Tape Drives And Heads In 1982

a look at the past and a glimpse at the future

For many years the computer industry has been predicting the demise of tape drives due to the increased capacity of disk drives. It didn't happen. Instead, Winchester technology, with non-removable media, created a tape drive resurgence. Today, the future of tape drives looks better than ever. Their popularity stems in part from their durability — and this has been enhanced by current tape head reconditioning techniques.

by Charles J. Spinnler and Robert Sillers

During the '50s and '60s, tape drives were used as primary storage with densities to 556 bpi and tape speeds up to 37½ ips. Early drives were costly to purchase and maintain. One of the most critical and costly components of the tape drive was (and is) the head. The first digital R/W heads were patterned after audio heads, using separate record and reproduce stacks which required precision alignment, keeping both head and drive costs extremely high. A major cost factor in drive maintenance was head replacement. Because head recovery was non-existent at this time, every head failure meant a new head purchase.

By the late '60s, tape speeds and bit densities doubled. Phase encoding recording raised bit densities past 800 to 1600 bpi, and tape speeds increased to 125 ips. Read while write capability allowed the tape drive to double-check errors while operating rather than rewinding the tape for error checking. Gap-to-gap spacing (timing) became more critical. This brought about the development of the three-piece head.

three-piece head developed

The three-piece head utilized a common center component which housed both the write and read return cores as illustrated in **Figure 2.** This allowed the head manufacturer to hold the dimensional tolerances for skew, scatter, and gap-to-gap spacing. A significant result was reduced drive manufacturing costs since now the burden of tolerance control shifted from the drive manufacturer to the head manufacturer. Perhaps even more important to the drive user was that after the head wore out, the three-piece head could be disassembled and the gap depth re-established to that of a new

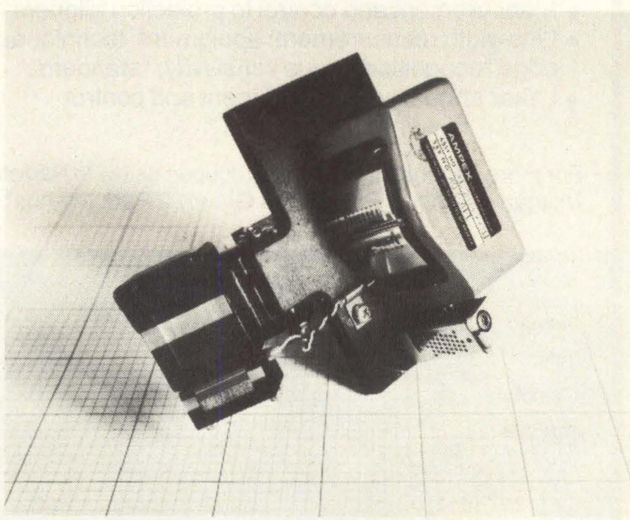

Figure 1: Four piece head with shield assembled. When worn-out, these heads can now be reconditioned rather than replaced.

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head. The field maintenance cost savings were substantial after the development and introduction of tape head rebuilding (by Magnetic Recovery Technologists, Inc. in the mid '70s).

During this time we also saw the advent of the auto-load tape drive, which necessitated advances in head shielding technology. Copper plating was most commonly used to internally suppress write to read cross-feed since an external flux shield could no longer be used. In addition to copper plating, hard chrome plating or other hard coat processes were introduced to combat the more rapid wear experienced in the higher speed drives.

At about this same period of time (mid-to-late '60s), the disk drive was introduced. The disk drive provided greatly improved access times, and gradually began to take over as the primary storage medium. Tape drive and head manufacturers countered in the early '70s with the development of GCR (Group Coded Recording), which increased bit densities to 6250. Tape speeds also increased from 125 to 200 ips. GCR encoding produced no major structural advances in head technology, but demanded many refinements and redefinitions of precision (See "GCR Increases Data Recording Rates and Reliability," **Digital Design**, July 1981, pp. 34-39). For example, a head gap in the '50s could be 0.00025″ or larger, where the 6250 bpi read gap must be 0.00004″ ±0.000005″. Head to tape interface became extremely critical as tape speeds reached 200 ips. This meant further refinements in head contours. Since the introduction of GCR in the early '70s there have been no major advances in tape drive or head technology.

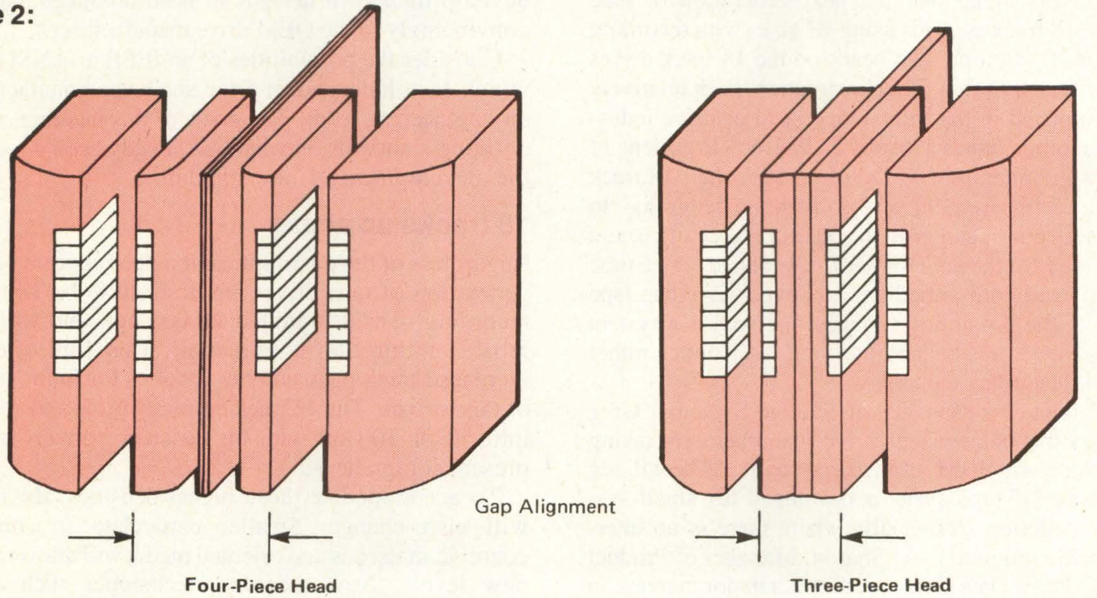
As Ray Freeman of Freeman Associates stated in an abstract he presented at an IEEE Workshop in June of this year, computer tape product technology advances essentially stopped in 1973. In the meantime, disk technology has continued an aggressive rate of improvement in performance and economy. The only evidence of technological advances has been in the area of contour refinement and experimentation with various hardcoat materials. These changes were initiated primarily by the head manufacturers, with each claiming his own particular method as best. However, changes have taken place in tape drives. There has been a trend toward size reduction and miniaturization.

disks boost tape sales

With the trend toward smaller business systems, large tape drives were no longer essential. Smaller drives were developed to fill that need. Cassette and cartridge tape drives were introduced at about the same time as disks began their predominance. They were used in the same function as ½″ drives, but for the separate, small system marketplace. Instead of 7 or 9 track heads on ½″ tape, the cassette and cartridge have developed their own track formats and use 0.150″ and 0.250″ tape widths. Recently, through advances in disk technology, the cassette, cartridge and ½″ drives have found themselves intimately involved with major computer applications. It is ironic that the same disk drive technology which almost drove tape drives to obsolescence has now brought about their resurgence.

The downward trend of tape drive use changed when the Winchester shot its way to the forefront of computer technology. The Winchester-type drives provide great advances in disk drive storage, but due to rigid tolerances and cleanliness requirements the disks themselves cannot be removed. Once the disk is full, the drive is useless unless the data can be transferred rapidly and economically to another media freeing the disk for more data. Streaming tape drives have

Figure 2:



Gap alignment is critical in read-after-write applications. The gaps must be perpendicular to the mounting surface and parallel to each other within .0001″. In addition to perpendicularity and parallelism, neither gap may bow more than .00005″, and the two gap lines must be .150 ± .001″ apart for timing purposes. Further, the distance from the mounting surface to the centerline of each track must be within .001″ for both read and write heads.

The four-piece heads were so thin that they were potted with epoxy to strengthen them. The solution was to laminate the two return core housings to the inter-head shield, reducing the total number of head components from five to three.

It becomes evident that machining, grinding, lapping, assembly, and alignment is not only far more accurate, but significantly easier in the three-piece head. It also allows disassembly for rebuilding, making it recoverable and providing the user with possibly two or more additional performance periods during the overall lifetime.

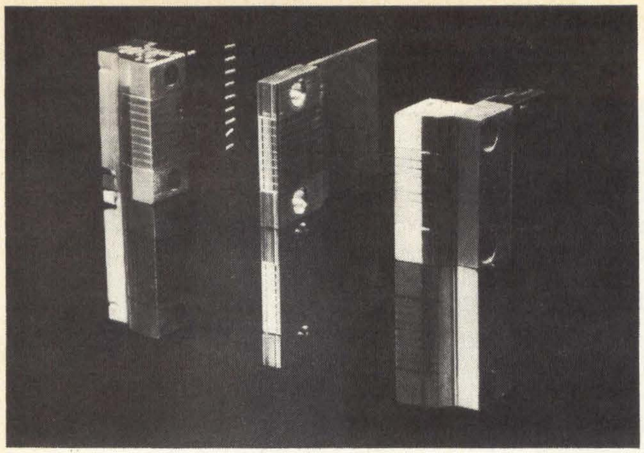


Figure 3: Three piece head, disassembled.

been developed for this purpose and include a niche for cassette, cartridge, and ½" drives. The streaming drives do not introduce new technology. In fact, they are in some ways evolutionary throwbacks, simply combining refinements of earlier technologies and current PE and GCR recording densities.

IBM compatibility mandatory

What then does the future hold for tape drives and the heart of the drive, the tape head? The industry is waiting for IBM to announce its next generation of tape drives. No one knows for sure, but it seems the announcement will be forthcoming sometime in early 1982. It's sometimes frustrating that an entire industry must wait for IBM. No one, apparently wants to produce a product that will not be IBM compatible. Compatibility and interchangeability have become mandatory for users and manufacturers around the world.

Most observers agree that the next generation of tape drives will be 18 track systems using ½" tape, with recording densities near 20,000 bpi. The heads on the 18 track drives will be either ferrite or thin film construction, both relatively unknown or untried in the digital tape head or drive industries. On the other hand, Donald J. Wilson, President of Telex Corp's Peripheral/OEM Division, feels the "18 track is not a huge improvement and something better has to come." He sees continued growth and acceptance of current GCR technology for the next four or five years, at which time it will be replaced with a medium less expensive than tape drives. One of the possibilities Wilson foresees is a system similar to the video disk, perhaps using laser optics rather than magnetic recording technology.

Wang's Production Manager of Storage Systems, Greg Pelletier, sees the independent drive manufacturers taking years to catch up with IBM's 18 track systems. "We will see more and more ¼" tape systems developed for small systems," says Pelletier, "especially where there is no interchange of media required." Al Sharon, Manager of Product Planning at Control Data Corp, predicts "a major increase in ¼" cartridge, ½" cartridge and improved higher density media." Joseph Zajaczkowski, Peripheral OEM Manager of Sperry Univac sees great advantages for the ½" cartridge because of easy handling. "Half inch tape is very entrenched by the big users," claims Zajaczkowski, "and it's hard to break old habits." Darrell Meyer, Pertec's Manager of Product Marketing and Planning, sees more lower cost GCR drives. However, their role will go from "active to passive moving more and more into a form of backup and offline storage." In Meyer's opinion, tape drives will be around for many years just as punch cards have been.

current media nears limit

Most industry observers feel that tape is still a highly economical, easy to store, and easily transported media which will continue in popularity for at least the foreseeable future. This foreseeable future may also be one of evolutionary transition. "Current iron oxide tape media is near its maximum capability for density," states Lewis Frauenfelder, Vice President of Tape Engineering at Storage Technology Corp. "New media will have a new particulate base and will be capable of greater than 25,000 bpi recording."

"Since at first, the new tape subsystems will be used for dump/restore type functions, the migration to these will be evolutionary," Frauenfelder adds. "As iron oxide tape wears out, users will replace it with the new particulate media and will also replace current technology drives with the new particulate capable drives."

In the evolutionary process, was higher density 9 track technology overlooked? Higher density 9-track technology is available, and rumor has it that a large drive manufacturer was planning to announce it, but pulled back to wait for IBM. No one today wants to be a pioneer and be incompatible with IBM in the future. Most agree that higher density 9 track would only be an interim step which should not be taken since IBM's 18 track appears to be close at hand. Whether or not we like it, IBM is our de facto standards-setter.

Head manufacturers must stay abreast of new trends and flex as technology changes. The independent head manufacturer is in no position to dictate bit density, track pack, speed, configuration, or initiate new trends in technology. Yet, according to Frank Chiaverini, President of Alternatives in Magnetics, Inc., "the independent head manufacturer may be in the best position today to innovate, create, and implement that which is necessary to breathe new life into the tape drive industry. Tape head manufacturers may have to develop their own designs in head products and sell them convincingly to the OEM drive manufacturer."

Consider the possibilities of an IEEE or ANSI meeting to which each independent drive and head manufacturer sends an engineering team. The goals of this meeting, rather than defining standards on what had already been done, could be the development of new standards.

18 tracks up ahead

Regardless of the possibilities, it indeed appears that the next generation of tape drives are destined to be 18 track, with recording densities around 20,000 bpi, and with heads of ferrite or thin-film construction. Thin film offers greatly increased track pack and bit densities for future generations of tape drives. The 18 track currently projected could evolve into 50 or 100 tpi with bit densities perhaps beyond our present comprehension.

To accommodate those higher densities, the tape media will also change. Smaller particulate structure, higher coercive materials and oriented media will allow recording at new levels. New recording techniques such as vertical recording will also evolve. Meanwhile, it appears that current 9 track GCR technology will be around for a number of years, and GCR will be applied to cartridge drives and perhaps cassettes as streaming becomes more widely accepted.

Tape drives have a long life ahead. Current heads, media, and media handling methods will undergo further refinement through the evolution of streaming drives. And finally, we will soon see the first new technological advances in almost a decade, with promise of a strong future for both tape drives and tape heads. D