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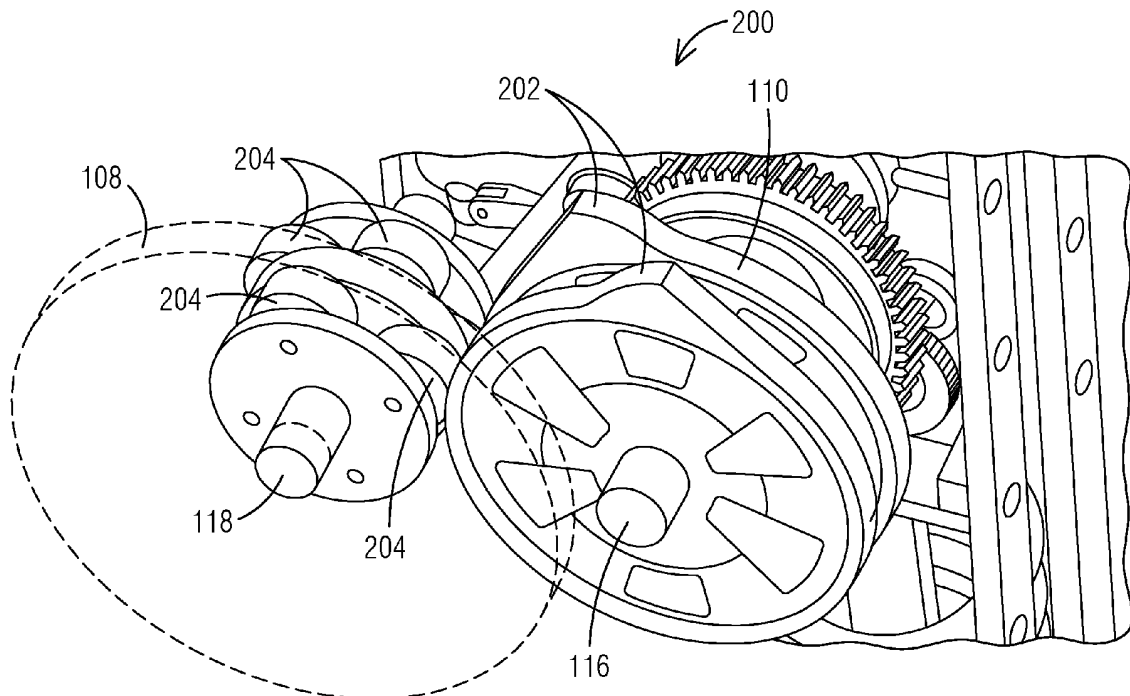
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(54) **FLYWHEEL WITH AN INDEXING MECHANISM FOR REGULATING A SWITCH-ON SPEED OF CIRCUIT BREAKER CONTACTS**

(57) A switch drive device for an electrical switchgear which uses an indexing mechanism arranged on a rotatable drive shaft, a flywheel arranged on a flywheel shaft that may be parallel to drive shaft, a drive rod driven by rotation of the indexing mechanism via a kinematic chain

of a drive movement, a fixed first contact plate, and a movable second contact plate driven by the drive rod moving towards the first contact plate at a switch-on speed, wherein the indexing mechanism is intermittently coupled to the flywheel.

**FIG. 2**

Description

BACKGROUND

[0001] Circuit breakers or switches used in power distribution or other high voltage/current applications, generally known as switch on devices, typically have two contact surfaces that are urged together to complete an electrical circuit during operation and can be pulled apart or disengaged the circuit as needed. When a circuit breaker is switched on, the flat contacts typical of the switch on device are urged together at a high velocity, due to a fixed speed of the contact and drive movement, that may cause the flat contacts to collide at such a high speed/force that the contacts are damaged, such as liberation of the contact surfaces, or subjected to excessive mechanical wear. In addition, relatively high forces in the form of surges/pulses may be introduced into the circuit breaker assembly during the mechanical operation that moves the contacts towards one another, e.g., when the circuit breaker is closed or switched on, other components can be subjected to resultant forces. This can negatively impact the durability or service life of the mechanical and electrical components of the circuit breaker. In order to improve the electrical switching capacity and the mechanical durability or service life of the electrical switching device, it is advantageous to replace the current fixed speed contact and drive movement of the electrical switching device with a variable speed curve for the contact and drive movement of the electrical switching device.

BRIEF SUMMARY

[0002] In one aspect, a indexing device for an electrical switch drive device, includes a rotating indexing mechanism arranged on a rotatable first shaft, a flywheel arranged on a rotatable second shaft configured to intermittently couple with the first shaft via the rotating indexing mechanism, a drive rod driven by rotation of the first shaft via a kinematic chain of a drive movement, a fixed first contact plate, and a movable second contact plate driven by the drive rod moving towards the first contact plate at a variable switch-on speed.

[0003] The indexing device may also include where the second contact plate initially moves towards the first contact plate in a first cycle at a first switch-on speed and then moves toward the first contact plate in a second cycle at a second switch-on speed.

[0004] The indexing device may also include, where the coupling of the flywheel to the rotating indexing mechanism enables a switch on speed curve.

[0005] The indexing device may also include where the first contact plate and the second contact plates are operable between a closed state in which the first contact plate and the second contact plate are in contact with one another and an open state in which the first contact plate and the second contact plate separated from one another

by a distance and not in contact with one another.

[0006] The indexing device may also include where the kinematic chain of the drive movement includes a contact spring, and where when the contact spring is tensioned, the contact spring compresses the first contact plate against the second contact plate [in a closed state].

[0007] The indexing device may also further include a switch-on spring coupled to the first shaft for driving the drive rod.

[0008] The indexing device may also further include a switch-off spring coupled to an operating shaft for driving the drive rod.

[0009] The indexing device may also include where the first switch-on speed is higher than the second switch-on speed.

[0010] The indexing device may also include where the second switch on speed is enabled by the coupling of the flywheel to the rotating indexing mechanism.

[0011] The indexing device may also include where the rotating indexing mechanism includes a first projection and where the flywheel includes a second projection that engages with the first projection to couple the flywheel to the rotating indexing mechanism.

[0012] The indexing device may also include where the distance between the first contact plate and second contact plate is at least 80mm. Other technical features may be readily apparent to one skilled in the art from the following figures, descriptions, and claims.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0013] To easily identify the discussion of any particular element or act, the most significant digit or digits in a reference number refer to the figure number in which that element is first introduced.

FIG. 1 illustrates a schematic view of an electrical switch device with vacuum tube.

FIG. 2 illustrates a perspective view of the flywheel and the indexing mechanism of the switch drive device.

FIG. 3 illustrates a perspective view of the closing spring and the opening spring.

FIG. 4 illustrates a graph depicting closing speed of the second contact plate and the closing speed of the drive rod.

DETAILED DESCRIPTION

[0014] Before any embodiments of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of components set forth in this description or illustrated in the following drawings. The

invention is capable of other embodiments and of being practiced or of being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting.

[0015] Various technologies that pertain to apparatus and methods will now be described with reference to the drawings, where like reference numerals represent like elements throughout. The drawings discussed below, and the various embodiments used to describe the principles of the present disclosure in this patent document are by way of illustration only and should not be construed in any way to limit the scope of the disclosure. Those skilled in the art will understand that the principles of the present disclosure may be implemented in any suitably arranged apparatus.

[0016] It is to be understood that functionality that is described as being carried out by certain system elements may be performed by multiple elements. Similarly, for instance, an element may be configured to perform functionality that is described as being carried out by multiple elements. The numerous innovative teachings of the present application will be described with reference to exemplary non-limiting embodiments.

[0017] Also, it should be understood that the words or phrases used herein should be construed broadly, unless expressly limited in some examples. For example, the terms "including," "having," and "comprising," as well as derivatives thereof, mean inclusion without limitation. The singular forms "a," "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. Further, the term "and/or" as used herein refers to and encompasses any and all possible combinations of one or more of the associated listed items. The term "or" is inclusive, meaning and/or, unless the context clearly indicates otherwise. The phrases "associated with" and "associated therewith," as well as derivatives thereof, may mean to include, be included within, interconnect with, contain, be contained within, connect to or with, couple to or with, be communicable with, cooperate with, interleave, juxtapose, be proximate to, be bound to or with, have, have a property of, or the like. Furthermore, while multiple embodiments or constructions may be described herein, any features, methods, steps, components, etc. described with regard to one embodiment are equally applicable to other embodiments absent a specific statement to the contrary.

[0018] Also, although the terms "first," "second," "third" and so forth may be used herein to refer to various elements, information, functions, or acts, these elements, information, functions, or acts should not be limited by these terms. Rather these numeral adjectives are used to distinguish different elements, information, functions or acts from each other. For example, a first element, information, function, or act could be termed a second element, information, function, or act, and, similarly, a second element, information, function, or act could be termed a first element, information, function, or act,

without departing from the scope of the present disclosure.

[0019] Also, unless specified or limited otherwise, the terms "mounted", "connected", "supported", and "coupled" and variations thereof are used broadly and encompass direct and indirect mountings, connections, supports, and couplings. Further, "connected" and "coupled" are not restricted to physical or mechanical connections or couplings.

[0020] In addition, the term "adjacent to" may mean: that an element is relatively near to but not in contact with a further element; or that the element is in contact with the further portion, unless the context clearly indicates otherwise. Further, the phrase "based on" is intended to mean "based, at least in part, on" unless explicitly stated otherwise. Terms "about" or "substantially" or like terms are intended to cover variations in a value that are within normal industry manufacturing tolerances for that dimension. If no industry standard as available a variation of 20 percent would fall within the meaning of these terms unless otherwise stated.

[0021] An indexing device for use with a switch drive device is provided for an electrical switching device such as a circuit breaker. The switch drive device includes an indexing mechanism for transmitting a drive movement. In an embodiment the indexing mechanism is a substantially circular disc, generally known as a cam disc, that rotates about a central axis or shaft wherein the disc includes geometries designed to interface with a flywheel, which includes mating geometries, at predetermined time intervals or clocking position of the indexing mechanism that are determined by the radial position of the interface geometries on the indexing mechanism and flywheel. The indexing mechanism may advantageously be intermittently coupled to the flywheel for a time interval or clocking position corresponding to a location within the stroke of a drive rod of the switching device, when the circuit breaker is closing, and the contact plates move from an off position which defines a maximum distance between the contact plate towards an on position where the contact plates are pressed together. In order to prevent damage to the contact plates as well as increasing the mechanical durability or service life of the whole electrical switching device, it is advantageous to regulate the speed at which the contact plates move toward one another, or the contact closing speed, according to a variable speed curve of the drive movement.

[0022] In an embodiment the drive movement of the electrical switching device has several time intervals that define the opening and closing cycle of the electrical switching device. For example, when the contact plates initially move towards one another in a first-time interval or acceleration cycle, it may be necessary for the closing speed of the contacts to be comparatively high to reduce the burning time of an arc that may be generated in the space between the contact plates which may result in burning and the melting of the contact plates. A person skilled in the art will know that at the current and voltages

typically seen in electrical switching devices the current can arc between the contact plates prior to physical contact, the on or closed position, which can melt or otherwise damage the surfaces of or entire contact plates. Furthermore, it may then be necessary in a second time interval or deceleration cycle shortly before the contact plates meet, to reduce the closing speed of the contacts to minimize the mechanical load or impact forces at the time the contact plates meet preventing damage to the contact plates or other components of the electrical switching device.

[0023] In order to move the contact plates towards one another at a higher speed initially and then at a lower speed before contact is made between the contact plates, a flywheel is utilized in conjunction with an indexing mechanism so that the flywheel may be driven by the indexing mechanism at the designated time intervals, that correspond to the position of the stroke of the drive rod, to absorb kinetic energy thereby reducing the speed of a kinematic chain of the drive movement by transferring the kinetic energy to the flywheel and after the contact plates are in physical contact transferring the kinetic energy by rotation of the flywheel to tension a contact pressure spring and an opening spring.

[0024] FIG. 1 illustrates a switching device 100 for an electrical circuit breaker used in a high voltage range, for example, such as those 72kV and above. The switching device 100 is enclosed by an enclosure 102. The switching device 100 enables movement of contact plates of the circuit breaker towards one another, e.g., the drive movement. When the contact plates come into contact, i.e., a closed position, the circuit breaker is switched on and when the contact plates are not in contact with one another, i.e., an open position, the circuit breaker is switched off. A second contact plate 104 moves towards/away from a fixed first contact plate 106 at a switching speed. In this embodiment the closing spring 122 and opening spring 120 are external of the enclosure 102, a rotating drive shaft 116 is mounted to the spring assembly. A closing spring 122 is coupled to the drive shaft 116 and an opening spring 120 is coupled to an operating shaft 300. In some applications the rotatable drive shaft 116 may be driven by an electric motor to compress the closing spring. The drive shaft 116 is attached to an indexing mechanism 110 which is arranged so that rotation of the drive shaft 116 rotates the indexing mechanism 110.

[0025] A flywheel 108 is coupled to a rotatable flywheel shaft 118, arranged for example parallel to the drive shaft 116 and driven via the first projections 202 of the indexing mechanism 110. In this embodiment the indexing mechanism 110 is series of cam discs with lobes or first projections 202. An operating shaft 300, is arranged for example parallel to the drive shaft 116 and also driven by the drive shaft 116 via second cam disc 308. Flywheel shaft 118 and operating shaft 300 are not coupled directly. One end of a drive rod 112 is coupled to the operating shaft 300 so that the rotation of the drive shaft 116 drives

the drive rod 112 via second cam disc 308 and operating shaft 300. Because the indexing mechanism 110 is always connected with the drive shaft 116, the flywheel 108 can influence the closing speed of the drive rod 112 when the flywheel 108 is connected to the drive shaft 116 via indexing mechanism 110. The opening speed of the drive movement or opening cycle is never influenced by the flywheel 108, because the opening cycle is only driven by the opening spring 120 which is coupled with the operating shaft 300 and drive rod 112, additionally during the opening cycle the drive shaft 116 is decoupled from the drive movement by the second cam disc 308. The opposite end of the drive rod 112 includes the second contact plate 104. A contact pressure spring 114 is positioned along the length of the drive rod 112. The drive components, the drive shaft 116, operating shaft 300, drive rod 112, contact spring 114, and second contact plate 104 define the kinematic chain of prior art drive movements. The Flywheel 108 of the present invention can redirect the kinetic energy of the kinematic chain and thereby modify the speed of the drive movement, when it is intermittently coupled via the projections 202 of the indexing mechanism 110 to the drive shaft 116. The indexing mechanism 110 is represented as a cam disc with projections 202, but a person skilled in the art will know that other indexing mechanisms, such as a Maltese cross or other known configurations can be used.

[0026] FIG. 2 illustrates a perspective view of the indexing device 200 which includes a flywheel 108 and the indexing mechanism 110 of the switch drive device 100 of FIG. 1. The flywheel 108 is coupled to a flywheel shaft 118 whose rotation enables the rotation of the flywheel 108. The indexing mechanism 110 is intermittently coupled to the flywheel 108 and a flywheel shaft 118. The rotation of the drive shaft 116 is driven by the closing spring 122 and can be advantageously assisted or primed by a motor. The flywheel shaft 118 is driven by the drive shaft 116 only when the indexing mechanism 110 is in the designated cycles, e.g., the acceleration and deceleration cycles of the drive movement, defined by the radial position of the first projections 202 on the indexing mechanism 110 and the second projections 204 on the flywheel 108. The indexing mechanism 110 includes first projections 202 that engage with second projections 204 of the flywheel shaft 118 during rotation to regulate the speed of the drive shaft 116 and drive rod 112 via the second cam disc 308 and operating shaft 300 during closing operation of the drive movement. The first projections 202 have geometries or projections that are designed to correspond to the deceleration cycle, closure cycle, and compression cycle of the drive movement depending on the radial position of the indexing mechanism 110. During the deceleration cycle the first projections 202 engage the second projections 204. The deceleration cycle continues as the cam discs 110 rotate into the about the 9 O'clock position which continues to move the drive rod 112 at a reduced velocity that continues to decrease until the first contact plate 104 and second contact plate 106 are in physical

contact, Figure 5. The closure cycle begins when the indexing mechanism has rotated past the 9 O'clock position. The compression cycle begins when the flywheel 108 rotates the cam discs 110 and the momentum of the flywheel 108 compresses the close spring 120 and contact spring 114. Once the first projections 202 of the cam discs 110 rotate past the second projections 204 of the flywheel 108, the flywheel 108 is no longer coupled to the drive movement.

[0027] During operation the indexing device 200 enables drive shaft 116 to accelerate flywheel 108 just before contact plates 104 and 106 are closed. In this phase the flywheel 108 will absorb kinetic energy and decelerate drive shaft 116 and reduce velocity of movable contact 104 via second cam disc 308, operating shaft 300 and drive rod 112.

[0028] FIG. 3 illustrates a perspective view of the opening spring 120 and the closing spring 122. The closing spring 122 is coupled to the drive shaft 116 via a crank arm 304 which converts the rotational movement of the drive shaft 116 to a linear movement substantially colinear with the central axis of the closing spring 122 which compresses the closing spring 122 from an initial or relaxed position. An opening spring 120 is coupled to the operating shaft 300 via operating lever 302 which operates to convert the rotational movement of the operating shaft 300 to linear movement of the drive rod 112 and opening spring 120 respectively.

[0029] FIG. 4 illustrates a graph 400 showing the percentage (0-100) of the drive stroke 408 of the drive rod 112 and the elapsed time between the transition from the open position to the switch-on or closed position of the switching device 100. During the acceleration cycle D1 the closing speed of the drive rod 408 and switch-on speed of the second contact plate 104 are substantially the same, a divergence of the speeds takes place in the closure cycle D2 when the second contact plate 104 contacts the first contact plate 106, the constant or stationary position of second contact plate 106 is shown as horizontal line 410, while the drive rod stroke 408 continues in the closure cycle D2.

[0030] During a first phase of operation of the closing operation a first travel interval or acceleration cycle D1 a closing spring 122 drives the drive shaft 116 and via the cam disc 308 the kinematic chain of the drive movement. The opening spring 120, coupled to the operating shaft 300, is continuously tensioned and the kinematic chain is accelerated with the excess spring energy of the closing spring 122. In the acceleration cycle (d1), the drive rod 112 moves the second contact plate 104 towards the first contact plate 106. The acceleration cycle (D1) initially accelerates the drive shaft 112 to a substantially constant velocity, represented by the slope of the drive rod stroke 408 in acceleration cycle D1 of Figure 4. The velocity of the drive rod 112 is about 2m/s and higher than the velocity of the drive rod 112 in closure cycle D2. The higher velocity during acceleration cycle D1 is required to minimize the amount of time that the first contact plate

104 and second contact plate 106 are kept below a minimum distance required to prevent a flashover event from an arc or minimize the arcing time that may be generated between the first contact plate 106 and the second contact plate 104. The deceleration cycle D2 begins when the gap between the first contact plate 106 and second contact plate 104 is about 10mm, shown as initiation point 404 in Figure 4. Parameters such as energy and spring rate of the opening spring 120 and the closing spring 122 as well as the size and mass of the components of the kinematic chain can be varied to influence the speed at which the second contact plate 104 moves towards the first contact plate 106. In an embodiment, the flywheel 108, is not coupled to drive shaft 116 during the acceleration cycle D1 and does not influence the kinematic chain during the acceleration cycle D1, nor does the flywheel 108 rotate during the acceleration cycle D1 because the first projections 202 of the indexing device 110 and the second projections 204 of the flywheel 108 are not aligned or timed for coupling. The rotation of flywheel 108 begins when first projections 202 contact the second projections 204 at the initiation point 404.

[0031] In a second phase of operation, i.e., a second travel interval or the deceleration cycle (D2), the flywheel 108 is coupled to the kinematic chain via engagement with the cam discs 110. In the deceleration cycle D2 the flywheel 108 is accelerated by the cam discs 110 which decelerates the cam disc 110 and produces a second closing speed of the kinematic chain, shown as the slope of the drive stroke 408 in the deceleration cycle D2 of Figure 4. The second closing speed is significantly reduced to about 0.5m/s, prior to contact between the first contact plate 106 and second contact plate 104, from the maximum-velocity of about 2 m/s of the drive rod 112 during the acceleration cycle D1. The deceleration of the closing speed is necessary in order to prevent damage or wear to the first contact plate 106 and the second contact plate 104 from the impact forces created by closing speeds around 2 m/s. During the decelerating cycle D2, the first projections 202 of the indexing mechanism 110 engage with second projections 204 on the flywheel 108, and a portion of the kinetic energy in the kinematic chain of the drive movement is transferred to the flywheel 108 via the rotation of the flywheel 108 which has the effect of slowing the closing speed of the kinematic chain of the drive movement as the flywheel 108 absorbs kinetic energy from the kinematic chain.

[0032] When the closed position is achieved, i.e., the first contact plate 106 and the second contact plate 104 come into contact with one another and rest in a closed position, as shown as closure point 412 in Figure 4, the drive rod 112 via the rotation of the operating shaft 300 has an additional amount of travel along the central ax

[0033] is of the drive rod 112 that is used to compress the contact pressure spring 114 and to complete the compression of the opening spring 120. The flywheel 108 can return its stored kinetic energy to the kinematic

chain via the cam disc 110, which is rotated by flywheel 108 when the first projections 202 are in contact with the second projections 204, in order to provide the necessary energy to compress the contact pressure spring 114 and the opening spring 120. The potential energy stored in the contact pressure spring 114 enables the first contact plate 106 and the second contact plate 104 to be compressed at a sufficient contact pressure force to prevent a reopening of the contact plates while the switch on device is in the closed or "on" position. In order to achieve sufficient contact pressure force, the kinematic chain continues to move in a third travel interval or compression cycle (D3) after the contact plates are in a closed position.

[0034] Although various embodiments that incorporate disclosed concepts have been shown and described in detail herein, those skilled in the art can readily devise many other varied embodiments that still incorporate these disclosed concepts. Disclosed embodiments are not limited to the specific details of construction and the arrangement of components set forth in the description or illustrated in the drawings. Disclosed concepts may be implemented by other implementations, and of being practiced or of being carried out in various ways, which now would become apparent to one skilled in the art.

[0035] None of the description in the present application should be read as implying that any particular element, step, act, or function is an essential element, which must be included in the claim scope: the scope of patented subject matter is defined only by the allowed claims. Moreover, none of these claims are intended to invoke a means plus function claim construction unless the exact words "means for" are followed by a participle.

Claims

1. A indexing device for an electrical switch drive device, comprising:

a rotating indexing mechanism arranged on a rotatable first shaft;
 a flywheel arranged on a rotatable second shaft configured to intermittently couple with the first shaft via the rotating indexing mechanism;
 a drive rod driven by rotation of the first shaft via a kinematic chain of a drive movement;
 a fixed first contact plate; and
 a movable second contact plate driven by the drive rod moving towards the first contact plate at a variable switch-on speed.

2. The indexing device of claim 1, wherein the second contact plate initially moves towards the first contact plate in a first cycle at a first switch-on speed and then moves toward the first contact plate in a second cycle at a second switch-on speed.

3. The indexing device of claim 2, wherein the first

switch-on speed is higher than the second switch-on speed.

4. The indexing device of claim 2, wherein the second switch on speed is enabled by the coupling of the flywheel to the rotating indexing mechanism.

5. The indexing device of claim 4, wherein the rotating indexing mechanism includes a first projection and wherein the flywheel includes a second projection that engages with the first projection to couple the flywheel to the rotating indexing mechanism.

6. The indexing device of claim 1, wherein the coupling of the flywheel to the rotating indexing mechanism enables a switch on speed curve.

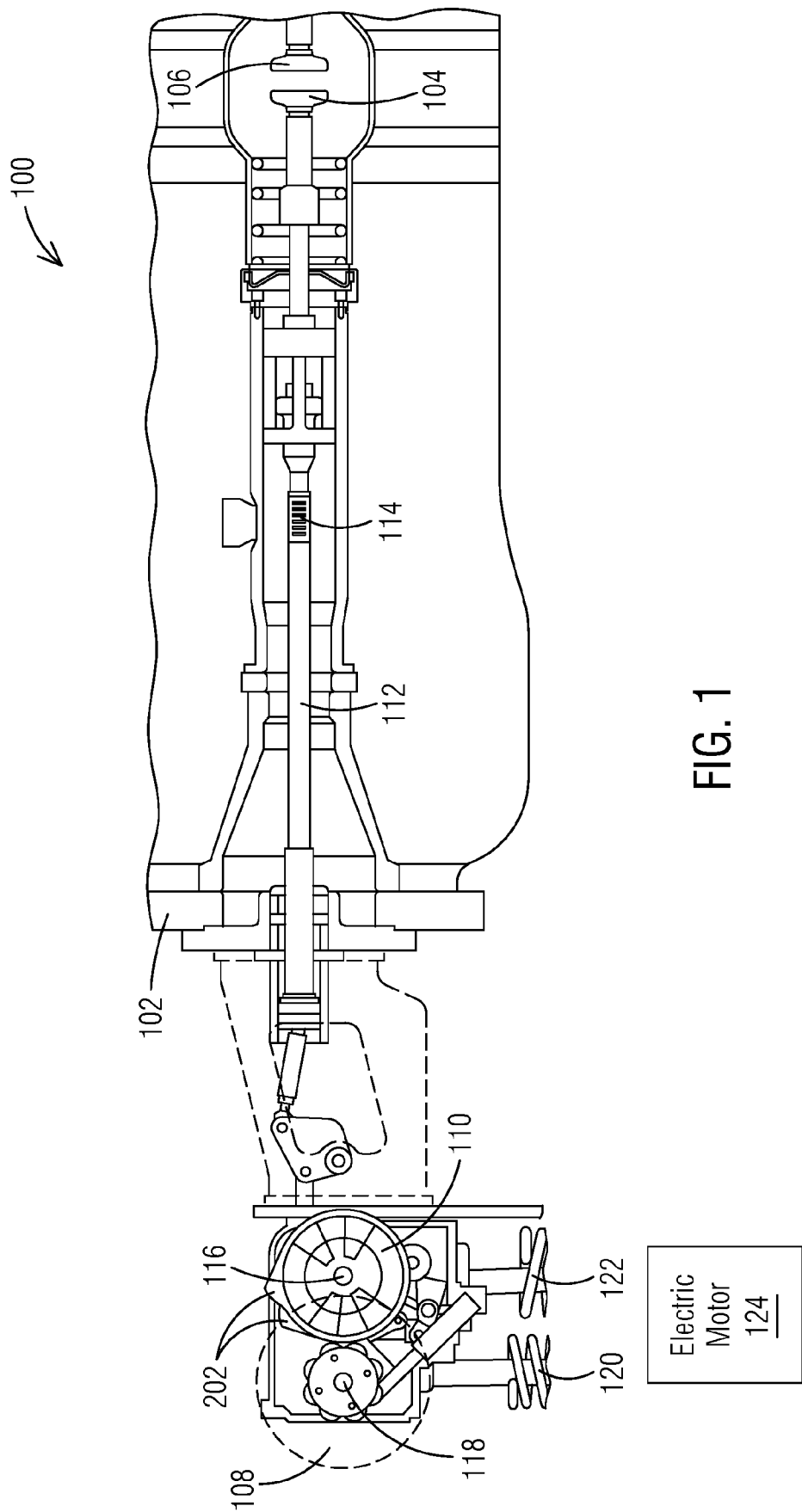
7. The indexing device of claim 1, wherein the first contact plate and the second contact plate are operable between a closed state in which the first contact plate and the second contact plate are in contact with one another and an open state in which the first contact plate and the second contact plate separated from one another by a distance and not in contact with one another.

8. The indexing device of claim 1, wherein the kinematic chain of the drive movement includes a contact spring, and wherein when the contact spring is tensioned, the contact spring compresses the first contact plate against the second contact plate [in a closed state].

9. The indexing device of claim 1, further comprising a switch-on spring coupled to the first shaft for driving the drive rod.

10. The indexing device of claim 1, further comprising a switch-off spring coupled to an operating shaft for driving the drive rod.

11. The indexing device of claim 7, wherein the distance between the first contact plate and second contact plate is at least 80mm.



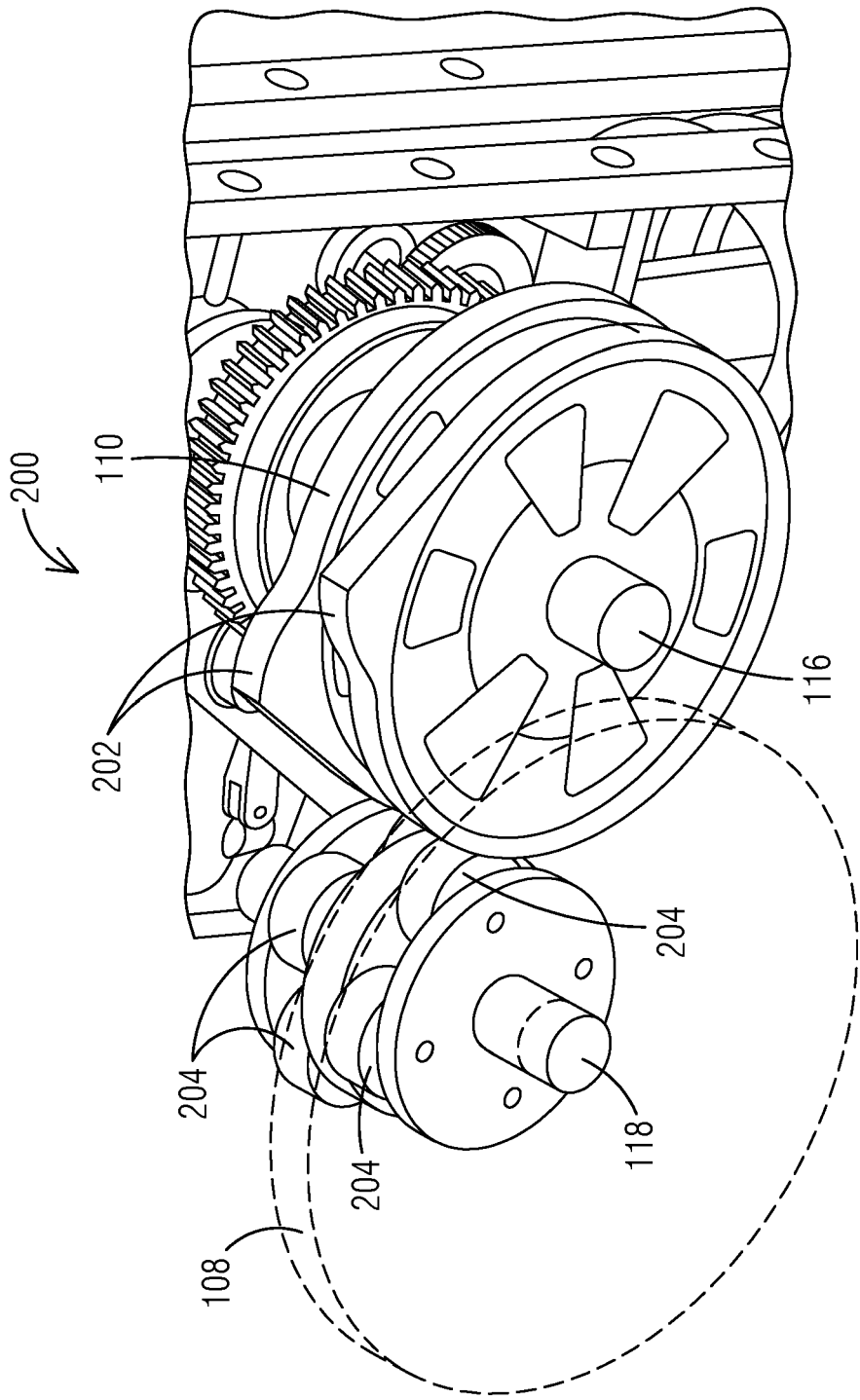


FIG. 2

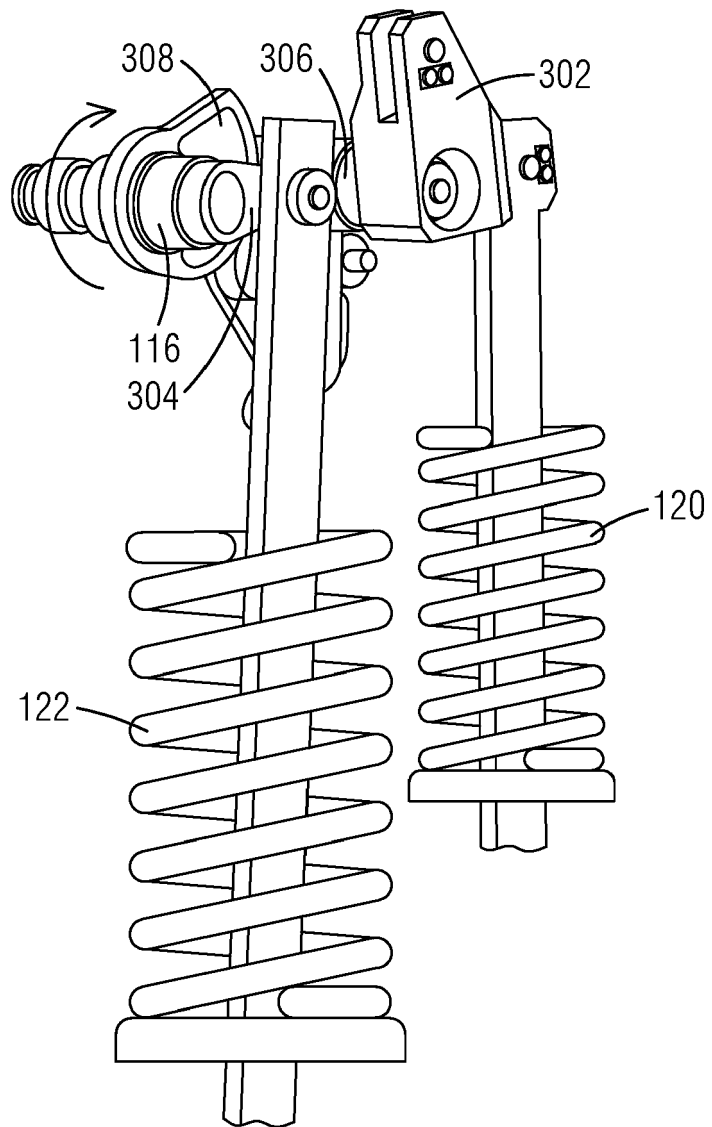


FIG. 3

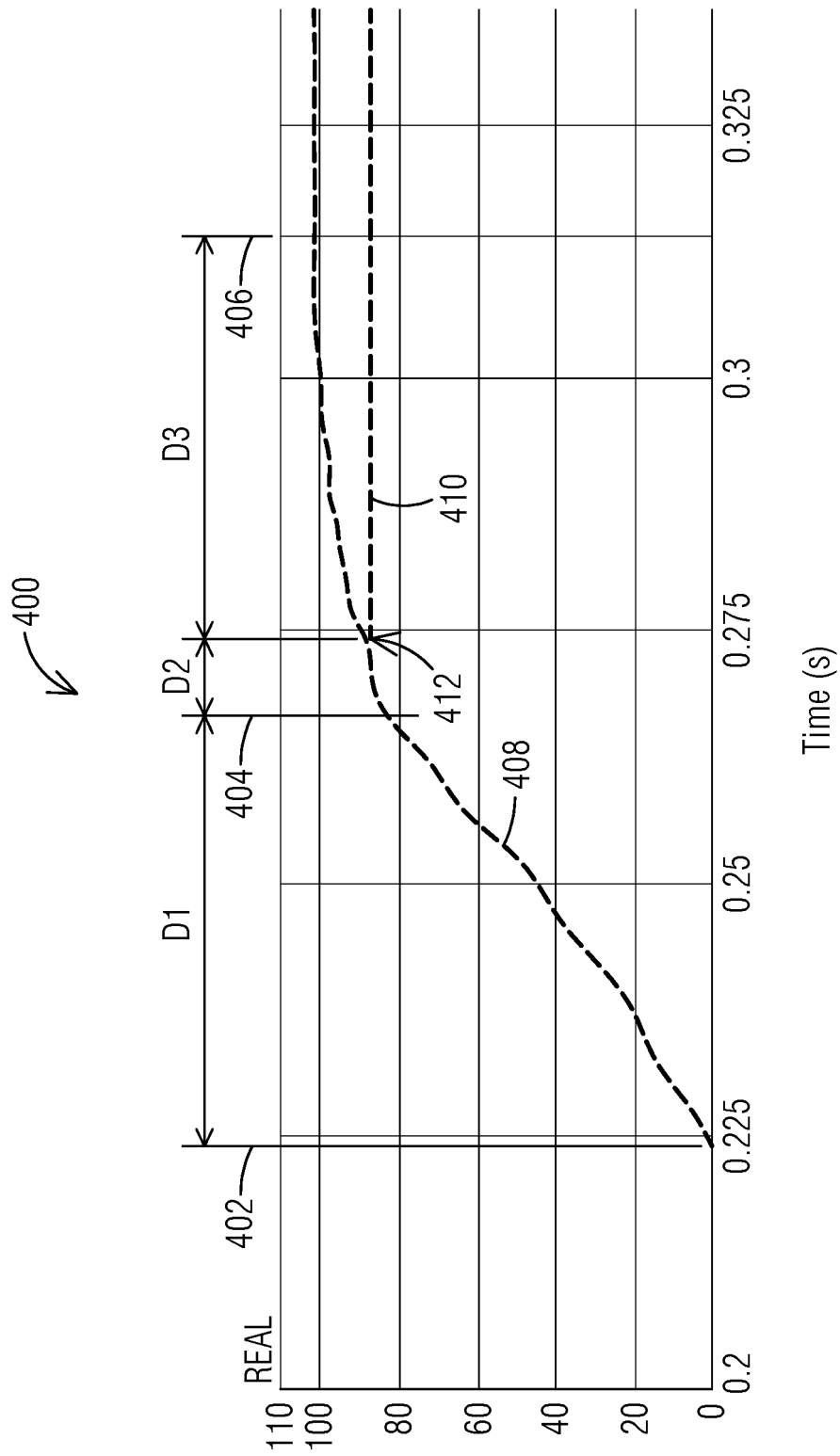


FIG. 4



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Application Number

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X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

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