



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
07.06.2000 Bulletin 2000/23

(51) Int. Cl.⁷: **H01H 9/56, H01H 11/00**

(21) Application number: **98204083.4**

(22) Date of filing: **03.12.1998**

(84) Designated Contracting States:
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE**
Designated Extension States:
AL LT LV MK RO SI

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(54) **Device for controlling the opening/closing of electrical switchgear and related procedure**

(57) Control device for the opening/closing of electrical switchgear such as circuit-breakers, isolators, reclosers and the like, in an electricity distribution and/or transmission network characterised by the fact that it comprises:

- direct or indirect information on the position, velocity, acceleration of the mobile part of said switchgear;
- information on the change, in relation to the nominal behaviour, of the entire actuator-kinematic chain-switchgear controlled system;

- an actuator with adjustable law of motion;
- a processing and control unit that receives an operating command and sends a control signal to the actuator that is processed in relation to:
- a predetermined nominal behaviour;

in such a way as to realise the desired law of motion of said mobile part.

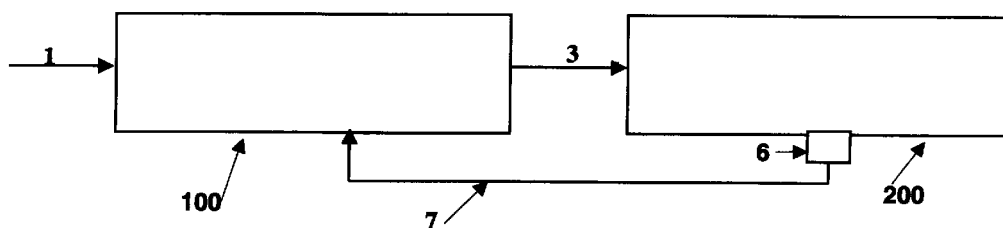


Fig. 1

Description

[0001] The present invention relates to a control device for the opening/closing of electrical switchgear such as circuit-breakers, isolators, reclosers and the like, in an electricity distribution and/or transmission network, and related method.

[0002] More specifically, the present invention relates to a control device that makes it possible to adjust the control parameters in input to an actuator in real time, thus allowing to obtain a desired law of motion for the moving parts of the switchgear moved by it.

[0003] As it is known, the switchgear operation is executed in relation to a control signal sent, for example, by a control panel or by a protection logic; in particular, this signal is sent to an actuator that causes the switchgear associated with it to perform a corresponding opening or closing operation.

[0004] In the prior art the actuators used for this purpose, generally of mechanical type, operate according to a law of motion that is not adjustable, not allowing the force they apply to the switchgear to be controlled. The behaviour of the actuator can therefore be defined as "binary", which is to say the force applied is either none or the maximum. This generally leads to oversize both the actuator and the energy storage system required to feed it in order to cope with every possible condition of use of the switchgear during its operating life; in this way the switchgear is in most cases supplied with more energy than it actually requires for the operation, which has a detrimental effect on the energy efficiency of the system and increases the energy dissipated in the impact at the end of the operation with consequent high mechanical stresses on the switchgear and lower overall reliability of the system. In addition, with these actuators it is impossible to stop an operation once it has started, which prevents one from improving the co-ordination of the circuit breakers in an electrical network; for example, it is not possible for a circuit-breaker to cancel its operation once it has started if it detects that a circuit-breaker downstream that eliminates the fault has been tripped, which would prevent it from opening and cutting off the power to fault-free parts of the electrical system and interrupting the service of the loads connected to it without reason.

[0005] One aspect that is essential to note consists in the fact that, using such actuators with a non-adjustable law of motion, the opening or closing operation obtained (simultaneously for all three phases) is generally asynchronous in relation to the phases of the electrical parameters, which is to say they do not have any temporal relationship with the electrical network; this in most cases leads to the generation of transients in the electrical network due to prestrike phenomena during closing and restrike phenomena during opening. In particular, depending on the type of load present in the electrical network, an operation performed at a non-optimal moment could cause high frequency oscillation

phenomena with high amplitudes compared to the rated values of the electrical parameters of the electrical network; the current values can, for example, even rise several orders of magnitude higher than the rated current value. These transients clearly subject the electrical network to anomalous stress and have the potential to reduce the expected life of the equipment connected to the electrical network; moreover they lead in any case to a greater wear of the contacts of the switchgear itself and consequently reduce its useful life.

[0006] In the prior art, some solutions have been proposed with the aim of making the operation of the switchgear synchronous with the electrical network in which it is used to thereby limit the problems explained above. It should be emphasised that the opening and/or closing operation may be considered synchronous when, having set an ideal tripping moment in relation to the type of load and the mode in which it is connected to the electrical network, such as the zero voltage for a capacitor or the peak voltage for a reactive load, for example, the end-of-operation moment falls within a synchronism time window around the ideal moment in which the transients obtained are sufficiently low.

[0007] One of the solutions proposed is illustrated in United States patent No. 5119260 which faces the problem regarding only the synchronised opening of an inductive load at a predetermined time in relation to the natural passage of the current through zero in such a way as to avoid overvoltages. In this patent, the time for the operation is provided, measured during one or more previous operations, in order to keep the opening operation within the synchronisation time window. In order to take account of the fact that the operating time is not constant but varies in relation to the ambient temperature and the opening coil temperature, these temperatures are supplied to the controller using an appropriate sensor. In particular, the controller is equipped with a system that is able to evaluate the characteristics of the variation in the operating time in relation to the temperature measured values; moreover, in order to take into account possible variations in the operating time in relation to the period of time that has elapsed between two successive operations, the controller also receives a measurement of this period of time and uses it to correct the operating time envisaged using a special predetermined function. The control time in relation to the envisaged zero is then calculated in relation to the behaviour observed during the previous operations and the influencing factors considered, namely the temperature and the time that has elapsed between two consecutive operations.

[0008] This solution therefore assumes a precise knowledge of the electrical and mechanical behaviour of the device in relation to the aforesaid variables; this knowledge derives from characterisation measurements performed in a test phase regarding a sample of devices that is considered to be significant regarding the behaviour of every possible similar switchgear prod-

uct manufactured.

[0009] The main limitation of the solution resides in the accuracy with which one is able to represent the behaviour of a specific circuit-breaker, in particular taking into account the different stresses to which it may be subjected during its operating life and, therefore, the mechanical and electrical wear that influences the operating time.

[0010] Furthermore, the use of a processor that calculates the actual operating time taken in real time makes it possible to evaluate the error committed, in relation to the predetermined operating time, only at the end of the operation itself and thus precludes any form of corrective action during its execution; since the correction to be applied is therefore evaluated in relation to the previous operation it is not possible to guarantee that the synchronism condition will be respected in the next operation.

[0011] Finally, it is to underline the fact that the inventors of the device illustrated did not equip it for opening operation in the event of a fault and thus during the transient of short circuit currents.

[0012] Another solution is illustrated in US patent 5,361,184 which faces the problem concerning the control of the circuit breakers or isolating equipment both in the opening and closing phases, taking the optimal moment of operation to be the zero voltage for closing and the zero current for opening. In particular, in the illustrated device, the actual operating time taken is recorded during every operation; in addition, the device is equipped with means for detecting transients in order to evaluate whether the operation has been performed synchronously. If this is not the case, the device produces a signal for correcting the predetermined operating time for subsequent operations and obtaining synchronous operation; in addition a suitable ambient compensation system makes it possible to perform further corrections that take into account the influence of the temperature and of the atmospheric pressure on the predetermined operating time.

[0013] The main limit of the solution therefore resides in the fact that the device relies on prior knowledge of the behaviour of the circuit breakers and/or isolators in relation to the ambient factors. In addition, the adaptive correction of the operating time following the result of a previous operation can lead to oscillations and does not ensure that synchronisation is achieved. Finally, taking the zero voltage in closing and the zero current in opening to be the optimum time for performing the operation limits the possible cases for application of the device; it is for example entirely unsuited to closing upon inductive loads.

[0014] In this solution, further errors can be caused by the chosen modes of synchronisation with the electrical network signals that either employ the use of a voltage reference and the determination of a current reference from a phase angle measurement that is subsequently considered to be constant, or determine the

moments of passing through the zero voltage from a single measurement, assuming the electrical network to be symmetrical and therefore operating with delays of 120° electrical degrees. This method of detecting the reference moments (zeros) makes the system ineffective with distorted voltages, in the presence of transient components and, more generally, with network parameters that have harmonic or non-symmetrical components and is therefore not applicable for synchronous opening upon faults.

[0015] In conclusion therefore, although the aforementioned solutions enable the said problems to be partially resolved in specific cases they are not, however, able to guarantee that synchronism is achieved in the actual time since even in those cases where adaptive control methods are adopted they do not act on the operation in progress but only introduce estimated corrections that have an effect, which cannot be totally controlled, on the next operation. They are, therefore, basically open loop control systems in which the implementation of feedback closes the control loop with a temporal dynamic that is significantly longer than the individual operation, such that it could be entirely ineffective.

[0016] The main task of the present invention is to provide a control device for the opening/closing of electrical switchgear that is able to adjust the parameters in input to the actuator in real time in order to control the force it applies at every moment in the operating time, thus allowing a desired law of motion to be imposed on the moving parts of the switchgear actuated by it.

[0017] As part of this task, an object of the present invention is to provide a control device for the opening/closing of electrical switchgear that makes it possible to act on the individual poles of a three-phase system to perform the operation in an optimal manner for the electrical system as a whole, enabling one, in the event of a fault, to operate only on the phase affected and to continue operation of the fault-free phases, thus ensuring greater availability and continuity of service.

[0018] Another object of the present invention is to provide a control device for the opening/closing of electrical switchgear that guarantees the repeatability of the operation to be performed as well as its optimisation in relation to the different types of breaking techniques chosen.

[0019] A further object of the present invention is to provide a control device for the opening/closing of electrical switchgear that makes it possible to decrease the energy used in the operation, thus making it possible to optimise the sizing of the actuator and of the energy storage system, with a consequent economic benefit.

[0020] Yet another object of the present invention is to provide a control device for the opening/closing of electrical switchgear that makes it possible to control the motion of the actuator both in the initial and final phases, making it possible, for example, to brake the switchgear decreasing the kinetic energy dissipated in

the impact, or to co-ordinate the operation of one circuit-breaker with others downstream, cancelling an operation that has been started if it is no longer necessary to ensure greater continuity of service.

[0021] A further object of the present invention is to provide a control device for the opening/closing of electrical switchgear that makes it possible to control the operating time of the moving parts of the said switchgear and to perform the operation synchronously, for each individual phase, in relation to the phases of the electrical parameters of the network, irrespective of the command moment sent from a control panel or a protection logic.

[0022] Yet another object of the present invention is to provide a control device for the opening/closing of electrical switchgear that simple modifications can enable to obtain synchronism of the operation with the waveform of the electrical network with different types of networks and loads present, thus distinguishing itself by considerable flexibility in use and enabling in particular to realise the synchronisation during opening upon a fault, significantly limiting electrical wear.

[0023] A further object of the present invention is to provide a control device for the opening/closing of electrical switchgear which by controlling the law of motion of the actuator-switchgear assembly in real time makes it possible to eliminate the voltage and current transients of the electrical network, or at least limit them as much as possible, thus reducing any anomalous stresses on the insulation systems of the components present, as well as electrodynamic and thermal stresses.

[0024] Yet another object of the present invention is to provide a control device for the opening/closing of electrical switchgear that allowing to obtain operations that are synchronous with the waveform of the electrical network makes it possible to increase its reliability while also increasing the electrical and mechanical life of the switchgear present in it.

[0025] An additional though not the last object of the present invention is to provide a control device for the opening/closing of electrical switchgear that is highly reliable and relatively easy to manufacture at competitive costs.

[0026] This task, together with the above-mentioned and other objects that shall emerge more clearly hereinafter, are achieved by Control device for the opening/closing of electrical switchgear such as circuit-breakers, isolators, reclosers and the like, in an electricity distribution and/or transmission network characterised by the fact that it comprises:

- an actuator with adjustable law of motion;
- a processing and control unit that receives an operating command and sends a control signal to the actuator that is processed in relation to:
- a predetermined nominal behaviour;
- information, direct or indirect, on the position, velocity,

ity, acceleration of the mobile part of the said switchgear;

- information regarding the variation, in relation to the nominal behaviour, of the entire actuator-kinematic chain-switchgear controlled system;

in order to realise the desired law of motion of said mobile part.

[0027] The above-mentioned task, together with the aforementioned and other objects are also achieved by a control method for the opening/closing of electrical switchgear such as circuit breakers, isolators, reclosers and the like, in an electricity distribution and/or transmission network characterised by the fact that it comprises the following phases:

- a) sending a control signal to an actuator with adjustable law of motion;
- b) directly or indirectly acquiring information on the movement or velocity or acceleration of the mobile part of said switchgear operated by the adjustable actuator and processing a control signal;
- c) modulating the flow of energy supplied to the actuator in relation to said control signal in such a way as to adjust the force it exerts on the kinematic chain-switchgear system and obtain the desired law of motion of said mobile part.

[0028] Further characteristics and advantages of the invention shall emerge more clearly from the description of preferred but not exclusive embodiments of the device as in the invention, illustrated purely by way of example and without limitation with the aid of the attached drawings, in which:

Figure 1 is a general block diagram of the control device as in the invention;

Figure 2 is a detailed block diagram of an embodiment of the control device as in the invention;

Figure 3 is a detailed block diagram of control means and converter means used in the device as in the invention;

Figure 4 is a detailed block diagram of a preferred embodiment of the device as in the invention;

Figure 5 is a diagram illustrating the voltage phase in relation to time in normal operating conditions;

Figure 6 is a diagram illustrating the current phase in relation to time in the presence of a transient.

[0029] With reference to Figures 1 and 2, the device according to the invention comprises a processing and control unit, indicated overall by reference number 100, which receives an operating command 1 in input from a control panel or protection logic and sends a control signal 3 in output to an actuator 2. In the embodiment of the device as in the invention, the actuator used advantageously operates with an adjustable law of motion; in this way the force applied by the actuator to the switch-

gear 4, through a kinematic chain 5 connecting them, can be adjusted and makes it possible to have an actuator-kinematic chain-switchgear system 200 that is perfectly controlled in relation to the different application requirements using the procedures that will be illustrated in detail hereinafter.

[0030] In particular, the actuator concerned is an electromagnetic actuator, the subject of European patent application number EP 97203501.8-2302, the description of which is to be understood as included herein for reference; the specific reference to said actuator is clearly to be considered solely for the purposes of explanation in that any actuator with adjustable law of motion, such as a pneumatic actuator for example, could be used in equivalent way in the device as in the invention.

[0031] As illustrated in the said figures, the control device suitably comprises feedback means 6 for evaluating, by direct or indirect measurement, the position of the mobile part of the switchgear connected to the actuator; in particular, these means 6 may comprise a position sensor that detects a movement of any point of the controlled system 200 and sends a corresponding signal 7 indicating in real time the position of the mobile contacts of the switchgear to control means 10 of the processing and control unit 100; alternatively, velocity or acceleration sensors could be used that detect the velocity or the acceleration of any point of the system 200 and send the corresponding information 7 on the velocity or acceleration of the mobile parts to means 10. This sensor, irrespective of whether it is a position, velocity or acceleration sensor, may be positioned in any point of the kinematic chain 5 or of the switchgear 4 to suit specific applications and/or needs.

[0032] In another embodiment, the information regarding the position of the mobile parts may be supplied to the control means 10 namely without the use of sensors ("sensorless system") using a mathematical model of the controlled system 200; this model, forming part of the unit 100, receives a signal in input that is a function of the actuator's control parameters, in this case the voltage and current of the power supply to the coil, and supplies a signal indicating the estimated position of the mobile contacts of the switchgear to the control means 10 in real time. If the actuator used is, for example, a pneumatic type, the control parameters could be the pressure and the volume of the compressible fluid used.

[0033] The control means 10, which receive in input the operating command 1 and the direct or indirect signal 7 indicating the position or velocity or acceleration in real time of the mobile contacts of the switchgear, send a corresponding control signal 19 to converter means 20 in output.

[0034] In particular, in the device as in the invention and as illustrated in greater detail in figure 3, the control means 10 comprise calculating means 11 that receive the signal 7 in input and by means of suitable integra-

tions/derivations send a signal 14 indicating the law of motion of the mobile contacts at that moment in output to open loop control means 12 and closed loop control means 13; this signal 14 thus constitutes information of the mode in which the mobile part of the switchgear moves from the initial time of motion to the time of measurement.

[0035] The open loop control means 11 compare the signal 14 indicating the actual law of motion of the mobile contacts with a predetermined law of motion and send a corresponding reference signal 16 in output to the closed loop control means 13 and to comparator means 15. In particular, this predetermined law of motion corresponds to a predetermined nominal behaviour of the entire actuator-kinematic chain-switchgear system.

[0036] The closed loop control means 13 compare the signal indicating the actual law of motion 14 with the reference signal 16 sending a corresponding correction signal 18 in output to comparison means 15; the comparison means 15 in their turn send the control signal 19 in output to converter means 20 in relation to the correction signal 18 and to the reference signal 16 received in input.

[0037] In the embodiment illustrated, the converter means 20 comprise power supply means 21 for the actuator that can be provided using, for example, batteries or capacitors; alternatively, in the case of an actuator that is not electromagnetic but can nevertheless be controlled, such as a pneumatic actuator, this storage unit could be provided using a compressible fluid plenum chamber.

[0038] In addition, the converter means 20 advantageously comprise means for modulating 22 the flow of energy supplied to the actuator by the power supply means 21; these modulation means adjust the flow of energy supplied by the means 21 to the actuator by modulating the power supply current and/or voltage of the actuator itself in relation to the control signal 19. The actuator, which converts the modulated electrical energy into mechanical energy, thus applies a continually adjusted force to the kinematic loop connected to it that makes it possible to move the mobile parts of the switchgear with the desired law of motion.

[0039] The control device proposed thus comprises an open loop control based on the nominal behaviour of the system to realise the opening and/or closing operation in the modes desired; this open loop control system is juxtaposed with a closed loop control system that corrects any possible changes in relation to the nominal behaviour to ensure implementation of the desired law of motion. In particular, given that the control is carried out in real time during the operation itself, the device as in the invention makes it possible to accurately take into account all the disturbance acting on the controlled system able to influence its response by varying the behaviour in relation to the predetermined nominal behaviour, namely the effect of environmental parameters, the elec-

trical and mechanical wear of the switchgear, the time elapsed between operations, the ageing of the control equipment, the number and type of operations performed etc..

[0040] The possibility of controlling the force applied by the actuator and therefore of adjusting the law of motion of the mobile parts of the switchgear makes it possible to perform operations that are currently impossible for the devices of known type; for example, in the case of three-phase circuit breakers, the control device as in the invention makes it possible to obtain optimal operation on a single pole while leaving the other two phases, which are not affected by faults, in operation; furthermore, by adjusting the force applied by the actuator it is possible to stop an operation that has been started whenever it is no longer essential, or even to reverse the direction of the operation itself at least within a certain time window. This makes it possible to implement a new protection logic with improved co-ordination for example between circuit-breakers that, once an operation has already been started, are able to detect the operation of a circuit-breaker downstream that eliminates the fault and cancel the operation, preventing the circuit-breakers from opening and cutting off the power to fault-free parts of the electrical network without reason, also doing so without having to insert any intentional delays, useful for the purposes of selectivity. In the same way, the circuit-breaker that is controlled can, when required to operate on a transient, cancel the operation when the transient is over and not interrupt the service of the loads that it powers.

[0041] A further advantage that should under no circumstances be overlooked resides in the fact that the device as in the invention ensures repeatability of the operation by adjusting the force applied by the actuator and makes it possible to optimise the law of motion of the mobile parts moment by moment following a preferred trajectory and in relation to the different types of breaking systems used; in this way, moreover, the energy transmitted to the actuator, and therefore to the switchgear, is adjusted perfectly and this makes it possible not just to optimise the sizing of the actuator and its power supply system, but also to decrease the energy dissipated in the end-of-operation impact, with lower stresses on the switchgear, lower contact wear and therefore, in short, higher reliability of the entire electrical network.

[0042] As illustrated in Figure 4, in a preferred embodiment of the device according to the invention, the processing and control unit 100 also comprises synchronisation means 33 capable of providing information for the opening or closing of the switchgear synchronously with the electrical network. These synchronisation means, through the use of means for detecting the voltage and current phases of the electrical network, such as, for example, a current transformer 30 and a voltage transformer 31, receive information 32 tracking the electrical parameters of the network; in relation to

this information, the synchronisation means, through suitable calculations, predict the succession of the zeros and maximums of the phases of the current and voltage following those detected, also taking account of frequency variations, harmonic components and single-phase transient components. In addition, they calculate the time between the zeros and maximums detected and those predicted.

[0043] In addition, the synchronisation means advantageously also comprise table means 34 that contain predetermined information regarding the state of the neutral, the type of load and of the electrical network, and send a signal 35 indicating the ideal end-of-operation times in relation to said predetermined information to a timer unit 36. In this embodiment and as illustrated in Figures 5 and 6, the operating command 1 is sent to the timer unit 36 and is a command that is generally asynchronous in relation to the electrical system. The timer unit 33 sends a corresponding synchronous start operation command 37 to the control means 10 in relation to this command 1, as well as to the signal 35 indicating the ideal end-of-operation times; this synchronous command 37 is delayed in relation to the asynchronous command 1 by a period of time 50 that is a function of the predetermined nominal operating time 51 and of the said signals 35 indicating the ideal end-of-operation times and the subsequent zeros or maximums predicted, in order to identify the first subsequent ideal moment useful for implementing the synchronous operation. The desired ideal moment 35 is clearly the optimal time for eliminating operation transients in relation to the type of operation, load and electrical network; as illustrated in Figure 6, this moment in time does not necessarily coincide with a zero or with a maximum but nevertheless ensures that the operation is performed within the synchronism window. The control means 10 thus receive the signal 37 indicating the co-ordinated control strategy for the three phases to perform the synchronous operation for each individual phase and operate analogously to that which has been described above.

[0044] A further advantage of the invention resides in the fact that, both in the synchronous operation situation and in the case only of adjustment of the law of motion of the mobile parts previously described, the control means 10 ensure execution of the operation in the nominal time envisaged thanks to the corrective action of the means 13 previously described; if, however, the deviation from the nominal behaviour at any point become accentuated during the operation, requiring a significant demand on the closed loop control, the device is able to correct the nominal characteristic of the system in a self-organising mode. In this case, the nominal operation time that is suitably monitored during the operations is redefined in relation to a new reference value; in the case of synchronous operation, this new reference time is obviously made available by the means 10 to the timer unit 36. This self-organising pro-

cedure is also used in the device's testing phase so that the control system corrects the nominal characteristic in relation to the real behaviour of the specific switchgear unit, making it possible to define the actual initial nominal characteristic.

[0045] It has in practice been noted how the device as in the invention makes it possible to achieve the task in full as well as the objects set in that it makes it possible to adjust the force applied by the actuator in real time moving the mobile parts following a desired law of motion and making it possible to obtain all the advantages previously described.

[0046] In addition, in the preferred embodiment illustrated, the device makes it possible to obtain operation synchronous with the electrical network, with the widest different types of electrical systems and loads present in them and even in the presence of faults. This therefore results in further and significant advantages in terms of the flexibility of application of the device, and in terms of the elimination or at least significant reduction of voltage and current transients in the network, as well as in terms of limiting electrodynamic and thermal stresses, with significant consequent benefits both for the insulation systems of the components present in the electrical system and of the switchgear used, considerably increasing its useful life and reliability.

[0047] It should, finally, be emphasised that the device as in the invention, while offering all the benefits stated, is obtained using a manufacturing solution that is extremely attractive from an economic standpoint, the costs of which are comparable with those of a conventional circuit-breaker and decidedly lower than the conventional synchronous solutions. The device conceived in this way is capable of many modifications and variants, all within the inventive concept; in addition all the details may be substituted by other technically equivalent elements.

[0048] In practice, the materials as well as the dimensions may be varied in any way to suit requirements and the state of technology.

Claims

1. Control device for the opening/closing of electrical switchgear such as circuitbreakers, isolators, reclosers and the like, in an electricity distribution and/or transmission network characterised by the fact that it comprises:

- an actuator with adjustable law of motion;
- a processing and control unit that receives an operating command and sends a control signal to the actuator that is processed in relation to:
- a predetermined nominal behaviour;
- information, direct or indirect, on the position, velocity, acceleration of the mobile part of the said switchgear;
- information regarding the variation, in relation

to the nominal behaviour, of the entire actuator-kinematic chain-switchgear controlled system;

in order to realise the desired law of motion of said mobile part.

2. Control device as in claim 1 characterised by the fact that said actuator with adjustable law of motion is an electromagnetic actuator.
3. Control device as in one or more of the previous claims characterised by the fact that it comprises a position or velocity or acceleration sensor suitable of detecting a movement or the velocity or the acceleration of said controlled system and sending a corresponding signal indicating the position or velocity or acceleration of the mobile contacts of the switchgear to the processing and control unit in real time.
4. Control device as in claim 1 characterised by the fact that it comprises a mathematical model of the controlled system that receives a signal in input that is a function of measurements of control parameters of the actuator and sends a signal indicating the estimated position of the mobile contacts of the switchgear to the processing and control unit in real time.
5. Control device as in one or more of the previous claims characterised by the fact that said processing and control unit comprises control means that receive an operating command and a signal, direct or indirect, indicating in real time the position or velocity or acceleration of the mobile contacts of the switchgear in input and send a corresponding control signal to converter means in output.
6. Control device as in claim 5 characterised by the fact that said control means comprise calculating means that receive a signal indicating the position or velocity or acceleration of the mobile contacts in input and send a signal indicating the actual law of motion of the mobile part to open loop control means and closed loop control means in output.
7. Control device as in claim 6 characterised by the fact that said open loop control means compare the signal indicating the actual law of motion of the mobile contacts with a predetermined law of motion and send a corresponding reference signal in output to said closed loop control means and to comparator means.
8. Control device as in claim 7 characterised by the fact that said closed loop control means compare said signal indicating the actual law of motion with said reference signal, sending a corresponding cor-

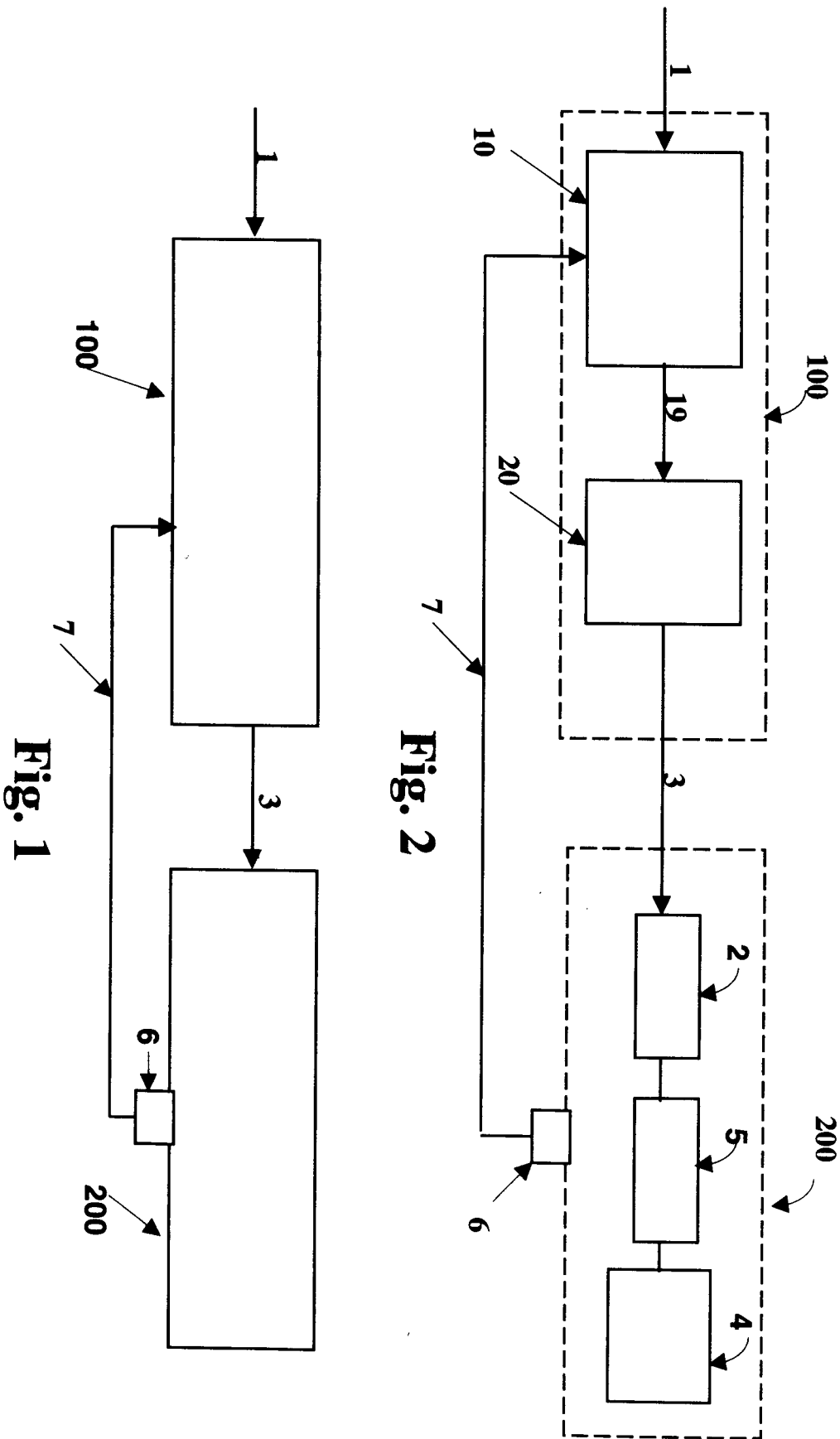
rection signal in output to comparator means.

9. Control device as in claim 8 characterised by the fact that said comparator means compare the correction signal and the reference signal received in input and send said control signal in output. 5
10. Control device as in one or more of the previous claims characterised by the fact that said converter means comprise: 10
 - power supply means for the actuator; and
 - means for modulating the flow of energy supplied to the actuator by the power supply means in relation to said control signal received in input. 15
11. Control device as in one or more of the previous claims characterised by the fact that it also comprises synchronisation means suitable for providing the processing and control unit with information for the opening or closing of the switchgear in a mode that is synchronous with the electrical network. 20
12. Control device as in claim 11 characterised by the fact that said synchronisation means comprise: 25
 - means for detecting the voltage and current phases of the electrical network;
 - means for predicting the zeros and maximums of the current and voltage phases subsequent to those detected; 30
 - means for calculating the period of time between the zeros and maximums detected and those predicted. 35
13. Control device as in one or more of claims 11 to 12 characterised by the fact that said synchronisation means comprise table means containing predetermined information regarding the state of the neutral, the type of load and of the electrical network, suitable of sending a signal indicating the ideal end-of-operation times in relation to said predetermined information to a timer unit. 40
14. Control device as in one or more of claims 11 to 13 characterised by the fact that said synchronisation means comprise a timer unit that receives in input: 45
 - an operating command that is asynchronous in relation to the electrical system; 50
 - the signal indicating the ideal end-of-operation times;
 - the signal indicating the subsequent predicted zeros or maximums; 55

and send to the control means a corresponding synchronous start operation command that is delayed in relation to the asynchronous command by a period of time that is a function of the predetermined nominal operation time and said of signals indicating the ideal end-of-operation times and the predicted subsequent zeros or maximums.

15. Electricity distribution and/or transmission network comprising a plurality of circuit breakers installed in a cascade arrangement, characterised by the fact that at least one circuit-breaker of said plurality is fitted with a control device as in one or more of the previous claims and by the fact that the opening/closing of said at least one circuit-breaker occurs in a manner that is co-ordinated with other circuit breakers upstream or downstream of it in such a way as to interrupt or reverse the opening or closing operation.
16. Electrical switchgear for electricity distribution and/or transmission network characterised by the fact that it comprises a control device as in one or more of claims 1 to 14 and by the fact that the amount of power delivered during an opening/closing operation is a function, moment by moment, of the residual travel of the mobile contacts.
17. Electrical switchgear as in claim 16 characterised by the fact that said adjustable actuator applies an adjustable force on the mobile part moment by moment and is capable of minimising the amount of energy dissipated in the impact in a closing operation.
18. Control method for the opening/closing of electrical switchgear such as circuit breakers, isolators, reclosers and the like, in an electricity distribution and/or transmission network characterised by the fact that it comprises the following phases:
 - a) sending a control signal to an actuator with adjustable law of motion;
 - b) directly or indirectly acquiring information on the movement or velocity or acceleration of the mobile part of said switchgear operated by the adjustable actuator and processing a control signal;
 - c) modulating the flow of energy supplied to the actuator in relation to said control signal in such a way as to adjust the force it exerts on the kinematic chain-switchgear system and obtain the desired law of motion of said mobile part.
19. Control procedure as in claim 18 characterised by the fact that in phase b) the acquisition of said information on the movement or velocity or acceleration of the mobile part comprises:

- detecting a movement, directly or indirectly, or the velocity or the acceleration of the mobile part;
 - processing, in relation to said detection, a signal indicating the actual law of motion of the mobile part. 5
- 20.** Control procedure as in claim 19 characterised by the fact that in phase b) the processing of the control signal comprises: 10
- comparing said signal indicating the actual law of motion of the mobile part with signal indicating a predetermined law of motion, and in relation to said comparison, 15
 - processing a control signal.
- 21.** Control procedure as in claim 19 characterised by the fact that in phase b) the processing of the control signal comprises: 20
- comparing said signal indicating the actual law of motion of the mobile part with a signal indicating a predetermined law of motion, and in relation to said comparison, 25
 - processing a reference signal;
 - comparing the reference signal with the signal indicating the actual law of motion and in relation to this comparison,
 - processing a correction signal; 30
 - comparing the correction signal and the reference signal, and in a relation to this comparison,
 - processing a control signal. 35
- 22.** Control procedure as in one or more of claims 18 to 21 characterised by the fact that phase a) comprises:
- detecting the voltage and current phases of the electrical network; 40
 - predicting the zeros and maximums subsequent to those detected;
 - calculating the time between the zeros and maximums predicted and those detected; 45
 - processing and sending an operating command to the actuator in such a way as to make the operation synchronous with the electrical network. 50
- 23.** Control procedure as in claim 22 characterised by the fact that the processing and sending of the operating command comprises:
- acquiring a signal indicating the ideal end-of-operation times, said signal being a function of predetermined information regarding the state of the neutral, the electrical network and the type of load; 55
 - sending a synchronous operating command to the actuator, delayed in relation to a received asynchronous operating command by a time that is a function of the predetermined nominal operating time and of said signals indicating the ideal end-of-operation times and predicted subsequent zeros or maximums.



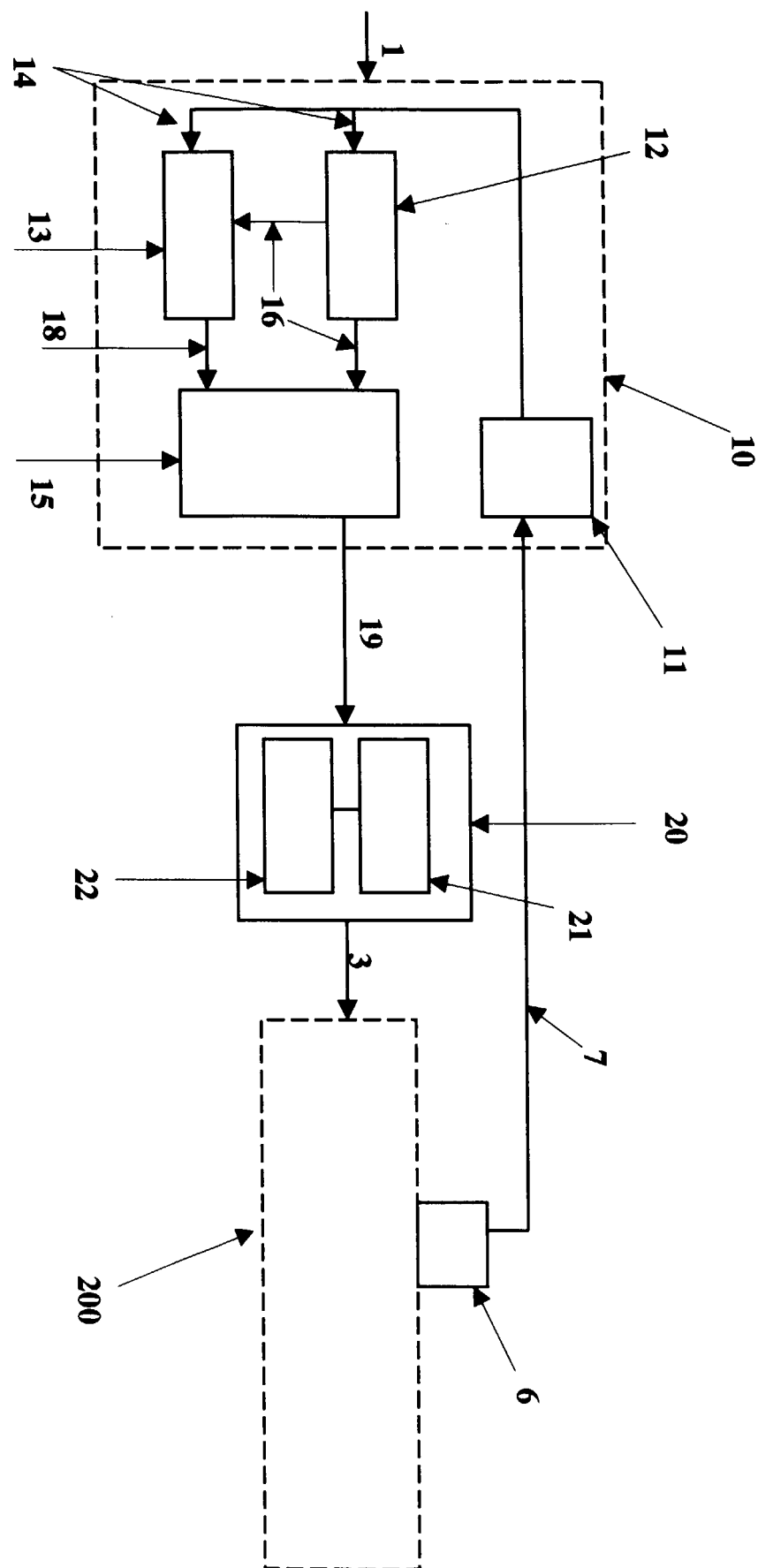


Fig. 3

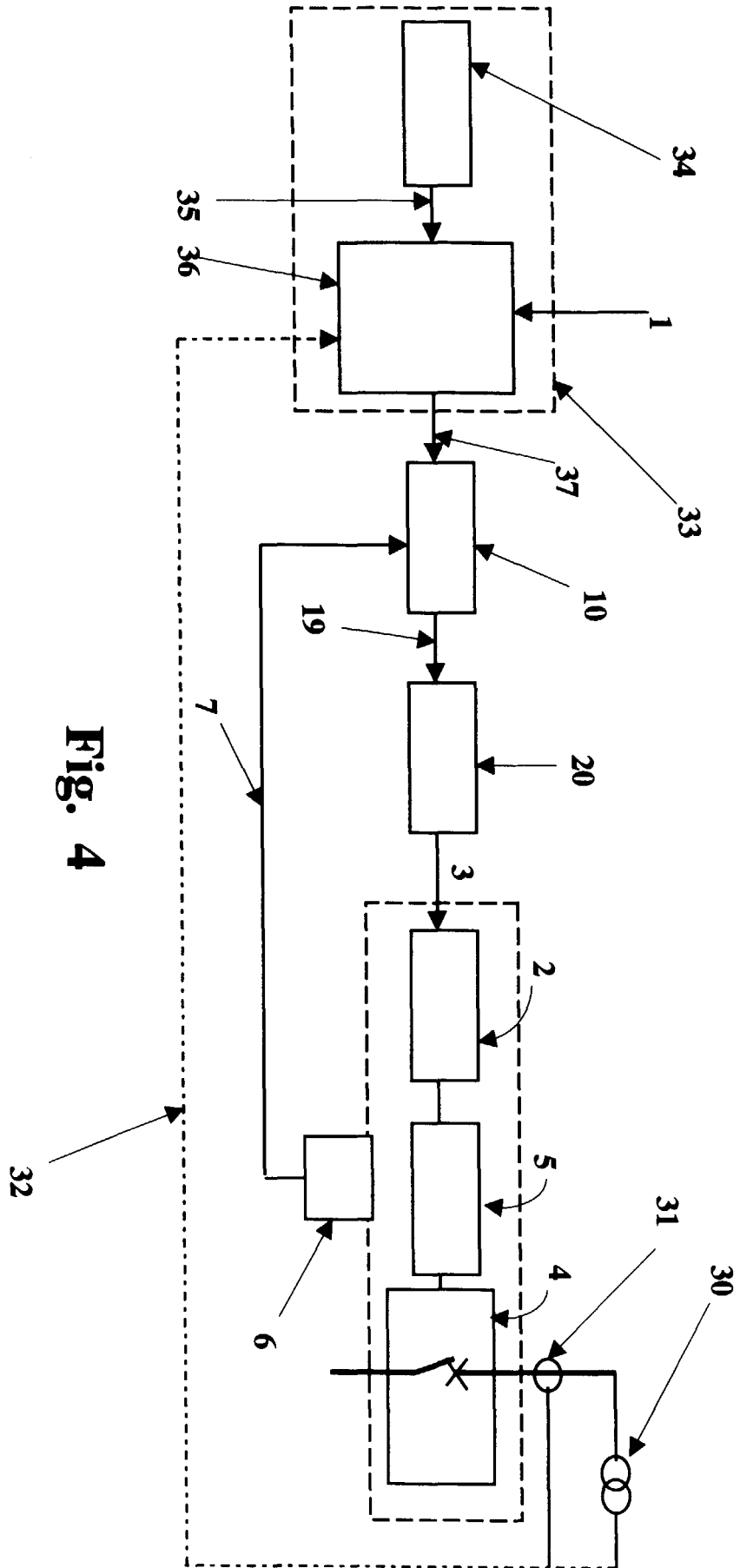


Fig. 4

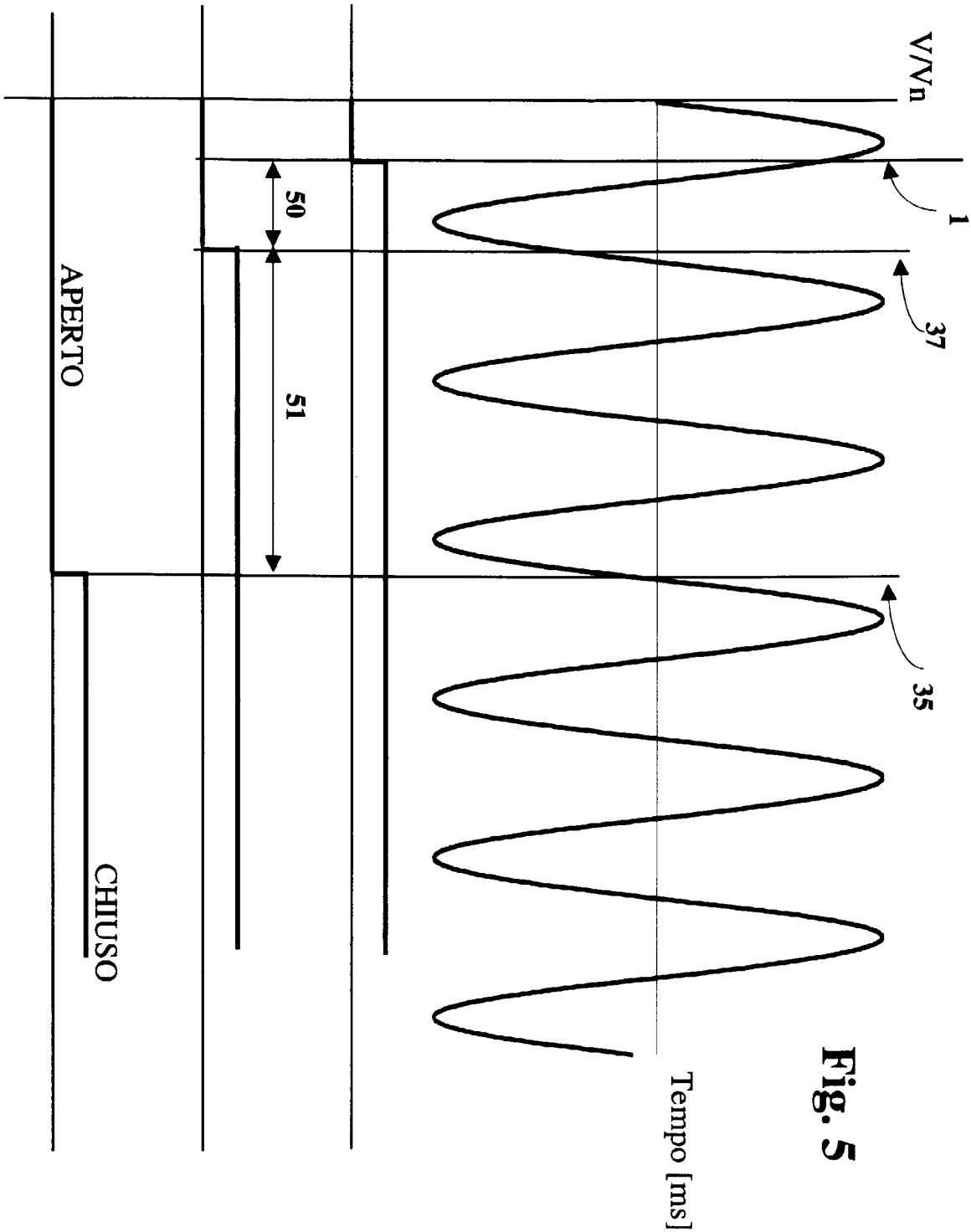
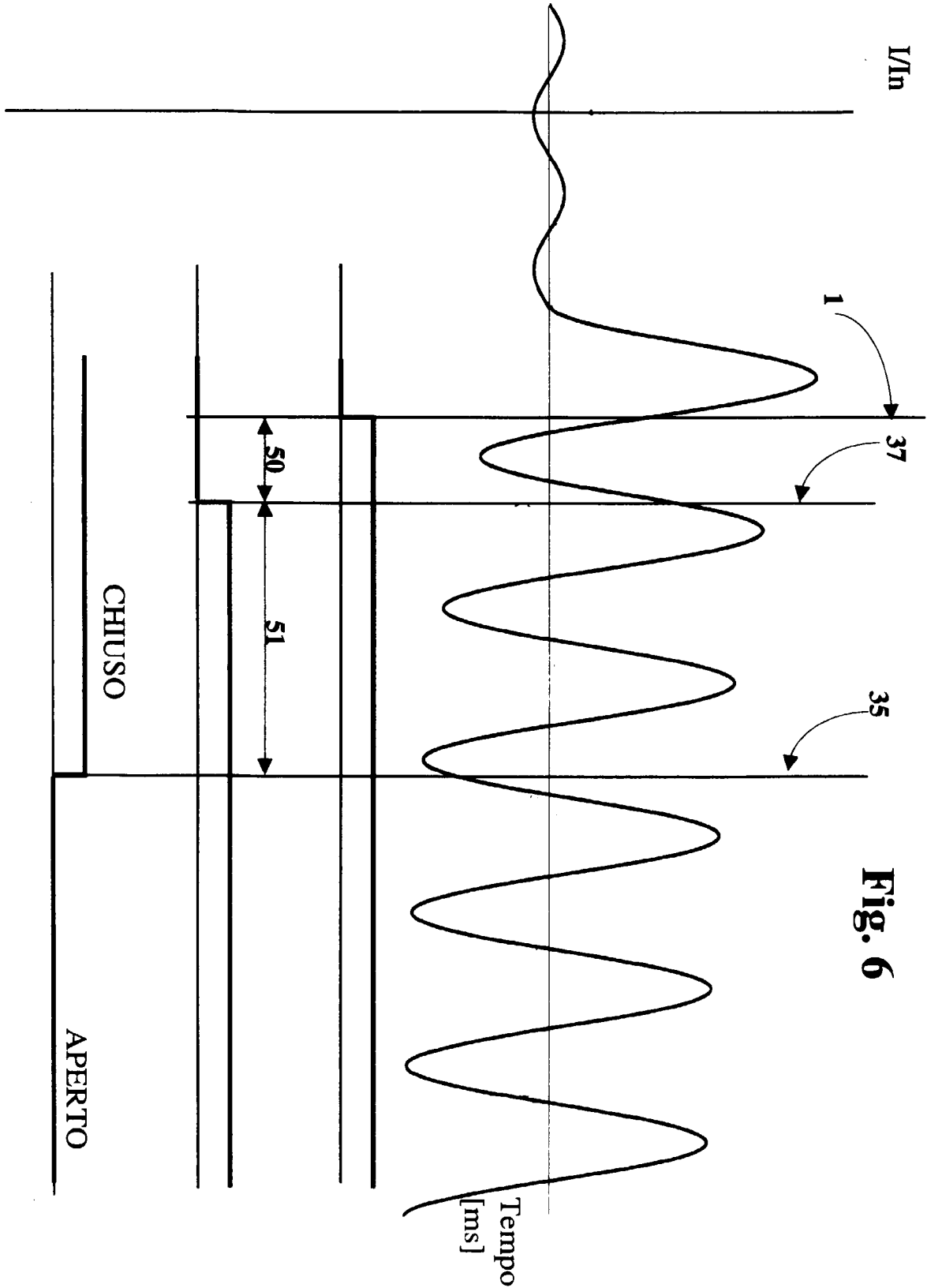


Fig. 5





European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 98 20 4083

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The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 17 February 1999	Examiner Ramírez Fueyo, M
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