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(54) **Control method for an air-cooled condenser of an electric power generation plant with automatic selection of state and electric power generation plant**

(57) A control method for an air condenser of an electric power generation plant, provides detection of a control quantity (P_A) indicative of conditions of a steam flow supplied to the condenser (8), and the selection of a state (S_K, S_K') of the condenser from among a plurality of available states ($S_1, \dots, S_P$), on the basis of the detected control quantity (P_A) and of a reference value (P_R). A first condition (C_1), a second condition (C_2), and a third condition (C_3) are verified, concerning respectively the control quantity (P_A), to an integral of the control quantity (P_A) and to a derivative of the control quantity (P_A), in relation to the reference value (P_R). State changes of the selected state (S_K, S_K') are decided on the basis of the first condition (C_1), the second condition (C_2) and on the third condition (C_3).

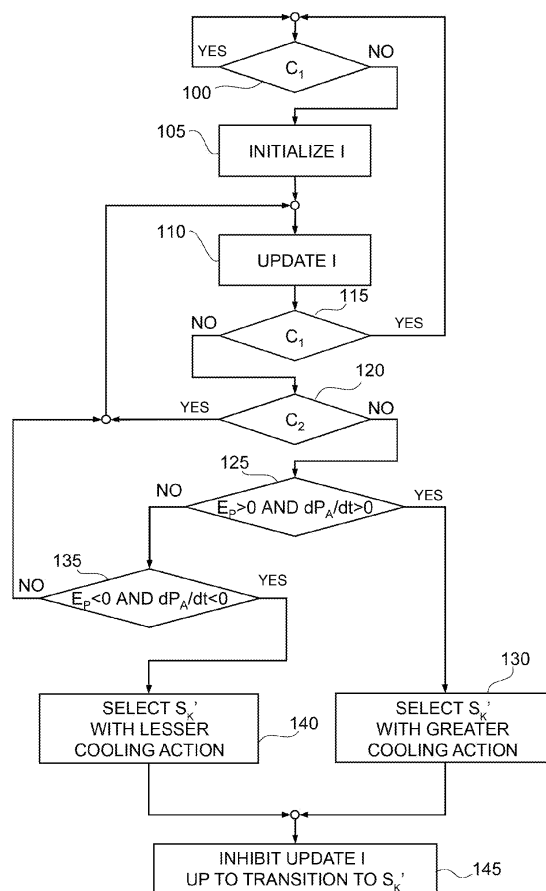


Fig.7

Description

[0001] The present invention relates to a control method for an air-cooled condenser of an electric power generation plant with automatic selection of state and to an electric power generation plant.

[0002] As known, the combined cycle plants for generating electric power can have different configurations, according to project needs. In any case, a combined cycle plant comprises at least one gas turbine and a steam turbine, one or more electric generators, a recovery boiler and a condenser.

[0003] The recovery boiler receives hot exhaust gases from the gas turbine and utilizes them for producing steam in appropriate conditions to be supplied to different sections (high, medium and low pressure) of the steam turbine.

[0004] The condenser is generally of the air type (ACC, Air-Cooled Condenser) and condenses the steam deriving from the steam turbine or from by-pass systems with which steam turbines are normally provided, transferring the residual heat into the atmosphere.

[0005] An air-cooled condenser typically comprises a plurality of tube bundle lines, in which the steam flows, and a plurality of fans, organized as a matrix in rows and columns and arranged so as to cool the steam flowing through the tube bundles.

[0006] The major fraction (about 90%) of the steam is condensed into tube bundles thus condensed by means of fans belonging to primary modules and therefore collected, by gravity, into a collection tank. The condensate will then be taken from the collection tank by means of extraction pumps and sent to the recovery boiler. The remaining fraction (about 10%) of the steam is condensed in tube bundles cooled by fans belonging to sub modules and the residual air (non-condensable gases) is conveyed to an air extraction system, to be evacuated into the atmosphere.

[0007] The cooling action required of the condenser naturally varies depending both on the power supplied by the plant (load), and the environmental conditions (pressure and temperature). The intensity of the cooling depends on the number of fans and by their speed, which must be properly controlled. The fans, in particular, can be switched off or operated at constant speed, selected in a set of values.

[0008] The monitoring operations are critical, however, due to the high power absorbed by each fan (often several tens of kilowatts). Turning on a fan, for example, involves the absorption of a high current peak, as well as, although to a lesser extent, the increase in speed. It is possible therefore that overloads may occur for the medium/low voltage transformers that power the motors of the fans. Even when the fan speed is reduced, it is necessary to ensure proper motor demagnetization. The speed variations lead to greater wear on mechanical parts.

[0009] In particular, a problem which affects known control systems is caused by control strategies, that do not adequately account for the evolution of steam conditions and generate requests for speed change too frequently. The critical issues related to the change in operating conditions of the fans reoccur more often than would be effectively needed, increasing the risk of malfunction or breakage.

[0010] The aim of the present invention is therefore to provide a control method for an air-cooled condenser of an electric power generation plant and an electric power generation plant that allows to avoid unnecessary state transitions, without compromising the performance of the condenser.

[0011] Implemented according to the present invention are a method for controlling an air-cooled condenser of an electric power generation plant and an electric power generation plant as defined respectively in claims 1 and 12.

[0012] The present invention will now be described with reference to the annexed drawings, which illustrate a non limitative example of an embodiment, in which:

- Figure 1 is a simplified block diagram of an electric power generation plant incorporating a condenser according to an embodiment of the present invention;
- Figure 2 is a simplified front view of a part of the condenser of Figure 1 sectioned along the traced plane II-II of figure 4;
- Figure 3 is a simplified side view of a part of the condenser of Figure 1 sectioned along the traced plane III-III of figure 4;
- Figure 4 is a simplified plan view from above of part of the condenser of figure 1;
- Figure 5 is a simplified block diagram relative to a portion of the condenser of figure 1;
- Figure 6 illustrates a table relative to the operation of the condenser of figure 1;
- Figure 7 is a flowchart relative to the method steps for controlling an air condenser according to an embodiment of the present invention;
- Figure 8 is a graph that represents magnitudes used in the method steps illustrated in Figure 7;
- Figure 9 is a flowchart concerning further method steps of figure 1;
- Figure 10 is a flowchart relative to the method steps for controlling an air condenser according to a different embodiment of the present invention; and
- Figure 11 is a flowchart relative to the method steps for controlling an air condenser according to a further embodiment of the present invention.

[0013] As shown in Figure 1, a combined cycle plant for generating electric power comprises a gas turbine group 2,

a steam turbine 3, two alternators, 4, 5, respectively, coupled to the gas turbine 2 and the steam turbine 3, a recovery boiler 7, which operates as a steam generator, a condenser 8, an acquisition module 9 and a control device 10.

[0014] The gas turbine group 2 comprises a compressor 11, which draws a flow rate of air from outside through a suction duct not shown, a combustion chamber 12 and a gas turbine 13, coupled to the combustion chamber 12 to receive and expand a flow rate of exhaust gas. The exhaust gas of gas turbine 2 are conveyed towards the recovery boiler 7 and are used for producing steam.

[0015] The steam turbine 3, which in the described example comprises a high pressure section 3a and a medium-low pressure section 3b, receives high pressure steam and low-medium pressure flow rates from the recovery boiler 7 and provides a flow rate of steam to the condenser 8 through the exhaust of medium-low pressure section 3b and through a by-pass system of a known type and not shown here for simplicity.

[0016] The condenser 8 is of the air type (forced ventilation). Through a controlled flow of forced cooling air, the condenser 8 cools the steam received by the steam turbine, causing condensation. The flow of cooling air is determined by the control device 10.

[0017] The condensed steam is conveyed to a storage tank 15 and then withdrawn by condensate extraction pumps 16 to be fed again to the recovery boiler 7.

[0018] The control device 10 has a plurality of processing units, assigned respectively, to the gas turbine control group 2, to the steam turbine 3, and to the condenser 8 and cooperating with each other to regulate the power delivered by the plant 1. In particular the processing units 18, 19 for the control of the gas turbine 2 and of the steam turbine 3 is of a known type and will not be described in detail. A further processing unit 20, in charge of the control of the condenser 8, receives from the acquisition module 9 a pressure signal P_A , indicative of the absolute pressure at the inlet of the condenser 8 and uses it to determine and set appropriate conditions for the condenser 8. The structure of the processing unit 20 and the methods of management of the operating conditions of the condenser 8 will be later described in detail.

[0019] Figures 2-4 illustrate in simplified form the condenser 8, which comprises a base 21 and a plurality of fans $F_{11}, F_{12}, \dots, F_{1N}, F_{21}, F_{22}, \dots, F_{2N}, F_{M1}, F_{M2}, \dots, F_{MN}$ (designated in synthesis for this purpose by way of the symbol F_{IJ}), supported by the base 21. The fans F_{IJ} are disposed as a matrix and are grouped into M side by side lines, also known as "paths" $ST_1, ST_2, \dots, ST_M$, of each N fans (for example 7 paths of 6 fans).

[0020] Tube bundles 22 (which are shown in Figure 4 are only hatch indicated, for simplicity), are traversed by the steam coming from the steam turbine 3 and are arranged along respective paths $ST_1, ST_2, \dots, ST_M$, in order to receive air from the fans F_{IJ} .

[0021] The fans F_{IJ} are driven by respective motors $M_{11}, M_{12}, \dots, M_{1N}, M_{21}, M_{22}, \dots, M_{2N}, M_{M1}, M_{M2}, \dots, M_{MN}$ (schematically illustrated in Figure 5 and designated in synthesis for this purpose by way of the symbol M_{IJ}), which are in turn fed by transformers of medium voltage/low voltage. In the non-limitative example here described, there are two transformers 24, 25. For example, the motors M_{IJ} of fans F_{IJ} in odd-positions in respective paths S_i are fed by the transformer 24; and the motors M_{IJ} of fans F_{IJ} in even-positions in respective paths are fed by the transformer 25.

[0022] With reference once again to Figure 1, the processing unit 20 assigned to the control of the condenser 8 comprises a reference generator module 26, a subtractor node 27, a state management module 28, a memory module 29 and a drive module 30.

[0023] The reference generator module 26 is programmable in order to provide a reference pressure value P_R , indicative of a target steam pressure obtainable at entrance to the condenser 8.

[0024] The subtractor node 27 determines a pressure error E_P on the basis of the difference between the pressure signal P_A and the value of reference pressure P_R (i.e. $E_P = P_A - P_R$ or, alternatively, $E_P = K(P_A - P_R)$, where K is a constant). The pressure error E_P is supplied to the state management module 28 and used here for determining and changing the operating conditions of the fans F_{IJ} .

[0025] The operating conditions of the fans F_{IJ} are encoded using a table 31 contained in the memory module 29 and illustrated by way of example in Figure 6. The table 31 has P rows and MxN columns. Each row of the table 31 defines one of H available states $S_1, \dots, S_P$ (in synthesis S_K) of the condenser 8, i.e. a particular configuration of operating conditions of the fans F_{IJ} . Whereas the columns of table 31 define the operating conditions of respective fans F_{IJ} in each state. Therefore, each cell defines the operating conditions of a specific fan F_{IJ} in a specific state of the condenser 8.

[0026] Each fan F_{IJ} can be selectively placed in one of a plurality of operating conditions, which comprise a state of isolation (wherein the fan stopped and the line of tube bundles is intercepted by specific isolation valves, in order to reduce the heat-exchange surface in winter conditions and to avoid, therefore, the formation of ice in the tubes), a condition of natural convection (fan stopped) and a plurality of speed values $R_1, \dots, R_Q$ (for example, expressed in revolutions per minute). In the embodiment described, the fans F_{IJ} are operable at a low speed R_1 and at a high speed R_2 . For example, the low speed R_1 is equal to 75% of the high speed R_2 .

[0027] In Figure 6, the possible operating conditions of the fans F_{IJ} are represented as follows:

N: natural convection (fan stopped)

R_1 : low speed

R_2 : high speed.

[0028] The procedure used by the state management module 28 will be later described in detail. Practically, the state management module 28 determines in which state S_K the condenser 8 must be reached or maintained.

[0029] A signal indicative of the selected state S_K is sent to the drive module 30, which controls the motors M_{IJ} of the fans F_{IJ} accordingly. In particular, if the state management module 28 requires a change of state, the drive module 30 manages the transition to the state S_K in order to avoid overloading for the transformers 24, 25 and problems connected with demagnetization of motors M_{IJ} .

[0030] With reference to Figure 7, the procedure performed by the state management module 28 is based on the verification of conditions on the pressure error value E_P , on its integral I and on the derivative of the absolute pressure P_A (represented by way of example in Figure 8). If neither of the conditions are verified, the state management module 28 determines a state change in order to increase or decrease the cooling action of the condenser 8.

[0031] In one embodiment, the following conditions are verified:

$$C_1: \alpha_{L1} P_R < E_P < \alpha_{H1} P_R, \text{ with } \alpha_{L1} \in [-0.3, 0], \alpha_{H1} \in [0, 0.3]$$

$$(e.g. \alpha_{L1} = -0.1, \alpha_{H1} = 0.1)$$

$$C_2: TH_L < I < TH_H, \text{ with } I = \int K_I E_P dt$$

[0032] In addition, a further condition is verified relative to the concordance between the sign of the pressure error E_P as defined in ($E_P = P_A - P_R$ or $E_P = K(P_A - P_R)$) and the sign of the derivative of the absolute pressure P_A .

[0033] The parameters α_{L1} , α_{H1} , respectively negative and positive, define in practice a dead band B_E around the value zero for the pressure error E_P (or, in a completely equivalent way, around the reference pressure value P_R for the absolute pressure P_A) and are preferably programmable.

[0034] In the expression relative to the condition C_2 , the integration constant K_I determines the rapidity of response of the state management module 28 and is calibratable, while the parameters TH_L and TH_H are respectively a negative threshold and a positive threshold and set a dead band B_I around the value zero for the integral I .

[0035] Evidently, the above expressed conditions can be explicitly formulated in terms of absolute pressure P_A and of the reference pressure value P_R :

$$C_1': (1 + \alpha_{L1}) P_R < P_A < (1 + \alpha_{H1}) P_R$$

$$C_2': TH_L < I' < TH_H, \text{ with } I' = \int K_I (P_A - P_R) dt$$

[0036] Even in this case a further condition is verified relative to the concordance between the sign of the error in pressure E_P as defined in ($E_P = P_A - P_R$ or $E_P = K(P_A - P_R)$) and the sign of the derivative of the absolute pressure P_A .

[0037] Initially (Figure 7 block 100), a current state S_K is selected and the state management module 28 performs a test on the condition C_1 until this is verified (block 100, silicon exit). When the condition C_1 is no longer verified, i.e. when the absolute pressure P_A exits the dead band B_E (Figure 7, block 100, exit NO, Figure 8), the state control module 28 initializes an integrator (Figure 7, block 105) which calculates the integral I (block 110).

[0038] The test on the condition C_1 (block 115) is then executed once again. If the condition C_1 is verified (block 115, exit YES), the procedure starts again from block 100, otherwise (block 115, exit NO) the state management module 28 performs a test on the condition C_2 , to check if the integral I is comprised between the negative threshold TH_L and the positive threshold TH_H (Figure 7, block 120, Figure 8). If affirmative (Figure 7, block 120, exit YES), the value of the integral I is updated (block 110) and the test on the condition C_1 (block 115) is repeated. If the integral I is out of the dead band B_I between the negative threshold TH_L and the positive threshold TH_H (Figure 7, block 120, exit NO, Figure 8), the state control module 28 performs a test on the concordance between the sign of the error of pressure E_P and the sign of the derivative of the absolute pressure P_A (block 125). If the error of pressure E_P and the derivative of the absolute pressure P_A are both positive (block 125, exit YES), the state control module 28 selects a new state S_K' , to

which corresponds a higher cooling action of the condenser 8 compared to the current status S_K (block 130). In this case, in fact, the absolute pressure P_A is greater than the reference pressure P_R and is increasing (positive derivative). Therefore, also the magnitude of the error of pressure E_P grows and it is necessary to increase heat dispersion by way of increased ventilation. The magnitude of the cooling action is determined by the number of active fans F_{IJ} and their speed.

[0039] On the contrary (block 125, exit NO), the state control module 28 performs an additional test on the concordance between the sign of the error of pressure E_P and the sign of the derivative of the absolute pressure P_A (block 135).

[0040] In particular, if the error of pressure E_P as defined and the derivative of the absolute pressure P_A are both negative (block 135, exit YES), the state control module 28 selects a new state S_K' , which corresponds to a lower cooling action of the condenser 8 (block 140). The absolute pressure P_A is in fact lesser than the reference pressure P_R and is also diminishing (negative derivative). Therefore, the amplitude (absolute value) of the error of pressure E_P grows and is necessary to reduce the heat dispersion by way of lesser ventilation.

[0041] On the contrary (block 135, exit NO), the amplitude (absolute value) error of pressure E_P is reducing, since the sign of the error of pressure E_P and the sign of the derivative of the absolute pressure P_A are not in accordance. In this case, the procedure continues from block 110, i.e. a new value of the integral I is calculated and the test is repeated on the condition C_1 (block 115).

[0042] Once the new state S_K' is selected, the state management module 28 inhibits the updating of the integral until the transition to the new state S_K' is completed (block 145). Therefore, the updating of the integral I is once again permitted, and the procedure ends.

[0043] As mentioned above, the drive module 30 receives a request to modify the state of the condenser 8 switching to state S_K' , to which corresponds a different cooling action, and acts upon the fans F_{IJ} in order to bring them under the operating conditions corresponding to the state S_K' .

[0044] In one embodiment, the procedure to actuate the change of state is performed as shown in Figure 9.

[0045] Upon receipt of the request to bring the condenser 8 from the current state S_K to the new state S_K' (block 200), the drive module 30 selects the fans F_{IJ} whose operating conditions must be modified (block 205) and determines the order for intervention upon the selected fans F_{IJ} (block 210).

[0046] The selection can be simply made by comparing the rows of the table 31 of Figure 6 corresponding to the states S_K and S_K' . Similarly, the final operating conditions are determined for each fan that has to change modes.

[0047] The order of intervention upon the fans F_{IJ} is however preferably determined so as to turn on the first fans belonging to the secondary modules ("dephlegmators") of the condenser 8 with respect to those belonging to primary modules and in general maintaining as much as possible the heat exchange conditions uniform throughout the entire condenser 8. For example, first to be modified is the speed of fans F_{IJ} placed in even positions in the central paths ST_1 , ST_2 , ..., ST_M and gradually the others.

[0048] Therefore, if there are fans F_{IJ} that need to be brought to a stopped condition, they are stopped at the same time (block 215). Oppositely, if at this step there are fans F_{IJ} that need to be started from the stopped condition, the drive module 30 puts them in function in sequence according to the speed shown in Table 31. More specifically, the drive module 30 simultaneously starts groups of no more than N_{MAX} of fans F_{IJ} and interpose a start-up time range T_S between the start of a group of fans F_{IJ} and the next (N_{MAX} is the maximum number of fans F_{IJ} that can be started at the same time without overloading the transformers 24, 25).

[0049] The drive module 30 then intervenes upon the already active fans F_{IJ} , of which speed R_1 , ..., R_L needs to be changed. A number of fans F_{IJ} not greater than N_{MAX} are stopped (block 220), while the others remain functioning in unchanged operating conditions. After a minimum rest time T_R has elapsed (block 225), the stopped fans F_{IJ} are reactivated at a speed R_1 , ..., R_L required in the new state S_K' (block 230). The rest time T_R can be shorter when a transition of a fan F_{IJ} is required at a higher speed R_1 , ..., R_L than a transition at a lower speed R_1 , ..., R_L . In addition, the rest time is related to the demagnetization time of motors M_{IJ} , so as to allow the correct demagnetization.

[0050] If all of the fans F_{IJ} are driven at the expected speed for the new state S_K' (block 235, exit YES), the drive module 30 notifies the state management module 28 that the transition to the new state S_K' has been completed (block 240). On the contrary (block 235, exit NO), a new group of no more than N_{MAX} fans F_{IJ} and is stopped (block 220) to be restarted at a speed R_1 , ..., R_L provided for the new state S_K' (block 230), after the rest time T_R (block 225) elapses. In this way, practically, while a group of fans F_{IJ} are started at a predefined speed, another group of fans F_{IJ} are stopped. The start-up and shutdown steps of these groups of fans F_{IJ} may be substantially simultaneous.

[0051] In this way, it is possible to make a transition between states in reduced time, avoiding however critical situations due to high inrush power absorbed by the fans. In particular, by limiting the number of fans started simultaneously the transformers 24, 25 are not overloaded. In addition, the waiting pause in the speed transition allows to properly demagnetize the motors M_{IJ} of fans F_{IJ} and to preserve the mechanical parts, especially the gear units, which may otherwise be too stressed.

[0052] Figure 10, wherein equal steps to those already described above are indicated with the same reference numbers, shows a procedure used by the state management module 28 in an alternative embodiment of the invention.

[0053] In this case, in addition to conditions C_1 , C_2 and the concordance condition of sign of error of pressure E_P and

of the derivative of the absolute pressure P_A above indicated, the state management module 28 utilizes a further condition C_0 on the error, defined as follows:

$$C_0: \alpha_{L2} P_R < E_P < \alpha_{H2} P_R$$

where $\alpha_{L2} \in [-1, \alpha_{L1}]$ and $\alpha_{H2} \in [\alpha_{H1}, 1]$ (e.g., $\alpha_{L1} = -0.4$ and $\alpha_{H1} = 0.4$). Practically therefore, a safety band B_S is defined around the value of the reference pressure P_R , comprising and being wider than the dead band B_E (see also Figure 8).

[0054] In the embodiment of figure 10, the state management module 28 cyclically monitors the condition C_1 (block 100). When the condition C_1 ceases to be verified, the control module 28 initializes the integrator (block 105) and performs a test on the condition C_0 (block 150). The value of the integration constant K_i is determined by the outcome of the test. In particular, assigned to the integration constant K_i is an initial value of integration K_{iL} (block 155), if the condition C_0 is verified (block 150, exit YES), and a second value of integration K_{iH} (block 160), greater than the first value of integration K_{iL} , on the contrary (block 150, exit NO).

[0055] Practically, if the absolute pressure P_A exceeds the safety band B_S , the responsiveness of state management module 28 is increased, so as to promptly cause a change of state.

[0056] The procedure then continues as described above, besides the fact that the test on the condition C_0 (block 150) and the assignment of the constant of integration (blocks 155 and 160) are repeated until the situation persists in which the condition C_1 is not verified, while the condition C_2 and conditions concerning the concordance of sign of the error of pressure E_P and of the derivative of the absolute pressure P_A are verified.

[0057] Figure 11 illustrates a procedure performed by the state management module 28 in a further embodiment of the invention. Also in this case, a test is executed on the condition C_0 as defined above (block 175), after the integrator is initialized (block 105). If the absolute pressure P_A is within the safety band B_S (block 175, exit YES), the procedure continues as described with reference to Figure 9, with the tests on conditions C_1 , C_2 and on the concordance of sign of the error of pressure E_P and derivative of the absolute pressure P_A (blocks 115, 120, 125, 135). If, on the contrary, the absolute pressure P_A exceeds the security band B_S (Block 175, exit NO), a new state S_K' is immediately selected, depending on whether the error of pressure E_P is positive or negative. More precisely, if the error of pressure E_P is positive (block 180, exit YES), the state control module 28 selects a new state S_K' , which corresponds to a higher cooling action of the condenser 8 (block 130). If instead the error of pressure E_P is negative (block 180, exit NO), the state control module 28 selects a new state S_K' , which corresponds to a lower cooling action of the condenser 8 (block 140).

[0058] It is finally clear that modifications and variations can be made to the method and plant described, without going beyond the scope of the present invention, as defined in the appended claims.

[0059] In particular, the invention can be advantageously applied to any type of plant based on a steam turbine, such as plants in a "single-shaft" configuration (with gas turbine and steam turbine coupled to the same shaft), and in a "2+1" configuration (with two gas turbines).

[0060] In addition, the steam turbine may have medium pressure and low pressure separated sections.

Claims

1. Method for controlling an air-cooled condenser of an electric power generation plant, comprising:

detecting a control quantity (P_A) indicative of conditions of a steam flow supplied to the condenser (8); and on the basis of the detected control quantity (P_A) and of a reference value (P_R), selecting a state (S_K , S_K') of the condenser from among a plurality of available states (S_1 , ..., S_P), which correspond to respective modes of a cooling action of the condenser (8); wherein selecting a state (S_K , S_K') comprises:

verifying a first condition (C_1), concerning the control quantity (P_A) in relation to the reference value (P_R); verifying a second condition (C_2), concerning an integral of the control quantity (P_A) in relation to the reference value (P_R); verifying a third condition, concerning a derivative of the control quantity (P_A); and deciding whether to change the selected state (S_K , S_K') on the basis of the first condition (C_1), of the second condition (C_2) and of the third condition (C_3).

2. Method according to claim 1, wherein the first condition (C_1) concerns an error (E_P) given by a difference between

the control quantity (P_A) and the reference value (P_R).

3. Method according to claim 2, wherein the second condition (C_2) concerns is an integral of the error (E_P).

4. Method according to claim 3, wherein the third condition concerns a relation between a sign of the error (E_P) and a sign of the derivative of the control quantity (P_A).

5. Method according to claim 4, wherein deciding whether to change the state (S_K , S_K') comprises selecting a new state (S_K') if:

the error (E_P) is outside a first dead band (B_E), defined by a first proportionality parameter (α_{L1}) and by a second proportionality parameter (α_{H1}); and

the integral of the error (E_P) is outside second dead band (B_I), defined by a negative threshold (TH_L) and by a positive threshold (TH_H);

and if, moreover, the control quantity (P_A) is greater than the reference value (P_R) and the derivative of the control quantity (P_A) is positive or else the control quantity (P_A) is lower than the reference value (P_R) and the derivative of the control quantity (P_A) is negative.

6. Method according to claim 5, wherein a greater cooling action of the condenser (8) corresponds to the new selected state (S_K'), if the control quantity (P_A) is greater than the reference value (P_R), and a lower cooling action of the condenser (8) corresponds to the new selected state (S_K'), if the control quantity (P_A) is lower than the reference value (P_R).

7. Method according to any one of claims from 2 to 6, wherein selecting a state (S_K , S_K') comprises verifying a fourth condition (C_0), concerning the control quantity (P_A) in relation to the reference value (P_R).

8. Method according to claim 7, wherein the integral of the error (E_P) is calculated using an integration constant (K_I) which is assigned a first integration value (K_{IL}), if the control quantity (P_A) is inside a safety band (B_S), which includes the first dead band (B_E), and a second integration value (K_{IH}), greater than the first integration value (K_{IL}), if the control quantity (P_A) is outside the safety band (B_S).

9. Method according to claim 7, wherein deciding whether to change the state (S_K , S_K') comprises selecting a new state (S_K'), if the control quantity (P_A) is outside a safety band (B_S), which includes the first dead band (B_E).

10. Method according to any one of the foregoing claims, wherein the condenser (8) comprises a plurality of fans (F_{IJ}) and wherein the states (S_K , S_K') of the condenser (8) are defined by sets of speed values (R_1 , ..., R_Q) of the fans (F_{IJ}).

11. Method according to claims 5 and 10, wherein selecting a new state (S_K') comprises modifying the speed (R_1 , ..., R_Q) of at least on of the fans (F_{IJ}).

12. Electric power generation plant comprising:

a steam turbine (3);

an air-cooled condenser (8), coupled to the steam turbine (3),

for receiving steam coming from the steam turbine (3); and

a detecting interface (9), configured to detect a control quantity (P_A) indicative of conditions of a steam flow supplied to the condenser (8);

characterized by a control device (10) configured to:

on the basis of the detected control quantity (P_A) and of a reference value (P_R), selecting a state (S_K , S_K') of the condenser form among a plurality of available states (S_1 , ..., S_P), which correspond to respective modes of a cooling action of the condenser (8);

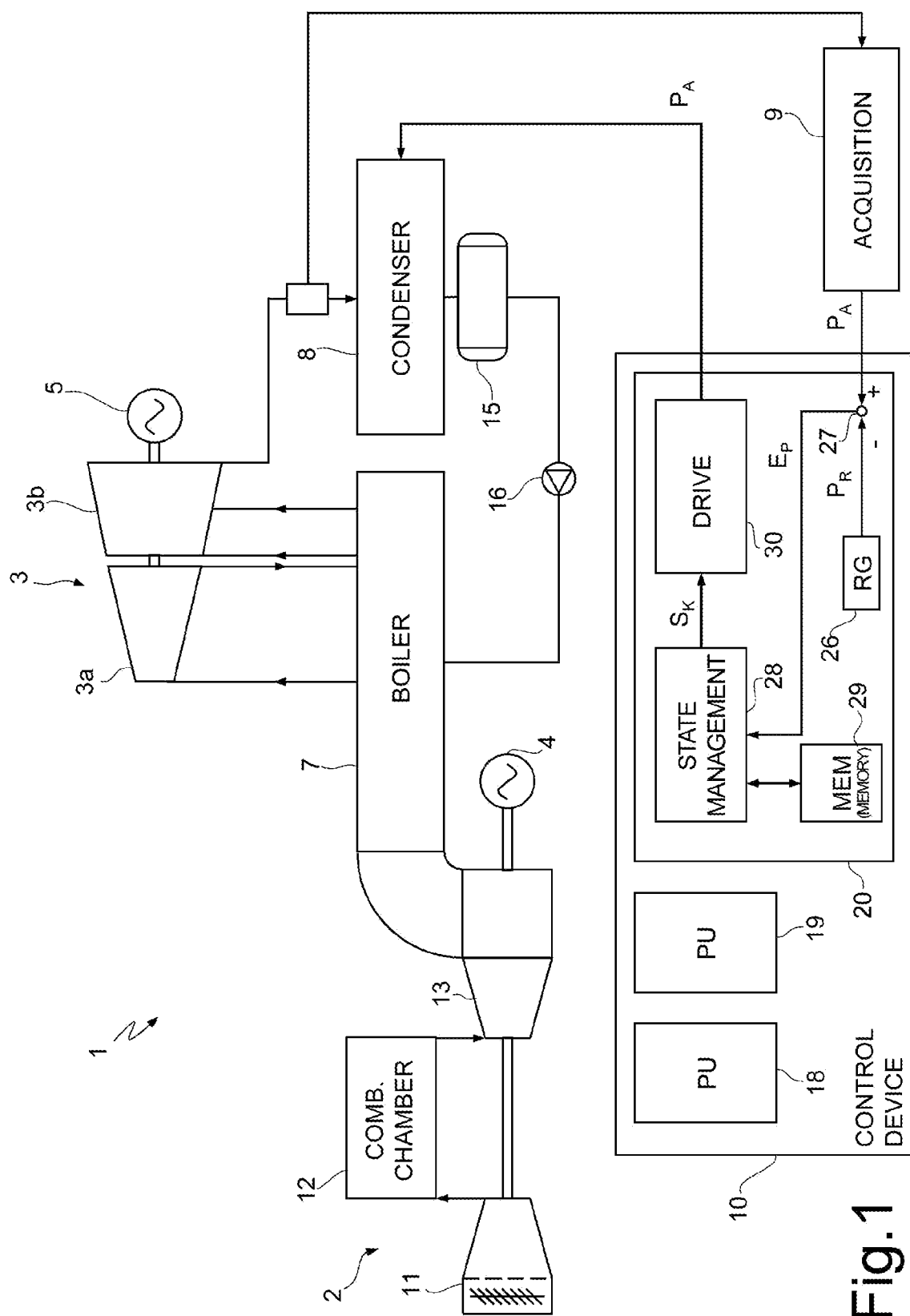
verifying a first condition (C_1), concerning the control quantity (P_A) in relation to the reference value (P_R);

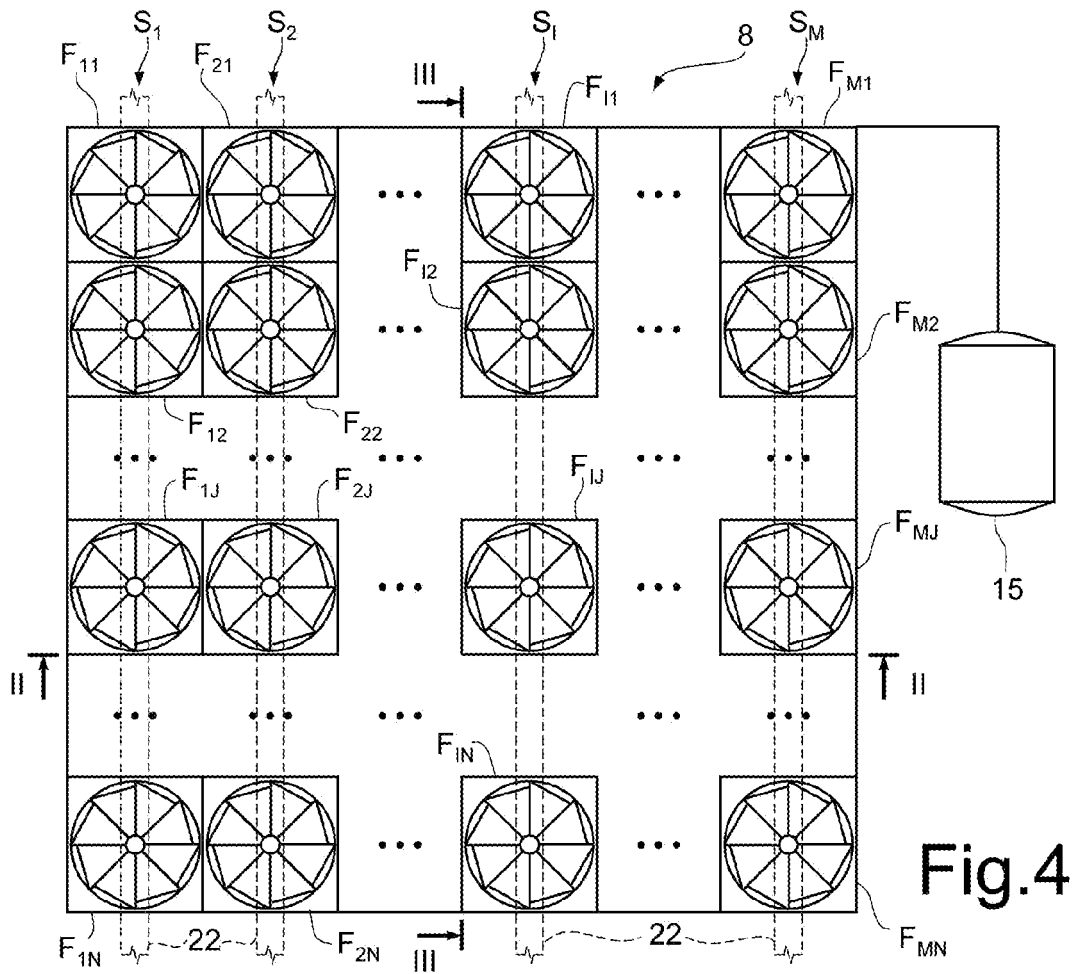
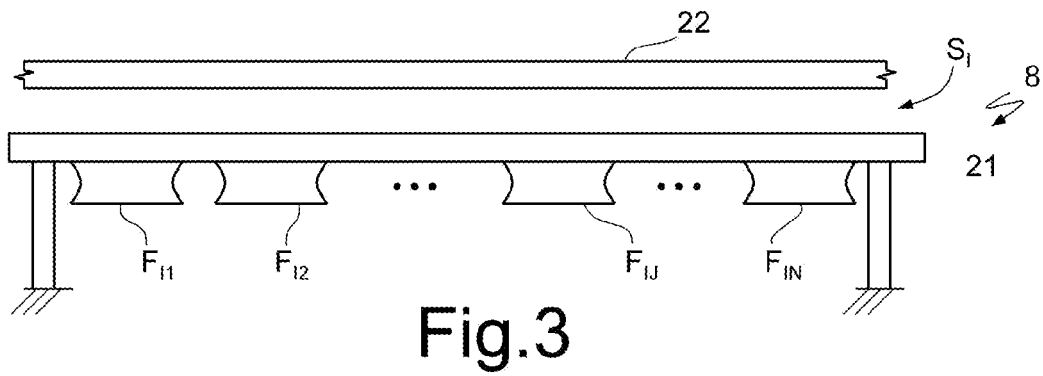
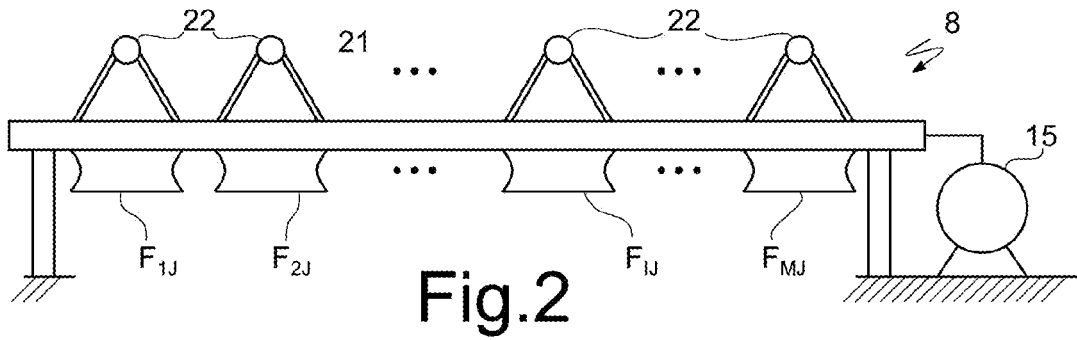
verifying a second condition (C_2), concerning an integral of the control quantity (P_A) in relation to the reference value (P_R);

verifying a third condition, concerning a derivative of the control quantity (P_A); and

deciding whether to change the selected state (S_K , S_K') on the basis of the first condition (C_1), of the second condition (C_2) and of the third condition (C_3).

13. Plant according to claim 12, wherein the first condition (C_1) concerns an error (E_P) given by a difference between the control quantity (P_A) and the reference value (P_R).
14. Plant according to claim 13, wherein the second condition (C_2) concerns is an integral of the error (E_P).
15. Plant according to claim 14, wherein the third condition concerns a relation between a sign of the error (E_P) and a sign of the derivative of the control quantity (P_A).
16. Plant according to claim 15, wherein the control device (10) is further configured to select a new state (S_K') if:
- the error (E_P) is outside a first dead band (B_E), defined by a first proportionality parameter (α_{L1}) and by a second proportionality parameter (α_{H1}); and
- the integral of the error (E_P) is outside a second dead band (B_I), defined by a negative threshold (TH_L) and by a positive threshold (TH_H);
- and if, moreover, the control quantity (P_A) is greater than the reference value (P_R) and the derivative of the control quantity (P_A) is positive or else the control quantity (P_A) is lower than the reference value (P_R) and the derivative of the control quantity (P_A) is negative.
17. Plant according to any one of claims from 12 to 16, wherein the control device (10) is further configured to check a fourth condition (C_0), concerning the control quantity (P_A) in relation to the reference value (P_R).
18. Plant according to claim 17, wherein the control device (10) is further configured to calculate the integral of the error (E_P) using an integration constant (K_I) and assign the integration constant (K_I) a first integration value (K_{IL}), if the control quantity (P_A) is inside a safety band (B_S), which includes the first dead band (B_E), and a second integration value (K_{IH}), greater than the first integration value (K_{IL}), if the control quantity (P_A) is outside the safety band (B_S).
19. Plant according to claim 17, wherein the control device (10) is further configured to select a new state (S_K'), if the control quantity (P_A) is outside a safety band (B_S), which includes the first dead band (B_E).
20. Plant according to any one of claims from 12 to 19, wherein the condenser (8) comprises a plurality of fans (F_{IJ}) and wherein the states (S_K, S_K') of the condenser (8) are defined by set of speed values ($R_1, \dots, R_Q$) of the fans (F_{IJ}).





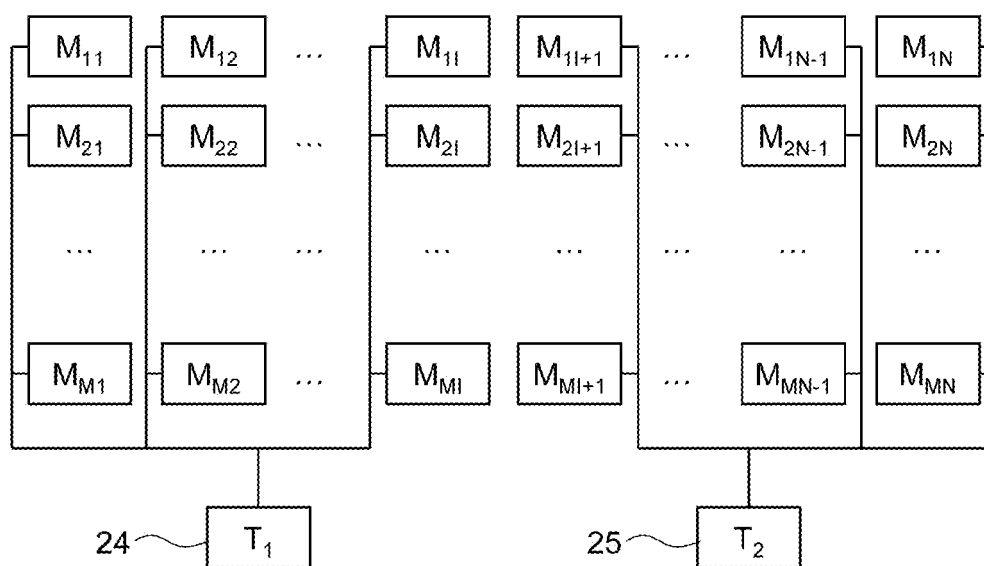
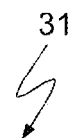


Fig.5



	F_{11}	F_{12}	F_{13}	...	F_{1J}	...	F_{1N}
S_1	N	N	N	...	N	...	N
S_2	N	N	R_1	...	R_1	...	N
...	...	...	...	...	...	...	...
S_K	R_1	R_1	R_1	...	R_1	...	R_1
...	...	...	...	...	...	...	...
S_P	R_2	R_2	R_2	...	R_2	...	R_2

Fig.6

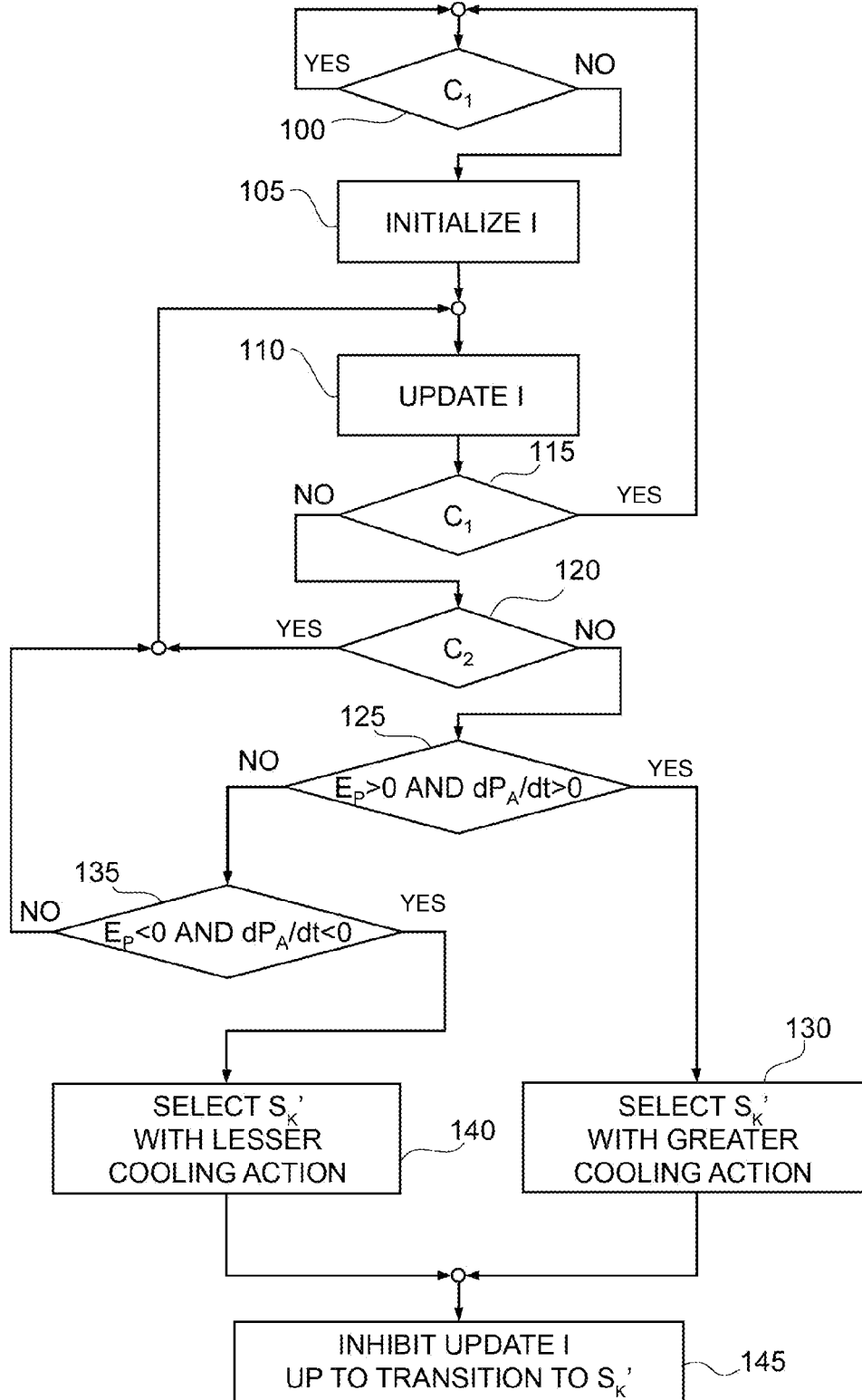


Fig.7

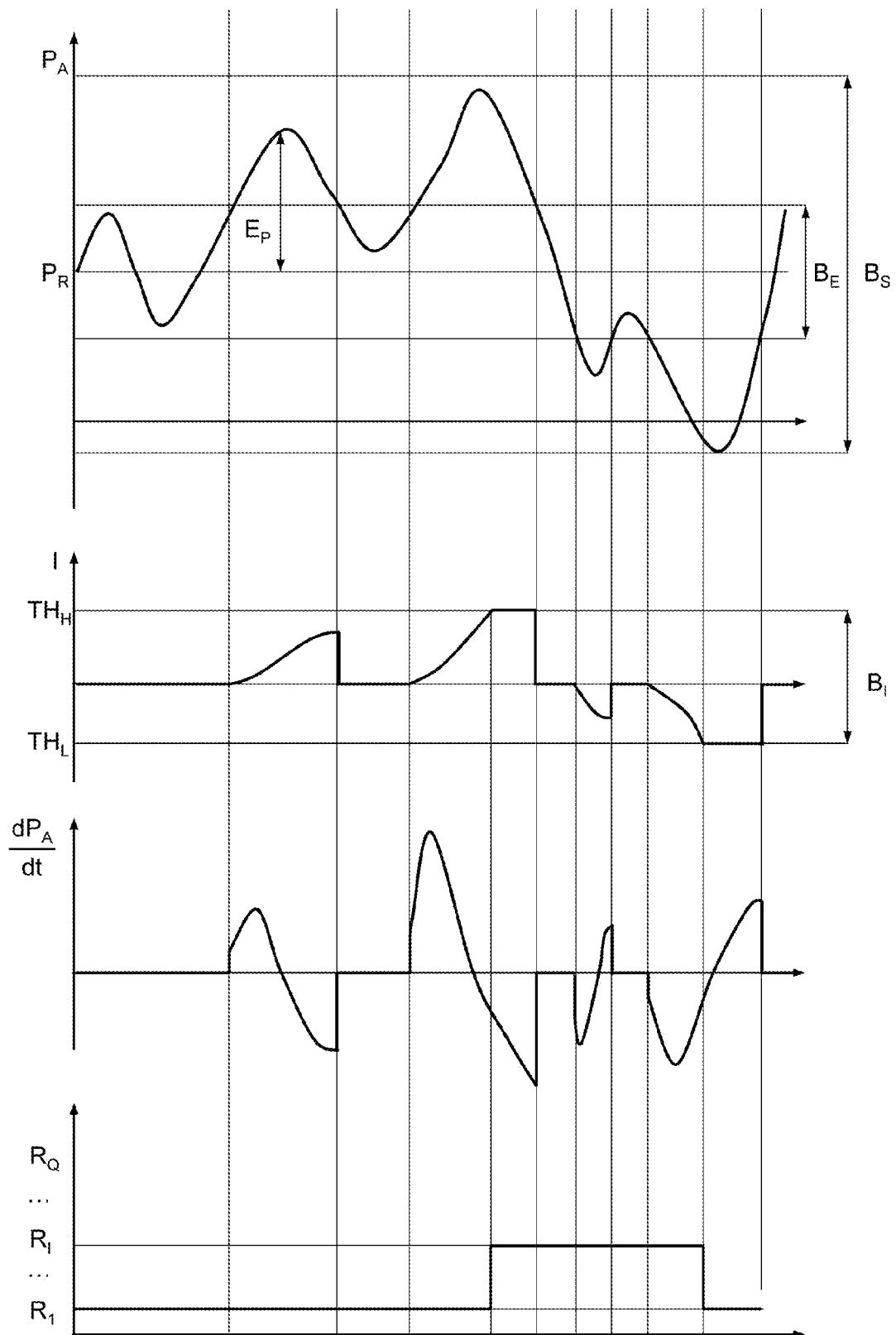


Fig.8

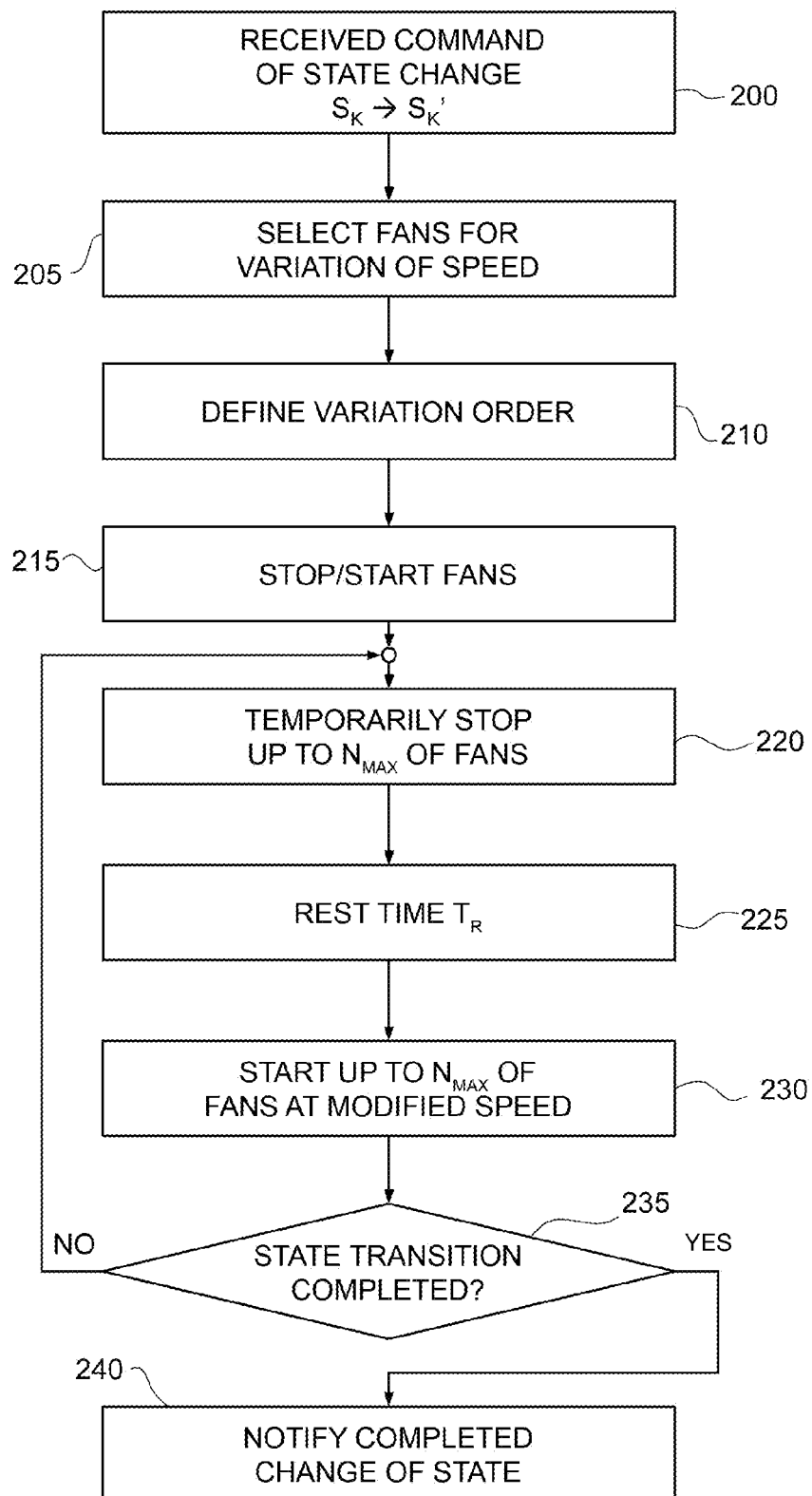


Fig.9

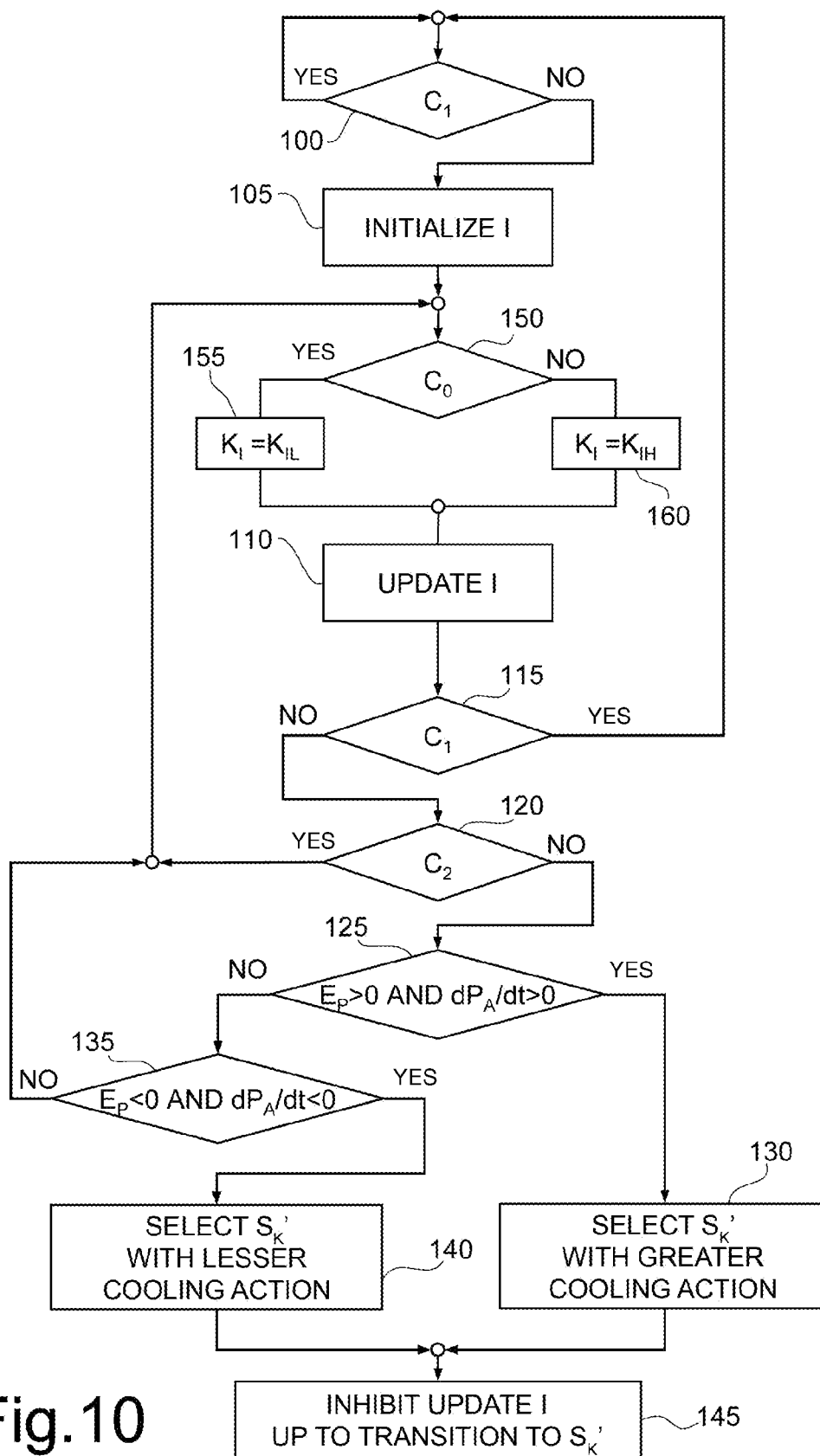


Fig.10

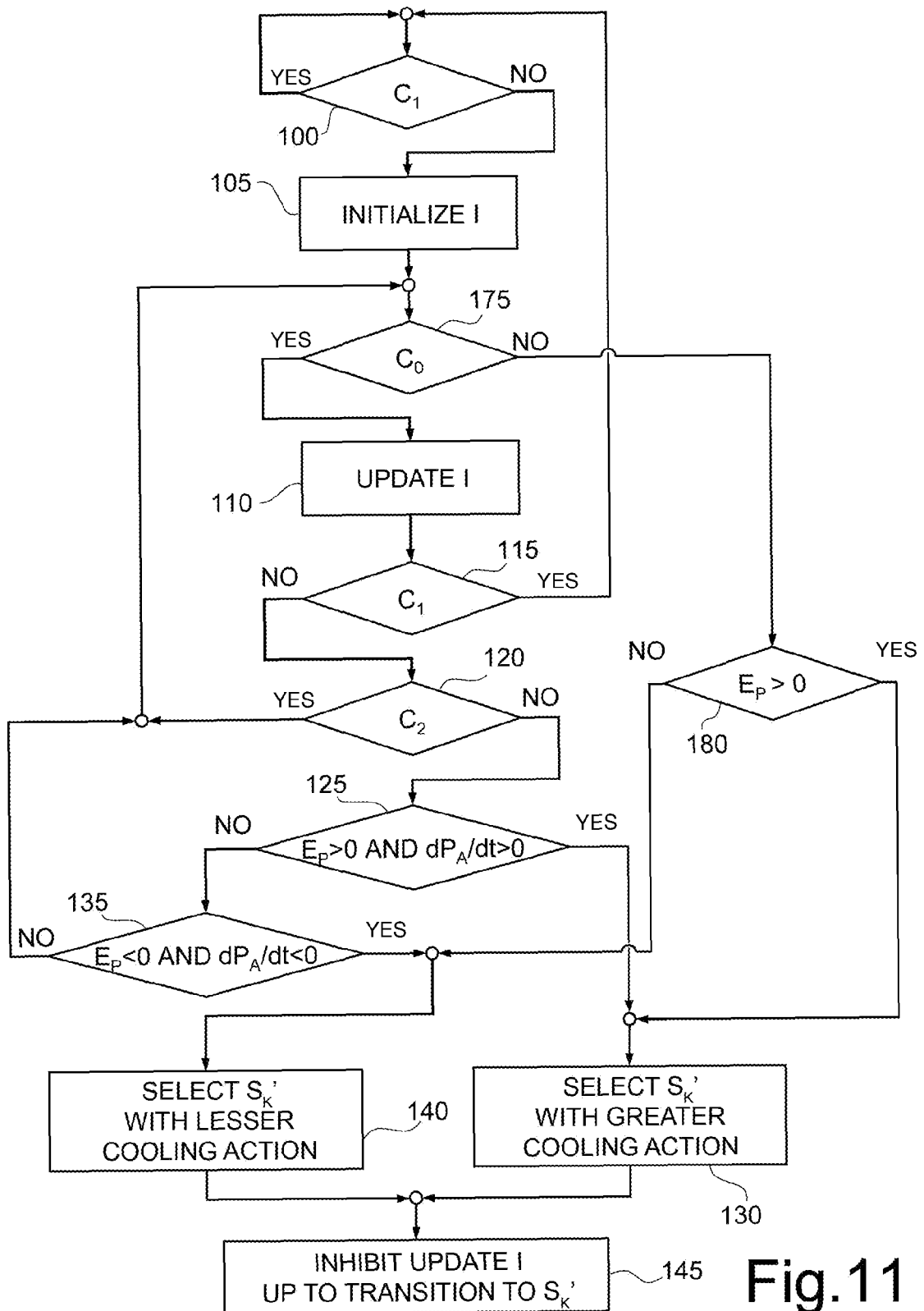


Fig. 11



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Application Number
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