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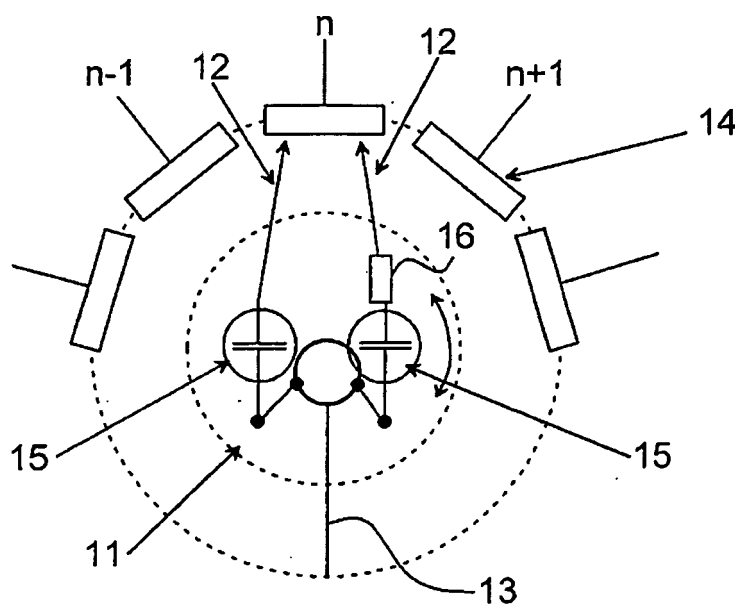
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(54) **Selector switch and method of operating a selector switch**

(57) A selector switch for switching taps of a transformer comprises a switching shaft insert (11) including two switch contacts (12) and a network terminal contact (13). Fixed step contacts (14) are circumferentially arranged on a cylinder (22) provided around the switching shaft insert, the fixed step contacts being connected to taps of the transformer. A respective vacuum switch (15) is connected between each of the switch contacts and the network terminal contact, a cam structure (23) is cir-

cumferentially arranged on the inner surface of the cylinder, and the switching shaft insert comprises further, for each of the vacuum switches, a radially movable lever (24) provided in its outer end with a cam follower (25) arranged to follow the cam structure. Each pair of the levers and vacuum switches comprises structural elements (26, 27) in mutual engagement with one another which force the vacuum switch to be actuated axially by means of the lever being moved radially.



**Fig. 1**

## Description

### Technical field

[0001] The present invention relates generally to tap changers for transformers, and in particular to a selector switch for switching over from one tap of the transformer to the next.

### Background of the invention and prior art

[0002] In power transformers, on-load tap changers (OLTC) are used to change tapping connections of transformer windings while the transformer is energised. To satisfy the needs of increased service life and reduced maintenance of on-load tap changers, they often use vacuum interrupters to control the switching and to quench the arc.

[0003] The vacuum interrupters in turn are controlled by rotating mechanisms. To actuate the vacuum interrupters and thus the tap changer in a predetermined certain pattern, the rotating mechanism can be provided with one or several cam followers following a cam surface located on the inside of a cylinder.

[0004] US 4,978,815 discloses an example of such tap changer. Fixed step contacts are disposed on a circle and are connected to taps of a step transformer. At least two switch contacts per phase are disposed in common on a pivotable contact carrier and are simultaneously pivotable on the circle. Two vacuum switches per phase are electrically built into the contact carrier and connected in series with the switch contacts. A cam race is disposed along the circle. Rollers run along the cam race for actuating the vacuum switches radially. The cam race and the rollers are current free. A slip ring is coaxial with the cam race and the circle. The cam race is disposed axially between and spaced apart from the fixed step contacts and the slip ring. Slip contacts slide on the slip ring. Each of the vacuum switches is electrically connected between a respective one of the switch contacts and a respective one of the slip contacts.

### Summary of the invention

[0005] The inventors of the present invention have noted some shortcomings with the known tap changer. The guidance of the vacuum interrupter seems not to be optimal. Horizontal movement of the vacuum interrupter may cause increased wear and tear caused by gravity and/or may put higher demands on the guidance of the vacuum interrupter.

[0006] Further, gas can be trapped outside the bellows of the vacuum interrupter, which may cause uneven mechanical strains and stresses and increased risk of fatigue of the material of the bellows.

[0007] It is therefore an object of the invention to provide a selector switch for switching over from one tap of a transformer to the next and a method for operating such

a selector switch which alleviate or at least reduce the shortcomings of the prior art.

[0008] Further, it is an object of the invention to provide such a selector switch which is rugged, robust, accurate, precise, and efficient.

[0009] Yet further, it is an object of the invention to provide such a selector switch which is easy and straightforward to assemble.

[0010] These objects, among others, are attained by selector switches and methods as claimed in the appended patent claims. According to a first aspect of the invention there is provided a selector switch for switching over from one tap of a transformer to the next, comprising a rotatable switching shaft insert, and fixed step contacts circumferentially arranged on a cylinder provided around the switching shaft insert and connected to taps of the transformer. The switching shaft insert includes, per phase, at least two switch contacts and a network terminal contact. A respective vacuum switch is connected between each of the switch contacts and the network terminal contact.

[0011] A cam structure is circumferentially arranged on the inner surface of the cylinder, and, for each of the vacuum switches, a radially extending and radially movable lever provided in its outer end with a cam follower is arranged to follow the cam structure when the switching shaft insert is rotated. The switch contacts are arranged to be moved in and out of contact with the fixed step contacts and each of the levers is arranged to actuate a respective one of the vacuum switches upon rotation of the switching shaft insert. In accordance with the invention, each pair of levers and vacuum switches comprises structural elements in mutual engagement with one another which force the vacuum switch to be actuated axially by means of the lever being moved radially.

[0012] Preferably, for each pair of levers and vacuum switches, the structural elements force the vacuum switch to be actuated axially through the medium of a wedging effect as the lever is moved radially.

[0013] In one embodiment the lever comprises an inclined plane and the vacuum switch comprises a roller or protrusion.

[0014] The switch contacts may be moved in contact with the fixed step contacts to establish a radially or axially arranged electric connection. By a radially arranged electric connection is meant a connection wherein the contact pressure between the contacts is obtained by a radially directed force and by an axially arranged electric connection is meant a connection wherein the contact pressure between the contacts is obtained by an axially directed force.

[0015] According to a second aspect of the invention there is provided a method of operating the selector switch of the first aspect of the invention. The method comprises the steps of moving the switch contacts in and out of contact with the fixed step contacts and actuating a respective one of the vacuum switches by means of rotating the switching shaft insert, wherein for each pair

of levers and vacuum switches, the vacuum switch is actuated axially by means of structural elements of the lever and the vacuum switch, which stand in mutual engagement with one another and which force the vacuum switch to be moved axially in response to the lever being moved radially.

**[0016]** An advantage of the present invention is that guidance of the moving vacuum interrupter is easier. Gas will not be trapped next to the bellows of the vacuum interrupter. The design of the selector switch is very robust and efficient. The switching shaft insert is more easily mounted in the correct position in the cylinder. Simultaneously, a selector switch with radial cam operation is less sensitive to manufacturing tolerances.

**[0017]** Further characteristics of the invention and advantages thereof, will be evident from the detailed description of preferred embodiments of the present invention given hereinafter and the accompanying Figs. 1-4, which are given by way of illustration only and thus, are not limitative of the present invention.

### Brief description of the drawings

#### **[0018]**

Figure 1 is a schematic top view of a selector switch illustrating the principles of the selector switch of the present invention.

Figure 2 is a perspective view of major parts of a selector switch according to the invention.

Figure 3 is an enlarged perspective view of a switch contact and a fixed step contact as comprised in the selector switch of Fig. 2.

Figure 4 is an enlarged side elevation view of the interface between a switching shaft insert and a cylinder as comprised in the selector switch of Fig. 2.

### Detailed description of embodiments

**[0019]** Referring now in detail to the figures of the drawing in which elements that are equivalent to one another are identified by the same reference numerals and first, particularly, to Figure 1 thereof, there is seen a selector switch used to change the ratio of a transformer, by electrically or galvanically connecting a mains or network terminal 13 to fixed step contacts 14, which in turn are firmly connected to taps of a step winding of a transformer. During a switchover, a right hand switch contact 12, which is connected in series with a transition resistor 16, is first pivoted from a step contact  $n$  to the adjacent step contact  $n+1$  by means of rotating a switch shaft insert 11, in the course of which a vacuum switch 14 connected in series with the right hand switch contact 12 and the resistor 16 opens prior to the lifting of the right hand switch contact 12 from the step contact  $n$ , and closes again only after

the right hand switch contact 12 has been applied to the next step contact  $n+1$ . Within the switchover process, the opening of a vacuum switch 15 that is electrically connected in series with a left hand switch contact 12 takes place, so that the load current commutes to the right hand switch contact 12 and the vacuum switch 15 connected in series with the right hand switch contact 12. In this process, the voltage increases whereas the voltage decreases when the switching is performed in the opposite direction.

**[0020]** When switching, an attempt is made to keep the time between the closure of the vacuum switch 15 (to the right in Figure 1) and the ensuing opening of the vacuum switch 15 (to the left in Figure 1) as brief as possible, because during this time a step of the step winding is electrically short-circuited, and the step short-circuit work during this period must be borne by the resistor 16.

**[0021]** The present invention relates to the vacuum switches 15 and their operation. In short, the switch shaft insert 11 comprises two levers with cam followers which follow a cam structure upon rotation of the switch shaft insert 11. Resulting radial movements of the levers are obtained. Structural elements of the levers and of the vacuum switches which are in mutual engagement with one another transfers the radial movements of the levers to axial movements of the vacuum switches.

**[0022]** Turning now to Figures 2-4 a selector switch for switching over from one tap of a transformer to the next according to a specific embodiment of the invention will be described.

**[0023]** The selector switch comprises a rotatable switching shaft insert 11 which includes, per phase, two switch contacts 12 and a network terminal contact 13.

**[0024]** Fixed step contacts 14 are circumferentially and fixedly arranged on an insulating cylinder 22 provided around the switching shaft insert 11, wherein the fixed step contacts 14 are connected to taps of a transformer. Upon rotation of the switching shaft insert 11, the switch contacts 12 are arranged to be moved in and out of contact with the fixed step contacts 14.

**[0025]** Preferably, the inventive selector switch is standing upright, i.e. its axial direction is parallel with a vertical axis and its radial direction is horizontal.

**[0026]** An electrically conductive sleeve or ring 28 is fixedly arranged on the inner surface of the cylinder 22. Upon rotation of the switching shaft insert 11, the network terminal contact 13 operates as a sliding contact providing continuous electric contact with the sleeve 28.

**[0027]** While the switch contacts 12 in the illustrated embodiment are arranged to be moved in contact with the fixed step contacts 14 to establish an essentially radially arranged electric connection (i.e. the force exerting the contact pressure is radially directed), the invention is not limited to such case. For instance, the switch contacts 12 may be arranged to be moved in contact with the fixed step contacts 14 to establish an essentially axially arranged connection (i.e. the force exerting the contact pressure is axially directed).

**[0028]** Similarly, the network terminal contact 13 may be arranged to be moved in contact with the sleeve 28 while establishing a connection with an axially directed force exerting the contact pressure.

**[0029]** A respective axially arranged vacuum switch 15 is connected between each of the switch contacts 12 and the network terminal contact 13. A typical current path is indicated at 41 in Figure 4 when the vacuum switch 15 is closed.

**[0030]** It can also be seen in Figure 4 that the switch contacts 12 and the fixed step contacts 14 on one hand and the network terminal contact 13 and the sleeve 28 on the other hand are arranged at different axial positions.

**[0031]** Each one of the switch contacts 12 and the network terminal contact 13 may be provided with spring biased contact pins in order to secure proper electric connection. Alternatively, other kind of means is provided for exerting an appropriate contact pressure.

**[0032]** In order to operate the vacuum switches as described with reference to Figure 1 a cam based mechanism is provided. A cam structure 23 is circumferentially arranged on the inner surface of the cylinder 28, and the switching shaft insert 11 is provided, for each of the vacuum switches 15, a radially extending and radially movable lever 24 provided in its outer end with a roller 25 arranged to follow the cam structure 23 upon rotation of the switching shaft insert 11, and as a result the lever 24 moves radially.

**[0033]** Each one of the levers 24 is arranged to actuate a respective one of the vacuum switches 15. To this end, each one of the levers 24 is provided in its inner upper end with an inclined plane or surface 26 and each one of the vacuum switches 15 is provided in its upper end with a roller 27 which is forced to rest against the inclined plane 26 during operation. As a result a movement of a lever 24 radially inwards forces the vacuum switch 15 in engagement with the lever 24 to be moved axially upwards and as a result the vacuum switch 15 opens.

**[0034]** Similarly, when the lever 24 is moved radially outwards the vacuum switch 15 in engagement with the lever 24 is forced to be moved axially downwards and as a result the vacuum switch 15 closes. In order to secure that the rollers 27 of the vacuum switches 15 follow the inclined plane 26 of the levers 24 during the radially inwards movements of the levers 24, the vacuums switches 15 are preferably spring biased with an axial force operating downwards. This force is also preferred to obtain appropriate electric contact pressure.

**[0035]** Similarly, to secure that the rollers 25 of the levers 24 follow the cam structure 23 during the radially outwards movements of the levers 24, the levers 24 are preferably spring biased with a radial force operating outwards.

**[0036]** It shall be appreciated that in the illustrated embodiment, the rollers 25 of the levers 24 are arranged to follow axially separated portions of the cam structure 23, which portions have different shapes. However, this is not a prerequisite. In an alternative embodiment, the le-

vers are arranged in the same axial position and their rollers follow the very same cam profile.

**[0037]** While the structural elements that transfer the radial movements of the levers 24 to the axial movements of the vacuum switches 15 in the illustrated embodiment comprise inclined planes 26 of the levers 24 and rollers 27 of the vacuum switches, the skilled person can readily find other kind of structural elements that provide an equivalent function.

**[0038]** Generally, each pair of levers and vacuum switches comprises structural elements in mutual engagement with one another which force the vacuum switch to be actuated axially by means of the lever being moved radially.

**[0039]** Preferably, for each pair of levers and vacuum switches, the structural elements force the vacuum switch to be actuated axially through the medium of a wedging effect as the lever is moved radially.

**[0040]** The structural elements may comprise an inclined plane as disclosed above, a groove, or a slot in mutual engagement with a roller as disclosed above, or protrusion. Advantageously, for each pair of levers and vacuum switches, the lever comprises the inclined plane, groove, or slot, and the vacuum switch comprises the roller or protrusion.

**[0041]** It shall be appreciated that the rotatable switching shaft insert may comprise one or several further switch contacts and a respective further vacuum switch connected between each one of the further switch contact(s) and the network terminal contact (not illustrated). For each of the further vacuum switches a radially extending and radially movable lever is provided, the lever being provided in its outer end with a cam follower arranged to follow the cam structure, wherein, upon rotation of the switching shaft insert 11, each one of the further switch contact(s) is arranged to be moved in and out of contact with the fixed step contacts 14, and each pair of the further lever(s) and the further vacuum switch(es) comprises structural elements in mutual engagement with one another which force the vacuum switch to be actuated axially by means of the lever being moved radially.

**[0042]** It shall be appreciated that while the invention has been described in detail above, the invention is not limited to such details. The invention is defined by the appended patent claims.

## Claims

1. A selector switch for switching over from one tap of a transformer to the next, comprising:
  - a rotatable switching shaft insert (11) comprising, per phase, at least two switch contacts (12) and a network terminal contact (13);
  - fixed step contacts (14) circumferentially arranged on a cylinder (22) provided around said

- rotatable switching shaft insert, the fixed step contacts being connected to taps of said transformer;
- a respective vacuum switch (15) connected between each of the switch contacts and the network terminal contact; and
  - a cam structure (23) circumferentially arranged on the inner surface of said cylinder, wherein
    - said rotatable switching shaft insert further comprises, for each of the said vacuum switches, a radially extending and radially movable lever (24) provided in its outer end with a cam follower (25) arranged to follow said cam structure; and
    - upon rotation of said rotatable switching shaft insert, said switch contacts are arranged to be moved in and out of contact with said fixed step contacts and each of said levers is arranged to actuate a respective one of said vacuum switches, **characterized in that**
      - each pair of said levers and vacuum switches comprises structural elements (26, 27) in mutual engagement with one another which force the vacuum switch to be actuated axially by means of the lever being moved radially.
2. The selector switch of claim 1 wherein, for each pair of said levers and vacuum switches, the structural elements force the vacuum switch to be actuated axially through the medium of a wedging effect as the lever is moved radially.
  3. The selector switch of claim 1 or 2 wherein, for each pair of said levers and vacuum switches, the structural elements in mutual engagement with one another comprise an inclined plane (26), groove, or slot in mutual engagement with a roller (27) or protrusion.
  4. The selector switch of claim 3 wherein, for each pair of said levers and vacuum switches, said lever comprises the inclined plane, groove, or slot, and said vacuum switch comprises the roller or protrusion
  5. The selector switch of any of claims 1-4 wherein said switch contacts are arranged to be moved in contact with said fixed step contacts to establish an essentially radially arranged electric connection.
  6. The selector switch of any of claims 1-4 wherein said switch contacts are arranged to be moved in contact with said fixed step contacts to establish an essentially axially arranged electric connection.
  7. The selector switch of any of claims 1-6 wherein the cam followers of the movable levers are arranged to follow axially separated portions of said cam structure, which portions have different shapes.
  8. The selector switch of any of claims 1-7 wherein a sleeve (28) is provided on the inner surface of said cylinder and the network terminal contact is a sliding contact providing continuous contact with said sleeve upon rotation of said rotatable switching shaft insert.
  9. The selector switch of any of claims 1-8 wherein
    - said rotatable switching shaft insert comprises a further switch contact and a further radially extending and radially movable lever provided in its outer end with a cam follower arranged to follow said cam structure;
    - a further vacuum switch is connected between the further switch contact and the network terminal contact; and
    - upon rotation of the rotatable switching shaft insert, the further switch contact is arranged to be moved in and out of contact with said fixed step contacts, and the further lever and the further vacuum switch comprise structural elements in mutual engagement with one another which force the vacuum switch to be actuated axially by means of the lever being moved radially.
  10. A method of operating a selector switch comprising a rotatable switching shaft insert (11) which includes, per phase, at least two switch contacts (12) and a network terminal contact (13); fixed step contacts (14) circumferentially arranged on a cylinder (22) provided around said rotatable switching shaft insert, the fixed step contacts being connected to taps of said transformer; a respective vacuum switch (15) connected between each of the switch contacts and the network terminal contact; and a cam structure (23) circumferentially arranged on the inner surface of said cylinder, wherein said rotatable switching shaft insert further comprises, for each of the said vacuum switches, a radially extending and radially movable lever (24) provided in its outer end with a cam follower (25) arranged to follow said cam structure, thereby moving the lever radially, said method comprising the steps of:
    - moving said switch contacts in and out of contact with said fixed step contacts and actuating a respective one of said vacuum switches by means of rotating said rotatable switching shaft insert, **characterized in that** for each pair of said levers and vacuum switches, the vacuum switch is actuated axially by means of structural elements (26, 27) of the lever and the vacuum switch, which stand in mutual engagement with one another and which force the vacuum switch to be moved axially in response to the lever being moved radially.

11. The method of claim 10 wherein, for each pair of said levers and vacuum switches, the vacuum switch is actuated axially by means of forcing the vacuum switch is to be moved axially through the medium of a wedging effect as the lever is moved radially.

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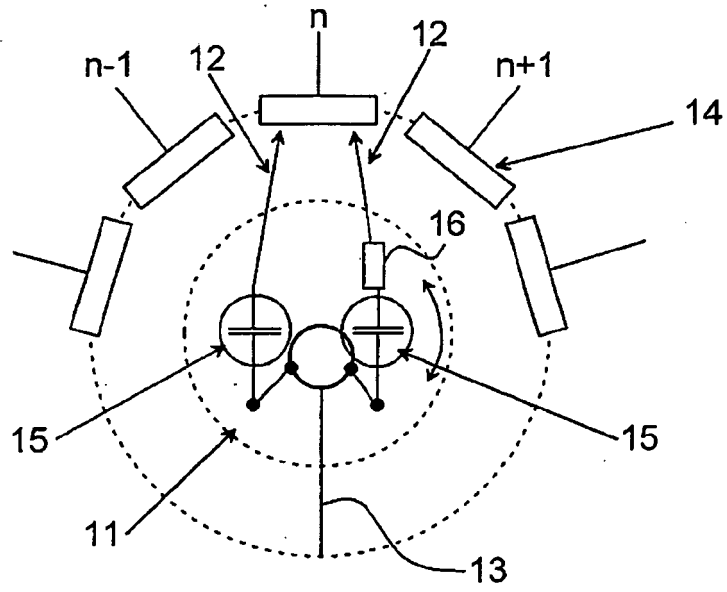


Fig. 1

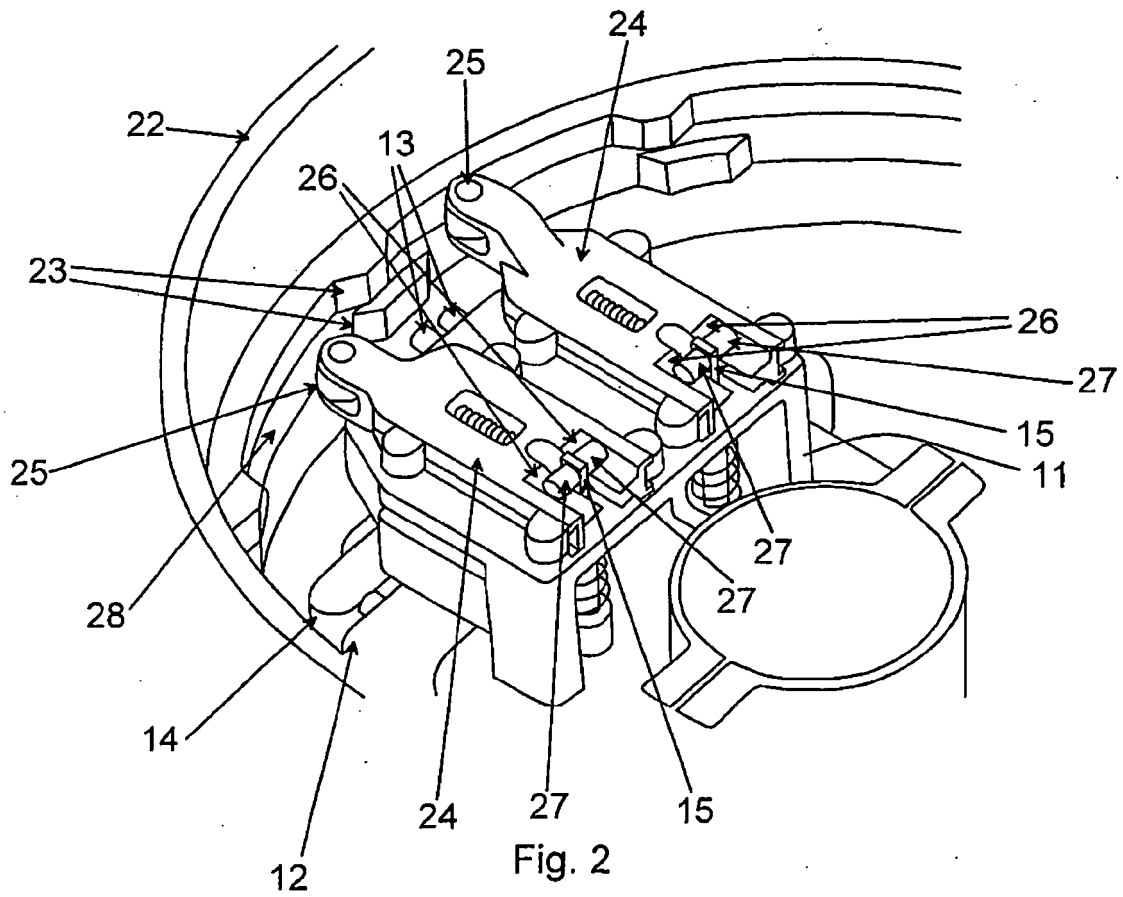


Fig. 2

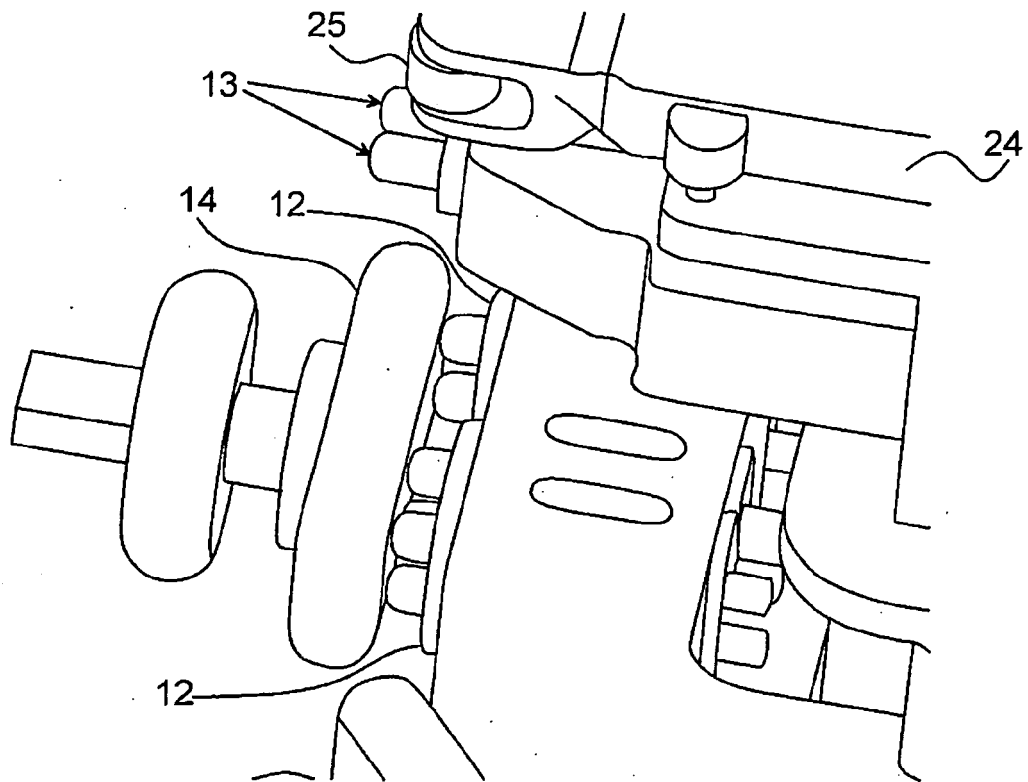


Fig. 3

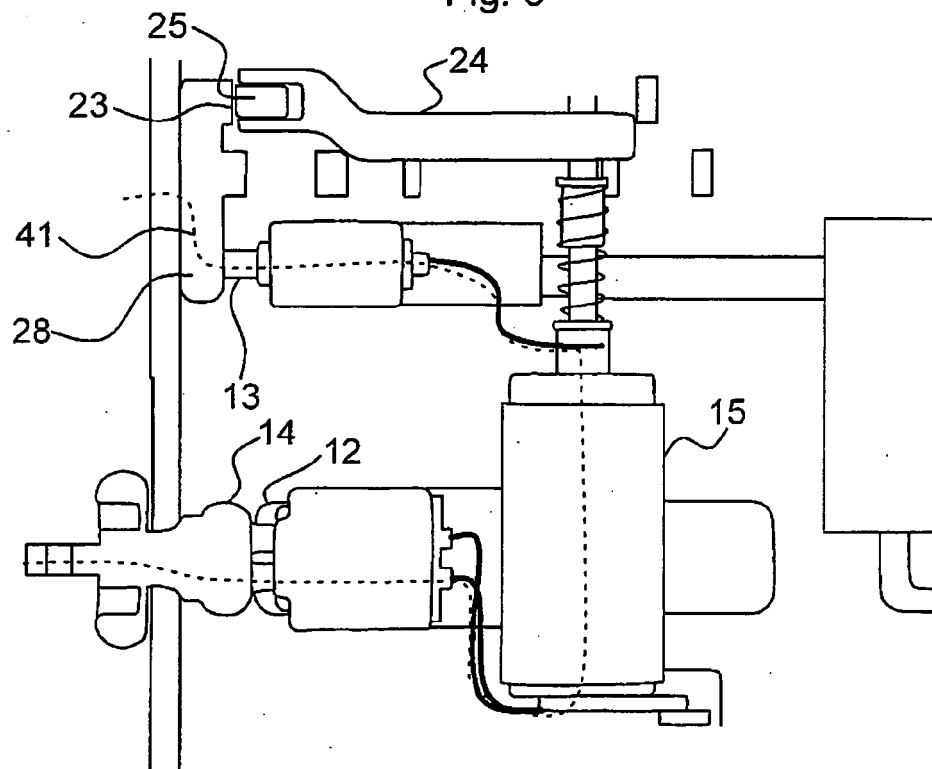


Fig. 4





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Application Number  
EP 09 16 2444

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Place of search		Date of completion of the search	Examiner
The Hague		30 October 2009	Overdijk, Jaco
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**ANNEX TO THE EUROPEAN SEARCH REPORT  
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