For instance, to consider an exaggerated example, if we were reproducing a sustained 1000-cycle tone at a tape speed of 7½ inches per second and that speed suddenly dropped to 6 inches per second our tone would be reduced to 800 cycles; then as normal speed was again attained the tone would return to 1,000 cps.

Differentiating between flutter and wow has historically been difficult, but speaking generally we can consider that flutter consists of components about 6 or 7 cycles per second, with wow components falling below that figure. (Normal flutter will extend to approximately 250 cps, but tape scrape flutter is usually about 3500 cps.) Flutter and wow can result from anything that affects tape motion; although the drive system of a transport is most commonly blamed it is not always at fault.

Drive Requirements

Designing a drive system usually entails a compromise between low flutter requirements and the amount of money we can expect in return. There are ways and means of producing transports that exhibit extremely low flutter; the accomplishment, however, is accompanied by a high price. These ultra precision drives are usually employed only in certain instrumentation and data type recorders, with the cost precluding their use in other than very special applications.

CAPSTAN ASSEMBLY — First, the capstan shaft. A small, round shaft seems quite simple and harmless, but it can be a real troublemaker. It must be round within small tolerances (0.2 mil) and mounted in its bearing it must exhibit minimum "run-out" (again, 0.2 mil) at the tape contact point. The shaft must be corrosion resistant, and sufficiently hard to withstand wearing.

The diameter of the capstan should be large enough to hold tape slippage and creep to a minimum, with a compromise normally necessary between the diameter and the speed of the shaft. For a given tape speed an increase in diameter demands a decrease in rotational speed, which in turn requires more flywheel.

We generally will use as much flywheel as the drive motor can handle while maintaining sync; this is simply a matter of filtering any cogging of the drive motor, or other irregularities. As the mass of the flywheel increases, its efficiency in damping out high frequency irregularities improves, but it might start to accentuate low frequency disturbances. If this occurs we must provide some damping arrangement — for example, silicone coupling between the shaft and flywheel.

DRIVE MOTOR — The drive motor must be of the synchronous type in order to maintain the necessary speed accuracy. Hysteresis synchronous motors are usually employed rather than salient pole (reluctance) types, although the latter is less expensive and provides as good results insofar as flutter is concerned. The reason for this preference is that the hysteresis motor will sync a greater mass and thus can handle a larger flywheel.

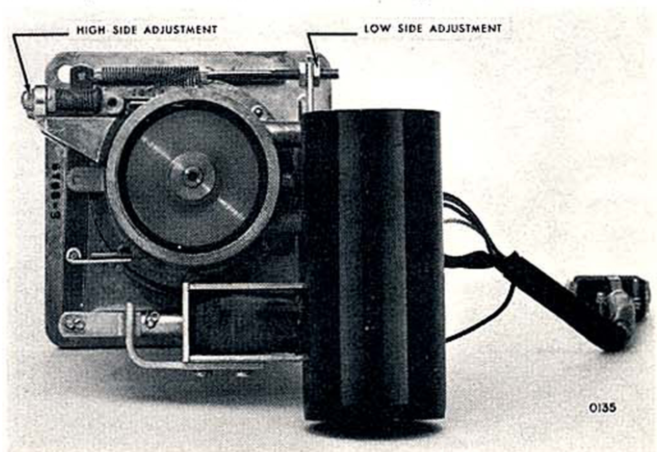
Supply and Takeup Assemblies

When motors are used in the supply and takeup assembly they are usually of the induction type, with high resistance rotors. Reel motors must be as free from cogging as possible, because cogging in the hold back system has been responsible for many flutter problems that have been blamed on the drive assembly. It would be nice if we could discover a reel motor whose torque would change with the tape diameter on the reel, thus providing a constant tape tension throughout the reel of tape. (Many constant tension devices have been used in the past, but those designed for audio equipment have not been too successful.)

AMPEX is now using eddy current clutches on the turntables of some of the latest recorders. These devices provide completely cog-free operation (dependent only on a well-filtered d-c supply voltage) and thus result in improved flutter and wow. There are no commutators or slip rings, therefore no replacement problem, and no rf interference is generated. Faster start times are realized because of the small mass, and an associated low inertia, when compared to the rotor of a conventional torque motor.

The brakes, generally associated with the turntable assemblies, can be either of the mechanical or dynamic type. At AMPEX, the feeling has always been that mechanical brakes are superior. With mechanical brakes, a self-limiting — or at least a non-energizing — configuration should be used. Energizing type brakes that are not limiting will give quite different braking forces as the coefficient of friction changes with variations in temperature and humidity.

Another consideration in designing the brake system is the differential. This differential, as applied to magnetic tape recorders, means the difference in braking force that exists between the two directions of turntable rotation — with the greater force always acting on the trailing turntable (in respect to tape motion). The differential is expressed as a ratio,



Typical mechanical brake assembly as used by Ampex, showing the two adjustment points.