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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
5 October 2006 (05.10.2006)

PCT

(10) International Publication Number
WO 2006/103553 A1

(51) International Patent Classification:
B62D 1/10 (2006.01) *B60R 16/02* (2006.01)

(21) International Application Number:
PCT/IB2006/000769

(22) International Filing Date: 3 April 2006 (03.04.2006)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
05007147.1 1 April 2005 (01.04.2005) EP

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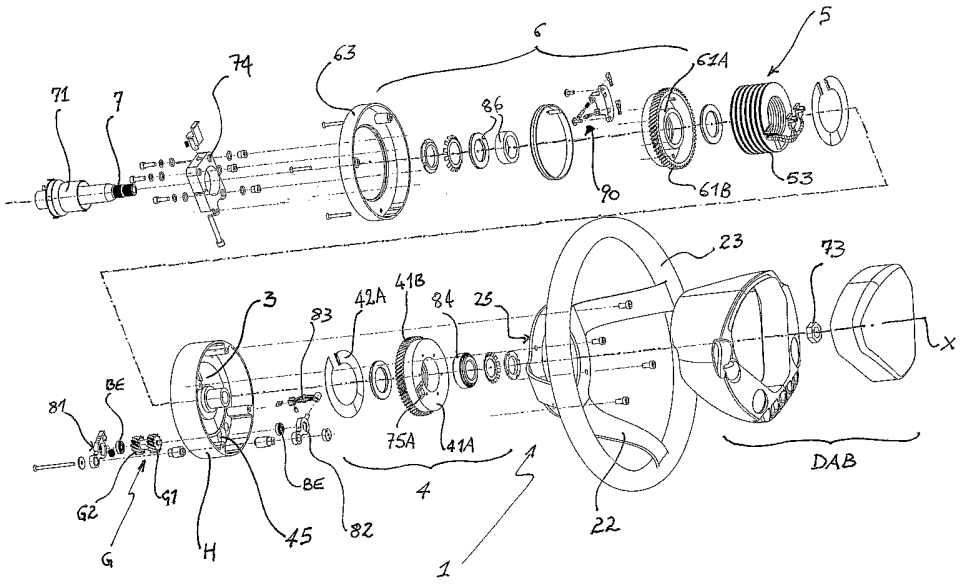
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LC,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

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

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

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

(54) Title: STEERING WHEEL WITH STATIONARY HUB MOUNTED PORTION



(57) Abstract: A steering wheel having a stationary portion supporting a DAB or similar module, comprises an armature (1) having a hub (2, H) directly mounted to a vehicle steering shaft and provided with an opening (3) through which a coiled element (5) passes. A non-rotating housing (41) is assembled with the hub (2) and the coiled element (5) connects the non-rotating housing (41) to a fixed part (61) of the vehicle and carries one or more electric wires to the DAB. The coiled element (5) is screwing or unscrewing itself to or from the hub (2, H) via the opening (3) when the steering wheel is rotated. A gear assembly is provided for supporting the stationary portion (41) when the steering wheel is rotated.

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STEERING WHEEL WITH STATIONARY HUB MOUNTED PORTION

Title of the invention.

The present invention relates to a steering wheel having a stationary hub mounted portion, in particular to a steering wheel having a static driver airbag module.

Background of the invention.

A typical driver airbag module (DAB) is mounted on a vehicle steering wheel usually fixed to a hub, which in turn is coupled to a steering shaft. Consequently a DAB rotates in unison with the steering wheel. Since the deployment of the airbag may occur at different rotation angles of the steering wheel with respect to the vehicle driver, the same airbag has to be circular or symmetrical shaped to provide always the same shape of protection surface to the driver.

In some motor vehicles, for instance in sport cars, the maximum diameter of the airbag is limited by the high inclination of the windscreen and the front door jambs. Recently, assemblies have been provided that allow the driver airbag module to remain in a stationary position with respect to the vehicle during rotation of the steering wheel. This type of module is known as a static driver airbag module. Advantageously, static DABs may provide airbags having shapes other than circular, since there is no rotation of the same with respect to the driver. Stationary modules allow for localized increases of the airbag volume. Thus airbags may be designed to fit the internal volume of a particular vehicle when deployed, in such a way to better protect the driver regardless of the angular position of the steering wheel.

Different solutions have been provided for stationary mounting a DAB on a steering wheel.

US 2003/0067147 A1 discloses a static driver airbag assembly that comprises a rotatable steering wheel encompassing an accessible space and coupled to the respective shaft by a planetary gear system. The planetary gear system transfers torque applied to the steering wheel ring portion directly to the steering shaft. An airbag module is positioned within the accessible space encompassed by the steering wheel and remains in a stationary position during rotation of the steering wheel.

DE 2131902 discloses a steering wheel provided with a non rotating DAB.

Rotation of the steering wheel is transmitted to the steering shaft either directly, by matching the internal teeth of the steering hub with the external teeth of the shaft, or indirectly by way of planetary gears interposed between the hub teeth and the shaft teeth. In both cases a space is left between the shaft and the steering hub for housing of both the electric wires and the stationary support elements to which the DAB module is fixed. This is achieved by providing the hub with a greater diameter than the shaft and using the gap between them for the passage of the wires and the stationary support elements.

Solutions provided with planetary gears (as the solution shown in fig. 2 of DE 2131902) have several drawbacks. First, the steering wheel is not directly mounted on the steering shaft: thus, there is a discontinuity in the structure. Because of the increasing of the mechanical clearance which occurs as the above gears get worn with usage, rotation of the steering wheel does not match with the rotation of the steering shaft. Moreover, when planetary gears are provided for connecting the steering hub to the steering shaft, it is necessary that the assembly gears have exact dimensions to avoid damping of the force transmitted by the driver to the steering shaft or the occurring of an offset between the rotation angle of the steering wheel ring portion and the rotation of the steering shaft. If one of the static DAB components has dimensions different from what is specified, a non-uniform rotation of the steering wheel ring portion may occur, for example due to the imperfect matching between the gears.

There usually is another drawback: rotation of the steering shaft is in the opposite direction with respect to the rotation imparted by the driver to the steering wheel ring portion. The steering box of the vehicle has to be designed to overcome such drawback so as to reverse the direction of rotation imparted by the steering shaft to the vehicle wheels. This leads to an increase in the vehicle production costs.

More generally, prior art assemblies provided with gears for coupling the steering hub to the steering shaft are complicated and require high accuracy in the manufacture of the gears, with evident increasing in production time and costs.

DE 3413009 A1 discloses a steering wheel provided with a stationary DAB module wherein the steering wheel hub is directly coupled to the steering shaft, that is in a traditional way. Two gears are provided for maintaining the DAB module stationary: a first gear matching the DAB module and a second gear matching the

steering shaft. The first and the second gear are coupled to the same driving shaft which is rotatably lodged within a seat of the steering hub. When the driver rotates the steering wheel ring portion, the second gear is rotated about its own axis by the steering shaft and is also rotated about the steering wheel axis by the steering wheel hub pushing the driving shaft. The same movement is transmitted by the driving shaft to the first gear. The gear ratio between the first gear and the DAB module and between the second gear and the steering shaft is chosen such that the DAB module rotates in the opposite direction with respect to the steering wheel ring portion, thereby remaining stationary.

Such solution requires two expensive "clockspring" connectors to be used for cabling the DAB module. A first connector is arranged on the steering shaft side of the hub and a second connector is arranged on the driver side of the hub, wired to the first one through the same hub. Another drawback of the solution according to DE 3413009 A1 is that the coupling of the driving shaft with the respective seat provided in the steering hub is critical. Inaccuracy in the machining of the seat may easily lead to misalignment of the first and second gears, thereby inducing movements of the DAB module when the steering wheel ring portion is rotated.

US 4,541,301 discloses a steering wheel assembly wherein the DAB module is supported stationary by a coiled element which screws or unscrews itself through a hub opening when the steering wheel is rotated clockwise or counterclockwise. The coiled element has a first end coupled to a stationary portion of the vehicle, a second end fixed to the module and wounds around the steering shaft. The main drawback of such solution is that the coiled element does not sufficiently resist torsion to avoid the DAB module from incurring in small movements. In other words, the coiled element does not provide the necessary mechanical strength to stationary support the DAB module in all the operating conditions.

US 2003/0164060 A1 discloses a steering wheel for a vehicle provided with a second shaft other than the steering shaft. The second shaft is supported via bearings by a stationary hub, which includes a DAB housing, such that it is rotatable about its own axis and is coupled to the steering shaft by an arm or an electronic actuator. The actuator includes a position sensor for detecting an angular displacement of the second shaft from a selected origin and producing a

signal indicative of the angular displacement. Such a signal is transmitted to a road wheel actuator so that the position of the road wheels properly corresponds with the position of the steering wheel.

Generally, solutions based on a plurality of shafts are complicated and expensive. Duplication of the steering shaft facilitates passing the airbag module wiring harness easily inside the steering wheel column, but requires accurate design and assembly, expensive mechanical components and eventually electronic devices. Moreover, traditional assemblies provided with a plurality of gears or shafts are normally cumbersome. Consequently, vehicle steering columns, i.e. the various components of the vehicle around and comprising the steering shaft, have to be re-designed accordingly to accomodate such assemblies.

FR 2833916 discloses a steering wheel wherein the DAB module is kept quasi-stationary by way of an electric motor which is operated to rotate the DAB module in the opposite direction with respect to the steering wheel ring portion but for an initial angle. Such solution is cumbersome, complicated, expensive and difficult to assemble and to set. Moreover an electronic control unit is needed to sense the rotation of the ring portion of the steering wheel and operate the motor consequently.

Therefore, there is the necessity of providing a reliable and compact driver airbag module assembly that does not rotate with the steering wheel and that can be fitted on existing steering columns without having to re-design the same.

Summary of the invention.

It is an object of the present invention to provide a steering wheel having a stationary central portion which overcomes the drawbacks of known solutions, being at the same time economical, reliable and simple to manufacture and assemble.

It is a further object of the present invention to provide a steering wheel having a stationary central portion which overcomes the drawbacks of prior art solutions related to the mechanical coupling between the steering wheel and the steering shaft and at the same time overcomes the drawbacks of prior art solutions related to the electrical connections of the DAB module.

It is a further object of the present invention to provide a steering wheel having a stationary central portion that can be directly mounted on common steering columns in a traditional way, with no need for re-designing of the same

columns.

It is a further object of the present invention to provide a steering wheel having a stationary driver airbag module which is adaptable to various needs in terms of dimensions, styling and cost requirements.

These and other objects are achieved by the steering wheel according to claim 1 of the present invention.

In a preferred embodiment of the invention, a coiled element supports a non-rotating housing via an opening through a steering wheel hub and the same hub can be directly fixed to a steering shaft in a traditional way, for instance by coupling the shaft to the centre of the hub. Thus the steering wheel according to the present invention does not need the vehicle steering column to be re-designed.

The coiled element preferably is a cylindrical helical element arranged coaxially with the steering wheel shaft, around the same, and is housed in two substantially symmetrical housings: a first non-rotating housing on the driver side of the hub and a second, stationary, housing on the opposite side of the hub, fixed to a fixed portion of the vehicle. The coiled element is fixed to both non-rotating and second, stationary, housings.

Thus, non-rotating housing, located on the hub facing the driver, is connected to a stationary part of the vehicle by the coiled element passing through the opening or aperture provided in the hub. Rotation of the coiled element around the axis of rotation of the steering wheel is substantially prevented. Consequently when the steering wheel is rotated, the hub rotates with respect to the coiled element and the opening runs on the coiled element, following its coils.

When the steering wheel is rotated and the hub aperture runs on the coiled element (i.e. the coiled element spirals through the hub opening), an increasing or decreasing length of the coiled element (i.e. a greater or smaller number of coils) is located on the hub side facing the driver, depending on the rotation being clockwise or counterclockwise.

The coiled element may be rigid or, preferably, deformable to extend along its longitudinal axis. Consequently the pitch between the coils of the coiled element, i.e. the distance between corresponding portions of adjacent coils, may be constant or may change for the coils which are displaced axially by external forces.

If the coiled element is rigid the pitch between the coils is constant and sufficient to accommodate the hub between the two adjacent coils and means are

provided for allowing axial movements of the same coiled element when the hub is moving on the coils. Such means allow the coiled element to move axially to screw and unscrew into and away from the hub which is itself axially fixed. For instance the ends of the coiled element may slide within axial slots provided in the non-rotating housing and in the fixed part of the vehicle and bearings may be provided to facilitate its sliding. Such means may be complicated to design and manufacture.

Preferably the coiled element is resistant to torsion and axially deformable, i.e. elastically extensible and compressible along its axis; the pitch between two adjacent coils will thus adapt to accommodate the hub, i.e. when the hub is interposed between two adjacent coils, the same coils are axially displaced by the hub from an initial, close, almost adjacent, position to an extended position, and when the hub proceeds along the coiled element the coils return to their initial position. If the coiled element is elastically extensible, at least one of its ends is axially fixed and the single coils may be axially compressed or extended to allow screwing and unscrewing into/from the hub which is itself fixed in the axial direction defined by the steering shaft.

When the steering wheel is in its neutral position, corresponding to the vehicle directed straight forward, the same number of coils of the coiled element may be located on opposite sides of the hub, for instance three coils on the driver side of the hub and three coils on the steering column side.

In a first embodiment of the invention, the coiled element is extensible and provides a first end coupled to the non-rotating housing located on the driver side of the hub. Rotation of the coiled element is prevented by coupling it to the fixed part of the vehicle, through the above mentioned second, stationary, housing. Thus also the rotation of the non-rotating housing is prevented. When the hub rotates, the non-rotating housing will slide on the hub; coupling between the hub and the non-rotating housing will slidingly support the non-rotating housing (supporting the DAB) and axial movements are avoided, i.e. the hub will retain and support the non-rotating housing in the axial direction.

According to the invention, the non-rotating housing contains at least a portion of the coiled element. The housing is intended to accommodate the coils of the coiled element that extend from the opening in the hub to the non-rotating housing, i.e. the coils that are "spiralled", or "screwed", through the hub into the

driver side of the hub, possibly within the same housing, when the steering wheel is rotated.

The non-rotating housing can thus support one or more of a plurality of different devices such as electronic devices, an airbag module, etc.

In this first embodiment, a second end of the coiled element, opposite to the first end with respect to the hub, is coupled to a fixed part of the vehicle, preferably by way of a second housing intended to contain at least a portion of the coiled element. The second housing accommodates the coils of the coiled element that extend from the opening of the hub to the fixed part of the vehicle, i.e. the coils that are "unscrewed" from the driver side of the hub when the steering wheel is rotated. The coupling between the second housing and the hub is such as to allow the rotation of the hub on the housing, for instance by sliding on the same, while axial movements of the housing is prevented.

If the coiled element is extensible and compressible, its total length is limited by the dimensions of the non-rotating housing and the second housing, i.e. the ends are fixed while the pitch between some coils will change when the hub is located between such coils. The coiled element preferably is at least partially compressible along its longitudinal axis, i.e. the coils may be separated in their initial position and may abut one another when the coiled element is compressed.

The coiled element is designed to house means of carrying power and/or signals through the hub. Wires or other conductors of power and signals for the devices mounted on the non-rotating housing are conveyed by the coiled element from the steering wheel column to such devices. To this end, the coiled element is provided with e.g. a continuous slot running along its coils to accommodate and protect from wear wires, harnesses or supplies. Advantageously, the coiled element is thus used as a conveyor for the electrical wires or harnesses instead of expensive standard clock-spring connectors.

According to a second embodiment of the steering wheel according to the present invention, in addition or alternatively to the coil, the non-rotating housing is kept in position by a gear assembly, which overcomes possible problems of insufficient strength of the coiled element against torsion. The coiled element may be fixed to both the stationary part of the vehicle and to the non-rotating housing located on the hub facing the driver so as to cooperate with the gear assembly for supporting the non-rotating housing.

The non-rotating housing located on the hub and the second housing on the fixed part of the vehicle are toothed and the gear assembly engages both them and the hub to compensate for rotation of the steering wheel. In particular, the gear assembly comprises a first gear, engaging the non-rotating housing, and a second gear, engaging the second housing on the fixed part of the vehicle. The first and second gears are coaxially mounted on a same driving shaft which is rotatable in a seat of the steering wheel hub (or in a hub housing). When the driver rotates the ring portion of the steering wheel, the driving shaft is also rotated with the hub about the axis of the steering shaft. The first and second gears, matching the respective stationary toothed portions, rotate about their common axis. As a consequence, as the steering wheel is rotated, the non-rotating housing "rotates" in the opposite direction relatively to the hub and at the same speed, thereby remaining stationary.

In a preferred embodiment one end of the coiled element is secured to the fixed part of the vehicle, and the coil end housed in the non-rotating housing is fixed to the same non-rotating housing. The coiled element will therefore cooperate with the gear assembly for supporting the non-rotating housing against rotation.

In this second embodiment, the non-rotating housing and the second housing fixed to the vehicle are both externally toothed housings wherein the coiled element is partially lodged. For example, the non-rotating housing is a first housing slidingly mounted on the hub, facing the driver and providing a support for a DAB module, and the second housing on the fixed part of the vehicle is secured to a fixed cover of the steering shaft.

Axial forces applied to the ring portion of the steering wheel, for instance by the driver, are sustained by the steering shaft to which the steering wheel armature is directly coupled via the hub. Axial forces applied on the non-rotating housing, for instance by the driver actuating the acoustic horn by pushing the DAB module, are sustained by the first and second housings, either directly or with the interposition of sliding elements or bearings.

By providing the aforesaid gear assembly for supporting the non-rotating first housing, the steering wheel armature can be directly coupled to the steering shaft. This feature is particularly advantageous since the steering wheel can be easily assembled on the vehicle simply by fitting the hub on the steering shaft and securing the second fixed housing to the steering shaft cover, for instance by means of a clamp. Mounting of the steering wheel on the respective vehicle can be

carried out in short time by a non specialized operator.

Thus, the steering wheel of the present invention allows stationary mounting of a driver airbag module and is unexpensive and easy to manufacture and assemble. The coiled element and the housings, together with the gears, can easily be pre-assembled on a steering wheel armature that is directly connectable to a steering wheel shaft in a traditional way.

The gear assembly can be mounted on the hub housing by means of bearings and levers which are biased by a spring to compensate for the mechanical clearance between various gears. Alternatively a torsion can be applied to the coiled element before assembling the same with the non-rotating housing and the fixed part of the vehicle, i.e. the coiled element is preloaded, thereby imparting a force to the gear assembly, when assembled, to compensate for mechanical clearances.

Moreover the steering wheel of the invention overcomes at the same time the drawbacks of prior art steering wheels for what concerns stability of the non-rotating housing and the cabling of the DAB module.

Brief description of the drawings.

The invention will now be described in greater detail with reference to the drawings enclosed as a non-restrictive example, where:

- figure 1 is an exploded view of a steering wheel according to the present invention;
- figure 2 is a side view of the steering wheel shown in figure 1, in a partially assembled configuration;
- figure 3A is an exploded view of a first portion of the steering wheel shown in figure 1;
- figure 3B is an exploded view of a second portion of the steering wheel shown in figure 1;
- figure 4 is a perspective view of a component of the steering wheel shown in figure 1; and
- figure 5 is a side view of the component shown in figure 4;
- figure 6 is an exploded view of a second steering wheel according to the present invention;
- figure 7 is a section view of the steering wheel shown in figure 6;
- figure 8 is an exploded view of a detail of the steering wheel shown in figure

6;

- figure 9 is a perspective view of the detail of the steering wheel shown in figure 8.

Detailed description of the invention.

An exploded view of a steering wheel according to the present invention is shown in figure 1. The steering wheel comprises an armature 1 that may be of a traditional type, a hub 2, one or more spokes 22 and a rim 23. The hub 2 is coaxially fixable to a steering wheel shaft 7 (figure 2) along a common axis of rotation X-X. The hub is provided with a through opening 3 that connects a side 24 of the hub 2 that will be proximal with a vehicle driver with an opposite side 25 of the hub 2 that will be distal from a vehicle driver, i.e. the side proximal a vehicle steering column. In the embodiment shown in figure 1, the opening or aperture 3 is positioned on the hub 2 spaced radially apart from the axis of rotation X-X.

The steering wheel has a coiled element 5 comprising coils 53 – 56 that are intended to pass through the through opening 3 of the hub. The coils wind, or spiral, in a continuous curve around a longitudinal axis. The overall shape of the coiled element is preferably cylindrical such that the coiled element has a helical-like structure, as the one shown in the figures. Alternatively, the coiled element may have other shapes, for instance having a longitudinal cross-sectional shape that is elliptical. The coiled element 5 is coaxial with the hub 2 and the steering shaft 7 along the axis of rotation X-X.

As shown in figure 2, after assembly of the steering wheel the coiled element 5 is at least partially placed around the steering shaft 7. In this first embodiment, the coiled element 5 is rigid against torsion and is intended to retain against rotation a non-rotating housing 41 mounted on hub 2. One end 51 (figure 5) of the coiled element 5 is fixed to the non-rotating housing 41 arranged on the side 24 of the hub 2 that will be proximal to a vehicle driver and a second end 52 of the coiled element is fixed to a non-moving part of a vehicle, for instance a frame portion of the vehicle instrument panel. In the shown embodiment, the second end 52 of the coil is housed in and fixed to a second housing 61 that is fixed to the vehicle (i.e. is stationary).

Thus, coiled element 5 is restrained against rotation around its longitudinal axis and consequently also the non-rotating housing 41 is prevented from rotating when the steering wheel is rotated.

With reference to the figures 1-2 and 4-5, when the driver rotates the steering wheel, the coiled element 5 moves along a curved path into or away from the hub 2, i.e. the opening 3 runs along the coils 53 – 56 and more coils will be positioned either on a side 24 of the hub 2 that will be proximal to a vehicle driver or, vice versa, on an opposite side 25 of the hub 2 that will be distal from a vehicle driver, i.e. the side proximal a vehicle steering column. When the steering wheel is rotated, the coils pass through the opening 3 in the hub 2 along a curved path defined by the coils. The hub 2 does not move longitudinally along the axis of rotation X-X, i.e. it is coupled to the steering shaft 7 in such a way that the hub rotates around the axis of rotation X-X but is not relocated along the length of the same axis. Consequently screwing and unscrewing of the coiled element 5 through the hub 2 requires the coils to axially move forward and back respectively. In other words, when the coiled element 5 screws through the hub 2, the coils near the first end 51 are relocated along the axis of rotation X-X toward the driver, i.e. some coils may pass through the hub opening 3 from the side 25 of the hub 2 that will be distal from a vehicle driver, i.e. the side proximal a vehicle steering column to the side 24 of the hub 2 that will be proximal with a vehicle driver. On the contrary, when the coiled element 5 unscrews from the hub 2, the coils near the second end 52 of the coiled element are relocated along the axis of rotation X-X toward the steering shaft, i.e. some coils may pass through the hub opening 3 from the side 24 of the hub 2 that will be proximal with a vehicle driver to the opposite side 25 of the hub.

Axial movement of the coils 53 – 56 may be provided in different ways. For instance, the coiled element 5 may be rigid and the first end 51 and second end 52 are coupled to support elements that are at least in part extensible and compressible along the axis of rotation X-X but are impeded from rotation around the same axis. Alternatively the ends 51, 52 of the coiled element may be coupled in a slideable manner to axial slots provided in the non-rotating housing or in the fixed part of the vehicle. However, this arrangement would complicate the designing of the steering wheel, and an axially deformable coiled element 5 is preferred.

Preferably the coiled element 5 is made of a material that allows the extension and compression of the coiled element along the axis of rotation X-X, for instance a plastic material, being at the same time rigid against torsion around axis of rotation X-X. Axial movement of the coils may be obtained by displacing some coils 53 – 56 and compressing other coils when the ends 51, 52 of the coiled

element are firmly secured. Figure 5 shows the coiled element 5 wherein the pitch between the coils 53, 56 nearest to the first end 51 and the second end 52 is substantially constant. The pitch between the coils 54, 55 is greater than the one between the remaining coils, i.e. a portion A of the coiled element 5 is axially displaced from another portion B of the coiled element. This is achieved by stretching a length 60 of the coiled element 5, i.e. by extending a portion of a coil along the axis of rotation X-X, by virtue of the hub 2 being positioned between adjacent coils 54, 55.

Figure 2 shows the steering wheel of the invention wherein the hub 2 is positioned between the coils 54, 55 illustrated in figure 5. The number of coils may be such that when the steering wheel is in its neutral position, thus guiding the vehicle in a straight direction, half of the coiled element 5 is positioned on the side 24 of the hub 2 that will be proximal with a vehicle driver and half is positioned on the opposite side 25 of the hub facing the instrument panel or the steering column. In the embodiment shown in the figures, the coiled element 5 comprises five coils.

When the hub 2 rotates, coils 53 – 56 move through opening 3 in hub 2. The pitch between two consecutive coils sandwiching the hub 2 increases to accommodate hub 2. A further rotation of the hub 2 leads to a repositioning of the same hub 2 between different coils, i.e. the coils initially sandwiching the hub return to their initial axial extension or pitch.

In order to minimize the axial extension of the coiled element 5, the coils nearest to the ends 51, 52 of the coiled element 5 are axially compressed and contained in suitable housings 41 and 61, i.e. the coils may be pushed to abut one the other, thus limiting axial extension.

As shown in figures 2, 4 and 5, coiled element 5 is provided with a slot 57 running continuously along the coils from the first end 51 to the second end 52 of the coiled member. As best shown in figures 2 and 5, the slot 57 is arranged within the coils, i.e. the coiled member has a U shaped cross section defining the slot 57. The slot 57 conveys wires 58 or other conductors of electric current or signals to devices installed on the non-rotating housing 41. In this way the coiled element 5 is used as a conveyor to carry conductors of electric current or signals or wiring harnesses 58 to the non-rotating housing 41 through the hub 2 with no need for an expensive and complicated traditional clock-spring connection. The two housings 41, 61 have openings 75, 68 therein to facilitate passage of the conductors 58 of

electric current or signals into and out of the housings.

The non-rotating housing 41 can thus support devices such as LCD displays, radio controls and/or an airbag module. The non-rotating housing 41 may itself house an airbag module (which may be adapted to be fixed to the end 51 of the coiled element 5).

As shown in figures 1 and 3B, the non-rotating housing assembly 4 comprises a non-rotating housing 41 intended to contain the coils 51, 56 that will remain on the side 24 of the hub 2 that will be proximal with a vehicle driver. The non-rotating housing 41 is substantially the same as the second housing 61 of figures 1 and 3A. The exterior of housings 41, 61 is best shown in figure 3B and the interior of the housings is best shown in figure 3A. The only significant difference between the two housings is that the non-rotating housing 41 does not need to have mounting holes 70, as used in the second housing 61 to attach the second housing to a fixed, non-moving part of the vehicle. Each of the housings 41, 61 has a substantially cylindrical shape, an outer circumferentially extending wall 76, 77 and an inner sleeve 44, 64 what cooperate to define a circumferentially extending space for receiving a portion of the coiled element. As the steering wheel is assembled, a portion of the coiled element 5 is placed around the sleeves 44, eventually abutting on the same. The sleeves 44, 64 may be made of, or covered with, a material having a low friction coefficient so to allow an easy sliding of the coils along the sleeves longitudinally with respect to the axis of rotation X-X of the steering wheel. The non-rotating housing 41 is coupled to the first end of the coiled element 5. On the central sleeve 44, 64, which have the same function in both housings 41, 61 are located two projections 67 that are complementary with and mated to the notches 59 in the coils to avoid rotation of the coiled element 5 and thus avoid rotation of the non-rotating housing 41.

The non-rotating housing 41 is sandwiched between two coupled rings 42, 43. The first ring 42 is coupled to the armature 1, for instance to the hub 2 and rotates with the same. The ring 42 is provided with a ledge 46 on which a corresponding flange 45 of the non-rotating housing 41 slides when relative rotation occurs between the non-rotating housing 41, retained by the coiled element 5 against rotation, and the ring 42 jointly rotating with hub 2. The second ring 43 retains the non-rotating housing 41 on the ring 42. Screws or equivalent means are coupling the rings 42, 43 and to the hub 2. Put another way, the two rings 42, 43

cooperate to provide a raceway or track that accommodates the circumferential flange 45 of the non-rotating housing 41, and while the rings rotate with the steering wheel the flange 45 simply slides in the track without rotating while the rotating rings secure the non-rotating housing to the steering wheel. It is evident that non-rotating housing 41 only slides on the rotating ring 42, i.e. on the hub 2, but its movements along, as well as rotations around, rotation axis X-X are inhibited.

As shown in figures 1 and 4, the coils of the coiled element 5 are provided with notches 59 intended to engage corresponding projections 67 provided on the sleeves 44, 64 to impede rotation of the coiled element 5.

Preferably, the non-rotating housing 41 serves as a support for a static driver airbag (DAB) module that does not rotate with the steering wheel.

The second end 52 of the coiled element is firmly coupled to a second housing 61 similar to the non-rotating housing 41. Figure 3A shows the second housing 61 and mounting respective rings 62, 63. Coils 52, 53 remaining on the side 25 of the hub 2 that will be distal from a vehicle driver are contained within the second housing 61.

The ring 62 is secured to the hub 2, on the side 25 of the hub 2 that will be distal from a vehicle driver, thus jointly rotating with the hub. The ring 62 is provided with a ledge 66 on which the corresponding flange 65 of the housing 61 slides when the ring 62 and the hub 2 rotate. Another ring 63 is coupled to the ring 62 to sandwich the second housing 61. In this embodiment the second housing 61 and the mounting rings 62, 63 interact in the same way as described above so that the mounting rings rotate with the steering wheel hub 2 but the second housing 61 does not rotate.

The second housing 61 is secured to a fixed part of the vehicle, for instance a frame part of the vehicle, by way of traditional means such as screws, nuts, bolts, etc. extending through mounting holes 70 in the second housing. By virtue of this coupling the coiled element 5 and the non-rotating housing 41 are impeded from rotating.

The non-rotating housing 41 and the second housing 61 act as compensators that exchange the coils 53 of the coiled element 5 axially moved by the hub 2 rotating clockwise or counterclockwise.

The steering wheel is easy to assemble as shown in figure 2 (wherein the outer circumferential wall 76, 77 of the housings 41, 61 are not shown to allow

viewing of the relationship of the coiled element 5 to the walls of the sleeves 44, 64). It is sufficient to pass the coiled element 5 through the opening 3 in the steering wheel hub housing H, couple the ends 51, 52 of the coiled member 5 to the respective housings 41, 61 and finally couple the housings 41, 61 to the hub 2 using the mounting rings 42-43 and 62-63.

Figure 6 is an exploded view of a second embodiment of the steering wheel; in this embodiment the same reference numbers are used for the same parts. In the embodiment of figures 6-9, the non-rotating housing 41A is coupled to a stationary portion, i.e. second housing 61A, of the vehicle by way of a gear means. The coiled element 5 has the function of conveying the electric wires 58 (fig. 5) and preferably also of supporting against rotation the non-rotating housing 41 (as above disclosed) together with gear means G. In a further embodiment, coiled element 5 is only a means of housing the electric wires. Advantageously, as in the previous embodiment, armature 1 is coaxially and directly coupled to the steering shaft 7 in a traditional way, i.e. by means of a nut 73 screwed onto the steering shaft thread 72.

The non-rotating housing 41A is externally provided at its periphery with teeth 41B intended to match the teeth of the gear means G. The stationary portion 61A is a second housing externally provided with teeth 61B that match and engage the teeth of gear means G. The two housings 41A and 61A are mounted on opposite sides of casing H, that is fixed to face 25 of the armature 1 and provides a hub with an opening 3. When the steering wheel is assembled, the coiled element 5 is partially lodged in housing 41A and partially lodged in housing 61A, as shown in the section view in figure 7. Thus, the hub H, on which the steering shaft has to be fixed, provides a recess, by means of casing H, in which non-rotating housing 41A is located; this arrangement advantageously results in a steering wheel wherein the housing 41A is substantially flush with the armature part 25, i.e. the space for the DAB is the same as in embodiments having a rotating DAB.

Gear means G comprises a first gear G1 and a second gear G2 coaxially mounted on the same driving shaft G3 at a distance. The first gear G1 is matching the teeth 41B of housing 41A and the second gear G2 is matching the teeth 61B of housing 61A. The two opposite ends of the driving shaft G3 engage the hub casing H by means of bearings BE and respective levers 81, 82 (figure 6) which, together with lever 83 and one or more biasing springs, provide for compensation of

mechanical clearance between gears G1, G2 and the toothed housings 41A, 61A. The portion G3 of the shaft of gear means G is housed in a hole 45 provided in hub casing H. Therefore, gear means G is rotated with the hub H and will rotate around its axis Y-Y when rotated by the hub casing H.

Alternatively, if the levers 81-83 are not provided, the coiled element 5 is pre-loaded, i.e. a torsion is applied to the same before its assembling with gear means G, in order to compensate for mechanical clearance between the gear means G and both the housings 41, 61. In other words, the coiled element has a function of a biasing spring.

As previously mentioned, hub casing H is fixed to, or integral with the steering wheel and moves with it. The hub casing H is shown in figures 6 and 7 screwed on the steering column side 25 of armature 1. One or more bearings BE are provided for promoting rotation of the gear means G around its own axis Y. As the driver rotates the ring portion 23 of the steering wheel, also the hub H is rotated. This causes gear means G to rotate with the hub H around the axis X-X of the steering shaft, in a clockwise or counter-clockwise direction. Such a rotation causes the teeth of the first gear G1 and the second gear G2 to engage the teeth 41B and 61B of the housings 41A and 61A respectively, thereby causing the same gear means G to rotate also about its own axis Y.

The hub H is directly coupled to the steering shaft 7. The housing 41A rotates at the same speed but in the opposite direction relatively to the hub H and steering wheel 1. In other words the gear means G and the toothed housings 41A and 61A provide a gear ratio 1:1 for the rotation with respect to the hub H (in the opposite direction). Thus the housing 41A remains stationary with respect to the driver as the steering wheel is rotated.

Figure 9 shows an enlarged perspective view of the housings 41A and 61A and the gear means G in the positions they take when the steering wheel is assembled. As it can be seen, the first gear G1 and the second gear G2 simultaneously match the respective housing 41A or 61A. The driving shaft G3 is rotated by the hub H around the steering wheel axis X-X, which is also the axis of the housings 41A, 61A. Thus the gears G1 and G2 rotate around the toothed periphery of the housings 41A, 61A, this causing the same gear means G to rotate about its own axis Y in the opposite direction.

As shown in figure 6, a DAB module is mounted onto housing 41A, for

instance by means of screws, through the hub. The coiled element 5 provides the passage for the necessary wirings through the casing H and non-rotating housing 41A up to aperture 3 of the hub housing H.

The housings 41A and 61A support axial forces applied by the driver to the DAB module, for instance when operating the horn actuator. The housing 61A is fixed to the steering shaft cover 71 which is secured to a fixed portion of the vehicle and the housing 41A slides on the hub H or other interposition elements, such as element 42A. Axial forces applied on the ring portion 23 are sustained by the steering shaft 7 to which the hub is directly coupled.

As shown in fig. 6 and 7, housings 41A and 61A are both supported on steering shaft 7 with bearings 84 and sliders 86 that are secured to the respective housings in a way known per se, e.g. with shown washers 85

The steering wheel of the present invention may be provided with the sliding contact 90 shown in the figure 6. Such contact 90 would allow for operating an electric device mounted on a rotating part of the steering wheel, for instance a horn actuator arranged on the ring portion 23.

The steering wheel of the present invention has various advantages over prior art steering wheels provided with stationary hub portions.

The number of components or elements is minimized. Moreover the coiled element 5 and the associated housings 41, 61 and 41A, 61A can be made of a plastic material. Consequently the steering wheel is much less noisy and less expensive than known solutions providing multiple satellite gears, duplication of the steering shaft, drive-by-wire, etc.

The housing 41, the gear means G and the levers 81-83 are arranged within the hub H which is secured to the armature 1 by means of screws (or is integral with it). The housing 61 is secured with the housing 63 to the steering shaft cover 71 (which is a stationary part of the vehicle) by means of the clamp 74. The steering wheel, so pre-assembled, is mounted on the steering shaft 7 and secured to the same by way of the nut 73.

Final assembling of the steering wheel with the vehicle involves the direct connection of the hub 2 to the steering wheel shaft 7, with no duplication of the same shaft. Safety of the connection is thus guaranteed.

Dimensions of the coiled element 5 and its housings 41, 61 may be easily adapted to be fitted in most common armatures, with evident advantages in

minimizing production costs and in providing customized aesthetic solutions.

The steering wheel shown in the figures 6-9 has many advantages over prior art solutions. Drawbacks of the prior art solutions for what concerns the cabling of the DAB module are overcome by providing the coiled element 5 for conveying the electric wires. The coiled element 5 provides an easy, effective and unexpensive way to convey the wires to the DAB module. No expensive "clockspring" connectors have to be used.

Drawbacks of the prior art solutions for what concerns stability of the non-rotating portion are overcome by providing the direct coupling of the hub 2 to the steering shaft 7 and a gear means G to transmit relative rotation to the non-rotating portion 41. Advantageously, the driving shaft G3 is not fitted for its entire length in a seat provided across the hub 2, as in the solution disclosed in DE 3413009 A1, but engages the external hub casing H and the same hub H with its ends, this minimizing or avoiding misalignment of the first gear with respect to the second gear as the hub H is rotated.

Any movement of the non-rotating portion 41A is prevented as the steering wheel is rotated. This is achieved by virtue of the rigidity of the gear means G and the housings 41A and 61A, for instance made of metal or an hard plastic as ABS, which do not undergo appreciable torsion. Rigidity can be maximized by fixing one end of the coiled element 5 to the housing 61 and the remaining end of the coiled element 5 to the housing 41. In this case gear G and housings could be all made of suitably rigid plastics, the sum of their single contributions being sufficient to provide sufficient rigidity of the system.

The coiled element 5 can also be preloaded to apply a torsion force to the housings 41A and 61A which compensate for the clearance with the respective gears G1, G2 when the steering wheel is assembled. This is obtained by initially assembling housings 41A and 61A on hub casing H in an arrangement out of alignment. When gear means is matched with teeth 41B and 61B one of the housings (usually 41A) is rotated with respect to the other, to align the housings with gear means G. This rotation will apply a torsion force to the coiled element that will thus act as a spring an compensate possible clearances. Alternatively, the gear means G is coupled to the hub housing H by the interposition of the biased levers 81-83.

CLAIMS

1. A steering wheel comprising an armature (1) having a hub (2,H) and means to directly couple said hub to a vehicle steering shaft (7), the hub (2,H) being provided with an opening (3), and a non-rotating housing (41, 41A) assembled on a side (24) of the hub (2, H) that will be proximal with a vehicle driver, characterized in that it further comprises a coiled element (5) that extends through the said opening (3) in the hub (2, H) to carry one or more electric wires and that is fixed to at least a fixed part (61,61A) of the vehicle, the coiled element (5) spiralling through the said hub opening (3) when the steering wheel is rotated.

2. The steering wheel according to claim 1, wherein the fixed part of the vehicle comprises a second housing (61, 61A) to contain at least a portion of the coiled element (5).

3. The steering wheel of claim 1 or 2, wherein said coiled element (5) housing electric wires is axially elastically extendible and compressible along the axis of rotation (X-X) of the steering.

4. The steering wheel according to claim 2 or 3, further comprising a gear means (G) which engages both said non-rotating housing (41A) and said second housing (61A), said gear means (G) being rotated by said hub (H) around the axis (X-X) of the steering shaft (7) thereby rotating also around its own axis (Y-Y) while matching teeth (41B,61B) of said non-rotating housing (41A) and said second, fixed to he vehicle housing (61A).

5. The steering wheel according to claim 4, wherein said gear means (G) comprises a first gear (G1) to match said non-rotating housing (41A) and a second gear (G2) to match said fixed part (61A), said first and second gears being fixed coaxially on the same driving shaft (G3) which engages said hub (H) at a distance from its axis (X-X).

6. The steering wheel according to any claim 2 to 5, wherein the gear ratio between said gear means (G) and both said non-rotating housing (41A) and said second (61A) is such that as the steering wheel (1) is rotated, the non-rotating housing (41A) rotates in the opposite direction relatively to said hub (H) and at the same speed, thereby remaining stationary.

7. The steering wheel according to any claim 2 to 6, wherein an end of said coiled element (5) is secured to said fixed part (61A) of the vehicle and the opposite

end is secured to said non-rotating housing (41A).

8. The steering wheel according to claim 7, wherein said coiled element (5) is biased under a torsion force.

9. The steering wheel according to any previous claim, wherein at least a portion (45) of the driver side non-rotating housing (41,41A) is slidable on the hub (2, H) when the steering wheel rotates.

10. The steering wheel according to any claim 3 to 9, wherein said driver side non-rotating housing (41A) and said second housing (61A) are externally provided with teeth respectively matching said first gear (G1) and said second gear (G2) of said gear means (G).

11. The steering wheel according to any previous claim, wherein at least a portion (65) of fixed part (61, 61A) of the vehicle is slidable on the hub (2,H) when the steering wheel rotates.

12. The steering wheel according to any previous claim 1-11, wherein the coiled element (5) is a cylindrical helix arranged coaxially with the steering wheel shaft (7).

13. The steering wheel according to any previous claim 3 to 12, wherein the coiled element (5) is provided with a slot (57) to convey conductors of power or signals (58) through the opening (3) in the hub (2).

14. The steering wheel according to claim 13, wherein the slot (57) runs along the coils (53) of the coiled element (5).

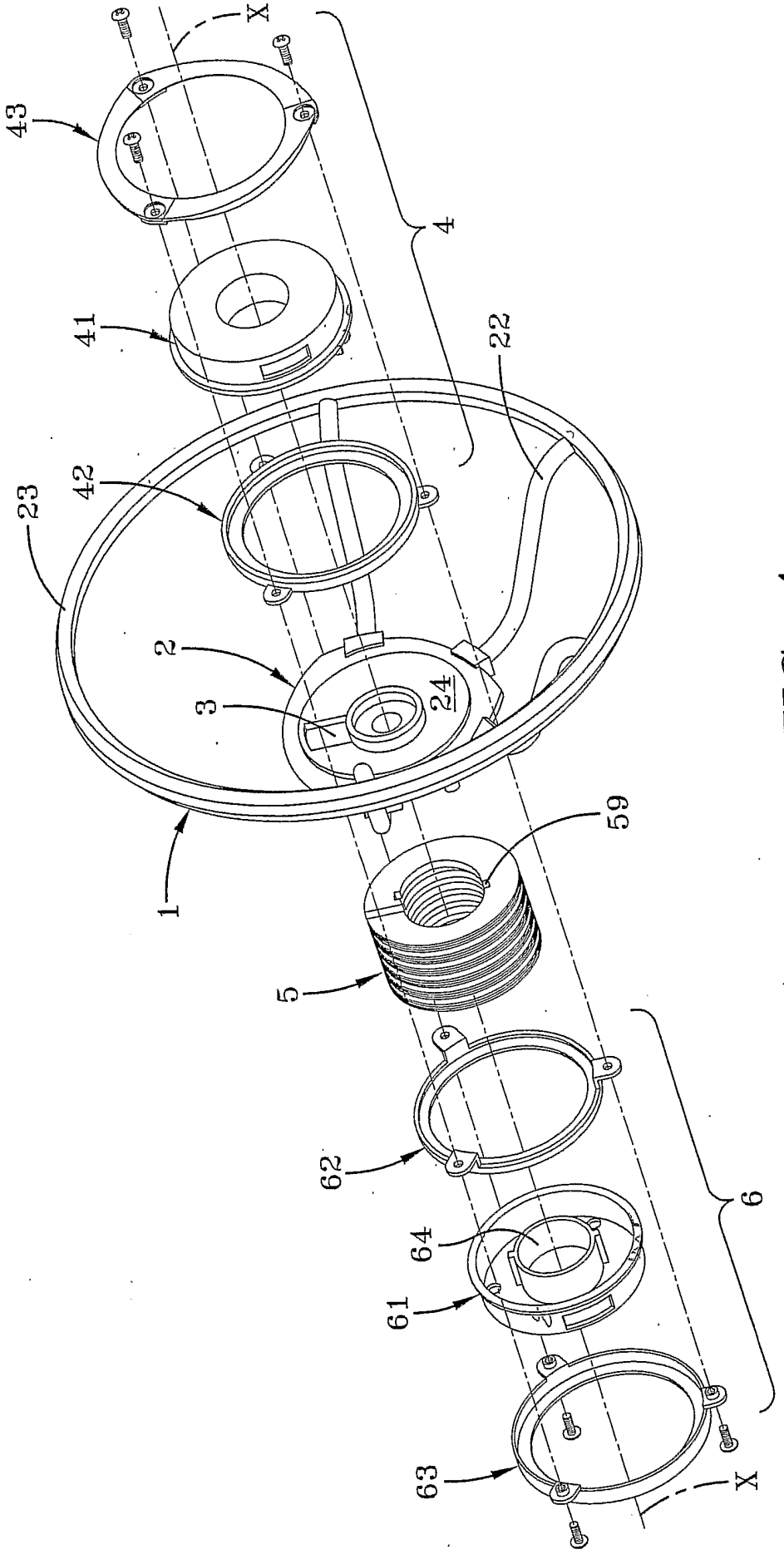

FIG-1

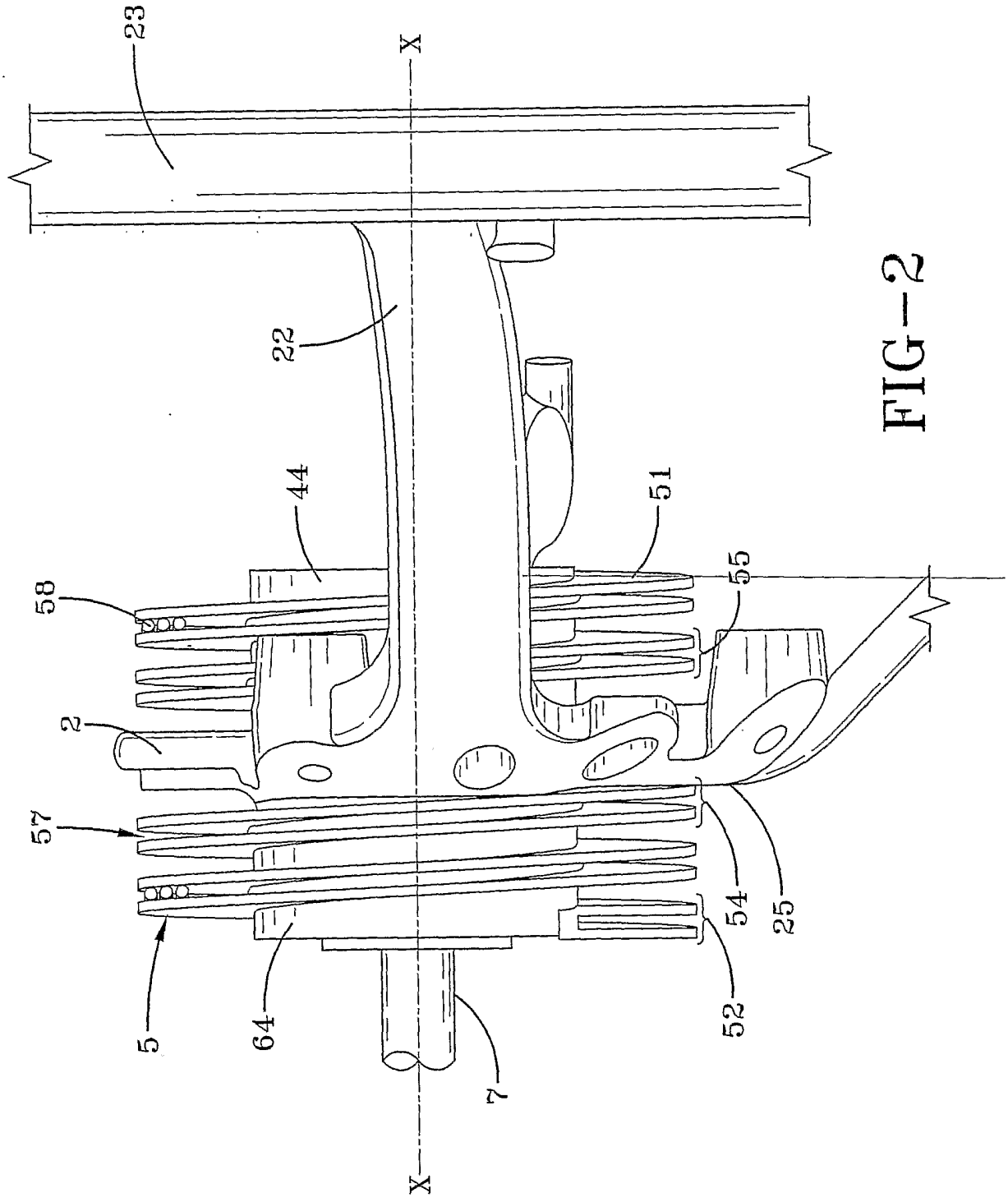

FIG-2

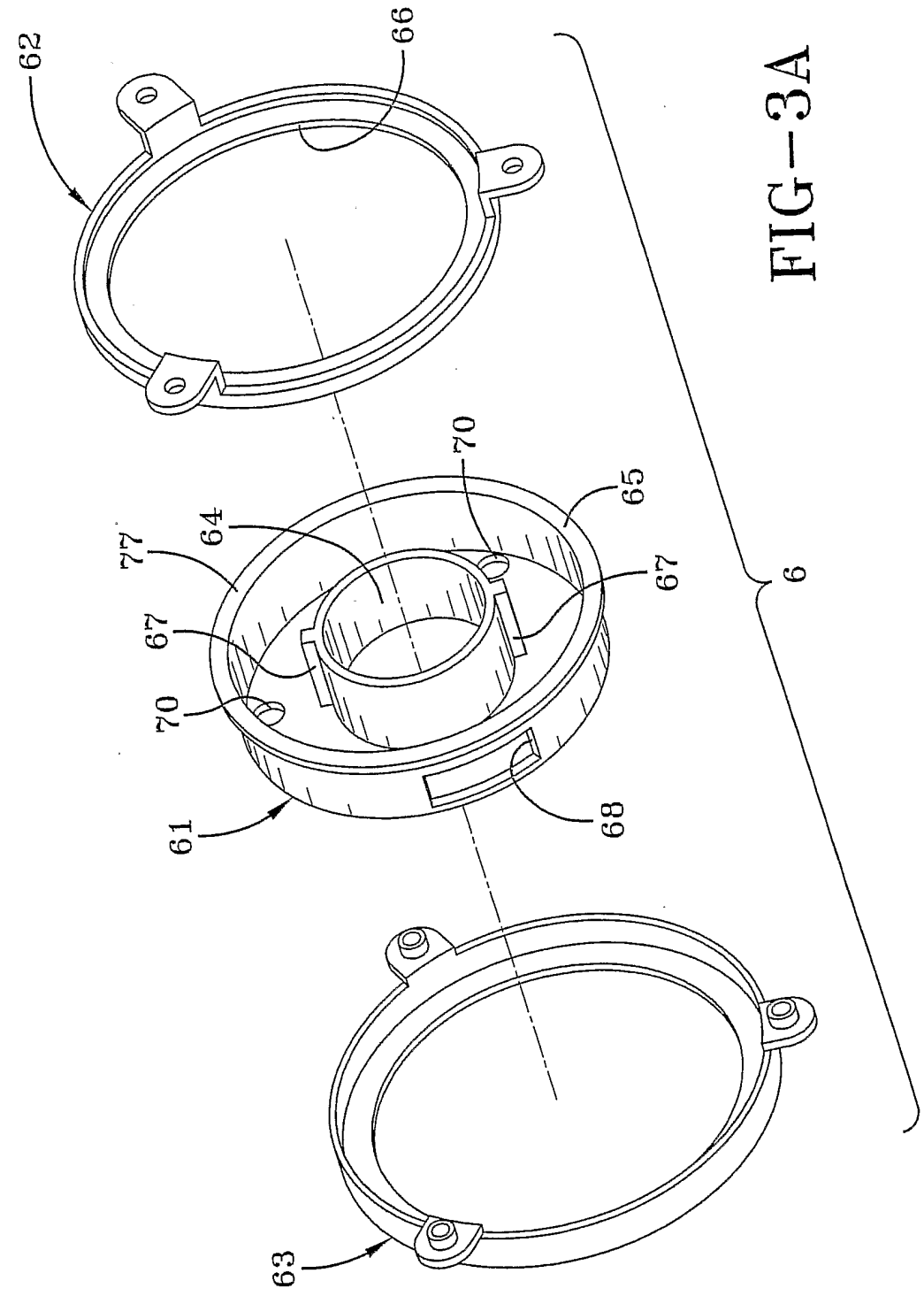

FIG-3A

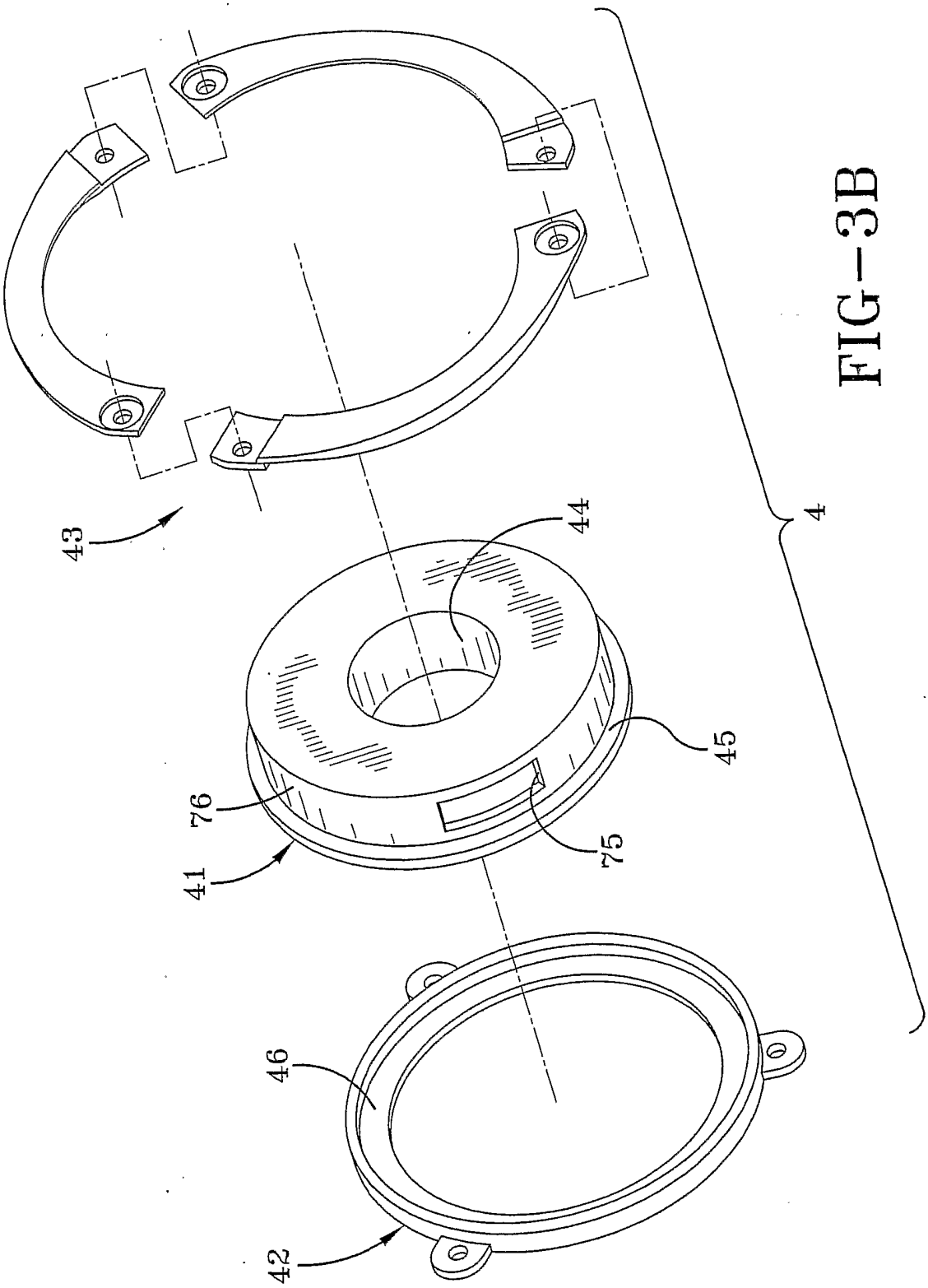

FIG-3B

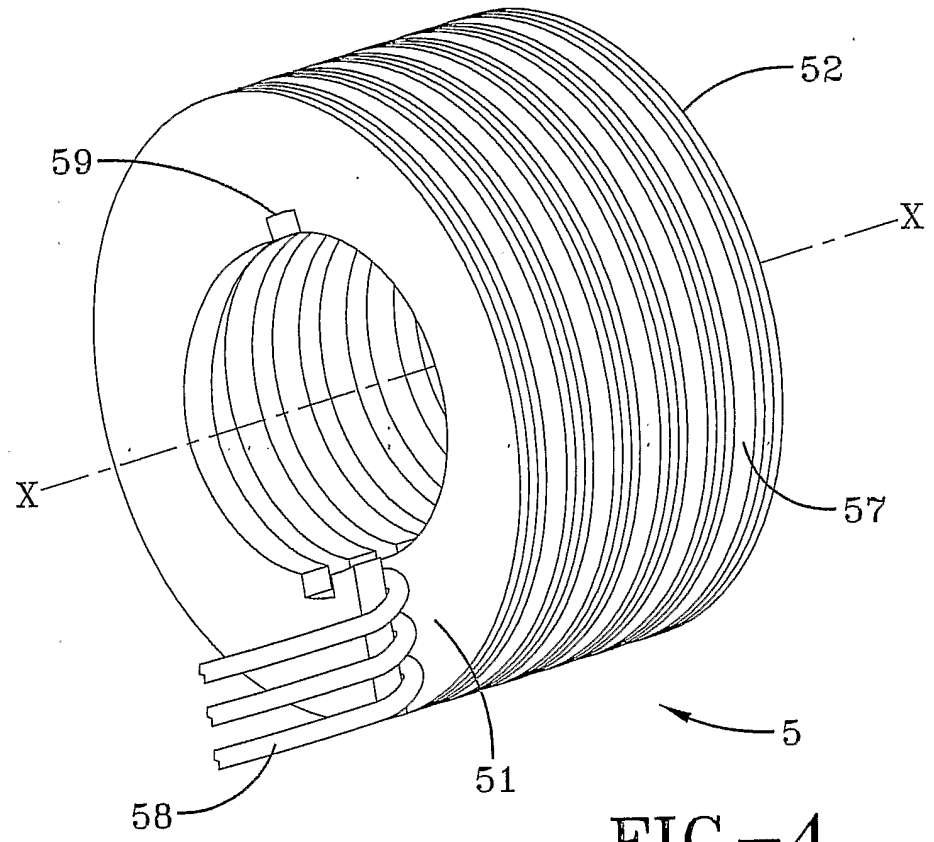

FIG-4

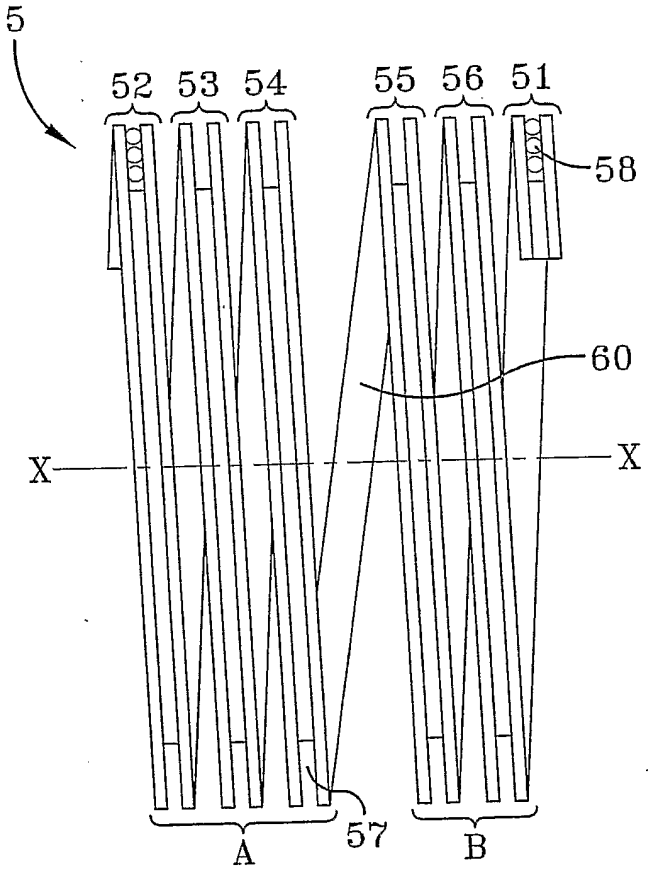

FIG-5

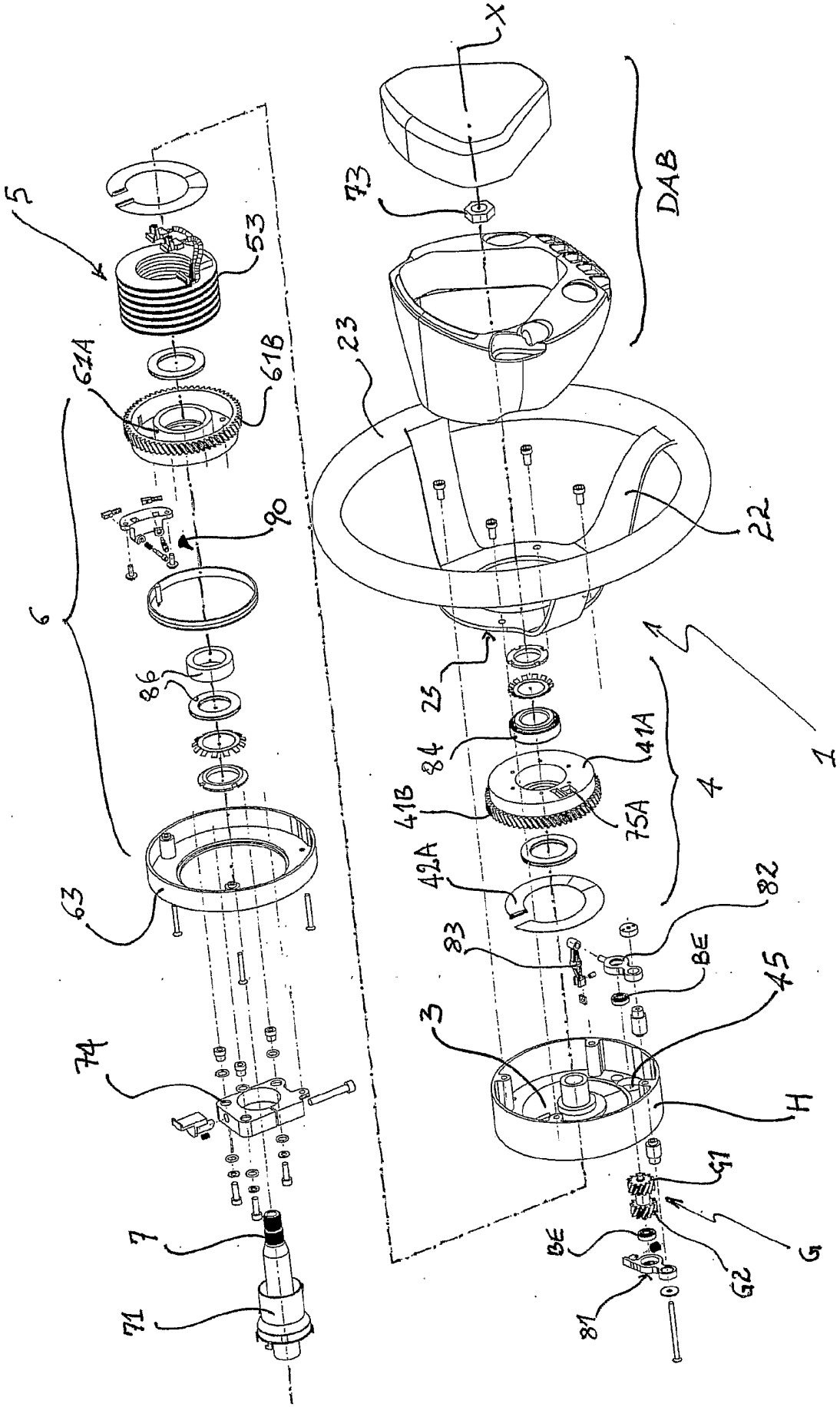
X
73
DAB
5
53
61A
61B
23
22
90
6
86
25
84
41A
1
41B
75A
4
42A
82
83
BE
45
3
74
H
63
7
71
41
G
G2
81
BE

FIG – 6

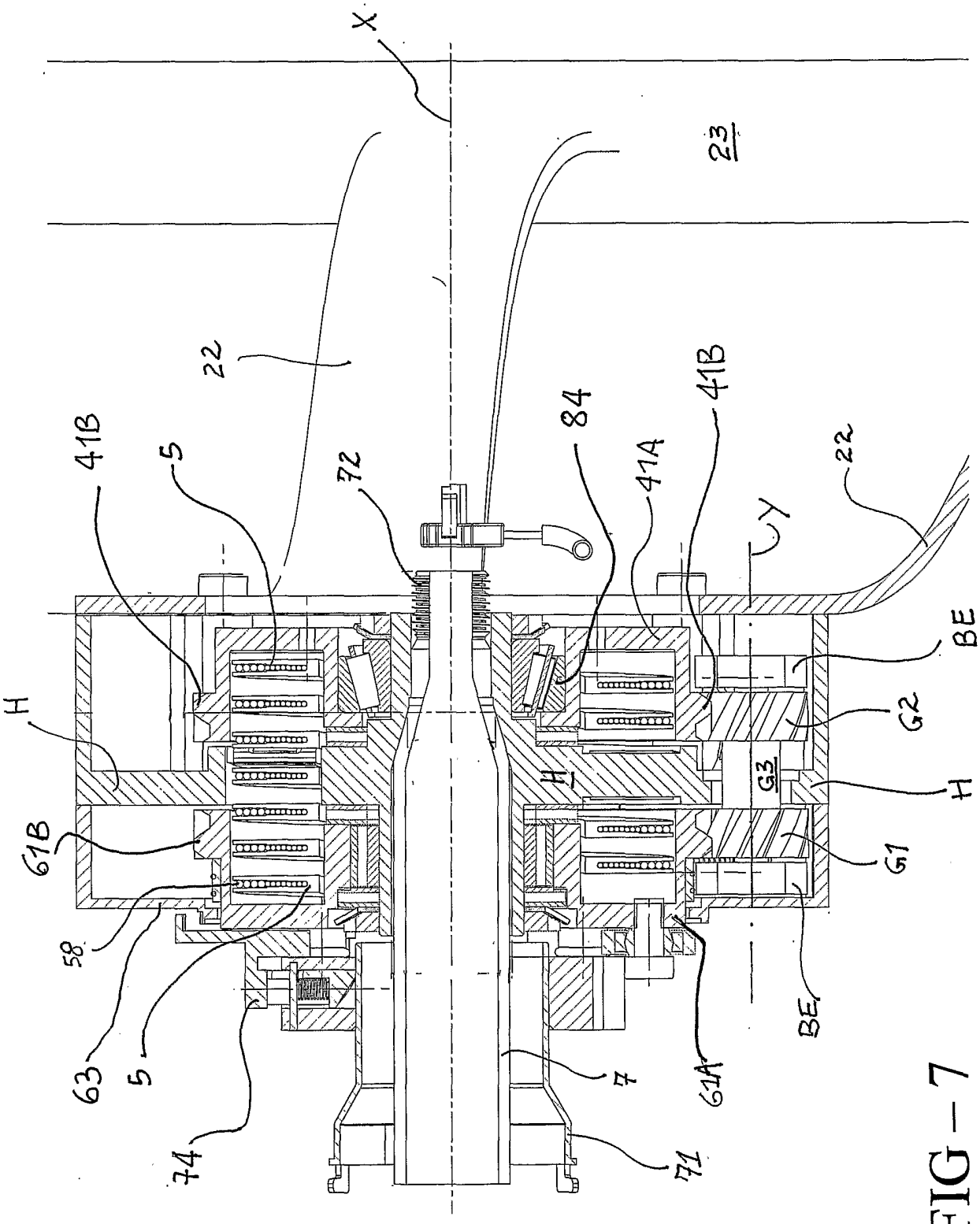
X
23
22
41B
5
72
84
41A
41B
22
Y
BE
H
G2
G3
H1
H
61B
G1
58
63
5
7
61A
BE
74
71

FIG – 7

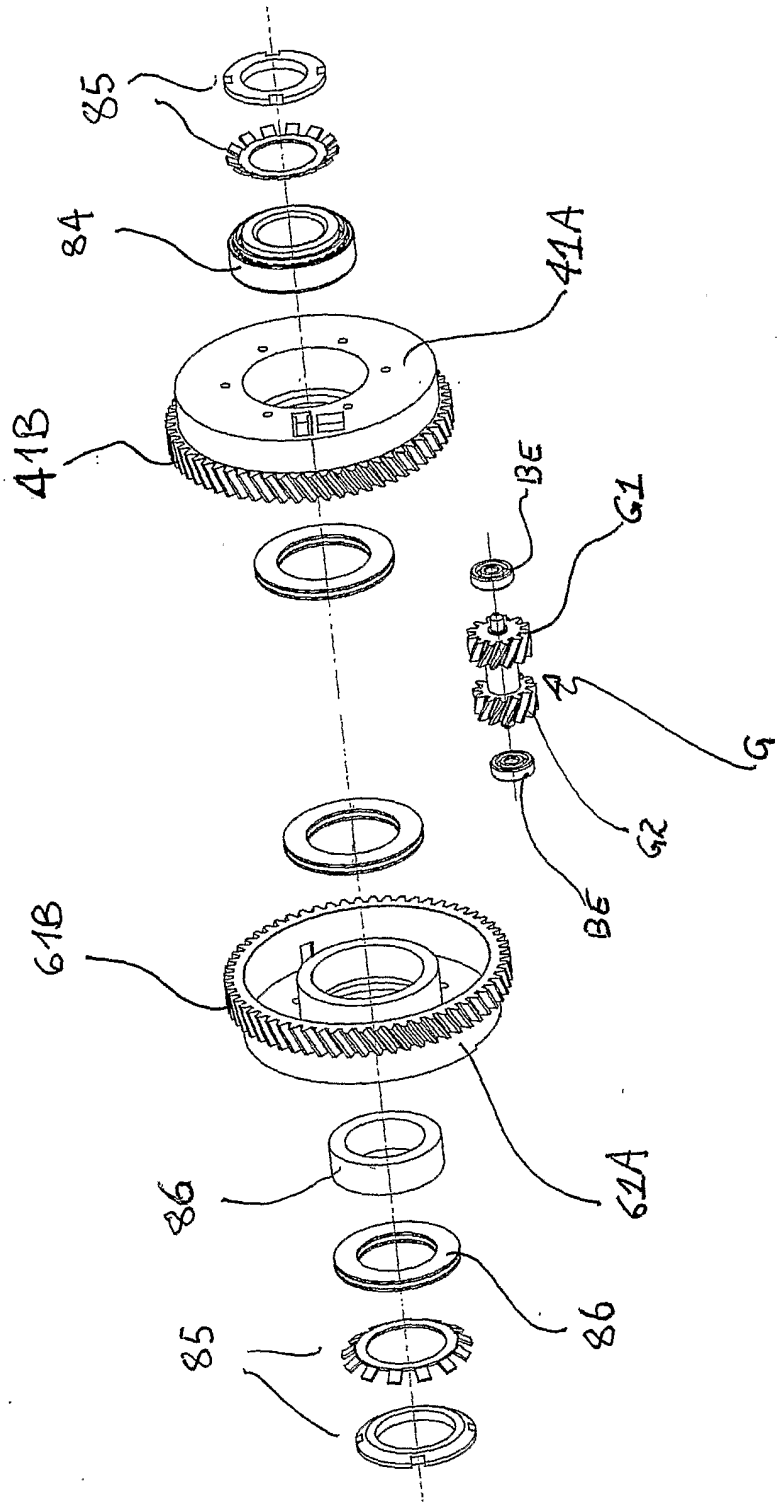

FIG – 8

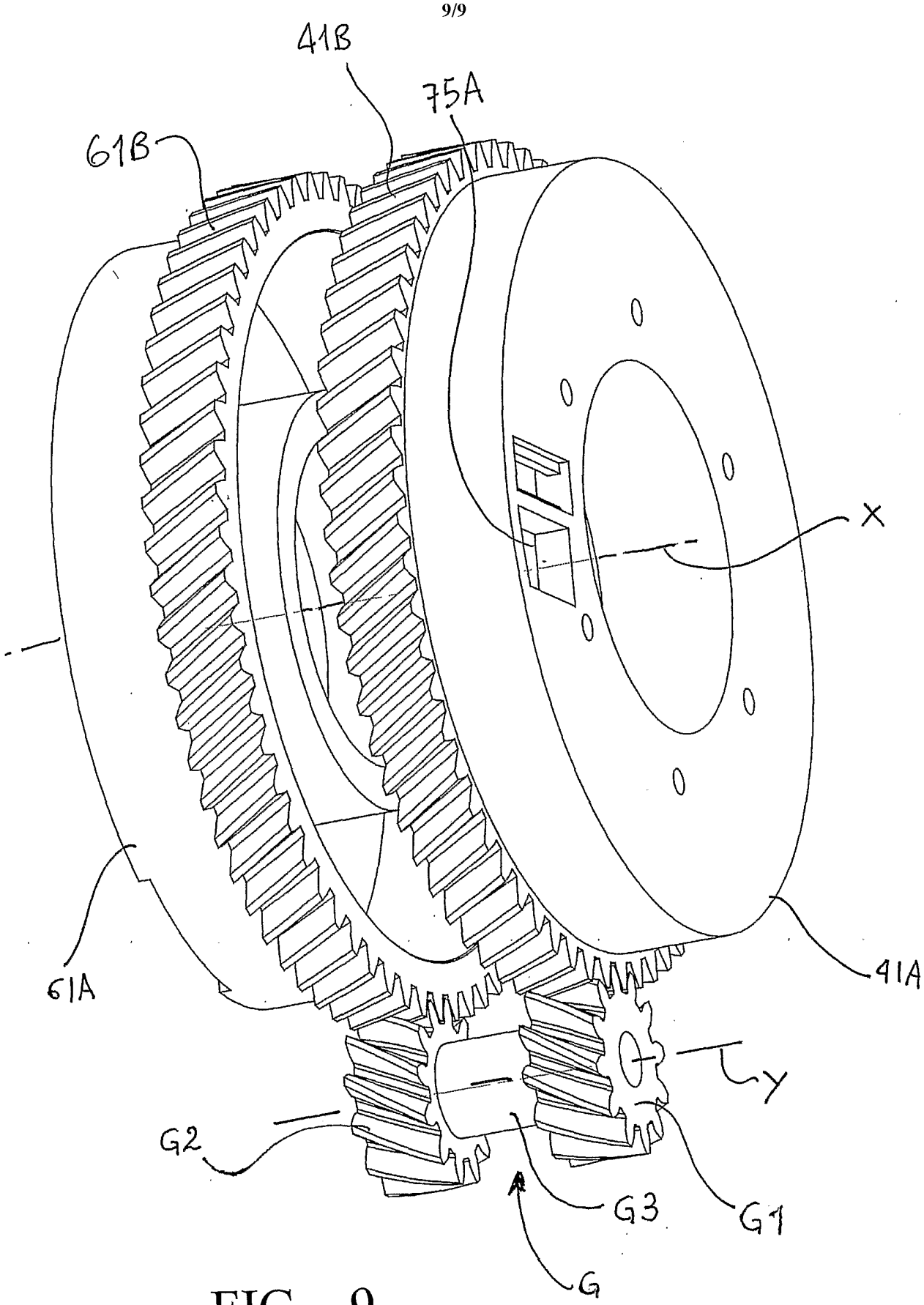

FIG – 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2006/000769

A. CLASSIFICATION OF SUBJECT MATTER
INV. B62D1/10 B60R16/02

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)
B62D B60R

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.
P,X	DE 20 2005 003848 U1 (TRW AUTOMOTIVE SAFETY SYS GMBH [DE]) 30 June 2005 (2005-06-30) paragraphs [0015] - [0021]; figures	1-8,10, 12
X	US 4 572 313 A (ONO ET AL) 25 February 1986 (1986-02-25) column 2, line 14 - column 3, line 65; figures 3-8	1-7,9, 11-14
X	US 4 541 301 A (ONO ET AL) 17 September 1985 (1985-09-17) cited in the application column 2, line 20 - column 5, line 12; figures	1-3,7,9, 11-14

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

[X] 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

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"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 June 2006	08/08/2006

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	Kulozik, E

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2006/000769

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 314 887 A (BAYERISCHE MOTOREN WERKE AG) 10 May 1989 (1989-05-10) column 4, line 5 - column 5, line 5; figure 3	1-3,7, 10,12

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2006/000769

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 202005003848 U1	30-06-2005	NONE	
US 4572313 A	25-02-1986	JP 60018434 A	30-01-1985
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EP 0314887 A	10-05-1989	DE 3737165 A1	18-05-1989