



(51) International Patent Classification:  
*F16D 1/02* (2006.01)

(21) International Application Number:  
PCT/EP2015/059723

(22) International Filing Date:  
4 May 2015 (04.05.2015)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant: VOLVO TRUCK CORPORATION [SE/SE];  
S-405 08 Göteborg (SE).

(72) Inventor: ALM, Ivar; Backevägen 10, S-475 31 Öckerö  
(SE).

(74) Agent: VOLVO TECHNOLOGY CORPORATION;  
Volvo Group Intellectual Property, BF14100, M1.7, 405  
08 Göteborg (SE).

(81) Designated States (unless otherwise indicated, for every  
kind of national protection available): AE, AG, AL, AM,  
AO, AT, AU, AZ, BA, BB, BG, BH, BN, 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, IR, IS, JP, KE, KG, KN, KP, KR,  
KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG,  
MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM,  
PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, 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, ST, SZ,  
TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, 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, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: SHAFT COUPLING

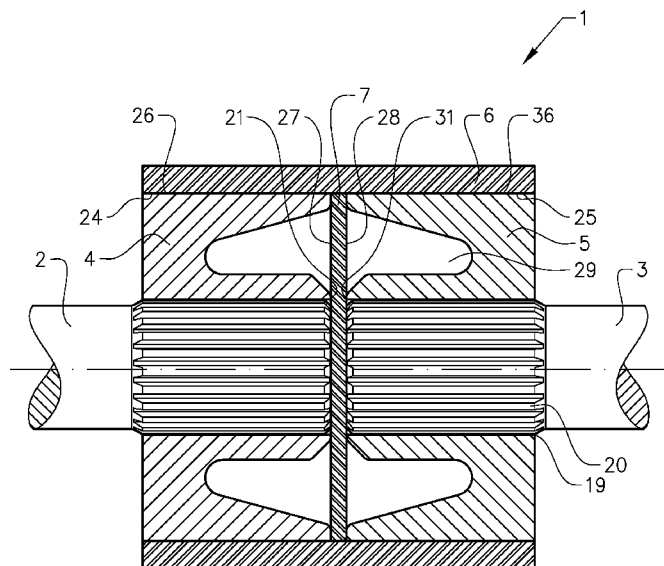


FIG. 2

(57) Abstract: The invention relates to a shaft coupling for coupling e.g. an input/output shaft of an electric machine to e.g. an input/output shaft of a transmission of a vehicle drivetrain. The shaft coupling comprises a first hub configured to be arranged to a first shaft and a second hub configured to be arranged to a second shaft, wherein the first hub and the second hub are drivingly interconnected. The shaft coupling further comprises a sleeve and a partitioning wall. When interconnected the first and second hubs are arranged on one side each of the partitioning wall. The sleeve is arranged coaxially to the first and the second hub wherein a surface of the first hub is fixed to a first surface of the sleeve and a surface of the second hub is fixed to a second surface of the sleeve. The sleeve and the partitioning wall are made of electrically insulating material in order to electrically insulate the first shaft from the second shaft.

## Shaft coupling

### TECHNICAL FIELD

The present invention relates to a shaft coupling for coupling of two shafts such as e.g. an  
5 input/output shaft of an electric machine to an input/output shaft of a transmission in a  
vehicle drivetrain. The invention is applicable in e.g. heavy-duty vehicles, such as trucks,  
buses and construction equipment. Although the invention will be described with respect  
to a heavy-duty vehicle, the invention is not restricted to this particular vehicle, but may  
also be used in other vehicles such as e.g. passenger cars.

10

### BACKGROUND

Electric machines of full electric powertrain vehicles or hybrid vehicles are generally  
associated with high voltage. In order not to jeopardize safety of vehicles with electric  
machines such applications are generally associated with stringent safety regulations.  
15 From a safety perspective it is desirable that such applications are sufficiently shielded,  
such that no person or engine component accidentally may come in contact with the high  
voltage application. This applies both to the high voltage application as such as well as to  
components in contact with the high voltage application. Even if being shielded, for high  
voltage applications there is also a risk that if there is a high electrical potential difference  
20 between the high voltage application and another component flashover may occur. The  
propensity of a flashover to occur is, except for the difference in electrical potential, e.g.  
dependent on the distance between the engine components with different electric  
potential.

25 An input/output shaft of an electric machine and an input/output shaft of a transmission, to  
which the electric machine is transferring torque, may e.g. have different electric potential.  
Thus, for vehicles equipped with an electric machine interconnected to a transmission it is  
essential that the electric machine is securely electrically insulated from the transmission,  
both in that the housing of the electrical machine needs to be insulated from the housing  
30 of the transmission but also in that the input/output shaft of the electric machine needs to  
be insulated from the input/output shaft of the transmission. Further, for such applications  
the torque transferred between an electric machine and a transmission is generally  
transferred at relatively high rpm which adds additional requirements to the interface

between the shafts. From packaging, available space utilization and weight perspective it is also desirable that the coupling between such shafts is as compact and has as low weight as possible.

5 US 7 514 635 discloses a shaft coupling and a method of producing such shaft coupling. According to the shaft coupling of US 7 514 635 two electrically conducting connecting pieces are rotatably connected in an electrically insulating manner by an insulating tube. The electrical insulation is provided by that said tube is made of a fibre-reinforced polymer or like and by that a cavity is formed inside the insulating tube. According to US 7 514 635  
10 the end of respective electrically conducting piece needs to be specifically adapted in order to be able to receive said tube and in order to secure that the electrically conducting pieces not are accidentally moved within said cavity such that they come in contact with each other. Further, a problem with what is disclosed in US 7 514 635 is that the coupling of US 7 514 635 needs to be of substantial length in order to not having the two  
15 electrically conducting elements arranged to close to each other. Arranging the two electrically conducting elements, which have different electric potential, to close to each other will increase the risk of flashover to occur.

Thus, there is a need for further improvements.

20

## SUMMARY

An object of the present invention is to provide an improved shaft coupling for interconnecting shafts that needs to be electrically insulated in respect to each other, such as e.g. an input/output shaft of an electric machine and an input/output shaft of a  
25 transmission in a fully electric or hybrid vehicle drivetrain. Other type of shafts may also advantageously be coupled by the shaft coupling of the present invention. The object is achieved by a shaft coupling according to claim 1. Further advantageous aspects of the present invention are disclosed in the dependent claims. The present invention further relates to a drivetrain comprising such shaft coupling and to a vehicle comprising a  
30 drivetrain comprising such shaft coupling.

From a safety perspective it is desirable that e.g. a high voltage application such as an electric machine is electrically insulated from a shaft of an interconnected transmission. However, at the same time the shaft coupling needs to be able to manage high rpms, high  
35 torque and cannot add too much weight or require too much space. According to the

present invention a shaft coupling providing electrical insulation and at the same time not requiring additional space, meaning e.g. that existing design of other, related components may still be used, is provided by securely arranging a hub of respective shaft to each other by means of a shaft coupling comprising an electrically insulating sleeve, securely  
5 arranging the hubs to each other, and an electrically insulating partitioning wall, arranged to the sleeve, electrically separating the hubs of respective shaft from each other.

Thus, the present invention refers to a shaft coupling for coupling e.g. an input/output shaft of an electric machine to e.g. an input/output shaft of a transmission in a vehicle  
10 drivetrain. For simplicity reasons the shafts coupled by the shaft coupling of the present invention will hereafter be referred to as shaft of electric machine and shaft of transmission, or simply the shafts, although the shaft coupling of to the present invention is also suitable for drivingly coupling other shafts. The shaft coupling comprises a first hub configured to be arranged to the shaft of e.g. an electric machine and a second hub  
15 configured to be arranged to e.g. a shaft of a transmission. The first hub and the second hub are drivingly interconnected. The shaft coupling of the present invention may also be used to interconnect other shafts that need to be interconnected in an electrically insulating manner. The shaft coupling further comprises a sleeve and a partitioning wall, wherein the first and second hubs when interconnected are arranged on each side of the  
20 partitioning wall. Since the electric machine is able to operate at considerable rpms the sleeve is preferably arranged essentially coaxially to the first and second hubs. The sleeve is arranged to the first and second hubs by that a surface of the first hub is fixed to a first surface of the sleeve and a surface of the second hub is fixed to a second surface of the sleeve. The first and second surfaces of the sleeve may be different parts of a  
25 larger surface of the sleeve such as e.g. different parts of an inside surface of the sleeve. The sleeve and the partitioning wall are made of electrically insulating material in order to electrically insulate e.g. the shaft of the electric machine from the shaft of the transmission.

30 By arranging the electrically insulating sleeve such that the sleeve holds together the hubs and arranging the electrically insulating partitioning wall between the hubs the present invention provides a shaft coupling which securely holds the hubs together and at the same time electrically insulates the hubs from each other. Also, by electrically insulating the hubs by arranging the partitioning wall between them, instead of by arranging the

hubs at a safe distance from each other, the shaft coupling can be made compact, which is advantageous from a packaging perspective.

When herein referring to electric machine what is considered is an electric device that  
5 may be used both as an electric motor, providing power to a drivetrain, or as a generator, enabling energy regenerating from e.g. brake regeneration.

According to aspects of the present invention the partitioning wall may be arranged such that a space is formed between the partitioning wall and respective axial surface of the  
10 first and/or second hub or the partitioning wall may be arranged such that at least a part of respective axial surface of the first and/or second hub abuts respective axial surface of the partitioning wall. According to further aspects of the present invention, if such space is formed the space may be filled with a suitable filling material such as e.g. a polymeric foam in order to prevent that e.g. wear deposits, waste oil etc. are accumulated within the  
15 space. Aspects of the present invention where the first and/or second hub abuts the partitioning wall has the advantage that the shaft coupling can be very compact. Also, in order to reduce material usage and lower the weight of the hubs the hubs may be provided with a hollowing. This will be disclosed more in detail in the detailed description.

20 According to one aspect of the present invention the sleeve is arranged coaxially outside of the first and second hubs wherein a radial outside surface of respective first and second hubs are fixed to a first and second radial inside surface of the sleeve.

According to another aspect of the present invention the sleeve is made of wound  
25 fiberglass composite. According to yet another aspect of the present invention the first and second hubs are made of metal such as e.g. steel. However, this is just examples of suitable materials for the sleeve, the partitioning wall and the hubs and the present invention should not be considered to be limited by these examples. The requirement of the hubs is that they need to be made of a material providing suitable strength, rigidity,  
30 wear resistance etc. and the sleeve and the partitioning wall, in addition to being sufficiently strong and rigid to securely hold together the shaft coupling, need to be electrically insulating.

According to yet an aspect of the present invention the first and second hubs are fixed to  
35 respective first and second surface of the sleeve by means of at least one fastening

means in a group of fastening means consisting of: adhesive, splines and press fitting. The stated examples of suitable fastening means are all adequate and well known means to ensure that respective hub is sufficiently fastened to the sleeve but also other ways of fastening the hubs to the sleeve may be used.

5

According to one aspect of the present invention one of the first and second hubs comprises an axially extending male part and the other hub comprises an axially extending female part configured to receive the axially extending male part such that a male-female coupling is provided. This aspect of the present invention provides the  
10 advantage that the coupling of the hubs is further enhanced in radial direction by the interacting male-female interconnecting parts.

According to yet one aspect of the present invention one of the first or second hubs is arranged to coaxially enclose the other hub such that a radial outside surface of the  
15 enclosed hub is facing a radial inside surface of the enclosing hub. The sleeve is arranged between the radial outside surface of the enclosed hub and the radial inside surface of the enclosing hub wherein a radial inside surface of the sleeve is fixed to the radial outside surface of the enclosed hub and a radial outside surface of the sleeve is fixed to the radial inside surface of the enclosing hub. The partitioning wall is arranged between the axial  
20 surfaces of the first and second hub.

According to yet an aspect of the present invention the hub may be part of an end portion of a shaft, wherein the hub is not a separate component but instead the end portion of the shaft is formed as a hub.

25

The latter aspects of the present invention are examples of how aspects of the present invention may be configured in order to fulfil currently prevailing, and for respective application, specific requirements of the shaft coupling. A shaft coupling wherein one hub is configured to enclose the other hub may e.g. be preferred due to engine packaging  
30 requirements and a shaft coupling wherein an end of one of the shafts is formed as a hub may e.g. be preferred from a manufacturing perspective.

The present invention further relates to a drivetrain comprising an electric machine, a transmission and a shaft coupling according to any aspect, or a combination of aspects of  
35 the present invention. The shaft coupling is configured for providing an electrically

isolating coupling of a shaft of e.g. an electric machine to e.g. a shaft of a transmission. According to another aspect of the present invention the shaft coupling is arranged inside of a transmission housing of a transmission.

5 Further, the present invention also relates to a vehicle comprising such a drivetrain.

#### BRIEF DESCRIPTION OF THE DRAWINGS

With reference to the appended drawings, below follows a more detailed description of  
10 embodiments of the invention cited as examples.

Fig. 1 shows a heavy-duty vehicle comprising a drivetrain comprising a shaft coupling according to an aspect of the present invention,

Fig. 2 shows a first embodiment of a shaft coupling according to the present invention,  
15 and

Fig. 3a-d show further embodiments of aspects of the present invention.

#### DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS OF THE INVENTION

20 Fig. 1 shows a heavy-duty vehicle V comprising an internal combustion engine ICE and a drivetrain DT, wherein the drivetrain DT in turn comprises a control unit CU, a transmission TR, an electric machine EM and a shaft coupling 1. The internal combustion engine ICE is drivingly coupled to the transmission TR and the electric machine EM is drivingly coupled to the transmission TR via the shaft coupling 1. The control unit CU is  
25 configured to control the operations of the drivetrain DT and the internal combustion engine ICE. The transmission TR is drivingly coupled to driven wheels in order to transmit torque from the electric machine or the engine to the driven wheels. The connection between the transmission and the driven wheels is performed in a known way and it is not disclosed in the figures.

30

Referring now to fig. 2, disclosing, in detail, a first embodiment of the shaft coupling 1 according to fig. 1. The embodiment of the shaft coupling 1 of fig. 2 shows how a first hub 4 is arranged to a first shaft, preferably an input/output shaft 2 of the electric machine EM, and a second hub 5 is arranged to a second shaft, preferably an input/output shaft 3 of  
35 the transmission TR. For simplicity reasons the shafts that are interconnected by the shaft

coupling 1 are hereafter referred to as the shaft 2 of the electric machine EM and the shaft 3 of the transmission TR, or simply the shafts 2, 3, but it should be highlighted that a shaft coupling 1 according to the present invention may be used also to drivingly interconnect also other shafts. According to the embodiment shown in fig. 2 the first and the second  
5 hub 4, 5 are arranged to respective shaft 2, 3 using splines, wherein the inside splines 19 of the first and second hubs 4, 5 interact with the outside splines 20 of the first and second shafts 2, 3 to arrange respective hub 4, 5 to respective shaft 2, 3. However, also other means of fastening the hubs 4, 5 to respective shaft 2, 3 are possible such as by means of e.g. an adhesive or by press fitting. The first and second hubs 4, 5 are  
10 interconnected by a sleeve 6, wherein the sleeve 6 is arranged to coaxially enclose the first and the second hub 4, 5.

A radial outside surface 24 of the first hub 4 is arranged to a first inside surface 26 of the sleeve 6 and a radial outside surface 25 of the second hub 5 is arranged to a second  
15 inside surface 36 of the sleeve 6. According to the embodiment of the present invention disclosed in fig. 2 the first and second radial inside surfaces 26, 36 of the sleeve 6 are parts of a larger radial inside surface of the sleeve 6. Respective outside surfaces 24, 25 of the hubs 4, 5 are fastened to respective inside surfaces 26, 36 of the sleeve 6 by means of a suitable fastening means. Such fastening means may e.g. be, but is not  
20 limited to, one of or a combination of fastening means in a group of fastening means comprising an adhesive, by using splines and by using press fitting.

The shaft coupling 1 further comprises a partitioning wall 7. The partitioning wall 7 is arranged between the first hub 4 and the second hub 5 to form an inner circular surface  
25 within the sleeve 6 such that an outer circumference of the partitioning wall 7 seals against an inner circumference of the sleeve 6. In the embodiment of the shaft coupling 1 shown in fig. 2 the first and second hubs 4, 5 are arranged such that an axial surface 21, 31 of respective first and second hubs 4, 5 abut the first and second axial surfaces 27, 28 of the partitioning wall 7. Such arrangement enables the shaft coupling 1 to be compact,  
30 which is preferable from a packaging perspective. However, it is also possible to arrange the first and/or second hubs 4, 5 at a distance from the partitioning wall 7 such that a space is formed between a first and second axial surface 27, 28 of the partitioning wall 7 and the axial surfaces 21, 31 of respective first and second hubs 4, 5.

However, it should be emphasized that the present invention is not to be considered to be limited by this embodiment. Variations of the shaft coupling, of which a few will be discussed below, are considered to also fall within the scope of the present invention.

- 5 According to the present invention the sleeve 6 and the partitioning wall 7 of the shaft coupling 1 are made of electrically insulating material such that the first shaft, preferably a shaft 2 of an electric machine EM, and the second shaft 3, preferably a shaft of a transmission TR, are electrically insulated from each other. This has the advantage that the shafts 2, 3 may have different electrical potential without an electric current being  
10 formed. No electric current is formed since the output shaft 2 of the electric machine EM is neither connected to the shaft 3 of the transmission TR directly, or via any electrically conducting material, nor since the output shaft 2 of the electric machine EM and the shaft 3 of the transmission TR are arranged in a way such that flashover may occur.
- 15 The sleeve 6 and the partitioning wall 7 may be manufactured from the same electrically insulating material or by different electrically insulating materials, and the material may be, but is not limited to, a fiberglass composite.

The first and second hubs 4, 5 are further provided with a hollowing 29. As is apparent for  
20 a person skilled in the art the hollowing 29 may be configured and arranged differently without affecting important properties such as e.g. wear ability, strength and rigidity adversely. The configuration of the hollowing 29 of fig. 1 has the advantage that an outer part in radial direction of respective hub, which is arranged to the sleeve 6, is slightly flexible in relation to the sleeve 6.

25

Fig. 3a, 3b, 3c and 3d shows four further exemplifying embodiments of shaft couplings 1a, 1b, 1c, 1d which all are considered to be within the scope of the present invention. Depending on prevailing requirements, in terms of e.g. available space in the engine compartment, and the configuration of the shafts the shaft coupling 1a, 1b, 1c, 1d is  
30 configured to drivingly interconnect, different aspects of the shaft couplings 1a, 1b, 1c, 1d are most suitable, of which a few embodiments are disclosed below.

Fig. 3a shows an exemplifying embodiment of a shaft coupling 1a wherein a first hub 4a is configured to receive a first shaft (not shown), such that the first hub 4a is enclosing the  
35 first shaft when the first hub 4a is arranged to the first shaft, and a second hub 5a is

configured to be coupled to a second shaft (not shown) by that an end portion of the second shaft encloses a protruding portion 12a of the second hub 5a. In the embodiment of fig. 3a the first and second hubs 4a, 5a are arranged at distance from a partitioning wall 7a.

5

The exemplifying embodiment of fig. 3a discloses that a radial inside through hole 11a, which is configured to receive a shaft, of the first hub 4a is provided with inside splines 19a and that the protruding portion 12a of the second hub 5a is provided with outside splines 20a. However, also other suitable means of fastening a shaft to respective first and second hubs 4a, 5a, such as e.g. by using an adhesive or by using press fitting, is  
10 considered to be within the scope of the present invention.

Further, in the embodiment of the shaft coupling 1a of fig. 3a the first hub 4a comprises a hollowing 29a and the second hub 5a comprises a differently configured hollowing 30a.

15

Fig. 3b shows another exemplifying embodiment of a shaft coupling 1b wherein a first hub 4b is formed by an end portion of a shaft 10. In the embodiment of fig. 3b a sleeve 6c and a partitioning wall 7b may be arranged to the first hub 4b when being manufactured. In the embodiment of fig. 3b the first and the second hubs 4b, 5b are arranged such that at least  
20 a portion of respective first and second hub 4b, 5b abuts the partitioning wall 7b. Further, in the embodiment shown in fig. 3b a radial inside through hole 11b, which is configured to receive a shaft, of the second hub 5b is provided with inside splines 19b.

Fig. 3c shows an exemplifying embodiment of a shaft coupling 1c wherein a second hub 5c is arranged to coaxially enclose a first hub 4c such that a radial outside surface 24c of the enclosed first hub 4c is facing a radial inside surface 25c of the enclosing second hub 5c. A sleeve 6c is arranged between the radial outside surface 24c of the first hub 4c and the radial inside surface 25c of the second hub 5c, wherein a radial inside surface 26c of the sleeve 6c is fixed to the radial outside surface 24c of the first hub 4c and a radial  
25 outside surface 36c of the sleeve 6c is fixed to the radial inside surface 25c of the second hub 5c. Further, a partitioning wall 7c is arranged inside the sleeve 6c such that the first and second hubs 4c, 5c are separated by the sleeve 6c and the partitioning wall 7c. In the embodiment shown in fig. 3c the partitioning wall 7c abuts the second hub 5c but is arranged at an axial distance from the first hub 4c. Further, in the embodiment shown in  
30 fig. 3c a radial inside through hole 11c, which is configured to receive a shaft, of the first  
35

hub 4c is provided with inside splines 19c and a protruding portion 12c of the second hub 5c is provided with outside splines 20c.

Fig. 3d shows an exemplifying embodiment of a shaft coupling 1d wherein a first hub 4d and a second hub 5d are formed as a male part 9 and as a female part 8 such that a male-female coupling is provided. The female part 8 of the first hub 4d comprises an axially extending hollowing and the male part 9 of the second hub 5d comprises an axially extending protrusion, wherein the axially extending hollowing of the female part 8 is configured to interact with the axially extending protrusion of the male part 9. A first shaft 2d is arranged to the first hub 4d and a second shaft 3d is arranged to the second hub 5d. A sleeve 6d coaxially encloses the first and second hubs 4d, 5d and a partitioning wall 7d is arranged between the first and second hubs 4d, 5d, inside of the sleeve 6d. The partitioning wall 7d is configured to follow the hollowing and protrusion of the female part 8 and the male part 9 such that the partitioning wall 7d forms a partitioning wall, separating the first hub 4d from the second hub 5d and sealing against an inner circumference of the sleeve 6d, which provides electrical insulation between the first shaft 2d and the second shaft 3d.

The embodiment of the shaft coupling 1d of fig. 3d may e.g. be advantageous where additional support of the coupling in radial direction is required or when the shaft coupling 1d is required to handle exceptionally high rpms since the male-female coupling may further ensure that the first and second hubs 4d, 5d are aligned.

The embodiment of fig. 3d discloses one example of how a male-female coupling according to the present invention may be configured. Other configurations and variations of interacting female parts and male parts, comprising mutually interacting protrusions, hollowings and like, are also considered to be within the scope of the present invention.

It is to be understood that the present invention is not limited to the embodiments described above and illustrated in the drawings; rather, the skilled person will recognize that many changes and modifications may be made within the scope of the appended claims.

## CLAIMS

1. A shaft coupling (1) for coupling a shaft (2) of an electric machine (EM) to a shaft (3) of a transmission (TR) in a vehicle drivetrain (DT) comprising:  
a first hub (4) configured to be arranged to the shaft (2) of the electric machine (EM) and a second hub (5) configured to be arranged to the shaft (3) of the transmission (TR), wherein the first hub (4) and the second hub (5) are drivingly interconnected,  
**characterized in that**  
the shaft coupling (1) further comprises:  
a sleeve (6) and a partitioning wall (7),  
wherein the first and second hubs (4, 5) when interconnected are arranged on each side of the partitioning wall (7), wherein the sleeve (6) is arranged coaxially to said first and second hub (4, 5), wherein a surface (24) of the first hub (4) is fixed to a first surface (26) of the sleeve (6) and a surface (25) of the second hub (5) is fixed to a second surface (36) of the sleeve (6),  
and wherein the sleeve (6) and the partitioning wall (7) are made of electrically insulating material in order to electrically insulate the shaft (2) of the electric machine (EM) from the shaft (3) of the transmission (TR).
2. A shaft coupling (1) according to claim 1, wherein the sleeve (6) is made of wound fiberglass composite.
3. A shaft coupling (1) according to claim 1 or 2, wherein the first and second hubs (4, 5) are made of metal.
4. A shaft coupling (1) according to claim 3, wherein the metal is steel.
5. A shaft coupling (1) according to any one of the preceding claims, wherein the first and second hubs (4, 5) are fixed to respective first and second surface (24, 25) of the sleeve (6) by means of at least one fastening means in a group of fastening means consisting of: adhesive, splines and press fitting.
6. A shaft coupling (1d) according to any of the preceding claim 1 to 5, wherein one of the first and second hubs (4d, 5d) comprises an axially extending male part (9) and the other hub (4d, 5d) comprises an axially extending female part (8)

configured to receive the axially extending male part (9) such that a male-female coupling is provided.

- 5 7. A shaft coupling (1c) according to any of the preceding claim 1 to 6, wherein one of the first or second hub (5c) is arranged to coaxially enclose the other hub (4c) such that a radial outside surface (24c) of the enclosed hub (4c) is facing a radial inside surface (25c) of the enclosing hub (5c), wherein the sleeve (6c) is arranged between the radial outside surface (24c) of the enclosed hub (4c) and the radial inside surface (25c) of the enclosing hub (5c),  
10 and wherein a radial inside surface (26c) of the sleeve (6c) is fixed to the radial outside surface (24c) of the enclosed hub (4c) and a radial outside surface (36c) of the sleeve (6c) is fixed to the radial inside surface (25c) of the enclosing hub (5c).
- 15 8. A shaft coupling (1) according to any one of the preceding claims 1 to 6, wherein the sleeve (6) is arranged coaxially outside of the first and second hubs (4, 5) and wherein a radial outside surface (24, 25) of respective first and second hubs (4, 5) is fixed to a first and second radial inside surface (26, 36) of the sleeve (6).
- 20 9. A shaft coupling (1) according to any of the preceding claims, wherein the shaft coupling (1) is arranged inside of a transmission housing of a transmission (TR).
10. A shaft coupling (1) according to any one of the preceding claims, wherein at least one of the first and/or second hubs (4, 5) is provided with a hollowing (29).
- 25 11. A shaft coupling (1) according to any one of the preceding claims, wherein an axial surface (21, 31) of at least one of the first and/or second hubs (4, 5) is provided at a distance from a first and/or second axial surface (27, 28) of the partitioning wall (7) such that a space is formed between at least the axial surface (21) of the first hub (4) and the first axial surface (27) of the partitioning wall (7) and/or the axial  
30 surface (31) of the second hub (5) and the second axial surface (28) of the partitioning wall (7).
- 35 12. A shaft coupling (1) according to any one of claims 1 to 11, wherein an axial surface (21) of the first hub (4) at least partially abuts a first axial surface (27) of the partitioning wall (7), wherein the first axial surface (27) is facing the axial surface (21) of the first hub (4), and/or an axial surface (31) of the second hub (5)

at least partially abuts a second axial surface (28) of the partitioning wall (7), wherein the second axial surface (28) is facing the axial surface (31) of the first hub (5).

- 5      13. A drivetrain (DT) comprising an electric machine (EM), a transmission (TR) and a shaft coupling (1) according to any of the preceding claims, wherein the shaft coupling (1) is configured for providing an electrically isolating coupling of a shaft of the electric machine (EM) to a shaft of the transmission (TR).
- 10      14. A vehicle (V) comprising a drivetrain according to claim 13.

1/6

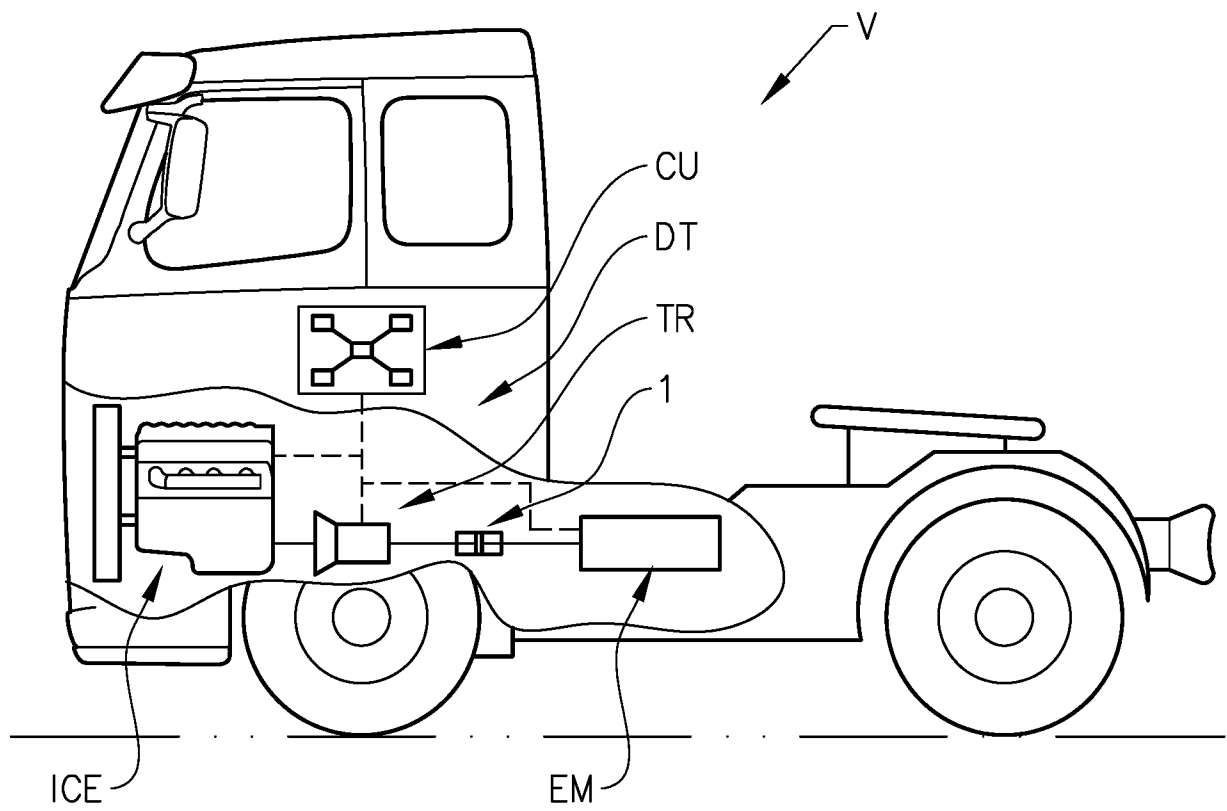


FIG. 1

2/6

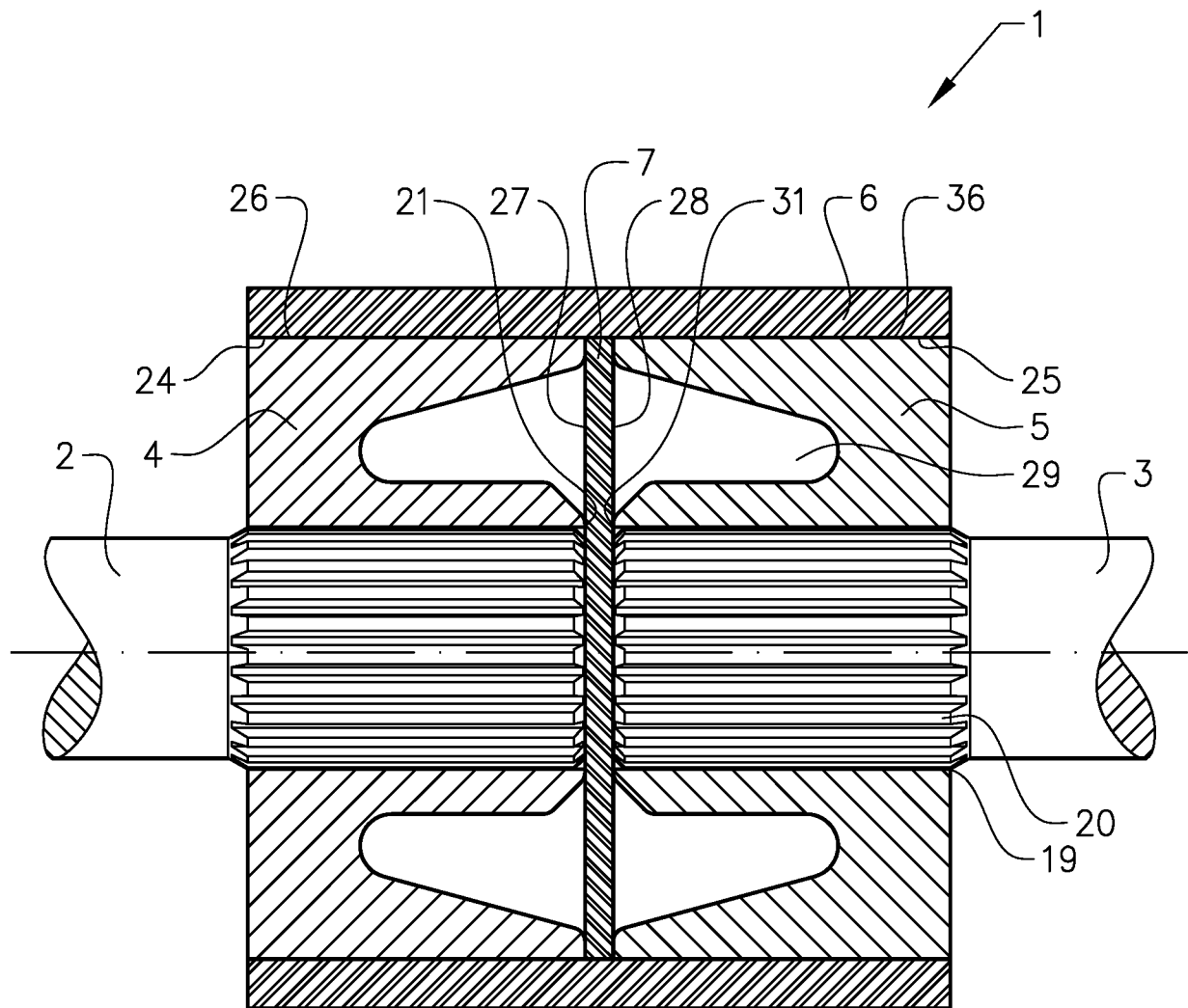


FIG. 2

3/6

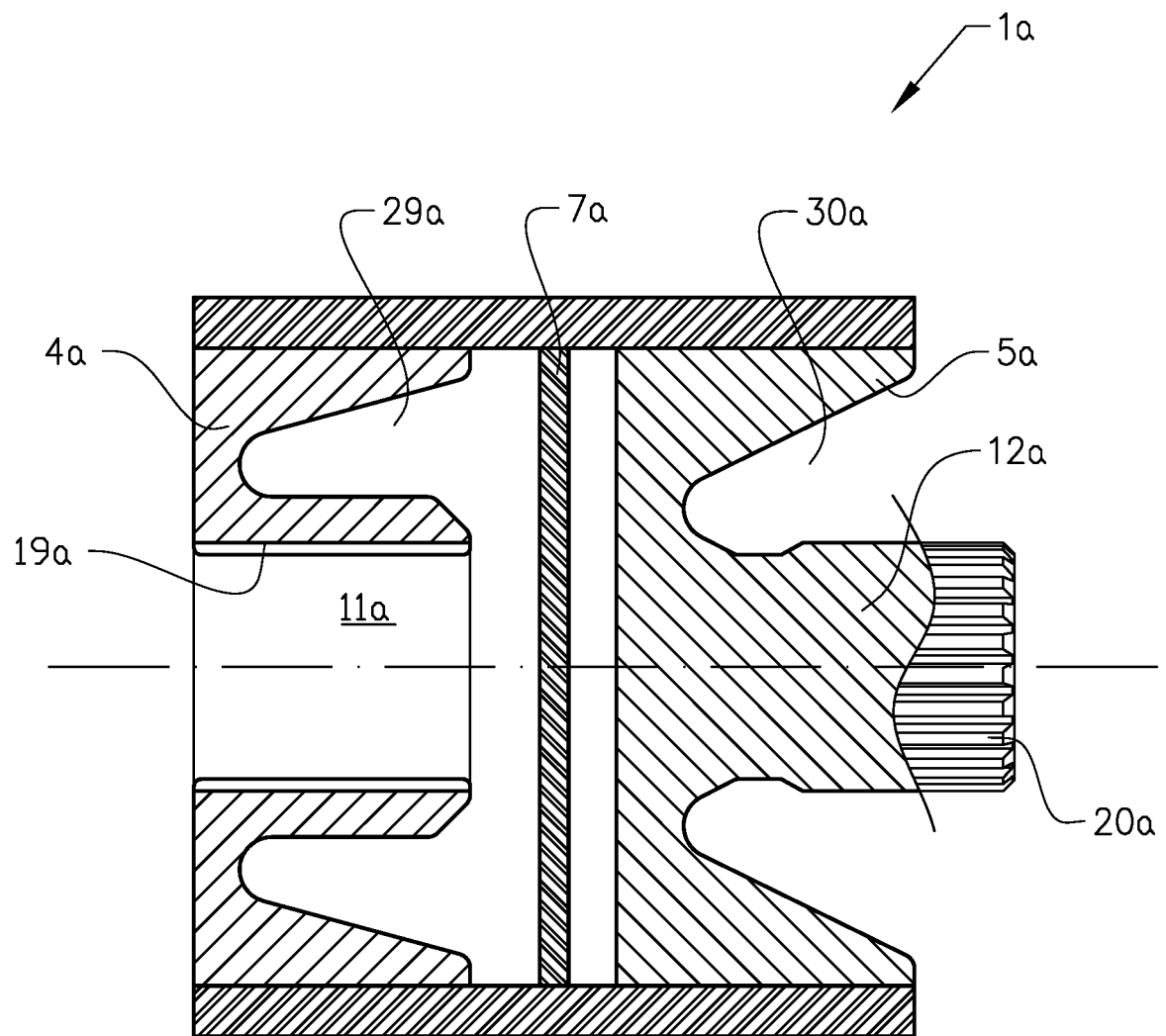


FIG. 3a

4/6

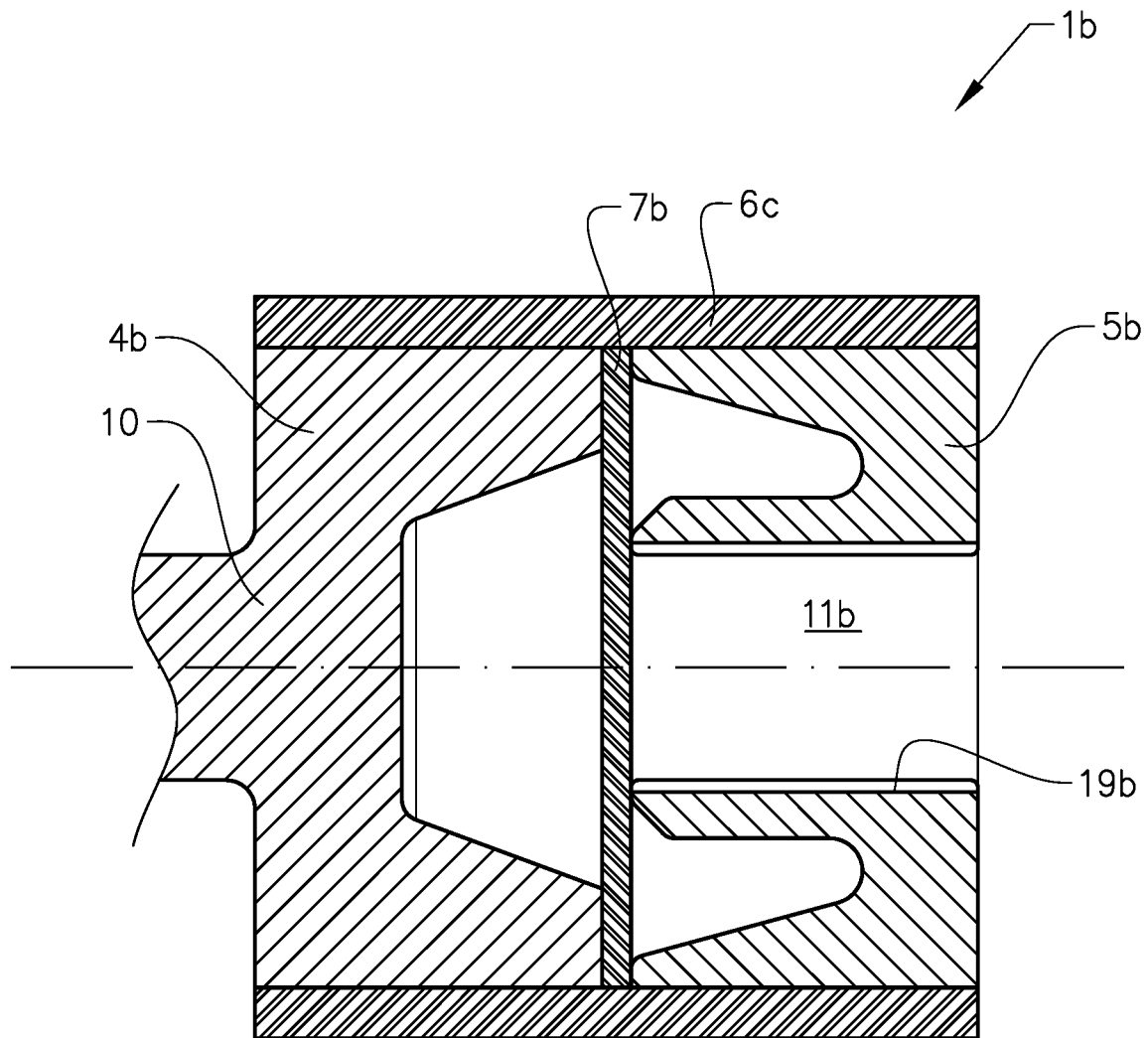


FIG. 3b

5/6

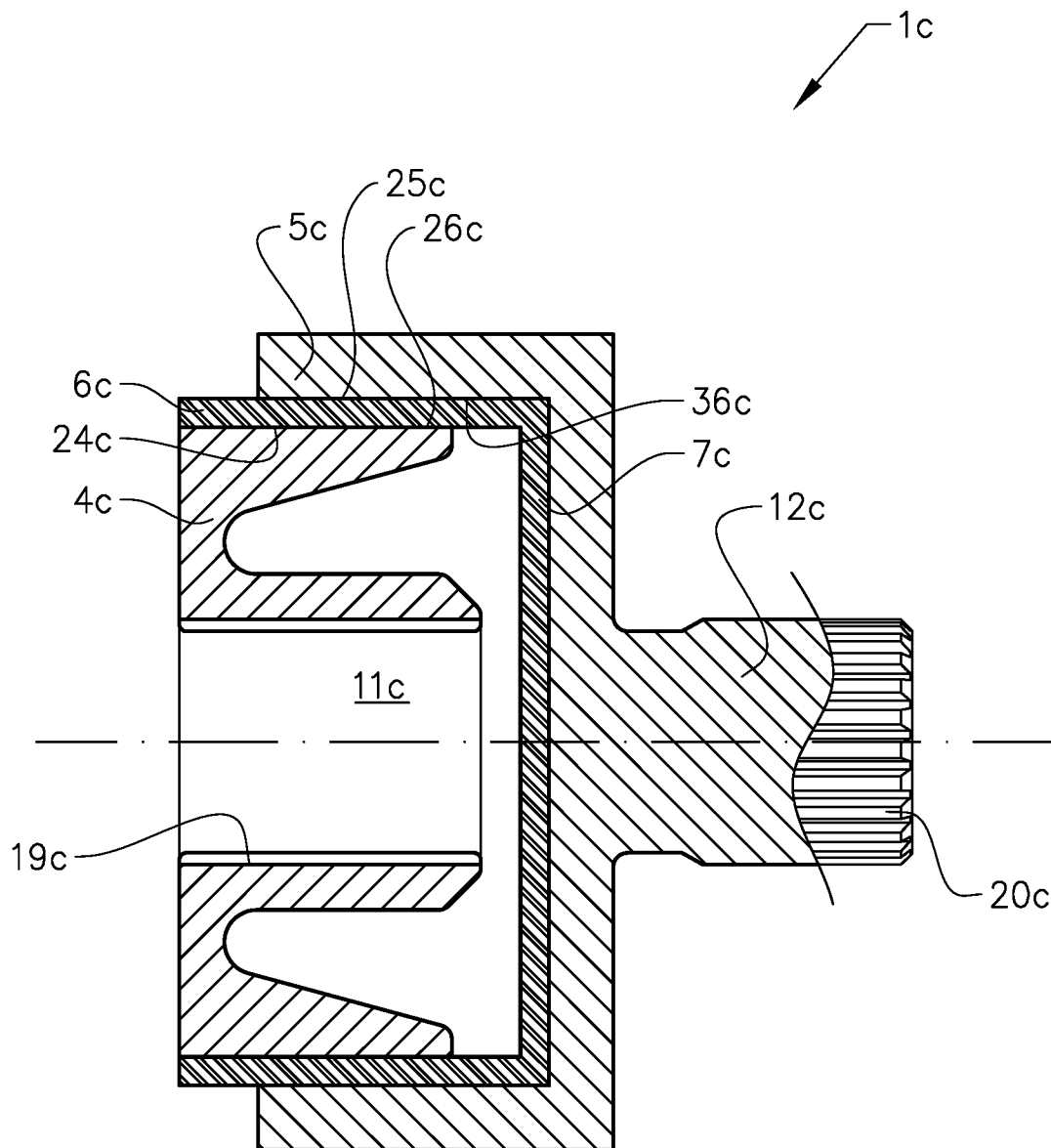


FIG. 3c

6/6

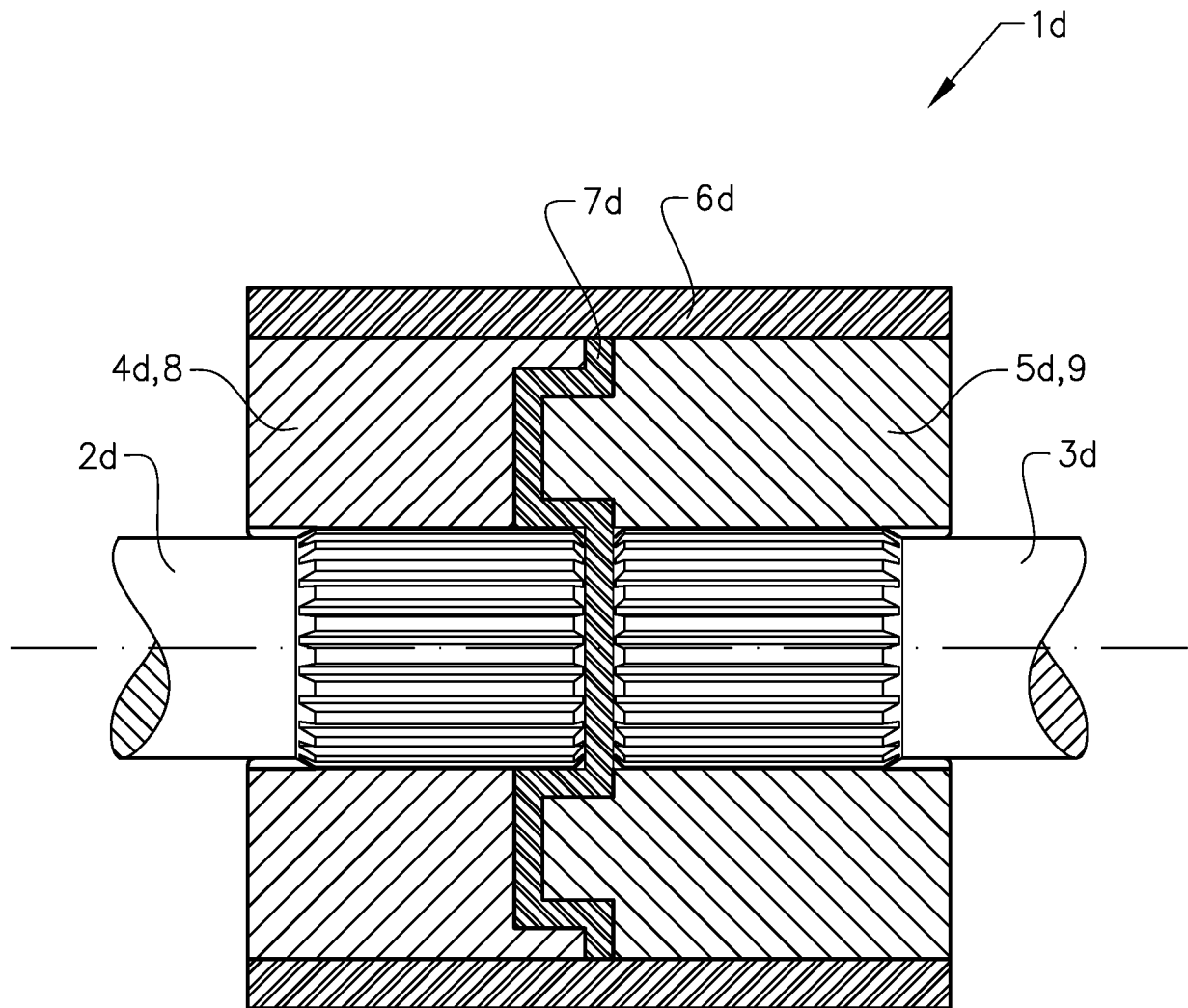


FIG. 3d

## INTERNATIONAL SEARCH REPORT

International application No  
PCT/EP2015/059723

A. CLASSIFICATION OF SUBJECT MATTER  
INV. F16D1/02  
ADD.

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)  
F16D

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)

EPO-Internal, WPI Data

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                                          | Relevant to claim No.    |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| X         | DE 10 2008 052760 A1 (BAYERISCHE MOTOREN WERKE AG [DE]) 29 April 2010 (2010-04-29) paragraphs [0002], [0021]; figure 1<br>-----                             | 1-5,8-14                 |
| X         | DE 613 428 C (CONTINENTAL GUMMI WERKE AG) 18 May 1935 (1935-05-18)<br><br>the whole document<br>-----                                                       | 1,3-5,<br>8-10,<br>12-14 |
| X         | DE 20 2014 007550 U1 (KWD KUPPLUNGSWERK DRESDEN GMBH [DE]) 23 October 2014 (2014-10-23) paragraphs [0016], [0040], [0041], [0063]; figure 4<br>-----<br>-/- | 1,3-5,<br>8-11,13,<br>14 |



Further documents are listed in the continuation of Box C.



See patent family annex.

\* Special categories of cited documents :

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

"E" earlier 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

17 December 2015

Date of mailing of the international search report

04/01/2016

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040,  
Fax: (+31-70) 340-3016

Authorized officer

Giráldez Sánchez, J

## INTERNATIONAL SEARCH REPORT

International application No  
PCT/EP2015/059723

| C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT |                                                                                                                                                       |                          |
|------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| Category*                                            | Citation of document, with indication, where appropriate, of the relevant passages                                                                    | Relevant to claim No.    |
| X                                                    | FR 506 166 A (SECHERON ATEL)<br>16 August 1920 (1920-08-16)<br>page 1, line 1 - page 2, line 4; figures 1,3<br>-----                                  | 1-5,8,<br>10-14          |
| X                                                    | US 2 586 604 A (BENNETT WESLEY B)<br>19 February 1952 (1952-02-19)<br><br>column 1, lines 28-30; figures 1-6<br>column 2, lines 32-36<br>-----        | 1,3-5,<br>8-11,13,<br>14 |
| X                                                    | GB 1 215 153 A (KANGO ELECTRIC HAMMERS LTD [GB])<br>9 December 1970 (1970-12-09)<br>page 1, lines 10-20; figures 1-4<br>page 2, lines 20-49<br>-----  | 1-7,10,<br>12-14         |
| X                                                    | FR 898 052 A (M. VOIGT)<br>10 April 1945 (1945-04-10)<br>the whole document<br>-----                                                                  | 1,3-5,8,<br>12-14        |
| X                                                    | FR 2 300 259 A1 (MECANIQUE ET METALLURG STE GLE [FR])<br>3 September 1976 (1976-09-03)<br>figures 1,2<br>-----                                        | 1,3-5,8,<br>9,12-14      |
| X                                                    | DE 101 56 711 A1 (HOERMANN KG ANTRIEBSTECHNIK [DE])<br>30 April 2003 (2003-04-30)<br>paragraph [0011]; figure 3<br>-----                              | 1,3-7,<br>12-14          |
| X                                                    | FR 2 971 310 A3 (STANLEY WORKS EUROPE GMBH [CH])<br>10 August 2012 (2012-08-10)<br>abstract; figures 7,8<br>page 6, line 32 - page 7, line 7<br>----- | 1-10,<br>12-14           |
| A                                                    | EP 1 494 254 A1 (ABB RESEARCH LTD [CH])<br>5 January 2005 (2005-01-05)<br>paragraph [0025]<br>-----                                                   | 2                        |

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2015/059723

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s) | Publication<br>date |
|-------------------------------------------|---------------------|----------------------------|---------------------|
| DE 102008052760 A1                        | 29-04-2010          | DE 102008052760 A1         | 29-04-2010          |
|                                           |                     | EP 2337963 A1              | 29-06-2011          |
|                                           |                     | WO 2010046003 A1           | 29-04-2010          |
| DE 613428 C                               | 18-05-1935          | NONE                       |                     |
| DE 202014007550 U1                        | 23-10-2014          | NONE                       |                     |
| FR 506166 A                               | 16-08-1920          | NONE                       |                     |
| US 2586604 A                              | 19-02-1952          | NONE                       |                     |
| GB 1215153 A                              | 09-12-1970          | CH 474324 A                | 30-06-1969          |
|                                           |                     | DE 1763230 A1              | 05-08-1971          |
|                                           |                     | GB 1215153 A               | 09-12-1970          |
|                                           |                     | NL 6805718 A               | 25-10-1968          |
|                                           |                     | US 3457438 A               | 22-07-1969          |
| FR 898052 A                               | 10-04-1945          | NONE                       |                     |
| FR 2300259 A1                             | 03-09-1976          | BE 838294 A1               | 05-08-1976          |
|                                           |                     | DE 2558880 A1              | 19-08-1976          |
|                                           |                     | ES 444727 A1               | 16-05-1977          |
|                                           |                     | FR 2300259 A1              | 03-09-1976          |
|                                           |                     | GB 1535821 A               | 13-12-1978          |
|                                           |                     | IT 1054091 B               | 10-11-1981          |
|                                           |                     | JP S5922087 B2             | 24-05-1984          |
|                                           |                     | JP S51102760 A             | 10-09-1976          |
|                                           |                     | LU 74306 A1                | 27-01-1977          |
|                                           |                     | NL 7601093 A               | 09-08-1976          |
|                                           |                     | OA 5229 A                  | 28-02-1981          |
|                                           |                     | US 4063433 A               | 20-12-1977          |
| DE 10156711 A1                            | 30-04-2003          | NONE                       |                     |
| FR 2971310 A3                             | 10-08-2012          | CN 103380307 A             | 30-10-2013          |
|                                           |                     | EP 2673518 A1              | 18-12-2013          |
|                                           |                     | FR 2971310 A3              | 10-08-2012          |
|                                           |                     | US 2013341069 A1           | 26-12-2013          |
|                                           |                     | WO 2012107299 A1           | 16-08-2012          |
| EP 1494254 A1                             | 05-01-2005          | AT 323943 T                | 15-05-2006          |
|                                           |                     | CN 1577681 A               | 09-02-2005          |
|                                           |                     | EP 1494254 A1              | 05-01-2005          |
|                                           |                     | JP 4549756 B2              | 22-09-2010          |
|                                           |                     | JP 2005024095 A            | 27-01-2005          |
|                                           |                     | RU 2339112 C2              | 20-11-2008          |
|                                           |                     | US 2005000722 A1           | 06-01-2005          |