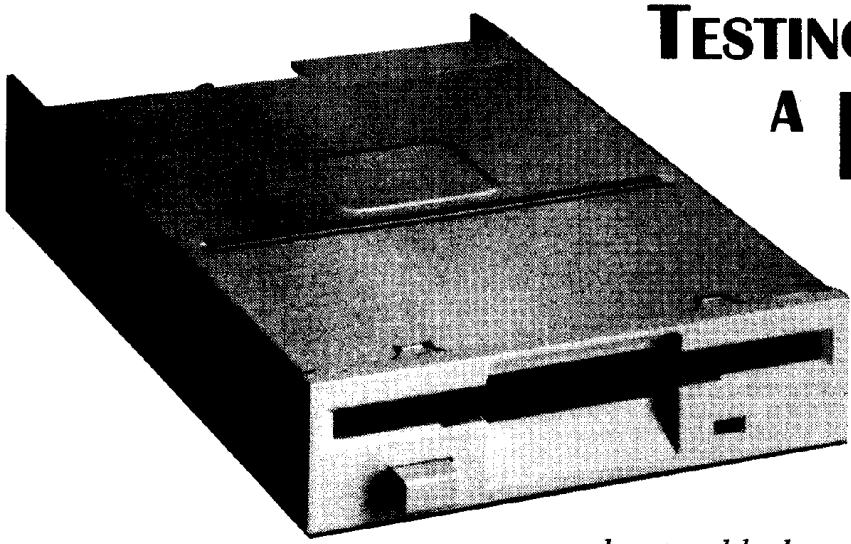

TESTING AND ALIGNING A FLOPPY DRIVE

STEPHEN J. BIGELOW

Today's alignment software makes troubleshooting a balky floppy drive easier than ever before. Here's how it's done.

The basic nature of a computer floppy-disk drive has changed very little since its introduction in the 1970s: A circular disk coated with magnetic media is inserted into the drive and spun at a fixed rate while clamped between two electromagnetic "read/write" heads. Those heads can be positioned across the disk to read or write data to any desired location on the media.

While the media itself (the "diskette") is remarkably simple and cheap to produce, floppy drives themselves are largely mechanical devices composed of motors, lead screws, sliders, levers, clamps, and a myriad of other assorted linkages. Over time and regular use, those mechanical elements will eventually wear out and cause the floppy drive to malfunction. In most cases, floppy-drive problems can be traced to a mechanical problem rather than an electronic failure. Fortunately, whether you fix PCs for a living, or tinker with your own system as a hobby, you can often recover a failing floppy drive with a few basic tools and some alignment software.

Knowing Your Way Around. Before you can work with a floppy drive, you need to know what all the major parts are, and how those parts are put together. Figure 1 is an exploded diagram of a typical 3.5-inch floppy drive. The diagram may appear confusing at first glance, but there are really only six parts you need to know; the spindle motor, the head-stepping motor, the read/write (R/W) heads, the electronics board, the frame, and the clamp/eject plates.

The spindle motor is a low-profile motor (and PC board) mounted to the bottom of the frame. It is the spindle motor that spins the disk. The head stepping motor carries the R/W heads back and forth along the radius of your diskette—that is what allows the heads to reach each concentric track on the disk. When the diskette is inserted into the drive, it is held in place by the clamp/eject plates. After pressing the eject button, the plates separate and allow the diskette to pop out. Finally, the electronics board operates the drive motors, checks the drive's sensors, and manages communication between the drive and the floppy-drive controller in the PC.

You can see how everything works together in the block diagram that is shown in Fig. 2. Figure 2 also shows the major control signals used by the floppy drive interface (that 34-pin ribbon cable that connects the drive to your floppy drive controller).

Recognizing Floppy Problems. Next, you will need to understand when a floppy drive is showing signs that might be related to alignment errors. There are three tell-tale signs of alignment problems:

- Files and data become lost or corrupted when saving to diskette (that might also appear as an intermittent or occasional problem).
- Files and data cannot be read from the diskette—usually resulting in a DOS "General Drive Error" (that might also occur as an intermittent or occasional problem).
- Files and data can be written and read from a diskette in one PC, but may have trouble being used in other PCs (suggesting that the original drive might be out of alignment).

The Cleaning Check. Unlike hard drives, where R/W heads float above the disk platters on a microscopic cushion of air, floppy R/W heads actually contact the diskette media. Over time, particles of media will rub off the diskettes and accumulate on the R/W heads. As accumulations develop on the heads, the dimensions of the heads change, and that can cause floppy errors similar to alignment problems.

Whenever you suspect a floppy-drive problem (especially on older drives with lots of running time), your first step should always be to clean the drive, then re-check it. Cleaning

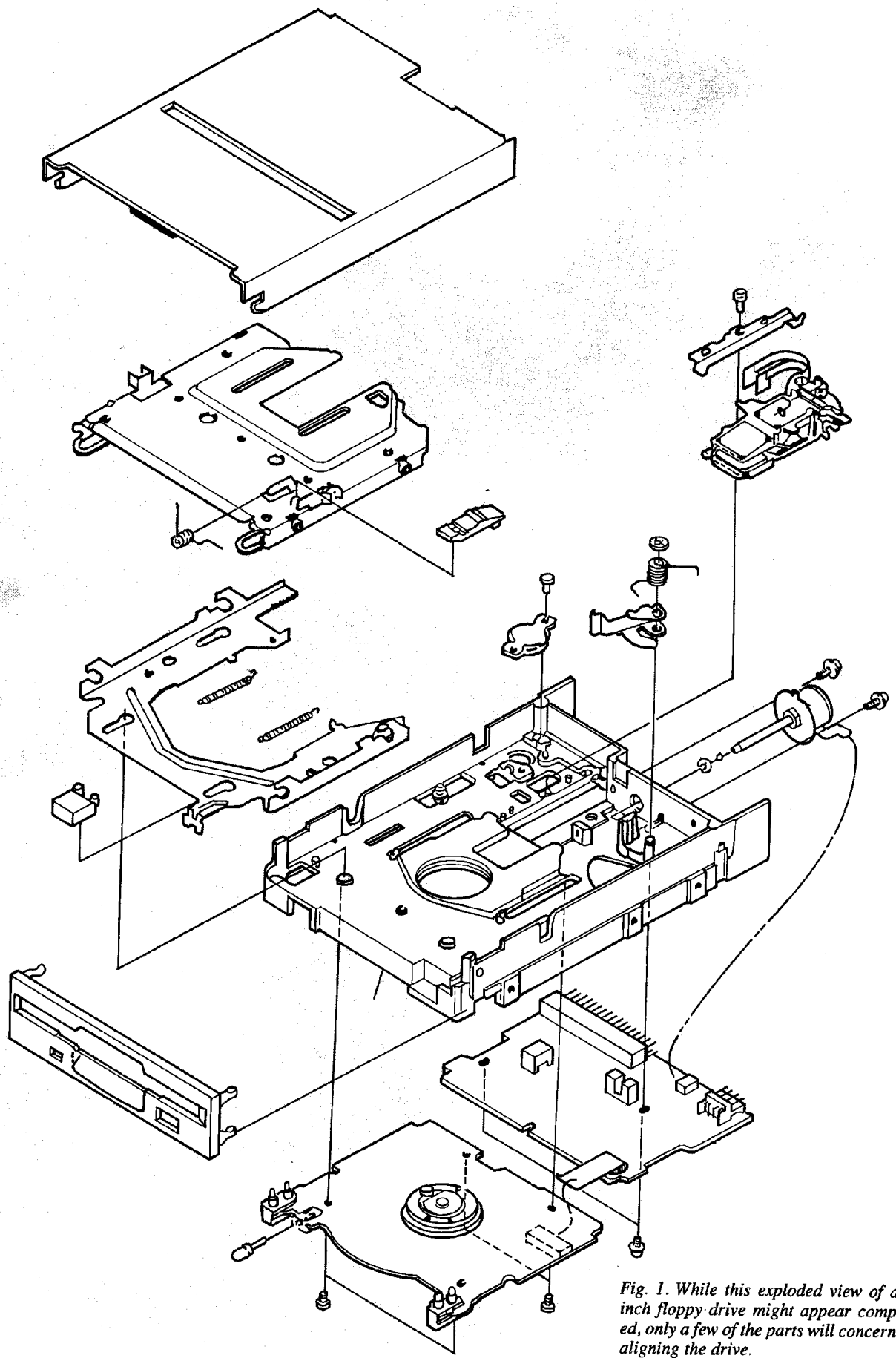

Fig. 1. While this exploded view of a 3.5-inch floppy drive might appear complicated, only a few of the parts will concern us in aligning the drive.

is also important because oxide deposits on the R/W heads are more abrasive than the heads alone, so running with "dirty" heads can actually shorten diskette life. More on the actual cleaning procedure can be found later on in this article. If problems persist after cleaning the drive, check its signal cable.

The Cable Check. Floppy drives depend on a reliable cable connection between the drive and floppy-controller card in the PC. In virtually all PCs, that connection is established through a single 34-pin ribbon cable. The cable may be terminated with "card edge" connectors or "IDC" (insulation displacement connector) sockets, but either way, those connectors must be attached cleanly and completely.

However, the contacts involved in the connection could eventually become oxidized from exposure to everyday air and moisture. Before replacing the drive or realigning it, it makes sense to check the cable to eliminate it as the source of your problems. Making sure computer power is off, try removing and reinserting the connector (once or twice) at each end of the 34-pin ribbon cable. If problems persist after checking the cable connections and cleaning the heads, it is time to decide whether to repair or replace the drive.

Repair vs. Replace. Floppy-drive alignment continues to be a matter of debate. The cost of a floppy-drive alignment package is often as high as the cost of a new drive, so many technicians question the practice of drive alignment when new drives are readily available; in fact, most professional technicians would not choose to align a misbehaving drive.

Even so, testing software has an important place in any toolbox. At the very least, test software can confirm a faulty drive and eliminate the guesswork involved in drive replacement. For enthusiasts and technicians who have a volume of drives to service, alignment tools offer a relatively efficient means of recovering drives that might otherwise be discarded. Ultimately, one of your most vital troubleshooting tools is an open mind—you can repair or replace the drive depending on what makes the most economic sense to you.

Using the Tools. Drive alignment is

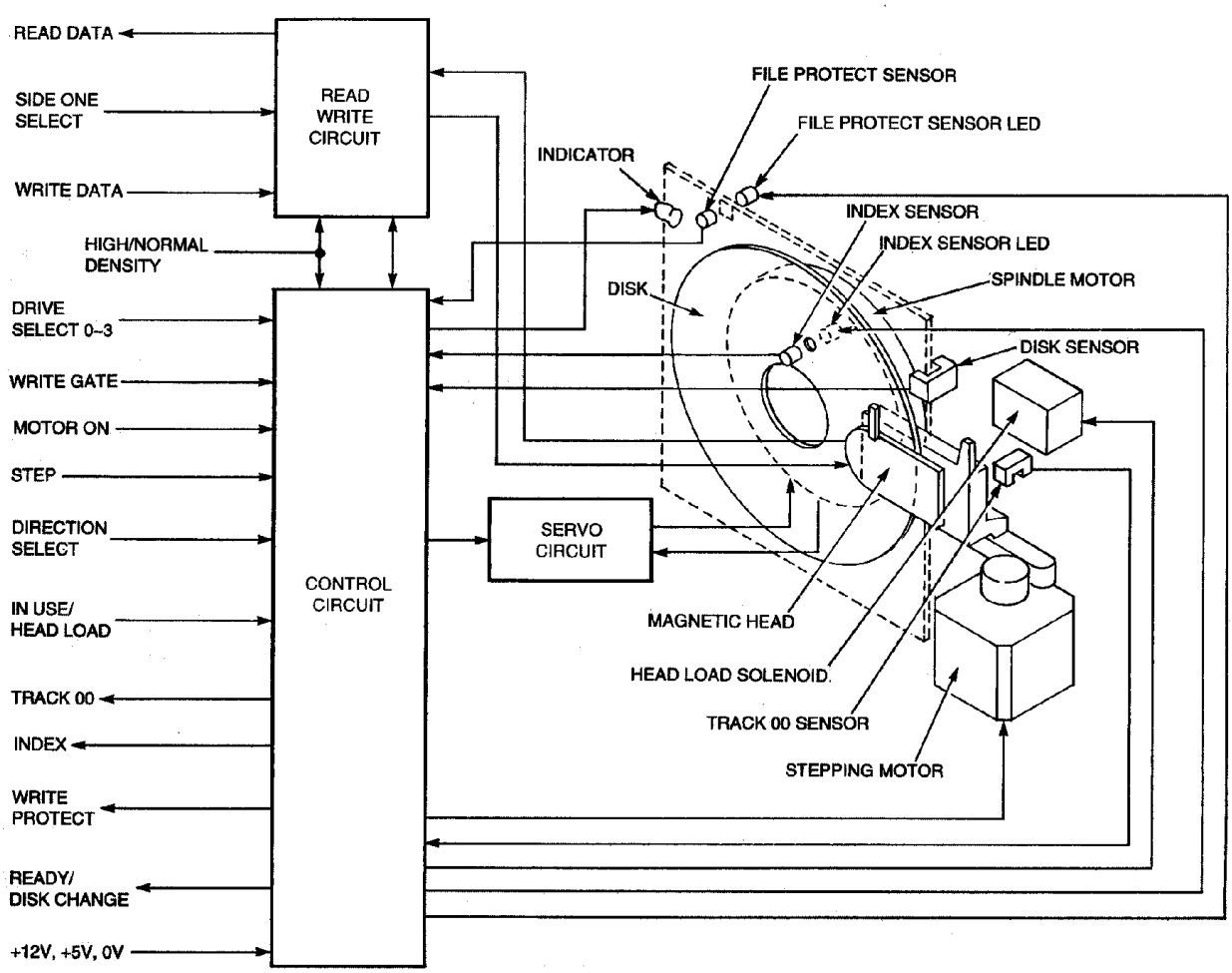

Fig. 2. This block diagram of a floppy drive shows us how everything works together. It also shows the major control signals used by the drive.

not a new concept. Technicians have tested and aligned floppy drives for years using oscilloscopes and test disks containing precise, specially recorded data patterns. You may already be familiar with the classic "cat's eye" or "index burst" alignment patterns seen on oscilloscopes. That kind of manual alignment requires you to find the right test point on your particular drive's PC board, locate the proper adjustment in the drive assembly, and interpret complex (sometimes rather confusing) oscilloscope displays. Manual alignment also requires stand-alone drive-exerciser equipment to run a drive outside of the computer. Fortunately, there is a better way.

Although manual drive-alignment techniques are still used today, they are being largely replaced by automatic alignment techniques. Software developers have created interactive control programs to operate with their specially-recorded data disks. Those software tool kits provide all the features necessary to operate a suspect drive through a wide variety of tests while displaying the results numerically or graphically right on a computer monitor. As you make adjustments, you can see real-time results displayed on the monitor (see Fig. 3). Software-based testing eliminates the need for an oscilloscope and ancillary test equipment. You also do not need to know the specific signal test points for every possible drive.

AUTOMATIC Drive Test — 'Esc'- For Previous Menu

Test	Track	Head 0 Data	Head 1 Data	Test Limits	Results	
Speed	NA	360 RPM / 166.5 mS		360 ± 6 RPM	Pass	NA
Eccentricity	44	50 ul	NA	0 ± 300 ul	Pass	NA
Radial	0	72% 750 ul	72% 750 ul	60 - 100 %	Pass	Pass
Radial	32	87% 300 ul	89% 250 ul	60 - 100 %	Pass	Pass
Radial	79	100% 0 ul	97% -50 ul	60 - 100 %	Pass	Pass
Azimuth	76	-7 Min	-13 Min	0 ± 15 Min	Pass	Pass
Index	0	143 uS	187 uS	200 ± 600 uS	Pass	Pass
Index	79	185 uS	255 uS	200 ± 600 uS	Pass	Pass
Hysteresis	32	200 ul	NA	0 ± 500 ul	Pass	NA

ul = Micro-inches uS = Microsecond mS = Millisecond
Min = Minutes NA = Not Applicable NT = Not Tested

Note: Radial is expressed as LOBE RATIO and OFFSET from track center line.
Auto Test Completed 'Esc' For Previous Menu

Fig. 3. Floppy-drive alignment software will display the results of its tests right on your computer's monitor. No oscilloscope or additional test gear is needed.

There are three popular tool kits on the market; AlignIt by Quarterdeck Select (formerly Landmark Research International Corp.), FloppyTune by Data Depot, Inc., and DriveProbe (shown in Fig. 4) by Accurite Technologies Incorporated. The contact information for each manufacturer is listed elsewhere in this article.

Aligning the Drive. Once you have alignment software available, you are ready to go to work. Before starting your software, however, you should disable any caching software that will cache your floppy drive(s). Because caching software effects the way in which data is read or written to the floppy disk, caching will radically effect the measurements produced by the alignment software. To ensure the truest transfer of data to or from the floppy disk, boot the PC from a "clean" boot disk to disable all TSRs or device drivers in the system.

Once the alignment software is started, there are eight major tests to gauge the performance of a floppy drive; clamping, spindle speed, track 00, radial alignment, azimuth alignment, head step, hysteresis, and head width. Keep in mind that not all tests have adjustments that can correct the corresponding fault.

It is also important to realize that a single test is not always fool-proof. When you see a test that indicates a problem, you should always repeat the test several times to confirm your results.

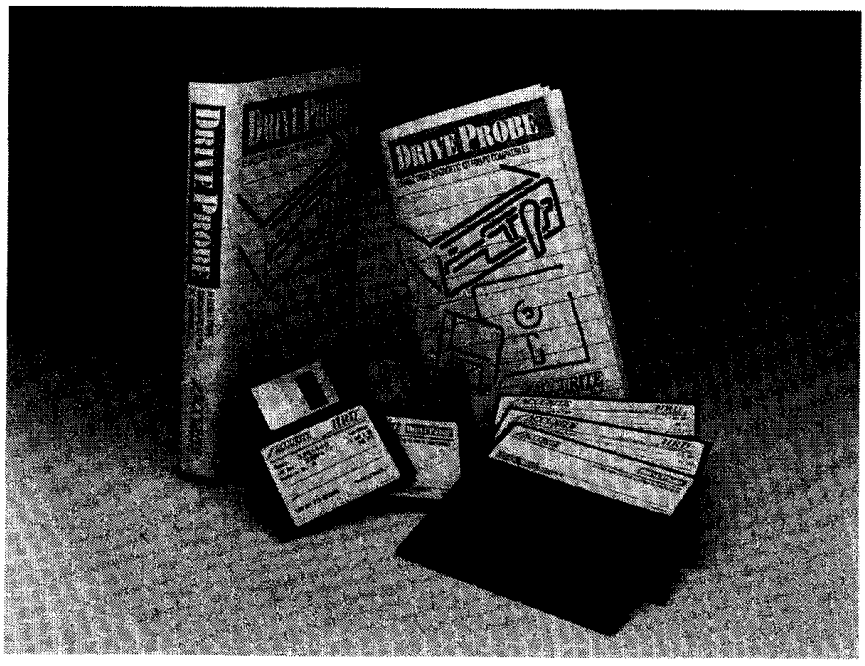

Fig. 4. DriveProbe from Accurite Technologies is among the more popular drive alignment products currently available.

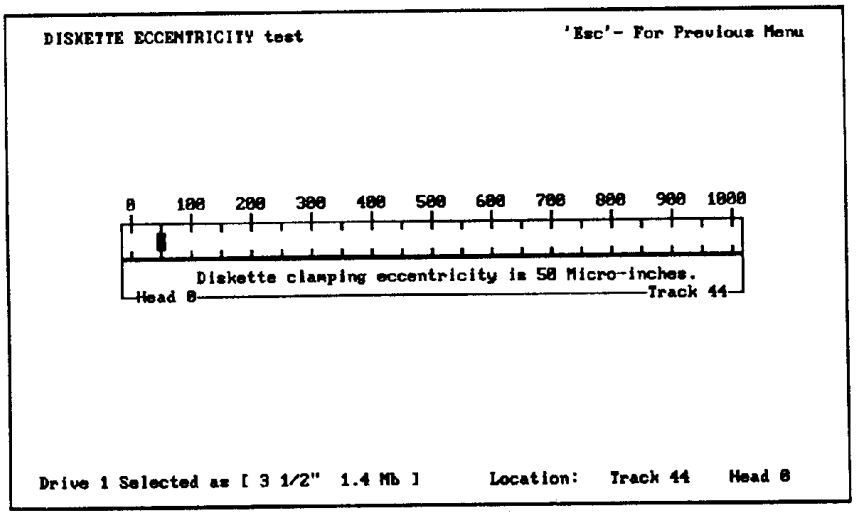

Fig. 5. The spindle clamp test measures disk eccentricity. That test should be performed first as any problem here will affect all the other tests.

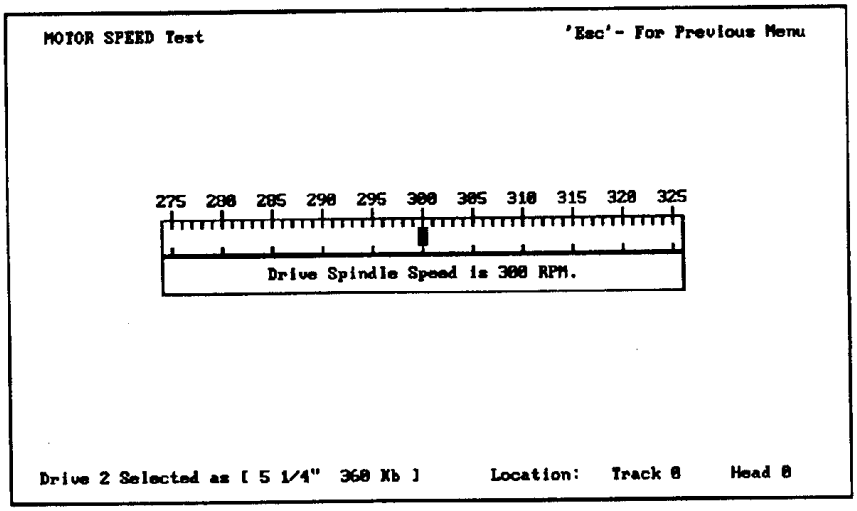

Fig. 6. Here's the display for a spindle-speed test. The drive's speed should be accurate to within ±1.5%.

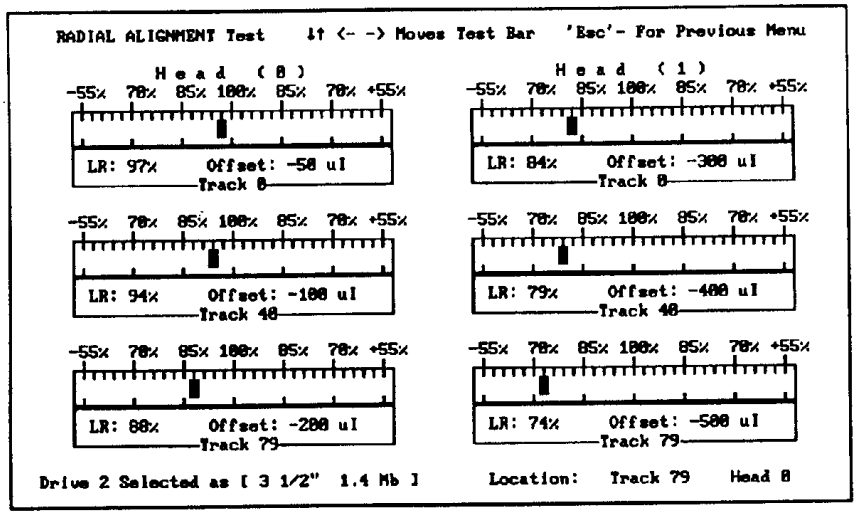

Fig. 7. If the radial-alignment test reveals an error of more than several hundred microinches, the head's alignment must be adjusted.

Cleaning the Heads. As we discussed earlier, dirty R/W heads are "wedged" away from the media by accumulations of oxides and ordinary dust. Dirty heads can cause erroneous readings during testing and alignment. Since alignment disks are specially recorded in a very precise fashion, faulty readings will yield erroneous information that can actually cause you to misadjust the drive. As a general procedure, clean the drive thoroughly before you test or align it.

Drive R/W heads can be cleaned manually or automatically. The manual method is just as the name implies. Use a high-quality head cleaner on a soft, lint-free, anti-static swab, and scrub both head surfaces by hand. Wet the swab but do not soak it. You may need to repeat the cleaning with fresh swabs to ensure that all deposits are removed.

It goes without saying that all computer power must be off before manual cleaning begins. Once cleaning is complete, allow a few minutes for the cleaner to dry completely before restoring power. If you do not have head-cleaning chemicals on-hand, you can use fresh ethyl or isopropyl alcohol. The advantage to manual cleaning is thoroughness—heads can be cleaned very well with no chance of damage due to excessive friction.

If manual cleaning sounds like something you'd rather not do, most software tool kits provide a cleaning disk and software option that allows you to clean the disk automatically. With computer power on and the software tool kit loaded and running, insert the cleaning disk and choose the cleaning option from your software menu. Software will then spin the drive for some period of time—10 to 30 seconds should be adequate, but do not exceed 60 seconds of continuous cleaning. Choose high-quality "dry" cleaning disks that are impregnated with a lubricant. Avoid "bargain" off-the-shelf cleaning disks that force you to wet the disk. Wetted cleaning disks are often harsh, and prolonged use can actually damage the heads from excessive friction. Once the

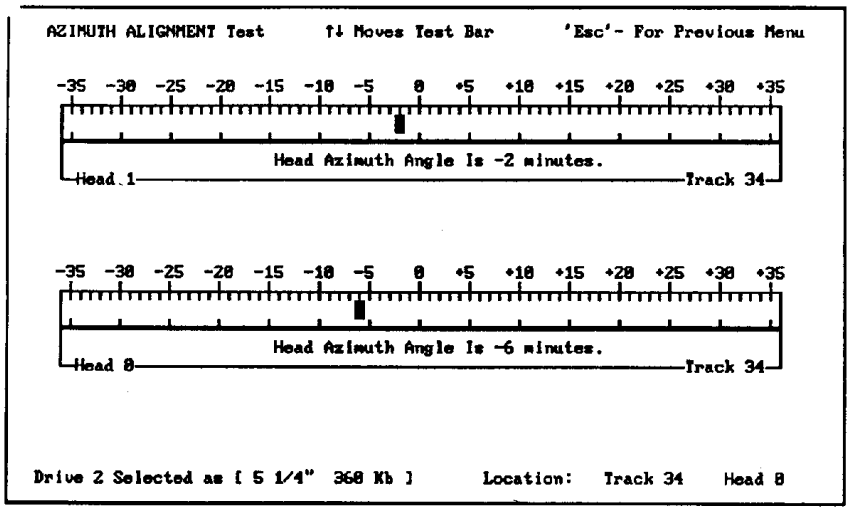

Fig. 8. When the heads are perfectly perpendicular to the disk, the azimuth-alignment test will show an angle of 0 minutes.

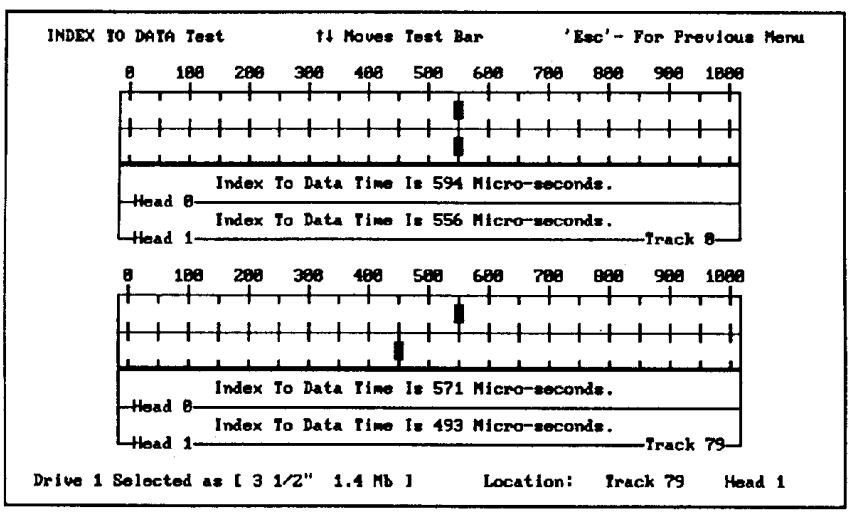

Fig. 9. The head-step test measures the amount of time between a step pulse from the coil driver circuits and a set of timing-mark data recorded on the test disk. As shown here, you typically will see time measurements for both heads on the inner and outer tracks.

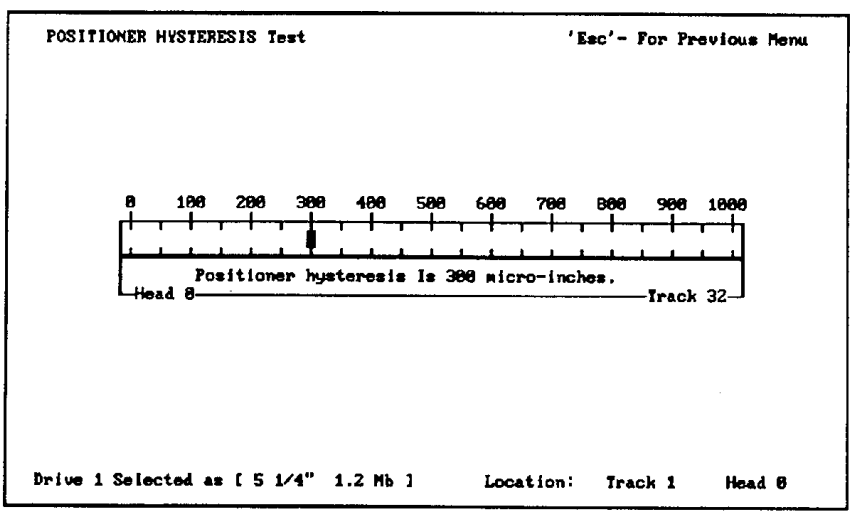

Fig. 10. The hysteresis test looks for excess play in the drive mechanism. If that is encountered, the best recourse is to replace the drive.

drive is clean, it can be tested and aligned.

Spindle Clamp (Eccentricity) Test. A floppy disk is formatted into individual tracks laid down in concentric circles along the media. Since each track is ideally a perfect circle, it is critical that the disk rotate evenly in a drive. If the disk is not on-center for any reason, it will not spin evenly. If a disk is not clamped evenly, the eccentricity introduced into the spin may be enough to allow heads to read or write data to adjoining tracks. A clamping test should be performed *first* after the drive is cleaned because high eccentricity can adversely affect other disk tests. Clamping problems are more pronounced on 5.25-inch drives where the soft Mylar hub ring is vulnerable to damage.

To perform the test, start your alignment software, then insert the alignment disk containing test patterns into the questionable drive. Select a clamping or eccentricity test and allow the test to run a bit. You will probably see a display similar to the one shown in Fig. 5. Typical alignment products can measure eccentricity in terms of microinches-from-true-center. If clamping is off by more than a few hundred microinches, the spindle or clamping mechanisms should be replaced. You can also simply replace the floppy drive. Try reinserting and retesting the disk several times to confirm your results. Repeated failures confirm a faulty spindle system.

Spindle-Speed Test. The diskette media must be rotated at a fixed rate in order for data to be read or written properly. A drive that is too fast or too slow may be able to read files that it has written at that wrong speed without error, but a disk so written might not be readable in other drives operating at a normal speed. Files recorded at a normal speed also might not be readable in drives that are too fast or too slow. Such transfer problems between drives are a classic sign of speed trouble (usually signaled by the operating system as "General

Disk Read/Write Errors"). Drive speeds should be accurate to within ±1.5%, so a drive running at 300 RPM should be accurate to ±4.5 rpm (295.5 to 304.5 rpm), and a drive running at 360 rpm should be accurate to within ±5.4 rpm (354.6 rpm to 365.4 rpm).

After cleaning the R/W heads and testing disk eccentricity, select the spindle-speed test from your alignment-software menu. The display will probably resemble the one in Fig. 6.

Today's floppy drives rarely drift out of alignment because rotational speed is regulated by feedback from the spindle's index sensor. The servo circuit is constantly adjusting spindle-motor torque to achieve optimal spindle speed. If a self-compensating drive is out of tolerance, excess motor wear, mechanical obstructions, or index-sensor failure is indicated. Check and replace the index sensor, or the entire spindle-motor assembly. You can also replace the floppy drive.

Track 00 Test. The first track on any floppy disk is the outermost track of side 0, which is track 00. Track 00 is important because it contains the boot record and FAT (File Allocation Table) information vital for finding disk files. The particular files saved on a disk can be broken up and spread out all over the disk, but the FAT data must always be in a known location. If the drive can not find track 00 reliably, the system may not be able to boot from the floppy drive or even use diskettes. Floppy drives use a sensor to physically determine when the R/W heads are over the outermost track.

Select the track 00 test from your alignment-software menu and allow the test to run. A track 00 test measures the difference between the actual location of track 00 versus the point at which the track 00 sensor indicates that track 00 is reached. The difference should be less than ± 1.5 mils (one-thousandth of an inch). A larger error might cause the drive to encounter problems reading or writing to the disk.

The easiest and quickest way to fix track 00 problems is to alter the track 00 sensor position. That adjustment usually involves loosening the sensor and moving it until the monitor display indicates an acceptable reading. Remember that you only need to move the sensor a small fraction, so a patient, steady hand is required. The track 00 sensor is almost always located along the head carriage lead screw. Mark the original position of the sensor with indelible ink so that you can return it to its original position.

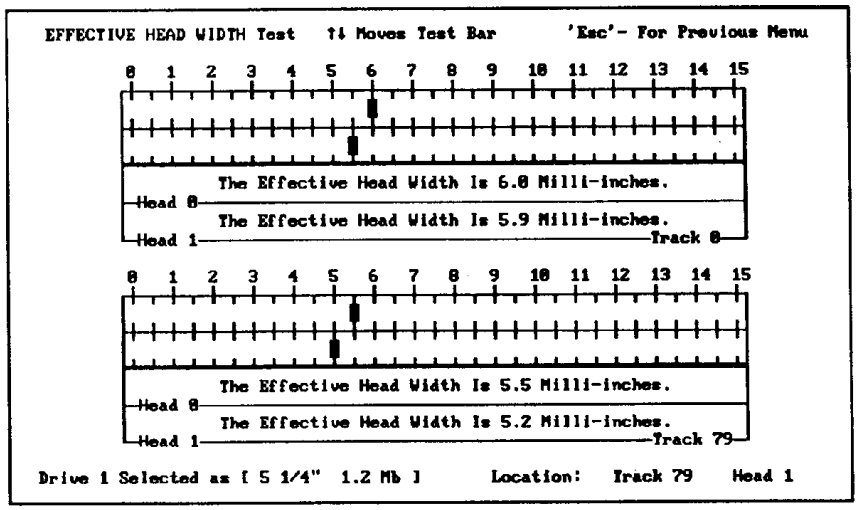

Fig. 11. As its name implies, the head-width test looks at the effective width of the R/W heads. If they are too wide, they are worn and the drive should be replaced; if they are too narrow, they are probably dirty and the drive should be cleaned.

Radial-Alignment Test. The alignment of a drive's R/W heads versus the disk is critical to reliable drive operation because alignment directly effects contact between heads and media. If head contact is not precise, data read or written to the disk may be vulnerable. The radial-alignment test measures the head's actual position versus the precise center of the outer, middle, and inner tracks (as established by ANSI standards). Ideally, the R/W heads should be centered perfectly when positioned over any track, but any differences are measured in microinches. A radial alignment error of more than several-hundred microinches may suggest a head-alignment error.

To check the radial alignment, select the radial-alignment test from your alignment software and allow the test to run. A radial-alignment test display is shown in Fig. 7.

If you must perform an adjustment, you can start by loosening the slotted screws that secure the stepping motor, and gently rotate the motor to alter the lead screw position. As you make adjustments with the test in progress, watch the display for the middle track. When error is minimized, secure the stepping motor carefully to keep the assembly from shifting position. Use *extreme* caution when adjusting radial head position—you only need to move the head a fraction, so a very steady hand is needed. You should also re-check the track 00 sensor to make sure the sensor position is acceptable.

Azimuth-Alignment Test. Not only must the heads be centered perfectly along a disk's radius, but the heads must also be perfectly perpendicular to the disk plane. If the head azimuth is off by more than a few minutes (1/60th of a degree), data integrity can be compromised and disk interchangeability between drives—especially high-density drives—may become unreliable. When the heads are perfectly perpendicular to the disk (at 90 degrees), the azimuth should be 0 minutes.

Select the azimuth test from your alignment software menu and

allow the test to run. Figure 8 shows an azimuth-alignment test display. An azimuth-alignment test measures the rotation (or twist) of R/W heads in terms of + or - minutes. A clockwise twist is expressed as a positive (+) number, while a counterclockwise twist is expressed as a negative (-) number. Heads should be perpendicular to within about ±10 minutes. It is important to note that azimuth adjustments are not easily made in most floppy drives. Unless you want to experiment with the adjustment, it is often easiest to replace a severely misaligned drive.

Floppy Drive Alignment Software

Accurite Technologies Inc.
(DriveProbe)
48460 Lakeview Blvd.
Fremont, CA 94538-6532
Tel: 510-668-4900
Fax: 510 668-4905
URL: www.accurite.com

Data Depot, Inc.
(FloppyTune)
1710 Drew St., #5
Clearwater, FL 34615-6213
Tel: 813-446-3402
Fax: 813-443-4377

Quarterdeck Select (formerly Landmark Research International)
(AlignIt)
5770 Roosevelt Blvd.,
Big 400
Clearwater, FL 34620-3431
Tel: 813-523-9700
Fax: 813-523-2391

Head-Step Test. The head-step (or index-step) test measures the amount of time between a step pulse from the coil driver circuits and a set of timing-mark data recorded on the test disk. In manual adjustments (using an oscilloscope), that would be seen as the "index burst". Average index time is typically 200 microseconds for 5.25-inch drives, and 400 microseconds for 3.5-inch drives. In automatic testing with your alignment software, you will see time measurements for both heads on the inner and outer tracks as shown in Fig.9. The actual range of acceptable time depends on your particular drive, but variations of ±100 microseconds or more is not unusual.

If the head-step timing is off too far, you can adjust timing by moving the index sensor. As with all other drive adjustments, you need only move the sensor a small fraction, so be *extremely* careful about moving the sensor. A steady hand is very important here. Make sure to secure the sensor when you are done with your timing adjustments.

Hysteresis Test. It is natural for wear and debris in the mechanical head positioning system to result in some "play"—that is, the head will not wind up in the exact same position moving from outside in, as moving from the inside out. Excessive play, however, will make it difficult to find the correct track reliably. Testing is accomplished by starting the heads at a known track, stepping the heads out to track 00, then stepping back to the starting track. Head position is then measured and recorded. The heads are then stepped in to the innermost track, then back to the starting track. Head position is measured and recorded again. Under ideal conditions, the R/W heads should wind up in precisely the same place, but natural play almost guarantees some minor difference.

You can see a typical hysteresis test measurement display in Fig. 10. If excessive hysteresis is encountered, the drive should be replaced.

Head-Width Test. As R/W heads wear down from use, their effective width increases. If the effective width is too low, the heads may be contaminated with oxide buildup. Normal effective head widths are 12 or 13 mils for 5.25-inch double-density drives, 5 or 6 mils for 5.25-inch high-density drives, and 4 or 5 mils for all 3.5-inch drives.

As you run the head-width test with your alignment software, you will see effective width displayed on the monitor as shown in Fig. 11. When small head widths are detected, try cleaning the drive again to remove any remaining contaminates. If the width reading remains too small (or measures too large), the heads or head carriage may be damaged. You can replace the R/W head assembly, but often the best course is simply to replace the drive.

Floppy Drive Glossary

Actuator—A motorized assembly that carries the R/W heads.
Alignment—The process of adjusting a device's characteristics in order to bring its operation into an acceptable range.
Centering Cone—On a 5.25-inch drive, an assembly that centers the disk as the drive door is being closed.
Clamping Ring—On a 5.25-inch drive, a part of the spindle that grabs the disk along its center hole in order to turn it.
Data Patterns—A data series used to generate an error if reading circuitry is too sensitive, not sensitive enough, or otherwise defective.
Guide Rod—A simple rod used as a rail for a moving assembly (such as the R/W heads). The guide rod helps to keep the assembly even and steady.
Ferrous Oxide—The generic magnetic layer used to hold magnetic information on a floppy disk.
Head—A R/W head.
Hysteresis—The amount of mechanical "play" in the R/W-head positioning system.
Lead Screw—A coarsely threaded rod that is turned—usually by a stepper motor—and in turn moves the R/W heads.
Load—Allowing the R/W heads to contact the disk surface.
Seek—The process of stepping a R/W head assembly in or out in order to find a desired track.
Spindle—The motor and clamping assembly that holds and spins the disk media.
Spiral Track—A disk with its tracks recorded as a spiral rather than concentric rings. The positioning of those tracks allows precise signal measurement, which allows the drive's operating characteristics to be determined very accurately.

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