A power tool incorporates a brushless or electronically commutated drive motor (BLDC). A number of drive trains are provided for connecting the BLDC to the drive shaft of a working tool, such as a rotary saw blade. In one aspect, the BLDC motor is disposed within an arm assembly of a power tool and provides power to the drive shaft of the tool through a gear train that minimizes the size and profile of the power tool.
POWER TOOL WITH BRUSHLESS DRIVE MOTOR

Reference to Related Application

[001] This application is a utility filing of and claims priority to co-pending provisional application No. 61/787,115, filed on March 15, the entire disclosure of which is incorporated herein by reference.

Field of the Disclosure

[002] The present disclosure relates to power tools and particularly to the drive mechanism for providing power to the tool.

Background

[003] Many types of power tools are available that are portable or easy to deploy at a job site, and that are ergonomically convenient for the operator. Such power tools may be a planer, miter saw, bevel saw, reciprocating saw, jig saw, compound saw, vertical saw, band saw, router, circular saw, or the like. A common feature among these types of tools is that the drive motor and driven tool are carried by the same structure. One example is the miter saw 10 shown in FIGS. 1(a)-(b). The miter saw 10 includes a saw assembly 12 that is supported on a base assembly 14 by a bevel mount 16. The bevel mount for this tool is configured to allow the saw assembly to pivot up and down relative to the base assembly in order to perform the cut. In addition, the bevel mount 16 is configured to allow the saw assembly to be oriented at a user-defined miter angle and may also be configured to allow the saw assembly to be positioned at a non-perpendicular angle relative to the work surface 15 of the base assembly.

[004] The saw assembly 12 is connected to the bevel mount 16 by an arm assembly 18. The arm assembly includes a housing 19 that supports the motor M and may be provided with a
handle assembly 20 that can be grasped by the operator to control the movement of the saw assembly when performing a cut. The housing 19 of the arm assembly contains the electrical and/or electronic components of the power tool 10, with electrical power fed to the motor M and electrical components by a power cord C. In the miter saw of FIGS. 1(a)-(b), as well as in many other power tools, the motor M is supported on the rotational axis of the tool, in this case a rotary saw blade. In many instances, the saw blade is mounted directly on the output shaft of the motor so that the blade speed matches the motor speed. In other power tools, a gearing arrangement may be provided to step up or step down the motor speed for driving the tool.

[005] For most power tools, including portable or bench top power tools, the drive motor M has traditionally been a universal AC motor because these types of motors are capable of the rotational speeds and torques necessary for an effective power tool. However, the benefits of the universal motor are countered by the bulkiness of the motor. As can best be seen in FIG. 1(b), the motor M projects significantly outward from the arm assembly 18, in many cases doubling the overall width of the power tool 10. In addition to the bulkiness, the size and weight of the traditional motor affects the moment of inertia of the power tool. These attributes of the universal AC motor require special design considerations to make the power tool as ergonomic and easy to use as possible, while allowing the operator to make an accurate and efficient cut in a workpiece.

[006] Although the traditional AC motor driven power tool has been an able workhorse for the tradesman and DIYer, there is still a need to improve the physical characteristics of the power tool to improve its ergonomics and ease of use.
Summary of the Disclosure

[007] The present disclosure contemplates incorporating a brushless or electronically commutated drive motor (BLDC) into a power tool. A drive train connects the output shaft of the BLDC motor to a drive shaft of the working tool, such as a rotary saw blade. In one aspect, the BLDC motor is disposed within an arm assembly of a power tool and provides power to the drive shaft of the tool through a gear train that minimizes the size and profile of the power tool.

[008] In a further aspect, the BLDC has a no-load operating speed that is less than the operating speed of the working tool. The drive train is thus configured to provide a drive ratio corresponding to the ratio of the no-load operating speed to the operating speed of the working tool. The gear trains may include a bevel-pinion gear arrangement, a worm-spur gear arrangement, or a planetary gear arrangement that provides a compact profile for both the motor and the gear train. The BLDC and gear train combination allows modifications to the housing and handle to provide not only compactness, but more ergonomic configurations.
Description of the Figures

[009] FIGS. 1(a)-(b) are perspective and top views of a conventional power tool, in particular a dual bevel miter saw.

[010] FIG. 2(a) is a schematic representation of drive train for a power tool, such as the power tool shown in FIGS. 1(a)-(b), with the drive train incorporating a brushless motor.

[011] FIGS. 2(b)-(c) are perspective and top views of a power tool incorporating the drive train shown in FIG. 2(a).

[012] FIG. 3(a) is a schematic representation of drive train for a power tool, such as the power tool shown in FIGS. 1(a)-(b), with the drive train incorporating a brushless motor.

[013] FIGS. 3(b)-(c) are perspective and top views of a power tool incorporating the drive train shown in FIG. 3(a).

[014] FIG. 4(a) is a schematic representation of drive train for a power tool, such as the power tool shown in FIGS. 1(a)-(b), with the drive train incorporating a brushless motor.

[015] FIGS. 4(b)-(c) are perspective and top views of a power tool incorporating the drive train shown in FIG. 4(a).

[016] FIG. 5(a) is a schematic representation of drive train for a power tool, such as the power tool shown in FIGS. 1(a)-(b), with the drive train incorporating a brushless motor.

[017] FIGS. 5(b) is a top view of a power tool incorporating the drive train shown in FIG. 5(a).
[018] **FIG. 6(a)** is a schematic representation of drive train for a power tool, such as the power tool shown in **FIGS. 1(a)-(b)**, with the drive train incorporating a brushless motor.

[019] **FIGS. 6(b)-(c)** are perspective and top views of a power tool incorporating the drive train shown in **FIG. 6(a)**.

[020] **FIG. 7(a)** is a schematic representation of drive train for a power tool, such as the power tool shown in **FIGS. 1(a)-(b)**, with the drive train incorporating a brushless motor.

[021] **FIGS. 7(b)-(c)** are perspective and top views of a power tool incorporating the drive train shown in **FIG. 7(a)**.

[022] **FIG. 8(a)** is a schematic representation of drive train for a power tool, such as the power tool shown in **FIGS. 1(a)-(b)**, with the drive train incorporating a brushless motor.

[023] **FIGS. 8(b)-(c)** are side and top views of a power tool incorporating the drive train shown in **FIG. 8(a)**.

[024] **FIG. 9(a)** is a schematic representation of drive train for a power tool, such as the power tool shown in **FIGS. 1(a)-(b)**, with the drive train incorporating a brushless motor.

[025] **FIGS. 9(b)-(c)** are side and top views of a power tool incorporating the drive train shown in **FIG. 9(a)**.

[026] **FIG. 10(a)** is a schematic representation of drive train for a power tool, such as the power tool shown in **FIGS. 1(a)-(b)**, with the drive train incorporating a brushless motor.

[027] **FIGS. 10(b)-(c)** are side and top views of a power tool incorporating the drive train shown in **FIG. 10(a)**.
FIG. 11(a) is a schematic representation of drive train for a power tool, such as the power tool shown in FIGS. 1(a)-(b), with the drive train incorporating a brushless motor.

FIGS. 11(b)-(c) are side and top views of a power tool incorporating the drive train shown in FIG. 11(a).

FIGS. 12(a)-(b) are perspective and top views of another conventional power tool, in particular a sliding miter saw.

FIG. 13(a) is a schematic representation of a drive train for a power tool, such as the power tool shown in FIGS. 12(a)-(b), with the drive train incorporating a brushless motor.

FIG. 13(b) is a top view of a power tool incorporating the drive train shown in FIG. 13(a).

FIG. 14 is a schematic representation of the drive train of FIG. 13(a) modified to include a cooling fan.

FIG. 15 depicts the use of an arm assembly modified to incorporate the BLDC motor and drive trains disclosed herein, used on different power tool base and mount configurations.

FIG. 16 is a perspective view of a power tool having a modified handle configuration.

FIG. 17(a) is a schematic representation of a drive train for a power tool, such as the power tool shown in FIGS. 12(a)-(b), with the drive train incorporating a brushless motor and a flexible shaft.

FIGS. 17(b)-(c) are side and top views of a power tool incorporating the drive train shown in FIG. 17(a).
[038] **FIG. 17(d)** is side view of the power tool shown in **FIG. 17(b)** with the arm assembly in a retracted orientation in relation to the extended orientation of **FIG. 17(b)**.

[039] **FIG. 18** is a side view of a power tool, such as the tool shown in **FIG. 12(a)-(b)**, incorporating a drive motor on the pivot axis of the arm assembly.

[040] **FIG. 19** is a plan view of a fold flat power tool.
Detailed Description

[041] For the purposes of promoting an understanding of the principles of the invention, reference will now be made to the embodiments illustrated in the drawings and described in the following written specification. It is understood that no limitation to the scope of the invention is thereby intended. It is further understood that the present invention includes any alterations and modifications to the illustrated embodiments and includes further applications of the principles of the invention as would normally occur to one skilled in the art to which this invention pertains.

[042] Brushless DC motors or electronically commutated motors (referred to herein generally as BLDC motors) have been developed that can generate rotational speeds and torques comparable to the conventional universal AC motor. However, BLDC motors occupy a much smaller envelop than the universal motor, typically about half the length and occupying less than one-fourth the volume of a comparably powered universal motor. The much smaller envelop provided by the BLDC motor permits significant modifications to the overall size and shape of a power tool. In addition, the small size of the BLDC motor permits different indirect drive train arrangements, rather than the direct drive arrangement of the AC motor.

[043] In one embodiment, a BLDC motor 30 is coupled to the drive shaft S of the working tool, such as the saw blade of the saw assembly 12 described above, by way of a gear train 35 shown in FIG. 2(a). The gear train includes a pinion gear 36 engaged to the output shaft 31 of the BLDC motor 30. A bevel gear 37 is engaged to the drive shaft S of the saw blade and in meshed engagement with the pinion gear 36. The gear train 35 thus provides a right angle drive for the saw blade, which means that the BLDC motor 30 does not need to project laterally outward from
the arm assembly, as in prior power tools. Instead, the BLDC motor 30 and drive train 35 may be compactly contained within the housing 19 of the arm assembly 18, as shown in FIGS. 2(b)-(c). The control unit or circuit board for the BLDC motor may also be mounted within the housing 19.

[044] The use of the bevel gear 37 allows the pinion gear 36 to be oriented at any location around the full circumference of the bevel gear. Thus, in order to minimize the size of the housing 19 the BLDC motor 30 may be arranged at an angle within the housing, as depicted in FIG. 2(b). The impact on the overall size of the power tool 10 relative to the traditional power tool 10 can be appreciated by comparing the top views of FIG. 1(b) and FIG. 2(c). In particular, the absence of the conventional motor M significantly reduces the lateral extent of the tool, without requiring modification to the handle assembly 20 or bevel mount 16. The drive ratio for the drive train may be adjusted according to the output speed of the BLDC motor and the speed requirements for the saw blade. In one specific embodiment, for a 4000 rpm saw blade speed, the gear train is configured for a gear ratio of 3.45:1 for a BLDC motor having a no-load operating speed of 1150 rpm.

[045] Another right angle drive gear train 45, shown in FIG. 3(a), a worm gear 46 is engaged to the output shaft 31 of a BLDC motor 30. The worm gear meshes with a spur gear 47 that is engaged to the drive shaft S of the tool or saw blade. Like the pinion-bevel gear train 35, the worm gear may mesh with the spur gear of the gear train 45 at any angular location around the circumference of the gear. Thus, the BLDC 30 and gear train 45 may be mounted with the modified housing 19, as illustrated in FIGS. 3(b)-(c). One advantage of the worm gear 46 over the pinion gear 36 is that the worm gear may be positioned directly over the spur gear, as seen in
FIG. 3(c), rather than offset to the side like the pinion gear, as seen in FIG. 2(c). This attribute of the worm gear drive train allows the housing 19' to be narrower, thereby further reducing the envelop of the power tool. As with the prior embodiment, the final ratio of the gear train 45 may be calibrated to match the BLDC motor speed with the desired shaft speed for the saw blade. In one specific embodiment, the worm gear 46 is a 4 start gear while the spur gear 47 is a 30 tooth gear for a final ratio of 7.5:1.

[046] As shown in FIG. 3(a), the BLDC motor 30 may be provided with a fan 32 at the rear face of the motor. The fan may be directly driven by the output shaft 31 of the motor in order to cool the motor and the interior of the housing 19'. It should be appreciated that the fan may be incorporated into the BLDC motor in each embodiment disclosed herein.

[047] Another gear train 55 is shown in FIG. 4(a) that incorporates a pinion gear 56 engaged to the output shaft 31 of the BLDC motor 30. The pinion gear meshes with the inboard face (i.e., facing the saw blade) of a bevel gear 57 which drives an idler gear 59 mounted on the bevel gear shaft 58. The idler gear 59 drives an intermediate spur gear 60 which meshes with a drive gear 61 engaged to the drive shaft S of the saw blade.

[048] The gear train 55 allows the BLDC motor 30 to be arranged nearly parallel to the housing 19'', as shown in FIG. 4(b), rather than at an angle as in the embodiments of FIGS. 2-3. As a consequence, the housing 19'' may have a reduced profile at the end coupled to the bevel mount 16, with a more tubular shape. The modified configuration of the housing 19'' also permits a modification to the orientation of the handle assembly 20'' to accommodate an overhand grip by the operator, as shown in FIG. 4(b). Again, the final ratio of the gear train 55 may be adjusted by selection of the bevel and spur gears. In one embodiment, an 11 tooth pinion gear 56 meshes
with a 38 tooth bevel gear 57. An 18 tooth idler gear 59 drives an 11/22 tooth gear set 60, 61 to the drive shaft S.

[049] The gear train 65 of FIG. 5(a) incorporates a worm gear 66 mounted to the output shaft 31 of the BLDC motor 30. The worm gear meshes with a spur gear 67 which shares an axle 68 with an idler gear 69. The idler gear meshes with the drive gear 70 to drive the shaft S of the saw blade. Like the embodiment of FIG. 4(a), the drive train 65 of FIG. 5(a) allows the motor to be oriented nearly parallel to the housing 19ii, as shown in FIG. 5(b). The gear train 65 is slightly more compact laterally because the worm gear 66 resides directly above the spur gear 67. A final gear ratio of 6.96:1 can be achieved in one embodiment with a worm gear 66 having 4 starts meshing with a 30 tooth spur gear 67. The gear set 69/70 to the drive shaft S can have a 28/26 tooth ratio.

[050] The reduced size of the BLDC motor 30 also provides a benefit for a laterally mounted motor, such as the arrangement shown in FIGS. 6(b)-(c). Since the BLDC operating speed is typically less than is required for a power tool, such as a miter saw, a gear train 75 is provided that steps down the speed of the motor output shaft 31. In order to maintain the alignment with the drive shaft for the saw blade, the gear train 75 is in the form of a planetary gear set as shown in FIG. 6(a). The sun or pinion gear 76 is mounted on the motor output shaft 31 and meshes with planetary gears 77 supported on a carrier 78. The carrier includes a hub 79 projecting inward for engagement with the saw blade drive shaft. The planetary gears 77 revolve within a fixed ring gear 80 to multiply the pinion gear speed. In one specific embodiment, the pinion gear can have 12 teeth, the ring gear can have 72 teeth and the planetary gears can have 30 teeth to achieve a final ratio of 7.0:1. Although the BLDC motor 30 projects laterally from the arm assembly 18, a
comparison of FIG. 6(c) to FIG. 1(c) illustrates the significantly reduced profile achieved by the BLDC motor. In addition to a smaller envelop, the lower weight of the BLDC motor provides improved inertia characteristics, making the arm easier to move in a precise, controlled fashion.

[051] The planetary gear arrangement may be implemented in a vertically mounted concept, such as shown in FIGS. 7(b)-(c). The gear train 85 shown in FIG. 7(a) includes a planetary set 86 that drives a right angle bevel set 87 to power the saw blade drive shaft S. The planetary set 86 includes a pinion gear 88 engaged to the output shaft 31 of the motor. The pinion gear meshes with planetary gears 89 which rotate within a fixed ring gear 90. The planetary gears are supported by a carrier 91 which drives the bevel gear 92 of the bevel set 87. The final bevel gear 93 is engaged to the shaft S. As can be appreciated from FIG. 7(b), the small size of the BLDC motor 30 does not significantly alter the envelop of the power tool, since the BLDC motor does not project significantly above the top of the saw assembly 12.

[052] As previously indicated, the BLDC motor 30 allows modifications to the arm assembly for a power tool that cannot be achieved with the traditional AC motor M shown in FIG. 1. Consequently, in one embodiment, a modified arm assembly 19"" shown in FIG. 8(b) is provided on a power tool in which the arm housing 19"" is an exaggerated C-shape from its engagement to the bevel mount 16 to the handle 20"". The housing 19"" includes a drive motor housing 103 that projects inwardly from the C-shaped housing 19"" toward the fan blade shaft S. As shown in FIG. 8(c) the arm assembly 18"" may be arranged directly above and in line with saw assembly 12, with the drive motor housing 103 laterally offset from the arm housing 19"". This alignment of the saw assembly and arm assembly eliminates any torquing that might occur with an arm assembly that is laterally offset from the saw blade. Instead, the line of action of the
force applied by the operator to the handle 20‴ is transmitted directly with no moment to the saw assembly 12. In addition, the inline arrangement makes the power tool well-suited for either left-handed or right-handed use, and provides maximum workpiece visibility from both sides of the saw assembly 12.

[053] In order to accommodate the modified arm assembly 18‴ a drive train 95 is provided as shown in FIG. 8(a). The drive train includes a pinion gear 96 mounted to the output shaft 31 of the motor 30 that meshes with a bevel gear 97. The bevel gear includes a central hub 98 that supports a spur gear 99 which then meshes with a spur gear 100 engaged to the drive shaft S of the saw blade. As shown in FIG. 8(b), the drive train 95 can be aligned along the axis of the motor housing 103, generally perpendicular to the modified arm housing 19‴. A final gear ratio of 6.91 : 1 can be achieved by a bevel gear set of 11/38 teeth and a spur gear set of 11/22 teeth.

[054] The small size of the BLDC motor 30 also allows the motor to be positioned farther away from the tool operator to minimize the noise near the operator. As shown in FIGS. 9(b)-(c), a modified arm assembly 18‴ includes a housing 19‴ and handle 20‴ that are similar to the housing 19‴ and handle 20‴ shown in FIG. 2(b) except that the drive motor 30 is supported in a housing 112 at the rear of the arm assembly, adjacent the bevel mount 16. This rearrangement of the drive motor is achieved by the drive train 105 shown in FIG. 9(a) that includes a belt 109. In particular, the drive train 105 includes a spur gear 106 driven by the motor 30 and which meshes with a spur gear 107. The spur gear 107 includes a pulley wheel 108 that drives a belt 109 to rotate another pulley wheel 110 connected to the saw blade shaft S. The pulleys and belt may be a friction drive or may incorporate teeth to prevent belt slip. As shown in FIG. 9(a) the spur gear 106 may be positioned inside the belt 109 to reduce the overall length of the drive train 105.
As opposed to the in-line arrangement of the drive train 105, the belt configuration may be implemented in an angle drive train 115 shown in FIG. 10(a). The drive train 115 includes a pinion gear 116 engaged to the motor output shaft 31 and which meshes with a bevel gear 117. The bevel gear includes a pulley wheel 119 mounted to a hub 118 of the bevel gear. The pulley wheel 119 drives a belt 120 that in turn drives an opposite pulley wheel 121 coupled to the drive shaft S. As shown in FIGS. 10(a)-(b), the drive train 115 may assume a near right angle between the BLDC motor 30 and the driven pulley wheel 121. The arm assembly 18v includes a motor housing 123 that carries the drive train and engages the bevel mount 16. As shown in the top view of FIG. 10(c) the drive train 115 fits into a narrow width so that the arm assembly housing 19v presents a narrow lateral profile.

In an alternative approach, a drive train 125 positions the BLDC motor 30 entirely inside the drive belt. Thus, as shown in FIG. 11(a) the motor drives a pinion gear 126 that meshes with a bevel gear 127. The bevel gear includes a hub 128 that carries a pulley wheel 129. The belt 130 is engaged between the pulley wheel 129 and an opposite pulley wheel 131 that is engaged to the drive shaft S. Due to the small size of the BLDC motor, it fits snugly within the belt 130. The drive train 125 thus allows for another alternative arm assembly 18vi that includes a housing 19vi in the form of a vertical beam extending from the bevel mount 16. The modified handle 20vi is offset from the housing 19vi to be positioned directly above and in line with the saw assembly 12, as shown in FIGS. 11b)-(c). The drive train 125 is disposed within a housing portion 132 that extends from the housing 19vi to the drive shaft S of the saw blade. The drive trains 115 and 125 that combine the bevel gear set and belt drive set can have a final gear ratio of 6.9 1:1, with an 11/38 tooth bevel gear set and a 2:1 belt reduction between the opposite pulley wheels.
A brushless motor such as the BLDC 30 described above can be used to the benefit of other types of tools, such as the sliding miter saw 200 shown in FIGS. 12(a)-(b). The saw 200 includes a saw assembly 202 supported by a slide assembly 206 on a base assembly 204 so that the saw assembly can translate across the working surface 205 of the base assembly. An arm assembly 208 supports the saw assembly on a bevel mount 210 that is slidably supported on the slide assembly 206 and is configured to allow the saw assembly to be oriented at a non-perpendicular angle relative to the work surface. As with the power tool 10, the power tool 200 includes a motor M that projects laterally from the arm assembly 208 across the work surface. Thus, the power tool 200 suffers from the same drawbacks associated with the bulky and heavy conventional universal AC motor.

The BLDC motor 30 may be incorporated into a drive train 215 disposed within a modified arm assembly 208', as shown in FIGS. 13(a)-(b). The drive train includes a spur gear 216 mounted to the output shaft 31 of the motor and in meshed engagement with a spur gear 217. The spur gear 217 includes an elongated shaft that is sized to extend from a motor position at the back of the arm assembly 208i to a position adjacent the drive shaft S of the saw blade. A pinion gear 219 is engaged to the end of the shaft 218 and is in meshed engagement with a bevel gear 220 that drives the shaft S. As seen in the top view of FIG. 13(b) replacing the conventional motor with the BLDC 30 provides a more compact package for the power tool.

The drive train 215 may be modified as shown in FIG. 14 to incorporate a cooling fan 228. In particular, a pulley wheel 224 may be engaged to the output shaft of the BLDC motor 30 inboard of the spur gear 26. The pulley wheel 224 drives a belt 226 that engages an opposite
pulley wheel 227 to spin the fan 228. The pulley wheels 224, 227 can be sized to achieve a desired fan speed relative to the output speed of the BLDC motor 30.

[060] It is contemplated that the arm assemblies and drive trains discussed herein can be part of a modular assembly that can be integrated into a variety of tools. For instance, as shown in FIG. 15, an arm assembly A, which may be like the arm assembly 19" and gear train 55 shown in FIGS. 4(a)-(c), may be mounted to the base and mount assemblies B₁ - B₄ for several different types of tools. Likewise, the arm assembly may support different saw assemblies.

[061] As previously discussed, the use of the BLDC 30 permits modifications to a power tool that cannot be achieved using the conventional AC motor. Thus, as shown in FIG. 16 a power tool 250 includes a saw blade 252 carried by an arm assembly 254 that is supported for angular adjustment and slide movement by a bevel mount 256 and a slide assembly 258. The arm assembly 254 may support a BLDC motor 30 laterally, as depicted in FIG. 15, or within the arm assembly housing using one of the drive trains described herein. The tool 250 incorporates a handle assembly 260 that allows the handle to be swiveled left or right, as indicated by the arrow P. The handle assembly thus includes a housing 261 that forms a handle grip at one end and that includes a pivot portion 262 at the opposite end. The pivot portion engages a pivot mount 263 on the arm assembly 254 so that the housing can be manually swung from side-to-side. This handle assembly 260 thus allows the tool operator to find a comfortable gripping position for performing the cutting operation.

[062] The compactness of the BLDC motor also allows the use of a flexible drive shaft. For instance, as shown in FIGS. 17(a)-(c) a drive train 270 includes a hub 272 mounted to the output shaft 31 of a BLDC motor 30, with a flexible shaft 273 engaged to the hub. A pinion gear 274 is
fixed at the end of the flexible shaft to mesh with a bevel gear 275 that drives the saw blade shaft S. As shown in the side and top views of FIGS. 17(b)-(c), the flexible shaft allows the motor 30 to be offset from the remainder of the drive train, which permits an arm assembly 280 that is more compact. In addition, the use of the flexible shaft 273 allows the motor 30 to be disposed in a fixed portion 282 of the arm assembly while the flexible shaft 273 extends through a movable portion 281 of the assembly, as depicted in FIG. 17(d).

[063] The BLDC motor 30 may also be oriented directly on a pivot axis for an arm assembly in a power tool. For instance, as shown in FIG. 18, an arm assembly 292 carries a saw assembly SA. The arm assembly includes a pivot hub 294 that is pivotably mounted to a base and mount assembly B. The drive motor 30 may be aligned along the pivot axis within the pivot hub 284. The drive train 285 includes a pinion and bevel gear arrangement 286/287 that drives a shaft 288 that extends between the pivot axis and the drive shaft S of the saw blade. A pinion and bevel gear arrangement 289/290 at the end of the shaft 288 transmits power to the blade shaft S.

[064] The reduced size of the BLDC motor also allows an entire power tool to be folded into a compact configuration. Thus, as depicted in FIG. 19 a power tool including a saw assembly 12, base assembly 14, mount assembly 16 and arm assembly 18 can be folded to fit within a carry case 300. Since the drive motor 30 is encased within the arm assembly in most of the above embodiments, the arm assembly can be pivoted to a "fold flat" position on top of the base assembly 14.

[065] While the invention has been illustrated and described in detail in the drawings and foregoing description, the same should be considered as illustrative and not restrictive in character. It is understood that only the preferred embodiments have been presented and that all...
changes, modifications and further applications that come within the spirit of the invention are desired to be protected.
What is claimed is:

1. A power tool comprising:
   a working tool having a drive shaft;
   a housing operatively supporting the working tool;
   a handle connected to the housing and configured to be engaged by the operator to move the working tool relative to a workpiece;
   a brushless DC (BLDC) motor having an output shaft and supported by the housing or the handle; and
   a gear train operably connecting the output shaft of the BLDC motor to said drive shaft.

2. The power tool of claim 1, wherein said BLDC motor is mounted within said handle.

3. The power tool of claim 1, wherein:
   said gear train is mounted within said handle; and
   said handle is pivotably connected to said housing so that said handle and said handle can be folded for storage in a container.

4. The power tool of claim 1, wherein:
   said working tool has an operating speed;
   said BLDC has a no-load speed less than said operating speed; and
   said gear train has a drive ratio corresponding to the ratio of the working tool operating speed to the BLDC no-load speed.
5. The power tool of claim 1, wherein said gear train includes a pinion gear engaged to the output shaft of said BLDC motor and a bevel gear engaged to the drive shaft of said working tool.

6. The power tool of claim 1, wherein:

   said gear train includes a worm gear engaged to the output shaft of said BLDC motor and a spur gear engaged to the drive shaft of said working tool; and

   said BLDC motor is positioned above the spur gear within said handle.

7. The power tool of claim 1, wherein the output shaft of said BLDC motor extends beyond opposite ends of the motor, one end of the drive shaft connected to said gear train and the opposite end of the drive shaft carrying a rotary fan.

8. The power tool of claim 1, wherein:

   said BLDC motor is supported on said housing along the axis of the drive shaft of the working tool; and

   said gear train includes a planetary gear set in which the sun gear is engaged to the output shaft of the BLDC motor and the planet gears are engage to the drive shaft of the working tool.

9. The power tool of claim 1, wherein said gear train includes an endless belt engaged between said output shaft of the BLDC motor and said drive shaft of the working tool.
10. The power tool of claim 9, wherein said endless belt is engaged to said output shaft of the BLDC motor by a reduction gear arrangement.

11. The power tool of claim 9, wherein said BLDC motor is disposed within said endless belt.

12. The power tool of claim 1, wherein said gear train includes an elongated flexible shaft operably connecting said output shaft of the BLDC motor to said drive shaft of the working tool.

13. The power tool of claim 1, further comprising a base, wherein:
   said handle includes a C-shaped arm pivotably mounted at one end to said base and including a grip portion at an opposite end;
   said handle further including a motor housing extending from said C-shaped arm and engaging said housing in alignment with the drive shaft of the working tool; and
   said motor and said gear train mounted within said motor housing.

14. The power tool of claim 1, wherein said handle includes:
   an arm assembly connected to said housing and configured to support said BLDC motor;
   and
   a handle assembly defining a hand grip portion and pivotably engaged to said arm assembly.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

B23D 45/04(2006.01)i, B23D 47/12(2006.01)i

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)
B23D 45/04; B26D 7/06; B26D 5/08; B23D 47/12; H02K 9/00; H02K 11/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic database consulted during the international search (name of database and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: brushless motor, bevel, worm, spur, flexible shaft, arm and miter saw

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>EP 1604764 A1 (BLACK &amp; DECKER INC.) 14 December 2005 See abst ract, paragraphs [0011H0017], [0027], [0032] and figures 6-11 .</td>
<td>1-14</td>
</tr>
<tr>
<td>Y</td>
<td>US 2004-0017119 A1 (YAMAMOTO et al.) 29 January 2004 See abst ract, paragraphs [0022], [0025], and figures 1-3 .</td>
<td>1-14</td>
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<tr>
<td>A</td>
<td>US 2005-0056128 A1 (CHANG, CHIN-CHIN) 17 March 2005 See abst ract, paragraphs [0016], [0019], and figure 3 .</td>
<td>1-14</td>
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Further documents are listed in the continuation of Box C.

See patent family annex.

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