

SPECIFICATION

TITLE OF THE INVENTION

METHOD AND APPARATUS FOR CONTROLLING ELEVATORS

5

BACKGROUND OF THE INVENTION

Field of the Invention:

The present invention relates to an apparatus for controlling elevators, particularly to a method and an control apparatus for allocating elevators corresponding to hall calls.

Description of the Related Art:

An old conventional control method makes the time intervals among elevators as equal as possible by controlling the time interval of each elevator starting from the standard floor. In the next conventional control method, a zone control method are popularly used, wherein each elevator takes a zone of floors in its charge and the time intervals among elevators are kept equal even after departure from the standard floor.

Then, as a microcomputer are very improved, a control method of minimizing a waiting time for a hall call is established, wherein evaluation functions are used for managing elevators for a hall call. Each of the evaluation functions are set to respective time zones. And a technique of measuring a traffic flow pattern in each building and making an evaluation function to each traffic flow mode is described in Japanese Patent Application Laid-Open No. 223673/1984. Further, in Japanese Patent Applications Laid-Open No. 26873/1984 and

No.223672/1984, an improved technique is described, wherein an evaluation function used before traffic demand change and an evaluation function used after traffic demand change are mixed and used at the transition interval of the traffic demand change.

Further, when a operation way to a hall call needs to be changed, a method of displaying an elevator operation situation and registering a new evaluation function from the outside is described in Japanese Patent Application Laid-Open No. 13385/1989.

In the above-mentioned conventional methods, since a traffic flow mode needs to continue during more than a definite period so that an evaluation equation designated to the traffic flow mode is usable, the methods are not effective in changing time of a traffic flow mode or in failing in to identify a prescribed traffic flow. In case a control method used before traffic demand change and a control method used after traffic demand change are mixed as described Japanese Patent Applications Laid-Open No. 26873/1984 and No. 223672 /1984, control methods themselves can be smoothly changed. However, elevator allocation can not be served enough in the transition time of the traffic demand change by mixing the evaluation functions used in stationary traffic flow modes since the traffic flow pattern is singularly in the transition time of the traffic demand change. Then, in Japanese Patent Application Laid-Open No. 13385/1989, it is easy manually to change evaluation functions from the outside. However, by the method of the patent application, evaluation functions are not

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automatically switched and evaluating control methods adequate to each hall call is not considered.

SUMMARY OF THE INVENTION

5 Objects of the Invention:

An object of the present invention is to aim such operation performance improvement as reduction of the waiting time by executing an elevator control more precisely fitting to operation situations, which newly selects an evaluation
10 function for each hall call.

Methods Solving the Problems:

Hall call information collecting means collects data of occurring hall calls and transmits the data to information
15 storing means. Elevator information collecting means collects information on elevator calls and the number of persons in each elevator and so on and transmits the information to the information storing means. Evaluation function selecting means selects an evaluation function adequate to elevator operation
20 situations or change a used evaluation function, based on such information as the number of un-served hall calls, every time elevators are allocated to hall calls. Then, elevator allocation means allocates elevators to hall calls by using the selected or changed evaluation function.

25 The evaluation function selecting means selects or changes an evaluation function for the next allocation if the present operation situations such as execution of allocation for hall calls, finishing services to users in each elevator,



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occurrence of requiring re-allocation, etc., change.

Another example of an apparatus by the present invention has control mode switching means, and executes allocation based on evaluation functions predetermined according to each traffic pattern or time zone during the present operation
5 situations agree with the predetermined conditions. And if the situations get out of the predetermined conditions, an evaluation function different in each hall call is adopted.

The hall call information collecting means collects data
10 of occurring hall calls, and the elevator information collecting means collects information on elevator call etc., and transmits the collected information to the information storing means. An elevator allocation means decides an elevator to serve an occurring hall call by using an
15 evaluation function determined in advance by the evaluation function selecting means. The evaluation function selecting means determines an evaluation function to be used for the next occurring hall call based on the results of the previous allocation and the present operation situations. The
20 determination of evaluation function is executed in all times not only after determination of allocation, but also when such a change of operation situations as arrival to destination, registration of a new elevator call, occurrence of long waiting, etc., occurs. Then, a modeless group control without
25 determining a traffic flow mode can be realized, wherein changes of control methods in accordance with the prescribed time zones or traffic flow modes are not necessary by preparing the next evaluation function after allocation

execution or in the change of operation situations.

In another example of the present invention, the control mode switching means is provided. Ordinarily, the control method predetermined to each traffic flow mode or time zone is executed. Then, if the operation situations such as the traffic flow get out of the prescribed range, the control mode switching means changes the control mode from the allocation method using the evaluation function prescribed to each traffic flow mode or time zone, to the allocation method of changing an evaluation function in every time allocation to a hall call is finished. Then, it get possible that the allocation is carried out by using the evaluation function prescribed to each traffic flow mode if traffic dose not change so much, and an evaluation function is determined in every time allocation to a call is finished if the traffic situations get out of the predetermined range. By the above-mentioned function, if change of the traffic flow is not much, the efficiency of control operations is improved in all time zones by using the conventional method, and if the traffic flow change so much and the desired control performance can not be attained by using the prescribed evaluation function, the allocation flexibly corresponding to the control operation change become possible.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 shows a constitution of an embodiment by the present invention.

Fig.2 (a) is a flow chart of a subroutine for an

evaluation function determination operations of the embodiment by the present invention.

Fig.2 (b) is a flow chart of a main routine showing operations of the embodiment by the present invention.

5 Fig.3(a), 3(b) and 3(c) show figures for explaining features of the present invention.

Fig.4 is a figure for explaining example ways selecting an evaluation function.

10 Fig.5 is a figure for explaining example ways shortening a riding time.

Fig.6(a) is a subroutine flow chart of selecting an evaluation function in case the next evaluation function is determined right after the previous elevator allocation is carried out.

15 Fig.6(b) is a main routine flow chart of selecting an evaluation function in case the next evaluation function is determined right after the previous elevator allocation is carried out.

20 Fig.7 shows a constitution of an embodiment by the present invention, having a function of switching a control method to a traffic flow mode method.

Fig.8 is a flow chart of selecting an evaluation function in the case of switching a control mode to the traffic flow mode method.

25 Fig.9 is a figure for explaining the outline of switching a control mode to the traffic flow mode method.

Fig.10 shows a feature of an embodiment in case a neural network is used to an evaluation function deciding part.

Fig.11 shows a feature of an embodiment in case a neural network is used to an traffic flow mode determining part for determining an unknown traffic flow mode.

Fig.12(a) is a subroutine flow chart of selecting an evaluation function based on the number of un-served hall calls.

Fig.12(b) is a main routine flow chart of selecting an evaluation function based on the number of un-served hall calls.

Fig.13(a) and 13(b) show figures for explaining the outline of evaluation function selection based on the number of un-served hall calls.

Fig.14(a) and 14(b) show figures for explaining the outline of evaluation function selection based on the number of hall calls or its estimated value.

Fig.15 shows a figure for explaining the evaluation function selection in the case of using an additional factor of the number of elevator calls.

Fig.16 shows a constitution of an embodiment in case the evaluation functions are described by a functional.

Fig.17(a) and 17(b) shows figures for explaining an example of an evaluation function table.

Fig.18 shows a constitution of an embodiment in case the evaluation functions are described by membership functions.

Fig.19(a) and 19(b) show figures for explaining a constitution of an embodiment in case the evaluation function is determined by referring to a table storing the evaluation functions corresponding to each predetermined time.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Embodiments are explained referring to drawings in the following. Fig.1 shows the whole constitution of an embodiment by the present invention.

5 Information from hall call buttons 101 to 10n are sent to a hall call information collecting part 31 of a group control apparatus 3 via a transmission line 2. The hall call information collecting part 31 collects information on hall calls at each floor, and an elevator information collecting
10 part 32 collects data of elevator calls, Then. the two parts 31 and 32 send the collected information to a traffic information collecting part 33. An elevator allocation control part 34 decides an elevator to serve an occurring hall call by using an evaluation function determined in advance by an
15 evaluation function deciding part 35. The evaluation function deciding part 35 determines an evaluation function by referring to an evaluation function table 36 based on the information stored in the traffic information collecting part 33, allocation results and the present operation situations.
20 As an evaluation function, for examples, the following evaluation functions can be used, that is, the minimum waiting time control for a hall call (selecting an elevator which firstly arrives at the hall where a hall call occurs), the minimization of the maximum waiting time control (selecting
25 an elevator for which the maximum waiting time for a hall call is minimum), the waiting time averaging control (averaging one around times of elevators) and so on. Further, more evaluation functions can be made by changing the parameters

of evaluation functions. An evaluation function is determined on occasion in such a change of operation situations as arrival at destination, registration of a new elevator call, an occurrence of long waiting time, etc., not only after the
5 determination of allocation. By preparing the next evaluation function in a change of operation situations or after the determination of allocation, it is not needed to judge the traffic flow mode. Therefore, a group control of elevators, without judging the traffic flow mode, can be realized since
10 it is not necessary to change a control method in accordance with each of time zones or each of traffic flow modes. In Fig.1, the numerals 41-44 indicate elevator call buttons, 51-54 elevator information transmission lines, 61-64 cage control apparatuses, 7 a group control signal transmission line, 81-84
15 motors, 91-94 windings, 111-114 cages, 121-124 counter weights and 131-134 floor indicators.

Fig.2 shows a flow chart of an elevator control method of the present invention. Fig.2(a) shows a control process routine. If an occurrence of hall call is detected at the step
20 (201), the traffic information collecting part 33 collects such information on operation situations as the present positions of elevators, allocation states of elevators to hall calls, occurrence states of elevator calls, the number of passengers, states of elevator stopping, elevator operating,
25 door opening and closing of each elevator and so on at the step (202). Then, the evaluation function deciding part 35 selects or changes an evaluation function for evaluating operation situations of elevators based on the present

operation situations at the step (203). Further, the elevator allocation control part 34 decides an elevator to be allocated to the occurring hall call based on the selected evaluation function at the step (204).

5 Actually, the detection of hall call occurrence (201) is executed by a main program as shown by of Fig.2(b). And if a hall call is detected, then the steps (202)-(204) are executed, otherwise, then the process goes back to the main program. In the main program, the following steps are
10 executed, that is, collection of elevator information (205), collection of information on hall calls (206), calculation of arrival time of each elevator (207), estimation of full up time of each elevator (208), calculation of duration period of each hall call (209), calculation of duration period of
15 each elevator call (210) and changes of allocation reservation, etc..

 In the conventional elevator operation methods, a traffic flow in a day as shown by Fig.3(a) is divided into several time zone or traffic flow modes as shown by Fig.3(b). And a
20 control method of elevators is determined so that a control method adequate to each time zone is selected. The above-mentioned determination way of elevator control is common in a traffic flow mode allocation method and a time zone allocation method, and the same control method is carried out
25 in the same time zone. The control methods are used by using such a traffic flow model that the traffic flow changes stepwise as shown by rectangles in Fig.3(b). Then, any means for smoothly changing elevator control way at the transition



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time of traffic flow modes is not considered in the above-mentioned conventional methods. Therefore, nevertheless the traffic flow situation departs from the one to which the selected control method is applicable and the selected control method is not adequate to the situation, the selected control method is used by neglecting the linkage of controls before and after the transition time. And whatever situation the actual traffic flow is in, the conventional control methods select the present traffic flow to one of the prescribed traffic flow modes and use an evaluation function corresponding to the selected traffic flow mode. Then, the control by the conventional method sometimes does not fit to the actual traffic flow.

In the present invention, for example, as shown by Fig.3(c), an evaluation function to be used is determined by judging the present traffic flow situation based on the number of persons getting on and off during the predetermined period, the number of hall calls in charge of each elevator, the number of elevator calls, etc. at every time of hall call occurrence. Since an evaluation function determined by such a way is used and fits to the actual traffic flow situation, it is possible to control elevators corresponding to the present traffic flow situation, without using the categorized traffic flow modes.

In the above-mentioned embodiment, evaluation functions are used. But a method of adjusting the start and stop conditions of each elevator besides a method using evaluation function is applicable to an elevator control method.

An example operation way of the embodiment by the present invention is explained. In the following, a control method of reducing the average waiting time under the conditions that a traffic flow increases from the light state to the crowded state, is described. In the light state that the numbers of hall calls and elevator calls are a few as shown by a case (a) of Fig.4, the average waiting time can be reduced by selecting an elevator of which the time needed for arrival at the floor of the hall call occurring is shortest. Then, the minimal time for arrival at the floor of the hall call is the elevator selecting evaluation base in the light state that the numbers of hall calls and elevator calls are a few as shown by the case (a) of Fig.4. In the state that crowdedness begins and the number of hall calls increases as shown by a case (b) of Fig.4, almost all elevators have hall calls in charge already. In such a situation, further allocation to a newly occurring hall call of the elevator already having hall calls in charge often affects the waiting time for the already reserved hall call. Then, for reducing the average waiting time in such a traffic situation, it is better to allocate an elevator to the occurring hall call by using a minimizing maximum waiting time method which can take account of the waiting time for the already reserved hall call. Then, in the case, minimizing the maximum waiting time for hall calls in charge of each elevator is the elevator selecting evaluation base. In the state that the crowdedness become further intense and hall calls occur at many floors as shown by a case (c) of Fig.4, by averaging the load in charge of each elevator, that is, the stopping

times of each elevator during a round-up and down, in order to reduce the round-up and down time of each elevator, the transport ability per unit time of each elevator can be secured, which leads to reduce the waiting time. Then, in the case, minimizing the estimated average time of a round-up and down is the elevator selecting evaluation base. However, since it is difficult to estimate a round-up and down time in real time and to control the elevator allocation based on the estimated round-up and down time, averaging the load in charge of each elevator, that is, the stopping times of each elevator during a round-up and down, is the elevator selecting evaluation base. Departing from the case, in the state that the intervals among elevators become very short as shown by a case (d) in Fig.4, that is, the so-called jam operation occurs, the intervals among elevators are adjusted equal for reducing the average waiting time. Therefore, in the case, equalizing the intervals among elevators is the elevator selecting evaluation base.

As explained above, if such a operation situation as the hall call number, the intervals among elevators and so on changes as shown by the cases (a), (b), (c) and (d), the control for reducing the average waiting time can be realized by selecting one of minimizing the waiting time, minimizing the maximum waiting time, averaging the loads and equalizing the intervals among elevators, as the elevator selecting evaluation base.

Nextly, the control for reducing a riding time is explained in the following. Since variables measurable in an

ordinary elevator are the elevator call duration period and the number of persons in an elevator, the elevator selection control is evaluated based on such measured variables. Since it is scarce that the number of persons in an elevator exceeds
5 a definite value in the state of a few hall calls as shown by a case (a) of Fig.5, the elevator call duration period is the elevator selecting evaluation base. Then, since the number of getting-on persons and the number of getting-off persons are almost equal in the ordinary traffic flow in spite of many
10 hall calls as shown by a case (b) of Fig.5 and the number of persons in an elevator does not exceed a definite value also, the elevator call duration period is the elevator selecting evaluation base.

In case the number of hall calls is many and the number
15 of elevator calls is a few as shown by a case (c) of Fig.5, the riding time can be reduced by using the number of persons in an elevator as the elevator selecting evaluation base. Then, in case the number of hall calls is a few and the number of elevator calls is many, the elevator call duration period
20 is used as the elevator selecting evaluation base. Further, in case the number of hall calls is many in a some measure and the number of elevator calls is a few, the number of persons in an elevator is used as the elevator selecting evaluation base. Now, the output of a weighing machine provided in an
25 elevator can be used in place for the number of persons in an elevator.

By changing and replacing the elevator selecting evaluation base corresponding to each operation situation in



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every time of hall call occurrences, as mentioned above, an elevator allocation control adapted to operation situation changes can be realized.

Then, the elevator allocation control adapted to
5 operation situation at the moment of each hall call occurrence gets possible. However, it probably occurs according to circumstances that the frequent changes of the elevator allocation control method cause the control unstable. In such a case, the unstable control can be avoided by memorizing the
10 history of the elevator selecting evaluations and determining an evaluation function so as not to derange the results of the previous determinations of an evaluation function.

Fig.6 is a flow chart of determining an evaluation function after finishing an elevator allocation. A flow of a
15 main program is the same as the flow shown by Fig.2(b). Fig.6(a) shows a control process routine. After a hall call occurrence is detected at the step (201), an elevator allocation is executed by using an evaluation function determined in advance to be used for the next hall call
20 occurrence, at the step (204). Then, such a situation as the number of un-served hall calls is grasped at the step (202), and an evaluation function is selected and changed based on the grasped situations, at the step (203). Further, it is checked whether such a change of the operation situations as
25 finishing of service for a hall call occur or not at the step (401), and if the situation change occurs, the process goes back to the step (202) and an evaluation function is selected and replaced.

Since the time from a hall call occurrence to determination of an elevator to be allocated can be reduced by selecting an evaluation function corresponding to operation situations in advance after the previous elevator allocation as mentioned above, the response time from a hall call occurrence to outputting a guidance of an allocated elevator can be made stay within a predetermined range, which makes it possible to use an instantaneous reservation method.

Fig.6(b) shows an example actual execution way of an operation program. In a main program, if a hall call occurrence is detected, the steps (204), (202) and (203) are executed. And if the change of the operation situations is detected, the process starts from the step (202) and goes back to the main program.

Fig.7 is a diagram showing an embodiment having a function of switching a control mode to a traffic flow mode method. The group control apparatus 3 further has a traffic flow mode determining part 37 and an evaluation function table for each traffic flow mode 38. The traffic flow mode determining part 37 determines which traffic flow mode applies to the present traffic flow mode, and if a traffic flow mode applying to the present traffic flow mode can be found, the name of the found traffic flow mode is sent to the elevator allocation control part 33. The elevator allocation control part 33 selects an evaluation function corresponding to the traffic flow mode name sent from the evaluation function table for each traffic flow mode 38 and determines an elevator to serve the hall call. If the traffic flow mode determining part

37 can not find any traffic flow mode applying to the present traffic flow mode, the purport is sent to the elevator allocation control part 33. Then, after receiving the purport, the elevator allocation control part 37 determines an elevator
5 to be allocated to an hall call based on an evaluation equation determined in each hall call occurrence.

Fig.8 is a flow chart showing operations of the embodiment having the function of switching the control mode to the traffic flow mode method. At first, if a hall call
10 occurrence is detected at the step (201), the traffic flow mode determining part 37 judges whether there exists an traffic flow mode prepared in the table, applying to the present traffic flow mode, at the step (601). If there exists an traffic flow mode prepared in the table applying to the
15 present traffic flow mode, the elevator allocation control part 33 determines an elevator to serve the hall call by using the corresponding evaluation function in the evaluation function table for each traffic flow mode 38, at the step (602). If an traffic flow mode prepared in the table applying
20 to the present traffic flow mode does not exist, the steps (202)-(204) are executed in the same process as shown in Fig.2(a) and the elevator allocation is carried out by using an evaluation function determined in each hall call. By determining an evaluation function before the next hall call
25 occurrence as shown by Fig.4 in the elevator allocation, the response time from pushing a hall call button to receiving a guidance of an allocated elevator can be made stay within the predetermined range, which makes it possible to use an

instantaneous reservation method. In the case, the flow of a main program is the same as the flow shown by Fig.2(b).

Fig.9 is a figure of traffic flow modes used for explaining the switching of control modes. In such a time zone as zone a, zone c, zone e and zone g shown in Fig.9, in which the almost same traffic continues during a definite period, it gives better efficiency and control continuity to use an evaluation function of which the fitness is confirmed enough by such means as simulation test, etc., in advance.

In such a traffic pattern transition time as the hatched zones b, d and f, neither of the evaluation functions used before and after the transition time fit to the transition time. Then, in the traffic transition time or in case the present traffic mode does not apply to any one of the assumed traffic modes, it is preferable to apply the elevator allocation method of the present invention wherein an evaluation function more adequately fitting to the transition time is selected and replaced in each hall call occurrence.

By the present embodiment, in case one of the previously assumed traffic modes continues during a definite time, that is, in the time zones a, c, e and g shown in Fig.9, the same efficiency and continuity of elevator control as the conventional methods is secured by using evaluation functions of which the effects are confirmed enough. Further, in the traffic transition time or in case the present traffic pattern deviates from any one of the assumed traffic modes, that is, in the time zones b, d and f, the elevator control can be improved by using an evaluation function fitting to operation

situations in each hall call, and the efficiency improvement of elevator control for all day traffic flow can be also secured.

Fig.10 is a diagram showing the constitution of the evaluation function deciding part to which a neural network is applied. Information sent from the traffic information collecting part 33 is stored in a memory of situations 351 as the present situation information. The stored information is sent to the neural network 352. The number of the present hall calls, the number of persons getting on and off during the predetermined period, the number of elevator call occurrences and so on are input to an input layer of the neural network 352, and the evaluation function number, to be used, is output to an output layer as the results. In the embodiment, since an evaluation function is selected by the neural network which finished a learning, the elevator control method by the present invention can be accomplished even in case the relation between an evaluation function and an operation situation is not quantitatively obtained.

Fig.11 is a diagram showing the constitution of the traffic flow mode determining part using a neural network for determining whether the present traffic flow mode applies to one of the presumed traffic flow modes or not. The constitution of the neural network 353 is the same as that of the neural network in Fig.10, except determining whether the present traffic flow mode applies to one of the presumed traffic flow modes or not. In the embodiment, means for selecting an evaluation function corresponding to an operation

situation is separately provided. By the embodiment, if it is judged by the neural network that the present traffic flow mode does not apply to one of the assumed modes to each of which an evaluation function is prepared in advance, then the modeless allocation method for each hall call occurrence is executed. Since a table for determining the unknown traffic flow mode is not necessary and not used, the unknown traffic flow mode determination can be quickly accomplished.

Figs.12(a) and (b) are charts for explaining the flows of operations in case an evaluation function is selected or changed based on the number of un-served hall calls. The flows of operations are the same as that in Figs.2(a) and 2(b) except the step (202-1) at which the number of un-served hall calls is used as the operation situation.

Since the number of un-served hall calls is one of the indexes precisely representing the relation among the number of provided elevators, the traffic flow and the present usable capacity of elevators, an evaluation function to be used can be determined by using the number of un-served hall calls.

Figs.13(a) and 13(b) are figures for explaining elevator operations based on the number of un-served hall calls. The number of un-served hall calls at an operation situation has the following character. A time needed for a round-up and down can be used as the usable capacity of elevators, and it is the time needed for going up and down and returning to the present place. Then, the number of persons which an elevator can transport depends on the time needed for a round. However, the time can not be obtained until an elevator goes up and down

and returns to the present place. Further, the time does not directly relate to the response time for each hall call. The number of un-served hall calls is the number of hall calls to be served hereafter, and can be regarded as the time needed for one round hereafter if the number represents the time to be needed for going up and down hereafter. Therefore, the traffic or the load which each elevator has to take in its charge can be estimated based on the number.

For example, if the number of hall calls is a few as compared with the number of available elevators, the waiting time for a hall call can be decreased by selecting the elevator for which the waiting time is minimal. On the other hand, if the number of hall calls exceeds a definite value, an evaluation of elevator allocation is executed as taking the crowdedness in an elevator into account so as to equalize the load of each elevator. Further, an elevator allocation control fitting to the present operation situations is possible by switching an evaluation function from one based on the waiting time principal way to one based on the load principal way, if the hall calls in charge of each elevator exceeds the predetermined value, or the difference in some measure occurs in the number of hall calls in charge of each elevator.

Further, since the number of un-served hall calls shows a phase of the present traffic situations and probably corresponds to the present traffic flow, as shown by Fig.13(b), the present load situations of elevators are precisely grasped, and quick responses to changes of the present traffic flow is also possible, by using the number of

un-served hall calls.

Figs.14(a) and 14(b) are figures for explaining elevator operations based on the number of hall calls during the predetermined period or the estimated value of the number. As shown by the figures, using the number of hall calls during the predetermined period brings the same effects as using the moving average of a traffic flow. In the case, the program executes the selection or change of an evaluation function as shown in Figs.12(a) and 12(b) by using the number of hall calls during the predetermined period in place of the number of un-served hall calls. In the method of using the number of hall calls during the predetermined period, the responses to changes of traffic flow become slower as compared with the method using the number of un-served hall calls, but the smooth control continuity and the stable control can be realized.

Fig.15 is a figure for explaining operations by taking an additional factor of the number of elevator calls into account. Since taking the additional factor of the number of elevator calls into account make it possible to grasp the traffic flow situations including also the destination of each elevator call, elevator allocation more adequately fitting to the present operation situations can be realized. For example, when a hall call is represented by a triangle, and an elevator call by a circle, in Fig.15, both of the call patterns shown by a figure (a) wherein getting on or off persons converge on the top floor or the bottom floor and a figure (b) wherein persons move almost on an average between floors, are

represented by the same pattern as shown by a figure (c), and one of the both can not be distinguished from the other one. If the additional factor of elevator calls is taken into account, the call pattern shown by the figure (a) is
5 represented by a figure (d), and the one shown by the figure (b) is represented by a figure (e). Then, the both call patterns are distinguished from each other, which realizes a elevator control finely adapted to operation situations by corresponding also to each elevator call.

10 Fig.16 shows the constitution of the evaluation function deciding part in an embodiment in case the evaluation functions are described by a functional. In a building of which main traffic flow features are a converging on specific floors, a scattering among floors or a moving between floors,
15 the relation between the operation situation and an evaluation function fitting to the situation can be sometimes expressed by a functional. In such a case, the evaluation functions are described as a functional 354, and an evaluation function is determined by substituting data value of each operation
20 situation stored in the memory of situations for variables of the functional in each situation change. Then, the elevator allocation is executed by using the evaluation functions determined in such a manner. Although the scope of using the embodiment is restricted since such a functional can be
25 obtained only in a few buildings or traffic flows, the constitution of the group control apparatus can be simplified since one functional has only to be prepared for obtaining the evaluation functions.

Figs.17(a) and 17(b) show examples of the evaluation function table. Combinations of operation situations are prepared, and an evaluation function corresponding to each of the combinations is determined in advance and described in the evaluation function table. By the method based on the table, the process from judgement of operation situations to elevator allocation is quickly executed although the scope of the process is restricted within the operation situations described in the table.

Fig.18 shows the constitution of the evaluation function deciding part in an embodiment in case the evaluation functions are described by membership functions. An evaluation function for each term of operation situations to be judged is described in the form of a fuzzy rule 355. Then, the evaluation function 356 is expressed by logical add of conclusion parts of the pertinent fuzzy rules and output as a function. The output function is the evaluation function, and the elevator allocation control part 34 allocates an elevator by obtaining the control value based on the evaluation function. By the embodiment, since the evaluation functions are prepared in the form of fuzzy rule, addition of rules becomes easy.

Figs.19(a) and 19(b) are figures for explaining an embodiment wherein the evaluation functions are determined at the predetermined times and each evaluation function is determined by referring to the table storing the evaluation functions described at the predetermined times. Fig.19(a) shows the constitution of the group control apparatus of the

embodiment and is the same as that shown by Fig.7 except a clock 39 for counting time is provided in the embodiment. The evaluation function table 36 stores the evaluation function prepared for each predetermined time zone, corresponding to the number of hall calls and elevator calls, as shown by Fig.19(b), and an evaluation function for allocating an elevator for a hall call occurrence is determined based on the time counted by the clock 39 and the evaluation function table 36. In the embodiment, since the good control continuity before and after each switching of control can be held by setting an evaluation function in each time zone so that the elevator control smoothly transits at the switching of control while each evaluation function can be set so as to correspond also to a specific operation situation, such a problem as a long waiting time probably occurring at the switching of control can be prevented.

By the present invention, since the precise elevator control fitting to the operation situation in each time of hall call occurrence can be realized for each hall call, it is possible to reduce the waiting time, the frequency of long waiting occurrences, the crowdedness of each elevator, the riding time and so on. Further, especially in the traffic flow pattern transition time to which the conventional method using an evaluation function fixed to each time zone or traffic flow mode can not correspond, the present invention can avoid the unexpected passing of an elevator due to no vacancy and considerably improve the operation performance of elevators.



WHAT IS CLAIMED IS;

1. An elevator operation controlling method of determining
an elevator to be allocated in a hall call occurrence by using
5 an evaluation function, from a plurality of elevators,
comprising the steps of:

memorizing a plurality of said evaluation functions; and
selecting and using one of said plurality of evaluation
functions in each hall call occurrence.

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2. An elevator operation controlling method of determining
an elevator to be allocated in a hall call occurrence by using
an evaluation function, from a plurality of elevators,
comprising the steps of:

15 memorizing a plurality of said evaluation functions; and
changing said evaluation function to be used in
accordance with situations of elevator operations and traffic
demands, in each hall call occurrence.

20 3. An elevator operation controlling method using a group
control apparatus, said apparatus determining an elevator to
be allocated, from a plurality of elevators, comprising the
step of:

changing a method of determining an elevator to be nextly
25 allocated on at least one of situation changes of completion
of determining an elevator to be allocated and completion of
elevator service to a hall call.



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4. An elevator operation controlling method according to claim 3, wherein an evaluation function is used to determine an elevator to be allocated to a hall call.

5 5. An elevator operation controlling method using a group control apparatus, said apparatus determining an elevator to be allocated, from a plurality of elevators, comprising the steps of:

preparing control methods according to each one of
10 patterns of traffic demands, traffic flows and time zones;

judging whether a present traffic state applies to one of said patterns of traffic demands, traffic flows and time zones;

using said prepared control methods if said present
15 traffic state applies to said one of said pattern; and

executing one of selection, generation and change of an elevator control method in each hall call occurrence if said present traffic state does not apply to any one of said pattern.

20

6. An elevator control apparatus for controlling a group of elevators, comprising:

control method determining means for executing one of selection, generation and change of a method of determining
25 an elevator to be allocated, based on the number of hall calls occurring during a predetermined period.



REPLACED



7. An elevator operation controlling apparatus for
determining and controlling an elevator to be allocated in a
hall call occurrence, from a plurality of elevators,
5 comprising:

information collecting means for collecting and storing
information on hall calls and elevator calls; and

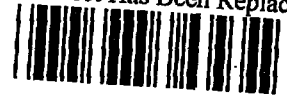
evaluation function deciding means for determining an
evaluation function used for allocating an elevator to a
10 nextly occurring hall call, based on said information stored
in said information collecting means, results of elevator
allocation and present elevator service situations.

15

20

IS SHEET HAS
REPLACE

This Sheet Has Been Replaced



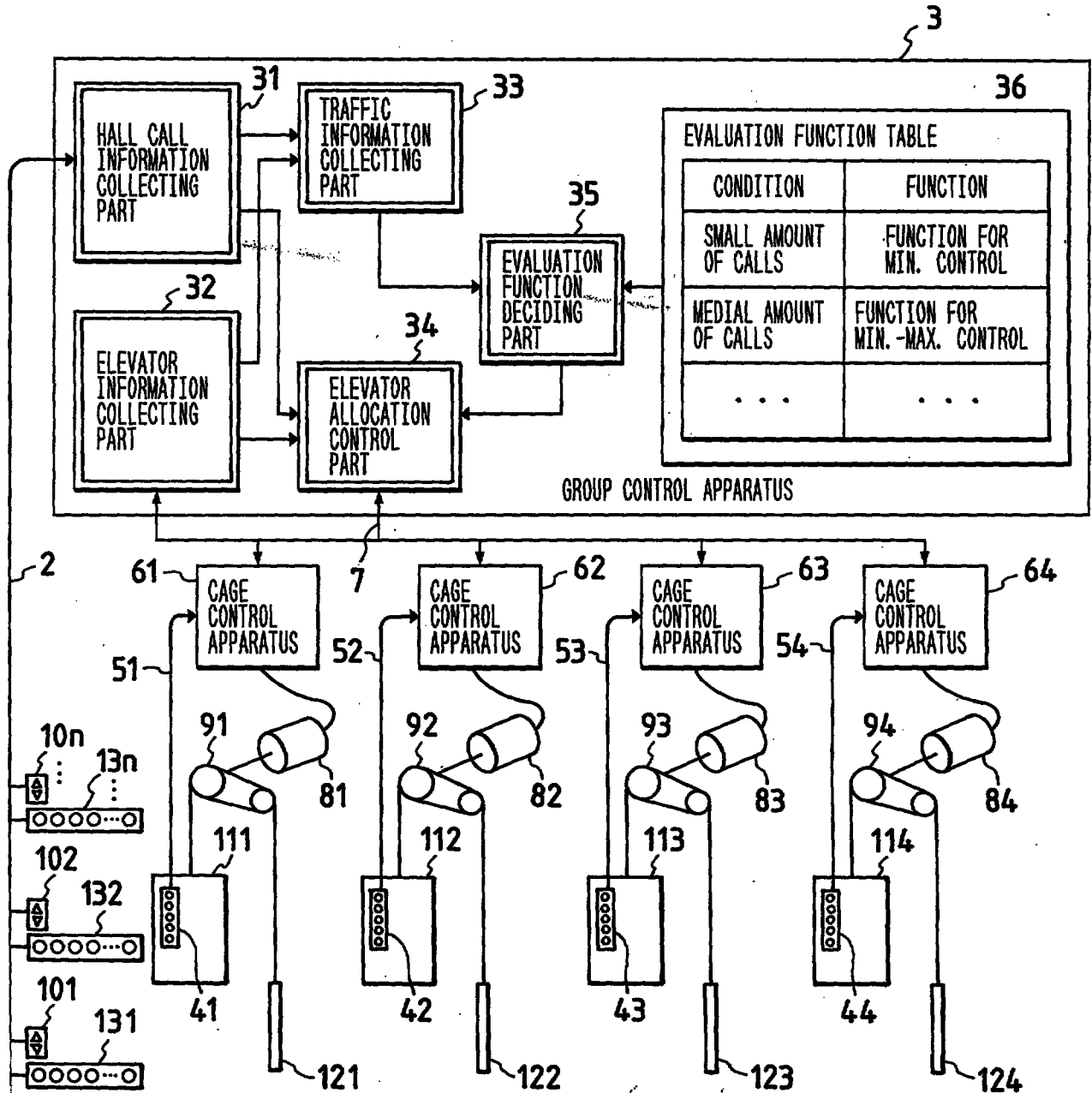
METHOD AND APPARATUS FOR CONTROLLING ELEVATORS

Abstract of Disclosures

An evaluation function used to the nextly occurring hall call is determined based on results of previous elevator allocation and present situations of traffic demands and traffic flow. The determination of the evaluation function is carried out on occasions in such an operation situation change as arrival of an elevator at the destination floor, registration of a new hall call, a occurrence of long waiting time and so on, besides after determining elevator allocation. By using such elevator operation control method wherein it is not necessary to judge a traffic mode, by preparing the nextly used evaluation function after determining elevator allocation or in the changes of traffic situations, it is further not necessary to change a elevator control method according to traffic slow modes or time zones, which realizes a modeless group control of elevators.



FIG. 1



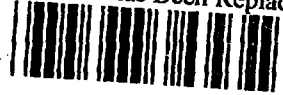


FIG. 2(a)

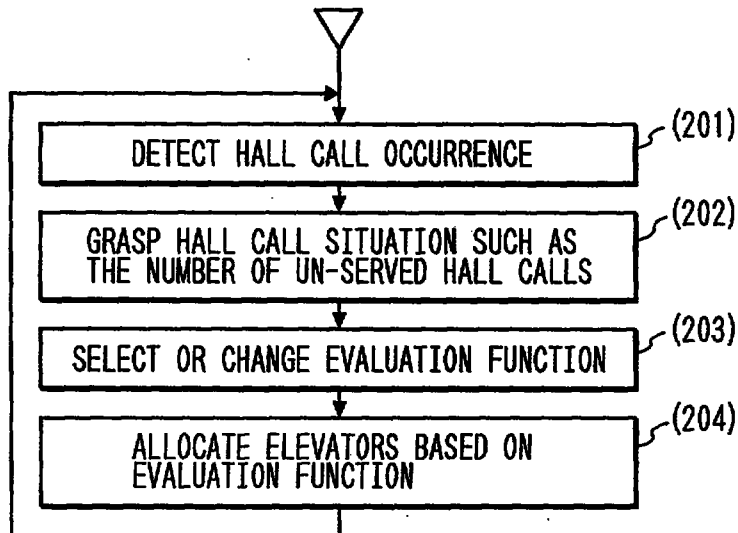


FIG. 2(b)

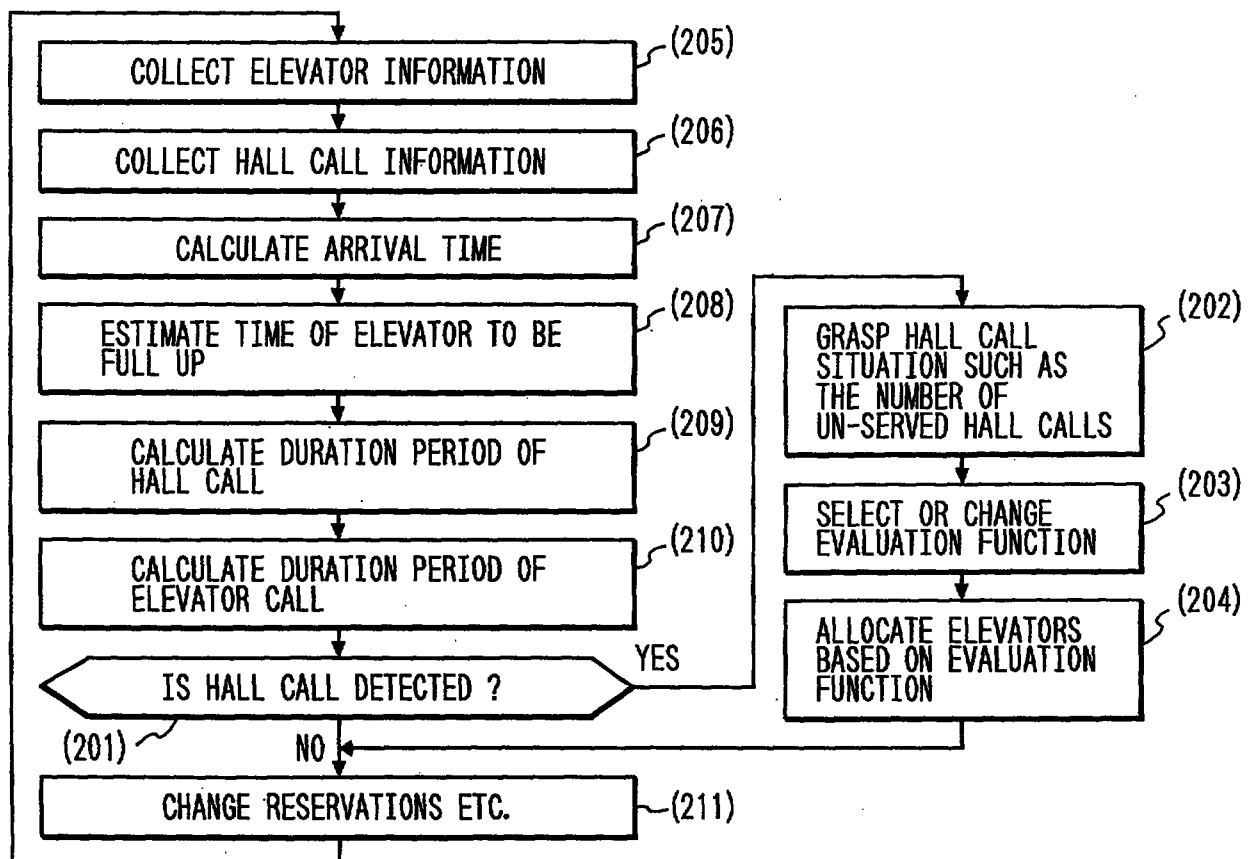


FIG. 3(a)

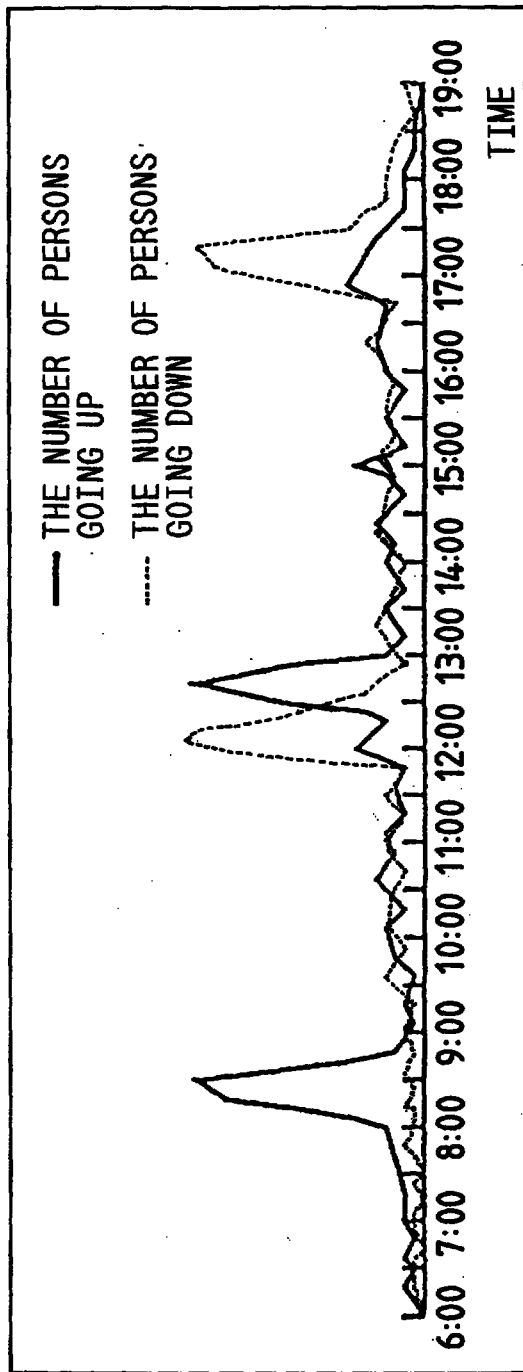
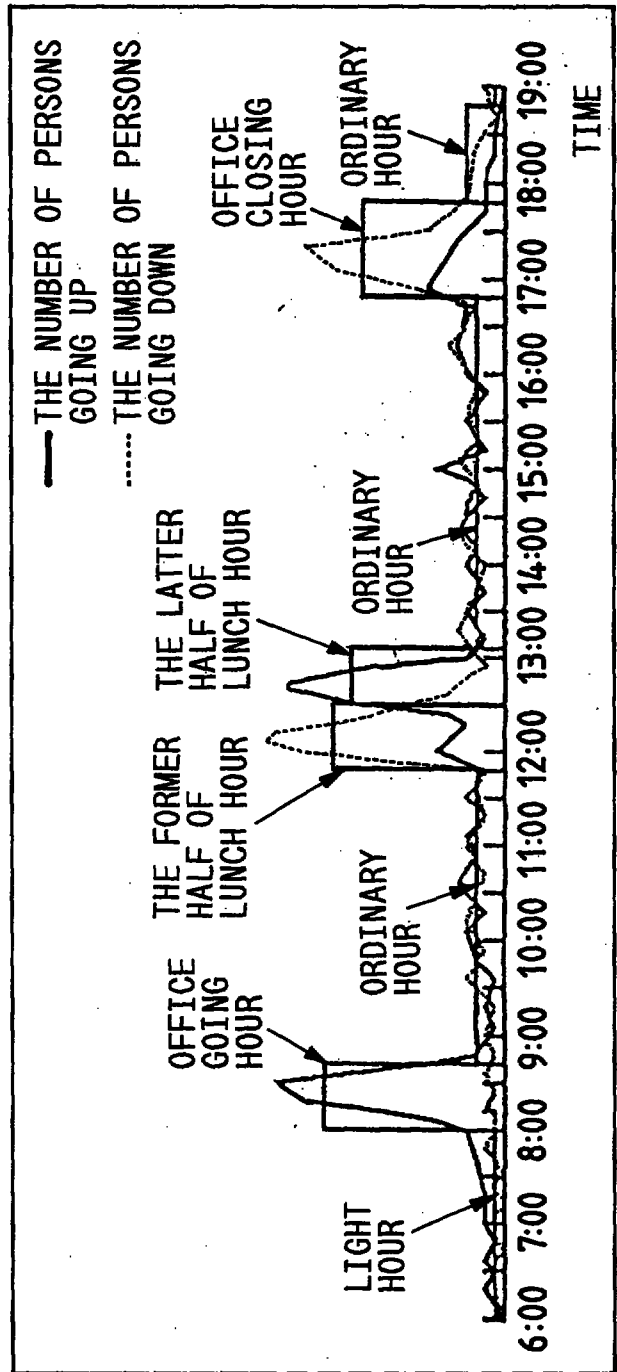
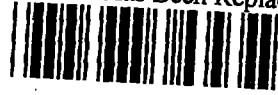


FIG. 3(b)





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FIG. 3(c)

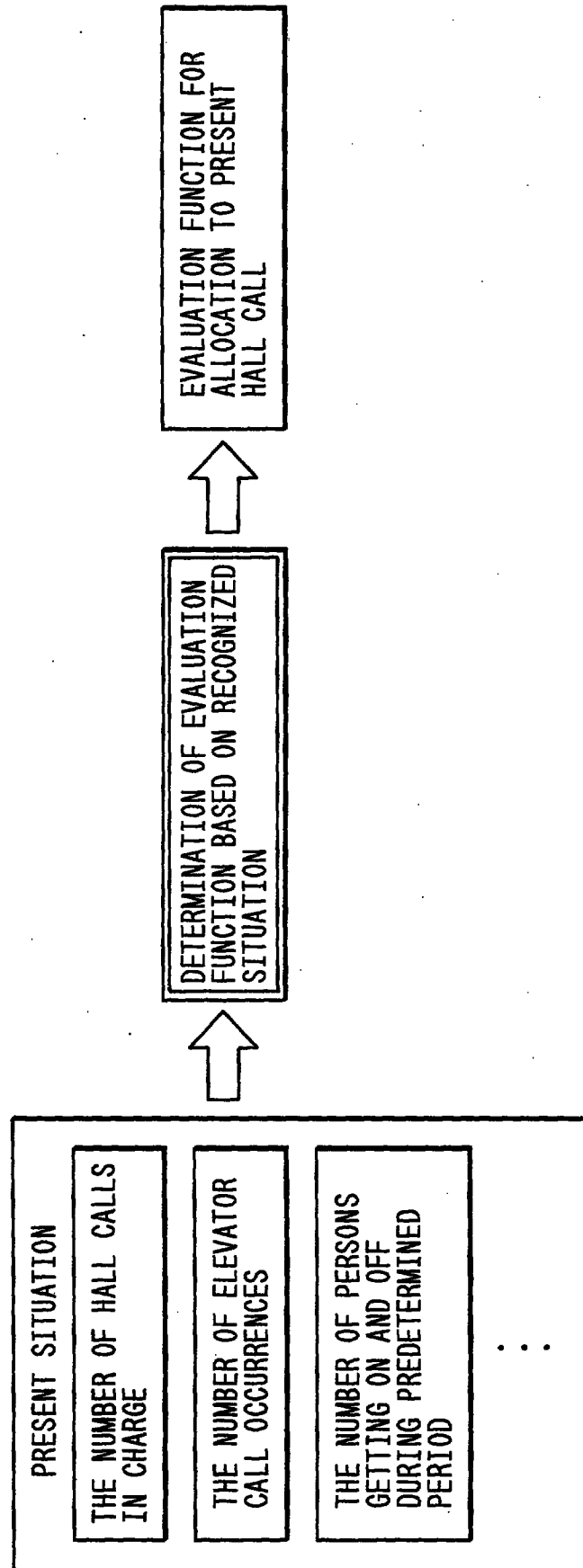
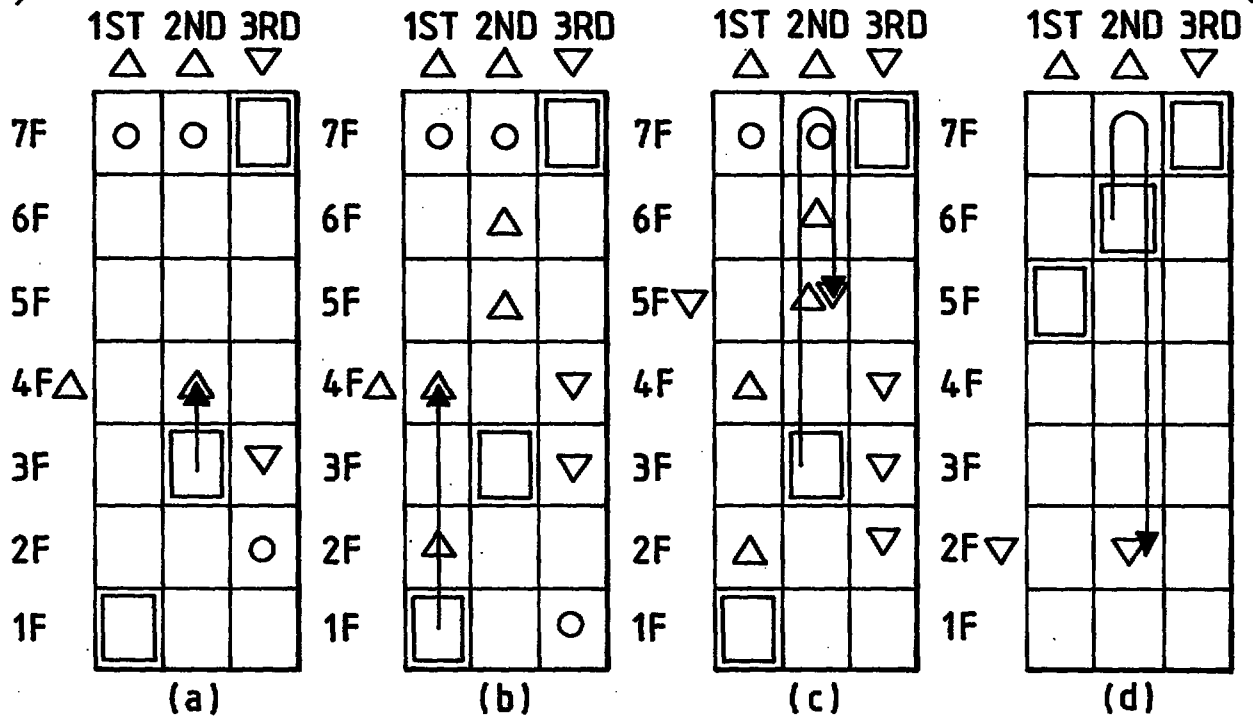


FIG. 4



□ : ELEVATOR △ : HALL CALL
○ : DESTINATION OF ELEVATOR CALL

FIG. 5

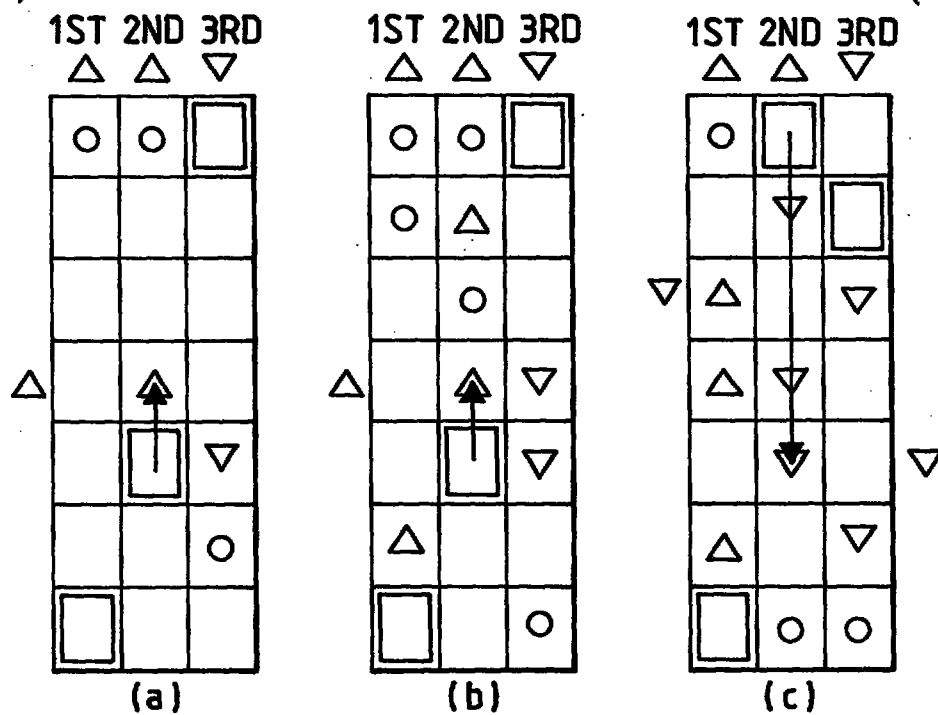




FIG. 6(a)

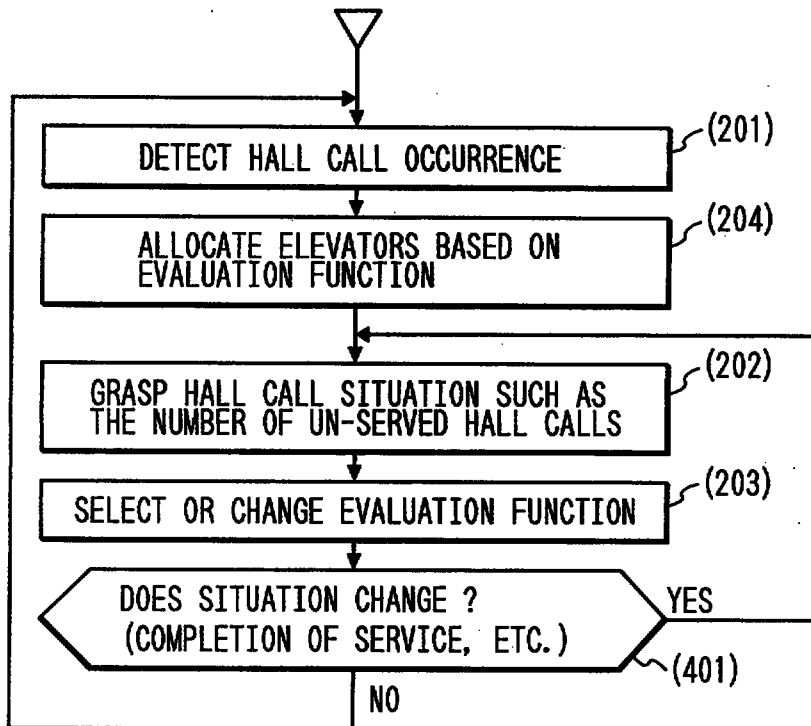
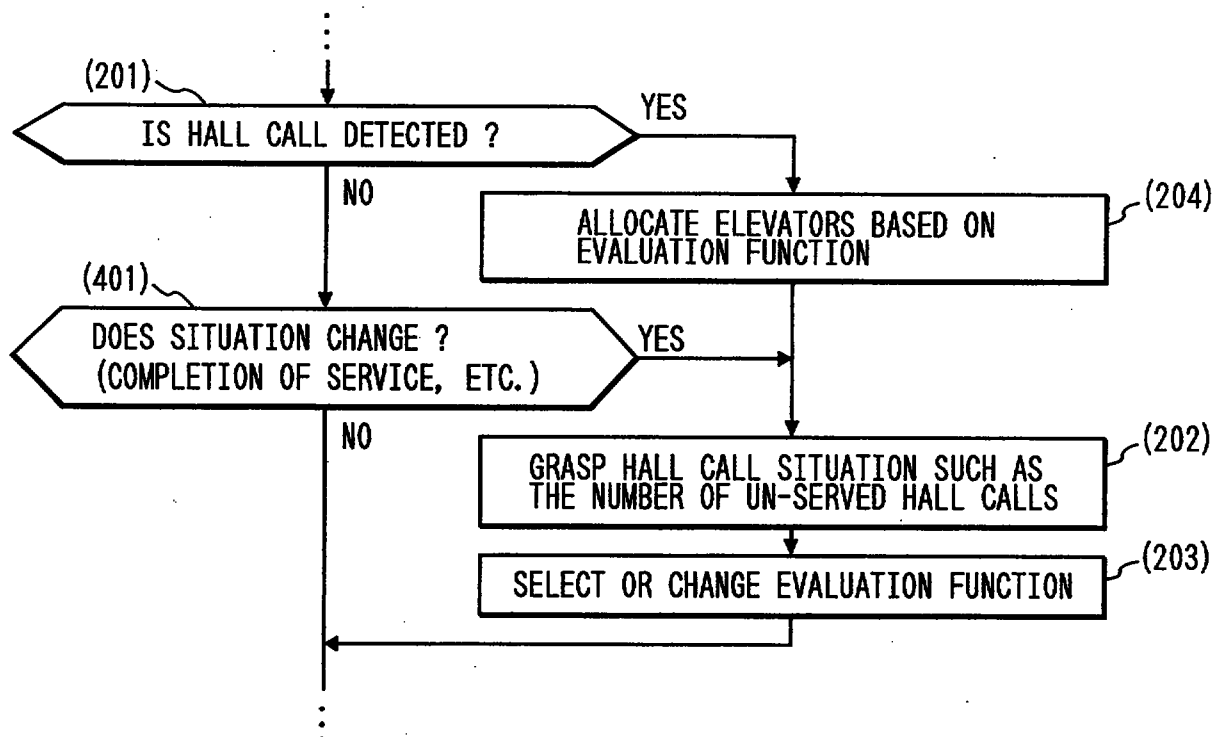


FIG. 6(b)





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FIG. 7

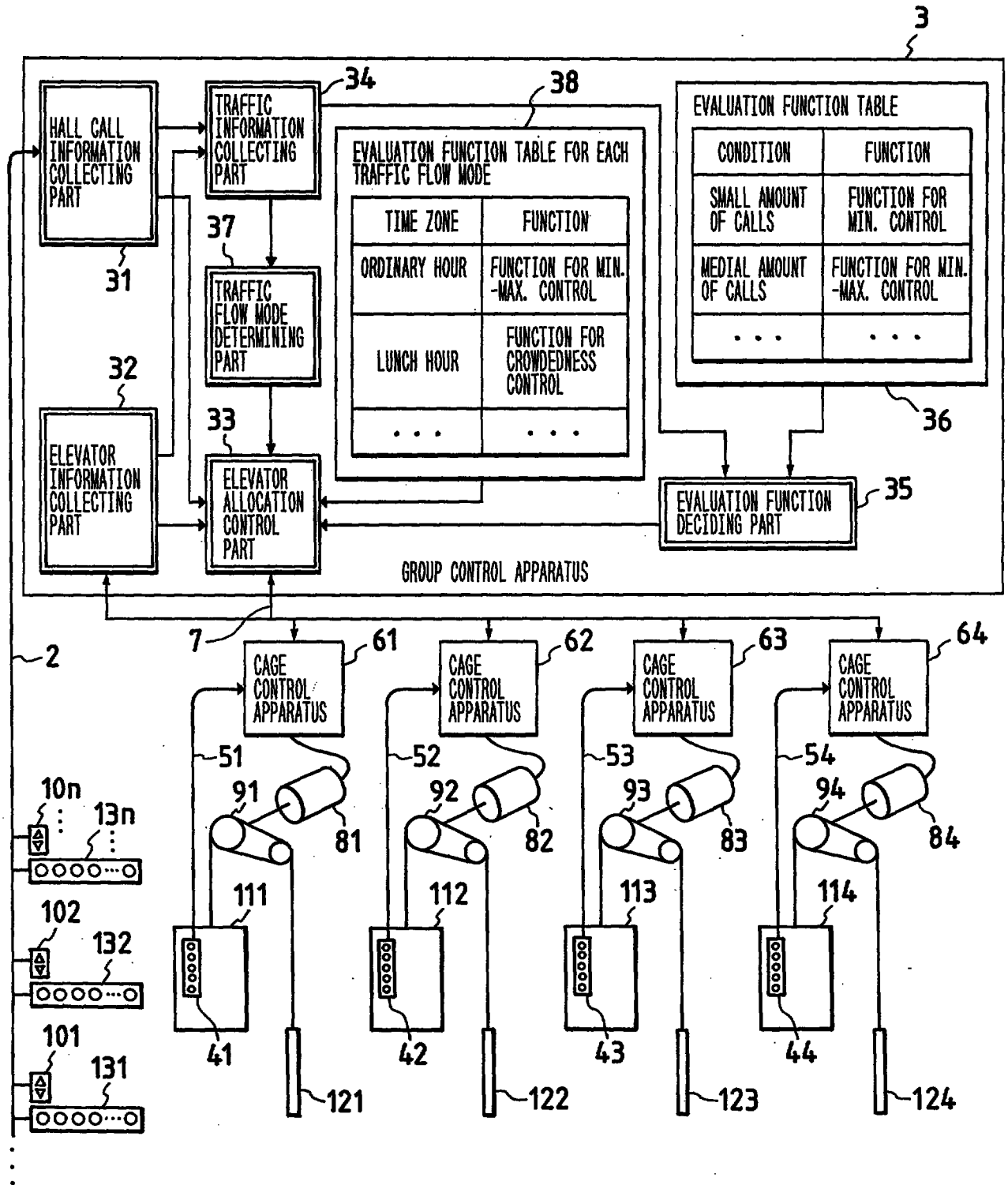




FIG. 8

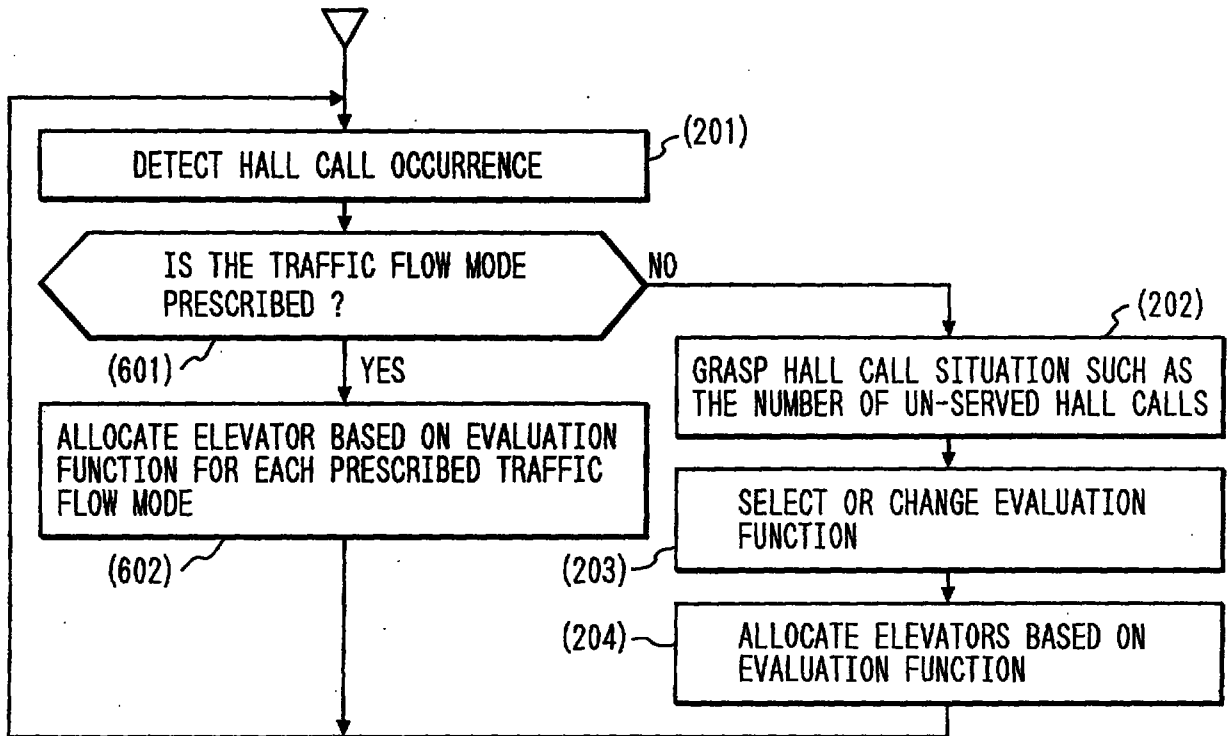
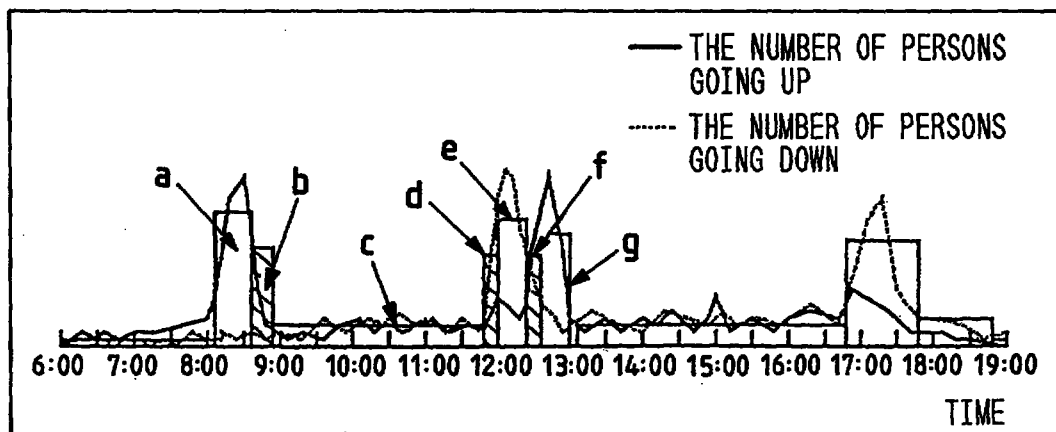


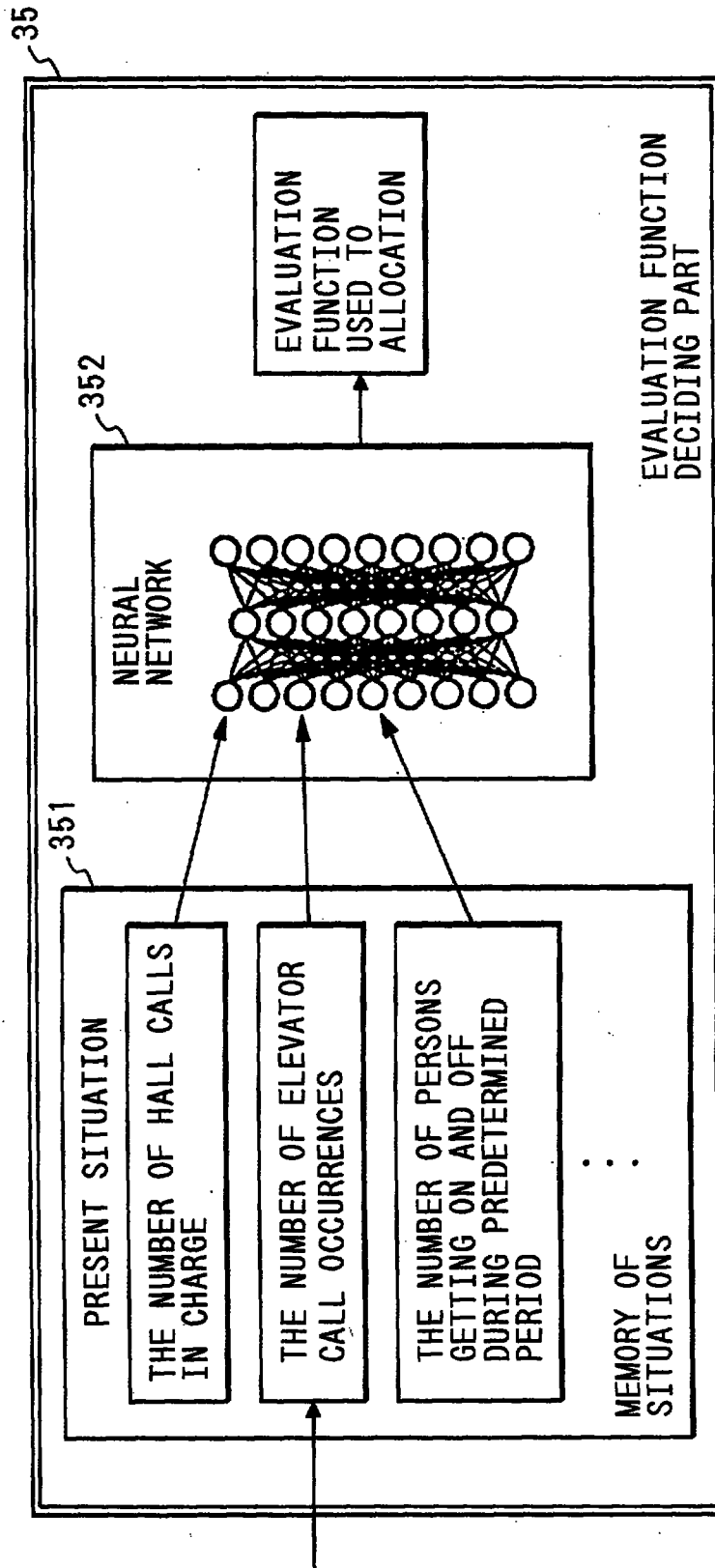
FIG. 9





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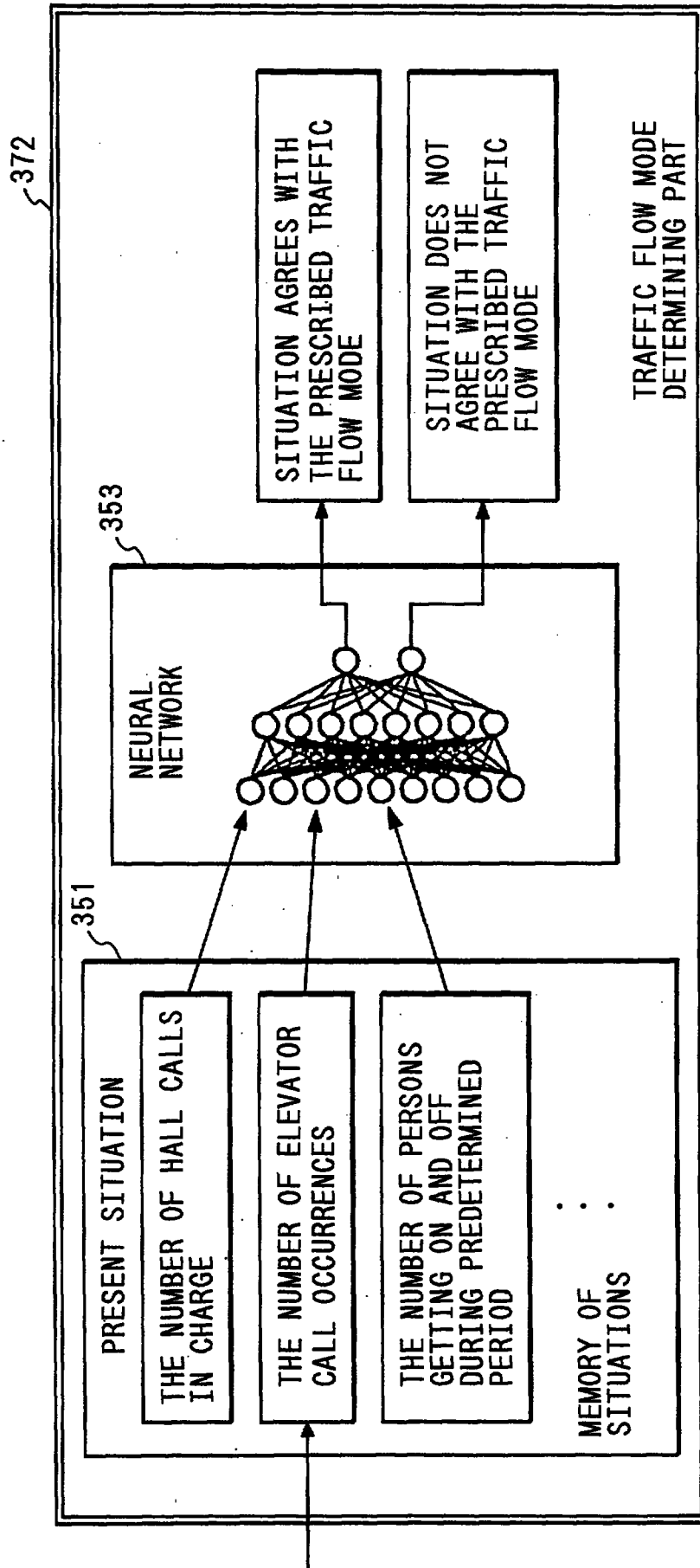
FIG. 10





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FIG. 11





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FIG. 12(a)

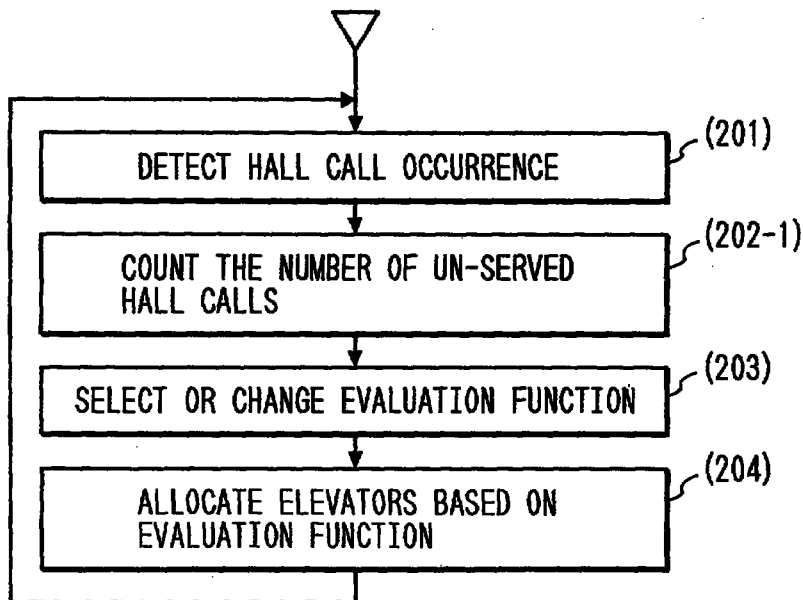
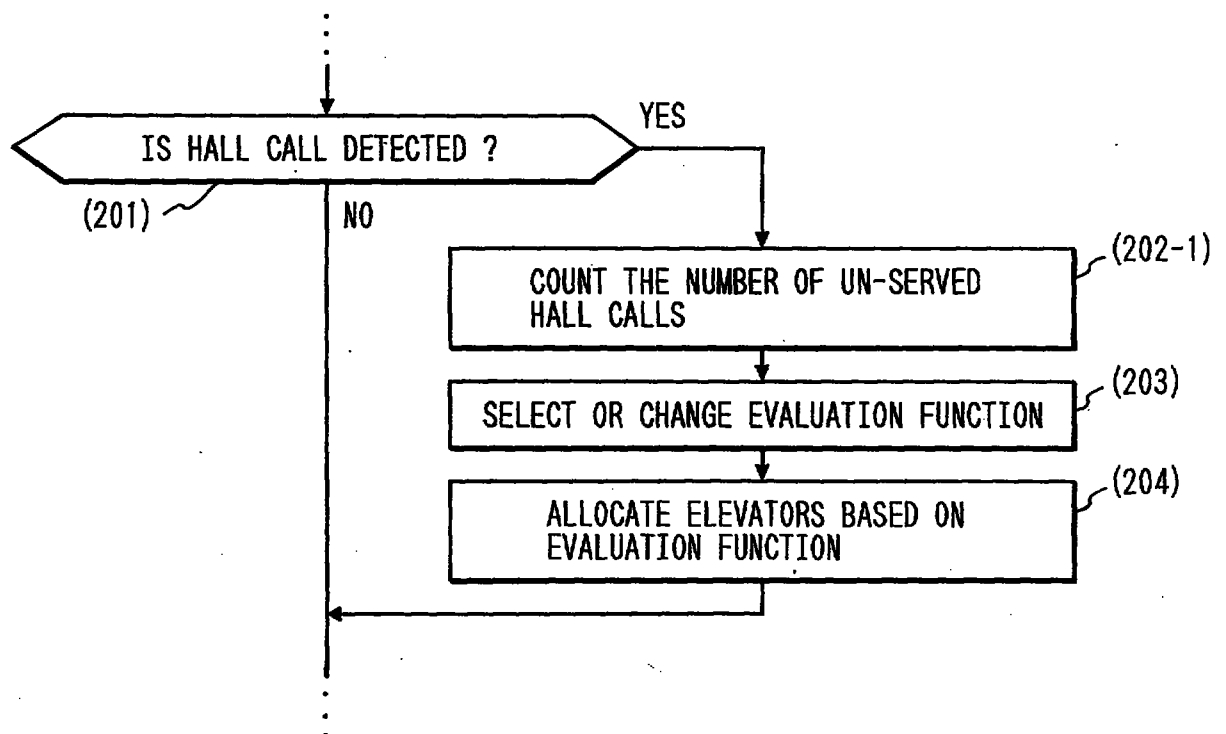


FIG. 12(b)



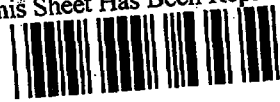


FIG. 13(a)

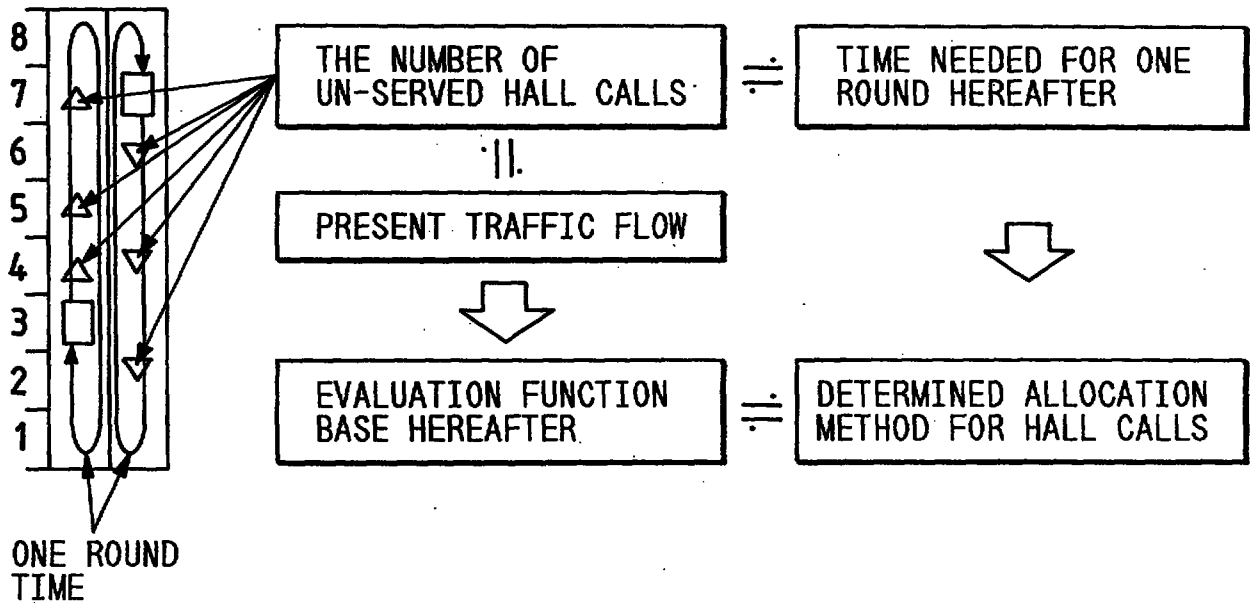
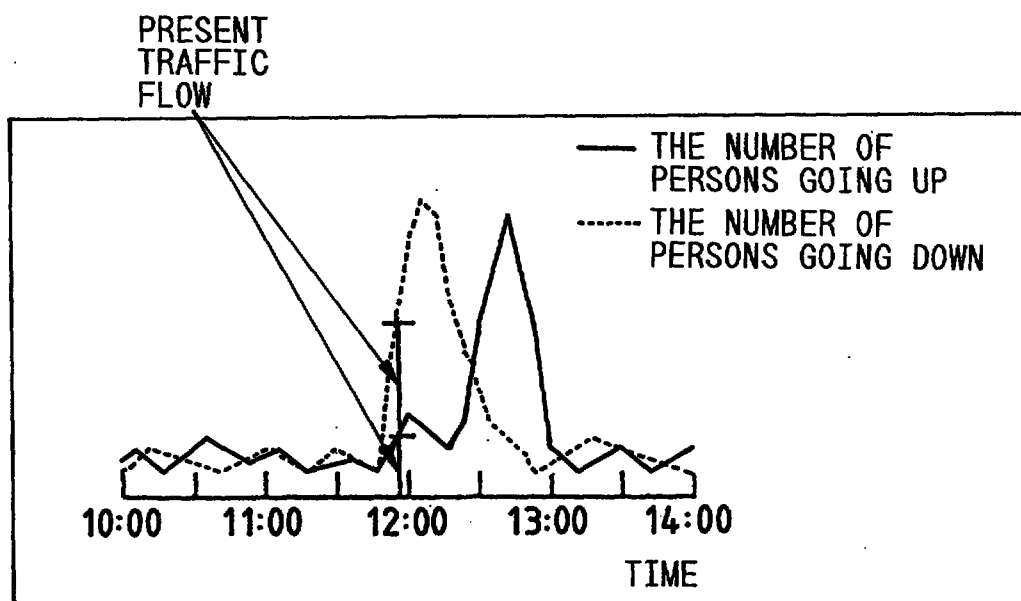
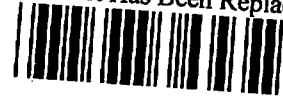


FIG. 13(b)





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FIG. 14(a)

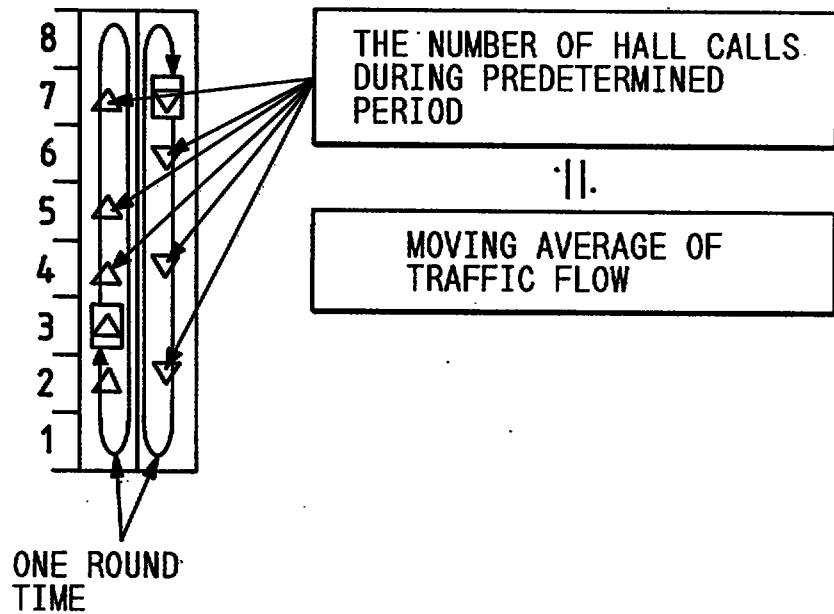
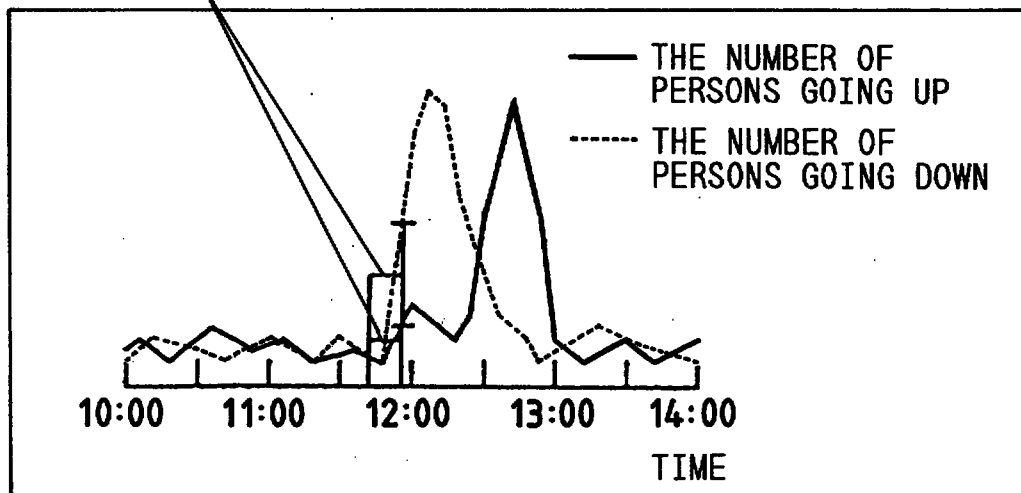
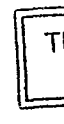


FIG. 14(b)

PRESENT MOVING AVERAGE OF TRAFFIC FLOW

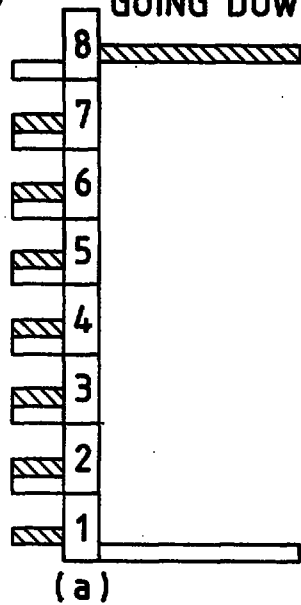


**FIG. 15**

 UP
 DOWN

THE NUMBER
OF PERSONS
GOING UP

THE NUMBER
OF PERSONS
GOING DOWN



THE NUMBER
OF PERSONS
GOING UP

THE NUMBER
OF PERSONS
GOING DOWN

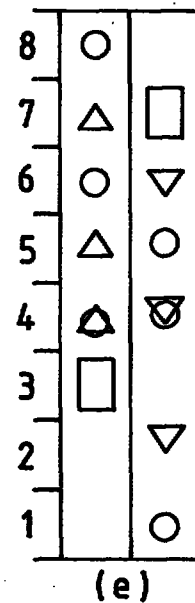
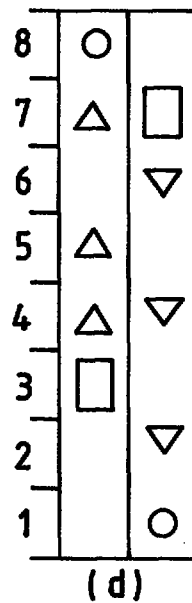
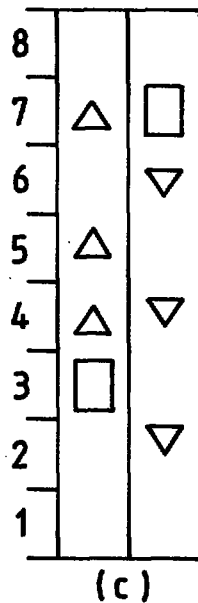
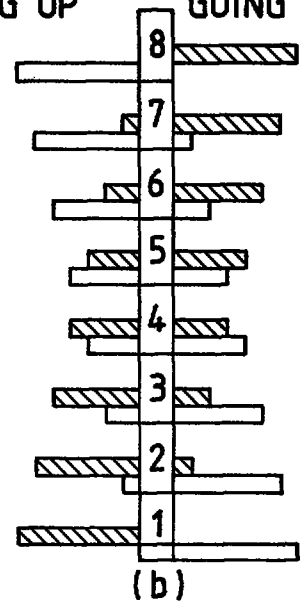
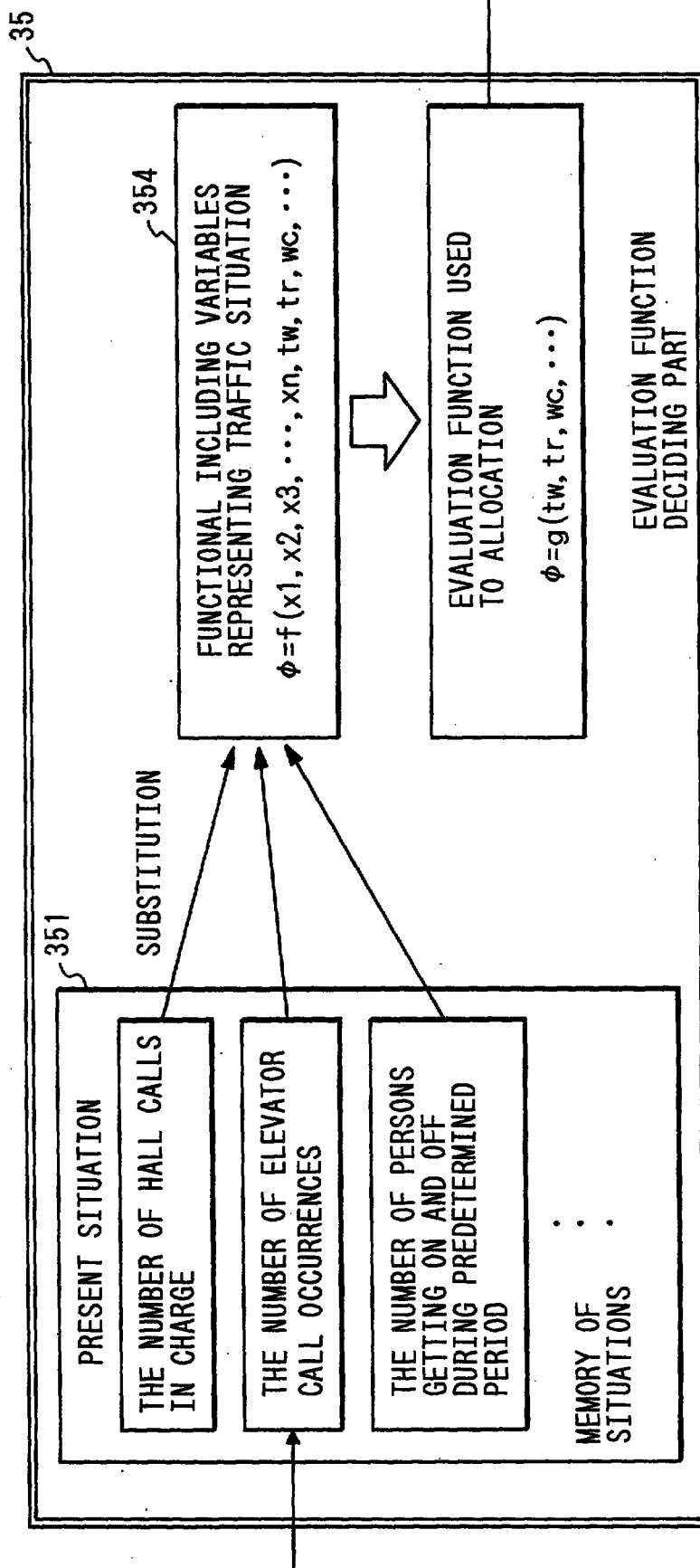
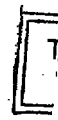


FIG. 16



*FIG. 17(a)*

CONDITION OF EXECUTION		FUNCTION USED TO ALLOCATION	36
REDUCTION OF WAITING TIME	HALL CALLS:FEW, ELEVATOR CALLS:FEW	WAITING TIME MINIMIZING CONTROL	
	HALL CALLS:MEDIAL, ELEVATOR CALLS:MEDIAL	MAXIMUM WAITING TIME MINIMIZING CONTROL	
	HALL CALLS:MANY, ELEVATOR CALLS:MANY	STOP TIMES AVERAGING CONTROL	
	. . .	. . .	
REDUCTION OF RIDING TIME	HALL CALLS:FEW, ELEVATOR CALLS:FEW	CONTROL OF ELEVATOR CALL DURATION TIME	
	HALL CALLS:MANY, ELEVATOR CALLS:FEW	CROWDEDNESS CONTROL	
	. . .	. . .	
⋮	⋮	⋮	

FIG. 17(b)

HALL CALL NUMBER	ELEVATOR CALL NUMBER	...	FUNCTION USED TO ALLOCATION	36
NOT MORE THAN $2n$	NOT MORE THAN 3	...	WAITING TIME MINIMIZING CONTROL	
NOT MORE THAN $3n$	NOT MORE THAN $f/3$	...	MAXIMUM WAITING TIME MINIMIZING CONTROL	
MORE THAN $3n$	MORE THAN $f/3$	...	STOP TIMES AVERAGING CONTROL	
⋮	⋮	⋮	⋮	



FIG. 18

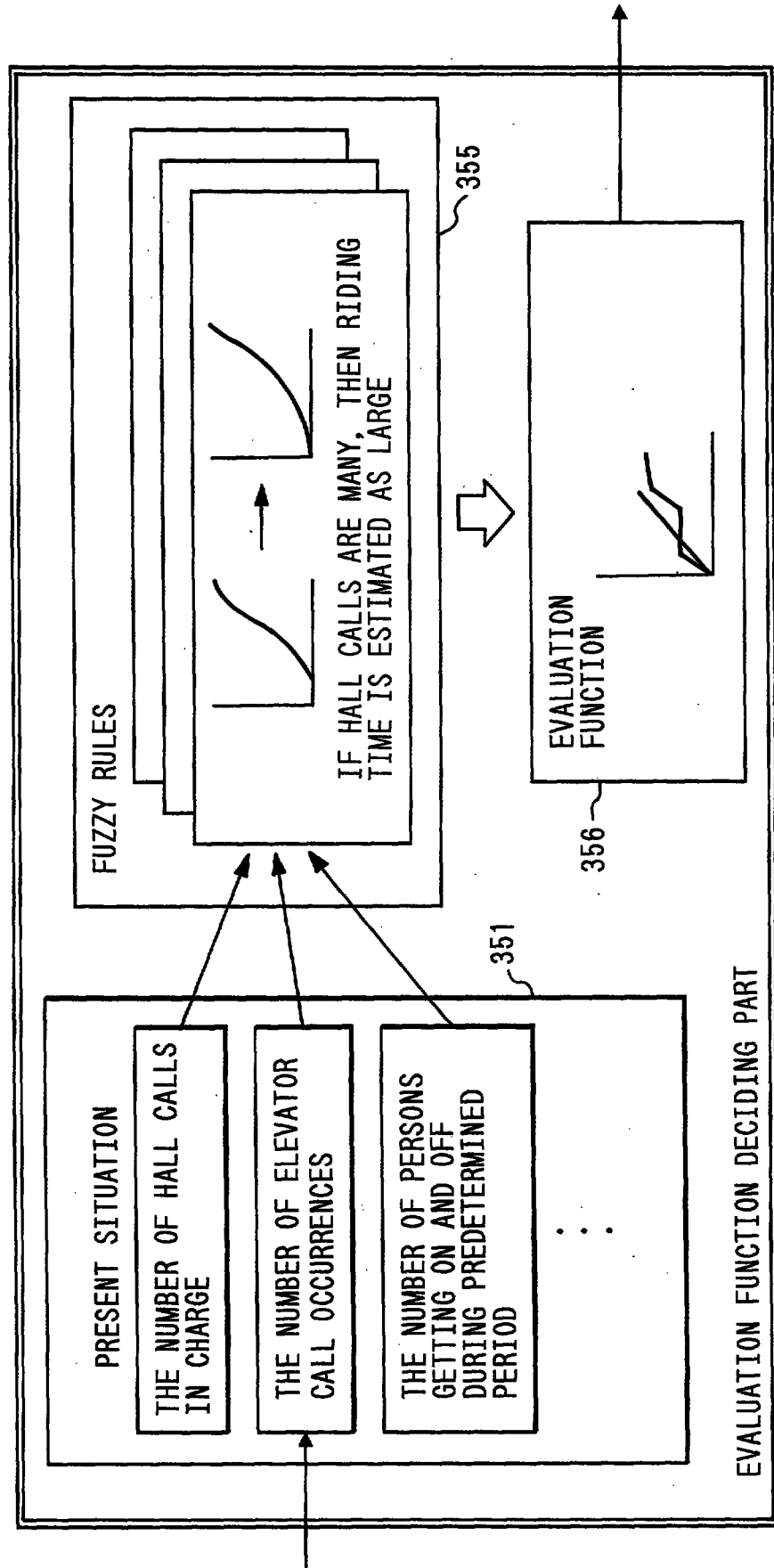




FIG. 19(a)

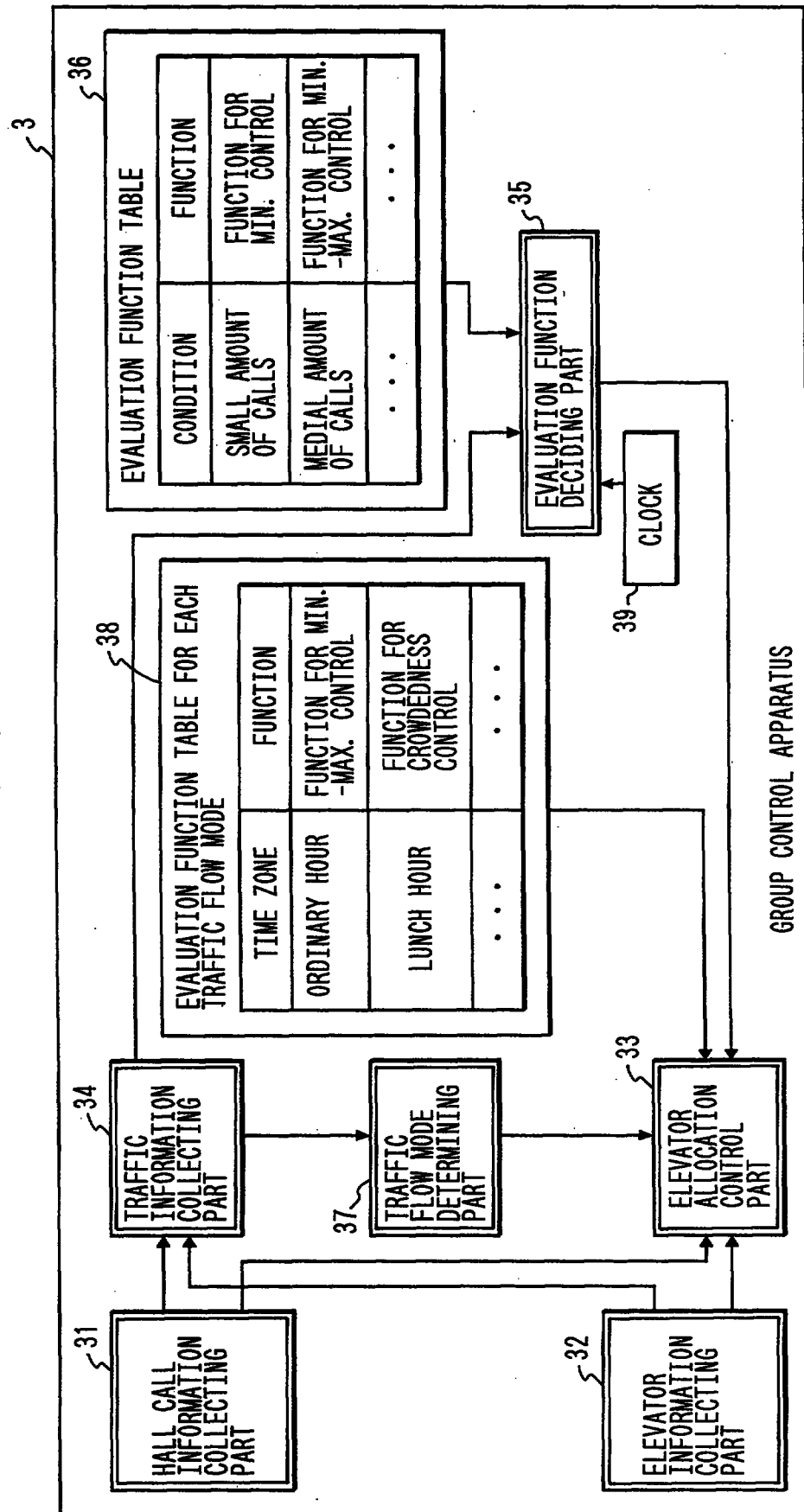


FIG. 19(b)

TIME	HALL CALL NUMBER	ELEVATOR CALL NUMBER	FUNCTION USED TO ALLOCATION
11:50~12:00	NOT MORE THAN 2n	NOT MORE THAN 3	WAITING TIME MINIMIZING CONTROL
11:50~12:00			
11:50~12:00			
12:00~12:10			
12:00~12:10			
. . . .			

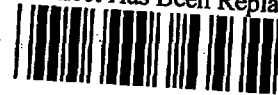


FIG. 1

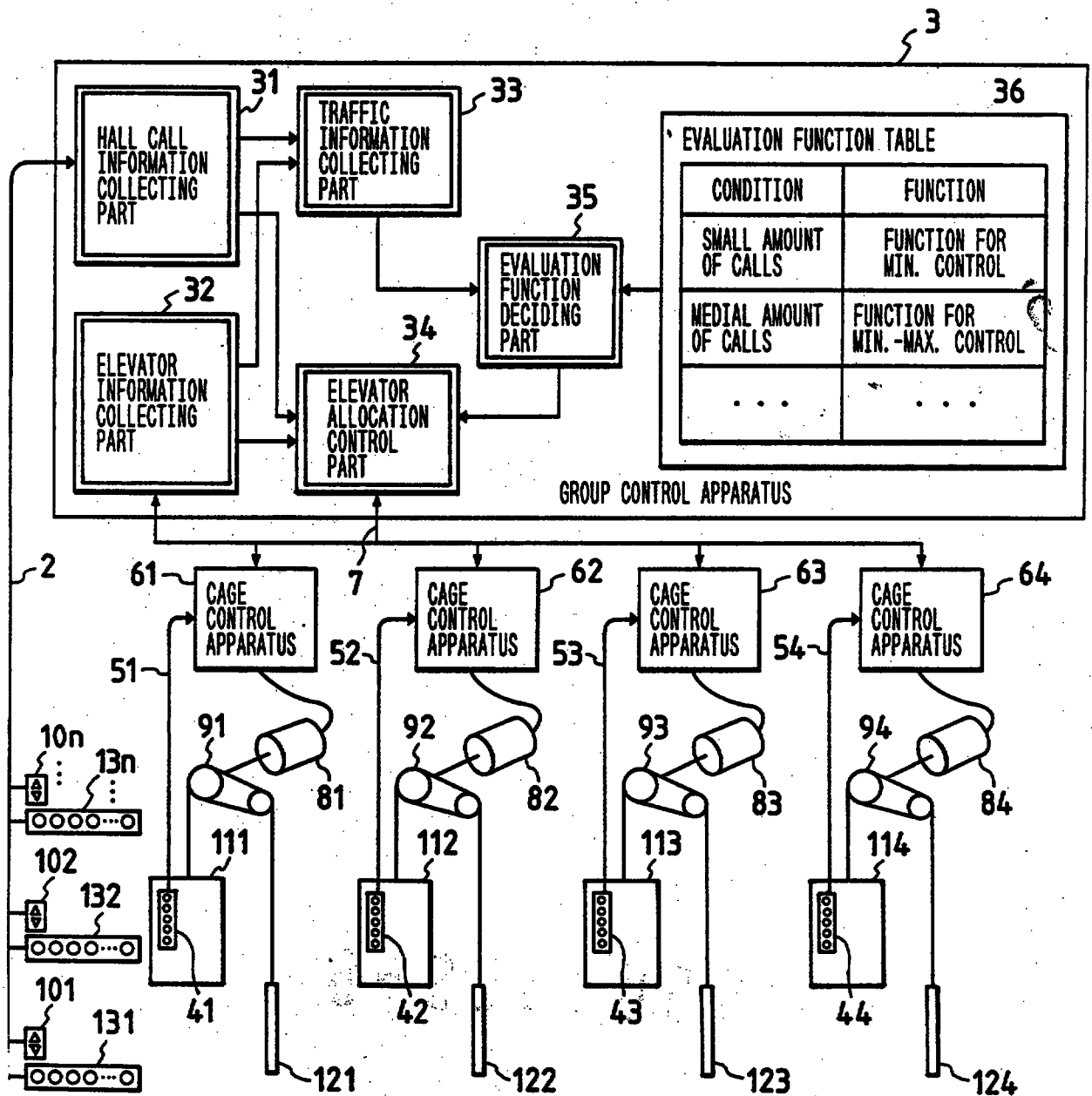


FIG. 2 a

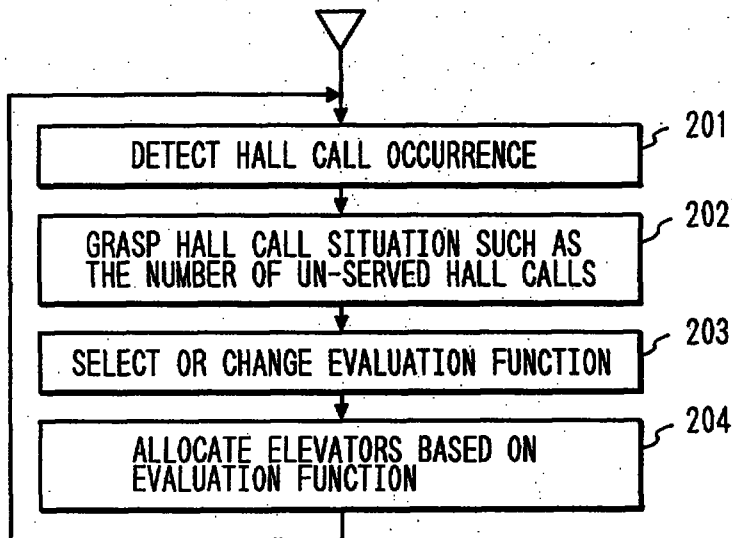


FIG. 2 b

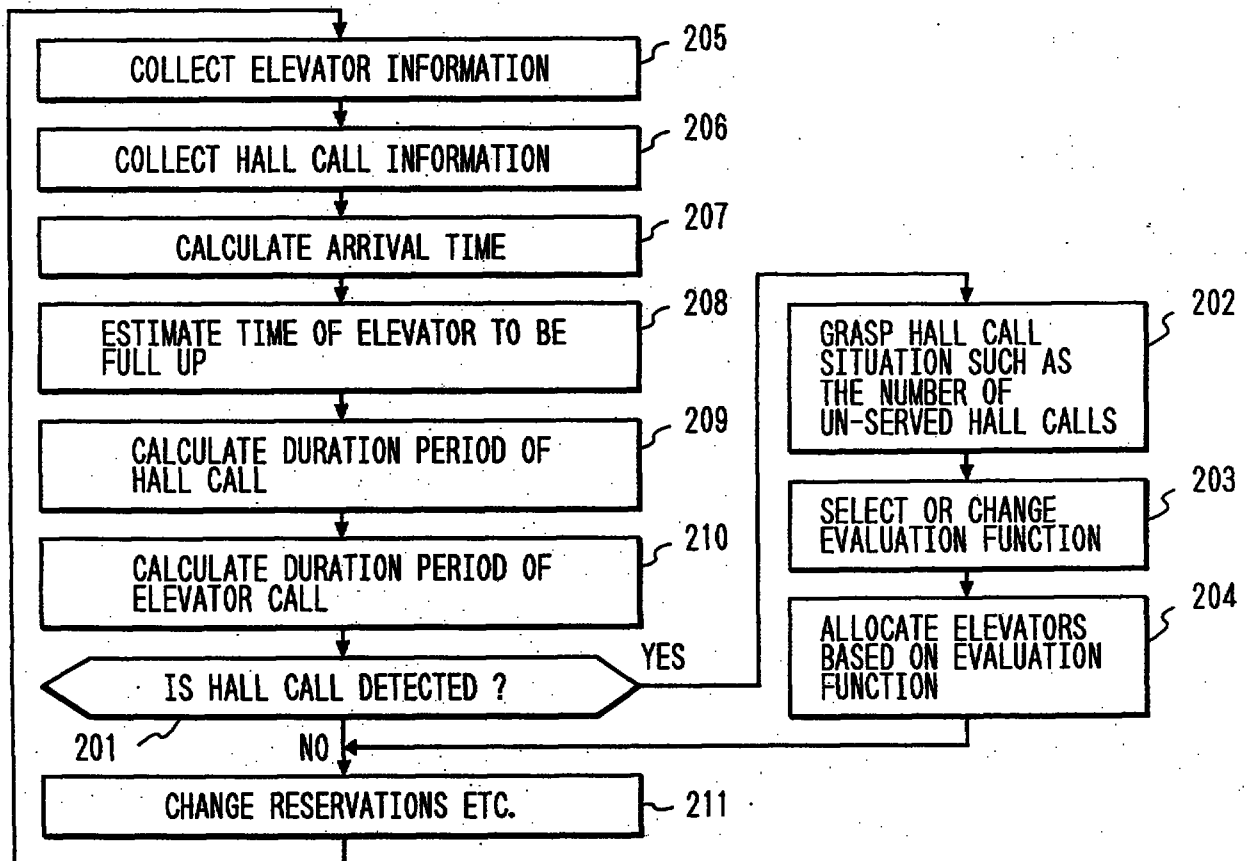


FIG. 3 a

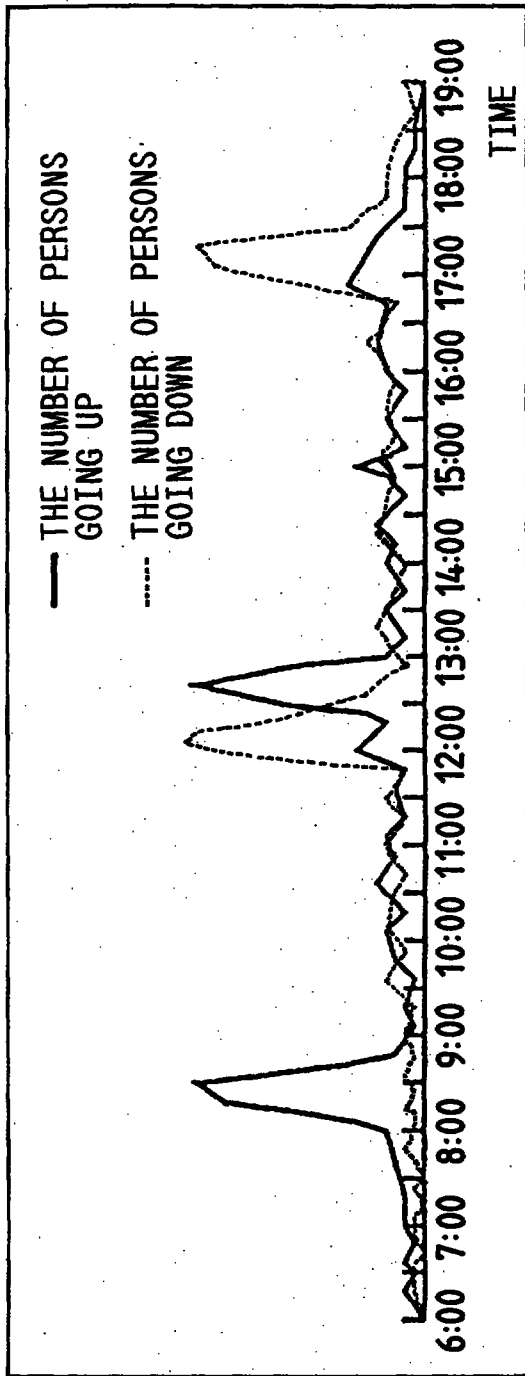
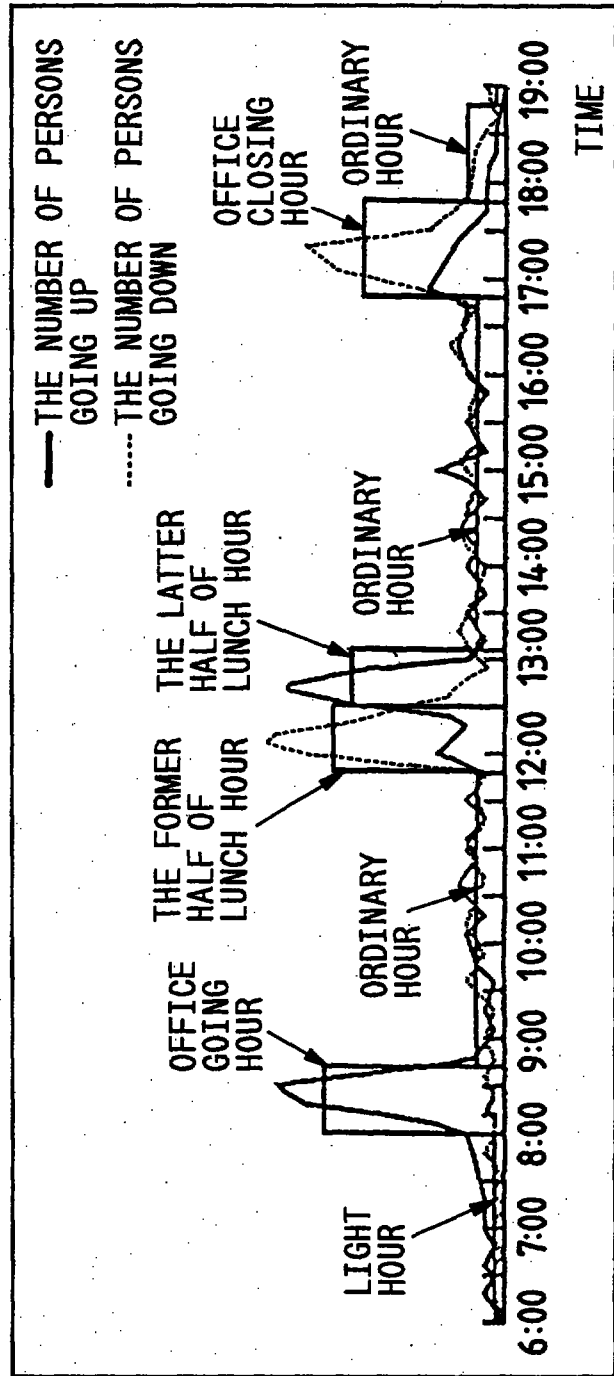


FIG. 3 b



4

FIG. 3c

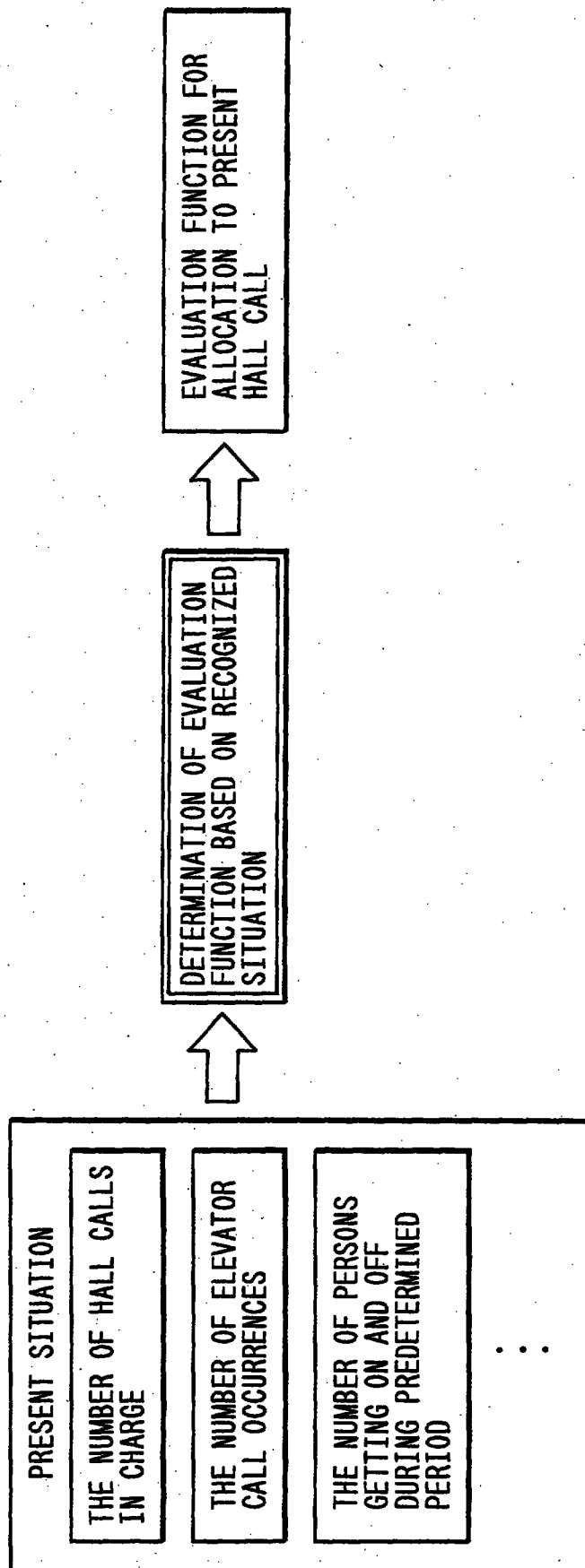


FIG. 4

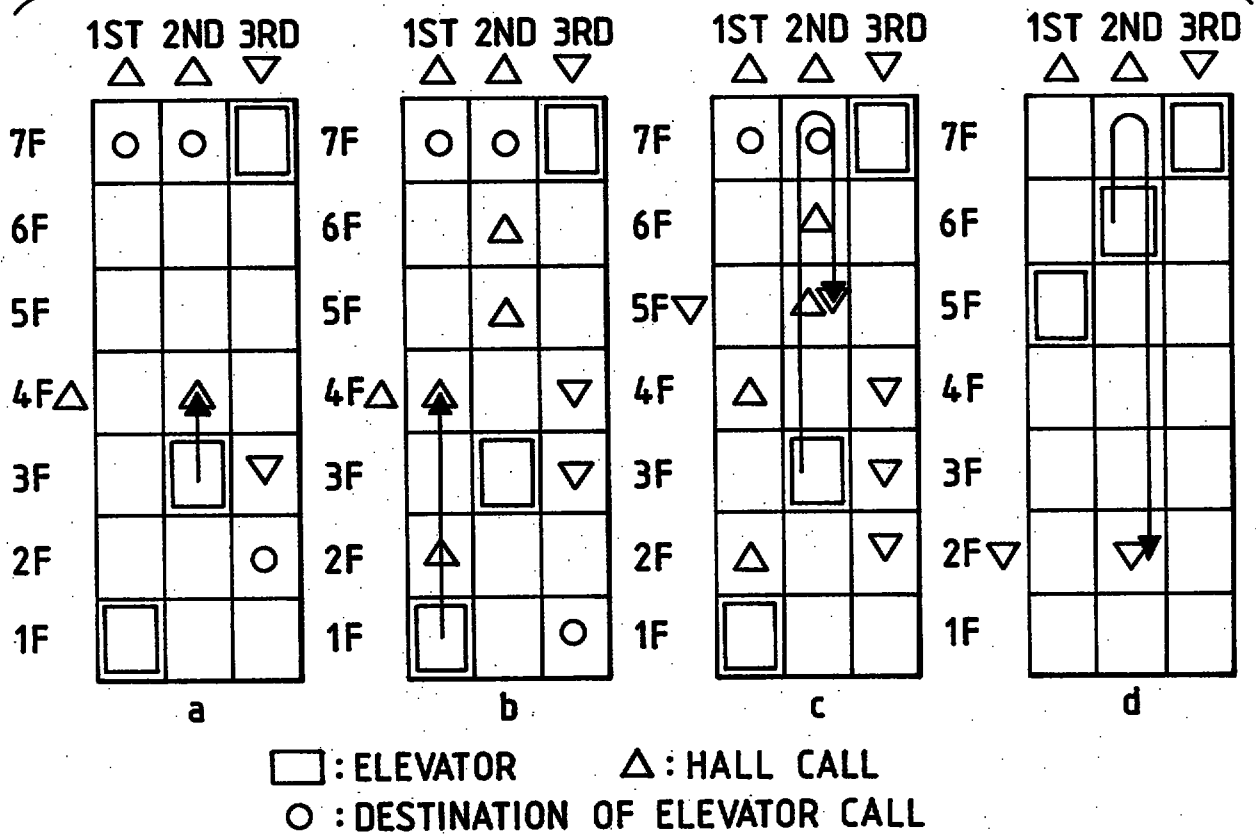


FIG. 5

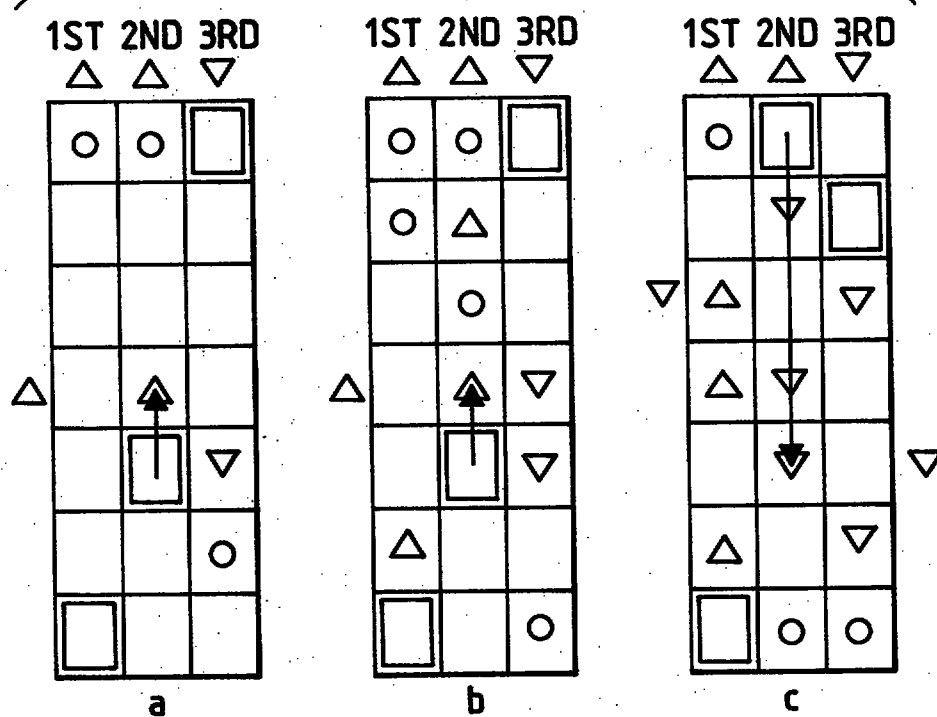


FIG. 6 a

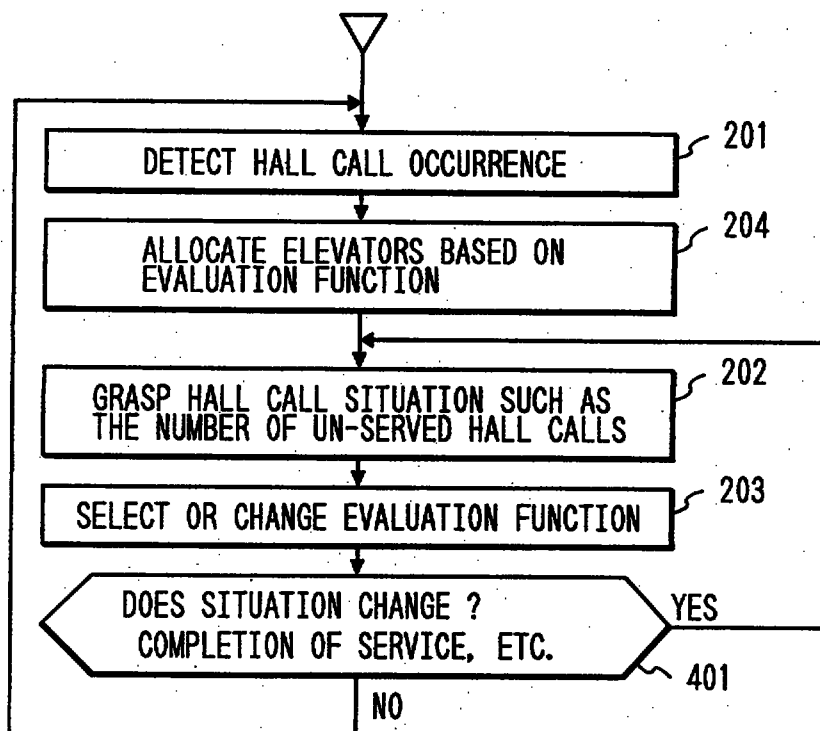


FIG. 6 b

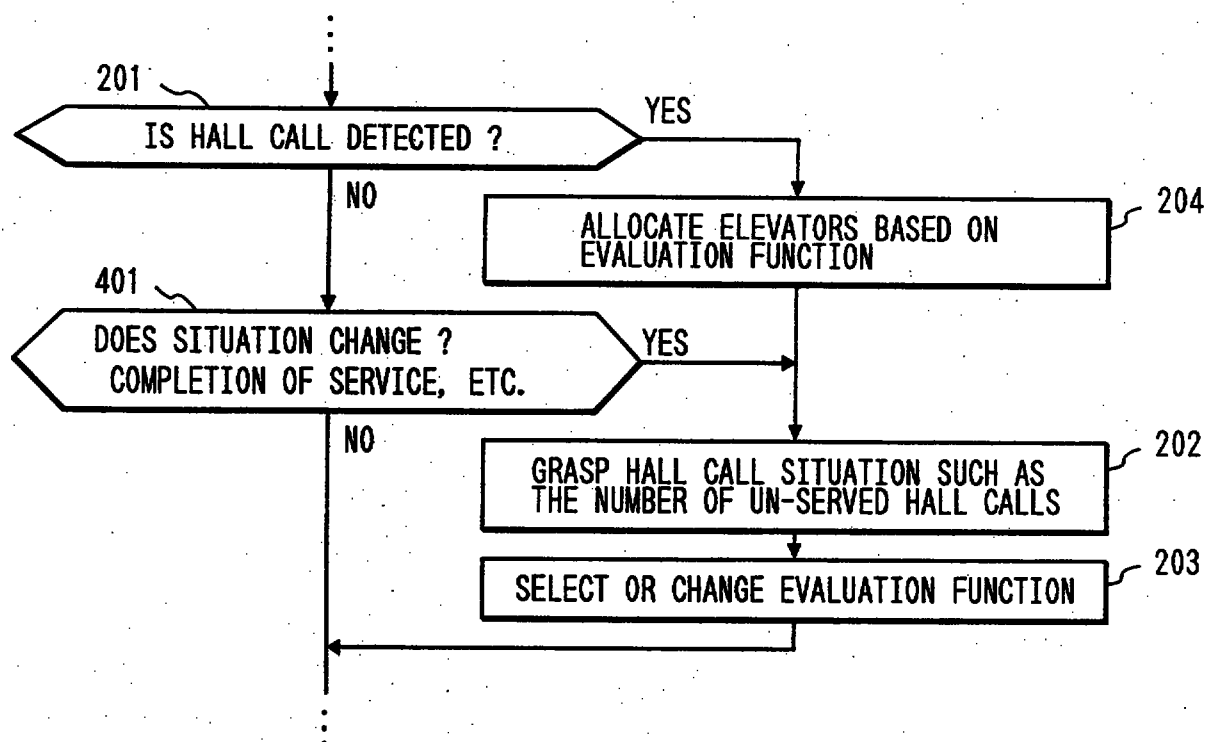


FIG. 7

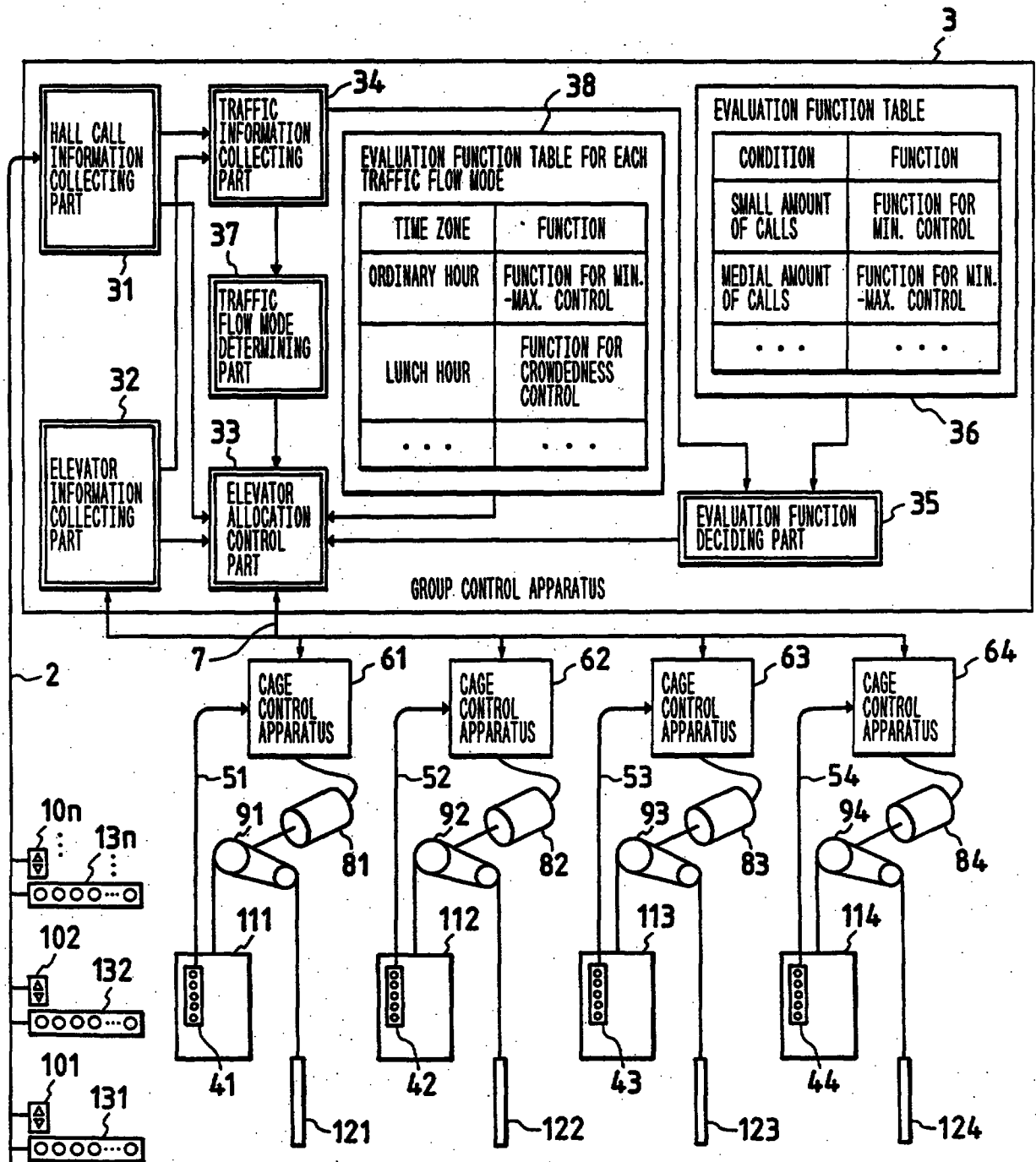


FIG. 8

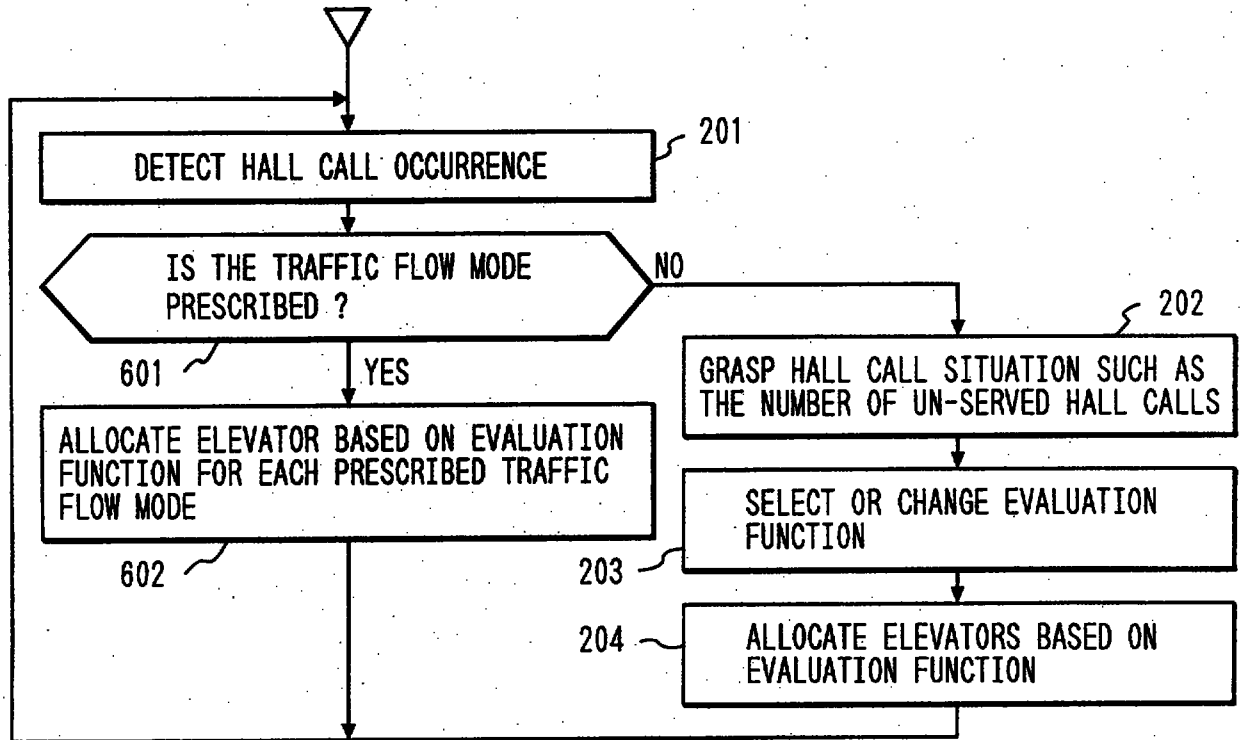


FIG. 9

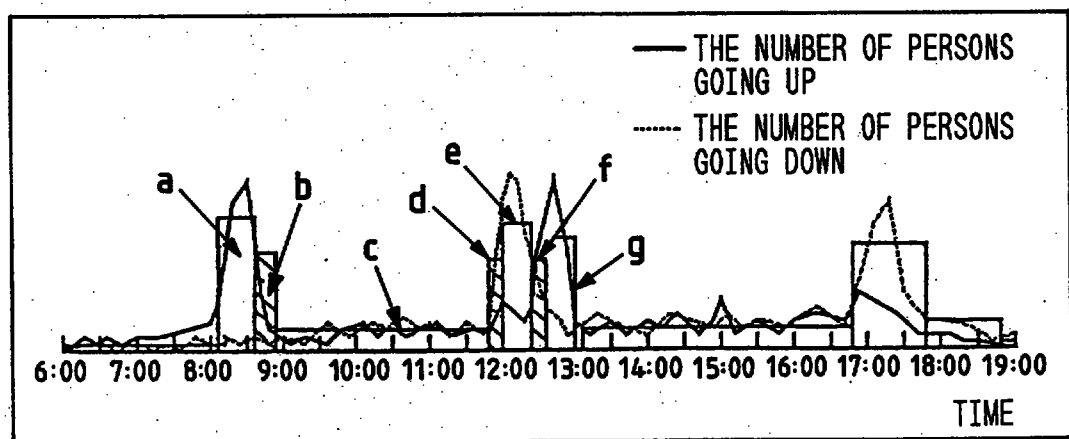


FIG. 10

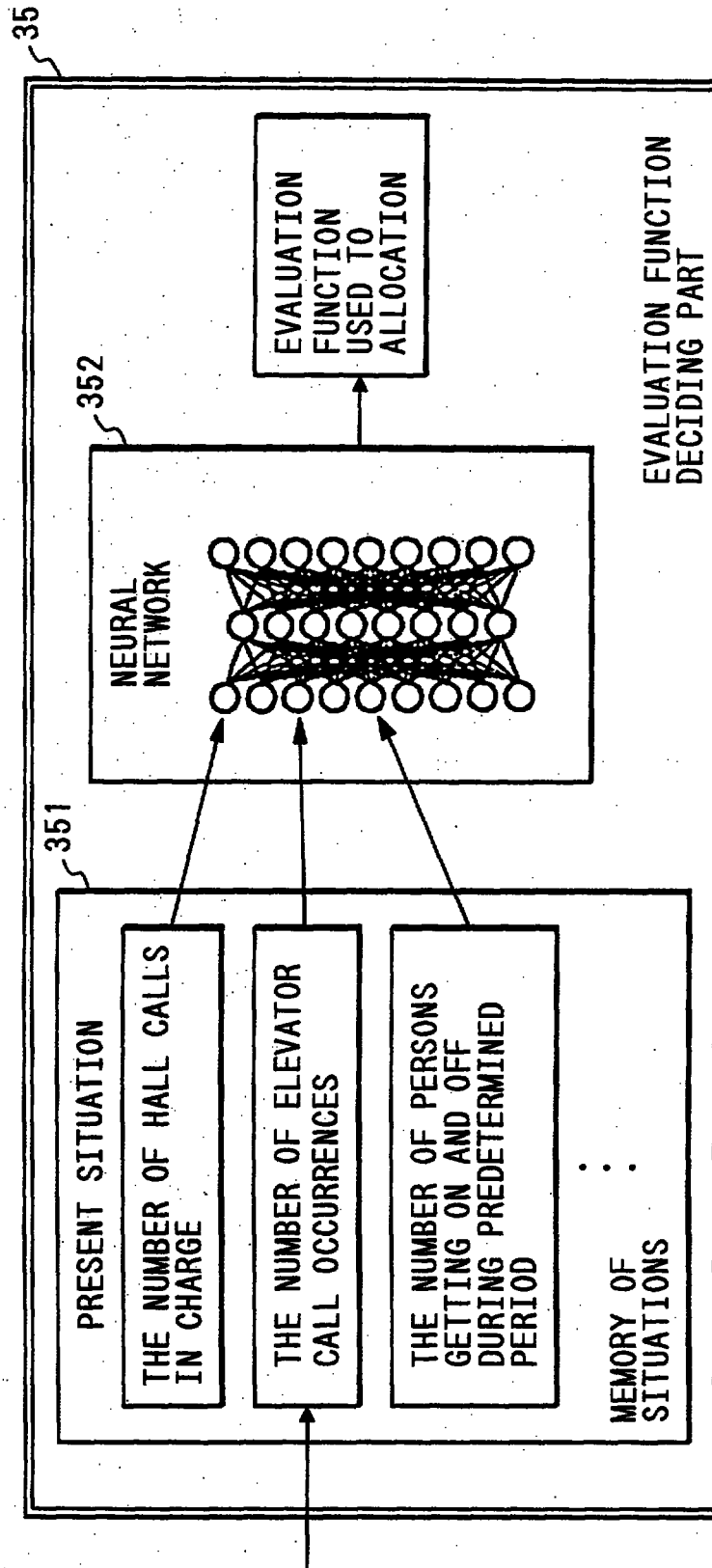


FIG. 11

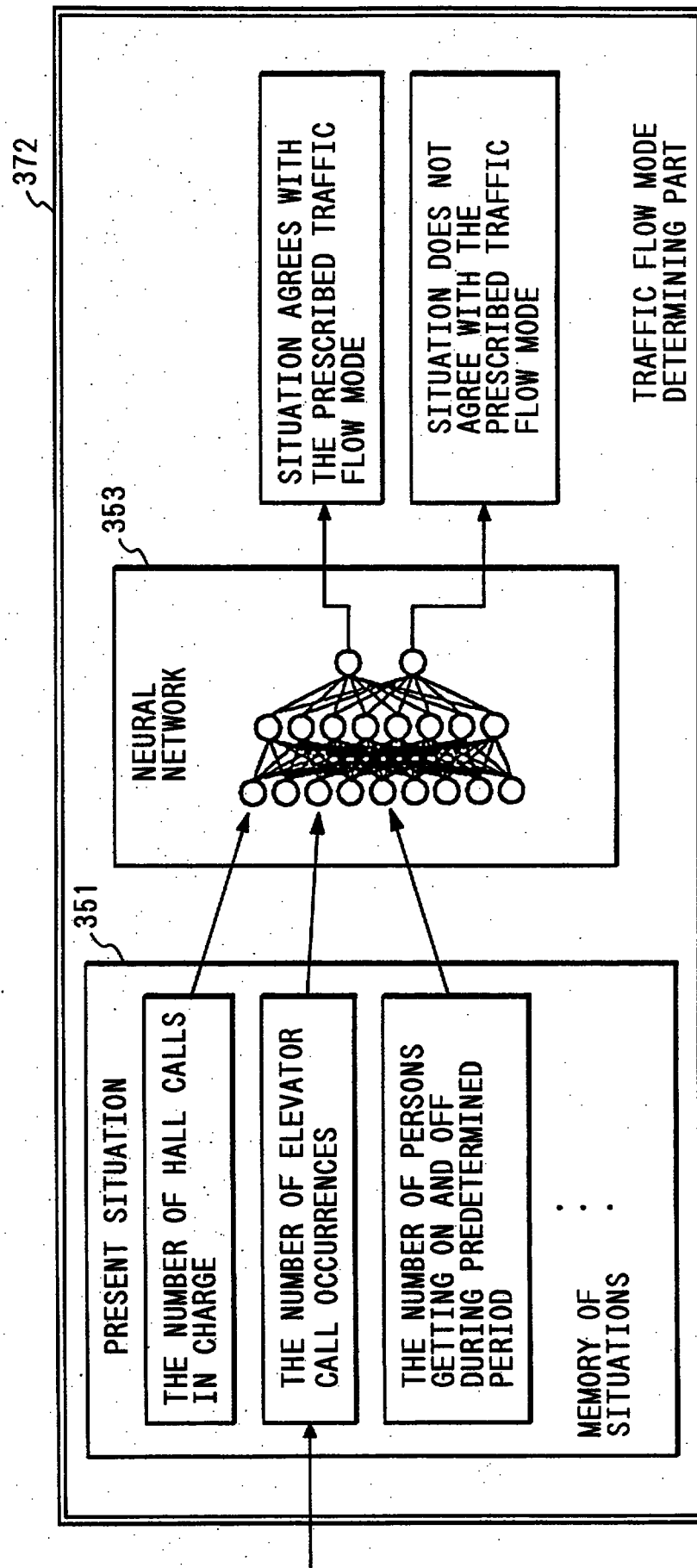


FIG. 12 a

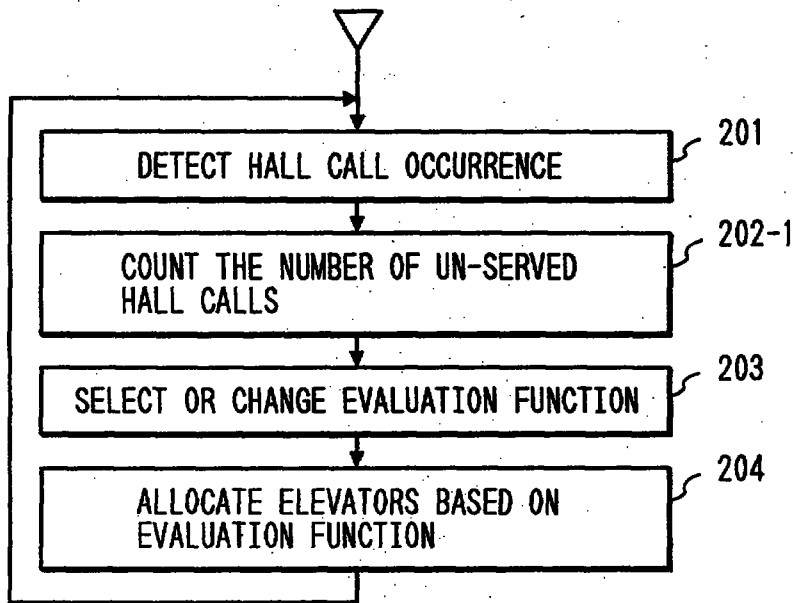


FIG. 12 b

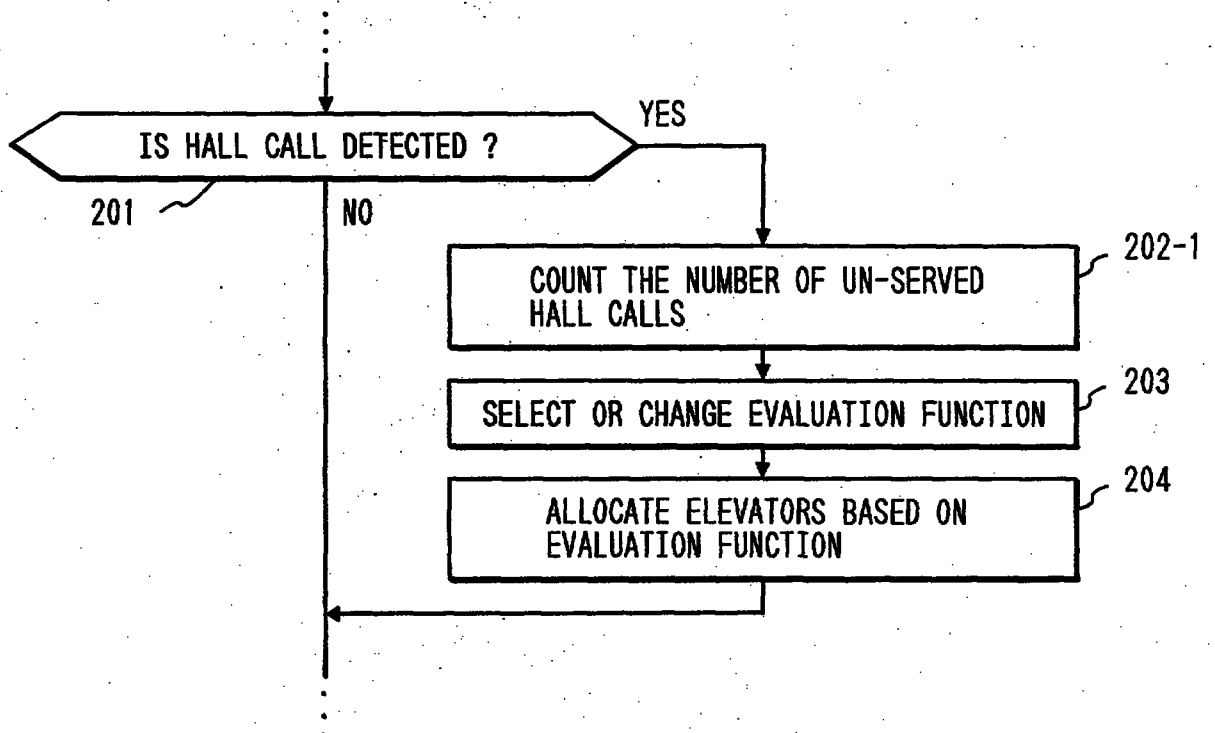


FIG. 13 a

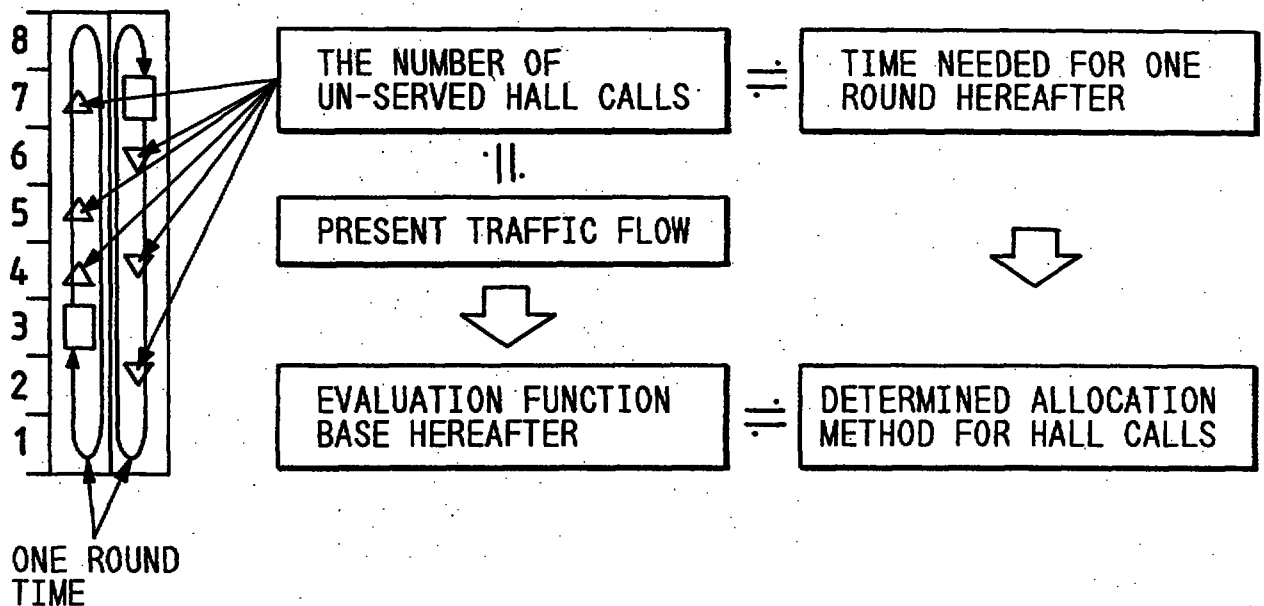


FIG. 13 b

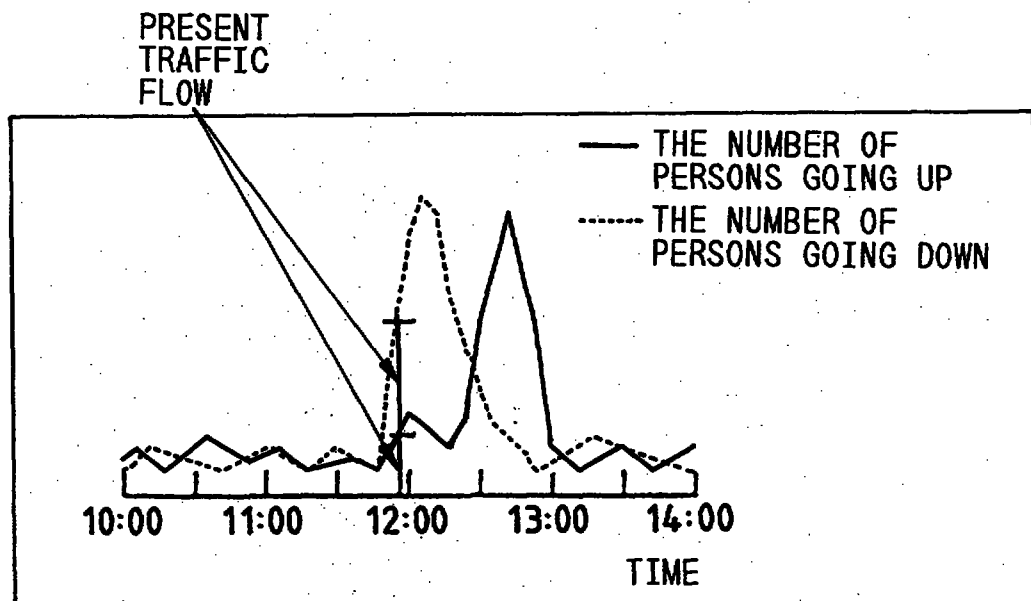


FIG. 14 a

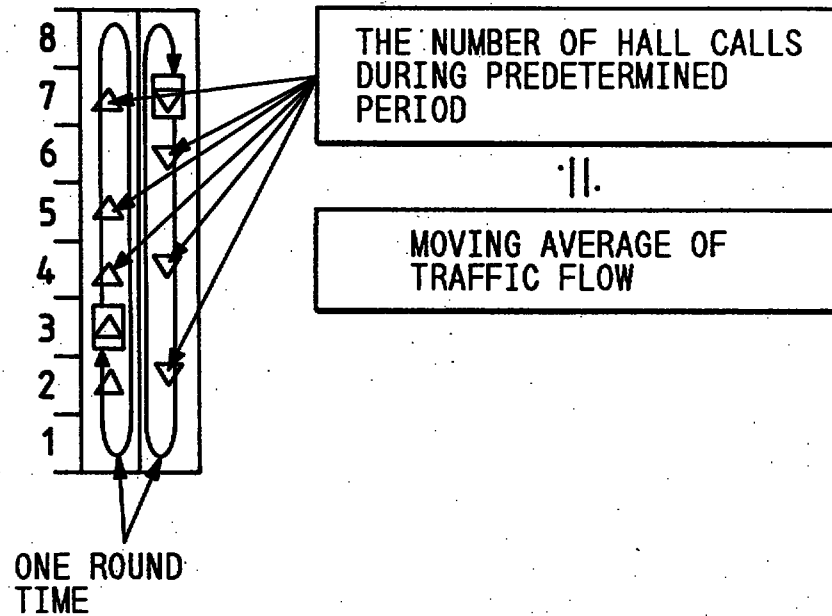


FIG. 14 b

PRESENT MOVING AVERAGE
OF TRAFFIC FLOW

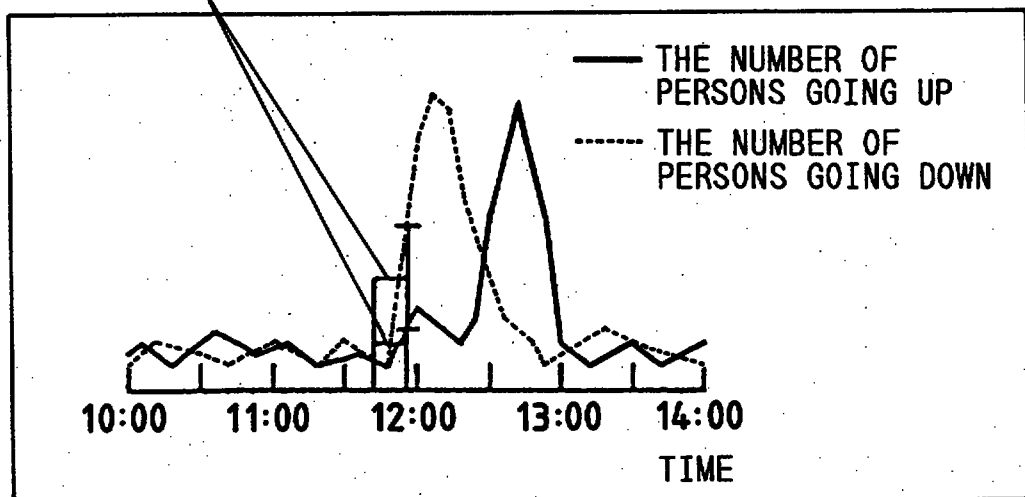
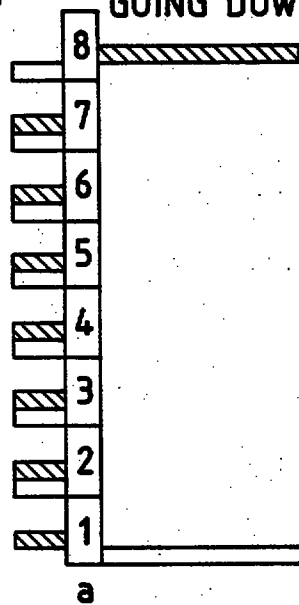


FIG. 15

 UP
 DOWN

THE NUMBER
OF PERSONS
GOING UP

THE NUMBER
OF PERSONS
GOING DOWN

THE NUMBER
OF PERSONS
GOING UP

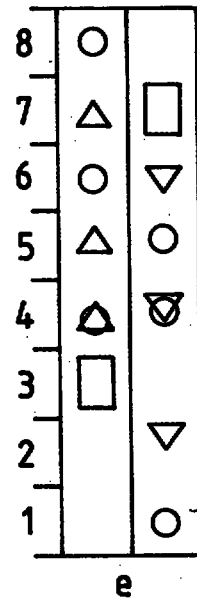
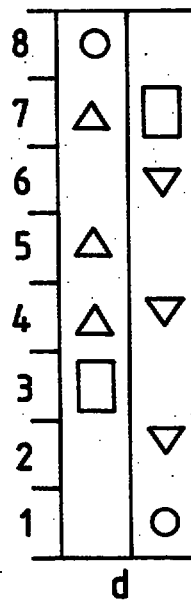
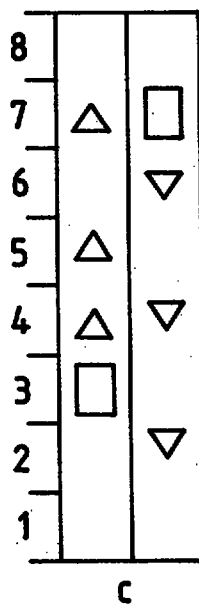
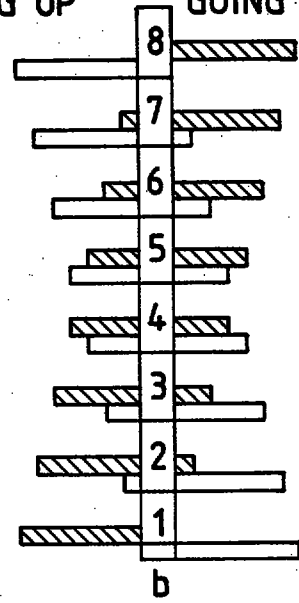
THE NUMBER
OF PERSONS
GOING DOWN


FIG. 16

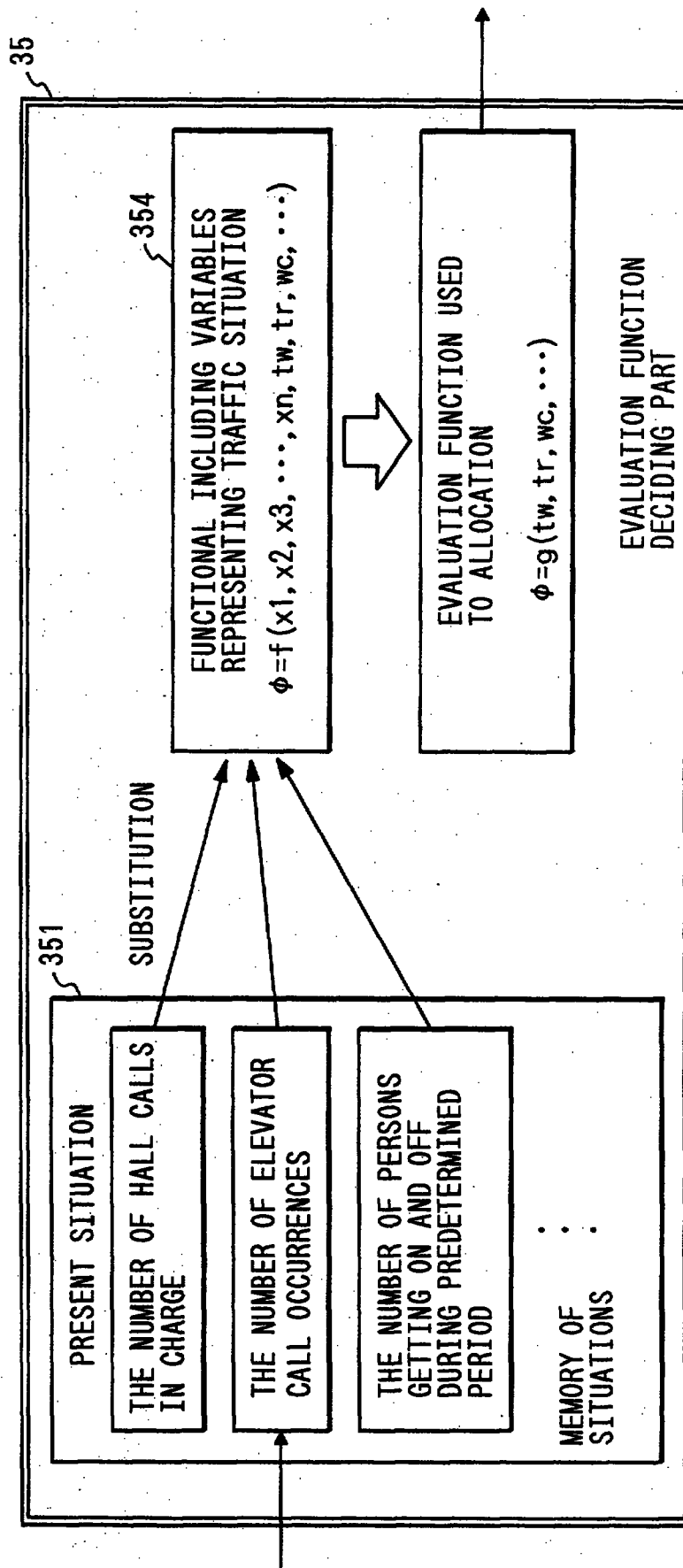


FIG. 17 a

CONDITION OF EXECUTION		FUNCTION USED TO ALLOCATION
REDUCTION OF WAITING TIME	HALL CALLS:FEW, ELEVATOR CALLS:FEW	WAITING TIME MINIMIZING CONTROL
	HALL CALLS:MEDIAL, ELEVATOR CALLS:MEDIAL	MAXIMUM WAITING TIME MINIMIZING CONTROL
	HALL CALLS:MANY, ELEVATOR CALLS:MANY	STOP TIMES AVERAGING CONTROL
	. . .	. . .
REDUCTION OF RIDING TIME	HALL CALLS:FEW, ELEVATOR CALLS:FEW	CONTROL OF ELEVATOR CALL DURATION TIME
	HALL CALLS:MANY, ELEVATOR CALLS:FEW	CROWDEDNESS CONTROL
	. . .	. . .
⋮	⋮	⋮

36

FIG. 17 b

HALL CALL NUMBER	ELEVATOR CALL NUMBER	...	FUNCTION USED TO ALLOCATION
NOT MORE THAN $2n$	NOT MORE THAN 3	...	WAITING TIME MINIMIZING CONTROL
NOT MORE THAN $3n$	NOT MORE THAN $f/3$	...	MAXIMUM WAITING TIME MINIMIZING CONTROL
MORE THAN $3n$	MORE THAN $f/3$	...	STOP TIMES AVERAGING CONTROL
⋮	⋮	⋮	⋮

36

FIG. 18

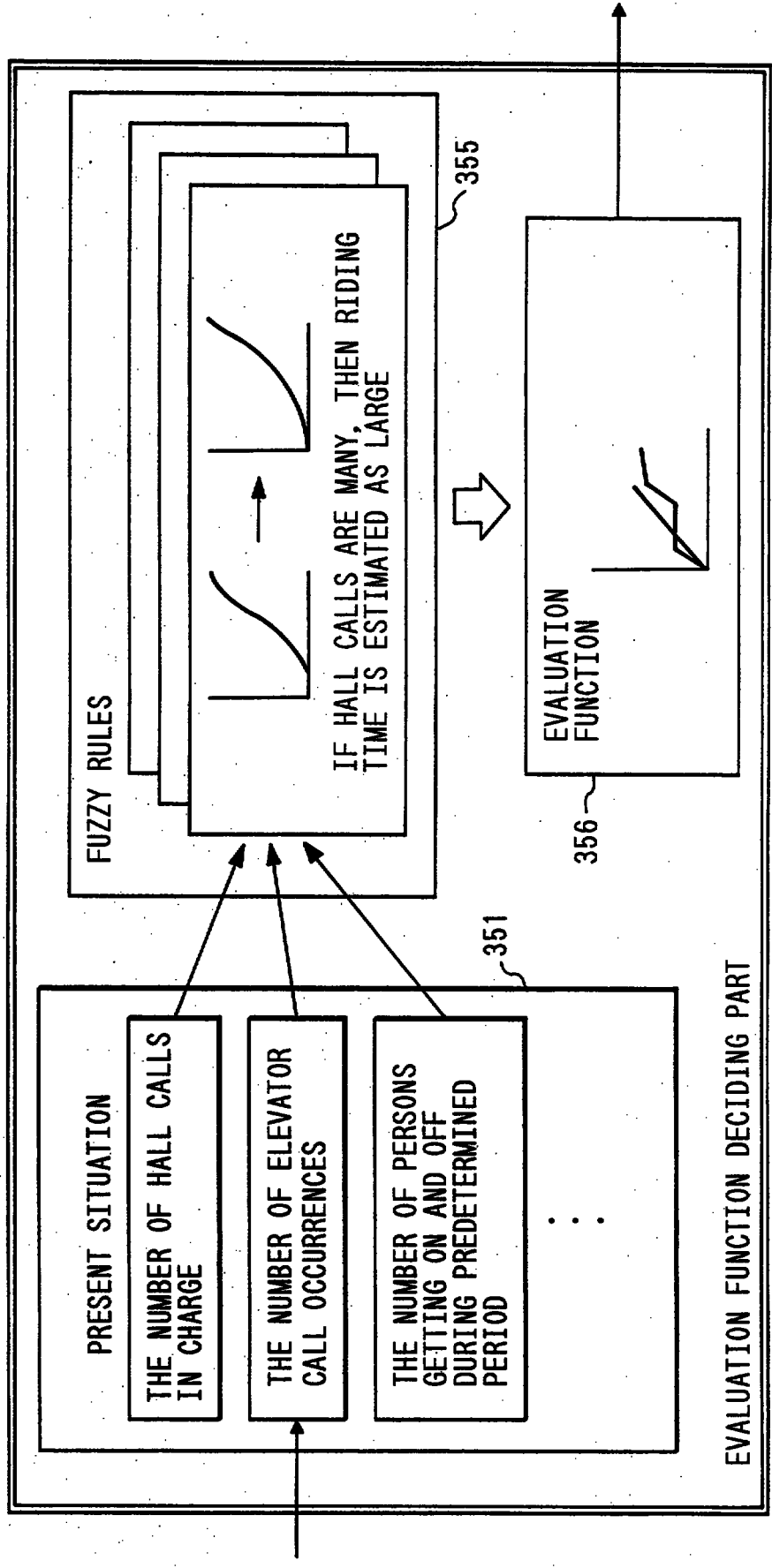


FIG. 19 a

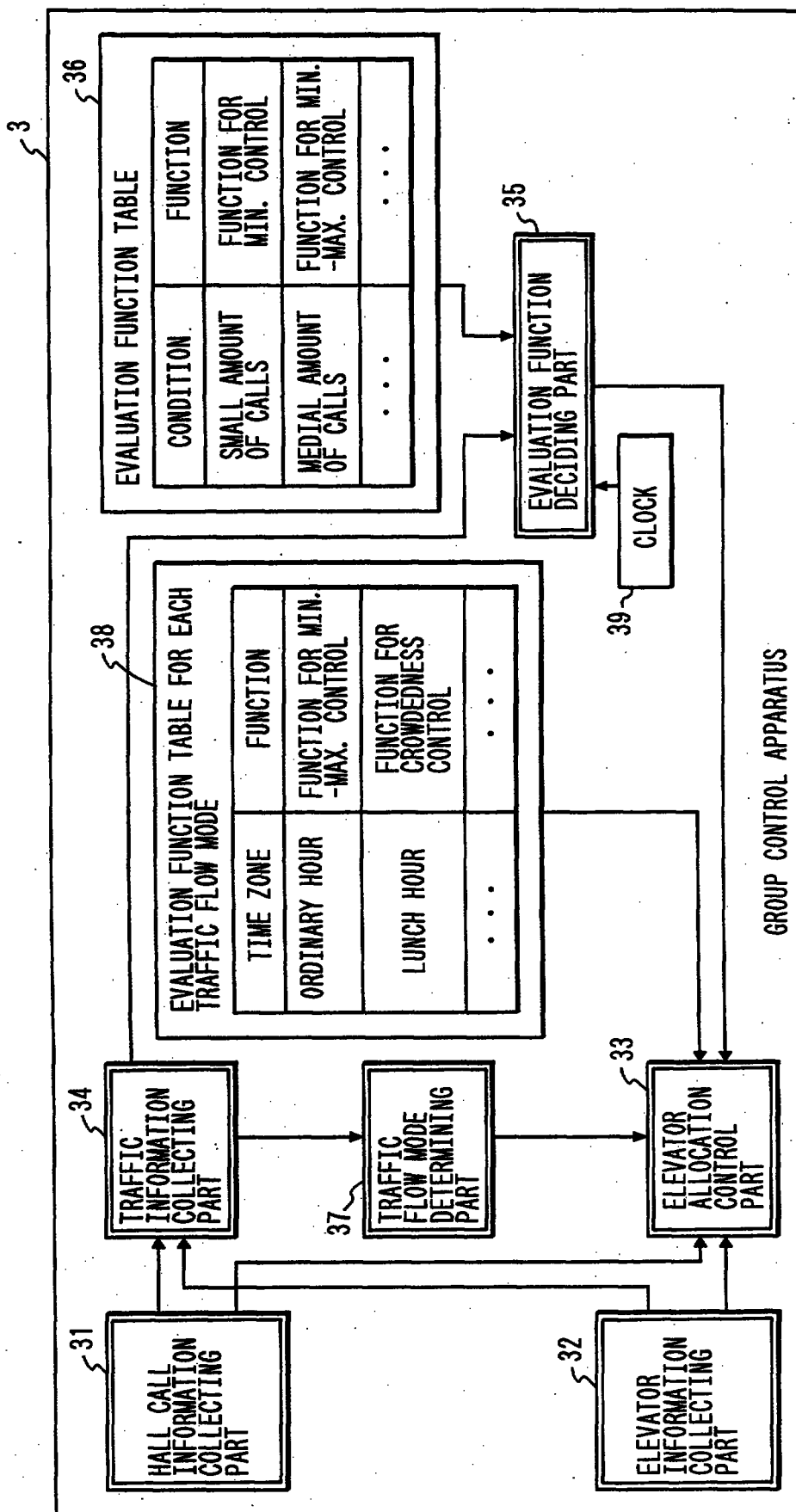


FIG. 19 b

TIME	HALL CALL NUMBER	ELEVATOR CALL NUMBER	FUNCTION USED TO ALLOCATION
11:50~12:00	NOT MORE THAN 2n	NOT MORE THAN 3	WAITING TIME MINIMIZING CONTROL
11:50~12:00	. . .	. . .	. . .
11:50~12:00	. . .	. . .	. . .
12:00~12:10	. . .	. . .	. . .
12:00~12:10	. . .	. . .	. . .
. . .	. . .	. . .	. . .

METHOD AND APPARATUS FOR CONTROLLING ELEVATORS

Abstract of Disclosures

An evaluation function used to the nextly occurring hall call is determined based on results of previous elevator allocation and present situations of traffic demands and traffic flow. The determination of the evaluation function is carried out on occasions in such an operation situation change as arrival of an elevator at the destination floor, registration of a new hall call, a occurrence of long waiting time and so on, besides after determining elevator allocation. By using such elevator operation control method wherein it is not necessary to judge a traffic mode, by preparing the nextly used evaluation function after determining elevator allocation or in the changes of traffic situations, it is further not necessary to change a elevator control method according to traffic slow modes or time zones, which realizes a modeless group control of elevators.

Figure 1