**ELECTRIC POWER TOOL SYSTEM**

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**ABSTRACT**

An electric power tool system comprises a tool main body, a battery pack detachably attached to the tool main body and a first charger that charges the battery pack. The first charger is detachably attached to the tool main body and/or the battery pack. The first charger is capable of charging the battery pack while the battery pack is attached to the tool main body. The first charger is preferably cordless and contains at least rechargeable battery for storing energy to charge the battery pack.
FIG. 1
FIG. 2
FIG. 8

Rechargeable Battery Cordless Charger 74
Pack Interface 70
AD–DC Converter 78
AC Charger 82
AC Source 82

Trigger Switch 16
Motor 14
Tool Main Body 10

Charger Interface 22
Pack Interface 18

Tool Interfac 32
Battery Pack 30

Rechargeable Battery 34
First Charger Interface 36

Charging Controller 54
Pack Interface 52

Rechargeable Battery 56
Second Charger Interface 58

Cordless Charger 50

Pack Interface 74
Charging Controller 76
First Charger Interface 72
FIG. 10

Battery Pack

Charging Controller

Pack Interface

Rechargeable Battery

Second Charger Interface

Second Charging Controller

AC-DC Converter

Cordless Charger

AC Charger

AC Source

AC Source
FIG. 15
FIG. 17

- Trigger Switch
- Motor
- Pack Interface
- Tool Main Body
- Battery Unit
  - Rechargeable Battery
  - Tool Interface
- Battery Pack
  - Rechargeable Battery
  - First Charger Interface
- Second Pack Interface
  - Charging Controller
  - First Pack Interface
- Adapter Unit
  - Cordless Charger
ELECTRIC POWER TOOL SYSTEM
CROSS-REFERENCE TO A RELATED APPLICATION

[0001] This application claims priority to Japanese Patent Application No. 2010-241480 filed on Oct. 27, 2010, the contents of which are hereby incorporated by reference into the present application.

TECHNICAL FIELD

[0002] The present disclosure relates to electric (cordless) power tool systems that use a battery pack as a power source.

RELATED ART

[0003] A well known type of electric (cordless) power tool system is disclosed in WO 2006/044693 A2. This electric power tool system comprises a tool main body, a battery pack detachably attached to the tool main body, and a charger for charging the battery pack.

SUMMARY

[0004] Such a cordless electric power tool system does not require an external power source (e.g., a wall socket) to drive the electric power tool. Instead, the user may simply charge the battery pack prior to using the electric power tool. However, in such a conventional electric cordless power tool system, the battery pack must be detached from the tool main body in order to charge the battery pack, which is inconvenient for the user.

[0005] It is an object of the present teachings to disclose an improved electric (cordless) power tool system and method, which may, e.g., simplify or facilitate the charging of the battery pack.

[0006] In a first aspect of the present teachings, an electric power tool system may comprise a tool main body, a battery pack that is detachably attachable to the tool main body, and a charger configured or adapted to charge the battery pack. At least one of the tool main body and the battery pack is detachably attachable to the charger. The charger is preferably configured to charge the battery pack while the battery pack is attached to the tool main body. With an electric power tool system having such a design, it is not necessary to detach the battery pack from the tool main body in order to charge the battery pack. Thus, the battery pack can be conveniently charged while it is still attached to the tool main body.

[0007] In typical power tool operations, the user intermittently operates the electric power tool, and each operation of the electric power tool is relatively short. Therefore, if the battery pack were to be charged frequently, e.g., during each interval between power tool operations, it may be possible to operate the power tool for long periods of time without ever completely depleting the battery pack, even if the charge storage capacity of the battery pack is relatively small. However, if the user were to frequently charge the battery pack of a conventional power tool system during each interval between power tool operations, it would be troublesome or inconvenient for the user, because it would be necessary to detach the battery pack from the tool main body and then attach it to the charger each time it is desired to charge the battery pack. In contrast, power tool systems according to certain aspects of the present teachings eliminate the need to remove the battery pack from the tool main body in order to charge the battery pack, thereby enabling frequent charging in a very convenient manner. That is, it may not be necessary to detach the (first) depleted battery pack from the tool main body and attach a (second) charged battery pack to the tool main body in order to operate the power tool over a relatively long period of time (e.g., more power tool operations may be performed than would normally be possible for a single charging of the battery pack). Moreover, such a power tool system may advantageously utilize a relatively small and light weight battery pack having a relatively small charge storage capacity, thereby reducing the overall weight of the power tool system. As a result, in such embodiments of the present teachings, user fatigue during the power tool operations may be reduced without sacrificing power tool performance (e.g., without reducing output power and/or length of power tool operation using a single charged battery pack).

[0008] Further objects, embodiments, advantages and details of the present teachings will be apparent after reading the following description of the exemplary embodiments in view of the attached drawings and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 shows a tool main body, a battery pack and a cordless charger of an electric power tool system according to Embodiment 1 of the present teachings.

[0010] FIG. 2 shows an AC charger configured to charge the cordless charger of Embodiment 1.

[0011] FIG. 3 is a block diagram that shows the construction and functional elements of the electric power tool system of Embodiment 1. In this drawing, connections shown with broken lines indicate detachable attachments between components, and the arrows show the direction of the current flow.

[0012] FIG. 4 shows a battery pack configured to be charged by the cordless charger.

[0013] FIG. 5 shows the battery pack attached to the tool main body that will be charged by the cordless charger.

[0014] FIG. 6 shows the battery pack attached to the tool main body that will be charged by the AC charger.

[0015] FIG. 7 shows a modification in which an interface for the cordless charger is provided on the tool main body.

[0016] FIG. 8 shows a block diagram that shows the construction and functional elements of the modified embodiment shown in FIG. 7. Similar to FIG. 3, connections shown with broken lines indicate detachable attachments between components, and the arrows show the direction of the current flow.

[0017] FIG. 9 shows a cordless charger according to Embodiment 2 of the present teachings, in which the cordless charger is capable of charging a rechargeable battery using an external power source.

[0018] FIG. 10 is a block diagram that shows the construction and functional elements of the cordless charger of Embodiment 2. Similar to FIG. 3, connections shown with broken lines indicate detachable attachments between components, and the arrows show the direction of the current flow.

[0019] FIG. 11 shows a cordless charger according to Embodiment 3 of the present teachings, in which a battery pack attached to a tool main body will be charged by the cordless charger.

[0020] FIG. 12 is a block diagram that shows the construction and functional elements of an electric power tool system that includes the cordless charger of Embodiment 3. Similar to FIG. 3, connections shown with broken lines indicate...
detachable attachments between components, and the arrows show the direction of the current flow.

**FIG. 13** shows the cordless charger of Embodiment 3 that is configured to be detachably attached to the tool main body in order to directly supply current to the tool main body.

**FIG. 14** shows the cordless charger of Embodiment 3 that is configured to be charged by an AC charger.

**FIG. 15** shows the cordless charger of Embodiment 3 attached to the tool main body, wherein the cordless charger of Embodiment 3 is also configured to be charged by the cordless charger of Embodiment 1.

**FIG. 16** shows a tool main body, a battery pack and a cordless charger according to Embodiment 4 of the present teachings.

**FIG. 17** is a block diagram that shows the construction and functional elements of an electric power tool system that includes the cordless charger of Embodiment 4. Similar to **FIG. 3**, connections shown with broken lines indicate detachable attachments between components, and the arrows show the direction of the current flow.

**DETAILED DESCRIPTION**

**[0021]** In one embodiment of the present teachings, an electric (cordless) power tool system may further comprise a second charger. In such an embodiment, the second charger is preferably capable of charging the battery pack while the battery pack is detached from the tool main body. With this system, the battery pack can be, e.g., frequently charged using the first charger during the day while the electric power tool is being periodically used, and the battery pack can then be fully charged using the second charger, e.g., overnight, when the electric power tool is not being used at all.

**[0027]** In the aforementioned embodiment, the second charger is preferably capable of charging the battery pack using (by supplying) a larger charging current than the first charger. The second charger is generally intended to be used after the battery pack is fully discharged. Therefore, in order to complete the charging operation within a relatively short period of time, the second charger preferably supplies a larger charging current to the battery pack. Any known charging protocol for power tool battery packs may be utilized with the present teachings in order to provide the second charger according to such an embodiment.

**[0028]** In addition or in the alternative, the battery pack may have a tool interface (e.g., battery terminals) that is electrically attachable to the tool main body (e.g., corresponding battery terminals). In addition, the second charger may be configured to be electrically attachable to the tool interface of the battery. According to this embodiment, the battery pack does not require an additional interface for the second charger.

**[0029]** In addition or in the alternative, the tool main body may include a first interface that is electrically attachable to the first charger. In such an embodiment, the first interface of the tool main body may be constructed or designed so as to be electrically connectable with the battery pack when the battery pack is attached to the tool main body.

**[0030]** The present teachings can be applied to any type of cordless electric power tool, including but not limited to electric power tools for processing metals, electric power tools for processing stone, and electric power tools for gardening. Specific examples include, but are not limited to, electric drills, electric impact and screw drivers, electric impact wrenches, electric grinders, electric circular saws, electric reciprocating saws, electric jigsaw, electric band saw, electric hammer, electric cutters, electric chain saws, electric planers, electric nailers (including electric rivet gun), electric staplers, electric shears, electric hedge trimmers, electric lawn clippers, electric lawn mowers, electric brush cutters, electric blowers (leaf blowers), electric flashlights, electric concrete vibrators and electric vacuum cleaners.

**[0031]** Rechargeable batteries housed within the battery pack and the first charger may include, but are not limited to, at least one lithium-ion cell. The rechargeable battery (or a plurality of rechargeable batteries connected in series and/or in parallel) housed within the first charger may have the same nominal voltage as, or a different voltage from, the rechargeable battery(ies) housed within the battery pack. In addition, the rechargeable battery(ies) housed within the first charger and the rechargeable battery(ies) housed within the battery pack may be the same type of rechargeable battery(ies), or may be different types (e.g., the same or different chemistries and/or configurations) of rechargeable batteries.

**[0032]** The tool main body, the battery pack, the first charger, and the second charger may be directly attachable to each other, or may be attachable via an adapter. In addition, these items may be electrically connectable via contact terminals, or in a contactless manner (e.g., electromagnetic induction using one or more coils).

**[0033]** Representative, non-limiting examples of the present teachings will now be described in further detail with reference to the attached drawings. This detailed description is merely intended to teach a person of skill in the art further details for practicing preferred aspects of the present teachings and is not intended to limit the scope of the teachings. Furthermore, each of the additional features and teachings disclosed below may be utilized separately or in conjunction with other features and teachings to provide improved power tool systems, as well as methods for using and manufacturing the same.

**[0034]** Moreover, combinations of features and steps disclosed in the following detail description may not be necessary to practice the teachings in the broadest sense, and are instead taught merely to particularly describe representative examples of the teachings. Furthermore, various features of the above-described and below-described representative examples, as well as the various independent and dependent claims, may be combined in ways that are not specifically and explicitly enumerated in order to provide additional useful embodiments of the present teachings.

**[0035]** All features disclosed in the description and/or the claims are intended to be disclosed separately and independently from each other for the purpose of original written disclosure, as well as for the purpose of restricting the claimed subject matter, independent of the compositions of the features in the embodiments and/or the claims. In addition, all value ranges or indications of groups of entities are intended to disclose every possible intermediate value or intermediate entity for the purpose of original written disclosure, as well as for the purpose of restricting the claimed subject matter.

**Embodiment 1**

**[0036]** An electric (cordless) power tool system of Embodiment 1 will be described with reference to the drawings. The electric power tool system of the present embodiment is a hand-held electric screwdriver and can be used, e.g., to drive...
screws both into and out of an object. However, the technolo-

gy described in the present embodiment is not limited to
electric screwdrivers, and can also be applied in the same
manner to a wide variety of other types of electric power
tools, such as the above-described electric power tools, or
even other electric power tools that are not specifically men-
tioned herein.

As shown in FIGS. 1 to 3, the electric power tool
system comprises a tool main body 10, a battery pack 30, a
cordless charger 50 and an AC charger 70.

The tool main body comprises a tool holder 12, a
motor 14, a trigger switch 16 and a battery pack interface 18.
The tool holder 12 is rotatably supported and constructed so
that a screwdriver bit (tool) can be detachably attached thereto.
The motor 14 may be, e.g., a brushless motor. The output of the
motor 14 is coupled to the tool holder 12 so as to
rotatably drive the tool holder 12. In other types of electric
power tools, the tool holder 12 or the tool may be driven by a
solenoide instead of or together with the motor 14. The trigger
switch 16 is manually operable by a user. For example, when
the user manually operates or actuates the trigger switch 16,
the motor 14 drives the tool holder 12, and when the user
releases the trigger switch 16, the motor 14 stops driving the
tool holder 12. The battery pack interface 18 detachably
receives (attaches to) the battery pack 30. The battery pack
interface 18 is electrically connected to the motor 14 via the
trigger switch 16. The battery pack interface 18 comprises at
least one battery (contact) terminal and also optionally at least
one (contact) port for electrical communications with a pro-
cessor and/or controller disposed in the tool main body 10
and/or in the battery pack 30, as is well known in the art.

The battery pack 30 is the power source for the tool
main body 10 and is detachably attached to the tool main body
10. The battery pack 30 comprises a tool interface 32, a
rechargeable battery 34 and a first charger interface 36. The
tool interface 32 electrically connects with the battery pack
interface 18 of the tool main body 10 when the battery pack 30
is attached to the battery pack interface 18 of the tool main body
10. The tool interface 32 is connected to the rechargeable
battery 34 and conducts electric current from the rechargeable
battery 34 to the tool main body 10. Similar to the
battery pack interface 18, the tool interface 32 comprises at
least one (contact) battery terminal (that is compatible with
the at least one (contact) battery terminal of the battery pack
interface 18) and also optionally at least one (contact) port for
electrical communications with a processor and/or controller
disposed in the tool main body 10 and/or in the battery pack
30, as is well known in the art. In the present embodiment,
the tool interface 32 of the battery pack 30 may be disposed
within the tool main body 10 (i.e. in an interior portion of
a housing of the tool main body 10), and thereby hidden by
the tool main body 10 when the battery pack 30 is attached to
the tool main body 10. The rechargeable battery 34 of the battery
pack 30 is preferably a lithium ion rechargeable battery. How-
ever, the rechargeable battery 34 is not limited to a lithium ion
rechargeable battery, and may be any other type of recharge-
able battery, such as other types of lithium-based batteries,
nickel-metal hydride batteries, nickel cadmium batteries, etc.

The first charger interface 36 of the battery pack 30
may include a pair of positive and negative (contact) termi-
nals that are electrically connectable (i.e. directly connectable
in a contacting manner) with the cordless charger 50. As
shown in FIG. 4, the first charger interface 36 is preferably
disposed on the bottom of the battery pack 30, although it may
also be disposed on a lateral side of the battery pack 30. It is
preferable that the first charger interface 36 always
remains exposed to the outside or is externally accessible even
when the battery pack 30 is attached to the tool main body 10.
Generally speaking, the top side of the battery pack 30 is
physically engaged with the battery pack interface 18, which
is disposed on a bottom face of the tool main body 10, when
the battery pack 30 is attached to the battery pack interface 18
of the tool main body 10. Therefore, when the battery pack 30
is attached to the battery pack interface 18 of the tool main body
10, the lateral and bottom sides of the battery pack 30 are
normally exposed to the outside. However, in case a lateral or
bottom side of the battery pack 30 attaches to the battery pack
interface 18, then the top side of the battery pack 30 may be
exposed to the outside and thus may be suitable for disposing
the first charger interface 36 thereon.

The cordless charger 50 is configured to charge the
battery pack 30. The cordless charger 50 comprises a battery
pack interface 52, a charging controller 54, at least one
rechargeable battery 56 and a second charger interface 58.
The battery pack interface 52 may include a pair of positive
and negative (contact) terminals that are electrically and
detachably connectable (i.e. directly connectable in a contact-
ing manner) with the first charger interface 36. The battery
pack interface 52 is electrically connected to the rechargeable
battery 56 via the charging controller 54. The rechargeable
battery 56 of the cordless charger 50 is preferably a lithium
ion rechargeable battery. However, the rechargeable battery
56 is not limited to a lithium ion rechargeable battery, and
may be any other type of rechargeable battery, such as other
types of lithium batteries, nickel-metal hydride batteries,
nickel cadmium batteries, etc. As was discussed above, a
plurality of batteries may be utilized by connecting them in
series and/or parallel.

In the present embodiment, the cordless charger 50
charges the rechargeable battery 34 of the battery pack 30
using energy stored in the rechargeable battery 56. In the
present embodiment, the charging current and the charging
voltage supplied to the battery pack 30 are preferably con-
trolled by the charging controller 54, although the charging
current and charging voltage could also be controlled, either
solely or in combination, by a controller disposed in the
battery pack 30 and/or even in the tool main body 10. The
cordless charger 50 of the present embodiment does not
require an external power supply (e.g., a wall socket) to
charge the battery pack 30 (i.e. the cordless charger 50 may
be disconnected from a separate power source during charging
of the battery pack 30). The rechargeable battery 56 is elec-
trically connected to the second charger interface 58. The
second charger interface 58 preferably includes a pair of
positive and negative (contact) terminals that are electrically
and detachably connectable with the AC charger 70. The
second charger interface 58 optionally may also include at
least one (contact) port for electrical communications with a
processor and/or controller disposed in the tool main body 10
and/or in the battery pack 30, as is well known in the art.

The AC charger 70 is configured to charge the at
least one rechargeable battery 56 of the cordless charger 50,
but optionally may be configured to also directly charge the rechargeable battery(ies) 34 of the battery pack 30, as will be further described below. The AC charger 70 comprises a first charger interface 72, a battery pack interface 74, a charging controller 76, an AC-DC converter 78 and a power cord 82. The power cord 82 is electrically connectable to an external AC power source (e.g., to a wall socket connected to a commercial AC power source or to a portable generator). The AC current supplied from the AC power source is converted into DC power by the AC-DC converter 78. The AC-DC converter 78 is electrically connected to the first charger interface 72 and to the battery pack interface 74 via the charging controller 76. Thus, the AC charger 70 is preferably configured to receive AC power from the external AC power source and to output DC power from the first charger interface 72 as well as optionally from the battery pack interface 74. The first charger interface 72 and the battery pack interface 74 each preferably comprises at least one appropriately configured (contact) battery terminal and also optionally at least one (contact) port for electrical communications with a processor and/or controller disposed in the tool main body 10 and/or in the battery pack 30, as is well known in the art.

[0044] As shown in FIG. 2, the first charger interface 72 of the AC charger 70 preferably may include a pair of positive and negative terminals that are electrically and detachably connectable (i.e. directly connectable) with corresponding or complementary positive and negative (contact) terminals of the second charger interface 58 of the cordless charger 50. In addition, as shown in FIG. 5, the first charger interface 72 is electrically and detachably connectable (i.e. directly connectable) with the first charger interface 36 of the battery pack 30. In other words, the AC charger 70 of this embodiment is configured to charge both the rechargeable battery 56 of the cordless charger 50 and the rechargeable battery 34 of the battery pack 30. Furthermore, as shown in FIG. 6, the tool interface 32 of the battery pack 30 is also attachable to the battery pack interface 74 of the AC charger 70. Thus, the AC charger 70 of this embodiment can charge the battery pack 30 via the battery pack interface 74 or via the first charger interface 72. However, it should be understood that the AC charger 70 may be configured to charge only the rechargeable battery 56 of the cordless charger 50, and need not be capable of charging the rechargeable battery 34 of the battery pack 30. That is, in such an embodiment, the rechargeable battery 34 of the battery pack 30 may be charged by the rechargeable battery 56 of the cordless charger 50 or a conventional charger.

[0045] As noted above, the electric power tool system of the present embodiment includes the cordless charger 50 that houses the rechargeable battery 56, such that the user can charge the battery pack 30 without requiring an external power source. For example, the cordless charger 50 is preferably portable and may be placed by the user near to the location where the user is performing power tool operations, so that the electric power tool system (i.e. the first charger interface 36) can be conveniently set on (or otherwise connected with) the cordless charger 50 (i.e. the battery pack interface 52) between power tool operations, thereby enabling frequently charging of the battery pack 30. Thus, even if the charge storage capacity of the battery pack 30 (at least one rechargeable battery 34) is relatively small, it still may be possible to avoid completely depleting the battery pack 30 while alternately performing power tool operations and recharging the battery pack 30 (i.e. between power tool operations), such that the depleted battery pack 30 would have to be replaced with a freshly-charged battery pack 30 in order to continue the power tool operations. Generally speaking, lower-capacity battery packs 30 have a smaller volume (smaller-sized) and weigh less, such that the overall weight of the electric power tool (tool main body 10 and the battery pack 30) can be reduced. Thus, by using a lighter-weight battery pack, the electric power tool can be made less burdensome to hold up for the user, thereby advantageously making usage of the power tool system easier and less fatiguing.

[0046] In the present embodiment, the battery pack 30 is chargeable by the cordless charger 50 while the battery pack 30 is attached to the tool main body 10. According to such a construction, there is no need to detach the battery pack 30 from the tool main body 10 when the user wants to charge the battery pack 30. As a result, the user can very conveniently charge the battery pack 30 between power tool operations. However, in certain aspects of the present teachings, it is not necessary for the cordless charger 50 to be capable of charging the battery pack 30 while it is attached to the tool main body 10. In other words, the cordless charger 50 may instead be capable of charging the battery pack 30 only while the battery pack 30 is detached from the tool main body 10, in a manner similar to conventional chargers.

[0047] In the present embodiment, the charge storage capacity of the rechargeable battery 56 housed in the cordless charger 50 is larger or greater than the charge storage capacity of the rechargeable battery 34 housed in the battery pack 30. Such an embodiment of the present teachings is particularly convenient for the user, because the overall size and weight of the electric power tool (the tool main body 10 and the battery pack 30) can be reduced by utilizing a lighter-weight battery pack. However, because the battery pack 30 can be frequently recharged using the cordless charger 50, the electric power tool is capable of performing a relatively large amount of work before it becomes necessary to recharge the rechargeable battery 56 of the cordless charger 50. That is, the power tool system may be operated much longer before the battery pack 30 must be recharged than would normally be expected.

[0048] In addition, in the present embodiment, the lithium ion battery(ies) used for the rechargeable battery 34 of the battery pack 30 may preferably have different properties (e.g., a different chemistry and/or configuration) than the rechargeable battery(ies) 56 of the cordless charger 50. For example, the rechargeable battery 34 of the battery pack 30 preferably utilizes a lithium ion rechargeable battery that has been specially developed and designed for use in electric power tools, i.e. a rechargeable battery having a relatively high maximum rated or nominal current output, so that heavy duty power tool operations can be performed using the battery pack 30. On the other hand, the rechargeable battery 56 of the cordless charger 50 may utilize, e.g., a lithium ion rechargeable battery specially developed or designed for use in notebook personal computers (PCs), which has a lower maximum rated or nominal current output, but has a higher charge storage density. Because the battery charging operation is typically performed using a much smaller current than a power tool operation, the at least one rechargeable battery 56 of the cordless charger 50 can utilize a battery chemistry and/or configuration that minimizes weight and size while maintaining a relatively high charge storage capacity. As a result, the cordless charger 50 can have a smaller weight and size (volume) overall without sacrificing stored charging power.
As compared to lithium ion rechargeable batteries for use in electric power tools, lithium ion rechargeable batteries for use in notebook PCs have a lower maximum allowable current, but advantageously have a large capacity relative to its size and weight. Accordingly, because the maximum current flow to the at least one rechargeable battery 56 may be relatively small according to the present teachings, lithium ion rechargeable batteries that are suitable for use in notebook PCs may be used in the cordless charger 50 of the present embodiment. In contrast, because a large amount of current needs to flow to the motor 14 during a power tool operation, lithium ion rechargeable batteries suitable for use in electric power tools must be used for the rechargeable battery 34 of the battery pack 30, so as to enable a relatively large current flow. Of course, the at least one rechargeable battery 56 of the cordless charger 50 is not limited to only lithium ion rechargeable batteries suitable for use in notebook PCs, and various other types of rechargeable batteries developed for other purposes can also be appropriately used with the present teachings.

In the present embodiment, the battery pack 30 is rechargeable not only by the cordless charger 50, but also by the AC charger 70. For example, the AC charger 70 can be configured to charge the battery pack 30 while the battery pack 30 is attached to the tool main body 10 (see FIG. 5). Thus, when AC power (e.g., a wall socket) is readily available, the AC charger 70 can be used instead of the cordless charger 50 to charge the battery pack 30. For example, as was described above, the battery pack 30 (while attached to the tool main body 10) can be set on the AC charger 70 (in particular on the first charger interface 72) between power tool operations, thereby charging the battery pack 30 on a frequent basis and thus possibly avoiding a complete depletion of the charge stored in the battery pack 30 during a particular set of power tool operations.

As was described above, the AC charger 70 may also be configured to charge the battery pack 30 when the battery pack 30 is detached from the tool main body 10 (see FIG. 6) by engaging the tool interface 32 with the battery pack interface 74. In such an embodiment, the AC second charger 70 could be used, e.g., to completely charge the battery pack 30 overnight while the electric power tool is not being used at all. In such a configuration, the AC charger 70 may preferably supply the battery pack 30 with a charging current that is larger than the charging current supplied by the cordless charger 50. In this case, the battery pack 30 can be charged in a relatively short period of time.

FIGS. 7 and 8 show an alternative embodiment, in which a charger interface 22 is additionally provided on the tool main body 10. This charger interface 22 is electrically connectable with the battery pack interface 52 of the cordless charger 50 and/or with the first charger interface 72 of the AC charger 70 while the battery pack 30 is connected to the battery pack interface 18 of the tool main body 10. Similar to the other interfaces described above, the charger interface 22 also preferably comprises at least one appropriately configured (contact) battery terminal and also optionally at least one (contact) port for electrical communications with a processor and/or controller disposed in the tool main body 10 and/or in the battery pack 30, as is well known in the art. In this embodiment, the charger interface 22 is electrically connected to the battery pack interface 18 within the tool main body 10. As a result, when the battery pack 30 is attached to the tool main body 10, the charger interface 22 of the tool main body 10 will be electrically connected to the at least one rechargeable battery 34 of the battery pack 30. The embodiment also enables the battery pack 30 to be charged by the cordless charger 50 or by the AC charger 70 while the battery pack 30 is attached to the tool main body 10.

Embodiment 2

A cordless charger 150 of Embodiment 2 will be described with reference to FIGS. 9 and 10. The cordless charger 150 of Embodiment 2 charges the battery pack 30 described in Embodiment 1, and is a modification of the cordless charger 50 described in Embodiment 1. In FIGS. 9 and 10, components that are common with the cordless charger 50 of Embodiment 1 have been assigned the same reference numbers.

As shown in FIGS. 9 and 10, the cordless charger 150 of Embodiment 2 further comprises a second charging controller 162, an AC-DC converter 164 and a power cord 166, which are not provided in the cordless charger 50 of Embodiment 1. The power cord 166 is electrically connectable to an external AC power source (e.g., to a wall socket in electrical communication with a commercial AC power supply). The AC current supplied from the AC power source is converted into DC power by the AC-DC converter 164. The AC-DC converter 164 is electrically connected to the rechargeable battery 56 via the charging controller 162.

In such a construction, the cordless charger 150 of Embodiment 2 is capable of directly receiving AC power from the external AC power source, which can be utilized to charge the rechargeable battery 56. Of course, the rechargeable battery 56 of the cordless charger 150 can also be charged by the AC charger 70, which was described in Embodiment 1.

Embodiment 3

A cordless charger 250 of Embodiment 3 will be described with reference to FIGS. 11 to 15. The cordless charger 250 of Embodiment 3 charges the battery pack 30 described in Embodiment 1, and is a modification of the cordless charger 50 described in Embodiment 1. In FIGS. 11 to 15, components that are common with the cordless charger 50 of Embodiment 1 have been assigned the same reference numbers.

As shown in FIGS. 11 and 12, the cordless charger 250 of Embodiment 3 further comprises a tool interface 252, which is not provided in the cordless charger 50 of Embodiment 1. The tool interface 252 is electrically connected to the rechargeable battery 56 inside the cordless charger 250. The tool interface 252 of the cordless charger 250 preferably has the same structure as the tool interface 32 of the battery pack 30, or at least has a structure that permits the tool interface 252 to be electrically connected to the battery pack interface 18 of the tool main body 10. Thus, such a configuration enables the cordless charger 250 to be attached to the tool main body 10 as shown in FIG. 13 as well as to the battery pack 30 as shown in FIG. 11. When the cordless charger 250 is attached to the tool main body 10 as shown in FIG. 13, the tool interface 252 of the cordless charger 250 is electrically connected with the battery pack interface 18 of the tool main body 10. Consequently, the cordless charger 250 of the present embodiment can not only charge the battery pack 30, but can also serve as a power source for the tool main body 10 so as to directly supply current from the rechargeable battery 56 of the cord-
less charger 250 to the motor 14 of the tool main body 10 (i.e. without a battery pack 30 interleaved therebetween).

[0058] As shown in FIG. 14, the cordless charger 250 of Embodiment 3 is chargeable by the AC charger 70. Thus, the AC charger 70 is configured to charge the cordless charger 250 either via the first charger interface 72 or via the battery pack interface 74. Furthermore, as shown in FIG. 15, the cordless charger 250 of Embodiment 3 can also be configured to be charged by the cordless charger 50 described in Embodiment 1. In this case, the cordless charger 250 is chargeable while it is attached to the tool main body 10.

Embodiment 4

[0059] A cordless charger 350 of Embodiment 4 will be described with reference to FIGS. 16 and 17. The cordless charger 350 of Embodiment 4 charges the battery pack 30 described in Embodiment 1, and is a modification of the cordless charger 50 described in Embodiment 1. In FIGS. 16 and 17, components that are common with the cordless charger 50 of Embodiment 1 have been given the same reference numbers.

[0060] The cordless charger 350 of Embodiment 4 comprises a battery unit 350a detachably attached to an adapter unit 350b. The battery unit 350a comprises a tool interface 352 that is electrically connected to at least one rechargeable battery 56. In such an embodiment, the battery unit 350a may be a conventional battery pack designed to be directly attached to, and supply power for, the tool main body 10. Thus, the battery unit 350a can also be attached to the battery pack interface 18 of the tool main body 10 in order to serve as a power source that supplies current to the tool main body 10.

[0061] The adapter unit 350b comprises a first battery pack interface 52, a charging controller 54 and a second battery pack interface 354. Similar to the interfaces described above, the tool interface 352 and the second battery pack interface 354 each preferably comprises at least one battery (contact) terminal and also optionally at least one (contact) port for electrical communications with a processor and/or controller disposed in the tool main body 10 and/or in the battery pack 30 (350a), as is well known in the art. When the battery pack 30 is attached to the tool main body 10, the first charger interface 36 can be electrically connected to the first battery pack interface 52. A tool interface 352 of the battery unit 350a can be mechanically (directly) and electrically connected to the second battery pack interface 354. The second battery pack interface 354 may be electrically connected to the first battery pack interface 52 via the charging controller 54. According to this construction, the cordless charger 350 of the present embodiment is also configured to charge the battery pack 30 using power stored in the rechargeable battery 56. The housing used for the AC charger 70 described in Embodiment 1 may also be used as the housing for the adapter unit 350b.

[0062] With the cordless charger 350 of the present embodiment, the battery unit 350a that houses the rechargeable battery 56 can be separated from the rest of the structure. Thus, the separated battery unit 350a can be attached to the tool main body 10 instead of the battery pack 30, and can be used as the power source for the tool main body 10. According to this construction, when the cordless charger 350 is used as the power source for the tool main body 10, the structures that are not used, i.e., the second battery pack interface 352 and the charging controller 54, can be removed. In this way, the size and weight of an electric power tool constructed with the tool main body 10 and the cordless charger 350 can be reduced.

[0063] In any of the preceding embodiments, the battery pack 30 is preferably adapted to output a nominal power of at least 300 Watts, e.g., more than 450 Watts, or even more than 600 Watts. Further, the first charger 50, 150, 250, 350 preferably comprises a plurality of series-connected battery cells adapted to store sufficient charge to completely recharge the battery pack at least once, more preferably at least twice, more preferably at least five times and even more preferably at least ten times.

[0064] In any of the preceding embodiments, the battery pack 30 preferably has a nominal voltage greater than 10 volts, e.g., between 10-40 volts, e.g., between about 14 to 30 volts, e.g., between about 21 to 30 volts. In addition or in the alternative, the battery pack 30 preferably has a nominal output current equal to or greater than 10 amps, more preferably equal to or greater than 15 amps. In addition or in the alternative, the battery pack 30 preferably has a nominal capacity of at least 0.5 amp-hour, e.g., equal to or more than 1.0 amp-hour, e.g., equal to or greater than 2.0 amp-hour.

1. An electric power tool system comprising:
   - a tool main body;
   - a battery pack detachably attached to the tool main body; and
   - a first charger configured to detachably attach to at least one of the tool main body and the battery pack and configured to charge the battery pack while the battery pack is attached to the tool main body.

2. The electric power tool system as in claim 1, further comprising a second charger configured to charge the battery pack while the battery pack is detached from the tool main body.

3. The electric power tool system as in claim 2, wherein the second charger is configured to charge the battery pack using a larger charging current than the first charger.

4. The electric power tool system as in claim 3, wherein: the battery pack comprises a tool interface that is electrically connectable with the tool main body, and the second charger comprises a battery interface that is electrically connectable with the tool interface of the battery pack.

5. The electric power tool system as in claim 1, wherein: the tool main body comprises a first interface that is electrically connectable with the first charger, and the first interface of the tool main body is also configured to be electrically connectable with the battery pack while the battery pack is attached to the tool main body.

6. The electric power tool system as in claim 1, wherein: the tool main body comprises a battery pack interface, the battery pack comprises a tool interface configured to attach to the battery pack interface to supply current to the tool main body, the battery pack further comprises a first charger interface configured to attach to a battery pack interface of the first charger while the battery pack is attached to the tool main body, and the first charger is adapted to supply charging current to the battery pack while the battery pack is attached to the tool main body.

7. The electric power tool system as in claim 6, wherein: the first charger interface is configured to attach to a first charger interface of the second charger and
the second charger is configured to supply charging current to the battery pack while the battery pack is attached to the tool main body.

8. The electric power tool system as in claim 7, wherein: the first charger further comprises a second charger interface configured to attach to the first charger interface of the second charger, and the second charger is configured to supply charging current to the first charger while the battery pack is attached to the tool main body and the first charger is attached to the battery pack.

9. The electric power tool system as in claim 8, wherein the battery pack is configured to output a nominal power of at least 300 Watts and the first charger comprises a plurality of series-connected battery cells adapted to store sufficient charge to completely recharge the battery pack at least twice.

10. The electric power tool system as in claim 9, wherein the battery pack has a nominal voltage between about 10-30 volts.

11. The electric power tool system as in claim 10, wherein the battery pack has a nominal output current equal to or greater than 10 amps.

12. The electric power tool system as in claim 11, wherein the battery pack has a nominal capacity of at least 0.5 amp-hour.

13. The electric power tool system as in claim 12, wherein: the battery pack comprises at least one first lithium ion battery cell, the first charger comprises at least one second lithium ion battery cell, and the at least one first lithium ion battery cell has a higher maximum current output, but a lower charge storage capacity, than the at least one second lithium ion battery cell.

14. The electric power tool system as in claim 13, wherein the electric power tool is one of an electric drill, an electric impact driver, an electric screw driver, an electric impact wrench, an electric grinder, an electric circular saw, an electric reciprocating saw, an electric jigsaw, an electric hand saw, an electric hammer, an electric cutter, an electric chain saw, an electric planer, an electric sander, an electric rivet gun, an electric stapler, an electric shears, an electric hedge trimmer, an electric lawn clipper, an electric lawn mower, an electric brush cutter, an electric blower, an electric flashlight, an electric concrete vibrator and an electric vacuum cleaner.

15. The electric power tool system as in claim 1, wherein the battery pack is configured to output a nominal power of at least 300 Watts and the first charger comprises a plurality of series-connected battery cells adapted to store sufficient charge to completely recharge the battery pack at least twice.

16. The electric power tool system as in claim 1, wherein the battery pack has a nominal voltage between about 10-30 volts, a nominal output current equal to or greater than 10 amps and a nominal capacity of at least 0.5 amp-hour.

17. The electric power tool system as in claim 1, wherein: the battery pack comprises at least one first lithium ion battery cell, the first charger comprises at least one second lithium ion battery cell, and the at least one first lithium ion battery cell has a higher maximum current output, but a lower charge storage capacity, than the at least one second lithium ion battery cell.

18. A cordless power tool system comprising: a tool main body, a tool mounted on or in the tool main body, at least one of a motor and a solenoid disposed within the tool main body and configured to movably drive the tool, a battery pack detachably attachable to the tool main body and configured to supply driving current to the at least one of the motor and the solenoid; and a first charger configured to detachably attach to at least one of the tool main body and the battery pack and configured to charge the battery pack while the battery pack is attached to the tool main body.

19. The cordless power tool system as in claim 18, wherein: the tool main body comprises a battery pack interface, the battery pack comprises a tool interface configured to attach to the battery pack interface to supply the driving current to the motor, the battery pack further comprises a first charger interface configured to attach to a battery pack interface of the first charger while the battery pack is attached to the tool main body, and the first charger is adapted to supply charging current to the battery pack while the battery pack is attached to the tool main body.

20. A method for recharging the electric power tool system according to claim 1, comprising: supplying charging current from one of the first charger or a second charger to the battery pack while the battery pack is attached to the tool main body.

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