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A Tutorial

on

¼ Inch Tape Drives

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Contents

Contents

Figures

Preface

This document was prepared by the Customer Support Engineering Department of Sun Microsystems, Inc. in Mountain View, California. It is intended to be an overview of the operation of tape drives. It is *not* intended to be used as a reference paper.

Audience

It is assumed that the reader has had no exposure to physics, electronics or computer theory. It is hoped that this information will enlighten non-technical users on the use and care of their equipment.

Purpose

Although this document describes the overall operation of tape drives, it is primarily concerned with ¼-inch cartridge drives. It is intended to give a light and brief description of the basic principles behind magnetic media recording and care for both the equipment and the media.

Summary of Contents

This manual has four chapters and an appendix:

Chapter 1 — *Overview* — presents an overview of the function of tape drives.

Chapter 2 — *The Basics of Tape Drives* — contains a basic description of a generic tape drive.

Chapter 3 — *Recording and Playback* — discusses the principles of reading and writing to and from a tape.

Chapter 4 — *Care and Handling of the Drive and Media* — describes preventive maintenance for both tape cartridges and tape drives.

Appendix A — *Attachment A* — contains information on tape retensioning.

Reader Comments

Finally, to help us maintain the currency and accuracy of this material we have supplied a reader comment sheet at the end of this guide. Please use the comment sheet to list errors and omissions. Your responses will help a great deal in our efforts to keep our documentation up to date.

Revision History

Revision	Date	Comments
50	15 August 1985	Preliminary release of this Engineering Manual.
A	15 July 1986	Release of this Engineering Manual.

1

Overview

1

Overview

Many computer systems used in office and business environments have a need to transfer data from one system to another; they also need to be "backed-up" so that in the event of a component failure important data is not lost. Back-ups can take place on a daily or weekly basis, depending on the needs of the user and reliability of their computer system. In today's business environment, one of the most popular back-up methods is to transfer the data onto tape and then save the tape until the next time the system is backed-up.

Because transfer onto tape is so popular, many people who have very little technical knowledge of computer hardware back-up their own systems. This document is intended to help those people understand, handle, and care for their tape drive and the media (tapes).

2

The Basics of Tape Drives

2

The Basics of Tape Drives

As discussed in the introduction, the marketplace offers a variety of tape drives to fill the different needs of industry today. All of these have common principles, described below.

2.1. Tape Construction

Tape is made up of two parts. The first is called the *base film*, which is then coated with the second part called the *coating*.

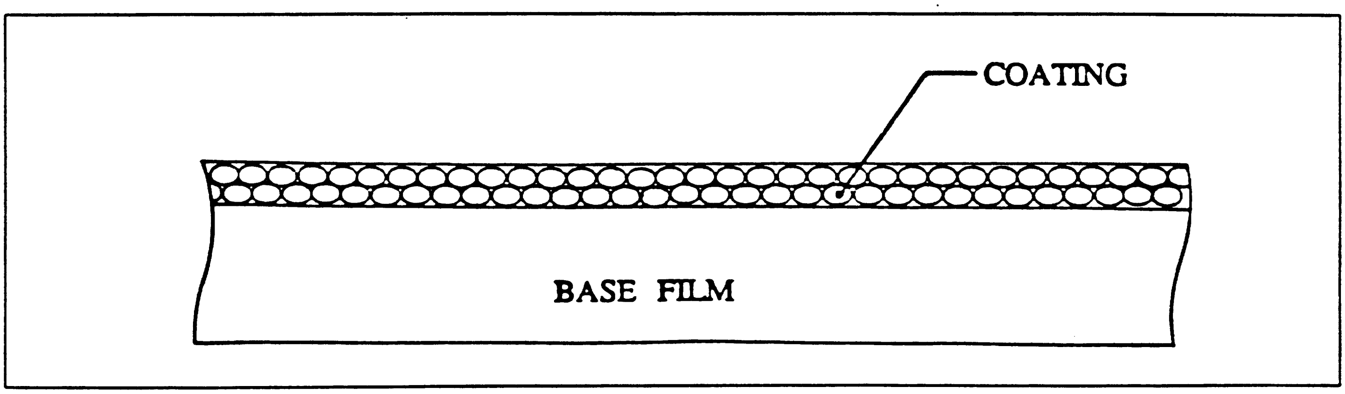
Several qualities are required of a base film. It must be flexible, able to withstand a certain amount of tension without stretching or breaking, able to operate within a variety of temperature environments, and inexpensive to produce.

In the early days of tape recording, cellulose acetate was used as the base film. This was soon replaced by polyvinyl chloride (PVC). Although they provided a better coating surface, both were replaced by polyester which has a wider temperature tolerance and more tensile strength for fast starts and stops. One of the most popular materials used presently is Mylar.

All coatings contain metal particles. As the tape passes under the recording head, these particles are magnetized into patterns. These patterns are permanent—the magnetic fields remain after the tape has been recorded. The two most-frequently used coatings are Gamma Ferric Oxide and Chromium Dioxide.

The diagram below illustrates a cross-section of a tape showing both of its parts.

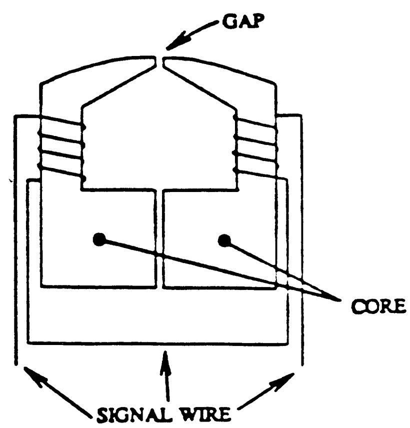
Figure 2-1 *Cross-Section of Recording Tape*



2.2. Heads

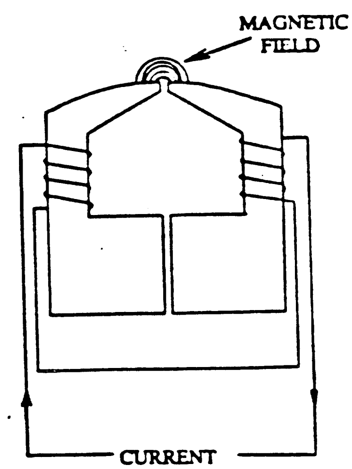
Heads are basically electromagnets. They are constructed from material that is easily saturated with current and therefore develops magnetic fields easily. Below is an illustration of a typical head.

Figure 2-2 *Typical Read/Write Head*



As a signal (in the form of current) is passed through the wire wrapped around the core, induces a similar current in the core. The result is a magnetic field created across the gap.

Figure 2-3 *Magnetic Field Forming Across the Gap of a Read/Write Head*

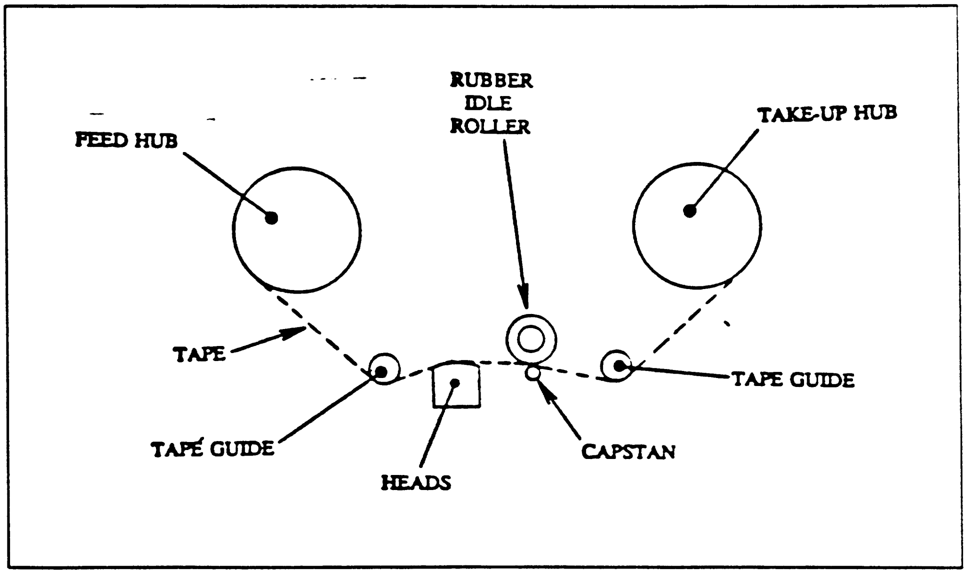


When a tape passes by the magnetized gap, the magnetic field magnetizes the metallic particles on the tape. (This will be discussed in more detail in another section.)

2.3. The Drive Transport

The purpose of the drive transport system is to move the tape across the heads in a smooth, uniform motion. Most of today's drives move in both directions. Included in the transport system is a method of detecting the beginning of tape (BOT) and the end of tape (EOT).

Figure 2-4 *Transport Mechanism of a Tape Drive*



The feed hub is generally the tape reel with the tape on it. In some drives, a slight amount of resistance is applied to this hub so that the tape remains taut.

The tape travels from the feed hub, around a tape guide, and over the heads.

The tape then passes between the rubber-coated idle roller and the capstan. The capstan's function is to pull the tape across the heads in a constant motion.

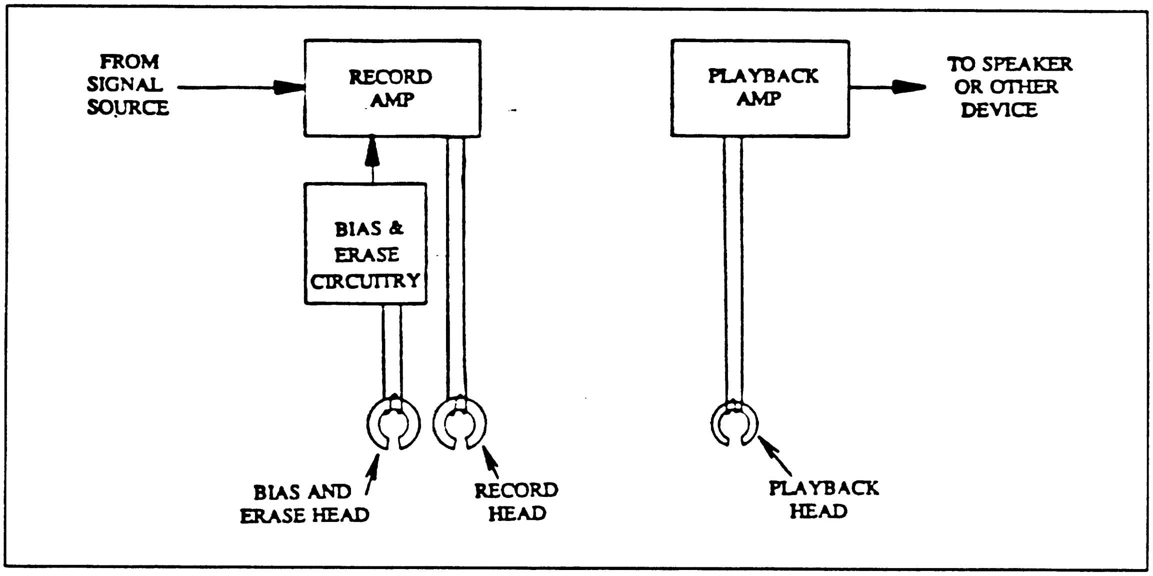
The capstan is attached to the drive motor. The drive motor is carefully controlled so that there are no fluctuations in speed. The idle roller is spring-loaded, forcing the tape against the capstan.

The tape then passes over another tape guide and is stored on the take-up hub. A slight amount of forward force is applied to the take-up hub so that the tape remains taut on this side of the capstan.

2.4. Other Similarities

The block diagram below shows other functions of a tape drive. While there are many ways to perform these functions, in this discussion we are concerned with function, not approach to performance.

Figure 2-5 *Functional Diagram of a Tape Drive*



In the block diagram above, the signal to be recorded comes in from the *source*. It is amplified (made larger), turned into a signal that the record head can understand, sent to the record head and recorded onto the tape.

When the drive is in record mode, a signal is put onto the tape. This signal is called *bias*. It helps reduce tape noise and electrically adjust the tape for the best recording.

When a tape is to be played back, the signals are extracted from the tape by the *playback head* and sent to the *playback amplifier*. The amplifier increases the signal and sends it to the output device (speaker or controller).

The erase head is used whenever the drive is in the record mode. It ensures that any signal that was present on the tape is erased prior to recording new information.

3

Recording and Playback

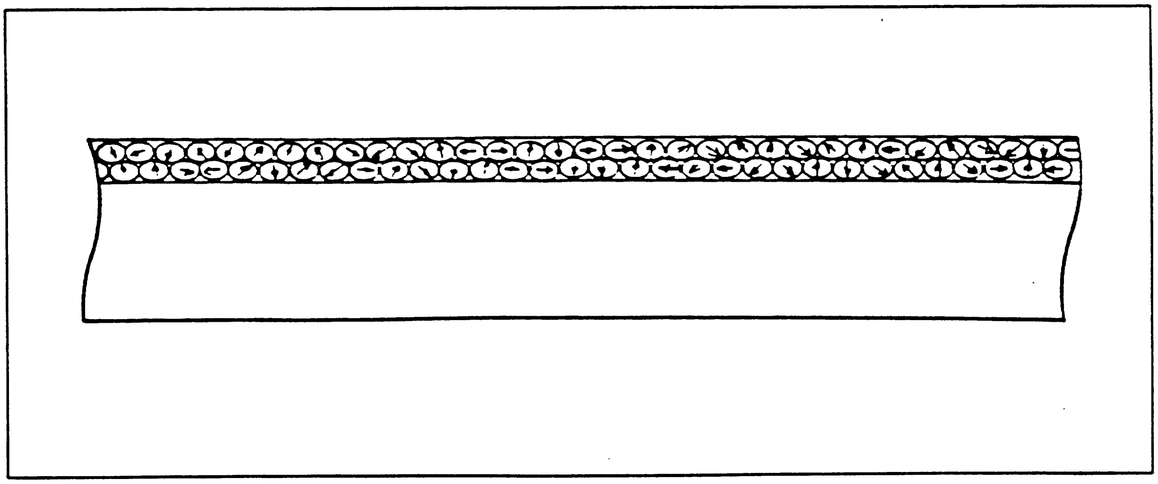
3

Recording and Playback

Since this discussion deals with drives that connect to computers, only the method of recording *ONES* and *ZEROS* will be discussed.

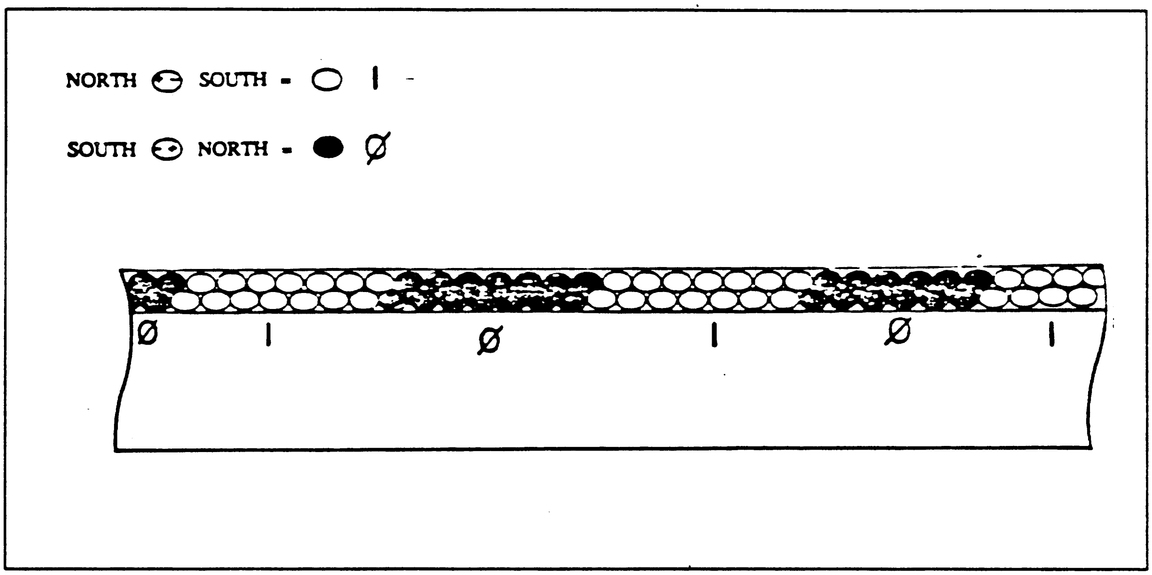
When a tape is new or has been erased, the metal particles are in complete disarray and exhibit no polarization (as shown below).

Figure 3-1 *View of Unmagnetized Media*



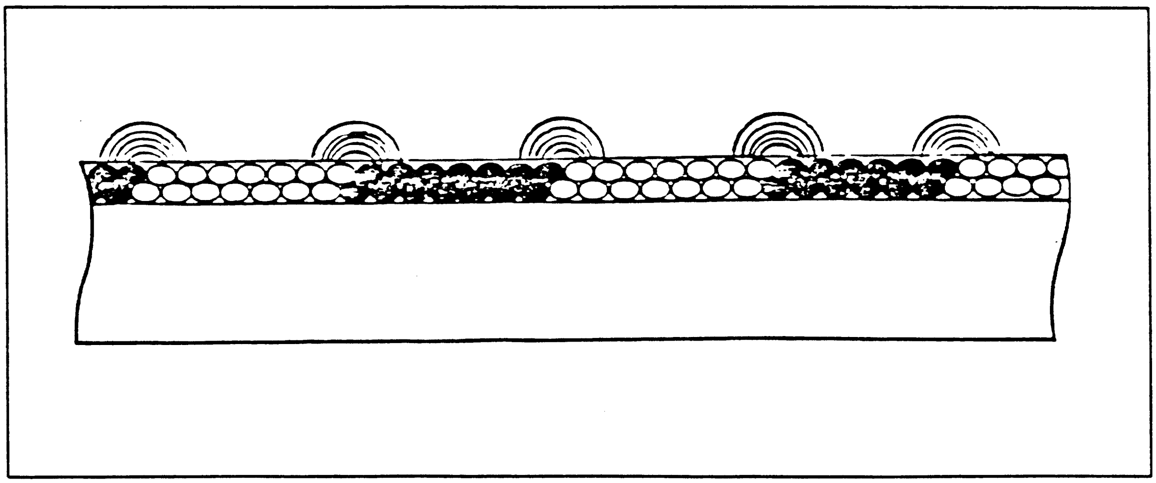
Now we decide to record ones and zeros alternately. The particles would look like the diagram below.

Figure 3-2 *View of Magnetized Media*



A magnetic field exists at each transition from a zero to a one (or vice-versa).

Figure 3-3 *Magnetic Fields at Transition Points*



As the tape moves across the playback head, the head will "read" the magnetic field at each transition point.

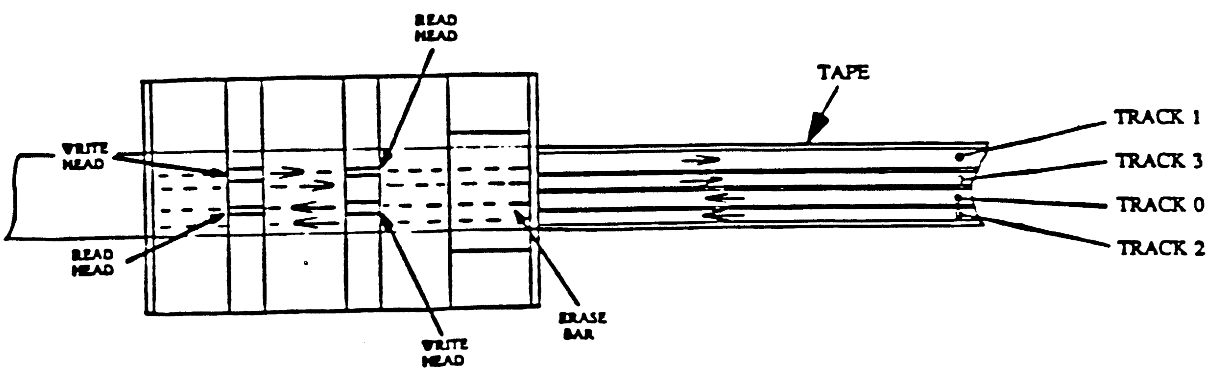
If two *ZEROS* or *ONES* appear next to each other, no transition will be recorded or seen during playback by the heads. The drive expects to see changes within a limited amount of time; if a change (that is, a magnetic field) does not appear within the allotted time, the drive assumes that the present piece of information is the repeat of the previous one.

3.1. Tracks

Now let's take a look at the tape from another viewpoint. The surface of the tape is a continuous coating of some type of metalized material. Drive heads come in numerous configurations. For purpose of illustration, let's assume the heads look like the example below. Let's also assume that the tape is 1/4-inch wide (a standard tape width). The tape shown below has four tracks (labeled 0 through 3). The arrows indicate the direction that the tape moves when reading or writing on each track. In this example, the heads would have to move down in order to access tracks 2 and 3.

Note that tracks are not physical entities. They exist only after the tape has been recorded on.

Figure 3-4 *Read/Write Heads in a 4-Track Drive*



3.2. Operational Modes

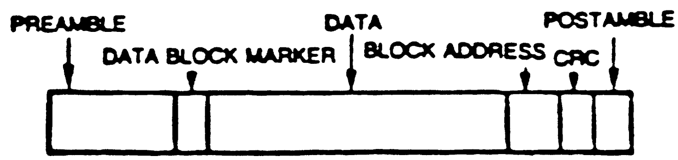
There are basically two operational modes used in digital drives.

- The first is *START/STOP MODE.* As the drive advances the tape across the heads, the information is read into a buffer (located in the computer). When the buffer is filled, the computer issues a command to the drive to stop. Since hardware mechanisms are much slower in their reaction times than electronic components, it takes a relatively long time for the drive to stop. By this time the tape has moved too far. Therefore when the computer is ready to accept more information from the tape, it issues the command to back up to the place where it was when it stopped taking data. Then the drive starts up again and fills the buffer. This process repeats until all of the desired information has been read (or recorded).
- The other operating mode is called *STREAMING MODE.* In this case, the computer has very large buffers and can empty them as fast as the data comes in from the drive. The buffer never fills up so it is not necessary to start or stop the drive.

3.3. Formatting The Tape

The illustration below shows how a standard cartridge-loading tape drive formats the tape.

Figure 3-5 *Tape Format*



- The Preamble is 12 bytes long. It is used to synchronize the tape drive electronics to the the recorded information on the tape. Slight variations occur between tapes and also between drives. An electronic circuit called the *phase locked loop* is used in this synchronization.
- The Data Block Marker tells the electronics that the information coming up next is actual information (data). This is one byte in length.
- The Data Block is the actual data and can be as long as 512 bytes.
- Next comes the Block Address, which can be up to four bytes long. This is used for error detection and tape positioning.
- Following this is the CRC—Cyclical Redundancy Check. This is a method for checking the accuracy of the data. The information in the 2-block CRC field is arrived at by using the bits in the Data Block and the Block Address and the performing an algebraic operation on these to provide a unique ''check'' number. As the information from the Data Block and the Block Address are read into the computer, the central processing unit repeats this same CRC operation and then compares its answer with the number held in the CRC field. If the two do not match, an error has occurred and the computer signals the operator that this error has occurred.
- The last field is the Postamble. Its purpose it to signal the end of the block.

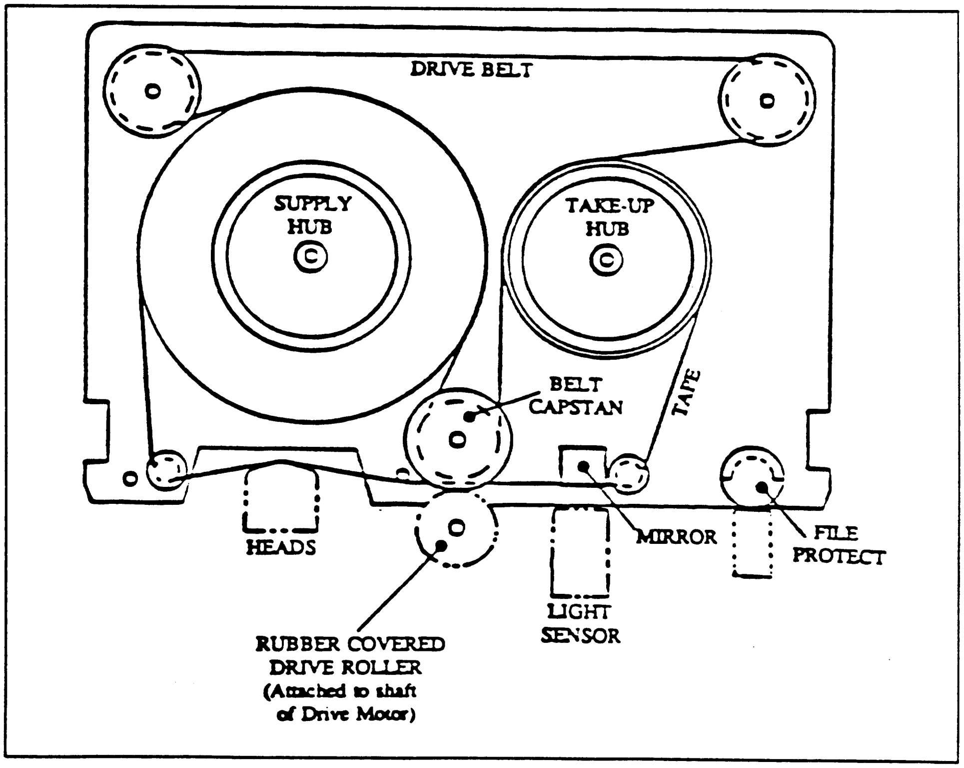
This completes one block of data. The system is ready to repeat this operation for additional blocks until all of the information has been stored (or read).

3.4. Tape Cartridges

As the tape industry has evolved, coatings and recording techniques have also improved considerably. One of the improvements has been the advent of the *cartridge*. It is much more convenient to use than reels. With reels, it is necessary to provide vacuum systems or other types of "tape tensioning" provisions so that the tape does not break when used in the start/stop mode. Cartridges are self-contained and because of their size and mass, do not experience the severe tape stresses that are present in reel-to-reel drives.

An example of a cartridge is shown below. Note that it is very similar to the Tape Drive Transport mentioned earlier.

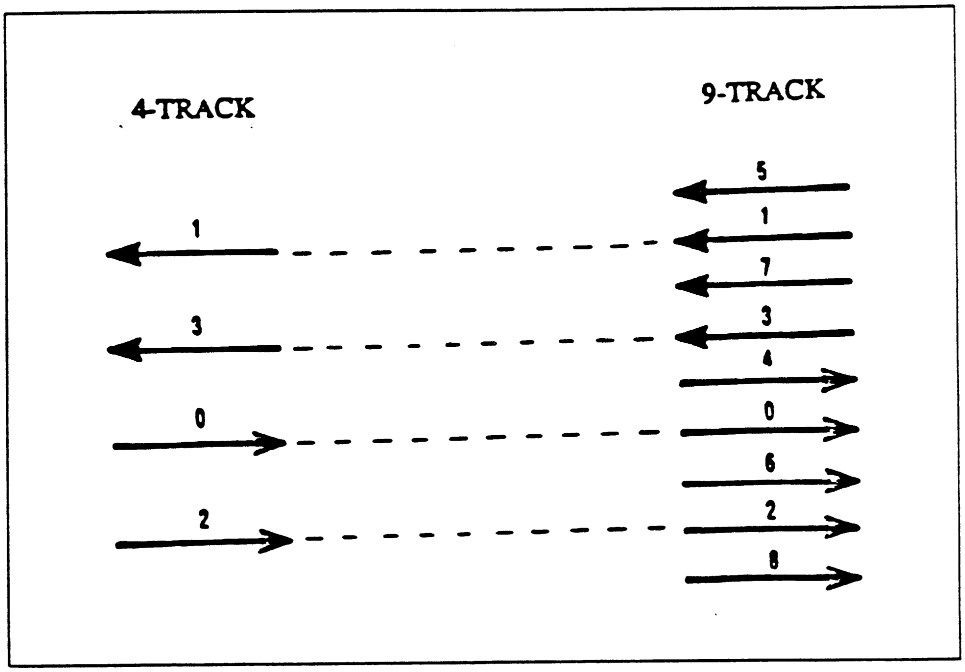
Figure 3-6 *Example of a Tape Cartridge*



3.5. Cartridge Compatibility and Interchangeability

There are a variety of cartridge tape drives in the marketplace. Sun Microsystems presently uses two basic types; the 4-track and the 9-track. The drawing below shows the track formatting for both.

Figure 3-7 *4-Track and 9-Track Tape Format*



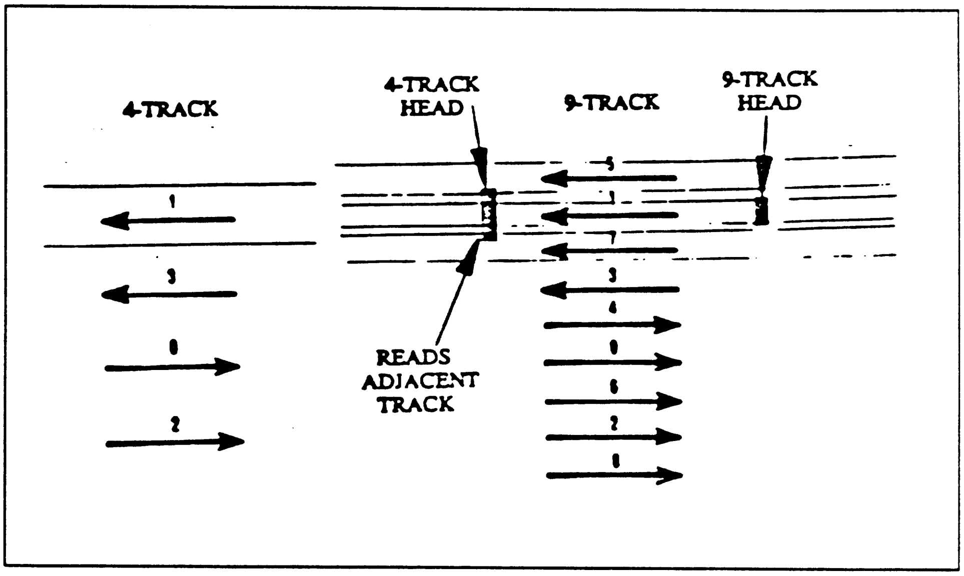
The dashes in the drawing show that for both formats, tracks 0, 1, 2 and 3 align with each other. This would lead to the presumption that a tape which has been formatted on one type of drive is readable on the other type of drive (tracks 0 through 3, only).

This presumption is partially in error.

The track width on the tape formatted on the 9-track drive is approximately half as wide as the tracks formatted on the 4-track. This is a result of the difference in head-gap length. Tapes written on the 4-track drives can be read reliably by the 9-track drive—if difficulties are experienced, the tape should be retensioned (see "Retensioning" in the next section and Attachment A).

Trying to read a 9-track tape with a 4-track drive *may* not bring the same reliable results. This is because the head-gap length on the 4-track is twice that of the 9-track. When a 4-track drive tries to read the 9-track tape, the head also picks up the edge of adjacent tracks. The drive reads the edge of the adjacent track, and if the signal is strong enough, it causes an error; a zero will be read as a one, or vice versa.

Figure 3-8 *Reading a 4-Track and a 9-Track Tape*



If it is necessary to read 9-track tape on a 4-track drive, it is recommended that the tape be retensioned two times (see "Retensioning" in the next section and Attachment A). Also, the heads on the drive should be cleaned (see "Caring For The Drive" in section four).

3.6. Tape Retensioning

As mentioned before, in order to read a tape reliably it is necessary to feed it over the heads at a steady rate. The cartridge tape drive does not use the capstan for this purpose. Instead, the capstan drives a belt which in turn drives the feed and take-up hubs. This means that tapes can have varying tension from end-to end. This varying tension can result in varying feed-speed over the heads. This results in errors.

In order to avoid this type of an error, the tape must be *retensioned*. Retensioning feeds the tape from "Start of Tape" to the "End of Tape" and then rewinds it to the beginning. This is done in one steady motion to even the tape tension out across the entire length of tape.

Tapes should be retensioned in the following situations:

- When the tape has been used to read 5 or more short records in "start/stop" mode.
- When the tape is new.
- When the tape has been stored for a prolonged time.
- Whenever read/write errors occur.
- Whenever a tape has been subjected to a physical shock (for instance, dropped).

4

Care and Handling of the Drive and Media

4

Care and Handling of the Drive and Media

Tape drives are easy to maintain, and there is not much to be done when performing preventive maintenance. The media is also easily maintained as long as common sense is used in its handling and storage.

4.1. Caring For Media

Following is a list of tips for caring for tape media.

- Always store tapes in their protective covers when not in use.
- Alway rewind tapes to the beginning before storing them in the protective covers.
- Never use or store tapes in environments that are outside of the manufacturer's recommended temperature range (see the manufacturer's specification sheet for storage parameters).
- Never touch (except the leader) the media with hands. Body oil will degrade the tape.
- Keep tapes away from magnetic fields (for instance, monitors, television sets, radar, etc.).
- Always retension the tape if it exhibits excessive read/write errors or if:
  - It was previously used in the start/stop mode.
  - It was stored for a prolonged time.
  - It was stored at extreme temperature.
  - It was dropped or jarred.

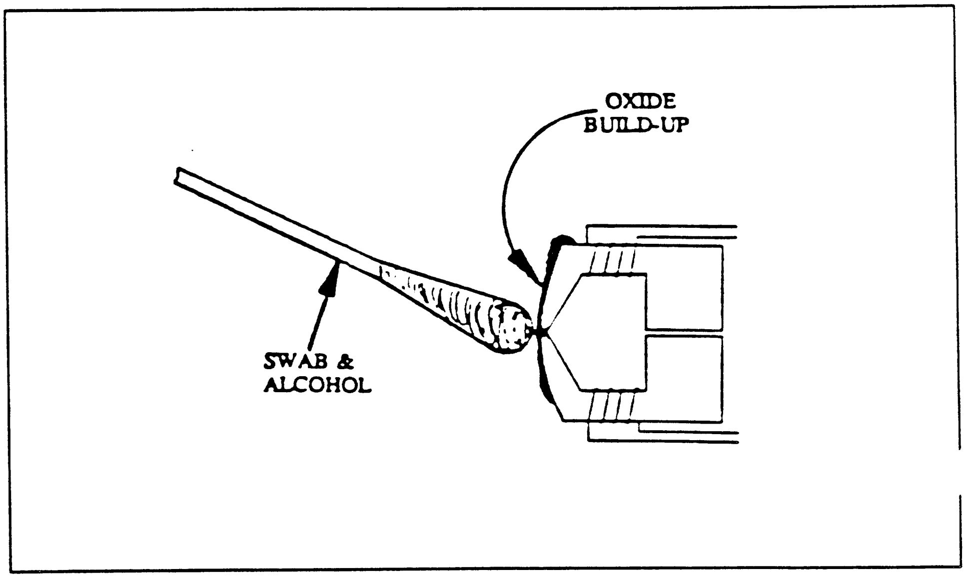
4.2. Caring for the Drive

The only preventive maintenance required is that of head cleaning. This should be done every 8 hours of tape motion time (or every 2 hours if ONLY new tapes are used).

The procedure is simple.

- Using a cotton swab and Isopropyl alcohol, clean the heads.
- After cleaning, wipe residue away with clean cotton swab.

Figure 4-1 *Cleaning the Tape Head*



A

Attachment A

A

Attachment A

Following is a tape retensioning procedure.

READER COMMENT SHEET

Dear Customer,
We who work at Sun Microsystems wish to provide the best possible documentation for our products. To this end, we solicit your comments on this manual. We would appreciate your telling us about errors in the content of the manual, and about any material which you feel should be there but isn't.

Typographical Errors:

Please list typographical errors by page number and actual text of the error.

Technical Errors:

Please list errors of fact by page number and actual text of the error.

Content:

Please list errors of fact by page number and actual text of the error.

Content:

Did this guide meet your needs? If not, please indicate what you think should be added or deleted in order to do so. Please comment on any material which you feel should be present but is not. Is there material which is in other manuals, but would be more convenient if it were in this manual?

Layout and Style:

Did you find the organization of this guide useful? If not, how would you rearrange things? Do you find the style of this manual pleasing or irritating? What would you like to see different?

Rev Q PROM – Tape Retensioning Feature

The Rev Q PROMs support **Tape Retensioning**. This feature allows the user to retension a quarter-inch tape before using it to boot up a Sun Workstation.

When to use retensioning

You should use the retensioning feature if booting from 1/4" tape with the usual retensioning command results in some kind of tape read error. If this happens, retry the boot command using the retensioning feature. You may have this problem with a Model 160 Workstations equipped with a Wangtek tape drive, since the boot tapes are written on "old style" Archive drives but are often read with machines containing "new style" Wangtek drives.

Retensioning a tape takes about three minutes – that's why it doesn't happen by default.

Retensioning will also work on the 2.0 Release version of the standalone copy program. It can also be done from Unix with the ***mt retension*** command.

How to use retensioning

To use the PROM monitor to load in a given tape file number, you normally type the following:

> **b***tape***(0,0,***tape_file_number***)**

tape is the variable that is replaced with the tape controller type, e.g. *tape*=st for SCSI tape controllers, *tape*=ar for archive drives, etc.

Note that parameters with a value of zero can be omitted since the default is zero, e.g. **bst()** is equivalent to **bst(,,0)** which is equivalent to **bst(0,0,0)**. Also note that the file number is in HEX, not decimal, so the file after file 9 is file A.

Usually the tape file number is 0, which corresponds to the general boot program stored in file 0 on the tape. If you want to retension the tape before loading in the tape file, simply add 100 to the tape file number. The tape will then retension the tape, subtract out the 100, and load in the resulting tape file.

For example, if you wanted to use the PROM boot code to retension the tape and then load in tape file 0, you would enter the following to the PROM monitor:

> **b***tape***(0,0,100)**

The PROM monitor would then retension the tape, then load tape file 0 into the Workstation.

Caveats

Please Note: The retensioning function is only supported on Rev Q PROMs or higher. If you try to retension a tape using an older revision PROM, the PROM will try to load in that file number literally, and run off the end of the tape, causing an error.

- There is no way to only retension the tape. Retensioning always occurs in combination with loading in a particular tape file.
- Trying to retension a 1/2" tape is pointless and will not work.
- If the retensioning command is attempted on a SCSI tape controller which does not support retensioning, the tape will just be rewound and the correct file read, but without any retensioning command, and without any kind of message warning that the tape was not retensioned.