ME112 Disk Drive Dissection

Prerequisite: View Disk Drive Multimedia Case Study available at Meyer cluster. Be sure to allow at least 2 hours to view this case study and take notes. This exercise is intended for an audience of junior/senior mechanical engineering students and anyone else with the curiosity and desire to explore the design and construction of a common electro-mechanical systems.

Purpose:

The purpose of the exercise is to give students hands on experience with disk drives and concrete examples of the following engineering principals: Design for Assembly, Motion Systems, Heat transfer, System Dynamics, Stiffness Considerations, Competitive Analysis.

Introduction:

Hard Disk Drives are used as the primary source of data storage for computers for which the data must be read or written and be accessible quickly, all at low cost. The disk drive is at the heart of personal computers for maintaining software and storing data. The disk drive is an excellent example of an electro-mechanical system where design of both the mechanical and electronic elements must be integrated into a single product.

This dissection exercise is concerned with the disassembly and reassembly of two computer hard drives and an inspection of a 3 1/2" floppy disk drive. The two hard drives are manufactured by Everex and Quantum Corporations and are examples of the progression of disk drive technology. The disk drives are very similar to those encountered by students on a daily basis in their use of personal computers. The exercise begins with the dissection of a 1980's vintage 5 Megabyte Everex hard drive. Next, a 1992 1 Gigabyte Quantum hard drive will be dissected. Many obvious and subtle design differences will be observed and cataloged and a list of questions must be answered.

Logistics:

The exercise will take about 2 hours to complete. The following tools and materials are necessary to complete this exercise:

Phase I:

- 1980's vintage everex or similar hard drive with stepper motor head position with linear drives.
- Small metric Allen wrenches.
- Small flat head screwdriver.

Phase II:

- 1992 Quantum 1GByte Hard drives.
- 1 set of small torx wrenches.
- Small flat head screwdriver.

Phase I: 5 MB EVEREX Hard Drive

Dissection Procedure:

Before you begin, assign one member of your dissection team the job of parts manager. The parts manager is responsible for keeping track of all parts as you disassemble the drive. This is a vital role, since the drive must be reassembled at the conclusion of the exercise. Follow the steps outlined below to complete this exercise. There are questions at the end of each drive dissection that must be answered and turned in at the end of this exercise. There are also questions in the procedure that are intended to spark discussion. You do not need to turn in answers to these. Ask questions of the coaches at any and all times. They are ready and willing to help.

STEP 1: EXAMINATION OF HARD DRIVE EXTERIOR

Examine the complete assembly. Make a list of all major components visible from the exterior, note what materials are used and how they were manufactured. Also note what function you think these components might serve. Fill out the following table to aid in this task.

Component	Material/Manufacturing	Function

STEP 2: INSPECTION OF DRIVE INTERIOR

Remove the 10 hex head screws that hold down the top cover and gently remove it (**note:** try not to touch the disk surfaces since they are easily marred and we would like to keep the drives in good condition for next year's class). Again complete the table of components, manufacturing and function for all the components in the interior of the drive. Throughout the exercise, refer to Figure 1 which contains a sketch of the drive in question.

Component	Material/Manufacturing	Function

Everex 5 MB Hard Drive

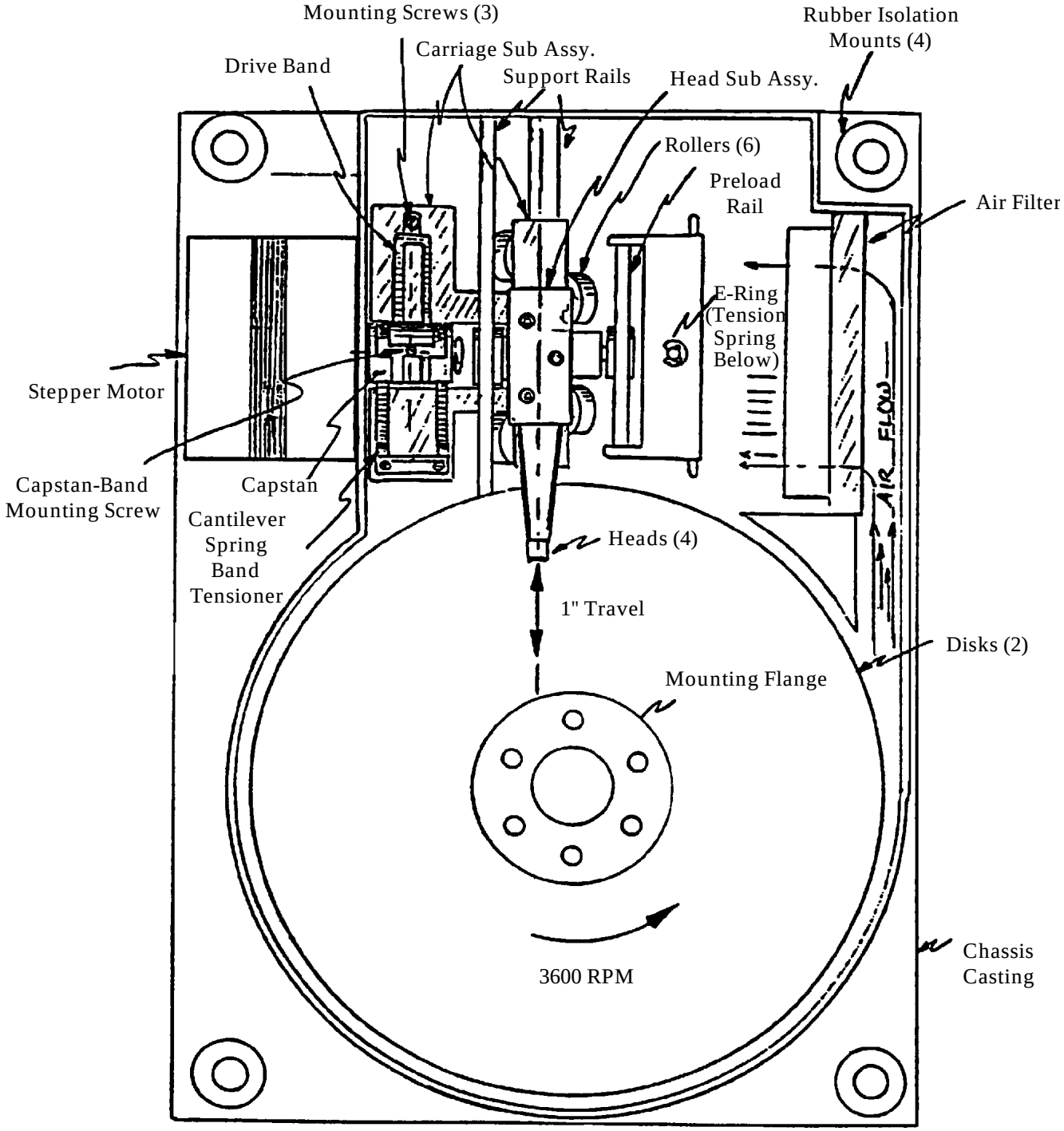

Figure 1: Sketch of major compenents of Everex 5MB Hard Drive.

STEP 3: REMOVAL AND INSPECTION OF HEAD AND FLEXIBLE CIRCUIT

Remove the two hex head screws that secure the flexible circuit. Next, remove the two cap socket screws that secure the head assemble to the carriage (these are the two larger of the three cap socket screws visible on the top of the head assembly. Now gently remove the head and circuit assembly from the drive.

- Examine the flexible read / write head suspension system. Note the fine flexible connections on the end of the arm holding the pad in place. This suspension is designed so that the head "flys" about 20 microns from the surface of the disk when they are rotating. Obviously, the heads lie on the disk when the disks are not rotating. What causes this flying action?

- The figure below contains an enlarged view of the suspension arm and read / write head. Note the preload between the arm and pad provided by the dimple on the flexure.

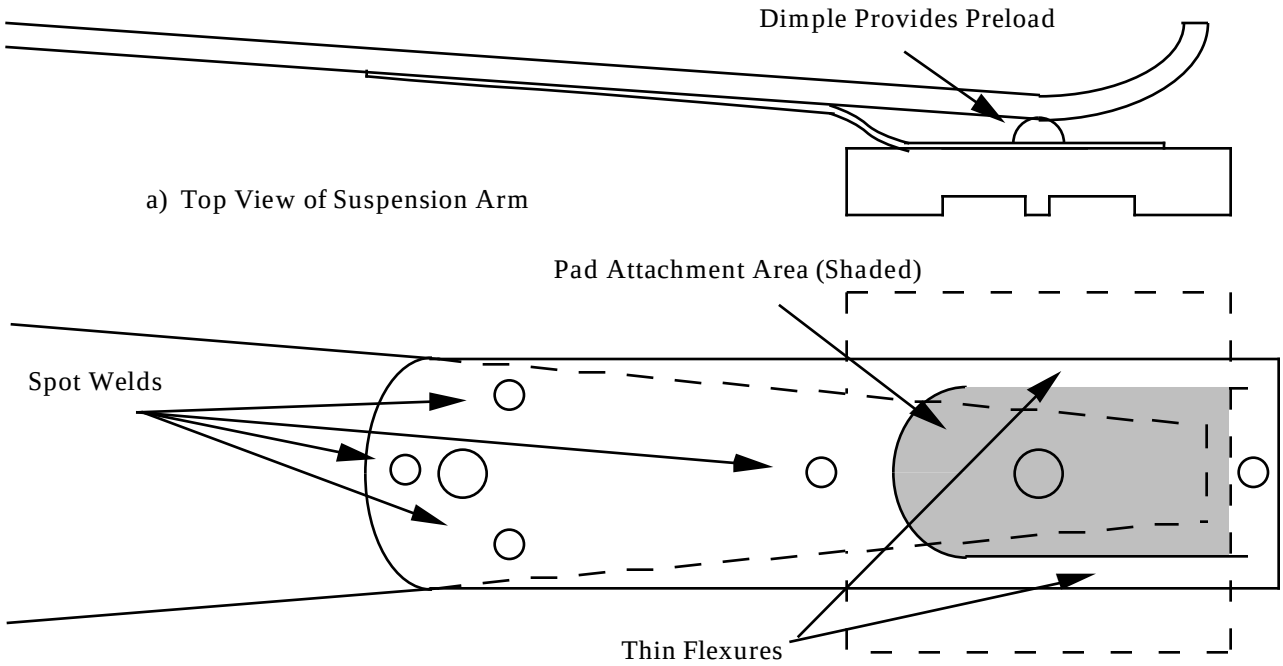

Figure 2. Enlarged View of Suspension arm and read / write head.

STEP 4: THE CARRIAGE SLIDER MECHANISM DESIGN

Examine the carriage slider mechanism.

- Determine the number of degrees of freedom it allows.
- Note that one rail is preloaded against the carriage. How is this accomplished and what is the purpose of this design decision?

STEP 5: REMOVAL OF THE DISKS

Remove the six hex button screws holding the disk cap and remove the two disks.

- Note that extremely tight tolerances are involved in the disk spindle assembly.
- Note the two slots in the casting on opposite sides of the disk. Speculate on their purpose. Castings allow designers to include these types of features at low additional cost.

STEP 6: REMOVAL OF THE DISK MOTOR AND FILTRATION SYSTEM

Remove the three screws that secure the disk motor. Pry the motor loose.

- The thin film of plastic is a gasket which keeps the drive sealed from contaminants.
- Note the weight of the motor as you will see in Phase II the progression of motor design.

Now remove and inspect the air filtration cartridge.

- Note the assembly clue marked on the molded cartridge housing. By merely opening the drive dropped its resale value to $5 because of the particles in the room air. Refer to Appendix A to get a graphical idea of how sensitive the drives are to dust and other particulate matter.

STEP 7: EXAMINE THE CHASSIS MOUNTING BRACKET

Note the four Phillips screws holding the chassis mounting bracket to the chassis. Depending on the computer case, this mounting bracket would be changed. For example a difference mounting bracket might be used for an Apple as opposed to an IBM computer.

- Speculate on the purpose of rubber mounts.
- Speculate the purpose of the wire attaching the chassis to the mounting bracket.

STEP 8: DISASSEMBLY OF CAPSTAN DRIVE

Remove the small cap screw from the motor head capstan. Next, remove the single cap screw from the rear mount of the drive band. **Be very careful with the band because it will easily kink**. Now remove the four button screws that hold the stepper motor on the outside of the chassis and remove the motor.

- The capstan drive has very low friction and no backlash.

- What is the purpose of the small looped pieces spot welded to the ends of the bands on the side closest to the disks?

- What is the purpose of the piece of metal bolted onto the motor shaft on the outside of the drive?

- What type of motor drives the slider and what are its advantages.

STEP 9: INSPECTION OF SLIDER MECHANISM

Loosen but do not remove the two button head screws that clamp the upper rail nearest the motor and slide the rail out.

- Inspect the slider mechanism. Are there any signs of wear?

STEP 10: REASSEMBLY

Follow the previous nine steps in reverse order to reassemble the disk drive. For STEP 3, the heads must be levered apart before sliding over the disks. Use a screw driver to accomplish this.

Questions for Phase 1: Student Names:

1) What material is the case made of and why? What manufacturing technique was used?

2) What might the sensor on the bottom of the drive be for?

3) What is the purpose of the rubber mounts and what characteristics would you expect this rubber to have?

4) What advantages does the capstan drive with the steel band have over using a timing belt or gear train?

5) What causes air flow so that the filtration system functions?

6) Which direction do the disks turn and why?

7) What do you think caused the wear of the slider mechanism.

8) Was the drive easy to assemble? If not, how could it be changed for improved ease of assembly?

9) Do you think that this drive was robotically assembled? Why?

10) List the number of seals used to prevent contaminants from entering the housing.

Phase II: 1 GB Quantum Hard Drive

Dissection Procedure:

Before you begin, assign a new team member of your dissection team the job of parts manager. Again, there are questions at the end of the dissection that must be answered and turned in at the end of this exercise. Ask questions of the coaches at any and all times. They are ready and willing to help.

STEP 1: EXAMINATION OF HARD DRIVE EXTERIOR

Examine the complete assembly. Make a list of all major components visible from the exterior, note what materials are used and how they were manufactured. Also note what function you think these components might serve. Fill out the following table to aid in this task. Note, there is no need to speculate on the internal workings of each IC on the printed circuit board!

Component	MaterialsManufacturing	Function

- How many motors do you speculate that the drive contains?
- What material is the housing make of and why?
- What do you think is the purpose of the hole in the side of the case?

STEP 2: INSPECTION OF DRIVE INTERIOR

Remove the hex nut and the 7 torx bolts that secure the aluminum cover plate on the drive and gently lift the cover plate off of the drive.(**note:** try not to touch the disk surfaces since they are easily marred and we would like to keep the drives in good condition for next years class). Again complete the table of components, manufacturing and function for all the components in the interior of the drive. A layout drawing of the disk drive is contained in Figure 3.

Component	Material/Manufacturing	Function

- Locate the air filtration device in this drive

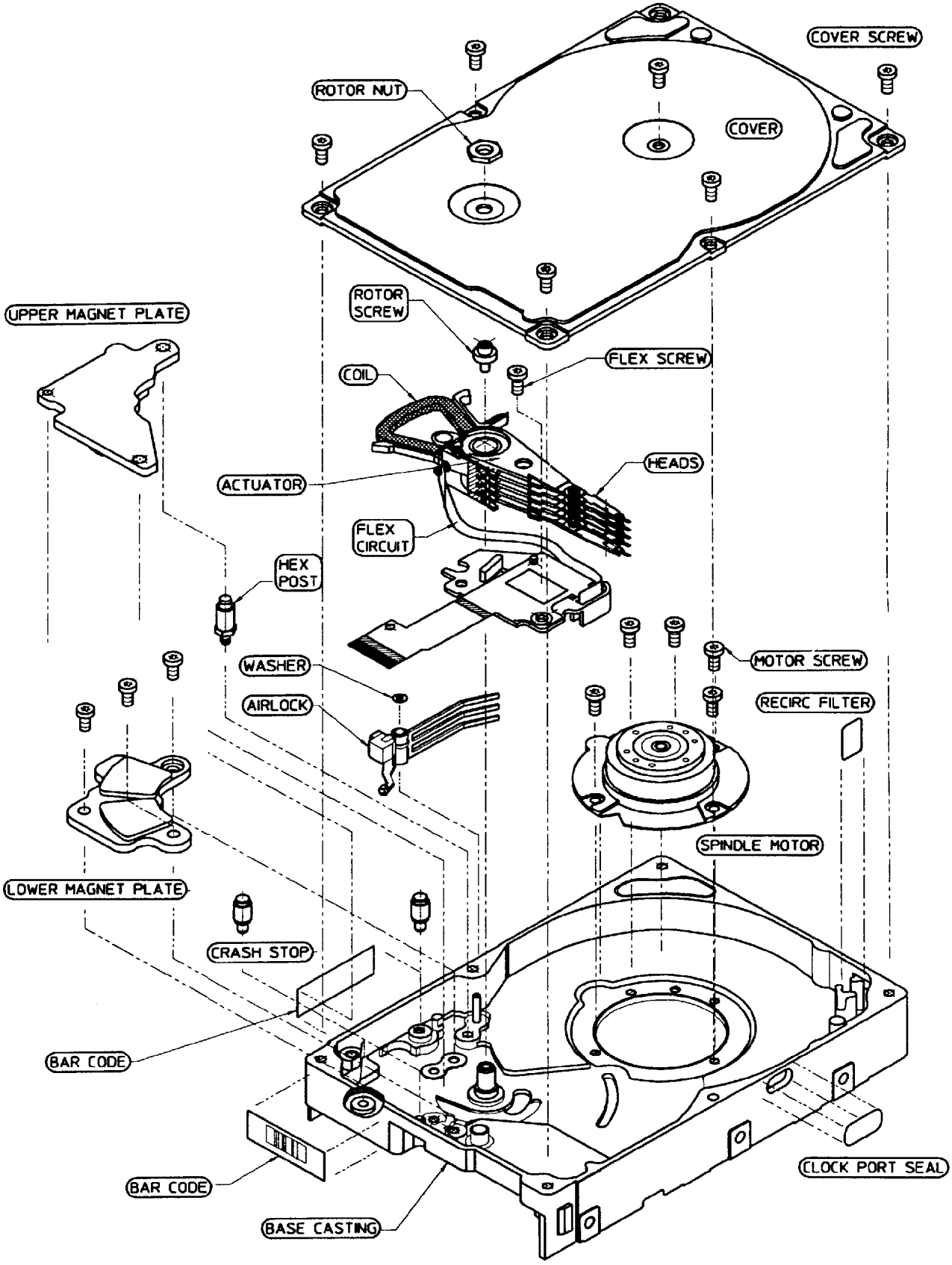

Figure 3: Quantum 1 Gigabyte Hard Drive Layout Without the Four Disks

STEP 3: INSPECTION OF THE HEAD POSITIONING MOTOR

Remove the upper magnet on the voice coil motor by carefully prying it up with a screwdriver. Warning: These magnets are strong, do not pinch your fingers!

- Notice that the swing arm is mechanically locked in place by a black plastic arm. This patented feature is known as an "air lock." What actuates this stop so that the head can swing across the disk and read data?

- The voice coil motor functions in a permanent magnetic field set up by the two magnets above and below the coil on the swing arm. Passing current through the coil in the presence of a magnetic field generates a force that moves the arm back and forth depending upon the strength and direction of the electric current.

- Determine how the voice coil motor is prevented from swinging the arm off of the edge of the disks and contrast with the 5 MB drive in Phase I.

STEP 4: REMOVAL OF SWING ARM AND FLEXIBLE CIRCUIT

First, remove the torx screw in the center of the swing arm which secures the arm through a bearing to the chassis. Next, remove the "air lock" hex post stop. This is the brass knob that keeps the "air lock" from swinging too far. Now remove the swing arm stop labeled crash stop in the assembly drawing. This is the metal pin with a black plastic cover located next the edge of the case. It can be remove by simply pulling it out. Next, remove the single torx bolt that secures the flexible circuit and detach the circuit from the green printed circuit board. Now carefully release the "air lock" by swinging it towards the disk stack and swing the arm across and off the disk.

- The swing arm stop prevents the swing arm from swinging too far and off of the disks which would effectively destroy the drive during operation.

STEP 5: REMOVAL OF THE FIXED DISKS

Remove the six torx screws that hold the disk stack and remove the stack.

- Note the size and weight of the disks are much less than for the first drive.
- Note that the "air lock" arm always returns to the same position if it is in its range of usual motion (i.e. if the stops were still present). Speculate how this is accomplished.

STEP 6: REMOVAL OF THE DISK MOTOR

Remove the five torx screws that secure the brushless DC disk motor to the chassis.

- How does electrical power get to the motor?
- Contrast this motor with the motor in the 5 MB drive in Phase 1.

STEP 7: REMOVAL THE PRINTED CIRCUIT BOARD

Unscrew the five torx screws that hold the printed circuit board to the chassis and remove the board.

- Note the amount of electronics that are part of the disk drive system. Some of the electronics control the voice coil motor using a feedback system to make sure that the heads are positioned on a track. Look on the flexible circuit and see that the two lines that carry the current to the coil bypass the chip and go directly to the printed circuit board.

STEP 8: INSPECTION OF THE AIR LOCK

Note the retaining washer that holds the "air lock" to the top of its post.

- Note that there is no spring on the airlock yet it returns to its home position. Note that on the end of this injection molded part that is closest to the arm, there is a small piece of metal implanted in the plastic. The attraction of this metal to the magnets of the voice coil motor provides the return force for the airlock.

STEP 9: REASSEMBLY

Follow the previous nine steps in reverse order to reassemble the disk drive.

Questions for Phase II: Student Names:

1) What purpose does the air lock serve and how does it function?

2) Parts managers, which drive has more parts?

3) From a Design for Manufacturability (DFM) standpoint, which drive is easier to assemble?

4) From a DFM standpoint, what are the features of the 1 GB drive that make it a good design from a DFM standpoint?

5) Note trends in the hard drive industry based on your observations of the two hard drives in this lab.

6) How could the designer lowered the cost of the drive?

7) Do you think that this drive was robotically assembled? Why?

8) Name any aspects of the design that you find ingenious and state why?

9) Based on the progression of technology, do you have any predictions as to the future design of hard drives?

10) What are the advantages of rotary head movement over linear?

Appendix: A Comparison of head flying distance to the size of common contaminants.

As you know from the disk drive case study, the head / disc spacing is key to the density of data which can be stored. Therefore, most modern disc drives have a very close spacing between the disc and the head called the "flying distance" The spacing is the result of the air bearing created by the relative motion between the disc and the head. The spacing in modern drives can range from 30 min to as small as 10 min. Figure A.1 below shows the relation of the flying distance of a modern hard drive and that of the common contaminants.

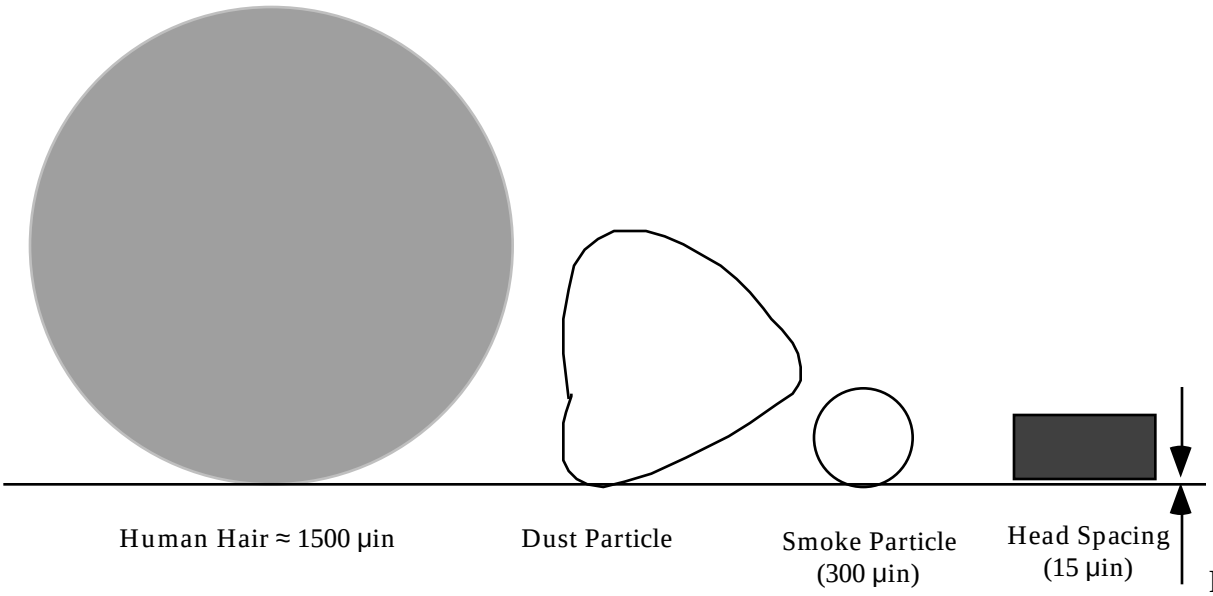

Figure A.1: Comparison of Flying Distance to Size of Contamination