

Description

[0001] The present invention relates to a control and monitoring device for the opening/closing of operating elements such as circuit-breakers, disconnectors and the like, in an electricity distribution and/or transmission network.

[0002] In particular, the present invention relates to a control and monitoring device that makes it possible, by implementing suitable monitoring strategies, to perform the electrical operation in a "synchronous" manner in relation to the network parameters, which is to say in such a manner that the moment of operation is located within a time window containing the optimal moment in which the electrical transients are minimal.

[0003] This window is large enough to ensure that synchronism is obtained throughout the entire expected life of the operating element. The minimisation of the transients of the electrical parameters, the limiting of the duration of the arc and the elimination of arc restriking phenomena are therefore guaranteed.

[0004] It is known from the state of the art that operating elements such as circuit-breakers, isolators and the like generally operate in response to commands, either automatic or manual, sent from a control and monitoring panel. This means that the operation can take place in a "random" manner, which is to say in a manner that is asynchronous in relation to the network parameters and, very frequently, able to generate electrical transients and/or electrical arcing phenomena that are generally extremely damaging.

[0005] In order to minimise these damaging transient effects, it would be necessary to perform the electrical operation in a manner that is "synchronous" in relation to the network parameters, which is to say to determine an optimum operating moment that makes it possible to minimise the damaging effects due to transients or electrical arcing phenomena.

[0006] For example, in the case of a closing operation on a capacitive load, with zero residual energy, the optimal moment occurs when there is zero voltage.

[0007] Solutions are known in which the choice of the optimal operating moment is pre-set and closely correlated to the type of load initially present, without taking any changes in its nature into account.

[0008] For example, US patent 5,119,260 offers a choice of the optimal moment in relation to the opening operation on an inductive load only.

[0009] A moment that is out of phase by a fixed amount of time in relation to the passage through the current zero is pre-set as the optimal moment.

[0010] This situation is entirely unsuitable for other types of operations or when changes occur in the load.

[0011] Other solutions allow one to choose the optimal moment in a relation to the type of operation only without taking the load into account. For example, US patent 5,361,184 takes the current zero as the optimal moment for opening operations and the voltage zero as

the optimal moment for closing operations, irrespective of the type of load.

[0012] This type of a solution is unsuitable if there is a change in the nature of the load or the network for any reason.

[0013] Solutions are known that propose the adoption, for certain pre-set types of operations only, of an adaptive procedure for diminishing the damaging effects due to transients and/or electrical arcing.

[0014] For example, in US patent 5,566,041 a device is proposed for adjusting the motion of the contacts of a circuit breaker, for the opening operation and single-phase systems only, in order to have the contact separation close to the moment of passage through the current zero.

[0015] The device is equipped with a position sensor that supplies information on the position of the contacts in relation to one another to a controller that sends a command to suitable actuation means in order to accelerate or decelerate the motion of the mobile contact, changing the operating time.

[0016] The operating time is adjusted in order to obtain the opening of the contracts as close as possible to the current zero, which is assumed to be symmetrical and at a constant frequency.

[0017] The solution proposed, although making technical progress in relation to the previous solutions described, is unsuitable and unable to effectively control the execution of the closing operation independently of the type of load; moreover, it is not able to effectively manage fault situations or situations in which transients are present because it is based on the assumption of having a symmetrical current/voltage and constant frequency.

[0018] In conclusion, one may assert that the known solutions of the state of the art, while achieving the task for which they were designed, do not guarantee the choosing of an optimal moment that is flexible and suitably adapted to the type of load, the type of network and the type of operation performed.

[0019] The principal task of the present invention is to provide a control and monitoring device for the opening/closing of operating elements such as circuit breakers, disconnectors and the like that is able to choose the optimal operating moment taking the status of the neutral, the nature of the network and load and the type of operation to be performed into account.

[0020] As part of this task, one object of the present invention is to provide a control and monitoring device that is able to choose the optimal operating moment by implementing an adaptive strategy.

[0021] A further object of the present invention is to provide a control and monitoring device that is able to choose an optimal operating moment following a strategy that is easy to develop and easy to implement in practice.

[0022] A further but not the last object of the present invention is to provide a control and monitoring

device that is easy to manufacture at low cost.

[0023] This task, together with these and other objects that shall emerge more clearly hereinafter, are achieved by a control and monitoring device for actuating means for the opening/closing of operating elements, comprising current and voltage measuring means and a processing unit that performs the following functions:

- determining an optimal current and/or voltage value at which to perform the opening/closing operation;
- determining, following an operating command and a predictive calculation, a succession of moments in which the current or voltage assumes said optimal value;
- determining a time window for the opening/closing of said operating elements that contains one of the moments in the succession determined;
- sending a command to said actuating means on the basis of the time window determined and of the operating times of said electric operating elements.

[0024] The control and monitoring device as in the invention is characterised by the fact that said optimal value is determined using an adaptive procedure that comprises the following phases:

- measuring the electrical transients following an opening/closing operation and/or generated following the injection of a suitable signal in the electrical network;
- updating said optimal current or voltage value at which to perform the opening/closing operation on the basis of the information obtained from measuring said electrical transients and on the basis of possible operating configurations previously saved in said processing unit.

[0025] Further characteristics and advantages of the invention shall emerge more clearly from the description of a preferred but not exclusive embodiment of the control and monitoring device as in the invention, illustrated purely by way of example and without limitation in the attached drawings, in which:

Figure 1 is a diagram of a preferred but not limiting embodiment of a control and monitoring device as in the invention;

Figure 2 is a diagram of the successive phases in an adaptive procedure executed by a control and monitoring device as in the invention;

Figure 3 is a diagram of the successive phases in another adaptive procedure executed by a control and monitoring device as in the invention.

[0026] With reference to Figure 1, a preferred embodiment of the control and monitoring device as in the invention is presented in diagrammatic form.

[0027] The control and monitoring device as in the invention (shown within the broken line and indicated by the arrow 1), comprises a processing unit 4 and means for measuring the current and voltage 2 and 3, in the form, for example, of current and voltage transformers. Said measuring means 2 and 3 perform a measurement of the current and voltage of the phase 5 and send the signals indicating the measurements made to the processing unit 4.

[0028] When an operation needs to be executed, the processing unit 4 receives an automatic or manual external command 7.

[0029] The processing unit 4 determines an optimal current and/or voltage value, on the basis of an adaptive procedure, at which to execute the opening/closing operation.

[0030] The adaptive procedures adopted by the processing unit 4 can be structured in different ways as described in detail below.

[0031] Said adaptive procedures comprise a phase in which the electrical transients following an opening/closing operation and/or following the injection of a suitable signal in the electrical network (such as a voltage pulse, for example) are measured, and a phase in which the optimal current or voltage value at which to execute the opening/closing operation is updated.

[0032] The update is performed on the basis of the measurement of the current or voltage transients, executed using measuring means 2 and 3, and on the basis of possible operating configurations that were previously saved in the processing unit 4.

[0033] After having determined said optimal value, the processing unit 4 proceeds to perform a predictive calculation of the sequence of the moments in which the current or voltage assumes said optimal value.

[0034] The predictive calculation makes it possible to determine a time window in which to execute the opening/closing operation.

[0035] On the basis of the calculation of said time window and on the basis of the operating times, known a priori, the processing unit 10 sends the command 8 to the actuator means 9 that move (arrow 10) the operating element 6, which could be a circuit breaker, for example.

[0036] The movement of the operating element 6 can be adjusted in real time during the operation itself to ensure that the operation is performed inside the time window, taking any changes due to wear of the components into account if necessary.

[0037] With reference to Figure 2, a preferred sequence of the steps that can form the structure of said adaptive procedure is shown in diagrammatic form.

[0038] The processing unit 4 determines the optimal values 20 and 21 for the closing and opening operation on the basis of possible configurations 22 and 23

for the closing and the opening operations respectively that are saved in the processing unit 4.

[0039] The opening/closing operation 24 is executed on the basis of the calculation of the optimal values 20 and 21. The measuring means 2 and 3 in Figure 1 measure the transients subsequent to the closing/opening operation (step 25).

[0040] If the transients do not exceed a predetermined threshold then the same optimal closing/opening values already used will be used for the next operation.

[0041] If the transients exceed said predetermined threshold then the optimal closing/opening values will be updated using different closing/opening configurations from those used previously (arrows 26 and 27).

[0042] The closing/opening operation will be executed again and if the electrical transients exceed said predetermined threshold again a new optimal value will be determined.

[0043] In a preferred embodiment, the optimal closing/opening values 20 and 21 can be corrected with the quantities 28 and 29 that take the residual energy present in the load 12 in Figure 1 into account. The residual energy, and therefore the quantities 28 and 29, are determined a priori on the basis of the time constant that characterises the discharge transient of the load, if it is capacitive, or on the basis of the opening modes of the previous operation and on the basis of the residual flows present if the load is inductive.

[0044] With reference to Figure 3, an alternative sequence of steps that could form the structure of said adaptive procedure is shown in diagrammatic form.

[0045] Suitable signals, such as voltage pulses for example, are injected in the electrical network (step 30) before each closing/opening operation 34.

[0046] The injection of the pulses can be made using the generator 11 in Figure 1 and can be performed both on the network side, in the direction of arrow 13, and on of the load side, in the direction of arrow 14.

[0047] Said injected signals cause network transients that are measured (step 31).

[0048] The measuring of the transients, which preferably involves spectrum analysis, makes it possible to determine the type of load in advance. This makes it possible for the processing unit 10 to choose the most suitable opening 32 and closing 33 configurations more easily.

[0049] Once the closing/opening configuration has been chosen, the processing unit 10 proceeds to determine the optimal closing/opening moments 38 and 39 and then executes the operation 34.

[0050] The electrical transients subsequent to the electrical operation 34 are then measured 35. If the said transients exceed a predetermined threshold the procedure is repeated (arrow 37).

[0051] The optimal values 38 and 39 are preferably corrected by the quantities 40 and 41 that take the residual energy present in the load 12 in Figure 1 into

account.

[0052] In this case, the residual energy can be evaluated following the injection 30 of a suitable signal on the load side (arrows 42 and 43).

[0053] In practice it has been verified that the control and monitoring device as in the invention performs its set tasks.

[0054] In particular, the adoption of an adaptive procedure makes it possible for the control and monitoring device to select the optimal closing/opening value, always taking the changes in the status of the network and load into account.

[0055] This always makes it possible to perform the electrical operation minimising the transients and electrical arcing phenomenon and thus significantly minimising the wear of the components.

[0056] The correction of the optimal value by evaluating the residual energy of the load makes it possible to further limit the transients, also taking the non-ideal behaviour of the load into account.

[0057] The injection of signals into the network and the evaluation of the transients generated by them makes it possible to further increase the speed of the adaptive procedure, enabling the correct optimal value to be chosen in a minimal number of operations.

[0058] It should, furthermore, be emphasised that the adaptive procedures described are easy to implement, making it possible to obtain a control and monitoring device that is relatively easy to manufacture at low cost.

[0059] The control and monitoring device as in the invention conceived in this way is capable of numerous modifications and variants that are all within the inventive concept.

[0060] Moreover, all the details can be substituted by technically equivalent elements.

Claims

1. Control and monitoring device for actuator means for the opening/closing of operating elements, comprising current and voltage measuring means and a processing unit that performs the following functions:
 - determining an optimal current and/or voltage value at which to perform the opening/closing operation;
 - determining, following an operating command and a predictive calculation, a succession of moments in which the current or voltage assumes said optimal value;
 - determining a time window for the opening/closing of said operating elements that contains one of the moments in the succession determined;

- sending a command to said actuator means on the basis of the time window determined and of the operating times of said electric operating elements;
characterised by the fact that said optimal value is determined using an adaptive procedure that comprises the following phases: 5
 - measuring the electrical transients of the network following an opening/closing operation and/or following the predetermined injection of voltage and/or current signals in the electrical network; 10
 - updating said optimal current or voltage value at which to perform the opening/closing operation on the basis of the information obtained from measuring said electrical transients and on the basis of possible operating configurations previously saved in said processing unit. 15 20
2. Control and monitoring device as in claim 1, characterised by the fact that said adaptive procedure comprises the following steps:
- i) determining an optimal current and/or voltage value for the closing operation on the basis of a possible configuration for the closing operation previously saved in said processing unit; 25
 - ii) determining an optimal current and/or voltage value for the opening operation on the basis of a possible configuration for the opening operation previously saved in said processing unit; 30
 - iii) measuring the network transients after the execution of an opening/closing operation based on said optimal value; 35
 - iv) iteratively repeating steps i) to iii) if said transients exceed a predetermined threshold, updating said optimal values for the opening and closing operations if said transients exceed a predetermined threshold. 40 45
3. Control and monitoring device as in claim 1, characterised by the fact that said adaptive procedure comprises the following steps: 50
- I) injecting a voltage and/or current signal in the electrical network;
 - II) measuring the transients caused by said voltage and/or current signal;
 - III) determining an optimal voltage value for the closing operation on the basis of a possible configuration for the closing operation previously saved in said processing unit if said network transients exceed a predetermined threshold, said possible configuration being identified on the basis of measuring said transient; 55
 - IV) determining an optimal current and/or voltage value for the opening operation on the basis of a possible configuration for the opening operation previously saved in said processing unit if said network transients are present, said possible configuration being identified on the basis of the measurement of said transient;
 - V) measuring the network transients after the execution of an opening/closing operation based on said optimal value;
 - VI) iteratively repeating steps I) to V), updating said optimal values for the opening and closing operations if said transients exceed a predetermined threshold.
4. Control and monitoring device as in claim 3, characterised by the fact that said voltage pulse is injected upstream and/or downstream of said electric operating element.
5. Control and monitoring device as in one or more of claims 3 to 4 characterised by the fact that said measuring of the transients generated by the injection of a voltage pulse in the electrical network is performed using a spectrum analysis procedure.
6. Control and monitoring device as in one or more of the previous claims, characterised by the fact that said optimal current and/or voltage value for the closing operation is corrected with a quantity that takes the residual energy present in the load at the moment of the operation into account, said quantity being determined on the basis of the nominal or measured time constant that characterises the discharge transient for capacitive loads, or the residual flows, determined by the previous operation, for inductive loads.

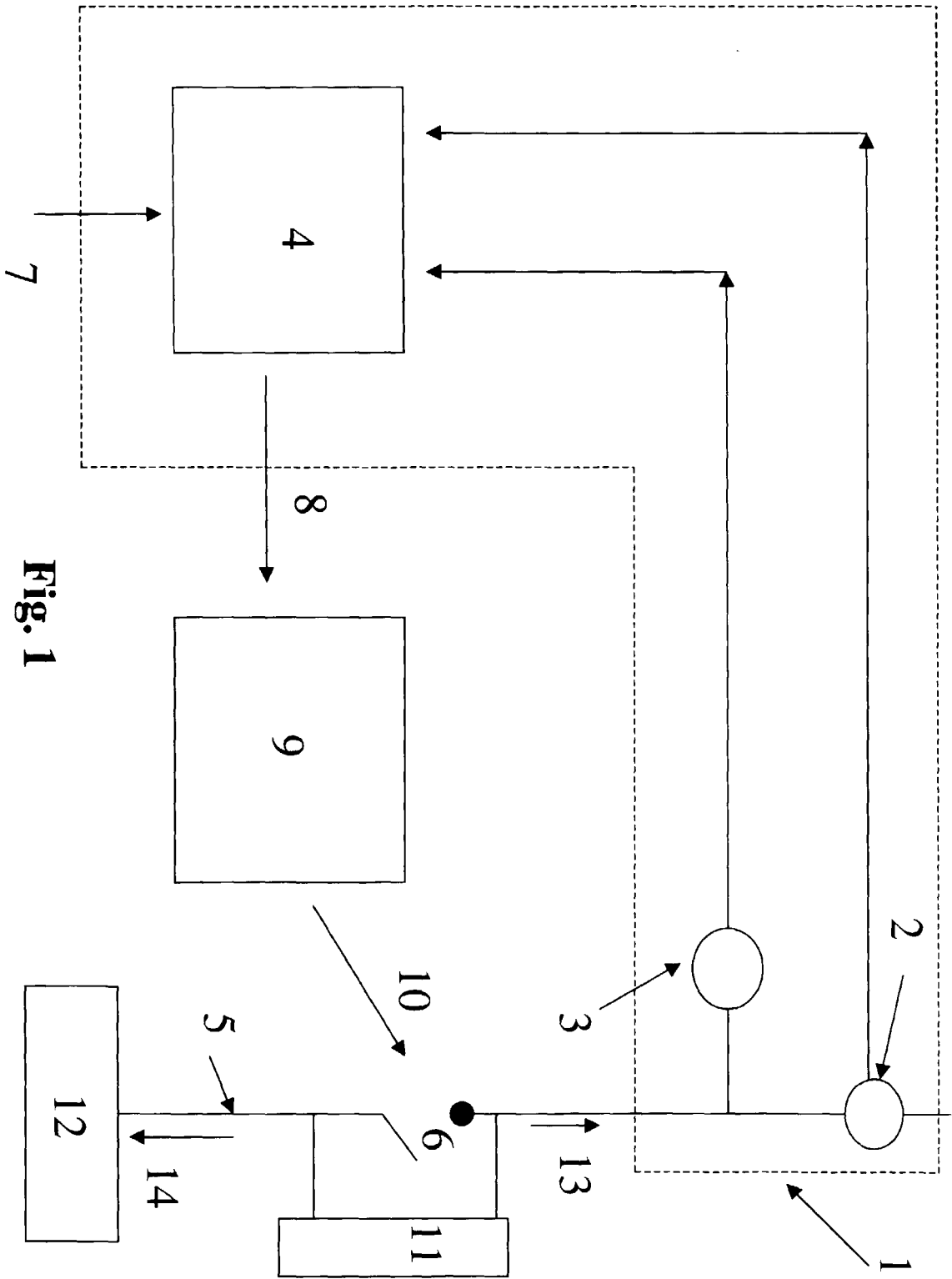


Fig. 1

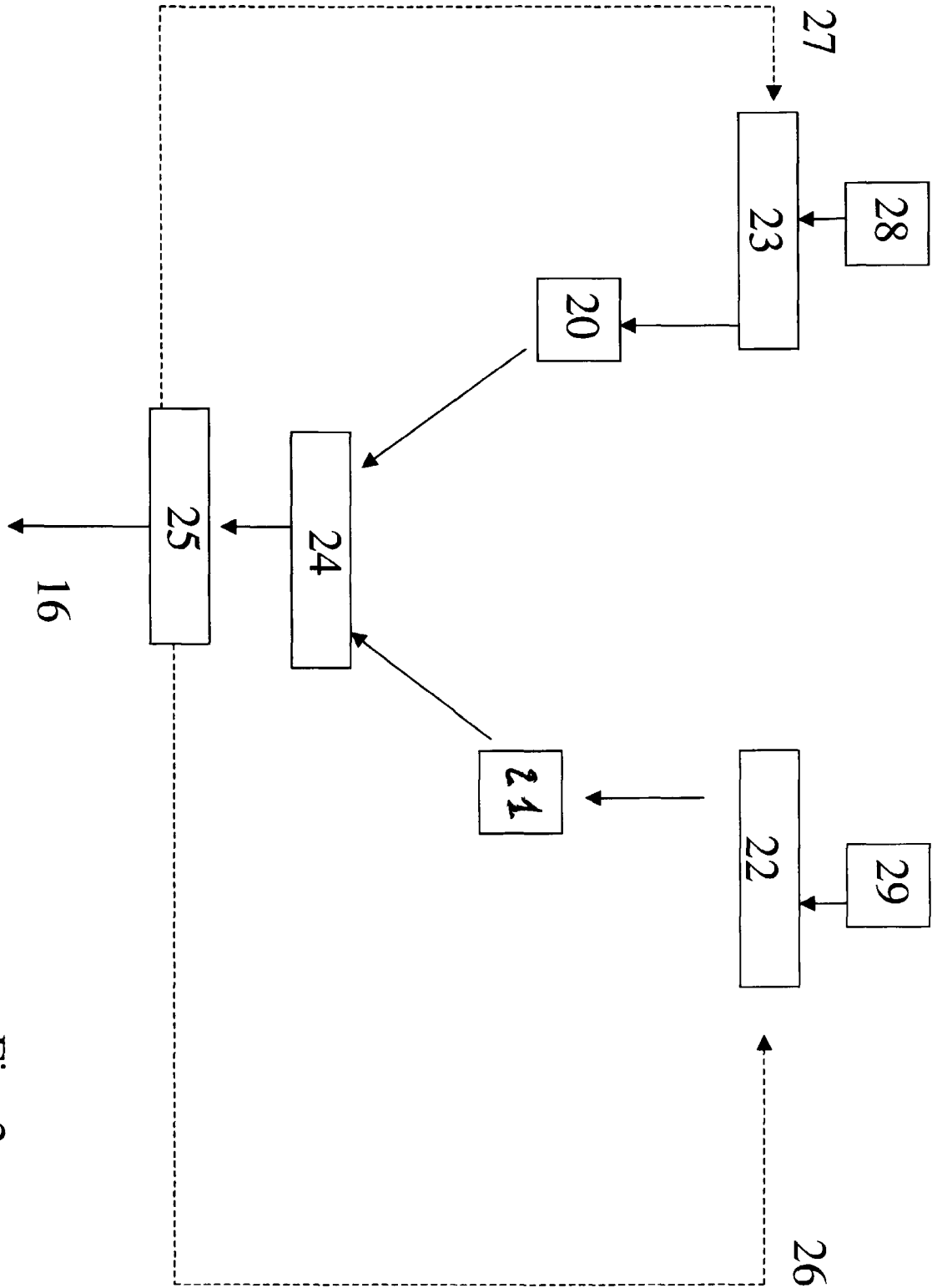


Fig. 2

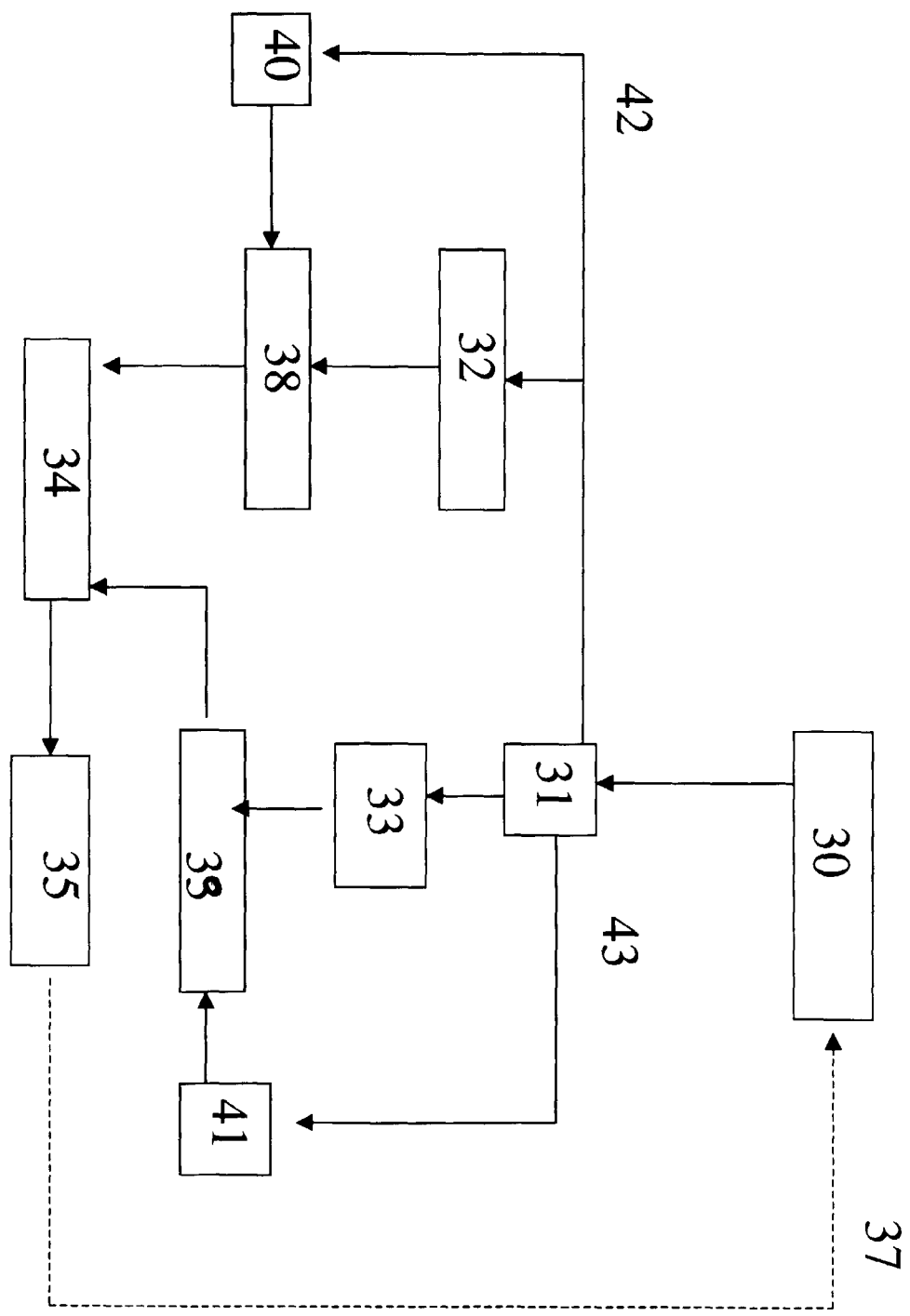


Fig. 3



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 98 20 4085

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	US 5 644 463 A (EL-SHARKAWI MOHAMED A ET AL) 1 July 1997 * column 16, line 66 - column 19, line 56; figure 19 *	1-6	H01H9/56
A	EP 0 222 727 A (SPRECHER & SCHUH AG) 20 May 1987 * page 1, line 1 - page 2, line 31 * * page 6, line 33 - page 7, line 31 * * figure 1 *	1-6	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			H01H H02H
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
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03/82 (P4/C01)

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

EP 98 20 4085

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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17-02-1999

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 5644463	A	01-07-1997	US	5361184 A	01-11-1994
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