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(54) MEDIUM VOLTAGE OR HIGH VOLTAGE SWITCH SYSTEM WITH A MAGNETIC SYSTEM APPLYING A TRANSVERSE FIELD TO A VACUUM SWITCH

(57) The present invention relates to a low voltage, medium voltage, or high voltage switch system, comprising:
- a vacuum interrupter (10); and
- a magnetic system (50);
wherein the vacuum interrupter comprises a fixed contact (11) and a movable contact (12);
wherein in a closed configuration of the switch system the vacuum interrupter is configured to maintain the movable contact in contact with the fixed contact;
wherein in an opening transition of the switch system the vacuum interrupter is configured to move the movable contact away from the fixed contact; and
wherein the magnetic system is configured to generate a magnetic field with magnetic flux lines that are directed through a gap between the movable contact and the fixed contact during the opening transition; and
wherein an axis of the vacuum interrupter is directed through the centre of the fixed contact and through the centre of the movable contact, and wherein the magnetic flux lines are directed perpendicularly to the axis of the vacuum interrupter.

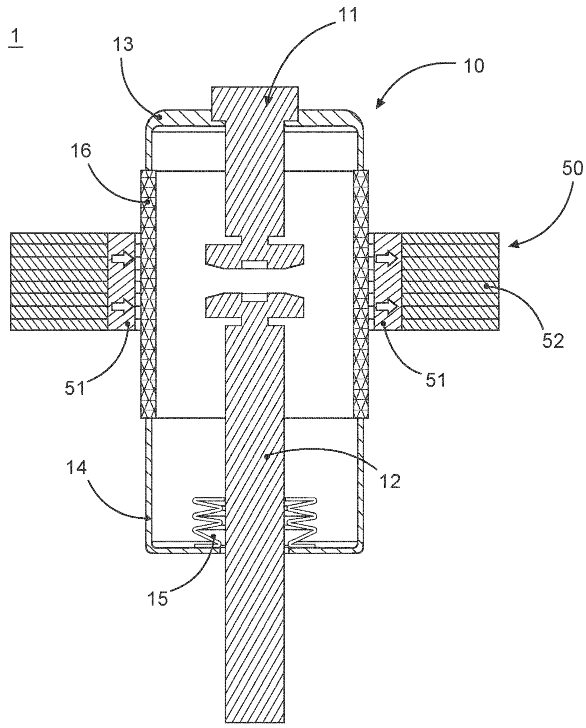

Figure 1

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a medium voltage or high voltage switch system, and a medium voltage or high voltage switchgear.

BACKGROUND OF THE INVENTION

[0002] A hybrid medium voltage or high voltage DC circuit breaker is a device where the arc voltage of a vacuum interrupter (VI) is used to transfer the current from a main path in which the VI is located to a parallel path with a semiconductor, where the current can then be switched off.

[0003] A critical aspect of such a hybrid DC circuit breaker is this commutation of the current from the VI to the parallel semiconductors. Normally, for example medium voltage (MV) vacuum interrupters generate arc voltages of only about 50V. For a fast and reliable commutation of the load current or short circuit current, a vacuum interrupter with an increased arc voltage is needed. However, state-of-the-art MV Vacuum Interrupters are practically unable to switch any DC currents when the circuit voltage is above 50V.

[0004] There is a need to address these issues.

SUMMARY OF THE INVENTION

[0005] Therefore, it would be advantageous to enable a standard VI to be able to switch higher voltages. For example, to shift the DC switching performance of a standard MV VI at least into the low range of MV load break switching.

[0006] The object of the present invention is solved with the subject matter of the independent claims, wherein further embodiments are incorporated in the dependent claims.

[0007] In a first aspect, there is provided a medium voltage, or high voltage switch system, comprising:

- a vacuum interrupter; and
- a magnetic system.

[0008] The vacuum interrupter comprises a fixed contact and a movable contact. In a closed configuration of the switch system the vacuum interrupter is configured to maintain the movable contact in contact with the fixed contact. In an opening transition of the switch system the vacuum interrupter is configured to move the movable contact away from the fixed contact. The magnetic system is configured to generate a magnetic field with magnetic flux lines that are directed through a gap between the movable contact and the fixed contact during the opening transition. An axis of the vacuum interrupter is directed through the centre of the fixed contact and through the centre of the movable contact, and wherein the magnetic flux lines are directed perpendicularly to the axis of the vacuum interrupter.

[0009] In an example, the magnetic system comprises a yoke structure. The yoke comprises a first arm and a second arm and ends of the first arm and second arm are located on opposite side of the axis of the vacuum interrupter.

[0010] In an example, the first arm of the yoke comprises a first permanent magnet and the second arm of the yoke comprises a second permanent magnet. The yoke is configured such that the first permanent magnet and the second permanent magnet are positioned on opposite sides of the axis of the vacuum interrupter. The magnetic field with magnetic flux lines that are directed through the gap between the movable contact and the fixed contact during the opening transition comprises a magnetic field generated by the permanent magnets.

[0011] In an example, the first permanent magnet is located at the end of the first arm of the yoke and the second permanent magnet is located at the end of the second arm of the yoke.

[0012] In an example, the magnetic system comprises at least one coil configured to carry current. The at least one coil is wound around at least one part of the yoke. The magnetic field with magnetic flux lines that are directed through the gap between the movable contact and the fixed contact during the opening transition comprises a magnetic field generated when current is carried by the at least one coil.

[0013] In an example, a coil of the at least one coil is wound around a part of the yoke between the first arm of the yoke and the second arm of the yoke.

[0014] In an example, a first coil of the at least one coil is wound around the first arm of the yoke and a second coil of the at least one coil is wound around the second arm of the yoke.

[0015] In an example, the at least one coil is electrically connected to the fixed contact.

[0016] In an example, the at least one coil is configured to carry at least a portion of the current that flows between the fixed contact and the movable contact during the opening transition.

[0017] In an example, the at least one coil is electrically connected to the movable contact.

[0018] In an example, the at least one coil is configured to carry at least a portion of the current that flows between the fixed contact and the movable contact during the opening transition.

[0019] In an example, the yoke comprises iron.

[0020] In an example, the switch system comprises a main path and a semiconductor path parallel to the main path. The vacuum interrupter is located in the main path, and in the closed configuration of the switch system is configured to carry current via the main path. During the opening transition the current commutes from the main path to at least the semiconductor path.

[0021] In an example, the switch system comprises a voltage limiting path parallel to the main path. During the opening transition the current commutes from the main path to the semiconductor path and the voltage limiting path.

[0022] In a second aspect, there is provided a medium voltage or high voltage switchgear comprising at least one switch system according to the first aspect.

[0023] The above aspects and examples will become apparent from and be elucidated with reference to the embodiments described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] Exemplary embodiments will be described in the following with reference to the following drawings:

Fig. 1 shows an example of a vacuum interrupter with a magnetic system;

Fig. 2 shows an example of the main components of a medium voltage hybrid DC switch or circuit breaker;

Fig. 3 shows a perspective view of the vacuum interrupter with the magnetic system as shown in Fig. 1, but with the ceramic insulator omitted;

Fig. 4 shows an example of a vacuum interrupter with a magnetic system;

Fig. 5 shows an example of a vacuum interrupter with a magnetic system; and

Fig. 6 shows an example of a vacuum interrupter with a magnetic system.

DETAILED DESCRIPTION OF EMBODIMENTS

[0025] A new medium voltage or high voltage switch system is now described. The new design utilizes that for quenching a DC arc between contacts of a vacuum interrupter, a magnetic field perpendicular to the current is used to increase the switching performance due to an increased arc voltage.

[0026] In an example a medium voltage, or high voltage switch system comprises a vacuum interrupter 10, and a magnetic system 50. The vacuum interrupter comprises a fixed contact 11 and a movable contact 12. In a closed configuration of the switch system the vacuum interrupter is configured to maintain the movable contact in contact with the fixed contact. In an opening transition of the switch system the vacuum interrupter is configured to move the movable contact away from the fixed contact. The magnetic system is configured to generate a magnetic field with magnetic flux lines that are directed through a gap between the movable contact and the fixed contact during the opening transition. An axis of the vacuum interrupter is directed through the centre of the fixed contact and through the centre of the movable contact, and wherein the magnetic flux lines are directed perpendicularly to the axis of the vacuum interrupter.

[0027] In an example, the magnetic system comprises a yoke structure 52. The yoke comprises a first arm and a second arm and ends of the first arm and second arm are located on opposite side of the axis of the vacuum interrupter.

[0028] In an example, the first arm of the yoke comprises a first permanent magnet 51 and the second arm of the yoke comprises a second permanent magnet 51. The yoke is configured such that the first permanent magnet and the second permanent magnet are positioned on opposite sides of the axis of the vacuum interrupter. The magnetic field with magnetic flux lines that are directed through the gap between the movable contact and the fixed contact during the opening transition comprises a magnetic field generated by the permanent magnets.

[0029] In an example, the first permanent magnet is located at the end of the first arm of the yoke and the second permanent magnet is located at the end of the second arm of the yoke.

[0030] In an example, the magnetic system comprises at least one coil 53 configured to carry current. The at least one coil is wound around at least one part of the yoke. The magnetic field with magnetic flux lines that are directed through the gap between the movable contact and the fixed contact during the opening transition comprises a magnetic field generated when current is carried by the at least one coil.

[0031] In an example, a coil of the at least one coil is wound around a part of the yoke between the first arm of the yoke and the second arm of the yoke.

[0032] In an example, a first coil of the at least one coil is wound around the first arm of the yoke and a second coil of the at least one coil is wound around the second arm of the yoke.

[0033] In an example, the at least one coil is electrically connected to the fixed contact.

[0034] In an example, the at least one coil is configured to carry at least a portion of the current that flows between the fixed contact and the movable contact during the opening transition.

[0035] In an example, the at least one coil is electrically connected to the movable contact.

[0036] In an example, the at least one coil is configured to carry at least a portion of the current that flows between the fixed contact and the movable contact during the opening transition.

[0037] In an example, the yoke comprises iron.

[0038] In an example, the switch system 60 comprises a main path 61 and a semiconductor path 62 parallel to the main path. The vacuum interrupter is located in the main path, and in the closed configuration of the switch system is configured to carry current via the main path. During the opening transition the current commutes from the main path to at least the semiconductor path.

[0039] In an example, the switch system comprises a voltage limiting path 63 parallel to the main path. During the opening transition the current commutes from the main path to the semiconductor path and the voltage limiting path.

[0040] In an example, the vacuum interrupter is axially symmetric.

[0041] In an example, the vacuum interrupter does not utilize an arcing chamber.

[0042] A medium voltage or high voltage switchgear can then comprise at least one switch system as described above.

[0043] The new medium voltage or high voltage switch system is now described in specific detail, where reference is made to Figs. 1-6. The new development enables a standard medium voltage vacuum interrupter to be utilized, where an external magnetic field is generated, to provide for medium voltage low-range load break switching of DC currents. The new development finds utility for any kind of switch where the vacuum interrupter carries the current when the switch is closed, and where an elevated arc voltage is desirable for commutating the current to a parallel arc quenching system for opening the circuit.

[0044] The vacuum interrupter, that can be a standard MV VI, can therefore be in general axially symmetric and does not require additional provisions like e.g. an arcing chamber. Thus, a MV VI can operate in a medium voltage situation in a manner comparable to a low voltage situation via utilization of the magnetic system.

[0045] Fig. 1 shows a sectional view of a vacuum interrupter 1 with an external magnetic system 50 to enhance the vacuum interrupter's performance. The vacuum interrupter 1 comprises a fixed contact 11, a movable contact 12, upper and lower lids 13, 14, bellows 15 and a ceramic insulator 16. The magnetic system 50 comprises two permanent magnets 51, driving magnetic flux in the direction indicated by the arrows, and an iron yoke 52 that is returning the magnetic flux back around the vacuum interrupter. The magnetic system 50 is arranged in a way that its magnetic flux passes through the area between the fixed contact 11 and movable contact 12, where an electrical arc will start burning between the contacts 11 and 12 when the vacuum interrupter is opening.

[0046] Fig. 2 shows the principal arrangement of the main components of a medium voltage hybrid DC switch or circuit breaker 60. A main path 61 with a vacuum interrupter 1 carries the nominal current with low losses. When the switch 60 is opening, the current has to commutate from the main path 61 to the semiconductor path 62 and to the voltage limiting path 63.

[0047] Fig. 3 shows the vacuum interrupter 1 as it is also shown in Fig. 1, but in a perspective view. The ceramic insulator 16 has been omitted so that the fixed contact 11 and movable contact 12 can be seen in their relative position to the magnetic system 50.

[0048] Fig. 4 shows an alternative way to generate magnetic flux in the magnetic system 50. Here, a coil 53 is connected in series to the vacuum interrupter as part of the main current path 61 of the medium voltage (MV) DC hybrid switch or circuit breaker 60. No permanent magnets 51 are required in this embodiment, as the magnetic flux perpendicular to the arc is generated by the main current itself. The movable stem of the vacuum interrupter connected to the movable contact 12 is electrically connected to one terminal of the coil 53 by a contact system 17, that may be a sliding contact system or a flexible conductor.

[0049] Fig. 5 shows a combination of flux generation by permanent magnets 51 and coil 53.

[0050] Figure 6 shows an embodiment where two coils 53 are arranged at the ends of the arms of the yoke 52, positioned closely to the vacuum interrupter.

[0051] In Figs. 1 and 3, the magnetic field is directed perpendicular to the gap and the arc, so that an arc would be driven by the Lorentz force towards the observer when the technical direction of the current is from the fixed contact 11 to the movable contact 12, and away from the observer when the current is running vice versa. Due to that driving, the arc is elongated and the arc voltage is increased. This effect can be used to 1) switch off load currents when the driving voltage of the circuit in the low MV range 2) ensure the commutation of the current from the main path 61 to the semiconductor path 62 and the voltage limiting path 63. Previously in some concepts of MV DC CBs or current limiters, for this purpose a separate commutation switch in series to the VI is required, but that can now be omitted. As the vacuum interrupter can be a standard vacuum interrupter it can be axially symmetrical. This means that there is no preferred direction for the current; the principle is working for any direction of the current. Also, additional provisions like an acring chamber are not foreseen in the standard MV VI.

[0052] In Fig. 4 a coil 53 is used for the same effect as provided by the permanent magnets 53, to induce a magnetic field perpendicularly to the gap. Also here, the principle will work for both directions of the main current. Alternatively, also two or more coils can be used; see Fig. 6.

[0053] Permanent magnets and coil based induction can both be used together to generate an appropriate magnetic field. The combination shown in Fig. 5 can generate an effective magnetic field, but here a certain direction of the main current has to be respected so that the magnetic flux from the coil 53 is in the same direction as the flux of permanent magnets 51, i.e. flux from 51 and from 53 are added and not subtracted. However, this is not difficult to achieve from standard electromagnetic knowledge.

[0054] Fig. 6 shows that two coils 53 are arranged in a way that their flux is pointing directly towards the contacts 11, 12. For very high currents, the effect is that more flux can reach the arcing area even when the iron yoke is already saturated. The embodiment shown in Fig 6 can also be equipped with permanent magnets 51.

[0055] The new development has shown that the arc voltage of a standard vacuum interrupter can be increased from about 50V to several hundred volts with peak voltages above 1000V.

Reference numerals

[0056]

- 1 VI with enhanced performance
- 10 Vacuum Interrupter (VI)
- 11 Fixed contact of VI
- 12 Movable contact of VI 1
- 3 Upper lid of VI
- 14 Lower lid of VI
- 15 Bellows of VI
- 16 Ceramic insulator of VI
- 17 Contact system of VI
- 50 Magnetic system
- 51 Permanent magnet of 50
- 52 Iron yoke of 50
- 53 Coil of 50
- 60 MV hybrid DC switch or CB
- 61 Main path of 60 with a VI 1
- 62 Semiconductor path of 60
- 63 Voltage limiting path of 60

[0057] While the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive. The invention is not limited to the disclosed embodiments. Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing a claimed invention, from a study of the drawings, the disclosure, and the dependent claims.

Claims

1. A low voltage, medium voltage, or high voltage switch system, comprising:

- a vacuum interrupter (10); and
- a magnetic system (50);

wherein the vacuum interrupter comprises a fixed contact (11) and a movable contact (12);
wherein in a closed configuration of the switch system the vacuum interrupter is configured to maintain the movable contact in contact with the fixed contact;
wherein in an opening transition of the switch system the vacuum interrupter is configured to move the movable contact away from the fixed contact; and
wherein the magnetic system is configured to generate a magnetic field with magnetic flux lines that are directed through a gap between the movable contact and the fixed contact during the opening transition; and
wherein an axis of the vacuum interrupter is directed through the centre of the fixed contact and through the centre of the movable contact, and wherein the magnetic flux lines are directed perpendicularly to the axis of the vacuum interrupter.

2. Switch system according to claim 1, wherein the magnetic system comprises a yoke structure (52), wherein the yoke comprises a first arm and a second arm and wherein the ends of the first arm and second arm are located on opposite side of the axis of the vacuum interrupter.

3. Switch system according to claim 2, wherein the first arm of the yoke comprises a first permanent magnet (51) and the second arm of the yoke comprises a second permanent magnet (51), wherein the yoke is configured such that the first permanent magnet and the second permanent magnet are positioned on opposite sides of the axis of the vacuum interrupter, and wherein the magnetic field with magnetic flux lines that are directed through the gap between the movable contact and the fixed contact during the opening transition comprises a magnetic field generated by the permanent magnets.

4. Switch system according to claim 3, wherein the first permanent magnetic is located at the end of the first arm of the yoke and the second permanent magnet is located at the end of the second arm of the yoke.

5. Switch system according to any of claims 2-4, wherein the magnetic system comprises at least one coil (53) configured to carry current, and wherein the at least one coil is wound around at least one part of the yoke, and wherein the magnetic field with magnetic flux lines that are directed through the gap between the movable contact and the fixed contact during the opening transition comprises a magnetic field generated when current is carried by the at least one coil.

6. Switch system according to claim 5, wherein a coil of the at least one coil is wound around a part of the yoke between the first arm of the yoke and the second arm of the yoke.

7. Switch system according to claim 5, wherein a first coil of the at least one coil is wound around the first arm of the yoke and a second coil of the at least one coil is wound around the second arm of the yoke.

8. Switch system according to any of claims 5-7, wherein the at least one coil is electrically connected to the fixed contact.

9. Switch system according to claim 8, wherein the at least one coil is configured to carry at least a portion of the current that flows between the fixed contact and the movable contact during the opening transition.

10. Switch system according to any of claims 5-7, wherein the at least one coil is electrically connected to the movable contact.

11. Switch system according to claim 10, wherein the at least one coil is configured to carry at least a portion of the current that flows between the fixed contact and the movable contact during the opening transition.

12. Switch system according to any of claims 2-11, wherein the yoke comprises iron.

13. Switch system according to any of claims 1-12, wherein the switch system comprises a main path (61) and a semiconductor path (62) parallel to the main path, and wherein the vacuum interrupter is located in the main path, and wherein in the closed configuration of the switch system is configured to carry current via the main path, and wherein during the opening transition the current commutes from the main path to at least the semiconductor path.

14. Switch system according to claim 13, wherein the switch system comprises a voltage limiting path (63) parallel to the main path, and wherein during the opening transition the current commutes from the main path to the semiconductor path and the voltage limiting path.

15. A low voltage, medium voltage or high voltage switchgear comprising at least one switch system according to any of claims 1-14.

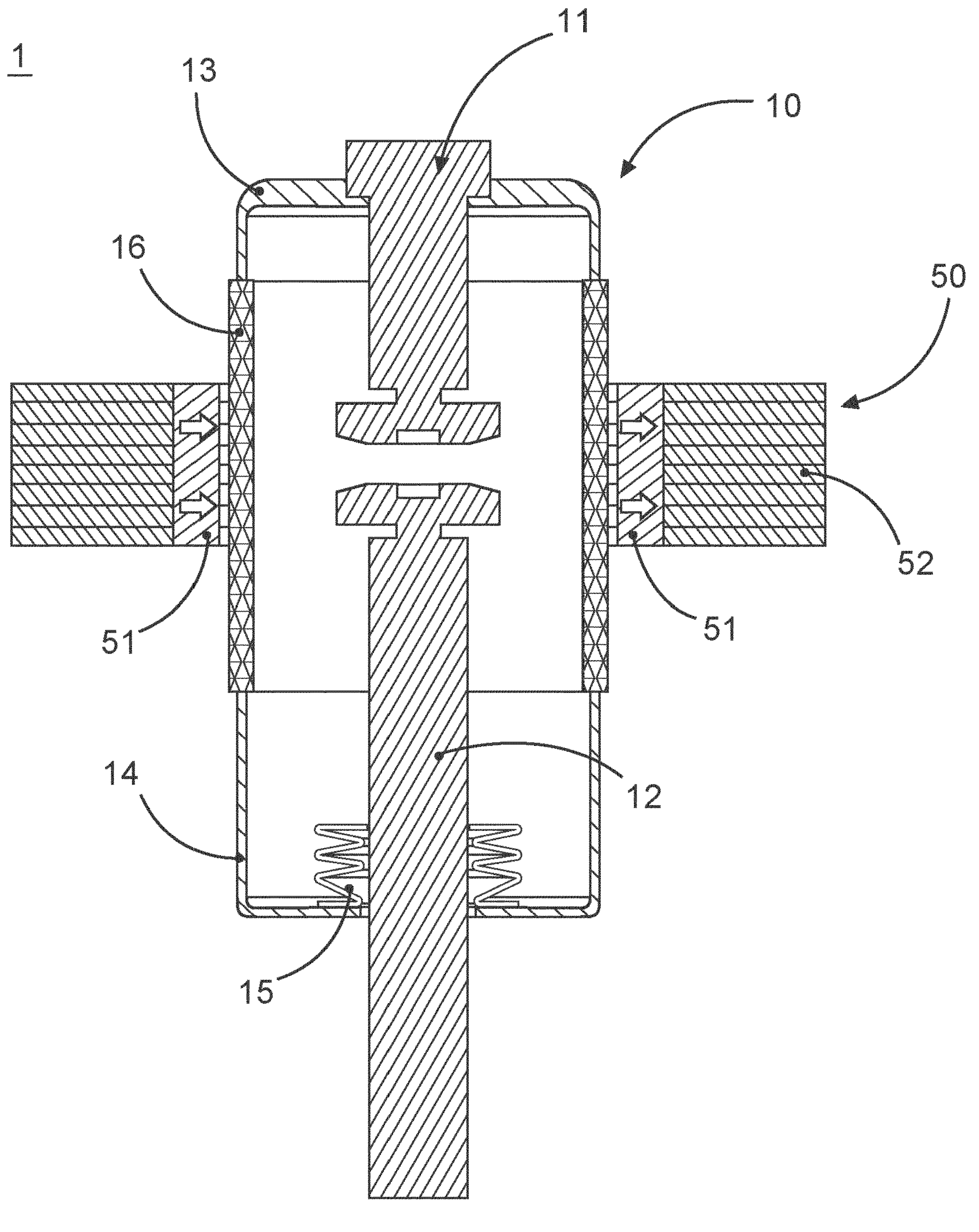

Figure 1

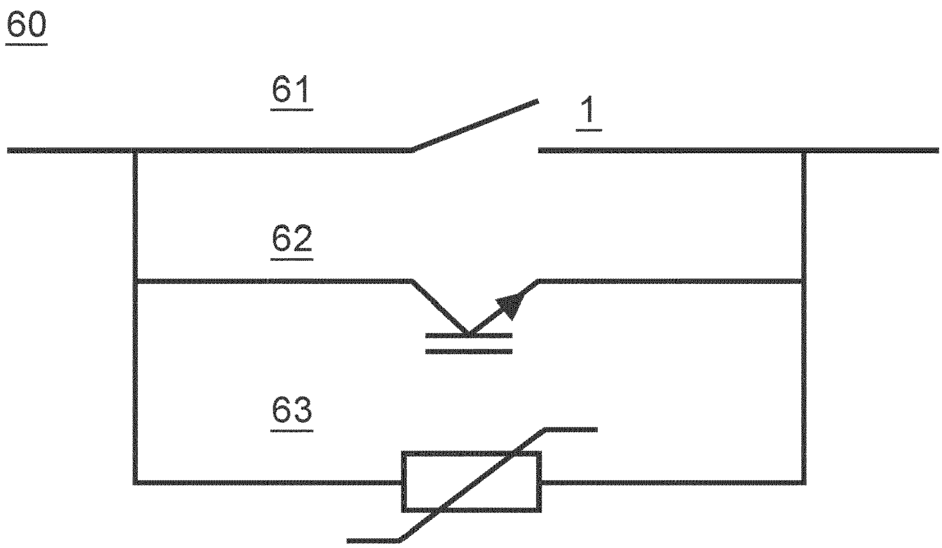

Figure 2

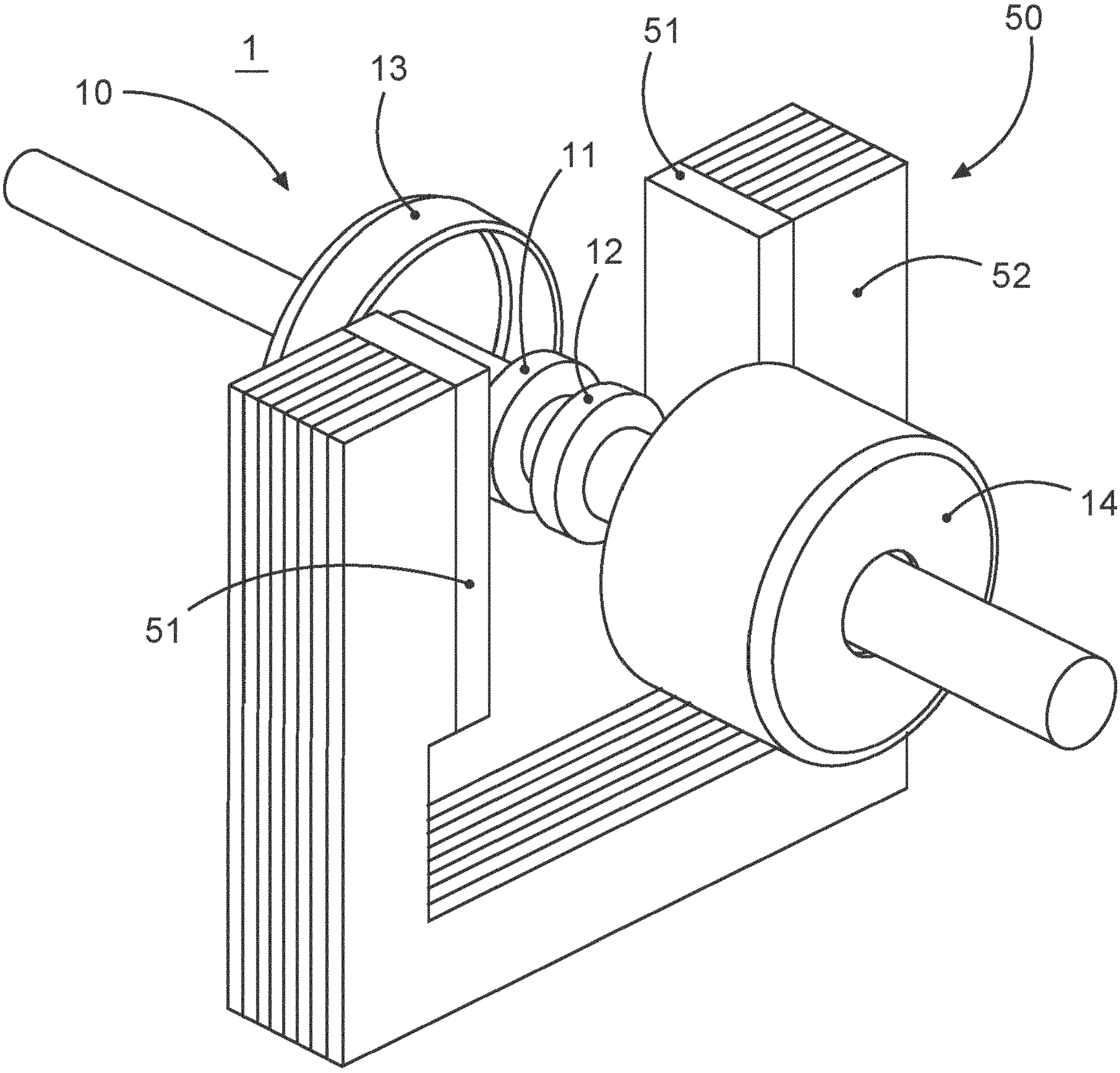

Figure 3

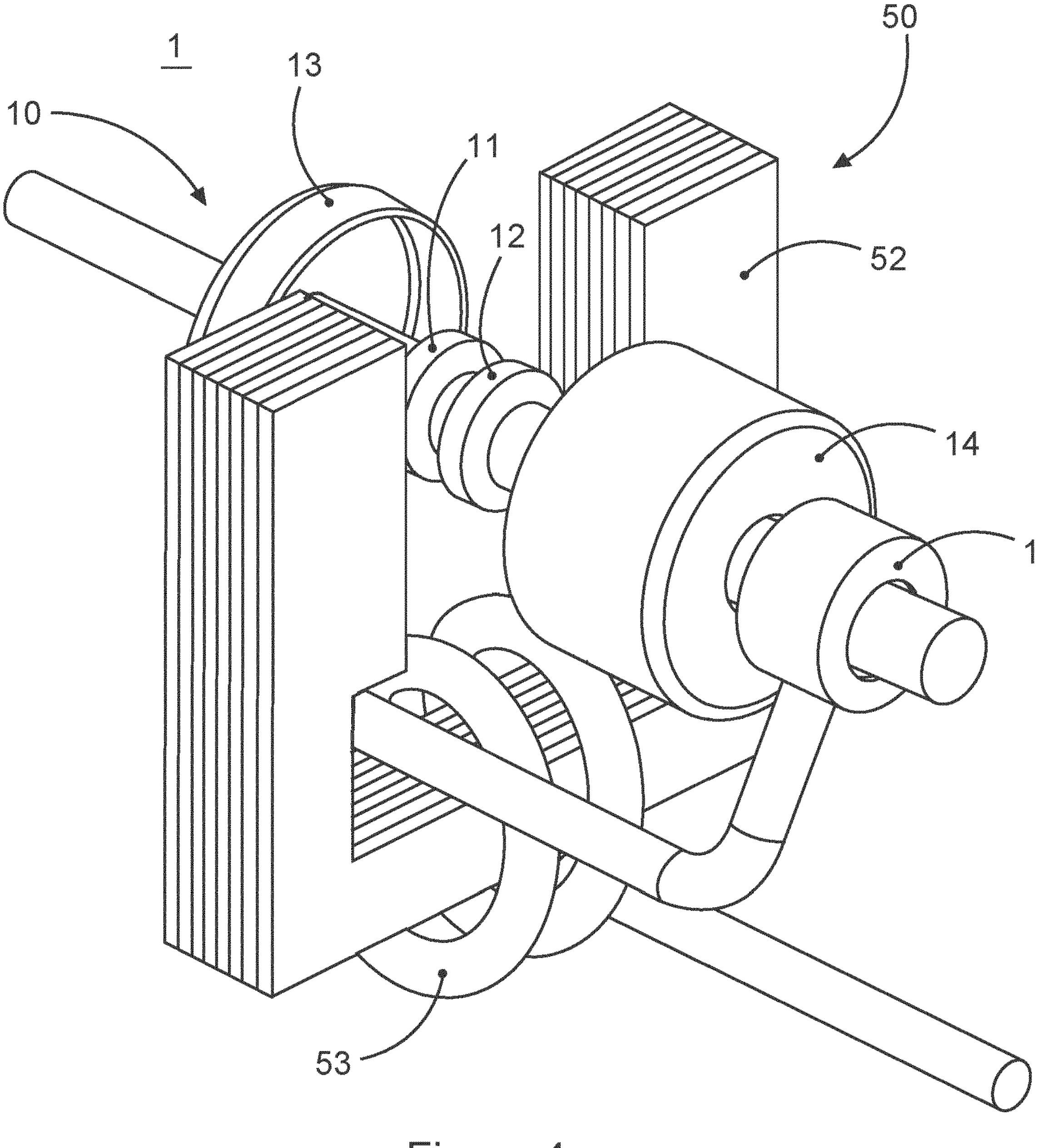

Figure 4

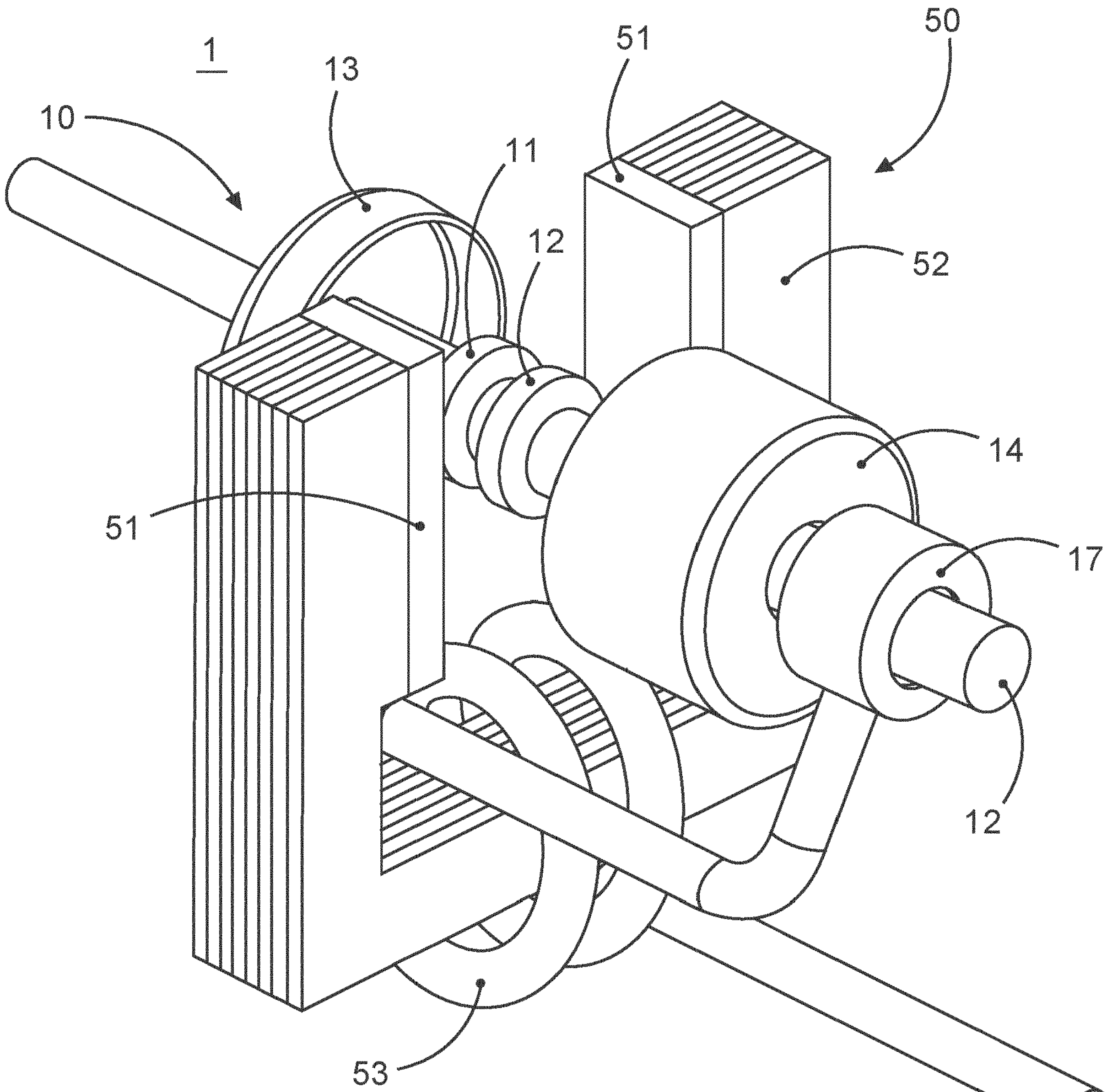

Figure 5

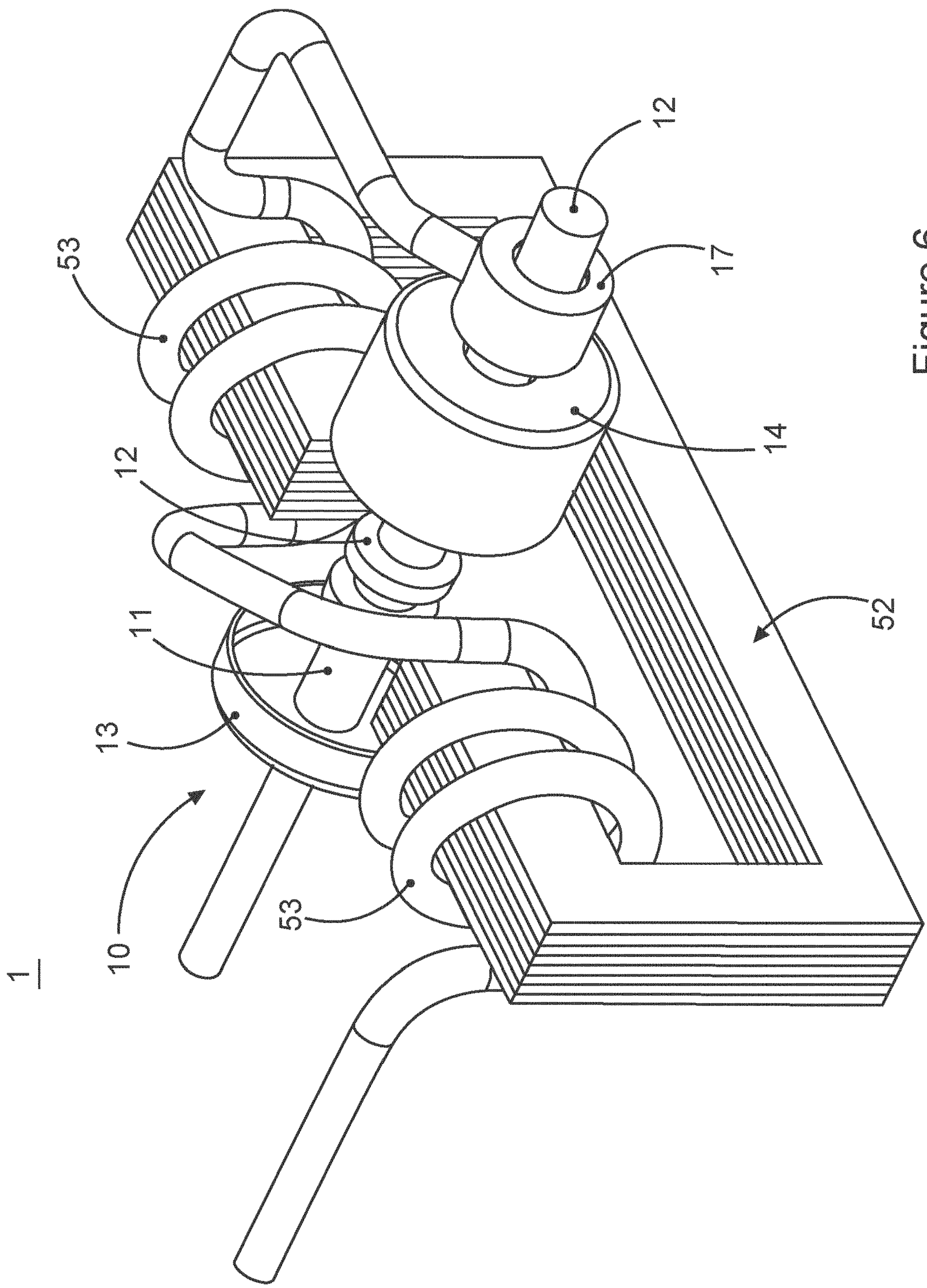

Figure 6

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EUROPEAN SEARCH REPORT

Application Number
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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	1 December 2022	Bauer, Rodolphe

CATEGORY OF CITED DOCUMENTS

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EUROPEAN SEARCH REPORT

Application Number
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DOCUMENTS CONSIDERED TO BE RELEVANT

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