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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
19 February 2004 (19.02.2004)

PCT

(10) International Publication Number
WO 2004/015242 A1

(51) International Patent Classification[7]: E21B 47/12, 17/02

(21) International Application Number: PCT/GB2003/003359

(22) International Filing Date: 30 July 2003 (30.07.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0218345.7 8 August 2002 (08.08.2002) GB

(71) Applicant *(for all designated States except US)*: **GEOLINK (UK) LIMITED** [GB/GB]; Walton Road, Dyce, Aberdeen AB21 0GZ (GB).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **HARRISON, James** [GB/GB]; 6 Markus Crescent, Kinellar, Aberdeen (GB).

(74) Agents: **ORR, William, McLean** et al.; Urquhart-Dykes & Lord, Tower House, Merrion Way, Leeds LS2 8PA (GB).

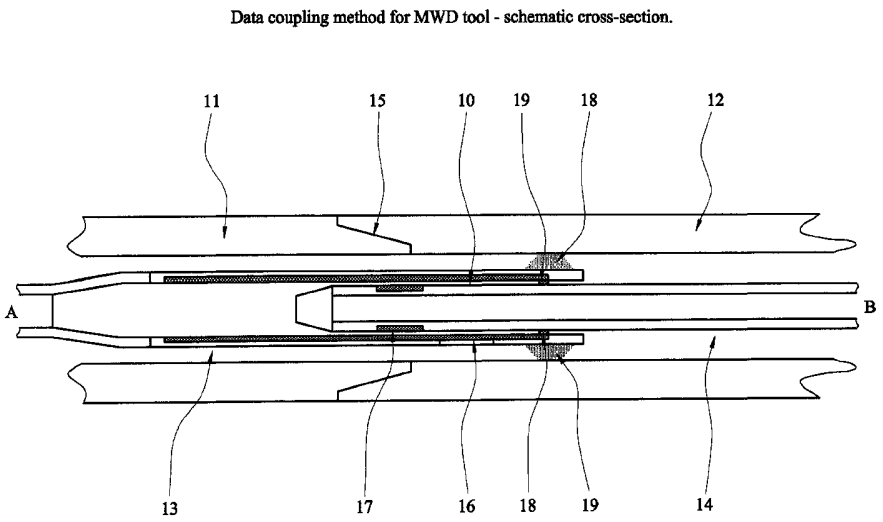
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH,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

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

Published:
— *with international search report*

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.

(54) **Title:** INDUCTIVE DATA COUPLER FOR USE WITH DOWNHOLE TOOL



(57) **Abstract:** An inductive data coupler (10) for use with an MWD downhole tool which extends internally and lengthwise of outer drilling tubulars, said coupler (10) being intended to join together an upstream tool portion (A) to a downstream tool portion (B) and in the region of a connection (15) between two outer drilling tubular portions (11, 12), in which the coupler comprises: a first tubular member (13) for connection to the upstream tool portion (A) and a second tubular member (14) for connection to the downstream tool portion (B), said tubular members being movable lengthwise and rotationally one within the other; and, a first coil (16) provided on one of the tubular members (13, 14), said coils (16, 17) axially overlapping each other in order to transmit data inductively from one coil to the other coil whereby to transmit drilling data to surface.

WO 2004/015242 A1

INDUCTIVE DATA COUPLER FOR USE WITH DOWNHOLE TOOL

This invention relates to an inductive data coupler for use with a downhole tool of the MWD type.

The technology of MWD tools (measurement while drilling) is well known to those of ordinary skill in the art, and need not be described in detail herein.

In MWD there is frequently a requirement to interconnect sections of the downhole tool across joints in the drilling tubulars. The tool sections are mounted axially in the tubulars, and the tubulars are interconnected by threaded connections. The requirement is to mount, say, two tool sections independently in their tubulars and then, after assembly, to be able to transmit data from one to the other.

If the connection between the tool sections is physical, the two connectors must be able to rotate relative to each other and the lengths of the tubulars must be carefully controlled. This creates a problem, since the threads on the tubulars have to be recut from time to time, changing the overall length of the piece. Furthermore the relevant tubulars are usually very expensive, being made of stainless steel and also often requiring special machining for the mounting of the MWD tool, so replacing them when they are out of length specification is costly. There are also logistic problems maintaining "matched sets" of equipment at locations remote from workshop facilities.

It is known to use a "stabber" connection (essentially a robust jack plug) with a telescopic spring-loaded section in one of the connectors to take up length mismatch between the inner and outer parts. It has the advantage that power, as well as data, may be transferred.

It is also known to provide a short range wireless communication between the two parts, either electromagnetic or acoustic. Both methods have disadvantages caused by the environment.

It is also known to provide inductive coupling between the two parts, where the two parts of the inductive coupler lie coaxially in a defined position. Such a method is used to recover data from MWD tools using a wireline. At the end of the wireline is a "cup" that fits over a cylindrical nose piece on the MWD tool.

According to the invention there is provided an inductive data coupler for use with an MWD downhole tool which extends internally and lengthwise of outer drilling tubulars,

said coupler being intended to join together an upstream tool portion to a downstream tool portion and in the region of a connection between two outer drilling tubular portions, in which the coupler comprises:

a first tubular member for connection to the upstream tool portion and a second tubular member for connection to the downstream tool portion, said tubular members being movable lengthwise one within the other; and,

a first coil provided on one of the tubular members and a second coil provided on the other of the tubular members, said coils axially overlapping each other in order to transmit data inductively from one coil to the other whereby to transmit drilling data to surface.

By providing axially overlapping coils to transmit data inductively, lengthwise adjustment of the first and second tubular members will still enable an inductive coupling between the two coils, and in which the transfer function between the coils in each direction is independent, or substantially independent of the position or angular alignment of one coil relative to the other coil.

Data may be transferred in either direction by energising one coil and using the other as a receiver.

Preferably, one coil is axially shorter than the other coil and the shorter coil is arranged within the longer coil.

Alternatively the coils may be of equal length, spanning the engagement portion of the tubulars; it may be desirable to make the coils and associated electronics as similar as possible, for example for ease of production.

To guide lengthwise adjustment movement of the first and second tubular members, when required, centralisers or bearings may be located between the inner surface of the outer member and the outer surface of the inner member.

Centralisers are preferably provided between the outer tubular member and the inner surface of the tubular item, for example a section of drill pipe or drill collar, in which the assembly is installed.

The data may be transmitted in the form of pulses, or may be contained on a modulated carrier.

The coils are preferably solenoid coils wound on magnetic cores suitably protected against the drilling environment in respect of pressure, temperature, shock and vibration.

A preferred embodiment of an inductive data coupler according to the invention will now be described in detail, by way of example only, with reference to the accompanying schematic cross sectional drawing.

The inductive data coupler is designated generally by reference 10 and is intended for use with an MWD downhole tool which extends internally and lengthwise of outer drilling tubulars 11 and 12. The coupler 10 is intended to join together an upstream tool portion A to a downstream tool portion B of an MWD tool, and in the region of a connection 15 between the two outer drilling tubular portions 11, 12. In the illustrated arrangement, the two outer drilling tubular portions 11, 12 are screwed together.

First and second tubular members 13 and 14 of the coupler 10 are connected to the tool portions A and B respectively, and are movable lengthwise one within the other.

A first coil 16 is provided on one of the tubular members, and a second coil 17 is provided on the other of the tubular members, the coils 16, 17 overlapping axially in order to transmit data inductively from one coil to the other whereby to transmit drilling data to surface. It is to be understood that the coils 16 and 17 are fitted on the inner surface of the outer MWD tubular member 13 and the outer surface of the inner MWD tubular member 14 respectively and will be suitably protected from the environment by encapsulation or other well-known method.

In the illustrated embodiment, the first coil 16 is a long coil, and the second coil 17 is an axially shorter coil.

Alternatively, both of the coils 16, 17 may be of similar length, both spanning the major portion of the engagement length of the tubular members 13, 14, and axially overlapping each other.

In the illustrated embodiment, the long coil is the outermost coil, and the short coil is located internally of the long outer coil. By such an arrangement, lengthwise adjustment of the first and second tubular members is permitted, while still enabling an inductive coupling between the two coils, and in which the transfer function between the coils in each direction is independent, or substantially so, of the position of the short coil within the long coil.

To guide lengthwise adjustment movement of the first and second tubular members, when required, centralisers or bearings 18 may be located between the inner surface of the outer tubular member and the outer surface of the inner tubular member. If

such elements are fitted their radial dimension must be minimised in order to maintain the coil separation as small as is practical.

To stabilise the whole assembly within the tubulars 11, 12, several centraliser fins 19 are positioned on the outer coil assembly 16 (externally on either one of the tubular members 13, 14).

The data which may be transmitted may be in the form of pulses, or may be contained on a modulated carrier.

The coils 16, 17, in the illustrated embodiment, are solenoid coils wound on magnetic cores.

By the arrangement illustrated, it is practical to provide length adjustment at least up to one metre, while still providing satisfactory data transmission between the coils.

Because of the unlimited rotational freedom between the tubular members 13, 14 it is possible to engage and make up concentric threaded joints in the assembly in which the equipment is installed for example in a drill string.

The inductive coupler assembly 10 is located internally of the outer drilling tubulars, and is therefore designed so as to be capable of running "wet" i.e. exposed to drilling fluid.

The illustrated embodiment therefore provides inductive coupling, along with the ability of the assembly to adapt to the length requirements of the particular assembly. The particular advantage is that the signal transmission characteristics across the gap between the coils are unaffected by the distance between the ends of the MWD tools, in contrast to existing short-range communication systems.

CLAIMS

1. An inductive data coupler (10) for use with an MWD downhole tool which extends internally and lengthwise of outer drilling tubulars, said coupler (10) being intended to join together an upstream tool portion (A) to a downstream tool portion (B) and in the region of a connection (15) between two outer drilling tubular portions (11, 12), in which the coupler comprises:

a first tubular member (13) for connection to the upstream tool portion (A) and a second tubular member (14) for connection to the downstream tool portion (B), said tubular members being movable lengthwise and rotationally one within the other; and

a first coil (16) provided on one of the tubular members (13, 14) and a second coil (17) provided on the other of the tubular members (13, 14), said coils (16, 17) axially overlapping each other in order to transmit data inductively from one coil to the other coil whereby to transmit drilling data to surface.

2. An inductive data coupler according to claim 1, in which the first coil (16) is a long coil and the second coil (17) is an axially shorter coil.

3. An inductive data coupler according to claim 2, in which the short coil (17) is arranged within the long coil (16).

4. An inductive data coupler according to any one of claims 1 to 3, in which lengthwise adjustment movement of the first and second tubular members (13, 14) is provided by internal centralisers or bearings (18) engaging between the inner surface of the outer member and the outer surface of the inner member.

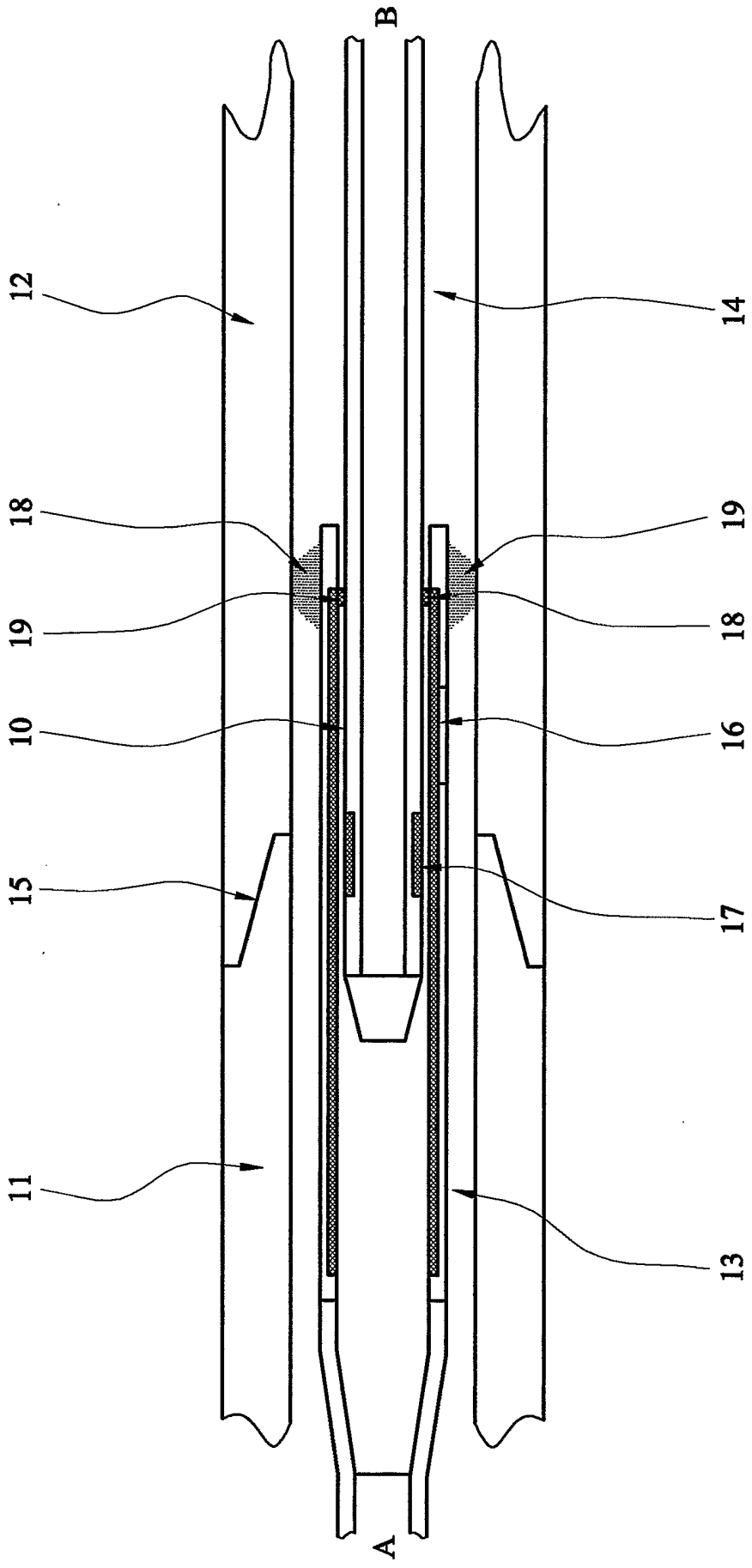
5. An inductive data coupler according to any one of the preceding claims, in which the data transmissible is in the form of pulses, or contained on a modulated carrier.

6. An inductive data coupler according to any one of the preceding claims, in which the coils (16, 17) are solenoid coils wound on magnetic cores.

7. An inductive data coupler according to any one of the preceding claims, in which the coils both span the full engagement length of the tubular elements (13, 14).

8. An inductive data coupler according to any one of the preceding claims, in which one of the tubular members (13, 14) carries an external centraliser (19) for locating the inductive coupler (10) internally of the outer drilling tubular portions (11, 12).

Data coupling method for MWD tool - schematic cross-section.



INTERNATIONAL SEARCH REPORT

PCT/GB 03/03359

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 E21B47/12 E21B17/02

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 E21B

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6 392 317 B1 (FOX JOE ET AL) 21 May 2002 (2002-05-21) column 2, line 8 - line 29	1
A	US 5 240 082 A (HAYABUCHI KEITARO ET AL) 31 August 1993 (1993-08-31) column 2, line 26 - line 38	1
A	US 6 286 595 B1 (OXNEVAD DAVID GARDNER ET AL) 11 September 2001 (2001-09-11) column 2, line 60 -column 3, line 33	1
P,X	WO 03 042499 A (ABB RESEARCH LTD ;ERIKSSON KLAS (NO); HAAHEIM SVEIN (NO); HANSSON) 22 May 2003 (2003-05-22) the whole document	1-3,5,6

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

☒ 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
30 October 2003	13/11/2003

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	Ott, S

INTERNATIONAL SEARCH REPORT

PCT/GB 03/03359

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6392317 B1	21-05-2002	NONE	
US 5240082 A	31-08-1993	JP 2669209 B2	27-10-1997
		JP 5033576 A	09-02-1993
US 6286595 B1	11-09-2001	NO 971320 A	21-09-1998
		AU 6125398 A	12-10-1998
		GB 2338974 A ,B	12-01-2000
		WO 9841731 A1	24-09-1998
WO 03042499 A	22-05-2003	NO 20015521 A	13-05-2003
		WO 03042499 A1	22-05-2003