Underlying each of these adjustments is at least one of the principles of magnetic recording we have been discussing.

Head Azimuth Adjustment

It is important that the heads be aligned so that the gaps are exactly perpendicular to the top and bottom edges of the moving tape. If the gaps are slanted across the width of the tape we have created a situation where the signal reproduced from the upper part of the tape is out of phase with the signal from the lower part of the tape. This phasing condition causes a cancellation of signal, accentuated at the higher frequencies. Of course, if the record and reproduce head gaps on an individual single channel recorder were exactly parallel, it would make little difference if they were slanted slightly, *as long as the equipment played only those tapes it had recorded and as long as those tapes were not to be reproduced on other equipment.* But as soon as we want interchangeability of tapes from machine to machine we must establish a universal head alignment. Also, as we have seen, we cannot tolerate phasing problems in stereophonic equipment.

The best method in procuring this alignment is to use a standard alignment tape, produced under stringent laboratory conditions. This tape will be recorded with a head alignment signal, and the reproduce head is adjusted to give a maximum output of this signal. The standard tape is then removed, and the record head is aligned so the its recordings result in a maximum output on the previously aligned reproduce head. Both heads are thus set to a universal standard.

Level Adjustments

The volume level in reproduction is strictly a matter of personal preference, but the record level must be accurately calibrated if optimum noise and distortion are to be maintained. This is again most easily accomplished by using a standard alignment tape to set the reproduce level to a reference amplitude. The record level is then calibrated to produce this reference playback level.

The record calibration *can* be set by using a distortion meter to measure the third harmonic content. Normal record level is usually at a 1% harmonic distortion level, so it can be adjusted to that value. However, distortion meters are seldom available in practice, the record level is nominal, and different tapes may vary by ±1 (or even ±2) db. Therefore the standard alignment tape procedure is certainly adequate.

Equalization Adjustment

A series of tones will be recorded on the standard alignment tape so that the reproduce amplifier response can be set on curve.

The rising characteristic of the reproduce head is not only the consideration in achieving an overall flat response; there are certain wavelength losses which, as we have already stated, are not fully understood. Therefore, a certain variable pre-emphasis is employed in the recording process, which is adjusted to achieve a flat response when the reproduce amplifier is set on a standard curve.

The easiest way to set the playback response on curve is to play a standard alignment tape, and adjust the variable equalizing components for a *flat* response as the precisely recorded tones are reproduced. Another widely used method is to use an audio oscillator and a vtvm to actually follow the response curve provided with the equipment; this, however, does not allow for variations in head characteristics.

The record pre-emphasis is then adjusted for a flat overall frequency response through the previously standardized reproduce system.

Record Bias Adjustment

We make the high frequency bias adjustment using a signal of specific wavelength (normally 15 mils — 1000 cycles at 15 ips, 500 cycles at 7½ ips, etc.) at the normal tape operating level. The bias is set, while recording this signal, to achieve a maximum output.

Because the output vs bias current is very broad near the peak bias current setting, the adjustment is simplified by increasing the bias current until the output drops ½ db then decreasing the bias until the output again drops ½ db; the correct setting is the average of the over- and under-bias.

The maximum amplitude point at the given wavelength will give low distortion and reasonable short wavelength losses. It is also comparatively easy to adjust and can be consistently repeated using simple test equipment.

Because the magnetization curve varies with different tapes, the bias voltage ideally should be adjusted each time the tape is changed — particularly if the change is to a tape from a different manufacturer. However, this would normally be done only when extreme fidelity was required, such as when recording a master tape for a commercial recording company. Usually, a carefully adjusted "average" bias setting will produce excellent results with a wide variety of tapes.

Tape Tension

As indicated in our discussion of Tape Transport Design, the tension of the tape as it winds through the system is very important. Proper tape guiding is, to a large degree, dependent on correct tensions. A good tape pack on the takeup reel is also determined by this function. And very importantly, if tape is stored under excessive tension, it will tend to stretch; also the phenomenon known as "print through" (where the magnetic signal on one layer of tape on the reel is transfered to adjacent layers) will be accentuated.

Tape tension control in professional quality equipment is normally adjusted by varying the resistance