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(54) **COMPACT-STRUCTURE THREE-POLE APPARATUS FOR ELECTRIC STATIONS**

KOMPAKT DREIPOLIGES ELEKTRISCHES SCHALTFELD FÜR ELEKTRISCHE STATIONEN

APPAREIL TRIPOLAIRE A STRUCTURE COMPACTE POUR STATIONS ELECTRIQUES

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Description

[0001] The present invention refers to a compact-structure three-pole apparatus for electric stations, in particular medium-voltage ones.

[0002] At present, the isolator and circuit-breaker devices present in medium-voltage electric stations comprise a circuit breaker which enables disconnection of the direct line for supplying the loads, a line-isolating switch, connected in series to the feeder, which enables physical interruption of the line (for instance, by means of a mechanical control from outside) after the circuit breaker has opened the circuit, so as to ensure physical separation of the power busbars from the devices set downstream therefrom, and an earthing switch which can be operated from outside and is able to connect the line directed to user loads in order to prevent further risks due, for example, to discharges or induced currents. A compact-structure three-pole apparatus having the above-mentioned features and forming the base for the pre-characterising part of claim 1 is known, for example from DE 4 445 172-A.

[0003] However, in traditional three-pole apparatus the movable parts which disconnect the live line and which thus give rise to the formation of an electric arc upon actuation mainly operate with insulation in air and consequently are subject to more or less serious oxidation and degradation, according to the environmental conditions and may give rise to electric arcs. The electric arc that is formed whenever these devices are operated also causes wearing-out of the contacts and degradation of the insulators on account of ionization phenomena.

[0004] All this leads to the need to carry out periodic overhaul of the entire system, with consequent maintenance expenses and the need to put the switchboard out of use for given periods of time.

[0005] In addition, the casing or switchboard that encloses known isolator and circuit-breaker devices has overall dimensions that it would be desirable to reduce. In fact, in traditional apparatus, only the circuit breaker works in vacuum conditions or in a protective gas (for example, SF_6) atmosphere, and hence the switchboard usually comprises three devices (two isolating switches and one circuit breaker), with the inevitable consequences represented by considerable encumbrance in terms of the dimensions of the container and by the need for a large supply of gas for protecting all the devices.

[0006] A purpose of the present invention is therefore to overcome the problems mentioned above, and in particular to provide a three-pole device for electric stations which has an extremely compact structure and is designed to enclose, within decidedly reduced overall dimensions as compared to the known art, whatever is normally contained in an electric switchboard with busbar section-disconnector device, circuit breaker and earthing switch.

[0007] Another purpose of the present invention is to provide a three-pole apparatus for electric stations which has a compact structure and will guarantee, for the devices present inside, a longer electrical service life as compared to the one achieved by traditional apparatus.

[0008] A further purpose of the present invention is to provide a compact-structure three-pole apparatus for electric stations, which is particularly reliable, effective and safe and will guarantee a limited wearing-out of the parts over time as compared to the known art.

[0009] Not the least important purpose of the present invention is to provide a three-pole apparatus for electric stations affording contained costs by virtue of the advantages achieved and without requiring the use of complex or particularly costly technologies.

[0010] The above purposes are achieved by a compact-structure three-pole apparatus for electric stations, in particular medium-voltage stations, as specified in Claim 1, to which the reader is referred for reasons of brevity.

[0011] Advantageously, this type of compact apparatus with stainless steel casing encloses practically whatever is contained in an electric panel or switchboard, with an isolating switch, circuit breaker and earthing switch. The isolating device, which functions as line/earth changeover switch, is set in an environment protected by gas, in particular sulphur hexafluoride (SF_6), which also performs the dielectric function for the conductors located inside the casing itself.

[0012] A vacuum circuit breaker which is placed downstream of the isolating device, enables its use both as a line circuit breaker for protecting the line and as an earthing switch with closing capability.

[0013] The solution of using the vacuum circuit breaker for protecting the line or for earthing the cable means that a very low pressure of the SF_6 gas can be used in the container (approximately 0.1 bar). The gas has the sole function of guaranteeing the dielectric shielding and stability of the internal components.

[0014] Furthermore, the extremely small amount of SF_6 gas used in the apparatus, which never comes into contact with the electric arc, maintains its properties intact over time, thus ensuring a longer electrical service life as compared to an SF_6-gas circuit breaker or a circuit breaker of an air/vacuum type.

[0015] An apparatus is obtained having decidedly reduced overall dimensions as compared to similar known apparatus, and one in which all those parts that are involved in the interruption of electric current and that, at the moment of actuation, generate an electric arc are sealed in a vacuum envelope in such a way that the protective gas does not undergo any degradation by contact with the electric arc, with consequent greater durability of the apparatus.

[0016] In addition, the movable parts, which are operated once power supply is interrupted, are protected in a gas atmosphere, and this enables elimination of the phenomena of degradation of the conductors and insu-

lators.

[0017] Finally, the configuration adopted makes it possible to eliminate an isolating device because the very function of the earthing switch is implemented in the busbar section-disconnector/changeover switch. In this way, a drastic reduction is obtained in the overall dimensions of the entire apparatus.

[0018] Further purposes and advantages of the present invention will emerge clearly from the ensuing description and from the annexed drawings, which are provided purely to furnish explanatory and non-limiting examples, and in which:

- Figure 1 is a front schematic view of a compact-structure three-pole apparatus for electric stations according to the present invention;
- Figure 2 is a perspective view of an isolating device installed inside the three-pole apparatus of Figure 1;
- Figure 3 is a schematic longitudinal cross-sectional view of the isolating device of Figure 2 in the circuit-opening position;
- Figure 4 is a schematic longitudinal cross-sectional view of the isolating device of Figure 2 in the circuit-closing position;
- Figure 5 is a partial and partially sectional schematic view of the isolating device of Figure 2 according to a cross-sectional plane orthogonal to the cross-sectional plane illustrated in Figures 3 and 4;
- Figure 6 shows a front view of a permanent-magnet actuator which is connected to a vacuum circuit breaker installed inside the three-pole apparatus of Figure 1 according to the present invention; and
- Figure 7 a schematic longitudinal cross-sectional view of the actuator of Figure 6.

[0019] With particular reference to the above figures, the number 20 designates a protective metal casing of the three-pole apparatus according to the present invention, usable in medium-voltage (MV) distribution systems for electric stations, in particular of a primary type.

[0020] By "medium voltage" is meant in general a voltage that may be derived from the remote transformation of a high-voltage line, the said medium voltage being of the order of 10-20 kV, and in any case within the 1 kV to 52 kV range.

[0021] With particular reference to Figure 1, the casing 20 has a substantially parallelepipedal shape with vertical development and usually comprises three areas arranged transversely, and, in particular, at least one first, bottom, area 21, which houses the circuit-breaker and isolator devices of the apparatus according to the invention, a second, intermediate, area 22, where the power busbars are arranged to which the outputs to the loads are to be connected, and a top area 23, which has inside a number of compartments and service lines.

[0022] The bottom area 21 comprises, at the front, at least one door 24, hinged at the side, which has a first plate 25 identifying the electric line, a plate 26 representing the electric wiring diagram of the apparatus, and possibly a window which may be used by the user for viewing directly the position of the busbar section disconnectors and the earthing switch.

[0023] The three-pole isolating device 1, which is set inside the casing 20, in turn comprises a busbar section-disconnector and earthing-switch device 2 set inside each insulator 11, and a vacuum circuit breaker, designated by 3, enclosed inside a hermetically sealed container 33, preferably made of stainless steel and provided with appropriate contacts 4 arranged on the bottom for connection to the external lines. The said busbar section-disconnector and earthing-switch device 2 is movable between one position, in which it connects the circuit breaker 3 to an electrical contact 5 connected to the medium-voltage or high-voltage feeder 6 (Figure 4), and a position in which the circuit breaker 3 is connected to an earth contact 7. The output of the circuit breaker 3 is connected to the line directed to the loads by means of the contacts 8. The busbar section-disconnector and earthing-switch device 2 and the vacuum circuit breaker 3 may be operated from outside by means of controls which act on the manoeuvring shafts 9 and 10 respectively of the isolating switch and of the circuit breaker.

[0024] In particular, the vacuum circuit breaker 3 may be equipped with mechanical control devices, such as levers and springs, or permanent-magnet devices, and in particular may include controls operated by springs with energy reserve, with or without motor and opening and closing coil, or else permanent-magnet controls (such as the one represented in Figures 6 and 7) used with opening and closing coil.

[0025] The interchangeability of the controls means that various requirements and specifications regarding opening times, closing times and electrical-life times may be met.

[0026] The permanent-magnet actuator, designated by 12 in Figure 6, has been developed to optimize the features of vacuum circuit breakers 3 for voltages of up to 36 kV; its operating characteristics, force and speed of opening and closing approach very closely those of the vacuum circuit breaker 3. The magnetic actuator 12 may work within a force range of between 1000 N and 13000 N in order to meet the requirements of the circuit breaker 3.

[0027] In addition, the magnetic actuator 12 requires a very limited supply of energy and, in order to carry out operations of opening and closing, a current pulse having a maximum duration of 100 ms is sufficient. Normally, to carry out an opening operation, 30 ms are sufficient, whereas for a closing operation 50 ms are sufficient.

[0028] In preferred, but non-limiting, embodiments of the invention the magnetic actuator 12 comprises a solid reinforcement 13, made of solid steel, designed to increase the characteristics of the welding, a screen 32 for shielding the magnet from the reinforcement 13, at

least one magnet 331 designed to supply the closing and opening force, a section 44 made of rolled iron, designed to reduce the current losses and improve the operating times, a set of coils 55, which supply the manoeuvring energy in each direction, a manoeuvring lever 66 for connection to the lever mechanisms of the circuit breaker 3, an auxiliary lever 77 for connection to the manual operating cam and to the auxiliary contacts, and a set of blocking supports 68 designed to guide the control.

[0029] The apparatus according to the present invention, with permanent-magnet control, has been developed to increase the safety of the compartment, to facilitate commissioning manoeuvres, and to reduce the overall dimensions and the weight with respect to the dimensions and the weight of the compartments that are built using traditional technologies and that contain a busbar section-disconnector device, an earthing switch and a circuit breaker which are physically separate from one another.

[0030] Operation of the compact-structure three-pole apparatus for electric stations, according to the present invention, is basically as described in what follows.

[0031] With the isolating switch 2 closed on the line contact 5 and the circuit breaker 3, which is in series with the isolating switch 2, in a closing position (Figure 4), the current coming from the feeder 6 is connected to the line 8 directed to the load.

[0032] In order to bring about electrical disconnection of the apparatus for the purpose of carrying out interventions, repairs or maintenance, first the circuit breaker 3 is operated for opening the circuit by acting, for example, on a manual control 10. Next, only after the circuit breaker 3 has opened the circuit is it possible to operate the control 9 to open the isolating device 2 on the line contact 5 and bring it to close on the earth contact 7 (Figure 3).

[0033] At this point, the circuit breaker 3 is operated again to close the circuit, so connecting to earth 7 the line 8 leading to the load in order to be able to proceed to opening the cable compartment and enable execution of the required maintenance operations. To restore the feeder 6, the circuit breaker 3 is first operated to open the circuit; next, the busbar section-disconnector and earthing switch device 2 is changed over onto the line contact 5, and then the circuit breaker 3 is operated to close the circuit.

[0034] In practice, the positions of the isolating device 2 and the circuit breaker 3 may be as follows:

- circuit breaker 3 in the circuit-closed position with the busbar section-disconnector device 2 in the closing position on the busbar contact 5 (switchboard in use);
- circuit-breaker 3 in the circuit-open position with the busbar section-disconnector device 2 in the closing position on the earth contact 7 (intermediate position);
- circuit breaker 3 in the circuit-closed position with the busbar section-disconnector device 2 in the closing position on the earth contact 7 (switchboard not in use and possibility of gaining access to the internal devices for maintenance or replacement of parts).

[0035] Finally, to guarantee operator safety and prevent possible manoeuvring errors, additional safety devices of a known type are provided, which are designed to prevent any manoeuvre unless the immediately preceding manoeuvre envisaged by the procedure has been duly completed.

[0036] In practice, the control of the apparatus according to the present invention operates with two separate and mechanically interlocked shafts, one for the line/earth selector (represented by the controls 9 and 10) and one for the vacuum circuit breaker 3. The mechanical interlock located on the manoeuvring shafts enables operation only in the correct sequence, unlike what takes place in compartments built using traditional technology, i.e., where the circuit breaker is separate from the isolating switch and the interlock between the two is performed by means of a key blocking mechanism.

[0037] Finally, according to the present invention, a panel for containing the apparatus is as a whole obtained, which presents an overall width ranging between 375 mm and 750 mm and a depth of 900 mm, whereas at present the overall dimensions of a traditional panel with circuit breaker are 750 mm (width) by 1150 mm (depth). Furthermore, the weight of the panel is reduced to approximately 40-70% of a conventional panel.

[0038] The characteristics, as well as the advantages, of the three-pole apparatus for electric stations, which forms the subject the present invention, emerge clearly from the foregoing description.

[0039] In particular, the advantages are the following:

- overall dimensions that are modest and smaller than those of known switchboards, given that the earthing switch is eliminated (its function being performed by the busbar section-disconnector and earthing-switch device designated by 2 in the Figures), whilst the remaining devices are incorporated within an insulator in a protective-gas atmosphere, and the movable parts designed for interrupting the load or the short-circuit are sealed inside a vacuum envelope;
- use of the protective gas only for electrical-insulation functions (the gas is kept in a state of slight overpressure, for example 0.1 bar, with respect to the environment);
- interruption of the rated currents or the short-circuit currents with a vacuum circuit breaker;
- capability of closing on the earth circuit carried out by a vacuum circuit breaker;
- elimination of the degradation and pollution of the

gas, in so far as it never comes into contact with the electrical arc; and

- possibility of operating the circuit breaker both via a permanent-magnet control and via a traditional control operated by a spring with energy reserve.

[0040] Finally, it is clear that numerous variations may be made to the three-pole apparatus for electrical stations according to the present invention, without thereby departing from the principles of novelty inherent in the inventive idea, as it is likewise clear that, in the practical implementation of the invention, the materials, shapes and dimensions of the items illustrated may be any whatsoever according to the requirements, and the said items may be replaced with others that are technically equivalent, without departing from the scope, as defined by the claims.

Claims

1. A compact-structure three-pole apparatus for electric stations, of the type comprising a series of insulators (11) which enclose at least a busbar section-disconnector device designed for connection with a feeder (6), at least one circuit breaker (3), and at least one earthing switch, wherein said circuit breaker (3) is sealed in a vacuum envelope and is positioned in series with a changeover isolating device (2) which is movable between a first position in which it connects said circuit breaker (3) to a contact (5) of the feeder (6), and a second position in which it connects said circuit breaker (3) to an earth contact (7),
   characterized in that said section-disconnector device, said circuit breaker (3), said earthing switch and said changeover isolating device (2) are all enclosed inside a metal casing (33) said casing (33) being provided with insulators (11), which are placed in correspondence with the input and output voltage terminals of the three-pole apparatus.

2. A three-pole apparatus according to Claim 1, **characterized in that** said circuit breaker (3) is set downstream of said isolating device (2) and enables its use both as an feeder disconnector, for protecting the feeder (6), and as an earthing switch with closing capability.

3. A three-pole apparatus according to Claim 1, **characterized in that** said protective gas is kept at a pressure slightly higher than atmospheric pressure.

4. A three-pole apparatus according to Claim 1, **characterized in that** said isolating device (2) and said circuit breaker (3) are actuated from outside the apparatus by means of control devices, which act on manoeuvring shafts (9, 10) of said isolating device (2) and of said circuit breaker (3).

5. A three-pole apparatus according to Claim 1, **characterized in that** said circuit breaker (3) is equipped with mechanical control devices or permanent-magnet devices.

6. A three-pole apparatus according to Claim 5, **characterized in that** said permanent-magnet devices comprise at least one magnetic actuator (12) including a solid reinforcement (13), a screen (32) for shielding a magnet (33) designed to provide a closing and an opening force, a section (44), made of rolled iron, designed to reduce the current losses and improve the operating times, a series of coils (55) which supply energy in each direction, a manoeuvring lever (66) for connection to said circuit breaker (3), an auxiliary lever (77) for connection to manual operating cams or to auxiliary contacts, and a series of supports (68) for blocking and guiding said control devices.

Patentansprüche

1. Kompakt dreipoliges elektrisches Schaltfeld für elektrische Stationen in einer Ausbildung, die eine Reihe von Isolatoren (11) umfaßt, die wenigstens einen sammelschienenleiterartigen Feldunterbrecher aufweisen, der dazu bestimmt ist, eine Verbindung mit der Stromzuleitung (6) herzustellen, und mit zumindest einem Leistungsschalter (3) und zumindest einem Erdungsschalter, wobei der Leistungsschalter (3) in einer Vakuumumhüllung abgedichtet angeordnet ist und in Reihe mit einer Umschaltisolationsvorrichtung (2) positioniert ist, welche beweglich zwischen einer ersten Stellung, in der diese den Leistungsschalter mit einem Kontakt (5) der Stromzuleitung (6) leitend verbindet, und einer zweiten Stellung, in der diese den Leistungsschalter (3) zu einem Erdungsschalter (7) verbindet, gelegen ist, **dadurch gekennzeichnet, daß** der Feldunterbrecher, der Leistungsschalter (3), der Erdungsschalter und die Umschaltisolationsvorrichtung (2) alle in einem Metallgehäuse (33) untergebracht sind, wobei das Gehäuse (33) mit Isolatoren (11) versehen ist, die den Eingangs- und Ausgangsspannungsanschlüssen des dreipoligen elektrischen Schaltfeldes zugeordnet sind.

2. Dreipoliges elektrisches Schaltfeld nach Anspruch 1, dadurch gekennzelchnet, daß der Leistungsschalter (3) stromabwärts der Isolationsvorrichtung (2) angeschlossen ist und eine Nutzung sowohl als die Stromzuleitung (6) schützender Stromzuteitungsunterbrecher als auch als Erdungsschalter mit Schlleßvermögen ermöglicht.

3. Dreipoliges elektrisches Schaltfeld nach Anspruch 1, **dadurch gekennzeichnet, daß** das Schutzgas bei leicht über atmosphärischem Druck liegendem Druck gehalten wird.

4. Dreipoliges elektrisches Feld nach Anspruch 1, **dadurch gekennzeichnet, daß** die Isolationsvorrichtung (2) und der Leistungsschalter (3) von außerhalb des Schaltfeldes mit Hilfe von auf Manöverschäften (9, 10) der Isolationsvorrichtung (2) und des Leistungsschalter (3) reagierenden Steuervorrichtungen gesteuert werden.

5. Dreipoliges elektrisches Schaltfeld gemäß Anspruch 1, **dadurch gekennzeichnet, daß** der Leistungsschalter (3) mit mechanischen Steuerungsvorrichtungen oder Dauermagnetvorrichtungen ausgestattet ist.

6. Dreipoliges elektrisches Schaltfeld nach Anspruch 5, **dadurch gekennzeichnet, daß** die Dauermagnetvorrichtungen zumindest einen magnetischen Schalter (12) mit einer festen Verstärkung (13), einem Entstörschirm (32) zum Abschirmen eines eine Schließ- und Öffnungsfunktion ausführenden Magneten (331), einem aus gewalztem Eisen bestehendem sowie die Stromverluste minimierenden und die Betriebszeit optimierenden Feld (44), einer Reihe von die Energie in jede Richtung verteilenden Spulen (55), einem Manövrlerhebel (66) zur Verbindung mit dem Leistungsschalter (3), einem Hilfshebel (77) zur Verbindung mit von Hand gesteuerten Nocken oder mit Hilskontakten, und einer Reihe von Trägern (68) zum Blockleren und Führen der Steuervorrichtungen, umfassen..

Revendications

1. Appareil tripolaire à structure compacte pour des installations électriques du type comprenant une série d'isolants (11) qui comprennent au moins un dispositif sectionneur de tronçonnement de barres conçu pour la connexion avec une ligne d'alimentation (6), au moins un disjoncteur (3), et au moins un interrupteur de mise à la terre, dans lequel ledit disjoncteur (3) est scellé dans une enveloppe sous-vide et est positionné en série avec un dispositif d'isolation de la commutation (2) qui est mobile entre une première position dans laquelle il raccorde ledit disjoncteur (3) à un contact (5) de la ligne d'alimentation (6) et une seconde position dans laquelle il raccorde ledit disjoncteur (3) à un contact à la terre (7), **caractérisé en ce que** ledit dispositif sectionneur de tronçonnement de barres, ledit disjoncteur (3), ledit interrupteur de mise à la terre et ledit dispositif d'isolation de la commutation (2) sont tous contenus à l'Intérieur d'un boîtier métallique (33), ledit boîtier (33) étant prévu avec des isolants (11), qui sont placés en correspondance avec les terminaux de tension d'entrée et de sortie de l'appareil tripolaire.

2. Appareil tripolaire selon la revendication 1, **caractérisé en ce que** ledit disjoncteur (3) est fixé en aval dudit dispositif d'isolation (2) et permet son utilisation à la fols comme un sectionneur de ligne pour protéger la ligne d'alimentation (6) et comme un interrupteur de mise à la terre avec la capacité de fermeture.

3. Appareil tripolaire selon la revendication 1, **caractérisé en ce que** ledit gaz protecteur est conservé à une pression légèrement plus élevée que la pression atmosphérique.

4. Appareil tripolaire selon la revendication 1, **caractérisé en ce que** ledit dispositif isolant (2) et ledit disjoncteur (3) sont actionnés de l'extérieur de l'appareil au moyen de dispositifs de commande, qui agissent sur les arbres de manoeuvres (9, 10) dudit dispositif d'isolation (2) et dudit disjoncteur (3).

5. Appareil tripolaire selon la revendication 1, **caractérisé en ce que** ledit disjoncteur (3) est équipé de dispositifs de commande mécanique ou des dispositifs à aimant permanent.

6. Appareil tripolaire selon la revendication 5, **caractérisé en ce que** lesdits dispositifs à aimant permanent comprennent au moins un actionneur magnétique (12) contenant un renforcement solide (13), un blindage (32) pour blinder un aimant (331) conçu pour fournir une force de fermeture et d'ouverture, un tronçon (44) constitué en acier laminé, conçu pour réduire les pertes de courant et améliorer les temps de fonctionnement, une série de bobines (55) qui fournissant de l'énergie dans chaque direction, un levier de manoeuvre (66) pour la connexion audit disjoncteur (3), un levier auxiliaire (77) pour la connexion aux cames de commande manuelle ou aux contacts auxiliaires, et une série de supports (68) pour verrouiller et guider lesdits dispositifs de commande.

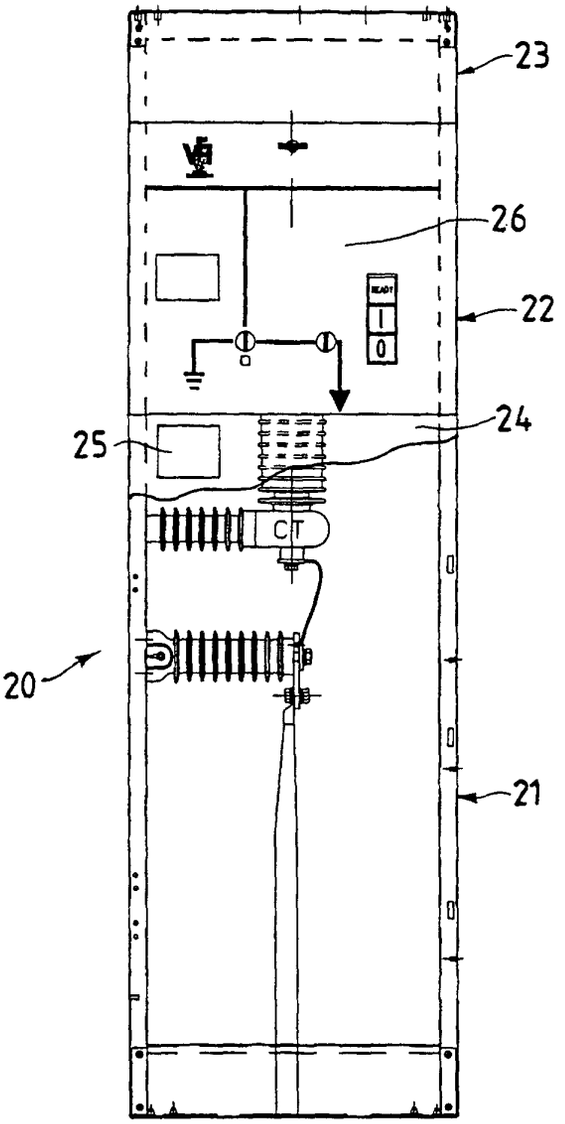

Fig.1

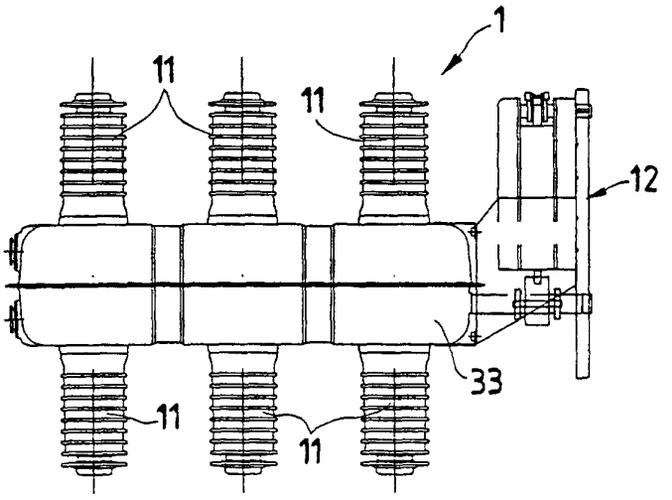

Fig.2

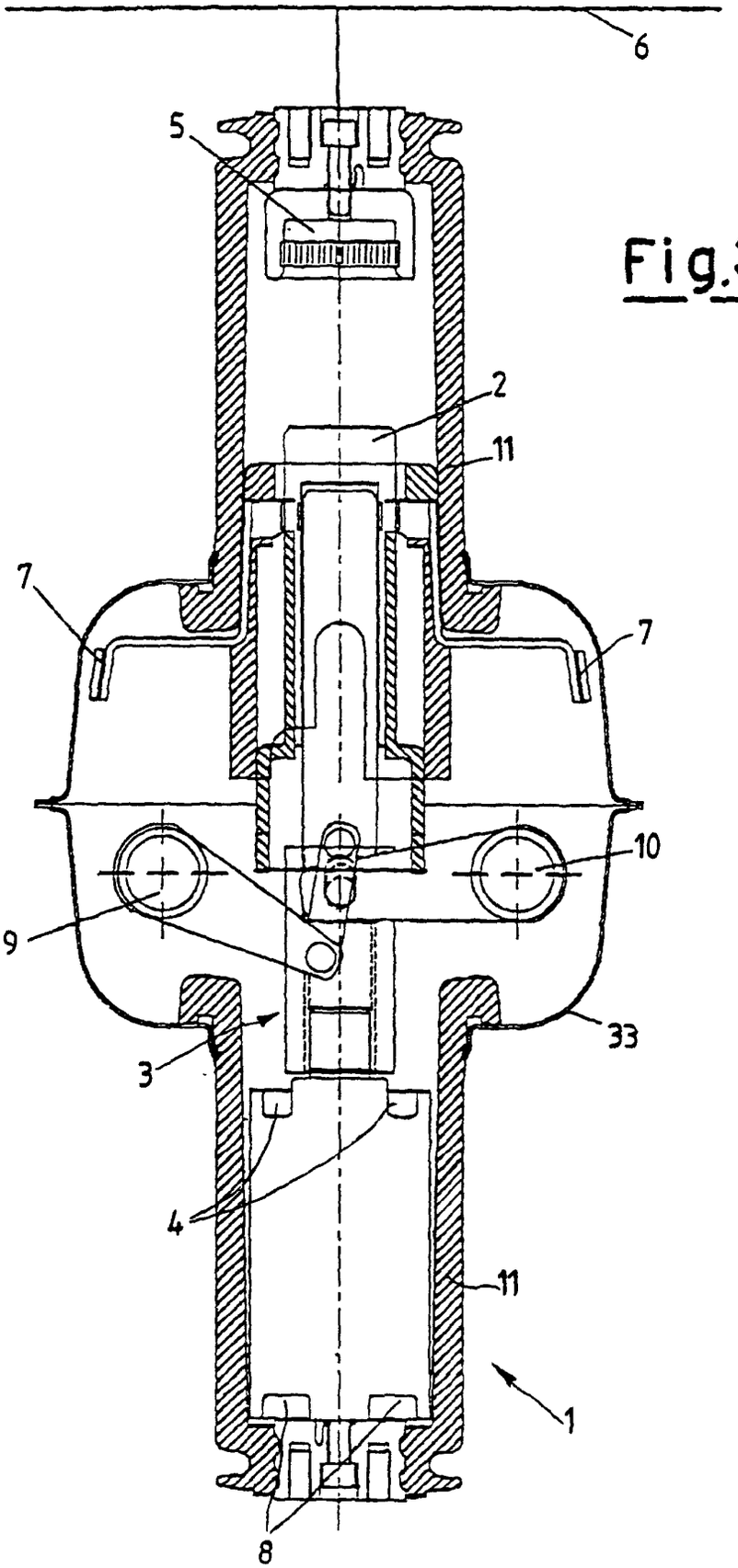

Fig.3

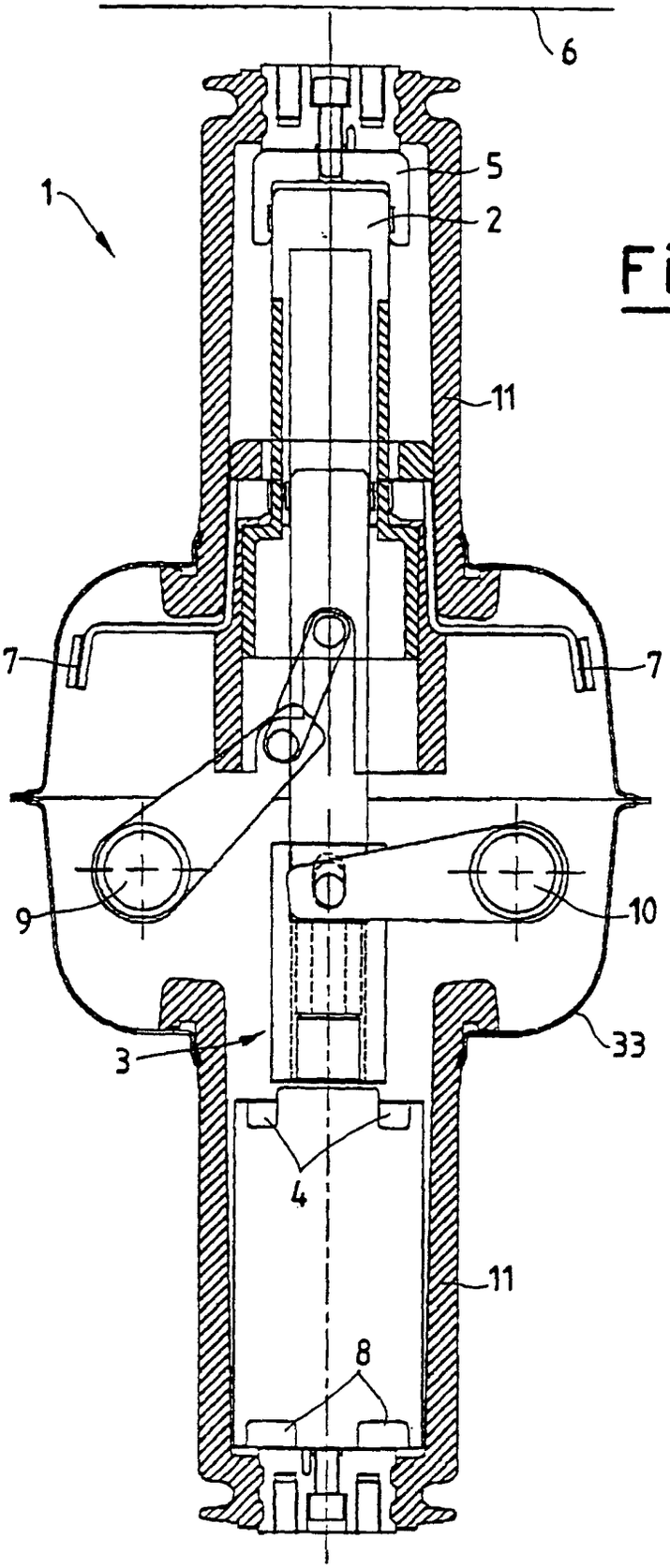

Fig.4

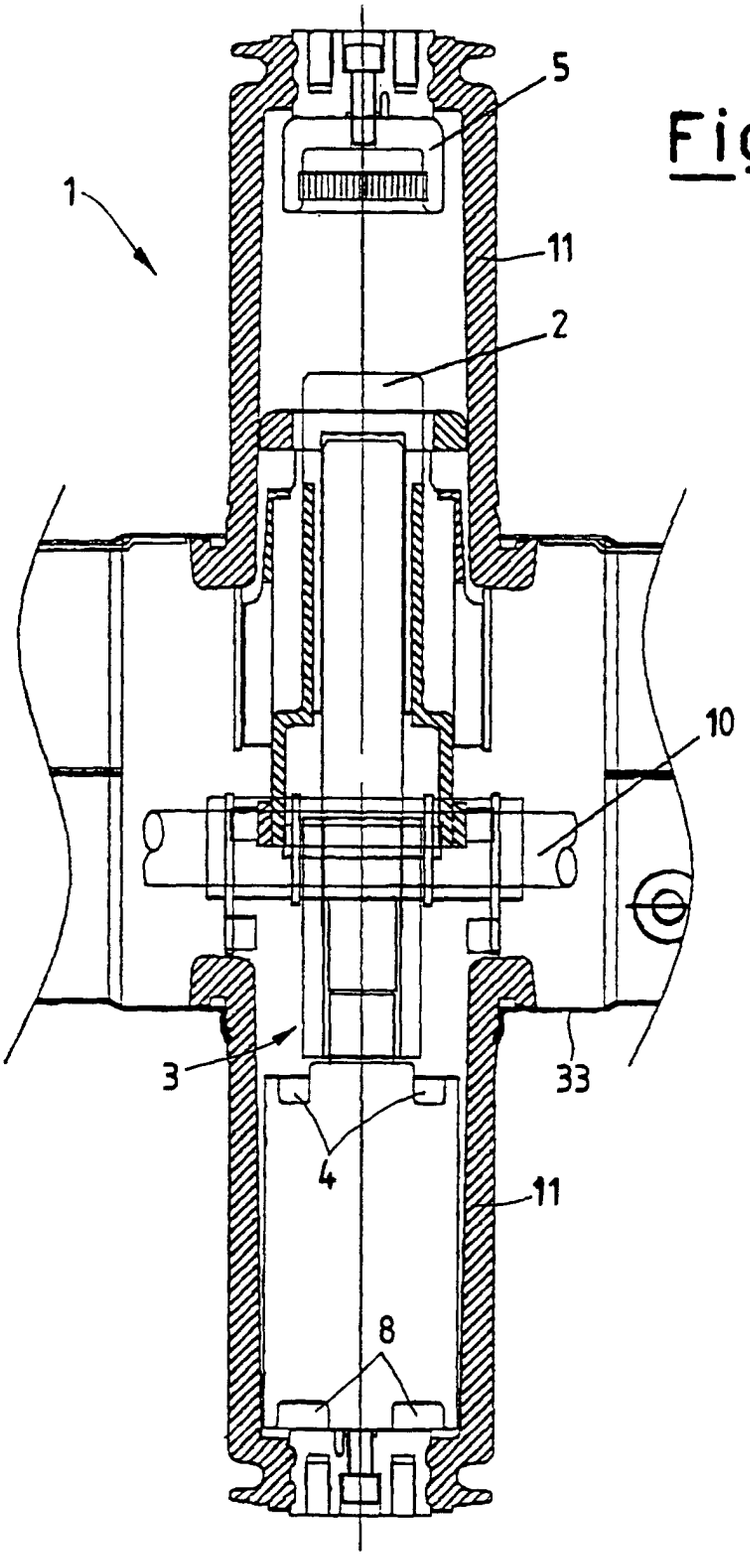

Fig.5

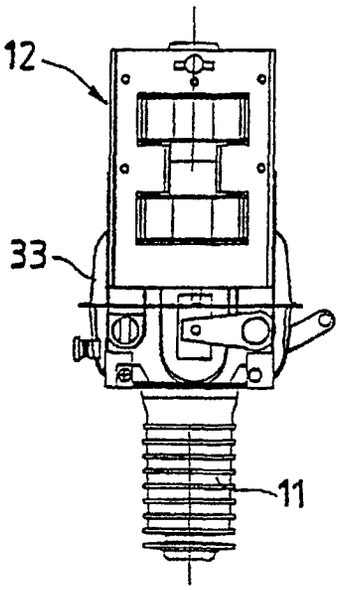

Fig.6

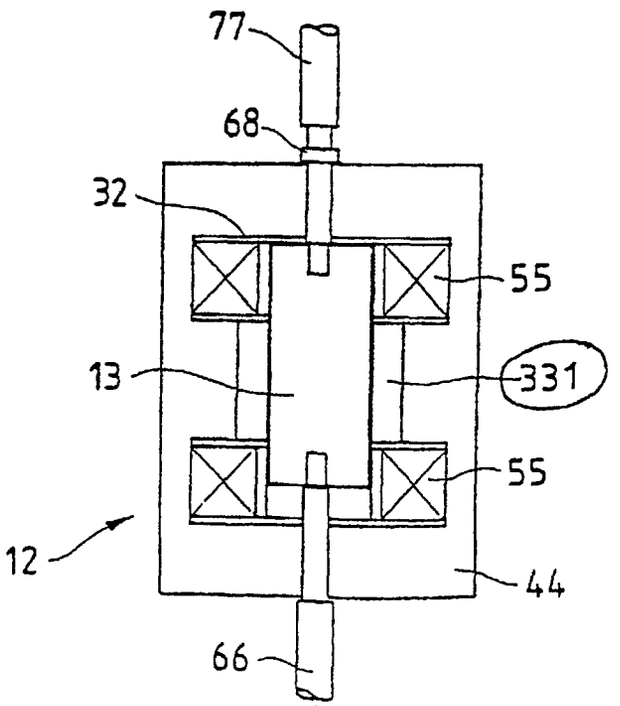

Fig.7