
# ORION SERVICE digest

issue 34 SEPTEMBER 1977

LOCKHEED · CALIFORNIA COMPANY

**MAGNETIC TAPE, REEL, AND RECORDER CARE**

## CONTENTS

**MAGNETIC TAPE, REEL AND RECORDER CARE 4**



**NOT FOR PUBLIC RELEASE**


ISSUE 34 SEPTEMBER 1977
LOCKHEED · CALIFORNIA COMPANY

## FRONT AND BACK COVERS

This issue the *Broadarrows* of *VP-62* are our cover squadron, the first Reserve Squadron that has been so featured. PATRON SIX TWO was commissioned in 1970 at NAS Jacksonville when the Navy reorganized the Selected Air Reserve squadrons to enhance their combat readiness posture. For its first eighteen months the squadron maintained a detachment at NAS Atlanta, but on 1 April 1972 this detachment merged with the parent squadron at Jacksonville.

Initially VP-62 was equipped with the venerable SP-2H Neptune, but in July 1972 they began transitioning to the P-3A Orion, their first fleet-compatible aircraft. By the end of September 1972 their last SP-2H had been transferred. September also saw the Broadarrows conduct their first annual cruise. During these operations the selected air reservists and active duty personnel performed around-the-clock as they demonstrated squadron readiness.

The following September PATRON SIX TWO deployed to Lajes, Azores and participated in the NATO exercise "Strong Express." During the fall of 1972 and throughout 1973, the squadron continued to improve their ASW capability as they replaced their initial P-3A aircraft with DIFAR-equipped P-3A's. In August 1973, VP-62 was tasked to augment the Regular Navy forces in the Mediterranean. The squadron worked one month with Task Force 67, logging over 1000 flight hours as they flew anti-submarine patrols over the Atlantic and the Mediterranean. This outstanding effort won the Broadarrows the ASW "A" from COMNAVAIRLANT, and the Battle Efficiency "E" (designated the Noel Davis Trophy in the Reserve community) for being the Reserve Force squadron with the highest capability to meet mobilization readiness.

In July 1974, VP-62 deployed to Rota Spain and flew more than 1100 hours in support of Mediterranean Fleet operations. Following this cruise, their readiness posture was recognized as the highest ever achieved by a reserve patrol squadron.

The summer of 1975 saw VP-62 demonstrate the "Mini-Det" concept, a new idea in Reserve Active Duty Training. In this concept, small detachments from a squadron perform their active duty training at a deployed site for extended periods – in this case Lajes, Azores. PATRON SIX TWO's demonstration of the Mini-Det concept proved mutually beneficial to the Fleet and the Naval Reserve.

The Broadarrows were detached to NAS Bermuda during the summer of 1976 for their active duty training. They conducted operations throughout the Atlantic theatre, staging flights from as far south as Roosevelt Roads, Puerto Rico and from as far north as St. Mawgans, England. Upon completion of their deployment, the Fleet Operational Commander addressed the achievements of VP-62, stating: "The ASW expertise exhibited by your crews during operations in this ASW sector has demonstrated what well-trained dedicated men can accomplish. Your exceptional responsiveness to tasking from higher authority has demonstrated the validity of the Total Force Concept."

February 1977 marked a high point in VP-62's history as the squadron was awarded their second Noel Davis Trophy, this time for the competitive period of July 1974 through September 1976. Shortly thereafter, they sent a detachment to Cartagena, Columbia and participated with that country's air, ground and naval forces in the "Operation Alcatraz III" phase of the Halcon Vista exercise. At press time, the Broadarrows are returning from deployment at Rota, Spain where they provided support for the Sixth Fleet. Our cover picture shows one of VP-62's P-3A Orions in flight over its home port of Jacksonville.

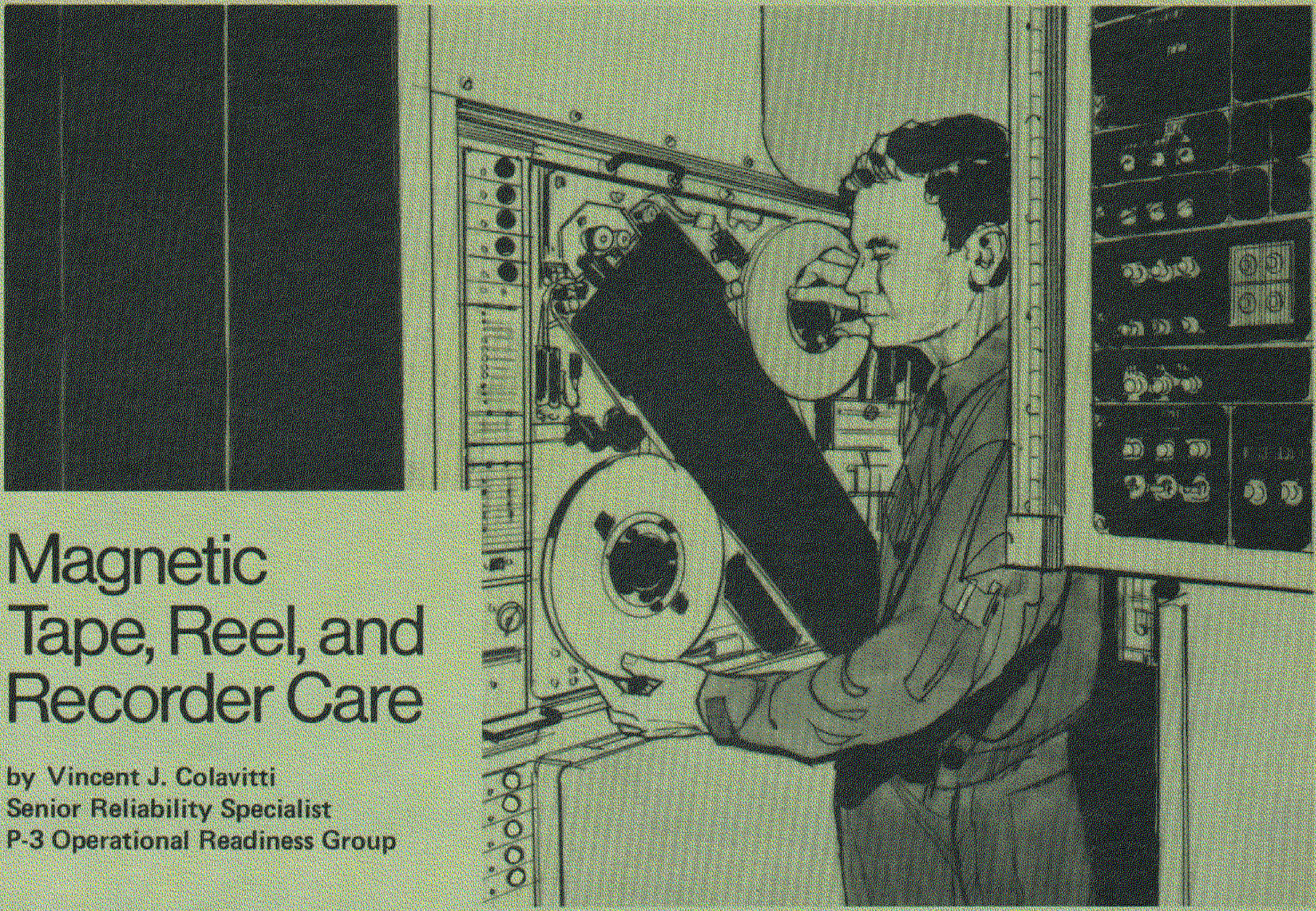
Lockheed ORION Service Digest



**COPIES REQUIRED OR CHANGE OF ADDRESS – Please send your name; present address; occupation; your organization's name; and, if applicable, your old address as imprinted on a Digest envelope to:**

**YOUR LOCAL LOCKHEED-CALIFORNIA COMPANY SERVICE REPRESENTATIVE OR LOCKHEED ORION SERVICE DIGEST, DEPT. 64-18, BURBANK, CALIFORNIA 91520.**

editor — WAYNE CRADDUCK
assistant editors — LUCILE HEMANN, EMERALD JONES
art and production by — ALLEN LUDLOFF



# Magnetic Tape, Reel, and Recorder Care

by Vincent J. Colavitti
Senior Reliability Specialist
P-3 Operational Readiness Group

The P-3 Aircraft Weapon System depends upon its magnetic tape recorder system to maintain weapon system equipment readiness, to supply operational program data, and to record mission results. In order to perform these ASW functions efficiently, the magnetic tapes, reels, recorders and support equipment require the highest standard of professional care.

In this article we shall examine the nature and characteristics of magnetic tape and tape reels. Following this, we shall discuss tape wear and damage, and tape handling and storage procedures. Topics also covered are tape erasure, recorder care and cleaning, and magnetic head degaussing.

## MAGNETIC TAPES

**TAPE COMPOSITION** Magnetic tapes are composed of a flexible backing material, magnetizable oxide particles, and a plastic binder compound. The binder compound encapsulates the oxide particles and holds them in place on the flexible backing material (Figure 1). The binder compound also contains lubricants to reduce abrasion of the magnetic head, fungicides to inhibit fungus growth, plasticizers to provide a flexible coating, antistatic agents to reduce dust attraction, and dispersants and wetting agents to evenly distribute the oxide particles.

Briefly, magnetic recording tape is produced as follows: First, the oxide particles are mixed with the plastic binder compound, then this mixture is applied wet to the flexible backing material. (At this point in production, the coating mixture is viscous and the encapsulated oxide particles can still be moved.) Next, the tape is passed through a magnetic field to orient its oxide particles uniformly in a specified direction – longitudinally for use with fixed magnetic heads, and transversely for use with rotating heads. The coating mixture, with its properly oriented oxide particles, is then dried onto the backing material. The coating is subsequently polished to a relatively smooth finish.

The oxide particles are the key elements in a magnetic tape. Each particle must be as near uniform in shape, size, and magnetic properties as possible. An ideal oxide particle is acicular (needle-shaped), about 5 to 40 microinches long, and has a length-to-width ratio varying from about 4:1 to

10:1. Broadly speaking, long particles are used to record long wavelength signals, and short particles to record short wavelength signals.

Oxide coating thickness is another wavelength-related factor that influences a tape's frequency response. Short wavelengths are recorded near the surface level of the oxide coating, while the longer wavelengths penetrate more and more of the oxide coating sublayers. Since a tape is designed to suit a particular range of wavelengths, its coating thickness usually is a compromise (chosen in conjunction with a given oxide particle size) that accommodates the shortest and longest wavelengths of the specified frequency range.

Traditionally, magnetizable particles have been a form of iron (gamma ferric) oxide. However, since 1965 chromium dioxide particles and thin films of iron-chromium-nickel compositions also have been used.* Tapes featuring these newer coatings have increased storage density and wearability. These tapes also require greater magnetic force (i.e., higher energy) to record and erase the signal, which enables the recordings to have higher signal-to-noise ratios.

Both cellulose acetate and polyester base films have been used as the backing material for magnetic tapes. Polyester films (Mylar, Scotchpar, etc.) have superior dimensional stability, tensile strength, tear strength, toughness at high temperatures, and resistance to mildew and fungus. Because of these superior characteristics, polyester films have been the predominant backing material for high performance magnetic tapes during the past 10 to 15 years.

**TAPE TYPES** Just as a magnetic recording system is designed to perform a particular function, so must the tape be designed to meet the electrical, magnetic and mechanical requirements of that recording system. For example, today's P-3 community uses both analog and digital data recording systems. Consequently, two basic types of magnetic recording tape are in common use – instrumentation (analog) tape and computer (digital) tape.

*Although these newer materials may have little, if any, chemical relationship to iron oxide, it has become common practice with magnetic tapes to casually refer to all magnetizable materials as "oxides" and magnetizable coatings as "oxide coatings."*

**Instrumentation Tapes** For ASW applications, magnetic instrumentation tapes are designed primarily to record analog acoustic signals. Since these tapes are generally used outside the relatively benign confines of the Tactical Support Center, they must be tough, dimensionally stable, and damage-resistant. They also must have high signal sensitivity and frequency response, low harmonic distortion, and be free of defects that would cause signal dropouts.† There are four basic grades of instrumentation tapes:

1. Standard Resolution ("B" oxide coatings)
2. High Resolution ("E" oxide coatings)
3. High Output (no oxide coating designation)
4. High Energy (no oxide coating designation)

*Standard Resolution Tapes* are used to record low band and intermediate band signals with good recording resolution. They are compatible with

†*Dropouts are generally defined as a 50 percent reduction in signal strength for more than 10 microseconds. More complex definitions of dropouts exist but are beyond the scope of this article.*

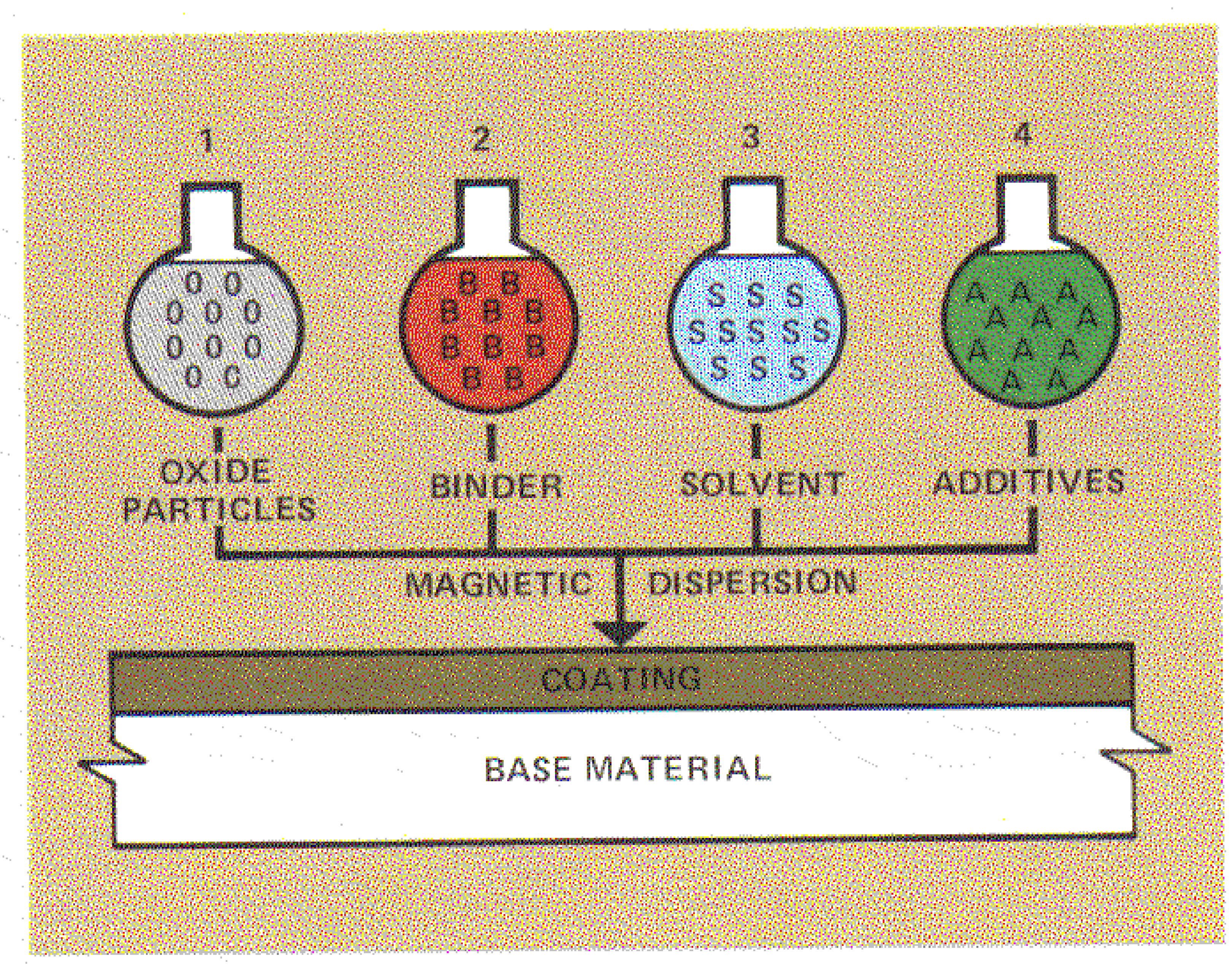



*Figure 1. Magnetic Recording Tape Composition. Magnetic dispersion solution coating is applied to the film base material.*

recorder/reproducers that have the capability of recording wavelengths as short as 0.24 mil (31,250 Hz at 7.5 ips).

*High Resolution Tapes* are used for wideband recording applications. Wavelengths as short as 0.06 mil (125,000 Hz at 7.5 ips) may be recorded. High resolution oxide coatings are defined in NSA (National Security Agency) Specification L14-2-75 as those oxides "designed to linearly record more than 5000 sine waves per longitudinal inch."

The AQH-1 and AQH-4 recorders were designed and adjusted to operate with "B" oxide tapes, such as types 766 and 871. However, the current "E" oxide tapes (such as types 786 and 795), although technically "wide band" tapes, appear to operate satisfactorily on the AQH-4 recorder without the need for readjusting the machine. With this development, the goal of using a single type of tape for all acoustic recorders is one step closer. This development is particularly timely because the forthcoming AQH-4(V)2 recorder, a 28-track wideband machine, is scheduled to enter service late this year.

Within the "E" category of oxides, there are two qualities: E1 and E2. E1 oxide tape permits up to 40 dropouts per 100 feet, while the higher quality E2 oxide tape permits only 15 dropouts per 100 feet. The AQH-4(V)2 recorder is designed for use with E2 oxide tapes, such as type 795.

*High Output and High Energy Tapes* Tapes with High Output (HO) oxide coatings are capable of making recordings with signal-to-noise ratios (SNR's) of 26 to 28 db, and are designed for wideband recording. Tapes with High Energy (HE) oxide coatings can make recordings with SNR's of 28 to 30 db, and operate in the same frequency range as HO tape. The higher SNR performance of HO and HE recording tapes is achieved through the use of newer oxides and refinements in the oxide coating. These refinements reduce the recording system's sensitivity to noise, while enhancing its ability to process signals of higher amplitudes.

Two new HE oxides are predominant today: chromium dioxide and cobalt-doped gamma ferric oxide. Tapes with these coatings require (a) higher record and bias current drive, and (b) optimum equalization in the recorder in order to take full advantage of the HE oxide's properties. However, there are a good many recording systems in use today that are incapable of using high energy tape without modification of their drive and equalization circuitry. Therefore, widespread use of high energy tapes in the future will probably be paced by the adaptability of the recording systems presently in use in the field.

**Digital Tape** Digital recording tape has design features tailored specifically for the computer application. For example, its base film thickness is about 1.5 mils compared to the 1.0 mil base film thickness of analog tape. The added thickness enables digital tape to withstand the more strenuous acceleration and deceleration forces inherent to digital computer search, read and write operations.

Digital tapes are held to much more stringent quality control standards than are analog tapes, particularly with regard to surface blemishes and coating imperfections. (The loss of one digital data bit can be far more significant than a brief discontinuity in an analog waveform.) The highest quality digital tapes are checked thoroughly before delivery, reel-by-reel, and are certified by their manufacturers as "error-free."

**Tape Backcoating** Recently, tape manufacturers have converted their production almost exclusively to backcoated tapes – both analog and digital. The backcoating is a finely textured, highly conductive, carbon-based layer that is applied to the tape in much the same way as the oxide coating, only it is much thinner. (See Figure 2.)

The backcoating is designed to serve several functions. It minimizes static electricity buildup on the tape so that contaminants will not be attracted and

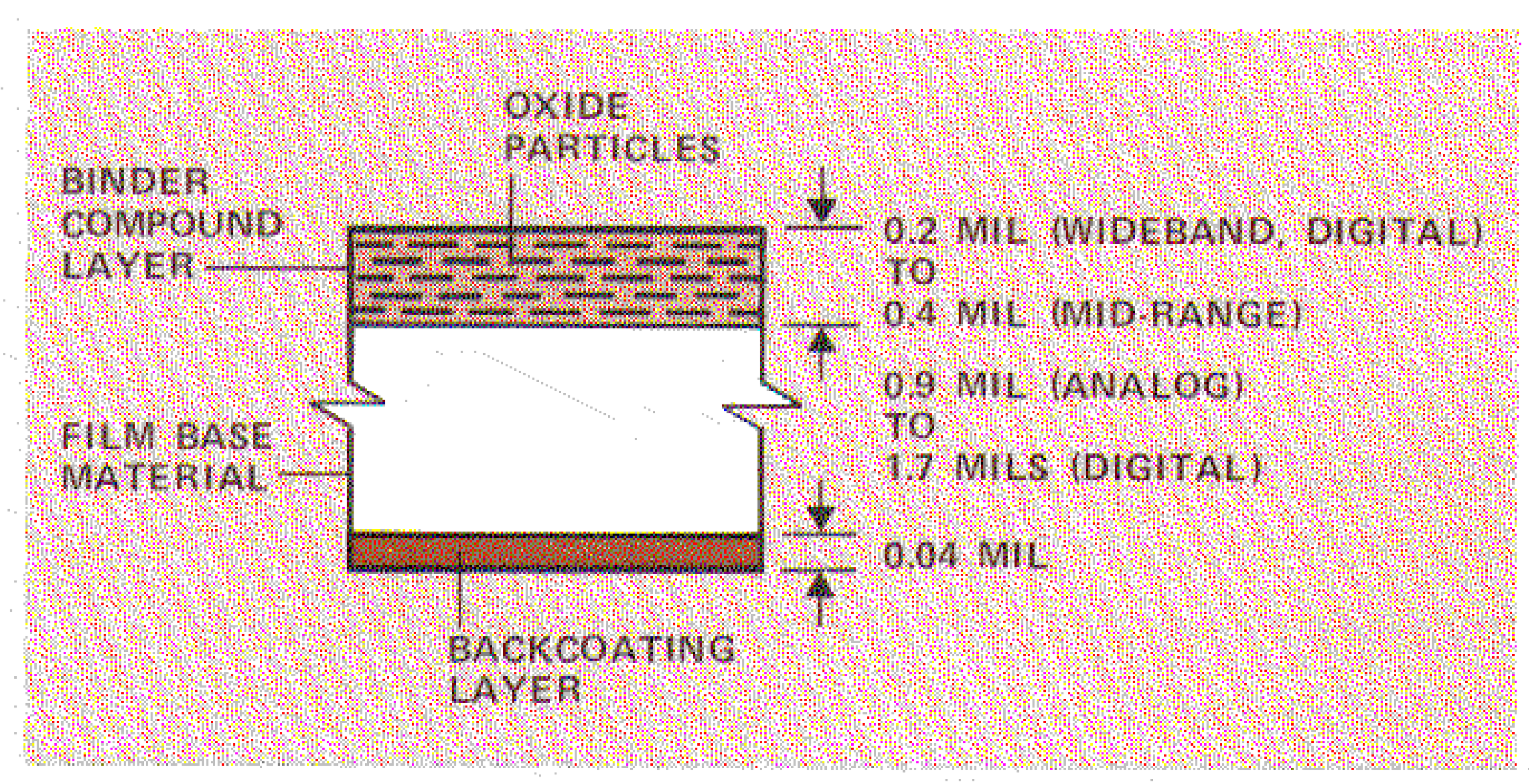



*Figure 2. Magnetic Tape with Backcoating.*

held. It provides the tape with a controlled coefficient of friction. This prevents cinching and pack slip, and improves tracking as the tape passes through the transport. It also resists abrasion, thus minimizing the shedding of wear products. Finally, the backcoating is somewhat compressible. It will absorb some distortions caused by particles that may become entrapped within the tape pack.

**IMPORTANT TAPE CHARACTERISTICS** A number of tape characteristics are evaluated before a given type of tape is selected for service use. Characteristics of particular importance in the ASW environment are: stick-slip, oxide uniformity, abrasivity, and tendency to shed.

**Stick-Slip** Friction may cause tape to instantaneously "stick" to the magnetic head. Then, as friction is overcome, the tape will accelerate or "slip." This uneven movement across the head distorts the signal being recorded or reproduced. The stick-slip characteristics of a tape depend upon its binder's susceptibility to moisture, heat and pressure. The extent of stick-slip can be determined by first accurately recording a signal of a specific frequency within the tape's design bandwidth, then reproducing that signal and carefully measuring its period for uniformity. Any frequency variations are an indication of stick-slip. (Other factors such as tape and head cleanliness, reproducer drift, and tape path alignment must be closely controlled because they, too, will give similar symptoms.)

**Oxide Uniformity** A tape's performance depends heavily upon the physical characteristics of the oxide particles and their distribution in the coating's binder material. Tape with high quality performance characteristics must have an oxide coating whose thickness is uniform and whose oxide particles are evenly distributed. Further, the size and density of the particles must be consistent with the wavelength or bit packing density that is to be recorded. If any of these physical prerequisites is lacking, dropouts will occur.

**Abrasivity** The frictional characteristic of tape that produces wear on the fixed surfaces of the tape transport is termed "abrasivity." A tape's abrasivity increases as the hardness and roughness of its coating increase. Ineffective lubricants in the coating mixture can also make a tape more abrasive. This characteristic is measured very carefully during tape qualification testing to screen out excessively abrasive tapes that might cause a high attrition of magnetic heads.

**Tendency to Shed** A tape's tendency to shed particles is related to its backing and binder composition, and to processing factors such as the slitting techniques that are employed during its manufacture. An additional consideration is the coating's surface texture – the rougher the surface, the more likely it is to shed particles.

**CONTAMINANTS AND THEIR EFFECTS** When contaminants come between the tape and magnetic head, the recording system suffers performance degradation. As mentioned above, the tape itself is one source of contaminants via shedding. During record and replay, oxide or backing particles that are shed by the tape will be deposited on the tape transport's fixed surfaces (e.g., the heads and guides) and slowly accumulate to form projecting lumps. Eventually, during subsequent operation, these lumps will be dislodged from the transport and deposited on the tape's surface – often becoming as firmly attached to the tape as the oxide coating itself (see Figure 3). When this contaminated tape is used subsequently, these lumps will cause separations between the tape's surface and

*Memorex Corporation*

*Figure 3. Redeposited Debris on Surface of Well-Worn Tape. Magnified 50X.*

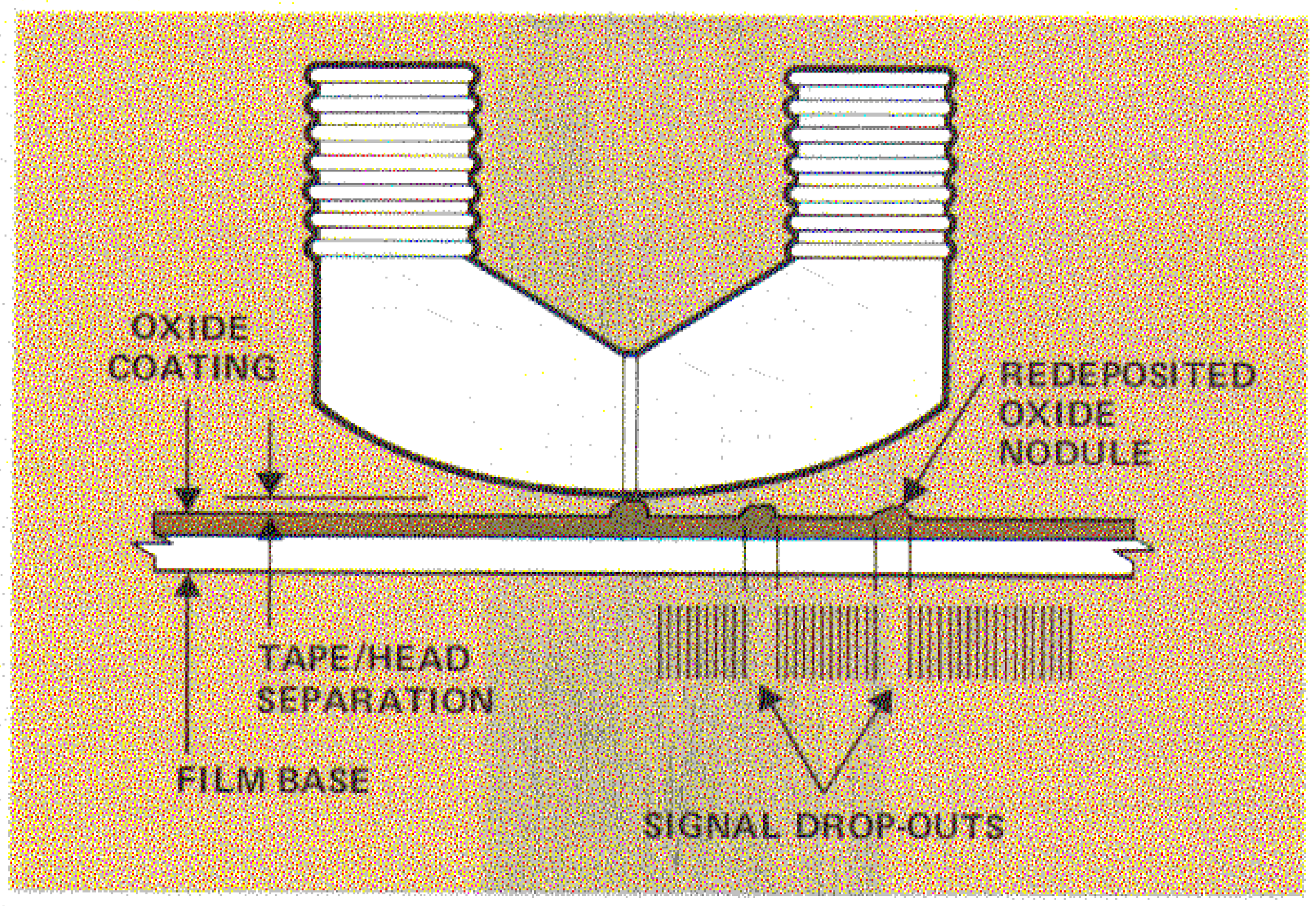



*Figure 4. Spatial Separations between Tape and Transport Head Caused by Oxide Deposits Result in Signal Dropouts.*

the transport heads that will cause signal dropouts (Figure 4).*

Both digital and analog recording systems are vulnerable to signal dropouts caused by contaminants. For example, in a typical digital computer tape drive operating at 800 bits per inch, a lump protruding only 150 microinches from the tape surface will cause a 50 percent signal reduction. To illustrate just how small such a lump is, relative to the tape itself, a 150-microinch particle on a 1/2-inch tape would be similar in proportion to a BB-pellet resting upon a 50-foot wide highway. Spatial separations affect analog recording systems similarly, increasing dropouts, modulation noise and nonuniform signals, and reducing the system's short-wavelength response (see Figure 5).

In the final analysis, the operator is the key to good tape system performance. He can minimize performance degradation by inspecting his equipment closely and frequently, and by cleaning it thoroughly and regularly.

**TAPE TEMPERATURE LIMITS** Ideally, magnetic tape should be used and stored at a constant temperature of about 70°F (21°C). However, if wound properly, high quality tape can withstand storage temperatures that range from -40°F (-40°C) to about +150°F (+66°C) without suffering severe damage. It is mandatory, though, that following such exposure the temperature of the tape be stabilized at approximately 70°F (21°C) for 24 to 48 hours and the tape be recertified before it is used again. The magnetic properties of tape oxide particles remain stable even beyond the above mentioned temperature limits of the tape's binder compound and backing material.

**RELATIVE HUMIDITY (RH) LIMITS** The ideal relative humidity for storing and using tape is about 45 percent. Appreciable change from 45 percent RH will cause the tape to expand or contract proportionately and thus affect the uniformity of its oxide coating. (Tape stretches as the RH increases.) Furthermore, high RH also adversely affects the *frictional* characteristics of the tape, causing increased head wear, head clog by oxide particles, and head-to-tape sticking. To avoid these effects, tapes should be operated in an environment below 55 percent RH if at all possible.

On the other hand, very low relative humidity encourages oxide shedding. Low RH also increases the static buildup on the tape surfaces, giving the tape a greater tendency to collect airborne contaminants.

One final note. There is a little understood phenomenon called "brown stain" that occurs at RH's below 30 percent, particularly when tape transports are operated at speeds of 75 ips or greater. This stain occurs on the face of the head in the area where the tape makes contact. Although

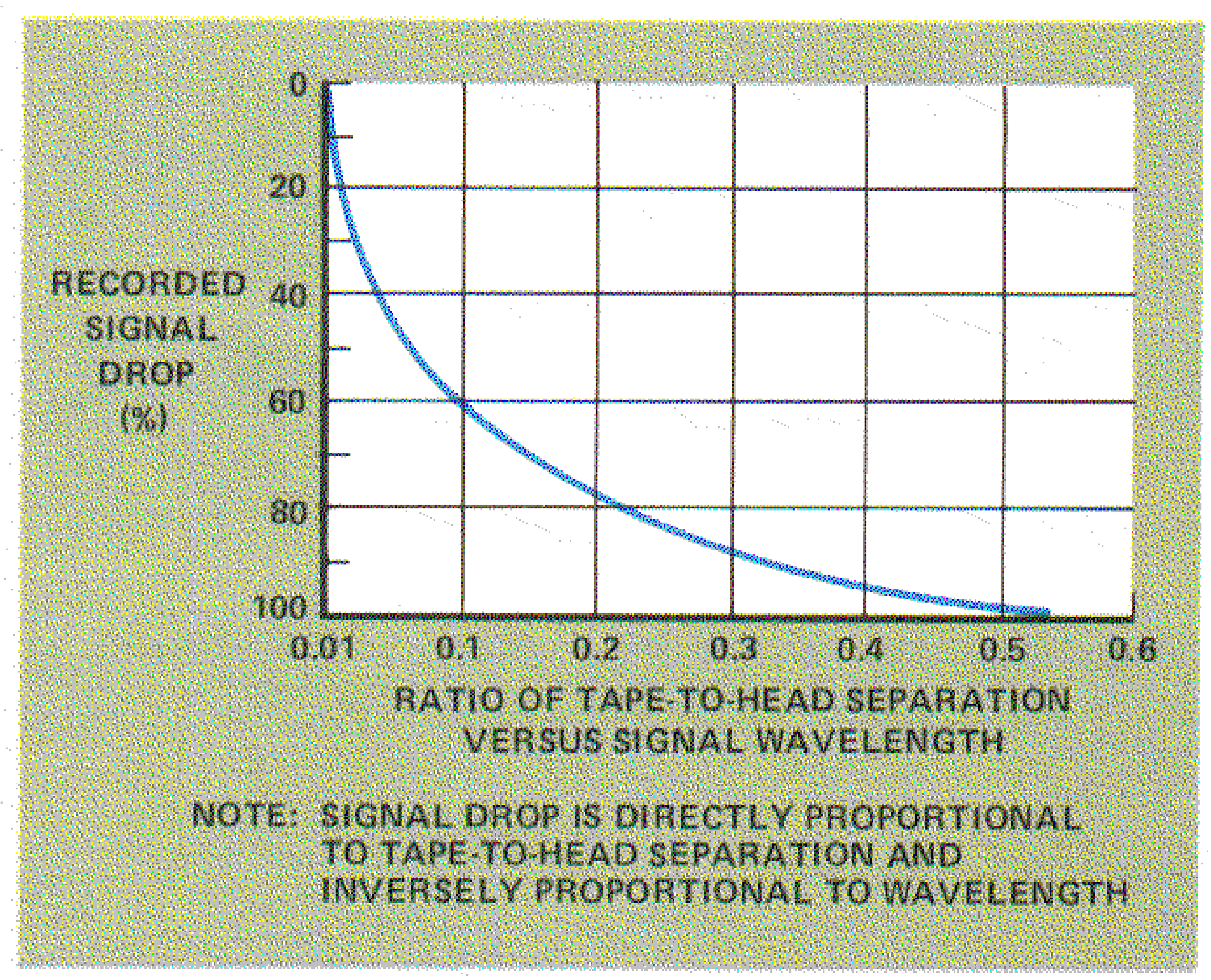



*Figure 5. Signal Drop versus Ratio of Tape/Head Separation to Signal Wavelength.*

---

*Accumulations of dust, lint, oils, and other contaminants that may adhere to the tape's surface can produce the same effect.*

the stain is usually brown, it may also appear to be bluish or greenish. Presently, brown stain is thought to be a chemical reaction within the head material that occurs at low RH in the presence of high temperature and friction.

Brown stain occurs on most head materials, including mu metal, but not on ferrites. The stain develops even when the polyester backing alone – without the oxide coating – is passed over the head. It creates a magnetically inactive "bulge" on the head that spoils tape-to-head contact and causes signal loss. At present, the only practical means of removing brown stain is by abrasion. For example, the stain may be removed by passing abrasive "green" tape over the head. However, this procedure must be done with the utmost care or too much head material will be removed.

**ADVERSE EFFECTS OF TEMPERATURE AND R/H EXTREMES** Temperature and humidity extremes affect both the tape's and the head's physical properties, and consequently cause system performance to degrade. Some of the more significant adverse effects are: tape deformation; increased oxide shedding; head-to-tape sticking; and layer-to-layer adhesion.

**Tape Deformation** Magnetic recording tapes are wound under tension on reel hubs, creating considerable layer-to-layer pressure within the reel pack. Changes in ambient temperature (as with changes in relative humidity) cause the tape's backing material to expand or contract, creating pressure changes within the pack that can be tremendous. These pressure changes, in conjunction with those pressures already present within the reel pack, can seriously deform the tape and, surprisingly enough, the reel hub as well.

Fabrication of reel hubs from aluminum or magnesium can help prevent such tape deformation. These metals have coefficients of expansion similar to that of the tape. This permits both the tape and reel hub to expand and contract at very nearly the same rate, at least when temperature variations are *gradual*.

However, when temperature changes are *rapid*, internal pack pressures will develop even though the reel hub is made of aluminum or magnesium. This occurs because the metal hub is a much better heat conductor than the polyester tape. As the ambient temperature changes, the inner layers of tape will stabilize at the hub temperature faster than the outer tape layers. If the ambient temperature variation is both rapid and great, one segment of the reel pack will be substantially warmer than the other. This wide temperature differential between segments of the reel pack will cause one segment to expand faster than the other, resulting in distortion. It is worth repeating that when there is a wide temperature difference between the stored tape and the environment in which it is to be used, a substantial period (at least 24 hours) should be allowed for gradual temperature stabilization before using the tape.

Many authorities believe that internal pack stresses and their resultant adverse effects can be prevented by winding the tape to a "programmed" (variable) tension profile. Programmed tension will be discussed later in this article.

**Oxide Shedding** The tape's oxide coating will deteriorate when it is exposed to extremes in temperature. Below -40°F (-40°C) most binders become brittle, and above 150°F (66°C) they begin to soften. At either temperature extreme the binders free magnetic particles from suspension and, at very low temperatures, the binders themselves may flake off. Oxide particles may be redeposited as lumps on the tape's oxide surface and cause tape-to-head separation. Oxide particles also may accumulate on the tape transport's head gap areas and magnetically short the heads.

**Head-To-Tape Sticking** At higher temperatures the tape binder material can soften to the extent that the tape will adhere momentarily to the tape transport head (stick-slip). The length of time that the tape remains stuck to the transport head depends upon the temperature differential between the head and the tape. Head-to-tape sticking produces irregular tape motion (wow or flutter); in extreme cases it can prevent tape movement completely.

**Layer-to-Layer Adhesion** At the upper temperature extreme the tape binder material can get hot enough to cause one layer of tape to adhere to an adjacent layer. This condition is called "blocking." When blocking is mild, the tape layers will tend to stick to one another slightly as the tape is unwound from the reel. This may cause disturbances in the tape tension control, but will not damage the tape. However, when blocking is severe, the tape's oxide coating may delaminate from the base film and destroy the tape.

The physical properties of the tape's binder determine the temperature at which blocking begins to occur. On some tapes mild blocking may begin as low as 150°F (66°C); blocking generally occurs on all tapes by the time the tape temperature increases to 200°F (93°C).

**SPOOLING DEFECTS** We have described how thermal and elastic forces can damage tape. Likewise, mechanical forces associated with winding the tape can cause tape damage. These deformations are termed "spooling defects." They are caused by improper winding practices that apply excessive or uneven energy to the tape pack, and thus deform it. The most common spooling defects are cinching, pack slip, spoking, and windowing.

**Cinching** When rapid deceleration is applied to a reel, inertia tends to cause the outer layers of tape to continue spinning momentarily after the hub and inner tape layers have stopped. This will cause any loosely wound lengths of tape within the pack to unwind and pile up between adjacent layers. Such pack deformation is called cinching, and is illustrated in Figures 6 and 7.

**Pack Slip** When a tape is wound with too low a tension and then subjected to vibration or thermal stresses, portions of the tape pack can shift laterally, causing "steps" in an otherwise smooth winding. This defect is called pack slip. Thereafter, when the tape is used, it will unwind unevenly and probably contact the reel flange or transport guide edges. The result – a damaged tape edge and perhaps a lost edge track. No doubt, the ever-present oxide shedding will increase too. Furthermore, skewed tape travel across the transport head and associated performance degradation often accompany pack slip. Where only single strands of tape slip, their edges become particularly susceptible to damage from compressed reel flanges. Figure 8 illustrates the scattered wind associated with pack slip, and Figure 9 shows the type of edge damage that will usually follow.

**Spoking** When a tape is wound initially at relatively low tension, then tension is increased toward

*3M Company*

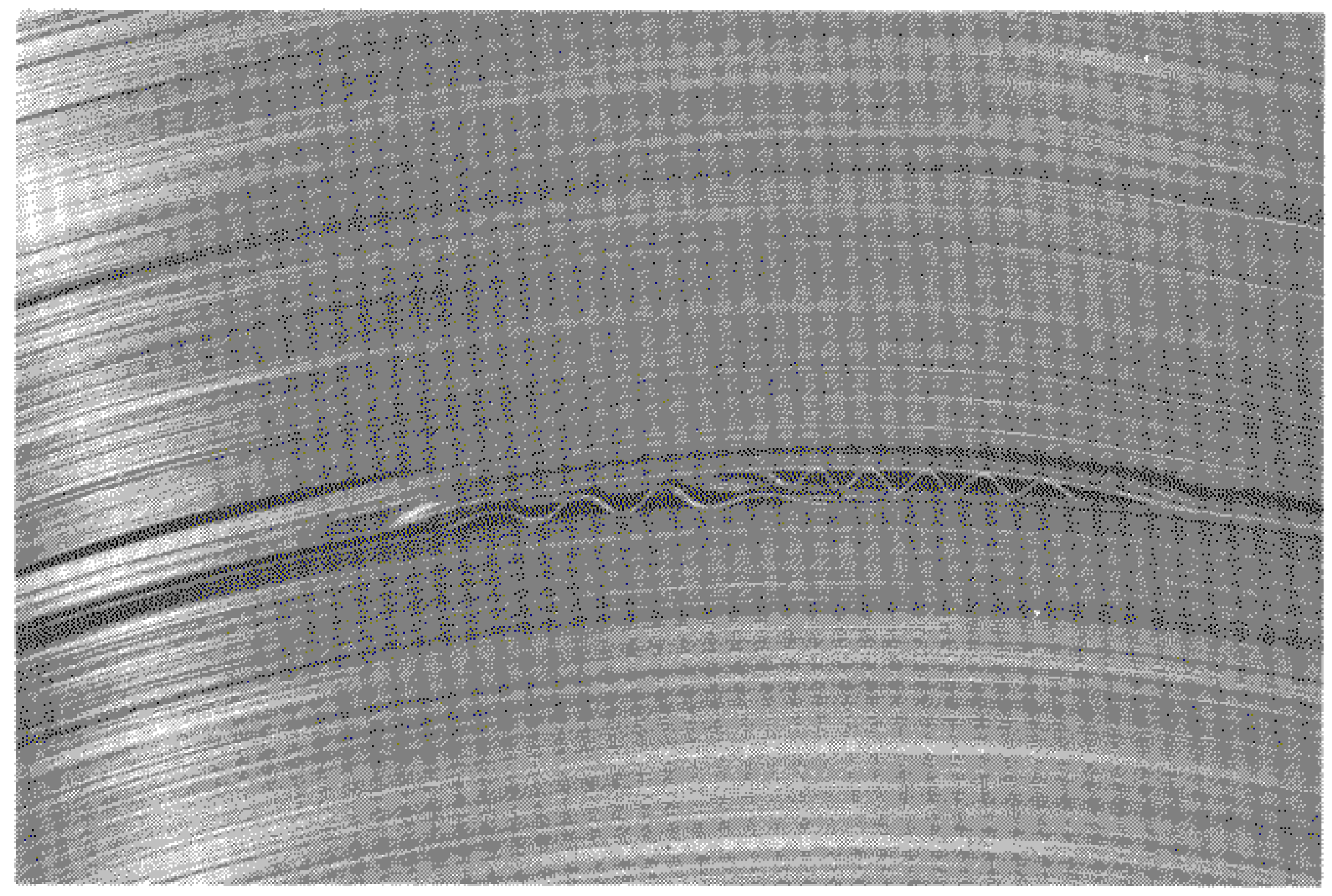


*Figure 6. Cinched Tape. Note the complete foldover of one tape strand.*

*3M Company*

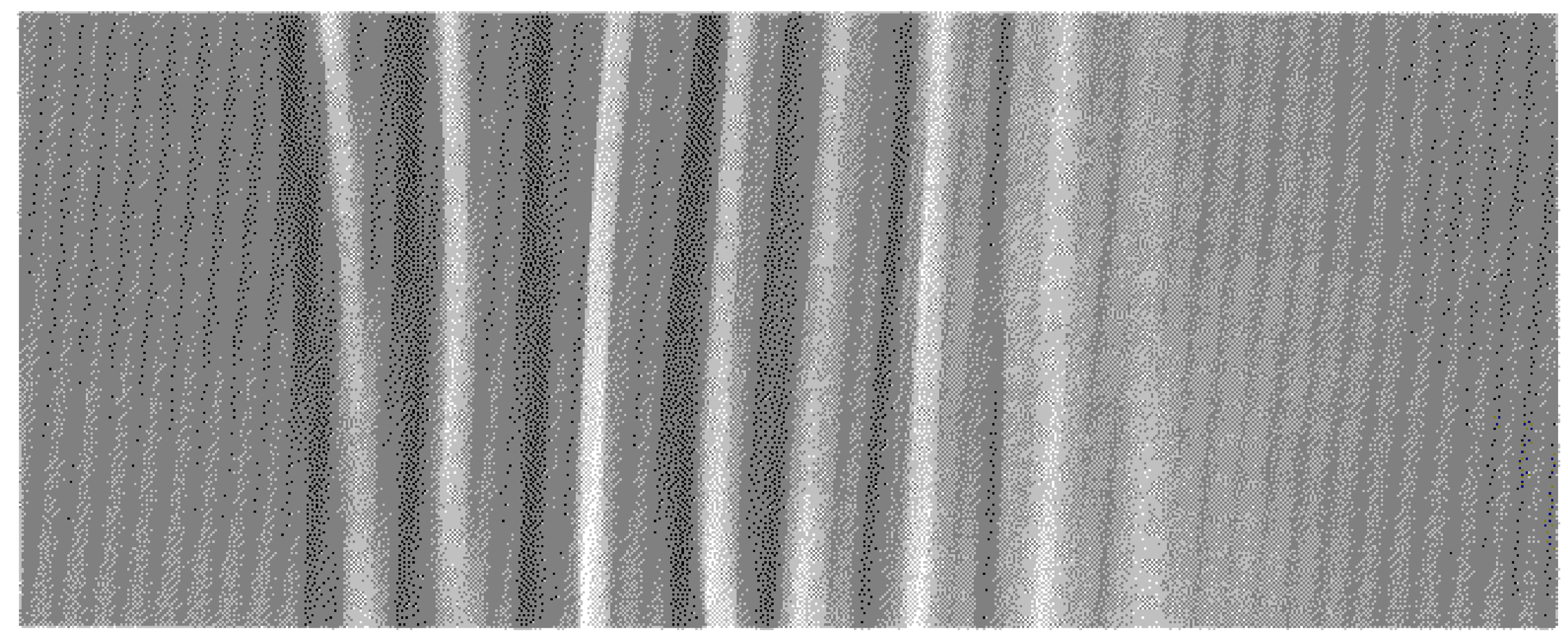


*Figure 7. Tape Damage Caused by Cinching. This 1-inch long strand of 1/2-inch computer tape has washboard-like wrinkles caused by cinching.*

*3M Company*

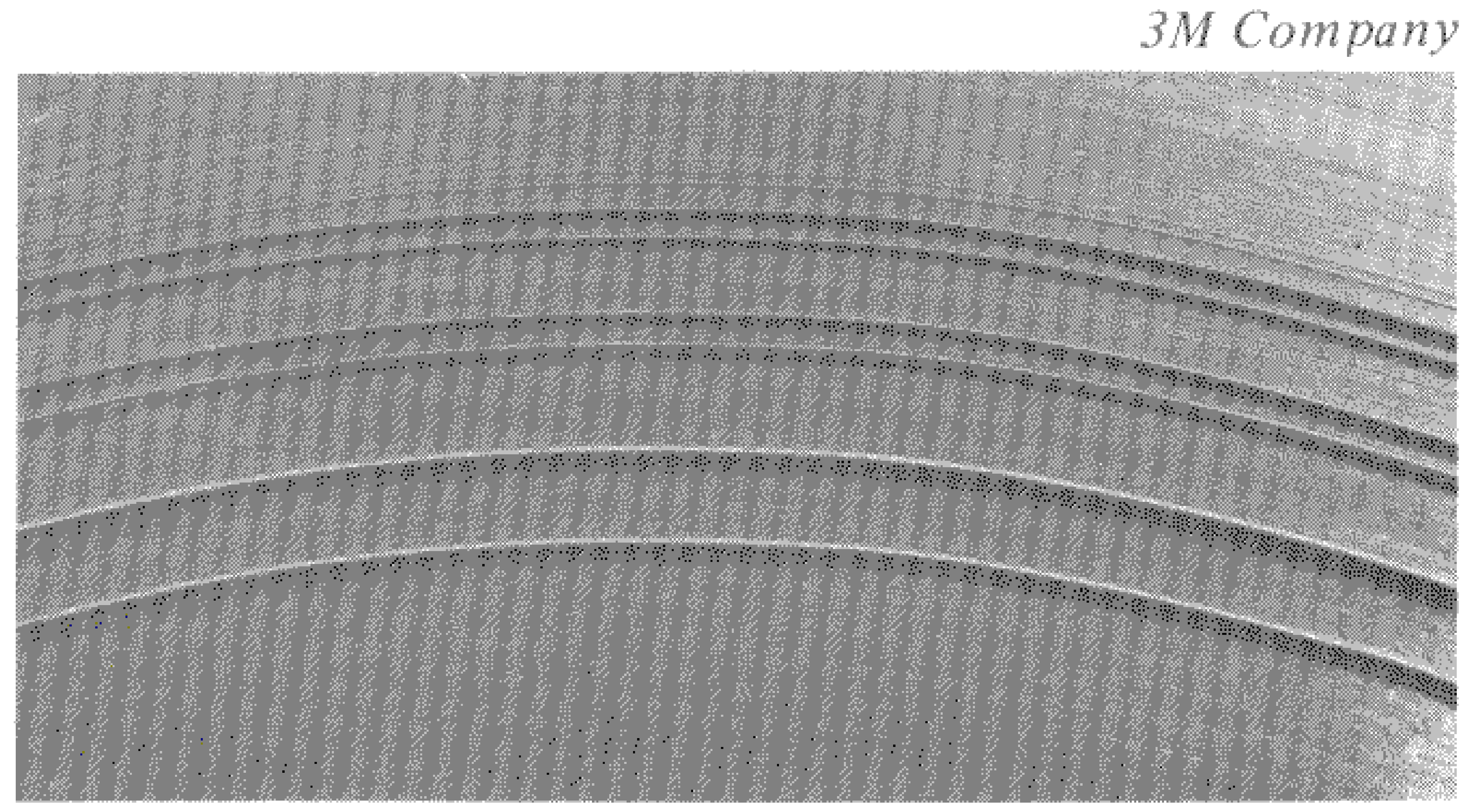


*Figure 8. Scattered Tape Wind. Individual strands of tape are exposed and vulnerable to damage.*

*3M Company*

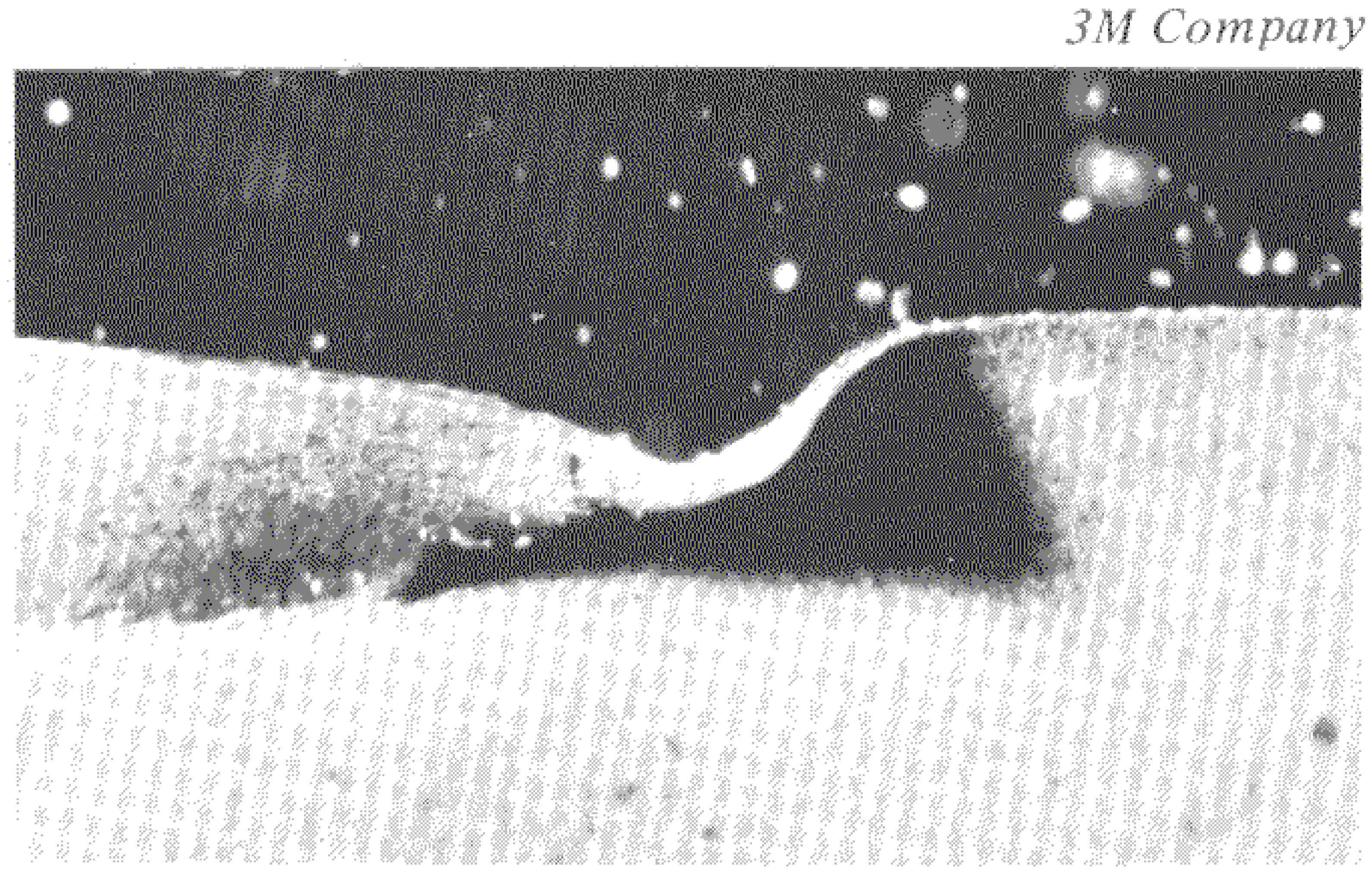


*Figure 9. Enlarged View of Damaged Tape Edge. Affected area extends about 15 mils into the tape.*

the end of the winding, high radial compression forces may buckle the tape pack into a polygon-like shape. This form of pack deformation is called spoking (Figure 10). The uneven pressures produced by winding a tape on a distorted hub also can cause spoking, even if the hub distortion is only slight. Spoking can also result from winding tape over a small particle that has been deposited on the hub.

**Windowing** Loose windings can lead to voids or "windows" in tape packs (Figure 11), especially those packs that are later subjected to temperature or humidity extremes. Windowing can occur independently of other spooling irregularities, or it can be accompanied by one or more of them.

**Conclusion** Naturally, a tape that becomes deformed due to any of these spooling defects will perform unsatisfactorily. A deformed tape will not maintain the intimate tape-to-head contact that is needed for the efficient transfer of magnetic energy. In many instances deformed tape can be rehabilitated by rewinding it into an even pack, then allowing it to stand for two days or so in the recommended 70°F/45 percent RH environment. Thereafter, it should be cleaned and evaluated before being returned to service.

## REELS

**GENERAL** The importance of the tape reel is often overlooked, for it is generally considered to be merely a tape storage container. However, the fact is that the reel is an integral part of the recorder's tape transport system. Its basic function is to protect the tape from damage and contamination. Ironically, it is often the reel itself, damaged through mistreatment, that in turn damages the tape. For this reason we shall discuss at some length (1) the important design features of a reel, (2) the different types of reels, and (3) the proper care and handling of reels.

**REEL DESIGN** A reel is basically made up of the hub and two flanges (Figure 12). Their design and the reel's moment of inertia are crucial aspects that determine how effectively the reel functions as a tape protector.

**Flanges** The reel must be designed to enable the tape to wind and unwind without contacting the flanges. Any contact of the tape with the flange will usually result in tape edge damage and loss of the edge recording track. Therefore, the flanges must be spaced evenly and they must be sufficiently rigid to withstand normal handling pressures and resist accidental nicking or gouging.

The flanges *do not* serve to guide the tape or help provide an even reel pack. To suggest this function would imply that it is permissible for the flange to

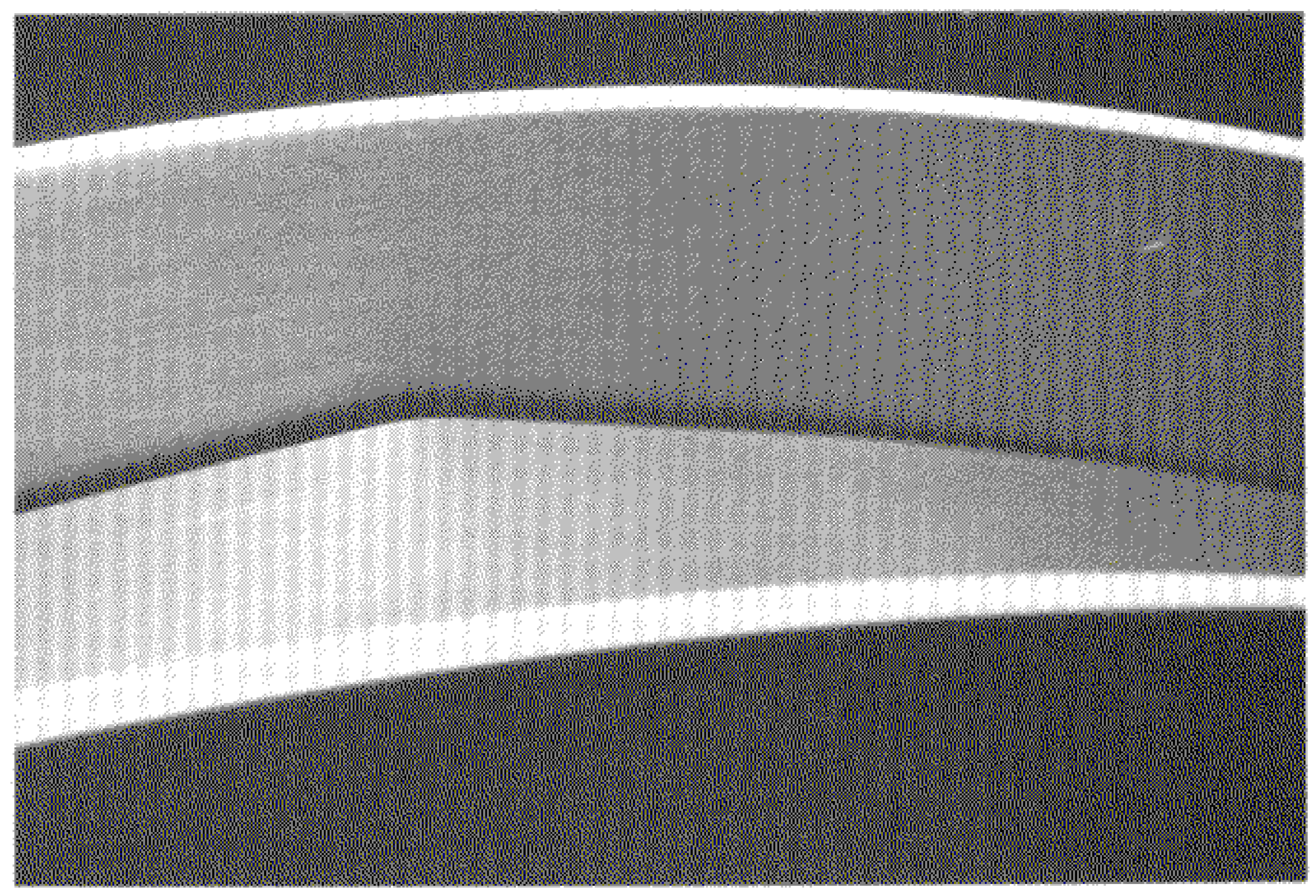


*Figure 10. Spoked Tape Pack.*

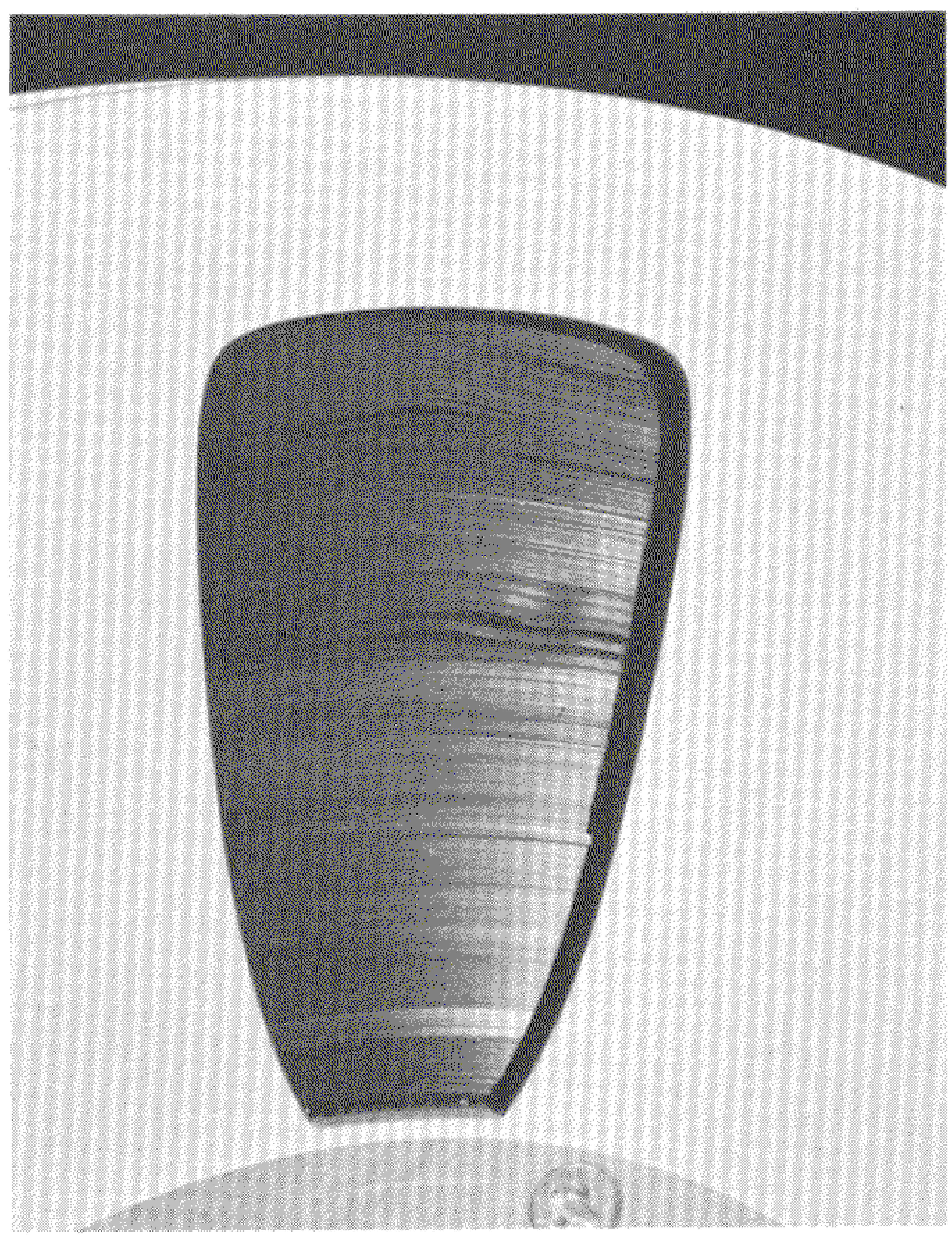


*Figure 11. Windowed Tape Pack.*

contact the tape. Such contact must be avoided for the reasons stated above.

**The Hub** It is vital that the hub be as near a perfect cylinder as possible, both on its inner and outer surfaces. If the hub inner surface is out of round, the reel will wobble on its spindle and feed the tape erratically onto the transport. This will almost certainly result in tape edge damage and skewed tape travel across the transport head. There is not much room for tape skew on today's ASW recorder, especially with the high bit-packing densities of contemporary digital recordings.

If the hub outer surface is out of round, the tape will stretch as it is stacked on the reel. When the deformed tape is replayed, signal distortion will occur. In addition, the stretching will create unevenly distributed tension within the stacked reel pack. This will cause erratic movement when the tape is subsequently unwound, which will contribute to the other spooling defects discussed previously.

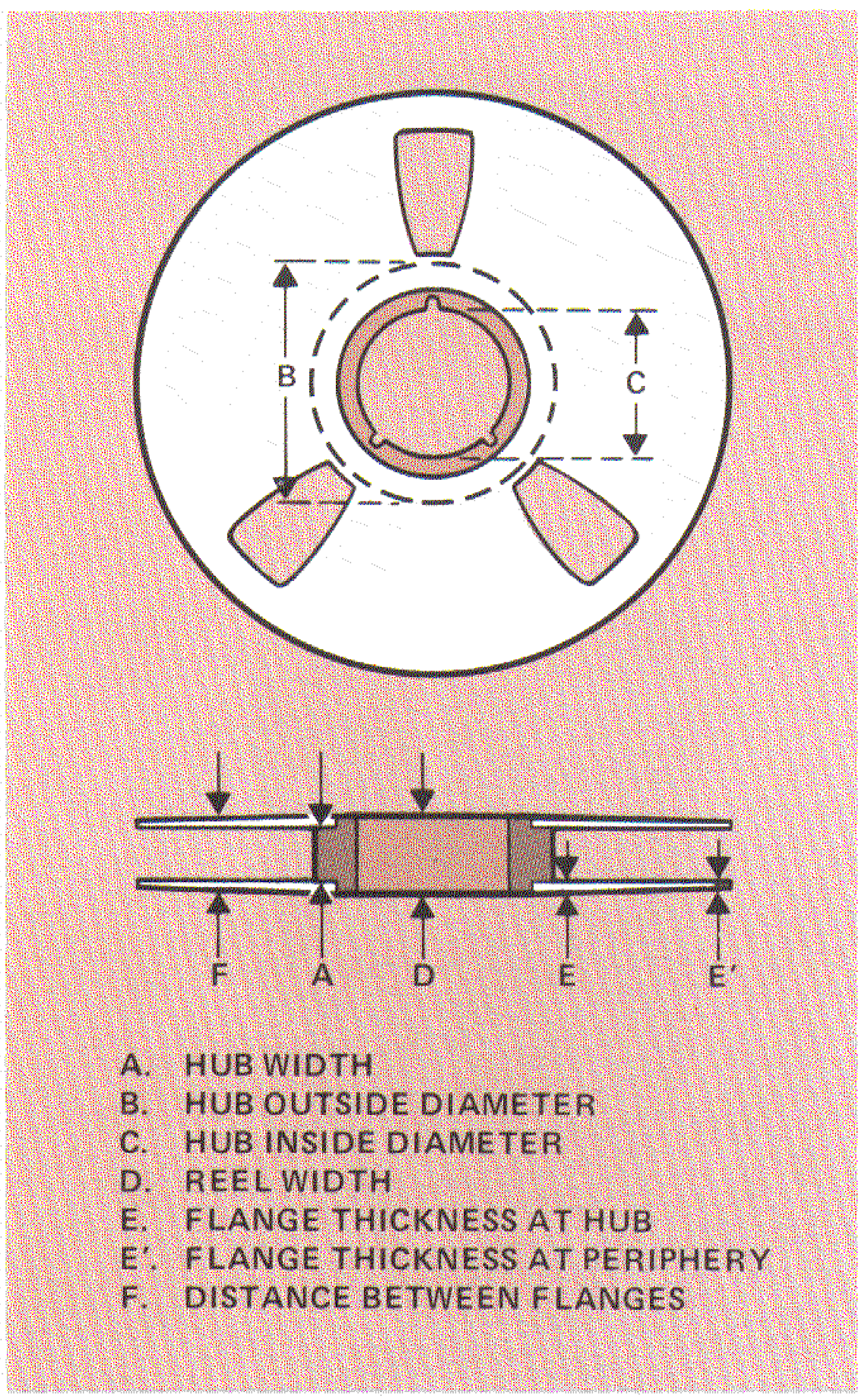



*Figure 12. Typical Reel Components and Their Reference Dimensions.*

Foreign particles on the reel hub surface also can cause the tape to stretch and create unevenly distributed tension within the reel pack. This is why it is imperative that the reel be routinely and frequently inspected and cleaned.

**Reel Inertia** During normal tape transport operations — particularly in computer applications — tape reels are subjected to rapid starts, stops and direction reversals. These rapid changes of rotational movement can create large moments of inertia. This is especially true at the outer circumference of a fast-spinning reel with thick flanges. We have previously seen how excessive reel inertia can subject the tape to undue stress. Excessive reel inertia will also adversely affect rotating and braking components of the tape transport, shortening their overall service life. Consequently, reel manufacturers generally keep mass to a minimum after other design requirements are satisfied.

**PRECISION REELS** P-3 tape transports require tape reels that are fabricated to close tolerances and have superior stability and flange rigidity. Only precision reels meet these requirements. Precision reels may be classified by their flange material (metal or glass) and by their service rating (instrumentation or heavy duty).

**Flange Material** Precision metal reels (Fed. Spec. W-R-175/4) have precision fabricated metal flanges and accurately machined metal hubs. These features provide better reel-for-reel interchangeability and uniform reel performance.

Precision glass reels (Fed. Spec. W-R-175/6) have precision fabricated glass flanges and accurately machined metal hubs (Figure 13). The chemically-strengthened glass is about 10 times as strong as ordinary glass. Reel flanges made of this material are coated with a tough plastic material that will restrain glass fragments should failure occur. Precision glass reels provide all the advantages of precision metal reels, plus the added advantage that (for all practical purposes) the flanges will not distort.

**Service Rating** Metal precision reels are classified as Instrumentation Reels (IR) or Heavy Duty Instrumentation Reels (IRH). IR reel flanges are 90 mils thick at the center, and taper on the outside surface to a thickness of 50 mils at the reel periphery. IRH reel flanges are uniformly 90 mils throughout.

The IR reel's tapered flange design gives it the desired low moment of inertia while still providing adequate flange strength and stability.

The IRH reel is a heavy duty reel with nontapered flanges designed for applications where the reel's moment of inertia is not a deciding factor. One such application is low speed acoustic recording. Maximum strength is inherent in the IRH reel flange design. This flange resists deflection and protects the tape from damage under most rigorous conditions.

The only types of tape reels recommended for use on P-3 aircraft with AQH-1, AQH-4, AQH-4(V)2, RD-319, and RD-319A equipment are precision reels – metal or glass. Reels with glass flanges are preferred because (a) the glass flanges resist flexing and (b) the glass flanges have no apertures that would permit contaminants to reach the tape.

During the past few years the National Security Agency (NSA) has conducted studies of tape reels. These studies have revealed that signals reproduced from exposed portions of tape mounted on metal-flanged reels have developed variations in amplitude uniformity. These signal variations were attributed to one or more of the following factors:

1. Expansion or contraction of the tape caused by temperature and humidity changes

2. Uneven tape pack stresses caused by varying air pressure during pack winding

3. Contaminants

4. Tape damage caused by physical handling

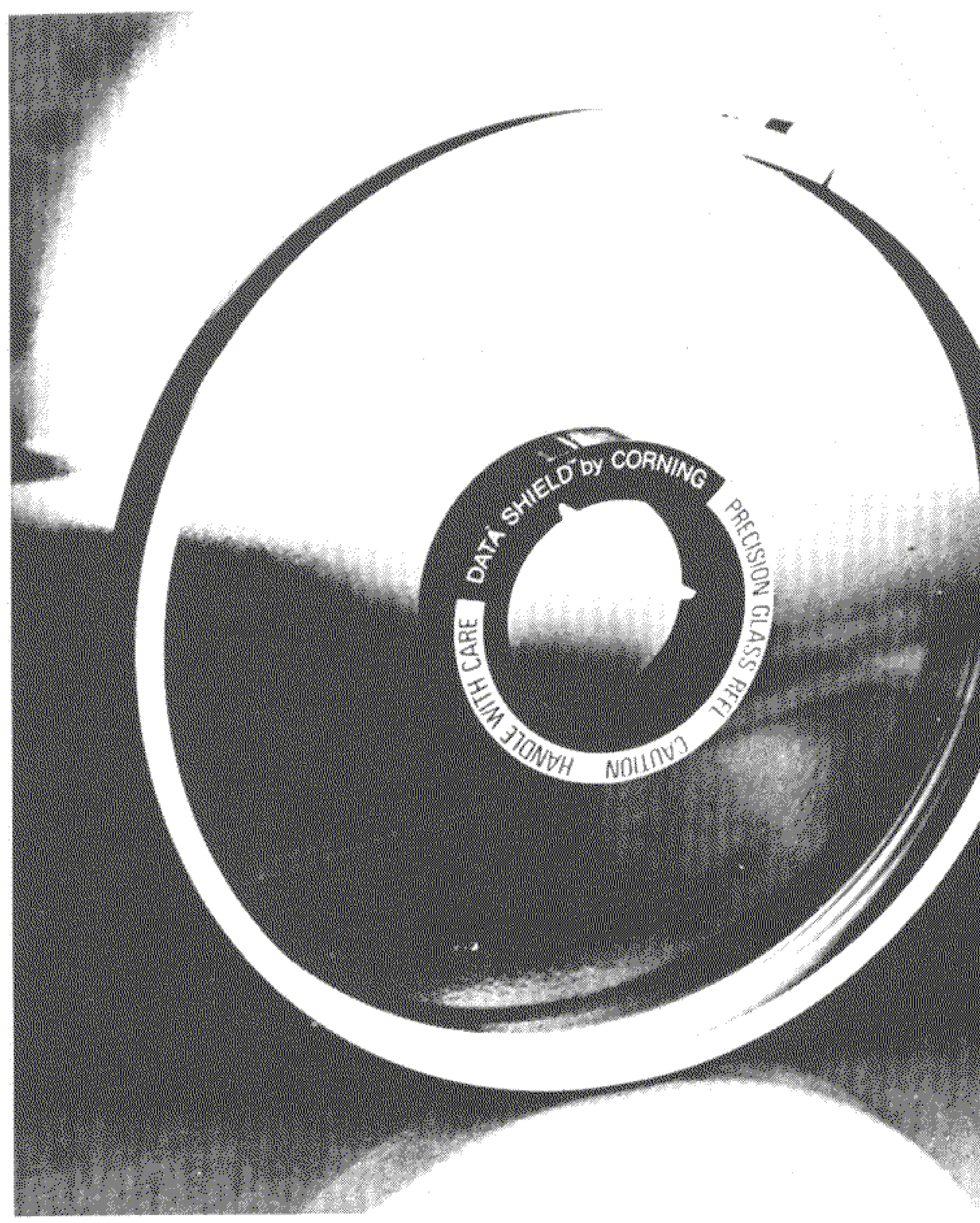
These conclusions provide a strong case for mounting tape on glass reels, particularly when the tape must be used in uncontrolled environments.

The manufacturer has anticipated the need to provide a simple means of threading a glass reel, since it has no apertures. A special coating has been applied to the outer diameter of the reel hub. Drawing the tape end over the reel hub creates a static attraction that causes the tape end to cling to the hub. Initially, it may be necessary to loop the tape around the hub and spin the reel to create the electro-static attraction. See Figure 14.

## TAPE HANDLING AND STORAGE

**GENERAL** Modern magnetic tape coatings can accept intelligence and retain it for an indefinite period. The recorded information is a permanent record that does not fade or weaken with age. It will remain unchanged unless altered magnetically or until the recording medium deteriorates physically. Those who work with magnetic tapes can help prevent needless performance degradation by carefully observing preventive tape handling and storage procedures.

*Figure 13. Glass Reel with Protective Plastic Flange Band.*




*Corning Glass Works*

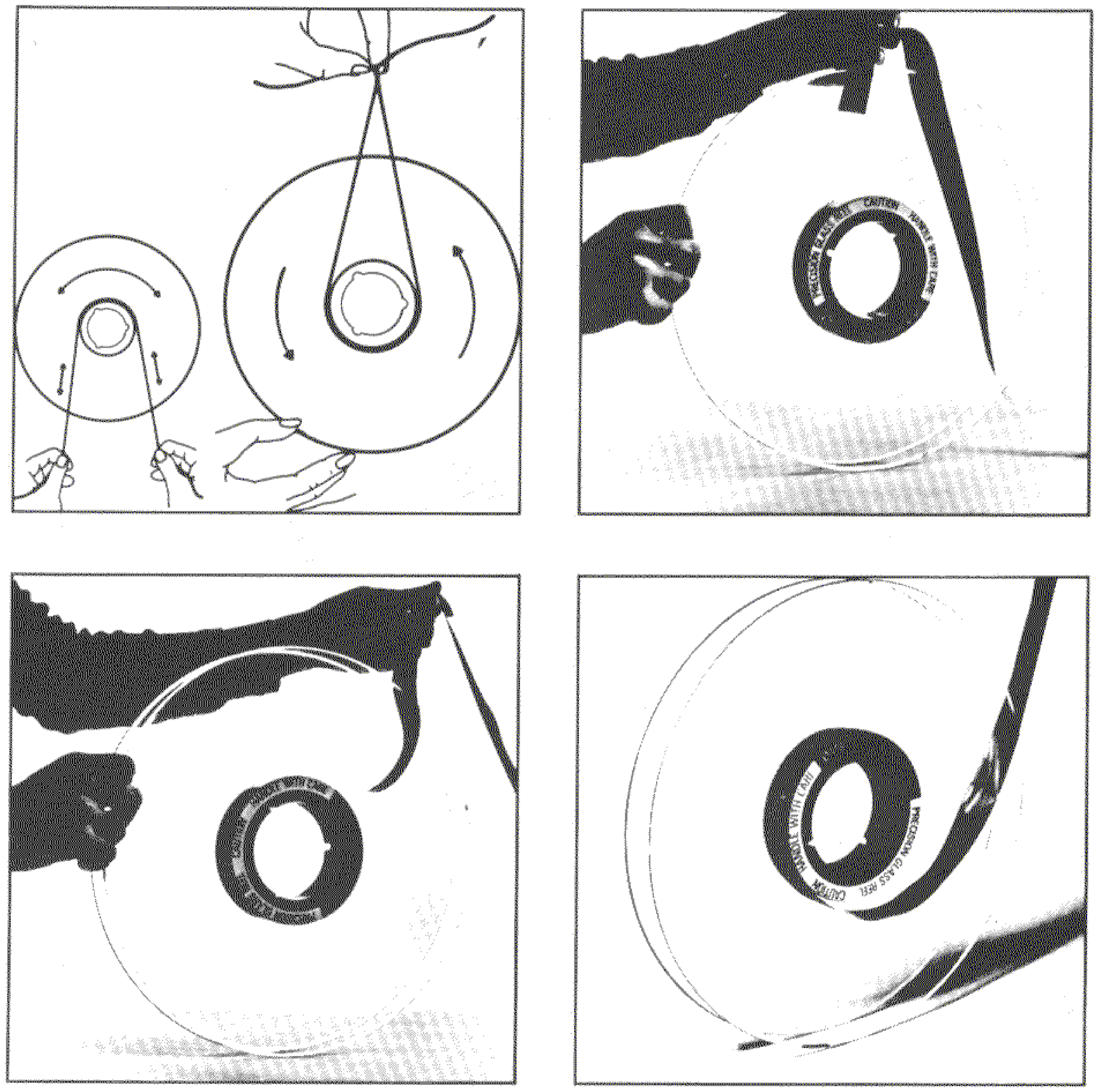


*Figure 14. Simple Procedure for Threading a Glass Reel. Electrostatic attraction between tape and reel hub is created by looping the tape around the hub, then spinning the reel.*

*Corning Glass Works*

**HANDLING** Both operator and maintenance technician must observe the highest degree of care and professionalism when they handle reels of tape and work with recording equipment. They must do so because instrumentation and computer tapes and their transports are perhaps the least forgiving of all the avionics equipments aboard the P-3 aircraft. The slightest defect in the reel, dirt particle on the tape or head, or misalignment of the tape transport will almost certainly cause information to be lost. In this section we shall point out what can be done to reduce the risk of a lost or degraded mission due to improper reel and tape handling.

**Reel Handling** Operators must exercise care when they hold, transport, or mount reels of tape. They should *always hold the reel by the hub* – the strongest and most stable part of the reel. Conversely, the reel should *never* be handled by its flanges, for the flanges are the most fragile parts of the reel structure and can be deflected inwardly. Since the distance from the reel flange to the edge of the tape pack is less than 9 mils, any inward deflection of the flange will very likely cause it to press against the edge of the tape pack. Any layers of tape offset from the pack will then sustain edge damage. Only slight distortion of the tape edge will probably affect the recording because the outer record track of a seven-track, 1/2-inch magnetic head begins about 15 mils inboard of the tape edge.

When a reel is mounted on the tape transport, the operator can avoid deflecting the flange by applying pressure only at the reel hub as shown in Figure 15. This practice will save tape and, at the same time, enhance chances of achieving good reel alignment with the transport's pedestal guides.

**Reel Protection** All available flange protecting devices should be used whenever possible. The basic protective device is the reel's protective container which may be a cardboard box or a plastic or metal canister. Figure 16 shows a cardboard protective container. Reels, either empty or wound with tape, should always be stored and transported in their protective containers.

Special plastic bands have been designed to fit over the reel flanges and protect the tape within. Figure 13 shows a protective band fitted onto a glass reel. As a rule, it is a good habit to keep the protective band in place. The only time it should be removed is *after* the reel is mounted on the tape transport. Likewise, the band should be put in place again *before* the reel is removed from the transport. Generally speaking, the reel band serves several important functions:

1. It protects the tape from harmful environmental conditions

2. It protects the tape and reel flange edges from physical damage

3. It helps keep plastic reel flanges from warping

4. It helps keep metal reel flanges from bending

Tape caddies provide the reels with added protection when reels are transported (still in their protective containers) to and from the aircraft. Figure 17 shows two sizes of tape caddies.

When reels of tape are in process (awaiting degaussing, cleaning, or certification), they should be supported by their hubs with fixtures like those shown in Figure 18. If such fixtures are not

*3M Company*

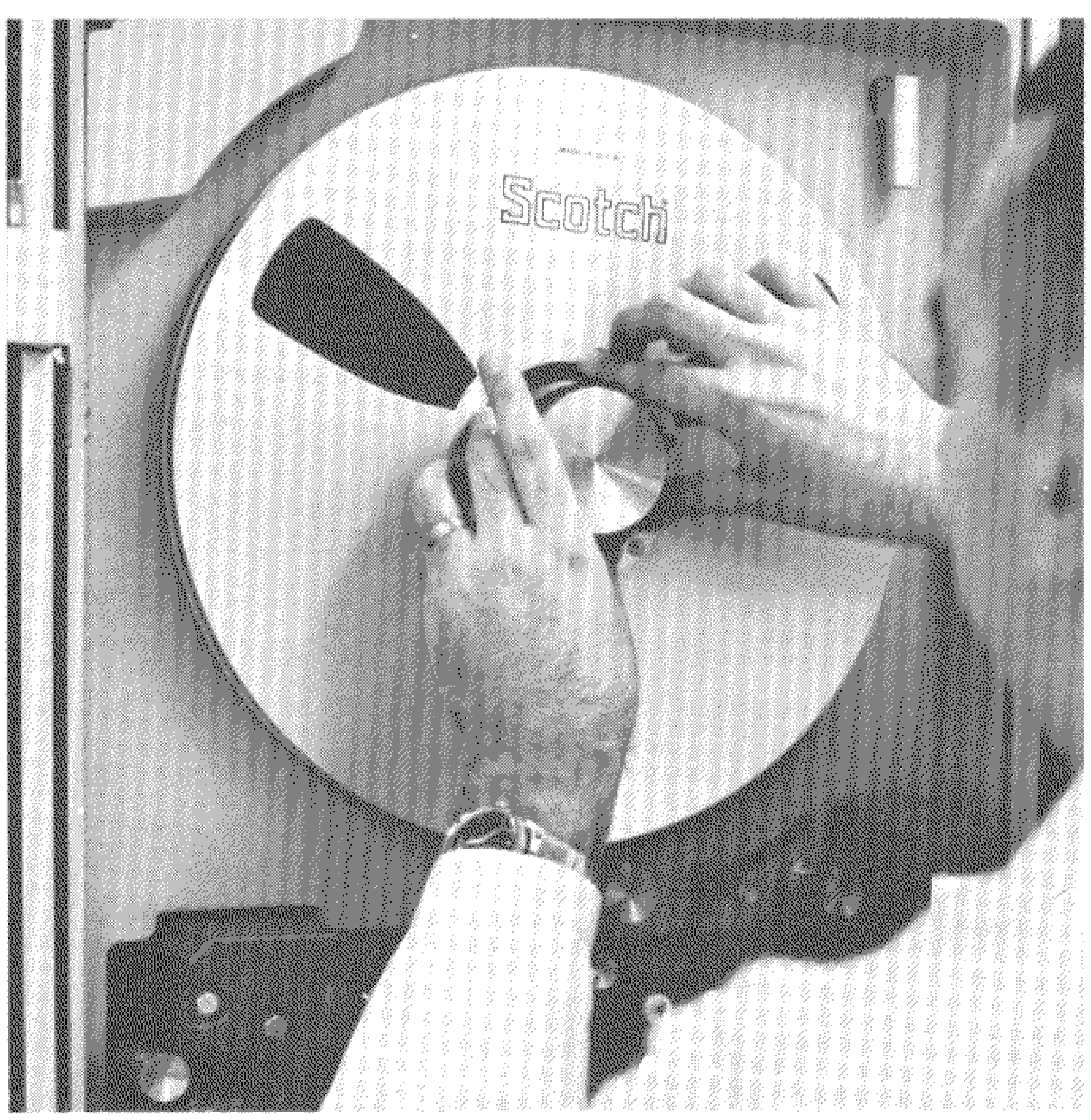



*Figure 15. Reel Mounting Procedure.*

*Figure 16. Protective Cardboard Reel Container.*

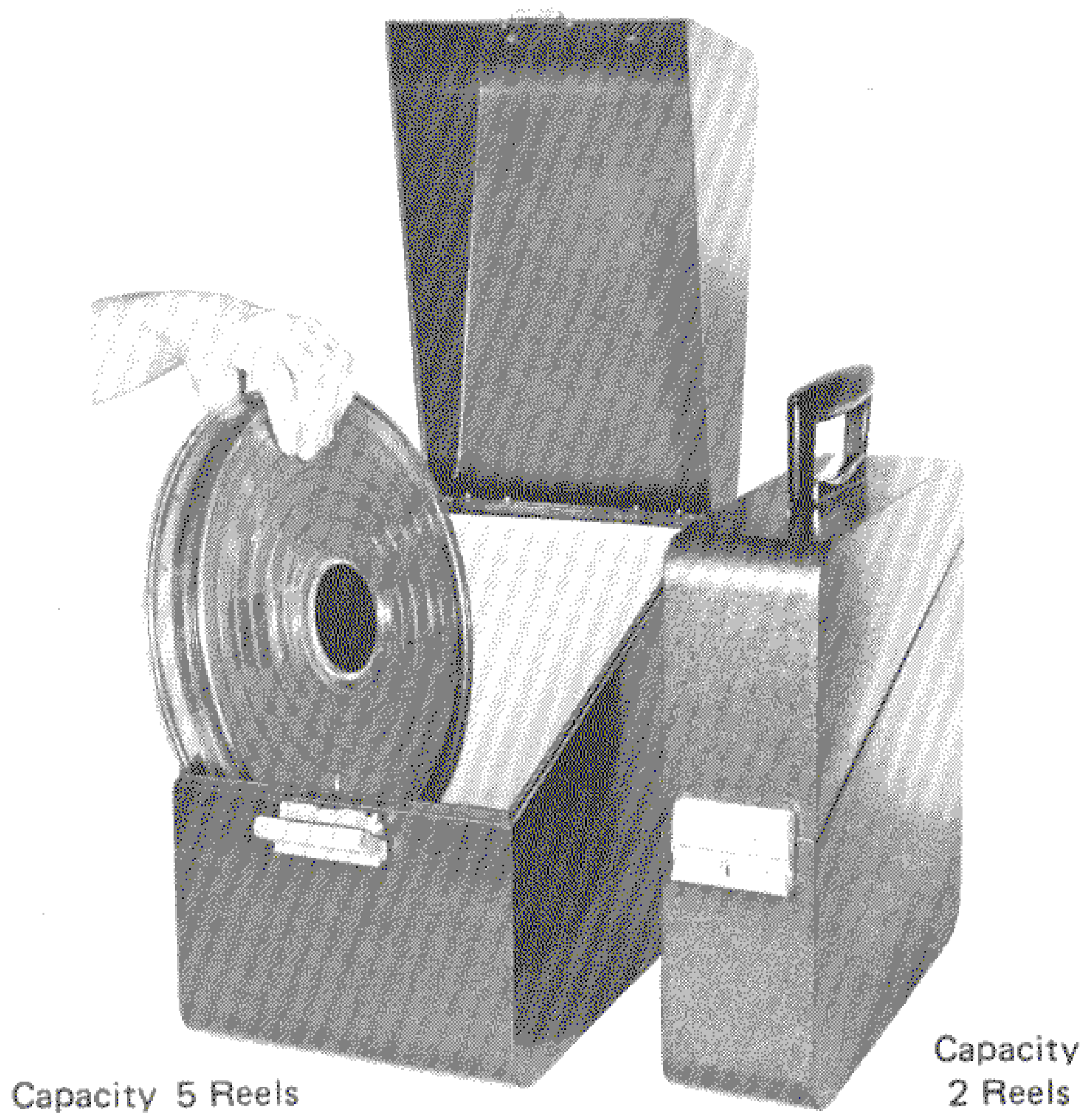



*Figure 17. Tape Caddies.* *3M Company*

*3M Company*

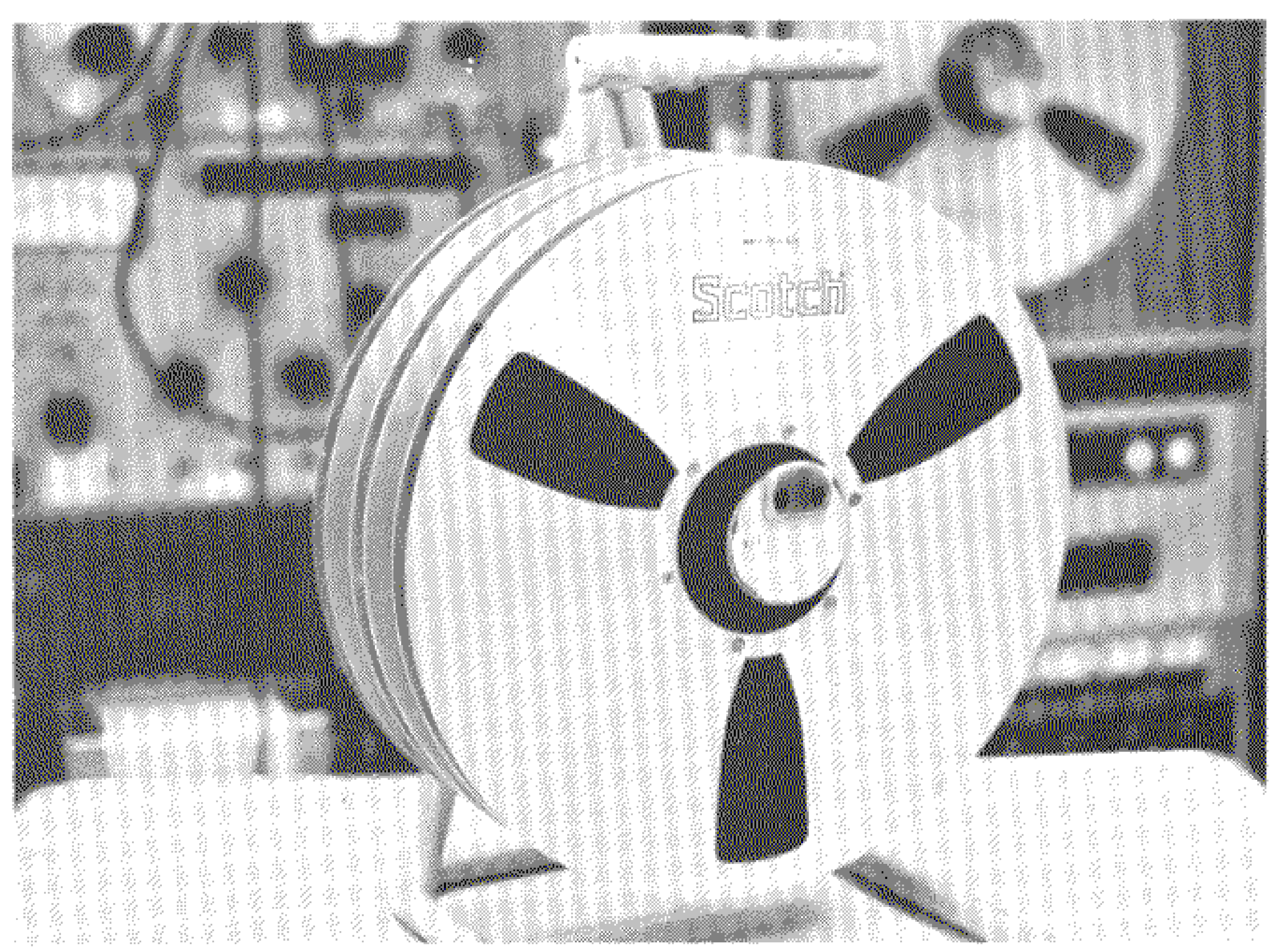



*Figure 18. Reel Support Fixture.*

available, the reels of tape should be kept upright, stored in their protective containers (Figure 19). Laying a reel of tape on its side makes the tape and reel vulnerable to three dangers. First, if the tape pack is loosely wound, it will slump down against the bottom flange. Second, there is a good chance that something will be put atop the reel and damage it. Third, if the tape is exposed and the reel flanges have aperatures (as do those on most metal reels), airborne contaminants will have a broad target to settle upon.

Damaged hubs, while not as prevalent as deformed flanges, also must be reckoned with. Empty reels should be inspected thoroughly for both flange and hub damage before tape is wound upon them. Since many turns of tape are wound upon a reel, even the slightest hub deformation (or dirt particle) will be magnified by its cumulative effect as layer is wound upon layer and cause the tape pack to stretch and spoke.

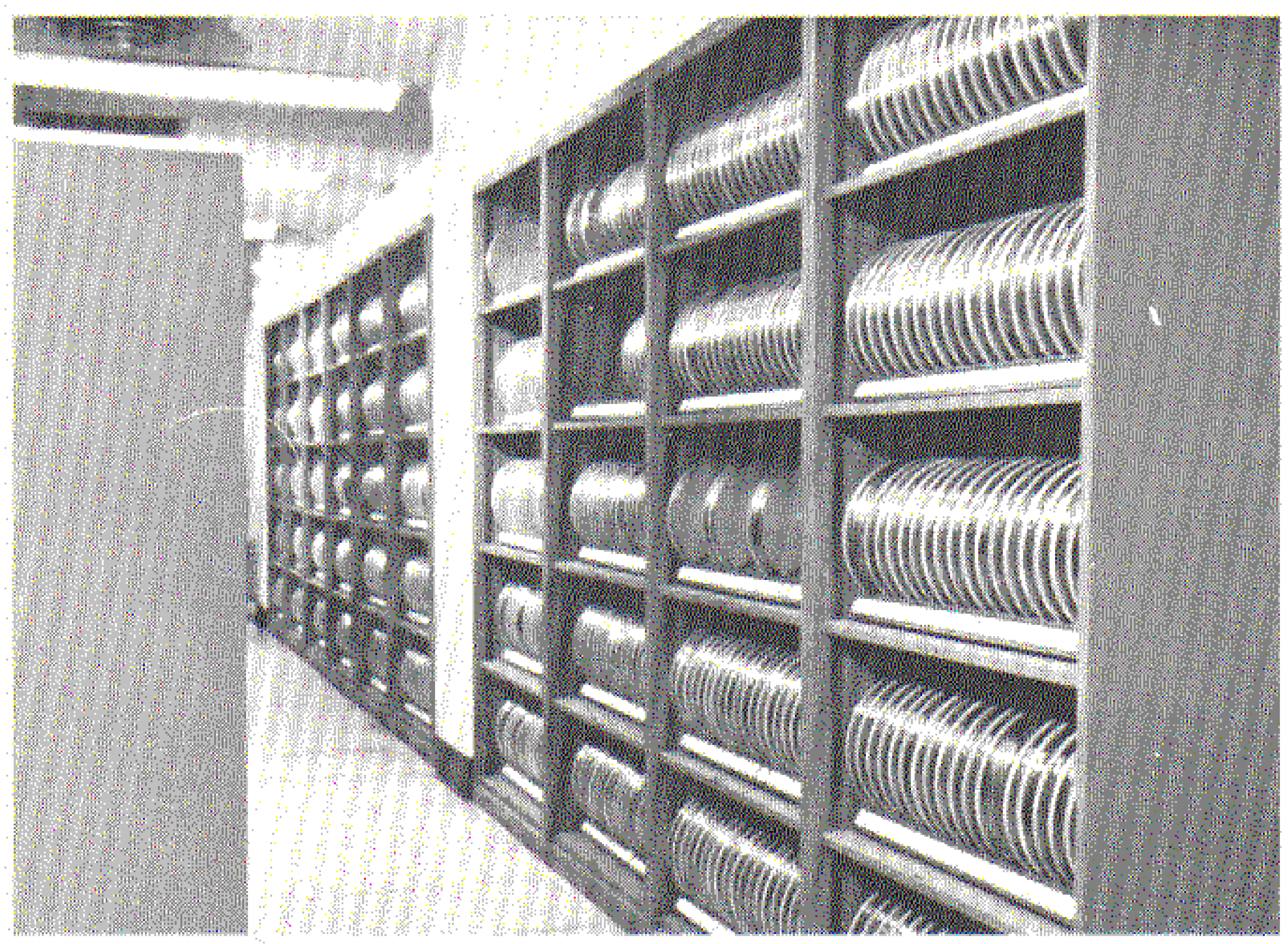


*Figure 19. Reels Stored Upright in Protective Containers.*

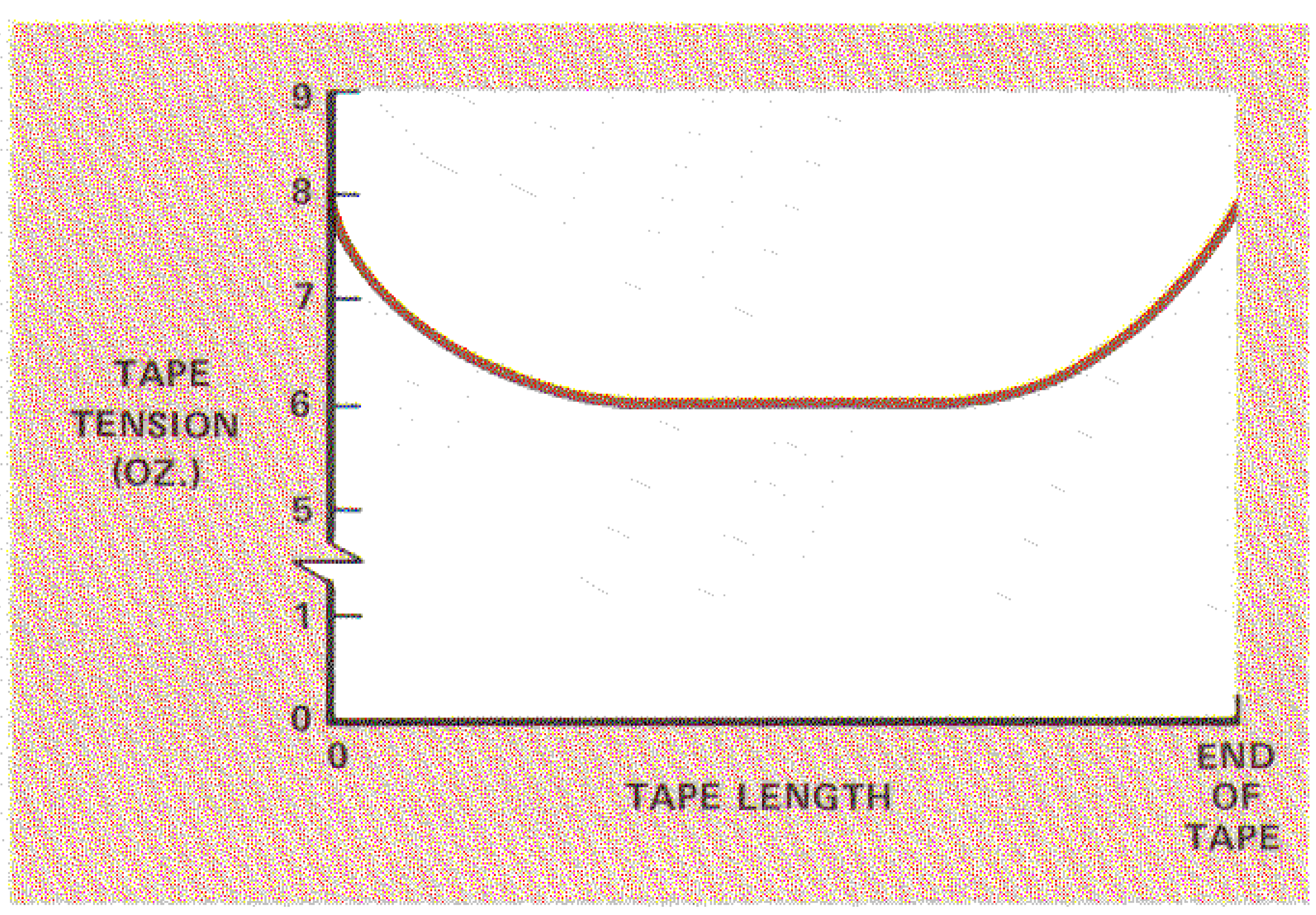



*Figure 20. Typical "Bathtub Curve" of Tape Wind with Programmed Tension.*

**Tape Handling** There are instances when handling the tape itself is unavoidable, e.g. when threading the tape on the transport. Under such circumstances it is good practice for the operator to wash his hands thoroughly before handling the tape. If lint-free gloves are available, they too should be worn.

These precautions should be observed because the slightest amount of oil or other contaminants on the fingers will be transferred to the tape – and fingerprint oils are excellent collectors of airborne dust and lint. Once the tape is contaminated, a lump of dropout-causing proportions will accumulate within a short time.

Even if the contaminants are deposited on only the first few unrecorded turns of the tape, they represent the genesis of a dropout. These contaminants will subsequently transfer from the end of the tape to the transport, and ultimately be redeposited on the inner layers of the tape pack. Consequently, it is equally important to keep the transport's tape handling surfaces fingerprint-free.

**STORAGE** Most reels of tape spend a significant amount of time in storage. During these periods they must be protected from contamination, environmental extremes, and physical damage. This leads us to a discussion of tape tension, storage environment, and storage practices.

**Tape Tension** When tape is being prepared for storage, the tape tension within the reel pack is a most important factor. Since tension is an unknown quantity on tapes recently removed from operation, it is prudent to clean and precision wind the tape prior to storing it.

Some activities have found that winding the reel pack under constant tension is the best all-around method of avoiding pack damage. Other activities prefer to "program" wind their tape to a tension profile similar to the "bathtub curve" shown in Figure 20. However, this school of thought is divided on whether the bathtub tension curve should be as it is shown in Figure 20, or be inverted. The consensus is that the "normal" bathtub curve that we have illustrated seems "to hold the most water."

In theory, reduced tension at the center of the wind best allows for expansion and contraction of the tape with temperature variations, which helps avoid layer-to-layer adhesion, spoking, windowing, etc. However, at present insufficient evidence has been brought forward to conclusively demonstrate this theory. All will agree, though, that a precision wind that gives a uniform tape pack is essential.

When tape is stored, it is usually desirable that the pack be wound at a slightly lower-than-normal tension (between 6 oz and 8 oz). However, care should be taken to ensure that the wind tension is *no less* than six ounces per half-inch of tape width. Less tension will make the tape susceptible to slip and windowing.

If a spooling defect occurs while the tape is being wound, stop the winding process immediately. Unwind the pack promptly so that the induced deformation does not have a chance to set, correct the cause of the defect, then rewind the tape to a smooth, firm pack.

**Storage Environment** We have already established that, magnetic tapes fare best in a clean environment that has a relative humidity of about 45 percent and a temperature of about 70°F (21°C). It follows that the pre-storage tape processing area (used for degaussing, cleaning and certifying tapes) and the storage area should approach, as closely as practicable, a "clean-room" environment – one that has a moderate temperature/relative humidity profile, and is relatively free of airborne dust and lint. If possible, the air pressure in clean-room processing and storage areas should be maintained slightly higher than that of the surrounding area. This positive pressure differential helps keep airborne dust from infiltrating through doors and windows.

Dust can also become airborne when the floors and shelves of processing areas are cleaned. Special liquid cleaners designed for clean-room areas are now available, and should be used exclusively in these locations. These cleaners are particularly desirable because they leave no residue. Conversely, the floor should never be waxed. Normal foot traffic will abrade the wax and cause fine wax particles to become airborne. Between the regular thorough cleanings, the clean-room area should be wet-mopped daily. When vacuum equipment is used for cleaning the area, the equipment's exhaust outlet should be located outside the room.

**Storage Practices** Since the hub is the strongest and most stable part of the reel, it is the best means of reel support during storage. Do not store an unprotected reel so that it is resting upon its flanges. Special fiberboard boxes, plastic canisters, and metal boxes have been designed to support the reel by its hub within the container (Figure 21). When the reel is supported in this manner, there is little if any weight resting upon its flanges. This protects the flanges from bending, nicks, etc. The container also protects the reel and tape from dust and other contaminants. Plastic reel bands afford reels additional protection from contaminants and maintain the flanges at their proper separation.

Under no circumstances should a reel be stored resting on its flanges. Needless to say, paper notes about stored data or other sources of contaminants should not be put in the storage container.

As mentioned previously, reel containers should be stored with the reel of tape upright. Canisters containing *empty* reels may be stacked flat if the canisters have interlocking molded ribs.

For long-term tape storage, additional protection from dust and moisture should be considered. This

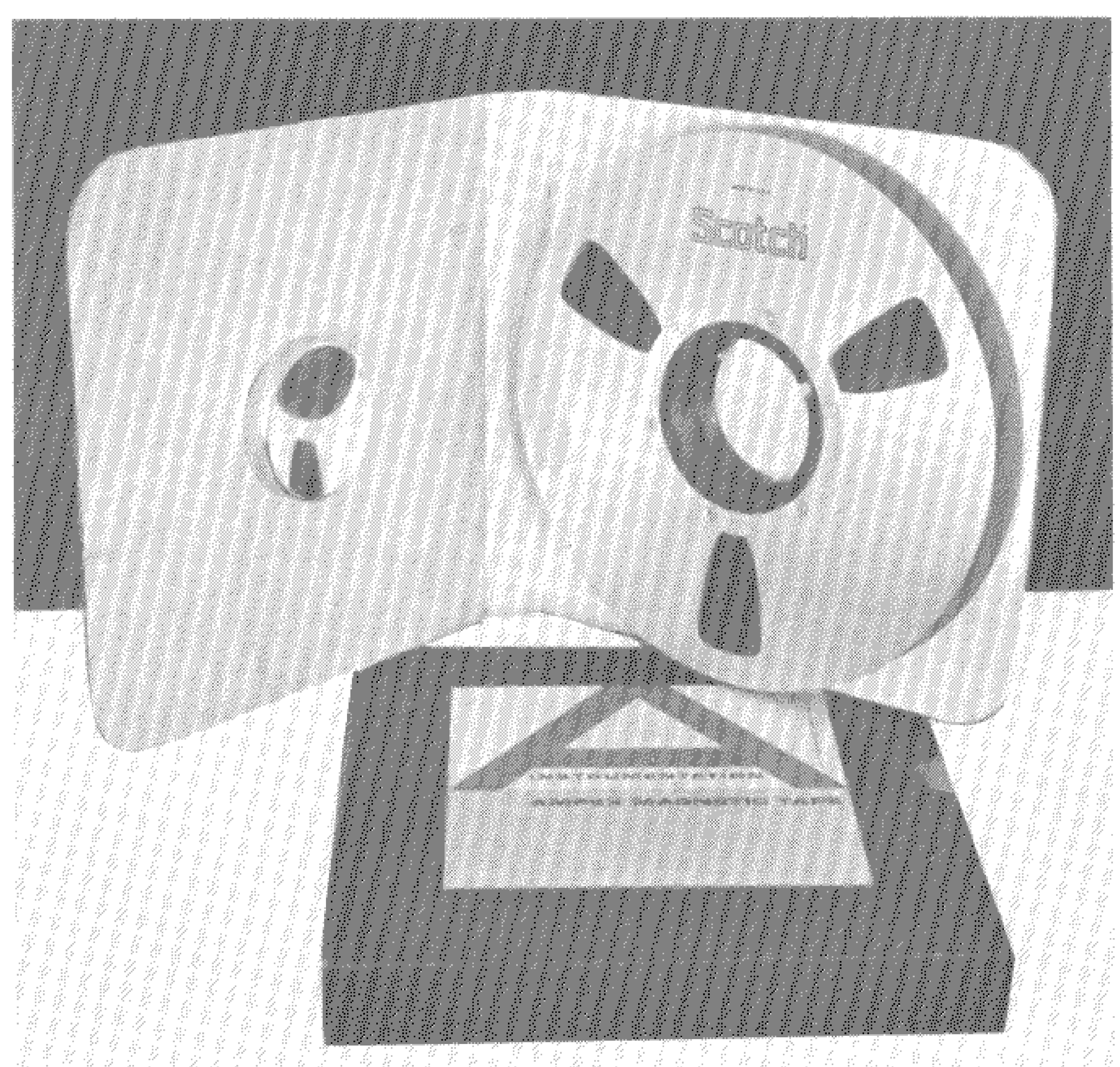



*Figure 21. Reel Supported by its Hub in a Cardboard Protective Container.*

can be done by sealing the tape storage container in a plastic bag. When the reel of tape is taken out of storage, accumulated dust should be cleaned thoroughly from the container's exterior (or plastic bag) before the tape is removed.

**Summary** Data can be preserved indefinitely on magnetic tapes if the operator observes the proper procedures for winding the tape, protecting and storing the reels, and maintaining them in a well-regulated, clean environment. Periodically, personnel responsible for tape storage should perform a visual check of a random sample of stored tapes. In this manner, the condition of the tape library can be monitored, and tapes can be rewound and reconditioned when necessary.

## TAPE ERASURE

**GENERAL** One big advantage of magnetic tape is that it can be reused. Old information can be erased with relative ease to make room for the new. A recorded signal may be removed from magnetic tape by either ac or dc erasure. In ac erasure, the tape is demagnetized (degaussed) by exposing it to an alternating magnetic field which is reduced in amplitude from a high value (saturation) to zero in gradually decreasing amounts. This process, shown graphically in Figure 22, totally removes the signal from the tape and leaves the oxide particles magnetized at random. AC erasure is used on instrumentation tapes because it produces considerably less background noise on analog recordings than does dc erasure. It is also a suitable method for erasing digital magnetic recordings. In dc erasure, the tape is magnetically saturated by applying a unidirectional magnetic field to the oxide coating. This process obliterates the signal on the tape. DC erasure can be used on digital tapes and on those analog tapes where background noise is not a primary consideration.

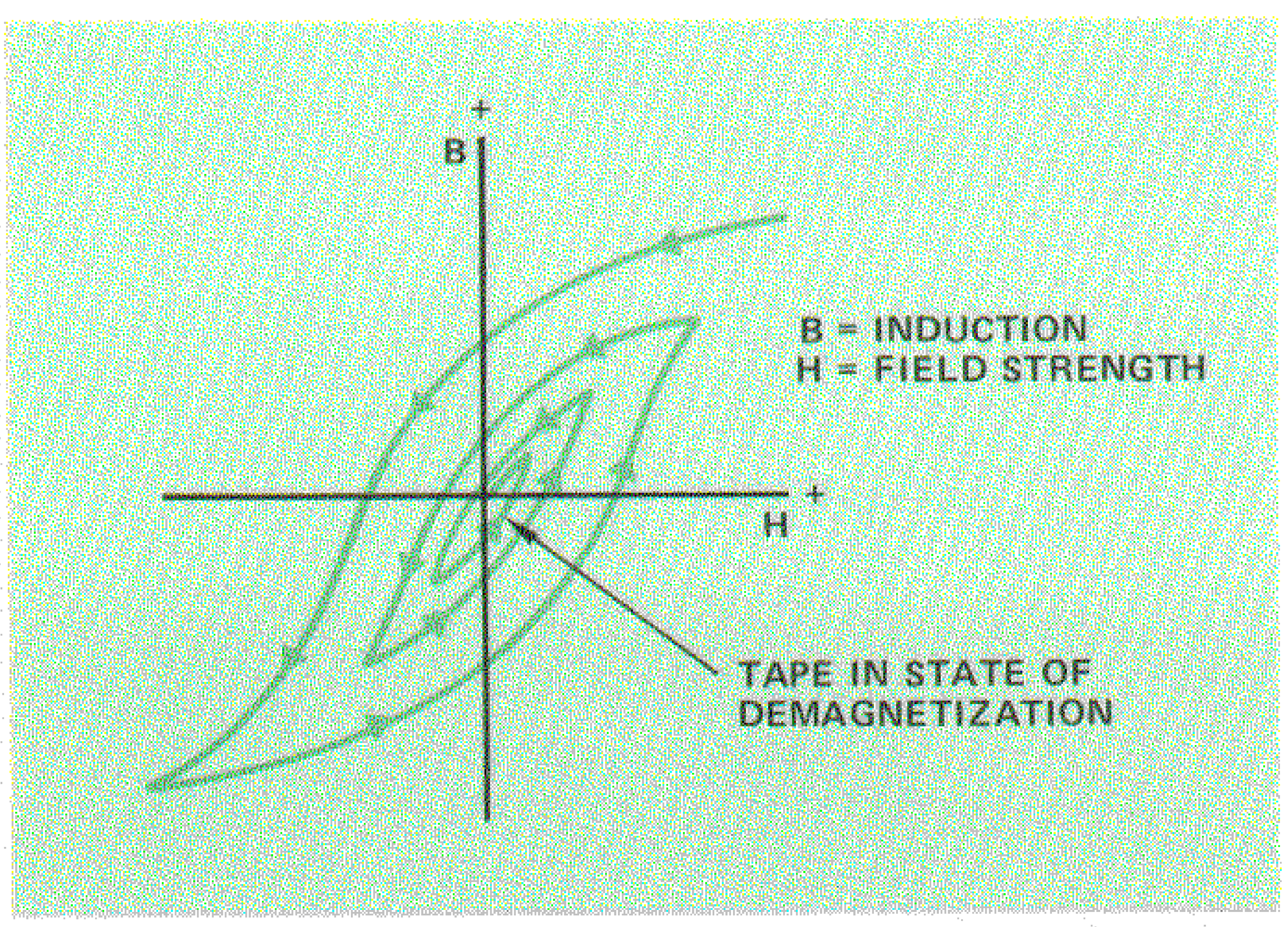



*Figure 22. Tape Demagnetization Curve. Note that the alternating magnetic field diminishes with each field reversal.*

AC erasure is carried out either by running the tape over an erase head fed with high frequency alternating current, or by bulk erasure in which the whole roll of tape is degaussed by placing it in a diminishing 60-Hertz magnetic field. Bulk erasure is preferred because it produces less background noise.

The external magnetizing force applied to tape to remove its residual magnetism during ac erasure is called *coercive force.* Coercive force is measured in *Oersteds,* the standard unit of magnetic strength in the cgs system. A tape's *coercivity* is the intensity of coercive force that is required to cause the tape's residual magnetism to go from saturation to zero.

For example, a material with a coercivity of 100 will have its residual magnetic field erased by another magnetic field that has a coercive force of 100 Oersteds. Standard and high resolution instrumentation tapes have a coercivity in the range of about 260 to 300. For example, Type 766 standard resolution tape has a coercivity of 275. Other instrumentation tapes exceed this coercivity range. Type 795 high output instrumentation tape has a coercivity of 310, and Type 971 high energy tape has a coercivity of 590.

**BULK TAPE ERASURE – P-3 APPLICATIONS** Used tapes must be degaussed before recording new data upon them. Bulk degaussers (Figure 23) afford a fast, effective means of tape erasure without unwinding the tape. One of the following approved models of bulk tape degaussers should be available at each Navy facility.

1. **Ampex SE-10** – 80 db degaussing capability; handles reels up to 14 inches in diameter.

2. **Ampex SE-20** – 90 db degaussing capability; handles reels up to 16 inches in diameter.

3. **Bell and Howell TD2903-4B** – 90 db degaussing capability; handles reels up to 16 inches in diameter.

4. **GKI Model K80** – 80 db degaussing capability; handles reels up to 14 inches in diameter.

The technician should pay particular attention to the following points when degaussing tape:

1. Secure the loose end of the tape with the plastic tab-down strip rather than adhesive tape. The latter may leave unwanted adhesive deposits on the magnetic tape.

2. During the degaussing cycle the reel is rotated slowly in a controlled magnetic field. Be certain that the reel hub locking pin is engaged securely.

3. Do not interrupt power while tape is being degaussed. This may leave a residual magnetic field in the tape. If power is accidentally interrupted, repeat the degaussing procedure from the beginning.

4. When degaussing is completed, remove the tape from the degausser *before* turning off the instrument's power. Again, this is done to avoid leaving a residual magnetic field on the tape.

5. When the reel of tape is removed from the degausser, it should be uniformly lukewarm. If the reel is warm in one sector and cold in the remaining sectors, the reel was not rotating properly during the degaussing operation. This condition indicates that either the degausser is defective, or the reel was installed improperly on the degausser hub. Re-degaussing is required in either case. It may be necessary to turn the reel over and repeat the degaussing procedure to ensure that the tape has been degaussed completely.

**ACCIDENTAL TAPE ERASURE** Aside from the physical destruction of a tape, two basic forms of energy can affect the data recorded on it – heat and magnetic fields. We have previously discussed the effects of temperature variations on magnetic tapes. Let us now consider magnetic fields.

How common is a magnetic field whose intensity is sufficient to cause accidental tape erasure? The fact is that a magnetic field of this magnitude is rare. The magnetic field from an electric hand drill, for example, is about 10 Oersteds at the surface of the drill case – too small to effect magnetic tape even if there were direct contact. Tests have shown that magnetic fields up to 50 Oersteds cause no discernible erasure on tapes. However, stronger magnetic sources such as magnetized hand tools can effect magnetic tape significantly if they come in direct contact with it. The residual magnetism that develops within analog recorder heads also presents similar problems.*

Small permanent magnets used as door latching devices or flashlight magnets have surface field intensities as high as 1500 Oersteds. Such a magnet would erase the portion of a tape that came in close proximity of it. Fortunately, magnetic field intensity falls off sharply with distance from the source. In this example, the 50 Oersted point (at

*On the other hand, residual magnetism within digital recorder heads presents no erasure problems to computer tapes. The digital signals recorded on the tape saturate in one direction or another, and are not sensitive to this residual magnetism.*

*Figure 23. Bulk Tape Degausser.*

which no discernible erasure takes place) is located 2.7 inches from our 1500 Oersted source, the magnetic door latch.

Experiments were conducted with a typical ac bulk tape eraser to determine the relationship between magnetic field intensity and magnetic signal erasure. The results are illustrated on Figure 24. Some erasure is noticeable at a field intensity of only 100 Oersteds, and a 6 db loss (50 percent signal reduction) occurs at 155 Oersteds.

There have been a number of stories that attribute tape erasure to exposure to energy sources that are commonly present at airports. Such energy sources include radar, magnetic anti-hijacking devices, and x-ray equipment. While the likelihood is small that these energy sources have been responsible for the erasures, the possibility, however remote, exists.

**Radar** It is possible for tape erasure to occur in the immediate vicinity of a radiating high power

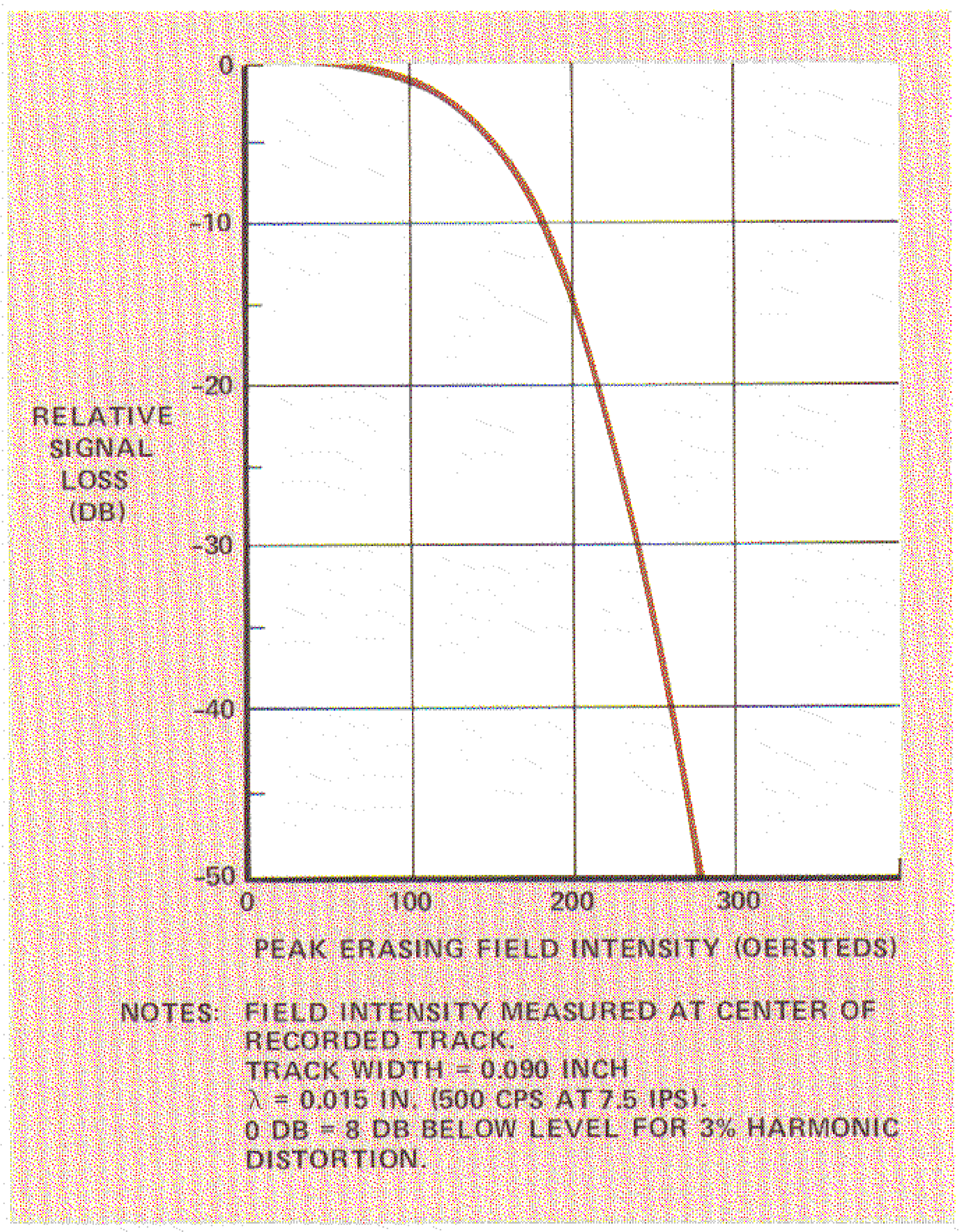



*Figure 24. Relative Signal Loss vs. Erasing Field Intensity.*

radar antenna, for the magnetic field in this area may be as much as several thousand Oersteds. This area is also well known for the radiation hazard that it presents to personnel. The safety precautions exercised to protect personnel from radiation will likewise protect the tape from erasure – a separation of a few feet is sufficient, at least for the tape.

While dynamite caps and flashbulbs may be triggered at some distance by the sharply focused electric field of a radar beam, its magnetic field is not so far-reaching and dissipates sharply with distance. In fact, experimentation on tape erasure has been conducted with tapes placed just 2 feet in front of a *scanning* X-band radar that had a 250-mile range. After 16 minutes no physical or magnetic degradation was found. However, it must be pointed out that if the radar had been continuously focused on the tape for the duration of the test, it is likely that the tape would have overheated and suffered physical damage. Based upon this experiment, we have concluded that magnetic fields produced by the P-3's radar sets or their magnetrons will not harm magnetically recorded data if the tapes are kept at least three feet away from this radar equipment.

**Anti-Hijacking Devices** Anti-hijacking devices at airports fall into one of two categories, either passive or active. The passive devices are designed to detect small changes in the earth's magnetic field that are caused by the presence of some metals. These devices do not generate a magnetic field of their own, consequently they cannot erase magnetic fields from recording tape.

Active anti-hijacking devices *do* generate their own magnetic field. Typical of these devices are the doorway and walkway types, most of which operate with magnetic fields of about 20 Oersteds. These magnetic fields, in line with our previous discussion on tape erasure, would be harmless to the recorded tape. However, some doorway devices with magnetic fields as strong as 100 Oersteds have been considered for use, and may now be in service. Exposure of magnetic tape recordings to devices with magnetic fields as strong as this would cause partial erasure of the recording. Since many operators of anti-hijacking stations may not know the magnetic field intensity of their detection equipment, it is suggested that travellers offer tape recordings for physical inspection.

**X-Ray Inspection** It is theoretically impossible for X-ray inspection devices to erase tape recordings because X-rays are non-magnetic. To demonstrate this, the 3M Company conducted tests in which carefully recorded tapes were exposed to X-rays of intensities far in excess of those used for routine package examination. Subsequent examination of the tapes showed no evidence of signal decay or erasure. One can only conclude that it is safe to permit X-ray examination of magnetic tape recordings. For those who have reservations about X-ray inspections, the physical inspection option is always available.

**Conclusion** When carefully weighed, the foregoing facts indicate that it is unlikely that magnetic tapes will be erased accidentally. The intensity of any magnetic field is weakened considerably by distance. However, some magnetic sources can affect magnetic tape significantly if they are brought near or in direct contact with it. Thus, in the ASW environment it is important to demagnetize tools and analog recorder heads regularly As a further precaution, maintain at least a three-foot separation between recorded tapes and suspected sources of strong magnetic fields.

## TAPE MAINTENANCE

**GENERAL** The service life of a reel of tape can be greatly extended and its performance significantly improved by an effective maintenance program. The elements of the program will differ from one organization to another, based upon their unique needs and circumstances. For this reason, we propose to offer sufficient information about tape maintenance to enable cognizant personnel to develop a customized maintenance program geared to their particular situation. The maintenance process includes such operations as degaussing, tape cleaning, tape certification or evaluation, and precision winding.

**TAPE CLEANING** There is probably no other area of tape maintenance that is subject to as many diverse views as is tape cleaning, its frequency and methods. In this section we shall discuss the various aspects of tape cleaning and offer some practical recommendations, bearing in mind the P-3 ASW environment in which the tapes are used.

**Why Clean Tape?** Even if it were possible to prevent foreign contaminants from reaching the tape and its transport, the tape still would require regular cleaning. Unfortunately, it is a fact that although the best of care may be lavished upon the tape, self-contamination (shedding) is unavoidable. Why? Well, for one thing, the tape's mylar backing material is produced in rolls that are several feet wide. After the oxide coating has been applied to the mylar and dried, the tape is slit to its final width (1/2-inch, 1-inch, etc.). This slitting process "fractures" the coating and backing material at the edges of the tape. As a result, binder components, oxide particles and backing material particles will shed continually throughout the lifetime of the tape, with more shedding occurring during the tape's first few uses.

In addition, tape will also shed debris from both its flat surfaces. This is due to the constant friction of the tape surfaces with the fixed surfaces of the tape transport. As mentioned earlier, shedding is accelerated when the tape is exposed to extremes in temperature and relative humidity.

Although tape is polished during its manufacture, the oxide coating surface still has some measure of "roughness" remaining. When the rough protrusions are dislodged from the tape surface, they become debris. As might be expected, the rougher the tape surface, the more debris that is shed. The polyester backing of the tape is also a source of debris, for polyesters are subject to scratching and chipping (particularly when they stiffen at low temperatures). However, with the advent of the texturized backcoatings there has been a considerable reduction in shedding of tape backing material.

**Frequency of Cleaning** The two ways to combat both foreign and self-contamination of tape are (1) fastidious care and handling and (2) periodic cleaning. Care and handling have already been discussed, but the question remains, "How often must the tape be cleaned?" The tape industry has given considerable thought to this question, but they have not arrived at a unanimous recommendation. Some tape cleaner manufacturers hesitate to recommend cleaning the tape after every use because of the increased risk of further damaging tape that has slight deformations. Their primary concern is that the cleaner's scraper may catch a slightly curled edge or other damaged portion of the tape and tear it. On the other hand, regular cleaning is crucial for computer applications like those on the P-3 which simply cannot tolerate tape recordings with excessive dropouts. Thus, the risk of damaging the tape from cleaning it too often must be weighted against the risk of having a tape with too many dropouts due to inadequate cleaning. In the final analysis, a compromise must be struck.

For a tape that is used in a relatively clean environment and is not degaussed between uses, a good rule of thumb is to clean the tape about every eight to ten uses. This rate of cleaning would apply to computer program tapes used exclusively in areas that are relatively free of contaminants, such as the Tactical Support Center. On the other hand, tapes used aboard the aircraft will obviously require cleaning more often because they are exposed to an environment with more contaminants. These tapes may be tissue-cleaned (scraper withdrawn from the cleaning path) after every use to remove loose debris, then scraper-cleaned in the normal manner after every fifth or sixth use. If the only tape cleaner available does not employ a tissue wipe (some cleaners use only a vacuum system to remove loose debris), a standard cleaning after every fourth use should suffice.

Likewise, it should be a general rule to clean a tape immediately after it is degaussed. This practice is recommended because degaussing may loosen oxide particles from the tape.

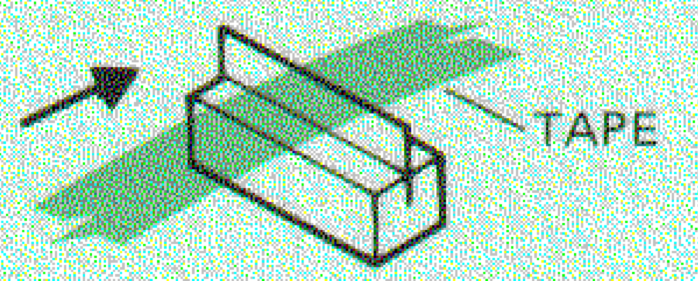
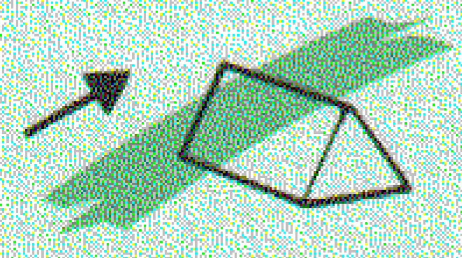
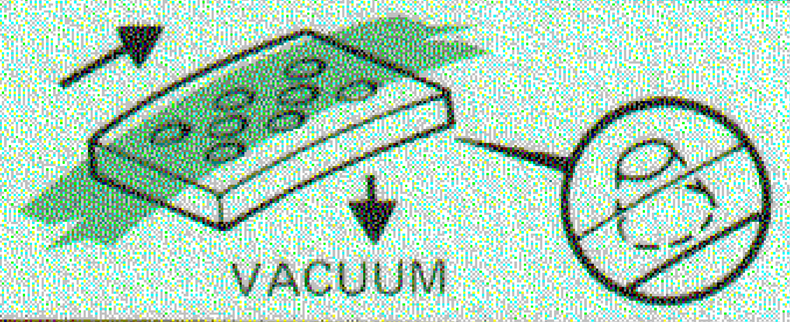
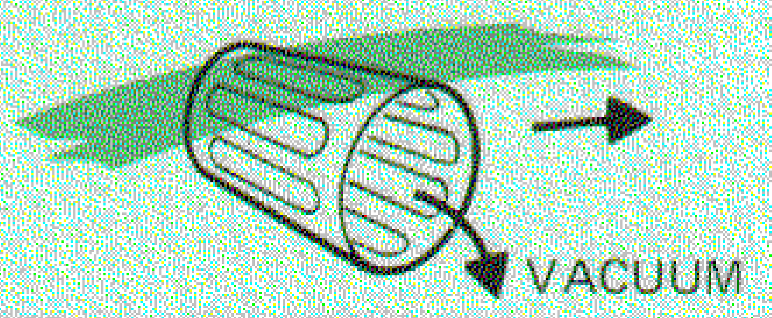
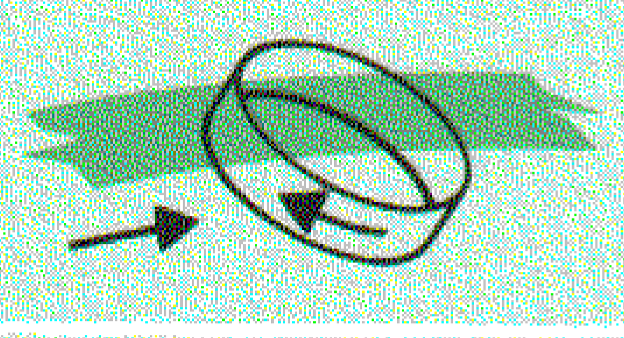
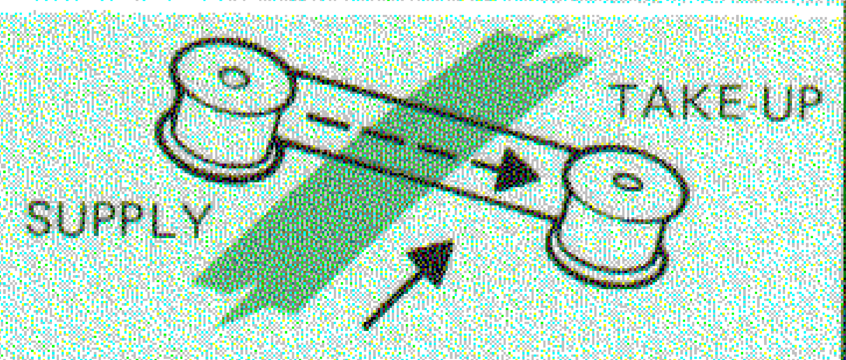
| TYPE SCRAPER | | SCRAPER LIFE (NUMBER OF 2400-FT REELS) | REMARKS |
|---|---|---|---|
| BLADE<br>STAINLESS STEEL |  | 1 | • BEST CLEANER<br>• LOSES EDGE QUICKEST<br>• MOST DANGER OF DESTROYING SLIGHTLY DEFORMED TAPE |
| BLOCK<br>A. SAPPHIRE<br>B. TUNGSTEN-CARBIDE<br>C. CERAMIC |  | A. 2500 PER EDGE<br>B. 2500 PER EDGE<br>C. 400 PER EDGE | • VERY GOOD CLEANER<br>• LONG LIFE<br>• LITTLE DANGER TO TAPE |
| GRID<br>STAINLESS STEEL |  | 20 000 | • GOOD CLEANER<br>• VERY LONG LIFE (SELF-SHARPENING)*<br>• LEAST DANGER TO TAPE<br>*MANUFACTURER'S CLAIM |
| SLOTTED CYLINDER<br>(ROTATING OR FIXED)<br>A. STAINLESS STEEL<br>B. TUNGSTEN BERYLLIUM |  | A. 20 000<br>B. 100 000 | • GOOD CLEANER<br>• LONGEST LIFE (SELF-SHARPENING)*<br>• LEAST DANGER TO TAPE<br>*MANUFACTURER'S CLAIM |
| BAND<br>(ROTATING LOOP)<br>STAINLESS STEEL |  | 500 | • VERY GOOD CLEANER<br>• MODERATE LIFE<br>• SOME DANGER TO TAPE |
| BAND<br>(CARTRIDGE)<br>STAINLESS STEEL |  | 500 | • VERY GOOD CLEANER<br>• MODERATE LIFE<br>• SOME DANGER TO TAPE |

*Figure 25. Tape Cleaner Scraper Types and Their Characteristics*

Naturally, these recommended tape cleaning practices must be complemented by a regular tape transport cleaning program if they are to be effective. This means that the tape transport must be cleaned before *each* mission, and it may require cleaning after every reel if the operator finds that debris is accumulating.

Finally, there is the question of whether or not *new* tapes should be cleaned. The recommendation is yes. Since the new tape's edges have only recently been "fractured" (slit during the manufacturing process), it should be fully cleaned with scraper and tissue (if applicable) before its first use. This recommendation is based upon tests on two randomly-selected tapes that were conducted by E-Systems, Inc., Garland Division. The test results of both tapes were similar. Before cleaning, one tape had a bit-error rate of $4.0 \times 10^{-6}$, while the other had a bit-error rate of $2.5 \times 10^{-6}$. After one cleaning pass, the bit-error rate of each tape improved to the range of $1.0 \times 10^{-6}$, and after a second cleaning pass to about $8.6 \times 10^{-7}$ – a significant improvement.

**Tape Cleaner Scrapers** The question arises, "What type of scraper is best?" Again, the answer depends upon the environment to which the tape will be exposed. Generally speaking, a more efficient scraper is needed either in a "dirtier" environment or under circumstances where frequent cleaning is impractical. Figure 25 presents a simplified illustration of various types of tape cleaner scrapers and their characteristics. This is not an all-inclusive list of scrapers, but it is representative of the major types that are available today. It is apparent that tape cleaner manufacturers have been striving to develop a scraper that will clean better and last longer.

*Razor Blade* As it turns out, most tape scrapers seem to operate at about the same efficiency with one notable exception – the stainless steel razor blade. The stainless steel razor blade is by far the sharpest and most efficient scraper, but it is not favored for the following reasons. First, since the razor blade is so sharp, there is greater danger of inadvertently cutting tape that has slight deformations. Second, each blade is good for cleaning only one reel of tape, after which the blade must be replaced. The razor blade dulls from "sharp" to an edge of up to 6 mils by the end of one 2400-ft reel.

*Kybe Corporation*

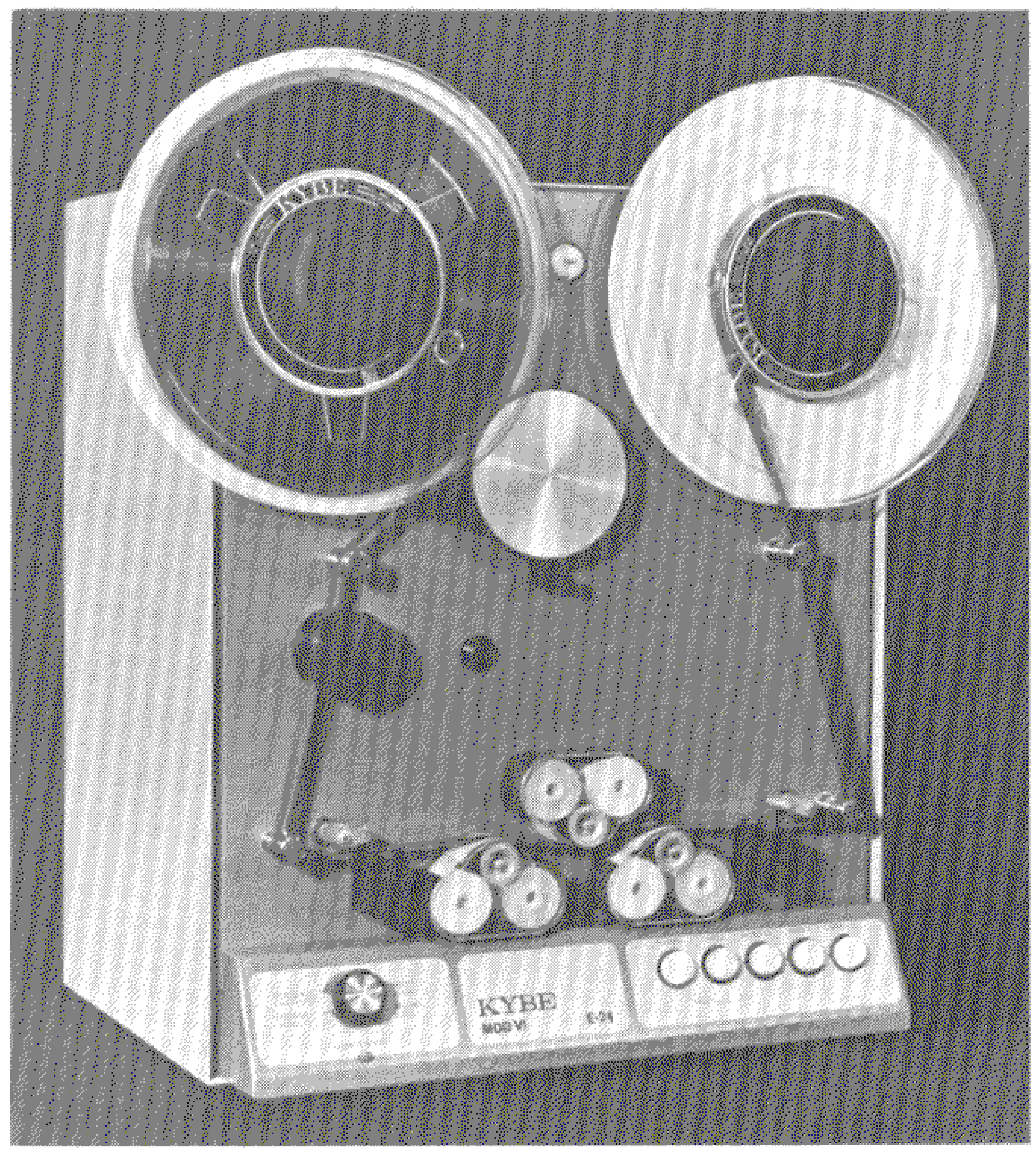



*Figure 26. Block Scraper-type Tape Cleaner.*

Some detractors further charge that the stainless steel blade dulls so rapidly that it loses its cleaning efficiency after scraping only the first 300 feet or so of a single reel.

*Block* The block is a triangular or wedge-shaped scraper that may be made of sapphire, tungsten-carbide, cermaic, or other material. It represents a good compromise that approaches the sharpness of the razor blade and the longevity of other scrapers. Since the block is not razor-sharp, it is less prone to cut slightly deformed tape. It is also less susceptible than a blade to nicking, which would damage even good tape. The block is recommended for tough tape cleaning jobs. Figure 26 shows a tape cleaner equipped with a block-type scraper.

*Grid* The stainless steel grid is the scraper that poses the least threat to slightly deformed tape. It employs the smallest "angle of attack" between the tape and the scraping edge, is self-sharpening, and has a very long service life. The grid is considered a good tape cleaning device best suited for tapes used in relatively clean environments.

*Slotted Cylinder* Experience at the Lockheed Missiles and Space Company (LMSC) has given rise to their preference for the rotating slotted cylinder scraper made of tungsten beryllium. Some of these tape cleaners have performed satisfactorily at LMSC for up to two years without replacement of the slotted-cylinder. During this period the cleaners were operated up to two shifts per day. Considering that this type of cleaner/evaluator runs typically at 160 to 180 ips, the slotted cylinder can clean up to 100,000 2400-ft reels of tape during its life-time. As an added benefit, the scraper's cylindrical shape has no sharp protruding edges and, like the grid, is somewhat "forgiving" of tapes that have slight edge damage or curl. A slotted cylinder-type tape cleaner is shown in Figure 27. On balance, the slotted cylinder-type scraper appears to have the edge for all-around cleaning efficiency, longevity and least danger to tape. It is best suited for cleaning tapes that are used primarily in a relatively contaminant-free environment, such as the typical Tactical Support Center.

*Band* The band scraper employs a 2-mil thick moving edge of stainless steel. It accepts a somewhat lesser cleaning efficiency than the new razor blade, but it offers an edge of a known maximum thickness for the life of the band. The two basic types of bands in use today are the rotating (endless loop) and the cartridge.

The endless loop is a rotating, continuous band of stainless steel operating on the principle shown in Figure 25. Since it is continuously rotating, a groove cannot develop that would eventually curl

*Data Devices International*

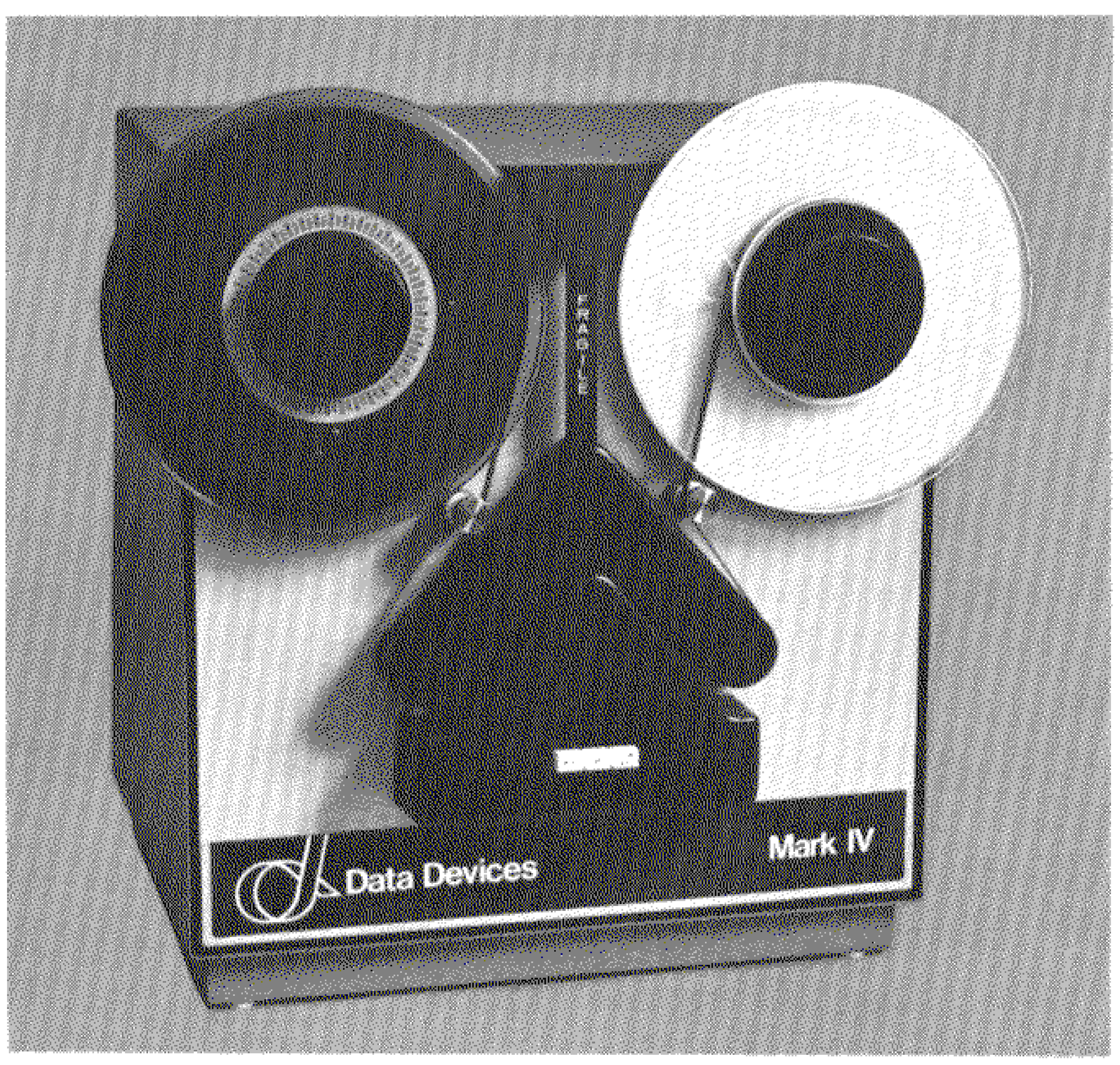



*Figure 27. Slotted Cylinder-type Tape Cleaner.*

or otherwise damage the tapes edge. Advocates of the rotating loop claim that its edge self-sharpens to less than the original 2-mil edge because the band crosses the tape first from one side and then the other. However, its critics point out that the rotating loop's edge is subject to nicks which, if undetected, could damage the tape each time one rotates into the tape path. Both points have merit.

The cartridge-type scraper reduces the danger to the tape from nicks in the band edge – each segment of the band comes in contact with tape only once, rather than rotating continuously. The band is enclosed in a casette, and is fed from a supply reel to a takeup reel at a rate of 0.25 mil/sec. In the event that a nick develops on the band, that band segment will eventually be wound upon the takeup reel. Unfortunately, the slow speed at which the band travels could allow a serious nick to affect more than one reel of 1/2-inch tape before the nick passes from the tape cleaning area.

Both the endless loop and cassette-type band scrapers are considered very good tape cleaners with moderate edge life. Also, due to their constant band thickness, neither type of device is as susceptible to nicks as the razor blade.

*Summary* As a final assessment, LMSC's experience indicates that reliable and satisfactory performance can be expected from the rotating slotted-cylinder scraper for cleaning tapes that are used in a relatively clean environment. The same is probably true for the grid-type scraper. However, when tapes are exposed to conditions of relatively high contamination and there is less opportunity for regular tape cleaning, the block or the band-type scrapers will probably do a better job. Regardless of the type of tape cleaner that is used, it is imperative that the scraper's edge and the debris removal system (vacuum and/or wiper tissue) be inspected regularly to ensure that they are clean and functioning properly.

**TAPE EVALUATION AND CERTIFICATION** Tapes may be "evaluated" or "certified" after the cleaning process to ensure that they have been cleaned properly. *Certification* usually connotes a stop-on-fail type of testing. This allows an inspector to view the area of tape where the dropout occurred to determine whether the dropout is temporary (due to a loose or adhered particle) or permanent (due to a hole in the oxide coating or to otherwise damaged tape). If the dropout is temporary, the tape may be recleaned; if the dropout is permanent, the tape may be relegated to less demanding roles (scratch tape) or discarded if too many permanent dropouts are present. Instrumentation tapes generally are permitted many more dropouts than computer tapes.

*Evaluation* generally means counting the number of dropouts and grading the tapes without stopping to inspect at each point of failure. One tape cleaner/evaluator manufacturer recommends evaluating computer tapes as follows:

| DROPOUTS/REEL | DISPOSITION OF TAPE |
|---|---|
| 0–5 | REFILE IN LIBRARY |
| 5–15 | SCRATCH |
| 15+ | REJECT |

Instrumentation tapes, on the other hand, are acceptable with as many as 40 dropouts per hundred feet because analog signals can be interpreted accurately so long as the dropouts are sufficiently spaced.

A typical cleaner/evaluator (or certifier) processes a tape in the following manner: With the evaluation circuitry deactivated, the tape passes through the evaluation section to the cleaning section. Upon entering the cleaning section, the tape's oxide coating is cleaned by a wiper, then the backing is cleaned by a wiper. Next, the oxide coating is cleaned by the scraper and wiped again. After this, the evaluator section is activated and the tape is run in the reverse direction and cleaned a second time, after which it reaches the evaluation section. Once there, the tape first passes over an erase head to remove any previous recording. A signal is then recorded on the tape at an adjustable wavelength in the range of interest, e.g. from 0.1 mil up to 2.5 mils. The tape then passes over the reproduce head and its output amplitude is measured. If the output drops below a preset percentage of the recorded signal level (between 20 and 80 percent) for some preset interval (between 5 and 50 microseconds), a dropout is registered on the evaluator's counter.

The cleaner/evaluator has separate counters for monitoring each of a number of recording tracks, usually three – the center and each edge track. Many machines are equipped to make strip chart printouts that record the number of dropouts per time interval. This value is easily convertible to dropouts per length of tape which, in turn, is a measure of the tape's usefulness.

**THE PAYOFF** There is little doubt that a well-administered tape maintenance program will pay handsome dividends. Not only will the performance level of the tape transports rise, but costs due to maintenance and tape attrition will decrease. It has been estimated that a tape's life can be extended by two years or more through regular cleaning. This estimate is based on a "normal" usage of the tape – about 20 to 30 times per year. Figure 28 gives a life cycle comparison of tapes with and without regular cleaning. Naturally, the life cycle shown on this graph must be considered an ideal case. It represents savings that are possible only if the other practices pertaining to good care and handling of the tape and its transport are strictly observed.

## TRANSPORT CARE

**CLEANERS AND CLEANING PRACTICES** Earlier we stated that normal wear causes magnetic tapes to shed minute particles of oxide and base film. These particles accumulate on all of the transport handling surfaces (i.e., guides, rollers, and heads). Subsequent redeposit of these particles on the tape increases the distance between the head and the tape surface, causing signal dropouts. Therefore, high quality tape recorder performance demands that all tape handler surfaces be cleaned properly and frequently. The requirements for cleaning tape guides, rollers, and heads have been arranged in the following categories: cleaning solvents; cleaning materials, cleaning practices; and cleaning intervals.

**Cleaning Solvents** The characteristics of Freon TF, Xylene, isopropyl alcohol, and methyl alcohol (methanol) were investigated to determine their suitability as tape handler surface cleaners. The strong and weak points of each solvent are presented in Table I. On balance, Freon TF has the most desirable combination of characteristics. It is important, however, that the tape handler surfaces be cleaned regularly, otherwise contaminants may build up to the point where Freon TF loses its effectiveness. If such is the case, use of a stronger cleaner such as Xylene may be necessary on a one-time basis. It must be kept in mind that Xylene will attack polycarbonates (e.g. AQH-4 pinch rollers), so extreme care must be taken to avoid splashing or spilling Xylene onto other surfaces. Also, remember that Xylene is flammable and extremely toxic.

Freon TF solvent is available in both aerosol and bulk containers. During analysis, it was discovered that minute metallic particles are present in most aerosol cans. Apparently, these particles are by-products of the can's manufacturing process. It was further determined that these metallic particles can possibly damage both the tape and the tape transport heads. Since bulk Freon TF solvent (in bottles or drums) is free of these particles, its use is recommended.

Contamination is always a possibility when a solvent is transferred from a larger container to a smaller one. The best way to avoid such contamination is simply to use solvent that is packaged in small disposable containers. Bulk Freon TF is available in convenient 6-ounce containers, NSN 6850-935-1082.

**Cleaning Materials** The materials used to clean tape transports must be chosen carefully. After chemical and physical analyses, both Kimwipe tissues and Q-tip cotton swabs on wooden sticks have

*Computer-Link Corporation*

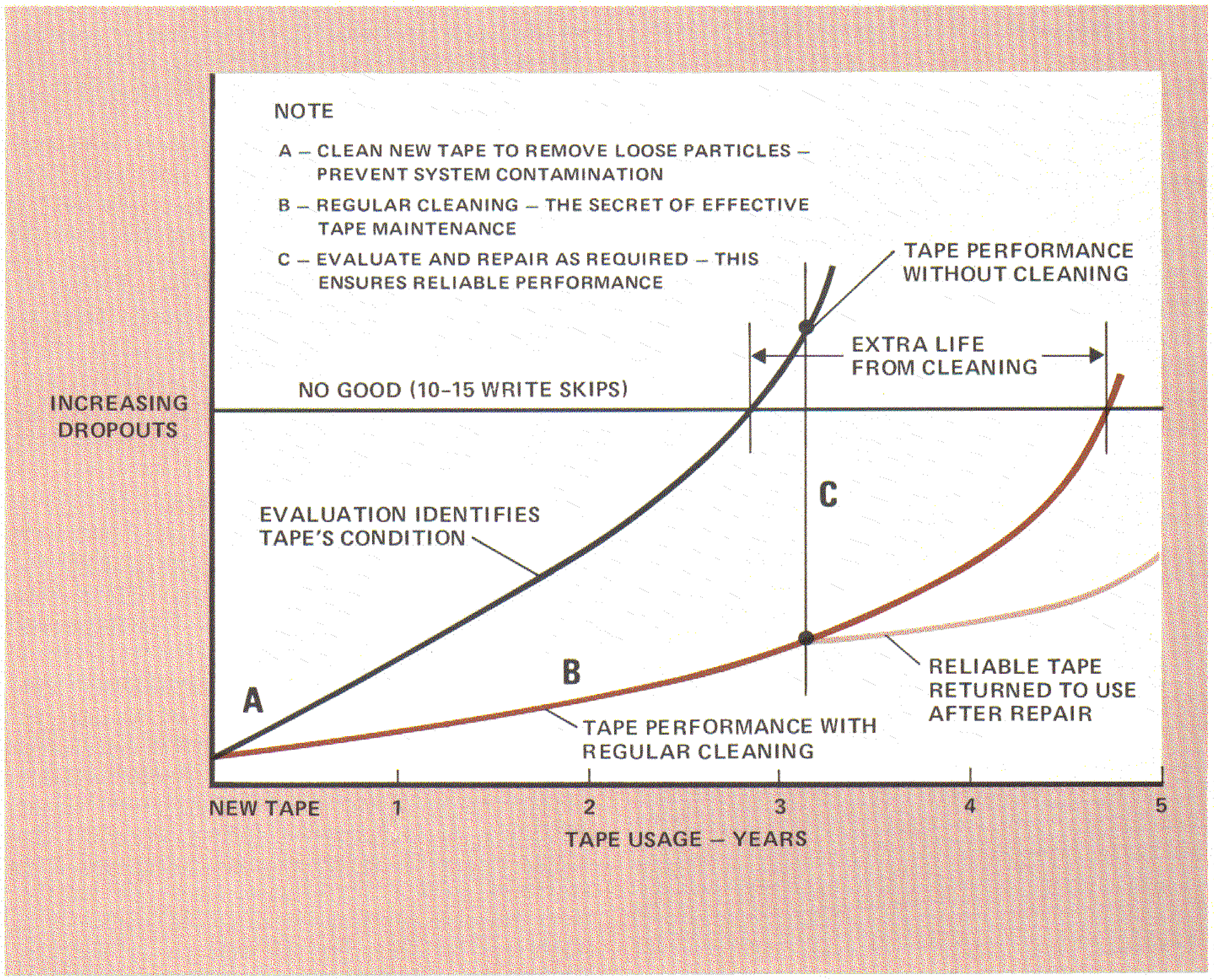



*Figure 28. The Life-cycle of a Computer Tape With and Without Regular Cleaning.*

been found to be acceptable cleaning materials. The tissues should be used to clean areas where there is sufficient space to apply finger pressure. Often a good deal of pressure is required to remove contaminants that have been deposited under the heat and pressure present during recorder operations. Swabs are useful in cleaning areas with limited access. Swabs with *plastic* sticks are *not* recommended; they tend to break when firm pressure is applied. Also, the glue that holds the cotton to the plastic stick has been observed to soften in the presence of the solvent and contaminate the surface being cleaned.

**Cleaning Practices** To get the equipment "microinch clean," the technician must begin with the proper cleaning material and solvent. Next, he must clean the equipment thoroughly and use the cleaning materials properly. He must be certain that once contaminants have been removed, they are not transferred by way of a soiled swab or wiping tissue to the solvent container or to another part of the equipment. Thus, the following practices should be observed when cleaning tape transports:

1. Apply bulk Freon TF to the cleaning material. Do not dip the swab or tissue in the solvent. Instead, transfer the solvent to the cleaning material with a clean dropper or other device. Do not apply so much as to cause it to run during cleaning. *Never* pour or

| CLEANING SOLVENT | CHARACTERISTICS |
|---|---|
| FREON TF | (1) DOES NOT DAMAGE POLYCARBONATES, PLASTICS OR NEOPRENE<br>(2) CUTS OIL AND GREASE<br>(3) LOWEST BOILING POINT OF SOLVENTS SURVEYED (DRIES QUICKLY)<br>(4) NONFLAMMABLE, LOW TOXICITY |
| XYLENE | (1) DAMAGES POLYCARBONATES* AND ACRYLICS; DOES NOT DAMAGE NEOPRENE<br>(2) CUTS OIL AND GREASE VERY WELL<br>(3) HIGH BOILING POINT<br>(4) EXTREMELY FLAMMABLE AND TOXIC<br>*AOH-4 PINCH ROLLERS ARE POLYCARBONATE |
| ISOPROPYL ALCOHOL | (1) DOES NOT DAMAGE POLYCARBONATES, ACRYLICS OR NEOPRENE<br>(2) LIMITED ABILITY TO CUT OIL AND GREASE<br>(3) MEDIUM BOILING POINT<br>(4) FLAMMABLE |
| METHYL ALCOHOL (METHANOL) | (1) DOES NOT DAMAGE POLYCARBONATES, ACRYLICS OR NEOPRENE<br>(2) LIMITED ABILITY TO CUT OIL AND GREASE<br>(3) LOW BOILING POINT<br>(4) FLAMMABLE |

*NOTE: NONE OF THESE SOLVENTS DAMAGES POLYESTERS (e.g. MYLAR)*

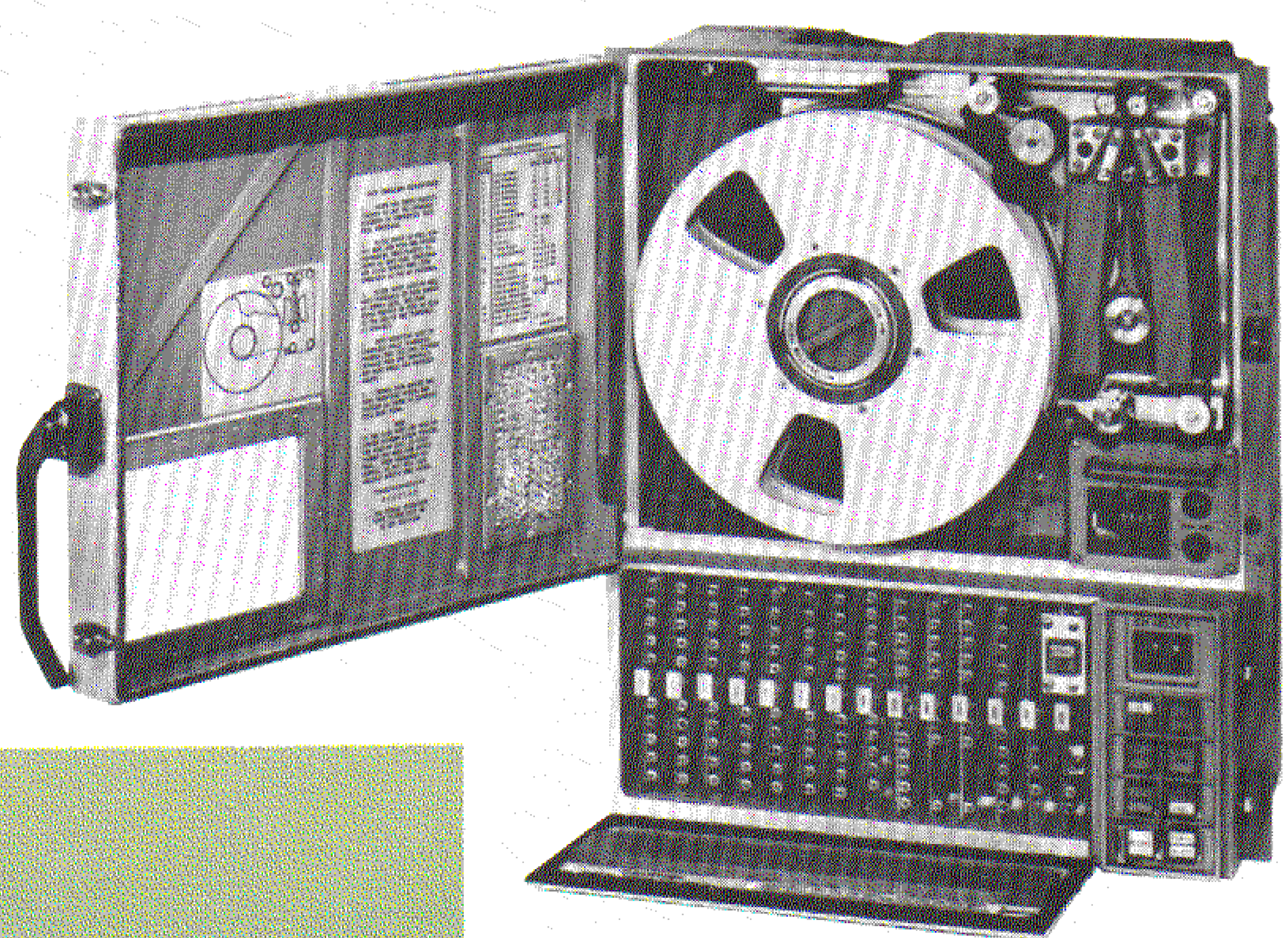
*Table I. Tape Transport Cleaning Solvents* spray solvent directly on any component of the tape transport.

2. Use firm finger pressure on the tissue to "scrub" the heads, guides and rollers.

3. While cleaning, *discard the cleaning materials as they become soiled.* Continue cleaning, changing the swabs and tissues until they show no evidence of dirt or contaminants.

4. Make the last cleaning pass across the heads in the direction of tape motion.

**Cleaning Interval** As a minimum requirement, the tape transport heads and rollers *must* be cleaned prior to each flight. It is preferrable that they also be cleaned just before each tape load. AQH-4 recorder/reproducer tape path components that require cleaning are designated on Figure 29; those components of the RD-319/319A tape transport that require cleaning are designated on Figure 30. The entire recorder or tape transport should be cleaned at specified intervals in accordance with the procedures set forth in its official maintenance manual – NAVAIR 01-75PAC-2-7.3 and 01-75PAC-12-4 for the AQH-4, and NAVAIR 01-75PAC-2-5.13 and 01-75PAC-12 for the RD-319/319A.



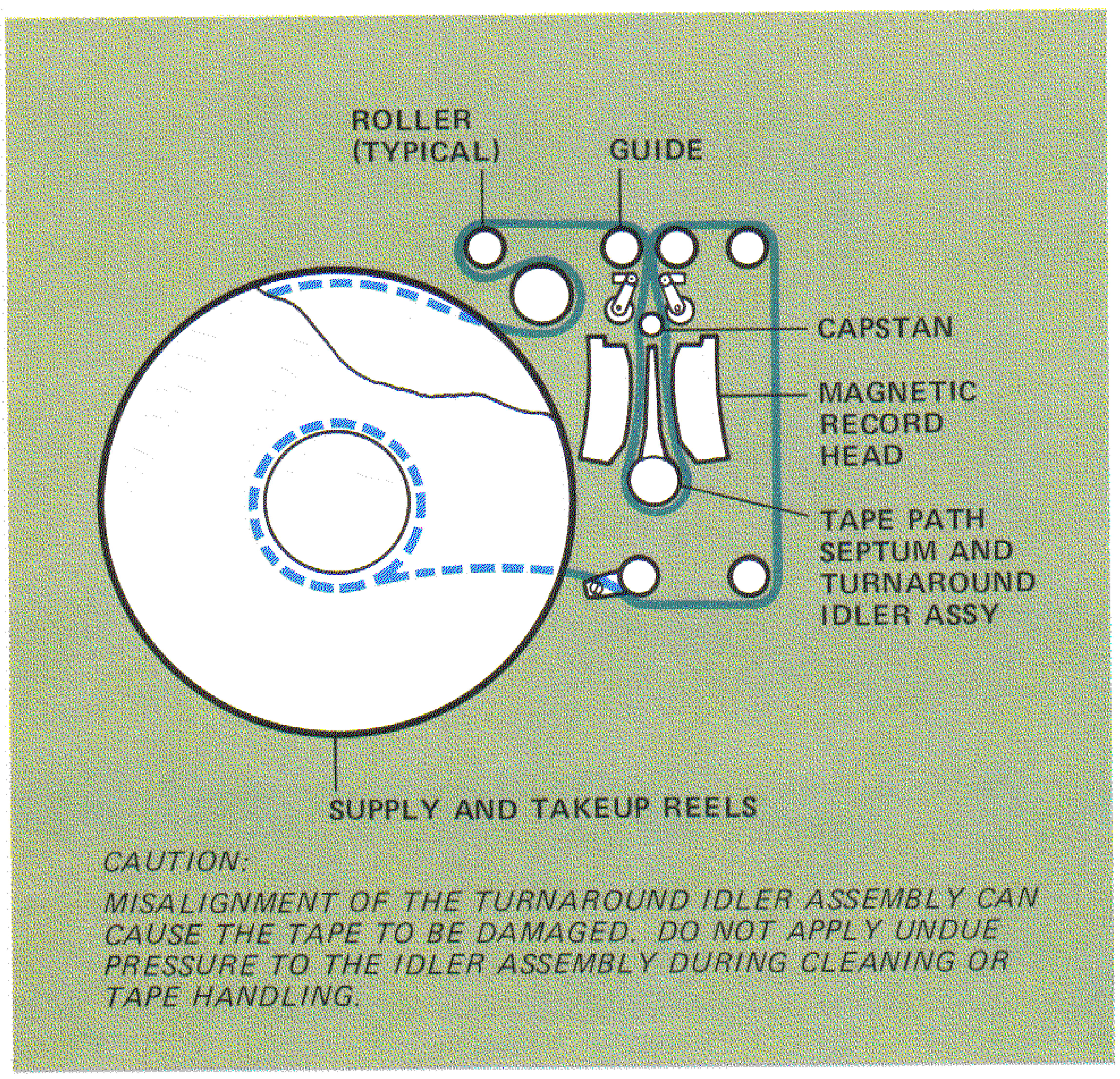


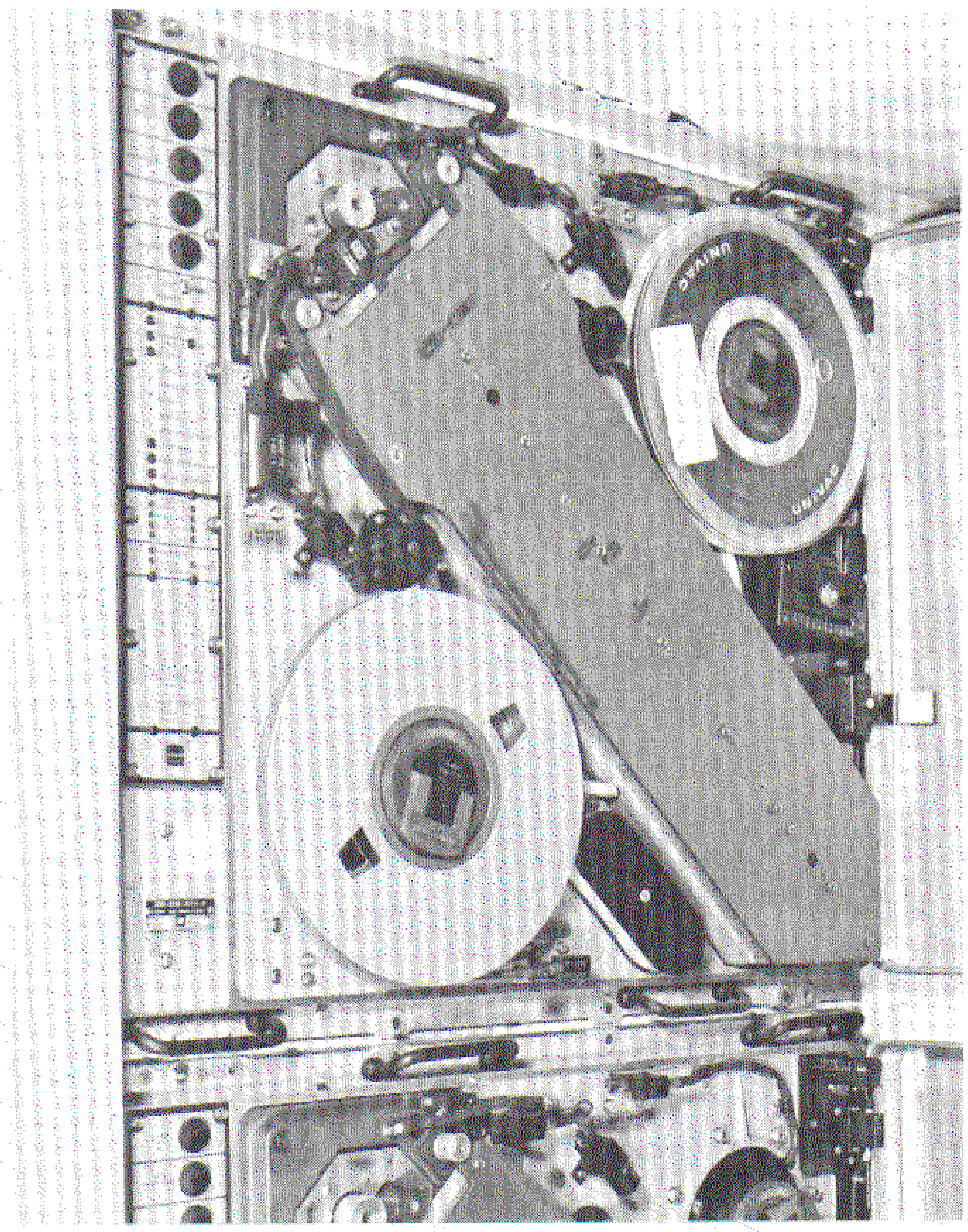

*Figure 29.*
*AQH-4(V)2 Recorder Tape Path Components that Require Regular Cleaning*

## HEAD DEGAUSSING

**GENERAL** Magnetic cleanliness is of equal importance to maintaining the performace requirements of ASW tape systems. Analog recorder heads must be magnetically neutral or "clean" to faithfully convert electrical impulses to magnetic impulses when recording and vice-versa during reproduction.* When heads acquire residual magnetism over a period of time, they become magnetically "dirty." Tools that contain iron also can acquire residual magnetism. During our discussion of Accidental Tape Erasure, it was shown that distance from the magnetic field is the controlling factor when magnetizing or tapes. The same is true for magnetizing recorder heads and all other materials that contain iron.

---

**Residual magnetism does not present a problem in digital tape transport heads, because during digital recording the heads are normally driven to magnetic saturation. Consequently, head degaussing is not a scheduled maintenance item for digital tape transports.*



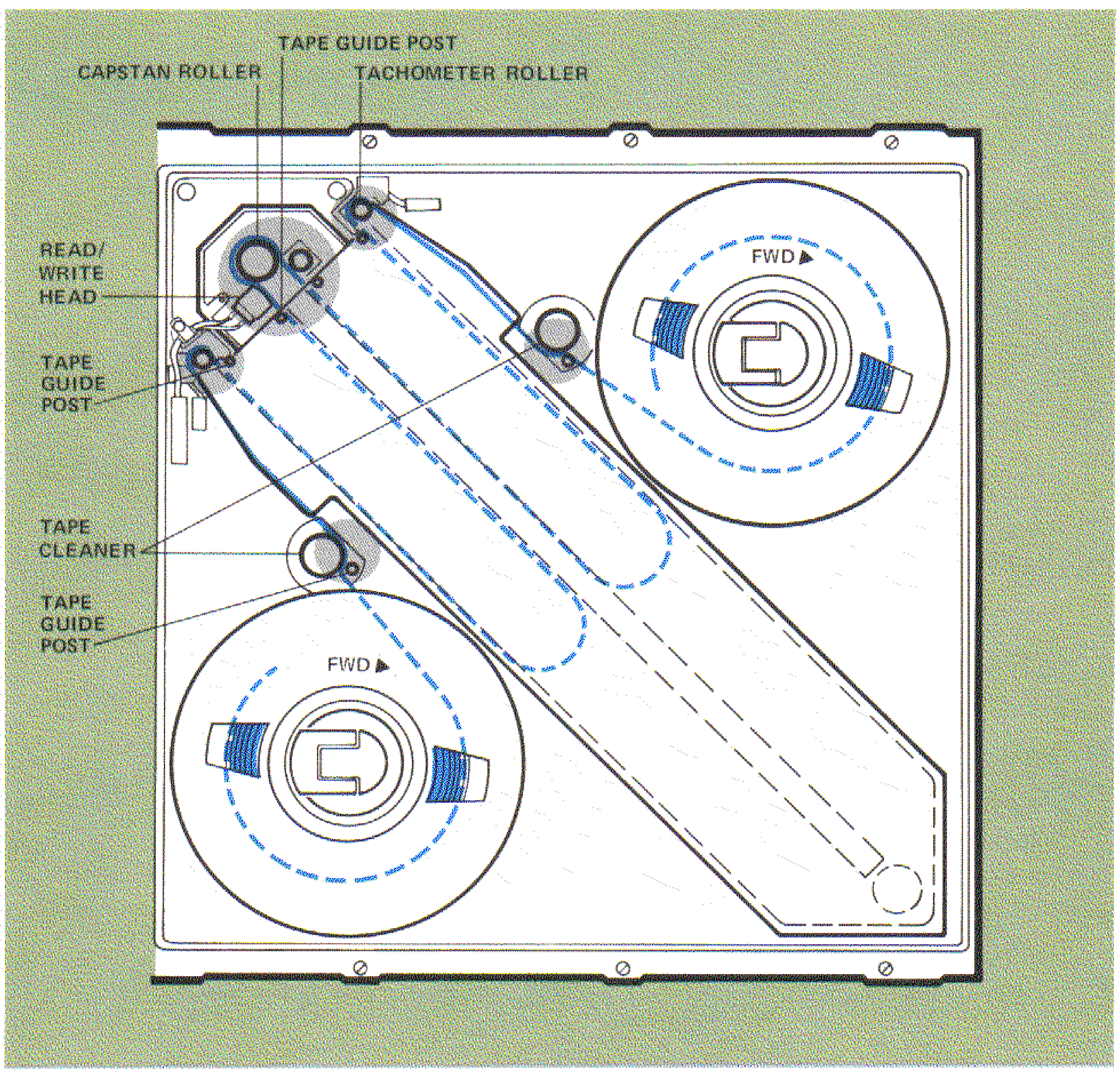



*Figure 30. RD-319/319A Recorder-Reproducer Tape Path Components that Require Regular Cleaning.*

**DEGAUSSING PRACTICES** Head degaussing is a scheduled maintenance item requirement for P-3 analog recorder/reproducers. It is a simple operation, but if not done properly the heads may be left with *more* residual magnetism than they had originally. A head degausser is shown in Figure 31. The following general practices should be observed when degaussing tape recorder heads:

1. The reels should be removed from the transport before beginning the head degaussing operations.

2. The tip of the degausser should be protected with a plastic cap or guarded in some other manner. Without such protection, the heads most likely will be scratched by the tip of the tool during the degaussing operation. Figure 32 shows a badly scratched tape head.

3. From the time that the degausser is initially powered (at a location several feet from the recorder) until power is removed from it, all operations with the degausser must be performed with deliberate, slow motions. Any erratic or abrupt movements may result in increasing, rather than decreasing, the head magnetism.

While observing these general practices, the technician must refer to the official Maintenance Instruction Manual NAVAIR 01-75PAC-2-7.3, and follow the published degaussing procedures *to the letter*. Remember, head degaussing is a critical link in the recording chain. An improperly deguassed recorder head can negate all the effort spent to get a clean, damage-free tape to the unit's recording surface.

## CONCLUSION

Magnetic recordings play a vital role in the success of the ASW mission. Minute contaminants or defects in magnetic tapes, reels, tape path components, or recorder heads can drastically affect the magnetic recording system's ability to fulfill its role. Effective system performance can be obtained only when the tapes, reels, and recording equipment receive the proper care. This is the responsibility of the Navy's professionals – the system operators and electronic technicians.

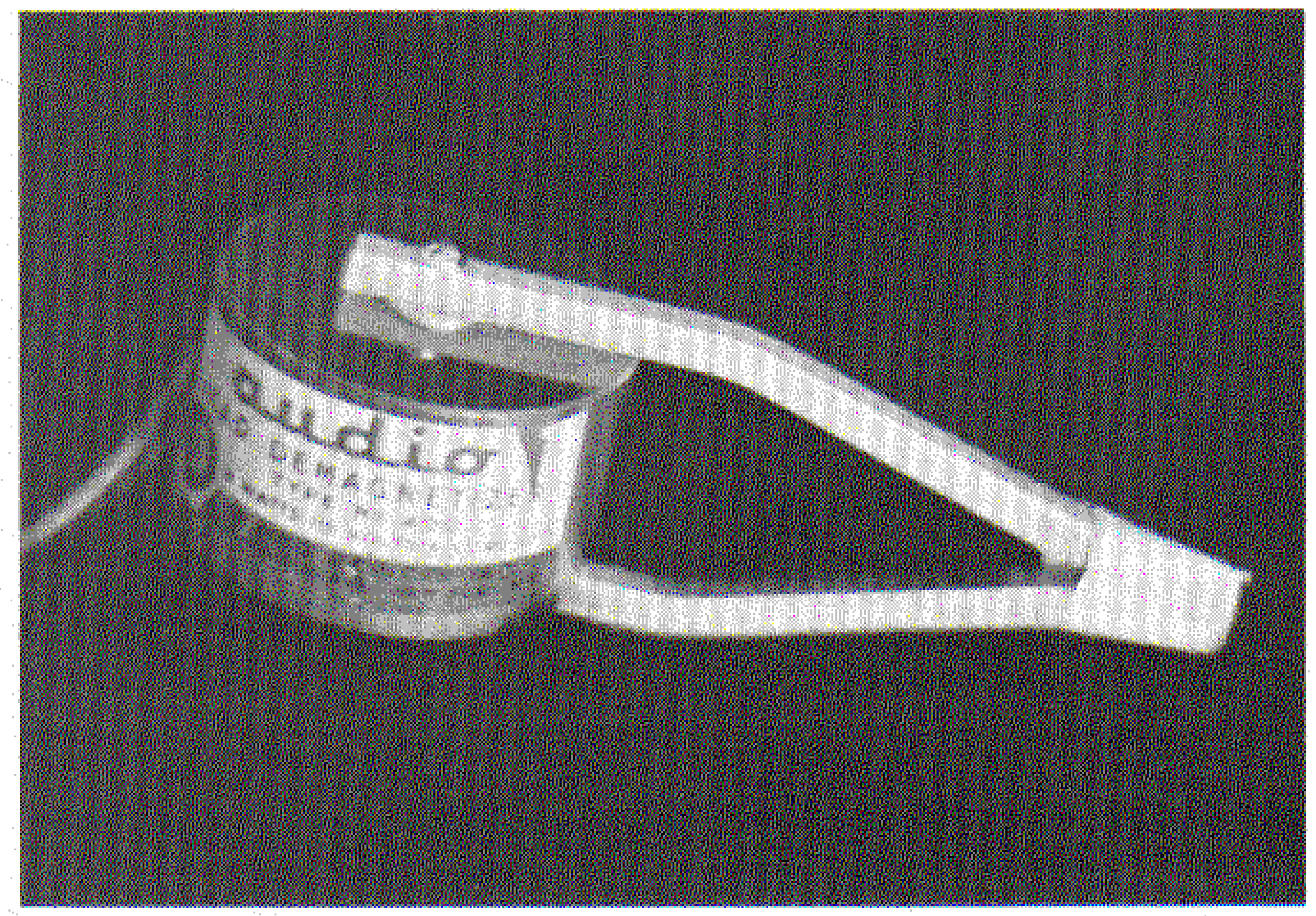


*Figure 31. Magnetic Head Degausser.*

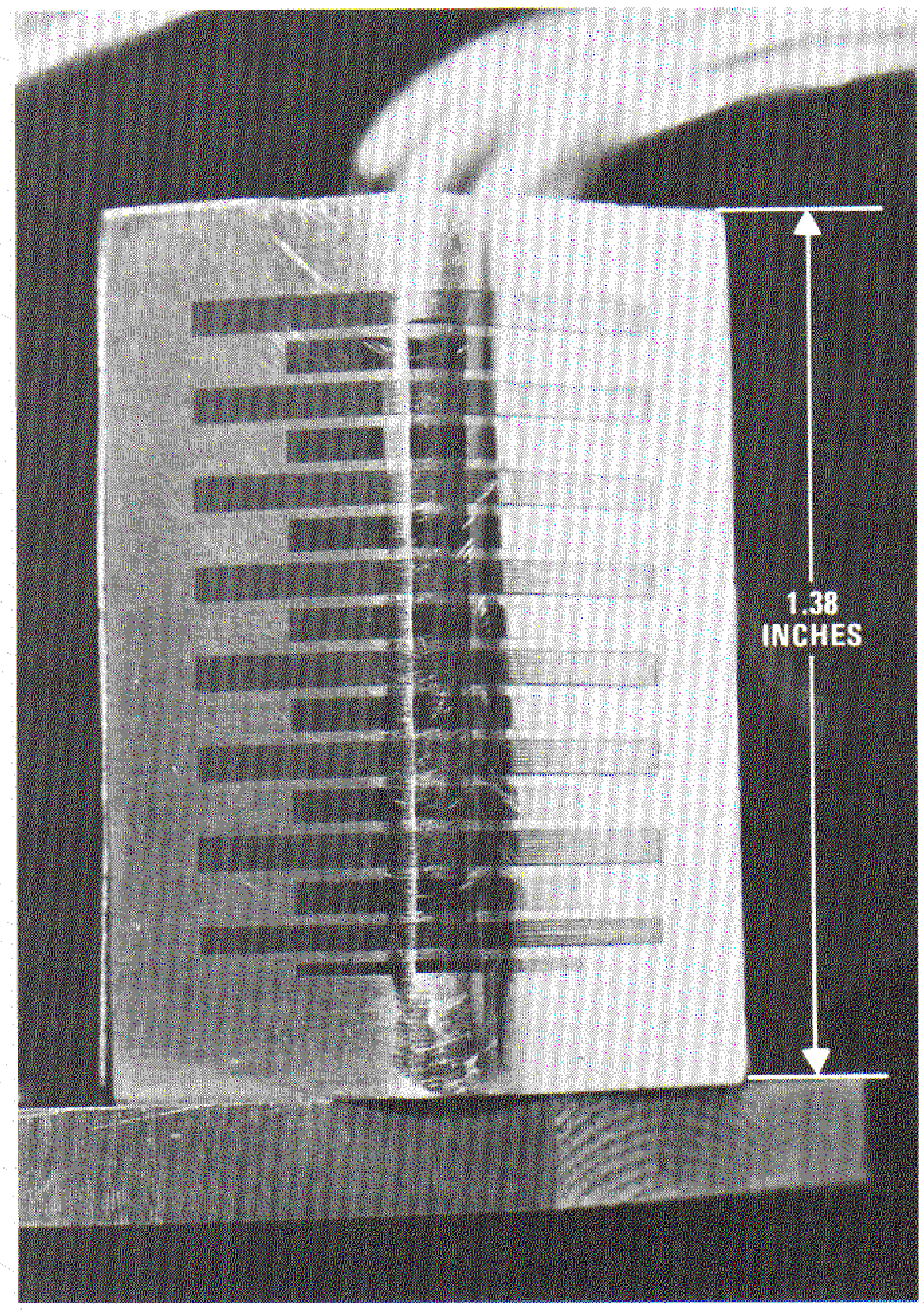



*Figure 32. Magnetic Head with Scratches on Head Face.*

## LOCKHEED-CALIFORNIA COMPANY
## PRODUCT SUPPORT — GOVERNMENT PROGRAMS
## T. J. BALL, DIRECTOR

| DIRECTOR INT'L SUPPORT PROGRAMS | DIRECTOR P-3 SUPPORT | DIRECTOR S-3 SUPPORT | DIRECTOR CP-140 SUPPORT |
|---|---|---|---|
| A. B. Stacey | H. A. Franck | E. E. Mouton | R. R. Humphrey |

### FIELD SUPPORT DIVISION — W. C. Bowden, Manager

| | |
|---|---|
| **P-3 Services** | **G. E. Bentley, Manager** |
| **S-3 Services** | **L. E. Atkins, Manager** |
| **Maintenance Training** | **F. N. Simmons, Manager** |
| **Administrative Services** | **H. R. Keatley, Manager** |

| Navy Service Group — P-3 | Readiness Tracking Group — P-3 | Aircraft Modification Group | Navy Service Group — S-3 |
|---|---|---|---|
| M. J. Galli, Supervisor | J. N. Shovald, Supervisor | R. V. Paddack, Supervisor | L. E. Atkins, Acting Supervisor |

### FIELD SERVICE OFFICES

| MAJOR LOCATION | MAILING ADDRESS AND BUSINESS TELEPHONE |
|---|---|
| NARF Alameda<br>F. E. Weaver | P.O. Box 1363<br>Alameda, CA 94501<br>*(415) 521-2283* |
| NAS Barbers Point<br>A. W. Vitaglin | P.O. Box 268<br>NAS Barbers Point, HI 96862<br>*(808) 681-3444/682-3671* |
| NAS Brunswick<br>C. E. Phillips | P.O. Box 38<br>Brunswick, ME 04011<br>*(207) 729-0000*<br>*(207) 921-2472, 921-2521* |
| NAS Cecil Field<br>W. H. Beydler | P.O. Box 162<br>NAS Cecil Field<br>Jacksonville, FL 32215<br>*(904) 772-8517* |
| NAS Jacksonville<br>J. R. Mercer | P.O. Box 1300<br>Yukon, FL 32230<br>*(904) 772-3535* |
| NS Keflavik<br>D. Babbitt | Box 16<br>U.S. Naval Station<br>FPO New York, NY 09571<br>*Keflavik 2290* |
| NAS Moffett Field<br>J. Berezonsky | Unit One P.O.<br>Moffett Field, CA 94035<br>*(415) 966-5461* |
| NAVAIRSYSCOM<br>D. R. Steele | Lockheed Corporate Office<br>900 17th St., NW<br>Washington, DC 20006<br>*(202) 872-5955* |
| NS Naples<br>K. M. Prideaux | Lockheed-California Co.<br>COMFAIRMED/NSA<br>FPO New York, NY 09521<br>*Naples 081-7605400* |

| MAJOR LOCATION | MAILING ADDRESS AND BUSINESS TELEPHONE |
|---|---|
| CNAVRES New Orleans<br>G. A. Seipp | P.O. Box 189<br>Gretna, LA 70054<br>*(504) 948-1220* |
| NAS Norfolk<br>A. W. Barber | P.O. Box 15148<br>U.S. Naval Base<br>Norfolk, VA 23511<br>*(804) 423-8321* |
| NAS North Island<br>R. B. Calvin | NAS Box 5<br>San Diego, CA 92135<br>*(714) 435-8910* |
| NATC Patuxent River<br>M. D. Garino | P.O. Box 218, NATC<br>Patuxent River, MD 20670<br>*(301) 863-8186* |
| USNAF Sigonella<br>R. Goodell | USNAF P.O. Box 1032<br>FPO New York, NY 09523<br>*Sigonella 590122, Ext. 5319* |
| NADC Warminster<br>J. Blalock | P.O. Box 220<br>Warminster, PA 18974<br>*(215) 674-3550* |
| Ottawa, Canada<br>E. C. Joslen | LAC of Canada, Ltd.<br>141 Cooper St., Suite 909<br>Ottawa, Ontario<br>Canada K2p 0e8<br>*(613) 233-5636* |
| Bonn, Germany<br>G. C. Lauffenburger* | Box 205<br>APO New York, NY 09080<br>*Bonn-Bad Godesberg 356621* |
| Teheran, Iran<br>J. Stottlemyre* | P.O. Box 66-1516<br>Niavaran, Iran<br>*Teheran 843940 or 848878* |
| Madrid, Spain<br>F. E. Kiewert | USAF Section MAAG<br>APO New York, NY 09285<br>*243-2800, Ext. 255 or 390*<br>*(Air Ministry Madrid)* |

**Services provided through LAIAG, a Lockheed affiliate*


PATRON 62

LOCKHEED CALIFORNIA COMPANY · A DIVISION OF LOCKHEED AIRCRAFT CORPORATION