Innovation, Sciences et Développement économique Canada
Office de la Propriété Intellectuelle du Canada

Innovation, Science and Economic Development Canada
Canadian Intellectual Property Office

CA 3204432 A1 2022/09/01

(21) 3 204 432

(12) **DEMANDE DE BREVET CANADIEN**
CANADIAN PATENT APPLICATION

(13) **A1**

(86) **Date de dépôt PCT/PCT Filing Date:** 2022/02/17
(87) **Date publication PCT/PCT Publication Date:** 2022/09/01
(85) **Entrée phase nationale/National Entry:** 2023/07/06
(86) **N° demande PCT/PCT Application No.:** EP 2022/053866
(87) **N° publication PCT/PCT Publication No.:** 2022/179920
(30) **Priorité/Priority:** 2021/02/23 (EP21158756.3)

(51) **Cl.Int./Int.Cl.** ***C25B 1/04*** (2021.01), ***C25B 15/023*** (2021.01), ***C25B 9/70*** (2021.01)

(71) **Demandeur/Applicant:**
HITACHI ZOSEN INOVA AG, CH

(72) **Inventeurs/Inventors:**
DOLL, MICHAEL, DE;
HERING, ALFRED, DE

(74) **Agent:** ROBIC

(54) **Titre : PROCEDE DE FONCTIONNEMENT D'UN ELECTROLYSEUR DU TYPE EMPILEMENT DE CELLULES ET DISPOSITIF D'ELECTROLYSEUR**
(54) **Title: METHOD OF OPERATING AN ELECTROLYZER OF THE CELL-STACK TYPE AND ELECTROLYZER ARRANGEMENT**

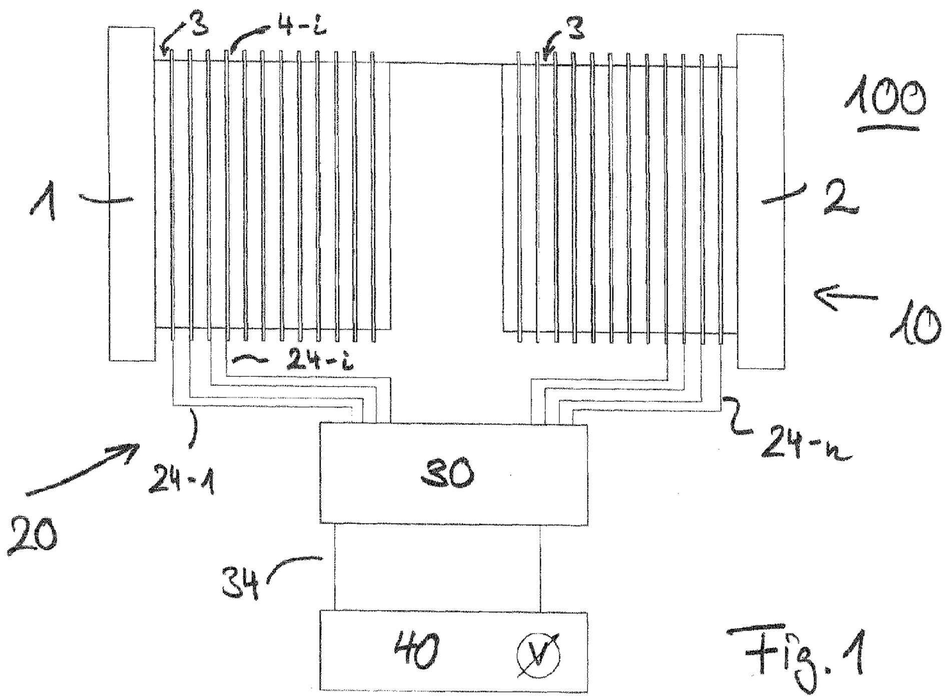

Fig. 1

(57) **Abrégé/Abstract:**
The invention relates to a method of operating an electrolyzer of the cell-stack type, wherein the respective cell voltage of at least two different cells of the cell-stack is measured, wherein said at least two cells are fixedly wired such as to allow automated measuring and that measuring signals from the wiring allocated for measurement of at least two different cells are, by an in particular automatic switching, channelled time-shifted with respect to each other via a common wiring path segment.

Date Submitted: 2023/07/06

CA App. No.: 3204432

Abstract:

The invention relates to a method of operating an electrolyzer of the cell-stack type, wherein the respective cell voltage of at least two different cells of the cell-stack is measured, wherein said at least two cells are fixedly wired such as to allow automated measuring and that measuring signals from the wiring allocated for measurement of at least two different cells are, by an in particular automatic switching, channelled time-shifted with respect to each other via a common wiring path segment.

METHOD OF OPERATING AN ELECTROLYZER OF THE CELL-STACK TYPE AND ELECTROLYZER ARRANGEMENT

The invention is related to a method of operating an electrolyzer of the cell-stack type, wherein the respective cell voltage of at least two different cells of the cell-stack is measured, as well as an electrolyzer arrangement having such an electrolyzer and cell voltage measuring device.

Such electrolyzers of the cell-stack type are well-known and f.i. disclosed in DE 10 2014 010 813 A1 Further, it is known that the performance of such electrolyzer may decrease in case of deterioration of the cells, recognizable in a drop of the cell voltage.

Therefore, roughly once a month or every two months, the cell voltage of the cells of the electrolyzer is measured.

The invention aims to improve electrolyzer arrangements having a measuring device for measuring the cell voltage.

This object is solved by the invention, regarding the method, by a further development of the method as initially introduced, being essentially characterized in that said at least two cells are fixedly wired such as to allow automated measuring and that measuring signals from the wiring allocated for measurement of at least two different cells are, by an in particular automatic switching, channelled time-shifted with respect to each other via a common wiring path segment.

Thereby, the long-term performance of the electrolyzer is improved by provision of a more reliable and easier performable approach to measure the cell voltages.

The fixedly wiring of the cells, respectively their electrodes, allow for cell voltage measuring without the need for an operator to directly access the electrodes f.i. with a portable measuring device. Rather, the wiring permits cell voltage measurement from a distance. Moreover, by having the common wiring path segment, the measuring device needs only a lower number of analog inputs, saving wiring effort and allowing a simpler construction of the measuring device.

In a preferred embodiment, the electrolyzer is performing water electrolysis to produce hydrogen. The measuring of the cell voltages can be performed during such operation.

Generally, the switch over of the switching could be done manually. It is, however, also envisaged that the switching occurs according to a preset sequence. Such sequence could, f.i., start for the electrode closest to an end plate, f.i. cathode-side end plate is f.i. grounded, to then follow the electrodes in the ranking of their arrangement from said one end plate to the other end plate.

In a preferred embodiment, the number of cells of the electrolyzer is more than 30, preferably more than 50, in particular more than 60. However, it is also envisaged to use even larger electrolyzers, having 80 cells or more, 100 cells or more, or even 120 cells or more. Even larger electrolyzer with 128 cells or more, 150 cells or more and even 192 cells or more are envisaged.

In a possible embodiment, the switching is a mechanical switching, f.i. by a rotary switch. However, in particular for large electrolyzers and also otherwise preferred is an electronic switching by multiplexing. Then, it is also envisaged to switch over between the wiring of 100 cells or more, directing their signals over the same common path segment.

The switching time from sending a measuring signal from one electrode to the common wiring path segment to sending a measuring signal from another electrode to the common wiring path segment is preferably less than 30 min, more preferably less than 10 min, in particular less than 5 min. Also even shorter switching times can be applied, f.i. 1 min or less, 40 sec or less, or even 20 sec or less.

In a further embodiment, the wiring is connected to a plurality, in particular all electrodes of the electrolyzer. In a further preferred embodiment, one switch and one only common wiring path segment is used. However, in alternative embodiments, there may be two switches for two common wiring path segments or even a plurality thereof. For instance, the electrodes of the electrolyzer can be allocated into 2, 3, 4, or even more groups, and there is one switch and one common wiring path for each group. This still reduces the number of analog inputs of the measuring device, which could be provided in the framework of a programmable logic controller. This could reduce the complexity of the multiplexing against provision of a plurality of devices. For instance, the groups could contain a number of not more than 64 cells, not more 32 cells, or not more than 16 cells.

In a preferred embodiment, the switching is performed at a first location, and the obtaining of the measuring results is performed at a second location spaced apart and being in particular more distant to the electrolyzer than the first location. This may further reduce the overall wiring length of the wiring between the electrodes of the electrolyzer and the switch.

In a cylinder-coordinate system with the height axis being the staple axis of the electrolyzer, it is preferred that the height position of the switch is closer to that of the center of the electrolyzer than to the height position of each end plate. Further, it is preferred that the radial distance from the height axis is lower than twice, in particular once the effective diameter of the cell staple (the effective diameter corresponding to the true diameter in case of circular configuration, otherwise to the square root of $4/\pi$ times the area of the staple in projection orthogonal to the staple axis). Preferably, each single cable for the wiring has a length of not more than 5 m, in particular 3 m.

While in a possible embodiment, the voltage measuring itself could be performed close to the switch, and even be contained within the same housing with the switch, in a preferred embodiment, separate units are provided at different locations. Further, preferably the distance of the location of the voltage measurement is more distant from the electrolyzer than the location of the switching.

In a preferred embodiment, the measurement of all cell voltages is repeatedly performed in particular at regular or selectable intervals, and measuring results are monitored, in particular stored and in particular sent to an analysis module. This provides for reliable surveillance of the status of the cells. Further, by extrapolation means considering not only the actual cell voltage but also their first and possibly even second derivative in combination with threshold values, prognostics can be made as to when one or more of the cells should be subject to maintenance or when other measures should be taken, as f.i. bridging a detrimental cell.

It is preferred that cell voltage measurement for all cells is effected at least once every two months, preferably at least once every month, more preferably at least once every two weeks. However, even more preferred is a measuring sequence of at least once a week, at least once every three days, at least once a day. Due to the ease of operation, the system can even be used as diagnostic for singular events detrimentally affecting a cell, by having the measuring sequence being at least once every 12h, at least once every 8h, even at least every 4h. Also a continuous surveillance where one sequence through the cells follows the previous with delay of less than 2h is envisaged.

Further, the invention provides such electrolyzer arrangement, comprising an electrolyzer of the cell-stack type and a measuring device for measuring the cell voltage of at least two different cells of the cell stack, which is essentially characterized by a wiring connecting electrodes of the cells with the measuring device, the wiring being fixedly connected to the electrodes, and by an in particular automated switch channelling measuring signal allocated for measurement for different cells in a time-shifted manner with respect to each other via a common wiring path segment. The electrolyzer can be built up by a certain number of insulated polymeric cells connected by a metallic electrode.

The advantages of said arrangement are recognizable from the above described advantages of the method. In a preferred embodiment, the electrodes are formed by bipolar plates arranged between respective two neighbored cell frames. That is, an electrolyzer construction as f.i. disclosed in DE 10 2014 010 813 A1 can be used. However, the invention is not limited to such kind of electrolyzers, the above document DE 10 2014 010 813 A1 being incorporated by reference for the general construction/function and arrangement of the electrolyzer cells (that is, irrespective of details of single elements); also other kind of electrolyzers of the staple type can form the electrolyzer of the electrolyzer arrangement.

As already said, the switch is preferably an electronic multiplexer, wherein it is also envisaged to use a plurality of multiplexer, each one for each allocated subgroup of the cells of the electrolyzer.

In a preferred embodiment, the switch is arranged in an encapsulated surrounding. In particular, an explosion-proof housing is provided, in which the electronic for the switching is received. In a preferred embodiment, explosion-proofness according to ATEX2014/34/EU is covering explosion group IIC. Further, it is preferably adapted at least for zone 2, possibly also zone 1, or zone 0. The housing can be certified by an authorized body and may contain an element which is indicative for granted authorization in a first state and can assume an irreversibly changed state caused by modification of the housing.

Thereby, the sensible electronics is protected even when arranged close to the electrolyzer and within an outer housing for the electrolyzer.

In a further preferred embodiment, the wiring between the encapsulated surrounding and the electrolyzer is protected. Said protection is provided preferably by double insulation and/or short circuit proof cables, preferably with protection level not inferior to that of a NSGAFÖU cable. The cables may have a flame resistant insulation according to VDE 0250-602. It is understood that also wiring from the output of the switching, in particular the common wiring path segment may be at least partly protected, preferably fully protected as described above.

The voltage measuring itself can be provided at a location (second location) different of that of the switching, and can be implemented in the framework of a programmable logic controller. This PLC can be incorporated into an overall control device for the electrolyzer or an enhanced system comprising not only the electrolyzer but also a rectifier connected to the electrolyzer and the connecting system connecting the rectifier with the electrolyzer. In a further preferred embodiment, the electrolyzer is housed within an (outer) housing, and preferably also the multiplexer is housed within said housing, and the voltage measuring f.i. within the framework of a PLC is outside said housing. For said housing containing the electrolyzer, the above mentioned explosion-proof properties may apply.

For the voltage measurement, a reference potential can be used, f.i. that of an end plate of the electrolyzer, which could be the, in particular ground, cathode-side end plate of the electrolyzer, and a respective wiring can be present from said end plate to the voltage measuring. In a further preferred embodiment, cell voltage is measured against the neighbor cell.

Further features, details, and advantages of the invention result from the subsequent description of exemplary embodiments with reference to the accompanying figures, wherein

Fig. 1 shows a setup of an embodiment of an electrolyzer arrangement, and

Fig. 2 is a representation, partly more in detail, for such setup of Fig. 1.

In the upper part of Fig. 1, an electrolyzer 10 of an electrolyzer arrangement 100 is shown. The electrolyzer 10 is of the stapled type, comprising a number of n cells stacked along a staple axis extending between two end plates 1, 2 of the electrolyzer 10. In the stack, cell frames 3 alternate with electrodes 4 radially extending at least partially out of the outer shell of cell frames 3. Each electrode 4, for the subject exemplary embodiment formed by a bipolar plate, is wired. Construction and regular operation of electrolyzer 10 is well known in the art and not further described here. Rather, reference is made to typical electrolyzers of the staple type, as f.i. disclosed in DE 10 2014 010 813 A1.

In the shown embodiment, each electrode 4-i (i=1,.....,n) is connected by a wire 24-i to a respective U-input of a multiplexer 30. Multiplexer 30 provides that only one U-signal at a time from said U-inputs is transmitted via wiring path segment 34 to measure the voltage of said electrode against a reference value, which can be that of an end plate (Fig. 2) of the electrolyzer, and in particular ground. Thereby, one after another the cell voltage of each cell of the electrolzyer 10 can be measured. For instance, the multiplexer 30 could provide for switching from one U-input to the next after a time sufficient for voltage determination, f.i. every ten seconds.

The cell voltage measurement itself is done within a programmable logic control (PLC) 40. Due to the multiplexer 30 set between the electrolyzer 10 and PLC 40, PLC 40 does not need to have a large number of analog inputs. For instance for an electrolzyer 10 having 64 cells, and a multiplexer multiplexing 64 U-inputs, only one analog input for these 64 cell voltages is required. The system further comprises a not-shown (long term) data logging system monitoring the cell voltages. Thereby, the cell voltage for each cell can be monitored on shorter time scales, in particular continuously on a scale of the necessary time to multiplex through all U-inputs of multiplexer 30, f.i. about every ten minutes for the example of 64 cells and 10s switching time. However, such close meshing is optional, and other suitable intervals can be selected, as f.i. one check every hour, one check any couple of hours, or one check a day.

In Fig. 2 it is additionally shown that the multiplexer 30, represented in Fig. 2 as rotary switch, to show the principle of the electronic multiplexer on the one hand side and a possible mechanical implementation of the switch over on the other hand side, is arranged in an explosion-proof housing 38. Thereby, in case of problems with the electrolyzer 10, the multiplexer 30/switch is protected against explosion risks arising from problems with the electrolyzer. To this end, also the wiring to and from the surroundings 37 of the multiplexer 30 encapsulated by housing 38 are protected, in the shown embodiment, short circuit-proof cables, f.i. NSGAFÖU cables are used.

Accordingly, at least part of the electrolyzer arrangement comprising the electrolyzer 10, wiring 20, and multiplexer 30 including housing 38 can be placed in a risk area for explosion (EX area, EX IIC).

The voltage measuring itself, in the subject embodiment by PLC 40, could be done at the same location as within the surroundings 37, and even encapsulated by the same housing 38.

However, in an even more preferred embodiment, as shown in Fig. 2, the voltage measuring, hereby PLC 40, is done at another location distant from housing 38 and in particular more distant from the electrolyzer than housing 38.

The part 34b of the common wiring path segment 34 leading to PLC 40 can also be provided by f.i. the NSGAFÖU cable.

Further shown in Fig. 2 is a connection 36b from output terminal of the switch 30 leading to PLC 40, and connected to the other hand side 36a to an end plate of the electrolyzer 10, f.i. to a grounded cathode-side end plate.

Connection 36 passes through surrounding 37 within housing 38 in the embodiment shown in Fig. 2. However, connection 36 could also bypass housing 38 to be directly input into PLC 40.

In Fig. 2, only some wiring 24-i is shown for the connection of the electrodes of the elctrolyzer 10 and the input terminals of multiplexer 30. However, it is to be understood that all electrodes are connected each to one input terminal of multiplexer 30 for the shown embodiment where only one multiplexer 30 is provided.

However, in a further embodiment not shown in the figures, also more than one multiplexer could be provided, which may in particular be useful for electrolyzer having more than 64 or more than 128 cells. In that case, more analog inputs can be provided at the PLC for the voltage measuring. Otherwise, to one or more multiplexer connected to the electrodes of the electrolyzer 10, a further multiplexing in series could be applied to the output of said more than one multiplexer, if it is desired to keep the number of analog inputs on the PLC as low as shown in the embodiment of Fig. 1.

The invention is not restricted to the details shown in the exemplary embodiments. Rather, the features of the description above and the features of the subsequent claims, along or in combination, can be essential for the invention.

Claims

1. Method of operating an electrolyzer of the cell-stack type, wherein the respective cell voltage of at least two different cells of the cell-stack is measured,

characterized in that said at least two cells are fixedly wired such as to allow automated measuring and that measuring signals from the wiring allocated for measurement of at least two different cells are, by an in particular automatic switching, channelled time-shifted with respect to each other via a common wiring path segment.

2. Method according to claim 1, wherein the switching is a mechanic switching.

3. Method according to claim 2, wherein the switching is an electronic switching by multiplexing.

4. Method according to any of the preceding claims, wherein the wiring is connected to a plurality, in particular all electrodes of the electrolyzer.

5. Method according to any of the preceding claims, wherein the switching is performed at a first location, and the obtaining of the measuring results is performed at a second location spaced apart and being in particular more distant to the electrolyzer than the first location.

6. Method according to any of the preceding claims, wherein a measurement of all cell voltages is repeatedly performed at regular or selectable intervals, and measuring results are monitored, in particular stored and in particular sent to an analysis module.

7. Electrolyzer arrangement (100), comprising an electrolyzer (10) of the cell-stack type and measuring device (40) for measuring the cell voltage of at least two different cells of the cell stack

characterized by a wiring (20, 34) connecting electrodes (4) of the cells for a connection with the measuring device and by an in particular automated switch (30) channelling measuring signals allocated for measurement for different cells in a time-shifted manner with respect to each other via a common wiring path segment (34).

8. Electrolyzer arrangement according to claim 7, wherein the wiring is connected to a plurality, in particular all electrodes, in particular to bipolar-plates arranged between respective two neighbored cell frames (3).

9. Electrolyzer arrangement according to claim 7 or 8, wherein the switch (30) is a mechanical switch, in particular a rotary switch.

10. Electrolyzer arrangement according to claim 7 or 8, wherein the switch (30) is an electronic multiplexer.

11. Electrolyzer according to any of claims 7 to 10, wherein the switch is arranged in an encapsulated (38) surrounding (37) at a first location.

12. Electrolyzer arrangement according to claim 11, wherein the wiring between the encapsulated surrounding (37) and the electrolyzer is protected.

13. Electrolyzer arrangement according to claim 11 or 12, wherein at least part of the common wiring path (34b) segment is protected.

14. Electrolyzer arrangement according to any of claims 7 to 13, wherein the common wiring path segment is connected to an input of the measuring device (40).

15. Electrolyzer arrangement according to any of claims 7 to 14, wherein the measuring device is arranged at a second location, in particular more distant from the electrolyzer than the first location, and in particular formed by a programmable logic controller.

16. Electrolyzer arrangement according to any of claims 7 to 15, wherein the wiring comprises an electric connection from an end plate (1) of the electrolyzer to the measuring device bypassing the switch, said connection preferably being at least partly protected and preferably crossing the encapsulated sourrounding (37).

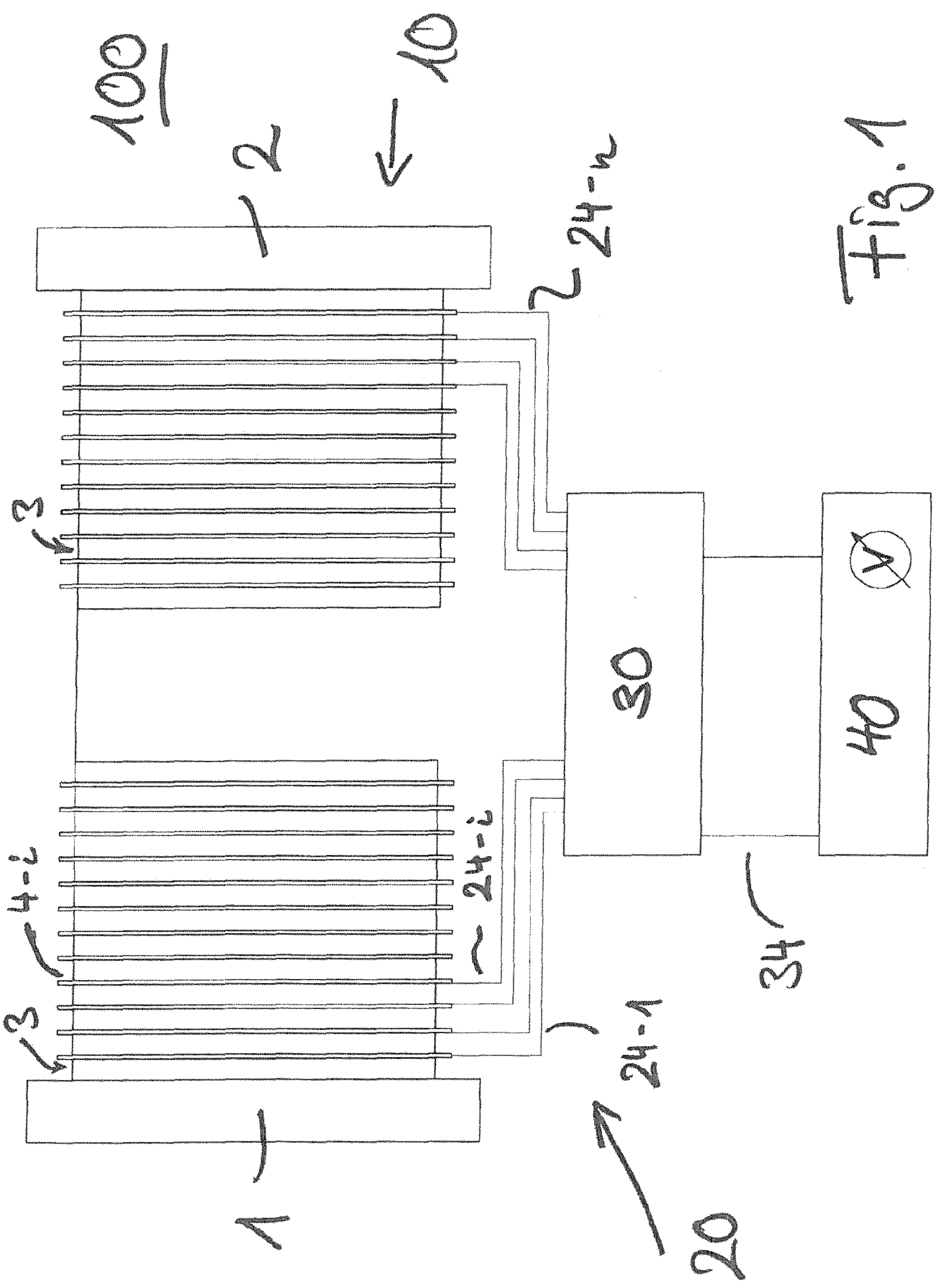

Fig. 1

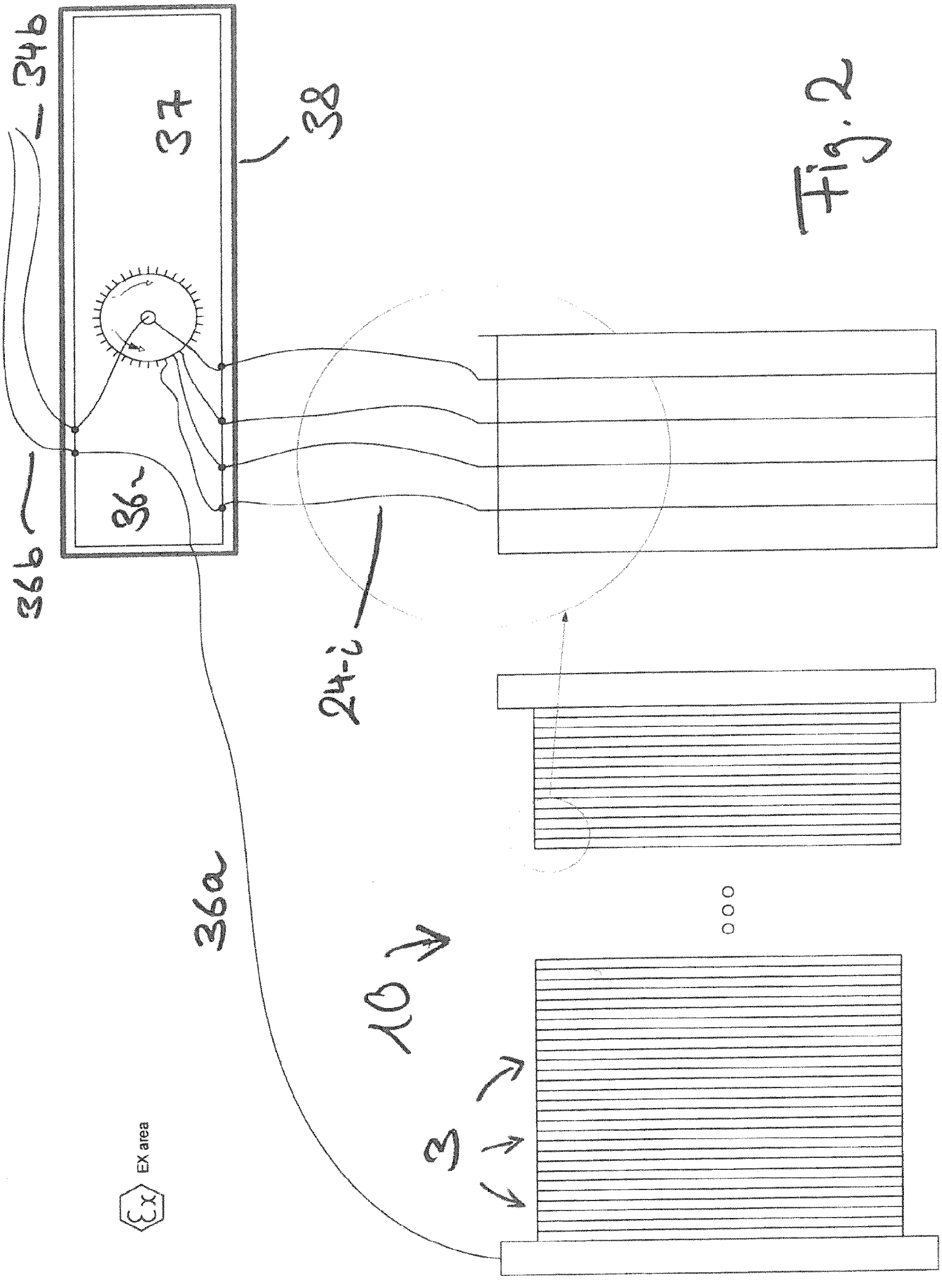

Fig. 2

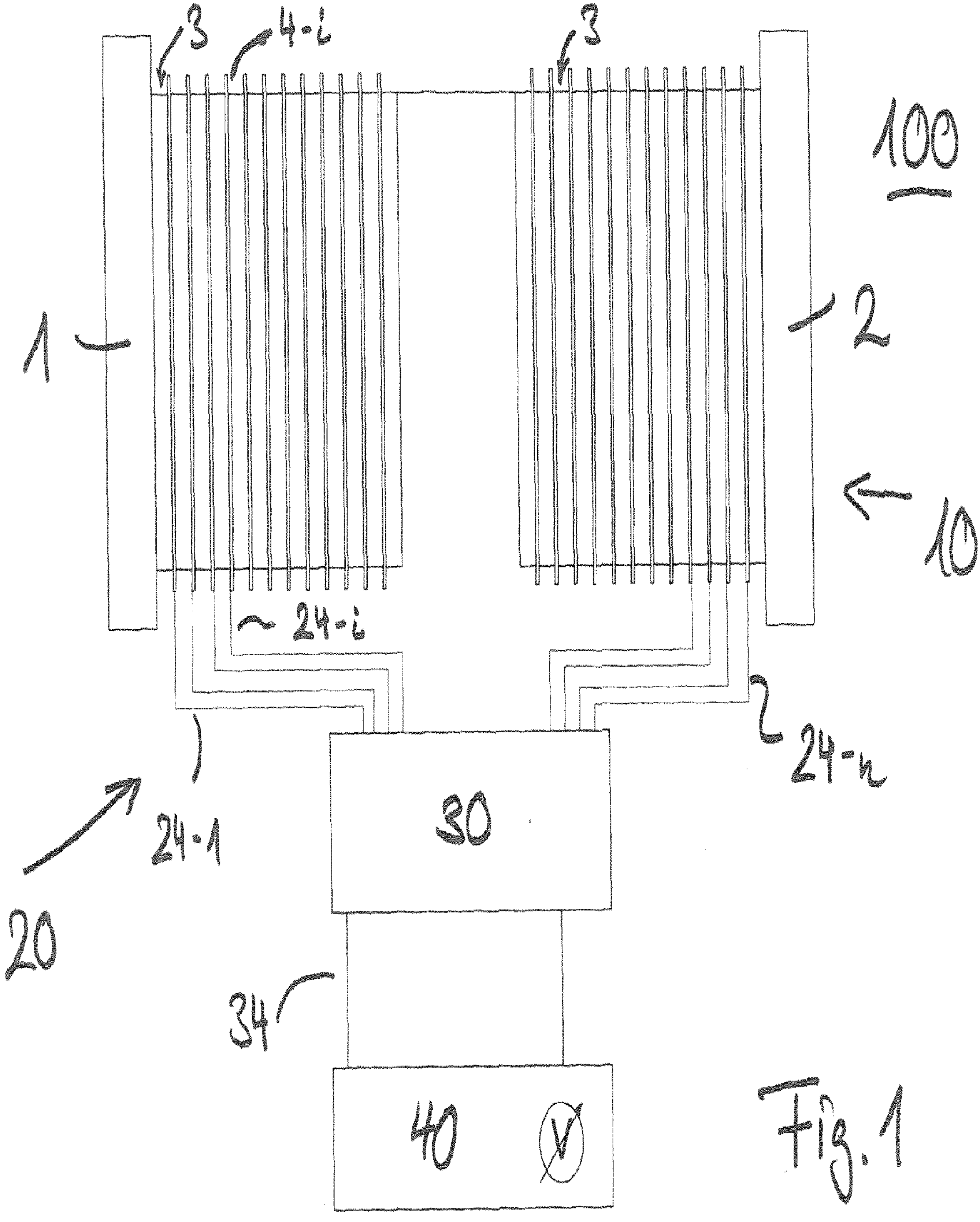

Fig. 1