An - Naj.J.Res., Section II, V1 (3) 85 - 91 January 1986

Note ملحوظة علمية

M.R.H. A NEW ERA IN MAGNETIC HEAD DESIGN

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ملخص

لقد تم موءخرا تطوير نوع جديد من الرووس المغناطيسية والتي يمكن استخدامها في كتابه وقراءة المعلومات من الاوساط المغناطيسية "مثال على ذلك : اشرطة واسطوانات التخزين في الكمبيوتر" . هذا النوع من الرووس والذى يسمى *Magnetoresistive head* يتالف من طبقتين : الاولى مستطيلة ورقيقة جدا (مثال : ١٠٠٠ × ١٠ × ٤ر٠ ميكرومتر) من الخليط المعدني النيكل والحديد "للقراءة" والثانية رقيقة ومعزولة عن الاولى ومصنوعة من الذهب او النحاس "للكتابة" . عند تعرض هذا النوع من الراس للمجال المغناطيسي (مثال على ذلك من الاشرطة المغناطيسية) تنخفض المقاومة الكهربائية للخليط المعدني بمقدار يتناسب طرديا مع شدة المجال المغناطيسي . يمكن قياس هذا الانخفاض بسهولة وتحويله الى اشارات كهربائية . ولكتابة المعلومات على الاوساط المغناطيسية "اشرطة" يمرر تيار كهربائي "متجانس مع الاشارة الكهربائية المنوى تسجيلها" خلال الطبقة الذهبية (او النحاسية) هذا التيار يولد مُجال مغناطيسي محلي ومماثل للاشارة الكهربائية يمكن تسجيل ذلك بسهولة على الاشرطة . هذا النوع من الرووس يتميز عن غيره من الرووس بسهولة الانتاج بكميات كبيرة وتكاليف معتدلة ولها استعمالات عدة في مجالات مختلفة في الحقل الصناعي .

The conventional method for reading/writing information from/on a magnetic media (e.g magnetic tapes in audio and video recorders, computers etc.) uses what is called an inductive head. This consists of several turns of enemelled wire, wound on a specially prepared former as shown in Fig.1

To write (record) information on the magnetic tape, a modulated current signal is injected into the coil. The current creats (induces) a magnetic field at the free ends of the former (poles) which in turn aligns the magnetic particels deposited on the tape, subsequently producing a record of the injected signal. To retrieve the information (i.e playback the recorded signals) the prerecorded tape is swiped across the poles of the inductive head. In this case the reverse of the write cycle occurs i.e. the magnetic field from the tape influence the former in such a manner as to cause a current flow through the coil having the same form as the recorded signal. A major disadvantage of this type of head is its speed dependence. Since the head senses the rate of change of field, $d\phi/dt$ (and not the field itself ϕ its output becomes greatly dependant[1] on the speed of the tape. Therefore, in tape system, and using an inductive head, it becomes necessary to use some form of electronic equalization in order to correct errors in the signal, resulting from any variations in the speed of the tape. In addition, because of their bulkness, they become difficult to implement in applications where high packing densities (video tapes) or multi-track system (computer tapes) are used. A new generation of heads have been developed [2]. The heads use the magneto-resistive effect for the read operation and a simplified inductive approach for the write operation.

The Magnetoresistive Head

In it.s simplest form, the magnetorsistive head may be thought of as a magnetic field sensitive resistor. The magneto-resistive effect in thin films of certain ferromagnetic materials arises from anisotropic contribution, Δp, to the total resistivity, p. For the arrangement shown in Fig. 2, where the dimensions of the magneto-resistive film are such that the magnetization is constrained to the plane of the film (Y,Z) we can write[3]

$$p = P_0 + \Delta P_{max} \cos^2 \theta \quad (1)$$

Where P_0 is the isotropic resistivity, P_{max} is the maximum change in the resistivity due to the magneto-resistive effect, and θ is the angle between the magnetization vector M_S and the current I. Note the resistivity is a maximum when $\theta = 0°$, therefore the resistivity decreases as θ increased

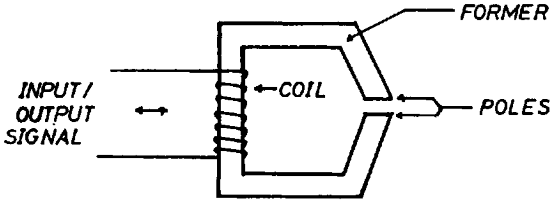

Fig. 1
The Inductive Head

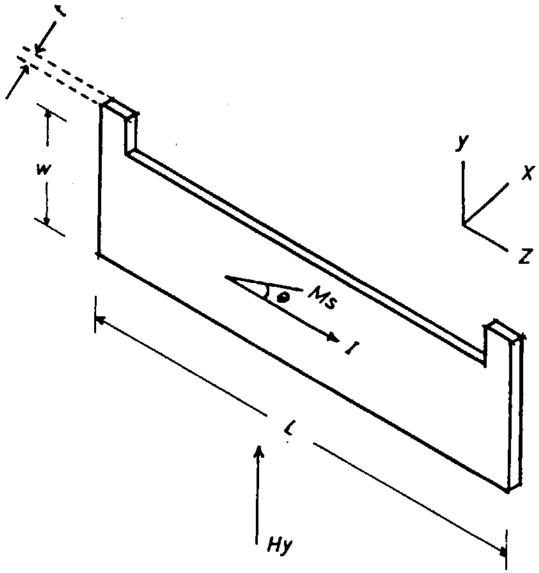

Fig. 2
The Magnetoresistive Element

from Θ° to 90° i.e. the resistivity decreases as the magnetization is rotated out of the current direction. Therefore for a thin film magneto-resistor (as shown in Fig. 2) supplied with a constant I a terminal voltage proportional to $\cos^2 \theta$ results. Hunt[3] was the first to show that equation 1 may be expressed as

$$P = P_0 + \Delta P_{max} (1 - H_y^2 / H_0^2)$$

Where H_y is the total uniform field in the Y direction, (Fig. 2) and Ho is the effective field acting to restrain the magnetization along the element length L. H_0 comprises a demagnetizing field, H_d and anisotropy field H_k ($H_0 = H_k + H_d$)' H_k arises when a uniaxial anisotropy is induced along the length of the element during the manufacturing of the film. In general Hunt.s analysis assumes a uniform demagnetizing, field across the width w of the strip resulting in a uniform rotation of M_s across the width for a uniform applied field. This assumption of a constant demagnetizing field is not strictly correct[4].[5] but Hunt.s analysis is an adequate first approximation. Equation 2 shows that the change in resistivity and hence the change in terminal voltage V (if the element is supplied with a constant current I) is a function of the field H_y. Therefore the magneto-resistor may be employed to detect the field H_y or a change in the feild. Fig. 3 shows a typical response of a magneto-resistive detector (the applied field is normalised to $H_d + H_k$). Application of a bias field Hb, in Fig. 3, can provide a quasilinear region of operation under the bias condition h_y becomes the field to be detected.

The structure of the now called magneto-resistive head (M.R.H), is shown in Fig. 4. The sense part is made of a thin film (300×10^{-10} Mm) of a permalloy (Ni-Fe) material. When this part is subjected to a magnetic field (e.g from a tape) its resistance, measured at points A and B changes. The maximum change (typically 10mv) was found to be approx. 3% of the original resistance of the element. The resistance change may be detected by measuring the voltage change across the element when a constant current is

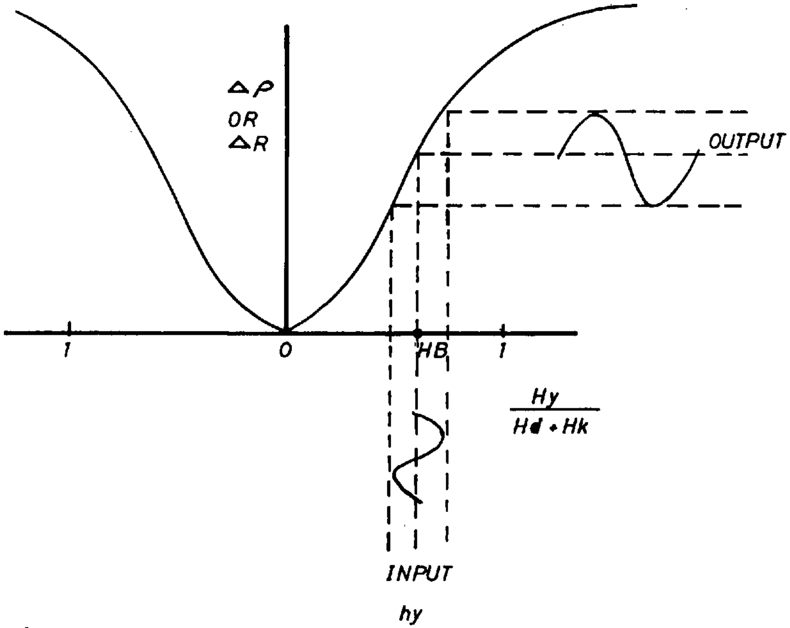

Fig. 3 Typical responce
The Magnetoresistive Head

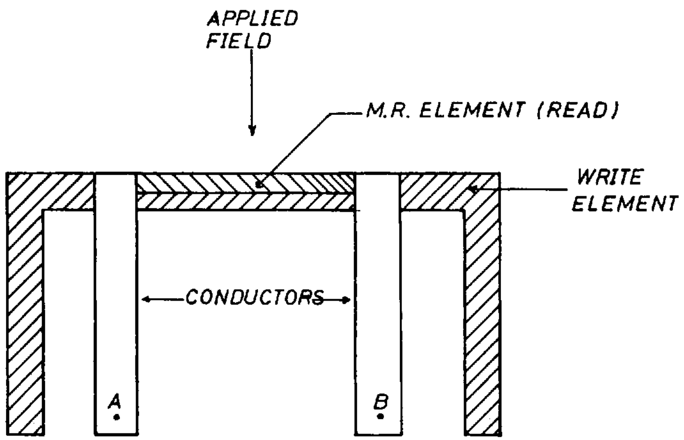

Fig. 4 The Magnetoresistive Head

passed through it. The write operation is similar to that of the inductive head, except in this case aninsulated (by means of a thin layer of sillicon monoxide) metalic strip is used in place of the coil. The purpose of the permanent magnet, Fig. 4, is to provide the optimum bias field for linear read/write operations.

It is clear that since the magneto-resistive head is a field sensing device (∅), it follows that its output when used in a tape system is independent of the tape speed. This is in contrast to a convetional inductive head as explained previously. Also because of their compactness and method of production (i.e standered semiconductor technology) the heads are particulary suited for reading from very high density recording media[6] (video tapes) employing narrow tracks and or slow speeds.

Finally, there are wide range of applictions[7,8] in which the magneto-resistive heads can be exploited relatively easily and cheaply. Some of these applications are currently being investigated by several scientific institutions throughout the world.

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