(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
7 February 2002 (07.02.2002)

PCT

(10) International Publication Number
WO 02/11129 A1

(51) International Patent Classification[7]: G11B 5/02, 5/008, 5/584

(21) International Application Number: PCT/NL01/00582

(22) International Filing Date: 30 July 2001 (30.07.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
1015834 28 July 2000 (28.07.2000) NL

(71) Applicant *(for all designated States except US)*: **ON-STREAM HOLDING B.V.** [NL/NL]; Lodewijkstraat 1, NL-5652 AC Eindhoven (NL).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **KALFS, Johannes, Jozef, Wilhelmus** [NL/NL]; Keverberg 20, NL-5655 BB Eindhoven (NL).

(74) Agent: **PRINS, A., W.**; c/o Vereenigde, Nieuwe Parklaan 97, NL-2587 BN The Hague (NL).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WO 02/11129 A1

(54) Title: METHOD FOR WRITING INFORMATION INTO A MAGNETIC TAPE AT DIFFERENT DEPTH

(57) Abstract: In a method for writing information into a magnetic tape at different depth by means of a writing current signal to be supplied to a magnetic writing head, the writing current signal (S) is composed of a first low-frequency writing current signal (SLF1) and a high-frequency writing current signal (SHF) which is pulse width modulated by means of a second low-frequency writing current signal (SLF2). By using this method, information can be efficiently written into a magnetic tape at different depth. In particular the first and the second low-frequency writing current signal form a similar low frequency writing current signal, such as, for instance, a servo current signal, and the pulse width modulation is such that the low-frequency component in the pulse width modulated signal, for instance a bias current signal, is in opposite phase with the latter low-frequency writing current signal, and the magnetization in the top layer of the magnetic tape through the pulse width modulated current signal is opposed to the magnetization through the latter low-frequency writing current signal.

Title: Method for writing information into a magnetic tape at different depth

The present invention relates to a method for writing information into a magnetic tape at different depth.

For ADR (advanced digital recording) systems servo signals with a relatively long wavelength are written "deeply" into a magnetic tape. "Deeply" is understood to mean here deeply with respect to data signals which are written into the tape at a relatively short wavelength. After writing or overwriting data signals the servo signals must remain intact as properly as possible. Since signals with a relatively long wavelength can be written more deeply into a magnetic carrier, this is generally successful. Only in the top layer of the magnetic carrier will servo signals be overwritten by data signals. The servo signals are therefore weakened by some db's.

For writing analogous signals diverse methods are known, namely bias recording and pulse width or pulse position recording. Hereinafter pulse width recording will also be understood to mean pulse position recording; for a pulse position modulated signal can be regarded as the first derivative of a pulse width modulated signal. These methods particularly differ in the depth at which the signals can be written. When using bias recording, the field can penetrate more deeply into the magnetic tape than in the other methods. Bias recording is used in practically all analogous recorders, while pulse width and therefore also pulse position recording are hardly used, if used at all.

Because of the continuous nature of the low-frequency servo information bias recording is also used for writing servo signals in ADR systems.

In new systems to be developed, however, the servo tracks become increasingly narrow, which renders deep writing more difficult, as a result of which the weakening of the servo signals when writing data will be greater.

The object of the invention therefore generally is to provide a method for writing information at different depth, which information is particularly suitable for relatively narrow servo tracks, and which method can be particularly used for the deep writing of servo information.

According to the invention the method as described in the opening paragraph is characterized in that this writing current signal is composed of a first low-frequency writing current signal and a high-frequency writing current signal which is pulse width modulated by means of a second low-frequency writing current signal.

In a special situation the first and the second low-frequency writing current signal form a similar low-frequency writing current signal, and the pulse width modulation is such that the low-frequency component in the pulse width modulated signal is in opposite phase with the latter low-frequency writing current signal, and the magnetization in the top layer of the magnetic tape through the pulse width modulated current signal is opposed to the magnetization through the latter low-frequency writing current signal. In this situation the latter low-frequency writing current signal can be a servo current signal for the purpose of following tracks through a magnetic reading head and/or reading-writing head, while the high-frequency current signal is a data signal or a bias current signal for the purpose of writing servo signals. By taking a bias current signal as high-frequency current signal, bias recording and pulse width recording are combined.

The invention further relates to a device in which the above method can be used. According to the invention this device is provided with a first and a second low-frequency writing current generator and a high-frequency writing current generator, and with a modulator for pulse width modulating the frequency of a high-frequency writing current signal produced by the high-frequency writing current generator with a low-frequency signal continuously produced by the second low-frequency writing current generator, while, furthermore, a writing current combination element is present for combining the low-frequency writing current signal from the first low-frequency writing current generator and the high-frequency pulse width modulated writing current signal to the above writing current signal to be supplied to the magnetic writing head. In particular for writing servo signals into a magnetic

tape by means of a writing current signal to be supplied to a magnetic writing head, the device is characterized in that it is provided with a low-frequency servo current generator and a high-frequency bias current generator, and with a modulator for pulse width modulating the frequency of a bias current signal produced by the bias current generator with a servo signal produced by the servo current generator, while, furthermore, a current combination element is present for combining the low-frequency servo current signal and the high-frequency pulse width modulated bias current signal to the above writing current signal to be supplied to the magnetic writing head, while through the modulated bias current signal a magnetization in the top layer of the magnetic tape can be effected, which is opposed to the magnetization through the servo current signal.

The invention further relates to a recorder and/or reproduction device, provided with an arrangement as indicated above.

The invention will now be explained in more detail with reference to the accompanying drawing in which:

Fig. 1 shows a number of diagrams in explanation of a known bias recording method;

Fig. 2 shows a number of diagrams in explanation of a known pulse width recording method;

Fig. 3 shows a simplified block diagram of a device according to the invention;

Fig. 4 shows a simplified block diagram of a device according to the invention, used for writing servo signals; and

Fig. 5 shows a number of diagrams in explanation of the method according to the invention.

When using bias recording of information, such as, for instance, a servo current signal, the writing current signal for a magnetic writing head is

formed by a combination of a low-frequency signal, such as, for instance, a low-frequency servo current signal, and a high-frequency bias current signal. The amplitude of these signals is plotted in Fig. 1A and Fig. 1B with respect to time. For simplicity's sake, the bias frequency with respect to the frequency of the servo signal is shown relatively low. In practice, the bias frequency is often 500 to 1000 times as high as the frequency of the information to be written. The magnetization in a magnetic tape effected by the writing current signal is diagrammatically shown in Fig. 1C. From this it appears that through the light/dark nuances shown the low-frequency information signal is written "deeply", while the high-frequency bias current signal only written into the top layer is such that when using a reading head with a relatively wide slit or a reading head of another type with high-frequency filtering, this signal is averaged completely. The bias current signal could only be read out when a reading head with a relatively narrow slit is used.

When using pulse width modulation recording, only a carrier is present, comparable with the bias frequency. The low-frequency information is written by modulating the duty cycle of the carrier with this low-frequency information. In Fig. 2A the writing current signal belonging to this recording method is plotted with respect to time, while in Fig. 2B the thus effected magnetization in a magnetic tape is diagrammatically shown. By means of a reading head with a relatively wide slit a low-frequency varying average field is read out.

To remove the above drawbacks inherent to these two known methods, the two known recording methods have been combined according to the invention. The device used therefor is generally shown in Fig. 3. This device comprises a first low-frequency writing current generator 1, a second low-frequency writing current generator 2, a high-frequency writing current generator 3, a pulse width modulator 4, and a writing current combination element 5. The writing current signal S produced by the writing current combination element is composed of a low-frequency writing current signal

S_{LF1} originating from the first writing current generator 1 and a writing current signal $S_{LF2} + S_{HF}$ produced by the pulse width modulator, in which the signal S_{LF2} originates from the second low-frequency writing current generator 2 and the signal S_{HF} originates from the high-frequency writing current generator 3. The signal S_{LF1} will be written "deeply" into a magnetic tape, while the signal $S_{LF2} + S_{HF}$ will be written into the top layer of this magnetic tape. By using a reading head with a wide slit, while the high-frequency component S_{HF} will be averaged, the two signals S_{LF1} and S_{LF2} are simultaneously read out and, provided the frequencies of these signals are sufficiently different, filtered out and detected. In other words, by using a combination of bias current recording technique and pulse width recording technique, different signals can be simultaneously read in at different depth and, provided their frequencies are sufficiently different, simultaneously read out and detected.

This principle can in particular be applied to the writing of servo current signals while avoiding the above drawbacks attached to the above techniques individually. The device used therefor is shown in Fig. 4. This device differs from that of Fig. 3 at two points. First of all, instead of two low-frequency writing current generators only one is present here, namely the writing current generator 6. It produces a low-frequency writing current signal S_{LF}, which is supplied both to the pulse width modulator 4 and directly to the writing current combination element 5. The writing current signal S produced by this combination element 5 is composed of a low-frequency writing current signal S_{LF} and a pulse width modulated high-frequency signal $S_{LF} + S_{HF}$. For writing servo current signals S_{LF} is a servo current signal S_{SERVO} and $S_{LF} + S_{HF}$ is a pulse width modulated bias current signal S_{BIAS}. The bias current signal is therefore written into the top layer of a magnetic tape, while the servo current signal is written more deeply. By using, for instance, a reading head with a wide slit for reading out servo information, only the servo information is read out, that is to say both the low-frequency servo signal and the low-frequency

component of the pulse width modulated high-frequency bias current signal. The second point at which the device of Fig. 2 differs from that of Fig. 1 resides in an introduced phase difference of 180° between the above low-frequency servo signal and the low-frequency component in the pulse width modulated signal. This phase difference can be realized through inversion of the low-frequency servo signal supplied to the modulator 4 over the line 7 or in the modulator 4 itself. Through this phase difference a magnetization in the top layer of the magnetic tape can be obtained, which is opposed to the magnetization through the servo current signal caused over a larger depth. The amplitude ratio between the two signals can be adjusted by regulating the bias writing current and the modulation depth.

The effect of this manner of writing of the servo current signal will be explained on the basis of the diagrams shown in Fig. 5. Fig. 5A shows the amplitude of a low-frequency servo signal with respect to time, while Fig. 5B shows the amplitude of a pulse width modulated of a bias current signal. The magnetization in a magnetic tape effected by the writing current signal is diagrammatically shown in Fig. 5C. It is now assumed that the pulse width modulated high-frequency bias signal is written into a top layer until a depth d1, and the low-frequency servo signal over the entire thickness of the tape layer shown. Here the low-frequency component of the pulse width modulated high-frequency basis signal is in opposite phase with the low-frequency servo signal written over the entire layer thickness. The resulting low-frequency servo signal is therefore weakened to a desired value.

When data signals having a frequency of the same order as that of the bias signals are written onto the band until a depth d1, then the pulse width modulated high-frequency bias signal disappears therein and with that the low-frequency component thereof, through which the servo signal to be read effectively increases with respect to the desired value, which is therefore deemed undesirable; an equal servo signal should be obtained, independently of whether the band is overwritten or not. When the data signals are written

until a depth d2, then at a correct adjustment of this depth d2 the servo signal will retain the desired value. When the data signals are written until a depth larger than d2, for instance d3, then, when reading, the servo signal will be weakened further than is desired.

Although, instead of bias current signals, data information the frequency of which is of the same order as the bias frequency, could be used as well, it is useless to apply a low-frequency component in the data signals; for after reading this would have to be filtered out again. When during reading a reading head with a wide slit were used, then the data information would be lost in a way similar to the way in which the bias component should be lost. When the low-frequency component in the pulse width modulated signal were equal to the low-frequency servo signal which is in opposite phase therewith, then the resulting low-frequency component is zero and servo information can only be read out after the top layer has been overwritten with data.

Claims

1. A method for writing information into a magnetic tape at different depth by means of a writing current signal to be supplied to a magnetic writing head, characterized in that this writing current signal is composed of a first low-frequency writing current signal and a high-frequency writing current signal which is pulse width modulated by means of a second low-frequency writing current signal.

2. A method according to claim 1, characterized in that the first and the second low-frequency writing current signal form a similar low-frequency writing current signal, and the pulse width modulation is such that the low-frequency component in the pulse width modulated signal is in opposite phase with the latter low-frequency writing current signal, and the magnetization in the top layer of the magnetic tape through the pulse width modulated current signal is opposed to the magnetization through the latter low-frequency writing current signal.

3. A method according to claim 2, characterized in that the latter low-frequency writing current signal is a servo current signal for the purpose of following tracks through a magnetic reading head and/or reading-writing head.

4. A method according to claim 2 or 3, characterized in that the high-frequency current signal is a data signal or a bias current signal for the purpose of writing servo signals.

5. A device for writing information into a magnetic tape at different depth by means of a writing current signal to be supplied to a magnetic writing head according to the method of any one of the preceding claims, characterized in that the device is provided with a first and a second low-frequency writing current generator and a high-frequency writing current generator, and with a modulator for pulse width modulating the frequency of a high-frequency writing current signal produced by the high-frequency writing current

generator with a low-frequency signal continuously produced by the second low-frequency writing current generator, while, furthermore, a writing current combination element is present for combining the low-frequency writing current signal from the first low-frequency writing current generator and the high-frequency pulse width modulated writing current signal to said writing current signal to be supplied to the magnetic writing head.

6. A device for writing servo signals into a magnetic tape by means of a writing current signal to be supplied to a magnetic writing head according to the method of any one of the preceding claims, characterized in that the device is provided with a low-frequency servo current generator and a high-frequency bias current generator, and with a modulator for pulse width modulating the frequency of a bias current signal produced by the bias current generator with a servo signal produced by the servo current generator, while, furthermore, a current combination element is present for combining the low-frequency servo current signal and the high-frequency pulse width modulated bias current signal to said writing current signal to be supplied to the magnetic writing head, while through the modulated bias current signal a magnetization in the top layer of the magnetic tape can be effected, which is opposed to the magnetization through the servo current signal.

7. A recorder and/or reproduction device, provided with an arrangement according to claim 5 or 6.

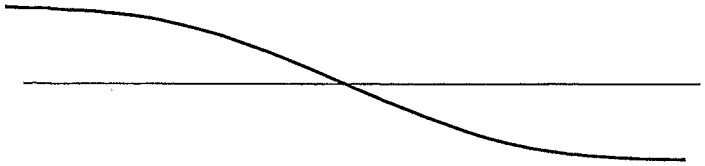

Fig. 1A

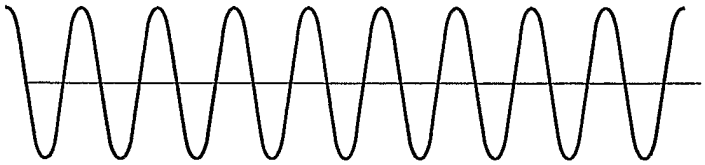

Fig. 1B

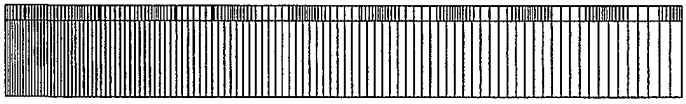

Fig. 1C

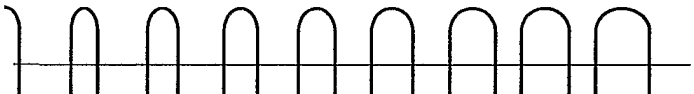

Fig. 2A

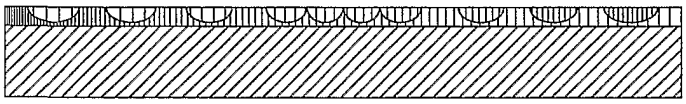

Fig. 2B

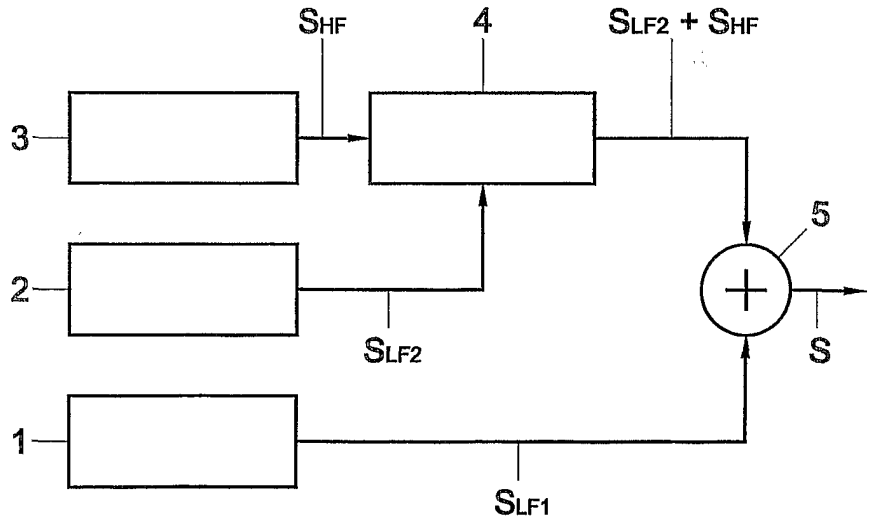

Fig. 3

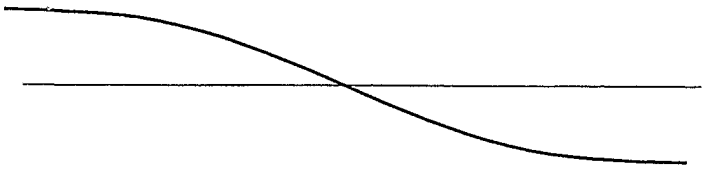

Fig. 5A

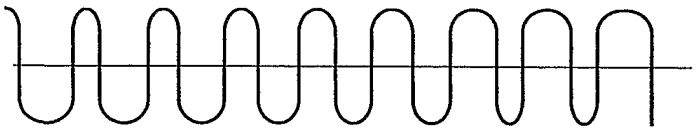

Fig. 5B

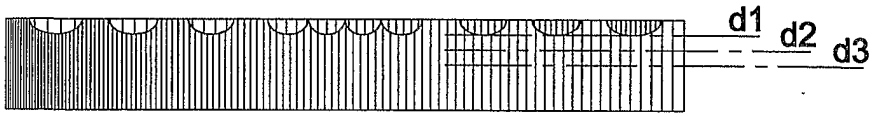

Fig. 5C

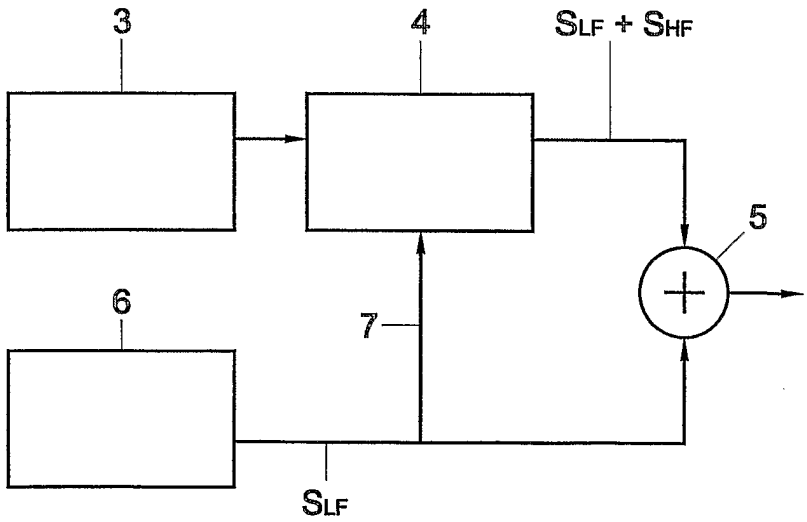

Fig. 4

INTERNATIONAL SEARCH REPORT

International Application No
PCT/NL 01/00582

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G11B5/02 G11B5/008 G11B5/584

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)
IPC 7 G11B

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, PAJ, WPI Data, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 917 816 C (MAX GRUNDIG) 13 September 1954 (1954-09-13) the whole document ---	1,2,5,7
A	GB 897 044 A (AMPEX CORP) 23 May 1962 (1962-05-23) the whole document ---	1,2,5,7
A	T.A. SCHWARZ: "Recording Servo Information Below a Data Surface in a Homogeneous Medium. July 1974." IBM TECHNICAL DISCLOSURE BULLETIN, vol. 17, no. 2, 1 July 1974 (1974-07-01), pages 536-539, XP002163442 New York, US page 538, paragraph 6 --- -/--	1

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in 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	Date of mailing of the international search report
12 December 2001	20/12/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Fux, J

INTERNATIONAL SEARCH REPORT

International Application No
PCT/NL 01/00582

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	GB 775 050 A (PHILIPS ELECTRICAL INDUSTRIES) 15 May 1957 (1957-05-15) the whole document	1
A	US 5 949 607 A (HOOGENDOORN ABRAHAM ET AL) 7 September 1999 (1999-09-07) column 3, line 65 -column 4, line 2	1
A	US 5 319 502 A (FEIG EPHRAIM) 7 June 1994 (1994-06-07) column 4, line 9 -column 5, line 15	1-4
A	US 4 318 141 A (HAYNES MUNRO K) 2 March 1982 (1982-03-02) abstract	1
A	US 4 313 140 A (KEIDL STEVEN D) 26 January 1982 (1982-01-26) the whole document	1
A	PATENT ABSTRACTS OF JAPAN vol. 012, no. 192 (P-712), 4 June 1988 (1988-06-04) -& JP 62 298068 A (NEC CORP), 25 December 1987 (1987-12-25) abstract	1
A	US 4 314 289 A (HAYNES MUNRO K) 2 February 1982 (1982-02-02) the whole document	
A	PATENT ABSTRACTS OF JAPAN vol. 016, no. 201 (P-1352), 14 May 1992 (1992-05-14) -& JP 04 032002 A (NEC CORP), 4 February 1992 (1992-02-04) abstract	

INTERNATIONAL SEARCH REPORT

Information on patent family members

tional Application No
/NL 01/00582

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 917816 C		NONE	
GB 897044 A	23-05-1962	DE 1136502 B	
GB 775050 A	15-05-1957	NONE	
US 5949607 A	07-09-1999	CN 1168189 A	17-12-1997
		EP 0803120 A1	29-10-1997
		WO 9717700 A1	15-05-1997
		JP 10512705 T	02-12-1998
US 5319502 A	07-06-1994	NONE	
US 4318141 A	02-03-1982	CA 1149508 A1	05-07-1983
		DE 3064977 D1	27-10-1983
		EP 0030644 A1	24-06-1981
		JP 1322303 C	11-06-1986
		JP 56083806 A	08-07-1981
		JP 60049966 B	06-11-1985
US 4313140 A	26-01-1982	BR 8007948 A	23-06-1981
		CA 1143831 A1	29-03-1983
		DE 3066613 D1	22-03-1984
		EP 0030256 A1	17-06-1981
		JP 1322304 C	11-06-1986
		JP 56105306 A	21-08-1981
		JP 60049967 B	06-11-1985
JP 62298068 A	25-12-1987	NONE	
US 4314289 A	02-02-1982	DE 3067195 D1	26-04-1984
		EP 0030300 A1	17-06-1981
		JP 1059667 B	19-12-1989
		JP 1573124 C	20-08-1990
		JP 56083820 A	08-07-1981
JP 04032002 A	04-02-1992	NONE	