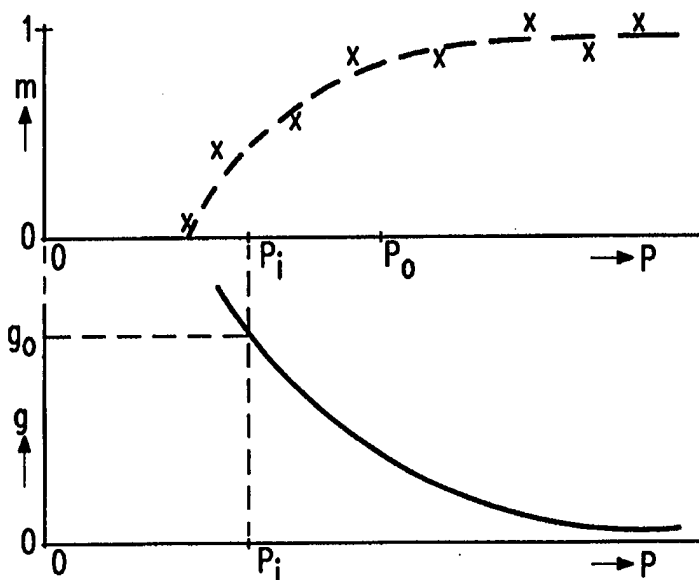




INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : G11B 7/125	A1	(11) International Publication Number: WO 98/25267 (43) International Publication Date: 11 June 1998 (11.06.98)
(21) International Application Number: PCT/IB97/01489 (22) International Filing Date: 1 December 1997 (01.12.97) (30) Priority Data: 96203397.3 6 December 1996 (06.12.96) EP (34) Countries for which the regional or international application was filed: NL et al. (71) Applicant: PHILIPS ELECTRONICS N.V. [NL/NL]; Groenewoudseweg 1, NL-5621 BA Eindhoven (NL). (71) Applicant (for SE only): PHILIPS NORDEN AB [SE/SE]; Kottbygatan 7, Kista, S-164 85 Stockholm (SE). (72) Inventor: DEN BOEF, Arie, Jeffrey; Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL). (74) Agent: VISSER, Derk; Internationaal Octrooibureau B.V., P.O. Box 220, NL-5600 AE Eindhoven (NL).		(81) Designated States: CN, ID, IL, JP, KR, MX, VN, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>

(54) Title: METHOD AND APPARATUS FOR WRITING OPTICAL RECORDING MEDIA



(57) Abstract

A method is described for setting an optimum write power for recording information on an optical recording medium. First a series of test patterns is written on the medium, each test pattern being written with a different write power. On reading the test patterns, the modulation of each read signal is determined. The modulations as a function of write power are curve-fitted to an analytic function. The normalised derivative of this function is determined analytically and is used to determine the value of the optimum write power for the medium.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon	KR	Republic of Korea	PL	Poland		
CN	China	KZ	Kazakhstan	PT	Portugal		
CU	Cuba	LC	Saint Lucia	RO	Romania		
CZ	Czech Republic	LI	Liechtenstein	RU	Russian Federation		
DE	Germany	LK	Sri Lanka	SD	Sudan		
DK	Denmark	LR	Liberia	SE	Sweden		
EE	Estonia			SG	Singapore		

Method and apparatus for writing optical recording media.

The invention relates to an optical recording apparatus for writing information on an optical recording medium by a radiation beam, and in particular to a method for setting an optimum write power level of the radiation beam, comprising a first step of writing a series of test patterns on the recording medium, each pattern with a different value of the write power level, a second step of reading the patterns to form corresponding read signals, and a third step of deriving a value of a read parameter from each read signal, and a fourth step of curve-fitting the values of the read parameter to a function defining a relation between the write power level and the read parameter. The invention further relates to an apparatus for writing information on an optical recording medium, comprising a radiation source for emitting a radiation beam having a controllable write power level, a control unit for writing a series of test patterns, each pattern with a different value of the write power level, a read unit for reading the patterns and forming corresponding read signals, a first processor for deriving a value of a read parameter from each read signal, a second processor for curve-fitting the values of the read parameter to a function defining a relation between the write parameter and the read parameter.

A processor may be of an analog or digital type and includes programmable processors and fixed-program processors. The processor may comprise memory means beside an arithmetic unit.

A recording method according to the preamble is known from the United States patent no. 5 185 733. In this method a series of test patterns is written on the medium, each subsequent test pattern being written with an increased write power level. After reading the written patterns, a curve fitting algorithm fits a second order polynomial to the amplitudes of the read signal of each pattern as a function of the write power level. The write power corresponding to the maximum of the polynomial is selected as the optimum write power for subsequently recording information of the medium. The problem of the noise character of the read signal is mitigated by the curve-fitting. A disadvantage of this known method is that the optimum power level as determined by the method does not sufficiently take into account variations in properties of recording apparatuses and variations in properties of recording media. Hence, use of this optimum write power may cause

unreliable storage of information on the recording medium.

It is an object of the invention to provide a reliable method for setting the optimum write power in dependence on read signals from test patterns written on a medium and being less affected by noise.

5 This object is achieved when the method according to the invention is characterized in that it comprises a fifth step of determining a derivative of the function and normalising the derivative by multiplying it by a factor equal to the value of the write power over the value of the read parameter, and a sixth step of selecting the optimum write power level in dependence on the normalised derivative of the function. The value of the normalised
10 derivative as a function of the write power turns out to be little affected by variations of parameters of the recording apparatus and the recording media. The variations of the apparatus may relate to the distribution of the radiation energy over the cross-section of the radiation beam used for recording, the power calibration of the radiation source. The variations of the media may relate to changes in write sensitivity or reflection over the
15 surface of a medium or between media. If the optimum write power level is selected in dependence on the normalised derivative, the selected level is suitable for reliable recording on a large variety of recording media by different recording apparatuses. The level may be selected by taking the power level corresponding to a preset value of the normalised derivative.

20 In alternative embodiment of the method according to the invention, the method is characterised in that it comprises a fifth step of selecting the optimum write power level in dependence on a predetermined value of a derivative of the function normalised by multiplication by a factor equal to the value of the write power over the value of the read parameter.

25 To achieve a stable curve fitting procedure, the function to be fitted is preferably defined in terms of orthogonal polynomials. Then the value of a coefficient for a polynomial determined by the procedure does not depend on the values of the coefficients determined for the other polynomials.

 The polynomials are preferably Legendre polynomials, which require
30 relatively little computing power in the curve fitting procedure because of their mathematical simplicity.

 The read parameter is preferably an amplitude of the read signal obtained from the medium, because this amplitude can easily be derived from a radiation detection system intercepting radiation coming from the medium. Moreover, the amplitude is a

satisfactory parameter for determining the quality of the recorded signals.

The selection process for the optimum write power may be refined by reading a parameter value from the medium and using this value in selecting the value of the write parameter. The value of the parameter may be characteristic for the specific medium
5 on which it is recorded. The parameter allows an adaptation of the selection process to the characteristics of the medium being scanned. The parameter may be an initial value of or range for the optimum write power level to reduce the range of power levels with which to write the test patterns. The parameter may also be a preset value of the normalised derivative, making it possible to select an optimum write power in dependence on the
10 properties of the medium. In contrast, a preset value fixed by the apparatus does not allow such a choice.

Before making calculations on signal values, the analog signals are preferably converted to digital signals by an analog-to-digital convertor. The derivative may be determined by taking difference values of the fitted function. The values of the function
15 must then be represented by a relatively large number of significant digits, and the calculations must also be performed over this large number of digits in order not to be affected by the additional noise introduced by this method of determining the derivative. The derivative of the function is preferably determined analytically, because such a determination introduces hardly any additional noise. The number of significant digits can then be reduced,
20 which reduces the required computing power of the second processor and allows a reduced quality of the analog-to-digital convertors.

In general, the write power levels for the test patterns are chosen in a range around the expected value of the optimum write power level. However, the optimum write power level is often close to the maximum power the radiation source can generate.
25 The range will then be limited by the maximum laser power. This problem can be avoided by selecting a power level from the derivative of the function and subsequently determining the optimum power level by multiplying the power level by a constant larger than one. The test patterns can then be written in a range further removed from the maximum laser power. This has the additional advantage that the measurements are made in a power range where
30 the function and its derivative are removed from their saturation values, which allows a higher accuracy of the determination of the function and its derivative.

A further aspect of the invention relates to the apparatus for writing information on the optical recording medium. This apparatus is according to the invention characterized in that the second processor is operatively connected for deriving a derivative

of the function, normalising the derivative by multiplying it by a factor equal to the value of the write power over the value of the read parameter, and for selecting a value of the write parameter in dependence on the normalised derivative.

5

The objects, features and advantages of the invention will be apparent from the following more particular description of preferred embodiments of the invention, as illustrated in the accompanying drawings.

Figure 1 is a diagram of an optical recording apparatus according to the
10 invention,

Figure 2 illustrates read signals from two test patterns,

Figure 3 is a graph showing the measured modulation as a function of
write power and its derivative,

Figure 4 is a plan view of a recording medium, and

15 Figure 5 is a plan view of a pattern of marks in the medium.

Figure 1 shows an apparatus and an optical recording medium 1 according to the invention. Medium 1 has a transparent substrate 2 and a recording layer 3 arranged on
20 it. The recording layer comprises a material suitable for writing information by means of a radiation beam. The recording may be of e.g. the magneto optical type, the phase-change type, the dye type or any other suitable material. Information may be recorded in the form of optically detectable regions, also called marks, on recording layer 3. The apparatus comprises a radiation source 4, e.g. a semiconductor laser, for emitting a radiation beam 5.
25 The radiation beam is converged on recording layer 3 via a beam splitter 6, an objective lens 7 and substrate 2. The medium may also be air-incident, where the radiation beam is directly incident on recording layer 3 without passing through a substrate. Radiation reflected from medium 1 is converged by objective lens 7 and, after passing through beam splitter 6, falls on a detection system 8, which converts the incident radiation in electric detector signals.
30 The detector signals are input to a circuit 9. The circuit derives several signals from the detector signals, such as a read signal S_R representing the information being read from medium 1. Radiation source, beam splitter 6, objective lens 7, detection system 8 and circuit 9 form together a read unit 10'. The read signal from circuit 9 is processed in a first processor 10 in order to derive signals representing a read parameter from the read signal

and necessary for controlling the laser power level. The derived signals are fed in a second processor 11, which processes a series of values of the read parameter and based thereon derives a value for an optimum write power control signal. The write power control signal is connected to a control unit 12. An information signal 13, representing the information to be written on medium 1, is also fed into control unit 12. The output of control unit 12 is connected to radiation source 4. A mark on recording layer 3 may be written by a single radiation pulse, the power of which is determined by the optimum write power level as determined by processor 11. A mark may also be written by a series of radiation pulses of equal or different lengths and a power determined by the optimum write power level.

The actual radiation power emitted by radiation source 4 may be measured by a not-shown detector arranged in an otherwise not-used side lobe of the radiation beam or in radiation reflected off an element in the optical path of the radiation beam. The signal of the detector may be connected directly to processor 11. Alternatively, the signal may be connected to control unit 12, where it may be combined with the peak amplitude of the read signal, which is a measure for the radiation power received at recording layer 3, and subsequently fed into processor 11.

Before writing information on medium 1 the apparatus sets its write power to the optimum value by performing the following procedure. First the apparatus writes a series of test patterns on medium 1. The test patterns should be selected so as to give a desired read signal. If the read parameter to be derived from the read signal is the maximum modulation of the read signal, the test pattern should comprise marks sufficiently long to achieve a maximum modulation of the read signal. When the information is coded according to the so-called EFM modulation, the test patterns preferably comprises the long I_{11} marks. The test patterns are recorded each with a different write power. Subsequent patterns may be written with a step-wise increased write power under the control of processor 11. The patterns may be written anywhere on the medium. They may also be written in specially provided test areas on the medium.

Figure 2 shows the read signals 18 and 19 obtained from two patterns written at two different write power levels. The patterns comprise a short mark, a long mark and a short mark, as shown by the signal parts 15, 16 and 17, respectively in both read signal 18 and read signal 19. An actual pattern may comprise a few hundred marks of different or equal lengths.

Processor 10 derives from the read signal S_R a read parameter used for finding the optimum write power. A possible read parameter is the ratio of the lowest

amplitude of the signal parts in a read signal, indicated by 'a' in Figure 2, and the maximum value of the read signal 'b'. A preferred read parameter is the normalised modulation being the ratio of the maximum peak-to-peak value of a read signal 'c' and the maximum value 'b' of the read signal.

5 After reading the test patterns on medium 1, processor 11 has available a series of pairs of values for the modulation of a pattern and the write power belonging to that pattern. The write powers may be taken from the value of the write power control signal during recording the test patterns, or from a measurement of the radiation power. Figure 3 shows schematically the result of reading; the crosses are measured values of the modulation
10 m as a function of the write power P. Processor 11 fits a curve through the measured modulation values in order to obtain an analytic expression for the variation of the modulation as a function of the write power. The curve is indicated in Figure 3 by a dashed curve. The fitting may be done by the well-known least-squares fitting algorithm.

 As a next step, processor 11 calculates analytically a normalised
15 derivative 'g' with respect to the write power of the modulation. The normalised derivative $g(P)$ is equal to the function $(dm/dP)P/m$. The function g derived from the fitted modulation m in Figure 3 is shown by the drawn curve.

 The processor derives an intermediate write power P_i from the normalised derivative by taking the value of the write power P belonging to a preset value g_0 , as
20 indicated by the dashed lines in Figure 3. The value of g_0 may be a value set by the manufacturer of the recording apparatus and stored in a memory of the apparatus, or it may be a value stored on the medium to be written and read prior to or during the procedure to set the optimum write power. As a next step, the value of the intermediate power P_i is multiplied by a constant h larger than one, resulting in the optimum write power level P_0 .

25 The values of the preset value g_0 and the multiplication constant h are determined by the manufacturer of the medium or by the user during initialisation of the medium. The value of g_0 is set within a range from 0.2 to 5.0. For values higher than 5.0 the normalised derivative loses its predicting value, because the proximity of an asymptote causes the values of P related to g_0 to lie closely together on the write power axis. For values
30 of g_0 lower than 0.2 the normalised derivative has a small slope, through which small errors in the value of the derivative result in a large spread of the values of P_i associated with g_0 . Experiments on rewritable recording media having a CD format gave values of g_0 within a range from 0.2 to 2.0 and on higher density media in a range from 2.0 to 4.0. The multiplication constant h is set preferably within a range from 1.00 to 1.35. The optimum

write power, P_0 , equal to $(h P_i)$, is in general set to a value near the write power where the modulation m starts saturating. In a preferred method of setting G_0 and h , the optimum write power of a specific medium is determined by finding the write power giving the lowest jitter of the read signal for information written on the medium. The information is preferably random information. Next, the normalised derivative dm/dP (P/m) is determined from a written series of test patterns as described above. A value for P_i is selected such that the associated value of g_0 lies within the above range, and where the normalised derivative is neither too flat nor too steep. The associated values of h , equal to P_0/P_i , and g_0 can now be used for all media of this type and for all recording apparatuses.

The value of the normalised derivative turns out to be hardly affected by variations of parameters of the recording apparatus and the recording media. If the optimum write power level is selected in dependence on the normalised derivative, the selected level is suitable for reliable recording on a large variety of recording media by different recording apparatuses. The level may be selected by taking the power level corresponding to a preset value of the normalised derivative. The advantages of the use of the normalised derivative may also be achieved when no curve-fitting is performed. In that case the derivative may be determined from the read parameter versus write power level data by e.g. calculating differences between the measured values. However, omitting the step of curve-fitting will increase the noise in the values of the derivative, thereby making it impossible for some media to use the derivative for setting the optimum write power.

The values of g_0 and h may be stored in the apparatus, thereby providing medium-independent values of the parameters. Preferably, the value of g_0 is stored in the medium, allowing media-dependent values. Figure 4 shows optically readable recording medium 1, provided with a track 30. The track may be spiral and in the form of for example an embossed groove or ridge. The area of the medium is divided in an information recording area 31 for writing user information and a control area 32 for storing information relevant for writing, reading and erasing information on the medium and in general not intended for recording user information. For some types of medium the information in the control is embossed. Control area 32 is marked by dashed track 32 in the Figure. Information recording area 31 is of a type which is subject to change in an optically detectable property when exposed to radiation above a specific write power level. The value of g_0 may be stored as a pattern of control information in control area 32 of the medium. When the control area is embossed, the manufacturer of the medium must record the value. Alternatively, the user may record the value in the medium during for instance initialisation of the medium,

allowing the recording of a disc-specific value. The value of h may also be recorded like the value of g_0 . Figure 5 shows a strongly enlarged portion of track 33 comprising a pattern of marks 34.

The curve to be fitted through the pairs of values (m, P) may be one or
5 more polynomials, which are preferably orthogonal. The curve may then be written as:

$$(1) \quad m(P) = \sum_i a_i f_i(P)$$

where $f'(P)$ is the derivative of function f with respect to the parameter P . The normalised
10 derivative is given in the analytic form

$$(2) \quad g(P) = \frac{P \sum_i a_i f'_i(P)}{m(P) \sum_i a_i f_i(P)}$$

The value of P_i can be found from the equation

15

$$(3) \quad g(P_i) = g_0.$$

Depending on the choice of the curve to be fitted, the value of P_i can be found in the form of an analytic expression or as the result of a numerical successive root approximation method
20 such as the regula falsi or Newton's method. The use of an analytic expression, when possible, has the advantage that it always provides the correct root, whereas a successive approximation may divert to an undesired root. When an analytic form of equation (3) can be found, the normalised derivative g need not be determined anymore, but the preset value g_0 may be inserted directly into equation (3) for determining the associated value of P_i .

25 A suitable set of orthogonal polynomials f_i are the Legendre polynomials. The three lowest order Legendre polynomials are given by:

$$\begin{aligned}
 f_0(P) &= 1 \\
 f_1(P) &= P \\
 f_2(P) &= \frac{3}{2}P^2 - \frac{1}{2}
 \end{aligned}
 \tag{4}$$

Since these polynomials are defined on the interval $-1 < P < +1$, the write power values to be fitted should be scaled according to

$$P_s = \frac{2P - (P_{\max} + P_{\min})}{P_{\max} - P_{\min}}
 \tag{5}$$

The scaled write power levels P_s must now be used in the formulae of equation (4). The value of P_i found from equation (3) must be scaled back to the range $P_{\min}, P_{\max}$.

When using a digital processor, the input values of m and P must be converted from an analog value to a digital value by an analog-to-digital convertor. The number of bits of the digital output values can be made to correspond to the noise in the measured values. If, for example, the noise in the values of a parameter is 1% of the maximum value of the parameter, the convertor should be at least 8 bits deep, thereby introducing an additional $1/2^8 = 1/256$ quantization noise.

If for reason of costs processor 11, in which the above calculations are made, is a small processor, the calculations are preferable performed in an integer format. The values of m and P should therefore be converted from real to integer values. The multiplication constant for this conversion should be large enough not to introduce additional noise and small enough not to require too much computing power. A good guide is to choose the constant such that the noise present in the value of m or P , as determined in the integer representation of the value, is slightly larger than the value corresponding to the least significant bit in the integer representation. The noise in the value includes the above-mentioned quantisation noise. If, for example, the noise in the values of m is 0.5% of the maximum value of m , then a multiplication factor of about 1000 divided by the maximum value of the parameter is reasonable.

Instead of using a series of polynomials for fitting the values of m and P ,

a single function may also be used. The function must have an asymptote for large values of P , a zero value for a non-fixed value of $P > 0$ and a non-fixed value of the derivative of the function for the value of P where the function is zero. A suitable function is

$$5 \quad (6) \quad f(P) = a_0 - \frac{a_1}{P - a_2}$$

The normalised derivative can be given in an analytic form. Equation (4) reduces to a quadratic equation, allowing to find the root without successive approximation.

Other suitable functions are the arc tangent and the hyperbolic tangent:

10

$$(7) \quad f(P) = a_0 \arctan(a_1 P - a_2)$$

$$(8) \quad f(P) = a_0 \tanh(a_1 P - a_2).$$

15 The values of the arc tangent and the hyperbolic tangent may be stored in a lookup table to speed up the calculations.

CLAIMS:

1. In an optical recording apparatus for writing information on an optical recording medium by a radiation beam, a method for setting an optimum write power level of the radiation beam, comprising
a first step of writing a series of test patterns on the recording medium, each pattern with a
5 different value of the write power level,
a second step of reading the patterns to form corresponding read signals, and
a third step of deriving a value of a read parameter from each read signal, and
a fourth step of curve-fitting the values of the read parameter to a function defining a relation between the write power level and the read parameter,
10 characterized in that the method comprises
a fifth step of determining a derivative of the function and normalising the derivative by multiplying it by a factor equal to the value of the write power over the value of the read parameter, and
a sixth step of selecting the optimum write power level in dependence on the normalised
15 derivative of the function.
2. In an optical recording apparatus for writing information on an optical recording medium by a radiation beam, a method for setting an optimum write power level of the radiation beam, comprising
a first step of writing a series of test patterns on the recording medium, each pattern with a
20 different value of the write power level,
a second step of reading the patterns to form corresponding read signals, and
a third step of deriving a value of a read parameter from each read signal, and
a fourth step of curve-fitting the values of the read parameter to a function defining a relation between the write power level and the read parameter,
25 characterized in that the method comprises
a fifth step of selecting the optimum write power level in dependence on a predetermined value of a derivative of the function normalised by multiplication by a factor equal to the value of the write power over the value of the read parameter.
3. The method according to Claim 1 or 2, wherein the function is defined in

terms of orthogonal polynomials.

4. The method according to Claim 3, wherein the polynomials are Legendre polynomials.

5. The method according to Claim 1 or 2, wherein the read parameter is an amplitude of a read signal.

6. The method according to Claim 1, wherein the sixth step includes reading a parameter value from the medium and using this value in selecting the value of the write power level.

7. The method according to Claim 1, wherein the derivative of the function is determined analytically.

8. The method according to Claim 1, wherein the sixth step includes selecting a power level in dependence on the derivative of the function and subsequently determining the optimum power level by multiplying the power level by a constant larger than one.

9. The method according to Claim 2, wherein the fifth step includes selecting a power level in dependence on the derivative of the function and subsequently determining the optimum power level by multiplying the power level by a constant larger than one.

10. An apparatus for writing information on an optical recording medium, comprising a radiation source for emitting a radiation beam having a controllable write power level, a control unit for writing a series of test patterns, each pattern with a different value of the write power level, a read unit for reading the patterns and forming corresponding read signals, a first processor for deriving a value of a read parameter from each read signal, a second processor for curve-fitting the values of the read parameter to a function defining a relation between the write power level and the read parameter, characterized in that the second processor is operatively connected for deriving a derivative of the function, normalising the derivative by multiplying it by a factor equal to the value of the write power over the value of the read parameter, and for selecting a value of the write power level in dependence on the normalised derivative.

11. The apparatus according to Claim 10, wherein the read parameter is an amplitude of a read signal.

1/2

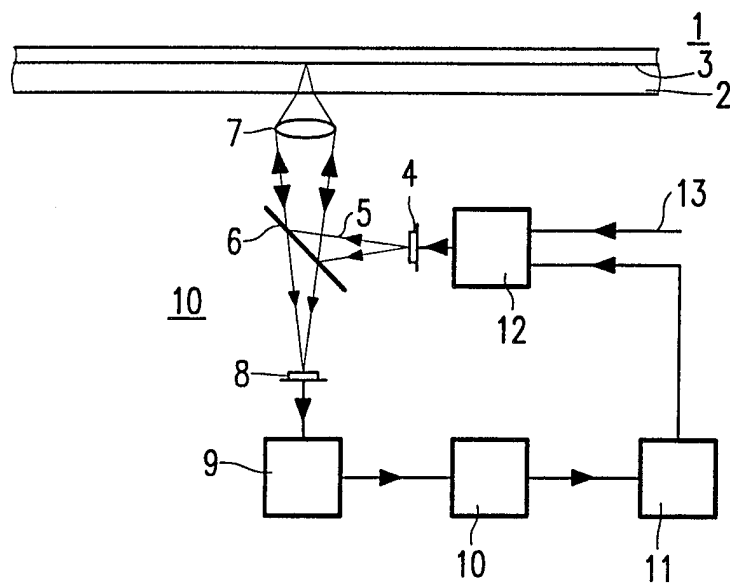


FIG. 1

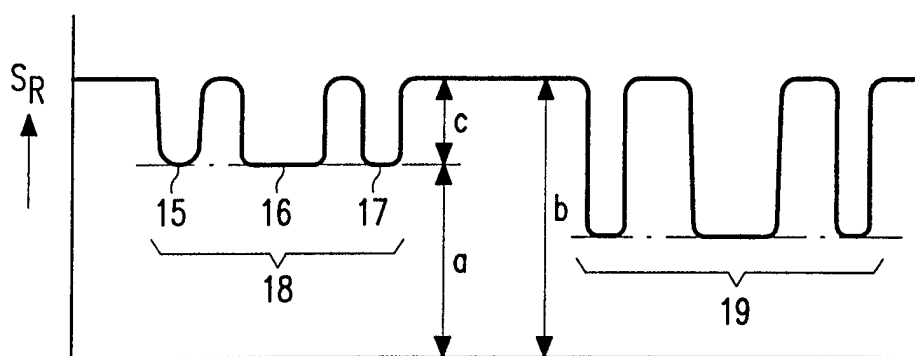


FIG. 2

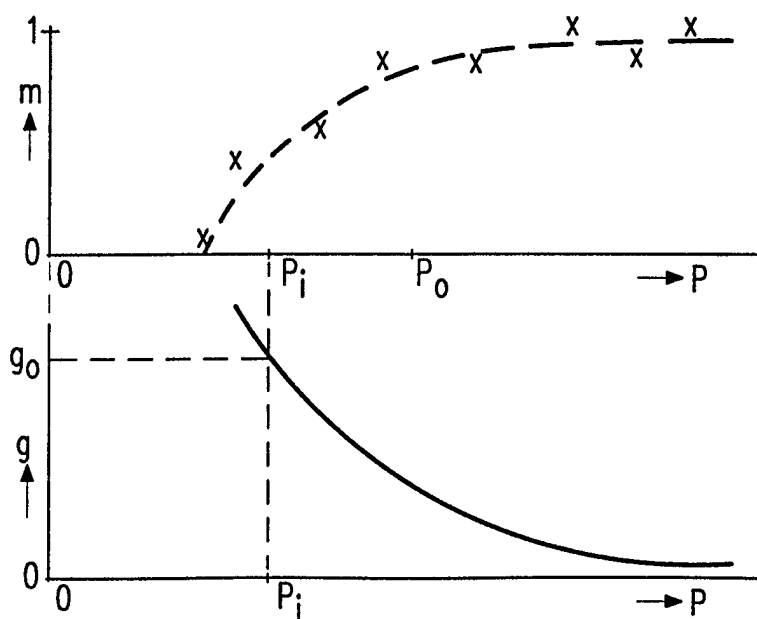


FIG. 3

2/2

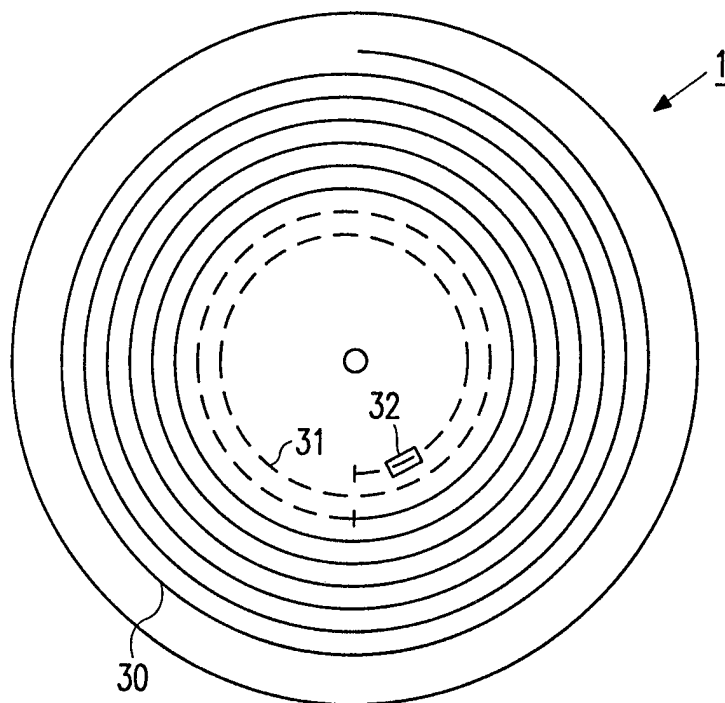


FIG. 4

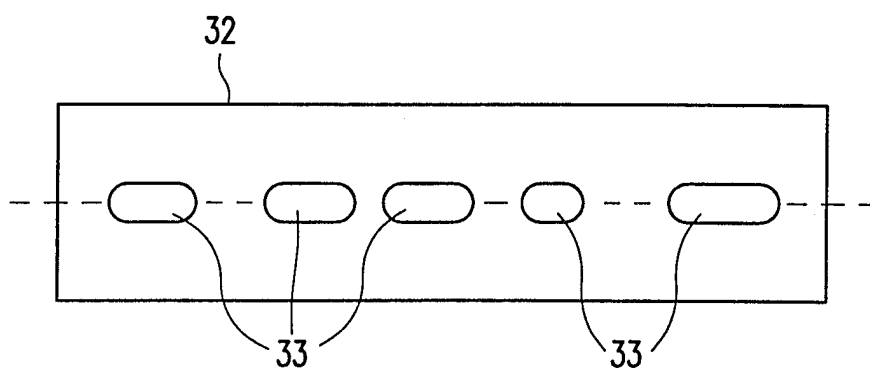


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB 97/01489

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: G11B 7/125

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: G11B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPAT, WPI, JAPIO

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 0737962 A2 (RICOH COMPANY, LTD.), 16 October 1996 (16.10.96), see the whole document --	1-11
Y	US 5268893 A (DAVID E. CALL ET AL), 7 December 1993 (07.12.93), figure 1, claim 1, abstract --	1-11
A	EP 0404251 A1 (N.V. PHILIPS' GLOELAMPENFABRIEKEN), 27 December 1990 (27.12.90) --	1-11
A	US 5185733 A (BLAIR I. FINKELSTEIN ET AL), 9 February 1993 (09.02.93) --	1-11

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

20 April 1998

Date of mailing of the international search report

20 -04- 1998

Name and mailing address of the ISA/

Swedish Patent Office

Box 5055, S-102 42 STOCKHOLM

Facsimile No. +46 8 666 02 86

Authorized officer

Benny Andersson

Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB 97/01489

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5226027 A (JOHANNES L. BAKX), 6 July 1993 (06.07.93) --	1-11
A	US 4932017 A (CORNELIS M.J. VAN UIJEN), 5 June 1990 (05.06.90) --	1-11
A	US 5001692 A (MARTIN A.J.P. FARLA ET AL), 19 March 1991 (19.03.91) -- -----	1-11

INTERNATIONAL SEARCH REPORT

Information on patent family members

02/04/98

International application No.

PCT/IB 97/01489

Patent document cited in search report			Publication date	Patent family member(s)		Publication date
EP	0737962	A2	16/10/96	EP	0778565 A	11/06/97
				JP	9138947 A	27/05/97
				JP	9219021 A	19/08/97

US	5268893	A	07/12/93	JP	2528594 B	28/08/96
				JP	5205342 A	13/08/93

EP	0404251	A1	27/12/90	AT	114855 T	15/12/94
				AT	114856 T	15/12/94
				CN	1022650 B	03/11/93
				CN	1024053 B	16/03/94
				CN	1048279 A	02/01/91
				CN	1048945 A	30/01/91
				CS	9003068 A	17/12/91
				DE	69014435 D,T	01/06/95
				DE	69014436 D,T	14/06/95
				EP	0404249 A,B	27/12/90
				SE	0404249 T3	
				HK	41396 A	15/03/96
				HK	41496 A	15/03/96
				HU	208877 B	28/01/94
				HU	210013 B	30/01/95
				JP	3034127 A	14/02/91
				JP	3102679 A	30/04/91
				NL	9000328 A	16/01/91
				PL	165214 B	30/11/94
				SU	1796076 A	15/02/93
				US	5226027 A	06/07/93
				US	5303217 A	12/04/94

US	5185733	A	09/02/93	CA	2036958 A	02/09/91
				DE	69116039 D,T	04/07/96
				EP	0475558 A,B	01/03/91
				JP	2647269 B	27/08/97
				JP	5189827 A	30/07/93

INTERNATIONAL SEARCH REPORT

Information on patent family members

02/04/98

International application No.

PCT/IB 97/01489

Patent document cited in search report			Publication date	Patent family member(s)		Publication date
US	5226027	A	06/07/93	AT	114855 T	15/12/94
				AT	114856 T	15/12/94
				CN	1022650 B	03/11/93
				CN	1024053 B	16/03/94
				CN	1048279 A	02/01/91
				CN	1048945 A	30/01/91
				CS	9003068 A	17/12/91
				DE	69014435 D,T	01/06/95
				DE	69014436 D,T	14/06/95
				EP	0404249 A,B	27/12/90
				SE	0404249 T3	
				EP	0404251 A,B	27/12/90
				HK	41396 A	15/03/96
				HK	41496 A	15/03/96
				HU	208877 B	28/01/94
				HU	210013 B	30/01/95
				JP	3034127 A	14/02/91
				JP	3102679 A	30/04/91
				NL	9000328 A	16/01/91
				PL	165214 B	30/11/94
				SU	1796076 A	15/02/93
				US	5303217 A	12/04/94
US	4932017	A	05/06/90	DE	3887842 D,T	28/07/94
				EP	0319102 A,B	07/06/89
				JP	1194140 A	04/08/89
				NL	8702904 A	03/07/89
US	5001692	A	19/03/91	AU	629792 B	15/10/92
				AU	1503788 A	27/10/88
				CA	1305253 A	14/07/92
				CN	1020137 B	17/03/93
				DE	3878293 A	25/03/93
				EP	0288114 A,B	26/10/88
				HK	87794 A	02/09/94
				JP	1033726 A	03/02/89
				NL	8800223 A	16/11/88
				RU	2024074 C	30/11/94
				SG	100794 A,G	16/06/95