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(54) **WINDOW ACTUATOR WITH OBSTACLE DETECTION**

(57) An actuator for operating a pivot hung or top hung window providing enhanced anti-pinch sensing. The actuator is adapted to perform a first closing operation while monitoring a closing force applied by the actuator. The actuator is adapted initiate a first reversing operation upon the closing force exceeding a first threshold during the first closing operation, and the actuator is configured to initiate a second closing operation after the first reversing operation.

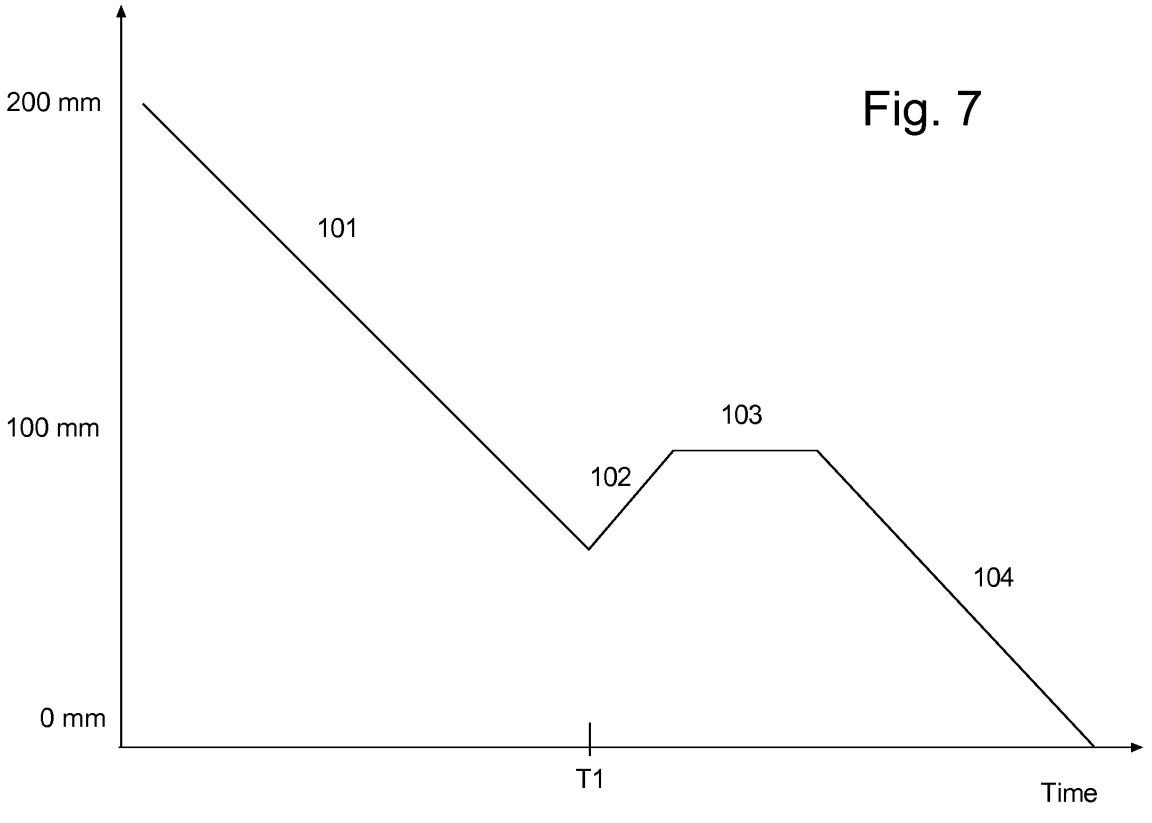



Fig. 7

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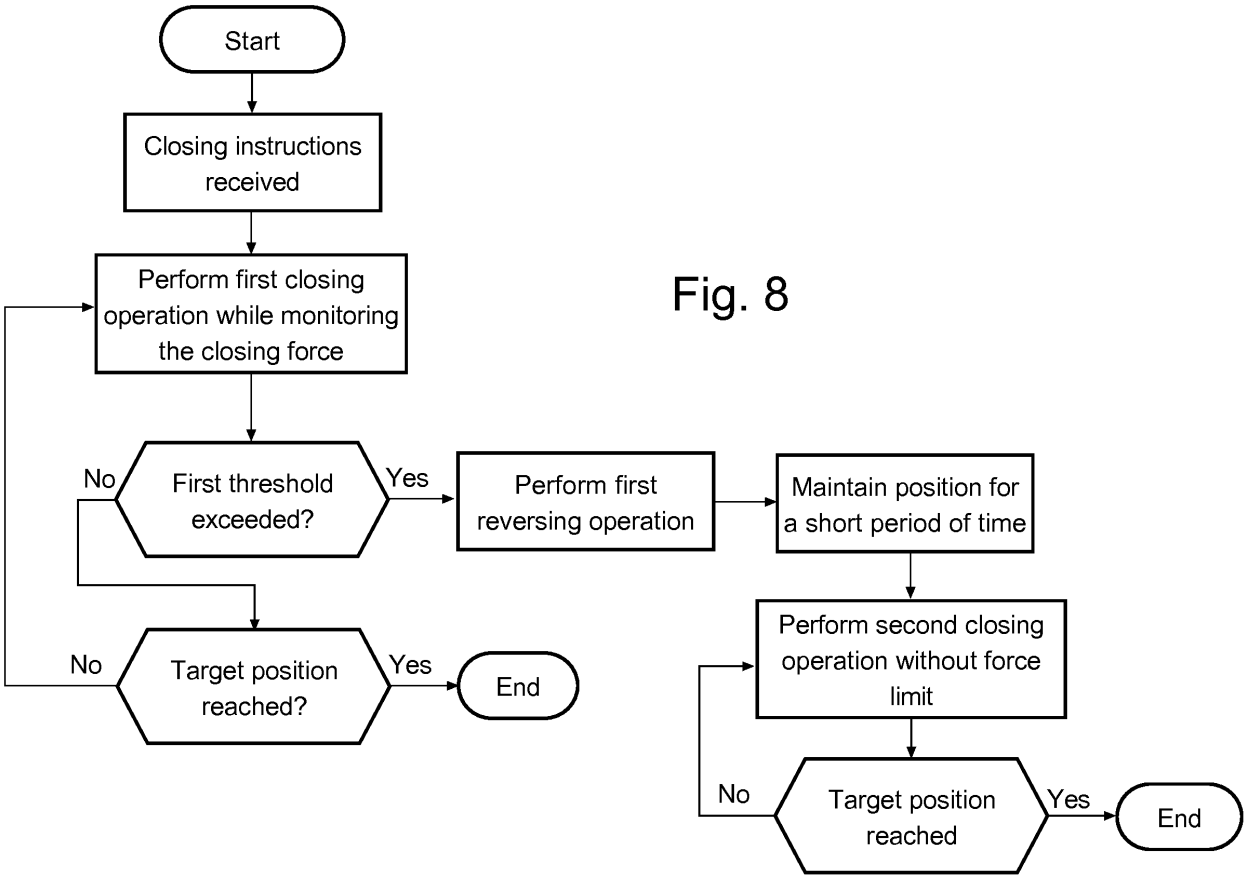

Start
Closing instructions received
Perform first closing operation while monitoring the closing force
First threshold exceeded?
No
Yes
Perform first reversing operation
Maintain position for a short period of time
Perform second closing operation without force limit
Target position reached
No
Yes
End
Target position reached?
No
Yes
End

Fig. 8

## Description

### TECHNICAL FIELD

**[0001]** This disclosure relates to an electrically pivotable window and the electrical drive of such window. Particularly, the disclosure relates to anti-pinch sensing and control of the window.

### BACKGROUND

**[0002]** EP 2754820 discloses a pivotable window with an actuator on each side. Each actuator has a safety strip 9 on the actuator housing to detect an object entrapped between the actuator housing and the window frame.

**[0003]** EP 1441100 discloses a pivotable window without pinch detection. Instead, the closing movement is performed stepwise to increase the attention of the person nearby and to limit the risk of pinching.

**[0004]** However there due to various reasons which are explained below, it has shown to be difficult to provide a reliable pinch detection, which also is cost effective. Further it is an object to provide an actuator, which is easy to retrofit to a window that is already installed in a building.

**[0005]** Different window sizes may use the same actuator drive, but yet require different closing forces. The final closing movement of a window creates a spike in the closing force needed due compress the gasket between the frame and sash.

**[0006]** Wind or draft can change the load of a window. Some pivoatable windows such as roof windows may be installed in different roof slopes and consequently the force requirements may be different. Further snow may change the weight of the window. Likewise, the window may be retrofitted with a blind or a shutter which also changes the weight of the window. As a window ages the resistance (friction) and closing forces also change.

### SUMMARY

**[0007]** It is an object of the invention to solve or at least reduce the problems indicated above.

**[0008]** This object is achieved according to a first aspect by an actuator for operating a pivot hung or top hung window, the actuator being adapted to perform a first closing operation while monitoring a closing force applied by the actuator, the actuator being adapted to initiate a first reversing operation upon the closing force exceeding a first threshold during the first closing operation, and the actuator being configured to initiate a second closing operation after the first reversing operation.

**[0009]** By closing the window with the force limited to a relatively low first threshold a pinching event or entrapment event can be detected without large force being applied to the trapped or pinched object. The reversing action allows the trapped or pinched object to be removed, before the second closing action takes place. The second closing action can be carried out with a higher threshold allowing a larger force to be applied to the window. This larger force may be necessary due to excessive friction or wind conditions. Thus, proper closing of the window is ensured whilst the risk of injury to e.g. fingers or other body parts of a person is reduced since the person will have a chance to remove their hand, fingers or other body part during the reversing operation. Thus, there is provided an enhanced entrapment detection, which does not terminate the closing operation due to false pinching signals caused, e.g. by strong winds. Further, it is ensured that the window closes while allowing trapped objects to escape.

**[0010]** In a first possible implementation form of the first aspect the actuator is configured to monitor the closing force applied by the actuator during the second closing operation, configured to initiate a second reversing operation upon the closing force exceeding a second threshold during the second closing operation and configured to initiate a third closing operation after the second reversing operation.

**[0011]** In a second possible implementation form of the first aspect the target of the first closing operation is a fully closed position.

**[0012]** In a third possible implementation form of the first aspect the first reversing operation has a magnitude that is small compared to a complete movement of the window between a fully open and a fully closed position

**[0013]** In a fourth possible and implementation form of the first aspect the target of the second closing operation is a fully closed position.

**[0014]** In a fifth possible implementation form of the first aspect the second reversing operation has a magnitude that is small compared to the complete movement of the window between a fully open and a fully closed position.

**[0015]** In a sixth possible implementation form of the first aspect the actuator is configured to initiate the second closing operation a short period of time after the first reversing operation.

**[0016]** In a seventh possible implementation form of the first aspect the second threshold is equal to the first threshold

**[0017]** In an eighth possible implementation form of the first aspect the second threshold is lower than the first threshold.

**[0018]** In a ninth possible implementation form of the first aspect the second threshold is higher than the first threshold.

**[0019]** In a tenth possible implementation form of the first aspect the first threshold is lower than a maximum force of the actuator.

**[0020]** In an eleventh possible implementation form of the first aspect the actuator is configured to hold the window still for a short period of time between the first reversing operation and the second closing operation.

**[0021]** In a twelfth possible implementation form of the first aspect the actuator is configured to hold the window

still for a short period of time between the second reversing operation and the third closing operation

**[0022]** In a thirteenth possible implementation form of the first aspect the actuator is configured to apply the maximum actuator force if needed during the during the second and/or third closing operation.

**[0023]** In a fourteenth possible implementation form of the first aspect the actuator is configured to allow the actuator to always allow use of the maximum actuator force when the opening of the window is smaller than a first opening threshold.

**[0024]** The object above is also achieved according to a second aspect by a method of closing a pivot hung or top hung window, the method comprising

performing a first closing operation while monitoring a closing force,
initiating a first reversing operation when the closing force exceeds a first threshold during the first closing operation,
and initiating a second closing operation after the first reversing operation.

**[0025]** In a first possible implementation form of the second aspect the method further comprises monitoring the closing force applied by the actuator during the second closing operation, initiating a second reversing operation when the closing force exceeds a second threshold during the second closing operation and initiating initiate a third closing operation after the second reversing operation.

**[0026]** In a second possible implementation form of the second aspect the method comprises second closing operation is initiated a short period of time after the first reversing operation.

**[0027]** In a third possible implementation form of the second aspect the method comprises holding the window still for a short period of time between the first reversing operation and the second closing operation.

**[0028]** In a fourth possible implementation form of the second aspect applying the maximum actuator force if needed during the during the second and/or third closing operation.

**[0029]** The foregoing and other objects are achieved by the features of the independent claims. Further implementation form forms are apparent from the dependent claims, the detailed description and the figures.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0030]** In the following detailed portion of the present disclosure, the invention will be explained in more detail with reference to the example embodiments shown in the drawings, in which:

Fig. 1 illustrates an example embodiment of a pivoting roof window with a thrust chain actuator drive,
Fig. 2 illustrates an example of a pivoting roof window with an exterior sun screening installed,
Fig. 3 is a diagrammatic illustration of a window actuator with a control unit,
Fig. 4 is an elevated view of the window actuator of Fig. 3,
Fig. 5, is an elevated cutaway view of a portion of the window actuator of Fig. 3,
Fig. 6a and 6b shows an example of measured motor current and a low-pass filtered motor current, respectively, of the motor of the window actuator,
Fig. 7 is a graph illustrating a closing procedure for a window with a window actuator,
Fig. 8 is a flowchart illustrating the closing procedure of Fig. 7,
Fig. 9 is a graph illustrating another closing procedure for a window with a window actuator, and
Fig. 10 is a flowchart illustrating the closing procedure of Fig. 9.

## DETAILED DESCRIPTION

**[0031]** Fig. 1 illustrates a window 1 with top hung rectangular sash 3 with a window pane 4 therein and a matching rectangular frame 2. Fig. 2 illustrates a roof window 1 with a pivot hung sash 3 and a matching rectangular frame 2. The roof window 1 of Fig. 2 is provided with an exterior sun screening 6. A compressible gasket (not shown) is provided between the rectangular sash 3 and the rectangular frame 2 and the compressible gasket is tightly compressed or deformed between the rectangular sash 2 and the rectangular gasket 3 when the roof window 1 is fully closed. The roof window of Fig. 1 and of Fig. 2 is provided with an actuator for moving the window i.e. moving the sash 3 between an open position (illustrated) and a closed position. The actuator can be a push-pull (thrust) chain actuator and in Fig. 1 the push-pull chain 11 of the actuator can be seen. The actuator itself can be installed in or on the frame 2, or in or on the sash 3.

**[0032]** For illustration purposes, a roof window has been shown in Figs. 1 and 2, but it is understood that actuator can be used for any top hung or pivot hung window.

**[0033]** Figs. 3 to 5 show the actuator 10 in the form of a push-pull chain actuator with a push-pull chain 11. However, it is understood that the actuator can be of another type, such as e.g. a spindle actuator. The actuator 10 comprises a housing 15 that holds an electric drive motor 12, a chain magazine, a push-pull chain 11, and a position sensor 14. The position sensor can e.g. be a rotary pulse generator on the electric motor 12. The actuator 10 is provided with an electronic control unit 50. The electronic control unit 50 can be external to the actuator 10 or can be located in in the housing 15. In one example the anti-pinch controller 50 is embedded in a secure separate processor to provide a fail safe operation. The electronic control unit 50 is connected to a source of electric power and configured to control the operation of the actuator

10, i.e. to control the operation of the electric drive motor 12. Typically, there will be a single electric drive motor 12. However, in an embodiment there can be to drive motors 12 in tandem, as shown in Fig. 5. The electric drive motor 12 drives a sprocket (not visible in the drawings) via a reduction gear 17. The sprocket engages the push-pull chain 11 and rotation of the sprocket in one direction extends the chain 11 and rotation in the opposite direction retracts the chain.

**[0034]** The push-pull chain 11 is configured to be able to transmit both tension and pressure and such push-pull chains are well known in the art. When the electric drive motor 12 is operated in the direction to retract the push-pull chain 11 the incoming chain length is stored in a chain magazine inside the housing 15. When the electric drive motor 12 is operated in the direction to extend the push-pull chain 11 the outgoing chain length is removed from the chain magazine.

**[0035]** The force that is applied by the actuator 10 is in an embodiment measured by monitoring the electric current to the electric drive motor 12. However, it is understood that the force can be measured by other means, such as for example a strain gauge.

**[0036]** Fig. 6a shows a graph that illustrates the measured electric current in A to the electric drive motor 12 over time. Fig. 6b illustrates the measured low-pass filtered current in A to the electric drive motor 12 over time. The increase of the current towards the end of the time span and thus of the force applied by the actuator 10 to the window and can be an indication of a pinching event. In one example the measured current derivative may be used for enhanced indication of a pinching event.

**[0037]** The electronic control unit 50 receives instructions, e.g. from a remote control unit (not shown) or from a control panel (not shown) to open or close the window 1 or to move the window 1 to a desired intermediate position, in accordance with the desire of an operator. The instructions can also come from a control system that controls the climate of a building by adjusting the opening of windows in such building.

**[0038]** If the window is open, as shown in Figs. 1 and 2, the electronic control unit 50 may receive an instruction to close the window 1. The electronic control unit 50 is configured to initiate a first closing operation upon receipt of such an instruction.

**[0039]** An example of a closing procedure is illustrated in Fig. 7. At the start of the closing procedure the electronic control unit 50 has received in instruction to close the window. Thereupon, the electronic control unit 50 initiates a first closing operation 101. During the first closing operation 101 the electronic control unit 50 monitors the force applied to the window by the actuator 10, e.g. by monitoring the current delivered to the electric drive motor 12. The electronic control unit 50 is configured to monitor that the force applied to the window does not exceed a first threshold. The first threshold is preferably a force low enough to avoid injury if a body part, such as the hand or fingers or person is trapped in the window opening, i.e. the opening between the sash 3 and the frame 2.

**[0040]** The electronic control unit 50 is configured to continue the first closing operation 101 until the window 1 is fully closed if the instructions received by the electronic control unit 50 are to close the window 1 completely. If the instructions are to close the window to a desired position, for example a ventilating position in which the window is slightly open the procedure lasts until the desired position is reached. In the example in figure 7 the instruction received by the electronic control unit 50 is to close the window 1 completely.

**[0041]** At T1 the force applied to the window exceeds the first threshold (indicate by the interrupted line in Fig. 6b) and the electronic control unit 50 is configured to terminate the first closing action 101 and to initiate a first reversing action 102. The first reversing action 102 is preferably a relatively small movement, i.e. relatively small compared to a full movement of the window 1 between its fully open position and fully closed position. The first reversing action should 102 be large enough for a person to move a trapped body part away from the window 1.

**[0042]** The electronic control unit 50 is configured to hold the window still for a first short period of time 103 after the first reversing action has been completed, in order to give a person that has a body part trapped time to move this body part away from the window 1. The short period of time 103 is a brief time. Or a momentary pause allowing a trapped body part to be removed.

**[0043]** The electronic control unit 50 is configured to initiate a second closing operation 104 at the end of the first short period of time 103. The electronic control unit 50 is in an embodiment configured to monitor the force applied by the actuator 10 to the window 1 during the second closing operation 104 and to terminate the second closing operation 104 if the force exceeds a second threshold. The second threshold can be identical to the first threshold, but also be higher or lower than the first threshold. In an embodiment the electronic control unit 50 is configured to allow the actuator to apply its maximum force during the second closing operation 104.

**[0044]** Fig. 8 is a flowchart illustrating the operation the actuator 10. After the start the electronic control unit 50 receives instructions to move the window 1 to a target position, e.g. the fully closed position of the window 1. Thereupon, the electronic control unit 50 initiates the first closing operation 101 while monitoring the closing force applied to the window 1. The electronic control unit 50 determines whether a first threshold is exceeded during the first closing operation 101. If the first threshold is not exceeded the electronic control unit 50 verifies whether the target position has been reached during the first closing operation 101. If the target position has not been reached the electronic control unit 50 continues with the first closing operation 101. When the electronic control unit 50 detects that target position has been reached the electronic control unit terminates the first closing procedurel0l. If the target position was the fully closed

position the first closing procedure 101 ends with the window 1 in its fully closed position.

**[0045]** If the electronic control unit 50 detects that the closing force exceeds the first threshold during the first closing operation 101 electronic control unit 50 initiates a first reversing operation 102 and thereafter maintains the position of the window 1 for a first short period of time 103, e.g. less than a couple of seconds.

**[0046]** At the end of the first short period of time 103 the electronic control unit 50 initiates the second closing operation 104. The electronic control unit 50 may or may not monitor the closing force during the second closing operation 104 and allows the actuator 10 to apply its maximum closing force during the second closing operation 104. The electronic control unit 50 is configured to verify whether the target position has been reached during the second closing operation 104. If the target position has not been reached the second closing operation continues. When the target position has been reached the process ends and electronic control unit 50 is ready to receive new instructions.

**[0047]** In an embodiment, that can be combined with any of the other embodiments, the electronic control unit 50 is configured to allow the actuator 10 to apply its maximum force during the very last part of the closing movement towards the completely closed position of the window 1. The very last part of the closing movement is preferably selected so small that it is difficult if not impossible for a person to get his fingers or other body part trapped between the frame 2 and the sash 3, and thus on one hand the risk of a pinching event is small and on the other hand a large force is typically needed for compressing the compressible gasket in this part of the movment. The portion of the closing movement in which the compressible gasket needs to be compressed typically requires a much larger force to be carried out.

**[0048]** In an embodiment, illustrated with reference to Figs. 9 and 10, the electronic control unit 50 is configured to perform at least two reversing actions when a respective first and second threshold are exceeded before a third closing operation is carried out with a higher third threshold or without any limit on the force applied to the window.

**[0049]** The closing process is identical to the process described with reference to Figs. 7 and 8 up to the end of the short period of time 103. During the second closing operation 104 the electronic control unit 50 is configured to verify that the closing force does not exceed a second threshold. The second threshold can be identical to the first threshold or can be lower than the first threshold or can be higher than the first threshold. An example of the first threshold can be 5 kg, with the second threshold being 10 kg. The electronic control unit 50 is configured to terminate the second closing operation 104 and to initiate a second reversing operation 105 upon detecting that the second threshold has been exceeded. The second reversing operation 105, is preferably a small operation with a small stroke, similar to the first reversing operation 102 and small relative to the maximum movement of the window 1 between its fully closed and fully open position.

**[0050]** The electronic control unit 50 is configured to hold the window 1 still for a second short period of time 106 after the second reversing action 105 has been completed, in order to give the person that has or had a body part trapped time one more opportunity to move this body part away from the window 1. The electronic control unit 50 is configured to initiate a third closing operation 107 at the end of the second short period of time 106. The electronic control unit 50 is in an embodiment configured to monitor the force applied by the actuator to the window during the third closing operation 107 and to terminate the third closing operation 107 if the force exceeds a third threshold. The third threshold is preferably be higher than the first and second threshold, e.g .40kg. In an embodiment the electronic control unit 50 is configured to allow the actuator 10 to apply its maximum force during the third closing operation 107.

**[0051]** The process of closing the window in accordance with the embodiment of Figs. 9 and 10, is identical to the process described in the flowchart in Fig. 8 up to and including maintaining the position of the window for the first short period of time 103. At the end of the first short period of time 103 the electronic control unit 50 is configured to initiate the second closing operation 104 while monitoring the closing force and to verify that the second threshold is exceeded or not.

**[0052]** If the second threshold is not exceeded, the electronic control unit 50 verifies whether the target position has been reached. If the target position is not been reached the second closing operation 104 continues until the target position has been reached and then the process ends. If the second threshold is exceeded during the second closing operation 104 the electronic control unit 50 performs the second reversing operation 105 and thereupon maintains the position of the window for a second short period of time 106.

**[0053]** At the end of the second short period of time 106 the electronic control unit 50 initiates the third closing operation, preferably without applying a force limit. The electronic control unit 50 verifies whether the target position has been reached during the third closing operation 107 and ends the third closing operation 107 with the window one in its target position when the electronic control unit 50 has detected that the window in the target position and then the electronic control unit 50is ready to receive new instructions.

**[0054]** The invention has been described in conjunction with various embodiments herein. However, other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. A single processor, controller, circuit or

other unit may fulfill the functions of several items recited in the claims. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measured cannot be used to advantage.

**[0055]** The reference signs used in the claims shall not be construed as limiting the scope.

## Claims

1. An actuator for operating a pivot hung or top hung window, said actuator being adapted to perform a first closing operation while monitoring a closing force applied by said actuator, said actuator being adapted to initiate a first reversing operation upon said closing force exceeding a first threshold during said first closing operation, and said actuator being configured to initiate a second closing operation after said first reversing operation.

2. An actuator according to claim 1, configured to monitor the closing force applied by said actuator during said second closing operation, configured to initiate a second reversing operation upon said closing force exceeding a second threshold during said second closing operation and configured to initiate a third closing operation after said second reversing operation.

3. An actuator according to claim 1 or 2, wherein the target of said first closing operation is a fully closed position.

4. An actuator according to any one of claims 1 to 3, wherein said first reversing operation has a magnitude that is small compared to a complete movement of the window between a fully open and a fully closed position

5. An actuator according to any one of claims 1 to 4, wherein the target of said second closing operation is a fully closed position.

6. An actuator according to any one of claims 1 to 5, wherein said second reversing operation has a magnitude that is small compared to the complete movement of the window between a fully open and a fully closed position.

7. An actuator according to any one of claims 1 to 6, wherein said actuator is configured to initiate said second closing operation a short period of time after said first reversing operation.

8. An actuator according to any one of claims 1 to 7, wherein said second threshold is equal to said first threshold

9. An actuator according to any one of claims 1 to 7, wherein said second threshold is lower than said first threshold.

10. An actuator according to any one of claims 1 to 7, wherein said second threshold is higher than said first threshold.

11. An actuator according to any one of claims 1 to 9, wherein said first threshold is lower than a maximum force of said actuator.

12. An actuator according to any one of claims 1 to 11, wherein said actuator is configured to hold the window still for a short period of time between said first reversing operation and said second closing operation.

13. An actuator according to any one of claims 2 to 12, wherein said actuator is configured to hold the window still for a short period of time between said second reversing operation and said third closing operation

14. An actuator according to any one of claims 2 to 13, wherein said actuator is configured to apply the maximum actuator force if needed during the during said second and/or third closing operation.

15. An actuator according to any one of claims 1 to 14, configured to allow said actuator to always allow use of the maximum actuator force when the opening of the window is smaller than a first opening threshold.

16. A method of closing a pivot hung or top hung window, said method comprising

    performing a first closing operation while monitoring a closing force,
    initiating a first reversing operation when said closing force exceeds a first threshold during said first closing operation,
    and initiating a second closing operation after said first reversing operation.

17. A method according to claim 16, further comprising monitoring the closing force applied by said actuator during said second closing operation, initiating a second reversing operation when said closing force exceeds a second threshold during said second closing operation and initiating initiate a third closing operation after said second reversing operation.

18. A method according to claim 17, wherein said second closing operation is initiated a short period of time after said first reversing operation.

19. A method according to claim 17 or 18, further com-

prising holding the window still for a short period of time between said first reversing operation and said second closing operation.

**20.** A method according to any one of claims 17 to 19, further comprising applying the maximum actuator force if needed during said second and/or third closing operation.

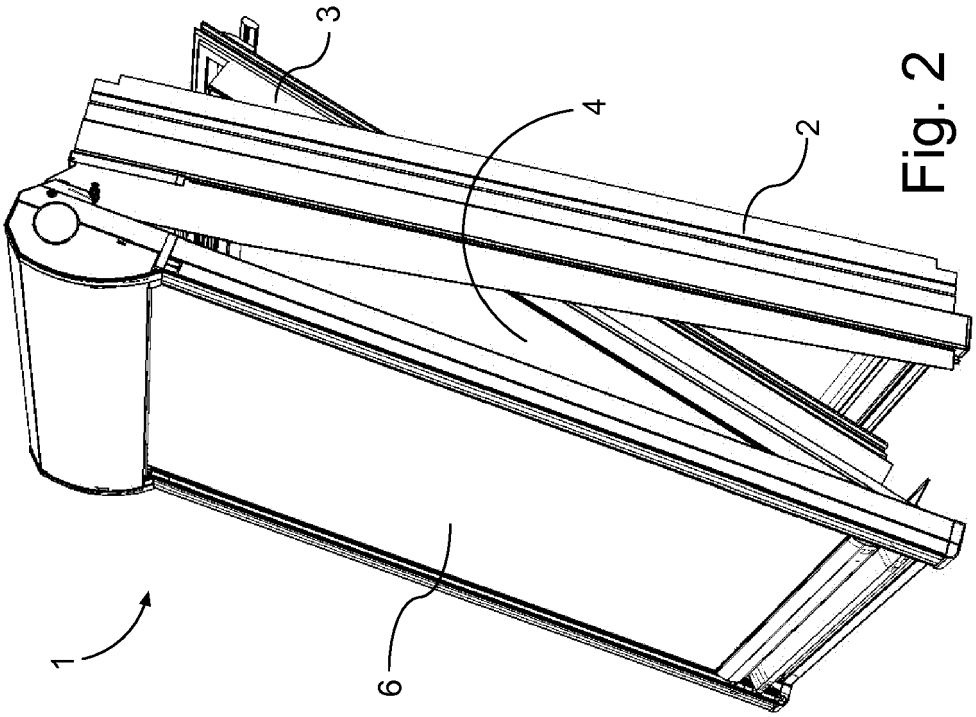



Fig. 2

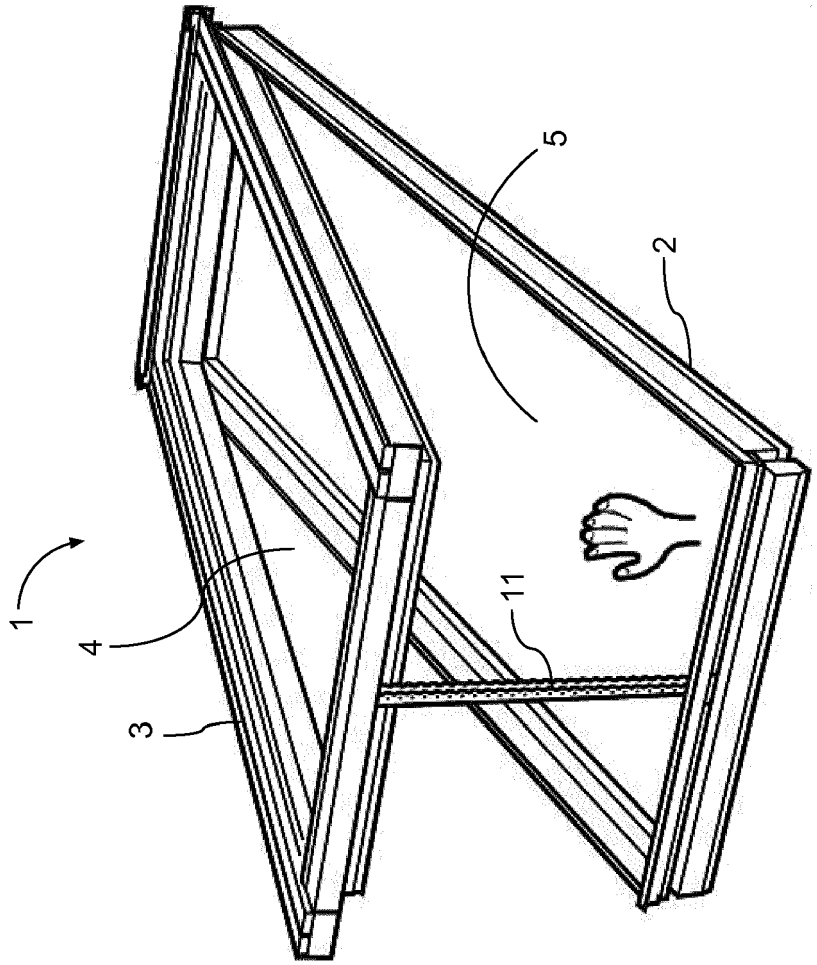



Fig. 1

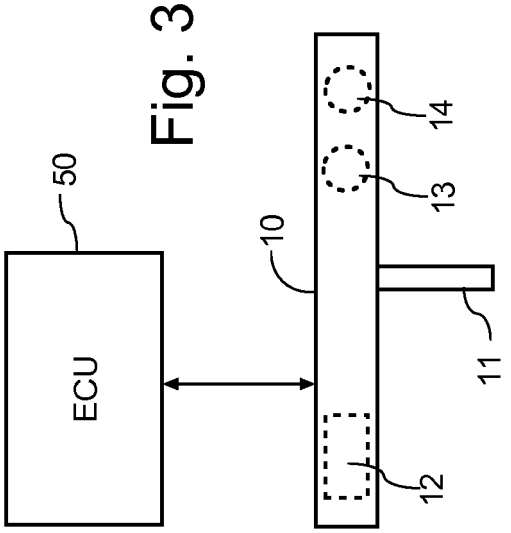



Fig. 3

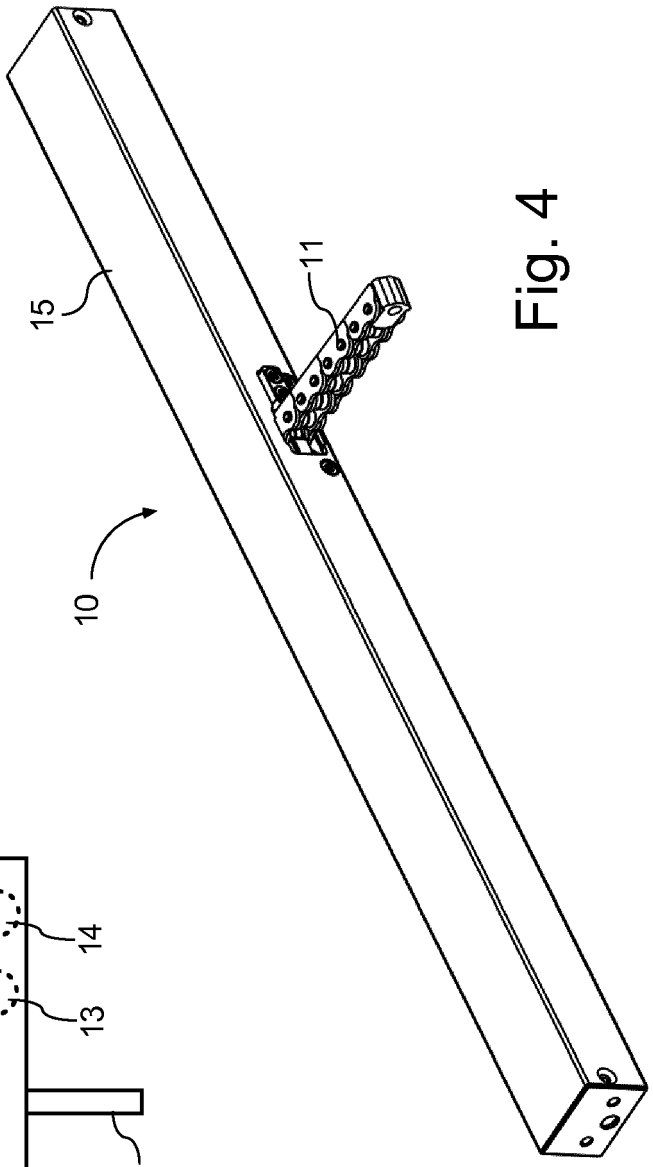



Fig. 4

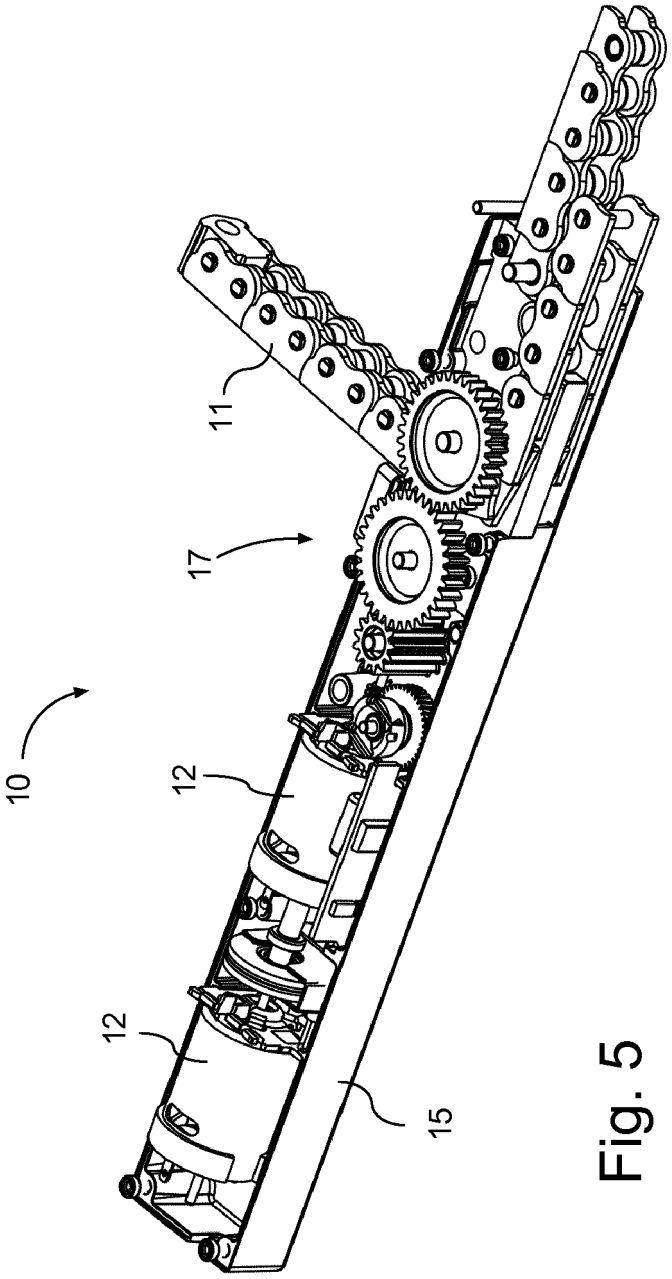



Fig. 5

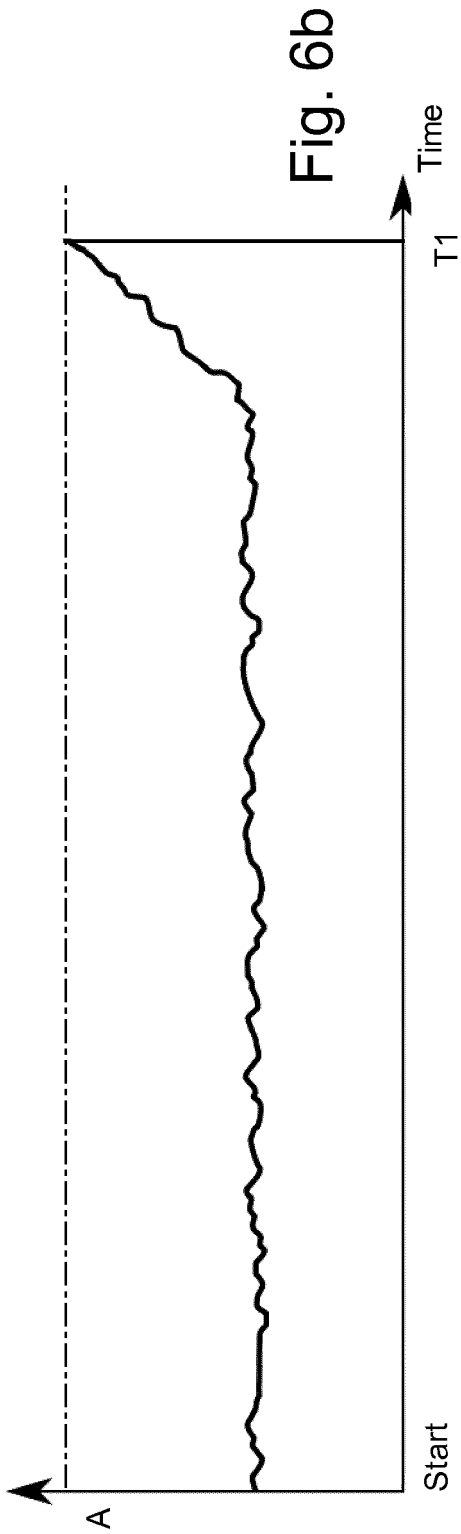



Fig. 6b

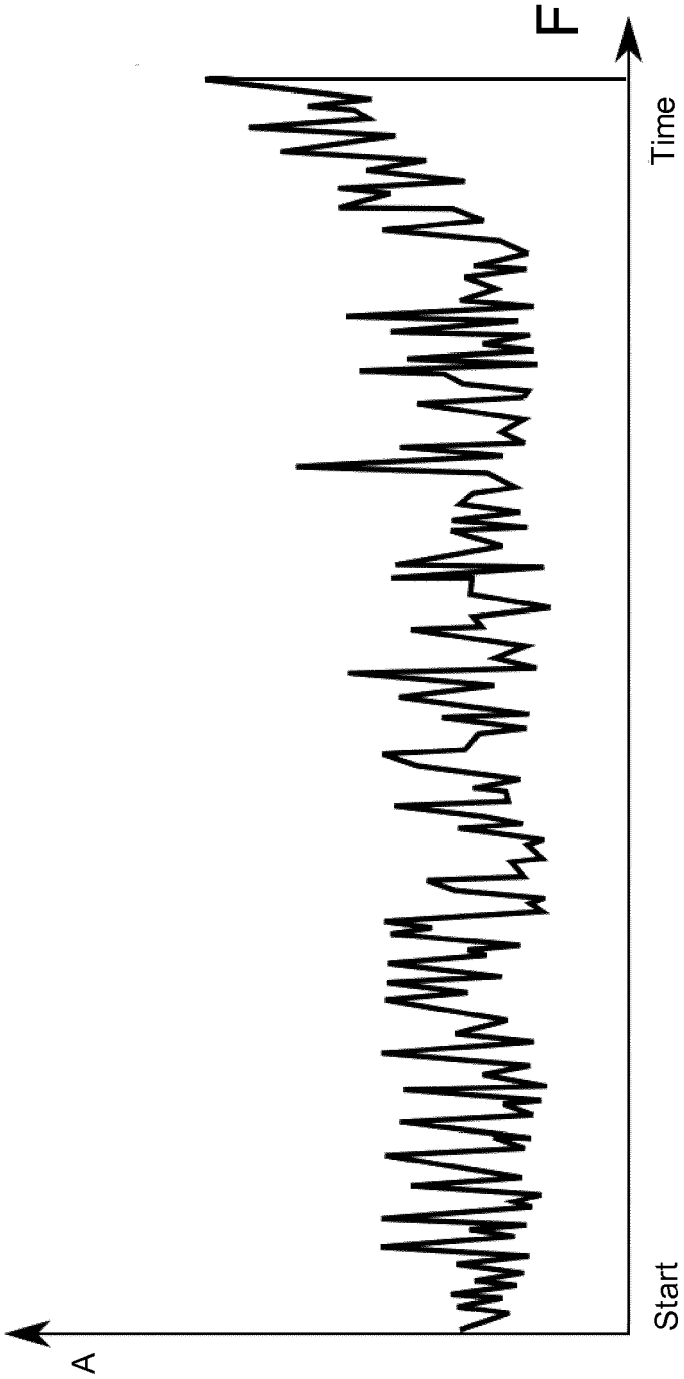
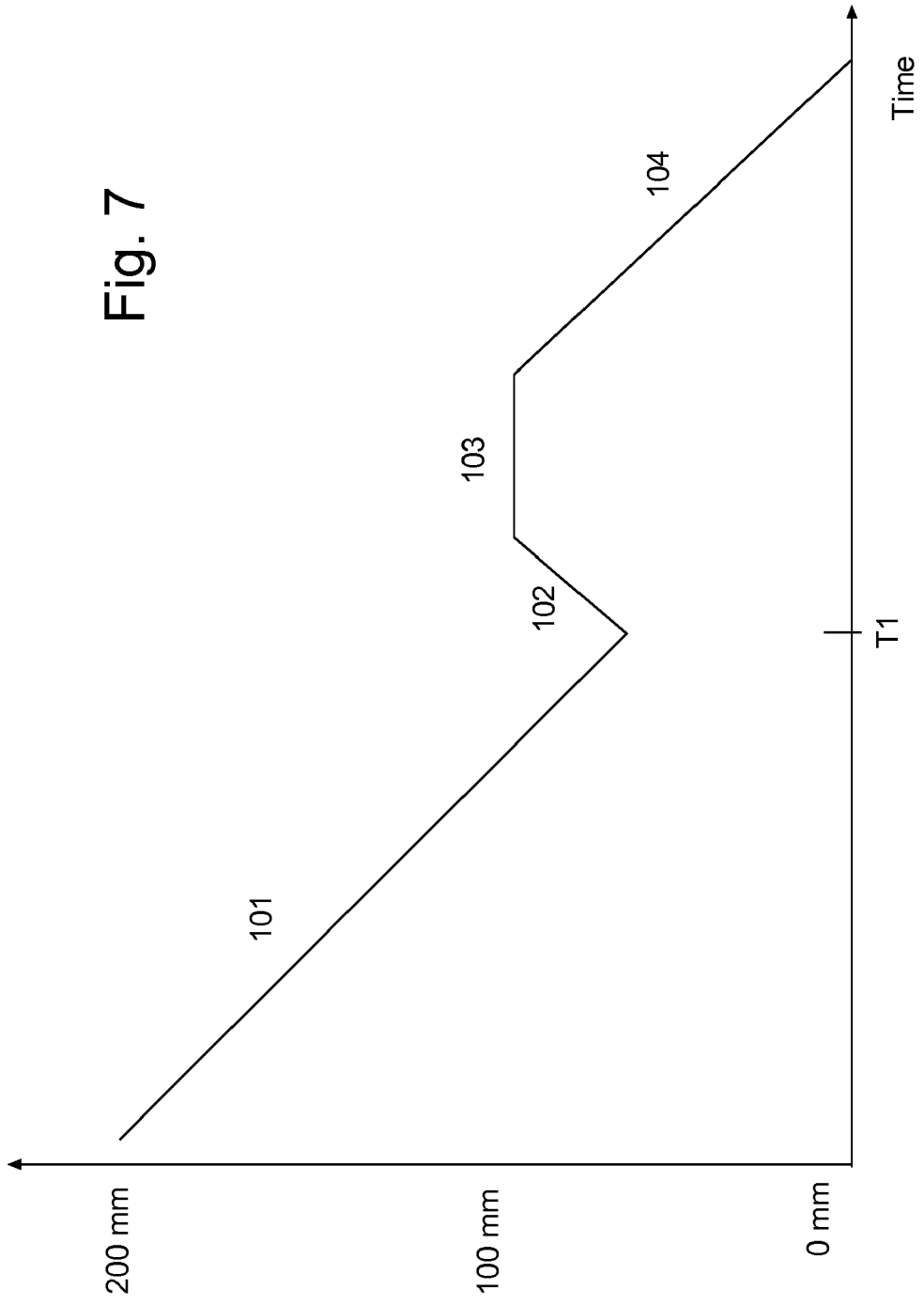



Fig. 6a

Fig. 7



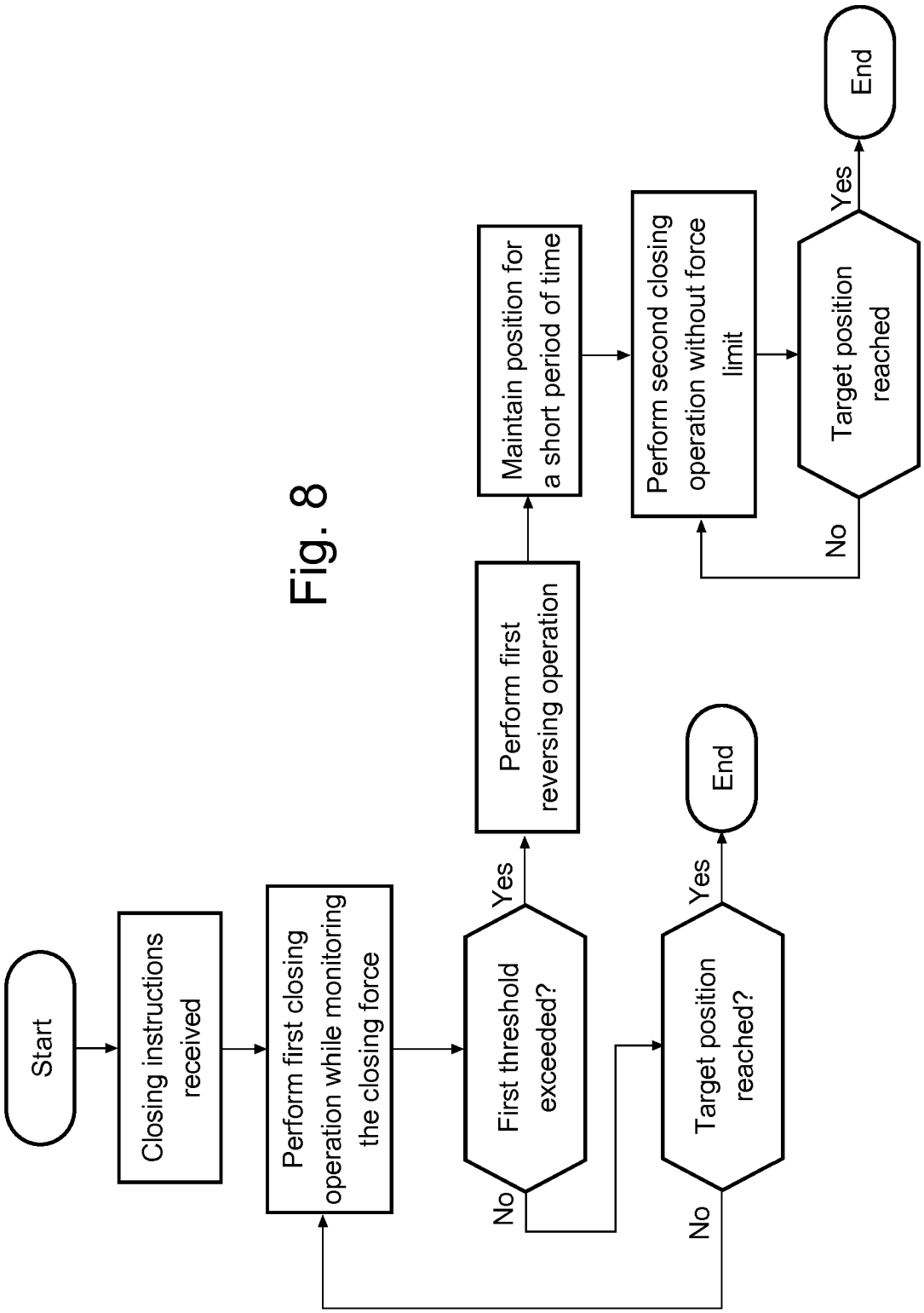

Start
Closing instructions received
Perform first closing operation while monitoring the closing force
First threshold exceeded?
Yes
No
Perform first reversing operation
Maintain position for a short period of time
Perform second closing operation without force limit
Target position reached
Yes
No
End
Target position reached?
Yes
No
End

Fig. 8

Fig. 9

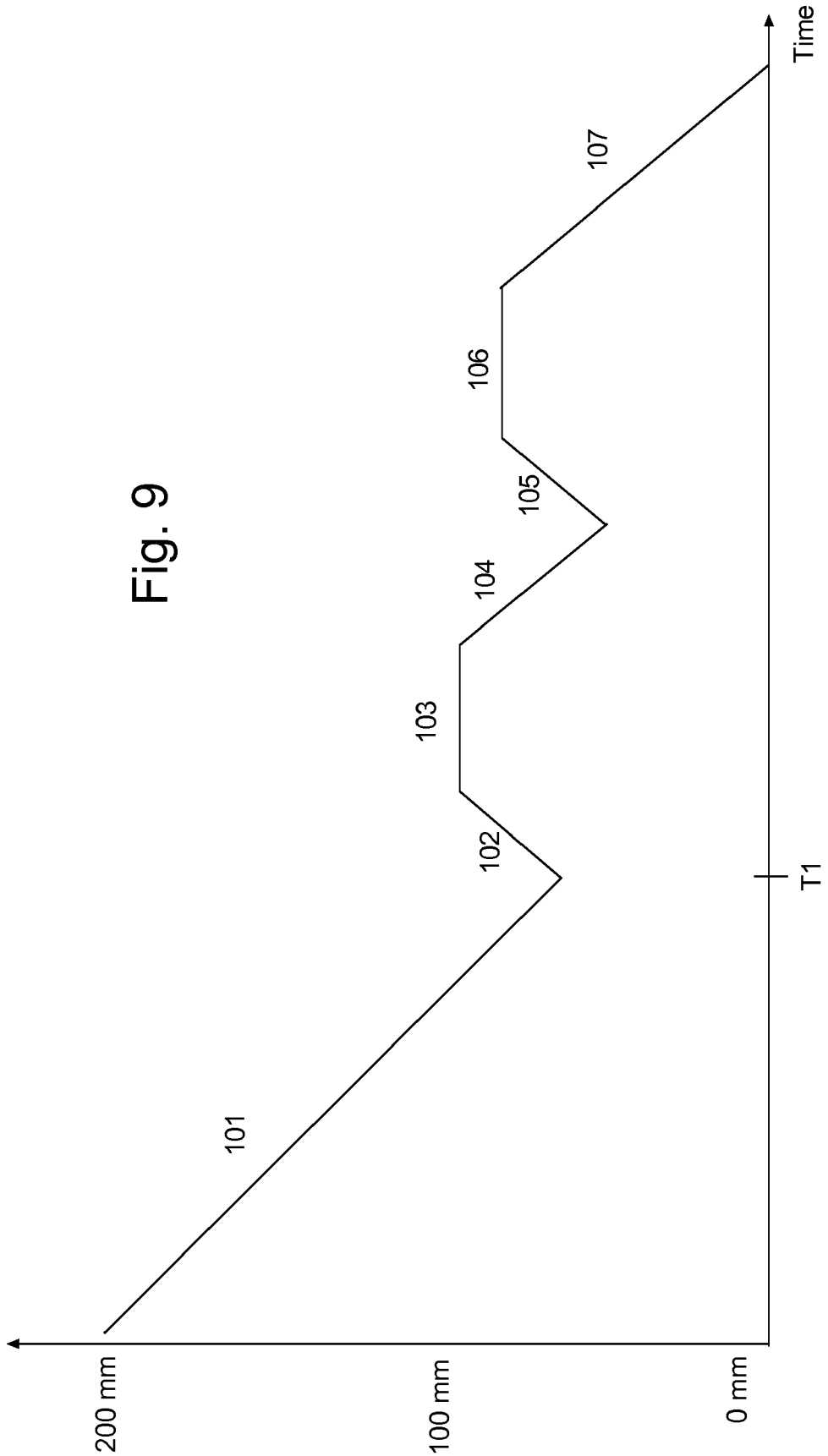
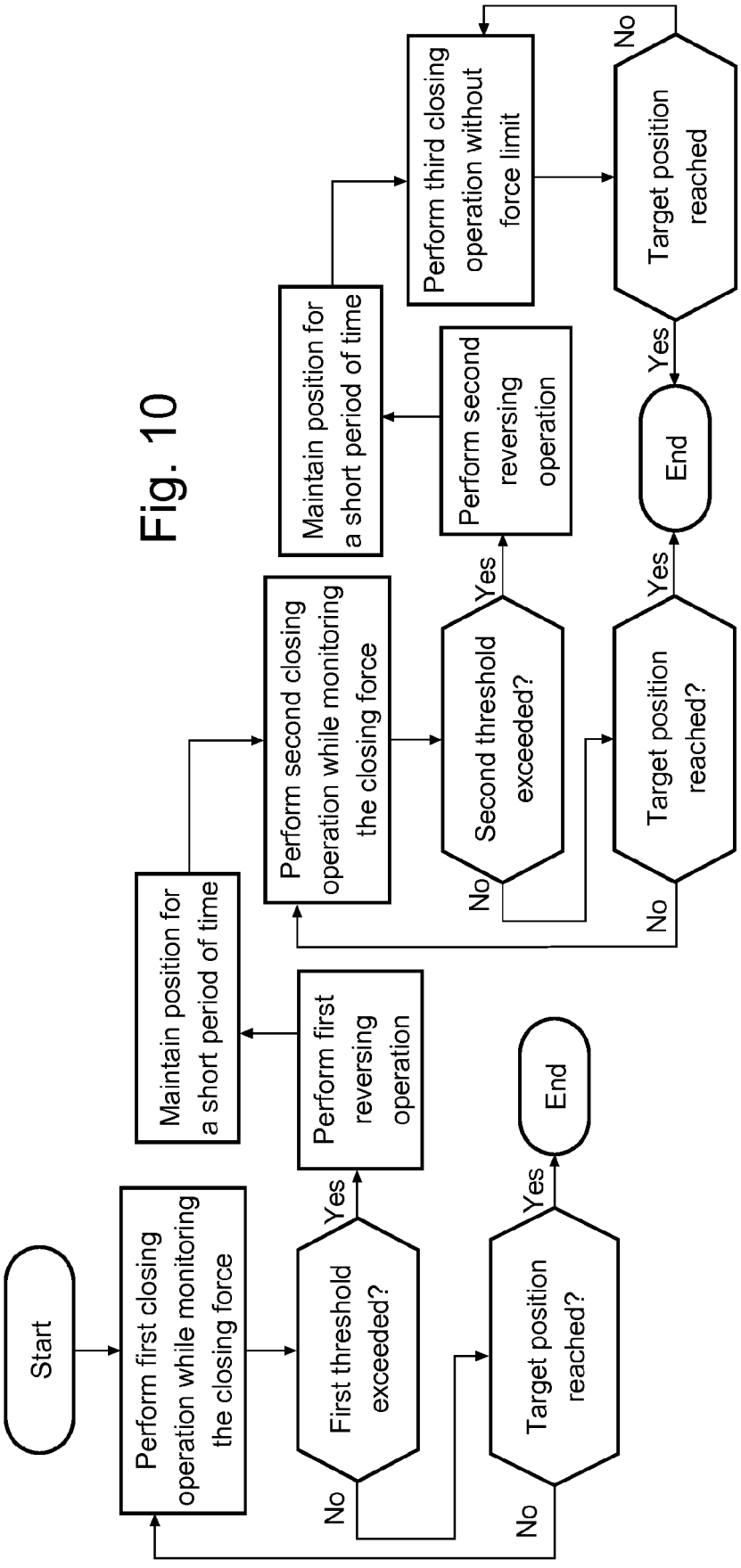


Fig. 10


Start
Perform first closing operation while monitoring the closing force
First threshold exceeded?
Yes
No
Perform first reversing operation
Maintain position for a short period of time
Target position reached?
Yes
No
End
Perform second closing operation while monitoring the closing force
Second threshold exceeded?
Yes
No
Perform second reversing operation
Maintain position for a short period of time
Target position reached?
Yes
No
End
Perform third closing operation without force limit

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# EUROPEAN SEARCH REPORT

Application Number
EP 16 16 5754

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
|---|---|---|---|
| Y | US 5 449 987 A (MCMILLAN SCOTT D [US])<br>12 September 1995 (1995-09-12)<br>* column 4, line 23 - column 5, line 7; figure 1 *<br>* column 11, line 31 - column 12, line 23; figure 8 *<br>----- | 1-20 | INV.<br>E05F15/41<br><br>ADD.<br>E05D7/08<br>E05D7/082<br>E05D7/081 |
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TECHNICAL FIELDS SEARCHED (IPC)

E05D
E05F

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| The Hague | 10 October 2016 | Rémondot, Xavier |

CATEGORY OF CITED DOCUMENTS

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10-10-2016

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

## REFERENCES CITED IN THE DESCRIPTION

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- EP 1441100 A **[0003]**