longer sufficient. Moreover, in studying the deviation between theory and experiment in the limiting case of extremely small spacings, great care must be taken to ensure minimum head/disk dynamic interference. Clearly, the head type used in our experiment is unsuitable for this limiting case, since very high head loads would be required and, consequently, excessive dynamic interference would result. It is apparent, however, that the experimental procedure developed in this investigation should be applicable not only in the limiting situation of small spacings, but also in the case of different magnetic media.

One last point should be made in this discussion. This point is that throughout our investigation we have assumed that the magnetic medium is fully saturated during the write process. While this seems likely to be true for our experiment, we have no direct means to verify how well this assumption is obeyed. The fact, however, that our experimental results agree well with the simple theories for saturation recording seems to indicate that nearly perfect saturation of the recording media is obtained in the present investigation.

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Letters

Head Fields of Asymmetric Recording Heads

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Abstract—Head fields of asymmetric recording heads have been measured using 5000:1 enlarged models. From these measurements the head field gradients have been derived and are discussed in view of the role of this quantity in the recording write process.

INTRODUCTION

The increase of the linear bit density within a single track in a recording medium is one of the goals of laboratory research which is directed to the improvement of digital magnetic recording memories.

Apart from the choice of a proper code, this linear bit density is determined by the length of the individual flux reversal, being the transition of an area magnetized in a positive direction to an area magnetized in a negative direction in the recording layer. An important factor determining the flux reversal length during the write process is the contour of the head field [1]. The write process is very complicated, however, and although it is qualitatively well understood, an explicite quantitative evaluation of the role of the head field contour during the write process cannot be formulated. Therefore, a prediction of the effect of a variation of the head field contour on the flux reversal can only be approximate. In our next considerations, we make use of the simplification in which the magnetic field in the recording layer is equal to the head field in the absence of that layer, as was used in the earlier literature. Although the shortcomings of such a description are evident, we can use it as a starting point; the results have to be viewed with this in mind.

We can define the head field contour as the function $H_x{}^d(x)$ (Fig. 1). As is usual in considerations of this kind, only the longitudinal component H_x of the head field is considered. The superscript d indicates the distance between the recording head and the layer (which is considered to be very thin) so that $H_x{}^d(x)$ is, in our approximation, the head field experienced in the recording medium. In the simple description of the recording write process given by Teer [2], the center of a flux reversal is determined by the value of x satisfying $H_x{}^d(x) = H_c$ (H_c is the coercive force of the layer material), while the flux reversal length is determined by the slope of $H_x{}^d(x)$ around this point. The steeper the slope, the shorter the flux reversal. Since in saturation recording, to which we confine ourselves, only one half of the head field contour is of importance in the write process, it seems to be valuable to consider asymmetric head gap configurations. One might hope that, maybe at the cost of the slope at the leading edge of the head field contour, the magnitude of the slope at the trailing edge can be increased.

EXPERIMENTAL RESULTS

We have investigated recording heads of the general type depicted in Fig. 1. For $\alpha = 90°$ and $h = 0$, this corresponds to the conventional recording head type.

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(a)

(b)

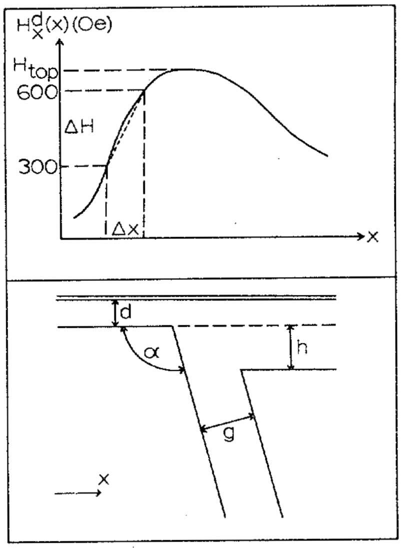

Fig. 1. (a) Head field contour $H_x{}^d(x)$. Slope $\Delta H/\Delta x$ is defined by the points on curve with H = 300 Oe and H = 600 Oe (ΔH = 300 Oe). (b) General head gap configuration. x direction is given by arrow.

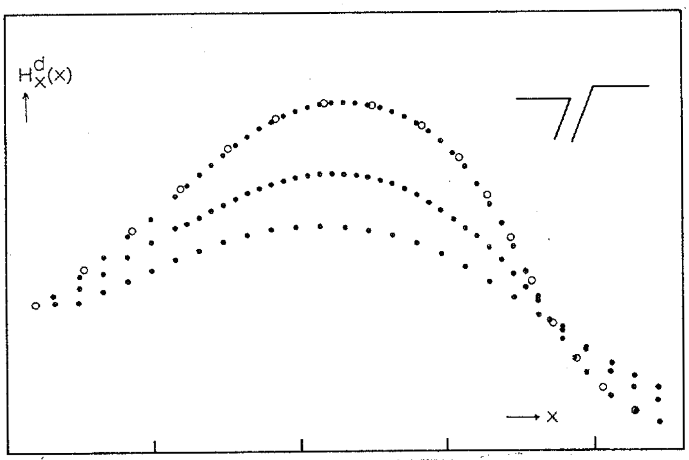

Fig. 2. Typical example of curves $H_x{}^d(x)$. In this configuration α = 60°, h = 7.8 mm, g = 6.05 mm, d = 2.9, 5.1, and 9.5 mm, respectively (top to bottom, dotted curves). Dots represent results of measurements, open circles calculated results [3] (calculations only for d = 2.9mm). Vertical scale is in arbitrary units, horizontal scale in units g = 6.05 mm.

In order to determine $H_x{}^d(x)$, two approaches may be followed, a measurement or a calculation. We have measured the head field contours on an enlarged recording head model (5000:1). Alternatively, a head field calculation, has been made by Duijvestijn *et al* [3]. The good agreement between measured and calculated results (Fig. 2) confirms the reliability of the measured results which prove to be easy to handle and which form the basis of the next analysis.

DISCUSSION

In this analysis we shall confine ourselves to the case h = 0, which might be the most practical configuration. From the head field contours we have calculated values for the slope around the points with $H_x{}^d(x) = H_c$. For H_c we used a value of 450 Oe [4], while the slope of the head field contour has been defined as $\Delta H/\Delta x$ with ΔH = 300 Oe (Fig. 1). These numbers are somewhat arbitrary. Any other reasonable choice, however, leads to practically the same final results. The head field slope $\Delta H/\Delta x$, as we have defined, depends, in a single configuration, on the value of the drive current though the head coil. To account for this, one needs a representative parameter in the description and for our purposes the quantity H_{top}, the maximum value of H in the head field contour, proves to be suitable.

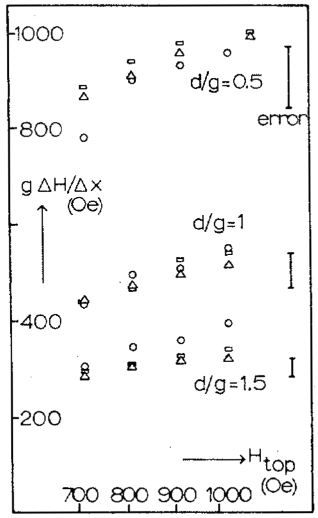

Fig. 3. Reduced head field slope $g\ \Delta H/\Delta x$ as function of H_{top} for three typical values of reduced head to layer distance d/g (0.5, 1, and 1.5). ○—α = 90° and h = 0 (conventional head). △—α = 60° and h = 0. □ α = 40° and h = 0

Next, to make possible a comparison between heads with different geometrical configurations, one has to introduce a common parameter. For this purpose, an obvious choice is the gap length g, so all dimensions are normalized by dividing by g. In Fig. 3 the reduced head field slope $g\ \Delta H/\Delta x$ of three head types is compared: the conventional head and two asymmetric heads with α = 60° and α = 40°, respectively, both with h = 0. This reduced slope is plotted against the parameter H_{top} (representing the dependence on the drive current) for three typical values of the reduced head-to-layer distance d/g (d/g = 0.5, 1, and 1.5). We note that for a fixed value of d/g there is some increase for increasing values of H_{top}. This is not of primary concern; however, the important fact we note from Fig. 3 is the absence of a clear increase of $g\ \Delta H/\Delta x$ with decreasing value of α. Only for d/g very small (contact recording) may there be some gain. This gain, however, may be expected to be reduced in the practical recording process by the influence of the thickness of the magnetic layer, by nonlinear effects of the head material (saturation effects at the pole tips may be expected to be of great importance as α decreases), etc. The same general conclusions are valid for the other head types which we have investigated (those with $h \neq 0$). We have to bear in mind that these conclusions are derived from a rather simplified starting point. Other important effects, such as self-demagnetization of the flux reversal, however, will probably only reduce the differences between the different head types.

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