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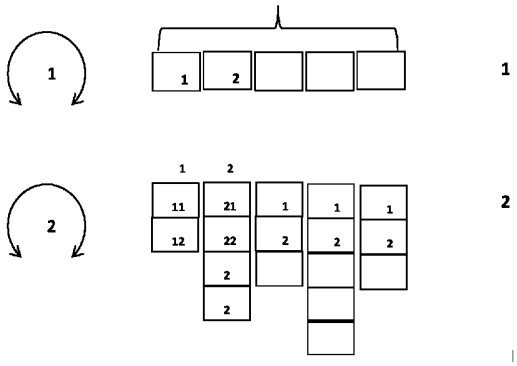
A method in which operative variables of a welding device are arranged into a first array of menu items, and values for the operative variables into second arrays of menu items, each of the second arrays corresponding to one menu item of the first array. Display objects of the menu items are arranged respectively into a first selection window and a second selection window, only one of which is active at a time. At least one of the selection windows is arranged to be scrolled with a rotary movement provided by a hand of a user.

Menetelmä, jossa järjestetään hitsauslaitteen toiminnallisia muuttujia ensimmäiseksi valikkokohteiden joukoksi ja toiminnallisten muuttujien arvoja toiseksi valikkokohteiden joukoksi, kunkin toisesta joukosta vastatessa yhtä ensimmäisen joukon valikkokohteista. Valikkokohteiden näyttöobjektit on järjestetty vastaavasti ensimmäiseen valintaikkunaan ja toiseen valintaikkunaan, joista vain toinen kerrallaan on aktiivinen. Vähintään yksi valintaikkuna on järjestetty vieritettäväksi käyttäjän kädellään suorittamaan kiertoliikkeen avulla.



Enhanced control unit and method for a welding device

Field of the invention

The present invention relates to welding devices and especially to a control unit and a method for controlling operations of a welding device, as defined in the preambles of the independent claims.

Background of the invention

The term control refers generally to actions with which one exercises authoritative or dominating influence over a controlled object. In technical and industrial context, control over entities or processes is typically performed with a control unit, a system with which a set of variable quantities may be held constant or caused to vary in a prescribed way.

Welding refers here to a coalescence process in which materials are melted to form a weld pool that cools to become a strong joint. A welding device represents here a system with elements capable of providing materials and physical conditions with which coalescence of desired materials is achieved.

Welds are often used in critical parts of industrial systems, like in pressure vessels and ships, and therefore requirements for the quality and strength of the weld are typically very high. In controlled conditions, some simple welding tasks can be modeled and designed accurately repeatable so that they can be performed automatically by industrial robots. However, in many practical situations, such controlled conditions are not available, and adaptable human mind and skilled experience is required for successful results. Focus of this invention is in control units that provide a user interface with which a person can control operations of a welding device.

Welders today are provided with a plurality of different welding processes and ranges of devices with different capabilities to perform and control these processes. A single industrial welding device may thus include numerous welding processes, and provide a plurality of parameters to control features of them.

The problem with these devices is that when the aim is towards greatest versatility, the crucial role of the welder person and his focused concentration is easily overlooked. The user interface of a conventional control unit of a welding device includes typically a complex menu structure through which the welder is expected to navigate with a normal keyboard and/or a touch screen. The menu structure display provides a variety of different types of display objects, all available for activation. The keyboard is, however, seldom operable with a gloved hand, and it is also difficult to work on minuscule icons of a touch screen with gloved hands. In addition, the welder is hardly willing to familiarize oneself with complex menu structures and their adjustment options, and spend working time by roaming between them. The focus of a welder is and always remains in the accurate and demanding welding task at hand. The control operations must be an easy and natural part of welding work, not a distraction from it.

Brief description of the invention

The object of the present invention is to provide a solution with which a welder can in a straightforward manner control operations of a welding device in various welding conditions and with minimal diversion from the actual welding work. The objects of the present invention are achieved with a method, a control unit and a computer program according to the characterizing portions of the independent claims.

The preferred embodiments of the invention are disclosed in the dependent claims.

The present invention applies a menu structure with two hierarchic levels, where the higher level includes an array of operative variables of the welding device and the lower level the values to be assigned for them. Selection of items in at least one of the two levels is facilitated by detecting a rotary movement, made with a hand of a user. The two levels provide to the user a flattened menu structure, which is clear and concise and therefore very easy for the welder to comprehend and use. The number of items in a level of the new menu structure may be sizeable, but said use of rotary movements for selection allows quick and efficient scrolling through numerous menu items. The user may thus operate the welding device with a simple and straightforward selection process. Further advantages of the invention are discussed in more detail with description of embodiments of the invention.

Brief description of the figures

In the following the invention will be described in greater detail, in connection with preferred embodiments, with reference to the attached drawings, in which

Figure 1 illustrates an embodiment of a welding device;

Figure 2 illustrates a configuration of an exemplary control unit apparatus;

Figure 3 illustrates rotary movement of a hand of a person;

Figure 4 illustrates a side view of detection means applicable for indirect detection in the control unit;

Figure 5 illustrates a simplified hierarchical structure of a two-level menu applicable in a control unit;

Figure 6 illustrates an exemplary display configuration and use of rotary movements that can be applied with the hierarchic structure of Figure 5;

Figure 7 illustrates a rotary knob suspended to the control unit to be moved in the direction of its rotary axis;

Figure 8 illustrates a further advantage achievable with the proposed use of two rotary movements;

Figure 9 illustrates en embodiment for inputting character strings;

Figure 10 shows an example of a display object for an exemplary menu item of Figure 6; and

Figure 11 discloses steps of an embodiment of a method performed in the control unit of Figure 1.

Detailed description of some embodiments

The following embodiments are exemplary. Although the specification may refer to "an", "one", or "some" embodiment(s), this does not necessarily mean that each such reference is to the same embodiment(s), or that the feature only applies to a single embodiment. Single features of different embodiments may be combined to provide further embodiments.

In the following, features of the invention will be described with a simple example of a device architecture, in which various embodiments of the invention may be implemented. Only elements relevant for illustrating the embodiments are described in detail. Various implementations of welding control units, methods and devices comprise elements that are generally known to a person skilled in the art and may not be specifically described herein.

In the following, embodiments of the invention are described using exemplary terms and elements of gas metal arc welding processes. It is noted, however, that the type of welding process or the type of features controlled in those processes are not, as such, essential details of the invention and the invention is not limited to any specific type of welding process. The disclosed welding control method can be applied to any type of welding devices and processes.

The block chart of Figure 1 illustrates an embodiment of a welding device 10 that includes a welding control unit 11 according to the present invention. The welding device comprises one or more functional elements 12, 13, 14, 15

configured to provide materials and physical conditions to achieve a specified coalescence of desired metal materials.

The welding device is exemplified herein by means of a gas metal arc welding device, in which an electric arc forms between a consumable wire electrode and workpiece metal material, causing them to melt and join. The wire electrode may be supplied to the process through a welding gun 12 that is connected to a wire feeding unit 13, a power supply 14, and a shielding gas supply 15. The wire feeding unit 13 may be a functional unit that feeds electrode wire to the welding gun during welding. The power supply 14 may be a functional unit that feeds electric power to the tip of the wire electrode to generate an electric field for the arc. The shielding gas supply 15 may be a functional unit that feeds a flow of shielding gas through the welding gun. The shielding gas may protect the welding area from atmospheric gases that easily compromise the weld if they come in contact with the electrode, the arc or the welding metal. The welding gun 12 may provide means, typically a switch, with which a welder can activate the wire feed, the electric power and the shielding gas flow, and thereby cause an electric arc to strike. It is noted, that these are exemplary functional units; in other welding processes, different types of functional units may be applied.

Operations of the functional units 12, 13, 14, 15 may be varied in many ways. In order to provide desired materials and physical conditions for the welding process, each of the functional unit comprises one or more functions, and at least some of these functions vary according to an operative variable.

For example, the wire feeding unit 13 may apply different wire types and wire may be fed to the welding gun with varying speed. The type of current (AC/DC) and level of current output from the power supply 14 may be varied, as well as composition or level of flow of gases from the shielding gas supply 15. In order to allow the welder to monitor and controllably adjust the operations of the functional units, the welding machine comprises a control unit 11.

The welding device 10 and the control unit 11 of figure 1 are operationally connected. At minimum the control unit 11 can output control data to one or more functional units of the welding device 10, and the functional units are responsive to the control data from the control unit 11. Advantageously communications between the control unit and the functional units flow in both ways, for example, control commands to the functional units from the control unit and status data from the functional units to the control unit. A functional unit is configured to operate its functions with a set of preset or input operative variables. In response to reception of control data from the control unit, the functional unit is configured to check whether one or more values of its operative variables need to be changed, and implement a change in its operations, if necessary.

The control data may include explicit operative variable values to be applied by the functional unit. The functional unit may also comprise one or more internal adjustment routines that run during operation and independently change values of the operative variables in the functional unit. The control data may thus include implicit operative variable values, for example threshold values that define a range within which the functional unit may operate independently. Hardware configuration of the operational connection may be varied in many ways. The control unit may be integrated into the welding device, or the control unit may be a separate physical element that includes one or more device or communication interfaces to the welding device. The control unit 11 comprises also user interface, by means of which the welder can give commands and receive visual indication to manage the operations of the welding device. The user interface may be a local interface available only to a person with physical access to the control unit. The user interface may also provide a networked user interface by means of which an operator may remotely adjust operative variables of the welding device.

Embodiments of the present invention include a computer apparatus, applicable as a control unit 11 of Figure 1. Figure 2 shows a block diagram that illustrates a configuration of an exemplary apparatus for the purpose. The apparatus comprises a processor unit 20 for performing systematic execution of operations upon predefined data. The processor unit 20 is an element that essentially comprises one or more arithmetic logic units, a number of special registers and control circuits. Memory unit 21 provides a data medium where computer-readable data or programs, or user data can be stored. The memory unit is connected to the processor unit 20. The memory unit 21 typically comprises volatile or non-volatile memory, for example EEPROM, ROM, PROM, RAM, DRAM, SRAM, firmware, programmable logic, etc. The apparatus also comprises an interface unit 22 with at least one input unit for inputting data to the internal processes of the apparatus and at least one output unit for outputting data from the internal processes of the apparatus.

If a line interface is applied, the interface unit 22 typically comprises plug-in units acting as a gateway for information delivered to its external connection points and/or for information fed to the lines connected to its external connection points. If a radio interface is applied, the interface unit 22 typically comprises a radio transceiver unit, which includes a transmitter and a receiver, and is also electrically connected to the processing unit 20. A transmitter of the interface unit 22 receives a bitstream from the processing unit 20, and converts it to a radio signal for transmission. Correspondingly, the interface unit 22 converts received signals into a bitstream that is forwarded for further processing to the processing unit 20. Different line, network and radio interfaces, well known to a person skilled in the art, may be applied in the interface unit.

The interface unit 22 of the apparatus may also comprise a user interface with a keypad, a touch screen, a microphone, or equal input devices for inputting information from a user and a screen, a touch screen, a loudspeaker, or equal output devices for outputting data to the user.

Configuration of the user interface will be discussed in more detail later in this document.

The processor unit 20, the memory unit 21, and the interface unit 22 are electrically interconnected to provide means for performing systematic execution of operations on the received and/or stored data according to predefined, essentially programmed processes of the apparatus. These operations comprise the procedures of the control unit of the welding device described herein.

In general, various embodiments of the apparatus may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. Some functions may be implemented in hardware, while some other aspects may be implemented in firmware or software, which may be executed by a controller, microprocessor or other computing device. Software routines, which are also called as program products, are articles of manufacture and can be stored in any apparatus-readable data storage medium and they include program instructions to perform particular predefined tasks. The exemplary embodiments of this invention also provide a computer program, readable by a computer and encoding instructions for executing a control method in an apparatus of Figure 2.

It is understood that despite the significant progress in the field of welding devices, the fundamental factor in the success of the welding process is the welder him/herself. The welding work requires high precision and is often made in challenging conditions. It is therefore imperative that operations for controlling or monitoring the ongoing work must not complicate the work of the welder, or take his/her concentration from the ongoing welding task. The user interface must be easily understood and control operations readily accessible, even with gloved hands.

The user interface of the control unit is based on detecting rotary movements of a hand of a person. A rotary movement refers here to a movement that turns

around an axis of rotation. Figure 3 shows a rotary movement 30 in the plane of the sheet or display around an axis of rotation 31 with non-zero radius R. It is noted that in the two-dimensional drawing, the rotation axis shows as a turning point. The control unit 11 of Figures 1 and 2 is configured to detect a rotary movement that a person makes with his or her hand, and translate this movement into explicit or implicit operative variable values for delivery to specific functional units of the welding machine.

The rotary movement of the hand of a person may be detected in various ways. In direct detection, a signal representing the movement of the hand is generated by detecting the hand itself. Rotary movement of the fingers of the hand may be detected, for example, resistively, capacitively or with surface acoustic waves on a touch screen. Movement of the hand may alternatively be detected with a camera and optical detection algorithms from video image screening the hand of the user. It is also possible to detect movement of the hand with microelectromechanical sensors that are attached to the hand or a glove in which the hand is.

In indirect detection, a signal representing the movement of the hand is generated by detecting movement of an object rotated by the hand. Figure 4 illustrates a side view of simplified detection means 40 applicable for indirect detection in the control unit. The detection means 40 may comprise a manual grip element 41, for example a circular knob, fixed coaxially to one end of a bar 42. The bar 42 may be secured with fixing elements 43 to the control unit in such a manner that the bar 42 cannot move linearly in relation to the control unit, only rotate around its elongated axial dimension. In the other end of the bar 42 may be fixed an indicator 44 that moves with the rotary movement of the bar. The indicator 44 interacts along the movement with a transducer 45, and thereby generates an electrical response S1 that corresponds to the rotary movement of the knob 41.

As another alternative, the detection means 40 may comprise a closed loop structure 41, for example a circular or angular knob, and a touch screen. The loop may be designed to generate an indication that may be detected resistively, capacitively or with surface acoustic waves on a touch screen when the loop is rotated on it. In an aspect, the circular knob may be a dual-mode object that can be detachably connected to the rotatable bar for interaction with the indicator and released from the bar for interaction with the touch screen. In embodiments where the rotary movement is detected on the touch screen, display objects are advantageously formatted such that the adjusted values remain visible to the user during the rotary movement. For example, the closed loop structure and the adjusted value may be arranged to be mutually compatible so that the adjusted value is visible within the loop when the loop structure is on the touch screen. The fingers of the user may remain in the outer surface of the loop and surround the visible area when the welder rotates the loop.

Various direct and indirect means for detecting rotary movement of a hand of a person are, as such, known to a person skilled in the art of control apparatuses. For conciseness, implementations of such means are not described in more detail in this document

Advanced technical devices typically include a number of functional elements, each with a range of functions operating according to one or more operative variables. Control of these devices is conventionally performed through a tree-like menu structure that begins from a main page and advances through level-specific selection steps towards a n^{th} sub-level where the controlled operative variable is finally available for adjustment. These tree-like menu structures allow variability and freedom to user selection, but for focused and demanding industrial environment their displays are not optimal; they are considered much too complicated and extensive. For example, in welding devices the conventional user interfaces require far too much navigation before one actually finds a correct branch, and in there a level in which one can select a value for a

specific parameter. Such navigation between levels and finding the point of adjustment from the plurality of different category levels is in most cases not possible without advanced knowledge of the whole system. Navigation also requires dedicated concentration to the control operations.

In order to optimally simplify and streamline the control operations to support the welding work, and not drive focus from it, a new type of user interface configuration is suggested. In the configuration, the adjusted options are structured into two levels, and the user of the control unit is provided with means to input rotary movements of his or her hand. At least one of the levels is associated with a corresponding rotary movement.

This suggested configuration is illustrated in more detail with Figure 5 that shows a simplified hierarchical structure of a two-level (N=2) menu applicable in a control unit of the welding device of Figure 1. The minimum amount of levels of hierarchy is two, because there must be one level for selecting an adjusted operative variable and one level for selecting the value for the operative variable. It has been noted that in a majority of implementations, also the optimal amount of levels is two, because the use of the rotary movement allows quick and efficient scrolling through a large number of menu items. In most cases all or nearly all functions that need to be adjusted in a welding device can, without compromising operative versatility of the device, be included in one level of selection. More than two hierarchic levels may, however, be included in the menu structure, without deviating from the scope of protection.

In Figure 5, the first menu level N1 may include a first array A of menu items m_i, each of which corresponds to one operative variable of the welding machine. As an example, let us assume that the operative exemplary variables are represented by MIG Double Pulse process menu items as follows:

m_1 = minimum wire feed (m/min)

m_2 = maximum wire feed (m/min)

m_3 = minimum voltage (V)

m_4 = maximum voltage (V)

m_5 = current pulse (%).

The first menu level N1 is associated with a rotary movement R1.

The second menu level N2 may then include arrays a_i of menu items, each array a_i of N2 being associated with a menu item m_i of the first menu level N1.

Menu items of the first menu level N1 and menu items of the second menu level N2 are arranged into two selection windows wherein one selection window at a time may be active for selection. Each menu item is represented in the selection window by a display object. A selection window thus represents herein a block of display objects, which block may be displayed as one entity in a visual display device (e.g. a display screen). The user may visually scroll through data displayed in the selection window without making a selection, and menu items in the scrolled selection window are parallelly available for selection. Selection of a menu item in the selection window triggers a transition from one selection window to another selection window.

Accordingly, for selection of a menu item m_i in the first menu level N1, a first selection window may be activated and displayed to the user. For selection of menu items in the second menu level N2, a second selection window may be activated and displayed to the user. Preferably only one array a_i is made available in the second selection window at a time. In the configuration of Figure 5, menu items v_{ij} of an array a_i may include many types of data elements, for example, images, characters, or values that can be given to the operative variable of the menu item m_i. The values may be Boolean values, or numeral values within a predefined range and a predefined increment between successive values. Advantageously the increments are small (tenth or more of the maximum value of the range) to give a user feeling of stepless control. This increases the number of menu items in an array, but this does not matter, because scrolling even through a larger group of menu values is quick and easy

with the rotary control movement. The second menu level N2 is associated with a rotary movement R2.

Figure 6 illustrates an exemplary display configuration and use of two separate rotary movements that can be applied with the hierarchic structure of Figure 5. The first selection window for the first array A of menu items of level N1 may be shown in the display 60 as a list of separate display objects. A display object 61 may include text, an image, an icon, or some other visual expression that identifies the controlled operative variable to the user. In the example of Figure 6, the display objects comprise texts listed to represent menu items m_1 to m_5 above. The display objects may be arranged in an order of succession such that one direction is intuitively associated as a forward direction F and the other direction as a backward direction B. In the example, of Figure 6, display objects are arranged into a columns, and forward direction F corresponds to moving from an upper display object to a lower display object (downwards) in the screen, and backward direction B in the same manner to moving from a lower display object to an upper display object (upwards) in the screen. A alternative intuitive order of directions may be applied, for example, with display objects arranged into a consecutive row, wherein forward direction F corresponds to moving from one display object to a sequential display object (from left to right), and backward direction B to moving from one display object to a preceding display object (from right to left) in the screen.

In an active selection window, one display object may be shown in an emphasized manner. In Figure 6, the first array A of menu items of the first level N1 is shown displayed in the screen as a first selection window with a continuous scrollable list of display objects. Emphasis may be displayed, for example, with highlight, changed font color, animated movement of the object, or the like. As long as a display object of a menu item corresponding to an operational variable is being selected, the selection may be changed by means of the rotary movement of R1. As shown in Figure 6, rotary movement of R1 in the clockwise direction typically associates with scrolling the display objects to

forward direction, and rotary movement in the counterclockwise direction associates with scrolling the display objects to backward direction.

The arrays a_i of menu items of level N2 may also be displayed as a continuous list of display objects. However, when the subordinate level is reserved for values of operative variable, the amount of possible values may easily be considerable, and some other display format may be better. Figure 6 illustrates a structure where an array a_i of menu items of level N2 is displayed with a scroll element in which an emphasized display object of a menu item v_{ij} of the array a_i is shown. In such a case the display object may thus be emphasized by including only that one into the display. For example, the array a_4 that corresponds to item m_4 = maximum voltage (V) in level N1 may be displayed with a scroll element 62. Let us assume possible values of the respective operative variable range from 110V to 140V in increments of one (120, 121, 122, ..., 140). The scroll element may include a value for selection, and this value can be increased by rotating R2 to the clockwise direction and decreased by rotating R2 to the counterclockwise direction without actually making the selection. Selection of the provisionally chosen emphasized value triggers a transition from the second selection window of level N2.

With separate rotary movements provisional selection and scanning through menu items is easy, effective and highly intuitive to the welder. The control operations may be further simplified by arranging the rotary movements R1, R2 to be mutually interactive. While at any time only one selection window is active, also one of the rotary movements R1, R2 may be active at a time. A transition from one rotary movement to another rotary movement may be directly interpreted to confirm selection in the transited level.

For example, in a two-level configuration of Figure 6, the control unit may comprise two separate physical elements for the rotary movement. Let us assume that they are, for example, two rotary knobs 63, 64 positioned to the immediate vicinity of the screen, side by side under the lower edge of the

screen such that their order can be associated with horizontal direction in the screen. The first knob 63 thus naturally associates with display objects in the left side of the screen and the second knob 64 with display objects in the right side of the screen. Operative variable to be adjusted may thus be scanned by rotating the first knob 63 and highlighting moves quickly in the string of display objects according to the movement of the welder's hand. When the adjusted variable has been found, the welder may be allowed to directly begin to move the second knob 64 and the selection of a menu item that corresponds to the highlighted display object is automatically confirmed in level N1. The value of the operative variable of level N2 may then be quickly increased and decreased by rotating the second knob 64. Transition from detection of one rotary movement to detection of another rotary movement thus happens in response to a change of a moved physical object 63, 64.

Due to this, contrary to the conventional menu structures, the welding device may be controlled without any explicit confirmation between the hierarchic levels. The control unit may, however, comprise also an input element 65 which the user can move to indicate and confirm selection of display objects emphasized with the rotary movements. In Figure 6, such input element is represented by a manual push button 65 integrated to the second rotary knob 64. The input element is, however, not necessarily part of an element used for detecting the rotary movement, and can be implemented in many ways. For example, the input element may be a separate manual button in the body of the control unit, or a separate soft button in a touch screen.

Due to the improved scrolling capability with rotary movements, a conventional complex menu structure can be flattened to a simple two-level configuration. In addition, due to the hierarchic interaction between the rotary movements, the control operations can be made with minimal or even without any explicit selection indications. The welder at work is thus provided with a simple route to the adjusted parameters; one does not have to click through a number of hierarchic levels and items to adjust one specific value in the welding process.

Neither is it necessary to navigate back and forth through several and varying hierarchic levels to adjust several related features. The whole set of operative variables become readily available after selection of a value for one operative variable.

In another embodiment, the control unit may comprise one physical element to input two separate rotary movements and to provide an explicit indication that separates the rotary movements from each other. The indication marks transition from one rotary movement to the other. Figure 7 illustrates such configuration with an example. In the configuration, the rotary knob 70 is again fixed to the control unit to rotate in R1 and R2 directions. The knob is also suspended to the control unit such that the knob may also be moved linearly up and down L1/L2 in the direction of its rotary axis (perpendicular to the sheet in Figure 7). The linear movement L1/L2 back and forth may be detected separate from the rotary movement and interpreted by the control unit as an indication of transition from one rotary movement to another. The suspension may be configured in a conventional manner to provide a tactile response such that pushing of the rotary knob corresponds to clicking of a computer mouse.

In an embodiment, the knob 70 may be positioned under the lower edge of the screen. Operative variable to be adjusted may thus be scanned first by rotating the knob 70 and, as in figure 6, highlighting moves quickly in the list of display objects according to the movement of the welder's hand. When the desired variable has been found, the welder may push to knob 70 and thereby select a menu item that corresponds to the highlighted display object in level N1. At the same time, a menu item array that corresponds to the selected menu item is made active and value of the operative variable of level N2 may now be quickly increased and decreased by rotating the knob 70. In this embodiment, both rotary movements and the indication of transition between them are provided with the same knob 70, but the knob provides an additional movement for a separate and explicit indication for transition between the rotary movements.

Emphasis in a selection window of one level may be arranged to be responsive to a non-rotary movement. For example, the menu items of level N1 may be displayed in the first selection window with a group of display objects, available for selection in a touch screen. When e.g. fingers or a closed loop structure is brought the touch screen, the display object at the touching point may be emphasized. In response to a rotary movement of the fingers or the closed loop structure, the menu item corresponding to the emphasized display object of level N1 may become selected. Emphasis of the display object of level N2 is moved according to the detected rotary movement. Selection of the menu item corresponding to the emphasized display object of level N2 may be confirmed in another way, for example moving the fingers or the closed loop structure to another display object of the first selection window. Alternatively, an explicit indication may be provided, for example, by tapping the touch screen in the end of the rotary movement.

Figure 8 illustrates a further advantage achievable with the proposed use of two rotary movements. In a demanding working environment, control operations are often interrupted or disturbed, and unintentional inputs are activated and returning back to the initial point is typically very complicated. In practice, welders therefore tend to avoid advanced control operations, or they are even categorically forbidden to do them by the management. In Figure 8, elements previously shown in Figure 6 are applied. The control unit may be further configured to store information on at least latest selected menu items. When transition from the first selection window of the first level N1 to the second selection window of the subordinate second level N2 occurs, the control unit may be configured to display the display object of the earlier selected menu item of the second level N2 in the screen, for example as long as the new selection is made. In Figure 8, this is shown in the context of the earlier exemplary operative variable m_4. After scrolling to m_4 with R1, the corresponding subordinate array including the possible values for the maximum voltage becomes active and the user may directly begin to adjust the value for the maximum voltage with R2. When the transition from the first selection

window to the second selection window occurs (e.g. when the user begins to rotate R2), the earlier selected maximum value 80 may be stored and shown in the display. Due to this, the welder does not have to be overly concerned about errors when seeking the new value. Ease of adjustment may be further improved by showing the provisionally chosen value in comparison with the earlier selected value. In the example of Figure 8, the new value 81 is shown as a numeral in the scrolling screen, and also as a horizontal bar that lengthens and shortens according to the rotary movement of R2. The size of the new value is immediately comparable to the old value and return to the old value is very easy. Adjustment is thus more convenient, and not as easily disrupted by interrupts and disturbances of the challenging work conditions.

In the previous embodiments, menu items in both levels have included predefined elements of the user interface. In a further embodiment, the proposed configuration may be used for user input of character strings. Typically any keyboard, tactile or one provided with a touch screen, is too small and sensitive to be conveniently operated in industrial environments and gloved hands. Figure 9 illustrates en embodiment with exemplary structures, previously described with Figures 6 and 7. Let us assume the operational variable m_i to be set with the control unit is now the username of the welder. The operative variable m_i "username" may be selected from menu items of the first array A of the first level N1 with the first rotary movement R1. The second level N2 array may include characters used in the system for usernames. As discussed earlier, when a display object representing a menu item for the operative variable m_i "username" is highlighted, a corresponding array a_i of letters may become active and the control unit to transit directly to detect input of the username with the second rotary movement R2.

Typically a username comprises more than one values (characters), so the user interface preferably comprises an intermediate indication for confirming selection of a character, and an end of selection indication confirming termination of a selection chain and triggering generation of the control signal.

In response to an intermediate indication the character emphasized with R2 is added to an intermediate selection, but the selection in the second level N2 is continued until the end of the selection indication. The indications may be given with separate input elements, but they can also be given with one input element. For example, the control unit may be configured to interpret one push (click) of a knob as an intermediate indication and a double-click as an end of the selection indication.

In the context of character input, one menu item may be considered to be a value formed of a group of sub-values. When the character string array in the second level N2 becomes active, only one sub-value at a time is active for selection. This may be shown with a visual effect in the display. Figure 9 illustrates such arrangement with an example, where a sub-value 90 active for input is shown as highlighted and the array 91 of characters available for selection for it is shown as a curvilinear band. The curvilinear form corresponds to the circular form of the rotary movement R2 used in the selection of the character. The curvilinear form again improves the user-friendliness of the interface by associating the actual movement of the hand with the display object shown in the screen. When an intermediate indication is detected, the control unit may include the selected sub-value into the menu item and activate a subsequent sub-value for selection. When the whole character string has been input, an end of the selection chain indication may be detected and the character string stored as the value for the menu item m_i "username".

The outlook of the display objects and their order may be varied in many ways. Figure 10 shows an example of a display object for an exemplary menu item of the second level N2 of Figure 6. Values of the second level N2 array may be shown in a scale 100 that turns in respect to a fixed point 101 along the rotary movement R2 102. This enhances the ease and accuracy of the adjustment with the rotary movement. In more general, the screen and the manual knob of R2 may be positioned in physical contact, or even made to overlap in the control unit. The display of the screen may then be programmed to provide

display objects that visually integrate to the manual rotating object. The display object may alternatively be used to provide a fixed scale in which a fixed symbol moves along the rotary movement R2. When a physical object, like a loop structure, is used to input the rotary movement, the physical object may include a protrusion, and the position of the symbol of the display object in the touch screen may be arranged to correspond with the position of the physical object.

Due to the optimal use of rotary movements, relatively long menu item lists may be applied, and most of the welding devices can in practice be controlled by means of the described two-level menu structure. If the device is very diverse, the amount of menu items in level N1 may, however, become excessive. Scrolling through the list of menu items may eventually require too many full rounds of R1 to be useful, and it may be too difficult to find a specific menu items from a long list of display items. As discussed above, additional levels of detail may naturally be provided by increasing the number of hierarchic levels and the amount of rotary movements applied in the user interface. However, this may happen with a cost of simplicity and user-friendliness of the control unit. In an alternative approach, the control unit is configured to comprise two or more robustly formed input elements, for example manual buttons or soft buttons in a touch screen, with which the user may activate one two-level menu structure at a time. The essential aspect is, however, that selections in an active two-level menu structure are made as a combination of two rotary movements, one for an operational variable to be adjusted and one for values of the operational variable.

Figure 11 discloses steps of an embodiment of a method performed in the control unit of Figure 1. Further details on the terms and expressions may thus be referred from description of any of the earlier Figures 1 to 9. In the beginning, the control unit is initialized (stage 110) to store a first array A of menu items mi for selections in a first menu level N1. A menu item of the array A corresponds to an operational variable adjustable in the functional units of the

welding device of Figure 1. The control unit is also initialized (stage 111) to store a group of second arrays a_i for selections in a second menu level N2. Each of the second arrays a_i corresponds to one menu item m_i of the first array A. The control unit is also initialized to store a first selection window including display objects d1 of menu items of the first array, and a second selection window including display objects d2 of menu items of a second array (stage 112).

During operation, one of the first selection window and the second selection window w1/w2 (stage 113) is activated in a display unit, one menu item m(w1/w2) of the active selection window is emphasized (stage 114) and the control unit is standby to detect a rotary movement. When the control unit detects (stage 115) a rotary movement R, it moves (stage 116) emphasis in the activated selection window in response to the detected rotary movement. When the control unit detects (stage 117) selection of the emphasized display object d1 or d2, it conveys the selection to (stage 118) a menu item that corresponds to the selected display object, and activates (stage 119) the other selection window.

Embodiments and aspects described with Figure 3 to 10 are directly applicable by a person skilled in the art to the control unit of Figure 2, the welding device of Figure 1 and the method of Figure 11. While various aspects of the invention have been illustrated and described as block diagrams, message flow diagrams, flow charts and logic flow diagrams, or using some other pictorial representation, it is well understood that the illustrated units, blocks, device, system elements, procedures and methods may be implemented in, for example, hardware, software, firmware, special purpose circuits or logic, a computing device or some combination thereof.

It is apparent to a person skilled in the art that as technology advances, the basic idea of the invention can be implemented in various ways. The

invention and its embodiments are therefore not restricted to the above examples, but they may vary within the scope of the claims.

Claims

1. A method, **characterized** by comprising:

arranging operative variables of a welding device into a first array of menu items;

arranging values for the operative variables into second arrays of menu items, each of the second arrays corresponding to one menu item of the first array;

storing a first selection window including display objects of menu items of the first array;

storing a second selection window including display objects of menu items of a second array;

activating the first selection window or the second selection window in a display unit;

emphasizing in the activated selection window one display object at a time;

detecting a rotary movement;

moving emphasis in the activated selection window in response to the detected rotary movement;

detecting selection of the emphasized display object;

selecting a menu item corresponding the selected display object;

activating another selection window in response to the detected selection of the emphasized display object.

2. A method according to claim 1, characterized by detecting the rotary movement with user interface means operable with a hand of a user.

3. A method according to claim 1 or 2, **characterized** by:

detecting selection of a menu item of the first array;

detecting selection of a menu item of the second array;

outputting a control signal including an adjusted value for an adjusted operative variable of the welding device, the adjusted operate variable corresponding to the selected menu item of the first array, and the adjusted value corresponding to the selected menu item of the second array.

4. A method according to claim 1, 2 or 3, **characterized** by:

activating the first selection window;

20135082 PRH 25-04-2014

emphasizing in the activated first selection window one display object of a menu item of the first array;

displaying at the same time one or more display objects of a second array, wherein the second array corresponds to the menu item of the first array, the display object of which is emphasized in the first selection window.

5. A method according to any of claims 1 to 4, **characterized** by:

moving emphasis in the first selection window in response to a first rotary movement;

moving emphasis in the second selection window in response to a second rotary movement, wherein the second rotary movement is separate from the first rotary movement.

6. A method according to any of claims 1 to 5, **characterized** by the first selection window comprising a group of display objects in an order of succession, each of the display objects corresponding to one menu item of the first array.

7. A method according to any of claims 2 to 6, **characterized** by detecting the first rotary movement or the second rotary movement with a physical object, rotatable with a hand of a user.

8. A method according to claim 7, **characterized** by detecting the first rotary movement or the second rotary movement with a physical object, rotated with a hand of a user on a touch screen.

9. A method according to claim 7, **characterized** by detecting the first rotary movement and the second rotary movement with two separate physical objects, rotatable with a hand of a user.

10. A method according to claim 9, **characterized** by transiting from detection of one rotary movement to detection of another rotary movement in response to detecting a change of a moved physical object.

11. A method according to any of claims 2 to 5, **characterized** by detecting the first rotary movement and the second rotary movement

with one physical object that is rotatable with a hand of a user and further movable in a non-rotary manner to indicate transition from one rotary movement to another.

12. A method according to any of claims 1 to 11, **characterized** by detecting selection of an emphasized display object in response to user activation of a predefined input element.

13. A method according to any of claims 1 to 12, **characterized** by the second display window comprising a scroll element in which an emphasized display object of a menu item of the second array is shown.

14. A method according to claim 13, **characterized** by the display object including a value that increases and decreases according to the second rotary movement, or a bar that lengthens and shortens according to the second rotary movement, or a scale that turns in respect to a fixed point along the second rotary movement.

15. A method according to claim 14, **characterized** by

detecting the second rotary movement with a physical object, rotatable with a hand of a user;

displaying a scale that turns in respect to a fixed point along the second rotary movement,

displaying the scale as visually integrated to the rotatable physical object.

16. A method according to any of claims 5 to 15, **characterized** by

storing selected menu items of the second array;

displaying the stored value in the activated second selection window.

17. A control unit comprising means adapted to execute each of the steps of any of claims 1 to 16.

18. A control unit according to claim 17, **characterized** by the means for detecting the first rotary movement or the second rotary movement comprising at least one of the following: a touch screen configured to

detect rotary movement of one or more fingers of the user, a touch screen configured to detect rotary movement of a circular object, one or two knobs rotatable by the user, a camera and optical detection algorithms configured to analyze video image screening the hand of the user, microelectromechanical sensors attached to a hand or a glove of the user.

19. A welding device comprising the control unit of claim 17 or 18.

20. A computer program, readable by a computer and encoding instructions for executing a method of any of claims 1 to 16 in a control unit of a welding device.

20135082 PRH 25 -04- 2014

Patenttivaatimukset

1. Menetelmä, tunnettu siitä, että menetelmä käsittää:

hitsauslaitteen toiminnallisten muuttujien järjestämisen ensimmäiseksi valikkokohteiden joukoksi;

toiminnallisten muuttujien arvojen järjestämisen toiseksi valikkokohteiden joukoksi, joista kukin toisesta joukosta vastaa yhtä ensimmäisen joukon valikkokohteista;

ensimmäisen valintaikkunan tallentamisen, mukaan lukien ensimmäisen joukon valikkokohteiden näyttöobjektit;

toisen valintaikkunan tallentamisen, mukaan lukien toisen joukon valikkokohteiden näyttöobjektit;

ensimmäisen valintaikkunan tai toisen valintaikkunan aktivoimisen näyttöyksikössä;

aktivoidun valintaikkunan korostamisen yhdessä näyttöobjektissa kerrallaan;

kiertoliikkeen havaitsemisen;

korostuksen siirtämisen aktivoituun valintaikkunaan vasteena havaitulle kiertoliikkeelle;

korostetun näyttöobjektin valinnan havaitsemisen;

valittua näyttöobjektia vastaavan valikkokohteen valitsemisen;

toisen valintaikkunan aktivoimisen vasteena korostetun näyttöobjektin havaitulle valinnalle.

2. Patenttivaatimuksen 1 mukainen menetelmä, **tunnettu** siitä, että kiertoliike havaitaan käyttöliittymävälineillä, joita käyttäjä voi käyttää kädellään.

3. Patenttivaatimuksen 2 tai 3 mukainen menetelmä, **tunnettu** siitä, että:

havaitaan ensimmäisen joukon valikkokohteen valinta;

havaitaan toisen joukon valikkokohteen valinta;

tulostetaan ohjaussignaali, joka sisältää hitsauslaitteen säädetyn toiminnallisen muuttujan säädetyn arvon, säädetyn toiminnallisen muuttujan vastatessa ensimmäisen joukon valittua valikkokohdetta ja säädetyn arvon vastatessa toisen joukon valittua valikkokohdetta.

4. Patenttivaatimuksen 1, 2 tai 3 mukainen menetelmä, **tunnettu** siitä, että:

aktivoidaan ensimmäinen valintaikkuna;

20135082 PRH 25-04-2014

korostetaan aktivoidussa ensimmäisessä valintaikkunassa yksi ensimmäisen joukon valikkokohteen näyttöobjekti;

näytetään samanaikaisesti yksi tai useampia toisen joukon näyttöobjekteja, jolloin toinen joukko vastaa ensimmäisen joukon valikkokohdetta, jonka näyttöobjekti on korostettu ensimmäisessä valintaikkunassa.

5. Minkä tahansa patenttivaatimuksista 1–4 mukainen menetelmä, **tunnettu** siitä, että:

siirretään korostusta ensimmäisessä valintaikkunassa vasteena ensimmäiselle kiertoliikkeelle;

siirretään korostusta toisessa valintaikkunassa vasteena toiselle kiertoliikkeelle, jolloin toinen kiertoliike on erillinen ensimmäisestä kiertoliikkeestä.

6. Minkä tahansa patenttivaatimuksista 1–5 mukainen menetelmä, **tunnettu** siitä, että ensimmäinen valintaikkuna käsittää joukon näyttöobjekteja peräkkäisessä järjestyksessä, jolloin kukin näyttöobjekteista vastaa yhtä ensimmäisen joukon valikkokohdetta.

7. Minkä tahansa patenttivaatimuksista 2–6 mukainen menetelmä, **tunnettu** siitä, että ensimmäinen kiertoliike tai toinen kiertoliike havaitaan fyysisellä esineellä, jota käyttäjä voi kiertää kädellään.

8. Patenttivaatimuksen 7 mukainen menetelmä, **tunnettu** siitä, että ensimmäinen kiertoliike tai toinen kiertoliike havaitaan fyysisellä esineellä, jota käyttäjä voi kiertää kädellään kosketusnäyttöä käyttäen.

9. Patenttivaatimuksen 7 mukainen menetelmä, **tunnettu** siitä, että ensimmäinen kiertoliike tai toinen kiertoliike havaitaan kahdella erillisellä fyysisellä esineellä, joita käyttäjä voi kiertää kädellään.

10. Patenttivaatimuksen 9 mukainen menetelmä, **tunnettu** siitä, että ensimmäisen kiertoliikkeen havaitsemisesta siirrytään toisen kiertoliikkeen havaitsemiseen vasteena havaitulle muutokselle siirretyssä fyysisessä esineessä.

11. Minkä tahansa patenttivaatimuksista 2–5 mukainen menetelmä, **tunnettu** siitä, että ensimmäinen kiertoliike tai toinen kiertoliike havaitaan yhdellä fyysisellä esineellä, jota käyttäjä voi kiertää kädellään ja jota voidaan lisäksi liikuttaa ei-kiertävällä tavalla sen osoittamiseksi, että siirrytään yhdestä kiertoliikkeestä toiseen.

12. Minkä tahansa patenttivaatimuksista 1–11 mukainen menetelmä, **tunnettu** siitä, että korostetun näyttöobjektin valinta havaitaan vasteena käyttäjän suorittamalle ennalta määritellyn syöttöelementin aktivoinnille.

13. Minkä tahansa patenttivaatimuksista 1–12 mukainen menetelmä, **tunnettu** siitä, että toinen näyttöikkuna käsittää vierityselementin, jossa näytetään toisen joukon valikkokohteen korostettu näyttöobjekti.

14. Patenttivaatimuksen 13 mukainen menetelmä, **tunnettu** siitä, että näyttöobjekti sisältää arvon, joka kasvaa ja pienenee toisen kiertoliikkeen mukaan, tai palkin, joka pitenee ja lyhenee toisen kiertoliikkeen mukaan, tai asteikon, joka kääntyy suhteessa kiinteään pisteeseen toisen kiertoliikkeen mukana.

15. Patenttivaatimuksen 14 mukainen menetelmä, **tunnettu** siitä, että

havaitaan toinen kiertoliike fyysisellä esineellä, jota käyttäjä voi kiertää kädellään;

näytetään asteikko, joka kääntyy suhteessa kiinteään pisteeseen toisen kiertoliikkeen reitillä,

näytetään asteikko visuaalisesti integroituna kierrettävään fyysiseen objektiin.

16. Minkä tahansa patenttivaatimuksista 5–15 mukainen menetelmä, **tunnettu** siitä, että

tallennetaan toisen joukon valitut valikkokohteet;

näytetään aktivoidun toisen valintaikkunan tallennettu arvo.

17. Ohjausyksikkö, joka käsittää välineet, jotka on sovitettu suorittamaan kukin minkä tahansa patenttivaatimuksista 1–16 mukaisista vaiheista.

18. Patenttivaatimuksen 17 mukainen ohjausyksikkö, **tunnettu** siitä, että välineet ensimmäisen kiertoliikkeen tai toisen kiertoliikkeen havaitsemiseksi

käsittävät vähintään yhden seuraavista: kosketusnäyttö, joka on sovitettu havaitsemaan käyttäjän yhden tai useamman sormen kiertoliike, kosketusnäyttö, joka on sovitettu havaitsemaan pyöreän kohteen kiertoliike, yksi tai kaksi nuppia, joita käyttäjä voi kiertää, kamera ja optiset ilmaisualgoritmit, jotka on sovitettu analysoimaan videokuvaa, joka esittää käyttäjän kättä, mikroelektromekaaniset anturit, jotka on kiinnitetty käyttäjän käteen tai hansikkaaseen.

19. Hitsauslaite, joka käsittää patenttivaatimuksen 17 tai 18 mukaisen ohjausyksikön.

20. Konekoodinen tietokoneohjelma, joka koodaa ohjeet minkä tahansa patenttivaatimuksista 1–16 mukaisen menetelmän suorittamiseksi hitsauslaitteen ohjausyksikössä.

20135082 PRH 25 -04- 2014

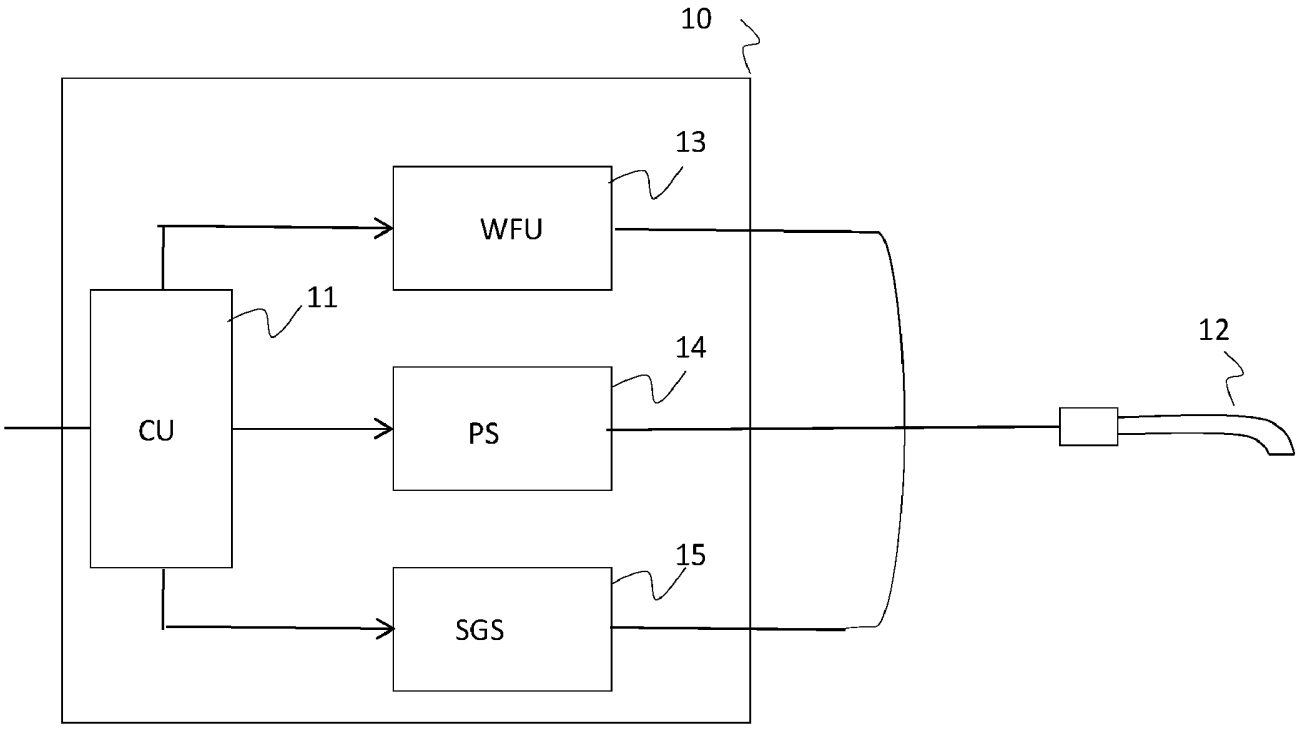


Figure 1

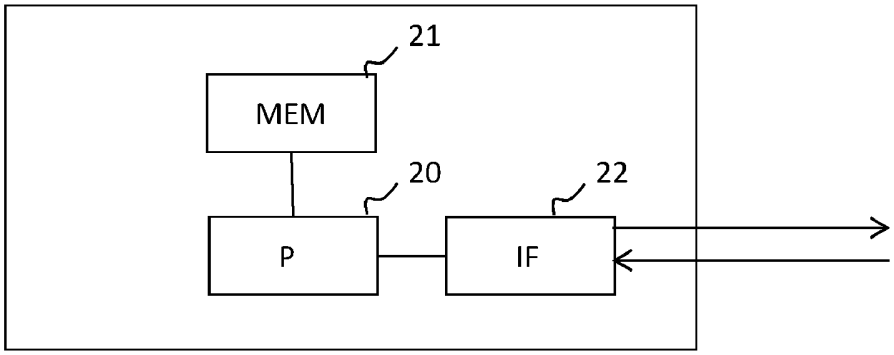


Figure 2

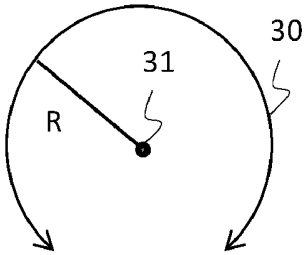


Figure 3

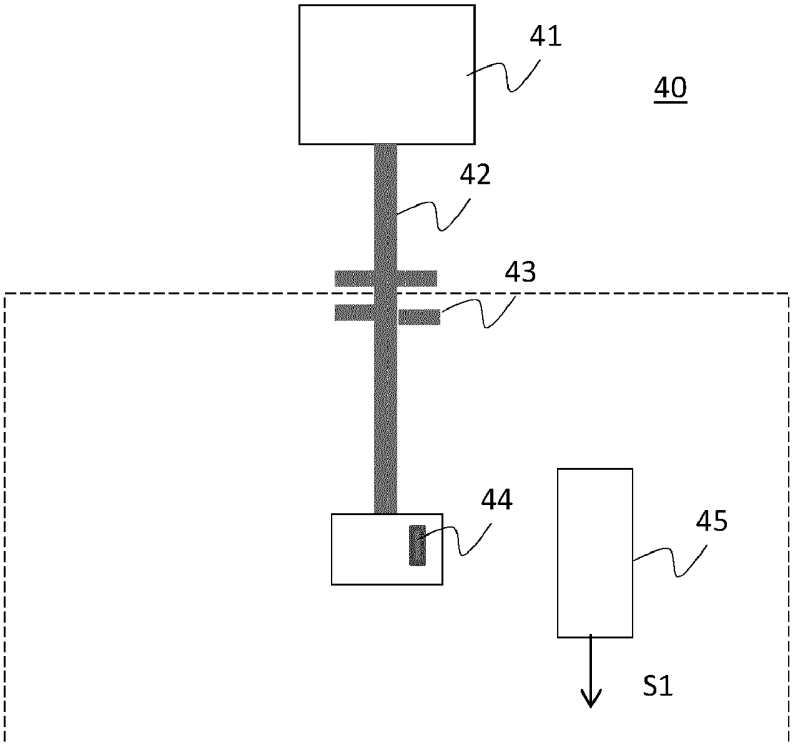


Figure 4

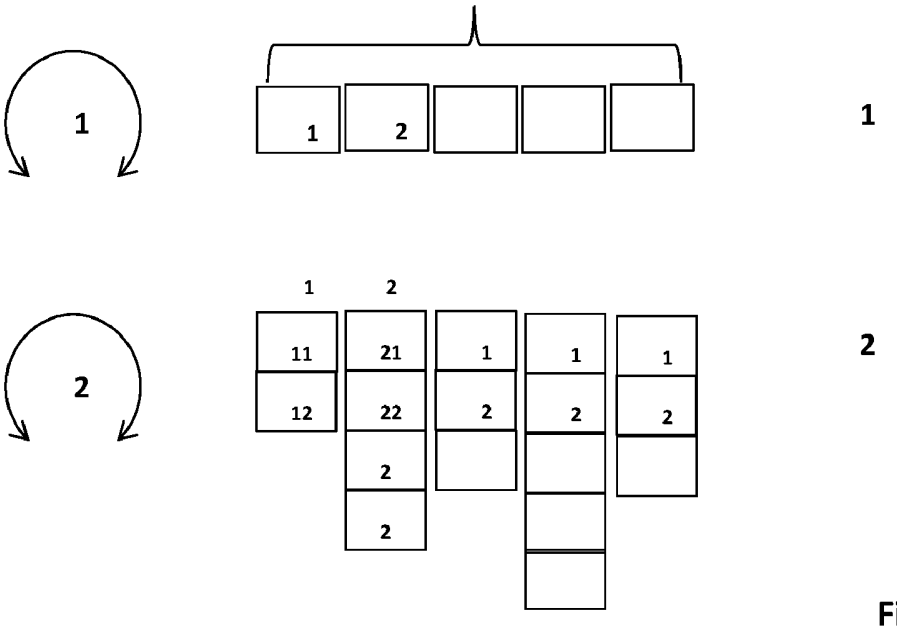


Figure 5

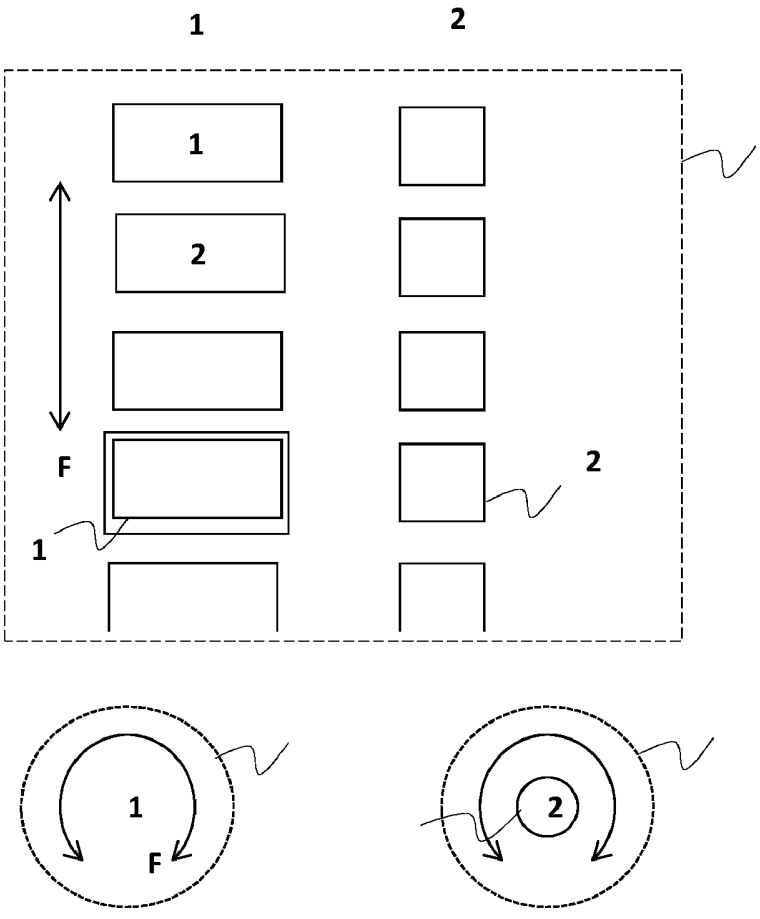


Figure 6

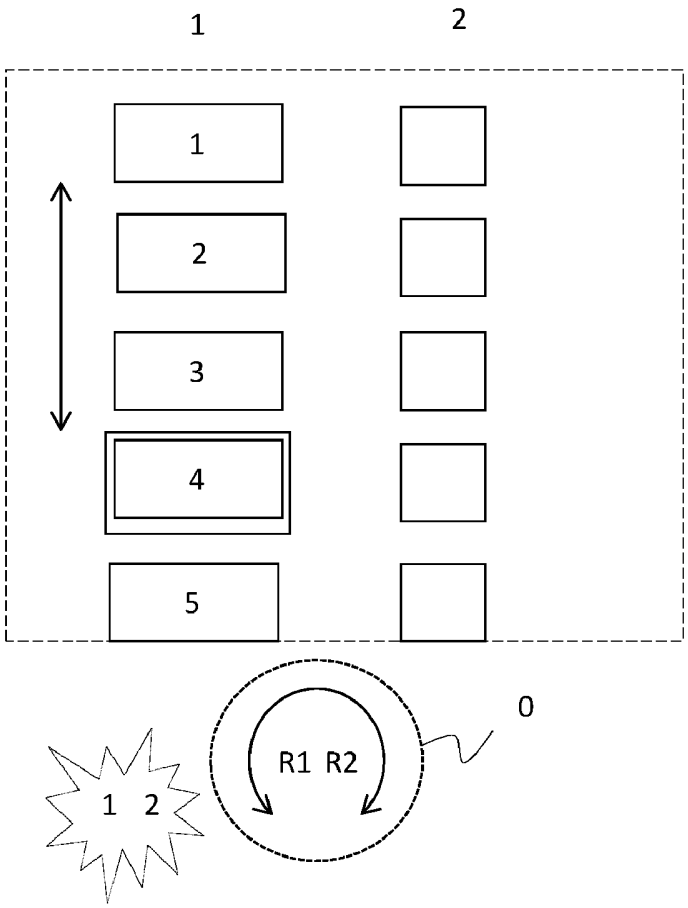


Figure 7

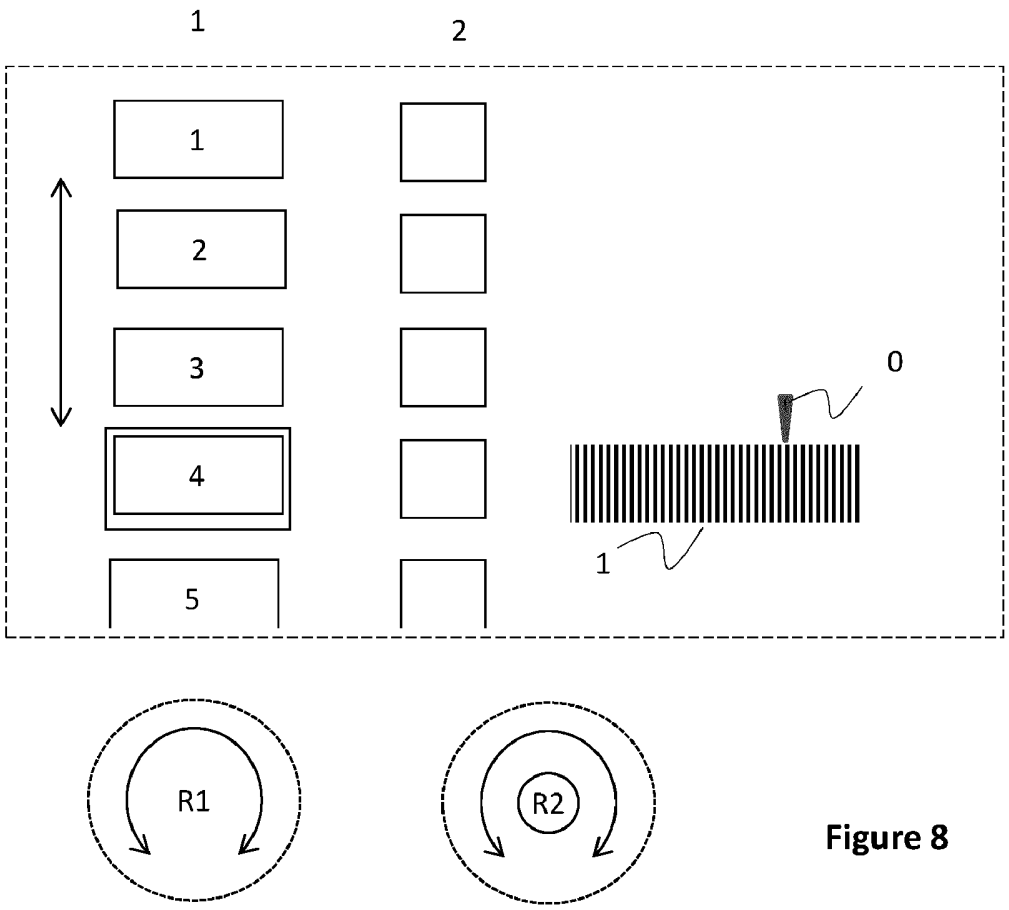


Figure 8

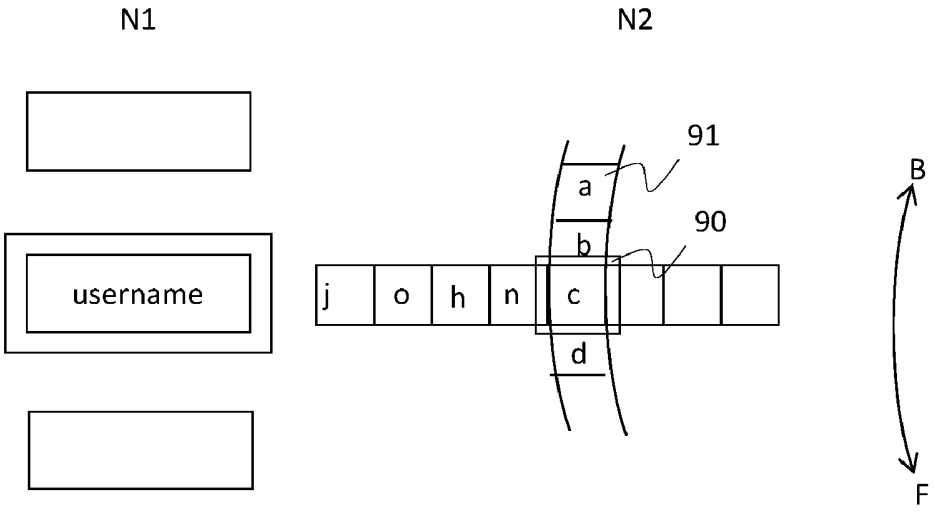


Figure 9

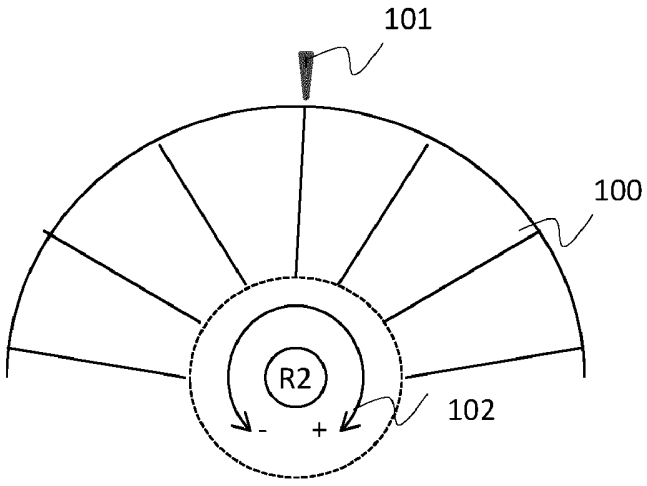


Figure 10

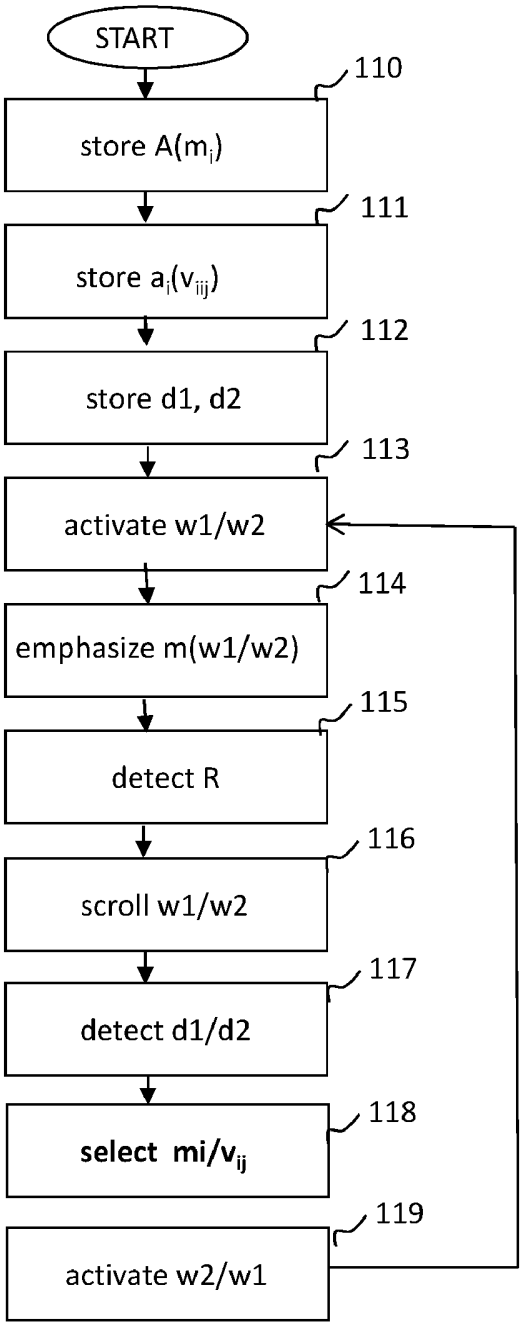


Figure 11