AMPEX
ELECTRIC CORPORATION
MAGNETIC RECORDERS

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PRODUCT SPECIFICATION SHEET DS-1

MODEL 500

Figure 1 — Model 500 Recorder

The Ampex Model 500 is a four-track, two-speed, magnetic tape recorder designed to achieve extreme stability of tape motion while recording information in the frequency range between 100 and 100,000 cycles. This stability of tape motion was developed specifically for the purpose of recording fm/fm telemetering information without introducing any objectionable error. This is accomplished by a radically new tape drive system.

THE IMPORTANCE OF STABLE TAPE MOTION

In fm/fm recording, stability of tape motion is of prime importance because the data being recorded is frequency modulated. Therefore any variation in tape motion will produce a noise signal. Furthermore, since telemetering channels are for the most part limited to a deviation of 7.5%, any instantaneous change in tape speed appears as a noise signal 13.3 times the magnitude of the actual speed change. Thus, mechanisms which are perfectly good for audio recording and critical broadcast applications are still not sufficiently good for telemetering because of this very large amplification in error. Figure 2 shows a comparison between the flutter record of a 500 and that of a Model 300, whose drive system is unsurpassed in the audio field.

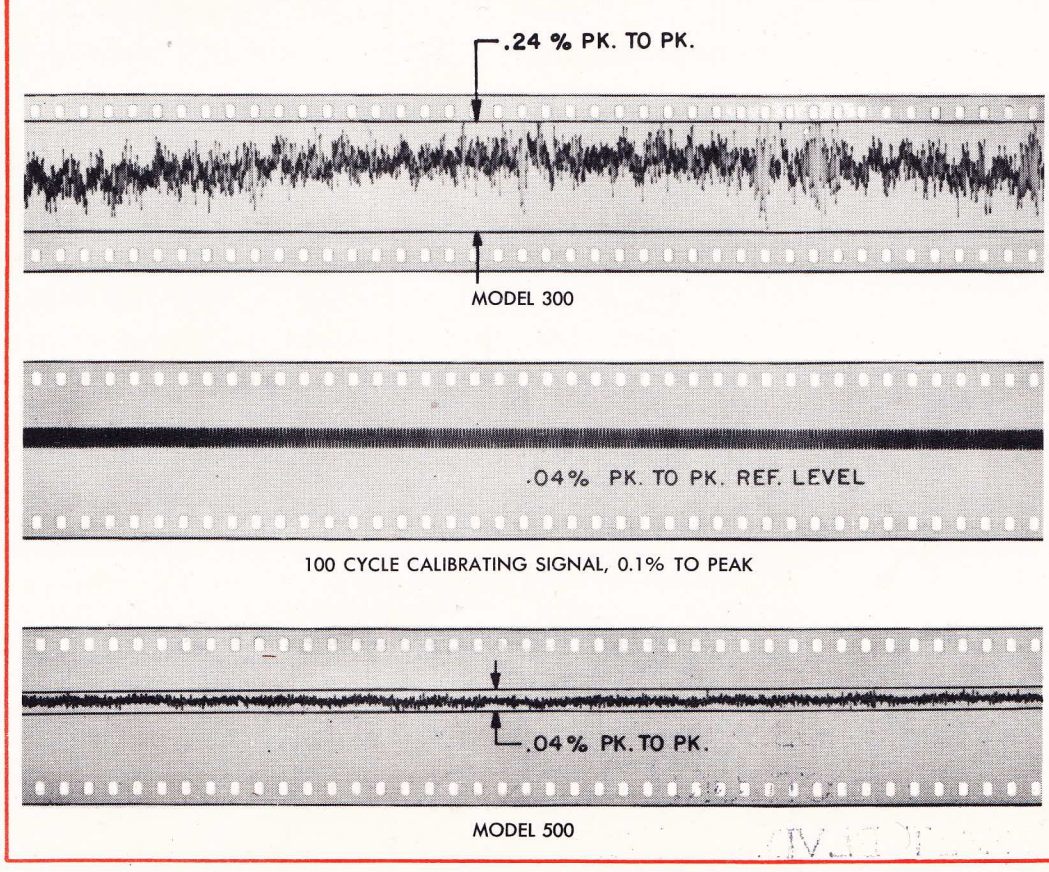

Figure 2 — Flutter records (using a discriminator with 4000-cycle response)

Figure 3 — Capstan, head assemblies and tension arms

TAPE DRIVE

To minimize error introduced by variations in tape motion, Ampex engineers have given careful attention to these design considerations:

1. Obtaining extreme uniformity of capstan motion
2. Locking the tape motion to the capstan motion
3. Locating the heads at the point of maximum stability of tape motion
4. Maintaining constant tape tension.

For high accuracy of capstan motion, it is necessary to isolate any disturbances of the synchronous drive motor from the capstan. This is done through a high-inertia double flywheel system. The outer flywheel is mounted at the bottom of the capstan shaft (figure 4) and is connected to the drive motor by a nylon belt. Inside this flywheel is a second flywheel, the two being coupled only by an oil film approximately 1/32-inch thick. The majority of the inertia is on the outer flywheel. As a further step in maintaining accuracy of capstan rotation, adjustable fit bearings are used (figure 4). These can be set to a very close tolerance, thus minimizing run out of the capstan.

To obtain a tape motion on the same order of accuracy as the capstan motion, the tape is "locked" to the capstan. The "locking" is accomplished by a vacuum arrangement, which holds the tape firmly in contact with the capstan. The vacuum is applied through numerous holes connecting four external annular grooves with the interior of the capstan. A vacuum manifold, connected to the interior of the capstan through a system of ports, insures that only the portion of the capstan covered by tape is evacuated.

Heads on the Model 500 are so positioned as to virtually eliminate a highly undesirable type of longitudinal vibration caused by friction between the tape and the heads. This might be likened to the vibration created by drawing a bow across a violin string, and is a function of the length of unsupported tape. It is one of the main sources of flutter on conventional tape drives, in which the tape is pulled over the heads. On the Model 500, the unsupported tape length is reduced to a practical minimum. The heads are spring-loaded against the tape at a point where the latter contacts the capstan. Here the tape has maximum stability of motion. Grooves in the capstan provide resiliency of contact between the tape and the heads. Otherwise, at the high speed employed, any variation in tape thickness would cause a pounding effect. Figure 5 shows the manner in which the heads contact the tape.

Maintaining constant tape tension prevents different portions of the tape in contact with the capstan from being stretched varying amounts. This is accomplished by the Constant Tension Arm, which operates a brake on the payout reel. Increase in tape tension moves the arm in a direction which releases the brake, while decrease in tension allows the arm to tighten the brake. Therefore, tape tension is relatively constant at all times.

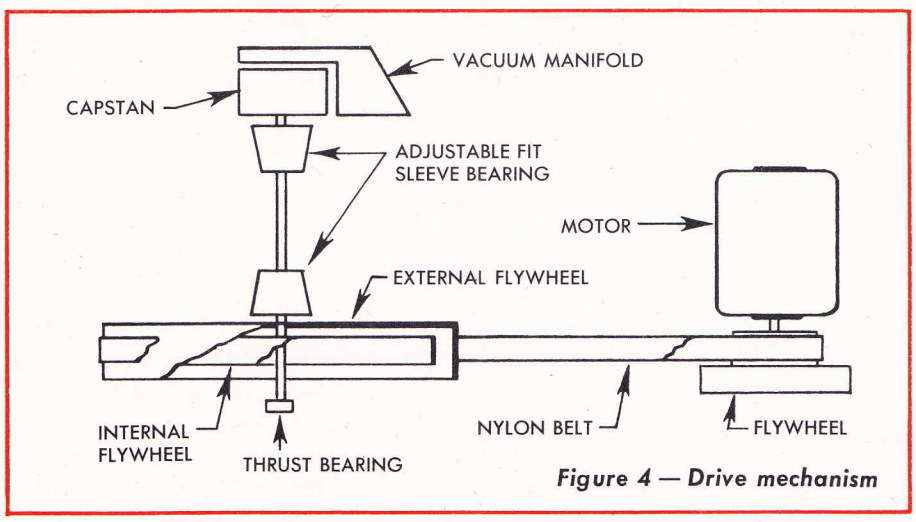

Figure 4 — Drive mechanism

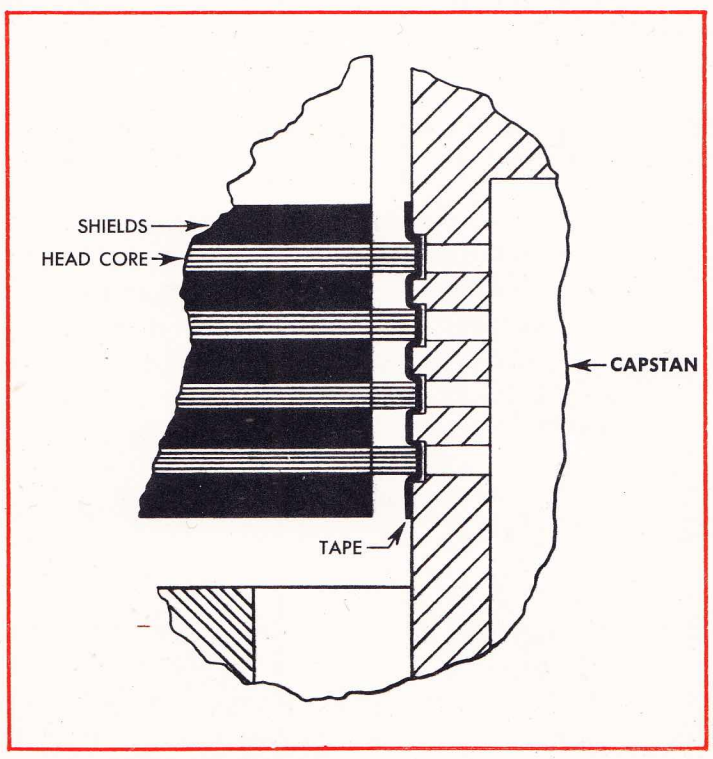

Figure 5 — Cross-sectional view showing head-to-tape contact

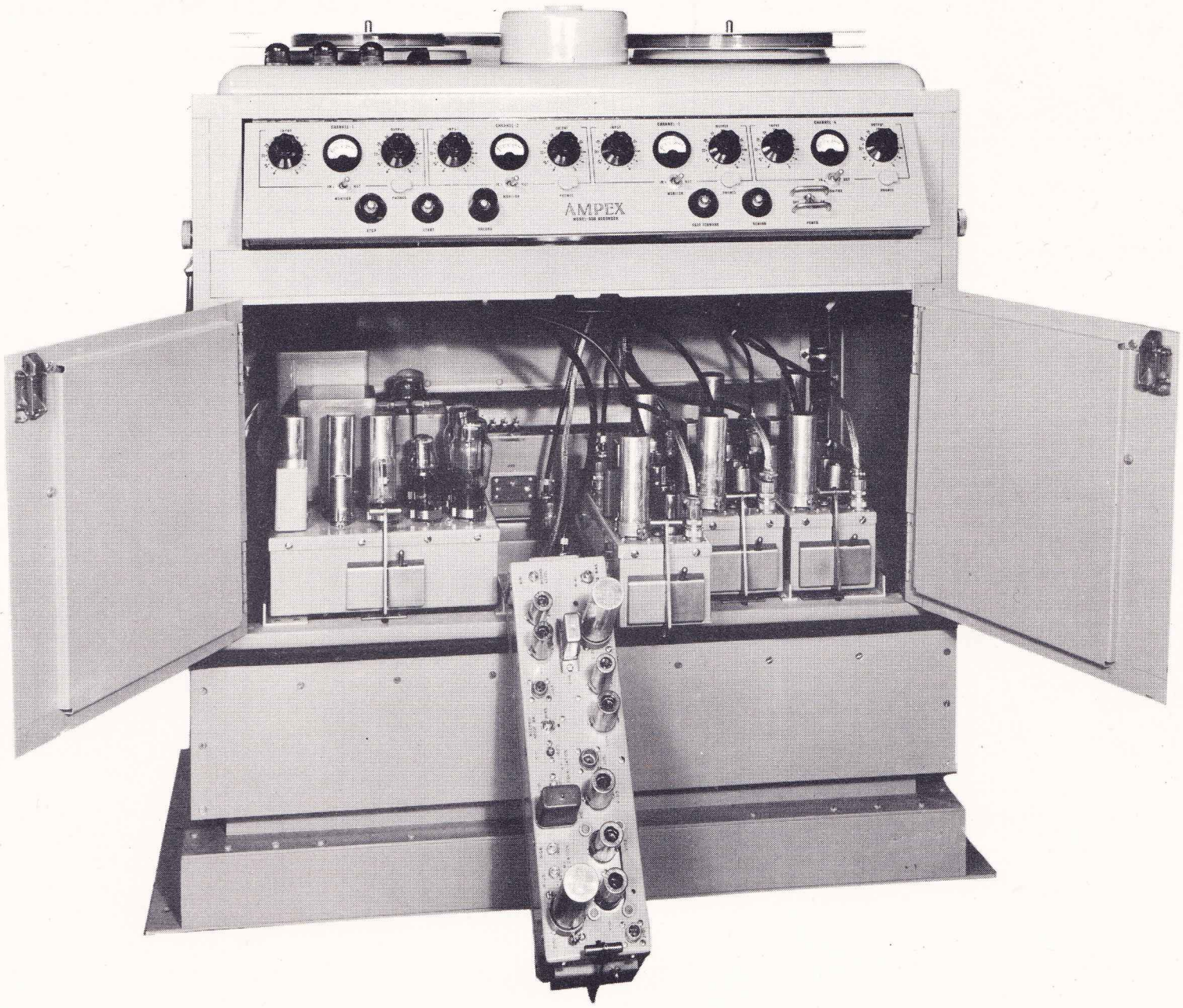

Figure 6 — Interior view, showing one of the plug-in type electronic assemblies pulled out.

DATA CHANNELS

So that the four parallel data tracks can operate independently of one another, there are four record and playback amplifiers (electronics), four record heads and four playback heads. Each of the two head assemblies consist of four heads stacked one above the other and separated by shielding, as shown in figure 5. The shielding between heads consists of alternate layers of mu-metal and copper, providing effective shielding in excess of 40 db. Each channel has its own db meter and input and output level controls (see figure 1). Figure 6 shows the four sets of plug-in type electronics (with one pulled out).

There is no equalization in the record circuitry; the information is fed to the heads on a constant current versus frequency basis. Playback equalization is used to provide flat overall frequency response.

MODEL 381-W SPEED-LOCK

The Speed-Lock is designed to compensate for changes in tape dimension and drive speed difference which would otherwise cause a dc shift on the final data. It does this by controlling the speed of playback to insure that it is an exact duplication of the original recording speed. The output of a tuning-fork amplifier is recorded as a reference frequency on one of the tracks during recording. During playback, this reference signal is compared to the standard. Any phase difference generates an error signal that adjusts the capstan motor speed to keep the frequencies matched. Correcting action is smooth and accurate so that at no time does the reproduced frequency differ from the original by more than .02%.

CONSTRUCTION

The Model 500 is built to comply insofar as practicable with U.S. Navy Department specifications 16-E-4 and therefore uses JAN components and is "ruggedized" throughout. Only the highest quality materials and workmanship have been incorporated. For example, the capstan is 84% pure silver which is non-magnetic and corrosion-resistant. The shafts are made of Monel Metal which is also corrosion-resistant and non-magnetic. External surfaces have been anodized and lacquered according to JAN specifications. All rectifiers, transformers and selenium rectifiers are hermetically sealed.

The Model 500 is also designed to withstand shock and vibration as specified in USN specifications 40-T-9; however, operation will not necessarily be within specifications during momentary periods of high shock.

MODEL 500

GENERAL PERFORMANCE CHARACTERISTICS AND SPECIFICATIONS

TAPE SPEEDS	*30 and 60 inches per second.*
FLUTTER AND WOW	*Less than 0.1% peak-to-peak, as measured in accordance with RDB standards. Tape nodules or other imperfections cause instantaneous variations lasting less than one millisecond.*
DATA PLAYBACK ACCURACY	*Over-all machine error including record, playback and dc drift does not exceed 0.7% as measured on the final data obtained from 7.5% deviated subcarriers of an fm/fm telemetering system.*
FREQUENCY RESPONSE	*At 60 inches per second: ± 3 db, 200 to 80,000 cycles. Down less than 10 db at 100 and 100,000 cycles.* *At 30 inches per second: ± 3 db, 200 to 40,000 cycles. Down less than 10 db at 100 and 50,000 cycles.*
SPEED CORRECTION	*After the Speed-Lock has stabilized, the average frequency reproduced from the tape will be within 0.02% of the original rcorded frequency, provided there is no change in the precision reference frequency supplied by the 60-cycle tuning-fork oscillator. This oscillator has a stability of 5 parts per million per degree centigrade. The rate of correction is directly proportional to the error in capstan speed. The time alignment of the 4 channels is within 0.2 millisecond at the 60 inch tape speed.*
DATA LIMITATIONS (TRACK 1 ONLY)	*Track 1 is used to record the reference frequency employed in compensating the playback speed for dc errors. An 18.24 kc ± 200 cycles carrier is amplitude modulated by the 60-cycle precision reference frequency and recorded on this track. Any data components equal to or greater than the control track level between 16.5 and 20.0 kc may cause improper operation of the Speed-Lock equipment. Therefore, when used to record an RDB fm/fm telemetering system, the 22 kc band may be deviated only 7.5%.*
SIGNAL-TO-NOISE RATIO	*Over 40 db below 1% harmonic distortion, measured in any 15% band.*
INPUT	*1 volt minimum at 100,000 ohms, unbalanced.*
OUTPUT	*10 volts maximum at 600 ohms, unbalanced.*
CONTROLS	*Pushbutton controls are provided for Start, Stop, Record, Fast Forward and Rewind. Provisions are made for remote operation of Start, Stop and Record.*
STARTING TIME	*The tape reaches full speed within 1 second after operating the Start control. Stable motion is reached within an additional 2 seconds.*
PLAYING TIME	*The 500 utilizes reels up to 14 inches diameter allowing a playing time of 16 minutes at 60 inches and 32 minutes at 30 inches tape speed.*
MONITORING	*Complete monitoring with individual meters and input and output controls for each channel. All channels are also provided with jacks for connecting external meters or headphones.*
TAPE	*Minnesota Mining & Manufacturing Company Type 109 Telemetering Tape (Scotch Brand) 0.500" $^{+\ 0.000}_{-\ 0.004}$ wide on ½-inch wide hubs.*
INPUT POWER REQUIREMENTS	*117-volt, 60-cycle, single phase power at 1800 watts starting and 960 watts running.*
DIMENSIONS AND WEIGHTS	*Recorder console weight 430 lbs.; depth 21½ in.; width 35¾ in.; height 38⅜ in.* *Accessories for 19" Rack Mount:* *(a) Model 375-W, weight 69 lbs., panel height 12¼ in.* *(b) Playback Demodulator Electronics, weight 50 lbs., panel height 13 15/16 in.*

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