Half-height minifloppy stores 3.3M bytes

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Mechanical design innovations ensure high-precision read/write accuracy

System integrators have greeted half-height minifloppy disk drives with open arms, but until recently, they haven't been able to store more than 1M byte or 2M bytes in these streamlined packages. Drivetec Inc.'s 320 "SuperMinifloppy," however, packs 3.3M bytes into a half-height, 5¼-in. drive that can also operate as a lower capacity industry-standard drive. Even in high-capacity mode, the 320 offers a 500K-bit-per-sec. transfer rate and a 160M-sec. average access time.

The 320's impressive capacity-to-size ratio is largely the result of innovative mechanical engineering. The combination of a high-precision track-following servo system, media-friendly "gumball" heads, vertical media clamping and a patented anti-backlash positioning system allows the drive to read and write high-density, 192-track-per-in. diskettes and standard media. A low-profile DC motor assembly and a reduced electronic parts count allow the drive to fit into the standard half-height minifloppy form factor, and a Shugart-compatible interface lets it use industry-standard controllers.

Dual-stepper positioning system

The key to both the accuracy and reliability of the drive is the dual-stepper, track-following servo positioning system (Fig. 1). A coarse-stepper motor and a fine-stepper motor under microprocessor control position the read/write heads. The heads read pre-written servo information from the disk, and the control logic adjusts the stepper motors accordingly. Both motors step in 15-degree increments and a 5:1 lever is used to provide the coarse/fine resolution.

In a track-seek operation, the coarse stepper positions the heads to a track as a result of a command from the control unit. The fine stepper then responds to the servo burst information and positions the head to within 100 μin. of the track centerline. The servo information is located at the end of each diskette sector (Fig. 2). The servo ID and the servo burst information (2 bytes of FF) are written exactly one-half track off-center from the data track. This means that when the read/write head is following the centerline of the data track, the signal strength of the servo burst on alternate tracks should be equal. If the head is off-center, either too far in or too far out, one of the servo signals will be stronger than the other. In this case, the appropriate fine-step corrections are made. This system ensures track-following accuracy regardless of the changes in the diskette itself due to thermal and humidity variations. It also guarantees diskette interchangeability from one drive to another.

Under worst-case conditions in which the data track

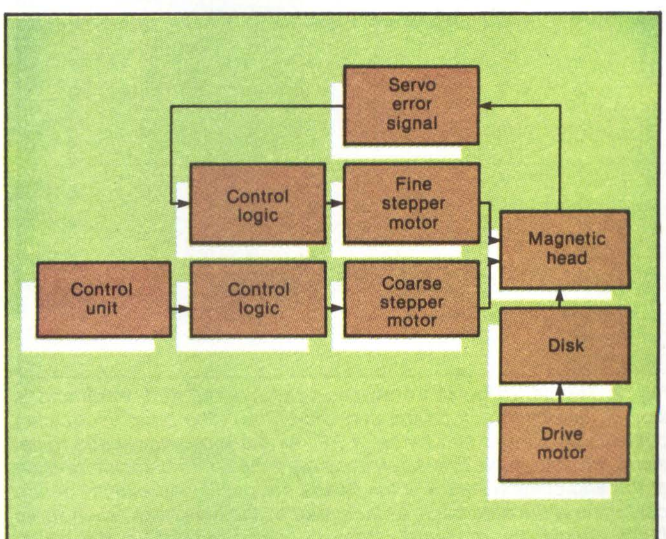


Fig. 1. The dual-stepper servo-positioning system's microprocessor-based control logic *monitors the servo error signal read from the diskette through the read head and controls coarse- and fine-stepper motors that position the read/write heads.*

centerline is not at a constant radius because of thermal, humidity or media-clamping variations, the head approaches the data track centerline at the rate of one step per sector until it crosses the centerline. At that point, it proceeds to track the data line within the 100-μin. accuracy of the system (Fig. 3).

The media used in the drive is a standard minifloppy 0.0003-in. substrate, coated with a lubricated, 50-μin. magnetic oxide. While the first minifloppy diskettes used 100-μin. oxide, many media vendors are now moving to the thinner oxide-coated diskettes in response to the need for higher density. BASF Systems Corp., Brown Disc Manufacturing Inc., Dysan Corp., Maxell Corp. of America, Memorex Corp., 3M Co., Verbatim Corp. and Xidex Corp. produce higher density diskettes.

Unformatted track capacity is 10,416 bytes, and formatted capacity is 7680 bytes, divided into 30 sectors of 256 bytes. Each sector is defined by the pre-written ID field, followed by the user-written data in the data field. There are cyclic redundancy checks for both the ID field and the data field and several gaps for timing and signal synchronization.

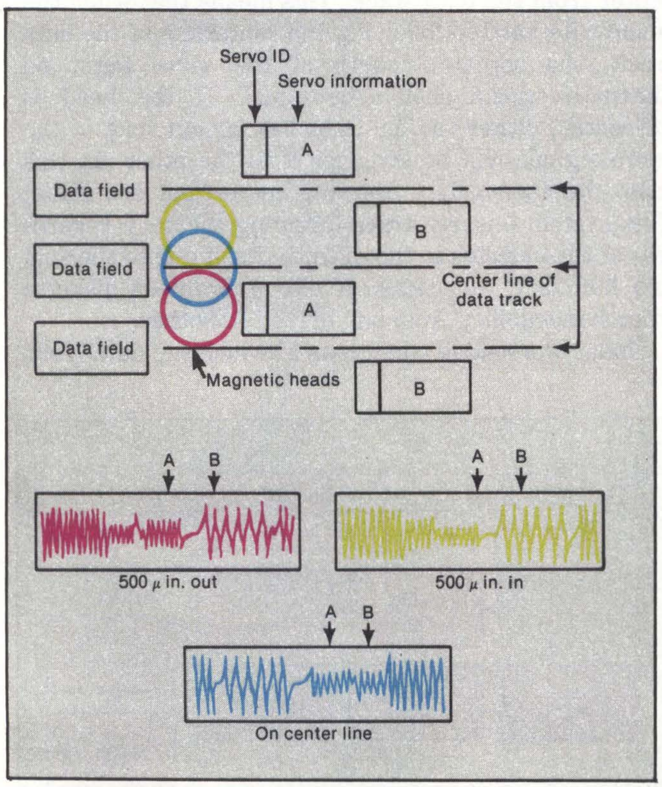


Fig. 2. The servo burst information follows the data track *and is located one-half track off the centerline (top). The burst information contains an ID and two bytes of FF. As the magnetic heads travel along the data track, they alternately read the servo burst information at the end of each sector. If the heads are positioned exactly on the centerline of the data track, as indicated by the blue head, each servo burst should be of equal strength, as indicated in the lower oscilloscope trace. If the heads are off-center, one or the other signal is stronger, indicating that the heads are too close to or too far from the centerline. The fine-stepper control logic then repositions the heads until the two signals match.*

Media/head registration

Drivetec uses spherical "gumball" heads that capitalize on the elastic properties of the diskette substrate. The two magnetic heads are opposing and identical (Fig. 4). The standard head centerline offset is 0.0833 in. Because of this offset and because each of the heads can be rotated through an angle, the centerline distance between the two spherical heads self-adjusts to match the elasticity of the media. One of the heads is mounted rigidly, and the other is mounted on an arm to allow only enough translation so that the diskette can be inserted. The translating head is loaded with a force that exactly opposes the spring force of the diskette. The heads are then held apart by the reaction force of the diskette. An elliptical zone is formed between each head and the diskette, and the head-to-disk spacing is very small, stable and uniform. In addition, unlike

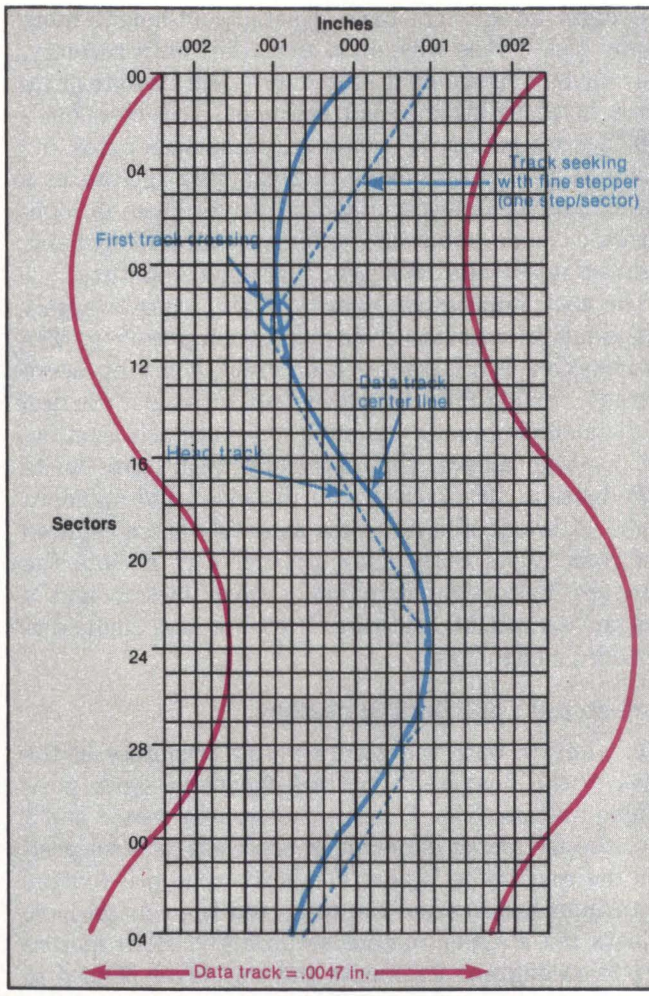


Fig. 3. A worst-case condition *is indicated by a solid line (the data track) when it is not at a constant radius from the spindle. The dotted line is the track of the head position. If the head is positioned off the data track centerline (top of the grid), it approaches the data centerline at a rate of one step per sector. When it crosses the centerline, the head proceeds to track it to within 0.0001 in., regardless of how the data track centerline fluctuates.*

conventional squarish heads, which can rub the media, slowly destroying the surface coating, the rounded gumball heads ease the passage of the media and cause less surface wear.

The head carriage assembly has a number of features that provide precise alignment. The head carriage is registered to the guide rod by the spring forces of the load rod (Fig. 5), which effectively holds the carriage in place, eliminating any need for field realignments. Further, an anti-backlash spring attached to the lead screw nut absorbs rotational and linear forces caused by the carriage movement along the lead screw. Thus, possible off-centering caused by movement in any direction is accounted for and corrected by the various spring attachments. The connection between the lead screw and the lead screw nut is also prone to possible mispositioning. As the nut is pushed forward and back, a gap between the two elements can cause a slight positioning error. This is eliminated by canting the lead screw nut at a slight angle relative to the threads in the screw (Fig. 6). When moving forward, the top edges of the screw move the nut forward; in reverse, the bottom edges move the nut backward. Meanwhile, a tight mechanical fit is maintained. This intentional cocking eliminates the tolerances of the connecting assembly and another source of potential positioning error.

The Drivetec 320 employs a modified acme thread to provide vertical clamping of the media (Fig. 7). Previous designs bring the media clamp down onto the media at a slight angle that can sometimes cause the media to be misclamped. In the Drivetec 320, the clamp is at the same centerline as the spindle. This is accomplished by using a self-centering shaft/bearing

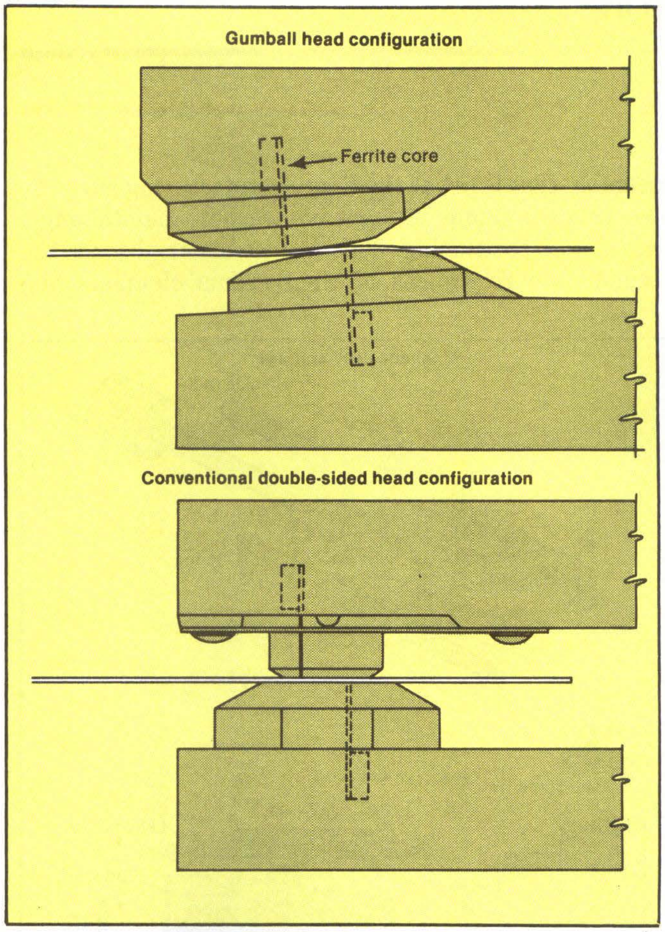
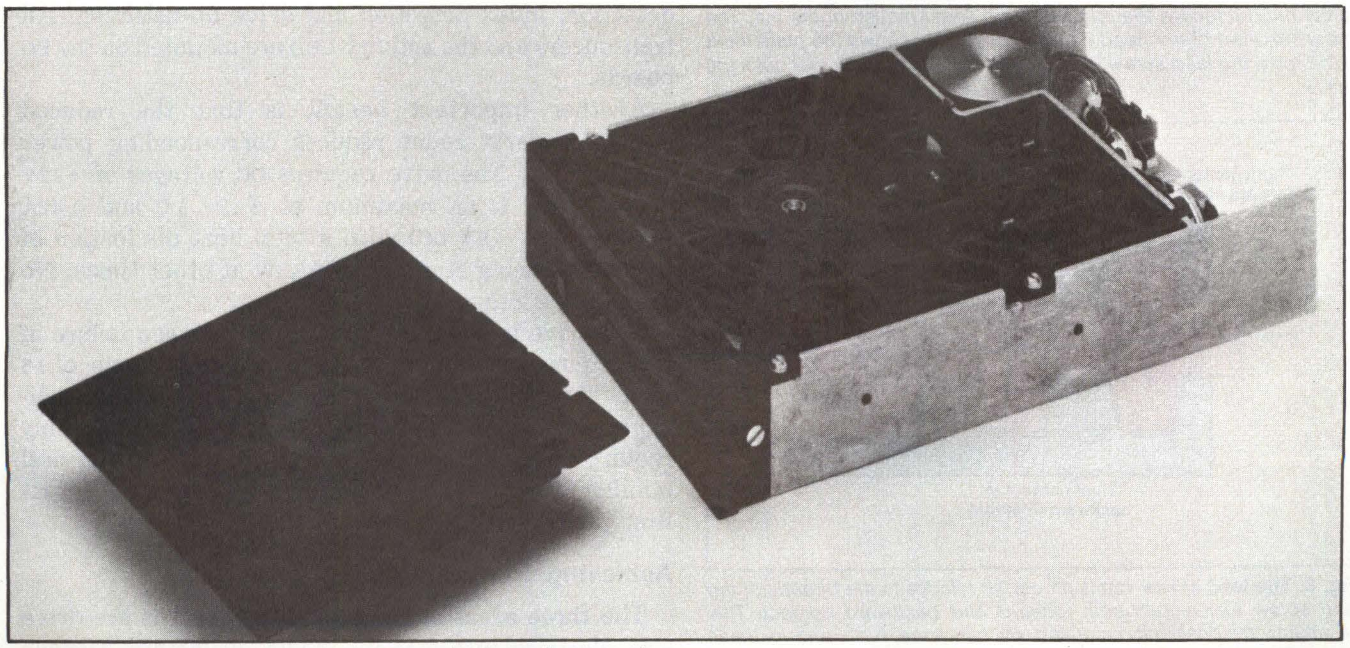


Fig. 4. The Drivetec gumball heads *are spherical to reduce media wear. Unlike conventional heads, there are no sharp edges that can damage the media. The angled positioning of the gumball approach promotes smooth media rotation between the heads while allowing enough proximity to achieve a strong signal.*



The Drivetec 320 "SuperMinifloppy" drive *offers 3.3M bytes of storage in a half-height, 1.62- × 5.75- × 8.48-in. package. The new drive is priced at $333 in large OEM quantities.*

assembly that is set at the final manufacturing stage by inserting the clamp onto a wave washer, maintaining a true center positioning. This wave washer absorbs the accumulated tolerances of the various elements and

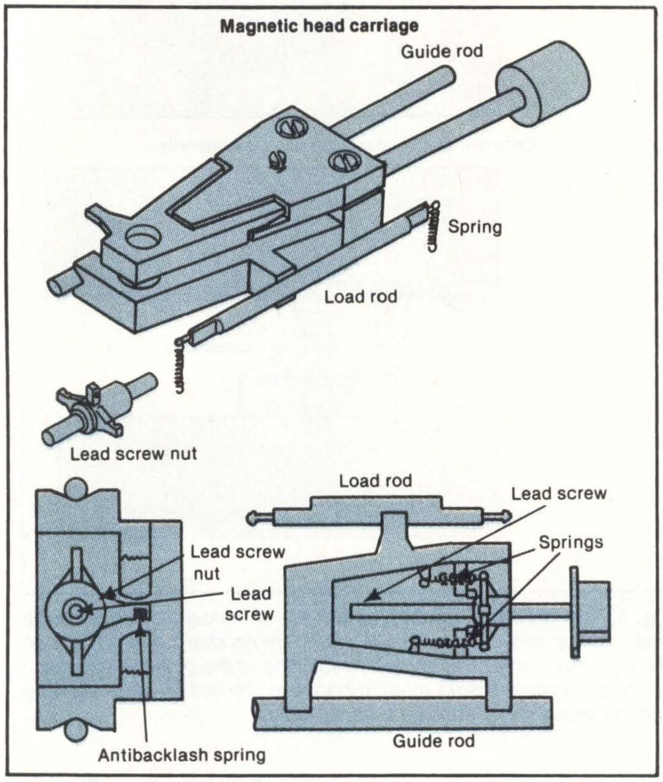


Fig. 5. The head carriage assembly *(top) has a spring attached to the load rod to align the assembly into the proper orientation for precise head/media alignment. An anti-backlash spring on the lead screw nut decreases the rotational and linear motion of the nut. The underside view of the head carriage assembly shows the placement of the rods, the lead screw, the nut and the two springs that cock the nut.*

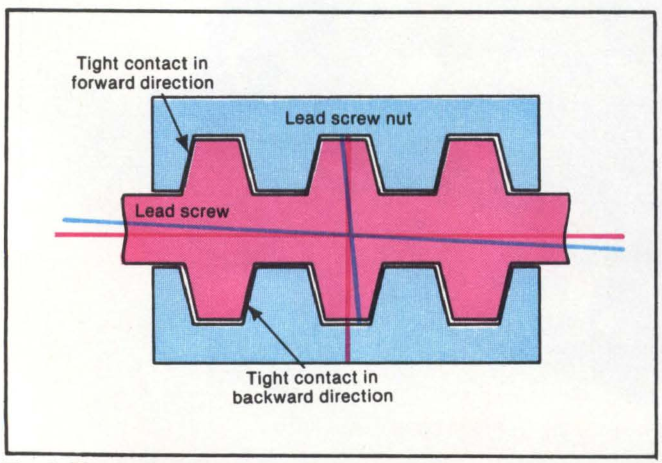


Fig. 6. The lead screw nut *is off-center relative to the threads of the lead screw to maintain both forward and backward contact. This eliminates mispositioning caused by tolerance problems in these parts. The overlapping centerlines show the center position of the lead screw versus the center position of the nut.*

assures that spindle/clamp centering is accurate. The tapered clamp grabs the media as it begins to rotate and centers it before clamping it into place. No center ring media reinforcement is necessary.

Down-sizing techniques

To pack the drive into the space of a half-height package, Drivetec employs a low-profile DC motor assembly and an integrated electronics design that uses four custom LSI chips and an 8-bit 6805 microprocessor. The motor assembly is a belt-driven, brushless DC motor rated for a five-year life within the defined specifications. Although some half-height drives use direct-drive DC motors, Drivetec finds that this type of motor mounted directly under the read/write heads causes unacceptable EMI radiation. Therefore, a belt-

An anti-backlash spring absorbs rotational and linear forces caused by the carriage movement along the lead screw.

driven, brushless motor is used. Belt-and-pulley systems previously had tolerance problems resulting from wear and thermal changes. Recently, however, belt materials that eliminate these problems have been developed.

Reducing the control electronics to a few custom LSI chips and the 6805 microcontroller enables the resulting printed-circuit board to fit into the space of a half-height drive. The electronic circuitry handles track-positioning control, drive motor speed control, read/write circuits, track zero detection, write protect detection, index detection and drive I/O selection. All transducers and the activity LED are mounted on the PC boards.

Another important benefit is that the reduced electronic parts count reduces corresponding power consumption. The drive requires DC voltages of +12V and +5V DC (1.2A maximum at +12V DC and 0.42A maximum at +5V DC) with a total heat dissipation of only 20W during stepping and 13W at other times. No AC power is required.

The drive is rated for mean time between failure of 10,000 power-on hours and a mean time to repair of 15 min. The embedded-servo information scheme, self-aligning head carriage and sealed DC motor assembly require no field alignments. By comparison, a typical minifloppy requires six or more alignments during its first year of use.

Achieving compatibility

The three areas of compatibility concerns are drive size, electrical interface and media availability. The 320 drive is designed to be exactly one-half the height of a

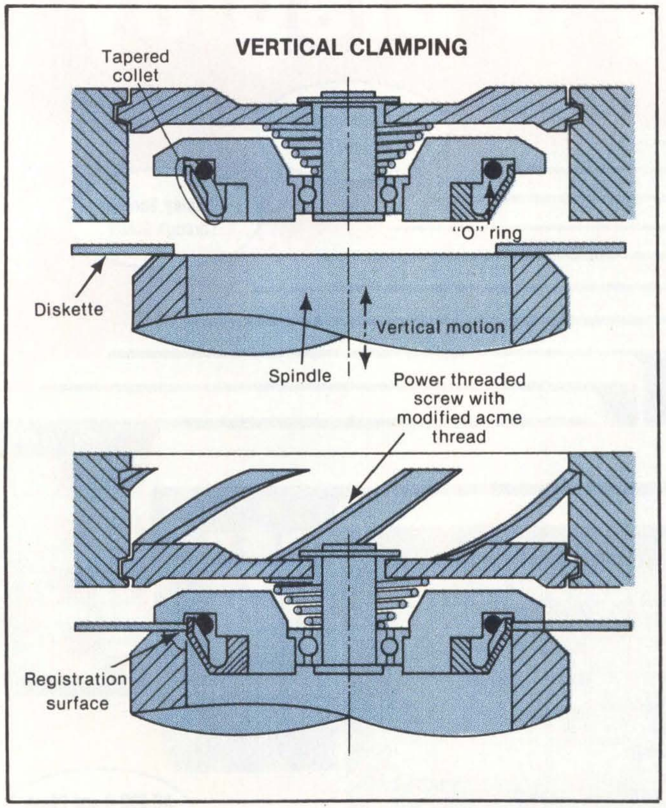


Fig. 7. The vertical clamping mechanism *is based on a power threaded screw with a modified acme thread that is maintained at exact centerline over the spindle shaft. As the clamp is lowered onto the media and spindle, the tapered collet grabs the media and centers it before clamping.*

standard 5¼-in. minifloppy drive, allowing two 320 drives to be mounted in the space typically occupied by a single standard minifloppy or an ST-506-type 5¼-in. Winchester. The 320 has four mounting holes on the bottom and two on each side. It must be mounted in a position that allows horizontal diskette entry.

The electrical interface is similar to the standard minifloppy drive interface. The IN USE and MOTOR ON signals are not needed because the activity LED is activated from the drive select lines and the DC motor runs continuously. The other significant change is that the DRIVE STATUS line has been changed to a ready signal that indicates that a seek operation is complete and the head is centered on the data track. These changes are easily handled in the microcode of most controllers.

The 320 has a data-transfer rate of 500K bits per sec., a disk rotation speed of 360 rotations per min. and a track density of 192 tpi. A speed adjustment must be made to enable the drive to read conventional 48- or 96-tpi diskettes. The position of the write protect cutout on the diskette jacket was changed to enable the drive to detect when a conventional diskette is inserted. In typical minifloppy diskettes, the cutout is on the lower left corner. In the 320, the cutout is on the upper right corner. The microprocessor logic of the drive electronics detects the presence of a 48- or 96-tpi diskette and automatically alters the speed of the motor. The drive rotates at 300 rpm for a 125K-bps rate (48-tpi diskettes) and at 600 rpm for a 250K-bps rate (96-tpi diskettes). After changing the drive speed, the control electronics seek the electrical index pulse and begin reading the diskette. All of this happens automatically and is user transparent.

It is the responsibility of the OEM to provide the pre-written servo information.

The final area of concern, availability of the diskettes with the pre-written servo information, will be the responsibility of OEMs. They will generate the servo-written diskettes and provide them to end users. A Drivetec servo-writer system will probably be available from several media manufacturers as well as from Drivetec. End users will be able to obtain the diskettes initially from OEMs and later from general suppliers at prices only slightly greater than those of double-sided, 96-tpi diskettes. □

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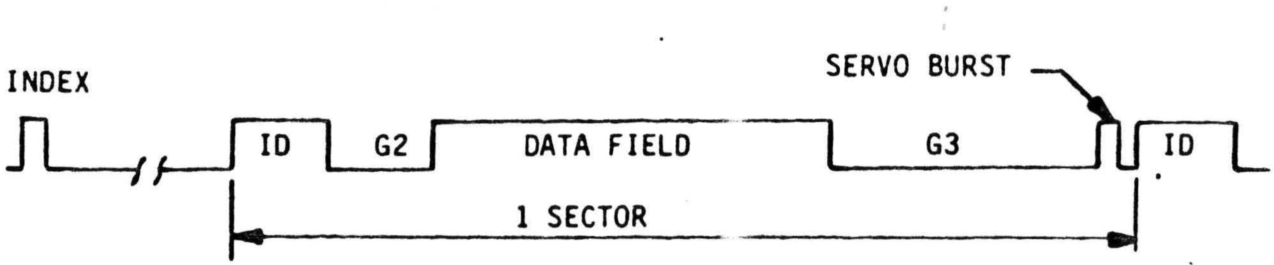
CORRECTION

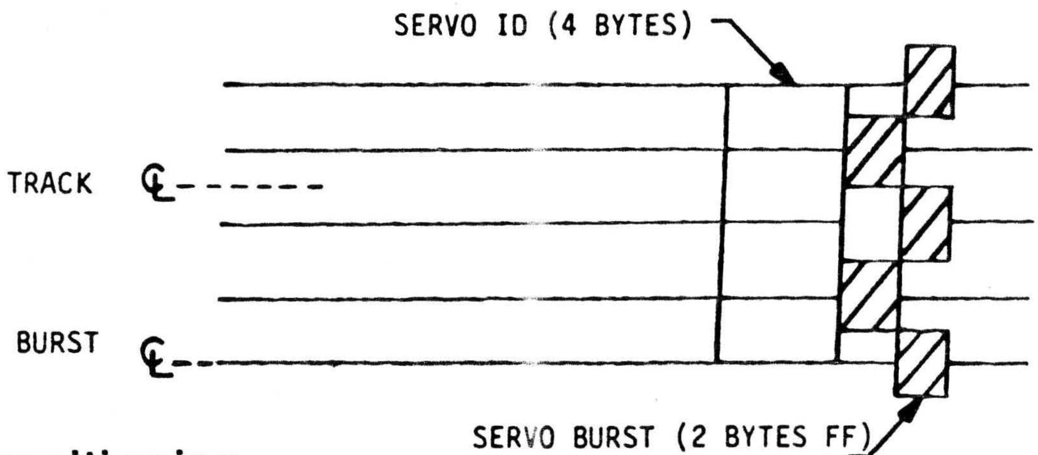
The following companies were omitted from our April survey of 32-bit minicomputers.

Vendor	BTI Computer Systems	Ridge Computers
Product line	BTI 8000	Ridge 32
Line announced	1980	1982
Smallest model	BTI 8000	Ridge 32
Model announced	1980	1982
Packaging	19-in. rack mounted in 6-in. cabinet	34-in. cabinet
Performance		8 MIPS; 1500 single-precision Whetstones (FORTRAN)
Main memory (bytes)	512K-4M	1M-8M
Mass storage (M bytes)	67-254 (formatted)	60-985
Maximum workstations	as many as 200	8: 4 for high resolution graphics, 4 for alpha
Software	demand paging, time sharing, transaction processing, data-base management	demand paging, time sharing, word processing, database management, electronic mail
Networking		LAN
Languages	ANS, COBOL 74, ANS FORTRAN 77, Pascal 8000, BASIC 8000	Pascal, FORTRAN, C, assembly
Purchase price	$105,000	$54,500
Comments:	CPU includes 32- or 64-bit integer arithmetic, virtual memory; as many as 8 CPUs can be connected	Designed for CAD, scientific, engineering applications

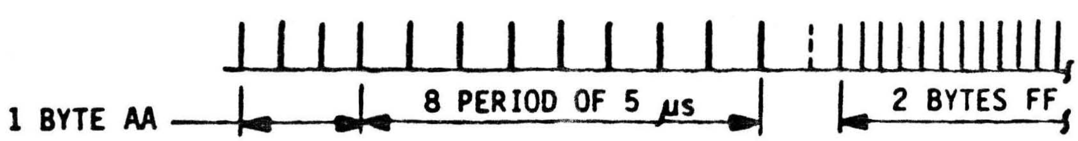
SERVO BURST



- Location

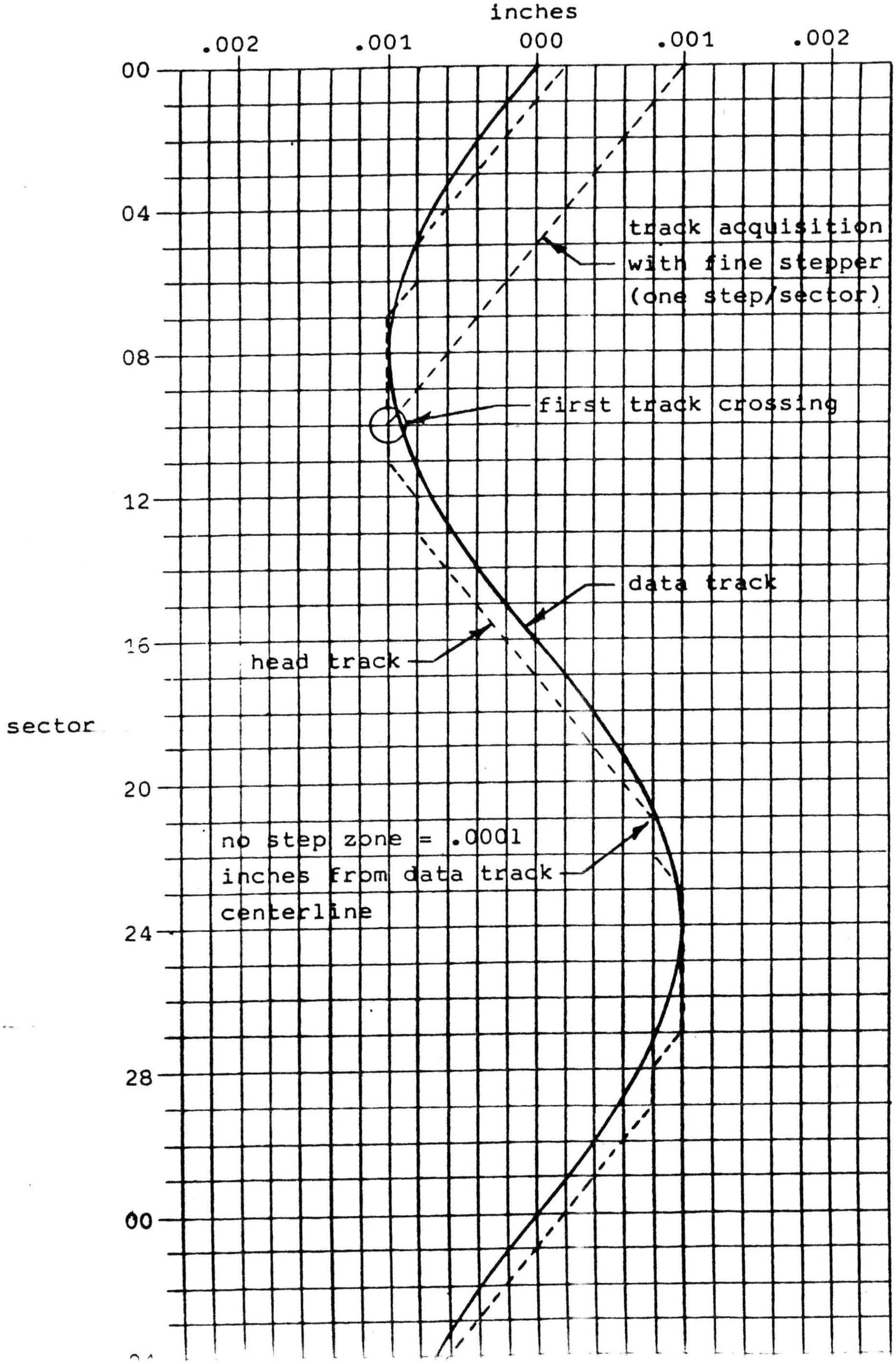


- Track positioning



- Servo ID

TRACK POSITIONING



MEDIA AVAILABILITY

- 50 micro-inch oxide coated high density diskettes

  (current low density diskettes have 100 micro-inch oxide)

- Six media manufacturers are currently in production

  or in development

- Dysan	In production
- Maxell	In production
- 3M	In pre-production
- Brown disk	In production
- Xidex	Prototypes
- Spin physics	Prototypes

- Diskettes must be pre-written with servo bursts