(19) Octrooicentrum Nederland

(11) **2032006**

(12) B1 **OCTROOI**

(21) Aanvraagnummer: **2032006**

(22) Aanvraag ingediend: **27 mei 2022**

(62)

(51) Int. Cl.:
E21B 3/02 (2022.01)

(30) Voorrang:
-

(41) Aanvraag ingeschreven:
11 december 2023

(43) Aanvraag gepubliceerd:
-

(47) Octrooi verleend:
11 december 2023

(45) Octrooischrift uitgegeven:
14 december 2023

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(54) **A DRILL STRING DRIVE TO IMPART ROTATIONAL POWER TO A TOP END OF DRILL STRING FOR DRILLING OF A WELLBORE**

(57) A drill string drive, e.g. a top drive, configured to impart rotational power to an upper end of drill string for drilling of a wellbore. The drive comprises one or more main drive motors and a torsional vibrations reducing auxiliary hydraulic drive motor. A transmission couples the drive motors to a rotary torque output member of the drill string drive that is configured to be coupled to the drill string. The auxiliary hydraulic drive motor is a swash plate hydraulic motor. A controller assembly for the swash plate angle is configured to receive data related to the occurrence of torsional vibrations in the drill string and to control the swash plate hydraulic motor so as to counter the torsional vibrations.

NL B1 2032006

P35755NL00

A DRILL STRING DRIVE TO IMPART ROTATIONAL POWER TO A TOP END OF DRILL STRING FOR DRILLING OF A WELLBORE.

The present invention relates to the drilling of a wellbore, e.g. for drill hydrocarbon wells, geothermal wells, etc. For example, wellbore depth can exceed 500 metres, e.g. multiple kilometres.

When drilling a wellbore, in particular of significant depth so involving the use of a lengthy drill string that makes the drill bit at the lower end of the drill string rotate, a well-known cause of loss of drilling efficiency and downtime due to equipment failure, e.g. drill bit failure, is the occurrence of torsional vibrations in the drill string, e.g. induced by stick-slip while rotary drilling.

In the field, top drive devices are known that have one or more electric top drive motors, often electric motors with a variable frequency drive controller, e.g. digitally controlled. In order to reduce these undesirable torsional vibrations it is known to employ a so-called soft torque control system. Herein basically dedicated software is run on a computerized controller of the one or more electric top drive motors allowing to vary the speed of the one or more electric motors. For example, the relation between torque load on the top drive and the speed of the motors is actively controlled.

For example, reference is made to US9624762. Here the occurrence of torsional vibrations in the drill string induced by stick-slip is discussed, as well as various strategies to counter this undesirable phenomenon.

In US10927657 a top drive is disclosed wherein multiple electric drive motors are connected via a transmission to a rotary torque output member of the top drive that is coupled to the top end of the drill string. Each of the top drive motors has an operable clutch device configured to selectively connect and disconnect upon command the rotor relative to the transmission of the top drive. Use is made of a computerized electronic controller comprising a processor, and a program is executed by the processor so as to control the multiple electric top drive motors of the top drive device and to selectively control the clutch devices individually so as to selectively connect and disconnect the rotor of each top drive motor relative to the transmission by operating the respective clutch device and thereby varying and controlling

said total inertial moment as a control parameter in order to reduce occurrence of drill string torsional vibration.

The present invention aims to provide an approach to counter torsional vibrations in the drill string that is highly effective and can be implemented in a compact and structurally attractive manner in a drill string drive.

According to the invention a drill string drive is provided that is configured to impart rotational power to an upper end of drill string for drilling of a wellbore, which drill string drive comprises:

- one or more main drive motors, preferably one or more hydraulic main drive motors,

- a torsional vibrations reducing auxiliary hydraulic drive motor,

- a transmission coupling the drive motors to a rotary torque output member of the drill string drive that is configured to be coupled to the drill string,

wherein the auxiliary hydraulic drive motor is a swash plate hydraulic motor having a variable swash plate angle,

wherein the drill string drive comprises a controller assembly for the swash plate angle of the torsional vibrations reducing auxiliary hydraulic drive motor, which controller is configured to receive data related to the occurrence of torsional vibrations in the drill string and to control the swash plate hydraulic motor so as to counter the torsional vibrations.

The invention is based on the insight that a swash plate hydraulic motor can effectively be controlled at an attractive frequency in view of the occurring torsional vibrations in a drill string. Also the inertia of such a hydraulic motor is relatively small, e.g. compared to an electric motor of the same maximum power, so that the inertia of the motor itself does not further exacerbate the problem. The swash plate hydraulic motor itself is relatively compact and light as well compared to an electric motor, e.g. beneficial for integrating the motor in a top drive.

It is noted that in the field of hydraulic drives, swash plate motors are often used in a secondary control circuit.

Speed and torque of the swash plate hydraulic motor can be controlled highly dynamic and with high accuracy.

In practical embodiments, the torsional vibrations reducing auxiliary hydraulic drive motor and related hydraulic circuit may be embodied and controlled so that it provides at some point extra drive power in addition to the main drive motor(s) and at another point in time it acts as a power sink counter to the main drive motor(s). For example, the circuit may comprise an accumulator.

In an advantageous embodiment, each main drive motor is embodied as a hydraulic motor. These main drive hydraulic motor(s) have the advantage of a relatively low inertia compared to an electric main drive motor, which is beneficial in view of countering the torsional vibrations of the drill string. These one of more main drive hydraulic motor(s) are also more compact that electric main drive motor(s) of the same maximum power output. The latter may be of relevance when the motors are integrated in a top drive. For example, each main drive motor is embodied as a swash plate type hydraulic motor, wherein the variable swash plate angle of the main drive motor is primarily controlled to adjust the torque.

In embodiments, the drill string drive has a single main drive motor, preferably a hydraulic main drive motor, and a single torsional vibrations reducing auxiliary hydraulic drive motor.

In an embodiment, the controller assembly is configured to control the swash plate angle of the torsional vibrations reducing auxiliary hydraulic drive motor at a frequency of at least 1 Hz, e.g. at most 14 Hz. These fairly low frequencies can be implemented in the control of such hydraulic motors and are effective for reducing torsional drill string vibrations.

In an embodiment, the controller assembly is configured to control the swash plate angle of the torsional vibrations reducing auxiliary hydraulic drive motor at a frequency of between 2 and 5 Hz, which is considered practical for effectively countering torsional vibrations in a drill string during drilling of a wellbore.

In an embodiment, the one or more main drive motors are configured to provide at least 65% of a maximum power output of the drill string drive, e.g. between 75% and 85%, the remainder being provided by the auxiliary hydraulic drive motor. Preferable, there is a single main drive motor and a single auxiliary hydraulic drive motor.

In embodiments, the drive is configured and operated such that the one or more main drive motors deliver most of the torque required to drive the drill string and such that the speed of the drill string drive, and thus of the drill string, is primarily governed by the torsional vibrations reducing auxiliary hydraulic drive motor.

The transmission couples all drive motors, so that main drive motor(s) and the torsional vibrations reducing auxiliary hydraulic drive motor, to the rotary torque output member of the drill string drive that is configured to be coupled to the drill string.

In an embodiment, the drill string drive device is a top drive. In another embodiment, the drill string drive is a rotary table.

In an embodiment, the drill string drive device is a top drive, wherein the drive motors are configured to be fed via one or more hydraulic hoses from a main pump device that is located remote from the top drive.

In embodiments, as known in the art, the swash plate angle controller comprises a control cylinder controlled by a servo valve.

In an embodiment, the circuit comprises an accumulator associated with the torsional vibrations reducing auxiliary hydraulic drive motor.

In an embodiment, the torsional vibrations reducing auxiliary hydraulic drive motor is arranged in a constant pressure hydraulic circuit, possible the one or more main hydraulic drive motors being arranged in the same constant pressure hydraulic circuit.

In an embodiment, the torsional vibrations reducing auxiliary hydraulic drive motor is arranged in an associated secondary-control circuit, e.g. embodied as a closed loop circuit.

In an embodiment, the secondary-control circuit comprises a boost pump and boost pressure valve.

The invention also relates to a drilling system for drilling a wellbore, wherein the system comprises drill string drive as discussed herein and a monitoring system configured to provide data related to the occurrence of torsional vibrations in the drill string, wherein the monitoring system provides said data to the controller assembly for the swash plate angle for control of the swash plate hydraulic motor so as to counter the torsional vibrations.

The invention also relates to a method for drilling a wellbore, wherein use is made of a drill string drive as discussed herein.

In an embodiment, the controller assembly controls the swash plate angle of the torsional vibrations reducing auxiliary hydraulic drive motor at a frequency of at least 1 Hz, e.g. at most 14 Hz.

In an embodiment, the controller assembly controls the swash plate angle of the torsional vibrations reducing auxiliary hydraulic drive motor at a frequency of between 2 and 5 Hz.

In an embodiment, the one or more main drive motors provide at least 65% of a maximum power output of the drill string drive, e.g. between 75% and 85%, the remainder being provided by the torsional vibrations reducing auxiliary hydraulic drive motor.

The invention will now be discussed with reference to the drawings. In the drawings:
- fig. 1 shows a mobile land rig for drilling of wellbores,
- fig. 2 shows the top drive of the land rig of figure 1,
- fig. 3 illustrates schematically the top drive of figure 2.

Figure 1 shows the mobile land 1 with a drilling tower 3 thereof in a working position and with a loader 17 thereof for drill string joints in a hand-off position thereof.

The mobile land rig 1 comprises a road vehicle, a trailer 4 in this figure, having a chassis 4 with a front end 5 and a rear end 6. The chassis 4 of the road vehicle is an elongated chassis 4.

Stabilizers 7 are provided near the rear end 6 of the chassis to support the chassis 4 when the drilling tower 3 is in the working position, as depicted. In embodiments, the stabilizers 7 are slidable connected to the chassis 4 to allow movement of the mobile land rig 1 relative to the wellbore, e.g. to slightly adjust the position of the mobile land rig 1 relative to the wellbore.

The drilling tower 3 is provided at the rear end 6 of the chassis 4 and is pivotally, e.g. by a hydraulic cylinder, relative to the road vehicle 2 between a substantial horizontal transport position and the vertical working position.

The mobile land rig 1 comprises a top drive system 8 comprising a traveling carriage 15 which is vertically mobile along the drilling tower 3 when in the working position by means of a motion drive. In this figure the motion drive 9 is a rack and pinion drive 9 with hydraulic pinion drive motors which allows precise movement of the top drive system 8 along the drilling tower 3.

The carriage 15 supports a top drive 40 as will be discussed in more detail below, having a main drive motor and a rotary torque output member adapted to be engaged with a top end of a drilling tubular 13.

The motion drive 9 is adapted to cause motion of the top drive system 8 parallel to the longitudinal axis of the drilling tower 1 in order to perform drilling and tripping operations.

The top drive 40 is pivotally supported by the traveling carriage 15 around a top drive pivot axis which extends parallel to the longitudinal axis of the drilling tower 3. The top drive 40 may be pivoted between a transfer position and a drilling position, when the drilling tower 3 is in the working position. The top drive system 8 is provided with an actuator assembly adapted to cause said pivot motion of the top drive 40. In this figure the top drive 40 is pivoted away from a drilling line 14 through a wellbore and is suspended in a transfer position above a drill string joint receiving line 20.

The mobile land rig 1 further comprises a drill floor 10 supported by the drilling tower 3 with a well center 11 positionable above a wellbore.

A slip device 12 adapted to suspend a drill string 20 in the wellbore is supported by the drill floor 10 and centered around the well center 11.

In embodiments, as shown, the drill floor 10 is supported by a motion drive allowing vertical motion of the drill floor 10. This allows repositioning of the drill floor 10 relative to the drilling tower 10 and the wellbore.

The drill floor 10 further comprises a slidable storage carrier 29 and mouse holes.

The drilling line 14 extends through the well center 11 parallel to the longitudinal axis of the drilling tower 3. In operations a drill string 20 extends along the drilling line 14, e.g. from the slip device 12 into the wellbore.

Figures 2 and 3 serve to illustrate the present invention, by way of an example.

The top drive 40 forms the drill string drive that is configured to impart rotational power to an upper end of drill string 20 for drilling of a wellbore.

The depicted top drive 40 (represented by a simple box in figure 3) has a single main drive motor 41, that is embodied as a hydraulic main drive motor.

The depicted top drive 40 has a single torsional vibrations reducing auxiliary hydraulic drive motor 50.

A transmission, e.g. a gear reducer transmission 60, couples the drive motors 41, 50 to a rotary torque output member 45 that is configured to be coupled to the drill string. In practical embodiments, the transmission has a fixed gear reduction ratio.

The auxiliary hydraulic drive motor 50 is a swash plate hydraulic motor.

As shown schematically in figure 3, this motor 50 is integrated in a hydraulic circuit that here is embodied (by way of example only) as a constant pressure, secondary-control hydraulic circuit that further comprises a pump 55 that is driven by an electric motor 56.

Figure 3 further schematically shows a controller assembly 70 for the swash plate angle of the motor 50.

The assembly 70 is configured to receive data related to the occurrence of torsional vibrations in the drill string and to control the swash plate hydraulic motor 50 so as to counter the torsional vibrations. The data is generated by a monitoring system 65 that is configured to provide data related to the occurrence of torsional vibrations in the drill string 20. The monitoring system 65 provides said data to the controller assembly 70.

By way of example, as known in the art, the swash plate angle controller assembly 70 comprises a control cylinder 71 that is controlled by a servo valve 72. The servo valve 72 is controlled by a further part of the controller assembly 70 on the basis of data related to the occurrence of torsional vibrations.

By way of example, the secondary-control circuit is a closed loop circuit.

By way of example, the secondary-control circuit comprises an accumulator 57.

By way of example, the secondary-control circuit comprises a boost pump 58 and boost pressure valve 59.

As discussed, the controller assembly 70 is configured to control the swash plate angle of the torsional vibrations reducing auxiliary hydraulic drive motor 50 at a frequency of at least 1 Hz, e.g. at most 14 Hz.

As discussed, the controller assembly 70 is, preferably, configured to control the swash plate angle of the torsional vibrations reducing auxiliary hydraulic drive motor 50 at a frequency of between 2 and 5 Hz.

The single main drive motor 41 is configured to provide at least 65% of a maximum power output of the drill string drive, e.g. between 75% and 85%, the remainder being provided by the single auxiliary hydraulic drive motor 50.

It is shown in figure 3, by way of example, that the main drive motor 41 is configured to be fed via one or more hydraulic hoses 42 from a main pump 43 that is located remote from the top drive 40, e.g. on the chassis of the land rig. For example, the main pump is driven by an electric motor.

It is shown in figure 3 that the swash plate hydraulic motor 50 in the secondary-control hydraulic circuit including the pump 55 driven by the electric motor 56 are mounted on the top drive 40. This allows for a small secondary-control circuit, which enhances its responsiveness and accuracy.

In other embodiments the hydraulic circuit may differ. For example, the swash plate hydraulic motor 50 could also be fed via the hoses 42 from the main pump, e.g. a single pair of hoses 42 being provided for all hydraulic motors of the top drive. For example, this arrangement provides for a constant pressure circuit for all hydraulic motors of the top drive.

C O N C L U S I E S

1. Boorstrengaandrijving, bijvoorbeeld een topaandrijving, ingericht om rotatievermogen aan te brengen aan een bovenste einde van een boorstreng voor het boren van een boorgat, welke boorstrengaandrijving omvat:

- een of meer hoofdaandrijfmotoren, bij voorkeur een of meer hydraulische hoofdaandrijfmotoren,

- een hydraulische torsietrillingen reducerende hulpaandrijfmotor,

- een transmissie die de aandrijfmotoren koppelt met een uitgangsorgaan voor draaitorsie van de boorstrengaandrijving, welk orgaan is ingericht om te worden gekoppeld met de boorstreng,

waarbij de hydraulische torsietrillingen reducerende hulpaandrijfmotor een hydraulische tuimelschijfmotor is met een tuimelschijf die een variabele tuimelschijfhoek heeft,

waarbij de boorstrengaandrijving een regelsamenstel voor de tuimelschijfhoek van de hydraulische torsietrillingen reducerende hulpaandrijfmotor omvat, welk regelsamenstel is ingericht om data die verband houdt met het optreden van torsietrillingen in de boorstreng te ontvangen en om de hydraulische tuimelschijfmotor te regelen om torsietrillingen tegen te gaan.

2. Boorstrengaandrijving volgens conclusie 1, waarbij het regelsamenstel is ingericht voor het regelen van de tuimelschijfhoek van de hydraulische torsietrillingen reducerende hulpaandrijfmotor met een frequentie van tenminste 1 Hz, bijvoorbeeld ten hoogste 14 Hz.

3. Boorstrengaandrijving volgens conclusie 1 or 2, waarbij het regelsamenstel is ingericht voor het regelen van de tuimelschijfhoek van de hydraulische torsietrillingen reducerende aandrijfmotor met een frequentie van tussen 2 en 5 Hz.

4. Boorstrengaandrijving volgens een of meer of conclusies 1 - 3, waarbij de een of meer hoofdaandrijfmotoren hydraulische motoren zijn.

5. Boorstrengaandrijving volgens een of meer of conclusies 1 - 4, waarbij de een of meer hoofdaandrijfmotoren zijn ingericht om tenminste 65% van een maximaal leverbaar

vermogen van de boorstrengaandrijving te verschaffen, bijvoorbeeld tussen 75% en 85%, waarbij de rest wordt verschaft door de hydraulische torsietrillingen reducerende hulpaandrijfmotor.

6. Boorstrengaandrijving volgens een of meer of conclusies 1 - 5, waarbij de boorstrengaandrijfinrichting een topaandrijving is.

7. Boorstrengaandrijving volgens conclusie 6, waarbij de een of meer hoofdaandrijfmotoren en de hydraulische tuimelschijfmotor zijn ingericht om te worden gevoed via een of meer hydraulisch slangen vanuit een hoofdpompinrichting die op een afstand verwijderd van de topaandrijving is opgesteld.

8. Boorsysteem voor het boren van een boorgat, waarbij het systeem een boorstrengaandrijving volgens een of meer of conclusies 1 – 7 omvat en een monitoring systeem dat is ingericht om data te verschaffen die verband houden met het optreden van torsietrillingen in de boorstreng, waarbij het monitoring systeem die data levert aan het regelsamenstel voor de tuimelschijfhoek voor het regelen van de hydraulische tuimelschijfmotor om zo torsietrillingen tegen te gaan.

9. Werkwijze voor het boren van een boorgat, waarbij gebruik wordt gemaakt van een boorstrengaandrijving volgens een of meer of de conclusies 1 – 7 of van een boorsysteem volgens conclusie 8.

10. Werkwijze volgens conclusie 9, waarbij het regelsamenstel de tuimelschijfhoek van de hydraulische torsietrillingen reducerende hulpaandrijfmotor regelt met een frequentie van tenminste 1 Hz, bijvoorbeeld ten hoogste 14 Hz.

11. Werkwijze volgens conclusie 10, waarbij het regelsamenstel de tuimelschijfhoek van de hydraulische torsietrillingen reducerende hulpaandrijfmotor regelt met een frequentie van tussen 2 en 5 Hz.

12. Werkwijze volgens een of meer of conclusies 9 – 11, waarbij de een of meer hoofdaandrijfmotoren tenminste 65% van een maximaal leverbaar vermogen van de boorstrengaandrijving verschaffen, bijvoorbeeld tussen 75% en 85%, waarbij de rest wordt verschaft door de hydraulische torsietrillingen reducerende hulpaandrijfmotor.

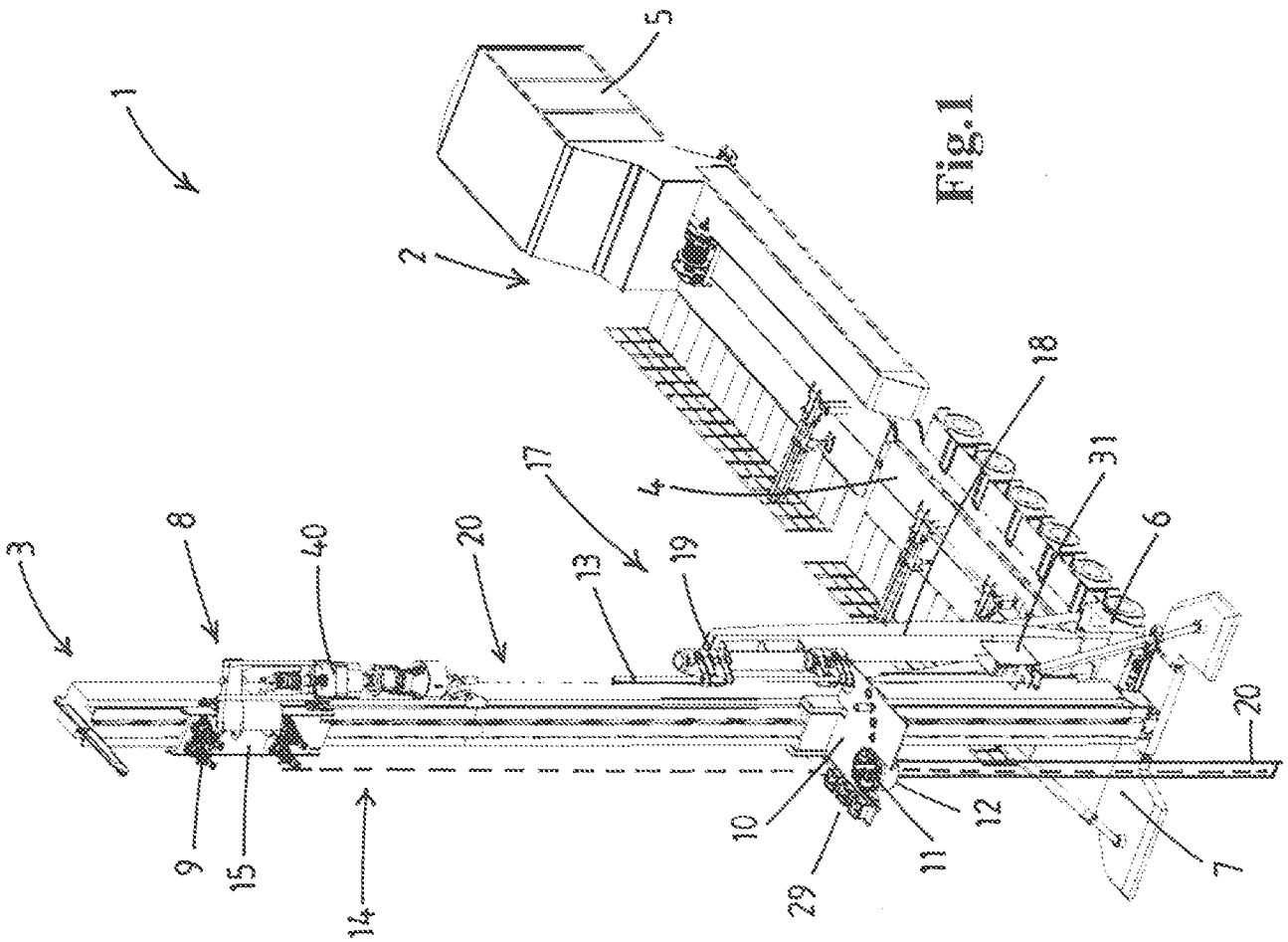

Fig.1

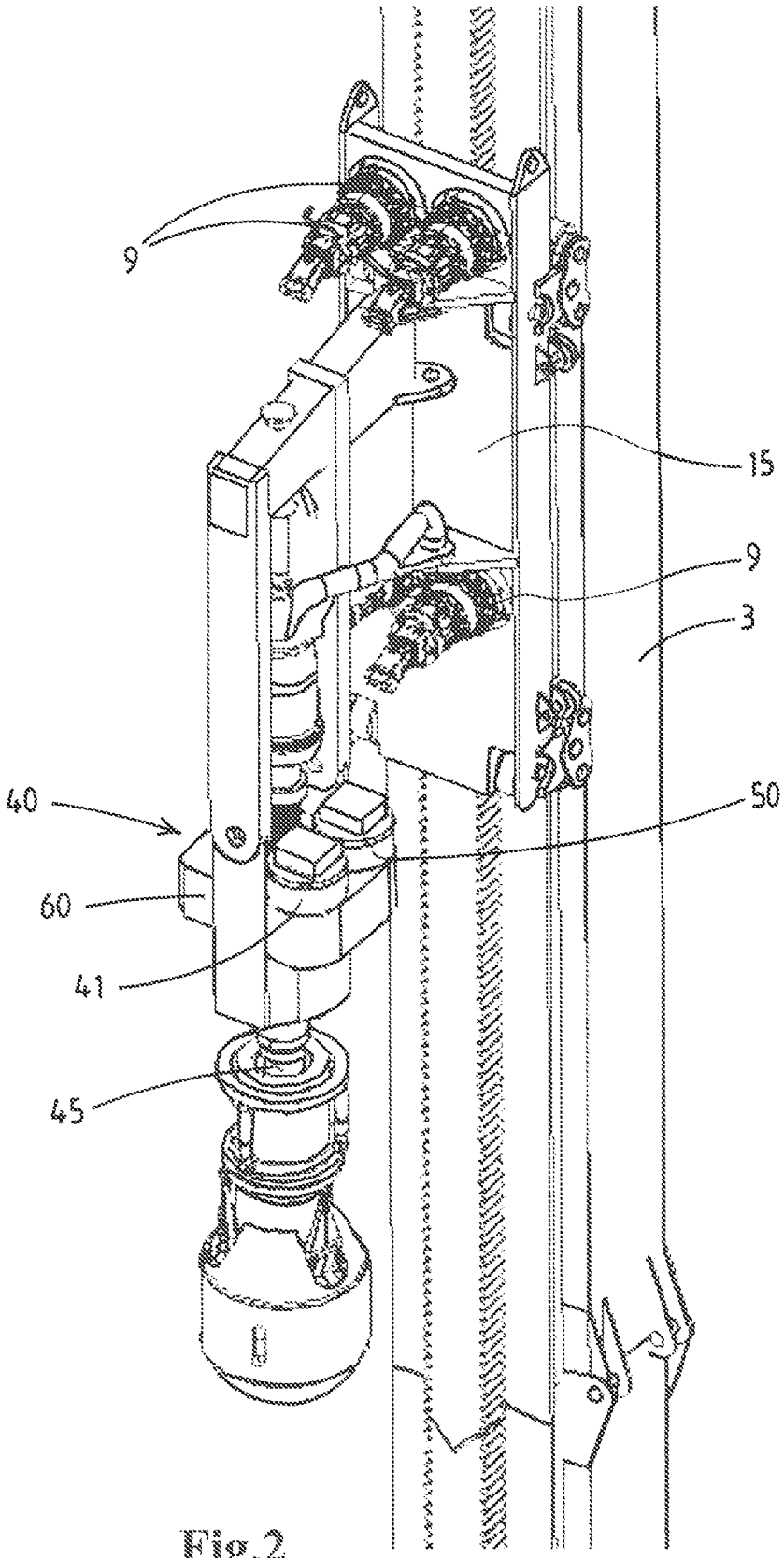

Fig.2

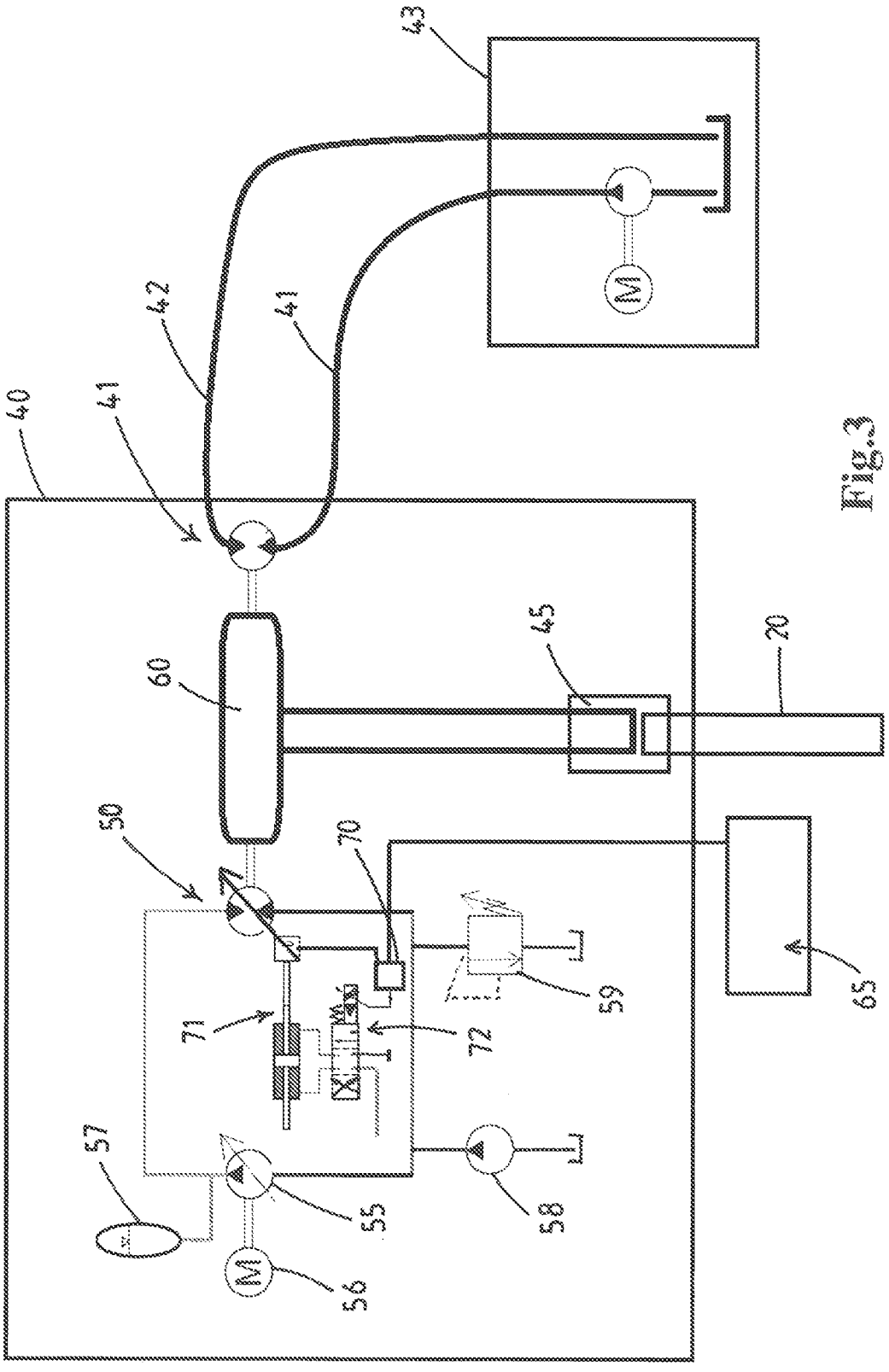

Fig.3

SAMENWERKINGSVERDRAG (PCT)

RAPPORT BETREFFENDE NIEUWHEIDSONDERZOEK VAN INTERNATIONAAL TYPE

IDENTIFICATIE VAN DE NATIONALE AANVRAGE	KENMERK VAN DE AANVRAGER OF VAN DE GEMACHTIGDE
Nederlands aanvraag nr. **2032006**	Indieningsdatum **27-05-2022**
	Ingeroepen voorrangsdatum
Aanvrager (Naam) **Itrec B.V.**	
Datum van het verzoek voor een onderzoek van internationaal type **10-09-2022**	Door de Instantie voor Internationaal Onderzoek aan het verzoek voor een onderzoek van internationaal type toegekend nr. **SN82112**

I. CLASSIFICATIE VAN HET ONDERWERP (bij toepassing van verschillende classificaties, alle classificatiesymbolen opgeven)

Volgens de internationale classificatie (IPC)

Zie onderzoeksrapport

II. ONDERZOCHTE GEBIEDEN VAN DE TECHNIEK

Onderzochte minimumdocumentatie

Classificatiesysteem	Classificatiesymbolen
IPC	**Zie onderzoeksrapport**

Onderzochte andere documentatie dan de minimum documentatie, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen

III.	☐	**GEEN ONDERZOEK MOGELIJK VOOR BEPAALDE CONCLUSIES**	(opmerkingen op aanvullingsblad)
IV.	☐	**GEBREK AAN EENHEID VAN UITVINDING**	(opmerkingen op aanvullingsblad)

ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Nummer van het verzoek om een onderzoek naar de stand van de techniek
NL 2032006

A. CLASSIFICATIE VAN HET ONDERWERP
INV. E21B3/02
ADD.

Volgens de Internationale Classificatie van octrooien (IPC) of zowel volgens de nationale classificatie als volgens de IPC.

B. ONDERZOCHTE GEBIEDEN VAN DE TECHNIEK

Onderzochte miminum documentatie (classificatie gevolgd door classificatiesymbolen)
E21B

Onderzochte andere documentatie dan de mimimum documentatie, voor dergelijke documenten, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen

Tijdens het onderzoek geraadpleegde elektronische gegevensbestanden (naam van de gegevensbestanden en, waar uitvoerbaar, gebruikte trefwoorden)
EPO-Internal, WPI Data

C. VAN BELANG GEACHTE DOCUMENTEN

Categorie °	Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages	Van belang voor conclusie nr.
A	US 2019/284924 A1 (ZHAO YIMING [US] ET AL) 19 september 2019 (2019-09-19) * alineas [0014] - [0015], [0019] - [0020], [0027] * * conclusies 1,11 * * figuren 1,3 * -----	1-12
A	CA 2 266 248 A1 (TESCO CORP [CA]) 22 september 2000 (2000-09-22) * samenvatting * * bladzijde 6, regels 25-28 * * bladzijde 7, regel 3 - bladzijde 8, regel 26 * * figuren 2,3 * -----	1-12

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[X] Verdere documenten worden vermeld in het vervolg van vak C.

[X] Leden van dezelfde octrooifamilie zijn vermeld in een bijlage

° Speciale categorieën van aangehaalde documenten

"A" niet tot de categorie X of Y behorende literatuur die de stand van de techniek beschrijft

"D" in de octrooiaanvrage vermeld

"E" eerdere octrooi(aanvrage), gepubliceerd op of na de indieningsdatum, waarin dezelfde uitvinding wordt beschreven

"L" om andere redenen vermelde literatuur

"O" niet-schriftelijke stand van de techniek

"P" tussen de voorrangsdatum en de indieningsdatum gepubliceerde literatuur

"T" na de indieningsdatum of de voorrangsdatum gepubliceerde literatuur die niet bezwarend is voor de octrooiaanvrage, maar wordt vermeld ter verheldering van de theorie of het principe dat ten grondslag ligt aan de uitvinding

"X" de conclusie wordt als niet nieuw of niet inventief beschouwd ten opzichte van deze literatuur

"Y" de conclusie wordt als niet inventief beschouwd ten opzichte van de combinatie van deze literatuur met andere geciteerde literatuur van dezelfde categorie, waarbij de combinatie voor de vakman voor de hand liggend wordt geacht

"&" lid van dezelfde octrooifamilie of overeenkomstige octrooipublicatie

Datum waarop het onderzoek naar de stand van de techniek van internationaal type werd voltooid	Verzenddatum van het rapport van het onderzoek naar de stand van de techniek van internationaal type
4 januari 2023	

Naam en adres van de instantie	De bevoegde ambtenaar
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	**Schouten, Adri**

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ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Nummer van het verzoek om een onderzoek naar de stand van de techniek
NL 2032006

C.(Vervolg). VAN BELANG GEACHTE DOCUMENTEN

Categorie °	Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages	Van belang voor conclusie nr.
A	US 2006/000643 A1 (JENKINS CHARLES [AU]) 5 januari 2006 (2006-01-05) * alineas [0015] - [0016] * * figuur 1 * -----	1-12
A,D	US 9 624 762 B2 (NAT OILWELL VARCO NORWAY AS [NO]) 18 april 2017 (2017-04-18) in de aanvraag genoemd * het gehele document * -----	1-12
A,D	US 10 927 657 B2 (ITREC BV [NL]) 23 februari 2021 (2021-02-23) in de aanvraag genoemd * het gehele document * -----	1-12

ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Informatie over leden van dezelfde octrooifamilie

Nummer van het verzoek om een onderzoek naar de stand van de techniek

NL 2032006

In het rapport genoemd octrooigeschrift	Datum van publicatie	Overeenkomend(e) geschrift(en)	Datum van publicatie
US 2019284924 A1	19-09-2019	BR 112019008537 A2	09-07-2019
		CA 3041236 A1	14-06-2018
		EP 3551847 A1	16-10-2019
		US 2019284924 A1	19-09-2019
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		EP 3472420 A1	24-04-2019
		EP 3472422 A1	24-04-2019
		US 2019195060 A1	27-06-2019
		US 2019264514 A1	29-08-2019
		WO 2017217839 A1	21-12-2017

WRITTEN OPINION

File No.	Filing date *(day/month/year)*	Priority date *(day/month/year)*	Application No.
SN82112	27.05.2022		NL2032006

International Patent Classification (IPC)
INV. E21B3/02

Applicant
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This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☒ Box No. VII Certain defects in the application
- ☐ Box No. VIII Certain observations on the application

	Examiner
	Schouten, Adri

Application number

WRITTEN OPINION

NL2032006

Box No. I Basis of this opinion

1. This opinion has been established on the basis of the latest set of claims filed before the start of the search.

2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the application, this opinion has been established on the basis of:

   a. type of material:

   ☐ a sequence listing

   ☐ table(s) related to the sequence listing

   b. format of material:

   ☐ on paper

   ☐ in electronic form

   c. time of filing/furnishing:

   ☐ contained in the application as filed.

   ☐ filed together with the application in electronic form.

   ☐ furnished subsequently for the purposes of search.

3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

4. Additional comments:

Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty	Yes:	Claims	1-12
	No:	Claims	
Inventive step	Yes:	Claims	1-12
	No:	Claims	
Industrial applicability	Yes:	Claims	1-12
	No:	Claims	

2. Citations and explanations

see separate sheet

WRITTEN OPINION

Box No. VII Certain defects in the application

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1 Reference is made to the following documents:

D1 US 2019/284924 A1 (ZHAO YIMING [US] ET AL) 19 september 2019 (2019-09-19)

D2 CA 2 266 248 A1 (TESCO CORP [CA]) 22 september 2000 (2000-09-22)

D3 US 2006/000643 A1 (JENKINS CHARLES [AU]) 5 januari 2006 (2006-01-05)

D4 US 9 624 762 B2 (NAT OILWELL VARCO NORWAY AS [NO]) 18 april 2017 (2017-04-18) in de aanvraag genoemd

D5 US 10 927 657 B2 (ITREC BV [NL]) 23 februari 2021 (2021-02-23) in de aanvraag genoemd

2 INDEPENDENT CLAIM 1

2.1 D1 is regarded as being the prior art closest to the subject-matter of apparatus claim 1, and discloses in paragraphs [0014] - [0015], [0019] - [0020], [0027]; claims 1,11; and in figures 1,3 (the references in parentheses applying to this document) a:

Boorstrengaandrijving (12), bijvoorbeeld een topaandrijving, ingericht om rotatievermogen aan te brengen aan een bovenste einde van een boorstreng (15) voor het boren van een boorgat, welke boorstrengaandrijving (12) omvat:
- een of meer hoofdaandrijfmotoren (13), bij voorkeur een of meer hydraulische hoofdaandrijfmotoren.

2.2 The subject-matter of claim 1 therefore differs from this known apparatus by:

- een hydraulische torsietrillingen reducerende hulpaandrijfmotor;
- een transmissie die de aandrijfmotoren koppelt met een uitgangsorgaan voor draaitorsie van de boorstrengaandrijving, welk orgaan is ingericht om te worden gekoppeld met de boorstreng, waarbij de hydraulische torsietrillingen reducerende hulpaandrijfmotor een hydraulische tuimelschijfmotor is met een tuimelschijf die een variabele tuimelschijfhoek heeft, waarbij de boorstrengaandrijving een regelsamenstel voor de tuimelschijfhoek van de hydraulische torsietrillingen reducerende hulpaandrijfmotor omvat, welk

regelsamenstel is ingericht om data die verband houdt met het optreden van torsietrillingen in de boorstreng te ontvangen en om de hydraulische tuimelschijfmotor te regelen om torsietrillingen tegen te gaan,

and is therefore new.

2.3 The problem to be solved by the present invention may be regarded as: to provide an alternative way of reducing torsional vibrations in a drill string driven by a top drive.

The solution to this problem proposed in claim 1 of the present application is considered as involving an inventive step for the following reasons: a swash plate hydraulic motor can effectively be controlled at an optimal frequency thereby countering the occurring torsional vibrations in a drill string. Also the inertia of such a hydraulic motor is relatively small, e.g. compared to an electric motor of the same maximum power, so that the inertia of the motor itself does not further exacerbate the problem.

3 DEPENDENT CLAIMS 2-8

3.1 Claims 2-8 are dependent on claim 1 and as such also meet the requirements with respect to novelty and inventive step.

4 INDEPENDENT CLAIM 9

4.1 Since the subject-matter of independent method claim 9 corresponds to the subject-matter of claim 1, the same reasoning as given for claim 1 will apply mutatis mutandis. Therefore claim 9 also meets the requirements in respect of novelty and inventive step.

5 DEPENDENT CLAIMS 10-12

5.1 Claims 10-12 are dependent on claim 9 and as such also meet the requirements with respect to novelty and inventive step.

Re Item VII

Certain defects in the application

- The relevant background art disclosed in D1 is not mentioned in the description, nor is this document identified therein.

- Independent claims 1 and 9 are not in the two-part form, which in the present case would be appropriate, with those features known in combination from the prior art document D1 being placed in the preamble and the remaining features being included in the characterising part.

- The features of claims 1-12 are not provided with reference signs placed in parentheses.