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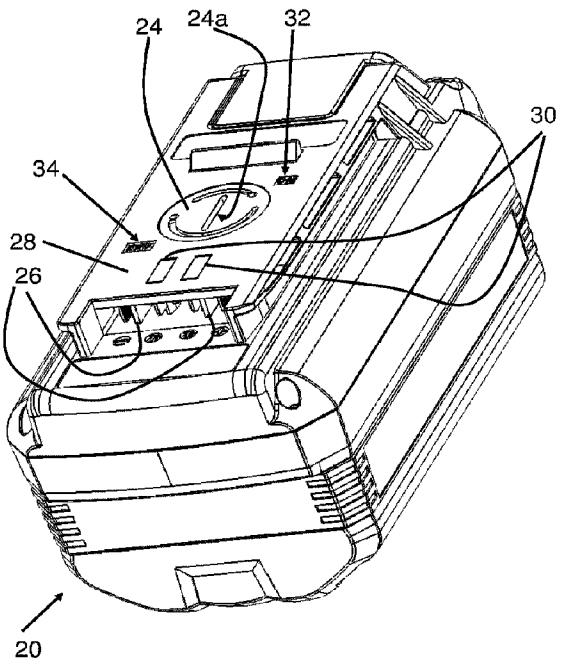

(57) Abrégé/Abstract:
A battery pack comprising a frame and two or more battery cells installed to the frame. The two or more battery cells are interconnected by a rotatable connector which is configured to enable electrical connections between the two or more battery cells. The rotatable connector is adapted to be switched between at least a first rotational position in which the two or more battery cells being electrically connected, and a second rotational position, in which the two or more battery cells being not electrically connected. When the user actuates the knob on the battery pack, the connecting terminals change their rotational positions from a non-conducting position to a conducting position, thereby enabling the electrical connections between the groups of battery cells

Abstract

A battery pack comprising a frame and two or more battery cells installed to the frame. The two or more battery cells are interconnected by a rotatable connector which is configured to enable electrical connections between the two or more battery cells. The rotatable connector is adapted to be switched between at least a first rotational position in which the two or more battery cells being electrically connected, and a second rotational position, in which the two or more battery cells being not electrically connected. When the user actuates the knob on the battery pack, the connecting terminals change their rotational positions from a non-conducting position to a conducting position, thereby enabling the electrical connections between the groups of battery cells.

BATTERY PACK CONTAINING A ROTATABLE CONNECTOR

FIELD OF INVENTION

[0001] This invention relates to an electrical energy storage device, and in particular a battery pack containing multiple battery cells.

BACKGROUND OF INVENTION

[0002] Battery packs are commonly used in portable electrical equipment and tools, so that these equipment and tools can be used in environments where no fixed power supply is available. For example, power tools manufacturers often manufacture a universal power pack which can be compatibly used in different types of cordless power tools, such as electric drills, hammers, screwdrivers, angle grinder, etc. The battery packs usually consist of a plurality of battery cells accommodated in an integral housing where the user can easily install the entire battery into the power tool, or remove it therefrom via latching mechanisms configured on the battery pack housing.

[0003] However, traditional battery packs are often manufactured in the factory to a ready-to-use status, which means that the battery pack before leaving the factory for shipping or selling is fully assembled and operational. The end user upon receiving the battery pack may instantly plug the battery pack into an electric device to start using the electric device. The battery packs manufactured in this way no doubt provide convenience to the user as no extra setup step is required on the user's side before starting to use the battery pack. On the other hand, such battery packs suffer from the problem that once it is manufactured in factory, there will be self-discharging of the battery pack, which ultimately leads to energy loss of electrical power n the battery pack, and degrading of battery life.

[0004] There have been some types of configurable connectors developed for battery packs which allow the electrical connections between battery cells to be on or off. However, these configurable connectors are often designed as a separate component from the battery pack and they easily run into the risk of being lost, damaged, or otherwise became unavailable for use.

SUMMARY OF INVENTION

[0005] In the light of the foregoing background, it is an object of the present invention to provide an alternate battery pack, as well as methods of manufacturing the battery packs and preparing the battery packs for use, which eliminate or at least alleviates the above technical problems.

[0007] One skilled in the art will derive from the following description other objects of the invention. Therefore, the foregoing statements of object are not exhaustive and serve merely to illustrate some of the many objects of the present invention.

[0008] Accordingly, the present invention, in one aspect, is a battery pack comprising a frame and two or more battery cells installed to the frame. The two or more battery cells are interconnected by a rotatable connector which is configured to enable electrical connections between the two or more battery cells. The rotatable connector is adapted to be switched between at least a first rotational position in which the two or more battery cells being electrically connected, and a second rotational position, in which the two or more battery cells being not electrically connected.

[0009] Preferably, the rotatable connector further contains a user actuated knob, and at least one connecting terminal connected to the knob. The connecting terminal is adapted to pivot as a result of the knob being actuated by a user.

[0010] More preferably, the rotatable connector contains a pair of connecting terminals which are formed on two ends of an elongated connecting strip.

[0011] According to one specific implementation, the rotatable connector includes a pair of connecting terminals which are formed on two ends of connecting member. The two connecting terminals are arranged such that they are separated from each other at an angle of α, wherein α satisfying $0° < \alpha < 180°$.

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[0012] In one variation, α is 90°.

[0013] According to another specific implementation, the two connecting terminals are offset from each other along the axis direction of the knob.

[0014] According to a variation of the preferred embodiments, the rotatable connector contains three pairs of connecting terminals. The battery pack further includes four groups of battery cells the electrical connections between which controlled by the three pairs of connecting terminals.

[0015] According to another variation of the preferred embodiments, the battery pack further includes a plurality of groups of battery cells. Each said group contains two or more battery cells. The rotatable connector is configured to enable electrical connections between the plurality of groups of battery cells.

[0016] Preferably, each group of battery cells contains two sub-groups connected in series, and each sub-group contains a plurality of battery cells connected in parallel.

[0017] According to another variation of the preferred embodiments, the battery pack further includes a circuit board to which the rotatable connector is rotatably installed. The circuit board contains one or more duck-billed terminal which is adapted to cooperate with the rotatable connector.

[0017a] In a broad aspect, moreover, the present invention provides a battery pack, comprising: a frame; and two or more battery cells installed to the frame; the two or more battery cells interconnected by a rotatable connector which is configured to enable electrical connections between the two or more battery cells; wherein the rotatable connector further comprises a user actuated rotatable knob; wherein, the rotatable connector is adapted to be switched between at least a first rotational position in which the two or more battery cells being electrically connected, and a second rotational position, in which the two or more battery cells being not electrically connected.

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[0018] There are many advantages to the present invention. The battery pack according to the present invention is not fully functional when it is manufactured in the factory. Such non-functional status continues during the storing, transporting, selling of the battery pack, and even when the consumer who bought the battery pack together or separately from the electric tool that is intended to be used together with the battery pack stores the battery pack in his premise without unpacking. The time when the battery pack becomes operational is when the user actuates the knob on the battery pack, so that the connecting terminals change their rotational positions from a non-conducting position to a conducting position, thereby enabling the electrical connections between the groups of battery cells. In this way, the internal circuit of the battery pack is completed only when the end user receives the battery pack and put it into the working mode by using the rotatory connector.

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[0019] A further advantage of the present invention is that the rotary connector provides an easy way for the user to manipulate the electrical connection between the battery cells. No installation of parts is needed, as the rotary connector is an integrated part of the battery pack. The risk of separate parts being lost or damaged is eliminated according to the present invention. In addition, as there is no separate part, there is no need to design any opening or channel on the housing of the battery pack for separate parts to install, and this prevents possible water splash or other types of environmental damage to the internal components of the battery pack.

BRIEF DESCRIPTION OF FIGURES

[0020] Fig. 1a shows the overall appearance of a battery pack according to a first embodiment of the present invention, where the top side of the battery pack is shown.

[0021] Fig. 1b is the perspective view of the battery pack in Fig. 1a from another viewing angle, where the bottom side of the battery pack is shown.

[0022] Fig. 2 shows the battery pack in Fig. 1a with the battery housing removed to expose the circuit board and the battery cells.

[0023] Fig. 3 shows a perspective view of the circuit board in partial, with the rotary connector hidden to show the on-board terminals on the circuit board.

[0024] Fig. 4 shows the back side of the circuit board in partial, where the rotary connector is shown to be connected to the circuit board.

[0025] Fig. 5 is an exploded view of the rotary connector in the battery pack of Fig. 1a.

[0026] Fig. 6 shows the user actuated knob in Fig. 5 from another viewing angle.

[0027] Fig. 7a shows independently the assembled rotary connector in the battery pack of Fig. 1a from its side.

[0028] Fig. 7b shows the assembled rotary connector in Fig. 7a from its bottom.

[0029] Fig. 8 is a schematic diagram showing the internal circuit of the battery pack of Fig. 1a.

[0030] Fig. 9a is a perspective view of the battery pack of Fig. 1a showing the rotary connector in its ON position.

[0031] Fig. 9b shows the rotary connector in its status of Fig. 9a from another viewing angle.

[0032] In the drawings, like numerals indicate like parts throughout the several embodiments described herein.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0033] In the claims which follow and in the preceding description of the invention, except where the context requires otherwise due to express language or necessary implication, the word "comprise" or variations such as "comprises" or "comprising" is used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

[0034] As used herein and in the claims, "couple" or "connect" refers to electrical coupling or connection either directly or indirectly via one or more electrical means unless otherwise stated.

[0035] Terms such as "horizontal", "vertical", "upwards", "downwards", "above", "below" and similar terms as used herein are for the purpose of describing the invention in its normal in-use orientation and are not intended to limit the invention to any particular orientation.

[0036] Referring now to Figs. 1a and 1b, the first embodiment of the present invention is a battery pack **20** which can be used in electric tools for example handheld power tools and outdoor electric garden tools. The battery pack **20** contains a housing **22**, which accommodates internal components (all of which are not shown in Figs. 1a and 1b) of the battery pack **20** including a plurality of battery cells, battery frames supporting these battery cells, and a control circuit board of the battery pack. The housing **22** exhibits a special shape which is made in accordance with the dimension of a battery receptacle (not shown) on the aforementioned electric tools, as those skilled in the art would understand.

[0037] Fig. 1b shows clearly the bottom side of the battery pack **20** on which the main battery terminals **26**, and the latching mechanism for fixing the battery pack **20** in the battery receptacle of the electric tool or a battery charger are located. The main battery terminals **26** are located at a level lower than the top face of a protruded part **28** of the battery housing **20**, so that the main battery terminals **26** are in fact concealed in the protruded part **28** and can only be physically contacted by corresponding terminals (not shown) on the charger or the electric tool when the battery pack **20** is inserted into the battery receptacle of the electric tool or the charger. There are in addition two secondary terminals **30** formed on the top face of the protruded part **28**, and thus the secondary terminals **30** are located above the main battery terminals **26**. The main battery

terminals **26** contain one positive power terminal as well as one negative power terminal, and also two communication terminals (not shown, which will be described in more details later). The secondary terminals **30** contain two communication terminals. The latch mechanism includes a post **34** configured on the protruded part **28** and the post **34** is movable relative to the protruded part **28**. The post **34** is normally biased by a resilient means (not shown) so that the post **34** is extending beyond the surface of the protruded part **28**. The post **34** therefore keeps the battery pack in the battery receptacle once it is installed, where the post **34** snap fits into a corresponding recess structure (not shown) in the battery receptacle. To remove the battery pack from the battery receptacle the user actuates a corresponding mechanism (either on the battery pack **20** itself or on the battery charger / power tool) which would urge the post **34** to move, and as a result the post **34** retreats back into the protruded part **28** and thus the battery pack is unlocked. The structure of latch mechanism and how the battery pack is securely installed to the power tool or battery charger is well-known to skilled persons in the art, and thus will not be described in details here.

[0038] On the protruded part **28**, there is configured a user actuated knob **24** for configuring the internal circuit of the battery pack **20**. The knob **24** is a part of a rotatable connector of the battery pack **20**. Also formed on the surface of the protruded part **28** are two labels, i.e. an "ON" label **32** and an "OFF" label **34**. These labels provide visual indications to the user to prompt the user rotating the knob **24** to one of the two correct positions. Such correct positions are arrived when the central indicator **24a** of the knob **24** points to either the "ON" label **32** or the "OFF" label **34**. Note that in the illustration of Fig. 1b, the knob **24** is not in either of the correct positions, as the central indicator **24a** does not point to either the "ON" label **32** or the "OFF" label **34**.

[0039] Referring now to Fig. 2, the battery pack described above is shown with its housing removed to reveal multiple battery frames **40** and a circuit board **38** of the battery pack. In the figure the rotatory connector including the knob **24** is also illustrated to have been installed on the circuit board **38**. There are four battery frames **40** in the battery pack to which the individual battery cells **42** are installed. The four frames **40** are aligned substantially in a head-to-tail manner which together forms an elongated shape of the battery pack. Each frame **40** contains a plurality of thorough holes (not shown) where each such thorough hole is used to accommodate

one battery cell **42**. The battery cell **42** has a cylindrical shape. Multiple battery cells **42** in the same frame **40** are connected by metal strips **47** so as to connect the battery cells **42** in parallel. In addition, battery cells **42** across different frames **40** are connected by connecting bars **48** which extend along the exterior surface of the frames **40**. The connecting bars **48** are made of thin metal strips, which have shapes closely fitting the exterior shape of the portions of frames **40** along which the connecting bar **48** extends. Each connecting bar **48** extends from an end of a frame **40** to the circuit board **38**, where the battery cells **42** in different frames **40** are electrically connected to each other at the circuit board **38**, subject to the status of the rotatable connector. One will see that some of the connecting bars **48** have a bent shape. There is also a heatsink **39** connected to an end of the circuit board **38**.

[0040] Although not shown, the battery cells **42** in the battery pack **20** constitute different groups and sub-groups. The groups are the largest unit of battery cells in the battery pack **20** and the rotatable connector described above enables / disables the electrical connections between the groups of battery cells **42**. Within each group, there is further a plurality of sub-groups, and these sub-groups each contain a plurality of battery cells **42**.

[0041] The aforementioned main battery terminals **26** are installed on the circuit board **38** and are electrically connected to the circuit board **38**. Four main battery terminals **26a-26d** are aligned in a side-by-side manner. Terminals **26a** and **26d** are the positive and negative power terminals that supply electrical power to the external power tool or receive electrical power from a charger. Terminals **26c** and **26b** are two communication terminals for communication with the power tool or the charger. Notably, from Fig. 2 one can see that the secondary terminals **30** which include two terminals **30a** and **30b** are located at a position above the communicational terminals **26b** and **26c** among the main battery terminals **26**. In particular, the communicational terminals **26b** and **26c** are in the conventional thin-plate shapes, but the communicational terminals **30a** and **30b** each have a special L shape with a bend. Each one of the communicational terminals **30a** and **30b** has its first portion (not shown) extending from the circuit board **38** upwardly in a way parallel to the communicational terminal **26b** or **26c**, but to an extent higher than the communicational terminal **26b** or **26c** from the circuit board **38**. The second portion of each one of the communicational terminals **30a** and **30b** after the bend then protrudes forwardly as same as

the communicational terminal **26b** or **26c**, but is above the communicational terminal **26b** or **26c**. In this way, within a limited space two different communication terminals can be implemented in a tight manner, and they are in good electrical isolation, as there is certain isolating material (not shown) between the first portion of the communicational terminals **30a** or **30b** and the respective one of the communicational terminal **26b** or **26c**.

[0042] Fig. 3 shows the on-board terminals on the circuit board **38** which are adapted to connect to respective connecting terminals of the rotatable connector. However, for the clarity of illustration the rotatable connector is not shown in this figure. Fig. 3 shows that six on-board terminals **44a-44f** are configured on the circuit board **38** in a circumferential fashion, and a mount hole **46** is formed on the circuit board **38** at the center of the hypothetic circle formed by the six on-board terminals **44a-44f**. The mount hole **46** is adapted to receive and secure a part of the rotatable connector. The six on-board terminals **44a-44f** are configured at different heights as they are support by supporting members **50a-50f** of different lengths. In particular, terminals **44a** and **44d** are the lower terminals among the six and they are arranged on opposite sides of the mount hole **46**, as they are located on a straight line which passes through the mount hole **46**. Terminals **44b** and **44e** are the middle terminals among the six and these two terminals are also arranged on opposite sides of the mount hole **46**. Terminals **44c** and **44f** are the higher terminals among the six and these two terminals are also arranged on opposite sides of the mount hole **46**. Thus, the six on-board terminals form three pairs, i.e. terminals **44a** and **44d**, terminals **44b** and **44e**, and terminals **44c** and **44f**. Starting from terminal **44a** to **44f**, their heights follow the sequence of "low-middle-high-low-middle-high". This is because their respective supporting members **50a-50f** are also having a similar pattern in terms of variation of heights. Each one of the supporting members **50a-50f** has a bridge-like structure, and each one of the on-board terminals **44a-44f** is a duck-bill shaped terminal. The on-board terminals **44a-44f** are arranged to be at different height so that they will not interfere with each other during the actuation of the rotatable connector.

[0043] Each one of the supporting members **50a-50f** is mounted to a respective trace **52a-52f**, through which the on-board terminals **44a-44f** are connected to respective groups of battery cells. Both the supporting members **50a-50f** and the on-board terminals **44a-44f** are made of metals in

order to be conductive. Each one of the traces **52a-52f** also contains a slit **54a-54f** through which the above-mentioned connecting bars (not shown in Fig. 3) can be inserted and be used to connect ultimately to the groups of battery cells.

[0044] Turning now to Fig. 4. The back side of the circuit board **38** have six traces **52a'-52f'**, which correspond to the above-mentioned traces **52a-52f** on the top side of the circuit board **38** in a one-to-one manner. The six traces **52a'-52f'** on the back side can be seen as "mirrored" ones of those on the top side of the circuit board **38**. The six traces **52a'-52f'** are each connected with its counterpart among traces **52a-52f** once a supporting member or a connecting strip is inserted into the circuit board **38**. For example, Fig. 4 shows a connecting strip **48** inserted into a slit (not shown) on the trace **52d'**. Fig. 4 also shows a rotating base **56** of the rotatable connector received and positioned in the mounting hole on the circuit board **38**.

[0045] As also shown in Figs. 3 and 4, there is further a pair of traces **52g**, **52h** on the top side of the circuit board **38**, and correspondingly a pair of traces **52g'**, **52h'** on the back side of the circuit board **38**. The traces **52g**, **52h** are adapted to be contacted by a connecting part of the rotatable connector, as will be described in more details below.

[0046] Next, in Figs. 5-7b the rotatable connector of the battery pack is shown, which contains the knob **24**, the rotating base **56** that is fixed to and co-rotatable with the knob **24**, and various connecting terminals. The components shown in Fig. 5 are not illustrated with their correct dimensions relative to each other or their correct orientations when assembled. There are three pairs of connecting terminals, with each pair formed by a single piece of component. The three pairs of connecting terminals are coupled on the rotating base **56** and are rotatable as a result of the rotating base **56** rotating. In particular, a first pair of connecting terminals **64a**, **64b** is formed on two opposite ends of an elongated connecting strip **64**. The second pair of connecting terminals **62a**, **62b**, and the third pair of connecting terminals **62c** and **62d**, are formed respectively on two connecting members **62**. The two connecting members **62** are identical to each other, and each one of them contains two bends **62e**. The existence of the bends resulting in that on one connecting member **62**, the connecting terminal **62a** is not only separated from the other connecting terminal **62b** at an angle of 90° in the radial plane, but also the connecting terminal **62a** is offset from the connecting terminal **62b** along the direction of the rotating axis

(not shown) of the rotatable connector. The two connecting terminals **62c** and **62d** on the other connecting member **62** have similar spatial relationship between each other. A screw **58** fastens the knob **24**, the connecting strip **64**, the rotating base **56**, and a tail connector **60** together. The tail connector **60** has two tail ends **60a** connected by a middle part **60b**, where the middle part **60b** is fastened to the rotating base **56** by the screw **58**. The two tail ends **60a** are arranged so that they face each other but are offset from each other along the axis direction. The two tail ends **60a** are adapted to contact with the traces **52g** and **52h**. In addition, the two connecting members **62** are mounted on the rotating base **56** by being received and fastened by various grooves **56a** form on the rotating base **56**.

[0047] As best seen in Fig. 5, on the top side (which is the side visible to the user when the battery pack is assembled) of the knob **24**, besides the central indicator **24a** which is formed as a groove, there are also two arc-shaped grooves **24b**, **24c** in different lengths, and two marks **24d**, **24e** each on an end of the two arc-shaped grooves **24b**, **24c**. All of the central indicator **24a** and the two arc-shaped grooves **24b**, **24c** are designed to facilitate the user operating the knob **24** for example using his/her nails, but at the same time prevents accidental actuation to the knob **24**. The two marks **24d**, **24e** may help indicating the direction of rotation if the user wants to turn on / turn off the internal circuit of the battery pack.

[0048] As will be explained below, the rotatable connector can be switched between a first status and a second status, which ultimately control electrical connections between the groups of battery cells in the battery pack. The first status and second status correspond to two rotational positions respectively. In the first rotational position the rotatable connector is switched on, thereby enabling the electrical connections between the groups of battery cells, and in the second rotational position the rotatable connector is switched off, thereby disabling the electrical connections between the groups of battery cells. The simplified schematic diagram in Fig. 8 shows how four groups **70** of batteries in the battery pack of Fig. 1a-7b can be electrically connected with the rotatable connector. Each group **70** contains a plurality of sub-groups **72** connected in series, either in the number of two or three. Then, in each sub-group **72** there are three individual battery cells **42** connected in parallel. In such a configuration, each sub-group **72** outputs the same voltage as a single battery cell **42**. However, the total voltage outputted by the

battery pack will be ten times the voltage outputted by a single sub-group **72**, as one can see from Fig. 9 that there are in total ten sub-groups **72** connected in series if the three "switches" **74** are closed. The switches **74** are actually formed by the connecting terminals of the rotatable connector, as well as their respective on-board terminals on the circuit board.

[0049] In the status as shown in Fig. 9, all the four groups **70** are not connected with each other, as the three pairs of terminals on the rotatable connector are not in contact with their respective on-board terminals. This is shown as three switches **74** being opened in Fig. 9. When the end user purchased or otherwise received the battery pack, he/she only has to perform a simple setup process to make the battery pack operational. In particular, the user only needs to rotate the rotatable connector of the battery pack to the "ON" position, and such action would place the connecting terminals in the rotatable connector into the on-board terminals, thus enabling the electrical connection between the groups of battery cells. In this rotation, the connecting terminals change from their non-conductive positions to their conductive positions. This is equivalent to the closing of three switches **74** in Fig.9. Then, the electrical circuit in the battery pack is completely closed and the battery pack is ready to use.

[0050] The exemplary embodiments of the present invention are thus fully described. Although the description referred to particular embodiments, it will be clear to one skilled in the art that the present invention may be practiced with variation of these specific details. Hence this invention should not be construed as limited to the embodiments set forth herein.

[0051] While the invention has been illustrated and described in detail in the drawings and foregoing description, the same is to be considered as illustrative and not restrictive in character, it being understood that only exemplary embodiments have been shown and described and do not limit the scope of the invention in any manner. It can be appreciated that any of the features described herein may be used with any embodiment. The illustrative embodiments are not exclusive of each other or of other embodiments not recited herein. Accordingly, the invention also provides embodiments that comprise combinations of one or more of the illustrative embodiments described above. Modifications and variations of the invention as herein set forth can be made without departing from the spirit and scope thereof, and, therefore, only such limitations should be imposed as are indicated by the appended claims.

[0052] It is to be understood that, if any prior art publication is referred to herein, such reference does not constitute an admission that the publication forms a part of the common general knowledge in the art, in Australia or any other country.

[0053] For example, the battery cells in the battery pack as described in Figs. 1-9b above are accommodated in thorough holes in the battery frames. However, it is clear that other structures and mechanisms may also be used according to the user's preference to install and fix the battery cells, including but not limited to non-encircling battery racks, heat shrink tubing, etc.

[0054] In addition, the battery pack internal circuit is exemplified in Fig. 8 as ten sub-groups of battery cells connected in series. In each sub-group the three battery cells are connected in parallel. Those skilled in the art should realize that the battery connections in battery packs according to the present invention are not limited to as such. The battery cells can be configured in parallel, in serial, or in hybrid to form a battery set, and the battery sets can also be configured in parallel, in serial, or in hybrid.

[0055] In the examples shown in Figs. 1-9b and 11, there are three switches (i.e. three pairs of connecting terminals) provided in the internal electrical circuit of the battery pack, which are used as circuit breakers at certain points between the four groups of battery cells. However, it should be understood that any number of the pairs of connecting terminals can be used in the battery pack as long as they serve the purpose of interrupting the electrical circuit in the battery pack unless terminal connectors are rotated to a position so that they complete the electrical circuit.

[0056] In addition, in the embodiments described above, the two connecting terminals on a connecting member with bends in the rotatable connector are offset from each other by 90° in the plane of rotation. However, skilled persons should realize that the angle does not have to be a right angle. Rather, depending on the design requirement, the connecting terminals can be arranged such that they are separated from each other at an angle of α, wherein α satisfying $0° < \alpha < 180°$.

CLAIMS

1. A battery pack, comprising:
   a) a frame; and
   b) two or more battery cells installed to the frame; the two or more battery cells interconnected by a rotatable connector which is configured to enable electrical connections between the two or more battery cells;
   wherein the rotatable connector further comprises a user actuated rotatable knob;
   wherein, the rotatable connector is adapted to be switched between at least a first rotational position in which the two or more battery cells being electrically connected, and a second rotational position, in which the two or more battery cells being not electrically connected.
2. The battery pack of claim 1, wherein the rotatable connector further comprises at least one connecting terminal connected to the rotatable knob; the connecting terminal adapted to pivot as a result of the rotatable knob being rotated by a user.
3. The battery pack of claim 2, wherein the rotatable connector comprises a pair of connecting terminals which are formed on two ends of an elongated connecting strip.
4. The battery pack of claim 2, wherein the rotatable connector comprises a pair of connecting terminals which are formed on two ends of a connecting member; the two connecting terminals arranged such that they are separated from each other at an angle of α, wherein α satisfying $0° < \alpha < 180°$.
5. The battery pack of claim 4, wherein α is 90°.
6. The battery pack of claim 4, wherein the rotatable knob is configured to rotate about a rotation axis, further wherein the pair of connecting terminals are offset from each other along an axial direction of the knob.
7. The battery pack of claim 2, wherein the rotatable connector comprises three pairs of connecting terminals; the battery pack further comprising four groups of battery cells the electrical connections between which are controlled by the three pairs of connecting terminals.
8. The battery pack of claim 2, further comprising a plurality of groups of battery cells; each group comprising two or more battery cells; wherein the rotatable connector is

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configured to enable electrical connections between the plurality of groups of battery cells.

9. The battery pack of claim 4, wherein each said group of battery cells comprises two sub-groups connected in series, and each said sub-group comprises a plurality of battery cells connected in parallel.

10. The battery pack of claim 1, further comprising a circuit board to which the rotatable connector is rotatably installed; the circuit board comprising one or more duck-billed terminal which is adapted to cooperate with the rotatable connector.

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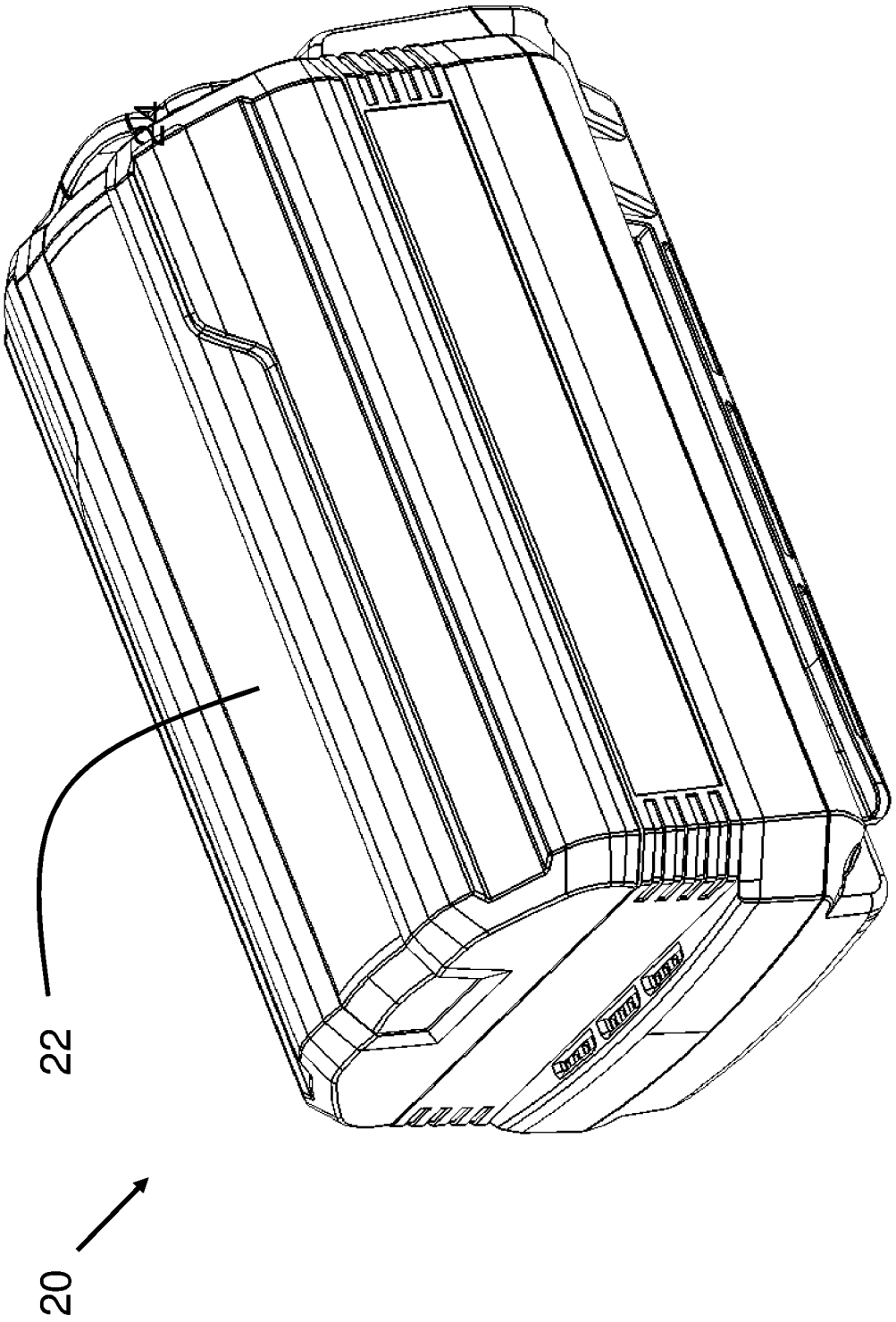


Fig.1a

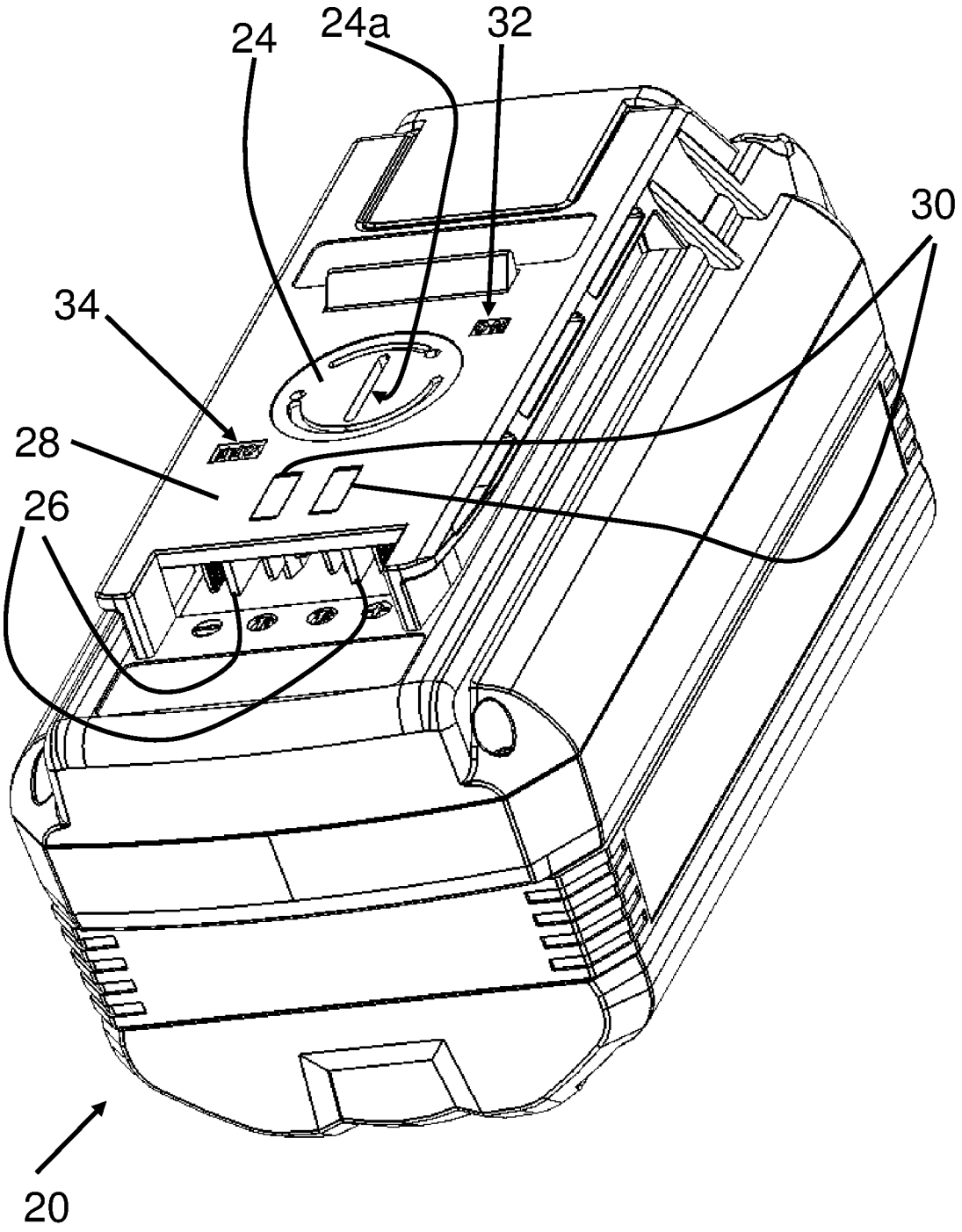


Fig.1b

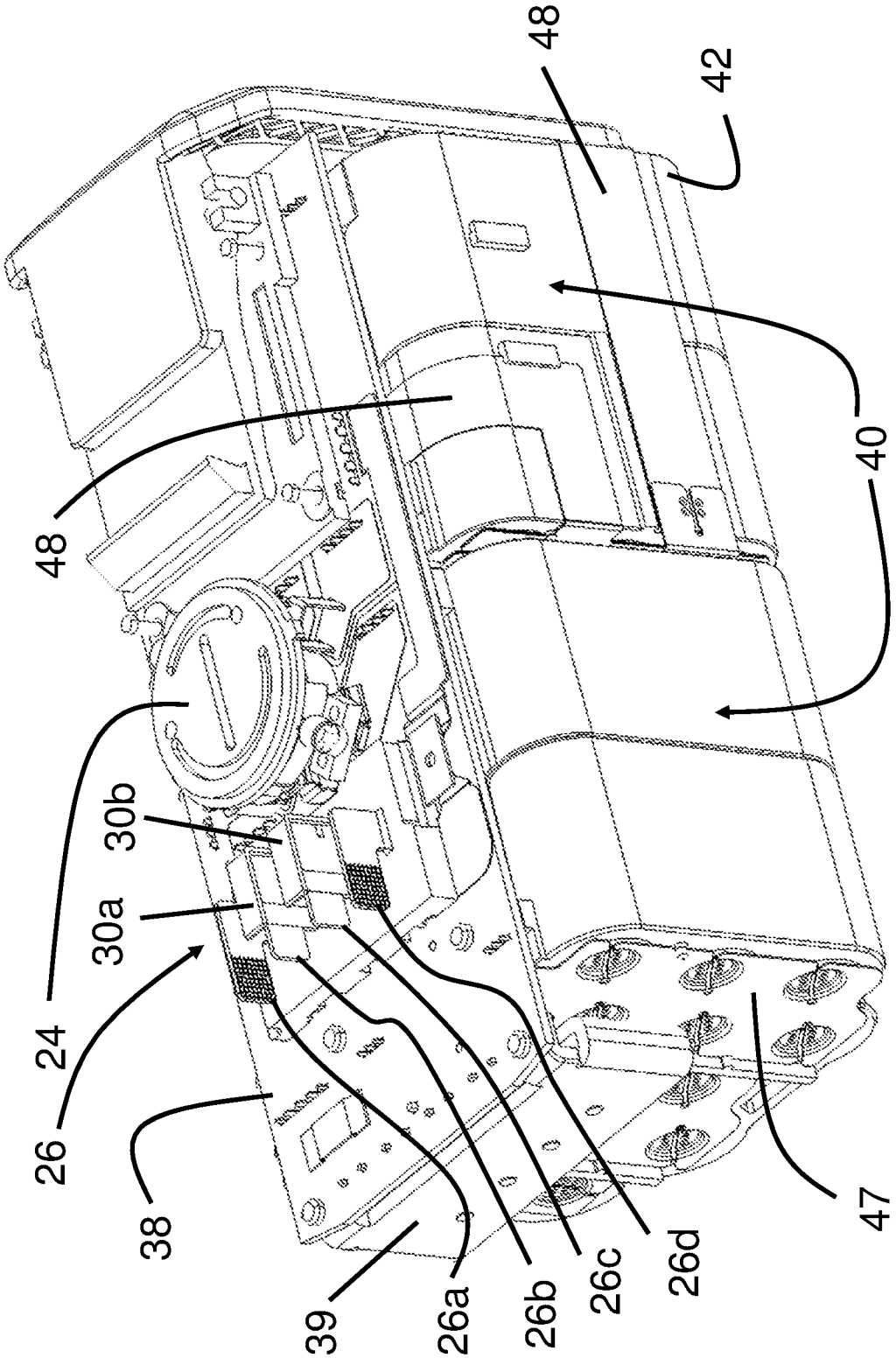
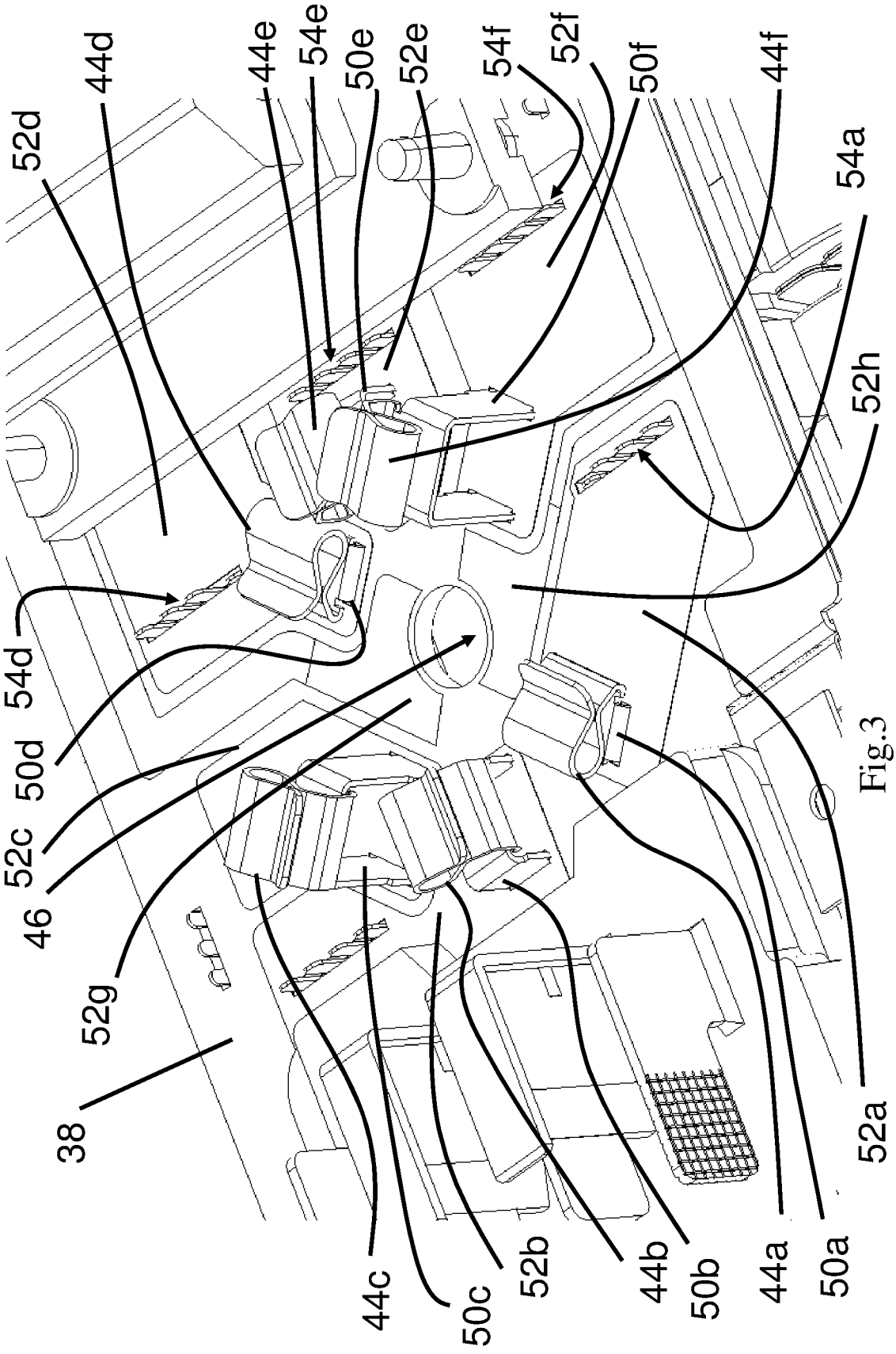


Fig.2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44d
44e
54e
50e
52e
54f
52f
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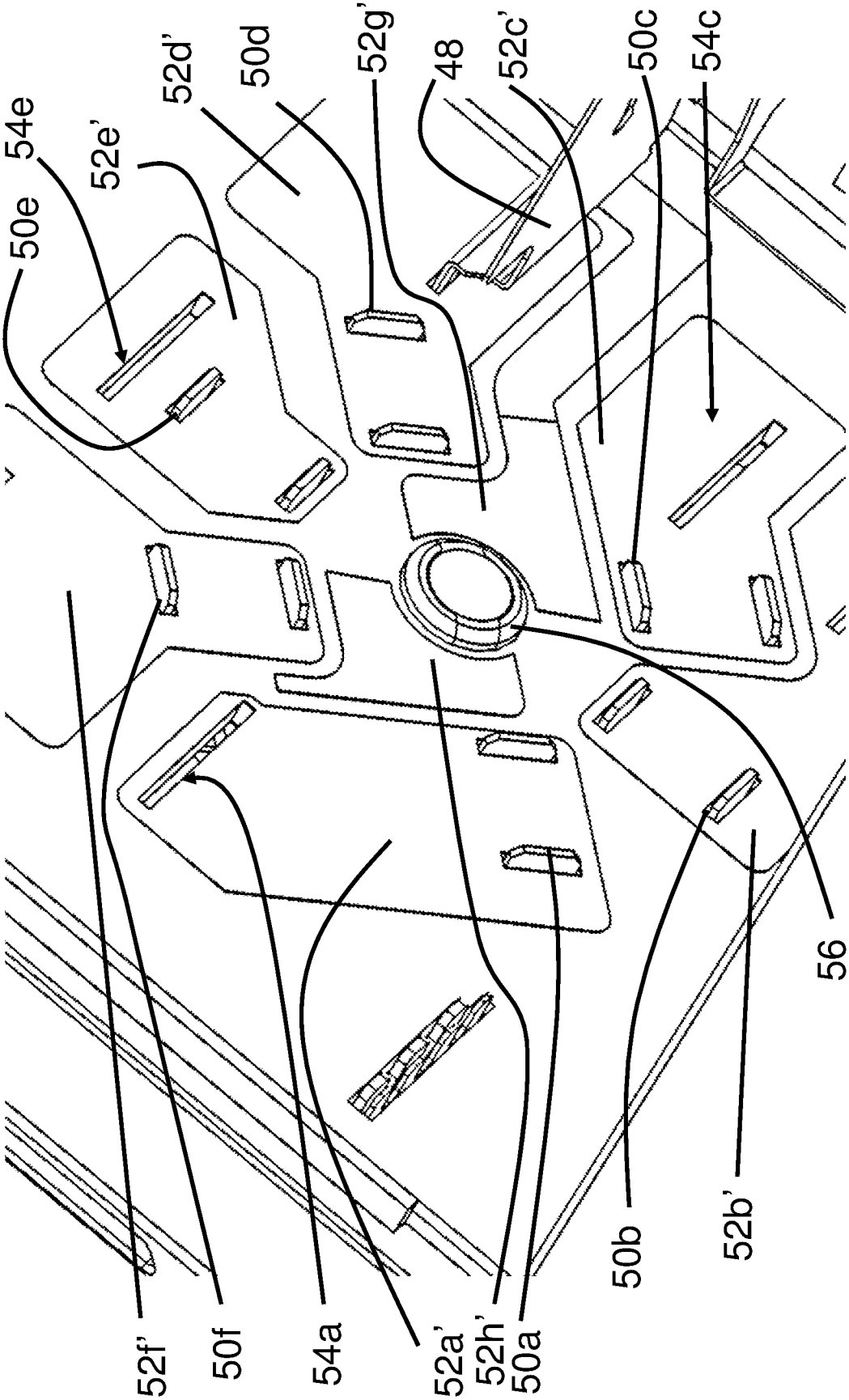
44f
54a
52h
54d
50d
52c
46
52g
38
44c
50c
52b
44b
50b
44a
50a
52a

Fig.3


54e
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52e'
52d'
50d
52g'
48
52c'
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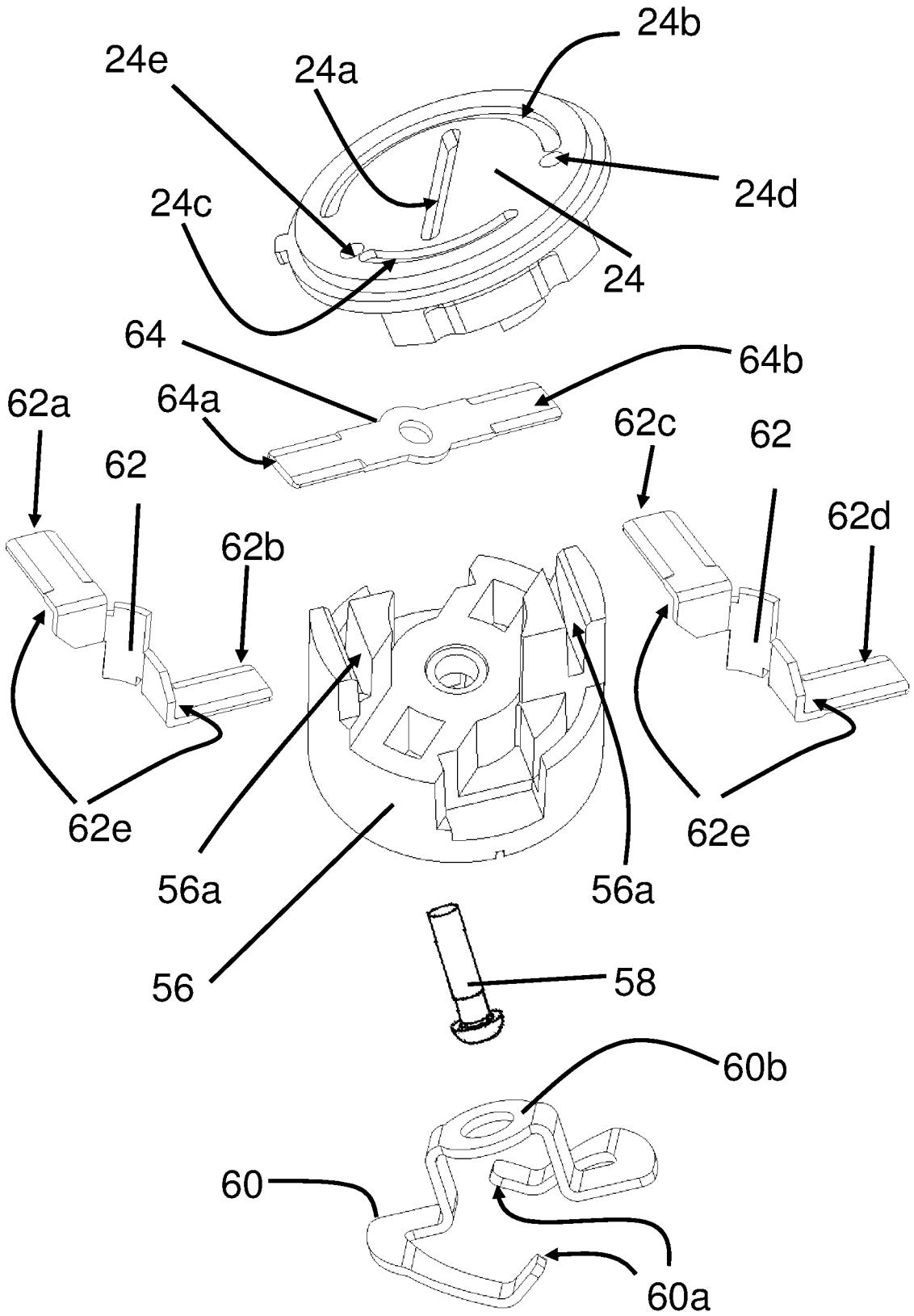
50f
54a
52a'
52h'
50a
50b
52b'
56

Fig.4


24b
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24c
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64a
62c
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62d
62b
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56a
56a
56
58
60b
60
60a

Fig.5

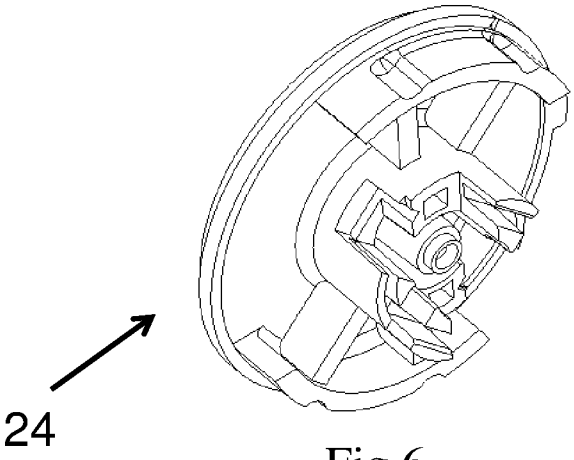


Fig.6

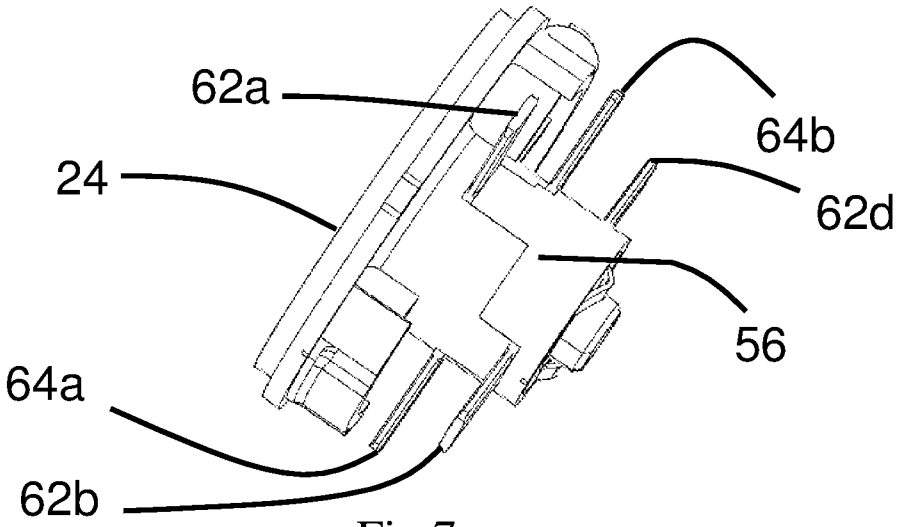


Fig.7a

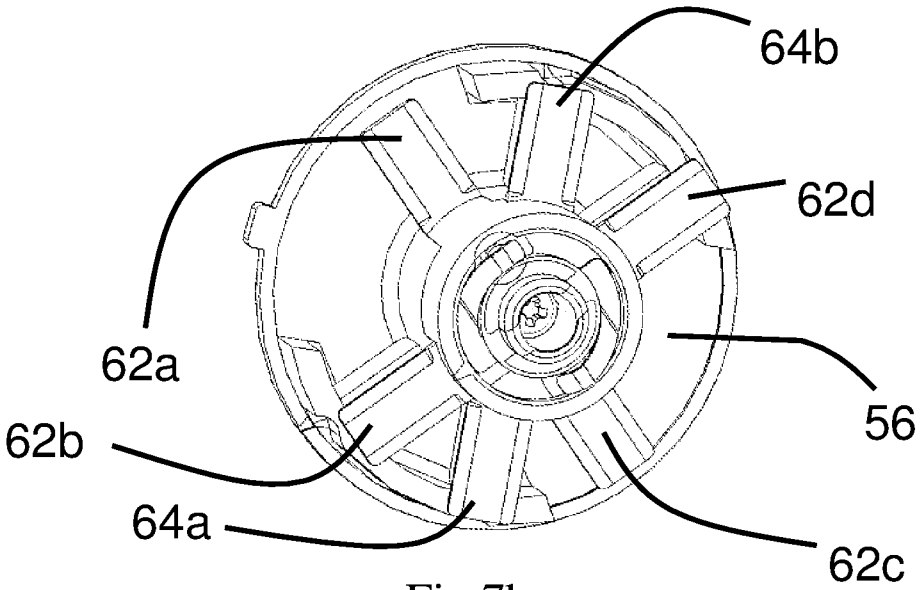


Fig.7b

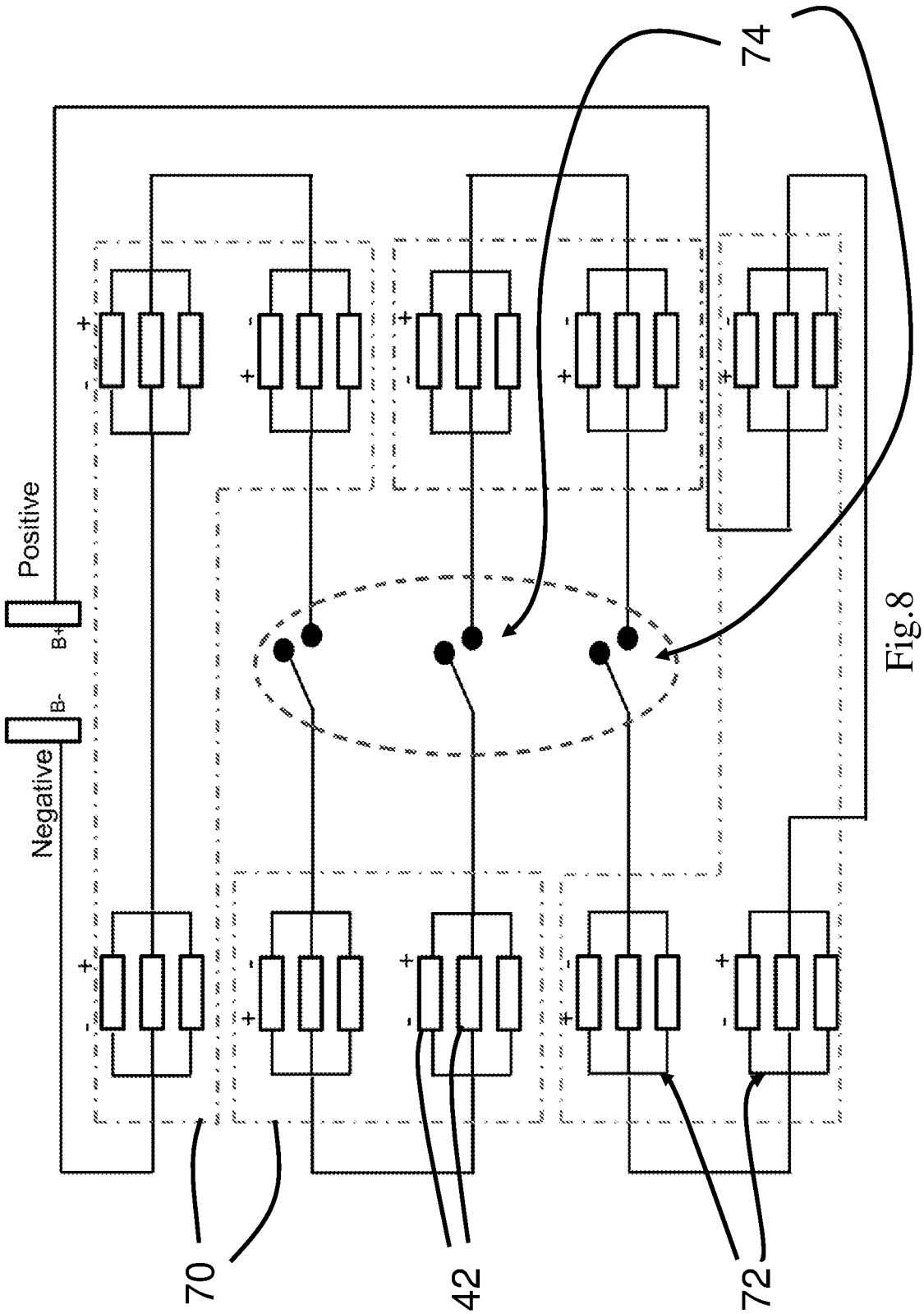


Fig.8

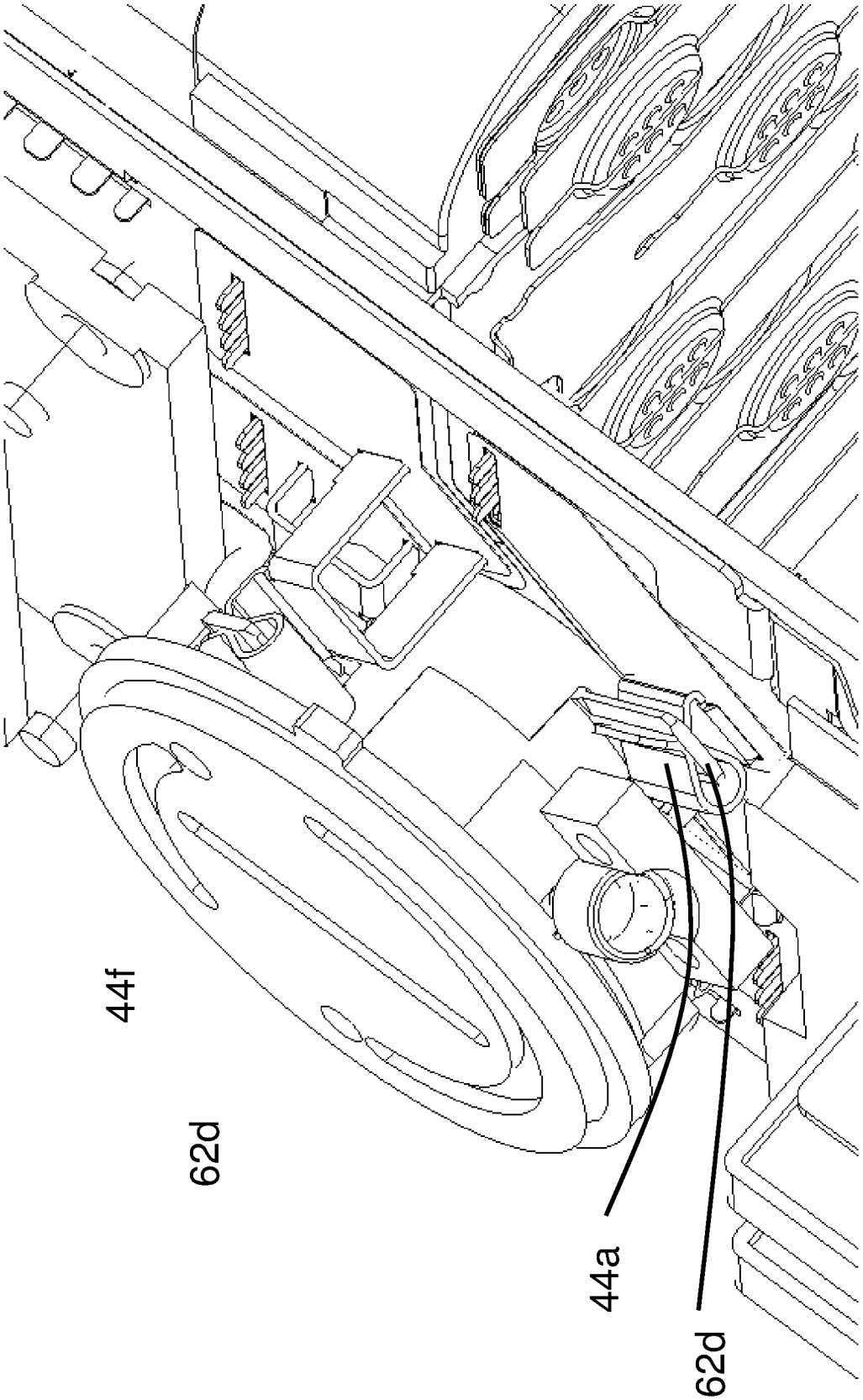


Fig.9a

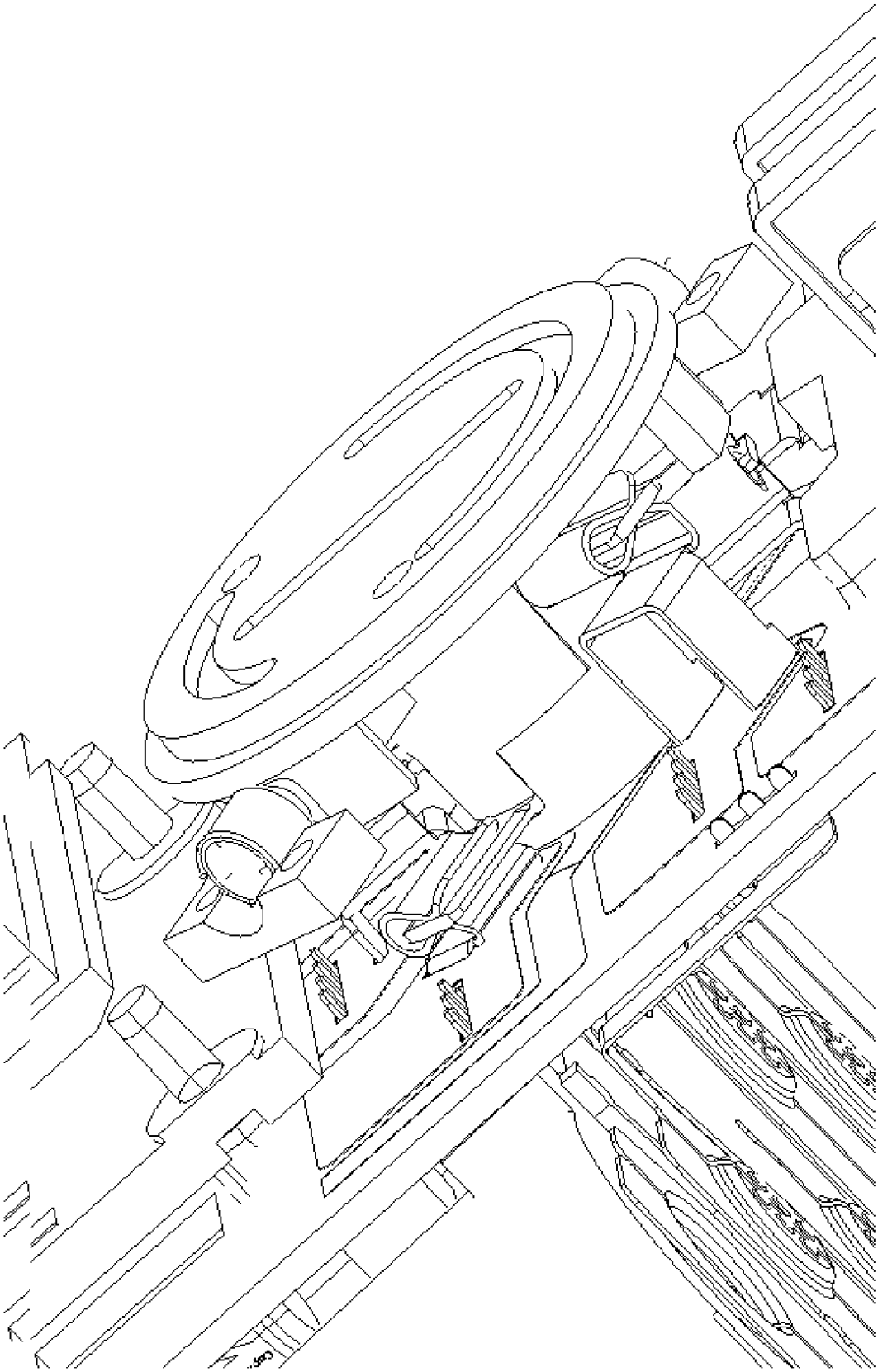
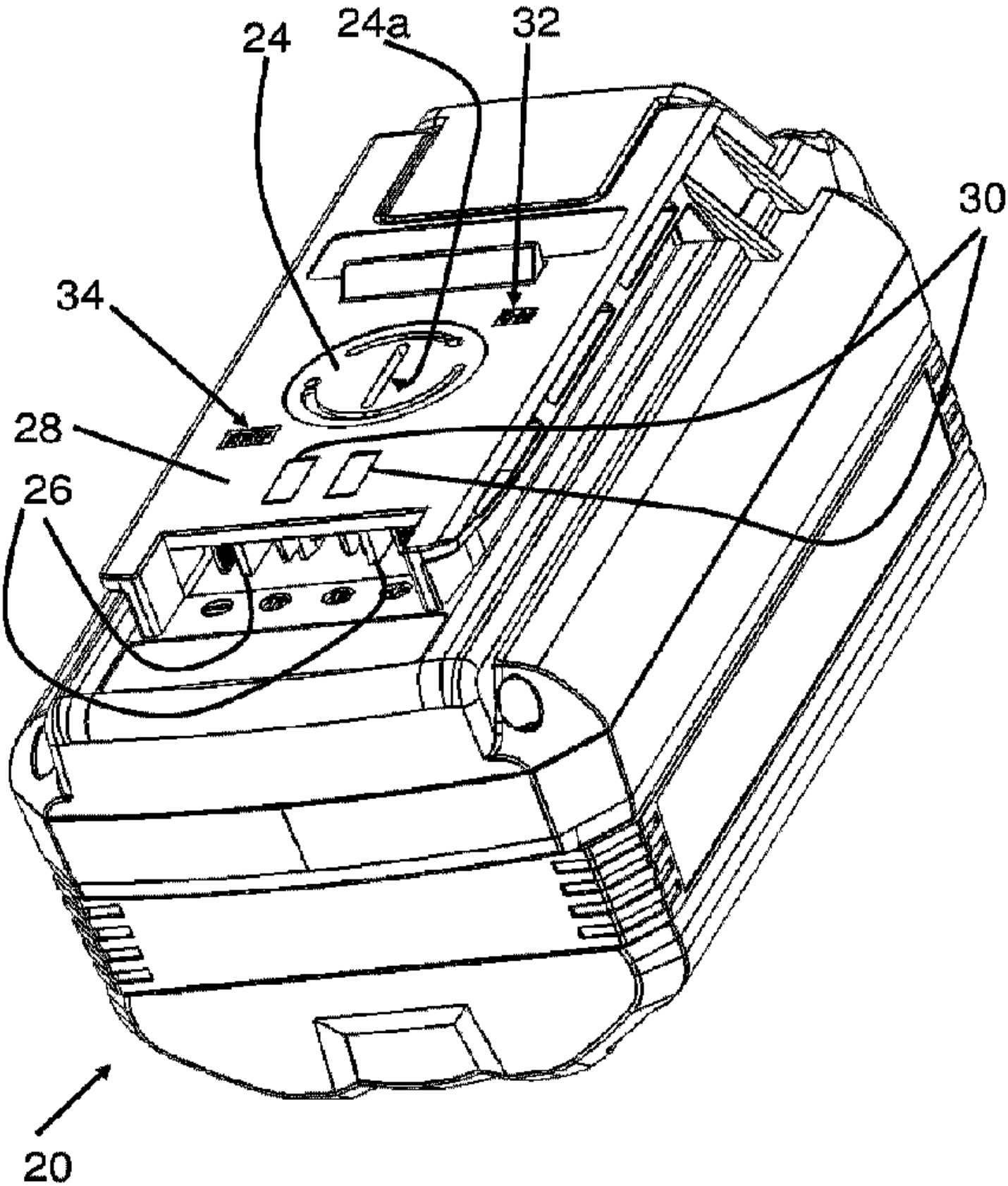


Fig.9b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24a
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