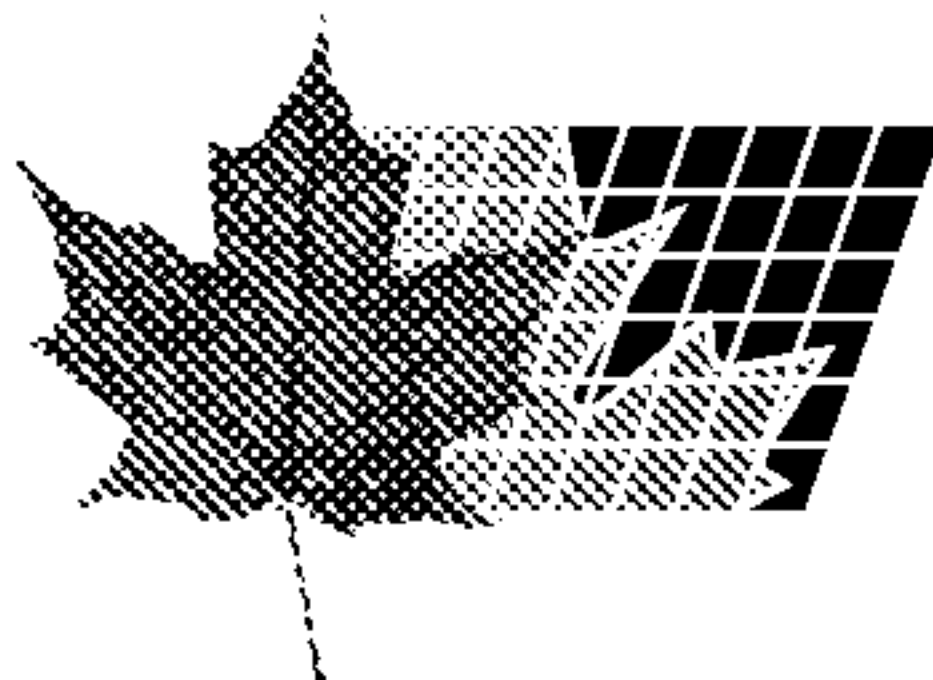




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(72) IKEDA, Chinatsu, JP

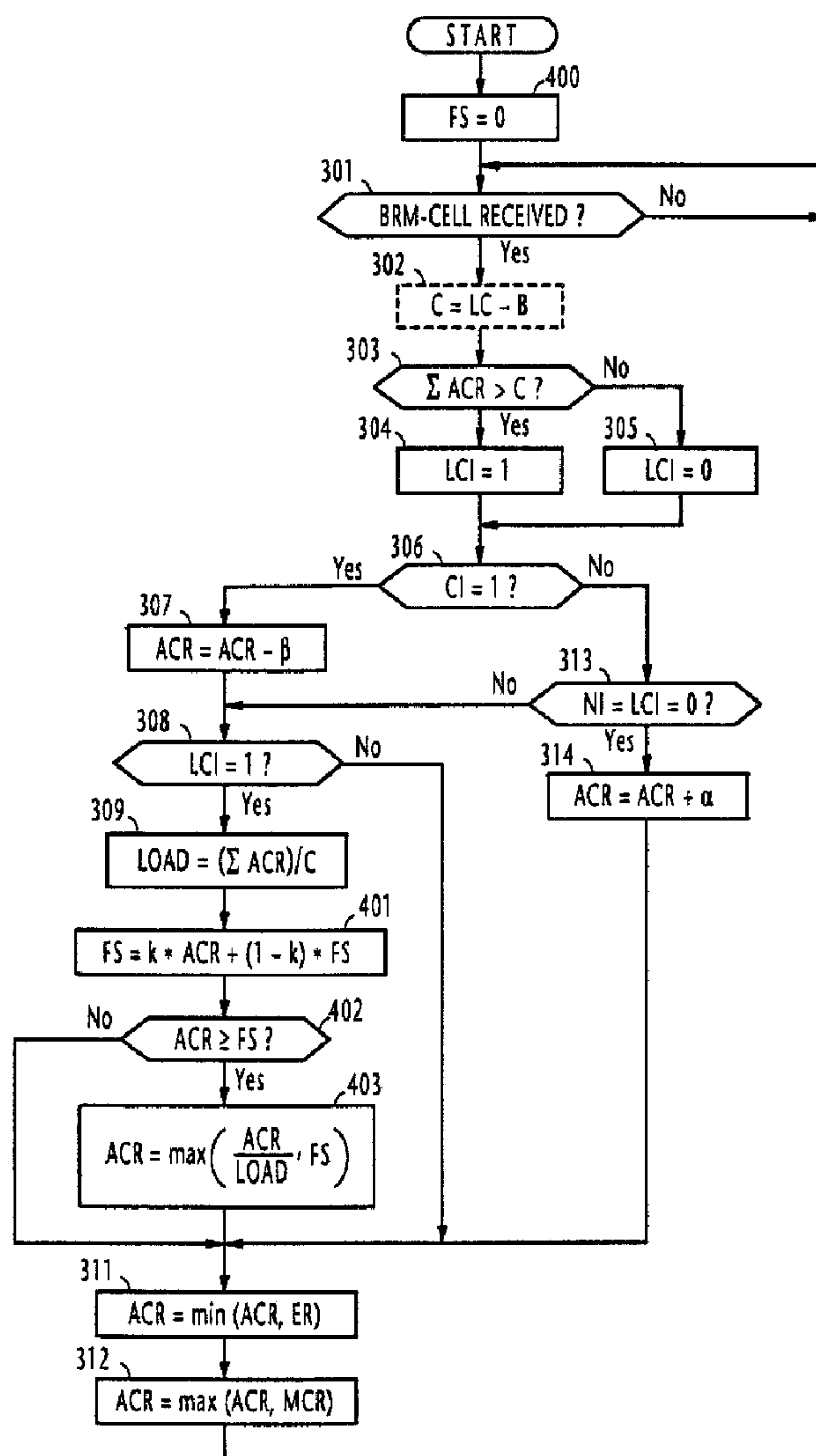
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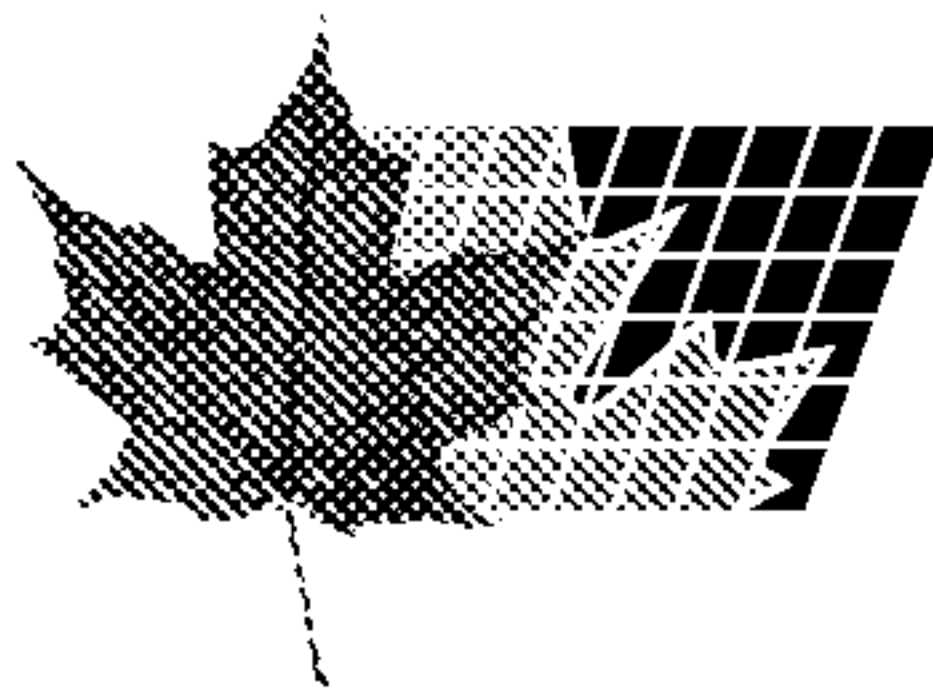
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(54) METHODE DE CONTROLE DU TRAFIC D'UNE SOURCE DANS
UN RESEAU MTA POUR EMPECHER LES
ENCOMBREMENTS LOCAUX GRAVES

(54) SOURCE TRAFFIC CONTROL METHOD IN ATM NETWORK
TO PREVENT SERIOUS LOCAL CONGESTION





(11) (21) (C) **2,205,328**

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(45) 2001/07/03

(57) In an ATM network, a source end system is connected through multiple virtual channels to destination end systems to exchange resource management (RM) cells at periodic intervals and transmit data cells at allowed cell rates (ACRs) respectively set for the virtual channels. The source end system transmits a forward RM cell through an associated virtual channel, and determines a sum of ACR values of the virtual channels in response to receipt of a backward RM cell through the associated virtual channel and compares the sum of ACR values with a predetermined capacity of the access link. The source end system resets a current ACR value of the associated virtual channel equal to a lower-than-previous value when the sum of ACR values is in excess of the predetermined link capacity. In one embodiment, the sum of ACR values is divided by the predetermined link capacity to produce a link load value and the ACR value is reset according to the link load value.

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ABSTRACT OF THE DISCLOSURE

1 In an ATM network, a source end system is connected through
2 multiple virtual channels to destination end systems to exchange resource
3 management (RM) cells at periodic intervals and transmit data cells at
4 allowed cell rates (ACRs) respectively set for the virtual channels. The
5 source end system transmits a forward RM cell through an associated virtual
6 channel, and determines a sum of ACR values of the virtual channels in
7 response to receipt of a backward RM cell through the associated virtual
8 channel and compares the sum of ACR values with a predetermined
9 capacity of the access link. The source end system resets a current ACR
10 value of the associated virtual channel equal to a lower-than-previous value
11 when the sum of ACR values is in excess of the predetermined link capacity.
12 In one embodiment, the sum of ACR values is divided by the
13 predetermined link capacity to produce a link load value and the ACR value
14 is reset according to the link load value.

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TITLE OF THE INVENTION

"Source Traffic Control Method in ATM Network to
Prevent Serious Local Congestion"

BACKGROUND OF THE INVENTIONField of the Invention

The present invention relates generally to ATM (asynchronous transfer mode) networks, and more specifically to a traffic control method for controlling source user traffic on an access link to an ATM network.

Description of the Related Art

In an ATM network, resource management cells are exchanged between source and destination end systems (user terminals) at periodic intervals to regulate the source traffic according to control data inserted into a received RM cell by the network. As described in "Traffic Management Specification Version 4.0", The ATM Forum, Technical Committee, March 1996, the source end system transmits data cells at an allowed cell rate (ACR) over an established virtual channel and this ACR value is altered according to the received control data. Since the ATM system allows an end system to establish multiple virtual channels simultaneously to different destinations, while the source traffic is controlled on a per-channel basis, there is a likelihood of the user's access link being overloaded. If the overloaded condition is left unattended, a serious local congestion would develop at the source end system.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to prevent serious local traffic congestion in an ATM network.

According to the present invention, there is provided a method for controlling the traffic of a source end system connected by an access link to an ATM network, wherein the source end system is connected through a plurality of virtual channels to destination end systems to exchange resource management (RM) cells at periodic intervals and to transmit data cells at

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1 allowed cell rates (ACRs) respectively set for the virtual channels. The
2 method comprises the steps of (a) transmitting a forward RM cell through
3 an associated virtual channel, (b) determining a sum of ACR values of the
4 virtual channels in response to receipt of a backward RM cell through the
5 associated virtual channel and comparing the sum of ACR values with a
6 predetermined capacity of the access link, and (c) resetting a current ACR
7 value of the associated virtual channel equal to a lower-than-previous value
8 when the sum of ACR values is in excess of the predetermined link capacity.

9 The step (c) may comprise the steps of producing a link load value
10 representing the sum of ACR values divided by the predetermined link
11 capacity, and resetting the ACR value to the lower-than-previous value
12 according to the link load value. The step (c) may comprise the steps of
13 producing a link load value representing the sum of ACR values divided by
14 the predetermined link capacity, producing a fair share value representing a
15 weighted mean of ACR values of virtual channels through which backward
16 RM cells are successively received, comparing the current ACR value of the
17 associated virtual channel with the fair share value, dividing the current
18 ACR value by the link load value if the current ACR value is greater than
19 the fair share value, comparing the divided ACR value with the fair share
20 value, and resetting the current ACR value equal to the divided ACR value
21 if the divided ACR value is greater than the fair share value and resetting
22 the current ACR value equal to the fair share value if the fair share value is
23 greater than the divided ACR value.

24 BRIEF DESCRIPTION OF THE DRAWINGS

25 The present invention will be described in further detail with
26 reference to the accompanying drawings, in which:

27 Fig. 1 is a block diagram of an exemplary ATM network for
28 describing the present invention;

29 Fig. 2 is an illustration of a control cell used in the network;

30 Fig. 3 is a flowchart of the operation of an ATM node according to

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1 a first embodiment of the present invention;

2 Fig. 4 is a flowchart of the operation of an ATM node according to

3 a second embodiment of the present invention;

4 Figs. 5A and 5B are flowcharts of a modification of the second

5 embodiment of the present invention; and

6 Fig. 5C is a flowchart of a modification of the flowchart of Fig. 5B.

7 DETAILED DESCRIPTION

8 Referring now to Fig. 1, there is shown an exemplary ATM
9 (asynchronous transfer mode) network for describing the rate control
10 algorithm of the present invention. The exemplary network is formed by
11 ATM nodes 10, 11 and 12 interconnected by links 20, 21 and 22. End
12 systems, or user terminals 100, 101, 102 and 103 are connected to the
13 network by links 13 to 16. For the purpose of disclosure, user terminal 100
14 establishes ABR (available bit rate) virtual channels VC_1 , VC_2 and VC_3 to
15 destination user terminals 101, 102 and 103, respectively. The minimum
16 cell rate (MCR) values of VC_1 , VC_2 and VC_3 are 30 Mbps, 10 Mbps and
17 60 Mbps, respectively. When establishing a virtual channel, the source
18 terminal determines an allowed cell rate (ACR) and inserts the value of this
19 rate into the current cell rate (CCR) field of a forward resource
20 management (FRM) cell 200, or FRM cell as shown in Fig. 2. The FRM
21 cell is transmitted from the source user terminal at periodic intervals to the
22 destination. Note that a "0" bit is initially set into each of the congestion
23 sub-fields CI and NI of the cell 200, indicating that no congestion exists. In
24 response to each forward RM cell, the destination terminal returns a
25 backward RM cell to the source terminal. As the returning BRM cell
26 propagates through the network, intermediate nodes insert a serviceable cell
27 rate into the explicit rate (ER) field of the BRM cell and rewrites the CI
28 (congestion indication) and NI (no increase) fields where appropriate. Since
29 each virtual channel has a particular value of allowed cell rate, the
30 transmission rate of RM cells of each virtual channel differs from the

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1 transmission rate of RM cells of the other virtual channels.

2 Following the transmission of a forward RM cell from the source
3 terminal on a given virtual channel, data cells are transmitted at the allowed
4 cell rate. The symbols ID, DIR and BN in Fig. 2 are "identifier",
5 "direction of transmission" and "backward notification", respectively. As
6 will be described later, the ACR of each virtual channel is modified
7 according to the present invention and subsequent data cells are transmitted
8 at the modified ACR rate and the CCR field of a subsequent forward RM
9 cell is updated with the modified ACR value.

10 The ACRs of established virtual channels are modified at the source
11 user terminal according to the flowchart shown in Fig. 3. Following the
12 transmission of a FRM cell over a virtual channel, the source user terminal
13 monitors the reception of a BRM cell at step 301. When a BRM cell is
14 received on a virtual channel, the source user terminal reads the CI, NI and
15 ER data from the received BRM cell and stores them into a memory. Flow
16 proceeds to optional step 302. If the network accommodates a plurality of
17 service classes, it is preferable to exclude the total bandwidth (B) of virtual
18 channels of higher class than ABR virtual channels. If the source terminal is
19 using a higher grade service, step 302 is executed for subtracting the
20 bandwidth B from the capacity (LC) of access link 23 and setting the
21 subtracted capacity as an effective value (C) of the link capacity.

22 At step 303, a sum of the ACR values of all virtual channels is
23 obtained and compared with the link capacity C. If the former is larger
24 than the latter, it is determined that there is a local congestion and flow
25 proceeds from step 303 to step 304 to set a local congestion indication
26 (LCI) flag to 1. Otherwise, flow proceeds to step 305 to set the LCI flag to
27 0.

28 At step 306, the source user terminal examines the CI bit of the
29 received BRM cell. If the CI bit is "1", the source user determines that a
30 virtual channel from which the BRM cell was received is congested and flow

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1 proceeds from step 306 to step 307 to decrement the ACR value of the
 2 virtual channel by a fixed correction value β . The LCI flag is then examined
 3 at step 308. If LCI = 1, flow proceeds to step 309 where the traffic load of
 4 the access link 23 is calculated by dividing the sum of the ACR values of all
 5 virtual channels with the effective link capacity C. At step 310, the ACR
 6 value is divided by the traffic load (LOAD).

7 At step 311, ACR is compared with ER and the smaller of the two
 8 is selected as a new ACR value, which is further compared, at step 312, with
 9 MCR of the current virtual channel and the smaller of the two is selected as
 10 a final ACR value of the current virtual channel.

11 If CI = 0, flow proceeds from step 307 to step 313 to check to see if
 12 both of the NI and LCI of the received BRM cell are 0. If so, flow proceeds
 13 from step 313 to step 314 to increment the current ACR by a fixed
 14 correction value α and then proceeds to execute steps 311 and 312. If the
 15 decision at step 313 is negative, flow proceeds to step 308. Following the
 16 execution of step 312, flow returns to step 301 to repeat the process on a
 17 subsequently arriving BRM cell.

18 The ACR updating algorithm of Fig. 3 will be best understood by
 19 the following description by assuming that the ACR_1 , ACR_2 , ACR_3 values
 20 of virtual channels VC_1 , VC_2 and VC_3 are initially 50 Mbps, 50 Mbps and
 21 100 Mbps, respectively, and the capacity of link 23 is 150 Mbps. Therefore,
 22 the link load is initially equal to $(50 + 50 + 100)/150 = 1.33$. Since the sum
 23 of all ACR values (= 200 Mbps) is greater than the link capacity (=150
 24 Mbps), it is determined that a local congestion has occurred and the
 25 decision at step 305 is affirmative, setting the LCI flag to 1 at step 306.

26 Assume that the CI and NI sub-fields of all virtual channels are set
 27 equal to "0" and the same ER values (50 Mbps) are inserted by the network.
 28 The traffic control parameters used in the following description are
 29 summarized as follows:

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VC ₁	ACR ₁ =50	ER ₁ =50	MCR ₁ =30	CI ₁ =0	NI ₁ =0
VC ₂	ACR ₂ =50	ER ₂ =50	MCR ₂ =10	CI ₂ =0	NI ₂ =0
VC ₃	ACR ₃ =100	ER ₃ =50	MCR ₃ =60	CI ₃ =0	NI ₃ =0

1 Since CI = 0 and LCI = 1 for all virtual channels, flow proceeds
2 from step 308 to step 315 and then to step 310 where it branches off to
3 steps 311, 312 and 313. Assume that BRM cells are successively received
4 from VC₁, VC₂ and VC₃, successive executions of steps 310, 311 and 312
5 will produce the following results:

6 Step 310-1: $ACR_1 = 50/1.33$ = 37.5 Mbps

7 Step 311-1: $ACR_1 = \min(37.5, 50)$ = 37.5 Mbps

8 Step 312-1: $ACR_1 = \max(37.5, 30)$ = 37.5 Mbps

9 Step 310-2: $ACR_2 = 50/1.25$ = 40 Mbps

10 Step 311-2: $ACR_2 = \min(40, 50)$ = 40 Mbps

11 Step 312-2: $ACR_2 = \max(40, 10)$ = 40 Mbps

12 Step 310-3: $ACR_3 = 100/1.18$ = 84.8 Mbps

13 Step 311-3: $ACR_3 = \min(84.8, 50)$ = 50 Mbps

14 Step 312-3: $ACR_3 = \max(50, 60)$ = 60 Mbps

15 At the end of the execution of these steps, $ACR_1 = 37.5$ Mbps,
16 $ACR_2 = 40$ Mbps, and $ACR_3 = 60$ Mbps are obtained in sequence with a
17 total traffic rate of 137.5 Mbps. Therefore, the user terminal 100 starts
18 transmitting data cells at 37.5 Mbps on VC₁, 40 Mbps on VC₂ and 60
19 Mbps on VC₃. With the total ACR value being updated to a value lower
20 than the link capacity, the arrival of subsequent BRM cells will cause the
21 source user terminal to reset the LCI flag to zero at step 305, so that step
22 310 is skipped.

23 A modified embodiment of Fig. 3 is shown in Fig. 4 in which parts
24 corresponding in significance to those of Fig. 3 are marked with the same
25 numerals. The flowchart of Fig. 4 differs from the previous embodiment
26 by the inclusion of steps 400 to 403, instead of step 310 of Fig. 3.

27 Following the starting point of the traffic control routine, step 400 is

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1 executed for setting a variable FS, and flow proceeds to step 301. The
 2 variable FS represents the "fair share" of the resource of link 23 to be shared
 3 among VC₁, VC₂ and VC₃ and is updated at step 401 for each successive
 4 arrival of a BRM cell according to the following equation:

$$5 \quad FS_{n+1} = k \cdot ACR_n + (1 - k) \cdot FS_n \quad (1)$$

6 where, k is a constant in the range between zero and 0.5 and n represents the
 7 time indicator. Flow proceeds to step 402 to compare the ACR value of the
 8 current BRM cell with the fair share FS. For practical purposes, equation (1)
 9 represents a weighted mean value of two or more preceding ACR values. If
 10 the ACR value of the current BRM cell is equal to or greater than FS, flow
 11 proceeds from step 402 to step 403 to update ACR by solving the equation

$$12 \quad ACR = \max (ACR/LOAD, FS) \quad (2)$$

13 by dividing ACR by the traffic load, comparing the quotient with FS and
 14 selecting the larger of the two as a new ACR value. The effect of step 403 is
 15 to ensure that the updated ACR value is not smaller than the fair share of
 16 the link capacity. If ACR is not greater than FS, flow branches at step 402
 17 to step 311, skipping step 403.

18 Assuming that the coefficient k is 0.5, the FS value is 40 Mbps at a
 19 given instant of time and BRM cells are successively received from VC₁,
 20 VC₂ and VC₃, steps 401, 403, 311 and 312 are repeatedly executed,
 21 yielding the following results:

22 Step 401-1: FS = 40 Mbps

23 Step 403-1: $ACR_1 = \max (50/1.33, 40)$ = 40 Mbps

24 Step 311-1: $ACR_1 = \min (40, 50)$ = 40 Mbps

25 Step 312-1: $ACR_1 = \max (40, 30)$ = 40 Mbps

26 Step 401-2: FS = 47.5 Mbps

27 Step 403-2: $ACR_2 = \max (50/1.25, 47.5)$ = 47.5 Mbps

28 Step 311-2: $ACR_2 = \min (47.5, 50)$ = 50 Mbps

29 Step 312-2: $ACR_2 = \max (50, 10)$ = 50 Mbps

30 Step 401-3: FS = 73.8 Mbps

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1 Step 403-3: $ACR_3 = \max(100/1.183, 73.8) = 84.53 \text{ Mbps}$

2 Step 311-3: $ACR_3 = \min(84.53, 50) = 50 \text{ Mbps}$

3 Step 312-3: $ACR_3 = \max(50, 60) = \underline{60 \text{ Mbps}}$

4 Therefore, $ACR_1 = 40 \text{ Mbps}$, $ACR_2 = 50 \text{ Mbps}$, $ACR_3 = 60 \text{ Mbps}$ are
 5 sequentially obtained with a total traffic rate of 150 Mbps which is equal to
 6 the link capacity. With the total ACR value being set equal to the link
 7 capacity, the arrival of subsequent BRM cells will cause the source user
 8 terminal to reset the LCI flag to zero at step 305, so that steps 401 to 403
 9 are skipped.

10 The embodiment of Fig. 4 is modified as shown in Figs. 5A and 5B.
 11 In this modification, steps 400 and 401 of Fig. 4 are replaced with step 500
 12 of Fig. 5B in which a common "fair share" (FS) value of the resource of link
 13 23 is obtained by dividing the effective link capacity $C (=150 \text{ Mbps})$ by the
 14 number of virtual channels $N (=3)$. The FS value is therefore equal to 50
 15 Mbps ($=150/3$). If BRM cells are successively received from VC_1 , VC_2 and
 16 VC_3 , steps 403, 312 and 313 are repeatedly executed, yielding the
 17 following results:

18 Step 403-1: $ACR_1 = \max(50/1.33, 50) = 50 \text{ Mbps}$

19 Step 311-1: $ACR_1 = \min(50, 50) = 50 \text{ Mbps}$

20 Step 312-1: $ACR_1 = \max(50, 30) = \underline{50 \text{ Mbps}}$

21 Step 403-2: $ACR_2 = \max(50/1.33, 50) = 50 \text{ Mbps}$

22 Step 311-2: $ACR_2 = \min(50, 50) = 50 \text{ Mbps}$

23 Step 312-2: $ACR_2 = \max(50, 10) = \underline{50 \text{ Mbps}}$

24 Step 403-3: $ACR_3 = \max(100/1.33, 50) = 75 \text{ Mbps}$

25 Step 311-3: $ACR_3 = \min(75, 50) = 50 \text{ Mbps}$

26 Step 312-3: $ACR_3 = \max(50, 60) = \underline{60 \text{ Mbps}}$

27 It is seen that the ACR_1 , ACR_2 , ACR_3 values are updated to 50
 28 Mbps, 50 Mbps and 60 Mbps, respectively. Although the total traffic rate
 29 exceeds the 150-Mbps limit of the user's access link 23, the amount of
 30 excess is such that no severe local congestion occurs.

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1 The fair share of link capacity can also be obtained by a subroutine
 2 which takes into account the minimum cell rate (MCR) value of each virtual
 3 channel. As shown in Fig. 5C, this is achieved by excluding those virtual
 4 channels whose MCR values are greater than the fair share value $FS = C/N$
 5 obtained at step 600 . At step 601, variables M and N_{MCR} are set equal to
 6 0, where M represents the total bandwidth of those virtual channels whose
 7 MCR values are greater than FS and N_{MCR} represents the number of such
 8 virtual channels. At step 602, the MCR value of each virtual channel is
 9 compared with FS . If the former is greater than the latter, flow proceeds
 10 from step 602 to step 603 to increment the variable M by an amount equal
 11 to the MCR value of that virtual channel. At step 604, the variable N_{MCR} is
 12 incremented by 1. If MCR is not greater than FS at step 602, flow
 13 proceeds to step 605 to repeat steps 602 to 604 for the remaining virtual
 14 channels. When steps 602 to 604 are performed on all virtual channels, flow
 15 proceeds from step 605 to 606 to update FS by calculating the equation $(C$
 16 $- M)/(N - N_{MCR})$ and setting the quotient as FS . Therefore, the fair share
 17 value FS is equal to $(150 - 60)/(3 - 1) = 40$ Mbps.

18 If BRM cells are successively received from VC_1 , VC_2 and VC_3 ,
 19 steps 403, 312 and 313 are repeatedly executed, yielding the following
 20 results which gives a total traffic rate of 140 Mbps:

21 Step 403-1: $ACR_1 = \max(50/1.33, 40) = 40$ Mbps
 22 Step 311-1: $ACR_1 = \min(40, 50) = 40$ Mbps
 23 Step 312-1: $ACR_1 = \max(40, 30) = \underline{40}$ Mbps
 24 Step 403-2: $ACR_2 = \max(50/1.267, 40) = 40$ Mbps
 25 Step 311-2: $ACR_2 = \min(40, 50) = 40$ Mbps
 26 Step 312-2: $ACR_2 = \max(40, 10) = \underline{40}$ Mbps
 27 Step 403-3: $ACR_3 = \max(100/1.2, 40) = 83.3$ Mbps
 28 Step 311-3: $ACR_3 = \min(83.3, 50) = 50$ Mbps
 29 Step 312-3: $ACR_3 = \max(50, 60) = \underline{60}$ Mbps

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What is claimed is:

- 1 1. A method for controlling the traffic of a source end system
2 connected by an access link to an ATM network, wherein the source end
3 system is connected through a plurality of virtual channels to destination
4 end systems to exchange resource management (RM) cells at periodic
5 intervals and to transmit data cells at allowed cell rates (ACRs) respectively
6 set for the virtual channels, said access link having a predetermined link
7 capacity, the method comprising the steps of:
 - 8 a) transmitting a forward RM cell through an associated virtual
9 channel;
 - 10 b) determining a sum of ACR values of said virtual channels in
11 response to receipt of a backward RM cell through the associated virtual
12 channel and comparing the sum of ACR values with the predetermined link
13 capacity; and
 - 14 c) resetting a current ACR value of the associated virtual channel
15 equal to a lower-than-previous value when said sum of ACR values is in
16 excess of said predetermined link capacity.
- 1 2. A method as claimed in claim 1, wherein the step (c) comprises
2 the steps of:
 - 3 producing a link load value representing said sum of ACR values
4 divided by said predetermined link capacity; and
 - 5 resetting said ACR value to the lower-than-previous value according
6 to said link load value.
- 1 3. A method as claimed in claim 1, wherein said lower-than-
2 previous value is equal to a previous ACR value of the associated virtual
3 channel divided by the link load value.
- 1 4. A method as claimed in claim 1, wherein the step (c) comprises

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2 the steps of:
3 producing a link load value representing said sum of ACR values
4 divided by said predetermined link capacity;
5 producing a fair share value representing a weighted mean of ACR
6 values of virtual channels through which backward RM cells are successively
7 received;
8 comparing the current ACR value of the associated virtual channel
9 with the fair share value;
10 dividing said current ACR value by said link load value if the
11 current ACR value is greater than said fair share value;
12 comparing the divided ACR value with said fair share value; and
13 resetting the current ACR value equal to the divided ACR value if
14 the divided ACR value is greater than the fair share value and resetting the
15 current ACR value equal to the fair share value if the fair share value is
16 greater than the divided ACR value.

1 5. A method as claimed in claim 4, wherein said fair share value is
2 derived from the relation $k \cdot Y + (1 - k)X$, where X represents a weighted
3 mean value of ACR values which was derived in response to receipt of a
4 previous backward RM cell, Y represents said current ACR value and k
5 represents a constant smaller than unity.

1 6. A method as claimed in claim 1, wherein the step (c) comprises
2 the steps of:
3 producing a link load value representing said sum of ACR values
4 divided by said predetermined link capacity;
5 producing a fair share value representing said link capacity divided
6 by the number of said virtual channels;
7 comparing the current ACR value of the associated virtual channel
8 with the fair share value;
9 dividing said current ACR value by said link load value if the

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10 current ACR value is greater than the fair share value;
 11 comparing the divided ACR value with the fair share value; and
 12 resetting said current ACR value equal to the divided ACR value if
 13 the divided ACR value is greater than the fair share value and resetting said
 14 current ACR value equal to the fair share value if the fair share value is
 15 greater than the divided ACR value.

1 7. A method as claimed in claim 1, wherein each of said virtual
 2 channels has a minimum cell rate (MCR), wherein the step (c) comprises the
 3 steps of:
 4 dividing said link capacity by the number of said virtual channels;
 5 producing a fair share value representing the relation $(C - M)/N -$
 6 N_{MCR} , where C is the predetermined link capacity, M is a total of MCR
 7 values of ones of said virtual channels which are greater than said divided
 8 link capacity, N is the number of all of said virtual channels and N_{MCR} is
 9 the number of said ones of virtual channels;
 10 comparing the current ACR value of the associated virtual channel
 11 with the fair share value;
 12 dividing said current ACR value by said link load if said current
 13 ACR value is greater than the fair share value;
 14 comparing the divided ACR value with the fair share value; and
 15 resetting said current ACR value equal to the fair share value if the
 16 fair share value is greater than the divided ACR value and resetting said
 17 current ACR value equal to the divided ACR value if the divided ACR
 18 value is greater than the fair share value.

1 8. A method as claimed in claim 1, wherein said access link is
 2 shared by a virtual channel having a service class higher than service classes of
 3 said virtual channels, and wherein said predetermined link capacity is an
 4 effective link capacity equal to a maximum link capacity of said access link
 5 minus a bandwidth of said virtual channel of higher service class.

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1 9. A method as claimed in any one of claims 1 to 8, wherein said
2 backward RM cell contains an explicit rate (ER) value inserted by said ATM
3 network, and each of said virtual channels has a minimum cell rate (MCR),
4 wherein the step (c) further comprises the steps of:
5 comparing the reset ACR value with said ER value;
6 selecting the reset ACR value if the reset ACR value is smaller than
7 said ER value and selecting the ER value if the ER value is smaller than the
8 reset ACR value, as an updated ACR value;
9 comparing the updated ACR value with an MCR value of said
10 associated virtual channel; and
11 selecting the updated ACR value if the updated ACR value is
12 smaller than said MCR value and selecting the MCR value if the MCR
13 value is smaller than the updated ACR value, as a new ACR value for said
14 associated virtual channel.

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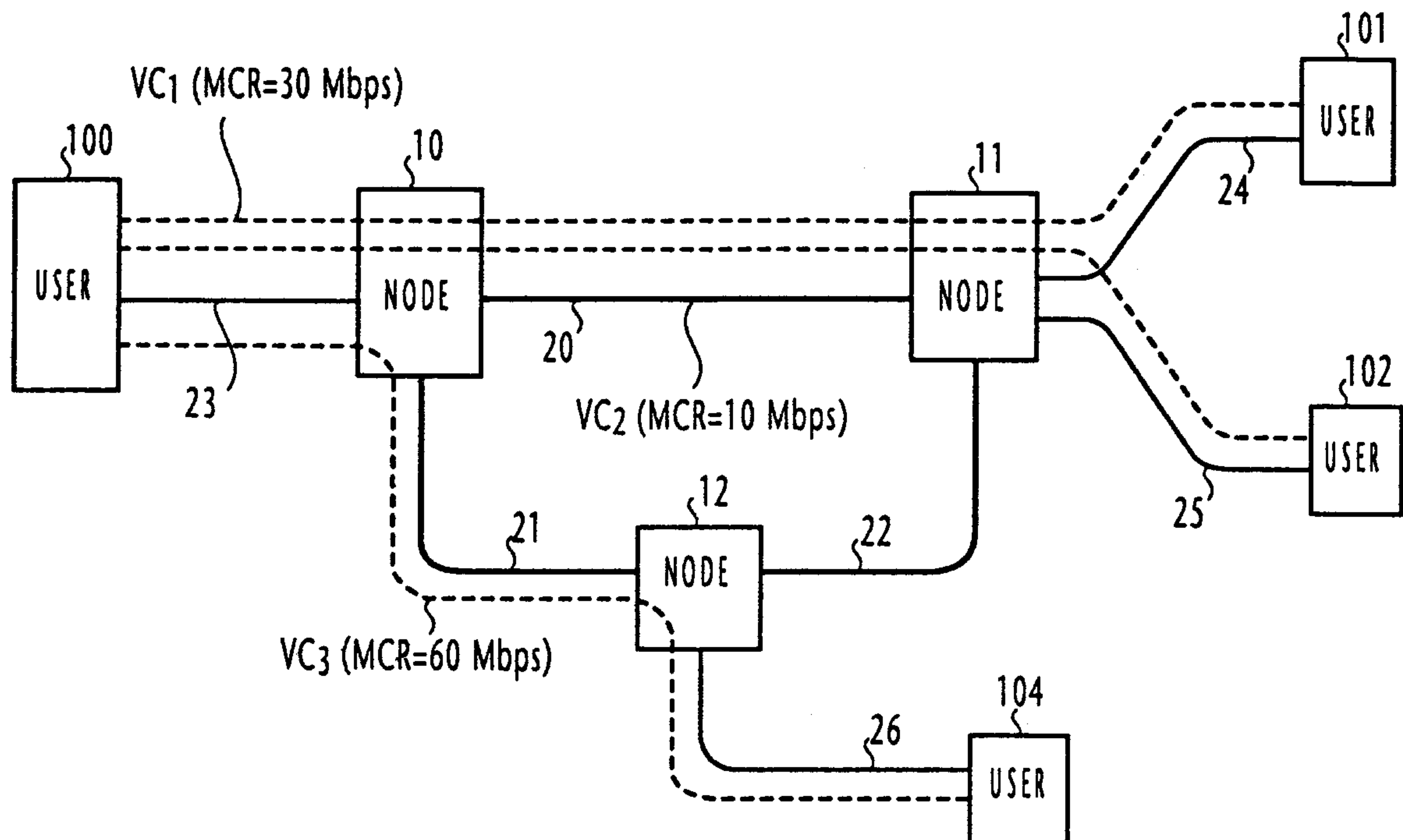
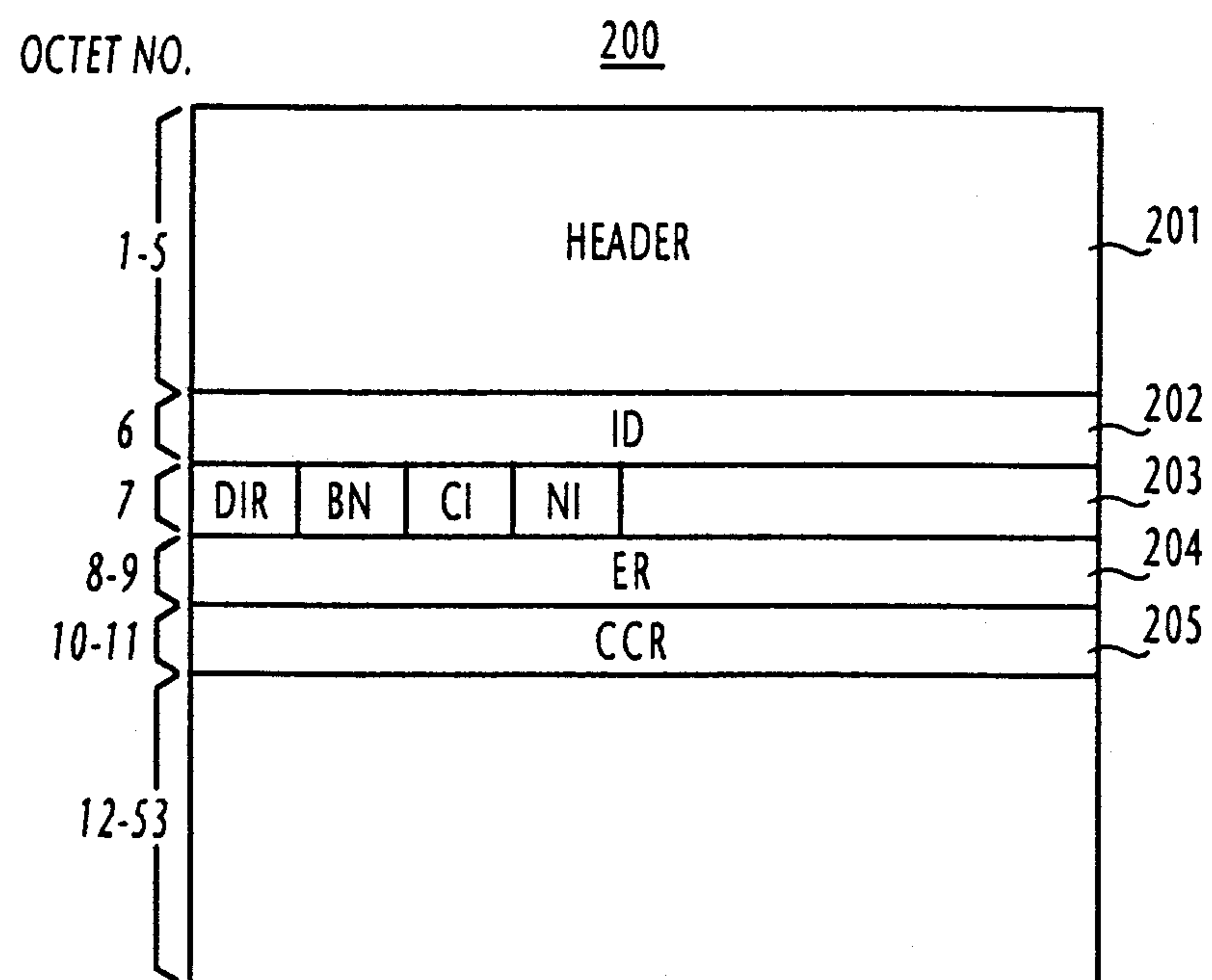
FIG. 1**FIG. 2**

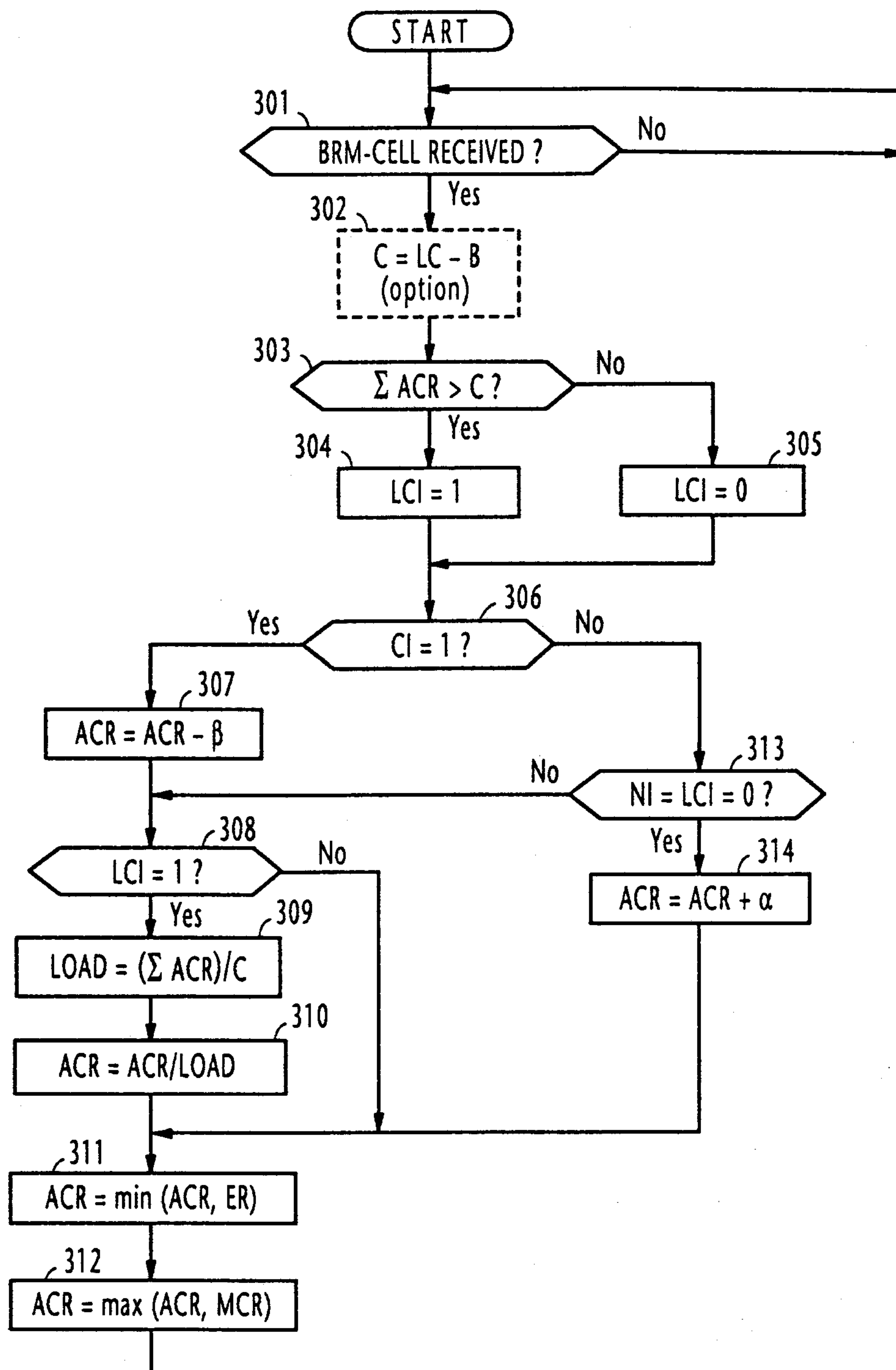
FIG. 3

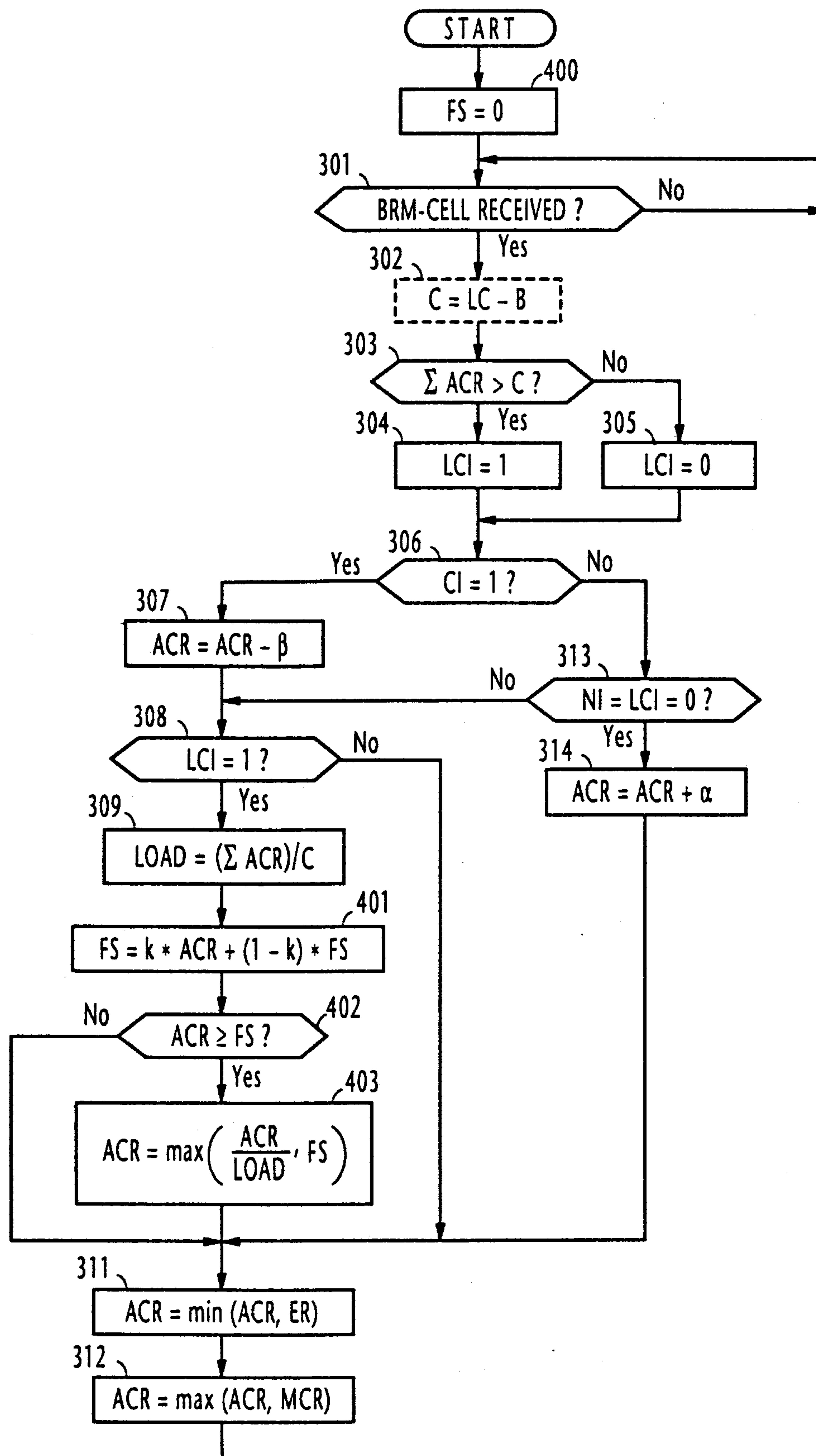
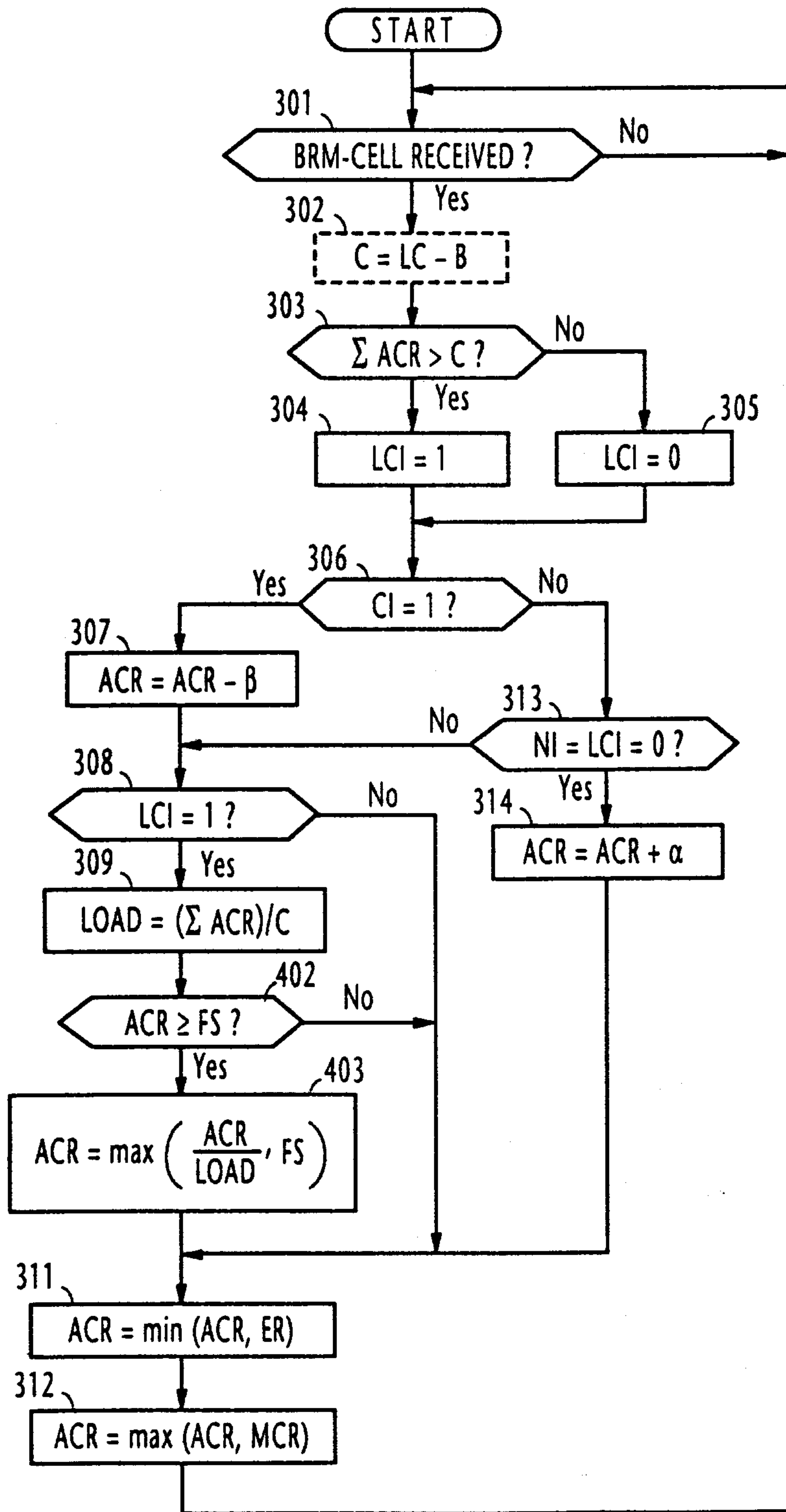
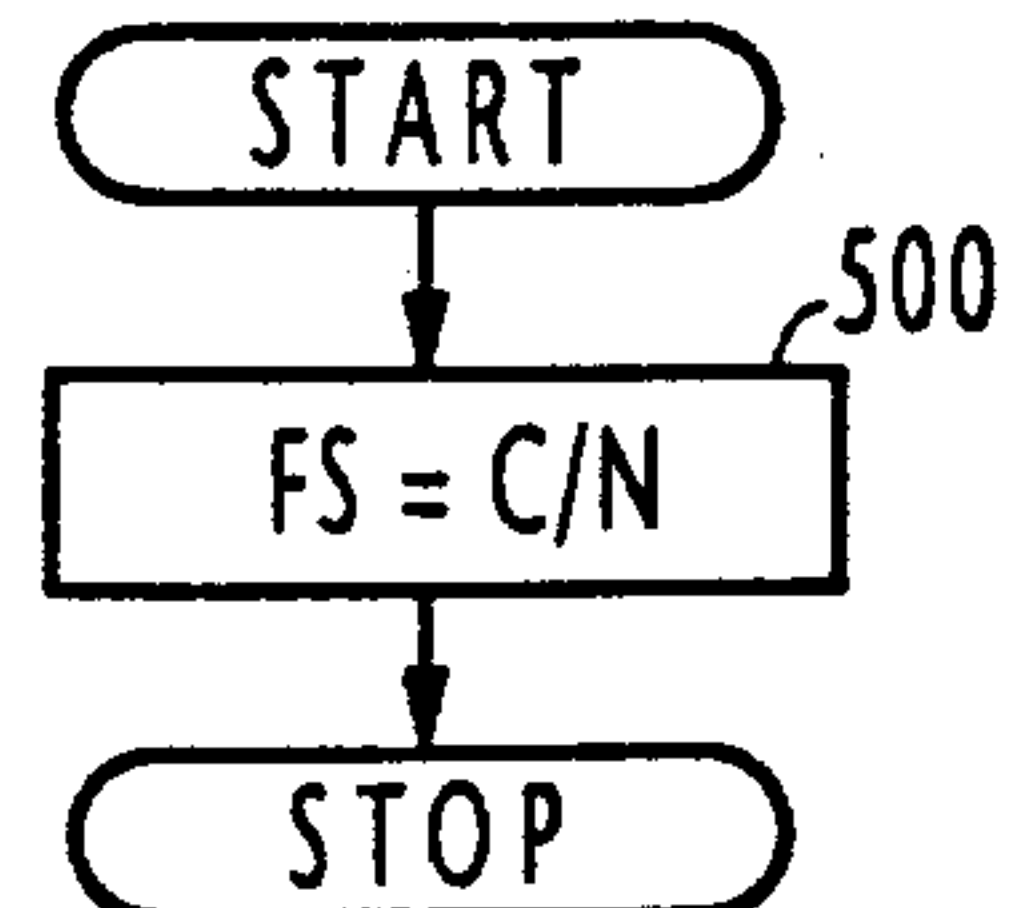
FIG. 4

FIG. 5A**FIG. 5B****FIG. 5C**