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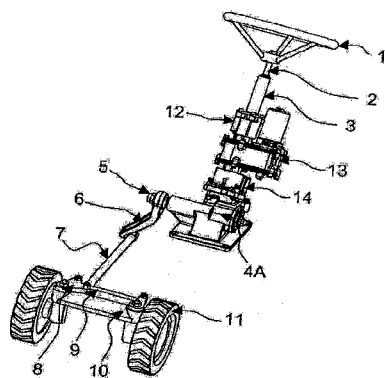
(54) **Title:** ELECTRIC POWER STEERING SYSTEM FOR FARM AND UTILITY TRACTORS

Figure 4

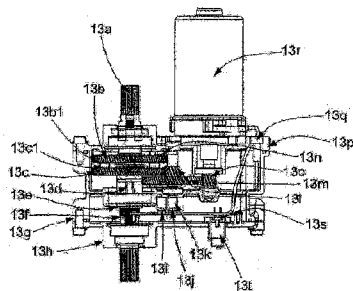


Figure 5

(57) **Abstract:** An electric power steering system for farm and utility tractors segment incorporates a unique and innovative electric power steering module (13) between steering gear box (4A) and steering shaft (2) of the manual steering system, thus making it a safe and much more reliable power steering system for tractors since it also has mechanical linkages present between various components. The electric power steering module (13) provides steering assist to the driver and is connected to steering shaft (2) via coupler inside upper bracket (12) and to steering gear box (4A) via coupler inside lower bracket (14). The electric power steering module (13) has a torsion bar (13d), an integrated torque sensor and integrated electronic control unit assembly (13s) on a printed circuit board for cost effective design, a motor (13r) and a robust reduction gear train comprising motor pinion (13o), intermediate gear (13m), intermediate pinion (131), and output gear (13c) mechanism.

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ELECTRIC POWER STEERING SYSTEM FOR FARM AND UTILITY TRACTORS

Technical Field

The subject matter of the present invention relates to an electric power steering system for farm and utility tractors having an integrated steering electronic control unit (ECU) and torque sensor.

Background

Conventionally in farm tractors having power less than 50 horsepower, manual steering systems are used, the schematic view of which is illustrated in Fig.1. In general and as schematically shown in Fig.1, the manual steering system comprises a steering wheel (1) which is mounted on a steering shaft (2) passing through a steering jacket (3). The steering shaft (2) is further connected to a steering gear box (4) having a sector shaft (5) and a drop arm (6).

An internal schematic of the steering gear box (4) used in manual steering systems for utility tractors is illustrated in Fig.2. A worm shaft (4a) is mounted in the gear box housing (4e) with the support of a lower spherical roller ball bearing (4d) and an upper spherical roller ball bearing (4g). A ball nut assembly (4b) is mounted on the worm shaft (4a). The worm shaft (4a) and ball nut assembly (4b) are perpendicular to each other. The sector shaft (5) is attached to the ball nut assembly (4b) by a dovetail guide (4c). As shown in Fig., 2, the drop arm (6) is mounted on the sector shaft (5). When the worm shaft (4a) is rotated in clockwise or anticlockwise direction, the ball nut assembly (4b) moves up or down respectively. The movement of the ball nut assembly (4b) enables rotation of the sector shaft (5) and hence, the drop arm (6) mounted on the sector shaft (5).

Referring Fig. 1, the drop arm (6) is connected to a steering knuckle arm (8) through a tie rod (7). The steering knuckle arm (8) is further connected by drag link (9). When the driver applies steering force on the steering wheel (1), the steering system operates to steer the tires (11) mounted on the front axle beam (10) in the driver

intended direction. In such conventional manual steering systems, the torque required to steer a tractor depends on various parameters such as "road conditions, weight of the tractor, speed of the tractor and loading condition of the tractor, etc." and is usually as high as about 90 Nm. The complex structure of the manual steering system makes it very difficult and painful to use and causes fatigue to the driver in long run. Further, because of very high steering torque requirements, it becomes very difficult for old aged and female drivers to drive the tractor.

In order to overcome the abovementioned limitations of the manual steering system, especially for tractors having more than 50 horsepower, hydrostatic power steering systems are used, the schematic of which is shown in Fig.3. In a hydrostatic steering system, there are no mechanical linkages like manual steering and the torque required to steer the tractor using hydrostatic power steering system is between 2 to 10 Nm when the tractor engine is running. Thus, the required torque to steer a tractor using hydrostatic power steering system is much less as compared to the manual steering system. The steering operation in a hydrostatic system is performed using pressurized oil in a hydraulic steering cylinder (h6). The steering wheel (1) mounted on the steering shaft (2) and passing through the column jacket (3) is connected to a hydraulic motor/direction control valve (h1). A hydraulic steering pump (h3) is connected to the tractor engine via a belt and pulley arrangement. The hydraulic steering pump (h3) is also connected to an oil reservoir (h2). The hydraulic motor/direction control valve (h1) is further connected to a hydraulic steering cylinder (h6) via hose pipes (h4). The hydraulic steering cylinder (h6) is connected to a knuckle joint (h5) passing through a front axle beam (10). The knuckle joint (h5) is mechanically connected to the tires (11) of the tractor.

When the driver applies force on the steering wheel (1), the hydraulic motor/direction control valve (h1) rotates and opens a passage for hydraulic oil to move towards the hydraulic steering cylinder (h6) to turn the tire (11). To make steering easy, the

hydraulic motor/direction control valve (h1) is provided with pressurized oil coming from the oil reservoir (h2) through the hydraulic steering pump (h3).

The use of hydrostatic steering system though makes steering of the vehicle easy for the driver but is not safe in case of situation when oil comes out from the hydraulic steering cylinder or hose pipes due to many reasons including damage. If oil seal is leaked or hose pipes are damaged, the tractor is unable to be steered which indicates a big concern for the safety of the users.

The tractor with manual steering can be towed without any problem in case tractor engine is not working due to non-availability of steering capability because of the presence of mechanical linkages between various components, whereas, it requires special vehicle to tow the tractor in hydrostatic steering system whenever there is oil leakage from the hydraulic steering cylinder or hose pipes because of the absence of mechanical linkages which results in loss of steering capability.

In view of foregoing, it is highly desirable to alleviate the limitations of both manual and hydrostatic steering systems respectively. Therefore, the present invention proposes an easy, less complex and safe steering system to be used by farm and utility tractors without loss of mechanical linkages and using state of the art EPS technology specially developed for tractors.

Summary

It is an object of the present invention to provide a compact, less complex and cost effective steering system.

It is another object of the present invention to provide a simple electric power steering (EPS) system for farm and utility tractors.

It is yet another object of the present invention to provide a safe and reliable steering system in various vulnerable conditions.

Brief Description of the Drawings

The foregoing and further objects, features and advantages of the invention will become apparent from the following description of example embodiments with reference to the accompanying drawings, wherein like numerals are used to represent like elements and wherein:

Fig. 1 is a schematic illustration of manual steering system used in tractors.

Fig. 2 is an isolated, internal schematic view of the steering gear box of the manual steering system of fig. 1.

Fig. 3 is a schematic illustration of the hydrostatic power steering used in tractors rating above 50 horse power.

Fig. 4 is a schematic illustration of an EPS system having mechanical linkages, in accordance with an aspect of the present invention.

Fig. 5 is an isolated, partially schematic, cross-sectional view of the EPS module/unit of EPS system of fig. 4.

Fig. 6 is an exploded view of the EPS module/unit of EPS system of fig. 4.

Fig. 7 shows schematic of position of sensor chips on integrated electronic control board and magnets for torque sensing, in accordance with an aspect of the present invention.

Detailed Description of the Invention

Referring in greater detail to the drawings, in which like numerals refer to like parts throughout the several views, examples of embodiments of the present invention are described in the following description.

It is an aspect of the present invention to provide an Electric Power Steering (EPS) system for farm and utility tractor segment with an integrated torque sensor and electronic control unit on a printed circuit board such that the torque sensor circuit is in-built in the electronic control unit. This eliminates the undesirable need of an external wire harness and connectors used to connect torque sensor and electronic control unit placed on different printed circuit boards in the conventional EPS systems.

Fig. 4 shows an EPS system for farm tractors in accordance with one embodiment of the present invention. To convert a manual steering into power steering, an EPS module (13) is placed in between steering gear box (4A) and steering shaft (2) of the steering system, which carries the steering wheel (1). The EPS module (13) provides steering assist to the driver and the EPS module (13) in the present invention is connected to steering shaft (2) via coupler inside upper bracket (12) and to steering gear box (4A) via coupler inside lower bracket (14).

Referring Figs. 5 & 6, the schematic and exploded views of proposed EPS module (13) are shown respectively in accordance with an aspect of the present invention. When force is applied at the steering wheel (1) (shown in Fig. 4) which is mounted on a steering shaft (2), it causes the input shaft (13a) which is connected to steering shaft (2) via coupler inside upper bracket to rotate and creates twist in the torsion bar (13d) (i.e., it experiences torsion) which further, causes rotation of the output shaft (13f). The input shaft (13a) and output shaft (13f) are connected by way of a torsion bar (13d) such that one end of a torsion bar (13d) rotates with the input shaft (13a) and the other end rotates with the output shaft (13f).

It is also an embodiment of the present invention to restrict the twisting in the torsion bar (13d) within elastic limits by way of any mechanical means so as to prevent hysteresis in the torsion bar (13d) and protect it from getting damaged. To control excessive twisting of the torsion bar (13d), an EPS module (13) in the present

invention incorporates an input gear female stopper (13b1) and output gear male stopper (13c1).

The rotation or rotational motion of the input shaft (13a) and output shaft (13f) is transmitted to input sensor pinion (13n) and output sensor cum intermediate pinion (13l) through input gear (13b) and output gear (13c) respectively. The rotation of the input sensor pinion (13n) and output sensor cum intermediate pinion (13l) further causes rotation of the magnets (13j1 & 13j2) mounted on input sensor pinion (13n) and output sensor cum intermediate pinion (13l) respectively as shown in Fig. 7. The magnets (13j1 & 13j2) are supported by magnet holders (13k1 & 13k2) respectively. The rotation angle of magnets (13j1 & 13j2) are sensed by sensor chips (13i1 & 13i2) placed on an integrated electronic control unit assembly (13s) as shown in Fig. 7.

The rotation angle information sensed by the sensor chips (13i1 & 13i2) is converted into torque information that detects the torque or force applied at the input shaft connected to steering wheel (1) (shown in Fig. 4) and this torque information is sent to the microprocessor of an integrated electronic control unit assembly (13s) which further supplies electrical current to the motor (13r) based on the signals or torque information received from the torque sensor in-built in an electronic control unit through supply connector (13t).

After receiving information in the form of electrical current, the motor applies assisting torque to the output shaft (13f) that helps rotate the output shaft (13f) through motor pinion (13o), intermediate gear (13m), intermediate pinion (13l) and output gear (13c).

Referring Fig. 4, the output shaft (13f) of EPS module (13) is connected to steering gear box (4A) via coupler inside lower bracket (14) having a sector shaft (5) and drop arm (6). The drop arm (6) is connected to tie rod (7) and tie rod (7) is connected to steering knuckle arm (8) which is further connected by drag link (9). The torque at

the output shaft (sum of torque applied at the steering wheel (1) and the assist torque provided by motor (13r)) helps turn the tires (11) mounted on front axle beam (10).

According to an aspect of the present invention, an EPS module (13) has an integrated housing (13g), an upper cover (13p) and a lower cover (13h). The upper cover (13p) and the lower cover (13h) are fastened with the integrated housing (13g) by means of fasteners (13q) such as bolts, nuts, rivets etc.

While the preferred embodiment of the invention has been described above, it will be recognized and understood that various modifications may be made therein and the appended claims are intended to cover all such modifications that may fall within the spirit and scope of the invention.

We claim:

1. An electric power steering system for farm and utility tractors comprising an electric power steering module placed between a steering gear box and a steering shaft, the electric power steering module comprising
an input shaft;
an output shaft;
a torsion bar connecting the input shaft and the output shaft such that one end of the torsion bar rotates with the input shaft and the other end rotates with the output shaft;
an integrated torque sensor and steering electronic control unit assembly on a printed circuit board, wherein said torque sensor is in-built in said electronic control unit;
a driving means for rotating the output shaft on receiving electrical current from said steering electronic control unit; and
a gear transmission for transferring motion from the driving means to the output shaft.
2. The electric power steering system as claimed in claim 1, wherein the input shaft is connected to the steering shaft such that the input shaft starts rotating on applying force on a steering wheel mounted on the steering shaft.
3. The electric power steering system as claimed in claim 1 or 2, wherein there is rotation of the output shaft with rotation in the input shaft.
4. The electric power steering system as claimed in any of the preceding claims, wherein rotational motion of the input shaft is transferred to an input sensor pinion through an input gear.
5. The electric power steering system as claimed in any of the preceding claims, wherein rotational motion of the output shaft is transferred to an output sensor cum intermediate pinion through an output gear.

6. The electric power steering system as claimed in claim 4 or 5, wherein rotational motion of the input sensor pinion and output sensor cum intermediate pinion is transferred to magnets mounted on the input sensor pinion and the output sensor cum intermediate pinion.
7. The electric power steering system as claimed in claim 6, wherein rotation angle of said magnets is sensed by sensor chips placed on said integrated electronic control unit assembly.
8. The electric power steering system as claimed in claim 7, wherein rotation angle information sensed by said sensor chips is converted into torque information and sent to said steering electronic control unit;
9. The electric power steering system as claimed in any of the preceding claims, wherein said steering electronic control unit sends electrical current proportional to the torque at the input shaft to the driving means and driving means is a motor.
10. The electric power steering system as claimed in claim 1, wherein the gear transmission is in the form of a reduction gear train.
11. An electric power steering system, substantially as herein described with reference to, and as illustrated in, the accompanying drawings.

SHEET 1/7

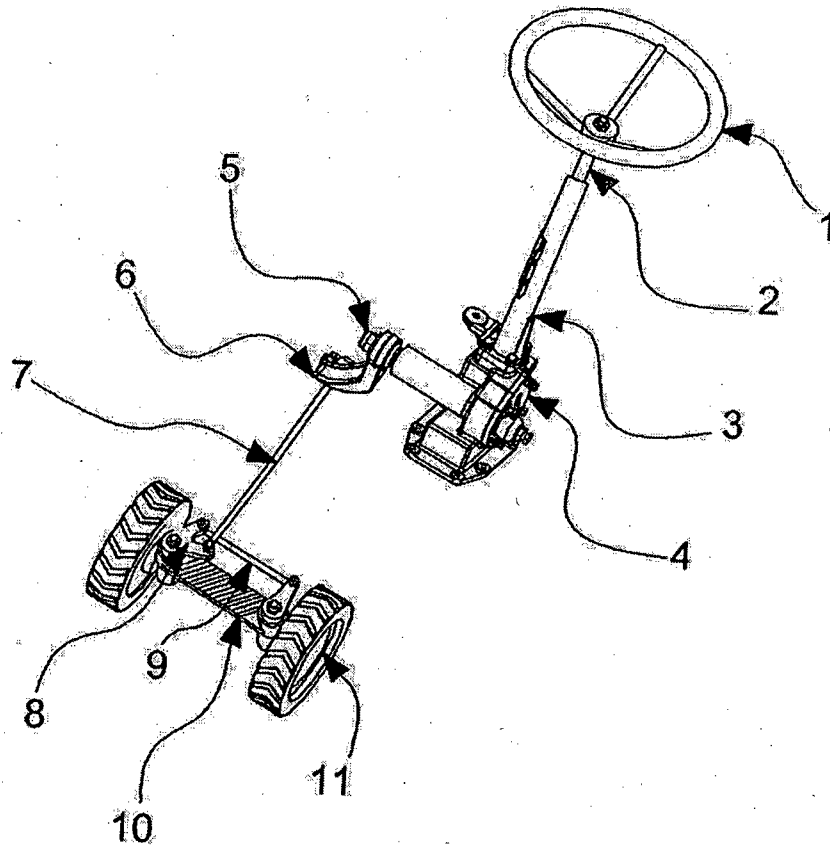


Figure 1

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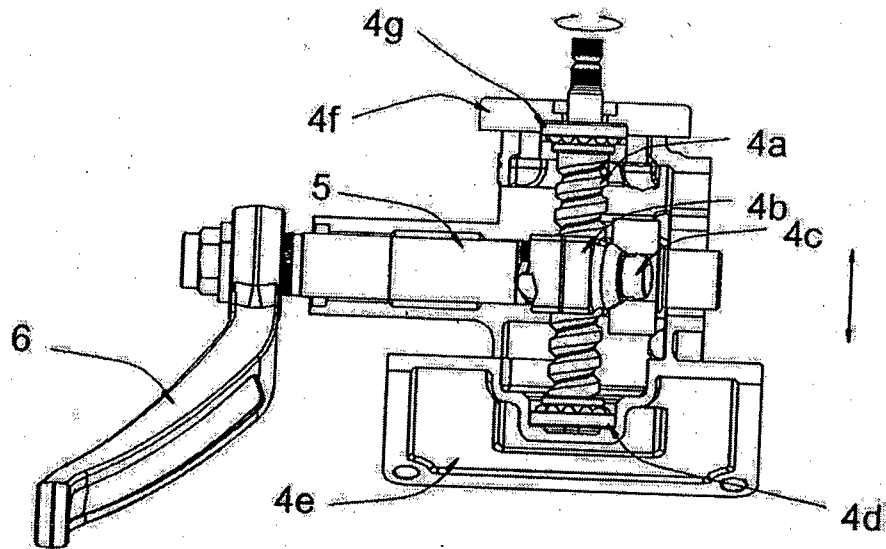


Figure 2

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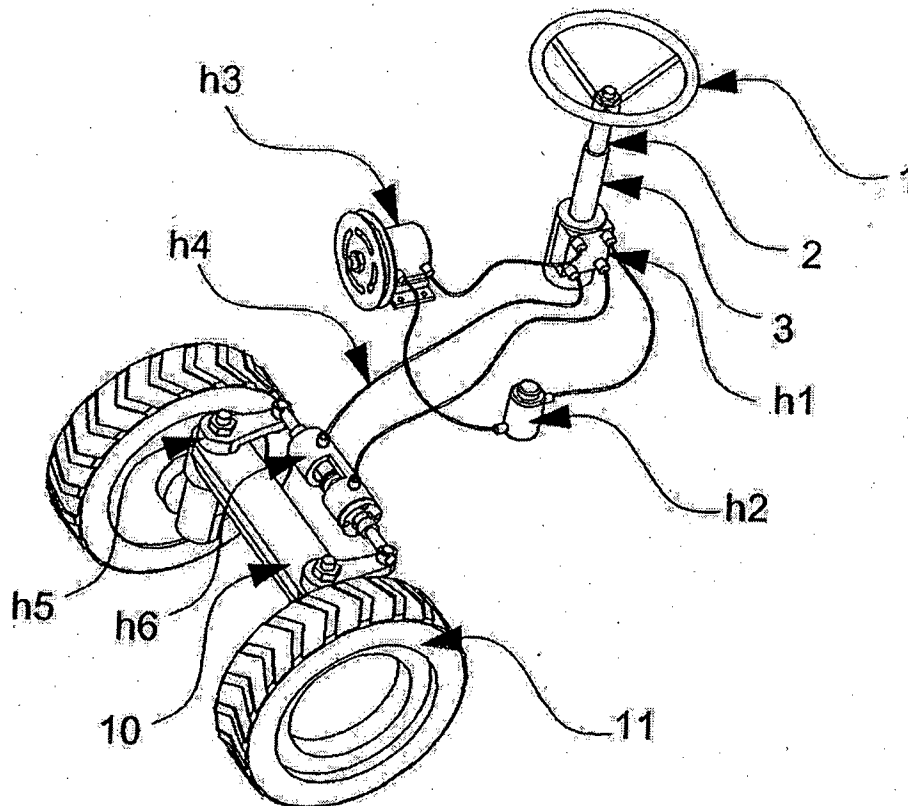


Figure 3

SHEET 4/7

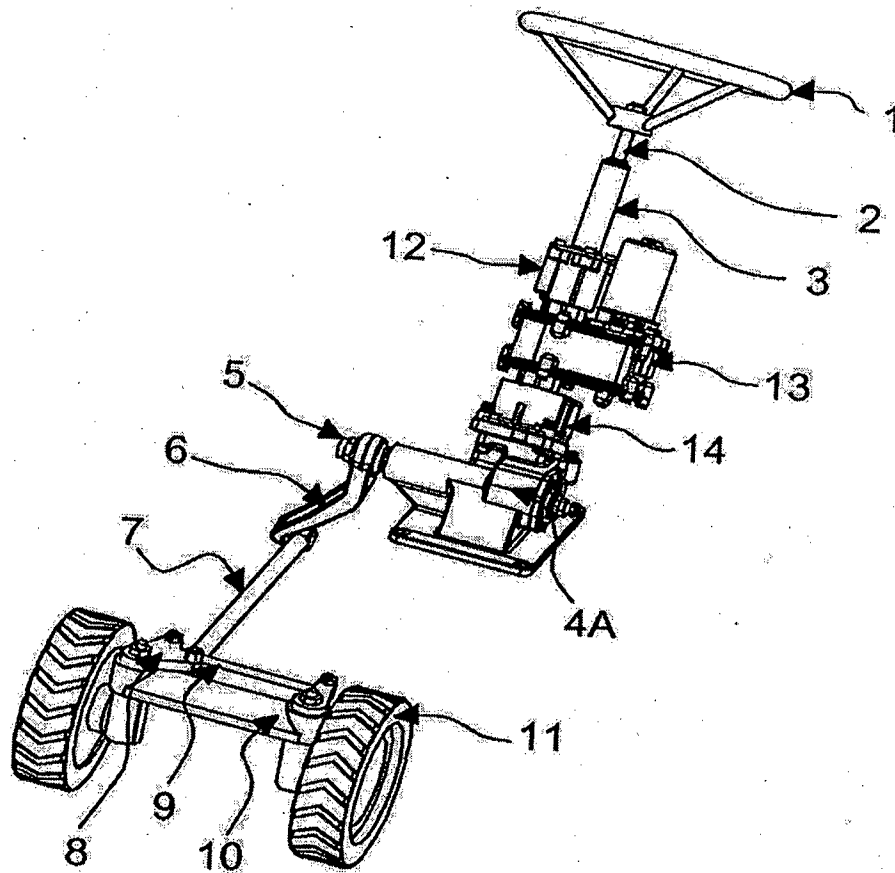


Figure 4

SHEET 5/7

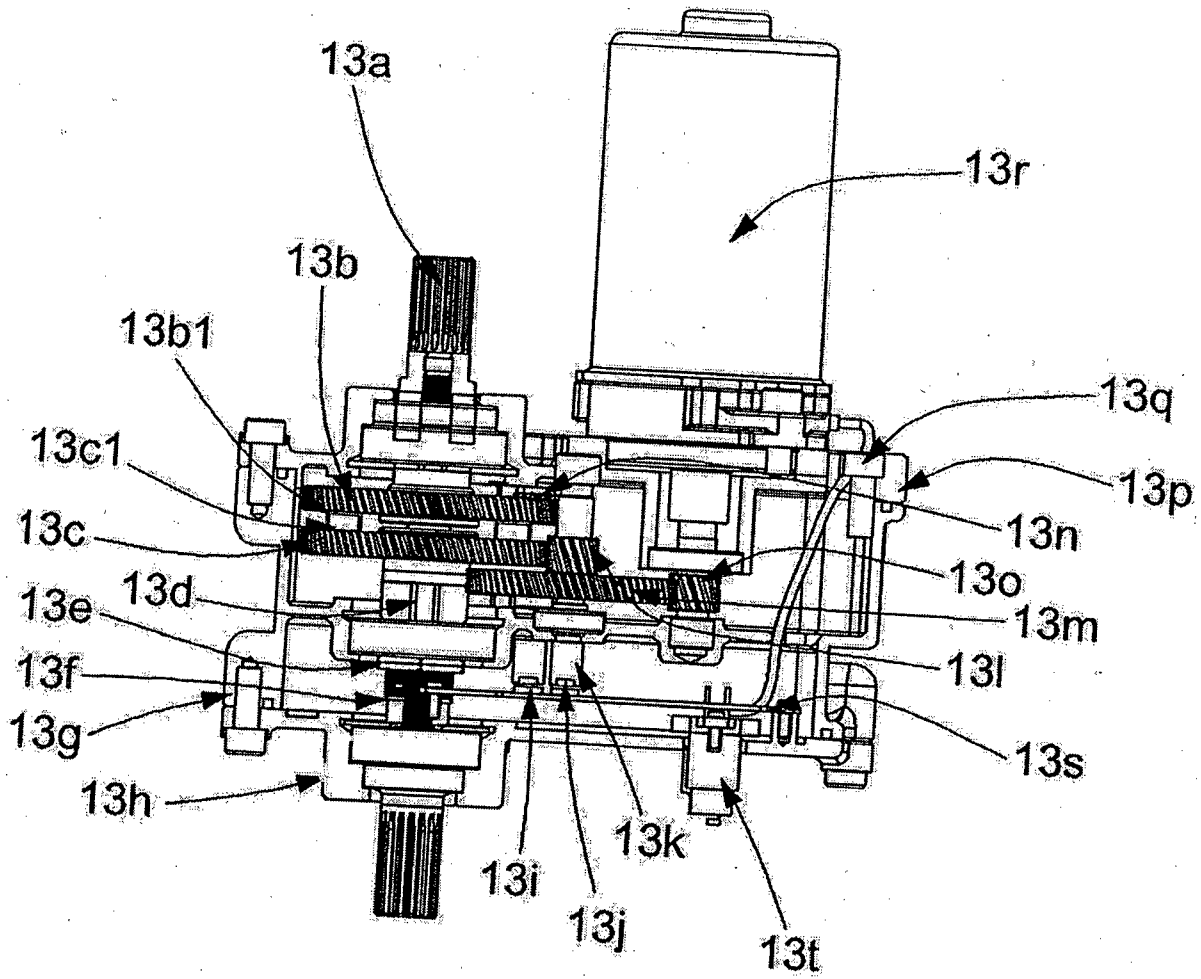


Figure 5

SHEET 6/7

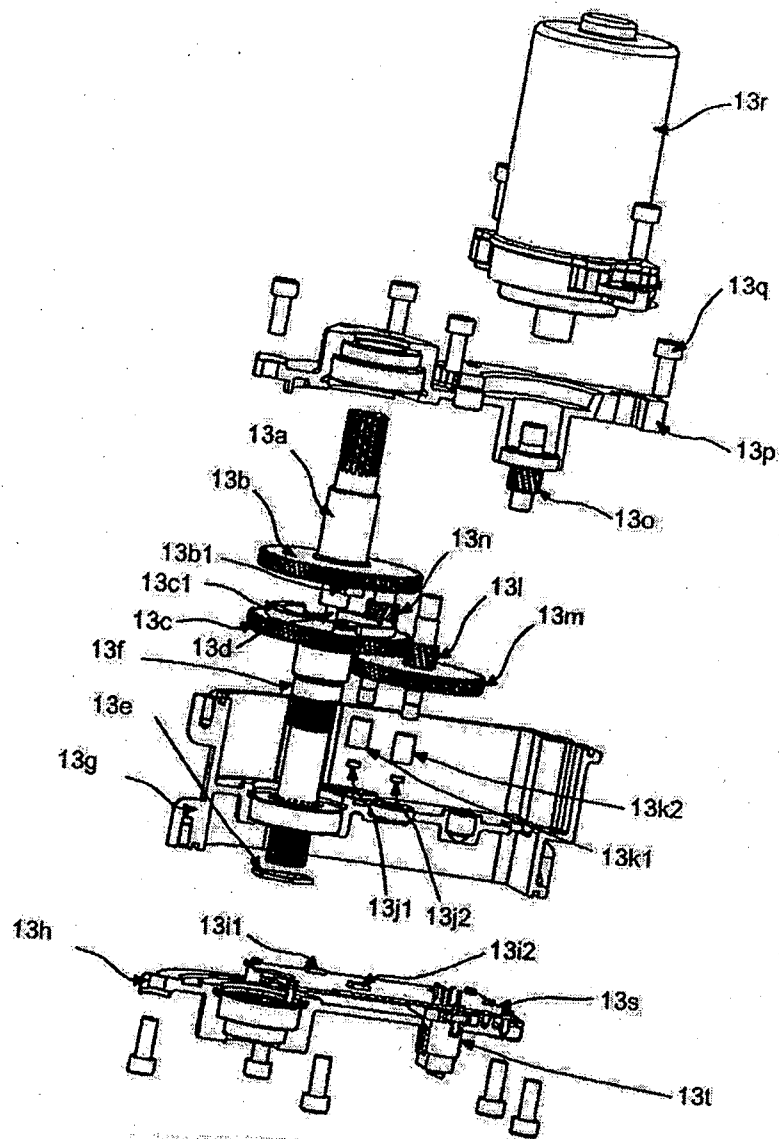


Figure 6

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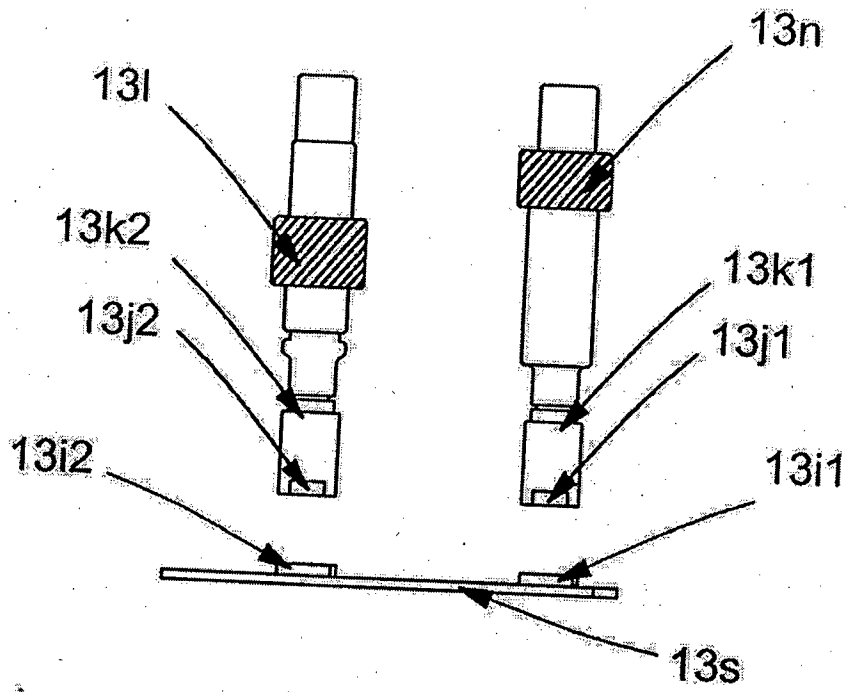


Figure 7