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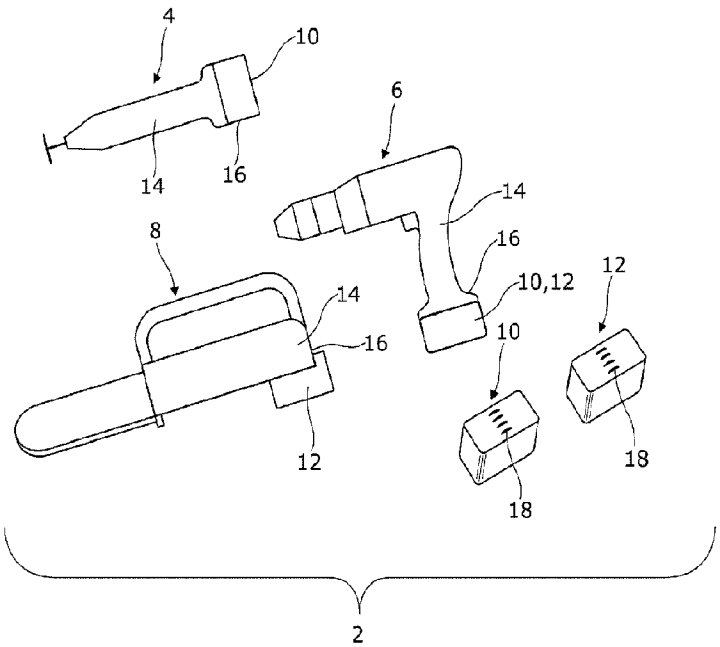

Figure 1

(57) **Abrégé/Abstract:**
The invention to which the application relates is a power tool and battery pack system which comprises at least two battery packs and a plurality of power tools with said power tools operable at any one of a range of three predetermined rated voltage levels and each of the three predetermined rated voltage levels can be supplied from at least one of the battery packs in the system, Typically each of the battery packs can selectively provide at least two of the three predetermined rated voltage levels. The particular rated voltage level which is provided by a battery pack to a power tool which is connected to the same at an instant of time, is determined by the configuration of an electrical circuit portion provided within the power tool. Thus, the system allows a range of power tools operable at different voltages, to be supplied with an appropriate voltage level and also prevent the supply of power at an incorrect voltage level to a power tool.

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Abstract:

The invention to which the application relates is a power tool and battery pack system which comprises at least two battery packs and a plurality of power tools with said power tools operable at any one of a range of three predetermined rated voltage levels and each of the three predetermined rated voltage levels can be supplied from at least one of the battery packs in the system, Typically each of the battery packs can selectively provide at least two of the three predetermined rated voltage levels. The particular rated voltage level which is provided by a battery pack to a power tool which is connected to the same at an instant of time, is determined by the configuration of an electrical circuit portion provided within the power tool. Thus, the system allows a range of power tools operable at different voltages, to be supplied with an appropriate voltage level and also prevent the supply of power at an incorrect voltage level to a power tool.

Power Tools and Battery Packs System

The invention to which this application relates is a power tool system which incorporates two or more power tools, with at least some of the tools in the system required to operate with power supplied thereto at different rated voltages in order to operate safely and provide an optimum performance level. The rated voltage for each power tool in the system is provided from one battery pack connected thereto and which is mechanically and electrically connected to the power tool via a battery pack interface. Typically, the said battery pack can be selectively disengaged from the power tool housing in order to allow the battery pack to be used with another power tool or to be charged using a suitable charging facility and, when charged, can be reengaged with the appropriate power tool to provide the appropriate rated voltage power level thereto.

The provision of power tools which are provided with a power supply from a battery pack rather than a mains electrical supply connected thereto by a cable, is well-known and power tools of this type, are generally referred to as portable power tools in that they can be provided to be operated at any location independently of whether or not there is a mains electricity power supply available. As such, power tools of this type have great attraction and the use of the same is widespread.

Conventionally, the portable power tool is provided with a battery pack which is specifically provided in a configuration to supply power at a particular rated voltage level to that particular power tool with which the same is provided and/or to other power tools which are of the same "power tool family", typically from the same tool manufacturer, in that the mechanical locations for the battery packs are the same, and the battery pack is provided to supply a particular predetermined rated voltage level required by the power tool to operate. However, increasingly portable power tools are provided which require different rated voltage levels of power in order for the same to operate and so, conventionally, a power tool owner who has a range of

power tools is also required to have a range of different types of battery packs in terms of different mechanical connection configurations to suit different manufacturer's power tools and/or different electrical configurations and/or power cells to provide a particular rated voltage of power to particular power tools. For example, the power tools can be categorised in terms of the type of task which they perform, typically categorised as light, medium and heavy duty tasks and the power tools in each category operate at different rated voltage levels. Typically, a low rated voltage battery pack and a low rated voltage operable power tool are required for light tasks such as a power tool which is required to operate to perform delicate tasks such as engraving, soldering and/or where access is difficult to be gained to reach the point at which the work is to be performed.

The medium duty tasks typically are a range of "DIY" tasks which are generally repetitive and require more robust work action and power tools so that a medium rated voltage battery pack and a medium rated voltage power tool combination is required to provide the required combination of power and endurance in order to perform the repeated tasks such as drilling of holes, or insertion and tightening of screws. For heavy duty tasks a higher rated voltage battery pack and higher rated voltage power tool combination is required as these work tasks are typically more demanding such as cutting thick or hard materials.

This can be expensive to the operator in that they have to purchase a battery pack and charger for each power tool. Furthermore, this can give rise to the risk of dangerous use of the power tool should the customer decide to try and save costs by adapting the battery pack which they already have to fit another manufacturer's power tool and/or to operate at a different rated voltage level than that for which the battery pack was intended. In order to avoid the risk of damage to the power tools and/or risk of a dangerous fire to the battery cells or power tool, different voltage battery packs and/or power tools are typically provided with a mechanical configuration intended to prevent the battery pack being fitted to a power tool

which has a different power rated voltage requirement than that which will be provided by the battery pack if connected thereto and typically this is ensured by providing differences in the mechanical connection means at the battery pack interface between the power tool and the battery pack in order to prevent the deliberate or mistaken attempt to fit an incorrect battery pack to a particular power tool and thereby prevent an active electric connection being made. However, these mechanical features can be easily accessed and are typically located on the outside of the battery pack or power tool and so operators, either by accidental damage or by deliberate actions, may remove the mechanical features that prevent incorrect connection or choose to modify the mechanical features on the battery pack or power tool to allow an incorrect rated voltage battery pack to be fitted onto a particular power tool to extend the range of possible uses of the battery pack across more tools having different rated voltage requirements but the operator will typically have no understanding of the safety risks which are created and the consequences of which can be extremely dangerous.

As a result of this, more recent developments include the provision of first and second power tools as part of a power tool system with the tools operable at different rated voltages and the system also includes the provision of a battery pack which operates to provide power to a first of the power tools at a first rated voltage and a second battery pack which can be provided to operate in two configurations in order to allow the first rated voltage to be provided to the first power tool and a second rated voltage to be provided to operate the second power tool. Typically this is achieved by the provision in the dual voltage battery pack of two groups of battery cells and, by connecting these battery cells in parallel, a first power rated voltage level can be supplied from the battery pack and by connecting the groups of battery cells in series, a second rated voltage power level can be supplied from the same battery pack. Thus, typically, the groups of power cells connected in parallel, will provide the first lower rated voltage and the connection of the groups of power cells in series, will allow the provision of a power rated voltage which is double that of the first

rated voltage. The control of the particular rated voltage, which is provided to the power tool, is typically achieved by the selective positioning of mechanical and electrical switching means on the battery pack and the position of which is defined by mechanical means located on the power tool when engaged with the particular battery pack interface, or may be achieved as a result of the provision of mechanical and electrical interaction of the connected power tool.

Thus, if, two power tools in the known system are of a type to be operated at any of two of light, medium or heavy-duty tasks, and the respective required rated voltages are a first rated voltage and a second rated voltage, which is twice the first rated voltage, then the two power tools, can receive the required rated voltage power from the same battery pack. However, this still means that power tools which require the third power voltage i.e., the remaining one of light, medium or heavy-duty task power tools, and which is most commonly the light duty task type of power tool, cannot be included in the system and will still require a separate battery pack to be provided and that battery pack will not be compatible with the other power tools which are required for the other two duty tasks.

A further problem is that the specific rated voltage required by the power tools to perform one of the light, medium and heavy duty tasks, may not be half or double the rated voltage required by power tools to perform the other two of the duty tasks and this can cause problems not only in the provision of a dual battery pack to provide power voltages at two rated voltage levels to different power tools but also with regard to any attempt to provide a second battery pack with a dual rated voltage capability as part of the same system. For example, the rated voltage of a power tool to perform a light duty task is not half that of the rated voltage required by a second power tool to provide the medium duty task and so a simple selection between series or parallel configuration of the connection of groups of power cells in the battery pack cannot always provide a solution.

In addition, in order to ensure that both first and second battery packs of a battery pack system can be connected to a second power tool, then significant safety risks arise, as a battery pack which provides two higher rated voltage levels for, for example, medium and heavy duty task power tools, could be connected to another power tool, for example a power tool to perform a light duty task, which requires a rated voltage power lower than the said higher rated voltages, resulting in significant safety risks such as overheating and fire. Conversely, should a battery pack which provides the first, lowest rated voltage of the system be connected to a power tool which requires the third, highest rated voltage then there is a significant safety risk that overheating and fire will result as the power tool demands a high current from an insufficient number of battery cells in the said battery pack. While mechanical features could be added to the battery pack interfaces to attempt to prevent accidental connection being made, if the system requires both the first and second battery packs to be capable of providing a second, intermediate rated voltage when connected to, for example, a power tool which requires the second intermediate rated voltage then this is not desirable or practical.

An aim of the present invention is therefore to provide a battery pack and power tool system which optimises the ability to allow power tools required to perform different tasks, such as for example, light, medium and heavy-duty tasks to be provided with the required different rated voltages from a minimal number of battery packs within the system, to thereby reduce the cost of the system, increase adaptability and functionality of the system. A further aim is to be able to provide these advantages whilst, at the same time, minimising the risk to the operator and opportunity for the operator to accidentally or deliberately manipulate the battery pack operation.

In a first aspect of the invention, there is provided a power tool and battery pack system including first and second battery packs, each of which is configured so as, when charged, to be able to provide power at two different rated voltage levels, a

plurality of power tools, each of said power tools operable when power at a predetermined rated voltage level selected from at least three predetermined rated voltage levels is supplied thereto, a battery pack interface formed between a said power tools and a said battery pack when mechanically connected, said battery pack interface including electrical connection means for the transfer of power from the battery pack to operate the power tool, and wherein the possibility, and selection, of the supply of a predetermined rated voltage level from a said battery pack to which a power tool of the system is connected at that time to form the battery pack interface, is determined by the configuration of an electrical circuit portion located within said power tool.

In one embodiment the said mechanical and electrical connection means at said battery pack interface are common to each of the said power tools and battery packs in said system .

In one embodiment the electrical connection means at the said battery pack interface comprise a series of female sockets provided in one of the battery pack or power tool which receive a series of male pins or plugs provided in the other of the battery packs or power tools.

Typically, in order to allow the appropriate one of the predetermined rated voltage levels to be supplied from the appropriate battery pack connected to a power tool at an instant of time, the said electrical circuit portion provided within the power tool connects the operating drive system of the power tool to the pins or terminals provided on the power tool at the battery pack interface, and the electrical circuit portion is configured so as to allow the appropriate predetermined rated voltage level to be supplied to the operating system of that power tool.

Typically, the configuration of the electrical circuit portion within a first power tool which is required to operate at the first predetermined rated voltage level is different

to the configuration of the electrical circuit portion of a second power tool provided to be operated at the second predetermined rated voltage level and furthermore the configurations of the electrical circuit portions of the first and second power tools are different to the configuration of the electrical circuit portion of the third power tool provided to be operated at a third predetermined rated voltage level.

Typically, the particular rated voltage level of power which is required for operation of each of the power tools in the system is predetermined at the time of manufacture of the power tool by the selection of the configuration of the electrical circuit portion within the power tool and thereafter the said configuration of the electrical circuit portion is unchanged during use of the power tool. In one embodiment the electrical circuit portion comprises electrical wiring and/or a circuit board located within the housing of the power tool.

Typically, therefore the battery pack interface formed between each of the power tools and battery packs of the system, has identical mechanical connection means and identical electrical connection pins and sockets. Typically, as a result, in accordance with the invention, no mechanical safety means are required to be provided to prevent particular power tools being mechanically connected to certain battery packs within the system.

In one embodiment, the system further includes a battery charger to allow a charge to be provided to the said battery packs in the system and typically said battery charger, when connected to the battery pack instead of a power tool, forms a substantially identical battery pack interface as used by the power tools in the system. Typically the charger is compatible with and capable of charging all of said battery packs in the system.

In one embodiment the system incorporates two battery packs and a number of power tools which can be selected from a range of power tools which are operable

at the three rated voltages which can be selectively provided from the said battery packs, with each battery pack in the system capable of providing at least two of said three predetermined rated voltage levels.

Typically each of the said battery packs is capable of delivering two of said predetermined rated voltage levels with the said rated voltage levels which are provided determined by the configuration of the electrical circuit portion within the power tool which is connected to the battery pack at that instant of time.

Typically, each of the battery packs include a plurality of power cells, with the configuration and/or number of power cells within a first battery pack differing to those provided in the second battery pack.

In one embodiment a first battery pack is capable of providing a first predetermined rated voltage level which is the lowest of the three predetermined rated voltage levels and a second predetermined rated voltage level which is intermediate in that the level is greater than the first but less than the third of the three predetermined rated voltage levels. Typically, a second battery pack of the system, is capable of providing two of the predetermined rated voltage levels, one of which is the said third predetermined rated voltage level. Typically, the other predetermined rated voltage level provided by the second battery pack is the second predetermined rated voltage level so that the said second predetermined rated voltage level can be supplied by both the first and second battery packs.

For each of the battery packs the selection of whether a predetermined rated voltage level can be supplied, and, if so, which of two possible predetermined rated voltage levels which can be provided by the battery pack is to be supplied to the power tool connected thereto at an instant of time, is determined by the configuration of the electrical circuit portion located within the power tool which is connected to the battery pack at that instant of time.

In one embodiment, the third predetermined rated voltage level supplied by the second battery pack is double the said second predetermined rated voltage level. Typically, for the second battery pack, the configuration of the respective electrical circuit portion of the power tools has the effect of groups of cells in the battery pack being effectively connected in series or parallel in order to supply the particular one of the two predetermined rated voltage levels.

In one embodiment, in the first battery pack, a selected number of a plurality of power cells are connected in a series circuit of at least two different forms which allow, in one form, the effect of all power cells being connected to deliver a maximum possible combined voltage of the cells i.e., the second predetermined rated voltage level from the first battery pack, or, in a second form, one or more power cells are bypassed or disconnected in order to deliver the first predetermined rated voltage level and again the selection of the particular form is made as a result of the configuration of the electrical circuit portion within the power tool which is connected to the battery pack at that instant of time.

Thus, in effect, the electrical circuit portion within the power tool is dormant when the power tool is not connected to the battery pack but, when connected to the battery pack, the electrical circuit portion within the power tool is capable of forming part of and completing the electrical power supply circuit which extends between the battery pack and the connected power tool via the battery pack interface should the power tool be connected to an appropriate battery pack for the rated voltage power that is required.

In one embodiment, the electrical circuit portion of each of the power tools in the system, also acts as a safety system such that each of the power tools can only electrically connect to the power cells of a battery pack in a correct rated voltage delivery configuration and the electrical circuit portion is configured in the power tool in dependence upon the particular rated voltage which that power tool requires

and therefore this prevents an incorrect voltage demand being placed by a power tool upon either of the first or second battery packs which is especially important if the power tool has been incorrectly mechanically connected to a battery pack which is incapable of safely providing the rated voltage which that power tool requires.

In a further embodiment, the safety system and/or electrical circuit portion, are located within the outer housing of the power tool and are therefore inaccessible from accidental access being gained and furthermore, if access is gained deliberately to try and reconfigure the electrical control means this will typically be apparent or in addition may be specifically rendered apparent by the provision of tamper evident means which will indicate if access has been gained in an unauthorised manner to the interior of the tool housing. This could be used as a deterrent such as for example rendering the warranty of the power tool void and so deter the incorrect usage of the power tool.

As a result of this inherent safety system within the battery pack and power tool system as herein described, even if the first battery pack is mechanically connected to a power tool which operates at the third, highest, rated voltage and which the first battery pack is incapable of providing safely, no viable electrical connection between the battery pack and the power tool is possible as a result of the configuration of the electrical connection portion provided within that power tool, As a result, the operating system of the power tool, including the motor, cannot be provided by power at an incorrect rated voltage level from the battery pack and so there is no risk to the user. Also, if the second battery pack is mechanically connected to a power tool which requires the first predetermined rated voltage level which cannot be provided from the second battery pack safely, the battery pack is not usable with at power tool.

In a further aspect of the invention there is provided a power tool and battery pack system including a plurality of power tools which can be selected from a range of

power tools configured to be operable at at least three different rated voltage levels and each of said power tools mechanically locatable with each of the battery packs and wherein the system includes two battery packs and at least one of the battery packs is selectively electrically connectable to said power tools to provide the power thereto at the correct one of the said three rated voltages for that power tool.

In a further aspect of the invention there is provided a power tool and battery pack system including a plurality of power tools selectable from a range of power tools configured to be operable at at least three different predetermined rated voltage levels, a first battery pack capable of providing two of said rated voltage levels and wherein a second battery pack is provided which is capable of providing two of said voltage rated voltage levels and one of which is different to the said rated voltage levels provided by the first battery pack.

Typically therefore the first and second battery packs are capable of providing the same rated voltage level. Typically the said same rated voltage level is the second, intermediate, rated voltage level of the said three different predetermined rated voltage levels.

Typically the said same rated voltage is the second, intermediate, rated voltage level.

In a further aspect of the invention there is provided a power tool and battery pack system including a plurality of power tools which can be selected from a range of power tools configured to be operable at at least three different predetermined rated voltage levels, first and second battery packs to allow the provision of said predetermined rated voltage levels and an electrical power supply circuit is formed between the battery pack power cells and the operating system of the power tool connected to the battery pack via a mechanically and electrically connected battery pack interface and wherein the said electrical power supply circuit is selectively completed by an electrical circuit portion located within the power tool and which

is configured, as a first step, to complete the said electrical power supply circuit only if the battery pack connected to the power tool at that time is capable of providing the particular predetermined rated voltage required to operate the power tool and, as a second step, if the first step is possible, to complete the electrical power supply circuit in a configuration to supply the said particular predetermined rated voltage level required to operate the power tool.

In a further aspect of the invention there is provided a power tool and battery pack system, said system including first and second battery packs, each battery pack capable of providing power at two different rated voltage levels, a plurality of power tools provided to be operable when power at a predetermined rated voltage level selected from at least three predetermined rated voltage levels is supplied thereto, a battery pack interface formed between mechanically connected one of the power tools and one of said battery packs said battery pack interface including electrical connection means for the transfer of power from the battery pack to operate the power tool, said mechanical and electrical connection means at said battery pack interface common to each of the said power tools and battery packs in said system and wherein the possibility, and selection, of the supply of a particular rated voltage from a battery pack with which a power tool is connected to form the battery pack interface is determined by the configuration of an electrical circuit portion located within said power tool.

Specific embodiments of the invention are now described with reference to the accompanying drawings wherein:

Figure 1 illustrates, schematically, a battery pack and power tool system in accordance with one embodiment of the invention;

Figure 2 illustrates a further embodiment of the system in accordance with the invention;

Figures 3a-f illustrate the first battery pack and power tools in accordance with an embodiment of the invention;

Figures 4a-d illustrate the second battery pack and power tools in accordance with the embodiment of the invention; and

Figure 5 illustrates schematically, a possible configuration of an electrical power supply circuit in accordance with the invention.

Referring firstly to Figures 1 and 2, there are illustrated examples of systems in accordance with two embodiments of the invention.

In Figure 1, the system 2 comprises three power tools 4,6,8 and two battery packs 10,12. In this embodiment, the first power tool 4 is provided to operate to perform a relatively low duty task, such as engraving, and in order to operate requires a power supply thereto, which in one embodiment, is a first predetermined rated voltage level of 12 Volts. The power tool 6 is provided to perform a medium duty task such as, for example, drilling, and in order to operate correctly, is required to be provided with power at a second predetermined rated voltage level, which in this embodiment, is 20 Volts. The third power tool 8 is provided to operate to perform a relatively heavy-duty task such as, for example, to perform a chainsaw cutting operation and is required to be provided with a third predetermined rated voltage level power supply to operate which in this embodiment is a rated voltage of 40 Volts. It will thus be appreciated that the second predetermined rated voltage level is intermediate the first and second predetermined rated voltage levels.

The power tools are provided to be portable and provided by power from the battery pack 10, or battery pack 12 which is selectively mechanically connected to the housing 14 of the power tool. Thus, in accordance with the invention, the system includes the first battery pack 10 which is capable of providing power at the first and second predetermined rated voltage levels, 12 Volts and 20 Volts and the second

battery pack 12 is capable of providing power at the second and third predetermined rated voltage levels of 20 Volts and 40 Volts. Thus, in practice, the first battery pack 10 is useable with either of the power tools 4 or 6 and the second battery pack 12 is useable with either of the power tools 6 and 8 to provide power at the required and correct rated voltage level thereto when the battery packs are electrically and mechanically connected to form a battery pack interface 16 with the appropriate power tool.

Figure 2 illustrates a further example of a system in accordance with the invention in which, in this case, there is again provided the engraving tool 4 which is to operate at the first low duty predetermined rated voltage level, three power tools 6, 6' and 6" which are all provided to be operable with the second predetermined rated voltage level in order to perform medium duty tasks such as drilling 6, driving screws 6' and power tool 6" operates to provide a sanding operation. Once again, there is provided a further power tool 8 which operates when supplied with power at the third predetermined rated voltage level. It will therefore be appreciated that in this embodiment, there are a number of tools which operate at the second, intermediate, predetermined rated voltage level and in accordance with this invention, at least two of those tools can be available to be operated simultaneously by a first operator fitting one of the tools such as for example power tool 6 to the first battery pack 10 to supply the second predetermined rated voltage level thereto and another of the power tools 6', or 6" to the second battery pack 12 to supply the second predetermined rated voltage thereto as both battery packs are capable of providing that rated voltage level.

It will also be appreciated that the number of tools which are provided in the system, can be adapted by the user to suit their particular requirements, and may be expanded over time as long as the power tools in the system can be mechanically connected to the particular battery pack type in the system.

Each of the power tools when mechanically connected to mechanical engagement means on the battery pack forms a battery pack interface 16 and, at the same time as the mechanical connection, pins or plugs on one of the power tool or battery pack and sockets provided on the other of the power tool or battery pack are electrically connected together with the particular configuration of pins or plugs and sockets which are provided, typically being the same across all power tools and battery packs in the system. Typically, the pins or plugs are provided on the power tool and the sockets 18 are provided in the battery pack. Thus, the battery packs 10,12 which each comprise a number of power cells, may be provided with part of an electrical power supply circuit therein which allows the connection of the power cells and wiring to the respective terminal sockets of the battery pack and in turn the pins or plugs on the power tool engage in the sockets when the battery pack interface is formed.

Each power tool is typically provided with a motor within the housing 14 which is provided to be provided with power at the required rated voltage in order to drive the work function of that power tool.

In accordance with the invention, the apparatus further includes an electrical circuit portion which is formed and located within the housing of each power tool and connected to pins or plugs of the power tool and the control system for operation of the motor. If the rated voltage level of the power supply required by the power tool is capable of being safely provided by the battery pack to which the power tool is located at that time, the configuration of the electrical circuit portion in the particular power tool completes the electrical power supply circuit in a configuration which provides power to operate the power tool at the required rated voltage from the battery pack to the motor.

The configuration of the electrical circuit portion within the power tools, differs between tools in the system and with respect to the particular rated voltage which

the power tool is required to receive so that for example, the electric circuit portion of the first rated voltage power tools 4 is of a first configuration, the electrical circuit portion of the power tools 6,6',6"operable at the second predetermined rated voltage level will be the same, second, configuration but will differ from the configurations of the electrical circuit portions of the tools, 4 and 8, and the third configuration of the electrical circuit portion of the power tools 8 to operate at the third predetermined rated voltage level will differ from those of tools, 4 and 6,6',6".

In accordance with the invention, if the power tool 4, 6, 6',6" connected to the first battery pack 10 requires a first rated voltage level or the second intermediate rated voltage level then electrical power supply is possible from the battery pack 10 to that power tool and the particular rated voltage of the power supply to that power tool is defined by the configuration of the electrical circuit portion within that power tool. However, if a power tool 8 which is required to be operable at the highest rated voltage which is not capable of being supplied by the first battery pack 10 then automatically, it is not possible for that battery pack to provide any power to that power tool 8 as a result of the configuration of the electrical portion within that power tool. Equally, should the power tool 4 which requires the first rated voltage, be connected to the second battery pack 12 which is not capable of safely providing the first rated voltage, the configuration of the electrical circuit portion within the first power tool 4 prevents any power supply from the second battery pack 12 to that tool 4. Thus, in accordance with the invention, for as long as the predetermined configuration of the electrical circuit portions within the respective power tools is maintained and unaltered, then it will not be possible for unsafe supply of power from the battery packs 10,12 to the power tools and furthermore, the predetermined configuration of the electrical circuit portion in each of the power tools ensures that when possible, the power is supplied to the said power tool at the correct rated voltage.

Typically, the configuration of the electrical circuit portion in each of the power tools is predetermined in as much as it is defined by the provision of a circuit board and/or wiring within the housing of the power tool at the time of manufacture of the power tool. In one embodiment, in order to prevent and/or deter attempts which may be made to alter the configuration of the electrical circuit portion, the same can be rendered inaccessible to end users of the power tool without the power tool being damaged and/or tamper evident means can be provided so as to show if an attempt has been made to alter the operating characteristics of the power tool from that which were determined at the time of manufacture.

Figure 5 illustrates schematically, the manner in which an electrical circuit 20 for the provision and control of power from a battery pack which is connected to a power tool at an instant of time, can be provided. The electrical circuit comprises a portion 22 in the battery pack housing 24 which allows the connection of the power cells of the battery pack to a plurality of terminals, typically sockets, which are exposed at an interface 26 of the battery pack housing 24 and which connect to terminals, typically plugs or pins, which are selectively received in the terminals, which are exposed on the power tool housing 28 at the interface 26 such that the plugs and sockets form the electrical interface 26 between the power tool 28 and the battery pack 24. Mechanical engagement means such as, for example, female guide channels and male elongate members and a locking mechanism, which can be slidably engaged, allow the secure location of the battery pack with the power tool so that during use, the power tool and battery pack effectively form an integral unit and, as part of the sliding engagement of the battery pack with the power tool, the plugs and terminals are brought together into mechanical and electrical connection in an appropriate manner for operation of the power tool with that battery pack. In the power tool housing 28 the electrical circuit includes a portion 30 which connects the power received from the batteries in the battery pack to the motor 32 which, when switched on, and provided with an appropriate power supply, operates to perform the working function of the power tool when switching means are moved to an on

position. Intermediate the said portions 22 and 30 of the electrical circuit of the power tool and the battery pack, there is provided a connection portion 34 which is configured within the power tool so as to ensure that the appropriate and safe power supply level required to operate the motor 32 of that power tool can only be supplied to the motor so that, for example, the configuration of the electrical circuit connecting portion 34, is designed with respect to the particular power tool, and the particular battery pack so as firstly, to ensure that power can only be supplied by a battery pack which is of a form to be capable of safely supplying the power and secondly, to ensure that the power is supplied at the appropriate level.

A specific embodiment of the invention is now described and in accordance with the invention, there are provided two battery packs, a first battery pack 36 of a form which is illustrated in Figures 3a-f and a second battery pack 38 which is illustrated in Figures 4a-d.

Referring firstly to Figures 3a-f, there is illustrated the first battery pack 36 with terminals in the form of sockets 40 and mechanical engagement means including a release button 42 which, when pressed, releases the locking means and allows sliding action between the battery pack and the power tool housings to locate the same and when engaged, maintains the battery pack and power tool in mechanical and electrical engagement. Figure 3b shows the components located within the housing of the battery pack and it will be seen that there are provided five, 4 Volt, power cells 44a,b,c,d,e which are located in a row and these can be connected so that all of the cells are electrically connected and provide power which, in this embodiment, provides power at 20Volts as shown in Figure 3f or alternatively, only three of the power cells 44 c,d,e are connected to provide power at 12 Volts as illustrated in Figure 3e. In both configurations, the particular power cells which are connected are connected in series. As illustrated in Figures 3d and 3e, the operation of the battery pack with only three power cells connected in series, means that the first predetermined, 12 Volts, rated voltage level power supply is provided to the motor

32 and this is achieved with the plugs B1- and B2- of the terminals 46 of the power tool 48 connected to the sockets B1- and B2- respectively of the terminals 40 of the battery pack so as to allow the connection of the three power cells 44 c,d,e of the battery pack. The particular connection of the plugs B1- and B2- in the power tool, in this configuration, is achieved by the configuration of the electrical connection portion 34 within the power tool which connects to these two plugs and in turn allows connection of power to the motor.

As shown in Figures 3d and 3f, when it is required that the second, 20 Volts, rated voltage level power supply is provided from the battery pack to operate a connected power tool as shown then the electrical connection portion 34 in the power tool, is connected to the plugs B2+ and B2- of the power tool. These plugs therefore locate with the electrical socket terminals B2+ and B2- of the battery pack, which therefore allows electrical connection of the five power cells in series as illustrated and therefore the provision of the 20 Volts rated voltage level supply via the electrical connection portion 34 of the power tool to the motor 32 to operate the same at 20 Volts as required.

With regards to the second battery pack 38 then, as shown in Figures 4a and b, similar mechanical location means 42 are provided to connect the battery pack to the power tool and the similar electrical socket terminals 40 are provided thereon. Within the battery pack housing, there are provided first and second groups 50 (50a,50b,50c,50d,50e), 52 (52a, 52b, 52c, 52d,52e), each of five 4V power cells so that each group is capable of operating to provide 20 Volts. In this case, the battery pack is rated at 2x20 Volts.

The interface 26 is identical across 12 Volts, 20 Volts and 40 Volt power tools between the first and second battery packs and therefore when connected to the second battery pack 38, the electrical connection means portion 34 in a power tool which requires power at 20V to operate the motor 32, allows connection of the

terminal plugs B2+, B1+, B2- and B1- of the power tool to the electrical terminals B2+, B1+, B2- and B1- respectively of the battery pack as shown in Figure 4c which, are connected to the first and second groups 50, 42 of cells so as to connect the groups in parallel which therefore allows a 20 Volts power supply to be provided for operation of the motor 32 of the power tool. As illustrated in Figure 4d, when the power tool which is connected to the battery pack is of a configuration and has a motor 32 which is required to operate at 40 Volts, then the electrical connection portion 34 within the power tool still uses the connection of the respective plugs B2+, B1+, B2- and B1- with the electrical terminal sockets B2+, B1+, B2- and B1- of the battery pack but, the electrical connection portion 34 of the power tool differs in that plug B1+ is connected to B2- so that the effect is that the first and second groups of power cells 50,52 of the battery pack are connected in series and therefore 40 Volts is supplied to the power tool motor 32 which is required to operate at that voltage.

Thus, in accordance with the invention, there can be provided first and second battery packs which are capable of providing a power supply to power tools of a type which are required to operate at any of three predetermined voltages and in which at least one of the power tools operating at one of the three predetermined voltages, can be used with either of the first or second battery packs to receive the required voltage for operation. Furthermore, the provision of the first and second battery packs and power tools as described, ensures that each of the battery packs is safely interchangeable for use with respect to at least two of the said power tools in the group of power tools to provide different voltages thereto but is prevented from being connected to provide power to another of the power tools in the said group of a different voltage so as to avoid any potential safety risk issues to the end user.

CLAIMS

1 A power tool and battery pack system including first and second battery packs, each of which is configured so as, when charged, to be able to provide power at two different rated voltage levels, a plurality of power tools, each of said power tools operable when power at a predetermined rated voltage level selected from at least three predetermined rated voltage levels is supplied thereto, a battery pack interface formed between a said power tools and a said battery pack when mechanically connected, said battery pack interface including electrical connection means for the transfer of power from the battery pack to operate the power tool, and wherein the possibility, and selection, of the supply of a predetermined rated voltage level from a said battery pack to which a power tool of the system is connected at that time to form the battery pack interface, is determined by the configuration of an electrical circuit portion located within said power tool.

2. A system according to claim 1 wherein the said mechanical and electrical connection means at said battery pack interface are common to each of the said power tools and battery packs in said system.

3 A system according to claim 1 or 2 wherein the electrical connection means at the said battery pack interface comprise a series of female sockets provided in one of the battery pack or power tool and a series of male pins or plugs provided in the other of the battery packs or power tool and which are locatable in at least some of said sockets.

4 A system according to claim 1 wherein the said electrical circuit portion within the power tool connects the operating drive system for the power tool to the electrical connection means on the power tool at the battery pack interface, and the electrical circuit portion is configured so as to allow the said connection of only the appropriate rated voltage level from the battery pack to be supplied to the operating system of that power tool.

5 A system according to claim 4 wherein the configuration of the electrical circuit portion within a first power tool which is required to operate at the first predetermined rated voltage level is different to the configuration of the electrical

circuit portion of a second power tool provided to be operated at the second predetermined rated voltage level and the configurations of the electrical circuit portions of the said first and second power tools are different to the configuration of the electrical circuit portion of a third power tool provided to be operated at the third predetermined rated voltage level.

6 A system according to any of the preceding claims wherein the rated voltage level which is required for operation of each of the respective power tools in the system is predetermined at the time of manufacture of the power tools by the selection of the configuration of the electrical circuit portion provided within the respective power tools.

7 A system according to claim 6 wherein the said configuration of the electrical circuit portion in each of the power tools in the system is unchanged during use of the power tool.

8 A power tool according to any of the preceding claims wherein the electrical circuit portion comprises electrical wiring and/or a circuit board located within a housing of the power tool.

9 A system according to any of the preceding claims wherein the system includes a battery charger to allow a charge to be provided to power cells in the said battery packs, said charger connectable to the said battery packs to form a battery pack interface as herein described.

10 A system according to claim 9 wherein the said charger is compatible with, and capable of charging all of said battery packs in the said system.

11 A system according to any of the preceding claims wherein the system incorporates two battery packs and power tools selected from a range of power tools, each of which is operable when provided with power at one of the said three predetermined rated voltage levels.

12 A system according to any of the preceding claims wherein each of said battery packs in the system is capable of providing at least two of said three predetermined rated voltage levels.

13 A system according to claim 12 wherein the particular one of the two predetermined rated voltage levels provided by a battery pack at an instant of time is determined by the configuration of the electrical circuit portion within the power tool which is connected to the battery pack at that instant of time.

14 A system according to any of the preceding claims wherein each of the battery packs include a plurality of power cells and the configuration and/or number of power cells within the first battery pack differ to those provided in the second battery pack of the system.

15 A system according to claim 14 wherein the first battery pack is capable of providing a first predetermined rated voltage level, which is the lowest of the three predetermined rated voltage levels, and a second predetermined rated voltage level greater than the first but less than the third of the three predetermined rated voltage levels.

16 A system according to claim 15 wherein a second battery pack of the system, is capable of providing two predetermined rated voltage levels and one of which is the said third predetermined rated voltage level.

17 A system according to claim 16 wherein the other rated voltage which can be provided by the second battery pack is the said second predetermined rated voltage level such that the said second predetermined rated voltage level can be supplied by both the first and second battery packs to a power tool with an appropriate electrical circuit portion configured to allow the operation of said power tool at said second predetermined rated voltage level.

18 A system according to any of the preceding claims wherein for each of the battery packs, the selection of which of the two predetermined rated voltage levels is provided to the power tool at an instant of time is determined by the configuration

of the electrical circuit portion located within the power tool which is connected to the battery pack at that instant of time.

19 A system according to any of the claims 14-18 wherein the said third predetermined rated voltage level supplied by the second battery pack is double the value of the said second intermediate rated voltage level.

20 A system according to claim 19 wherein for the second battery pack, the configuration of the respective electrical control portions of the power tools which are provided to be operable at the predetermined rated voltage levels provided thereby has the effect of receiving power from groups of power cells in the battery pack connected in series or parallel.

21 A system according to any of claims 14-20 wherein in the first battery pack, a selected number of a plurality of power cells act in a series circuit of at least two different and selectable forms which allow one or more of said power cells to be bypassed or disconnected in order to deliver the first predetermined rated voltage or the effect of all the power cells being connected to deliver the second predetermined rated voltage level from the first battery pack wit the selection made as a result of the configuration of the electrical circuit portion of the power tool connected to the said battery pack.

22 A system according to any of the preceding claims wherein the said electrical circuit portion within the power tool is dormant until the power tool is connected to one of said battery packs.

23 A system according to any of the preceding claims wherein the electrical circuit portion of each of the power tools allow each of the power tools to only electrically connect to a battery pack including power cells in a correct rated voltage delivery configuration for the power level required for operation of that power tool.

24 A system according to any of the preceding claims wherein the safety system and/or electrical circuit portion are located within the outer housing of the power tool and inaccessible from accidental access being gained thereto and tamper evident

means are provided such that if access is gained to the electrical circuit portion, any such access is evident thereafter.

25. A system according to any of the preceding claims wherein the system allows a first and second of said plurality of power tools which are both configured to be operable at a same rated voltage level of the three predetermined rated voltages, to be operable simultaneously, by connection of the first power tool to the said first or second battery pack and the second power tool to the other of said first or second battery pack.

26 A power tool and battery pack system including a plurality of power tools which can be selected from a range of power tools configured to be operable at at least three different predetermined rated voltage levels and each of said power tools mechanically locatable with each of the battery packs and wherein the system includes two battery packs and at least one battery pack is selectable electrically connectable to said power tools to provide the power thereto at the correct one of the said three predetermined rated voltage levels for that power tool.

27 A power tool and battery pack system including a plurality of power tools selectable from a range of power tools configured to be operable at at least three different predetermined rated voltage levels, a battery pack capable of providing two of said predetermined rated voltage levels and wherein a second battery pack is provided which is capable of providing two of said predetermined predetermined rated voltage levels and at least one of which is different to the said predetermined rated voltage levels provided by the said first battery pack.

28 A power tool and battery pack system including a plurality of power tools which can be selected from a range of power tools configured to be operable at at least three different predetermined rated voltage levels, first and second battery packs to allow the provision of said predetermined rated voltage levels and an electrical power supply circuit is formed between the battery pack power cells and the operating system of the power tool connected to the battery pack via mechanically and electrically connected battery pack interface and wherein the said electrical power supply circuit is selectively completed by an electrical circuit portion located within the power tool in which the configured, as a first step, to complete the said electrical

power supply circuit only if the battery pack connected to the power tool at that time is capable of providing the particular predetermined rated voltage required to operate the power tool and, as a second step, if the first step is possible, to complete the electrical power supply circuit in a configuration so as to supply the said particular predetermined rated voltage level required to operate that power tool.

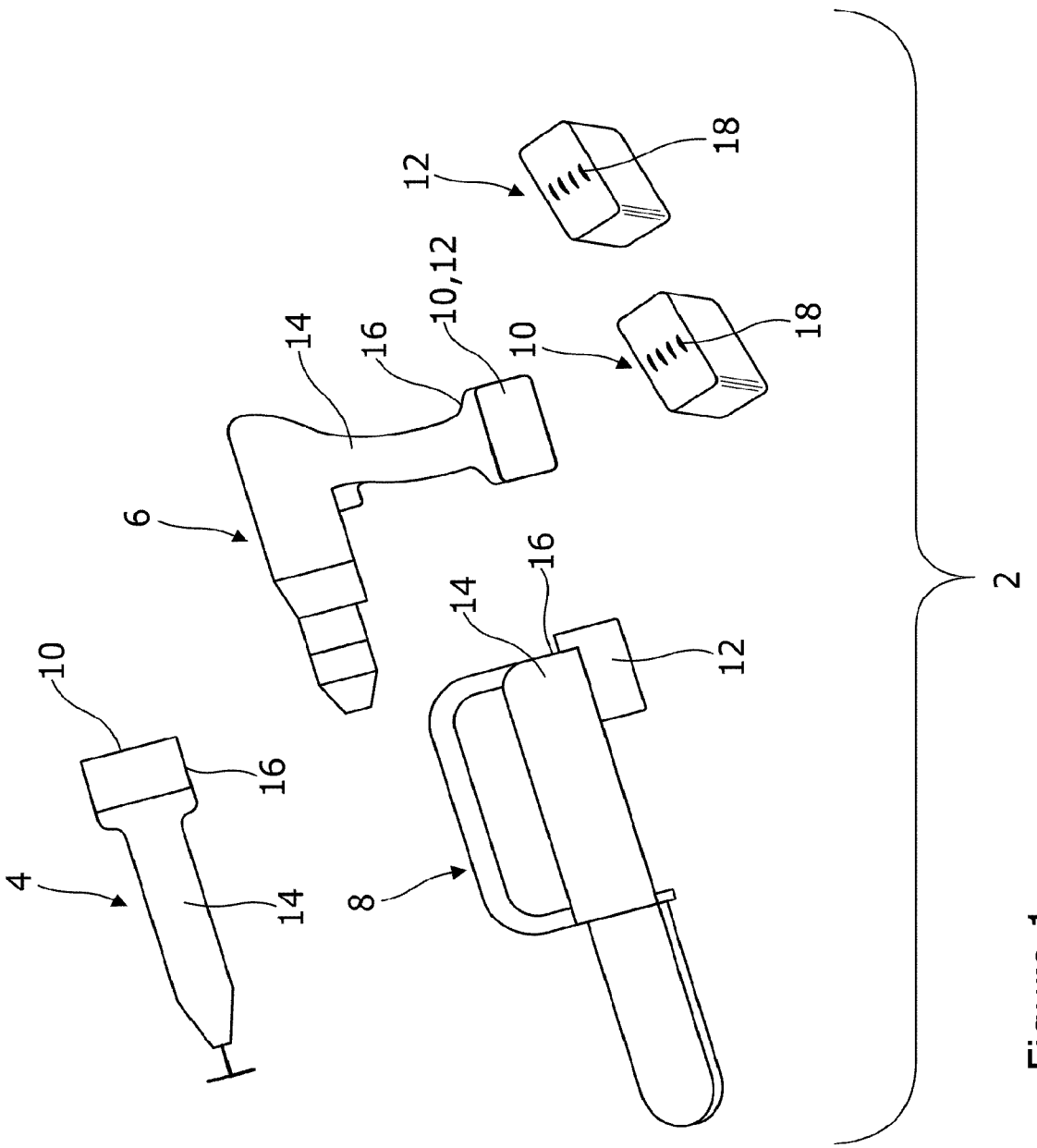

Figure 1

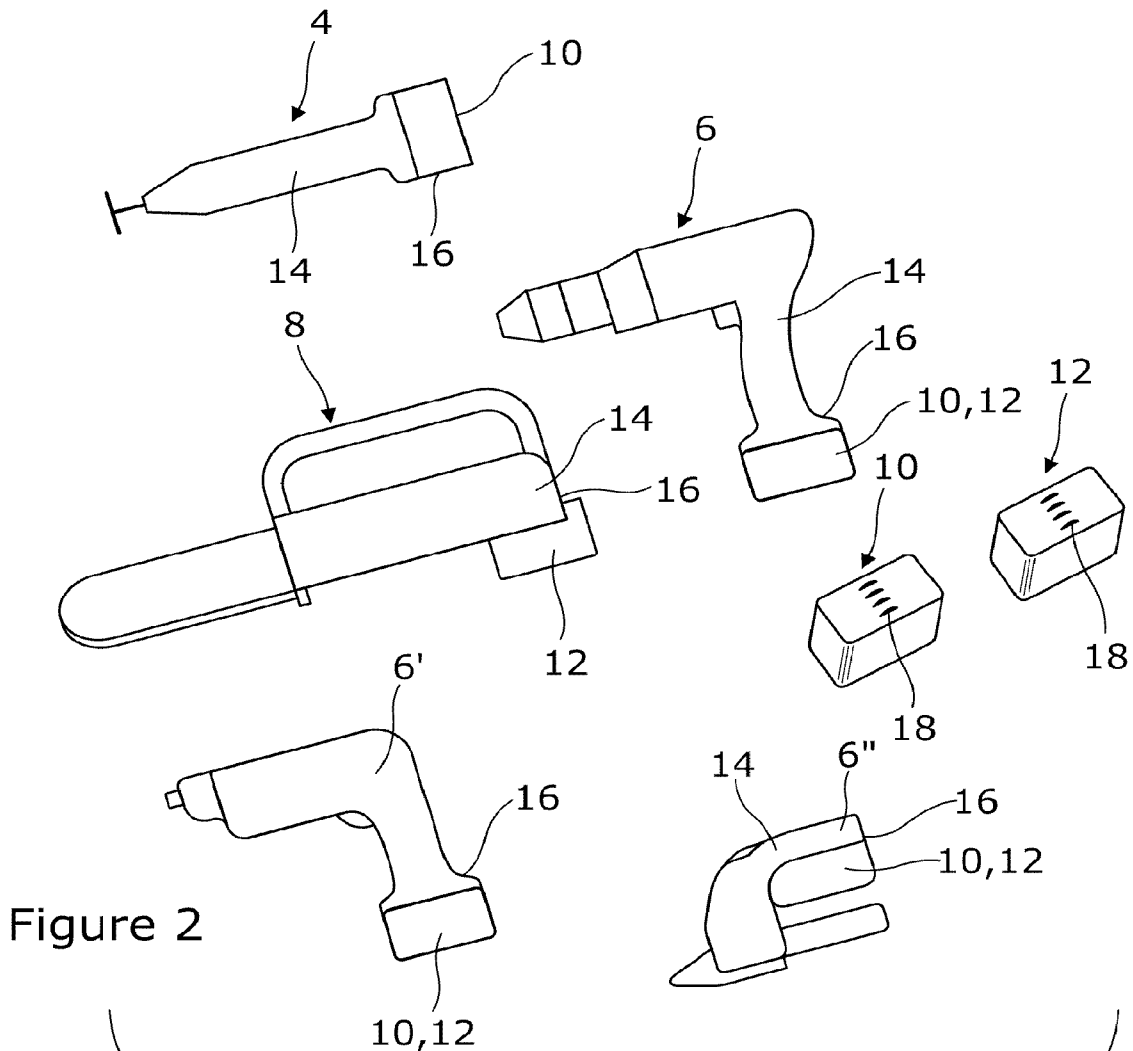

Figure 2

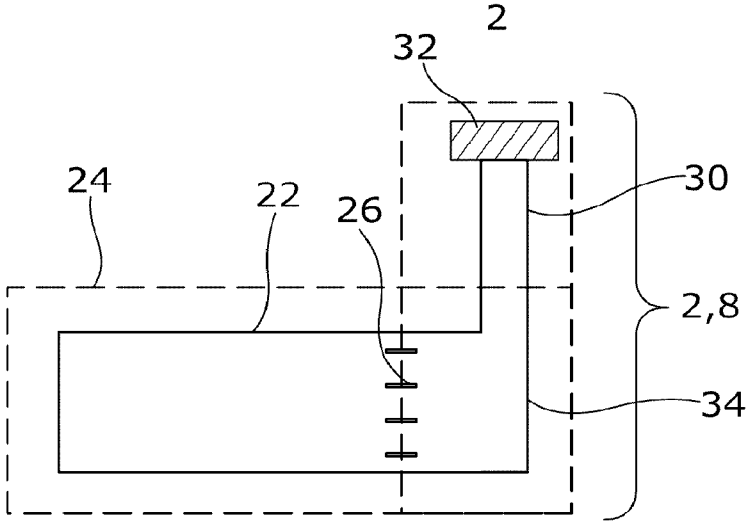

Figure 5

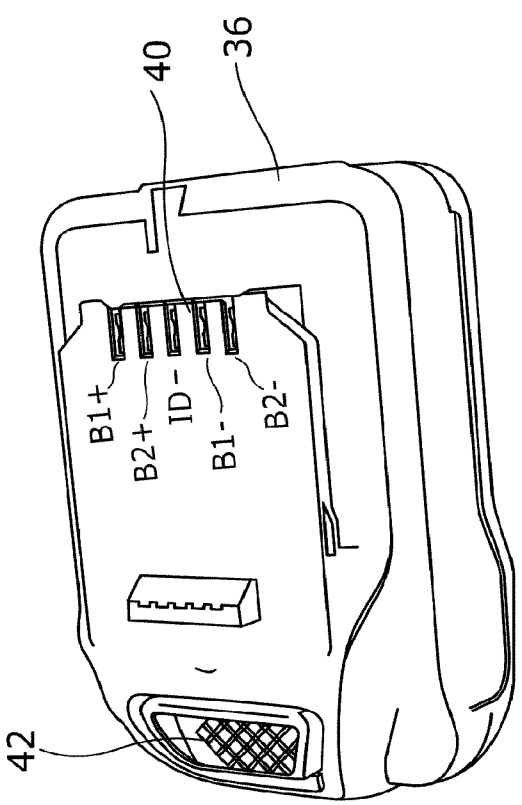

Figure 3a

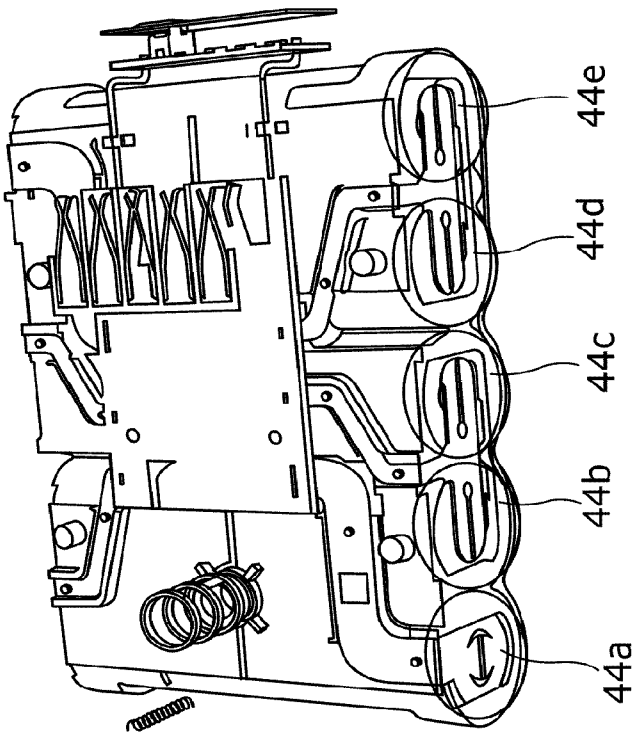

Figure 3b

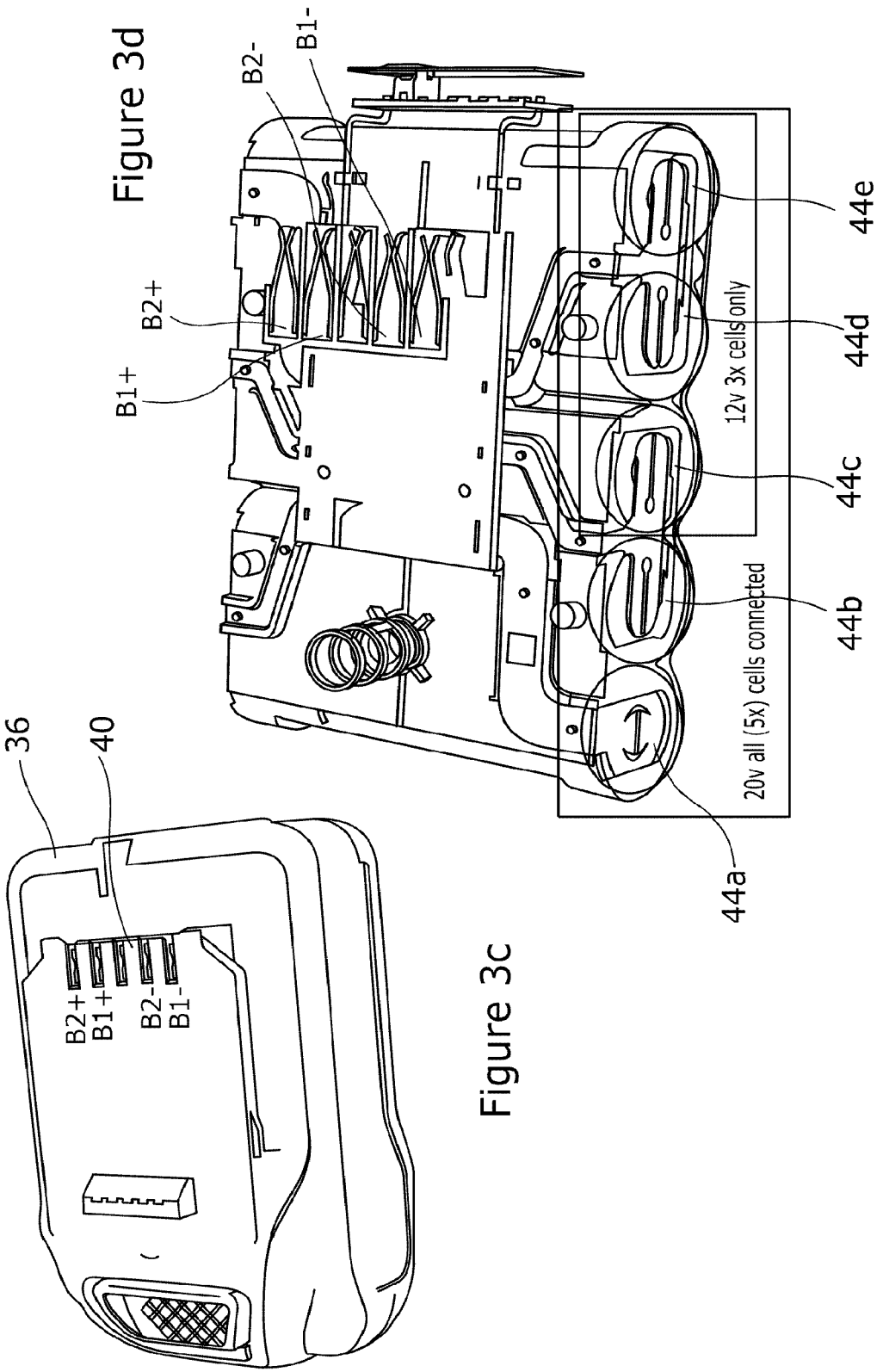

Figure 3c

Figure 3d

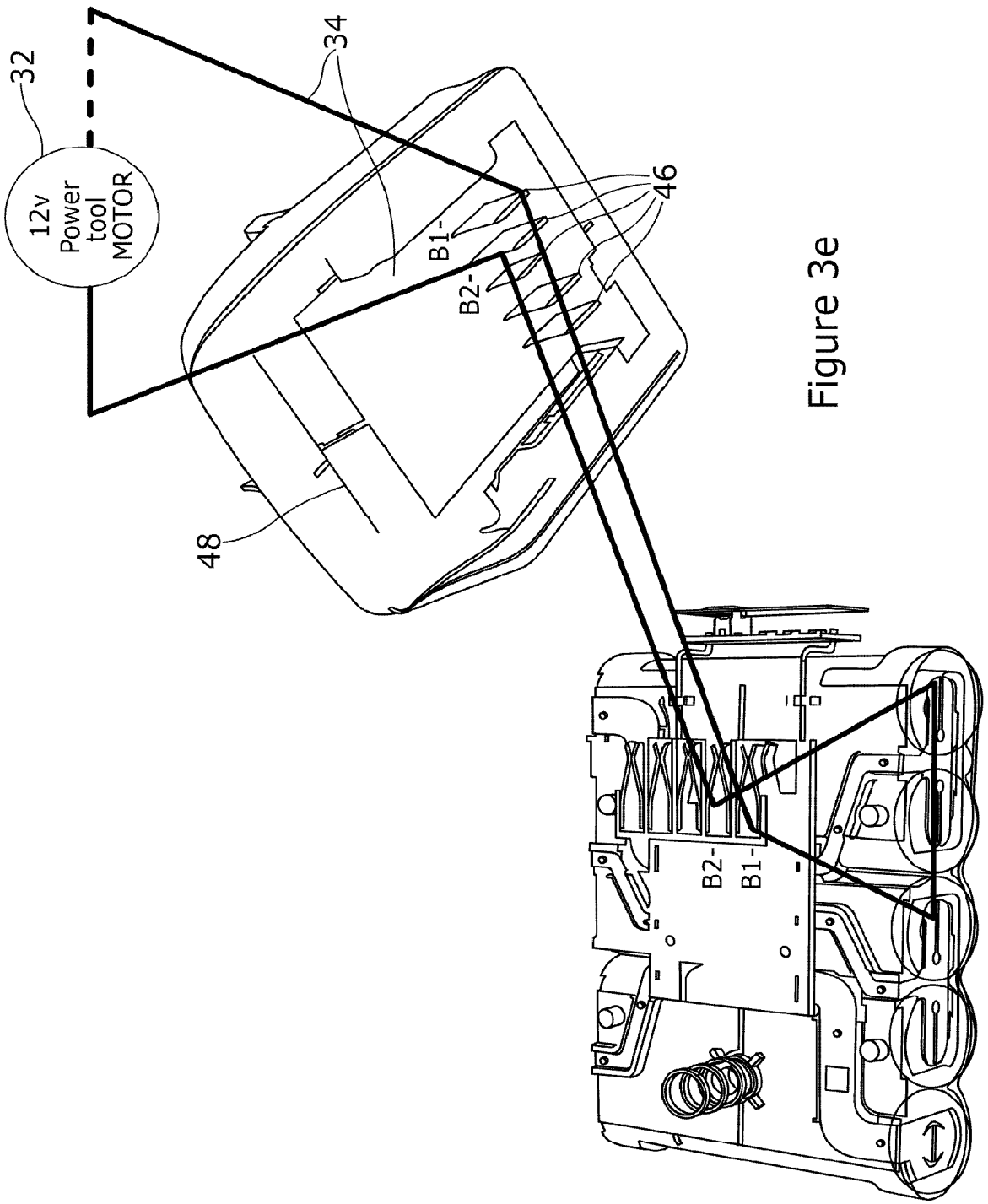

Figure 3e

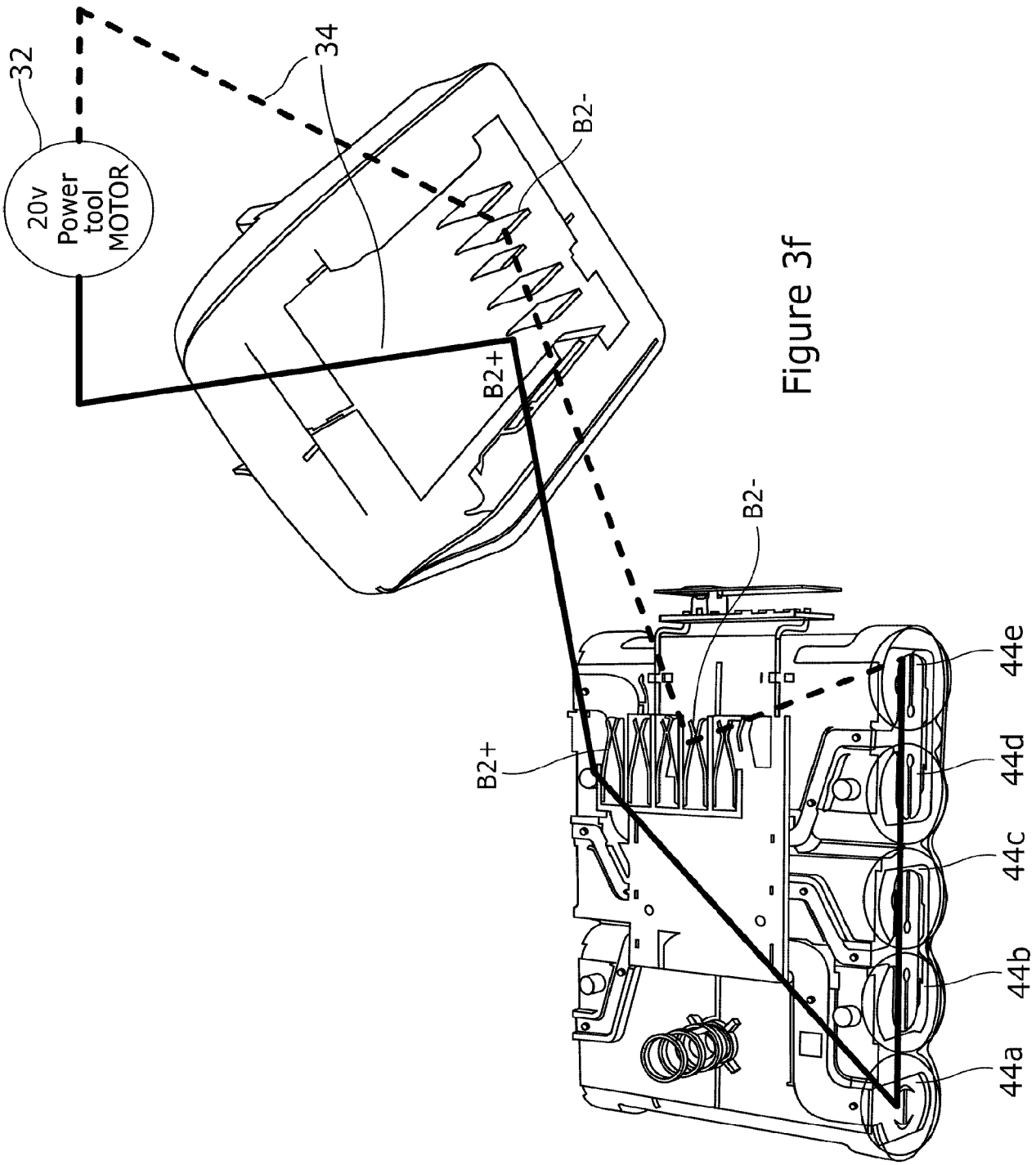

Figure 3f

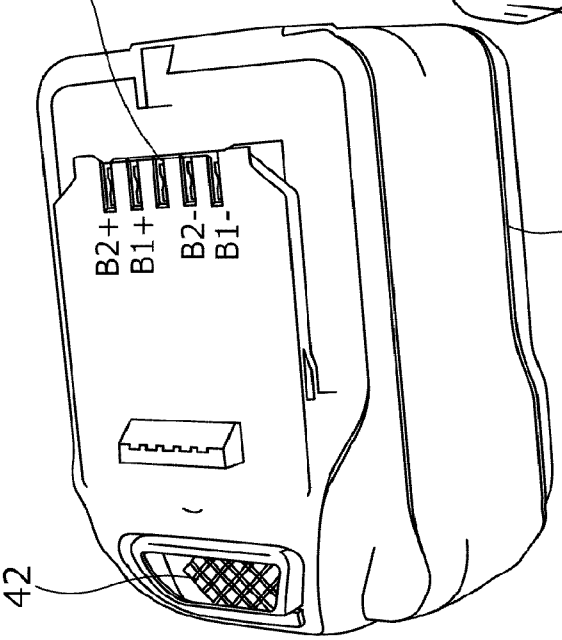

Figure 4a

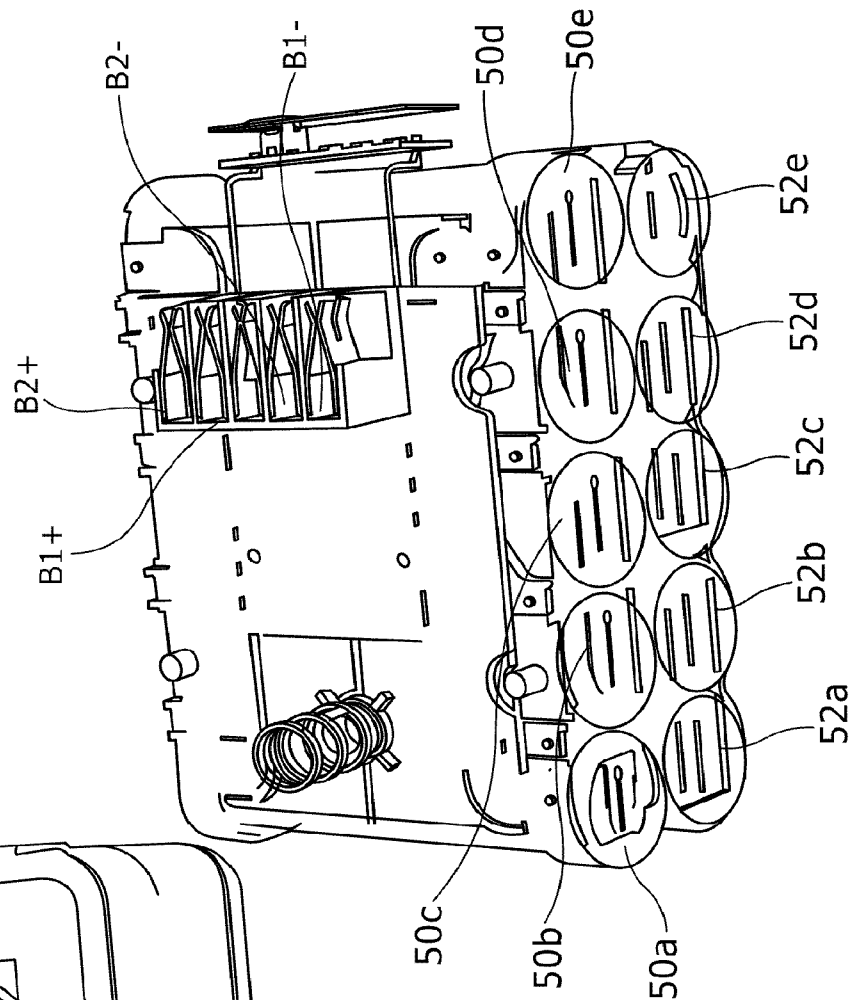

Figure 4b

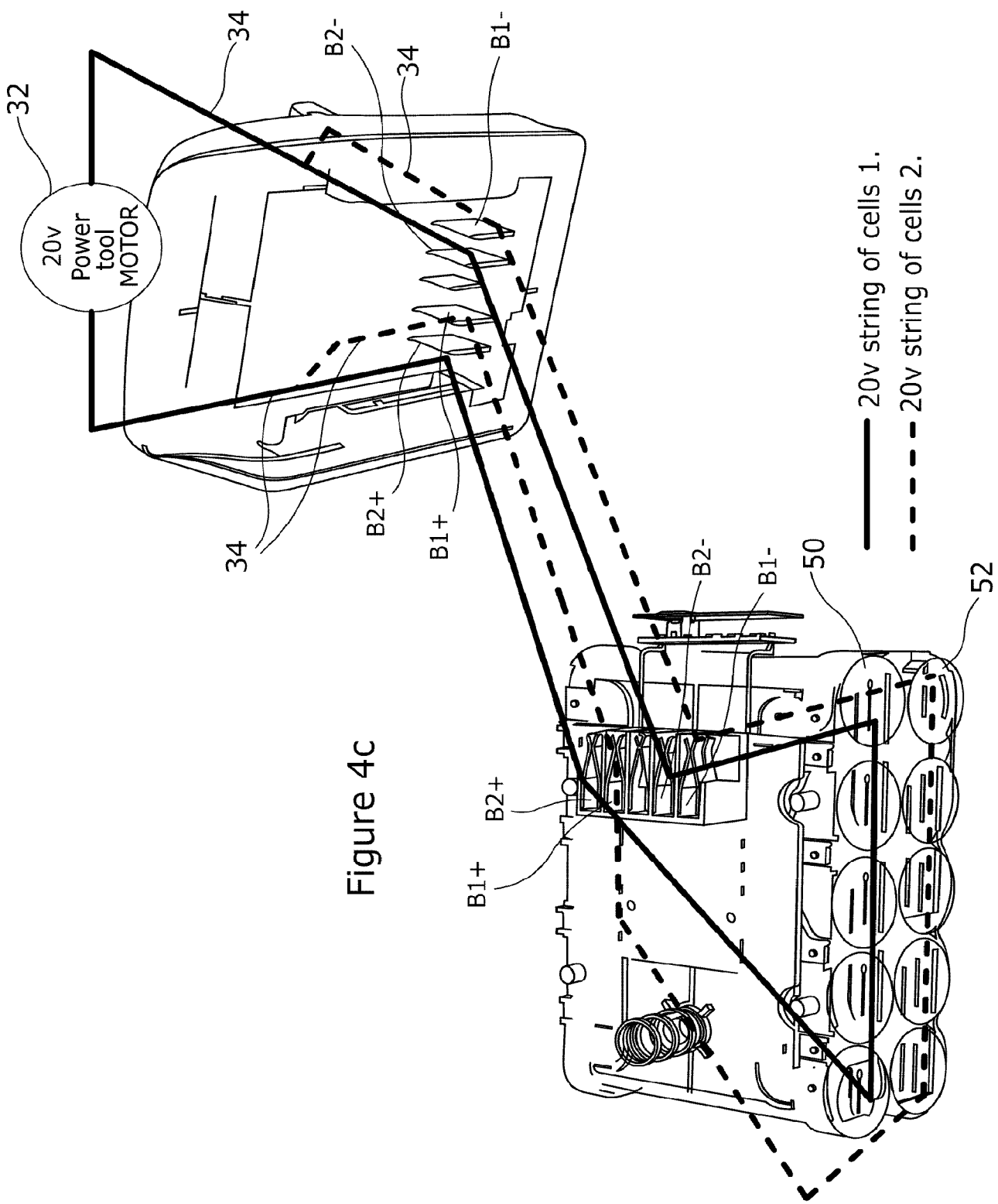
32
20v Power tool MOTOR
34
B2-
34
B1-
34
B2+
B1+
B2-
B1-
50
52
B2+
B1+
20v string of cells 1.
20v string of cells 2.

Figure 4c

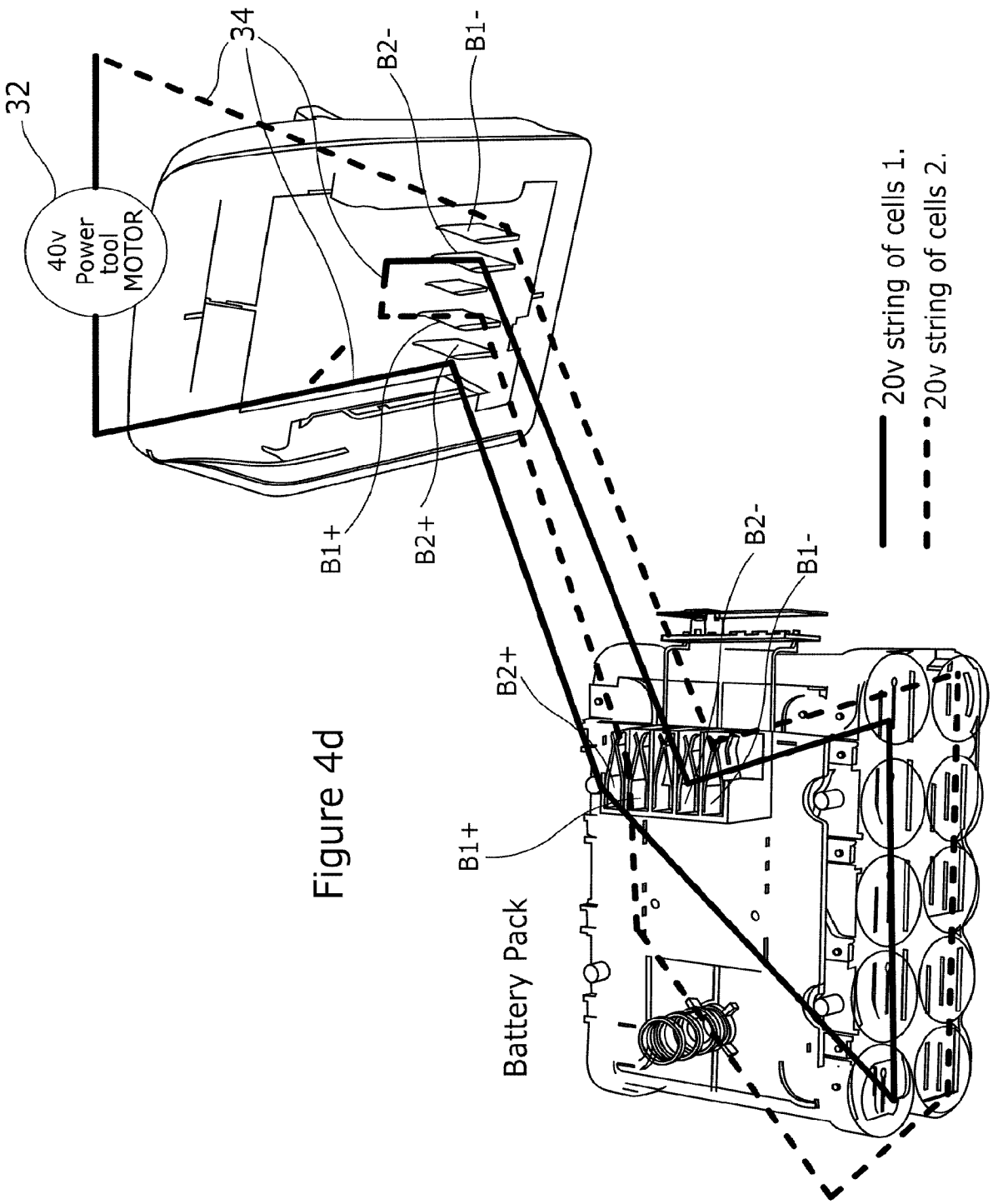
32
40v Power tool MOTOR
34
B2-
B1-
B1+
B2+
B2-
B1-
B2+
B1+
Battery Pack
20v string of cells 1.
20v string of cells 2.

Figure 4d

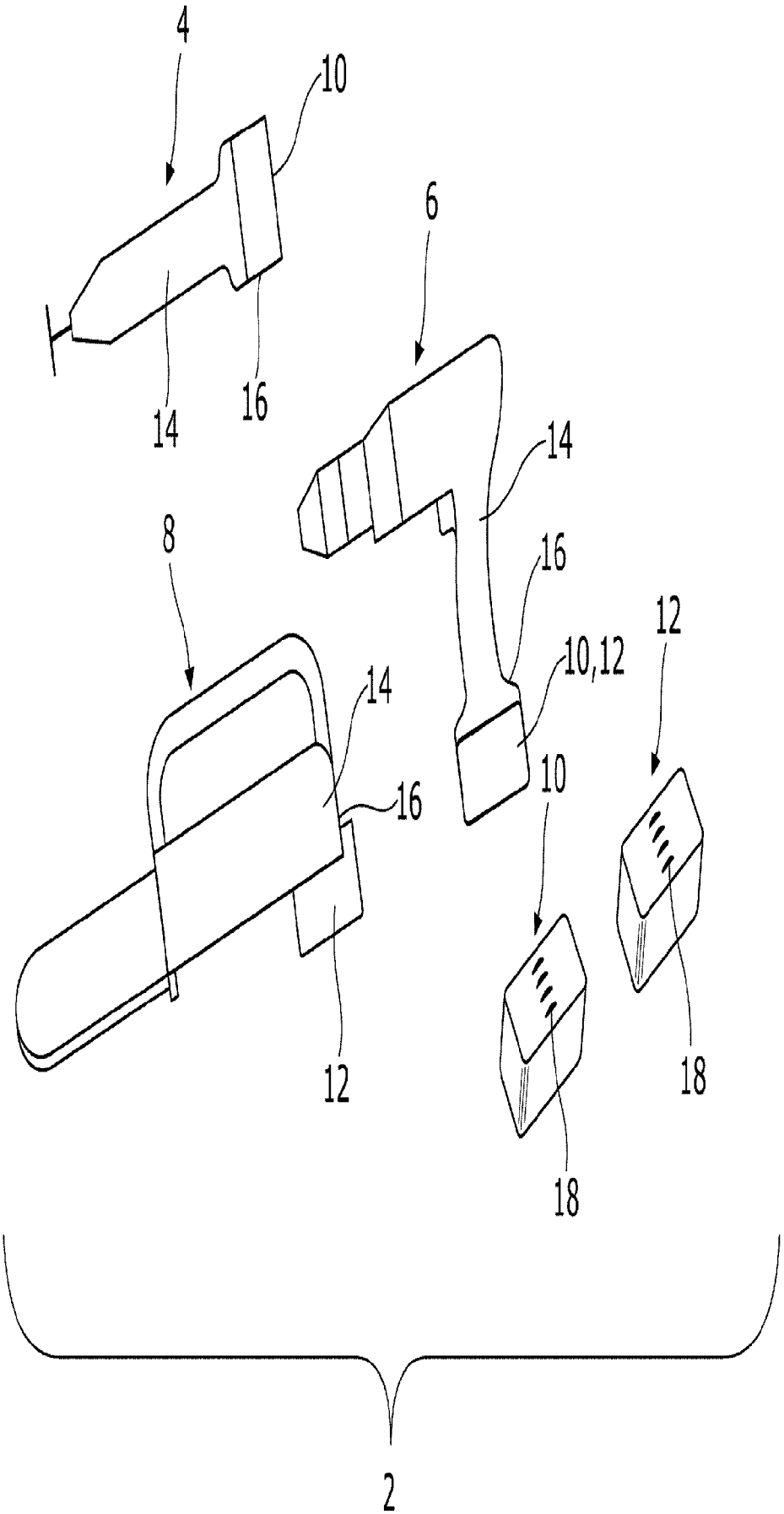

Figure 1