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## (54) Flexible shaft starter

(57) A flexible shaft starter system for an internal combustion engine of a recreational vehicle. The internal combustion engine is mounted to a chassis of the recreational vehicle and has at least one driven member. The flexible shaft starter system includes a starter having an output shaft and is mounted remotely from the engine; and a flexible shaft having a first and second end, the first end being driven by the output shaft of the starter and the second end driving the at least one driven member.

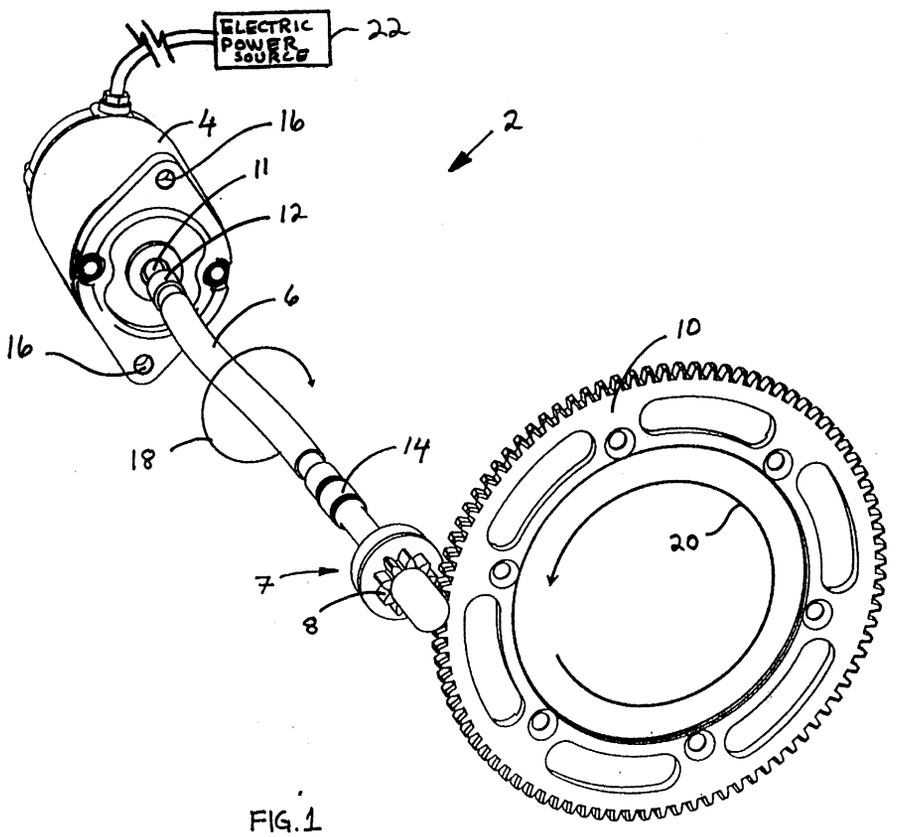


FIG. 1

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## Description

### TECHNICAL FIELD

**[0001]** The present invention relates to a flexible shaft starter. More particularly, the present invention relates to a flexible shaft starter apparatus, system and method for an internal combustion engine.

### BACKGROUND

**[0002]** Conventional starters for internal combustion engines are generally mounted to the engine. For example, electric starter motors are generally mounted to the engine of a vehicle to be powered by the engine. As a result, many failures of electric starter motors mounted to the engine can be traced to engine induced vibration. Furthermore, mounting the starter motor directly to the engine limits how the engine may be positioned within a chassis of the vehicle. For example, it is desirable to have a low center of gravity for certain vehicles (e.g., recreational vehicles such as snowmobiles). How low the engine is situated within the vehicle chassis determines how low the center of gravity can be. Accordingly, mounting the starter motor to the engine impacts the vehicle's overall center of gravity since space must be made available to accommodate the starter motor.

### SUMMARY

**[0003]** The present invention relates generally to a flexible shaft starter. For example, the present invention relates to a flexible shaft starter for starting an internal combustion engine of a vehicle. The starter motor is mounted remotely from the engine, which is a relatively high vibration area, and for example is mounted to the vehicle's chassis, which is a relatively low vibration area.

**[0004]** One aspect of the invention provides an internal combustion engine assembly for a vehicle to be mounted to a chassis of the vehicle. The engine assembly includes an internal combustion engine; a starter having an output shaft and being mounted to the chassis remotely from the engine; and a flexible shaft having a first and second end, the first end being driven by the output shaft of the starter and the second end driving at least one driven member of the engine.

**[0005]** Another aspect of the invention provides a flexible shaft starter system for an internal combustion engine of a vehicle (e.g., a recreational vehicle). The internal combustion engine is mounted to a chassis of the recreational vehicle and has at least one driven member. The flexible shaft starter system includes a starter having an output shaft and is mounted to the chassis remotely from the engine; and a flexible shaft having a first and second end, the first end being driven by the output shaft of the starter and the second end driving the at least one driven member of the engine.

**[0006]** Still another aspect of the invention provides a flexible shaft starter kit for an internal combustion engine of a recreational vehicle, the internal combustion engine being mounted to a chassis of the recreational vehicle and having at least one driven member. The flexible shaft starter kit includes a starter having an output shaft and being adapted for mounting to the chassis of the recreational vehicle; and a flexible shaft having a first and second end, the first end being adapted to be driven by the output shaft of the starter and the second end being adapted to drive the at least one driven member.

**[0007]** Yet another aspect of the invention provides a recreational vehicle. The recreational vehicle includes an internal combustion engine mounted to a chassis of the recreational vehicle and having at least one driven member; a starter having an output shaft and being mounted to the chassis of the recreational vehicle remotely from the engine; and a flexible shaft having a first and second end, the first end being driven by the output shaft of the starter and the second end driving the at least one driven member.

**[0008]** Still another aspect of the invention provides a method of starting an internal combustion engine of a recreational vehicle, the internal combustion engine being mounted to a chassis of the recreational vehicle and having at least one driven member. The internal combustion engine is in communication with a starter having an output shaft and being mounted to the chassis of the recreational vehicle remotely from the engine. The output shaft of the starter is coupled to a flexible shaft having a first and second end, the first end being driven by the output shaft of the starter and the second end being adapted to drive the at least one driven member of the engine. The method includes actuating the starter to rotate the output shaft; and transferring the rotation of the output shaft of the starter to the at least one driven member through the flexible shaft.

**[0009]** For a better understanding of the invention reference should be made to the drawings which form a further part hereof, and to the accompanying descriptive matter, in which there are illustrated and described specific examples in accordance with the invention.

### BRIEF DESCRIPTION OF THE DRAWINGS

**[0010]** Referring now to the drawings in which like reference numbers represent corresponding parts throughout the several views, where:

Fig. 1 is an illustration of one embodiment of a starter system according to the present invention;

Fig. 2 is an illustration of one embodiment of an engine including a starter system according to the present invention;

Fig. 3 is an illustration of one embodiment of an engine including a starter system according to the present invention;

Fig. 4A is an exploded view of one embodiment of a starter system according to the present invention;

and

Fig. 4B is an exploded view of one embodiment of a pinion drive assembly according to the present invention.

## DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

**[0011]** In the following description of specific embodiments, reference is made to the accompanying drawings which form a part hereof, and in which is shown by way of illustration specific embodiments in which the invention may be practiced. It is to be understood that other embodiments may be made and used without departing from the scope of the invention, which is defined by the claims attached hereto.

**[0012]** The present invention provides a starter that is mounted remotely with respect to an engine to be started, for example to a chassis of a vehicle. The starter is provided with a flexible torsion shaft for transferring the rotation of an output shaft of the starter to a driven member of the engine. Mounting the starter to the chassis of the vehicle remotely from the engine reduces vibration related failures of the starter.

**[0013]** Turning now to Fig. 1, a flexible shaft starter system 2 is illustrated. In one embodiment of the invention, an electric starter motor 4 having an output shaft 11 is coupled to a flexible torsion shaft 6. The flexible torsion shaft 6 has a first end 12 coupled to the output shaft 11 of the starter motor 4 and a second end 14 coupled to a pinion drive assembly 7. The pinion drive assembly 7 includes a pinion gear 8. The pinion drive assembly 7 is coupled to a driven member of an internal combustion engine. For example, in one embodiment of the invention, the pinion gear 8 of the pinion drive assembly 7 is coupled to a starter gear 10 of a clutch at a power takeoff (PTO) end of the internal combustion engine. Furthermore, in one embodiment of the invention, the pinion gear 8 of the pinion drive assembly 7 is coupled to a starter gear 10 of a fly wheel at a magneto end of the internal combustion engine. It will be appreciated by those skilled in the art that the starter gear 10 may be bolted to the clutch or the fly wheel or may be made integral with the clutch or the fly wheel.

**[0014]** The electric starter motor 4 may be provided with openings 16 in order to mount the starter motor 4 to a chassis of a vehicle operated by the engine. Upon the application of electric power from an electric power source 22 to the starter motor 4, the flexible torsion shaft 6 rotates in a direction indicated by reference numeral 18. The flexible torsion shaft 6 transfers the rotation of the output shaft 11 of the electric starter motor 4 to the pinion drive assembly 7, thereby causing the starter gear 10 to rotate in the direction indicated by reference numeral 20. Accordingly, the electric starter motor 4 is capable of starting the engine from a remote location through the flexible torsion shaft 6.

**[0015]** Those skilled in the art will recognize that selecting a flexible shaft 6 for a given application depends on several variables. For example, in one embodiment, the application may require a bi-directional or uni-directional flexible shaft 6. Also, the flexible shaft should be selected according to a maximum continuous torque required to be transmitted through the shaft 6 to the starter gear 10. Other design variables of the flexible shaft 6 to consider include selecting the flex angle of the flexible shaft 6; the types of end fittings of the flexible shaft 6 (e.g., internal spline steel couplers, smooth bore, split roll-pin secured and the like). Casings are generally recommended when the length of the flexible shaft 6 exceeds about eight inches. The casing helps to protect the shaft from dirty, dusty or corrosive environments. Also, casings may be provided to prevent injury when the flexible shaft 6 is in use. In one embodiment, the casing helps to prevent helexing of the flexible torsion shaft. Helexing may occur, for example, when the flexible torsion shaft is rotated with small or no loads connected to a distal end of the shaft. Of course those skilled in the art will appreciate that the inclusion of a casing is a design choice. Flexible torsion shafts may be obtained, for example, from S.S. White Technologies.

**[0016]** An example of a flexible torsion shaft to be used with the present invention is manufactured by S. S. White Technologies is a POWER-FLEX shaft model number #375AMX8.00FF. The POWER-FLEX shaft may be obtained in various lengths (e.g., 8 inches) with a variety of end fittings (e.g., #F or #E fittings).

**[0017]** Other variables to be selected by design choice include the electric starter motor 4 speed, usually rated in revolutions per minute (RPM); the normal output cranking torque of the electric starter motor 4; and the rotation of the electric motor torque, whether it is counterclockwise or clockwise.

**[0018]** Fig. 2 illustrates an internal combustion engine assembly 24 including an electric starter motor 4 mounted remotely from the engine 24 to a chassis 26 of a vehicle to be powered by the engine 24. In one embodiment, the electric starter motor 4 is mounted to the chassis 26 through a bracket 28 using a suitable fastener 30 which is inserted through openings 16 of the electric starter motor 4. The distal end of the shaft 6 is coupled to the pinion drive assembly 7. The pinion drive assembly 7 is mounted to the engine 24 through a bracket 32. Those skilled in the art will appreciate the bracket 28 may be an integral part of the chassis. Likewise, the bracket 32 may be an integral part of the engine block or may be secured to the engine block by suitable fasteners. Those skilled in the art will appreciate that a variety of fasteners are suitable for mounting the brackets 28 and 32 to the chassis and the engine, respectively, without departing form the spirit and scope of the invention.

**[0019]** The electric starter motor 4 is mounted to bracket 28 and secured to the vehicle chassis 26 remotely from the engine 24 in a low-vibration chassis region. In contrast, the pinion drive assembly 7 is mounted

to the bracket 32 which is located in a high-vibration engine region. In use, the electric starter motor 4 is mounted to the chassis 26 away from the high-vibration region of the engine 24. Accordingly, the starter motor 4 does not experience vibration induced stress which can lead to engine vibration induced failures in the electric starter motor 4.

**[0020]** Furthermore, since the flexible portion shaft 6 allows the starter motor 4 to be remotely located from the engine 24, the engine 24 may be situated in a lower position within the chassis 26 and thereby reduce the vehicle's overall center of gravity.

**[0021]** Turning now to Fig. 3, one embodiment of the invention provides an engine 24 having a starter motor 4 coupled to a chassis 26 through a bracket 28. The starter motor 4 is attached to the bracket 28 by means of a suitable fastener 30. In an alternative embodiment, a flexible shaft 6A is illustrated. The flexible shaft 6A is not a continuous flexible shaft type, but rather is comprised of individual segments 34 which are coupled by flexible joints, e.g. universal joints, located on either end of the individual segments. Of course, those skilled in the art will appreciate that flexible shafts having different configurations may be utilized without departing from the spirit and scope of the invention.

**[0022]** In one embodiment, the invention may be adapted to a recreational vehicle having an engine assembly 24 that includes an electric starter 4 mounted to a vehicle chassis 26 through a bracket 28. In one embodiment, the vehicle may be a recreational vehicle (e. g., a snowmobile).

**[0023]** Accordingly, in one embodiment of the invention, a suitable flexible shaft starter for a snowmobile internal combustion engine may be selected as follows. The starter motor should have a normal cranking speed of about 3500 RPM under normal loads and about 7500 RPM under no-load speeds. The torque can be applied by the starter motor in a counterclockwise direction (although those skilled in the art will appreciate that this is a design choice). The electric starter motor 4 should have a normal cranking torque of about 2.5 foot-pounds (ft-lbs) with stall torques of around 4.0 ft-lbs. In one embodiment, a flexible shaft 6 having a flexed angle of 45° with a bend radius of about 6 inches would be suitable for use. However, a 90° bend radius with a 6 inch production bend radius also may be utilized in this embodiment.

**[0024]** Again, those skilled in the art will appreciate that many design configurations of electric starter motors and torque requirements of the engine will require the specification of flexible torsion shafts to vary. However, this should not be construed as a limiting factor of the present invention, in that variations of the flexible shaft design may be made without departing from the spirit and scope of the invention.

**[0025]** Turning now to Fig. 4A, where an exploded view of one embodiment of a starter system according to the present invention is illustrated. The electric starter motor 4 is mounted to a chassis through the bracket 28 using suitable fasteners 30 which are inserted through openings provided in the electric starter motor 4. The bracket 28 is mounted to the chassis by way of fasteners 36 and 42, for example fastener 36 may be a self tapping screw and fastener 42 may be a screw cap 42 which includes lock washer 40 and washer 38. A retaining clip 44 may also be provided and attached to the bracket 28 with a fastener 46 (e.g., a self tapping screw).

**[0026]** The second end of the flexible torsion shaft 14 may be attached to the pinion drive assembly 7 by way of set-socket screw 48. Snap rings 50, thrust washers 52 and wave washer 54 are provided to position the drive pinion shaft 56 properly in bracket 32. The pinion drive assembly 7 may be attached to the second end of the flexible torsion shaft 14 through a drive pinion shaft portion 56. The pinion drive assembly 7 is attached to the engine bracket 32. The starter gear 10 may be bolted to a clutch or a fly wheel portion of an engine by way of machine screw 58 or, as recited above, may be made integral with the clutch or the fly wheel.

**[0027]** The pinion drive assembly 7 is illustrated in exploded view in Figs. 4A-B. The pinion drive assembly 7 comprises a drive pinion 62, which includes the pinion gear 8, and a pinion stopper assembly 60.

**[0028]** The foregoing description of the specific embodiments of the invention has been presented for the purpose of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. Many modifications and variations are possible in light of the above teaching. It is intended that the scope of the invention be limited not with this description, but rather by the claims appended hereto.

## Claims

1. An internal combustion engine assembly for a vehicle to be mounted to a chassis of the vehicle, the engine assembly comprising:

   an internal combustion engine having at least one driven member;
   a starter having an output shaft and being mounted remotely from the engine; and
   a flexible shaft having a first and second end, the first end being driven by the output shaft of the starter and the second end being driven by the at least one driven member.

2. An internal combustion engine according to claim 1, wherein the second end of the flexible shaft is coupled to a first gear mounted to the engine and having a first portion adapted to receive the second end of the flexible shaft and a second portion driving a second gear adapted for cranking the engine.

3. An internal combustion engine according to claim

2, wherein the first gear is a pinion gear.

**4.** An internal combustion engine according to claim 2, wherein the second gear is a drive gear adapted to rotate a drive shaft of the engine.

**5.** An internal combustion engine according to claim 1, wherein the flexible shaft is a continuously flexible torsion shaft.

**6.** An internal combustion engine according to claim 5, wherein the continuously flexible torsion shaft comprises a plurality of strands of steel wire.

**7.** An internal combustion engine according to claim 1, wherein the flexible shaft comprises a plurality of adjacently disposed segments, each segment having at least one end adapted for flexible coupling to an adjacent segment.

**8.** An internal combustion engine according to claim 7, wherein each segment of the flexible shaft is coupled to an adjacent segment through a universal joint.

**9.** A flexible shaft starter system for an internal combustion engine of a recreational vehicle, the internal combustion engine being mounted to a chassis of the recreational vehicle and having at least one driven member, the flexible shaft starter system comprising:

a starter having an output shaft and being mounted remotely from the engine; and
a flexible shaft having a first and second end, the first end being driven by the output shaft of the starter and the second end driving the at least one driven member.

**10.** A flexible shaft starter system according to claim 9, wherein the second end of the flexible shaft is coupled to a first gear mounted to the engine and having a first portion adapted to receive the second end of the flexible shaft and a second portion driving a second gear adapted for cranking the engine.

**11.** A flexible shaft starter system according to claim 10, wherein the first gear is a pinion gear.

**12.** A flexible shaft starter system according to claim 10, wherein the second gear is a drive gear adapted to rotate a drive shaft of the engine.

**13.** A flexible shaft starter system according to claim 9, wherein the flexible shaft is a continuously flexible torsion shaft.

**14.** A flexible shaft starter system according to claim 13, wherein the continuously flexible torsion shaft comprises a plurality of strands of steel wire.

**15.** A flexible shaft starter system according to claim 9, wherein the flexible shaft comprises a plurality of adjacently disposed segments, each segment having at least one end adapted for flexible coupling to an adjacent segment.

**16.** A flexible shaft starter system according to claim 15, wherein each segment of the flexible shaft is coupled to an adjacent segment through a universal joint.

**17.** A flexible shaft starter kit for an internal combustion engine of a recreational vehicle, that is mounted to a chassis of the recreational vehicle and has at least one driven member, the flexible shaft starter kit comprising:

a starter having an output shaft and being adapted for mounting to the recreational vehicle remotely from the engine; and
a flexible shaft having a first and second end, the first end being adapted to be driven by coupling to the output shaft of the starter and the second end being adapted to drive the at least one driven member.

**18.** A flexible shaft starter kit according to claim 17, further comprising a first gear having a first portion adapted to receive the second end of the flexible shaft and a second portion adapted for driving a second gear adapted for cranking the engine.

**19.** A flexible shaft starter kit according to claim18, wherein the first gear is a pinion gear.

**20.** A flexible shaft starter kit according to claim 17, wherein the flexible shaft is a continuously flexible torsion shaft.

**21.** A flexible shaft starter kit according to claim 20, wherein the continuously flexible torsion shaft comprises a plurality of strands of steel wire.

**22.** A flexible shaft starter kit according to claim 17, wherein the flexible shaft comprises a plurality of adjacently disposed segments, each segment having at least one end adapted for flexible coupling to an adjacent segment.

**23.** A flexible shaft starter kit according to claim 22, wherein each segment of the flexible shaft is coupled to an adjacent segment through a universal joint.

**24.** A recreational vehicle comprising:

an internal combustion engine mounted to a chassis of the recreational vehicle and having at least one driven member;
a starter having an output shaft and being mounted to the recreational vehicle remotely from the engine; and
a flexible shaft having a first and second end, the first end being driven by the output shaft of the starter and the second end driving the at least one driven member.

**25.** A recreational vehicle according to claim 24, further comprising a first gear mounted to the engine and having a first portion adapted to receive the second end of the flexible shaft and having a second portion driving a second gear adapted for cranking the engine.

**26.** A recreational vehicle according to claim 25, wherein the first gear is a pinion gear.

**27.** A recreational vehicle according to claim 25, wherein the second gear is a drive gear adapted to rotate a drive shaft of the engine.

**28.** A recreational vehicle according to claim 24, wherein the flexible shaft is a continuously flexible torsion shaft.

**29.** A recreational vehicle according to claim 28, wherein the continuously flexible torsion shaft comprises a plurality of strands of steel wire.

**30.** A recreational vehicle according to claim 24, wherein the flexible shaft comprises a plurality of adjacently disposed segments, each segment having at least one end adapted for coupling to an adjacent segment.

**31.** A recreational vehicle according to claim 30, wherein each segment of the flexible shaft is coupled to an adjacent segment through a universal joint.

**32.** A recreational vehicle according to claim 24, wherein the recreational vehicle is a snowmobile.

**33.** A method of starting an internal combustion engine of a recreational vehicle, the internal combustion engine being mounted to a chassis of the recreational vehicle and having at least one driven member, the internal combustion engine being in communication with a starter having an output shaft and being adapted for mounting to the recreational vehicle remotely from the engine, the output shaft of the starter being coupled to a flexible shaft having a first and second end, the first end being driven by the output shaft of the starter and the second end being adapted for driving the at least one driven member, the method comprising:

actuating the starter to initiate rotation of the output shaft; and
transferring the rotation of the output shaft of the starter to the at least one driven member through the flexible shaft.

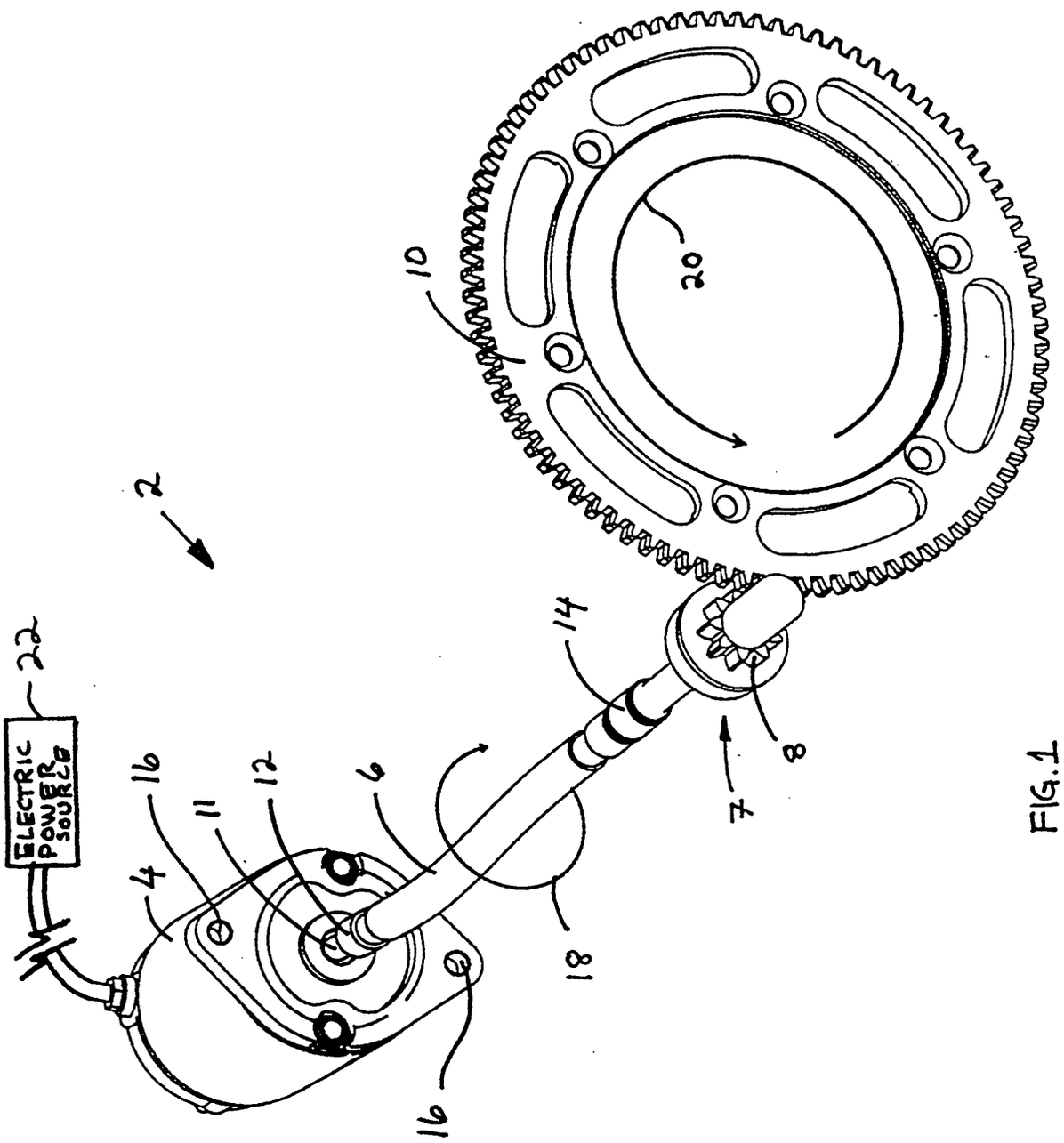


FIG. 1

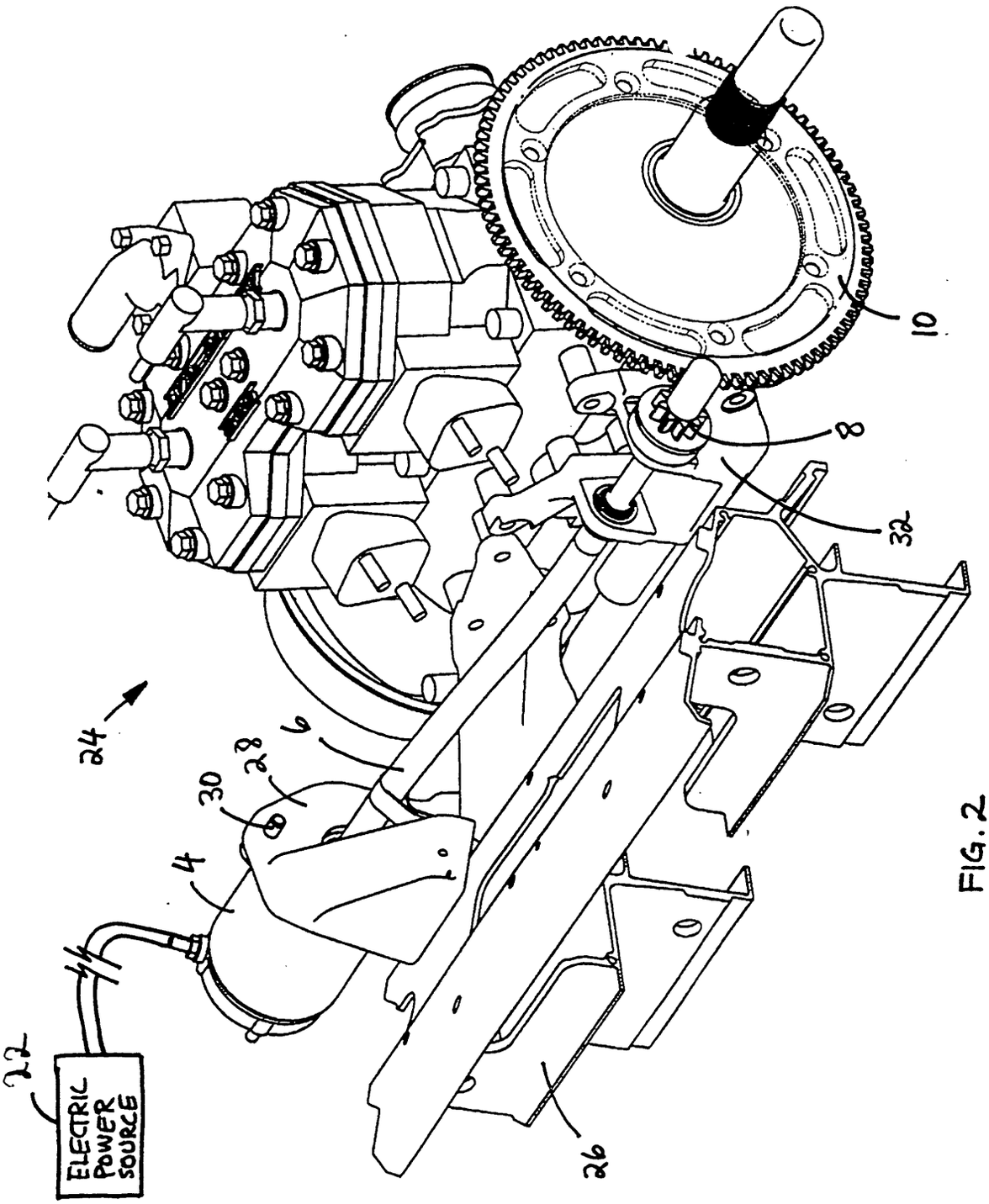


FIG. 2

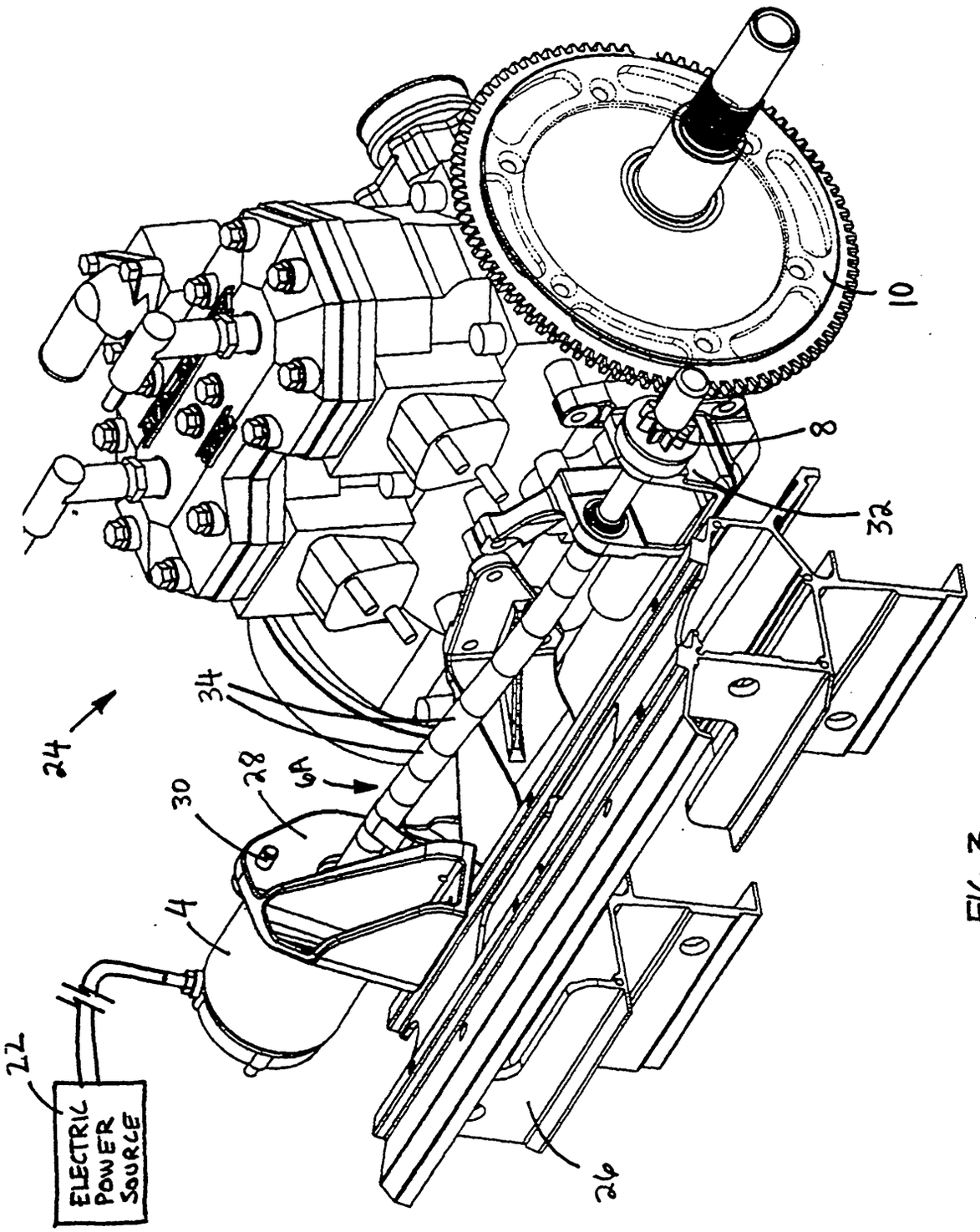


FIG. 3

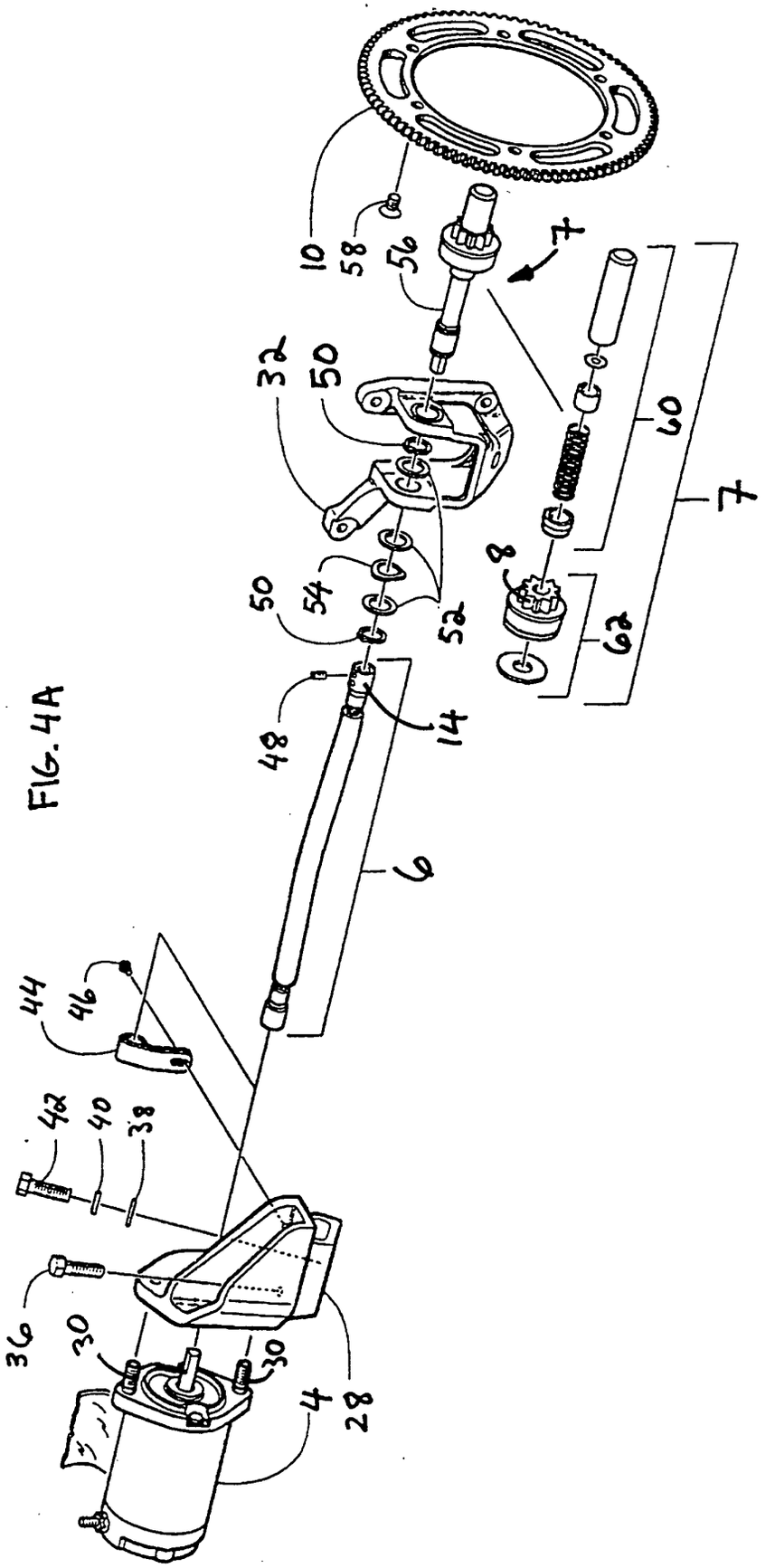


FIG. 4A

FIG. 4B