The double-sided floppy is reborn

BILL KLEVESAHL and ROGER STROMSTA, Shugart Associates

Shugart solves earlier production problems by simplifying and stabilizing head assembly

Worries about the reliability and availability of double-sided floppy-disk drives are a thing of the past. The drive is alive and well, and its future as a low-cost system storage technology is secure. Concerns about double-sided floppies developed during recent years after Shugart Associates and other suppliers were unable to mass-produce the drives because of problems with an earlier read/write-head design. Shugart has since redesigned the entire head and actuator mechanism, and in the past year has delivered more than 50,000 drives incorporating the new design.

The impact of product design and manufacturing changes by OEM vendors has been dramatic. According to industry observer James Porter's *1980 Disk/Trend Report*, worldwide OEM shipments of double-sided 8-in. drives in 1980 were nearly three times what they were in 1979. This growth was partly spurred, Porter says, by the rapidly growing small-business system market with its requirement for high-capacity floppy-disk drives.

Still remaining from the early problems, however, is some skepticism about the viability of double-sided recording. But Shugart, for one, can point to many customers who have expressed satisfaction with the new Bi-Compliant disk drives. Owing to their inherent simplicity and ruggedness, the drives will easily withstand any buffeting they may meet in shipment.

The tools and processes being used in the Bi-Compliant design are more similar to those that had been used all along in the manufacture of single-sided floppy drives, than to those developed from scratch for the original tri-compliant head actuator carriage (HAC). An interesting conclusion can be drawn from this. In developing their new double-sided drives, Shugart and other OEM vendors created new tools, processes and designs for the new concept. However, Shugart eventually resorted to refining and enforcing its own single-sided processes—processes that have successfully produced more than 1 million units—and would probably have made quicker progress by choosing that course sooner.

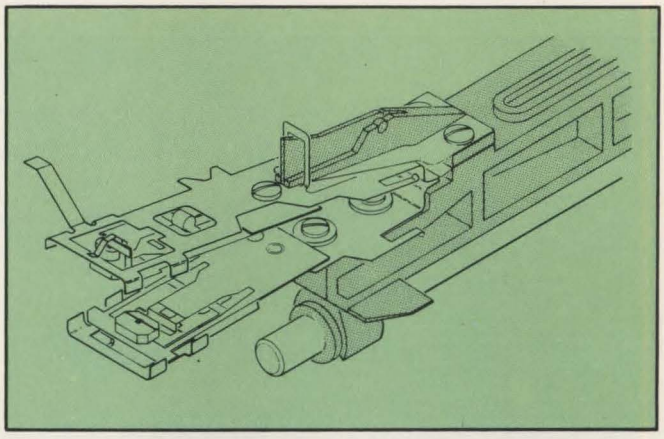


Fig. 1. Original tri-compliant *double-sided floppy technology uses two gimballed heads.*

Evolution of the double-sided drive

A brief review of the development of double-sided technology will provide a basis for understanding the issues involved and the reasons double-sided problems have been surmounted.

IBM Corp. was the first company to design a workable 8-in. double-sided floppy-disk drive. Like other IBM products, it was intended for a captive market of IBM systems and customers. Within this market, the new drive was to be used primarily as a program-loading or I/O device, with either application requiring relatively low duty rates.

The OEM industry subsequently came out with its own version of the double-sided floppy. Shugart introduced the first such drive for OEM use in 1977, and other vendors soon followed. These drives were

The tools used in the Bi-Compliant design are more similar to those used in single-sided floppy drives than to those developed for the tri-compliant head actuator carriage.

intended for highly duty-intensive applications such as system disks—the primary storage media in OEM system products.

A number of problems surfaced early, caused directly or indirectly by the design of the tri-compliant head assembly, which had three movable components: the disk itself and two gimballed read/write heads—one fixed to the lower carriage; the other hooked to a pivoted swing arm (Fig. 1). The problems in this design were: the instability of the head's amplitude, excessive media wear and inability to mass-produce the device.

Problems of tri-compliant design

To understand the double-sided evolution, each of the functions affected by this design should be examined.

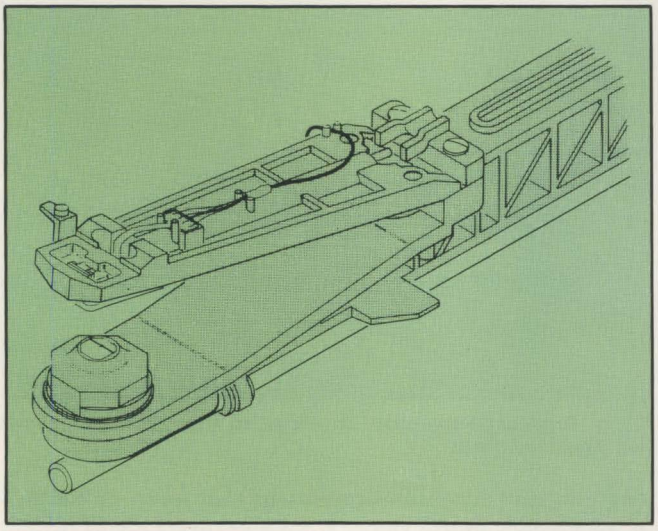


Fig. 2. New Bi-Compliant *double-sided floppy technology uses a fixed lower head and a gimballed upper head.*

The first problem is head-amplitude instability. Some users of the first double-sided drives found that the signals from the disks were weak or inconsistent. The reasons for this can be traced to the disk itself. Because it is not rigid, its amplitude constantly undulates about ⅛ in. above and below the horizontal as it revolves, much like a 45-rpm record rotating on a turntable. Shugart's original tri-compliant design, with its twin gimballed heads, attempted to compensate for the undulation.

One possible solution to the problem would have been to fix the floppy disk in a rigid plane, an effort reportedly now under way at other drive manufacturers. For Shugart, however, such a move would have required completely redesigning and retooling the drive—an effort calculated to take at least a year.

The other solution—and the one ultimately adopted by the company—was to use a head assembly that more adequately compensated for the undulations of the disk.

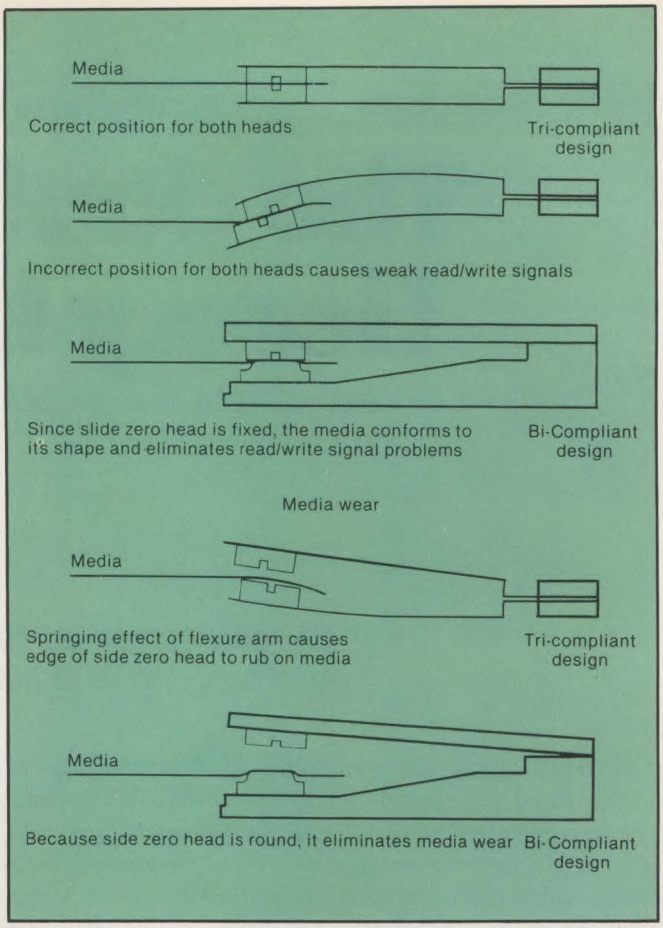


Fig. 3. If one of the head actuator *carriage's flexures is bent at the wrong point, the head would not be parallel to the disk, causing media wear.*

The Bi-Compliant design, which Shugart began using in late 1979, has only two moving parts—the disk and a pivoted, gimballed upper head. The lower of the two heads—the "side 0" head—is nonmovable. Therefore, the disk gains stability and is forced into a more rigid plane as it is pushed down onto the lower head by the spring-loaded arm attached to the upper "side 1" head. The result is that the head location in the Bi-Compliant design achieves a head-to-media dynamic accuracy within several millionths of an in., despite the ⅛-in. undulation characteristic of the media.

The second area of concern relating to the older tri-compliant design was media wear caused by the drive's double-sided design. Even while the drive was not in use, the disks apparently were being subjected to wear. The reason was that rather than being retracted from the disk when the heads were unloaded, the movable side 0 head was left in place, scratching the disk with its sharp edges.

This problem could have been solved in several ways. First, both heads could have been made to retract while the drive was not in use—an approach that IBM took in designing its original double-sided drive. Second, the head's sharp edges could have been eliminated and the head angled away from the disk so that the flexure on which the head was mounted would be parallel to the

The modular approach used to mount the HAC in the drive mechanism prevented Shugart from measuring and controlling the depth of the head's penetration into the media.

disk. Both were tried, but with limited success. The third solution was found in the Bi-Compliant's design, which not only eliminated the lower head's sharp edge (via a new head design and manufacturing technique) but also fixed the side 0 head firmly and accurately in place so that it would not present any edges to the disk.

The final problem, and one of special importance to OEM vendors that buy large quantities of drives, was that the double-sided drive as originally designed could not be produced reliably in high volume. The original dual gimbal-mounted head-actuator carriage was fragile, and could tolerate only minimal movement and handling without damage. This is not a desirable characteristic in products that must be shipped worldwide.

The design could be manufactured relatively problem-free in small quantities, with highly technical engineering expertise at every stage of the process, including assembly. The complex assembly process could then be carefully monitored, and the necessary controls instituted. But when the design was produced in very high volume by semi-skilled workers on assembly lines, the required controls and expertise were not efficiently or economically available.

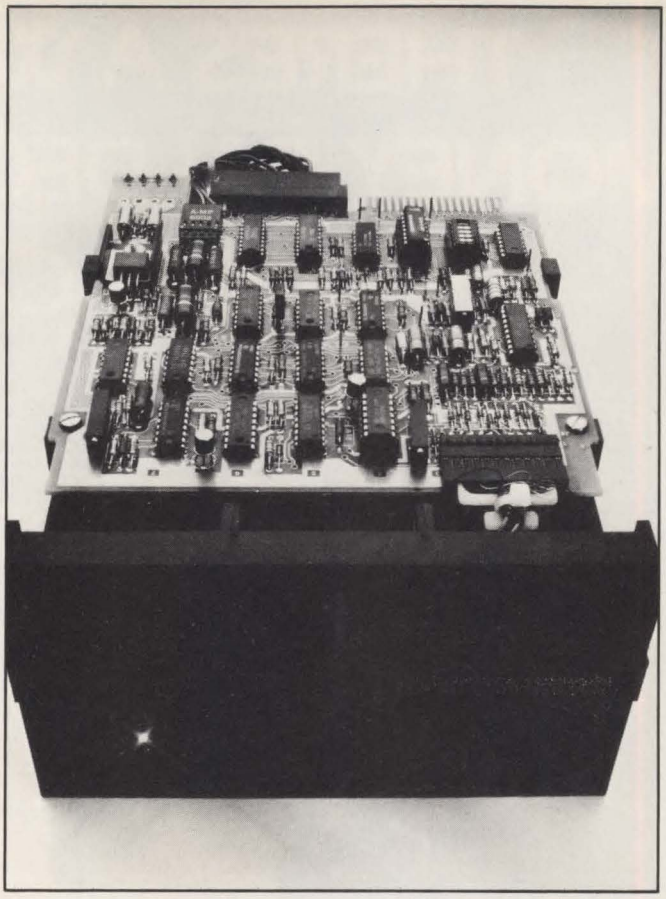
Furthemore, the modular approach used to mount the HAC in the drive mechanism itself prevented Shugart from measuring and controlling the depth of the head's penetration into the media. Although the Bi-Compliant design still uses this modular approach, its fixed and stable side 0 head facilitates easy measurability and, therefore, excellent control.

The Bi-Compliant solution

At no time during Shugart's evaluation of the problem was the flexure-mounted or tri-compliant design considered unworkable. The opposite is instead true: many drives based on this design are still performing successfully for customers. Shugart made that design work but it was clear that continuing to do so would be impractical in the long run. A simpler, more rugged design that would be easier to manufacture and maintain was required. Almost three years of effort went into developing that design—the Bi-Compliant HAC (Fig. 2).

The Bi-Compliant HAC offers a head-actuator design that is easy to build, more reliable and more durable than any design previously available. Its fixed side 0 head is part of a sturdy carriage assembly constructed of a single piece of material, much like the carriage used in Shugart's single-sided SA801 floppy-disk drive.

In addition, the new head-manufacturing technique reduced both the process time and the complexity of the



The 300 percent growth *in shipments of 8-in. double-sided floppy-disk drives from 1970 to 1980 was spurred partly by the rapidly growing small-business systems market.*

equipment required. The tools used in the original design were more expensive than those necessary with the Bi-Compliant design, and their complexity was a potential problem-causer in high-volume manufacturing. For example, if a certain combination of tools was slightly out of adjustment, one of the HAC's flexures could be bent at the wrong point. As a result, the head would not be parallel to the disk, and this, in turn, would cause media wear (Fig. 3). This cannot happen in the Bi-Compliant design because the use of the flexure that caused the problem is eliminated and replaced by a fixed side 0 arm.

The key was design simplification. With the Bi-Compliant HAC, Shugart reduced the number of process steps almost 50 percent—from 19 to 10. And the more rugged design that resulted does not require a high degree of engineering-level monitoring in day-to-day assembly. The Bi-Compliant HAC lends itself well to the same mass-production techniques successfully used to make single-sided drives.

Today double-sided floppy drives are being produced in large volume and a number of vendors are successfully pursuing the Bi-Compliant approach. ■

Bill Klevesahl is marketing manager, double-sided products, and **Roger Stromsta** is director, flexible-disk product engineering, Shugart Associates, Sunnyvale, Calif.