MAGNETIC TAPE TRENDS

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APPLICATION ENGINEERING BULLETIN

RECORDING THEORY AND TECHNIQUES AS APPLIED TO TAPE

PART III - VIDEO

Magnetic tape for video applications falls into two distinct categories: transversely oriented and longitudinally oriented. Each one will be discussed separately, but first a few general comments on video tape recording will be made to point out the unique requirements for this phase of magnetic recording.

The basic recording principle for video is the same as that employed in audio and computer recording, but this is where the similarity ends. Audio and computer techniques were discussed in TRENDS 7 and 8. Since video signals embrace a very broad spectrum, up to 4.5 mc, it is necessary to develop a very high tape-to-head speed. This is evident from the fundamental relation of $V = \lambda f$, where V is relative tape-to-head velocity, λ is wavelength, and f is frequency. The actual recording process is a function of wavelength, not frequency, so the system parameters must be designed to assure that signal frequencies are delivered to the tape within the wavelength capabilities of the tape. This is done by increasing the relative tape-to-head velocity to a value where the wavelength is an optimum value. For example, a frequency of 4.5 mc would require a tape-to-head speed of 1500 ips to record a wavelength of 0.33 mil. Obviously, a tape speed of 1500 ips is not practical, so the rotary head concept was developed. With a rotary head it is possible to sweep the head transversely (or across the tape) at speeds approaching 1500 ips. A wavelength of 0.33 mil corresponds to an audio signal of 11.2 kc recorded at 3 3/4 ips. This appears simple enough and the inevitable question is asked, "Why is it so difficult to record video if a nice, comfortable wavelength of 0.33 mil is used?" This article will explain in great detail why this is so difficult.

TRANSVERSE VIDEO TAPE

The most obvious difference between video tape and conventional magnetic tape is the width of 2 inches vs 1/4" for audio and 1/2" or 1" for computer. The wide tape is required because the heads record in a series of transverse tracks across the tape.

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Conventional, longitudinal recorders employ a head that consists of a laminated assembly of several individual heads. The complete head assembly presents a broad contact surface to the tape, and the unit pressure is relatively low. Under normal operating conditions, there is little or no physical distortion in the tape as it moves across the head. Relative speeds are low, and heat generation is held to a minimum.

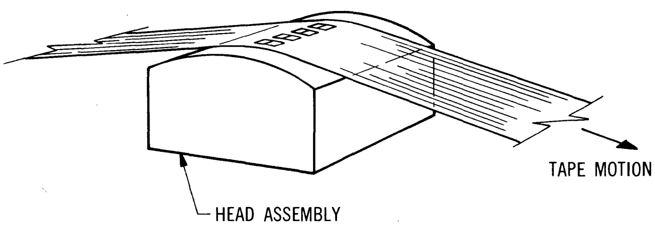

FIG. 1A CONVENTIONAL LONGITUDINAL HEAD

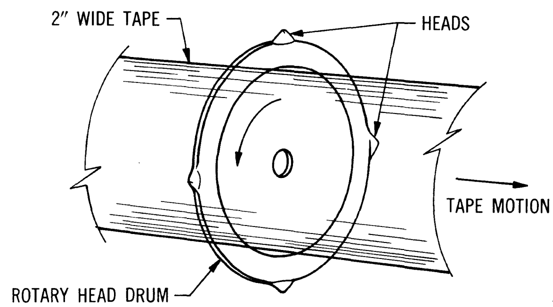

FIG. 1B ROTARY HEAD

In the case of rotary head techniques, the narrow heads dig deeply into the tape and instantaneously distort the base film significantly. Extremely high tape-to-head speed creates a detrimentally high temperature. Rotary head recording is the most stringent application from a physical standpoint of any recording application. There are four recording heads on the edge of a thin 2" diameter drum that rotates approximately 14,400 RPM.

It is appropriate at this point to review the basic scanning pattern for video. Each frame or individual picture consists of 525 horizontal lines called the raster. Commercial TV systems are required to operate at 30 frames per second, so there are 525 x 30 or 15,750 lines per second. Each individual line requires 1/15,750 or 63.5 microseconds to traverse the screen. Actually, 53 microseconds are used to trace the screen from left to right and 10.5 microseconds are needed to fly back from right to left to begin the next line.

If each picture is changed every 30 seconds this would correspond to a flicker rate of 30 per second, which would be objectionable. An effective flicker rate of 60 changes per second is accomplished by interlacing 2 fields of 262-1/2 lines.

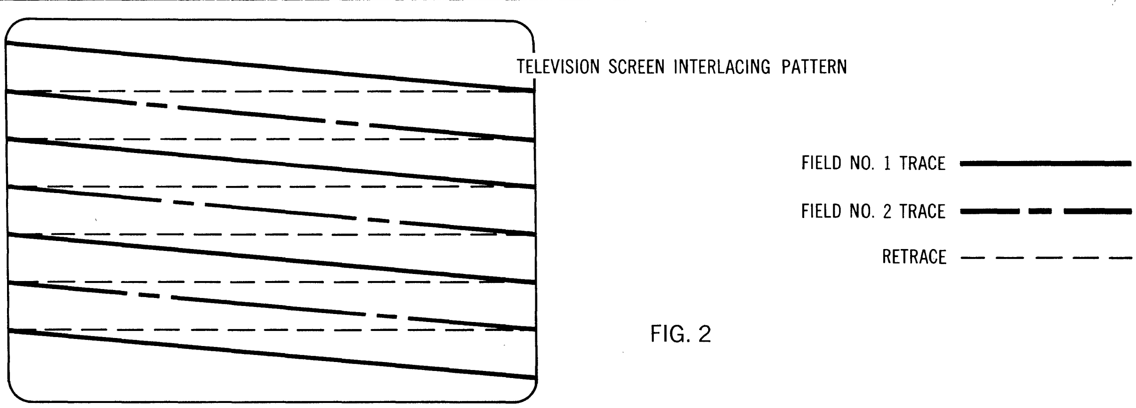

FIG. 2

TAPE CONSTRUCTION

Video tape consists of an 0.4 mil gamma ferric magnetic oxide coating on 1.0 mil polyester base. Essentially, the same type of acicular shaped oxide is used in video as in audio and computer tape. Rotary head recorders require a transversely oriented (particles dispersed at right angles to the longitudinal direction of the tape) coating.

Linear tape speed (usually 15 ips) is carefully synchronized with the rotating head to lay each short track down in its proper relation to prohibit overlapping of the recorded signal. The heads are mounted on the rotary drum and protrude approximately 3 to 4 mils. As the drum rotates each head "digs" into the tape a minimum of 2.0 mils. This tape dig is required to maintain intimate tape-to-head contact. A phenomenon unique to rotary head recording called "tenting effect" is the result.

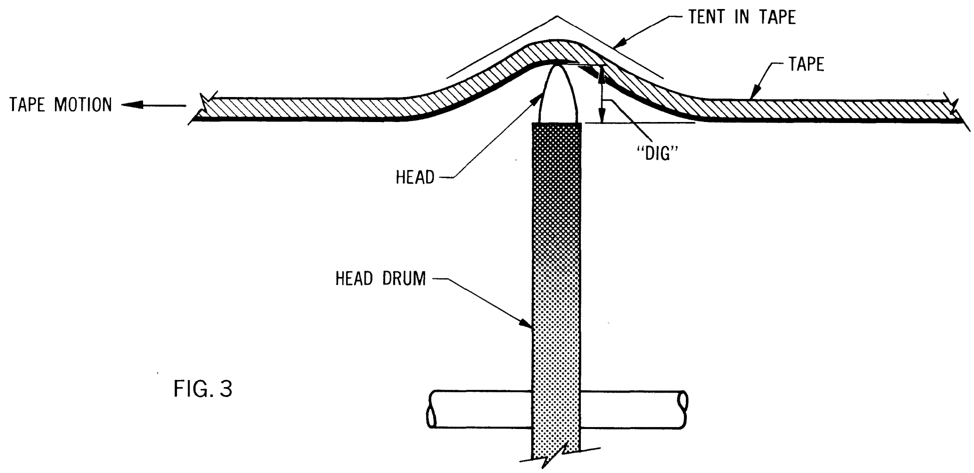

FIG. 3

As the high speed head digs into the tape, it penetrates and distorts the tape to a depth more than twice the thickness of the 1.0 mil base film. In addition to the extreme stress resulting from this dig, tremendous point contact temperatures are generated at the heads. Heat is one of the worst enemies of tape, and this action accelerates end of life for the tape.

The linear speed of the tape is synchronized with the angular velocity of the head-wheel by means of a longitudinally recorded control track so that the tape advances 15 mils in a linear fashion for each quarter revolution of the head-wheel. This results in transverse tracks on 15 mil centerlines. Since the track widths are 10 mils, a 5.0 mil guard band is maintained. Video signal is fed to the four heads simultaneously, and because the 2 inch tape occupies a 120° arc around the head-wheel periphery, two heads spaced 90° apart will be recording redundant data at the beginning of each transverse track and the final fraction of the preceding track.

Conceivably, 18.4 horizontal lines of video information can be recorded on each track(each horizontal line requiring 0.1

inch), but in playback only 16 lines are used. As a point of information, 16 transverse tracks make up one field, and a frame consists of 32 transverse tracks. So, one complete frame, or one "still shot" requires a 1/2" x 2" segment of tape.

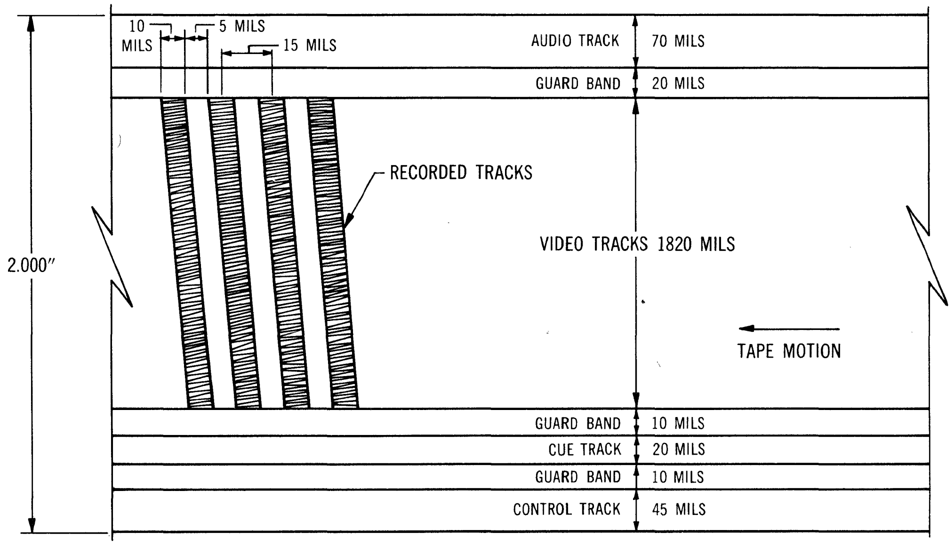

FIG. 4

TRANSVERSE VIDEO TAPE RECORDING PATTERNS

One line, 63.5 microseconds, requires a track length of approximately 100 mils (0.1 inch) on the tape. If the playback head is lifted from the tape by a nodule or surface imperfection while it is scanning this section of tape, a portion of the information on the line will be lost. The example in figure 5 shows a 32 microsecond dropout where a half line of information is lost as the result of a small nodule.

Many tape surface defects are longitudinal in nature, such as scratches, and they will appear as standing patterns on the monitor affecting numerous lines, whereas redeposits, foreign particles, and transient errors may affect only one or two lines or portions thereof. Thus, video dropouts are classified by time duration, such as 30 microsecond dropouts, 20 microsecond dropouts, etc. Obviously, all dropouts, whatever their origin, degrade the picture quality, and every precaution should be taken to minimize damage or contamination of the tape.

DROPOUTS

Dropouts in video tape are defined in the same way as in computer tape. A dropout is any tape caused phenomenon that results in an instantaneous reduction of signal below an acceptable level. They manifest themselves differently in video recording, but the basic principle is the same. For example, a nodule or surface defect on a computer tape will pull the tape from the head briefly and the tape will return quickly to the head as the nodule passes. In video recording, the heads sweep across the tape at such a high rate of speed that when a nodule lifts the head from the tape there is a relatively long period of time before the head and tape come together. This is illustrated in figure 5.

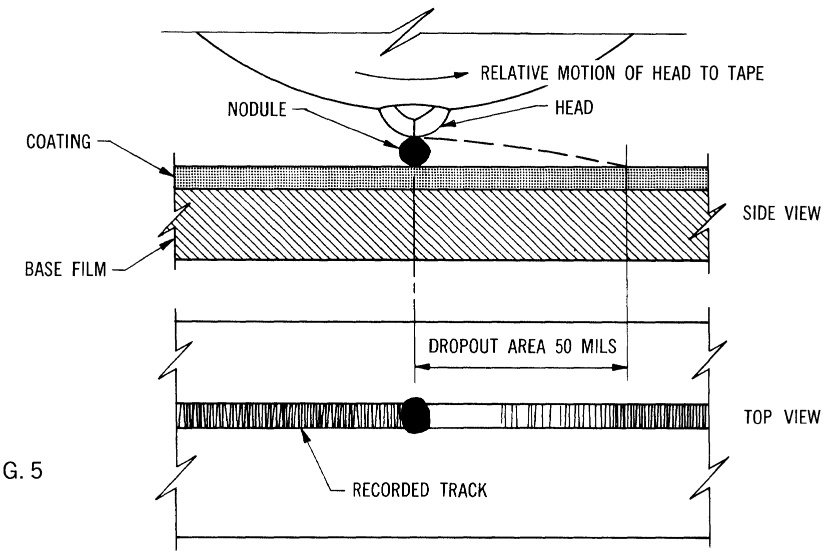

FIG. 5

As evident in figure 5, nodules on video tape "cast a shadow", and the height of the nodule is more important than the width. Some new video tapes require burnishing or "running in" to minimize the effect of surface imperfections.

The adjustable head is another parameter that makes video tape unique. Dropouts may be virtually eliminated by increasing tip penetration to the maximum. This also improves the signal-to-noise ratio, but it increases head wear and drastically reduces tape life. Most tape life figures are based on optimum operating environment and a tip penetration of 2.0 mils.

CARE AND HANDLING

Since video tape is very wide and appears to be more rugged than narrower precision tapes, many operators tend to abuse it. Video tape is most susceptible to physical damage, and it should be handled with extreme care at all times. The edges are most fragile (remember, video tape is on 1.0 mil polyester, not 1.5 mil polyester) and should be protected against damage. Guiding is most critical, and edge damage to any degree however slight will affect the performance. The tape should not be handled or touch any surface that could contaminate it. Transports should be cleaned thoroughly on a regular basis, and an active, effective cleaning program should be maintained in the library as well as in the recording studio. As is true in other precision recording operations, the overall efficiency of operation is directly proportional to the degree of maintenance and cleanliness. The slightest deposit of grease on the surface will attract foreign particles which will drastically affect head wear. The operating environment should be as dust free as possible to minimize head wear, and temporary dropouts. For optimum performance the tapes should be operated in a controlled ambient with maximum limits of 50°F to 90°F, and 50% RH to 80% RH. Storage conditions should be held within 40°F and +120°F, and 20% RH to 90% RH. All tapes should be normalized in the operating ambient for at least 8 hours before using if they had been stored under different environment conditions.

HELICAL SCAN VIDEO TAPE

Video tape for helical scan machines is longitudinally oriented because the head sweeps across the tape in a lengthwise, helical path.

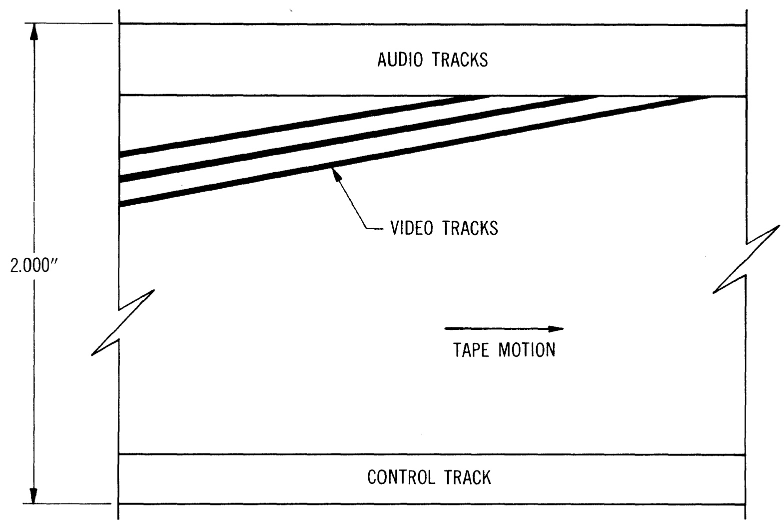

FIG. 6

DIAGONAL PATTERNS ON HELICAL SCAN VIDEO TAPE

This is normally accomplished by a large rotating drum with two heads spaced on the periphery 180° apart. The heads are adjustable, and nominal tape dig is about 2.0 mils. Helical scan tape is 2" wide and has an 0.4 mil (approximate) oxide coating on 1.0 mil polyester. Tape dig with corresponding "tenting" and base film distortion is also prevalent in helical scan recorders.

Helical scan recorders provide a stop motion feature, where the tape is stopped and the head continues to sweep over the same recorded track to "still frame" or hold the picture signal constant. This develops extremely high temperatures that will break down the binder so it must be limited to a few minutes. This presents a unique lubricating problem, and the tape must be designed with an adequate lubricant dispersed uniformly throughout the coating. In addition to this, the surface must be extremely uniform with excellent dispersion characteristics. If there is any imbalance in the formulation or inherent weakness in the processing and manufacture, head clogging will occur.

Helical scan machines are most sensitive to temperature and humidity fluctuations. A high humidity condition will invariably cause "stiction" problems, where the tape advances in a slip-stick fashion making proper synchronization and stability impossible. Ambient conditions must be controlled closely to minimize this effect. The optimum operating environment is 70°F and 60% RH. Any departure from these conditions will proportionately enhance the occurrence of tape problems. The absolute maximum limit is reached at 80°F and 90% RH. It is impractical to constantly control the operating environment for portable video recorders, for by their very definition they must be able to go anywhere. However the degree of successful operation is directly proportional to the control of the operating ambient.

DROPOUTS

For a given physical defect or nodule resulting dropouts on helical scan recorders tend to be more noticeable than on rotary head transverse recorders. This is due to the fact that a longer, continuous head scan on the tape is required on a 2-headed, helical scan than the 4-headed rotary head. The tape flap, or nodule shadow, would result in a longer dropout on the monitor. Each helical scan on the tape represents one complete field on the monitor whereas an individual scan on the 4-headed, transverse recorder represents only 18 horizontal lines or approximately 1/15 of a field. To put it another way, each horizontal line, 63.5 microseconds, requires a track length of about 30 mils, whereas transverse recorders record 1 line on 100 mils of track length.

LONGITUDINAL, STATIONARY HEAD VIDEO

Some of the new portable video recorders are longitudinal, stationary head machines where 1/4" tape is pulled at a high tape speed past a stationary head. This requires specially developed high resolution tape to adequately handle the short wavelength. For example, longitudinal instrumentation recorders presently have the capability of recording 1.5 mc at 120 ips (λ = 80 microinch), and it is entirely feasible to divert this technology into a 1/4" video recorder. To get a proper playing time at the high tape speeds it is necessary to use longer tapes on thinner base films. This increases the tape care and handling problem tenfold. Intimate tape-to-head contact is an absolute must, and dropouts caused by surface defects are more significant than in transverse or helical recordings.

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