AMPEX

MAGNETIC TAPE TRENDS

APPLICATION ENGINEERING BULLETIN

BULLETIN NO. 2 JULY 1963

TO ALL PRECISION TAPE USERS:

This is issue Number 2 of Magnetic Tape "Trends" - - - a new engineering service from Ampex Corporation, Magnetic Tape Division. It is part of a series of application notes containing information on the latest trends in magnetic tape development and use throughout the industry.

The technical information appearing in "Trends" is designed to be retained as basic reference material and each sheet is punched for easy insertion into a three ring binder.

We hope you will route "Trends" to others in your organization by using the routing space provided on the mailing folder. These names may also be added to the regular mailing list (see below).

The last page of this issue is a multi-purpose "coupon" for your convenience in:

* Adding other names to the "Trends" mailing list.
* Making suggestions for future subjects to be covered.
* Requesting information on other Ampex products.

"Trends" is for you... we hope you will find it useful and informative.

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Litho in U. S. A. 1753-7-63
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AMPEX

MAGNETIC TAPE TRENDS

APPLICATION ENGINEERING BULLETIN

I. EFFECTS OF STRAY FIELDS ON MAGNETIC TAPE

A major advantage of magnetic tape as a storage medium is its ability to be erased and recorded over many times. Normally this is accomplished by one of two methods. One approach is to use a bulk eraser that is capable of erasing entire reels in seconds, which is done by slowly rotating and moving the reel through a concentrated AC field. The second technique is the more familiar erase head incorporated in the tape transport. The erase head is energized during the record mode to insure that a new recording is never made over previously recorded information.

Virtually all equipment incorporating an erase head contains a simple interlock to minimize unintentional erasure. The danger of unintentional erasing is recognized by most operators, and their attention to it minimizes the problem. However, a less understood phenomenon is the effect of stray fields on tape during handling and storing.

An understanding of the relationship between gauss and oersted as applied to measurement of field strength will help to clarify the effects of stray fields on tape.

Both the gauss and the oersted are units of magnetic measurement. The oersted is the measure of magnetizing force and the gauss is a measure of the resultant magnetic intensity. When measuring field strength in air the gauss and oersted are numerically equal. This relationship is altered in magnetic materials such as tape which have a greater permeability than air. In these materials of high permeability the oersted - gauss relation is a function of the permeability.

Different types of stray fields affect tape in different ways. The first field to consider is a steady DC field, such as that produced by a permanent magnet. If a reel of tape remains within a DC field, the resultant effect is that an extra signal is recorded on the tape. This will take the form of background noise, and will vary in strength in proportion to an exponential of the applied field and proportional to the length of time the field is applied.

This will be similar to the effect that a magnetized recording head which was not properly degaussed will have on tape during recording. This points up the need and advisability of degaussing heads frequently. (Consult equipment operating guide for specific degaussing procedures.)

A different phenomenon occurs when tape is exposed to an AC field. If a tape is moved rapidly through an AC field, the effect is about the same as recording on the tape without using AC bias. A highly distorted time variant signal can be left on the tape. This noise is recorded in much the same manner as significant data coming through the record head in normal operation. With a stray AC field present, the possibility of erasure always exists, and the degree of erasure is nonlinear with respect to the AC field strength. If the peak strength of the field is less than the coercivity of the tape, it is impossible to have a complete erasure regardless of how long the tape remains in the field. In AC fields greater than the tape coercivity (usually 250-260 oersteds), the signal on the tape will be completely obliterated. Tape erasure in an AC field may be considered a time function. A brief exposure to a 700-1000 oersted field will completely erase the signal on the tape, whereas longer exposures to weaker fields will be required for complete erasure.

Another effect suffered from exposure to stray fields is that of increased print-through. This can occur at relative small field strengths. For instance, a five minute exposure to an RMS field of 20 oersteds will cause a print-through increase of 10 db. The print-through increases roughly at the rate of 2 db for every additional 5 oersteds.

The effect on tape of the earth's magnetic field of approximately 0. 5 oersteds is negligible. Generally stated, a stray field of up to approximately 10 oersteds should have no detrimental effects on magnetic tape. When tape is exposed to more powerful fields, up to about 100 oersteds, low-level and short wave length signals may be erased. As the field strength increases, the longer wave-length and higher level signals will be affected. Field strengths of 700 oersteds or more will completely destroy all magnetic data previously recorded on the tape.

Although field strength decreases significantly as we move away from the source, a safe storage space away from electric motors and other known sources of magnetic fields should be provided.

II. CARE AND STORAGE OF MAGNETIC TAPE

Your recording of valuable data is done under precise and closely controlled operating and ambient conditions to insure exact reproducibility. Every care is taken to provide optimum performance of the machine, tape, and all components. It is equally important to provide the same care in the handling and storage of the tape to protect the valuable recorded data.

In order to understand more clearly the factors affecting magnetic tape storage, there are a few basic concepts to be understood. The magnetic ability of the oxide on a magnetic tape does not degenerate. In other words, the magnetic particles will never get tired and allow the data they are holding to "leak off". The only thing that will cause the particles to change their orientation is the influence of an external field.

However, degeneration can occur in another fashion. Basically, magnetic tape consists of three constituents: base material, binder, and oxide. The oxide does not lose its magnetic potency with time, however the base materials may become brittle, distorted, and lose their intrinsic properties if not stored under proper conditions. The binder system also may degenerate which will result in complete loss of stored data if proper precautions are not taken.

Base Material. The main broad function of the base material is to provide a means to hold the iron oxide and move it past the heads of the recorder in a controlled fashion. It must also electrically insulate one layer of oxide coating from the other to prevent print-through. Dimensional stability (resistance to physical change as a result of varying ambient conditions) is the keynote in a good base material. It must also maintain resilience so that in this flexible state it may provide good tape to head contact. It is obvious that if a base material becomes brittle, warped, or wavy, the tape will be useless regardless of how superior the oxide coating may be. Temperature and humidity extremes should be avoided to maintain the dimensional integrity of the base material.

Mylar* (or polyester) affords the best characteristics to meet the demands for magnetic tape base material. Plastic or Acetate base does not possess the dimensional stability and durability required for instrumentation and computer tape requirements.

Binder. The function of a binder system is more complex and critical. Actually there are several distinct functions that a binder must perform. The binder must provide even dispersion of the oxide particles and confine them within a very thin layer. It must maintain a durable, frictionless surface possessing long wear characteristics. All this must

*TM for Dupont Polyester Film

be accomplished while the binder provides an efficient bond (adhesion) of the oxide coating to the backing material, and an effective bond (cohesion) of the magnetic particles to each other. There must be no physical or chemical reaction between the binder and the tape backing or any material normally encountered in the tape handling mechanism. The life of the binder system is critically dependent upon the storage environment.

Ideal temperature and humidity conditions are shown on Fig. 1. In the case of long term storage, it is imperative that these conditions be met to eliminate unnecessary and accelerated degradation of magnetic tapes.

Physical Damage. All tapes in storage must have proper protection from physical damage. The reels should be sealed in dustproof bags, replaced in original cartons and stored on adequate shelves where they will not be moved or subjected to vibration. The storage area must be free from all external magnetic fields (See Part I: Effects of Stray Fields on Magnetic Tape.) The boxes of tape should be stored on edge with proper support to prevent them from falling.

The usual precautions of tape handling apply in the preparation of reels for storage. Tape should be used, handled, and packaged in a dust free, controlled ambient. Nothing should come in contact with the tape edges exposed through the flange windage holes. Tape should always be handled by the reel in such a manner that fingers never touch the tape. Reels should be handled by the hub. When handling a reel by the flanges you may pinch the flanges together to the point where they assume a permanent set and will not track properly on the transport. Final winding of the tape must be done as accurately as possible to minimize poor tape pack, internal stress, pack slip, etc. The rewind mechanism should be checked frequently and must always meet the published specifications of the equipment manufacturer, particularly in regard to braking systems, hold-back tensions, etc.

It is advisable that all tape in long term storage be rewound once a year. This is done to relieve any internal stress that may have built up within the tape pack during storage.

Stored tape should be normalized before it is used. If the storage ambient is different from the operating ambient, the tape should be placed in its operating ambient at least 6-8 hours prior to its use to insure the tape has reached thermal equilibrium.

For best results with medium or long term tape storage, it is recommended that Mylar base film tape be used. A 1.5 mil Mylar backed tape provides optimum strength and print-through characteristics.

THE EFFECT OF ENVIRONMENT ON MAGNETIC RECORDING TAPE

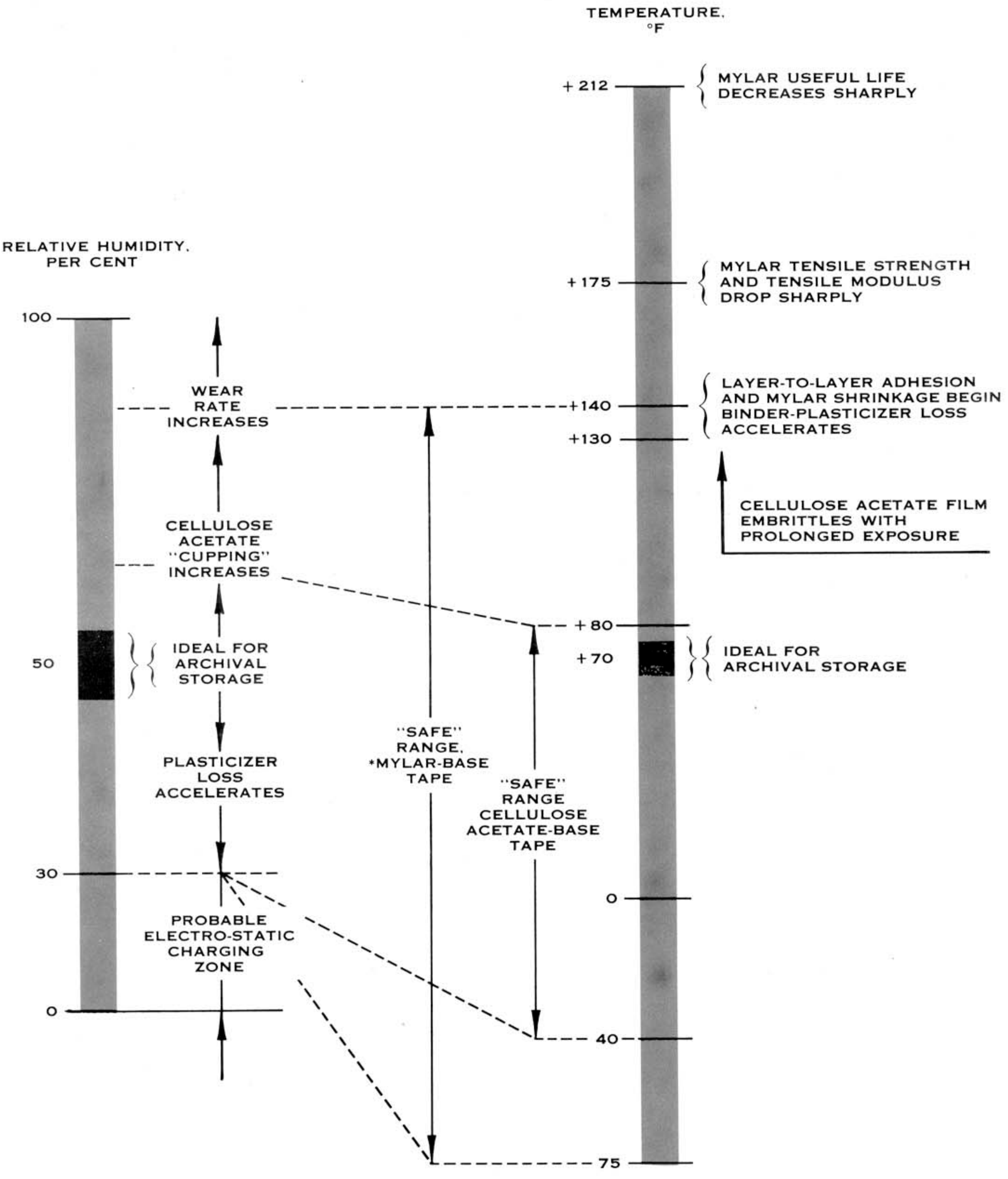

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Fig. 1

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MAGNETIC TAPE

TRENDS

APPLICATION ENGINEERING BULLETIN

BULLETIN NO. 4 OCTOBER 1963

IN THIS ISSUE

I. INSTRUMENTATION TAPE DROPOUTS

II. GLOSSARY OF TAPE TERMS

I. INSTRUMENTATION TAPE DROPOUTS

Instrumentation recording applications are moving into the area of higher frequencies and shorter wavelengths, and along with this growth is an increasing requirement for a basic understanding of tape dropouts. TRENDS issue No. 3 discussed the nature of computer tape dropouts, and in this issue we will investigate some of the general, underlying principles of instrumentation tape dropouts.

Instrumentation recording techniques differ greatly from computer techniques. Because of the nature of the data to be captured, the majority of all instrumentation systems employ an analog approach to recording, and computers use digital format. Dropouts and their effect on the computer electronics are quite obvious. A self contained, discrete bit of information may be lost due to a dropout which renders the associated data meaningless. For this reason, it is imperative that reliable computer tapes be 100% tested and certified error free. Instrumentation tape dropouts, although more subtle in their effect on the total information, are also most important and must be adequately controlled.

At this point the difference between computer dropouts and instrumentation dropouts should be clarified. A digital dropout is any tape phenomena that produces a reduction or loss in signal below a preset level (usually 50%). Any individual bit that suffers this effect is classified as a dropout. If a system is operating at 800 BPI, a loss of signal for any one of the 800 bits of information recorded on each inch of the tape would constitute a dropout.

An analog instrumentation dropout must have another parameter defined to properly classify it. This additional parameter is time - the duration of the reduction in signal. Quoting from W-T-0070, paragraph 4.5.3.4.2 - "Dropout counting for tape speed of 60 inches per second - a 70,000 cps signal shall be recorded at a constant level such that on playback it will be between 40 and 50 db above the noise level. The bias level

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shall be adjusted to that value which is optimum for the tape being tested. The recorded signal shall be reproduced. All discontinuities in output which for a period of 40 microseconds or more are equal to or exceed a 60% decrease in the average output shall be counted."

Although the preceding description of an instrumentation tape dropout is the definition provided by MIL standards, it does not necessarily classify all the dropout specifications throughout the industry. Any specific instrumentation installation may set forth its own specifications on dropout classification. However, for any instrumentation dropout specification to be meaningful, it must not only define the minimum level of a signal, it must also specify the duration of the reduction.

Analog recording and reproducing, by its very nature, is relatively insensitive to instantaneous losses in signal. The original data is still preserved, and may be interpreted quite accurately despite the presence of a few instantaneous discontinuities in the waveform. This is made possible through the use of sophisticated electronics and proper application of ingenious recording and analyzing techniques. For this reason, W-T-0070 (paragraph 3.7.3) allows 4 dropouts per nominal 100 feet of instrumentation tape. A tighter specification than this is actually unnecessary for practically all instrumentation applications of today. That is to say that very little will be gained in the overall performance of an instrumentation installation by specifying analog instrumentation tape that is free from all dropouts. This would increase the tape cost by a significant factor, and would be usually impossible to justify.

As in the case of computer tape dropouts, instrumentation tape dropouts are due primarily to the presence of foreign particles on the tape surface. Obviously, oxide voids on the tape will also cause dropouts, but with the present state of the art in precision tape manufacture, it is indeed rare to run into this phenomena. The foreign particles may be nodules of oxide that have been improperly dispersed during manufacture, or clumps of oxide shed that have been redeposited onto the tape, or any particle of dust, lint, or matter that is present in the vicinity of the tape handling mechanism. The present trend to conductive coatings on tape will undoubtedly improve their performance heretofore affected by the static buildup of an electrical charge which enhanced the tapes affinity for attraction of foreign particles.

As the tape passes over the head, any embedded particle in the tape surface will lift the tape from the head. Under certain tape speed and tensioning conditions, "tape flap" will occur. This is the condition where the tape actually flaps, or bounces away from the head after the embedded particle has passed the head. The signal drops drastically as a result of this tape to head separation. The relation of loss in signal, wavelength, and tape to head separation is expressed in the formula -

$$\text{db loss} = \frac{55\,d}{\lambda}$$

Where d = tape to head separation

λ = wavelength

It is readily apparent that even the smallest particle will significantly reduce the output as it pulls the tape away from the head. Base material deformations will also cause dropouts. If the deformation is such magnitude to reflect through to the oxide coating side, a loss in signal will occur as the deformed portion of the tape moves past the heads.

II. GLOSSARY OF TAPE TERMS

INSTRUMENTATION

ANALOG RECORDERS — Devices designed to record continuously variable functions in which the recorded information has a direct relationship to the input information.

BIAS — A high frequency signal supplied to the record head to compensate for the hysteresis effect of tape, to improve the linearity of the system. It is usually much higher in frequency than the highest frequency to be recorded.

CARRIER FREQUENCY — The frequency of the system at rest or with no input. This frequency is generally deviated in amplitude, frequency, or by interruption to impose recoverable data into the system. The carrier frequency is usually much higher than its modulating frequencies.

CHANNELS — Separate data origination sources. This is not necessarily a separate tape track, since numerous channels may be recorded on one tape track by various multiplexing techniques.

DECIBEL (db) — Logarithmic expression of a power voltage, or current ratio. $db = 10 \log \frac{P1}{P2} = 20 \log \frac{E1}{E2} = 20 \log \frac{I1}{I2}$

DRIFT — Tape velocity deviations from nominal velocity occurring at frequencies below 0. 1 cps.

WOW — Tape velocity deviations from nominal velocity occurring at frequencies between 0. 1 and 10 cps.

FLUTTER — Tape velocity deviations from nominal velocity occurring at frequencies above 10 cps.

DYNAMIC RANGE — The ratio of the maximum signal which can be recorded (at a given level of distortion) to the minimum signal which can be recorded (determined by the inherent noise level of the system) over a narrow frequency range. Over a broader band spectrum, this is better known as signal-to-noise ratio. Generally the noise figure is unweighted with a recorded signal.

DROPOUT — An instantaneous reduction in signal below some given level. In the case of analog dropouts this is usually defined both as to length of time as well as amplitude.

SATURATION	That point in a magnetic material where an increase in the magnetizing force will not cause an increase in magnetic intensity to be exhibited by the sample under test.
H	Magnetizing force measured in Oersteds
B	Magnetic intensity measured in Gauss.
RETENTIVITY (Br)	Remanence of magnetization. The amount of magnetization or flux density remaining in a magnetic material after the magnetizing force has been increased to saturation and returned to zero. (see fig. 1)
Bmax	Maximum magnetization a given material is capable of supporting. Occurs at saturation, (see fig. 1).
SQUARENESS FACTOR	Ratio of Br to Bmax
COERCIVITY (Hci)	The magnitude of magnetizing force required to reduce the remanence to zero. (see fig. 1)
HYSTERESIS	The inherent characteristic of a ferro-magnetic material for the magnetic intensity to lag the magnetizing force.
DEGAUSS	The act of reducing all residual magnetization to a given object to zero.
PRE-EMPHASIS	Peaking or increasing system gain at the high frequency end to compensate for inherent, system recording losses, and in some cases at the low frequency end also.
POST EMPHASIS	Increasing gain at lower frequencies to compensate for inherent, system recording losses.
ERASURE	Clearing magnetic tape of all previous signals and data preparatory to recording new information, i.e., reducing both B & H (external) to zero in gradually decreasing amounts. The same as degaussing.
LIVE DATA	Data in electrical form, hence reproducible and completely flexible as to further use.
FREQUENCY MODULATION (FM)	A modulation technique whereby a center carrier frequency is shifted or deviated by the signal to be recorded, thus recording the original data in a reproducible form.
CARRIER FREQUENCY DEVIATION (FM)	The swing or deviation of the center carrier frequency caused by a signal being recorded using FM techniques.
MODULATING FREQUENCY (FM)	The signal which represents the data being imposed on the carrier frequency.

Sometimes the last few layers of a tape wound on an NAB hub will carry the imprint of the threading slot, and as many as 10 or 15 layers of tape will contain the resulting dropouts. Winding under improper tensions, or long term storage under adverse conditions will accelerate this effect. However, it may be minimized by being careful when threading NAB reels, and rewinding and storing tapes under controlled conditions. (See Tape TRENDS No. 2, July 1963). The use of precision reels will eliminate the threading slot deformation problem entirely.

Markers of any and all description (such as slips of paper, Mylar, etc.) should never be inserted into a tape pack for purposes of identifying or marking positions of the tape. This will deform the tape and will ultimately cause dropouts. Proper tape handling techniques should always be observed. The tape should never be handled in such a way that the fingers come in contact with the edge of the tape pack. The reels should never be handled by using their edges as a sole support.

As tape is used, normal oxide buildup occurs at various machine points such as guides and heads. For optimum performance this oxide buildup should be removed regularly, at least once after each complete pass of the reel of tape. Precautionary methods of cleanliness should be taken in all areas where tape is used and handled. The amount of dust particles in the air is directly related to the number of dropouts experienced. The expense of an environmentally controlled tape installation will be more than justified by the immediate increase in efficiency over that realized in a dusty atmosphere.

Since proper tape performance is highly dependent upon tape to head contact, the machine should be checked periodically to insure that its performance is according to machine specifications. This is particularly important in areas such as the braking and tensioning systems.

Many times skew or misaligned guides will manifest themselves as excessive dropouts in the tape, and it is necessary to isolate the malfunction to properly analyze the problem. Almost every fault in a tape installation will initially manifest itself as a tape defect, so a basic understanding of the inherent nature of tape dropouts is necessary for effective trouble-shooting.

Conclusive tests have revealed that FM recording techniques are no less prone to dropouts than direct methods. The actual FM recording process on the tape itself is done in a direct manner, so it will also be affected by instantaneous loss of signal. However, due to the manner in which the FM recording is demodulated and handled by the electronics, the final result appears to be independent of dropouts. Regardless of the actual recording technique employed, the general rules of good machine maintenance, proper care and handling of the tape, and a clean, controlled atmosphere apply to all installations where optimum tape performance is desired.

GFA/c

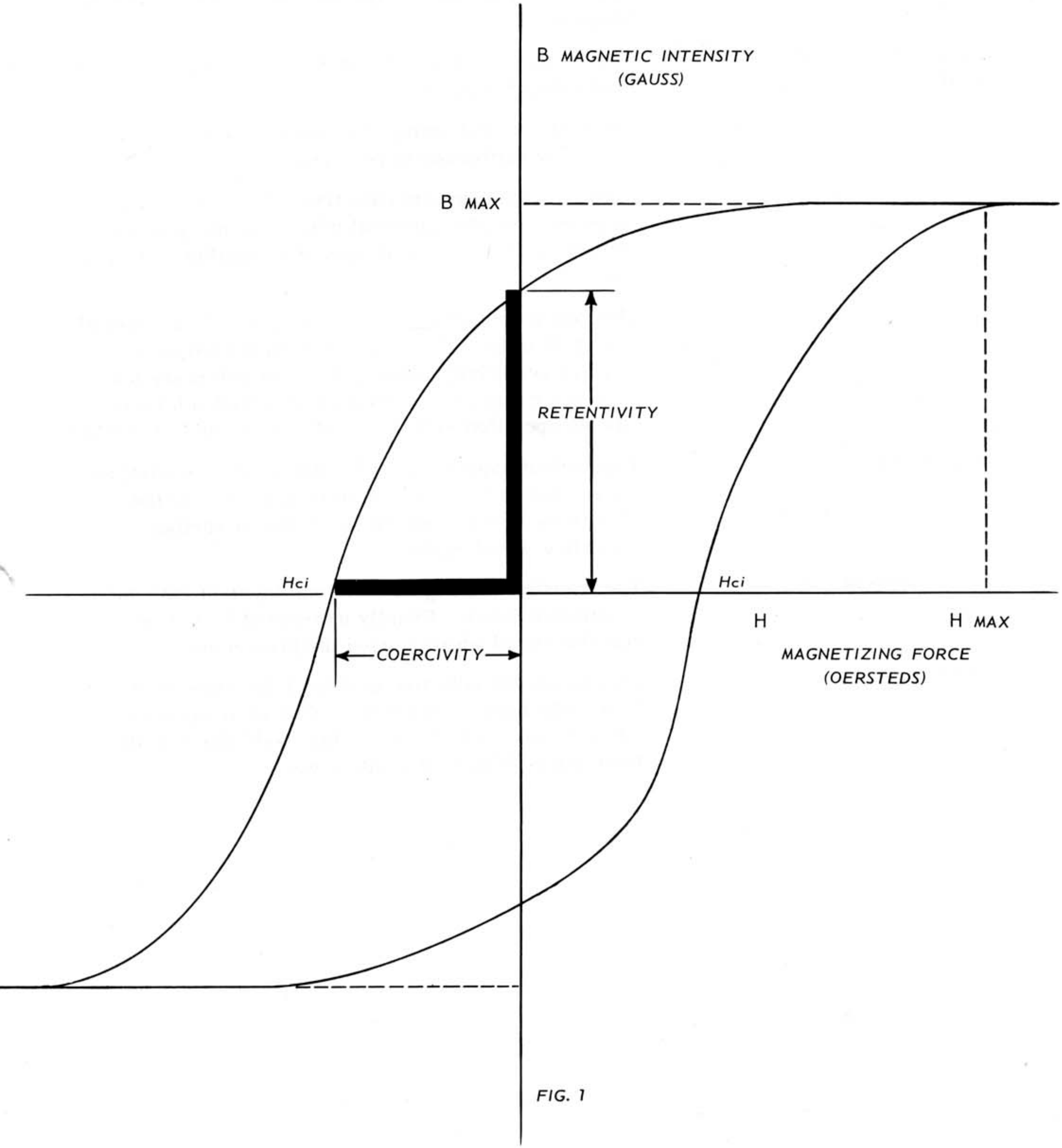
B MAGNETIC INTENSITY
(GAUSS)
B MAX
RETENTIVITY
Hci
Hci
COERCIVITY
H
H MAX
MAGNETIZING FORCE
(OERSTEDS)

FIG. 1

MODULATION INDEX (FM)	The ratio of carrier frequency deviation to modulating frequency.
DEVIATION RATIO (FM)	This is the modulation index for a maximum value of modulating frequency.
PERCENTAGE DEVIATION	The ratio of modulating frequency to center carrier frequency expressed in per cent.
TRANSDUCER	A device that converts data from its natural form (such as a weight, physical vibration, etc.) into an electrical signal for purposes of recording on magnetic tape.
SENSITIVITY	The tape output at a relatively long wavelength usually 7.5 or 15 mils. This is usually expressed as a relative sensitivity relating to some reference such as another tape, i.e., BuShips standard reference tape as specified in MIL-T-21029A and MIL-T-22756A.
RESPONSE	Tape output expressed in db difference compared to a given reference tape, or in most cases, to the sensitivity of the same piece of tape at various recording wavelengths.
PRINT THROUGH	The transfer of a signal from one layer of tape onto an adjacent layer. Usually expressed in db lower than the signal which caused the phenomena.
ANCHORAGE	Pertains to the adhesive quality of the oxide coating to the tape backing material. This is as opposed to cohesion qualities of the coating itself which is the determining factor on relative wear.

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MAGNETIC TAPE TRENDS

APPLICATION ENGINEERING BULLETIN

BULLETIN NO. 7 APRIL 1964

RECORDING THEORY AND TECHNIQUES AS APPLIED TO TAPE

PART I - AUDIO

In keeping with the over-all theme and intent of the TRENDS series, the next group of four articles will discuss the basic magnetic recording theory behind audio, video, instrumentation, and computer techniques and factor the exact role of tape into each of these discussions. Although the use and appearance of magnetic tape is known to many, a true understanding of its exact operation is held by few.

We will begin with audio; subsequent issues of TRENDS will be published on video, instrumentation, and computer.

* * *

ACTUAL RECORDING PROCESS

The phenomenon of magnetic recording is possible because of the nature and characteristics of flux leakage in the vicinity of the recording head gap. (Strictly speaking, this is flux fringing and not "leakage".) The flux in the head is established by, and is proportional to the input signal current flowing through the head windings.

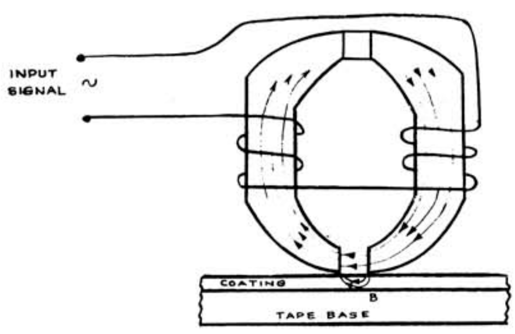

FIGURE 1. RECORD HEAD

The flux leakage penetrates the magnetic coating of the tape as it is pulled past the heads. This penetration sets up a magnetic field within the magnetic coating and causes the individual magnetic domains to assume this pattern, or to line themselves up with the lines of force. Remember, the individual particles do not change their physical orientation because they are set permanently in the binder. It is their flux pattern that changes and lines up with influencing field. Longitudinally oriented tape has all particles lined up in the longitudinal direction of the tape. Each individual particle may be considered a separate domain because of its physical size (approximately 8 x 25 microinches), and it maintains a very small magnetic charge at all times. Unrecorded tape consists of many, many domains possessing individual magnetic charges, the net charge of which is virtually zero. This is depicted in Fig. 2.

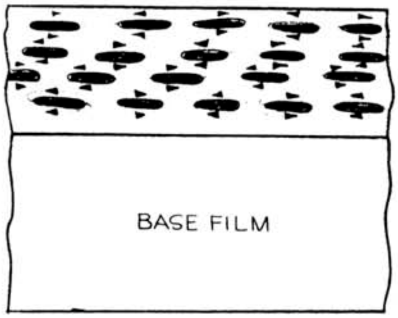

FIGURE 2. NO SIGNAL ON TAPE

Although each domain (particle) has a slight magnetic induction and associated field or flux pattern, the net result of all the domains is essentially a zero magnetic induction. As the tape moves past the head, the flux leakage pattern from the record gap extends into the region of the domains (Fig. 3) and coerces the domains to increase their magnetic induction to a value proportional to the gap flux pattern.

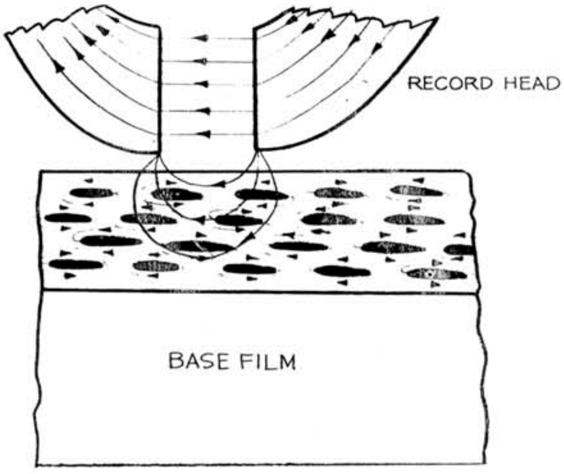

FIGURE 3. RECORD GAP FLUX PATTERN PENETRATING TAPE COATING

Each individual domain (particle) then assumes a given magnetic induction which, when combined with the magnetic inductions of all other particles influenced by the same flux pattern of the head, gives a resultant net magnetic pattern that is proportional to the magnetizing field intensity existing throughout the region of influence of the gap.

As this particular group of domains leaves the influence of the record gap flux, each domain "remembers" or continues to hold the magnetic flux pattern corresponding to the last remaining record gap flux line exerting an influence.

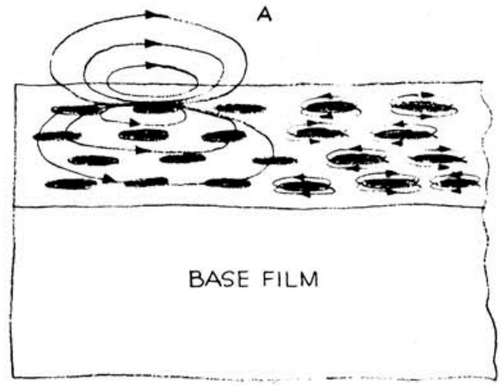

FIGURE 4. RESULTANT FLUX PATTERN OF RECORDED SIGNAL

The net pattern retained by the system of domains (oxide particles) will have a magnitude and direction that is a function of the magnetizing field that existed at the instant the tape left the region of influence of the record gap. This explains why the trailing edge of the record gap is the most effective region in the recording process.

* * *

PLAYBACK

Playback is essentially the reverse of recording. The recorded tape has a magnetic field that extends above the surface of the tape (point A, Fig. 4) as a result of the net magnetism retained by the domains (particles). As the tape is transported past the playback head, this field enters the gap and sets up a magnetic induction inside the head that generates a voltage in the head windings proportional to the rate of change of flux (magnetic induction).

To sum up, the input signal is fed into the record head windings as a current. This fluctuating current creates a varying magnetic induction inside the head (point A, Fig. 1). As these flux lines "jump" the gap, a certain portion of them leak out and set up the flux leakage (fringing) pattern (point B, Fig. 1). As the tape is transported past the heads and through this field, a magnetic field is induced in the tape. In playback, the tape with its external field is pulled across the heads and the magnetic field fills the gap and induces flux in the head which in turn creates a voltage in the playback head windings.

From the previous discussion on the recording process, it is obvious that a quality tape must have high quality magnetic oxide that is properly processed and dispersed uniformly in the binder system to give satisfactory performance. This is simply one parameter of many that must be carefully controlled to produce quality tape. To understand the other areas where constituent variables have a marked effect on performance, let's briefly look into biasing techniques.

* * *

BIAS

Recording on magnetic tape was impractical until proper biasing techniques were developed. Magnetic tape must be biased for the same reason that vacuum tubes are biased because of non-linearity performance characteristics. The transfer characteristics of magnetic tape are shown in Fig. 5.

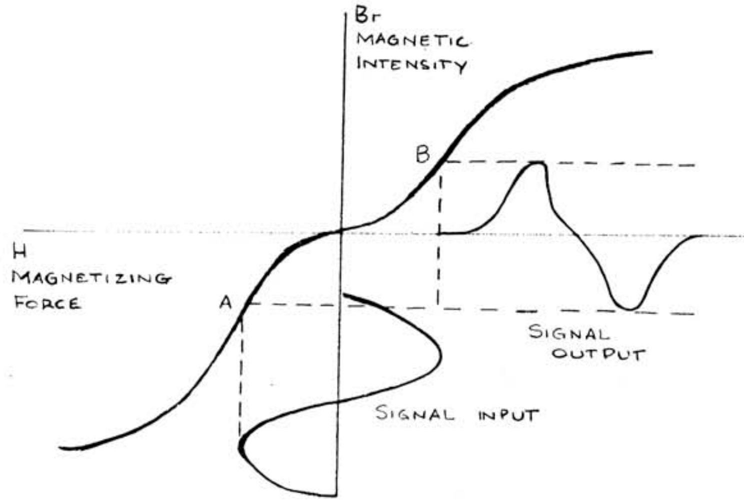

FIGURE 5. TRANSFER CHARACTERISTIC WITHOUT BIAS

The input signal contains excessive distortion on playback (signal output) because the tape is being operated over non-linear portions of its "BH" curve (points A to B in Fig. 5).

The output fidelity may be increased substantially by limiting the operation to a more linear portion of the "BH" curve (points C to D in Fig. 6). This may be accomplished by adding DC bias.

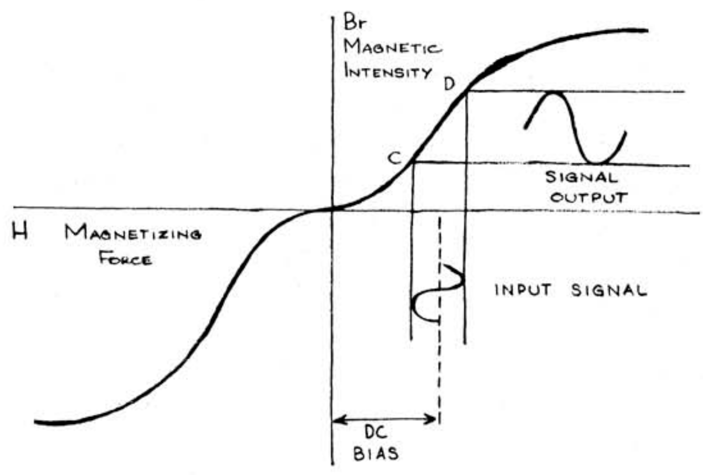

FIGURE 6.

The input signal is now operating above and below (i.e., superimposed on the DC level) the pre-set bias instead of operating above and below the zero bias level as in Fig. 5.

Many inexpensive tape recorders use DC bias. The main disadvantage is the noise and distortion introduced by this method of biasing. Proper AC biasing will limit operation to the more linear portions of the BH curve without introducing excessive noise or distortion. This operation is shown graphically in Fig. 7.

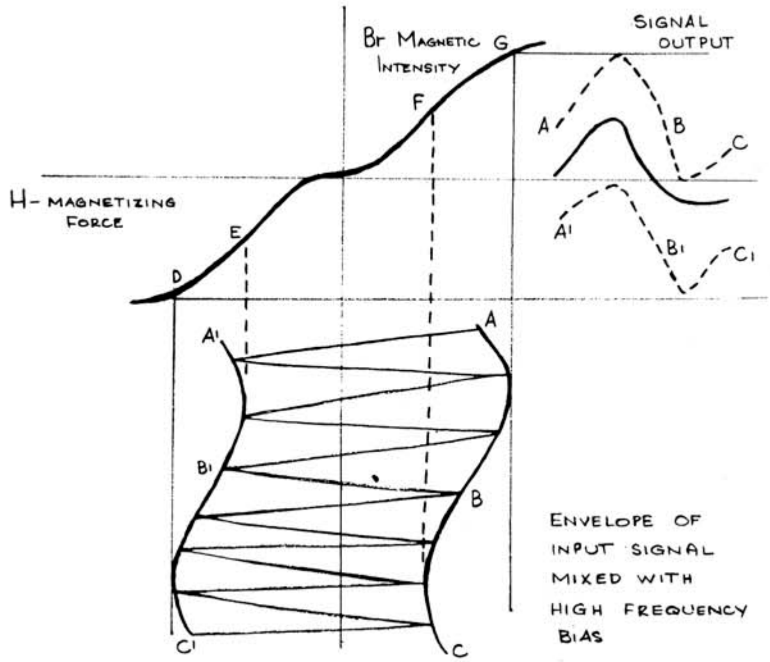

FIGURE 7.

AC bias is a high frequency (usually four to five times the maximum signal frequency to be recorded) and generally has a greater amplitude. The resulting envelope as seen in Fig. 7 now utilizes the more linear portions of the B-H curve, D-E, and F-G. This method of biasing is most efficient and enables the full utilization of the linear portions of the B-H curve without introducing excess noise or undue distortion. All quality audio recorders use AC biasing.

Once again we see that premium tape must contain only the highest quality elements to deliver proper performance.

* * *

GENERAL

Obviously the previous discussion has merely touched the surface of the magnetic recording phenomenon and details have been omitted. The main purpose, however, was to provide a little background to assist in understanding the role that magnetic tape plays in the process.

An important point to remember is that virtually all the recording and reproducing is done on the surface of the tape. The thickness of the oxide coating (0.40 mil average) is required solely for low frequencies or long wavelengths. Because all the work is performed right at the tape's surface, the importance of a perfect surface is obvious. Excellent tape-to-head contact must be maintained at all times to insure satisfactory performance. If a tape is pulled away from the head by a nodule or surface imperfection, the signal is affected as follows:

$$\text{Signal loss (db)} = \frac{55d}{\lambda}$$

where: d = tape-to-head separation
λ = wavelength

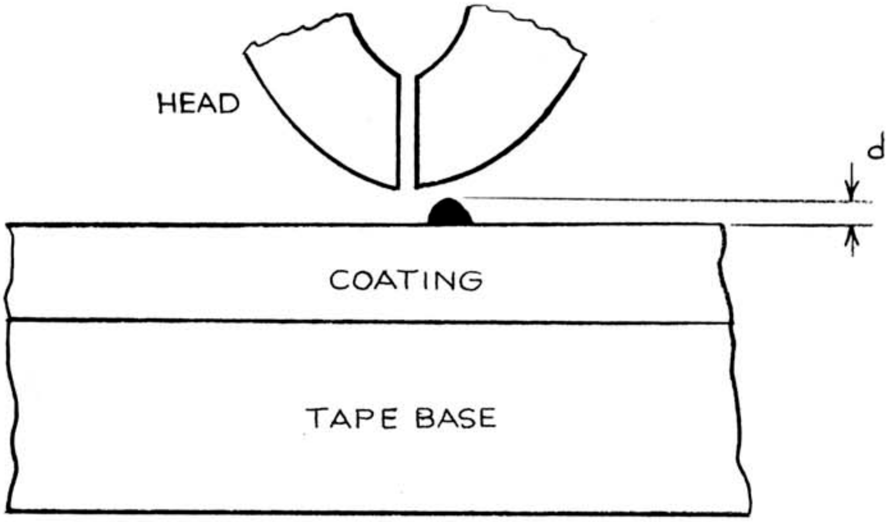

FIGURE 8. SEPARATION LOSS

Example: if freq. = 10 kc
and tape speed = 7.5 ips
then λ= 0.75 mils because, tape speed = freq. x wavelength.

If there is a bump on the tape surface measuring 50 microinches
then

$$\text{signal loss} = \frac{(55)\ (50 \times 10^{-6})}{0.75 \times 10^{-3}} = \underline{\underline{2.75 \text{ db}}}$$

To understand the importance of tape surface uniformity, the previous example illustrated that a 50 microinch irregularity reduced the playback signal almost 3 db. Incidentally, the average size of a particle of cigarette smoke is 25 microinches in diameter!

This explains why some tapes will not deliver their maximum output until after they have been run for ten or twenty passes, and the surface has been "worn in".

Surface characteristics of magnetic tapes are also important in considering head wear. Tape TRENDS No. 6 discussed in detail the relationship between head wear and tape surface.

Because tape is the recording medium, virtually all recording system malfunctions manifest themselves as apparent tape problems. For instance, excess edge shed may be the result of misaligned guides or pressure pads. Poor guiding and skew will show up as tape output variations. Other common machine problems are WOW, FLUTTER, and DRIFT, which are the results of instantaneous tape speed variation. FLUTTER denotes speed variations occurring at frequencies above 10 cps. WOW includes those between 0.5 and 10 cps, and DRIFT covers frequencies below 0.5 cps. For audio applications, obviously FLUTTER and WOW are more important than the sophisticated DRIFT.

A common question is, "I have a high quality audio recorder and since all audio tapes are about the same, what difference does it make whether I use a medium or high quality tape?" The performance of any tape recorder is solely dependent upon the tape used. We have already discussed the importance of tape surfaces. Of equal importance are the additional parameters such as oxide uniformity, coating and dispersion uniformity, binder formulations, quality slitting, and uniform base film. Because there is no industry standard for magnetic tape, it is most difficult and almost impossible to evaluate different tapes by comparing their respective published specifications. Each tape manufacturer offers a wide line of audio tapes from the top of the line, mastering, on down to white box. White box tape is the cheapest tape available. It is factory reject tape, usually downgraded computer tape that is re-slit to 1/4". It has no guaranteed specifications and should be avoided if any degree of performance is desired.

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This edition has dealt primarily with audio, but many concepts were introduced that will be used in later "TRENDS" written for instrumentation, computer, and video.

George F. Armes
3 April 1964