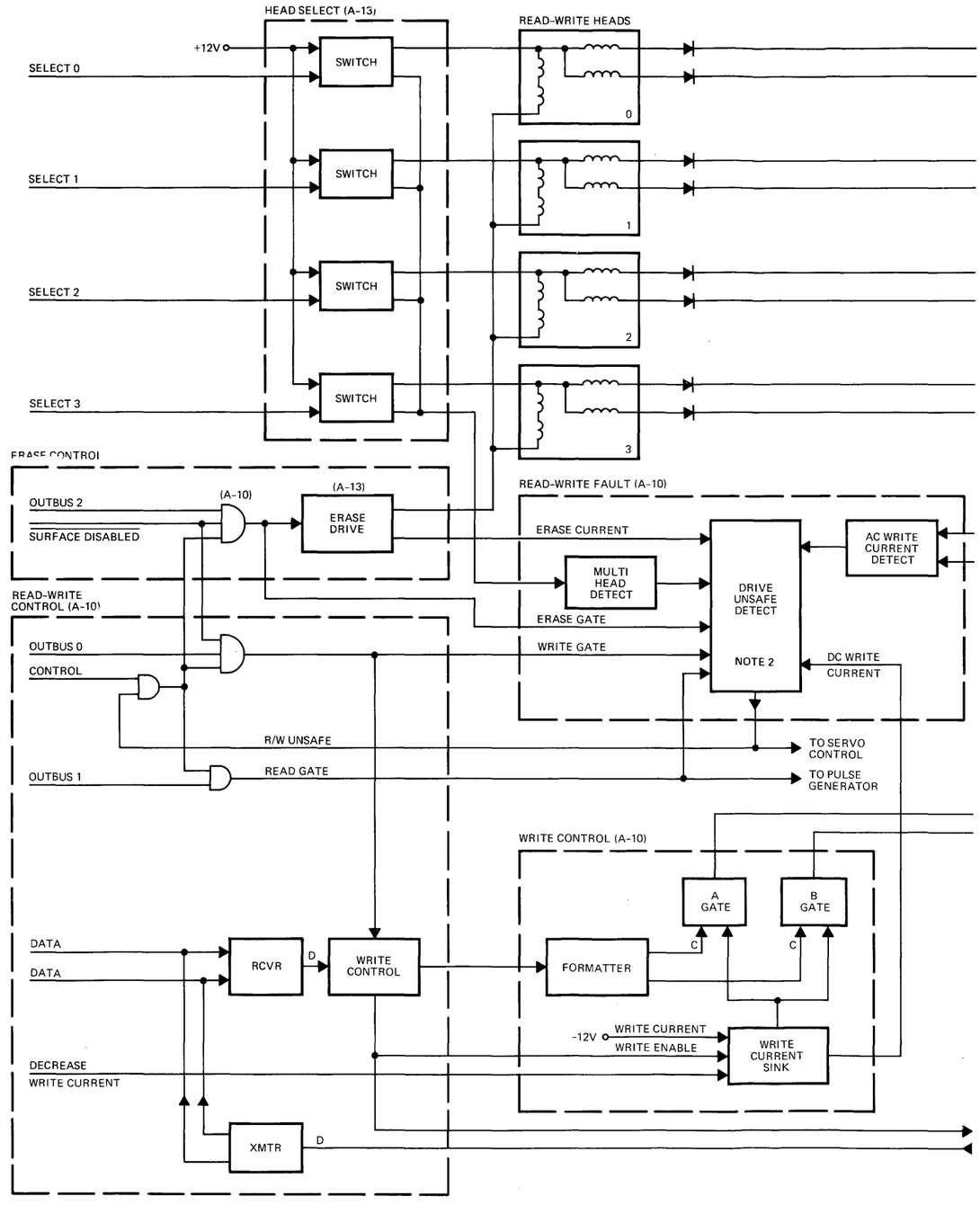
A write operation requires outbus 0 and outbus 2, along with Control. Outbus 2 activates Erase Gate; outbus 0 activates Write Enable and Write Gate. Serial data is received and gated to the Formatter which changes the pulse data to the NRZI format. The NRZI data is fed to a pair of Write Gates. These gates are controlled by the NRZI data and are used to toggle write current for each data or clock bit. For write operations on tracks 128 through 202 the write current is decreased approximately 20 percent to optimize the write characteristics over the entire disc. As the write current toggles between the A and B gates, current is passed from the write current source (-12V) alternately through the Read/Write coils, through the head select circuitry to the +12 volt supply.

READ/WRITE CONTROL (CONT)

The Read/Write Fault circuitry tests the 7 possible illegal combinations of latches and current conditions. Illegal combinations are:

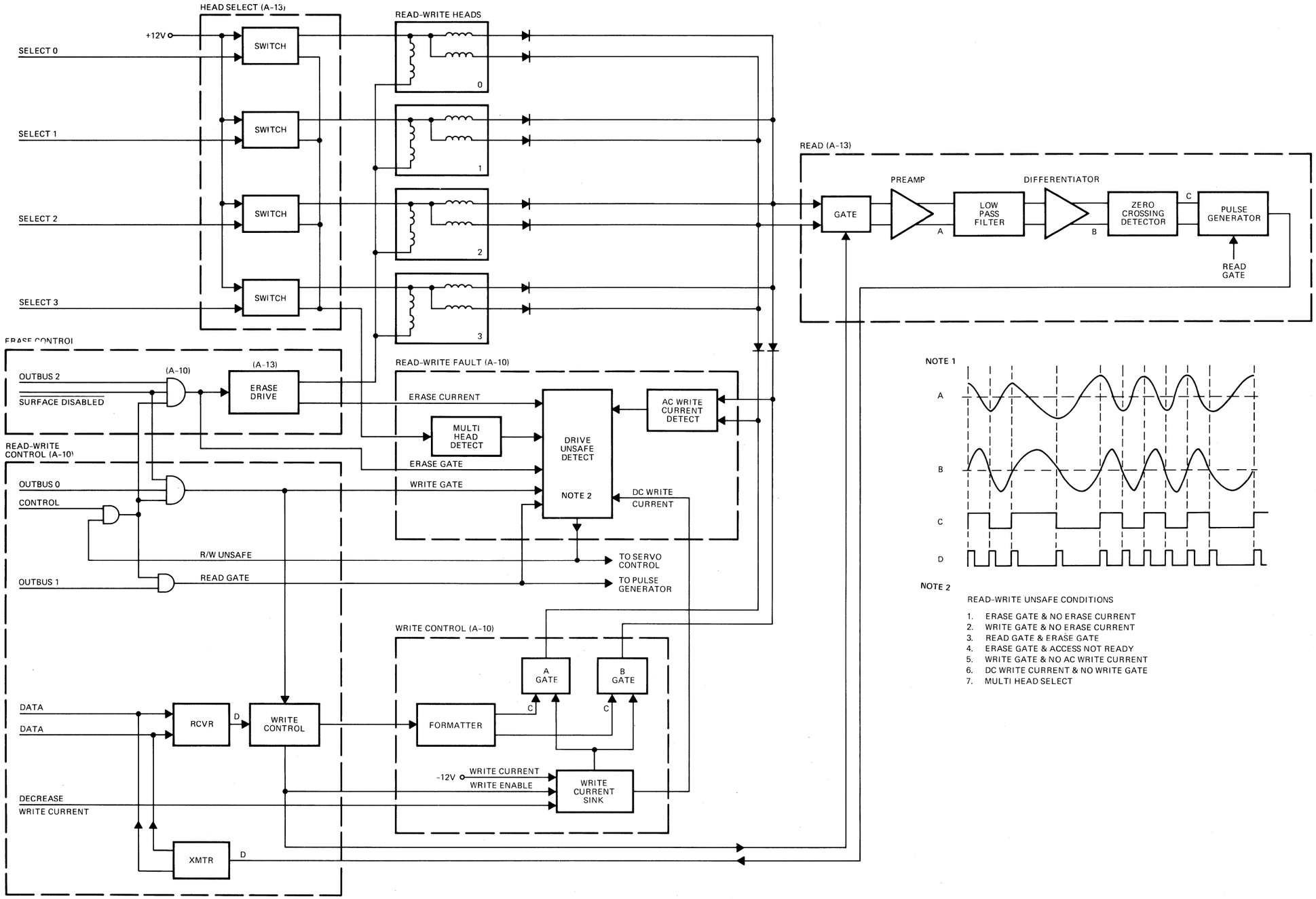
1. Erase current without erase gate.
2. Write gate without erase current.
3. Read gate and erase gate.
4. Multiple heads selected.
5. Write gate and no write data (AC write current).
6. DC Write current and no write gate.
7. Erase gate and access not ready.

Any one of these fault conditions will set the Read/Write unsafe latch which terminates any operation in progress, retracts and unloads the heads, and illuminates the "DRIVE FAULT" indicator on the front panel.



nt conditions.

/ operation in
e front panel.



NOTE 1

NOTE 2

READ-WRITE UNSAFE CONDITIONS

1. ERASE GATE & NO ERASE CURRENT
2. WRITE GATE & NO ERASE CURRENT
3. READ GATE & ERASE GATE
4. ERASE GATE & ACCESS NOT READY
5. WRITE GATE & NO AC WRITE CURRENT
6. DC WRITE CURRENT & NO WRITE GATE
7. MULTI HEAD SELECT

SECTION VII

POWER SUPPLY

During operation, the input line voltage passes through the power transformer to the rectifiers and filters. The rectifier filter converts the AC input to unregulated +5, +12, -12, +24 and -24 VDC supplies. The unregulated +5, +12, and -12 volt supplies are fed to the regulator board for current and voltage regulation.

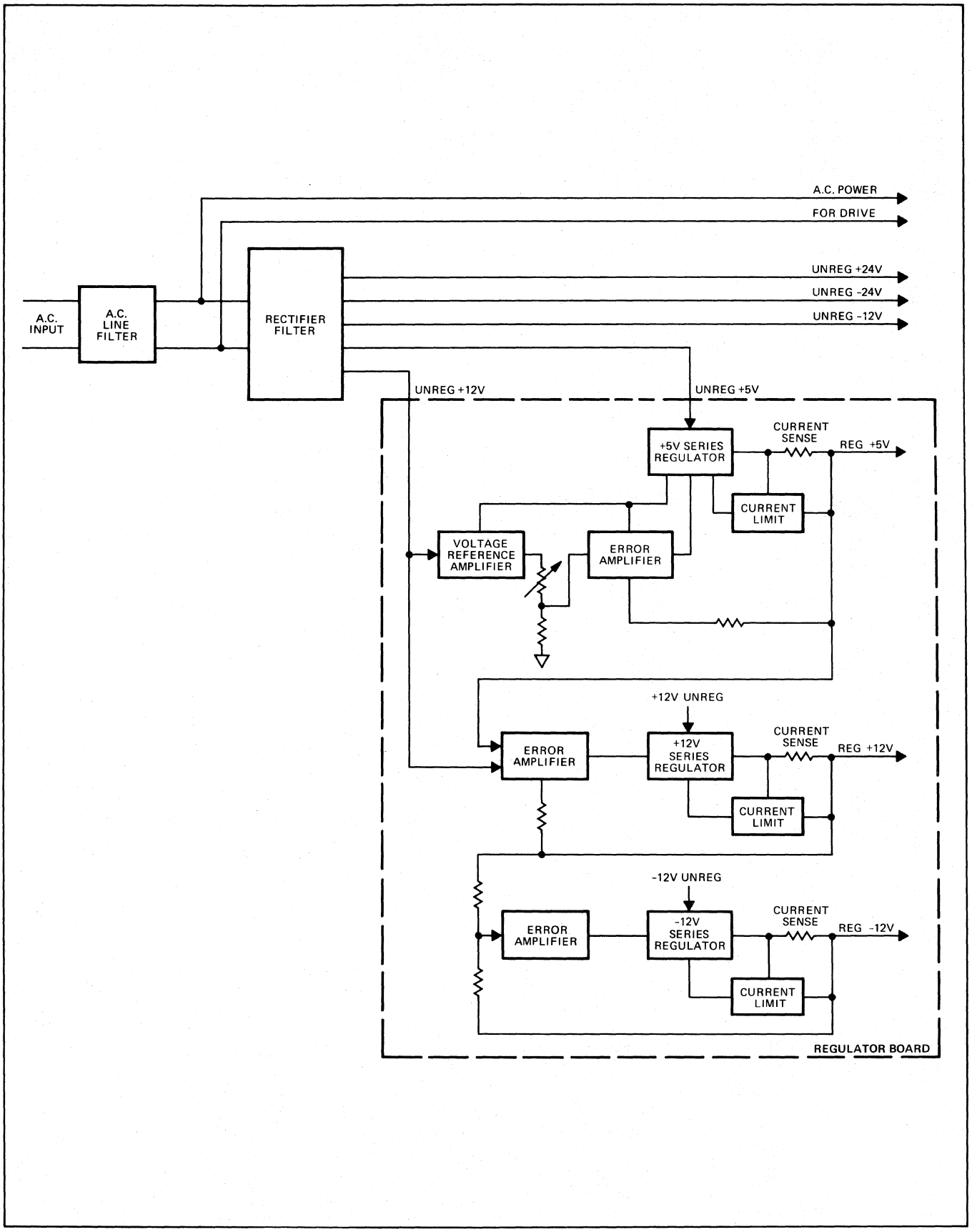
Voltage regulation is accomplished through the use of +5V, +12V, and -12V series regulators. Error amplifiers for the +5V, +12V, and -12V regulated supplies provide control over the conduction of the series regulator transistors.

The voltage from the +5V series regulator is divided by resistors and applied to the +5V error amplifier. There it is compared to an established reference. The +5V error amplifier controls the conduction of the +5V series regulator transistor to maintain a regulated output whenever comparison voltage differences are detected.

The voltage from the +12V series regulator is divided by resistors and applied to the +12V error amplifier. There it is compared to the +5V regulated output reference. The +12V error amplifier controls the conduction of the +12V series regulator transistor to maintain a regulated output whenever comparison voltage differences are detected.

The voltage from the -12V series regulator is divided by resistors and applied to the -12V error amplifier. There it is compared to the +12V regulated output reference. The -12V error amplifier controls the conduction of the +12V series regulator transistors to maintain a regulated output whenever comparison voltage differences are detected.

POWER SUPPLY



SECTION VIII

13219A DISC SERVICE UNIT

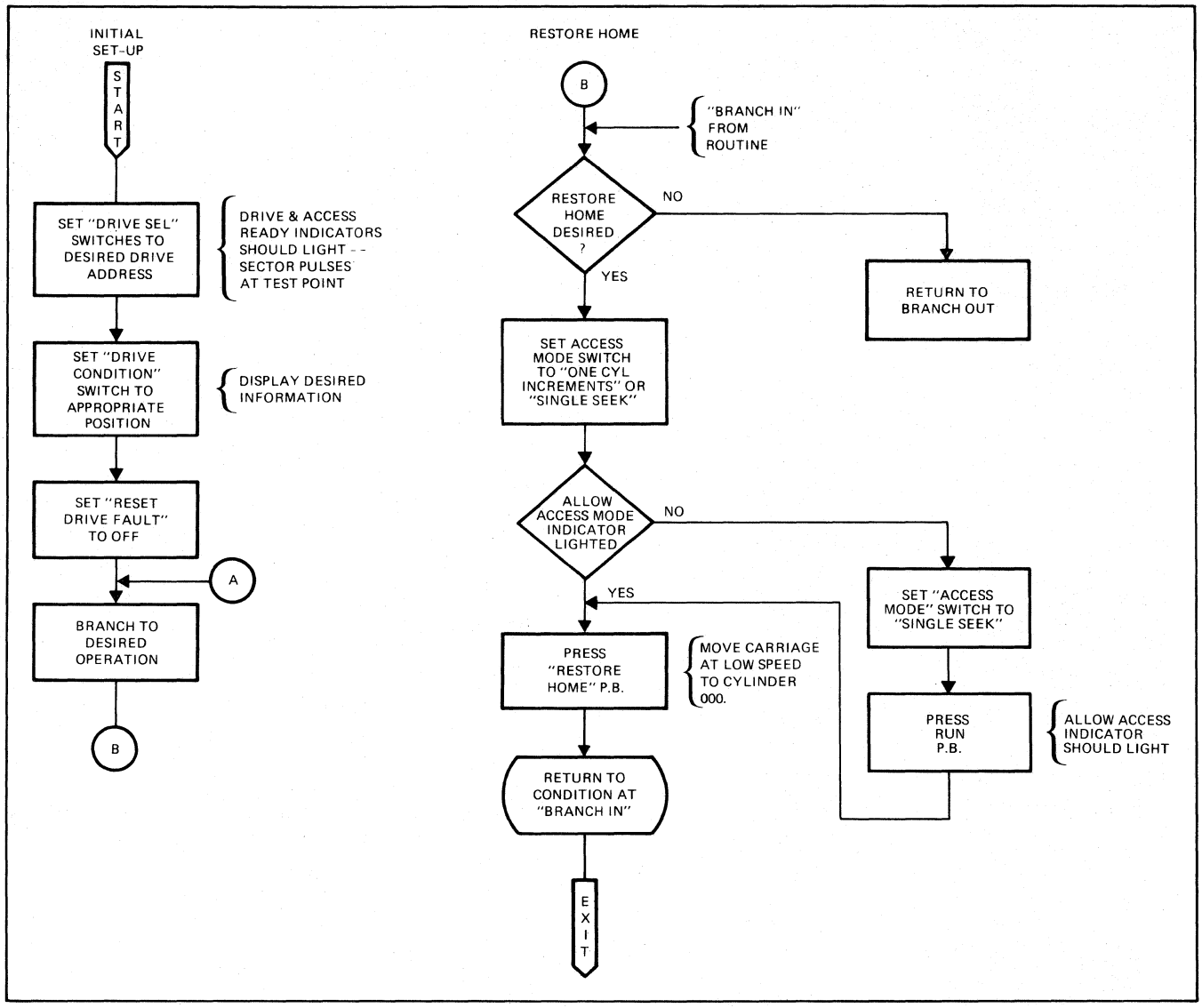
The 13219A Disc Service Unit (DSU) is used to exercise the 7900 Disc drive in an off-line mode of operation. The DSU has the following capabilities.

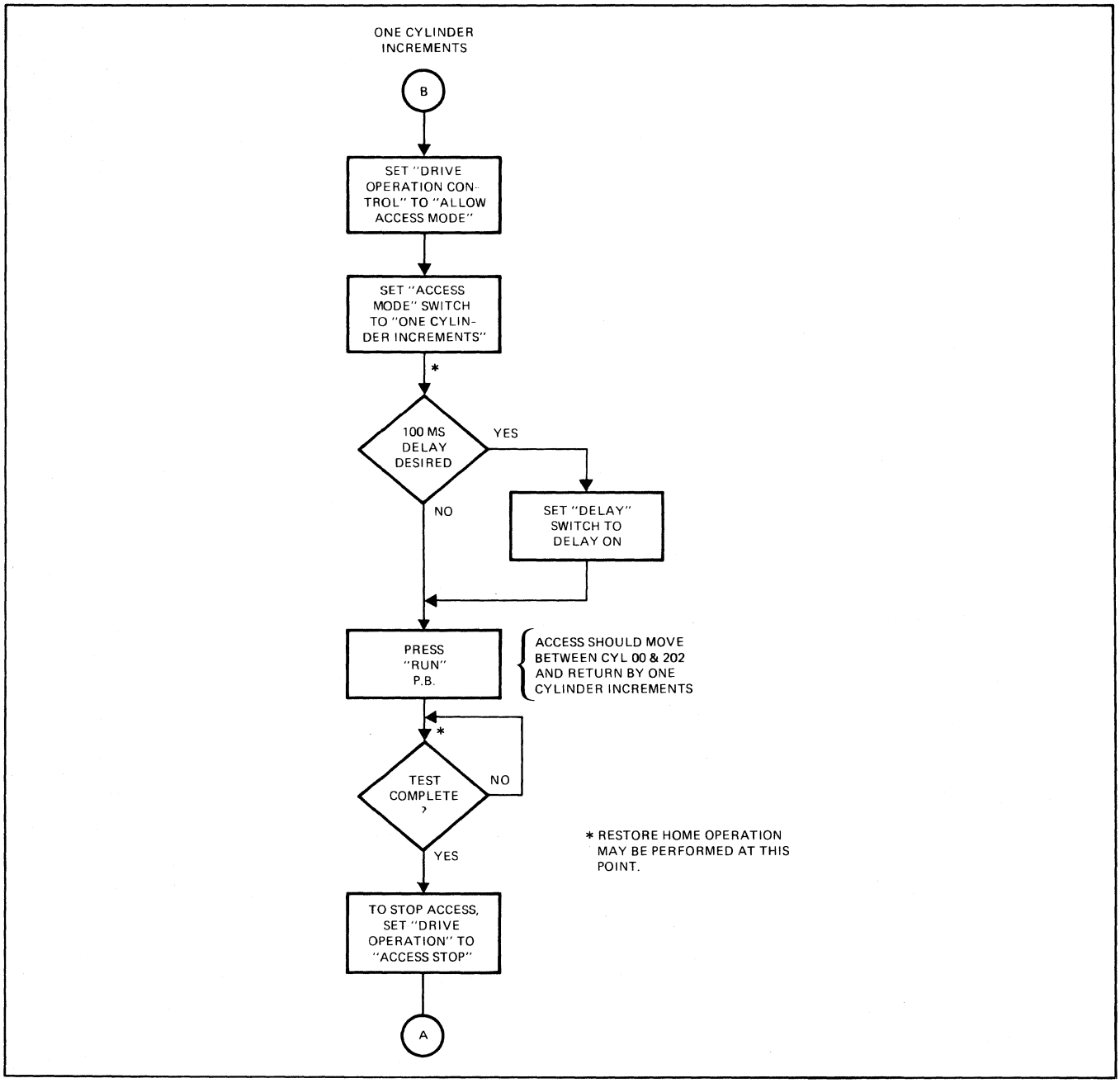
1. Selecting any drive in a series of four or less
2. Displaying all status information
3. Displaying coded R/W fault information
4. Provides common drive test points
5. Perform seek operations:

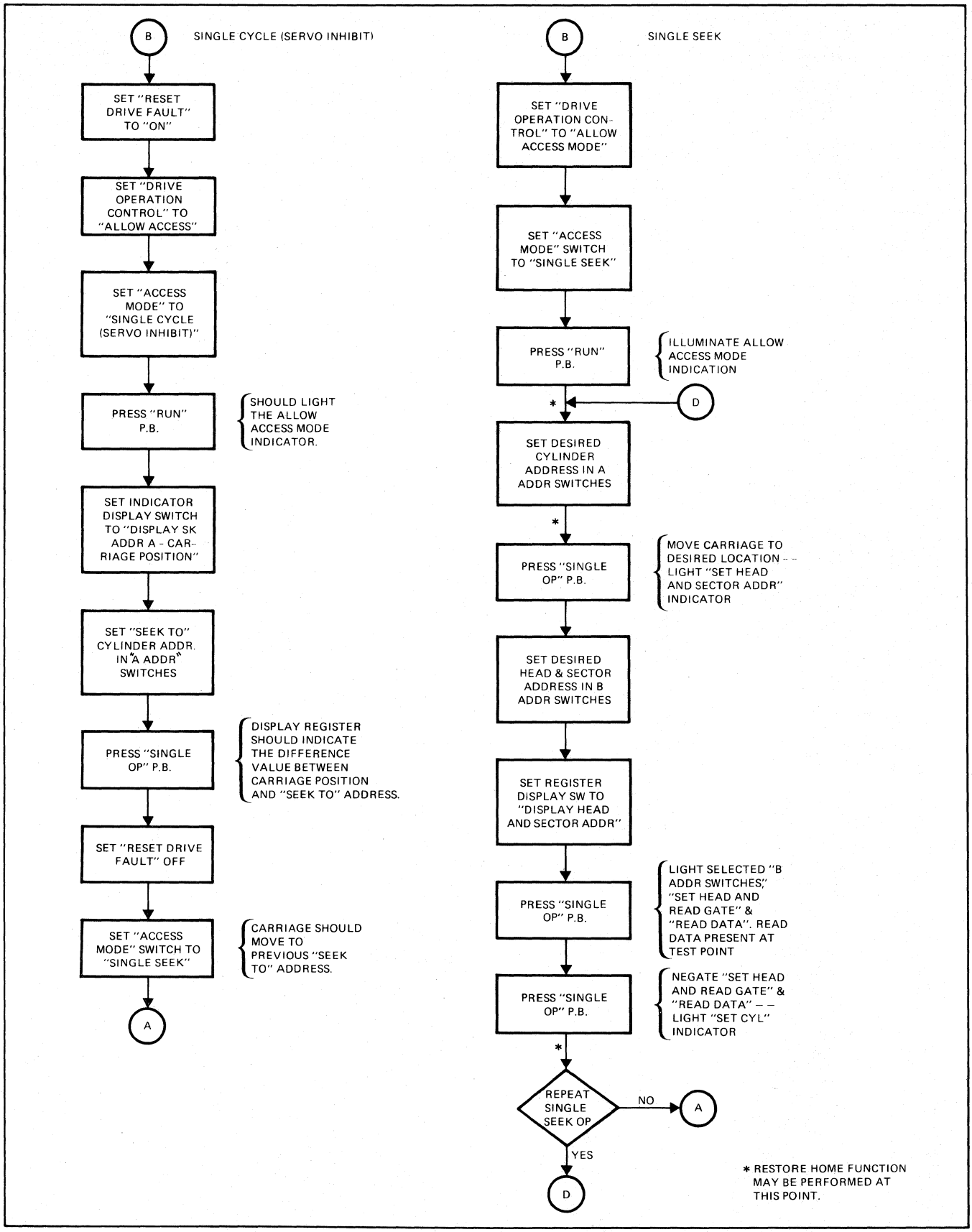
    a. At one cylinder increments
    b. In single cycle operation
    c. Alternately between any two cylinders
    d. In single cycle operation with the servo inhibited

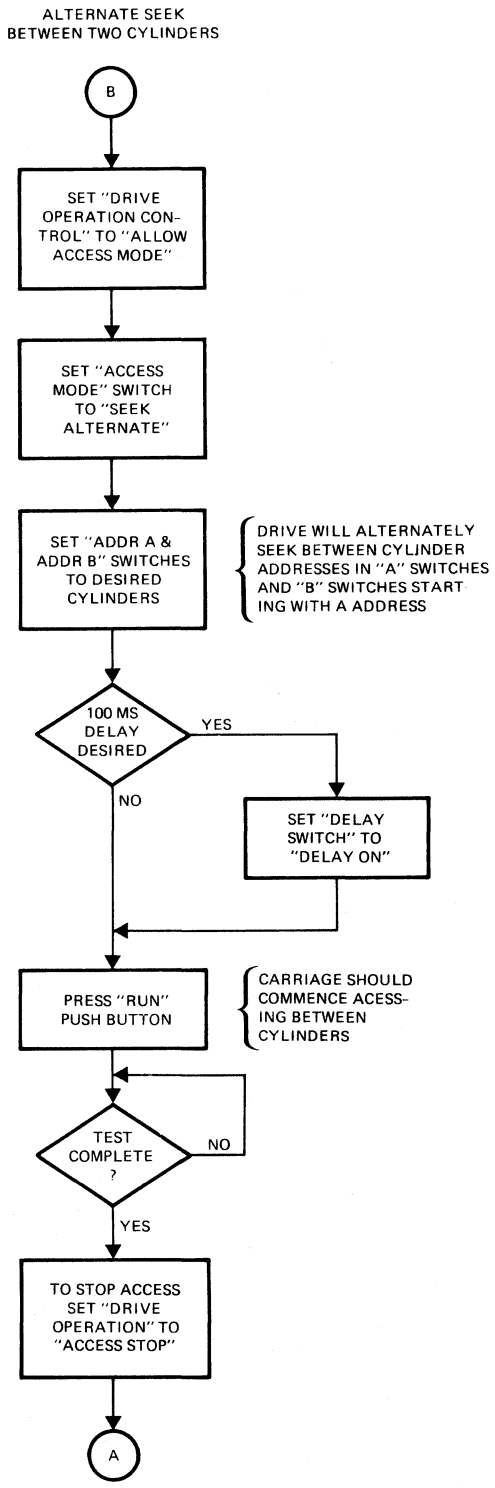
6. Select any head and sector address
7. Display "Head/Sector" address
8. Display "Seek To" address minus "Current Cylinder Address"
9. Perform a "Restore Home" operation

To install the DSU, unload the disc and remove drive power. Connect the DSU signal cable between the DSU and the Service Connector located on the left side of the drive. Bring up drive power and load the disc.


INITIAL SET-UP
START
SET "DRIVE SEL" SWITCHES TO DESIRED DRIVE ADDRESS
DRIVE & ACCESS READY INDICATORS SHOULD LIGHT - - SECTOR PULSES AT TEST POINT
SET "DRIVE CONDITION" SWITCH TO APPROPRIATE POSITION
DISPLAY DESIRED INFORMATION
SET "RESET DRIVE FAULT" TO OFF
A
BRANCH TO DESIRED OPERATION
B
RESTORE HOME
B
"BRANCH IN" FROM ROUTINE
RESTORE HOME DESIRED ?
NO
YES
RETURN TO BRANCH OUT
SET ACCESS MODE SWITCH TO "ONE CYL INCREMENTS" OR "SINGLE SEEK"
ALLOW ACCESS MODE INDICATOR LIGHTED
NO
YES
SET "ACCESS MODE" SWITCH TO "SINGLE SEEK"
PRESS "RESTORE HOME" P.B.
MOVE CARRIAGE AT LOW SPEED TO CYLINDER 000.
PRESS RUN P.B.
ALLOW ACCESS INDICATOR SHOULD LIGHT
RETURN TO CONDITION AT "BRANCH IN"
EXIT


ONE CYLINDER INCREMENTS
B
SET "DRIVE OPERATION CONTROL" TO "ALLOW ACCESS MODE"
SET "ACCESS MODE" SWITCH TO "ONE CYLINDER INCREMENTS"
*
100 MS DELAY DESIRED
YES
NO
SET "DELAY" SWITCH TO DELAY ON
PRESS "RUN" P.B.
ACCESS SHOULD MOVE BETWEEN CYL 00 & 202 AND RETURN BY ONE CYLINDER INCREMENTS
*
TEST COMPLETE ?
NO
YES
* RESTORE HOME OPERATION MAY BE PERFORMED AT THIS POINT.
TO STOP ACCESS, SET "DRIVE OPERATION" TO "ACCESS STOP"
A


B
SINGLE CYCLE (SERVO INHIBIT)
SET "RESET DRIVE FAULT" TO "ON"
SET "DRIVE OPERATION CONTROL" TO "ALLOW ACCESS"
SET "ACCESS MODE" TO "SINGLE CYCLE (SERVO INHIBIT)"
PRESS "RUN" P.B.
SHOULD LIGHT THE ALLOW ACCESS MODE INDICATOR.
SET INDICATOR DISPLAY SWITCH TO "DISPLAY SK ADDR A - CARRIAGE POSITION"
SET "SEEK TO" CYLINDER ADDR. IN "A ADDR" SWITCHES
PRESS "SINGLE OP" P.B.
DISPLAY REGISTER SHOULD INDICATE THE DIFFERENCE VALUE BETWEEN CARRIAGE POSITION AND "SEEK TO" ADDRESS.
SET "RESET DRIVE FAULT" OFF
SET "ACCESS MODE" SWITCH TO "SINGLE SEEK"
CARRIAGE SHOULD MOVE TO PREVIOUS "SEEK TO" ADDRESS.
A
B
SINGLE SEEK
SET "DRIVE OPERATION CONTROL" TO "ALLOW ACCESS MODE"
SET "ACCESS MODE" SWITCH TO "SINGLE SEEK"
PRESS "RUN" P.B.
ILLUMINATE ALLOW ACCESS MODE INDICATION
*
D
SET DESIRED CYLINDER ADDRESS IN A ADDR SWITCHES
*
PRESS "SINGLE OP" P.B.
MOVE CARRIAGE TO DESIRED LOCATION -- LIGHT "SET HEAD AND SECTOR ADDR" INDICATOR
SET DESIRED HEAD & SECTOR ADDRESS IN B ADDR SWITCHES
SET REGISTER DISPLAY SW TO "DISPLAY HEAD AND SECTOR ADDR"
PRESS "SINGLE OP" P.B.
LIGHT SELECTED "B ADDR SWITCHES," "SET HEAD AND READ GATE" & "READ DATA". READ DATA PRESENT AT TEST POINT
PRESS "SINGLE OP" P.B.
NEGATE "SET HEAD AND READ GATE" & "READ DATA" -- LIGHT "SET CYL" INDICATOR
*
REPEAT SINGLE SEEK OP
NO
A
YES
D
* RESTORE HOME FUNCTION MAY BE PERFORMED AT THIS POINT.


ALTERNATE SEEK
BETWEEN TWO CYLINDERS
B
SET "DRIVE OPERATION CONTROL" TO "ALLOW ACCESS MODE"
SET "ACCESS MODE" SWITCH TO "SEEK ALTERNATE"
SET "ADDR A & ADDR B" SWITCHES TO DESIRED CYLINDERS
DRIVE WILL ALTERNATELY SEEK BETWEEN CYLINDER ADDRESSES IN "A" SWITCHES AND "B" SWITCHES STARTING WITH A ADDRESS
100 MS DELAY DESIRED
YES
NO
SET "DELAY SWITCH" TO "DELAY ON"
PRESS "RUN" PUSH BUTTON
CARRIAGE SHOULD COMMENCE ACESSING BETWEEN CYLINDERS
TEST COMPLETE ?
NO
YES
TO STOP ACCESS SET "DRIVE OPERATION" TO "ACCESS STOP"
A

HEWLETT hp PACKARD

DATA SYSTEM PERIPHERALS

PRINTED IN U.S.A.

07900-90022