

An Axially-Compact Gear Assembly

Background of the Invention

The present invention relates to an axially-compact gear assembly, to communicate rotation about a first axis of rotation to rotation about a second axis of rotation.

In a typical coupling of a gear assembly, a drive motor, a rotary drive shaft and a gear shaft are spaced out in-line. That is the drive motor, the drive shaft and the gear shaft are axially mounted to transmit the torque generated by the motor to the gear shaft. Such in-line configurations are used in conventional transmission assemblies like pick, carry and place mechanisms, for example.

In one application, that is an apparatus for furling sails on sailboats, as disclosed in US Patent No. 5,493,988, the driving device for the sails comprises a worm gear and is accommodated internally within a space in the worm gear inside its worm gear screw. The worm gear acts between the driving device and a sail furling stay and/or sail furling shaft on the mast.

In another application, that is a battery operated toothbrush, as disclosed for example in US patent No. 5,170,525, a battery powered motor drives a drive rod which in turn drives a rotary shaft, and then a bevel gear mechanism. In this disclosure, the motor, the rotary shaft and the bevel gear are in-line and spaced out axially. It is therefore, not possible to minimize the overall length of the toothbrush to make it compact, if desired.



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In another application, for example US Patent 5,970,813, a drive motor, a rotary drive shaft and a worm gear are also in-line, thereby not economizing on space configuration.

A disadvantage of such prior art gear transmission assemblies is that the overall axial dimension to house the in-line arrangement is more than is

sometimes desired. The usual solution is to miniaturize the components, but this may make it more expensive a product than is warranted.

Another disadvantage is to do with the torque required to overcome the inertia of a solid mass of the gear shaft and drive gear when a gear of a non-small diameter is required. The inertia depends on how far the mass of the gear is from the driving shaft. Whilst it may be advantageous in certain applications to have a high inertia, for e.g. traction required to move a car from a slippery surface, a reduction in the inertia force is usually advantageous in most rotary applications where torque is only applied for a short time to achieve precise translation e.g. in robotic grippers and end effectors.

These disadvantages of the prior art can be overcome with the present invention.

Summary of the Invention:

The present invention introduces a compact gear assembly comprising a drive motor within a hollow cavity of a gear shaft.

According to one aspect of the present invention, there is provided a gear assembly for communicating rotational movement, comprising a drive motor having a front portion and a rear portion; a drive shaft protruding from said motor; a gear shaft, having a driver gear on its outer surface and an axial hollow cavity; a front end and a rear end bearing rotatably mounting said gear shaft in a stationary housing; said drive shaft being coupled to said gear shaft to rotate said gear shaft about a first axis of rotation; said driver gear cooperating with a driven gear; and the majority of the axial length of the drive motor being located within the

hollow cavity of the gear shaft, or the drive motor extends within the majority of the axial length of the gear shaft, or both,

characterized in that to said stationery housing is fixed a motor sleeve in which said rear portion of said drive motor is fixedly mounted and into which one end of said gear shaft is inserted and journalled via said rear end bearing, and said front portion of said drive motor is housed with a close fit within said hollow cavity of said gear shaft.

Preferably, the said rear end bearing is a sleeved bearing.

Preferably, the gear is a wormed thread. Alternatively, other known gear threads like bevel gears may also be used to communicate the rotary movement of the drive.

Preferably, the said motor is axially fully within the said hollow cavity of the gear shaft.

Advantageously, the said arrangement reduces the overall axial distance required to house the assembly within the housing of the assembly. The hollow gear shaft also reduces the moment of inertia of the assembly.

Advantageously, the torque needed by the motor can be substantially reduced, or the torque applied by the gear can be increased and the precision of rotation of the said drive motor is increased as compared to conventional motor drives.

An embodiment of the invention provides an axially-compact gear assembly wherein a drive motor is provided within a hollow cavity of a gear shaft, the drive motor having a rotary drive shaft that is coupled to the said gear shaft by suitable locking means. The gear shaft is rotatably connected to the rear end of the drive motor by means of a rear end bearing located in a motor housing sleeve. The drive gear is meshed with a driven gear to provide translation movement, for example to multi-finger grippers, end effectors and the like. Providing the motor within the hollow cavity of the gear shaft allows for the reduction of the overall axial dimension of the gear assembly thereby reducing the physical space needed for such an assembly, as well as its weight.

Brief Description of the Drawings:

The present invention will now be further described by way of non-limitative example only with reference to the accompanying drawings, in which :-

Figure 1 shows a perspective exploded view of an embodiment of the gear assembly according to the invention;

Figure 2 shows a cross-sectional view of the gear assembly showing details of the various components of the exemplified embodiment of the invention.

Detailed Description of the Invention:

The present invention will now be described with reference to the preferred embodiments thereof and with reference to the drawings.

As can be seen in Figures 1 and 2, there is a gear assembly (11) which has a drive motor (1), a rotary drive shaft (4) and a gear shaft (2), all mounted in-line and axially to each other. The gear shaft (2) is rotatably mounted in a housing assembly (8) by means of front end bearing (5) and to a motor sleeve (10) by means of a rear end bearing (6). Such bearings may be friction bearings, such as roller bearings, sintered sleeve bearings, plastic sleeve bearings or the like.

Figure 2 show that the gear shaft (2) is hollow internally. However, the wall thickness of the gear shaft (2) is still sufficient to withstand the load required for the application to transfer the torque for transmission purposes. To the front of the gear shaft (2), and having a smaller outer and inner diameter than the main body of the gear shaft, there is a drive shaft contact portion (2b). In front of that, with an even smaller outer diameter is a sleeve bush (2c). In this embodiment the drive shaft contact portion (2b), sleeve bush (2c) and main

body of the gear shaft are integrally formed. The sleeve bush (2c), and thereby the whole gear shaft (2), is mounted for rotation by means of the front end bearing (5).

A drive motor (1) is housed for the most part within the hollow cavity of the gear shaft. The drive motor (1) is preferably a close fit as this can reduce vibrations. The rotary drive shaft (4), protrudes from the front end of the drive motor (1) and is located within the drive shaft contact portion (2b) of the gear shaft (2). The drive shaft preferably has the same or almost the same outer diameter as the inner diameter of the drive shaft contact portion. The gear shaft (2) is coupled to the drive shaft (4) by means of one or more set-screws (3) in the drive shaft contact portion (2b), or some other known form of coupling.

The outer annulus of the gear shaft (2) is provided with a driver gear (2a). This may be a suitable screw thread, for example a worm thread, as shown in Figure 2 in a worm gear application. Other types of thread or rack type teeth may also be used, depending on the application. The driver gear (2a) is used to drive a driven gear (7). The driven gear (7) may usually be a pinion wheel but can also be a rack, a helix gear or any other type of gear depending on the usage.

The rear portion of the drive motor (1) extends beyond the gear shaft (2) and is fixedly mounted within the motor sleeve (10). This too can be by means of set-screws (9) or other known locking means for locking the motor to the motor sleeve (10). The rear end of the gear shaft (2) extends into the motor sleeve (10), but only a short distance, at least sufficient that the gear shaft (2)

is rotatably mounted within the motor sleeve (10) by means of a rear end bearing (6), allowing the free rotation of the gear shaft (2). The motor sleeve (10), or at least the front portion of it, may be sintered metal or suitable plastic that reduces friction during rotation, or similar materials known, in which event the rear bearing (6) may be dispensed with.

In this form of setup, the sleeve (10) gives good alignment and stability during use, and provides a mounting point for the gear assembly (11) to the housing assembly (8).

The drive motor (1) is fixed to the housing assembly (8) by means of the motor sleeve (10). Thus it can cause the drive shaft (4) to rotate within the housing. However, the drive shaft (4) is in fixed contact with the gear shaft (2), via the drive shaft contact portion (2b). Thus rotation of the drive shaft (4) causes rotation of the gear shaft (2) in the front end bearing (5) and rear end bearing (6). This, in turn, achieves the rotation of the driven gear (7).

In the exemplified embodiment, the sleeve bush (2c) and drive shaft contact portions (2b) are shown as different diameters. However, that is not necessary. Moreover, these parts can be replaced with any other component or components that achieve the same result.

Further, although the motor sleeve (10) is shown as an integral item housing the motor and the rear end bearing (6), this can be replaced with one or more other components that achieve fixing of the motor to the housing and a rear bearing for the gear shaft (2). For instance, rather than fixing the motor to the housing by means of screws or the like along the side, the fixing can be in the

rear end face of the motor. An additional alternative, which such a fixing (as well as other possible fixings) would allow, would be for the motor to fit entirely within the drive gear (2).

Another possible alternative is to provide one or more bearings at different axial points along the outside of the motor to support the drive gear. It may then be possible to dispense with the motor sleeve completely.

Thus the present invention, by mounting at least the majority or all the axial length of the motor within the gear shaft (2), provides a saving of overall axial length over the prior art. Additionally, the hollow gear shaft has a much lower moment of inertia than that of the prior art, with improved response times and accuracy. Further, the lower inertia of the drive gear means that the same torque can be applied to the driven gear by a motor providing less torque than that needed in the prior art, or a motor providing the same torque leads to a higher torque being applied to the driven gear.

CLAIMS

1. A gear assembly for communicating rotational movement, comprising:
 - a drive motor (1) having a front portion and a rear portion;
 - a drive shaft (4) protruding from said motor;
 - a gear shaft (2) having a driver gear (2a) on its outer surface and an axial hollow cavity;
 - a front end and a rear end bearing (5 and 6) rotatably mounting said gear shaft in a stationary housing (8);
 - said drive shaft (4) being coupled to said gear shaft (2) to rotate said gear shaft about a first axis of rotation;
 - said driver gear (2a) cooperating with a driven gear (7); and
 - the majority of the axial length of the drive motor (1) being located within the hollow cavity of the gear shaft or the drive motor extends within the majority of the axial length of the gear shaft, or both,characterised in that
 - to said stationary housing (8) is fixed a motor sleeve (10)
 - in which said rear portion of said drive motor (1) is fixedly mounted and
 - into which one end of said gear shaft (2) is inserted and journaled via said rear end bearing (6), and
 - said front portion of said drive motor (1) is housed with a close fit within said hollow cavity of said gear shaft.

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2. A gear assembly according to claim 1, wherein said rear end bearing (6) is a sleeved bearing.
3. A gear assembly according to any one of the preceding claims, wherein the gear (2a) is a worm thread.
4. A gear assembly according to any one of the preceding claims, wherein said gear shaft includes a front end (2c) rotatably mounted via said front end bearing in said stationary housing.
5. A gear assembly according to any one of the preceding claims, wherein the gear shaft has a drive shaft contact portion (2b) into which said drive shaft is fixedly inserted, whereby said drive shaft contact portion (2b) has a smaller inner and a smaller outer diameter than the main body of the gear shaft.
6. A gear assembly according to any one of the preceding claims, wherein at least part of said driver gear (2a) and said driven gear (7) are axially at the same position as at least part of said motor.