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(54) Channeling with dynamic number of elevator cars

(57) An elevator system includes elevator cars connected to a controller having a channeling program which controls car dispatching during up-peak. The channeling program automatically or dynamically adjusts or changes the number of cars controlled by the channeling program, dependent upon various service parameters such as Lobby Arrival Interval, Average Waiting Time, Overall Service Time or Hall Call Registration Time.

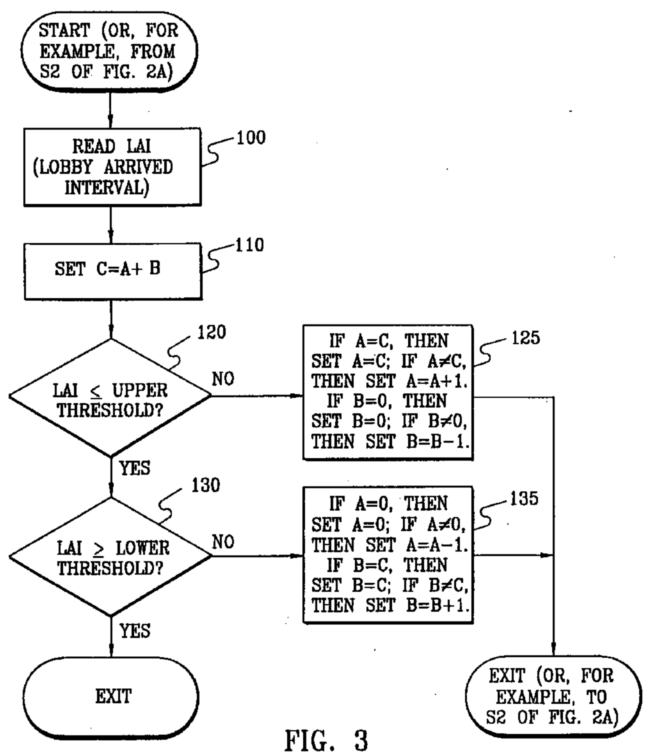

FIG. 3

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Description

The present invention relates to elevator dispatching and, more particularly, to channeling in which building floors above a main floor or lobby are grouped into sectors, with each sector including a set of contiguous floors and with each sector assigned to a car, such channeling being used during up-peak periods.

During the up-peak period, when two cars leave the lobby partially loaded within a predetermined period of time, the elevator dispatching system typically recalls all elevator cars to the lobby to handle traffic in-coming from the lobby. Hence, a well-known channeling operation is activated.

During one known channeling operation, a group controller or an operational control subsystem (OCSS) divides a building into sectors. The number of sectors is equal to the number of cars in operation minus one; thus, one car is left free. The size of each sector includes an equal number of floors being served.

U.S. Patent No. 4,792,019 to Bittar teaches one known typical channeling routine as shown, for example, in Figures 2A-2C herein which correspond to Figures 2A-2C of U.S. Patent '019. Four elevator cars 1-4, which are part of a group elevator system, serve a building having a plurality of floors, e.g. 12, above a main floor or lobby. See Fig. 1, which corresponds to Fig. 1 of the '019 patent, but which will have portions discussed again below to explain the operating environment for the present invention. Each car 1-4 contains a car operating panel 12 through which a passenger makes a car call to a floor by pressing a button, producing a signal (CC) identifying a floor to which the passenger intends to travel. On each of the floors, there is a hall fixture 14 through which a hall call signal (HC) is provided to indicate the intended direction of travel by a passenger on the floor. At the lobby (L), there is also a hall call fixture 16 through which a passenger calls the car to the lobby. The depiction in Fig. 1 illustrates cars selected during an up-peak period at which time floors 2-13, above the main floor, are divided into three sectors (SN), each sector containing four floors. Each of the sectors, which are contiguous, is served by only one of the four cars 1-4 at any time. Such channeling operation is explained in more detail by reference to the flow charts of Fig. 2A-2C, steps S1-S31, and the remainder of U.S. Patent 4,792,019. As shown in Fig. 1, one car, e.g. car 1, is left free. Each car 1-4 will only respond to car calls that are made in the car from the lobby to floors that coincide with the floors in the sector assigned to the car. The car 4, for instance, responds only to car calls made at the lobby to the floors 10-13. Some other known elevator channeling arrangements are taught, for example, in U.S. Patent Nos. 4,804,069, 4,846,311 and 5,183,981.

During the channeling operation, interfloor traffic often occurs. Interfloor traffic is, e.g., normal traffic between the floors above the lobby. In the prior art, down hall calls are handled by the cars travelling in the down direction using well known relative-system response (RSR) routines separate from the channeling routines. See, for example, RSR routines contained in U.S. Patent Nos. 4,363,381 and 4,323,142. Up hall calls, using known RSR routines, are answered by cars serving the sectors in which the hall call exists. However, the cars serving the top 2/3 of a building may be assigned to answer these hall calls. Therefore, passengers travelling to the upper sectors from the lobby will likely suffer from decreased elevator system performance because of at least one stop to pick up the hall call and most likely another stop to answer the car call caused by the in-coming traffic at the lobby.

Therefore, for buildings with heavy interfloor traffic, people travelling to the upper sectors from the lobby will likely suffer from decreased elevator system performance during up-peak when known-channeling routines, whether or not in conjunction with known RSR routines, are utilized. Also, such a condition increases the round-trip time back to the lobby such as the lobby arrival interval (LAI) which is the time between a car leaving from the lobby and returning to the lobby during the up-peak period. The present inventors believe that further improvements in channeling operations can be achieved.

According to the present invention, an elevator system includes a controller having an electronic processor connected to a memory, a group of elevator cars electronically connected to the controller, and a channeling program stored within the memory. The channeling program includes instructions for controlling dispatching of a number of the elevator cars from a floor, for example, the lobby during up-peak. The channeling program further includes instructions for reading a parameter, e g. a lobby arrival interval (LAI), for all of said cars in the group during a predetermined time period, comparing the parameter to an upper threshold, and then increasing the number of elevator cars controlled by channeling by one if the parameter is greater than the upper threshold. The upper threshold is selectable according to the invention. The upper threshold is, for example, approximately (± 10%) 60 seconds. The predetermined time interval is also selectable according to the invention and is, for example, 5, 10 or 15 minute intervals.

According to a further aspect of the present invention, if the parameter (e.g., the lobby arrival interval) read or measured during the predetermined time period is less than or equal to the upper threshold, and not greater than or equal to a lower threshold, then the routine according to the present invention decreases the number of elevator cars assigned to the channeling routine by one. In addition, according to another aspect of the present invention, when the number of cars assigned to or controlled by channeling is increased by one, a number of floating cars is decreased by one; when the number assigned to (or controlled by) channeling is decreased by one, a number of floating cars in increased by one. A floating car is a car not controlled by or assigned to the channeling program, and is available to answer interfloor/counterfloor traffic.

It is a principal object of the present invention to increase overall elevator system performance.

It is an additional object of the present invention to modify dynamically the number of cars assigned to channeling when there is heavy interfloor traffic.

It is an additional object of the present invention to reduce the lobby arrival time during up-peak conditions.

Further and still other objects of the present invention will become more readily apparent in view of the following detailed description of certain embodiments of the invention, given by way of example only, when taken in conjunction with the accompanying drawings, in which:

Figure 1 is a functional block diagram of an elevator system comprising a four car group serving 13 floors;
Figures 2A-2C are flowcharts showing a dispatching routine according to the prior art channeling program of U.S. Patent No. 4,792,019;
Figure 3 is a flowchart showing a channeling modification according to the present invention;
Figure 4 is an additional flowchart showing further channeling modifications according to optional embodiments of the present invention;
Figure 5 shows the group controller 32 and a controller 30, each having a respective CPU coupled to a respective memory M.

In Figure 1, four elevator cars 1-4, which form part of a group elevator system, serve a building having a plurality (e.g., 13) of floors. Each car 1-4 contains a car operating panel 12 through which a passenger makes a car call to a floor by pressing a button producing a signal CC identifying the floor to which the passenger intends to travel. On each of the floors, there is a hall fixture 14 through which a hall call signal HC is provided to indicate the intended direction of travel by a passenger on the floor. At the lobby L, there is a hall call fixture 16 to which a passenger calls the car to the lobby. In Fig. 1, the floors 2-13, above the main floor or lobby, are divided into three sectors, each sector containing four floors. Each of the sectors, which are contiguous, is served by only one of the four cars 1-4 at any one time. One channeling routine according to the prior art is disclosed in Figs. 2A-2C, in which N = number of sectors, and NC = total number of cars, SN is the sector number while CN is the car number. Each car 1-4 will only respond to car calls that are made in the car from the lobby to floors that coincide with the floors in the sector assigned to that car. The car 4, for example, will only respond to car calls made at the lobby to floors 10-13. The car will take passengers from the lobby to those floors (10-13) (provided car calls are made to those floors) and then return to the lobby empty, unless it is assigned, using other dispatching sequences, to answer an up or down hall call that has been made on one of the floors. See, for example, other dispatching routines which are accessed during the up-peak (channeling) condition: U.S. Patents 4,363,381 and 4,323,142 to Bittar.

In Fig. 1, each car 1-4 is connected to a drive and motion control 30. Each of these motion controls 30 is connected to a group controller or group control 32. Alternative architecture for an elevator system in which the present invention (Fig. 3) may be implemented is taught, for example, in U.S. Patent No. 5,202,540 entitled Two-Way Ring Communication System For Elevator Group Control. Although it is not shown, each car's position in the building would be served by the controller through a position indicator as shown in the previous patents to Bittar. The controls 30,32 contain CPUs (central processing units or signal processors) for executing instructions and/or processing data from the system. A group controller 32, using signals from the drive and motion controls 30, sets the sectors that will be served by each of the cars. Each motion control 30 receives the HC and CC signals and provides a drive signal to the service indicator 51. Each motion control also receives data from the car that it controls on the car load signal LW. It also measures the lapsed time while the doors are open at the lobby (the "dwell time", as it is commonly called). The drive and motion controls are shown in a very simplified manner herein because numerous patents and technical publications showing details of drive and motion controls for elevators are available.

Therefore, the CPUs in the controllers 30,32 are programmable to carry out the routines described herein to effect the dispatching operations of Figs. 2A-2C, and of the present inventive modification as shown in Fig. 3 at a certain time of day or under settled building conditions. It is also assumed that at other times the controllers are capable of resorting to different dispatching routines, for instance, the routines shown in the aforementioned Bittar patents. This system can collect data on individual and group demands throughout the day to arrive at a historical record of traffic demands (e.g., LAI, etc.) for each day of the week and compare it to actual demand to adjust the overall dispatching sequences to achieve a prescribed level of system and individual car performance. Following such an approach, car loading and lobby traffic may also be analyzed through the signal LW, from each car, that indicates the car load. Actual lobby traffic may also be sensed by using a people sensor (not shown) in the lobby. U.S. Patent Nos. 4,330,836 and No. 4,303,851 show approaches that may be employed to generate those signals. Using such data and correlating it with the time of day and the day of the week and the actual entry of car calls and hall calls, a meaningful demand demograph can be obtained for allocating the sectors throughout the up-peak period by using a signal processing routine that implements the sequences described on the flow chart comprising, e.g., Figs. 2A-C in order to minimize the waiting time from the lobby.

According to the present invention (Fig. 3), the number of cars assigned to a channeling program is dynamically changed in accordance with the routine as shown in Fig.3. As a result, a number of floating cars B is also changed so that $A + B = C$, wherein C is the total number of elevator cars in service. Usually, all cars in the group are in service. The routine of Fig. 3 can be implemented, for example, as a replacement for step S3 (Fig. 2A) of the channeling routine according to the prior art; in which case, steps S29 and S30 (Fig. 2C) can optionally be omitted. Thus, overall elevator service during a channeling period is further improved because the number of floating cars to handle interfloor (or even counterfloor) traffic can be dynamically adjusted rather than, for example, remain fixed. The routine of Fig. 3 is suitably coded and stored (in combination, e.g., with the appropriate steps of Figs. 2A-2C) in the memory M of the controller 32, or in a memory of an OCSS (described in US-5,202,540).

In Fig. 3, the inventive arrangement determines a number A of cars to handle all incoming traffic, and determines the remaining number B of the cars to be floating to handle interfloor (or even counterfloor) traffic. $A + B = C$, wherein C is a total number of cars in service (for example, four). The number A of cars controlled under the channeling program varies according to the invention depending upon, for example, the lobby arrival interval, or the overall service time, or the average waiting time (AWT) or any desired combination of these factors measured for a past "I" time interval. I is selectable or programmable by, e.g., the building owner to be, for example, 5, 10, 15 etc. minutes or any other desired time interval. Dispatching of floating cars is controlled by other (e.g., non-channeling) dispatching routines such as those taught in patents '381 or '142 to Bittar.

If LAI, or AWT, or overall service time is greater than a certain upper threshold (selectable or programmable), the arrangement according to the invention will automatically increase the number A of cars assigned to channeling and automatically decrease the number B of cars assigned to be floating - i.e., $A=A+1$, $B=B-1$. The boundary conditions are $A=C$ and $B=0$ such that $A+B=C$. An increase in the number A of cars assigned to channeling will also decrease sector size and also improve service from the lobby.

If LAI or AWT is less than the upper threshold, and less than a certain lower threshold, then A is decreased by one and B is increased by one to handle increased interfloor (or even counterfloor) traffic. B is the number of cars assigned to be floating. The boundary conditions in this case are $A = 0$ and $B = C$, such that $A + B = C$. The invention accommodates incoming traffic during up-peak while dynamically handling heavy interfloor (or even counterfloor) traffic.

In the routine of Fig. 3, start, read lobby arrival interval (step 100), set $C = A + B$, step 110. If LAI is not less than or equal to an upper threshold, e.g. 60 seconds in a step 120, go to step 125. In step 125, if $A = C$, then set $A = C$, if A is not equal to C, then set $A = A + 1$ and set $B = B - 1$. Then exit. If LAI is less than or equal to the upper threshold, go to step 130. In step 130, if LAI is not greater than or equal to a lower threshold (e.g., 20 seconds) go to step 135. In step 135, if $A=0$, then set $A=0$, if A is not equal to 0, then set $A=A-l$. If $B=C$, then set $B=C$; if B is not equal to C, then set $B=B+1$.

As shown by the inventive arrangement including the routine or program of Fig. 3, the number of elevator cars assigned to be controlled by channeling and the number to be floating are varied in accordance with upper and lower thresholds. Of course, average waiting time or overall service time or any combination can be used as the measured or read criterion for the steps 120, 130, rather than LAI.

Figure 4 shows an additional embodiment of the inventive arrangement wherein an upper hall call registration time (UHC) is used as a determining criterion rather than LAI, AWT or the overall service time. UHC registration time is understood to be the time period beginning when an upper hall call is registered and ending when a car answers the call. The lobby arrival interval (LAI) is understood to be a time between a car leaving from the lobby and arriving at the lobby during up-peak period. Average waiting time is that period between a passenger arriving at a landing (e.g., lobby) to when the passenger boards a car at that landing. Overall service time is that period beginning when a passenger arrives in the building and ending when the passenger exits the car at its destination landing. Average registration time is the period between a passenger arriving at the landing to when the car doors begin to open at that landing. Each of these parameters is such that an increase in the parameter indicates a decrease in the quality of elevator service provided to the passengers. Interfloor traffic and counterfloor traffic can be defined as set forth in U.S. Patent 4,792,019 or alternatively interfloor traffic can be understood: interfloor traffic - normal traffic between floors above the lobby.

While there has been shown and described what are at present considered preferred embodiments of the present invention, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the scope of the present invention which shall be limited only by the appended claims.

Claims

1. An elevator system, comprising:

a controller having an electronic processor connected to a memory;

elevator cars controlled by said controller;

a channeling program stored within said memory, said channeling program including instructions for controlling dispatching of a number A of said elevator cars from a floor, wherein said channeling program further includes instructions for reading a parameter for said elevator cars during a predetermined time interval, said parameter being such that an increase in the parameter indicates a decrease in the quality of elevator service provided to passengers, comparing said parameter to an upper threshold, and then increasing said A number by one if said parameter is greater than said upper threshold.

2. A system as claimed in claim 1, wherein said parameter is lobby arrival interval and said upper threshold is approximately 60 seconds.

3. A system as claimed in claim 1 or 2, wherein said channeling program further includes instructions for comparing said parameter to a lower threshold, and then decreasing said number A by one if said parameter Is less than said upper threshold and less than said lower threshold.

4. A system as claimed in claim 3, wherein said parameter is lobby arrival interval and said lower threshold is approximately 20 seconds.

5. A system as claimed in claim 1, 2, 3 or 4 wherein said channeling program further includes instructions for decreasing a number B of floating cars such that $A + B = C$, wherein C equals a total number of said elevator cars in service.

6. A system as claimed in claim 1, wherein said parameter is a lobby arrival interval.

7. A system as claimed in claim 1, wherein said parameter is an average waiting time.

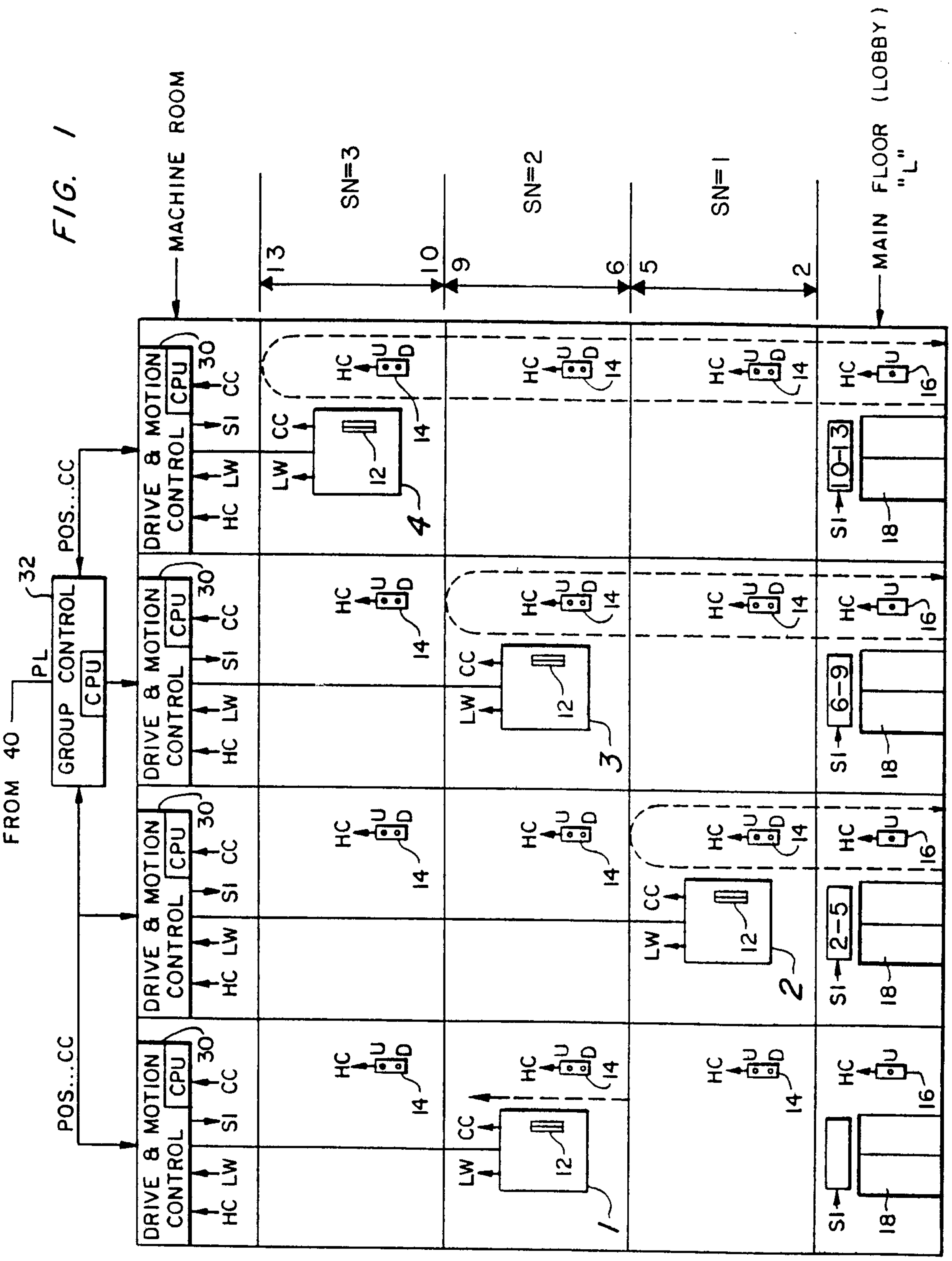
MACHINE ROOM
MAIN FLOOR (LOBBY) "L"
FROM 40
PL
GROUP CONTROL
CPU
32
POS...CC
DRIVE & MOTION CONTROL
CPU
30
HC
LW
SI
CC
SN=3
SN=2
SN=1
13
10
9
6
5
2
10-13
6-9
2-5
12
14
16
18
U
D
1
2
3
4

FIG. 1

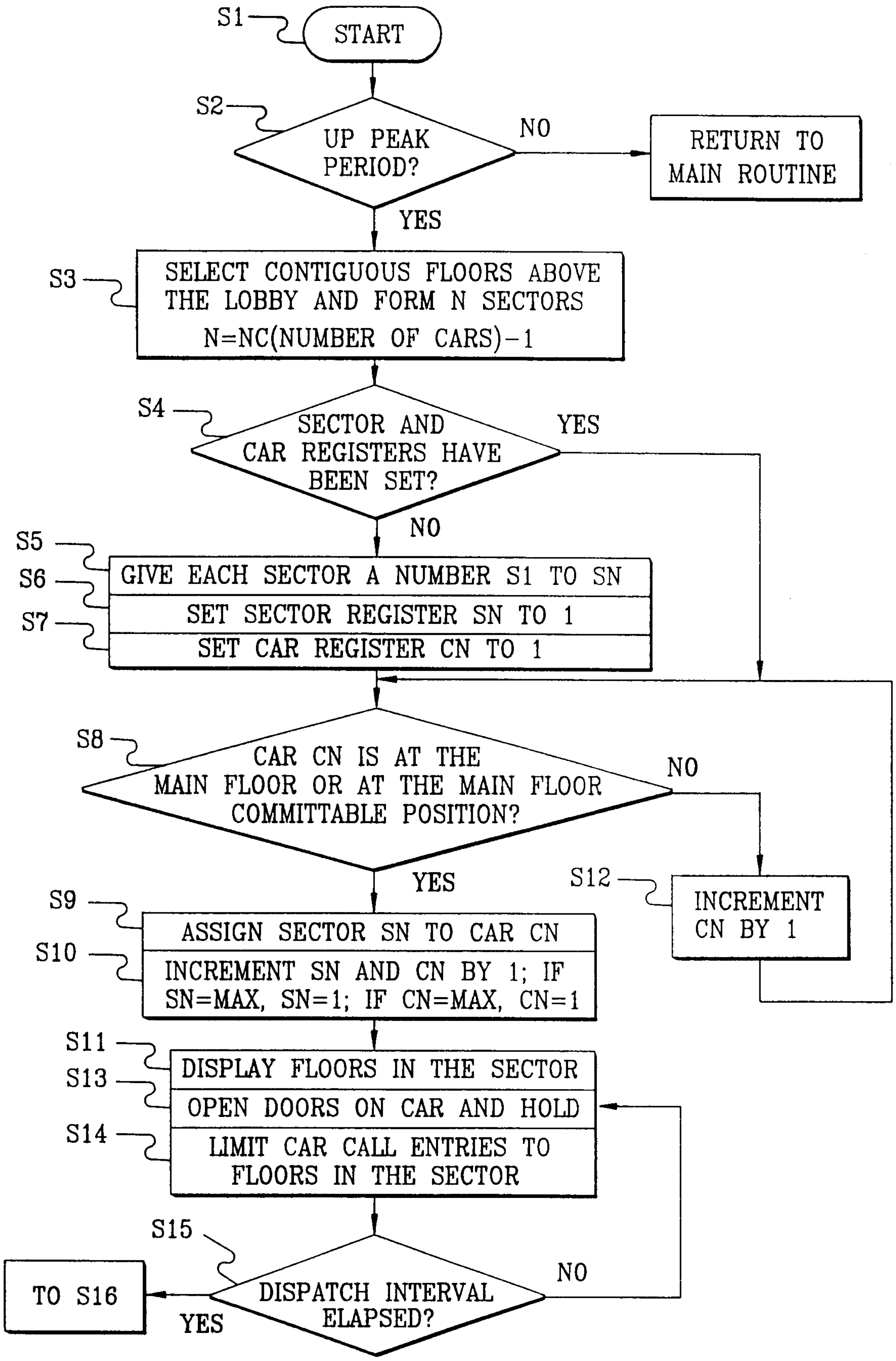

FIG. 2A (PRIOR ART)

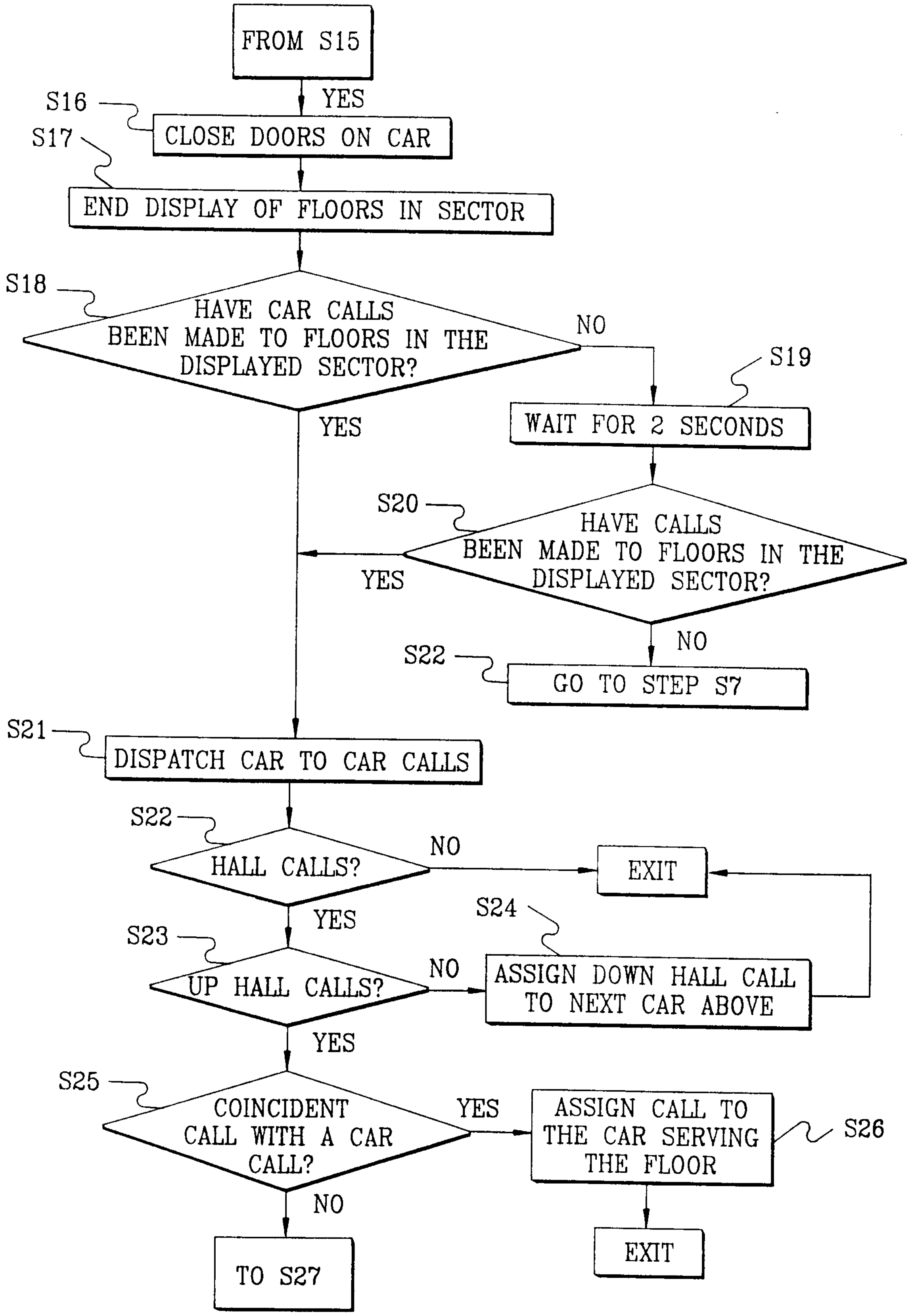

FIG. 2B (PRIOR ART)

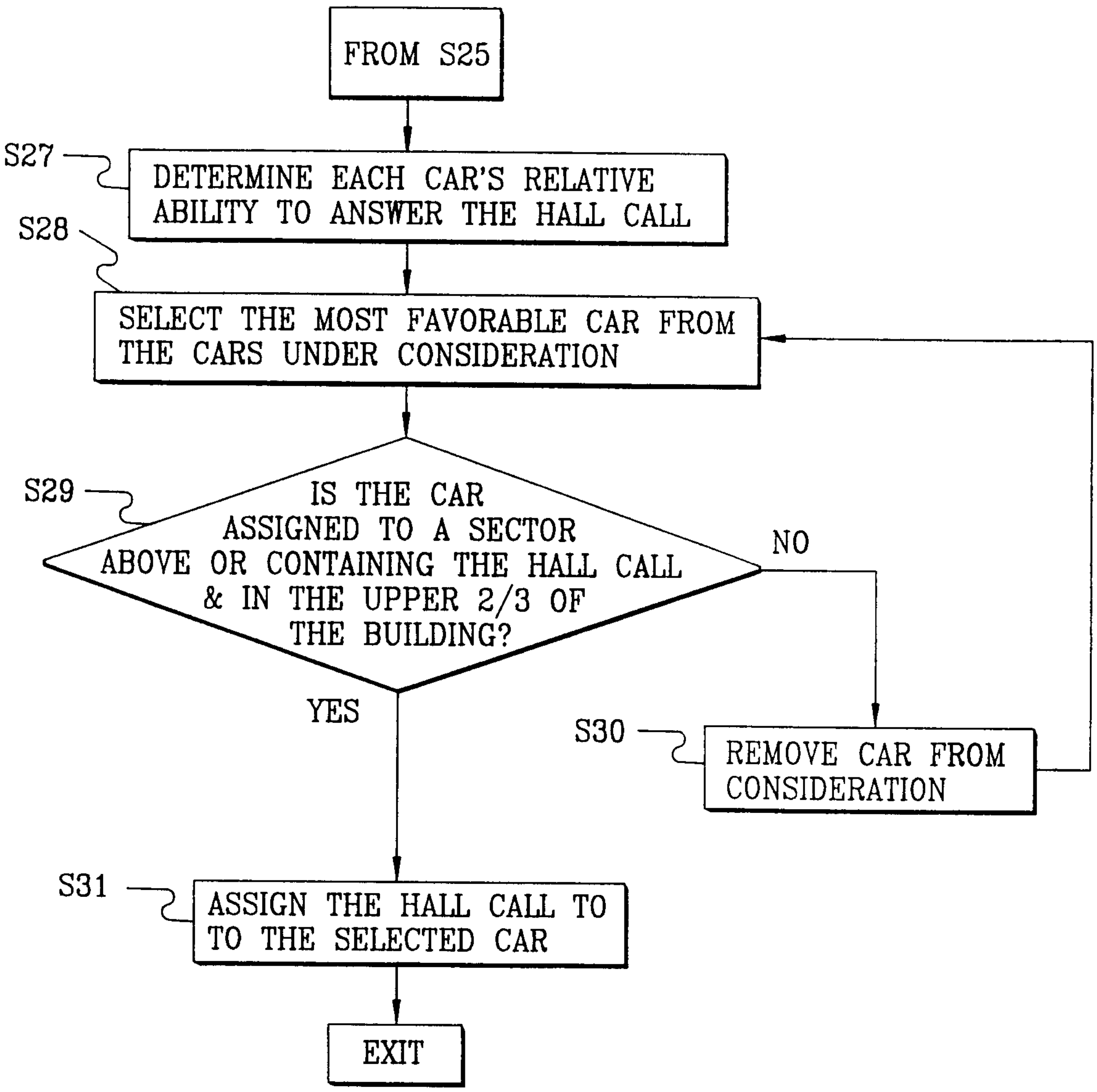

FIG. 2C (PRIOR ART)

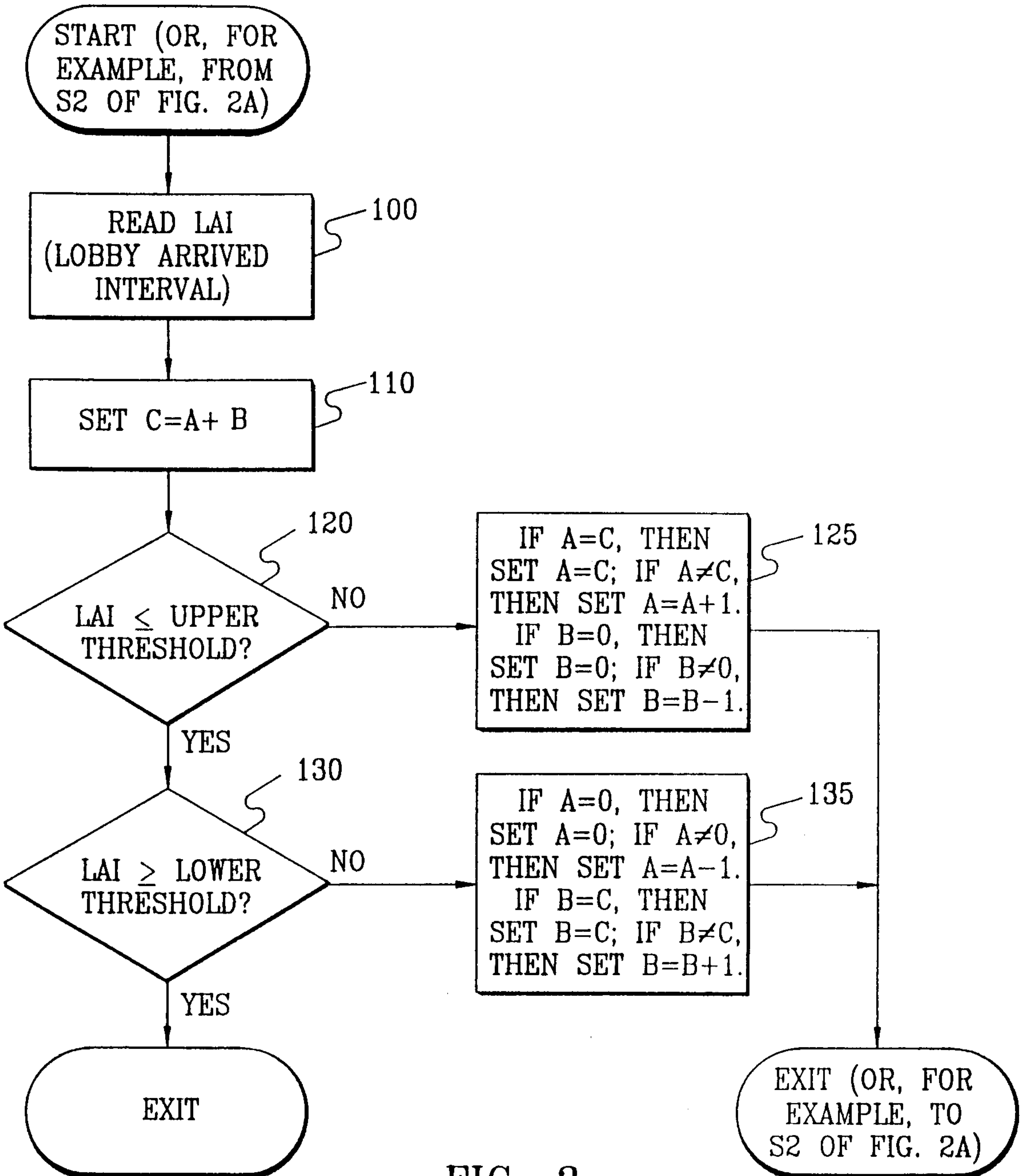
START (OR, FOR EXAMPLE, FROM S2 OF FIG. 2A)
READ LAI (LOBBY ARRIVED INTERVAL)
100
SET C=A+ B
110
LAI ≤ UPPER THRESHOLD?
120
NO
YES
IF A=C, THEN SET A=C; IF A≠C, THEN SET A=A+1. IF B=0, THEN SET B=0; IF B≠0, THEN SET B=B−1.
125
LAI ≥ LOWER THRESHOLD?
130
NO
YES
IF A=0, THEN SET A=0; IF A≠0, THEN SET A=A−1. IF B=C, THEN SET B=C; IF B≠C, THEN SET B=B+1.
135
EXIT
EXIT (OR, FOR EXAMPLE, TO S2 OF FIG. 2A)

FIG. 3

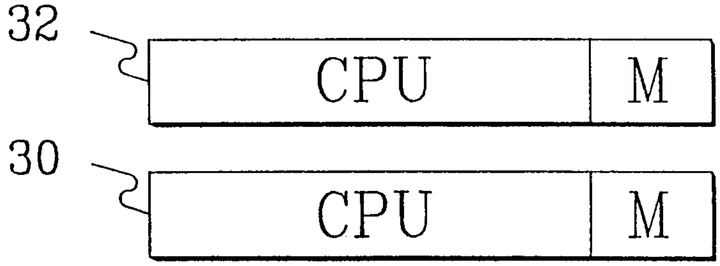
32
CPU
M
30
CPU
M

FIG. 5

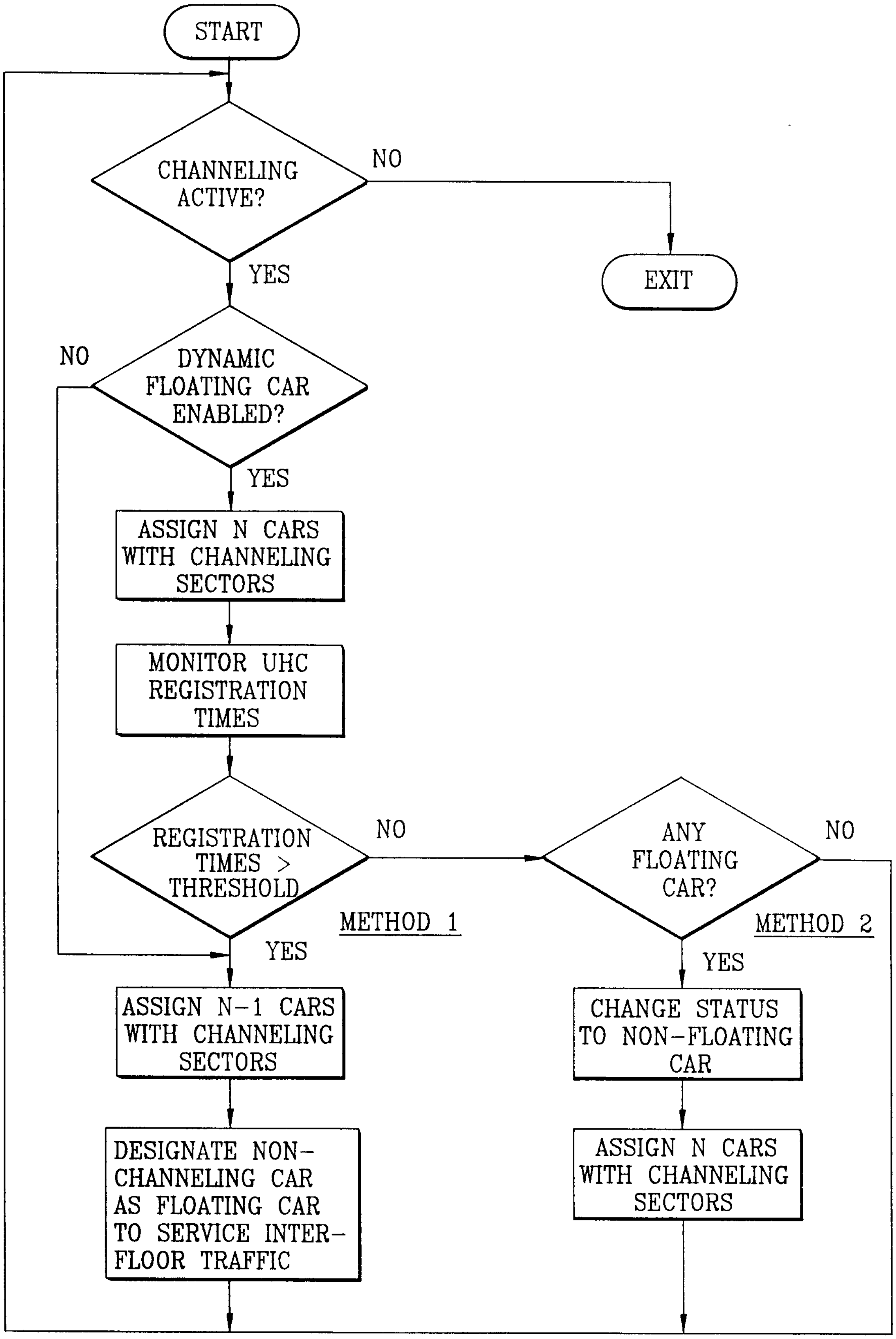
START
CHANNELING ACTIVE?
NO
EXIT
YES
NO
DYNAMIC FLOATING CAR ENABLED?
YES
ASSIGN N CARS WITH CHANNELING SECTORS
MONITOR UHC REGISTRATION TIMES
REGISTRATION TIMES > THRESHOLD
NO
ANY FLOATING CAR?
NO
METHOD 1
METHOD 2
YES
YES
ASSIGN N-1 CARS WITH CHANNELING SECTORS
CHANGE STATUS TO NON-FLOATING CAR
DESIGNATE NON-CHANNELING CAR AS FLOATING CAR TO SERVICE INTER-FLOOR TRAFFIC
ASSIGN N CARS WITH CHANNELING SECTORS

FIG. 4

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 95 30 9173

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	US-A-3 614 995 (PROBERT ALFRED JOHN ET AL) 26 October 1971 * the whole document * ---	1-7	B66B1/20
X	US-A-3 572 470 (HIRSCH MELVYN ET AL) 30 March 1971 * the whole document * ---	1,2	
A	US-A-4 029 175 (WINKLER CHARLES L) 14 June 1977 * abstract * ---	1	
A,D	US-A-4 792 019 (BITTAR JOSEPH ET AL) 20 December 1988 * abstract * -----	1-7	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)
B66B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	18 March 1996	Sozzi, R

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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