



- (51) International Patent Classification:
G01V 3/38 (2006.01)
- (21) International Application Number:
PCT/US2012/022822
- (22) International Filing Date:
27 January 2012 (27.01.2012)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
61/437,122 28 January 2011 (28.01.2011) US
- (71) Applicant (for AL, AM, AU, AZ, BF, BG, BJ, BY, CF, CG, CI, CM, CO, CZ, DE, DK, GA, GN, GQ, GR, GW, HU, ID, IE, IL, IT, KG, KP, KR, KZ, LT, MD, ML, MR, MX, MY, NE, NO, NZ, OM, PL, RO, RU, SI, SK, SN, TD, TG, TH, TJ, TM, TN, TR, TT, UZ, ZA only): **SCHLUMBERGER TECHNOLOGY B.V.** [NL/NL]; Parkstraat 83-89, NL-2514 JG The Hague (NL).
- (71) Applicant (for CA only): **SCHLUMBERGER CANADA LIMITED** [CA/CA]; 525-3rd Avenue Southwest, Calgary, Alberta T2P 0G4 (CA).
- (71) Applicant (for FR only): **SERVICES PETROLIERS SCHLUMBERGER** [FR/FR]; 42 rue Saint Dominique, F-75007 Paris (FR).
- (71) Applicant (for GB, JP, NL only): **SCHLUMBERGER HOLDINGS LIMITED**; P.O. Box 71, Craigmuir Chambers, Road Town, 1110 Tortola (VG).
- (71) Applicant (for all designated States except AU, BG, CA, CO, CZ, DE, DK, FR, GB, GR, HU, ID, IE, IL, IT, JP, KR, LT, MX, MY, NL, NO, NZ, OM, PL, QA, RO, SE, SG, SI, SM, SV, TN, TR, TT, US, UZ, ZA): **PRAD RESEARCH AND DEVELOPMENT LIMITED**; P.O. Box 71, Craigmuir Chambers, Road Town, 1110 Tortola (VG).
- (72) Inventor; and
- (75) Inventor/Applicant (for US only): **SONG, Yi-Qiao** [CN/US]; Schlumberger Doll Research, 1 Hampshire Street, Cambridge, Massachusetts 02139 (US).
- (74) Agents: **LAFFEY, Bridget M.** et al.; 10001 Richmond Avenue, IP Administration, Room 4720, Houston, Texas 77042 (US).
- (81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM,

[Continued on next page]

(54) Title: TWO DIMENSIONAL NMR OF DIFFUSION AND RELAXATION FOR MATERIAL CHARACTERIZATION

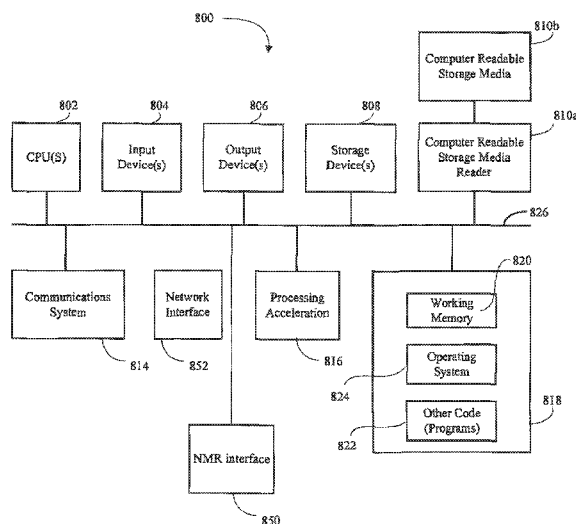


Figure 8

(57) Abstract: Processing nuclear magnetic resonance data to obtain information regarding material properties is described. This processing can include, for example, compression techniques that can be implemented to lower the required operating memory. In some embodiments, a compression technique can be chosen based on the available operating memory of the computer system. By doing so, an efficient compression algorithm can be selected. In some embodiments, a Lanczos bidiagonalization algorithm, for example, an IRLBA algorithm, can be used for data compression.



AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

- (84) **Designated States** (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ,

DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

- with international search report (Art. 21(3))
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

- (88) **Date of publication of the international search report:**

4 October 2012

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2012/022822

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - G01V 3/38 (2012.01)

USPC - 324/303

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(8) - G01R 3/44; G01V 3/00, 3/18, 3/38 (2012.01)

USPC - 324/300, 303, 306, 307, 309, 318, 322; 703/2, 5, 6, 13

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 practicable, search terms used)

MicroPatent, Google Patents, Google Scholar

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6,462,542 B1 (VENKATARAMANAN et al) 08 October 2002 (08.10.2002) entire document	1-7, 21-23
Y	BAGLAMA et al. Augmented Implicitly Restarted Lanczos Bidiagonalization Methods. SIAM Journal on Scientific Computing, Vol. 27, No. 1. 2005. pages 19-42. [retrieved on 2012-07-18]. Retrieved from the internet: <URL: http://www.math.kent.edu/~reichel/publications/auglbd.pdf>. entire document	1-7, 21-23
A	US 6,597,171 B2 (HURLIMANN et al) 22 July 2003 (22.07.2003) entire document	1-7, 21-23
A	US 6,937,014 B2 (SUN et al) 30 August 2005 (30.08.2005) entire document	1-7, 21-23
A	US 7,394,251 B2 (LIN) 01 July 2008 (01.07.2008) figures 1, 6-7; column 7, line 59 through column 8, line 65	1-7, 21-23
A	US 2002/0067164 A1 (VENKATARAMANAN et al) 06 June 2002 (06.06.2002) figure 10; paragraphs 67-70; claim 1	1-7, 21-23

☐ Further documents are listed in the continuation of Box C.

* 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 application or patent 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

18 July 2012

Date of mailing of the international search report

02 AUG 2012

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents

P.O. Box 1450, Alexandria, Virginia 22313-1450

Facsimile No. 571-273-3201

Authorized officer:

Blaine R. Copenheaver

PCT Helpdesk: 571-272-4300

PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2012/022822

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See extra sheet.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-7, 21-23

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2012/022822

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I, claims 1-7, 21-23, drawn to a nuclear magnetic resonance processing system for analyzing physical properties of a material, and a method of extracting information about a system of nuclear spins, comprising: compressing the nuclear magnetic resonance data using a Lanczos bidiagonalization algorithm.

Group II, claims 8-20, 24-25, drawn to a nuclear magnetic resonance processing system, and a method of extracting information about a system of nuclear spins, comprising: operating memory with a finite size, and compressing the kernel of the nuclear magnetic resonance data using a compression algorithm that does not require any more memory than the available operating memory.

The inventions listed as Groups I-II do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: the special technical feature of the Group I invention: compressing the nuclear magnetic resonance data using a Lanczos bidiagonalization algorithm as claimed therein is not present in the invention of Group II. The special technical feature of the Group II invention: operating memory with a finite size, and compressing the kernel of the nuclear magnetic resonance data using a compression algorithm that does not require any more memory than the available operating memory as claimed therein is not present in the invention of Groups I.

Groups I and II lack unity of invention because even though the inventions of these groups require the technical feature of a nuclear magnetic resonance processing system having a nuclear magnetic resonance interface, performing/receiving measurements on the system of nuclear spins, a processing unit coupled with the interface and configured to determine the kernel of the magnetic resonance data using a kernel function; compress the kernel of the data using a compression algorithm, and analyzing the data to extract information about the system of nuclear spins, this technical feature is not a special technical feature as it does not make a contribution over the prior art in view of US 7,394,251 B2 (LIN) 01 July 2008 (01.07.2008) figures 1, 6-7; column 7, line 59 through column 8, line 65 and US 2002/0067164 A1 (VENKATARAMANAN et al) 06 June 2002 (06.06.2002) figure 10; paragraphs 67-70; claim 1.

Since none of the special technical features of the Group I or II inventions are found in more than one of the inventions, unity of invention is lacking.