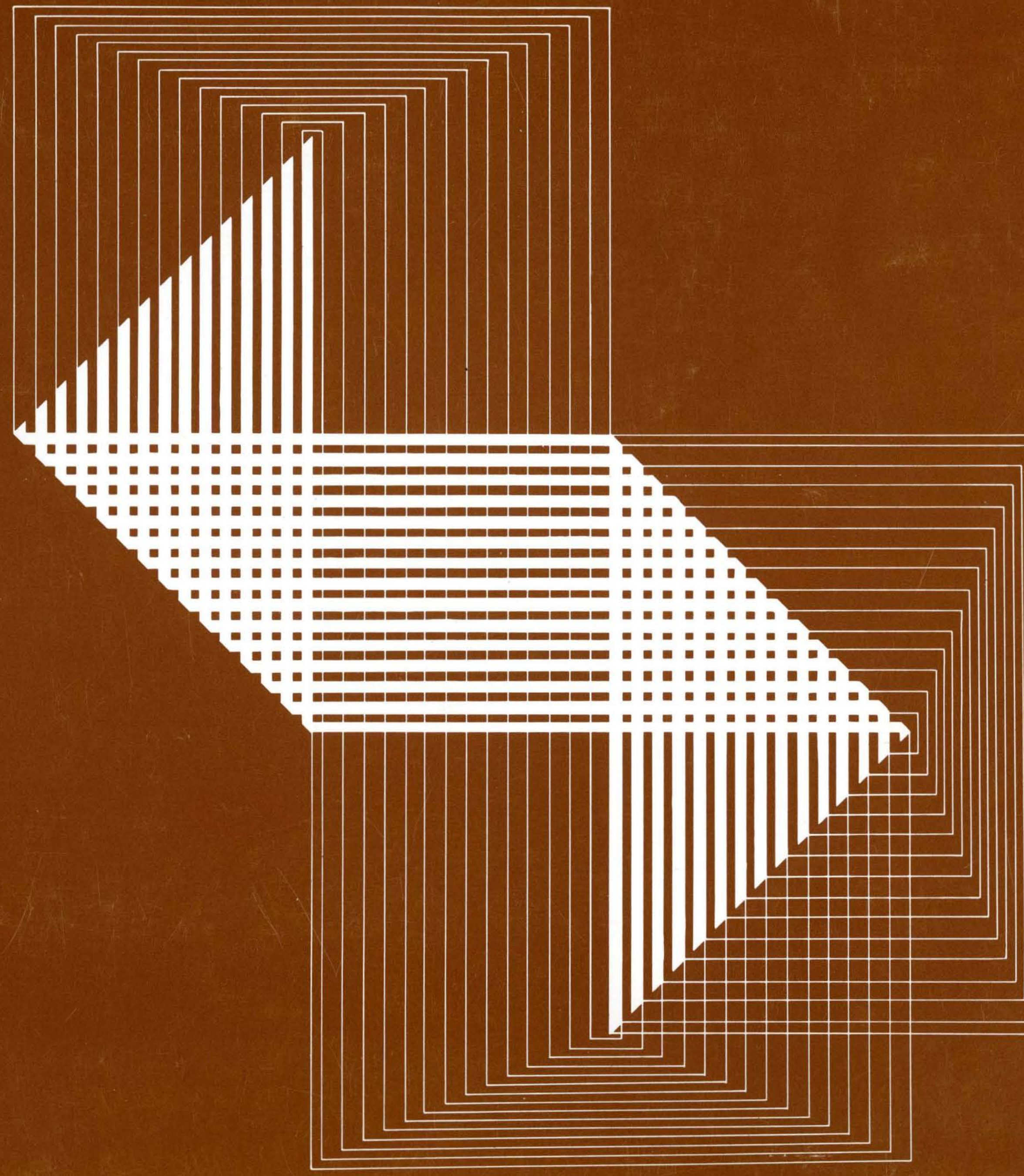
MEMOREX

# Handbook for Precision Magnetic Computer Tape



# Handbook for Precision Magnetic Computer Tape

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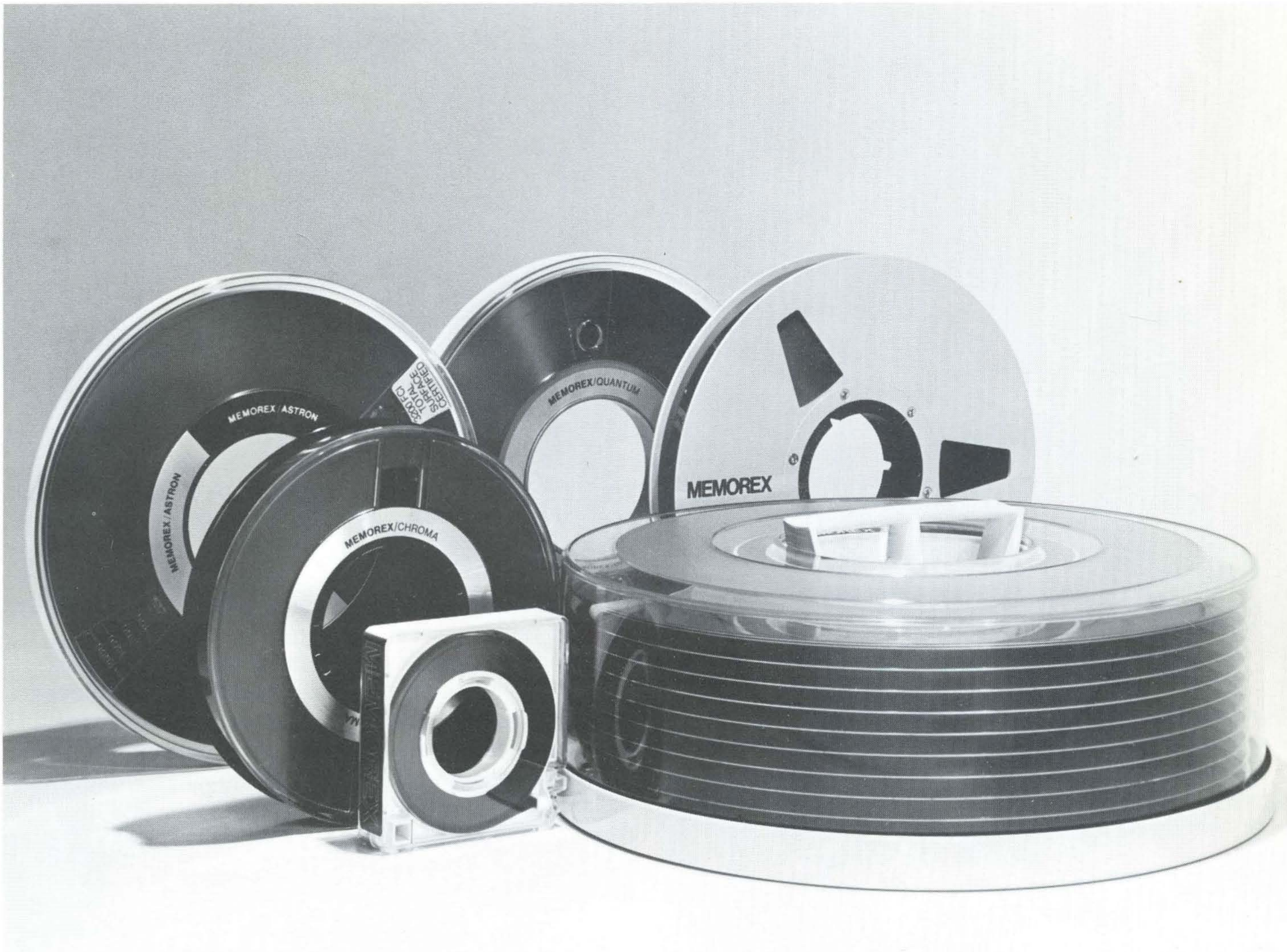



**The product line**

Memorex is a world leader in the development and manufacture of media and equipment products for information handling systems.

The development of Memorex business reflects continued expansion in areas of information and data acquisition. Media products include computer tapes, disc packs, magnetic tape cartridges, magnetic cards, tapes for broadcast and helical scan television and audio-range tapes.

Memorex is also the world's largest independent computer peripheral equipment manufacturer with product lines which include disc drives, communication terminals and microfilm printer systems.

**The Memorex home office — Santa Clara, California**

Memorex precision products are manufactured at facilities in Santa Clara, Sunnyvale and Los Angeles, California; Minneapolis, Minnesota and Liege, Belgium. More than 80 sales and service offices are located worldwide.

**Memorex — World leader in precision media and equipment.**

Memorex customers are located throughout the world— in industry and government, in finance and mercantile, space and defense work, science and education, and television entertainment. Memorex customer diversity reflects deep involvement in the widening uses of complex memory devices at almost every level of human activity.

# Magnetic Tape as Storage Media

In any discussion of magnetic recording tape for use as storage media, a fair question to ask at the onset would be: "Why magnetic recording?" That is, why not electrostatic recording, or dielectric recording, or punched-paper tape, or any of a multitude of other recording techniques which have been used in the past or are presently being employed as alternatives to magnetic recording. It is the purpose of this discussion to acquaint you with the good points of magnetic recording—as well as the bad—so you can gain a better appreciation of why this type of storage medium is the most widely used in the computer industry.

### What Is required of Storage Media?

To begin with—let's ask the question: "What is required of storage media?"

### Perpetual Stability

By this we mean information recorded today must remain unchanged with the passage of time. The stability of magnetic media is legend—rocks magnetized two billion years ago still retain their magnetization.

### 100% Erasable

As new information becomes available, we need to be able to quickly and rapidly update previously recorded data. Here again magnetic recording outperforms every other storage media—literally billions of erasures can be accomplished without the slightest change in media performance.

### Highest Resolution

We must be able to store a large number of information bits per unit area. The consequence of high resolution is usually—but not necessarily—low cost/bit, fast access to desired information, and overall compactness of the storage system. Magnetic tape, composed as it is of individual magnetic particles as small as the wavelength of green light, has inherently high resolution capabilities. Wavelengths of $25\mu''$ have been recorded and reproduced on commercial magnetic tape (the wavelength of green light is about $20\mu''$).

### Exceptional S/N (Signal to Noise) Ratio

Storage media must add a negligible amount of noise to the signal, and the detected signal level must be of sufficiently large amplitude so noise in the detection circuitry is also negligible. Here once more the magnetic material working in conjunction with magnetic reproduce heads—provides a signal that is low in noise to the electronic logic circuitry associated with digital computers.

### Unequalled Record/Reproduce Speed

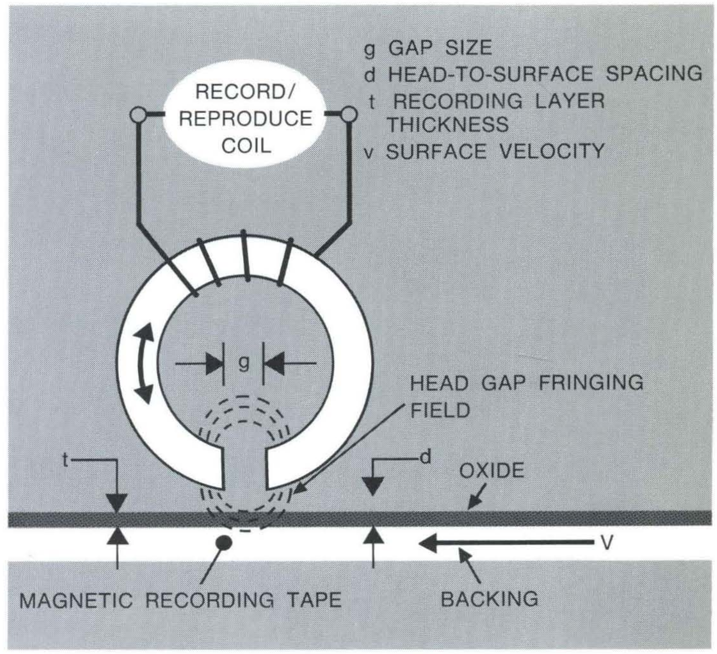
In digital computers speed is money, and magnetic tape has an ultimate speed limitation somewhere in the vicinity of a thousand megacycles per second. This is more than two orders of magnitude greater than the digestive capacity of the fastest computers now available. It is an understatement to say that magnetic media will be ready to meet the needs of tomorrow's high-speed computers.

### The Record/Reproduce Process

Now, with the general introduction about the nature and behavior of storage media behind us, let's consider the recording and reproducing process in more detail.

### The Ring Head Structure

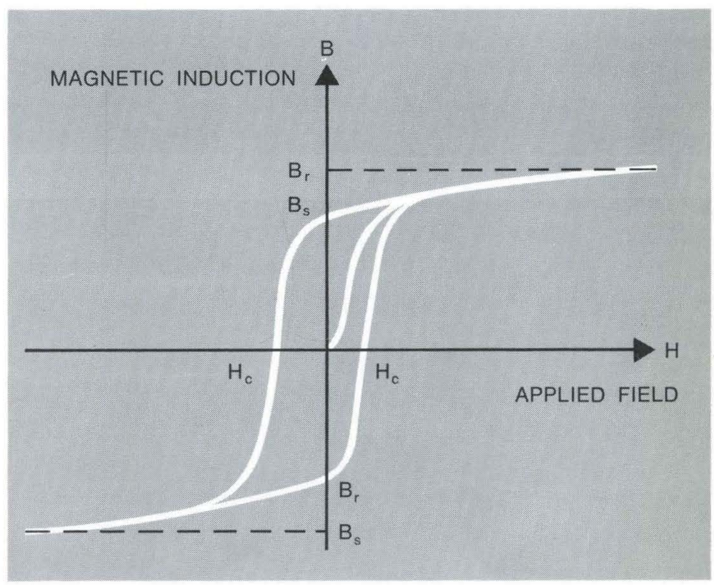
First, let's consider some of the more important parameters in a magnetic tape-head system. The illustration shows that the field created at the gap fringes and intersects the magnetic recording layer. This field must be of a given intensity (determined by the coercive force of the media) if effective recording is to occur. The spacing between the head and tape "d" can be due to either surface roughness of head and/or tape, foreign particles on the tape surface or tape physical deformities. In all instances, there is a loss in recording effectiveness due to the presence of "d". Reduction and control of "d" is an absolute necessity in quality precision magnetic tapes.




The Ring Head Structure

### The Magnetic Saturation Phenomena

The magnetic characteristics of the media are shown in the illustration. The applied field (h) is merely the fringing field from the gap, which acts on the media and thereby magnetizes it. The final magnetic state of the media after leaving the region of the gap is given by B . The greater B is, the greater the output signal upon reproduction. For this reason, an effort is made both in the choice of media properties and recording parameters to make B as large as possible. The reproduce signal is generated when the magnetized tape is moved past the reproduce head. The magnetic flux from the recorded tape passes through the magnetic head gap and generates a signal voltage in the reproduce coil. The magnitude of this signal is proportional to the magnitude of the flux. The magnitude of the flux is in turn proportional to B .




The Magnetic Saturation Phenomena

### Magnetic Recording Concept

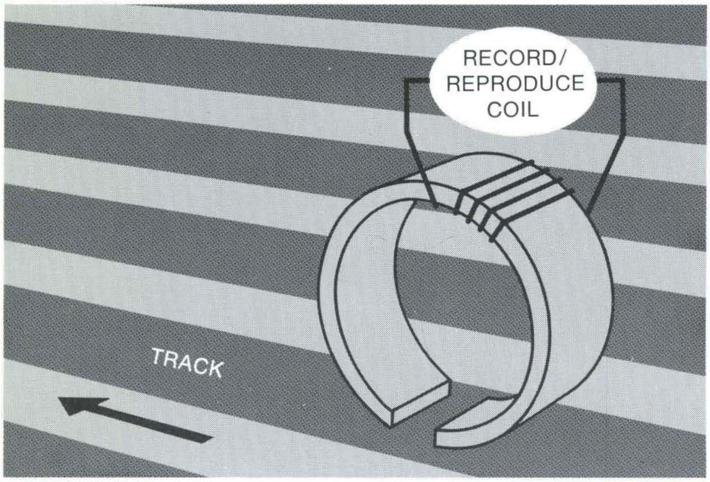
The illustration shows the physical relationship between the magnetic tape and the record/reproduce head.

### Magnetic Recording

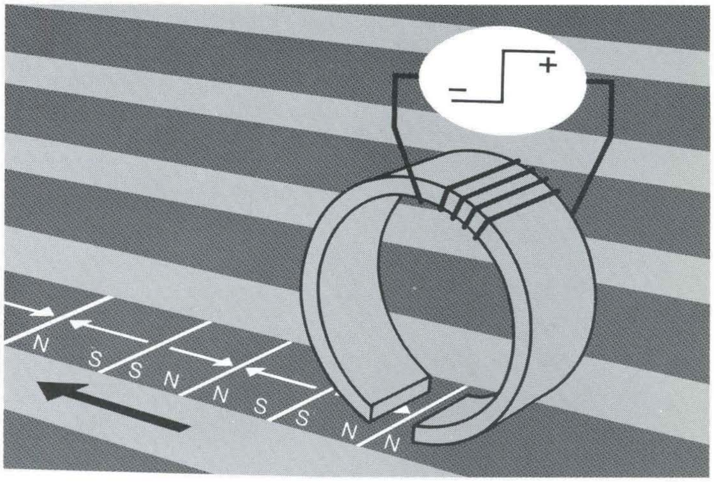
A recording is made by applying current to the record coil which in turn produces a magnetic field in the record gap. Reversing the current will reverse the field, thus changing the polarity of the magnetized region.

### Magnetic Recording — Reverse Current

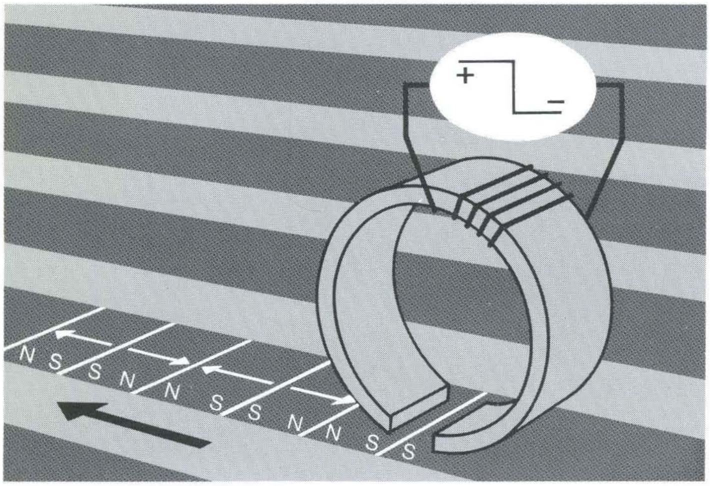
In the case of digital recording, each magnetized region is saturated in the plus or minus direction and the presence or absence of the transition region constitutes one bit of information in NRZI recording. The minimum length of a bit which can be reliably detected determines the resolution of the system. in order to pack more information per unit area of media, more than one track of information is recorded.



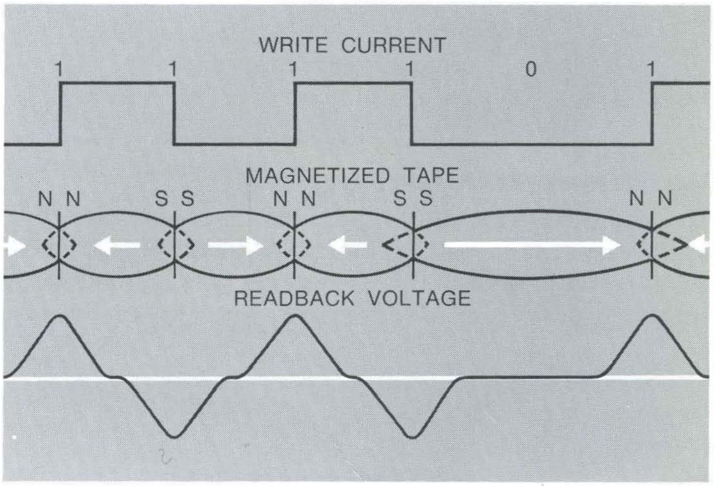

Magnetic Recording Concept




Magnetic Recording — Reverse Current




Magnetic Recording




NRZI - Record Reproduce Cycle

The track width cannot, however, be reduced indefinitely, or the reproduce signal level will decrease to a point where reliable detection of the bits is not possible. One unique characteristic of magnetic recording is that the record and reproduce heads can be identical, and, if desired, the same head can serve both functions. High performance recording equipment, however, generally requires separate record/reproduce heads with the special design of the reproduce heads determining the pickup sensitivity.

### NRZI Record/Reproduce Cycle

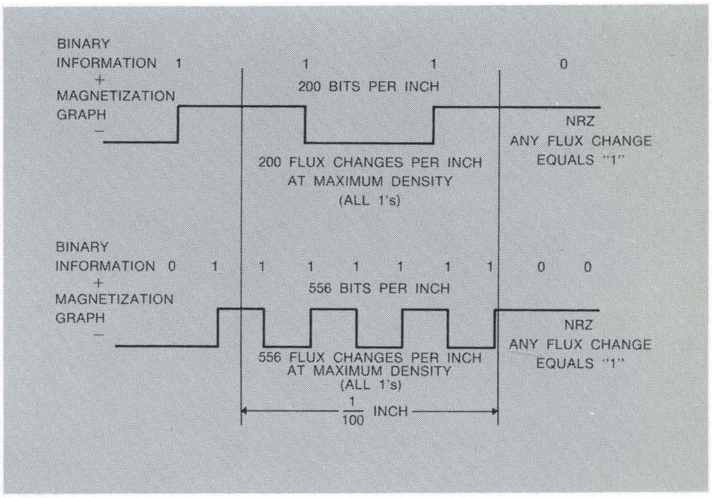
The top profile in the illustration shows the Write Current pattern during the record cycle. Note at each one bit there is a current reversal, but at the zero bit there is no reversal and therefore no change. In the Magnetized Tape profile, we see the Write Current pattern in the form of magnetized bits on the tape with flux eminating from them. Note that in the area of the zero bit where there has been no current reversal there is no flux change.

In the bottom profile we see the Readback Voltage. Note the vast difference in this profile from that of the Write Current pattern. This profile is considerably less precise and accounts, in part, for the extreme necessity of maintaining a clean, uncontaminated tape surface.

Debris, or any contaminant which spaces the tape away from the head, reduces the flux which enters the head, and thereby decreases the signal. The result: losses in both the recording and reproduce process.

Along with the introduction of the third generation computer systems has come the demand for higher packing densities on magnetic tape. At this point in time, we began to hear the terms FCI (flux changes per inch) and phase encoding. Many people became somewhat confused as to why the industry began using FCI in place of BPI and what was the difference.

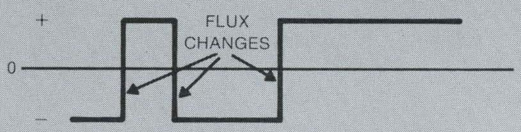
In order to understand the difference between FCI and BPI and when they are used, the following must be understood. When the NRZ method of recording is being used, any flux change is equal to a "1", so for 800 BPI there must be 800 FCI. Conversely, when the NRZ Phase Encoding method is being used, any flux change can equal a "1" or a "0", depending upon the phase of the signal. Therefore, at maximum density, using the Phase Encoding system, it requires 3200 FCI to obtain 1600 BPI.



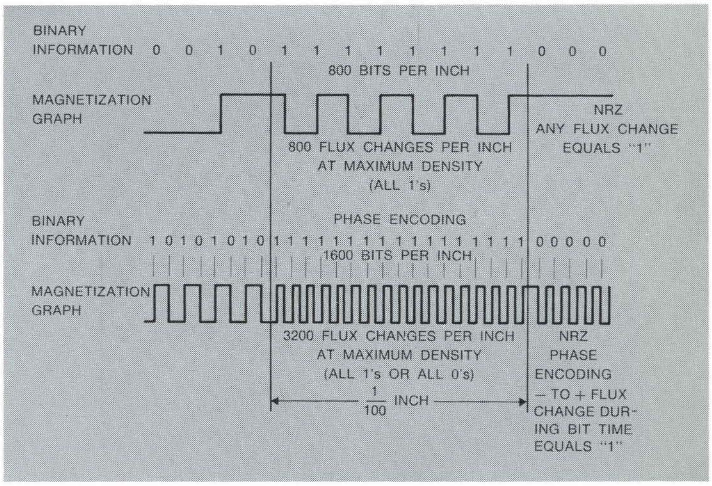

DIGITAL INFORMATION IS RECORDED ON MAGNETIC TAPE BY MAGNETICALLY SATURATING THE TAPE IN ONE DIRECTION OR THE OTHER

CHANGING THE DIRECTION OF MAGNETIZATION CAUSES A **FLUX CHANGE.** FLUX CHANGES ARE USED TO REPRESENT BINARY BITS OF INFORMATION.

THE TWO DIRECTIONS OF MAGNETIZATION CAN BE DESIGNATED + AND − AND REPRESENTED GRAPHICALLY




THIS SYSTEM IS CALLED **NRZ** FOR NON-RETURN TO ZERO BECAUSE THE MAGNETIZATION IS ALWAYS + OR −, NEVER ZERO.



# How Magnetic Tape is Manufactured

## The Manufacturing Concept

### 1. Raw Materials

Typical raw materials used by Memorex to prepare coating for its precision magnetic tapes are magnetic iron oxides, additives, resins, and solvents to dissolve the resins.

### 2. Mixing Operation

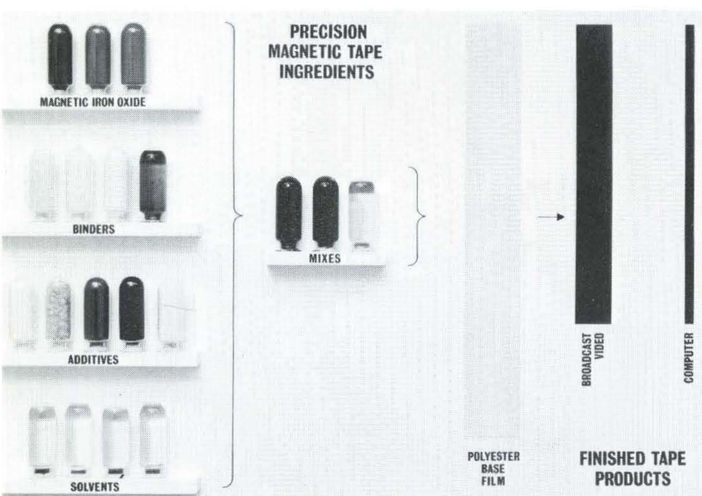
The first step in producing magnetic tape consists of mixing. This is done to obtain an extremely uniform intermixture of the various ingredients that go to make up the coating. This is normally a two-stage uniform procedure: premixing and dispersing.

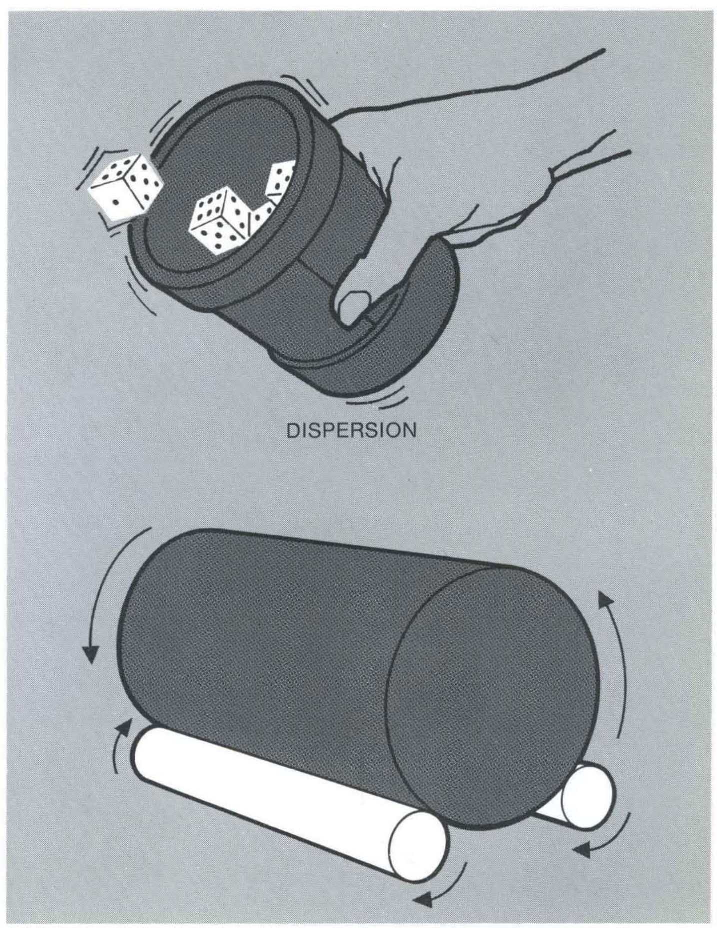
If the resin is solid or granular, it has to be dissolved in a solvent. The various additives are usually mixed at this point. Once the premix is homogeneous, the resin is set for the final step—dispersing.

### 3. The Dispersion Operation

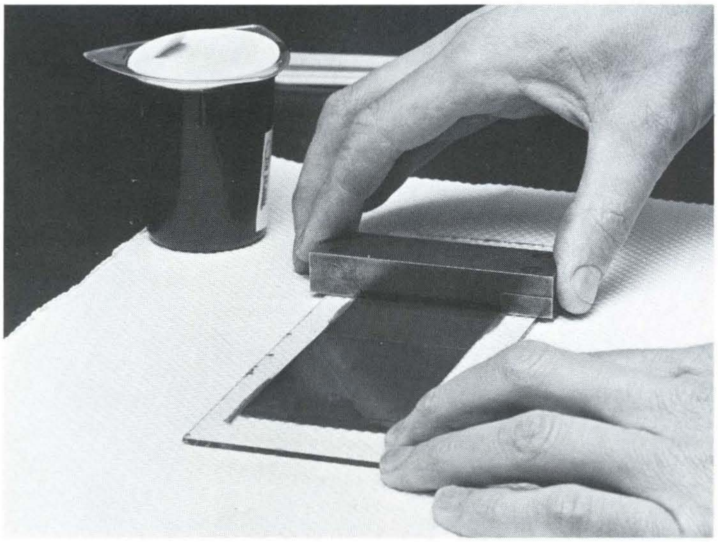
Dispersing is used to distribute the oxide particles uniformly throughout the coating resin and to provide wetting of the oxide particles by the resin. These small magnetic particles have a strong tendency to bunch up into clumps.

The presence of clumps degrades performance in several ways. Clumping can produce noise output and non-uniformity. If clumps protrude from the surface, they may also cause errors. It is difficult for the resin to wet all the particles if some remain inside the clump. A clump can become a potential weak spot in the tape coating.

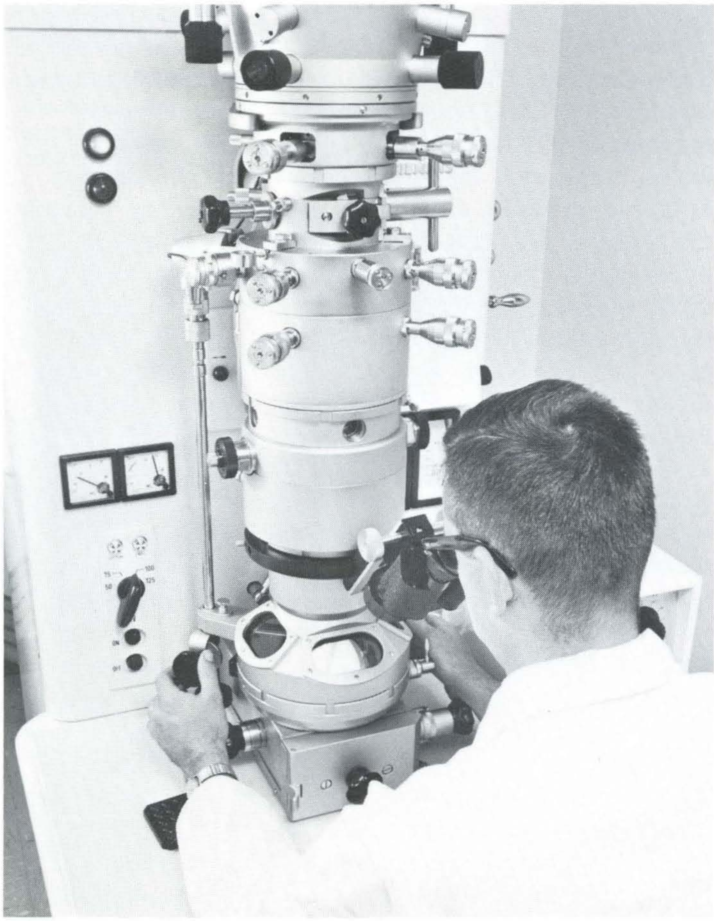



The Dispersing Techniques. The violent shaking and interaction of dice in a dice cup is a good illustration of the concept of mechanical dispersion. Very high shear forces are developed using solid dispersing media.



Dispersing Factors. Draw down test is used to maintain continuous quality control during the dispersion operation.



Precision instruments, such as the electron microscope, are essential to the maintenance of a finer QC analysis of the dispersion operation.

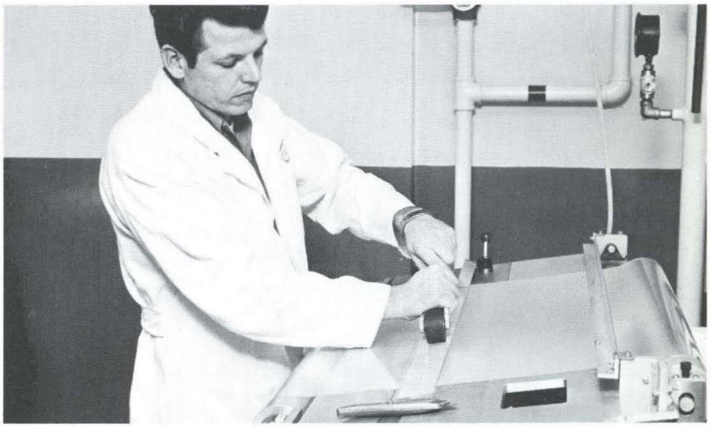
For these reasons, dispersing is one of the most important steps in the manufacture of Memorex precision magnetic tape.

**4. Dispersing Techniques**

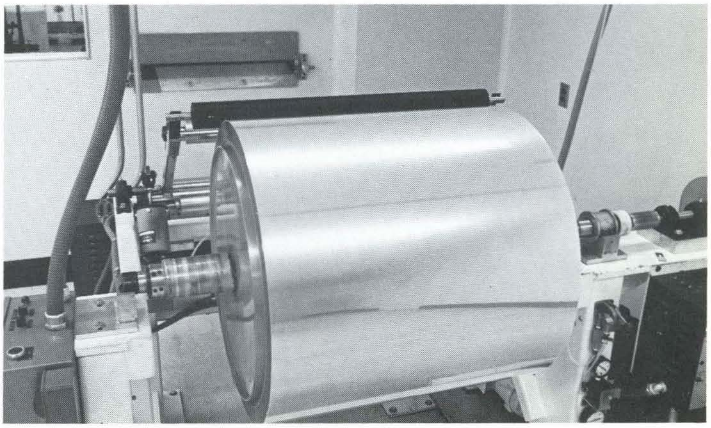
To get a good dispersion, very high shear forces must be developed to separate the particles and to force the resin-solvent mixture into intimate contact with them. This is usually accomplished by using solid dispersing media (metal or ceramic balls, cylinders, or rods, or possibly sand) and mechanically mixing the solution. During mixing, the particles come continually into proximity with the media and large shear forces are developed between adjacent particles.

**5. Dispersing Factors**

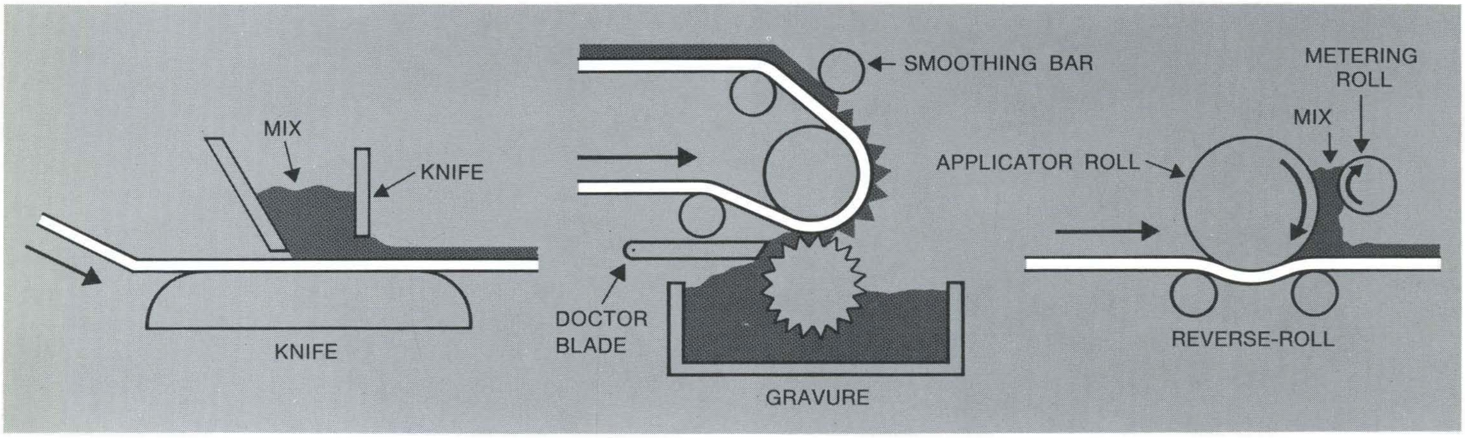
The time it takes to achieve uniform dispersion may vary from a few minutes to days. This time variance



Clear Polyester webs spliced into jumbo rolls.



Polyester jumbo rolls are ultrasonically cleaned and transferred into clean room.




Coating Techniques

often depends on the degree of agitation used, the power input, the size, shape and density of the dispersing media, the presence or absence of wetting agents, the type of resins employed, the type of oxide and the physical state of the mix itself. Certain key characteristics (usually color and viscosity) are noted in order to evaluate the quality of dispersion.

Small amounts of the coating mix are drawn off onto a glass slide at various times during the dispersion operation. Coated samples are then examined physically with a microscope for the presence of agglomerates. A wide variety of tests are employed to assure that the dispersion is adequately mixed and ready for coating.

**6. Polyester Preparations**

Memorex initially receives its raw polyester from vendors in unique widths. This gives the Company a built-in quality assurance that the material has never been submitted and rejected before. Splice free webs of polyester usually arrive in 2,600 to 12,000 foot lengths, depending upon need.

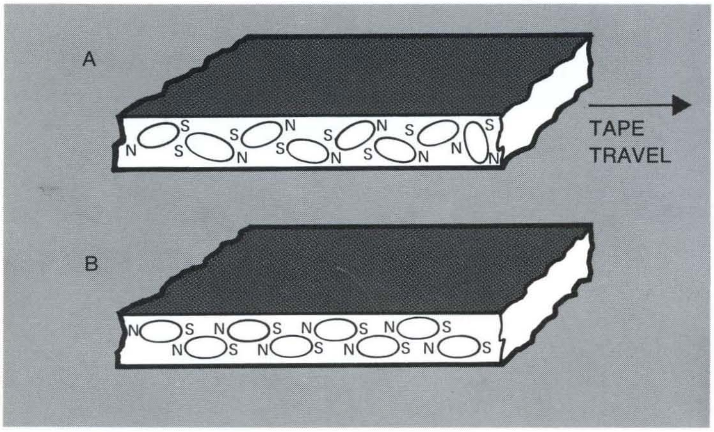
The full webs of clear polyester in varying lengths are spliced together to make up large (jumbo) rolls. These rolls are ultrasonically cleaned and transferred into Memorex's hygienically clean rooms. After the polyester rolls are spliced together, the material is never again handled outside of the "white room" until it becomes finished tape rolls sealed inside poly bags.

**7. Coating Preparation**

The function of this step is to apply a very thin, uniform coating of mix to a web of base film. The key word here is uniformity (if a typical coating of 0.4 mil is to have a uniformity of ±2.5%, the coating must be uniform within ±10 microinches). The coating must be uniform both along the web and across the web. It should not contain any ridges, bumps, bubbles, pits, etc.

**Knife Coating.** The simplest and most common form of coating is knife coating. The blade of the "knife" extends across the web and forms a dam behind which is the mix. There is a small gap between the bottom of the knife and the top of the base film. This gap produces a metering action. The coated thickness depends on the gap dimension, mix viscosity and coating speed. The knife may be fixed so the total gap through which the base film and the coating move is constant, or the gap may be maintained at a constant distance above the top surface of the base material. When the total gap is constant, gauge variations in the base film will produce variations in the gap dimension and in coating thickness. This problem can be lessened by referencing the gap to the top surface of the base film. It is impractical to compensate for gauge variations that occur over short distances.

**Gravure Coating.** The gravure type of coating is similar to that used in some types of printing presses. The surface of the gravure roll is engraved with a series of fine grooves closely spaced together. The grooves of given shape and pitch will pick up and hold the mix. All excess mix is then removed from the surface of the roll so that the only material left is that contained in the grooves. Thus, the metering action is produced by the size, shape and pitch of the grooves rather than by the spacing between two moving parts. The mix is finally transferred to the base material which is moving in the same



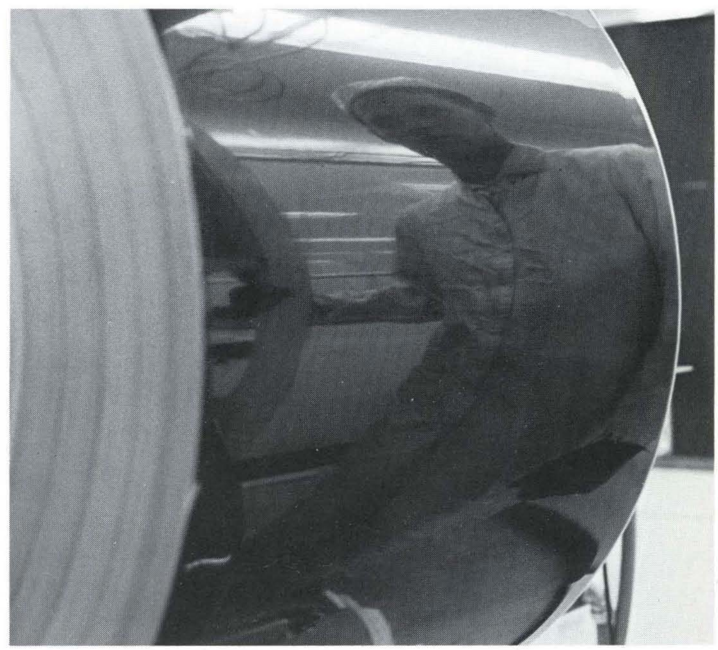

Tape—before and after orientation.

direction and at the same speed as the gravure roll. If the mix has a much greater affinity for the base material than for the gravure roll, it will transfer entirely to the base material. As applied to the base material it is, of course, in the form of small ridges usually running diagonally across the base material. These must be smoothed out if a truly uniform coating thickness is to be achieved. It is this smoothing that is really the major difficulty or shortcoming of the gravure coating method.

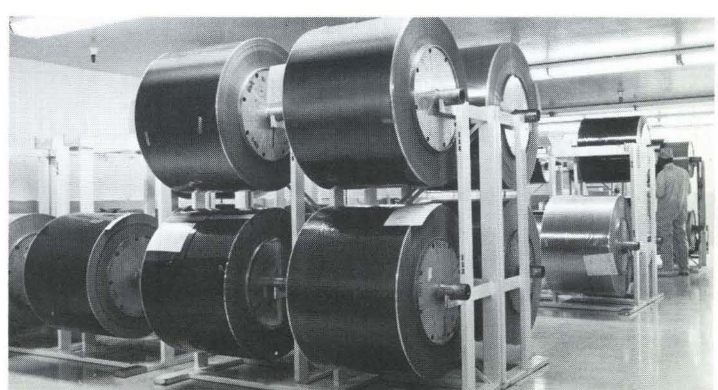
**Reverse-Roll Coating.** Variations in coating thickness, due to variations in base film, are eliminated in various types of roll coaters. Here the metering action is independent of the base film thickness. The mix is applied in a relatively thick layer to a very accurate, smooth-surfaced roll called the applicator roll. The layer of mix carried around the roll is then metered either by another roll rotating in the same direction or by a doctor blade similar to that used in knife coating. The metered mix is then transferred from the applicator roll to the base film, the surface of which is supported in one or more rolls so that the film is moving opposite to the surface of the applicator roll. The coating is thus applied in a wiping action. Although this type of coater reduces coating thickness variations in the base material, it does not eliminate all variations. The size of the metering gap may vary due to imperfections in the roll bearings or doctoring knife or due to vibration or other external motion. Here as in other types of coatings, the viscosity and other properties of the mix play a very important part.

**8. Orienting**

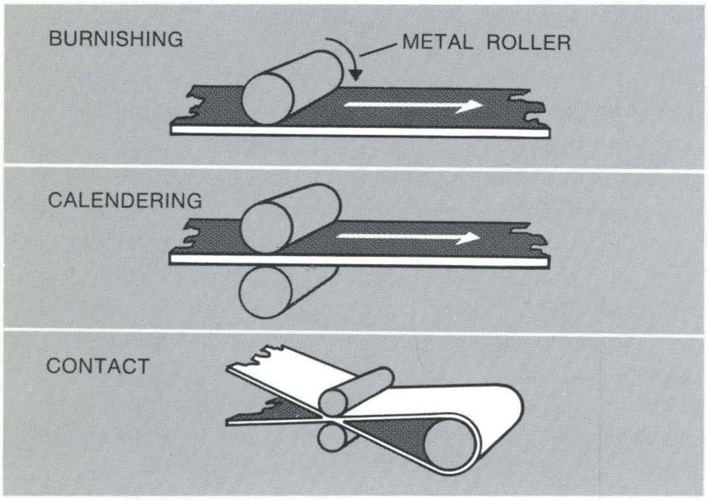
Immediately after coating—while the mix is still quite fluid—a magnetic field is applied to properly orient the oxide particles in the binder. In the case of cigar shaped oxide particles, the individual particles tend to rotate and align their long axes with the applied magnetic field. The degree of alignment achieved with magnetic tape isn't perfect. The magnetic field is usually applied in the direction of tape motion but sometimes at an angle. Both permanent magnets and electromagnets are commonly used. It is important for digital tape that the applied field be precisely longitudinal and not tilt towards the vertical direction, such as occurs if a single bar magnet or horseshoe magnet is used. An imperfect longitudinal orientation which is inclined towards the perpendicular direction can produce a rather strange effect: an enhancement of the recording when the tape is played in one



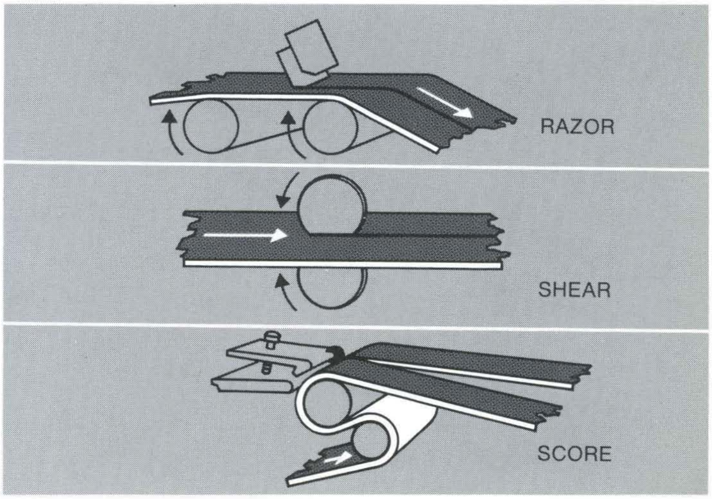
Jumbo Takeup



Jumbo Storage




Surface Treating

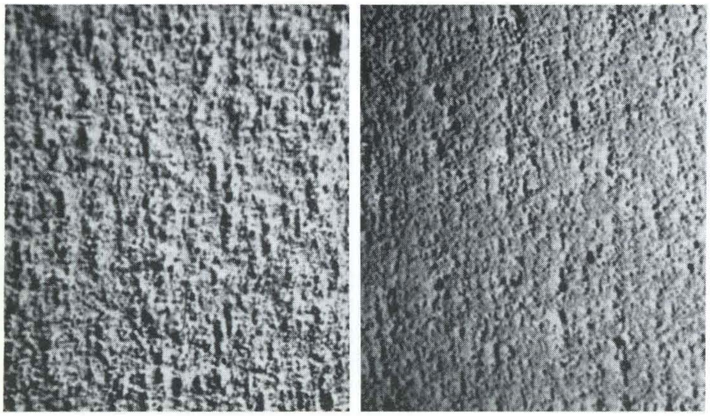



Slitting Techniques

of the recording when the tape is played in one direction, but a decrease in output when the tape is played in the reverse direction. This arises because, in one direction of play, the orientation is aligned with the trailing recording field (which is also inclined to the vertical), while in the opposite direction the orientation is opposed to the trailing recording field. This effect is particularly noticeable at short wave lengths and can be observed in some magnetic tapes.

### 9. Drying and Curing

After orienting, the coating solvents must be evaporated with the aid of heat and a substantial flow of air. This airflow is necessary to remove the solvents from the drying area because they are usually explosive or toxic. It is very important to accomplish complete solvent removal and complete curing after orienting. Otherwise the mechanical properties of the resulting magnetic tape will change with time as additional solvent removal or curing occurs.



Photomicrographs—before and after surface treatment.

### 10. Jumbo storage

After the webs of polyester have been coated, oriented, and cured, they are put in temporary storage to provide the customer with any configuration of tape desired.

### 11. Surface Treating

An optional processing step which Memorex performs to enhance certain properties of the tape is surface treatment. The condition of the recording surface is one of the most important factors in determining overall recording performance.

The main goal of surface treatment is the enhancement of short wavelength performance by allowing more intimate contact between the head and the tape surface. Various methods accomplish this either by removing some of the peaks and ridges, or by flattening down to the surface level. Surface treatment also reduces dropouts—they are usually caused by protrusions from the tape's surface of either parts of the coating material or foreign matter.

One of the simplest means of surface treating is burnishing. This is done by passing the tape over a metal surface which may be fixed but more commonly rotates counter to the direction of tape movement. This type of surface treatment simulates what normally happens during the first few plays of a tape on a recorder.

A second method of surface treating is calendering. Here, the tape is placed in contact with a highly polished metal surface under pressure. This forces the plastic surface to conform to the metal's surface. Calendering is usually accomplished by passing tape between rollers.

Still another technique, contact treatment, is that of rubbing the surface of the tape against itself (that is, passing the tape around a loop and bringing the two portions of the surface into contact with one another). This method produces some improvement in output, but sometimes has a tendency to damage the tape's surface and pull oxide particles away from the binder material. When oxide particles are loosened in this manner there can be a high degree of oxide shed during the first few runs on a recorder.

**12. Slitting Operation**

Webs of magnetic tape are now ready to be slit into widths appropriate to their applications. Computer tapes are usually ½″, ¾″ or 1″ wide.

**Slitting**

The basic types of slitting are shown in the illustration. In razor slitting, the blade is held firmly in position to slit the web. The shear cutting technique utilizes a scissors-like action on the web through the use of circular male and female knives. In score cutting, a circular blade is forced through the web and against a hardened metal lock-up roll.

Rotary shear cutting is the slitting technique usually employed in the manufacture of magnetic tape. Circular knives make intimate contact with one another performing a scissor-like action on the tape. These knives may be thick and extremely rigid or they may be thin and flexible. Great care has to be exercised in this manufacturing step to produce tapes slit to the very high accuracy required by today's precision tape handling machines.

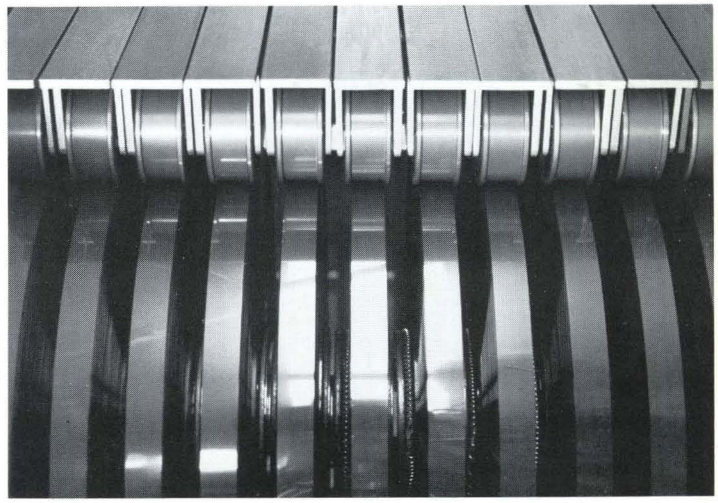
Damage to edges during cutting must be carefully checked—knives not adequately sharp may tear rather than shear, thus producing a ragged tape edge. This edge will be weak and will tend to wear out rapidly, producing wear products which may lead to an early end of tape life.

**13. Slit Tape Inventory**

Prior to final certification and inspection, ½″, ¾″ and 1″ tapes are wound onto intermediate aluminum hubs and stored away for orderly flow in manufacturing. Any tape width may be easily moved into the certification phase upon order.

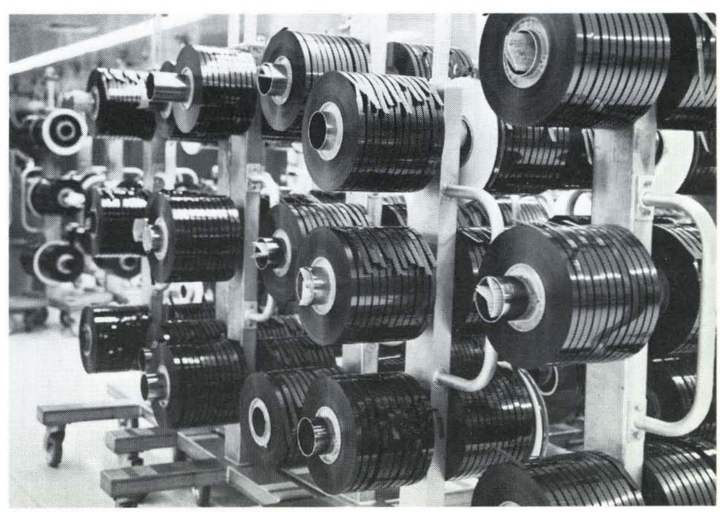
**14. Finished Product Components**

The precision tape, reels, containers, and other basic components which make up the product are now

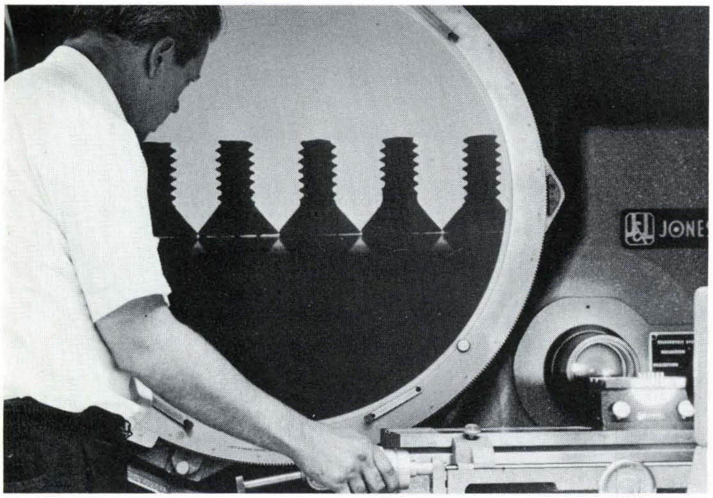


Tapes are slit to a very high degree of accuracy.

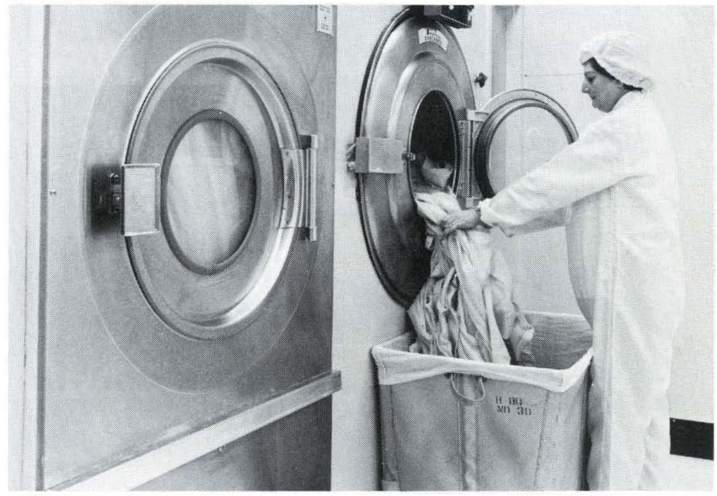
QC checks monitors the quality of the slit.



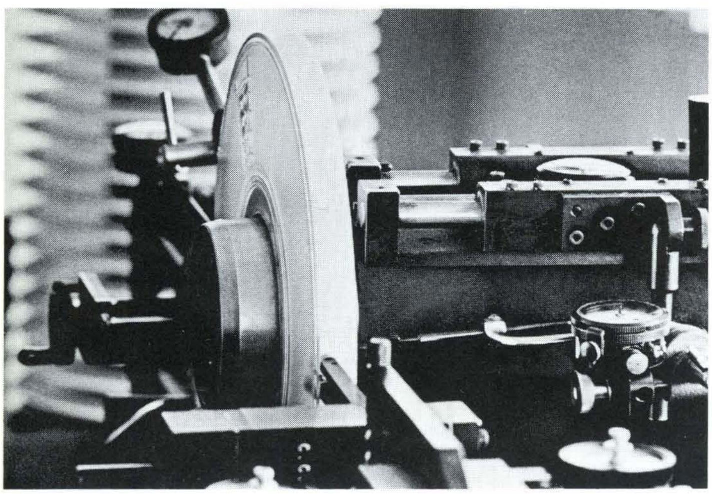
Tapes stand ready for final production stages.



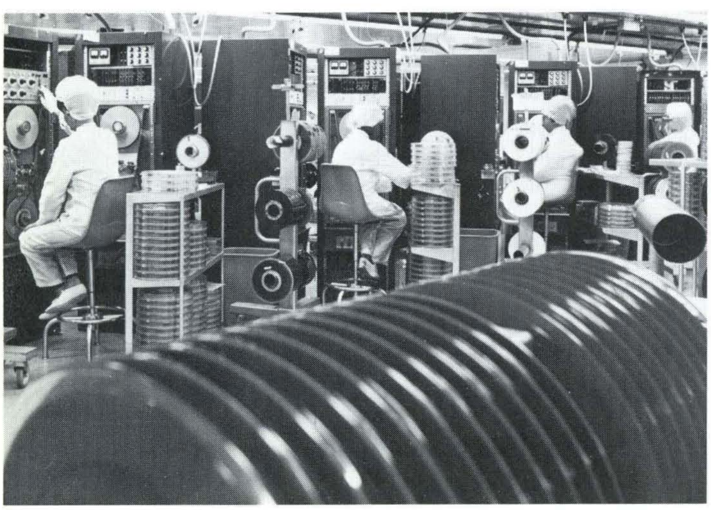
Hub Screws. Visual check for precision reels.



One of the world's most exacting laundries.



Four critical flange measurements are checked.



Memorex tapes are certified 100% error free.

ready for certification and inspection. Quality control extends even beyond our plant. Our inspectors verify production standards of components at the plants of our suppliers. Then the components are tested again in our laboratories before we accept them for processing. Not all in-process testing or certification can guarantee the finished product will meet all specifications. For this reason, every lot of Memorex tape is subjected to a series of rigorous and exacting physical tests to ensure compliance with manufacturers' and users' standards. It is felt that such examination is as important to final product excellence as the step-by-step procedures during actual manufacture.

In addition to lot-by-lot testing, periodic samples from among production lots are given a wide range of magnetic, physical, chemical and performance tests to guard against any long-term change or drift in processes or raw materials.

**15. Certification**

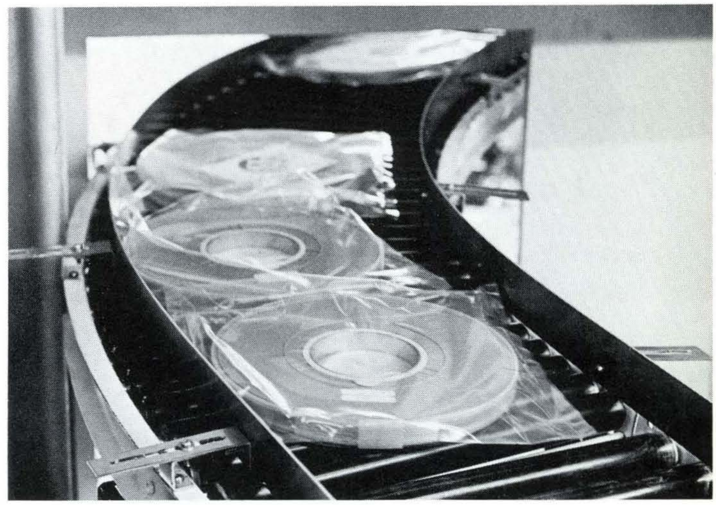
One hundred percent inspection is used on all Memorex precision tapes destined for computer use. Every tape must be certified error-free on a Memorex proprietary certifier.

Each in-process reel of tape is placed on a computer tape certifier, and actual recordings are made across the total tape surface. This method of certification assures error free tape for all track formats. Whenever an error is detected—due to a missing pulse or to a noise spike and can't be eliminated, the tape is rejected.

**16. Manufacturing Facility**

Memorex's clean room area closely resembles a

Every reel and container is thoroughly inspected.



Tapes leave "clean room" in sealed polyester bags.

pharmaceutical laboratory. The entire area is filtered by powerful air conditioning systems and a particle counter keeps track of its purity down to 2 microns. Built-in safeguards keep one room from contaminating another. Employees entering the manufacturing rooms first put on lint-free caps and outer garments (cleaned at the plant in one of the world's most exacting industrial laundries) and then pass through air showers that vacuum away any dust they may be carrying.

### 17. Packaging

Each precision tape product goes through a final cleaning process. The flanges of tape reels and the insides of the plastic containers are thoroughly vacuumed before tape is placed inside.

The certified tape is then placed into its dust-proof plastic container, and the whole unit is put into a clear, poly bag. These bags are sealed and the tape continues out of the "white room" environment and into the storage and warehousing area.

### 18. Warehousing and Shipping

Precision tapes, in their separate poly bags, are packaged into shipping cartons as soon as they leave the clean room conveyor belt.

To make sure Memorex products get to a destination in perfect condition, we ship them in specially designed containers and use special handling techniques. We routinely airship our products to all field offices both in the U. S. and aboard where inventories are maintained. In this way, we can give our customers immediate delivery of most orders.


Tapes maintain a "clean room" environment until opened by the user.

Memorex products airshipped daily from all our plants.

# Digital Magnetic Tape Transport

The basic purpose of the digital magnetic tape transport is to provide a means to record and recover data from magnetic tape. Though the purpose is quite simple, the equipment necessary to achieve this end is very complex.

The tape transport is an electromechanical/electronic device. The electromechanical portion moves the tape past the Read/Write heads under the direction and control of the electronics. Information is recorded on or recovered from the tape for storage or use by a digital computer system.

Among the estimated 250,000 tape transports in use, there are essentially two distinguishing characteristics. There is the tape driving method and the tape buffering method.

Both of these characteristics have three variations which, if combined, provide six combinations. Though these combinations are possible, not all are practical or desirable. In fact, tape transports are typically identified by the driving method hence there are only three types usually considered.

**Driving Methods**

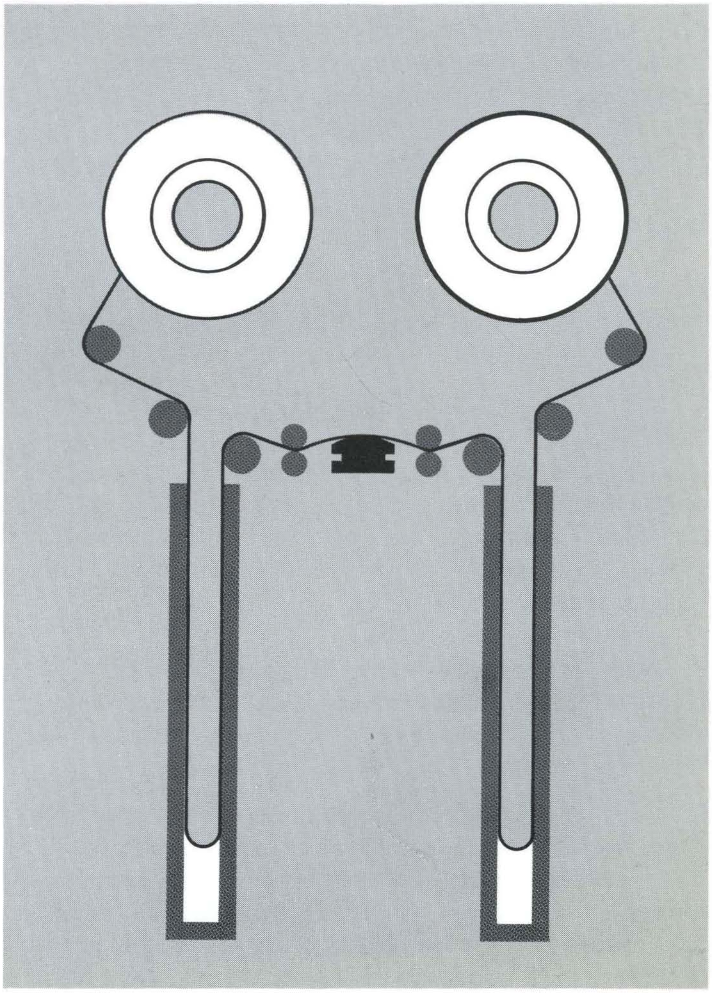
Driving methods in common use are the pinch roller, vacuum capstan and the single capstan. The operation of each is as follows:

**Pinch Roller**

The most common tape drive is the pinch roller. In most designs the pinch roller is rubber covered and is driven by friction from a capstan. To drive the tape, an electromagnetic actuator moves the pinch roller down to the capstan and pinches the tape between them. The pinch roller compresses slightly and imparts drive to the tape.

Since start-stop times and distances depend largely upon pinch roller clamp performance, actuators require large forces to shift the mass of the pinch roller from one position to another in the shortest possible time. Thus, the tape is trapped and held in position between the pinch roller and capstan while both are continuously moving. To get the tape up to speed quickly, energy is imparted to the length of tape and is maintained until the function is completed.

A pinch roller drive must be designed carefully to minimize tape damage and distortion. Assuming that the pair of rollers are absolutely parallel and the tape is perpendicular to the roller axis, tape thickness variation may cause the driving roller to produce skew and permanent tape deformation. The hammer blow of the pinch roller upon the capstan may emboss wear particles or other foreign matter into the oxide of the tape. This action may create ridges of loose oxide that can accumulate on the magnetic head, thereby reducing the life of the tape and the magnetic head. These problems and others do not invalidate the use of the pinch roller. The clamp pressure is not very high and the tape thickness on high quality tape is uniform and has sufficient resilience to resist wear. Most tape transports extract dust and dirt, purify the air, and scrape the tape to ensure good performance.



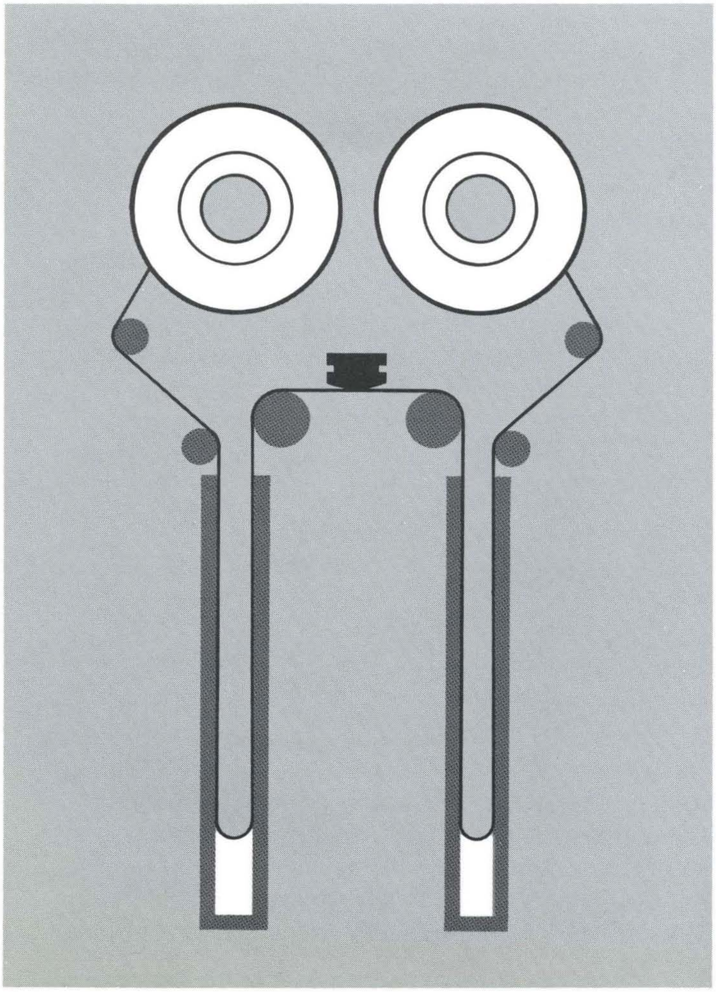
Pinch Roller

## Vacuum Capstan

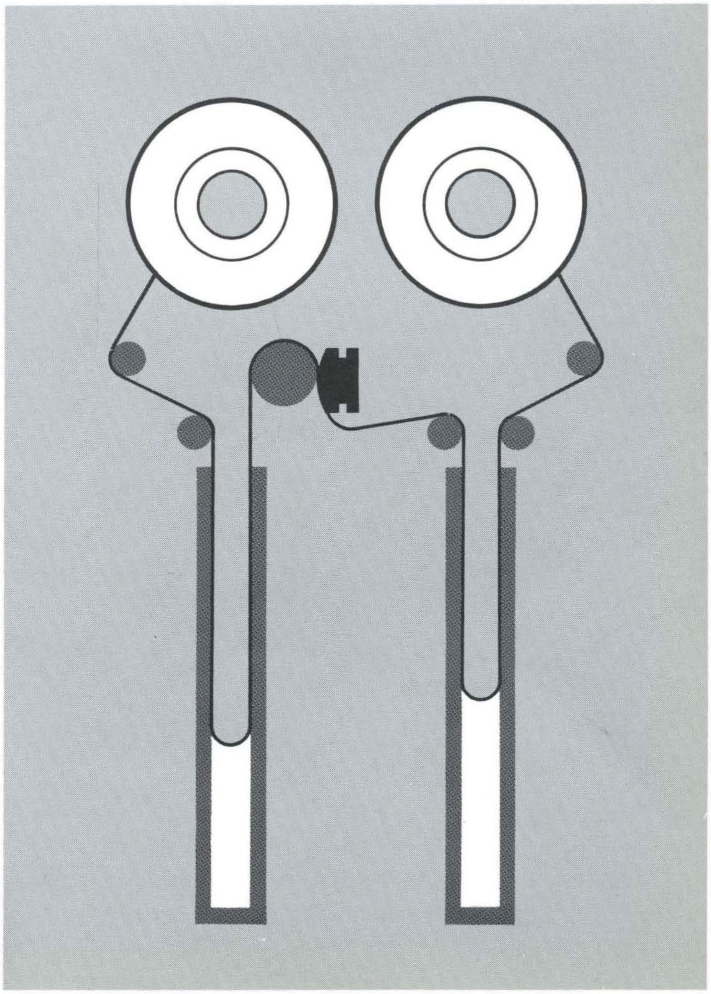
Although the pinch roller performs well, demand for a more sophisticated unit permitting more gentle tape handling, higher speeds and more reliable operation has brought about the development of a new drive method, the vacuum capstan. The vacuum drive utilizes a hollow rotating drum with slots or holes on its periphery. The reservoir within the capstan is connected to a valving arrangement that permits either evacuation or pressurization.

As the tape passes over the drum it is in contact with over 90° of the drum's surface. Under normal conditions, the friction between the capstan and the tape is insufficient to cause the tape to move. When the capstan reservoir is evacuated, however, atmospheric pressure forces the tape into intimate contact with the drum greatly increasing the frictional forces. As a result, the tape is propelled in the direction of the capstan's motion. The tape can be released by increasing the pressure within the capstan above normal atmospheric pressure. The tape will then float above the drum surface on a film of air. The digital transport using this concept is made of two counter-rotating capstans connected to a regulated pressure supply. To drive the tape forward, one capstan is evacuated and the other is pressurized. To drive in reverse, the above operation is reversed.

Tape life may be longer with vacuum drive than with the pinch roller drive. However, there are particular problems associated with vacuum drive. Although tape acceleration is more gentle, it is limited by the pressure differential between atmospheric pressure and absolute vacuum. Also, the switching arrangement is complicated by the fact that the capstan pressure variation must be changed over a wide range and at high speeds.



Vacuum Capstan

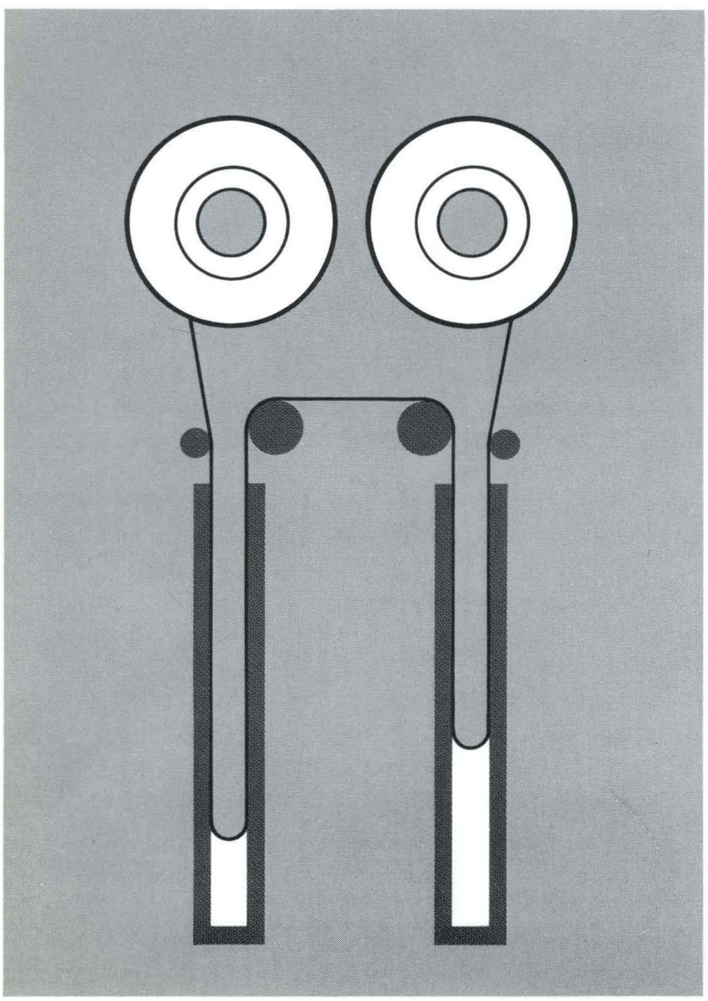


Single Capstan (Friction Capstan)

### Single Capstan (Friction Capstan)

The single capstan driving method uses friction of the tape against a moving capstan to produce tape motion. Friction drive is so-called because the surface of the capstan is composed of a substance with a high coefficient of friction, which moves the tape without recourse to rollers or directly-applied air pressure. Tape tension, on the capstan is maintained constant by the buffer system. In this method the direction and speed of the tape are directly related to the motion of the capstan.

A friction drive technique offers a simpler electro-mechanical function and probably longer tape life since there are fewer mechanical contact points to rub against the moving tape. The disadvantage is that start-stop times tend to be longer and speed stability is poorer than with other methods.



Vacuum Buffering-Vacuum Chambers

### Buffering Methods

In a digital tape transport the computer may start and stop the tape movement at random times and at high frequency. The unit is at the mercy of the data format and program; consequently, it takes a sophisticated machine to keep up.

The problem is to bring a fragile tape up from rest to high speed as quickly as possible, and to revert from high speed to rest also as quickly as possible. To achieve this operation a buffering arrangement must be used so the mass of the entire reel will not be involved at each start and stop.

The solution is a tape reservoir system, in which a relatively short length of tape is always available to move freely, limited by its own small mass and the control system. Two reservoirs are commonly used: one associated with the feed reel and one with the take-up reel. During tape start, the feed reservoir must be able to supply tape fast enough to prevent breaking while the reel comes up to speed. Similarly, the take-up reservoir must accept tape without overloading while the take-up reel is attaining speed. The three standard buffering methods use vacuum chambers, tension (compliance) arms and bins.

### Vacuum Chambers

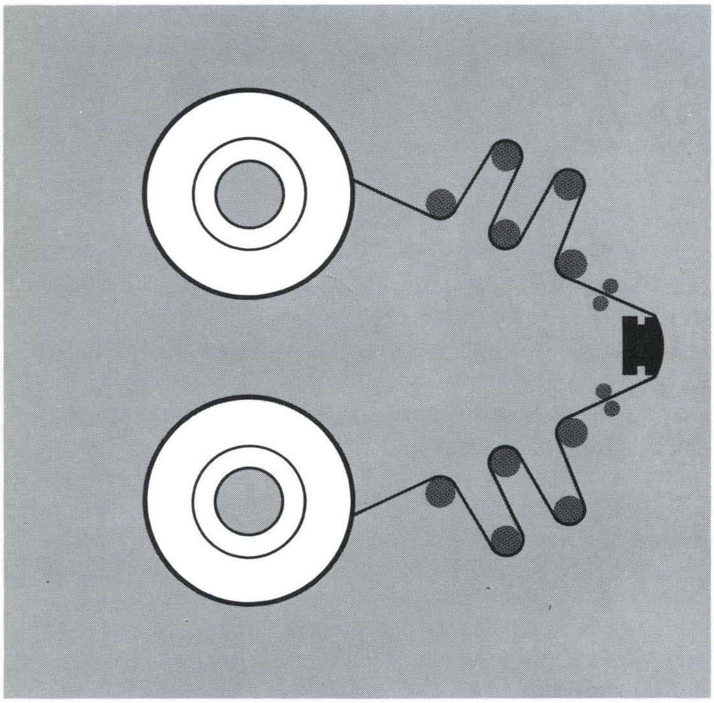
In the vacuum chamber approach tape is passed through a low pressure chamber between the reel and drive mechanism. Higher air pressure outside the chamber forces the tape into a loop, whose length is sensed to control the reel motor. For example, if the loop in the feed chamber becomes too small, the motor is started to feed more tape; when it is too large the motor is stopped.

Vacuum chamber buffering is most commonly used and provides the best compromise in mechanical sophistication, electronic sensing and tape wear.

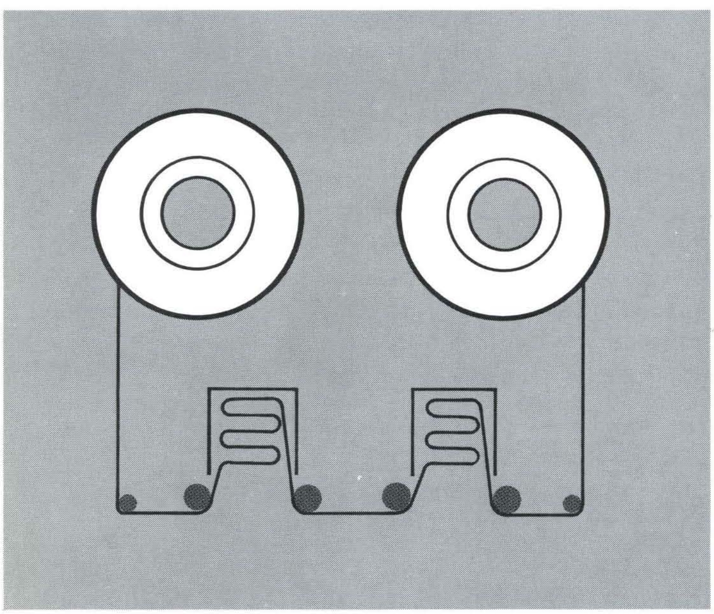
### Tension (Compliance) Arm

With the tension arm approach a length of free tape is provided by threading it back and forth between two sets of rollers. One set is fixed; the other is mounted on a free-swinging arm whose pivotal motion is sensed to control the reel servo-motor. When the arm mounted rollers approach the fixed rollers, tape is too short and the reel motor is signalled accordingly. Sensing is performed usually at the arm pivot point.

The advantage of tension arms is the relatively simple mechanism, however, the tape flexing around a



Mechanical Buffering-Tension (Compliance) Arm

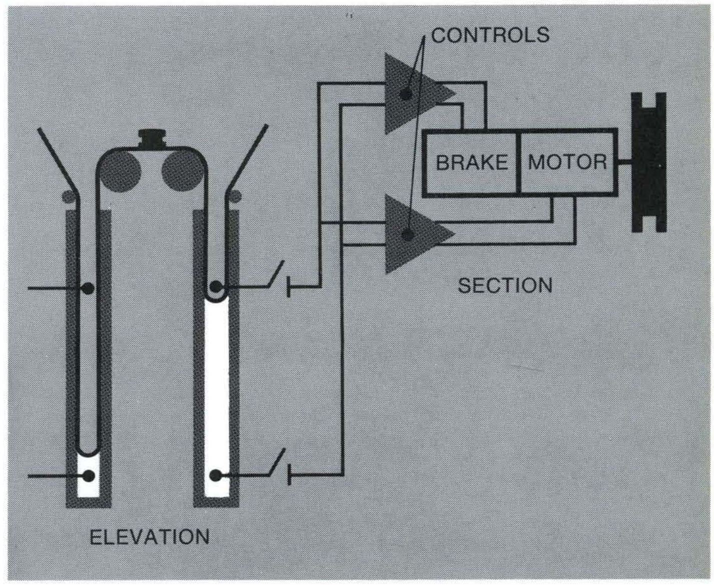


Bin Buffering-Scramble Bin

large number of rollers causes faster tape wear and shorter life.

**Bin**

With the bin techniques the tape is gravity-fed into a deep chamber between the reel and heads and is




Servo Systems

allowed to pile up. As the drive system removes tape from the bin a sensing system is employed to operate the reels to maintain an appropriate supply. The advantage to bin buffering is that it allows the longest length of free tape. The disadvantage is the difficulty in sensing the quantity in the bin.

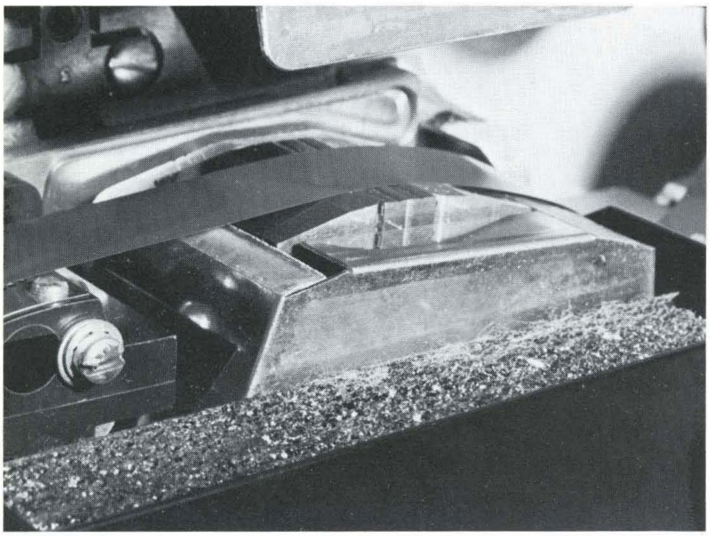
**Servo Systems**

The electronics for controlling the reel operation is called a servo system. The control involves starting and stopping the tape reels to supply or retrieve tape as it is used in the Read/Write, or rewind operations. There are several systems in common use on tape transports. A particular system is chosen on the basis of tape transport performance.

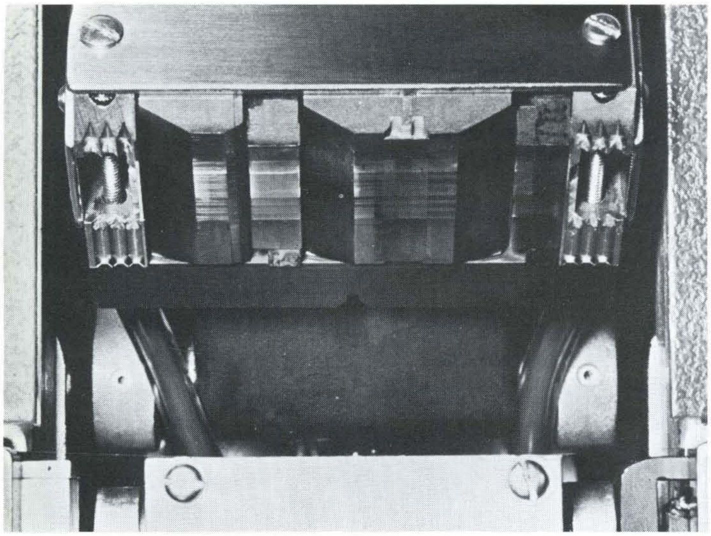
**Read/Write Heads**

The Read/Write heads are the functional units used to record magnetic impulses onto the tape and read them back to recover the data. There are two types of heads in common use. These are termed the wrapped head and the flat head. In the wrapped head type, tape is held in contact with the head by keeping tension on the tape. Tape-to-head contact in flat head types is provided by a jet of air which holds the tape firmly against the head. Mechanical pressure pads are sometimes used to force the tape into intimate contact with the head.

The materials used in the manufacture of the head must be selected so that they are compatible with the tape and do not cause excessive tape wear. These



Wrapped Read/Write Head



Flat Read/Write Head

materials must also be sufficiently hard themselves so that they do not wear rapidly.

Generally, the action of the tape passing over the head causes a slight groove to form. If this is allowed to continue, damage to both the head and the tape can result. Excessive head wear is caused by tape that is abrasive and does not have a smooth uniform surface.

The sharp corners of the groove shoulders can cause edge damage to the tape. This is especially true if the tape width is not maintained to very close tolerance.

Since the tape must always be in contact with the head, localized heating may result if the tape is too abrasive. This heating can result in errors and will definitely shorten tape life. These problems can be avoided by using tapes which have exceptionally smooth and uniform surfaces.

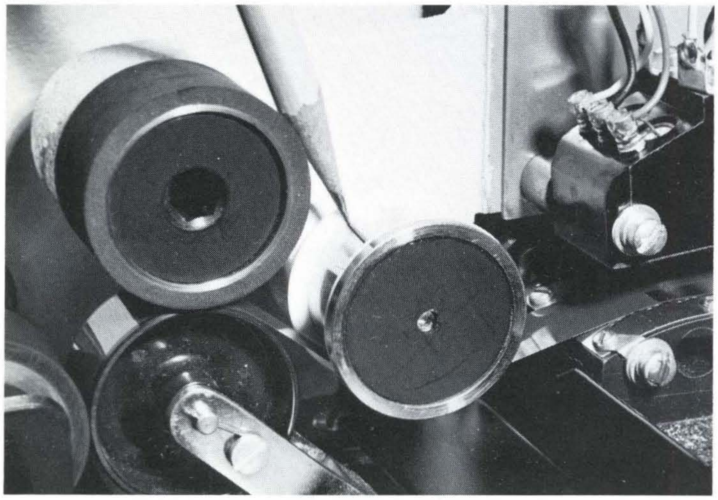
**Tape Guiding**

In order to assure that the tape passes the head with the edges perpendicular to the head, it is necessary to guide the tape by mechanical means. Also the tape must be properly guided to the reels to assure a smooth tape pack. A smooth tape pack refers to a wound reel of tape in which all successive layers are in the same plane.

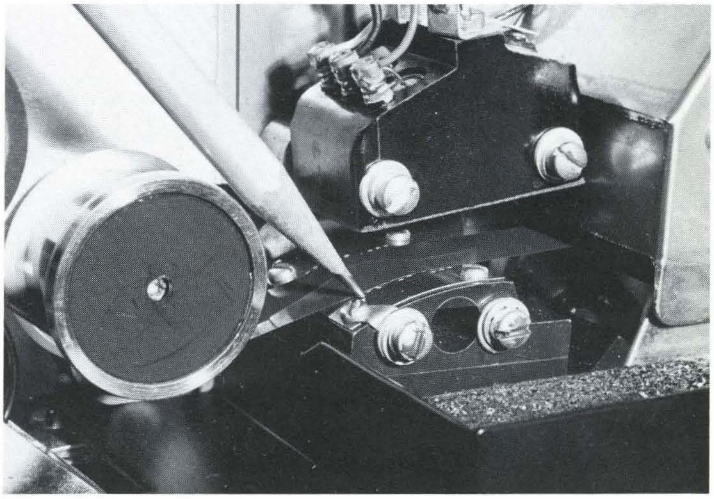
Two methods are used to guide tape. Spring loaded guides, commonly called edge guides, are used on the majority of transports. With this approach, one edge of the tape contacts a fixed guide while the other edge of the tape contacts a spring loaded moveable guide. The force of the spring holds one edge of the tape in a straight line parallel with one plane of the tape path. The moveable guide is allowed to follow the irregularities of the tape edge. Precision grades of magnetic tape suitable for computer use must be slit so that both edges are parallel within very close tolerances. If they are not, it is possible that the tape will not be guided properly and skew errors will result. Also, tape edges which are uneven, and tape slit too wide will be subject to excessive wear and damage from high localized pressure from the guide. Debris from tape wear, especially from the edges, then become deposited between the spring loaded guide and the supporting post. When this occurs, improper guiding will result, with the chance for errors to occur.

Tape may also be guided by allowing it to pass through a channel that contacts both edges. This approach to guiding also requires a tape which is very carefully slit to prescribed standards. If it exceeds the width specification, it will curl in the channel and eventually cause grooves in the guide plate. A narrow tape will not be guided properly and again skew will result.

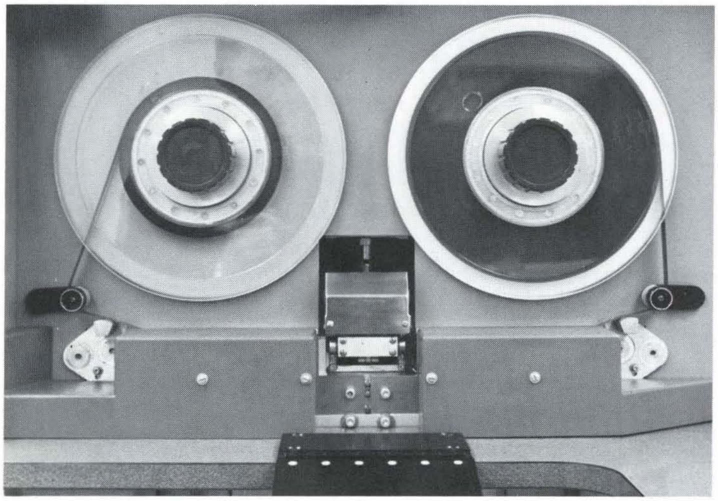
Roller guides are a special form of channel guides and are commonly used to guide tape onto the reel. These must be maintained in adjustment so that they are perpendicular to the tape path plane. Also care must be taken so that the bearings do not wear and allow excessive lateral movement. Improper guiding onto the reel will cause edge damage to the tape and offsets in the tape pack on the reel.



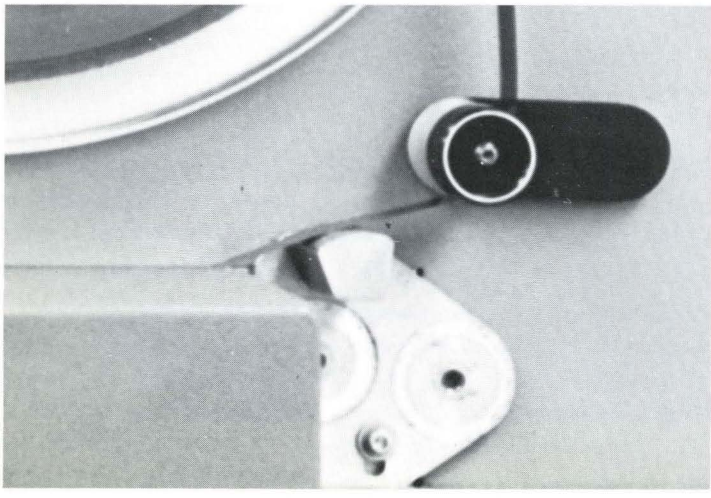
Spring Loaded Guide



Screen Cleaner



Channel Guide



Roller Guide

### Tape Cleaners

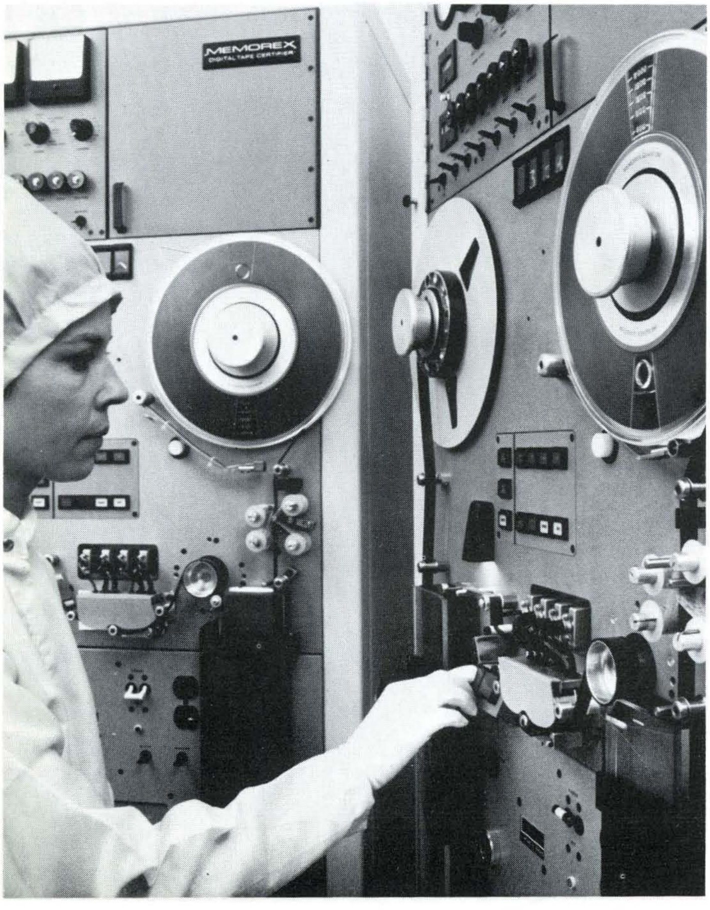
A tape cleaner is a device mounted in the tape path. As the tape makes contact with the cleaner device, contaminants which cause tape to head separation, are removed.

Several different kinds of cleaners are used although the most common is called a screen cleaner. This is a small strip of metal with about 20 conically shaped holes. As the tape passes over it the edges of the holes scrape on the oxide surface. The screen may become worn by abrasive action of the tape. However, the holes maintain their sharp edges because of the conical shape. A groove is worn into the screen similar to that described earlier in the Read/Write section. This groove can cause tape edge damage and excessive wear.

The two other types of cleaners used are the knife blade and the contoured port. Both are intended to remove particles from the oxide surface. The contoured port is generally a device with a contoured opening, and often vacuum is employed to carry away any accumulated or dislodged particles. The metal used in these cleaners is generally very hard and is not subject to the grooving found with the screen cleaner.

Cleaners are very effective in reducing errors. However, care must be taken to assure that they are not grooved or otherwise damaged, and are replaced when they become worn.

# Certification is a Meaningful Process; It is 100% Quality Assurance




Type of certification equipment built and operated by Memorex.

A fact of life in the manufacturing process is that a wide variation always exists at the end of a process. And every manufacturer knows that it's his responsibility to the customer to set standards for what he will ship and what he will not ship. Obviously, the only way to do this is to test end products to see if they meet set standards.

Some manufacturers prefer only to spot check by mass production testing and random sampling. Their philosophy is: "you can't inspect quality in." True, but you can inspect 100% of poor quality out. Random sampling tests inevitably result in marginal or poor quality tape ending up in a customer's computer center.

If you were a customer, would you like to be the one who receives the marginal shipment of tape?

Today we are all conditioned to "statistical control," to accept the average. But we are flooded with average or below average products by this philosophy. It's a common phenomena.

Some manufacturers, however, feel it is in their best long-term interest to reverse this trend. Memorex is one of these. At Memorex, 100% of every product is tested. Its quality is "known," not guessed at. And this is really keeping faith with our customers, for marginal products are always caught and never sent to you.

**Critical Aspects of Magnetic Tape**

Magnetic tape when used as a storage media provides: perpetual stability, 100% erasability, highest resolution, exceptional signal-to-noise ratio, and excellent record/reproduce speed.

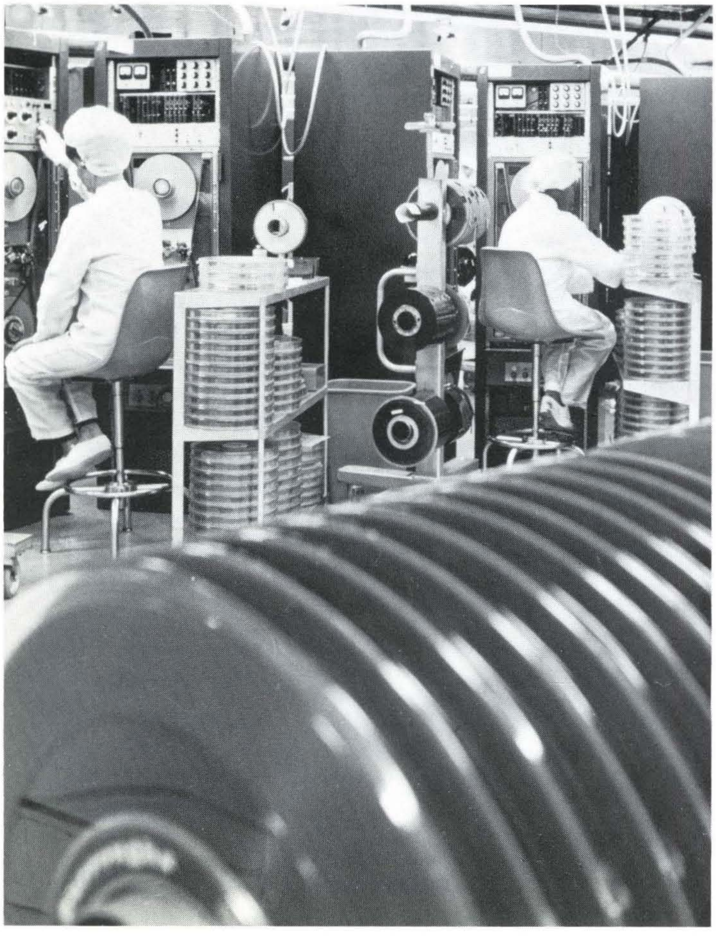
During manufacture of Memorex precision tape, quality control and production check points are established at various stages to assure a continuing attitude of excellence during the total operation. If one single check is missed, the whole manufacturing procedure could become worthless.

Each Memorex plastic tape container is automatically sealed inside a poly bag filled only with dust-free air. The tape remains uncontaminated and fully protected until it arrives at your facility.

**What is a Dropout?**

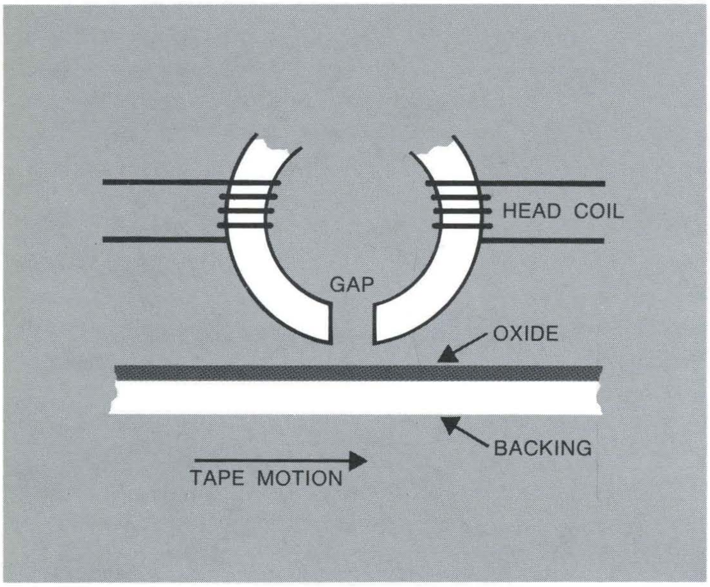
There are two common causes of computer tape failure—wear and mechanical damage. Failure because of wear is a direct function of the oxide coating integrity. Failure because of mechanical damage may be attributed to transport malfunction, misalignment, and/or unsatisfactory tape handling techniques. In either case, reduced tape performance becomes evident through the loss of recorded information. This lost information, commonly referred to as "dropouts," occurs when the computer tape fails to maintain intimate contact with the record/reproduce head assembly. As the tape is lifted and separated from the head, the magnetic signal level is reduced, with the signal loss being directly proportional to the distance of separation.

Debris is the major cause of dropouts. When magnetic tape is passing a record or reproduce head any particle of debris or any mechanical damage to the tape will cause some separation of the tape from the head.

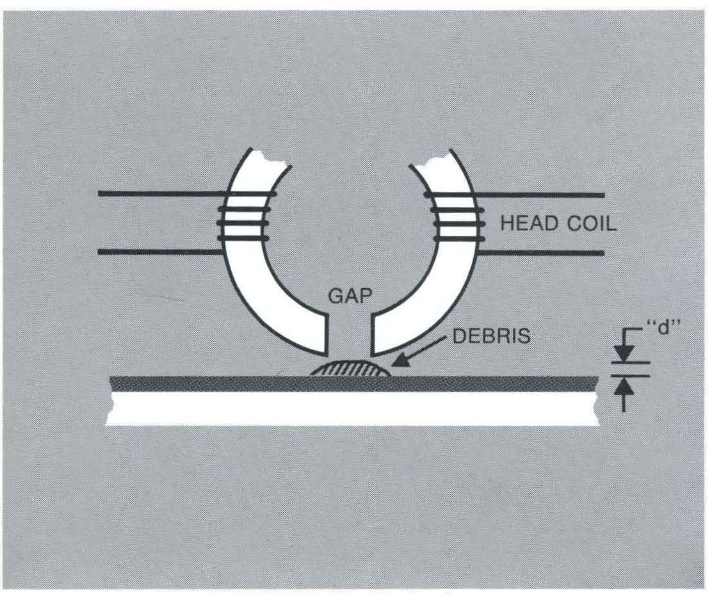


Memorex Computer Tape is 100% Certified.

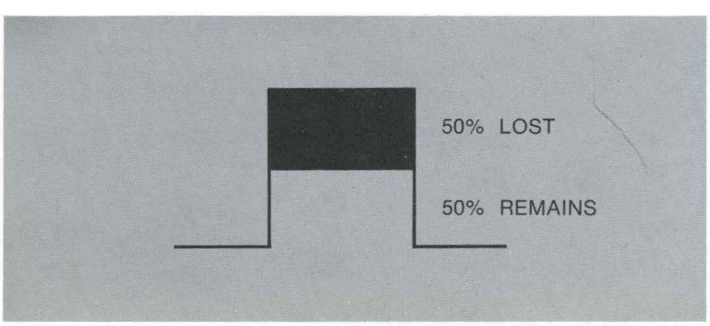

Tape container sealed in dust-free poly bag.




Ring Head profile is free of debris.




Debris causes head to tape separation.




Dropout profile when the computer clips at 50%.

If this distance of separation ("d") becomes too great, the computer will recognize that area as containing a dropout. We can actually calculate the "go" or "no go" size limits of that particle (or damage area) as follows, based upon two valid laws of magnetic recording.

**First Law:**

$C = \frac{d}{\lambda} \times 54.4$ dB

C = Change in magnetic output (Decibels)
d = Distance of head to tape separation (Inches)
$\lambda$ = Recorded wavelength (Inches)
54.5 = Constant (Decibles)

**Second Law:**

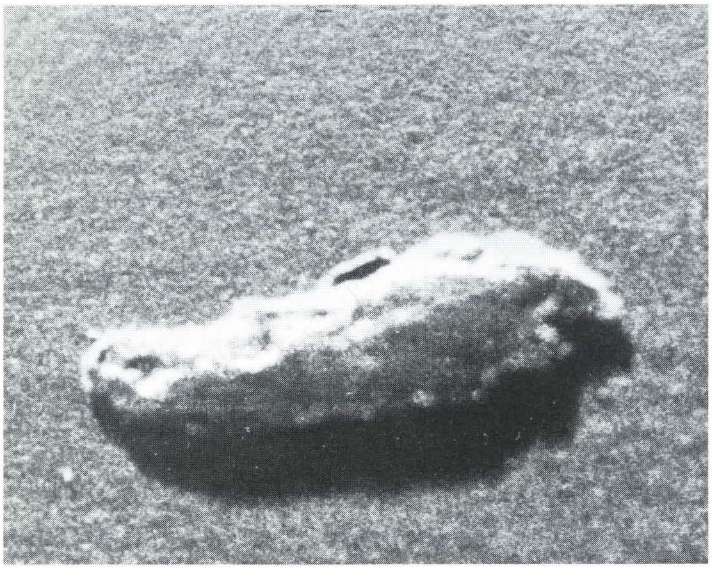
$L_S = LOG_{10} \frac{A}{B}$

$L_S$ = Loss in signal due to separation (Decibels)

$20\ LOG_{10}$ = Constant

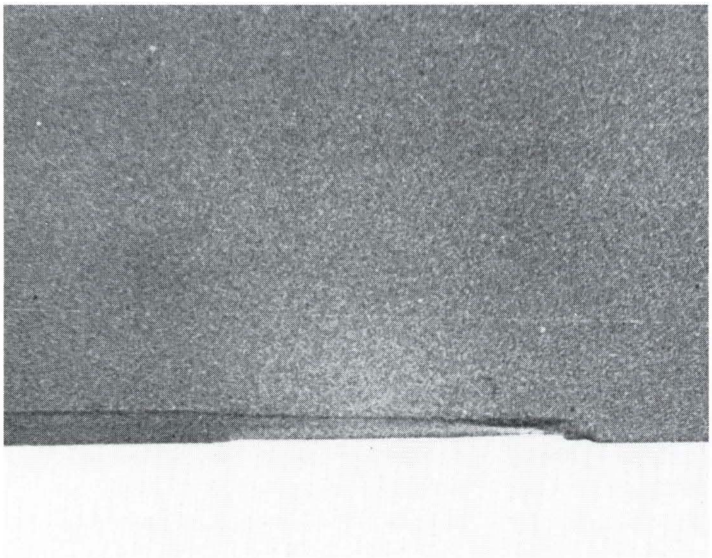
$\frac{A}{B}$ = Ratio of a "Before" (A) and "After" (B) The spacing is introduced.

When the computer "clips" at 50%, it will see a 50% loss of signal as a dropout.

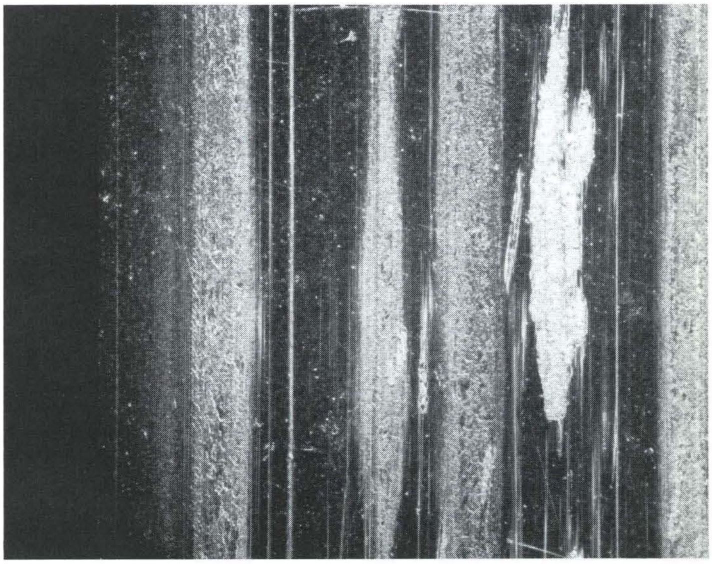


**Debris (100X)**
The evidence as we have seen it.
(Redeposited oxide particle)

**Polyester Scratches (40X)**
Source: It could be caused by defective Vacuum Capstans as well as dirty/contaminated guides.

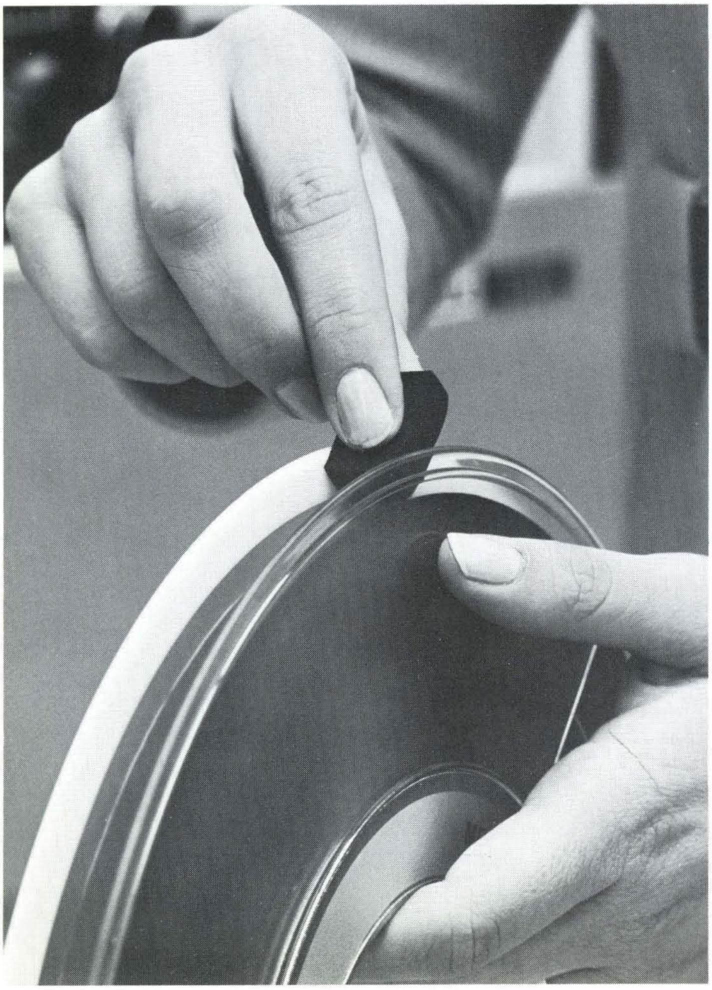


**Edge Damage (10X)**
Source: It could be caused by a worn guide, dirty guides or defective components in the tape path.



**Oxide Scratches (40X)**
Source: It could be caused by defective guiding and contaminated tape path components.

# Care and Handling of Magnetic Tape



Data processing people are aware that a single reel of computer tape may contain priceless information. The preservation of this information is, of course, of primary concern. However, there is another and equally important reason for preventing damage to the magnetic tape; that is, the maximum utilization of every reel of tape. In many cases, master or history tapes are stored in special vaults under controlled environments at a high cost to the customer. Yet failure to stress the importance of correct care and handling has often rendered these tapes useless.

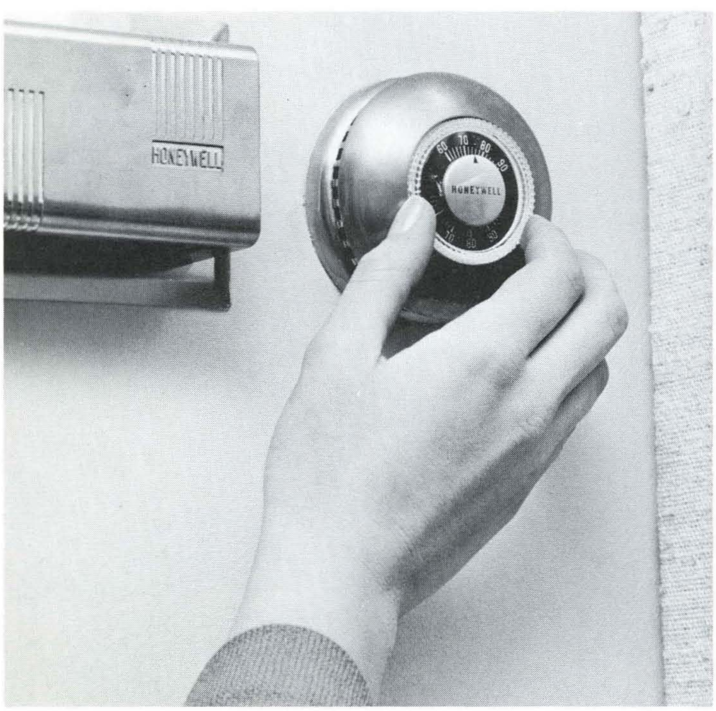
For years, Memorex has been sending field engineers to facilities where handling problems have arisen. These men have been exposed to countless incidents. After all of the gathered evidence was analyzed, certain key factors became apparent. Ninety percent of all tape damage at the customer's facility can be avoided if certain procedures and methods are rigorously observed.

Illustrated on the following pages are the do's and don'ts of computer tape care and handling.

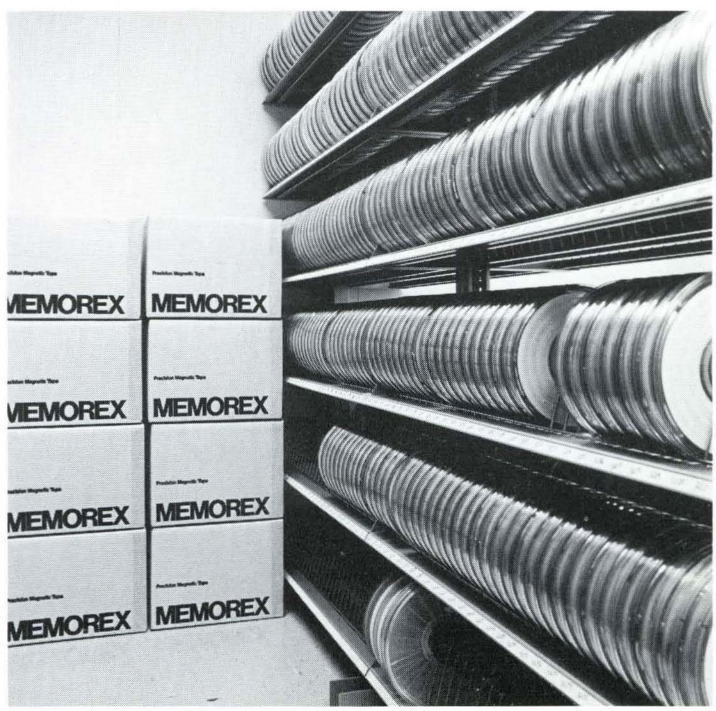
Memorex precision tape is manufactured to extremely critical tolerances and subjected to numerous tests and a continuing inspection before the tape is shipped. The story doesn't end there. If you are having tape-equipment problems, Memorex wants to know about it and help. Memorex has hardware-oriented people— and these engineers can talk your language about computer room problems.


**Initial Inspection**
Proper care and handling begins with the receipt of the tape products from the manufacturer. Make a careful inspection for external damage to the shipping carton.


**Thorough Inspection**
If damage is detected, make an immediate inspection of each reel and canister and report any visual damage to the carrier.




**Environment is Important!**
Precision magnetic tape should be stored within the following environmental range: 60° to 90°F, 20 to 80% RH.
Preferable environment is 70°F, 50% RH.



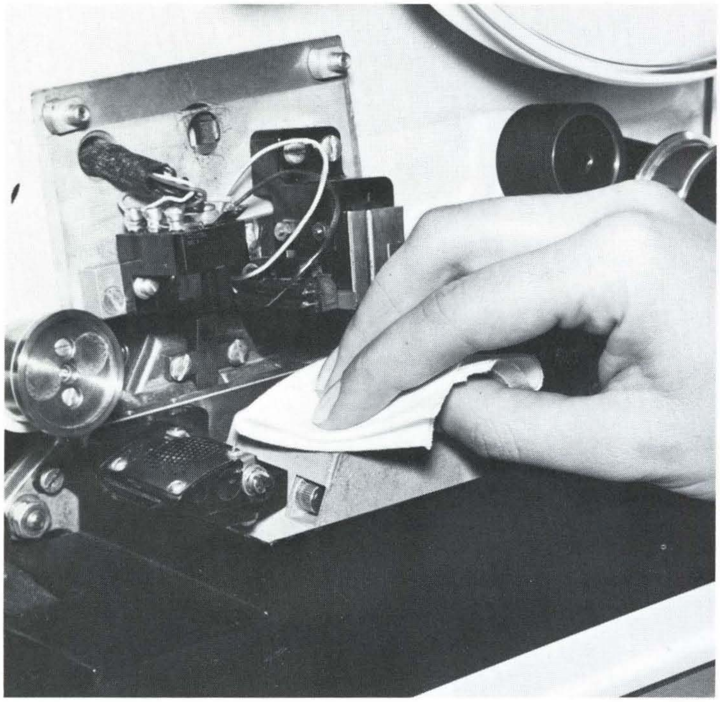

**Tape Acclimation**
When at all possible allow tape to acclimate in the shipping cartons. This will insure against any rapid temperature changes.


**Tape Storage**
Store tape upright in its protective canister. This practice not only protects the tape from airborne contamination but also properly supports the reel by its hub.

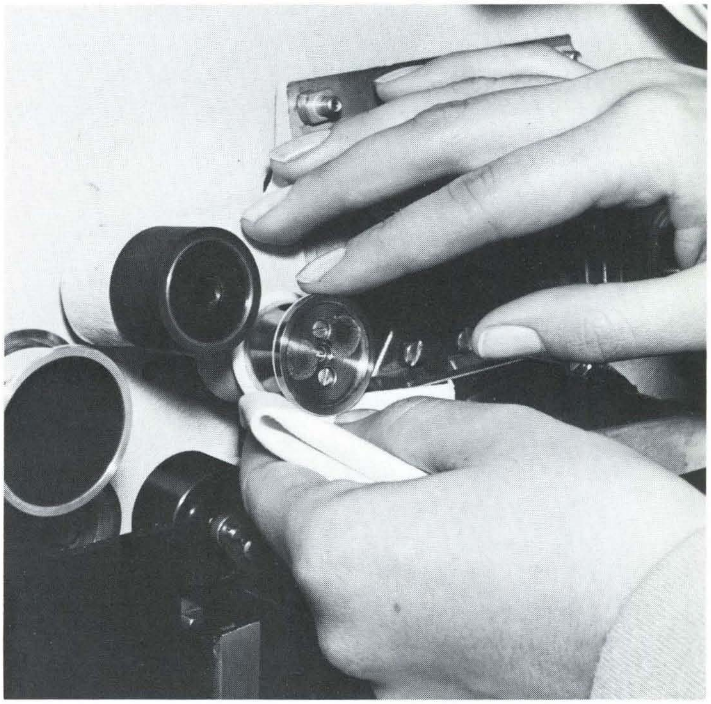
**Proper Labeling Procedures**
Labels should be made out prior to placing them on the reels. When labeling the reel, care must be taken not to exert any pressure on the flanges.

**Maintain Proper Records**
Each reel of tape should be promptly logged in by your librarian. Our records show that 80% of all damaged tape does not have a proper library record.

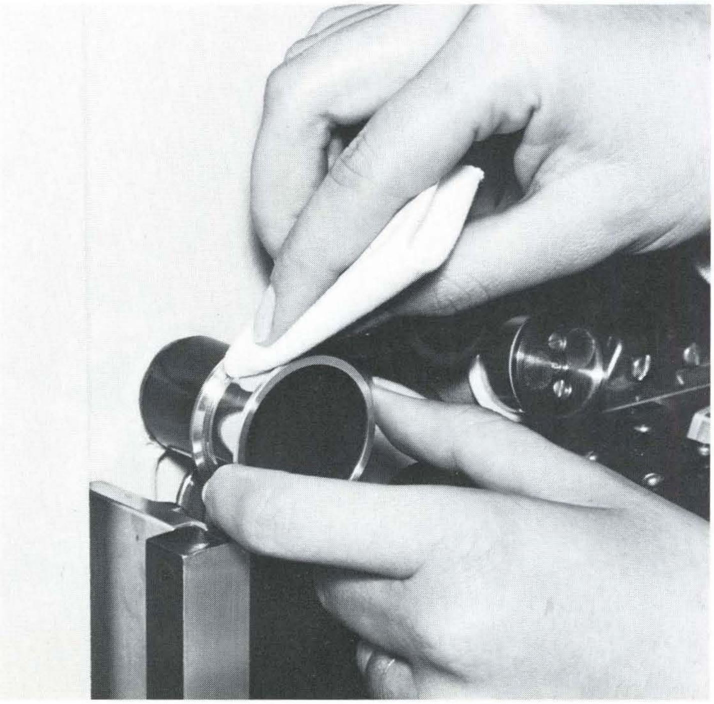

**Proper Cleaning Procedures**
The tape transport should be cleaned with a solvent recommended by the transport manufacturer.



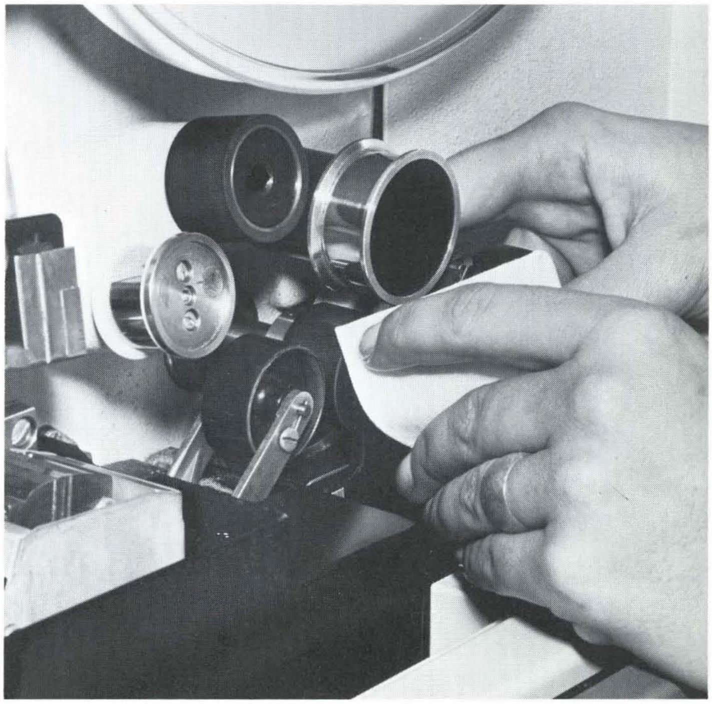
**Cleaning the Head Area**
Care should be taken to remove any contamination on the head area. The correct cleaning motion on the head is the same direction as the tape path.



**Spring Guides**
Special attention should be given to insure no build-up that may cause edge damage to the tape.



**Rewind Idler**
Although such idlers rotate with the tape movement, they still can collect contamination.



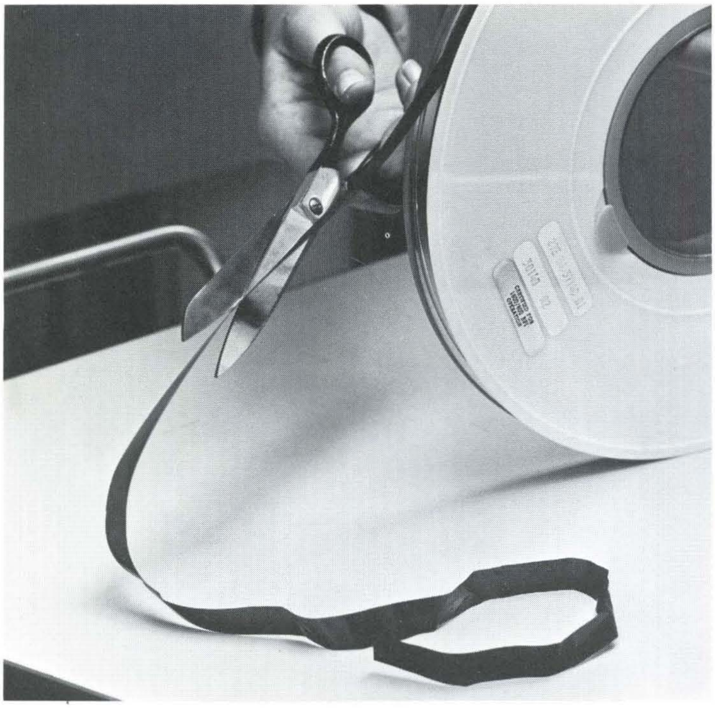
**Rubber Capstans**
Rubber parts such as capstans and pinch rollers generally come in direct contact with the oxide surface. To prevent tape contamination cleaning rubber parts is a must.

**Loop Columns and Vacuum Chamber**
To insure error-free operation, it is essential to clean the entire tape path. The most frequently overlooked are the loop columns and vacuum chambers.

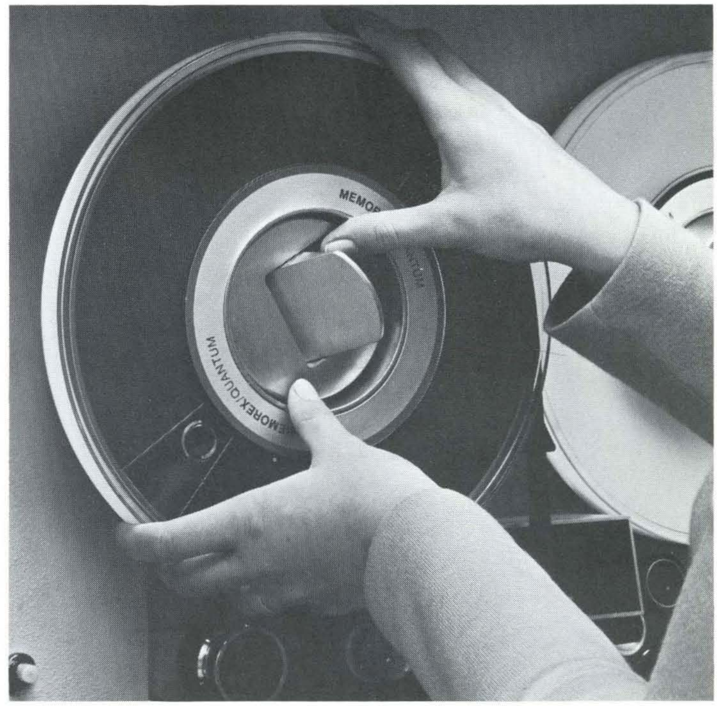
**Handling the Canister**
Always place the canister lid with the handle side facing upward.

**Proper Tape Handling**
Care should be taken not to compress the flanges when removing tape from the canister.

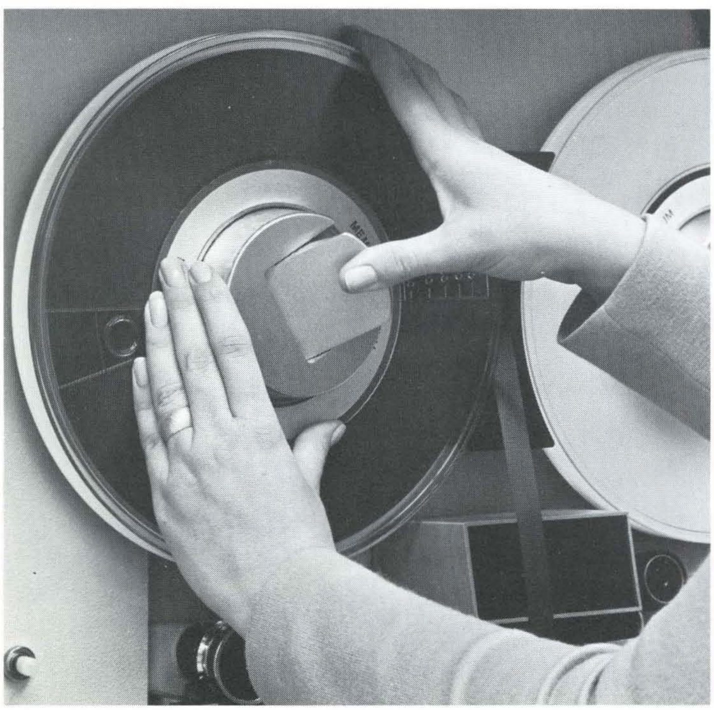
**Write Enable Ring**
If the "write" mode is to be used, place a write enable ring in the slot provided on the reel. Be sure that the ring is seated correctly.



**Remove Damaged Leader**
When mounting used tape, check the leader. If the leader is damaged or contaminated, snip off the affected portion and replace beginning of tape marker.

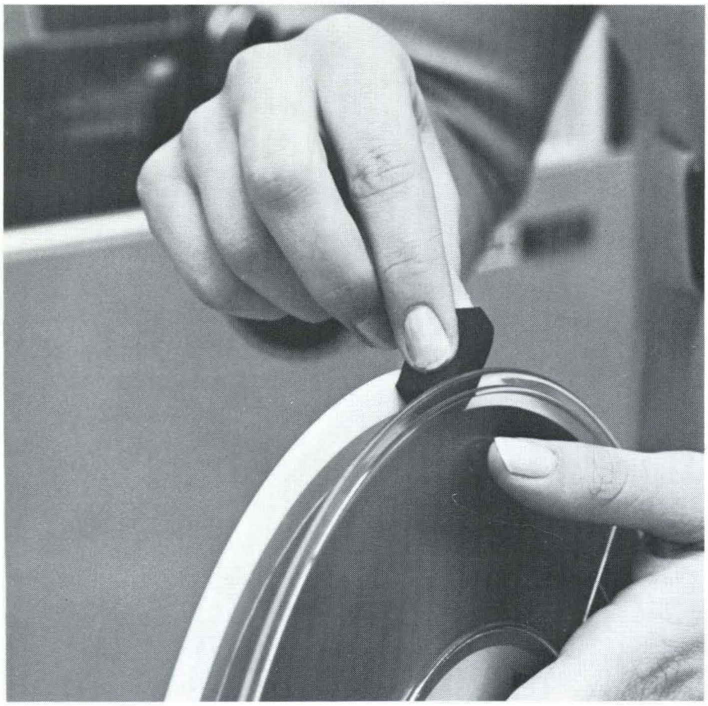



**Proper Mounting**
The thumbs are placed inside the hub while fingers are placed lightly on both flange edges. The operator maintains this hand position as she prepares to mount reel on the drive. Weight of the reel is supported by thumbs.



**Locking the Reel**
Keeping equal pressure on the hub of reel, lock the reel securely into position.

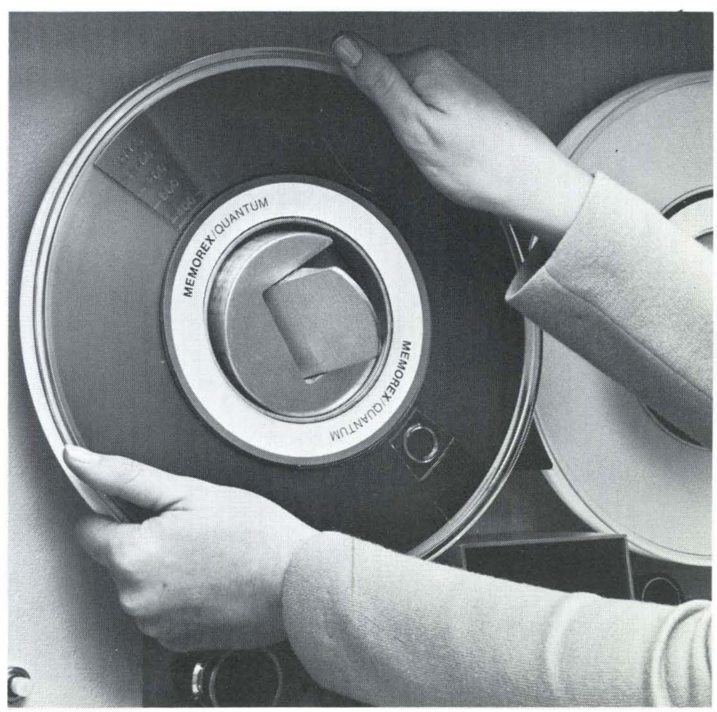
**Guard Against Dust**
Operator then completes the operation by fastening the top of the canister in place and returning it to the storage cart.



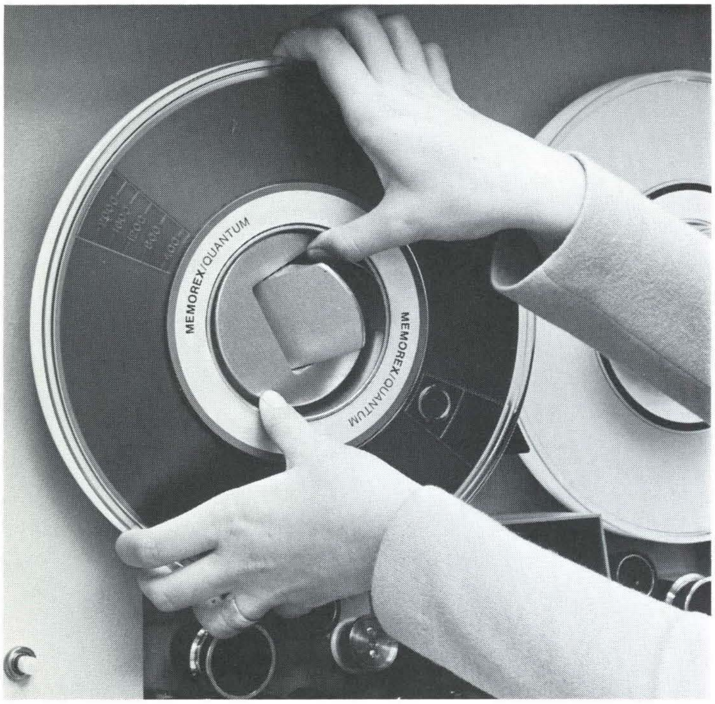
**Keep the Tape on the Reel!**
After the tape has been used, a rubberized hold-down sponge should be replaced on the rim to keep the tape from unravelling off the reel.


**Improper Canister Handling**
Operator is placing the lid upside down on the cart. The open lid now becomes a collector of dust and airborne contaminants.

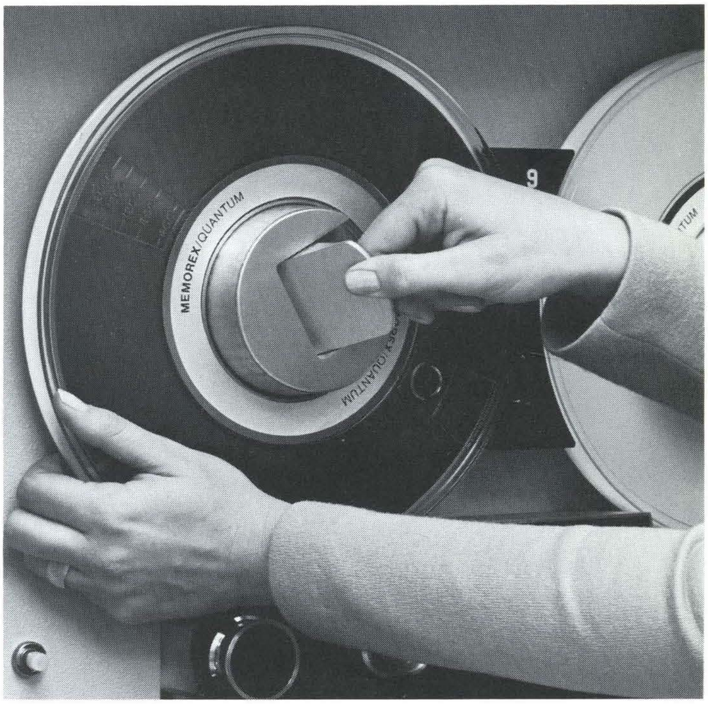

**Drives are not Storage Racks**
Operator places canister lid on the top of the drive. This is disastrous as almost all drives vent exhaust from the top.




**Improper Mounting**
Completely wrong! Operator has grasped the reel by both flanges, and in the process she has squeezed the outer tape edges.




**Poor Handling**
While the thumbs are in the correct position, her finger nails are damaging the tape between the flanges.

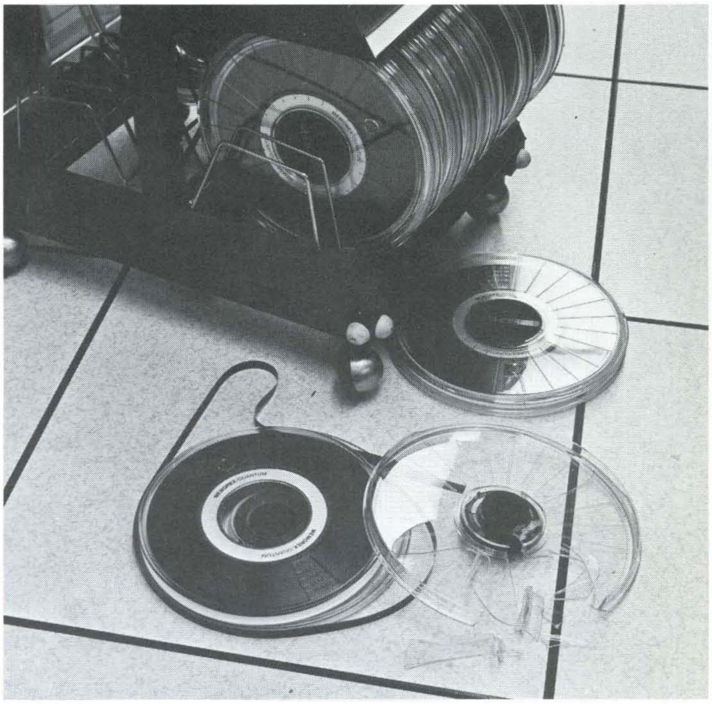



**A Sure Bet for Edge Damage**
Operator is putting pressure on the outside flanges, and locking the reel at an angle to the drive.

**Tape Spill**
A few feet of tape have unwound from the reel. Operator is careless—now she must cut off the damaged portion.

**Proper Transporation**
A preferable method of transporting tape to and from the system is the use of a mobile cart designed to carry tape in an upright position.

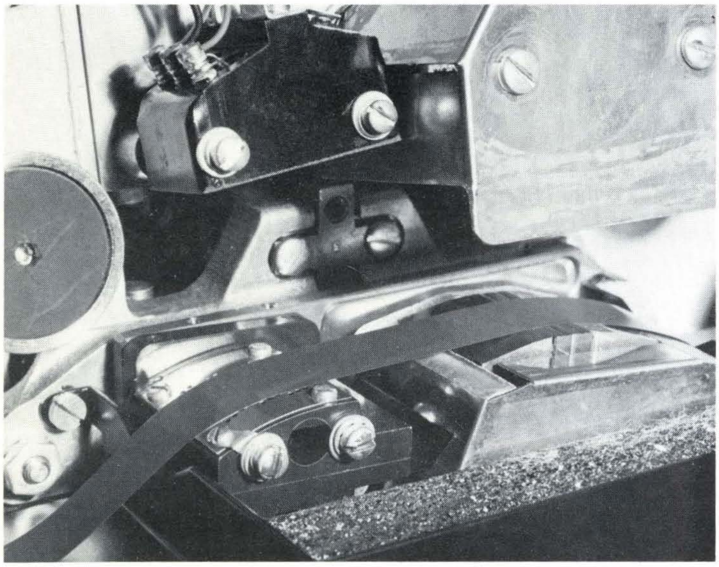
**Stacking for Trouble**
Operator has started out inviting trouble by stacking several canisters on top of the mobile cart.



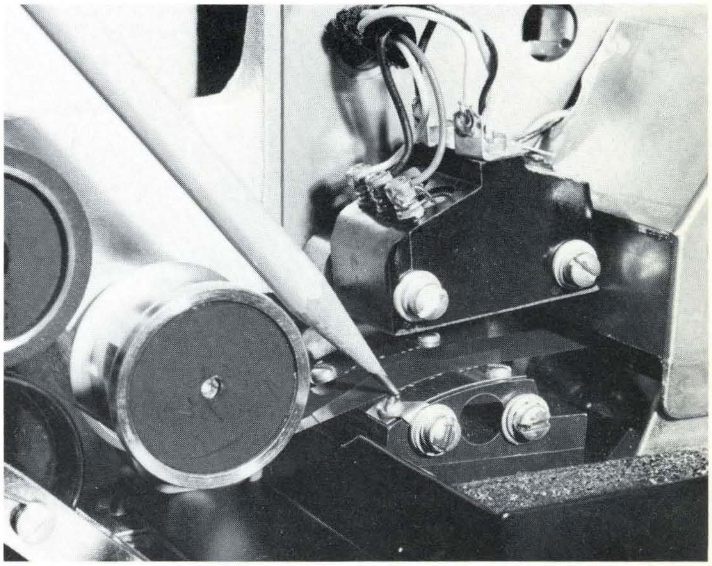
**Carelessness is Expensive**
Stacking tapes usually results in a loud CRASH—and possibly a broken reel and/or badly contaminated tape.


**Invitation to Trouble**
Smoking and eating in the computer room are two of the most frequent causes of contamination.

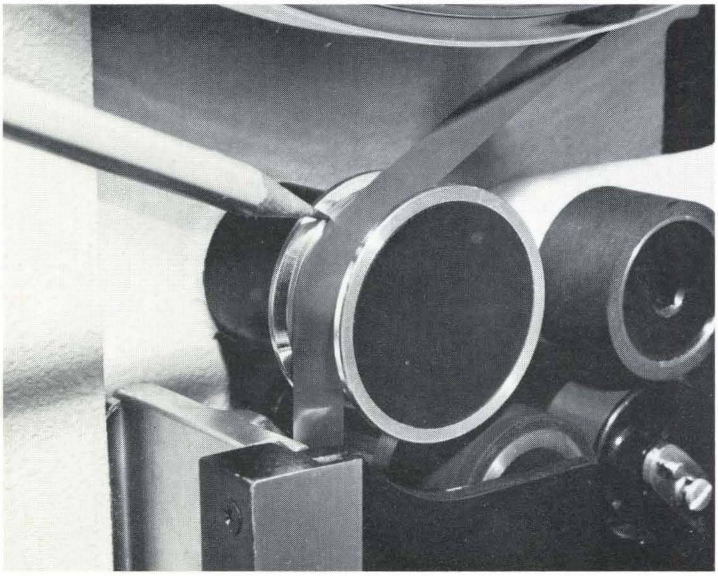

**Improper Storage**
These tapes are headed for early failure. Take the time to store unused tapes properly; it pays off!



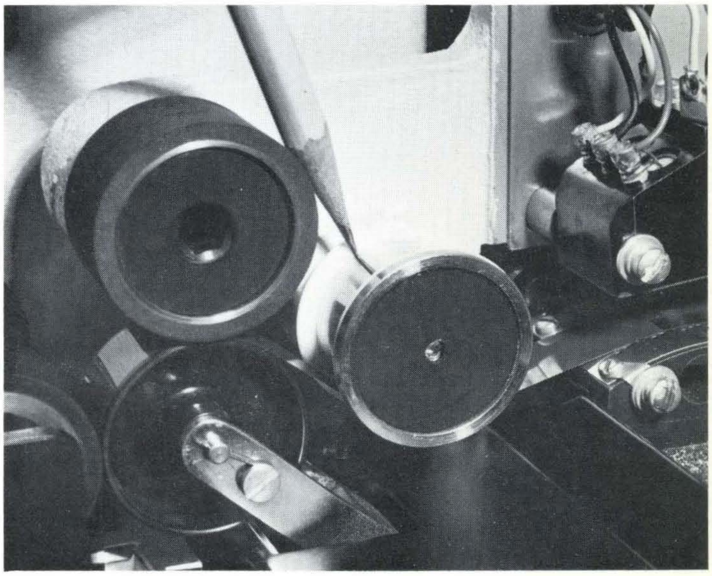
**Head**
Common fault: Worn area caused by tape wear creates improper head to tape contact.
Result: Signal instability and low output resulting in loss of data. Notify your C.E.



**Cleaning Plate**
Worn or channeled cleaning plate may result in edge damage and contamination. Notify your C.E.



**Rewind Idler**
Common fault: Edges of the idler become worn or contaminated, causing damage to tape edge. Contamination may be wound into the reel. Notify your C.E.



**Spring Loaded Guide**
Common fault: Spring guide can become contaminated and cause tape to skew across the head.
Result: Edge damage and loss of data.

The entire tape drive should be cleaned after every use. The smallest particle of debris can generate a chain reaction that will result in contamination creating dropouts and serious loss of information.

Good housekeeping really pays off in the maintenance of your computer drives. We might mention general computer room cleanliness. Don't use a broom on your floors. Instead provide for a vacuum cleaner with a long hose attachment so that the power unit and exhaust bag can remain outside the room.

Use a cleaning mechanism that won't redistribute the contaminants in the room.

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