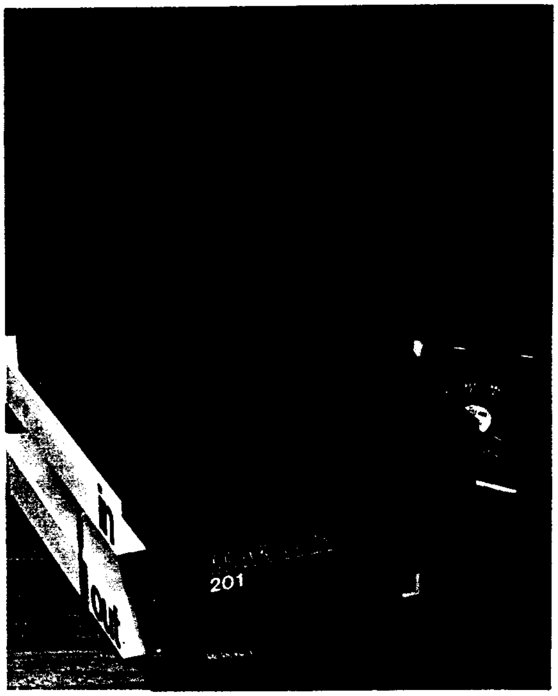


The 8" Fixed Disc Removeable Cartridge Drive Integral Backup For Small Systems

A. Keith Plant,
Memorex Corp. Santa Clara, CA

Rigid disc drive technology has taken another significant step forward with the introduction by a few manufacturers of the the 8-inch fixed disc/removable cartridge storage device. This new product derives its essential engineering from the computer industry's nearly ten years of experience with Winchester storage devices, and it is, therefore, an innovation with roots deeply embedded in a proven technology.

Since their introduction, Winchester drives have been used successfully in many different applications. Until recently, however, they have been used primarily in large computer systems because both their standard 14-inch media size and their large data capacities have not been well suited to the desktop-size and lower-capacity needs of the small systems user. This picture changed dramatically in 1979 with the coming of the 8-inch Winchester disc drive, which expanded the range of Winchester applications to small systems users – the largest and most rapidly growing sector of the storage device marketplace.

This important market segment was being served by flexible disc drives. Yet it generally is recognized that the widespread reliance on flexible drives in this area was due largely to the absence of a viable alternative. Small systems users were willing to use floppy devices, despite their small capacities and sometimes irregular reliability, because they were cheap and the media was removable. Removability meant they were well suited for archival storage, for protection of important data and for reuse. The reliablility problem especially plagued flexible drive makers in their efforts with the higher-capacity double-headed design.

The broad acceptance of the flexible disc devices, given their limitations, hampered the efforts of small systems designers in their pursuit of increased system performance, lower system cost in terms of dollars per megabyte of storage and further simplification of the user/system interface. On the other hand, one issue continued to impede the full acceptance of 8-inch rigid disc drives as alternatives to flexible disc drives – and that was the question of backup or, to put it another way, the availability of removable storage media.

The introduction earlier this year of the fixed disc/removable cartridge 8-inch drive provides an answer to this question. This new drive takes its place among a number of 8-inch Winchester drives with varying capacities and performance rates.

The technology associated with Winchester devices, both 14-inch and 8-inch, is well known. It provides a sealed environment for the magnetic media, heads and head actuators as protection from contamination by

	Capacity (Unformatted MBytes)	Transfer Rate (KBytes/Sec)	Track-Track Access Time (MSec)	$/MB
[illegible]	0.1-0.25	16-64	8-40	550-1800
[illegible]	0.25-0.4	16-64	5-25	550-1800
[illegible]	0.25-0.8	31-62	6-30	500-1120
[illegible]	0.5-1.6	31-125	[illegible]	312-800
[illegible]	5	625	[illegible]	145
[illegible]	5-75	542-1229	10-19	48-300
[illegible]	16-25	1209	10	100-169
[illegible] (CMD)	16-96	1209	6	67-200

This chart compares the 8-inch fixed disc/removable cartridge drive to other disc drive types in capacity, performance and price.

dust or other particles which would cause the low-flying heads – they fly about 20 microinches above the disc surface – to crash. A crash causes damage to both the heads and the disc and consequently results in a loss of data.

The essential features of this technology are: low-mass, lightly-loaded heads; lubricated media; low flying heights of heads; and sealed head-disc assemblies (HDAs). Benefits stemming from these features include: large capacities, fast access and increased reliability and cost effectiveness in terms of dollars per megabyte.

This familiar, proven technology has transferred easily from the 14-inch disc size to the new 8-inch drives, and it is expected that, while the 14-inch disc drive will continue to be used widely in OEM and large system applications, the 8-inch drive will capture an ever-increasing share of the small systems market.

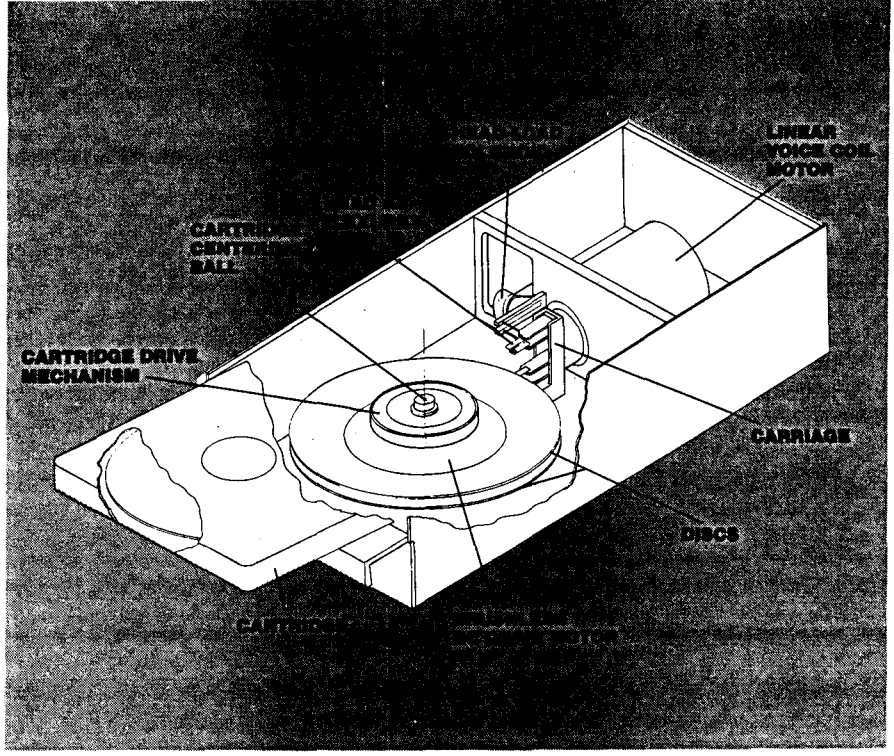
Also, imminent refinements to Winchester technology will have as immediate an effect on 8-inch drives as on their 14-inch counterparts. Even before the use of thin-film heads and media, it can be expected that performance will increase within the bounds of present technology. For example, some engineers predict that capacity will be multiplied five or six times by increases in aerial density still possible within the ferrite head/oxide media context.

However, with the coming of thin-film heads and thin-film media, the capacity of Winchester units, 14-inch and 8-inch, will be increased even further. Higher reliability also can be expected as sophisticated servo systems and head-positioning devices are introduced. Such impending technological advances will improve system cost effectiveness as well.

Range of 8″ offerings

The 8-inch disc drive products now being offered by a variety of manufacturers range across a broad spectrum of price, performance, capacity and system compatibility parameters. This array can be grouped by price and performance into two, medium and high categories. The drives also can be grouped according to their use of fixed or moving heads and fixed or removable media.

Some manufacturers have chosen to compete only at one end or the other of these scales – some producing low-capacity drives, some producing very high-capacity devices. Other drive



This drawing shows the various parts of an 8-inch fixed/removable drive.

makers, such as Memorex or Control Data Corporation, will compete initially in the low and medium ranges, with future products at the high-cost, high-capacity levels. Memorex, for instance, has introduced its Model 101, with 11.7 megabytes of storage and with an average access time of 70 milliseconds, and it also will be making a drive with twice this capacity, 23.4 megabytes, as a multiple-user flexible disc drive replacement.

Types of head and media technology provide further means of categorizing 8-inch drives. *Fixed head/fixed media drives,* usually with less than five megabytes of storage, have low access times and compete directly with flexible disc units.

Moving head/fixed media drives, such as the Memorex 101 and Shugart 1002, have higher capacities (between five and 25 megabytes) and access times of 70 milliseconds, and they employ band-actuated stepper motors. Other drives of this type use voice-coil actuators. They offer access times between 30-50 milliseconds and capacities up to 75 megabytes, putting them into the medium capacity/performance/price range. Still other drives of this type, such as the IBM 3310, are aimed at replacing the 14-inch drives in high-cost systems, and they offer capacities which begin at, and go beyond, the 65 megabyte range.

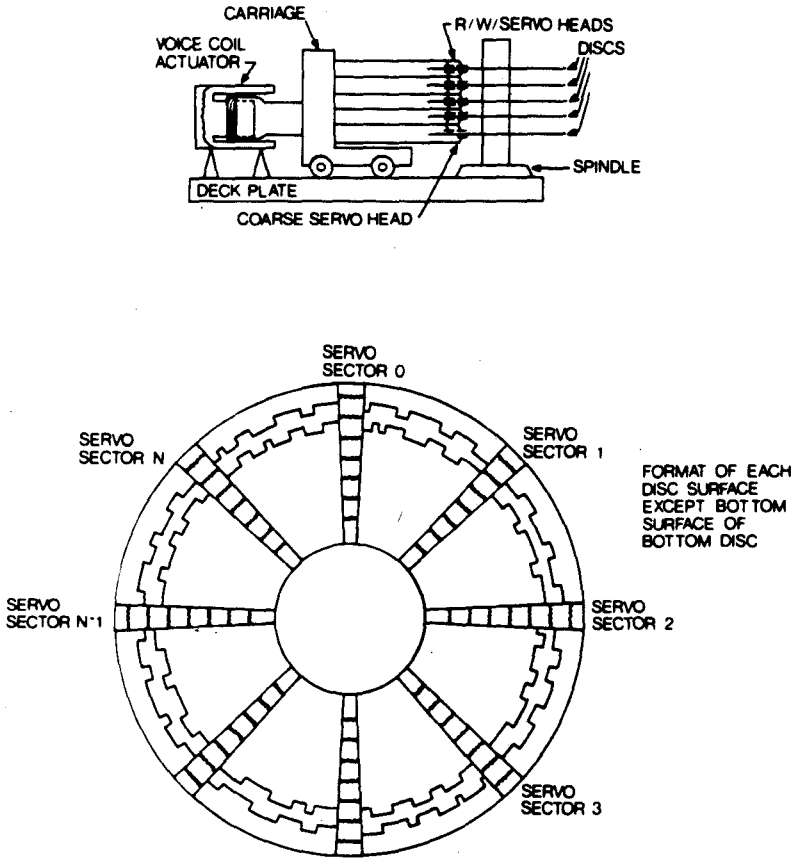
Finally, the *moving head/fixed and removable media drives,* such as Memorex's Model 201 and the CDC "Lark," will be aimed at multiple-user, multiple-tasking systems demanding relatively fast access (30-50 milliseconds). The storage capacity for the entire system usually will be under 100 megabytes. These devices also will compete with cartridge or storage module devices in relatively large systems.

Drives in this category, with both fixed discs and removable cartridge media, obviously confront head-on the question of 8-inch disc drive backup, and they solve that problem by providing integral removable storage. Backup, as mentioned earlier, is still a key issue affecting the acceptance of 8-inch fixed disc storage devices. Thus, the removable cartridge feature of the new drives should facilitate their acceptance by flexible disc users.

Backup alternatives

To protect data stored on a magnetic disc in case of a power outage or simply to provide for archival storage, requires the transfer of the data from the 8-inch disc to a removable form of storage media.

At present, except for the new fixed/removable disc drives, backup alternatives are limited to flexible discs or various magnetic tape products, including the new streaming-tape devices. Tape alternatives include quarter-inch, half-inch, cartridge and cassette formats. In general, the half-inch streaming-tape backup alternative is not suit-



The above drawings are a generic representation of an embedded or sample data servo system.

able for low-capacity 8-inch drives because the streaming tape's high capacity means large unit size and higher costs. Such alternatives might better be matched with high-capacity 8-inch drives, above 25 megabytes. Tape drives using the quarter-inch format are smaller and cheaper, to be sure, but they also generally have lower capacities and slower transfer rates, making them more compatible with lower-capacity 8-inch drives.

Flexible disc storage units also can be used for 8-inch rigid disc backup. However, the floppies' low capacities, high error rates and low data transfer rates limit their backup use to low-capacity 8-inch drives even though they are cheap, easy to use and standardized for compatibility.

The question of 8-inch rigid disc backup is not yet completely solved. A recent report on the 8-inch market concludes, "Those who wait for the perfect backup will wait a long time" (There also are some interfacing and software roadblocks standing in the way of simple and compatible utilization of 8-inch drives in OEM systems). But the 8-inch fixed/removable media drive suits a number of applications and meets the need for integral backup within certain capacity, performance, price and size parameters.

Anatomy of a drive

Although the following description of an 8-inch fixed/removable rigid disc drive is based on the specifications of the Memorex Model 201, it generally fits the specifications of fixed/removable products from other manufacturers as well.

These drives are medium-priced (approximately $3,000 a unit in OEM quantities), medium-capacity (16-50 megabytes), medium/high performance (30-50 milliseconds access time) products, serving as disc cartridge or storage module replacements.

Utilizing Winchester technology, they feature a sealed head, head actuator and media environment to protect them from contamination, combined with a removable rigid disc cartridge, typically front-loaded. Cartridge sizes are not standardized and vary from one manufacturer to another. The Model 201 cartridge measures 8.3" X 8.4" X 1". When inserted above the fixed discs, the cartridge engages with the drive motor spindle and the head actuator assembly.

In the Memorex Model 201, actuators are of the linear voice-coil motor type, mounted on a six-bearing carriage. Heads are the low-mass Winchester type, made of a magnesium-zinc ferrite material.

The 201's two fixed discs are fully sealed. They are driven by a DC brushless motor with an integral spindle. This eliminates the need for belts, pulleys or gears, thereby reducing noise, vibration, thermal effects and production costs. This design simplicity also increases reliability.

In the 16-50-megabyte capacity range generally associated with these products, the Memorex Model 201 has a capacity of 25 megabytes – the two fixed discs provide 12.5 megabytes and the removable cartridge another 12.5 megabytes. The fixed discs include one disc with one surface of dedicated servo information and another with two data surfaces and embedded servo information. The removable cartridge provides one disc, using two data surfaces with embedded servo in each track.

The factory-embedded servo gives the device very fast access times and very accurate tracking. For instance, in the Model 201, the dedicated servo information provides accurate positioning and fast access to within one-half track of the sought-for data. At that point the embedded servo takes over for the last half-track search. This technology enables the Model 201 to access data at an average speed of only 30 milliseconds, or 20 milliseconds faster than the CDC "Lark".

The two fixed and one removable discs are all identical in size and composition, and in the Model 201 they feature a proprietary oxide coating formulation as well as an extra lubrication layer, wiped across the disc and then buffed to a thickness of a few molecules. These discs are sized at 200 millimeters outside diameter and 100 mm inside diameter, a size which conforms to a "principle of similitude," which maintains that the OD/ID ratio should be similar to that for the standard 14-inch disc. By use of this principle, experience with 14-inch technology can be applied to 8-inch discs, thereby taking some of the guesswork out of solving modal vibration or mechanical resonance problems.

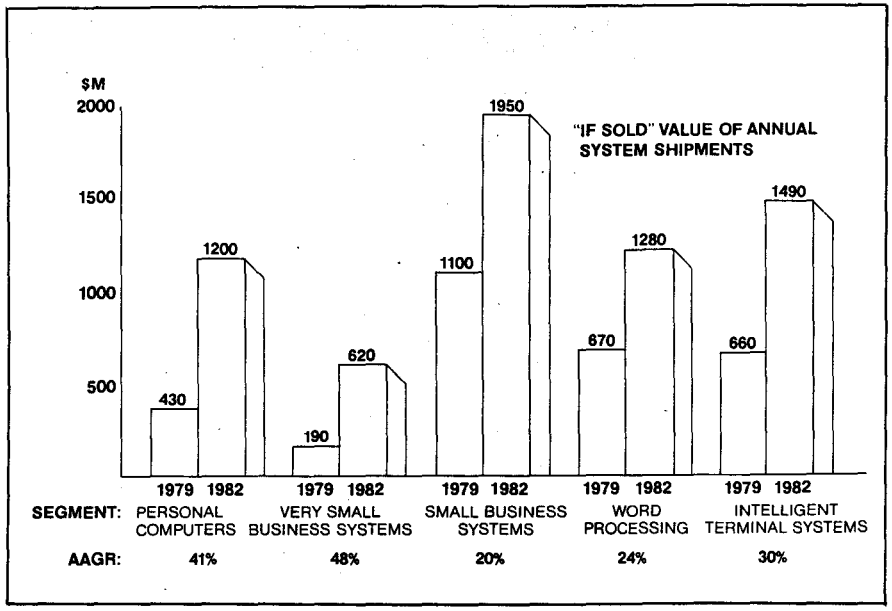
There are several permutations of the generic 8-inch disc size media now on the market – ranging from 63.5-mm ID/200-mm OD through 100 milli-

meters ID/195-mm OD to 100 millimeters ID/210-mm OD. Any reduction in outside diameter below 200 millimeters, however, results in less than the optimal capacity which can be stored on a disc that fits a floppy drive envelope. A very small inside diameter, on the other hand, will increase the moment of inertia, requiring more energy to maintain angular rotation speeds.

In some fixed/removable cartridge drives, such as CDC's "Lark," the cartridges are "ramp-loaded," because they use modified 3330 heads. On the other hand, the Memorex 201 employs an "active-loading" system, using a rotary solenoid to expand a simple mechanism which loads or lifts off the Winchester heads upon insertion or withdrawal of the cartridge. The cartridge doors fully seal when the cartridge is withdrawn and require door-actuating mechanisms for loading. A write-protect feature needs to be located on the cartridge; in the case of the Model 201, this feature is a simple removable foolproof button, while in some competitive units a switch is used.

The dual air system of the fixed/removable disc drive is a recirculating, absolute-filtered system which flushes the fixed disc and cartridge areas, provides contamination protection and reduces heat. It is positively pressurized to ensure that any contamination is forced out of the drive during loading or withdrawal of the cartridge. Because the 201's cartridge loading door can be opened only when the power is on, this positive pressurization is always present when the door is open.

The overall size of the fixed/removable storage device (the Model 201 is 4.38″ high, 8.55″ wide and 18″ deep) makes it exchangeable with the flexible disc units it is designed to replace. The first fixed/removable products on the market employ a conservative design approach which requires a "two-box" system, with heads, media and associated mechanical and electrical assemblies in one flexible drive-size package and the electronics in another similar-sized package. In other words, designers of the early products have chosen an MSI approach, rather than an LSI circuit design approach. We and others will soon take the LSI step, however, using a single board to be inserted into the head/disc unit without changing the overall dimensions of the drive. This can be accomplished in the field, and the second or electronics box can then be replaced by an additional drive in the same space. The only electronics



The graph indicates projected growth in small systems markets, targets for new 8″-Winchester drives. (AAGR = Average Annual Growth Rate).

in the drive unit are in the R/W chip that controls the head actuators.

The disc drive interface for the 8-inch fixed/removable device made by Memorex is designed to be compatible with SMD-type controllers, although a higher-level parallel-type interface also will be introduced.

Data retrieval times are an important measure of disc drive function. Again within the general parameters of available fixed/removable devices, the Model 201 features a track-to-track access time of ten milliseconds, with an average access time of 30 mm and a transfer rate of 1.20 megabytes/second. The discs spin at 3510 RPM. Tracks per inch on the 8-inch discs are 480, with 8,450 bpi. In some ways, it is easier to increase TPI on 8-inch rigid discs than on the 14-inch discs because there is less vibration and wobble and because the smaller discs require less power to spin less mass. These factors facilitate more accurate head positioning, for example.

Most manufacturers of 8-inch fixed/removable disc storage units are expected to match fairly closely the general specifications outlined above. The devices are, after all, aimed at essentially the same users. These are users with computer systems with multiple-user, multiple-tasking configurations who require relatively large capacity, faster access, increased data transfer and at least equal cost-efficiency when compared to 8-inch drives without integral backup or to flexible disc drives now in use in many small systems. The OEM's choice of vendor then will be based on overall vendor capabilities, production capacity, design efficiency and sophistication and future upgradeability of the product, rather than simply on listed specifications. Buildability, deliverability, reliability and evolvability are the catchwords by which the OEM and end-user will judge the market offerings.

Thin-film heads and media

The question of evolvability is a crucial one for OEMs considering the use of the new 8-inch drives, especially in light of the attention being paid to advances in thin-film head and thin-film media technology. Memorex's applied research centers, particularly its Recording Technology Center, along with the research establishments of other manufacturers, have been studying thin-film heads and thin-film media for years.

Thin-film recording utilizes technology which the semiconductor industry has developed over the past 25 years. This technology includes photolithography and a highly accurate masking technique which makes possible the batch processing of thousands of heads at one time. Thin-film recording heads are produced by sputtering, vacuum deposition and plating – all semiconductor production processes.

Testing procedures developed by the semiconductor industry also can be applied to the manufacture of thin-film heads. As a result of the application of these manufacturing and testing techniques, thin-film heads have some major advantages over ferrite heads. The improved performance characteristics of the materials used in the thin-film process are one advantage –

thin-film head permalloys can operate at higher frequencies, and they have greater overall permeability. Other major advantages result from the geometrical and dimensional control provided by the photolithographic process. The heads produced are much smaller than ferrite heads, and, therefore, they are more efficient in transmitting and receiving flux from the recording surface. Also, much smaller recording gaps and track widths are achieved than can be achieved by the machine-shop techniques used in ferrite head production.

The development of thin-film heads heads has been accompanied by similar work with thin-film recording media. For many years, particulate oxides have been used as the primary coating for disc media. The thickness of this particulate oxide coating has been steadily reduced over time. Now coating uniformity defects have become critical because mass production coating thickness has reached the order of 35 millionths of an inch. Under a microscope, the individual particles of oxide look like a forest of Fe_2O_3 slivers, whereas a media sample produced by the thin-film process appears as a continuous film of coating, resulting in a continuum of much smaller magnetic domains. In addition, signal-to-noise ratio measurements show that thin-film magnetic recording media outperform particulate oxide coatings by a factor of nearly ten.

Industry technologists predict the combined use of thin-film heads and thin-film media will result in an increase in aerial density from the present 3 to 8 million bits per square inch to 50 million bits per square inch by the mid-1980s. Thin-film heads will influence bits per inch by their electrical and magnetic performance, as well as influencing tracks per inch by the geometrical control of the recording transducer. Recording at 25,000 bpi will be achieved in standard longitudinal recording at a track density of 2,000 tracks per inch. With further advances in magnetic recording techniques based on thin-film heads and thin-film media, which open the door to "perpendicular" or "vertical" recording, the promise of 100 Mbits/in^2 becomes more and more likely. Increased aerial density means greater capacity at lower costs. This can be examined in terms of rapidly declining costs per megabyte or in terms of relatively constant costs per disc spindle. These advances, now on the horizon, will of course affect the 8-inch rigid disc drives as well as the larger 14-inch drives because the basic technology contains no important barries to the use of a reduced disc.

Increased subsystems performance by the use of LSI circuit design also is available and readily transferrable to the 8-inch rigid disc drive. The evolvability of the 8-inch drives, including the fixed/removable units, is assured, and users will find they can continue to upgrade storage components without radical departures in size and other physical standards. The steady evolution of the Winchester rigid disc drive from the first 14-inch products toward the advanced thin-film 8-inch products is a prime example of the advantages of continuing to exploit a proven technology.

The marketplace

It was said earlier that the 8-inch rigid disc drive is designed to provide higher capacity and faster performance for small systems users – the largest and most rapidly-expanding sector in the computer peripheral marketplace. Just how large is that sector? The number

of present and potential users is enormous.

In round figures, there are approximately four million businesses of all kinds in the Unites States alone. The very large businesses, the "Fortune 1000" businesses and some others, are already using sophisticated electronic data processing equipment – primarily large mainframe systems and multiterminal distributed data processing configurations.

Below this fairly exclusive group of major businesses is another larger group of perhaps 1.5 million businesses, some employing no more than 50 persons or even fewer. It is this marketplace which is targeted as the primary market for small business systems needing the storage support provided by the 8-inch disc drive, in different formats and with different capacities. This market, if not employing electronic data processing on a large scale, is already somewhat experienced with computer-based business and scientific support systems for use in the office, laboratory, warehouse and manufacturing plant.

Here the desktop computer or small business system has been used for manipulation of business information of all kinds. Applications include word processing, intelligent and graphics terminal support, protocomposition and inventory and process control. In many cases, very small business systems and "personal" computers will also demand support from 8-inch disc drive devices.

The remaining 2.5 million or so businesses in the United States, with sales of only a few million dollars or less each year, employing from one to 25 persons, rely for the present on such electronic devices as desk and hand calculators to process data. Yet this market, too, will soon be ripe for penetration by the small business computer manufacturer and will require compatible storage devices such as the 8-inch disc drive.

Indeed, there is hardly a business-known that is not potentially available to the vendor of small systems, and all of them will need and want integral backup 8-inch storage. As programs grow in length, as high level languages take up more memory space, and as the storage requirements continue to grow for 16-bit and the coming 32-bit μPs, the capacity, access time, size and cost of the 8-inch disc drive make it an ideal choice. (See chart #6).

The fixed/removable choice

The selection of an 8-inch fixed/removable media disc drive is not yet a bewildering matter; only a few manufacturers have introduced such products to date, although more such storage devices will appear soon.

Also, since 8-inch drives are similar in specs, size and cost, it at first seems that the choice is easy or not important. This is not true. Although the choice of an 8-inch fixed/removable disc drive would not be based entirely on raw spec data, it's important that the OEM (or the end-user configuring his own system) look carefully at some broad selection criteria.

Competitive advantages in this still-narrow field will largely be based on the ability to produce 8-inch fixed/removable media drives efficiently, reliably and at high production levels. Only manufacturers committing major resources to ensure buildability, reliability, deliverability and evolvabililty – including capability of manufacturing essential components, such as heads and media in-house – will have viable options.