Some Considerations on the Recording Process on Magnetic Tape with Application of H. F. Bias

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The explanation of the effect of H.F. bias in magnetic recording as given by WESTMIJZE[1] (based on the theory of ideal magnetization) is now generally accepted.

In a more schematic form it can be expressed as follows: The tape is characterised by a quantity H_{CT}, the so-called critical field intensity. The recording on an element of the tape is assumed to take place at the moment at which the decreasing amplitude of the bias field falls below H_{CT}, and the residual magnetization is determined by the value of the signal field intensity at that instant.

This means that we can define the so-called recording depth y_0 as the greatest distance from the recording head for which the bias-field amplitude reaches the value H_{cr}.

For an idealized head with a semi-infinite gap, as considered by WESTMIJZE[2], this recording depth is given by

$$y_0 = l\,(\tfrac{1}{2}r\sqrt{r^2+1} - \tfrac{1}{2}\,\mathrm{arcsh}\,r) \ldots\ldots (r < \sqrt{3})$$
$$y_0 = l\,(r - \mathrm{arctgh}\,r^{-1}) \ \ldots\ldots\ldots\ldots (r > \sqrt{3}) \qquad (1)$$

in which $r = H_0/H_{cr}$ (H_0 = bias-field amplitude deep down in the gap) and l = gap length.

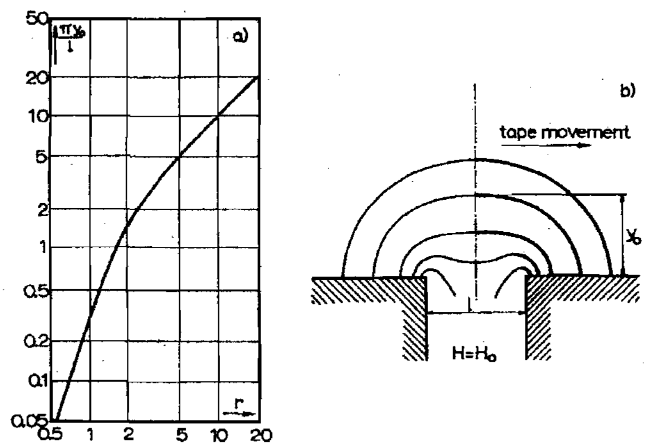

Fig. 1. a. Relation between recording depth and bias intensity. b. Field configuration around a semi-infinite gap.

This relation is shown in the graph of Fig. 1, together with the field configuration around the gap. The lines of constant field intensity on one of which, depending on the value of the bias current, the critical field intensity will be reached, are shown. The recording takes place on the bold part of the curve.

The direction of the signal field on this curve will vary considerably as a function of the distance from the head. On the tape surface the field is purely perpendicular; the longitudinal component H_x increases more or less linearly with the distance from the tape surface.

By recording square-wave pulses and studying the waveform of the reproduced signal on an oscilliscope we can investigate the extent to which the perpendicular component of the recorded magnetization plays a role in determining the surface induction of the tape. We then find that under normal circumstances the contribution of the perpendicular component is negligible in comparison with that of the longitudinal component.

We must therefore conclude that the sensitivity in the two directions of the recording process is different. This may be due, though not necessarily, to an anisotropy in the tape itself, particularly with oriented tapes. The sensitivity is also determined by demagnetization effects in the tape, and these can be expected to be greater in the perpendicular direction. For the present we shall neglect the perpendicular component of the magnetization. As previously mentioned, H_x can be expected to increase approximately linearly with the distance from the tape surface, which means that the apparent sensitivity of a tape, recorded under optimum bias conditions, will be about half the sensitivity of the same tape when recorded in a solenoid with a longitudinal field. This is in reasonable agreement with our measurements.

For a certain bias current the recording depth will be equal to the total coating thickness. Beyond this point the sensitivity will again decrease. In Fig. 2 are shown measured curves for the relation between sensitivity and bias current for some different tapes and heads, as compared with the theoretical curve derived from Eq. (1) when the assumption is made that only H_x is responsible for the recording. In the latter curve the effect of the finite coating thickness is not incorporated.

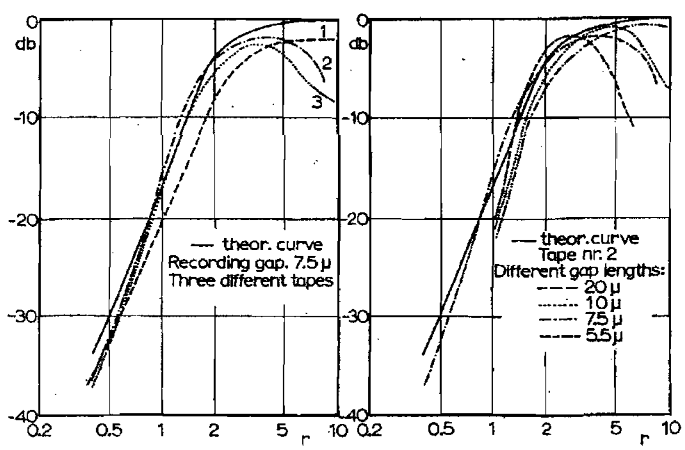

Fig. 2. Sensitivity as a function of bias intensity, a) for some different tapes, b) for some different recording heads.

Now we will investigate the consequence of the foregoing on short-wavelength response. The effect of the distance between a recorded layer of the tape and the reproducing head surface can be expressed by a factor exp $(-2\pi y/\lambda)$ in which y is the distance and λ is the wavelength recorded. Assuming a magnetization which is constant over the recording depth, this gives rise to the frequently quoted expression for the so-called thickness loss (WALLACE[3])

$$f_1(ky_0) = (1 - \exp[-ky_0]) / ky_0$$

If, however, the magnetization increases linearly with y, this expression should be replaced by

$$f_2(ky_0) = \{1 - (1 + ky_0) \exp[-ky_0]\} / \tfrac{1}{2}k^2y^2_0$$

We see that, as ky_0 increases, the thickness loss becomes proportional to $(ky_0)^2$.

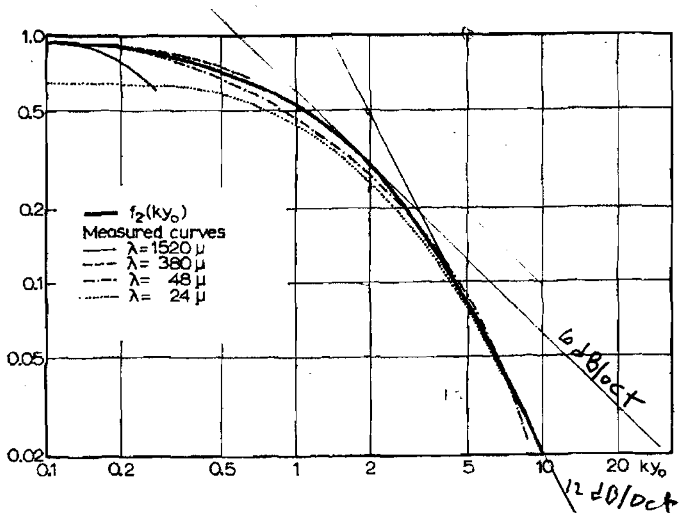

Fig. 3. Bias-dependent part of the losses.

If we want to check this expression with the results of measurements we must try to separate the thickness loss from the other losses in the recording–reproducing process. This can be done as follows: In the first place, frequency dependent losses can be eliminated by using various tape speeds with the same frequency. The gap loss of the reproducing head can be calculated and accounted for. The losses remaining at very low bias currents can be explained in terms of the distance between tape and reproducing head. The rest of the losses are bias-dependent and are considered as thickness-losses. In Fig. 3 are shown measured curves for the bias-dependent part of the losses as a function of ky_0, together the graph of $f_2(ky_0)$. Agreement with the latter is fairly good.

The investigations are still in progress, and the results will be published elsewhere in more detailed form.

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3. R. L. WALLACE, *Bell Syst. Techn. J.*, 30 (1951) 1145.

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