BIAS – You dont need it... Your tape recorder does!

No tape recorder will record and reproduce signals with acceptable fidelity unless it is provided internally with some form of recording bias — usually a high frequency or supersonic field. It is an extraordinarily difficult matter to explain, but the following note should be helpful until you are ready to tackle the heavy theory!

by W. N. Williams

In transforming sound waves into magnetic patterns on a wire or a tape, engineers encountered a problem which is a fundamental one and which had to be solved before magnetic recording could be considered as a really satisfactory method.

It was found that, when a magnetising force is applied to ferrous material, the degree of magnetisation produced and retained is not strictly proportional to the applied magnetising force. Beginning from zero, the amount of magnetisation first tends to rise very slowly, then rises more rapidly, then tapers off again as the ferrous material becomes magnetically saturated.

This occurs for magnetisation in either direction, so that the overall curve of induced magnetic flux (B,-B) plotted against magnetising force (H,-H) is as shown in figure 1.

The diagram also illustrates what happens to a signal which is passed through such a recording system without any bias.

For clarity, the input is shown as a pure sine wave. When transformed into a magnetic pattern, then recovered for subsequent amplification, the kink in the centre of the magnetisation curve is found to have produced a kink in the signal waveform.

The end result is very severe distortion in the reproduced sound.

To overcome this effect, it is necessary to apply a magnetic "bias" to the tape so that the signal does not, as it were, centre on the kinked part of the magnetisation curve.

The earliest system of magnetic bias involved placing a magnet near the recording gap, or passing a direct current through the recording head. This produced a fixed magnetic field which (hopefully) caused the signal to centre on one of the straight portions of the curve.

While a relatively simple method, "DC" or "permanent magnet" bias tended to produce a recording with undue background noise. This was due largely to the fact that each discrete particle on the tape was magnetised in the same direction, so that the tiny pulses they produced were all additive and were heard as noise on playback.

Nowadays, all but the most elementary recorders use a system of high frequency bias. A special oscillator in the recorder produces a signal well above the limit of hearing. During recording, this supersonic or high frequency bias signal is fed in to the recording head, along with the input signal.

Because the bias signal is at a very much higher frequency than the sound signal, the head is responding to a powerful magnetising force, even during instants when the sound signal waveform is passing through zero. This modifies fundamentally the way in which the particles on the tape respond to the sound signal.

In fact, as far as the recording head is concerned, the input signal is a composite waveform as illustrated in figure 2. As it passes across the gap in the record head, each particle is subjected to one or more complete cycles of high frequency energy, displaced bodily somewhere along its magnetising (or BH) curve by the simultaneous presence of the audio waveform.

What each particle retains in the way of remanent flux would take far more space to explain than is available here. For those who want to follow it up, however, the key thought is that the bias signal swings the particles through a series of magnetic cycles known as hysteresis loops. As the particles move to and beyond the edge of the recording gap, the loops collapse towards the B,-B axis but not as a direct transfer from the basic non-linear transfer curve.

The action of these loops, collapsing into the space between the BH curve and the B,-B axis makes the system behave as if it had a magnetisation curve quite different from the curve shown and without a kink in the centre.

The end result, when the tape is played back, is an output waveform which is substantially free from non-linear distortion, as in figure 2.

Because the particles are not all uniformly magnetised in one direction, as with DC bias, they do not tend to generate additive noise pulses as they pass across the replay head. The background noise with high frequency bias therefore tends to be much lower than with DC bias.

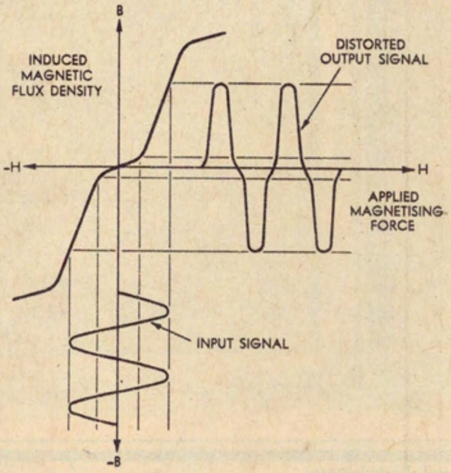

Figure 1: If the induced magnetic flux is plotted against magnetising force, the resulting curve is kinked near the centre. Recorded on this basis, an input signal would be distorted as shown.

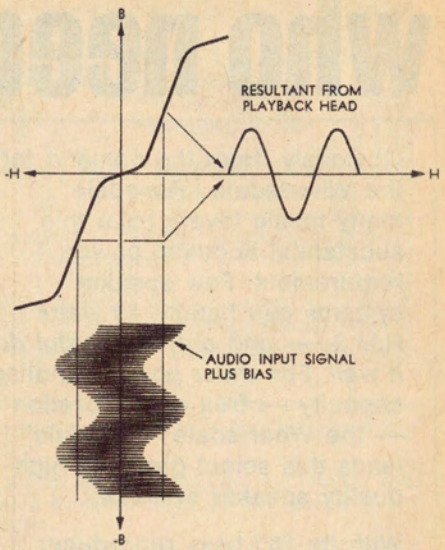

Figure 2: When a high frequency bias signal is present along with the audio signal to be recorded, the tape particles are subjected to a complex magnetising signal so that remanent flux is no longer dependant on the basic magnetisation curve. The tape exhibits a much more linear transfer characteristic.

It is not surprising to find that the magnitude and the frequency of the high frequency bias current through the record head is important.

The magnitude of the bias current affects the slope and the linearity of the apparent magnetisation curve, referred to earlier. It therefore has a direct bearing on the distortion content of the reproduced signal, the level of signal that can be impressed on the tape and the level of the recovered signal.

By inference it must have a bearing also on the noise level, since the larger the signal than can be impressed on the tape without distortion occurring, the better will be the signal/noise ratio.

As far as bias frequency is concerned, it is in the interest of overall recording quality to use a quite high figure — 100KHz or more. However, designers commonly have to settle for a figure nearer 50KHz for the sake of design economy.

In most tape recorders, the high frequency oscillator incorporated to provide the bias is actually made to serve double duty.

In a normal tape recorder the threading is arranged so that the tape passes over an "erase" head just before it reaches the record/play head. During replay, the erase head is inert — just a thing across which the tape happens to pass.

When a recording is being made, however, a strong signal from the high frequency oscillator is fed into the erase head, creating an intense high frequency magnetic field across the gap in its exposed surface.

The amplitude of this erase signal is made such that it magnetically saturates the particles on the tape in both directions as they pass across the erase gap. As they move out of the gap the magnetic cycling diminishes to zero and the particles are left with zero magnetisation.

In other words erasure eliminates any previous recording and (hopefully) noise content, so that the tape passes to the record head magnetically "clean".