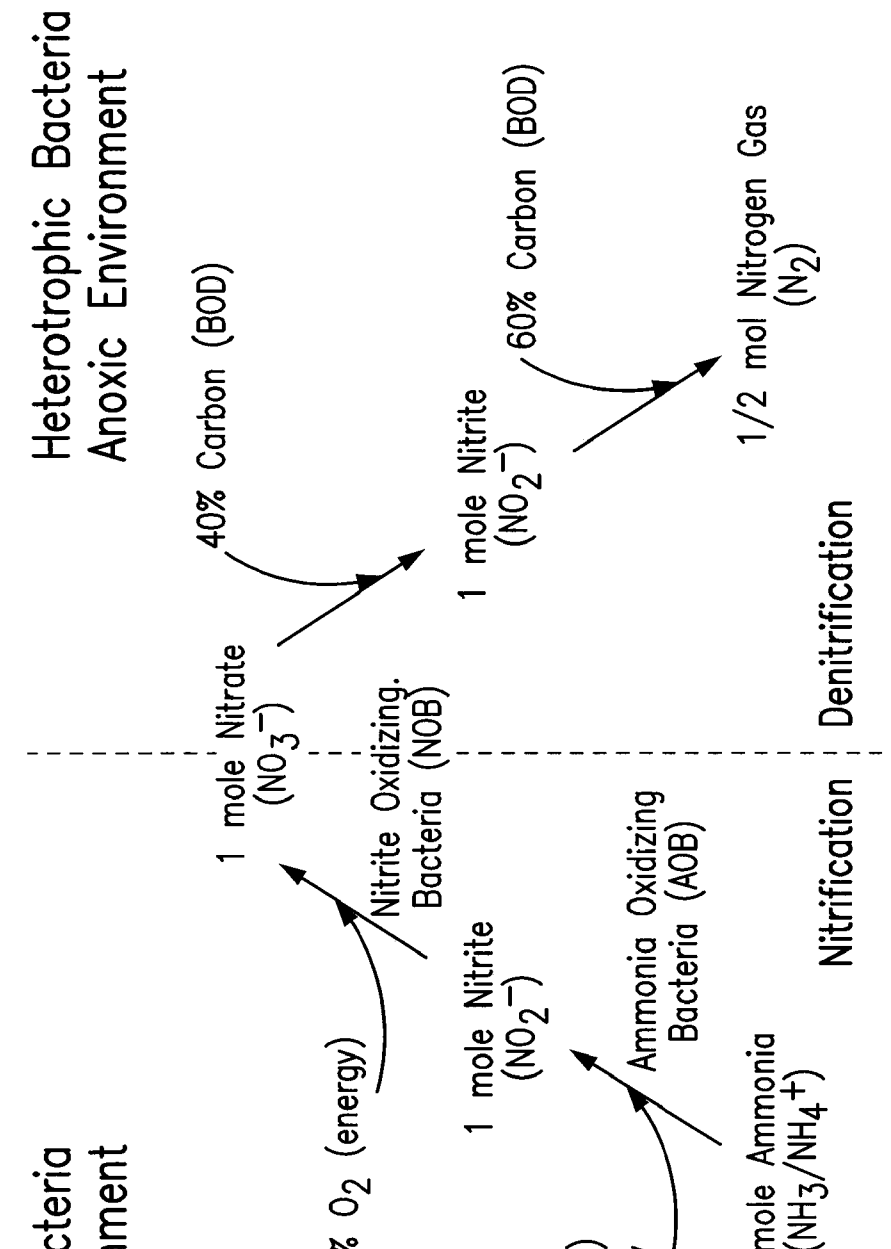
Autotrophic Bacteria
Aerobic Environment
Heterotrophic Bacteria
Anoxic Environment
75% O_2 (energy)
~100% Alkalinity
1 mole Ammonia
(NH_3/NH_4^+)
Ammonia Oxidizing
Bacteria (AOB)
1 mole Nitrite
(NO_2^-)
25% O_2 (energy)
Nitrite Oxidizing.
Bacteria (NOB)
1 mole Nitrate
(NO_3^-)
40% Carbon (BOD)
Nitrification
1 mole Nitrite
(NO_2^-)
60% Carbon (BOD)
1/2 mol Nitrogen Gas
(N_2)
Denitrification

FIG. 1

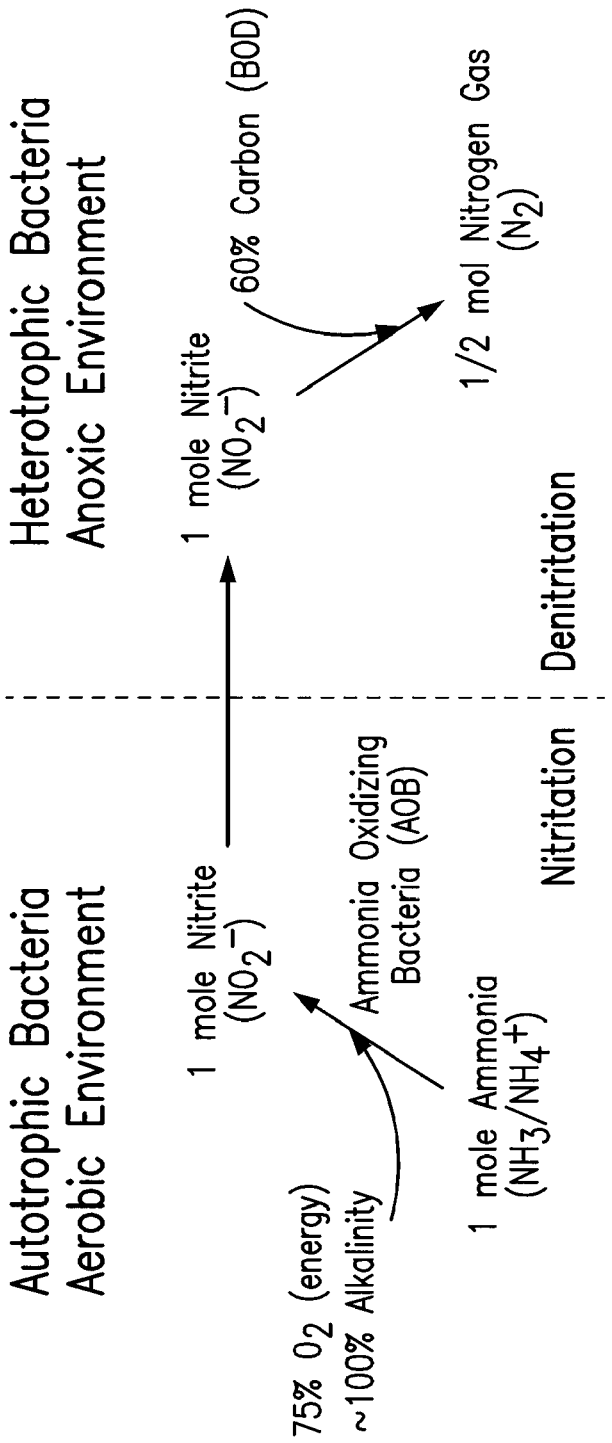
Autotrophic Bacteria
Aerobic Environment
Heterotrophic Bacteria
Anoxic Environment
1 mole Nitrite
(NO_2^-)
60% Carbon (BOD)
1/2 mol Nitrogen Gas
(N_2)
1 mole Nitrite
(NO_2^-)
Ammonia Oxidizing
Bacteria (AOB)
75% O_2 (energy)
~100% Alkalinity
1 mole Ammonia
(NH_3/NH_4^+)
Nitritation
Denitritation

FIG. 2

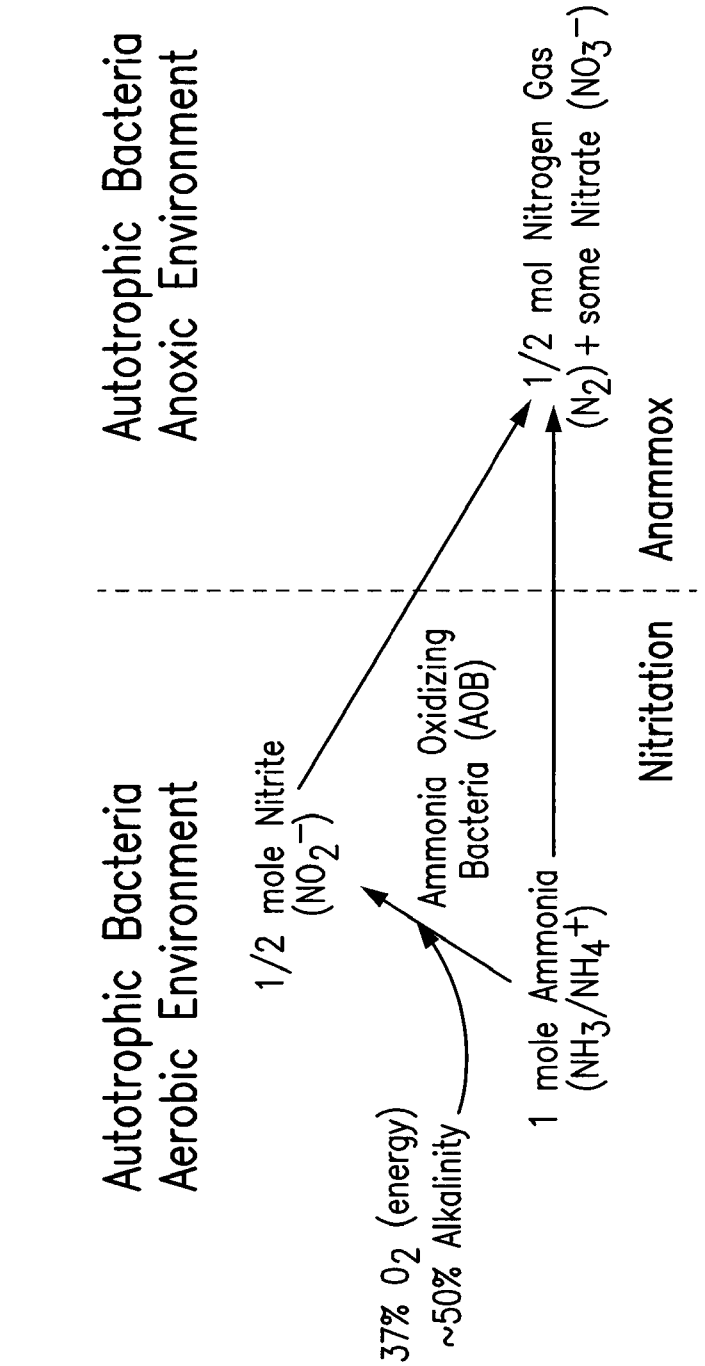
Autotrophic Bacteria
Aerobic Environment
Autotrophic Bacteria
Anoxic Environment
1/2 mole Nitrite
(NO_2^-)
Ammonia Oxidizing
Bacteria (AOB)
1/2 mol Nitrogen Gas
(N_2) + some Nitrate (NO_3^-)
37% O_2 (energy)
~50% Alkalinity
1 mole Ammonia
(NH_3/NH_4^+)
Nitritation
Anammox

FIG. 3

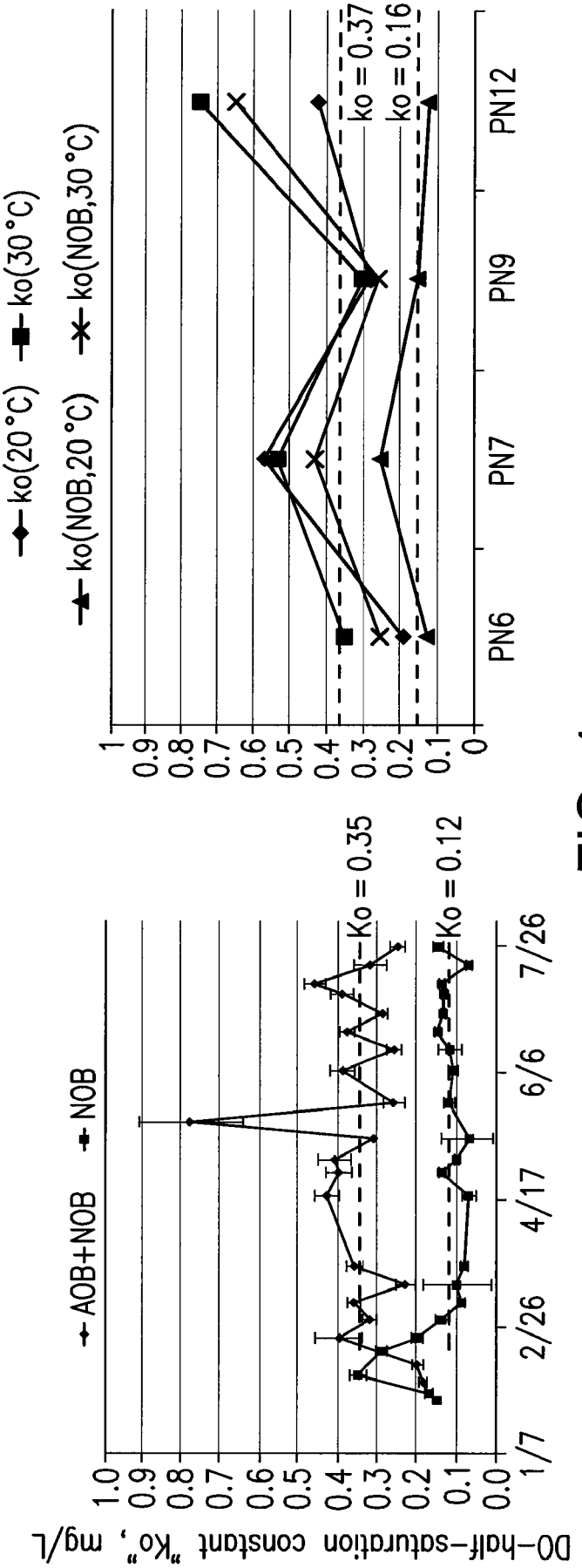
ko(20°C)
ko(30°C)
ko(NOB,20°C)
ko(NOB,30°C)
ko = 0.37
ko = 0.16
PN6
PN7
PN9
PN12
AOB+NOB
NOB
Ko = 0.35
Ko = 0.12
1/7
2/26
4/17
6/6
7/26
DO-half-saturation constant "Ko", mg/L

FIG. 4

	AOB–growth Monod	NOB–growth Monod
$\mu_{max} * X_a / Y_a$	193	137
k_o [mg DO/L]	0.40	0.06

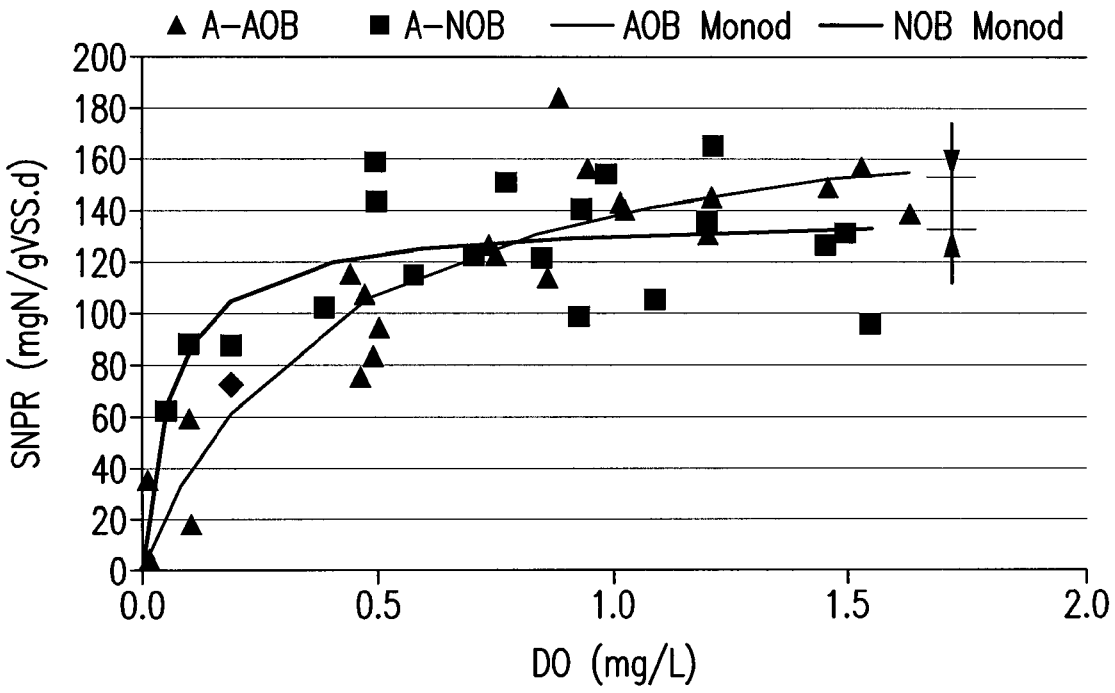

FIG. 5

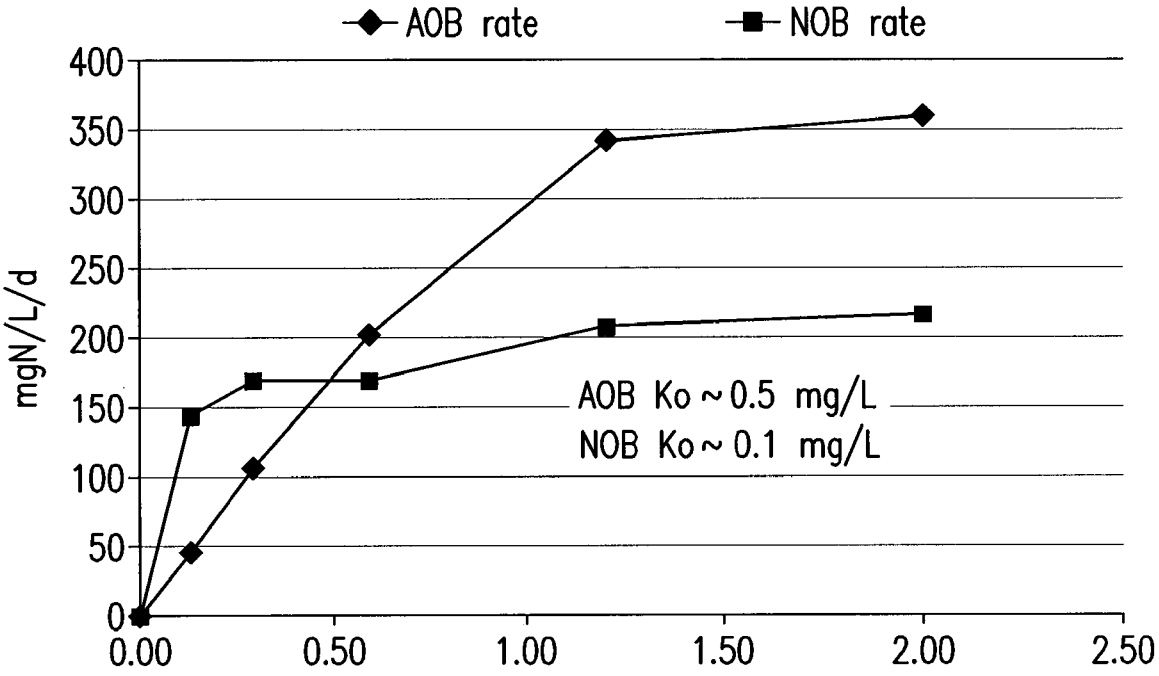

FIG. 6

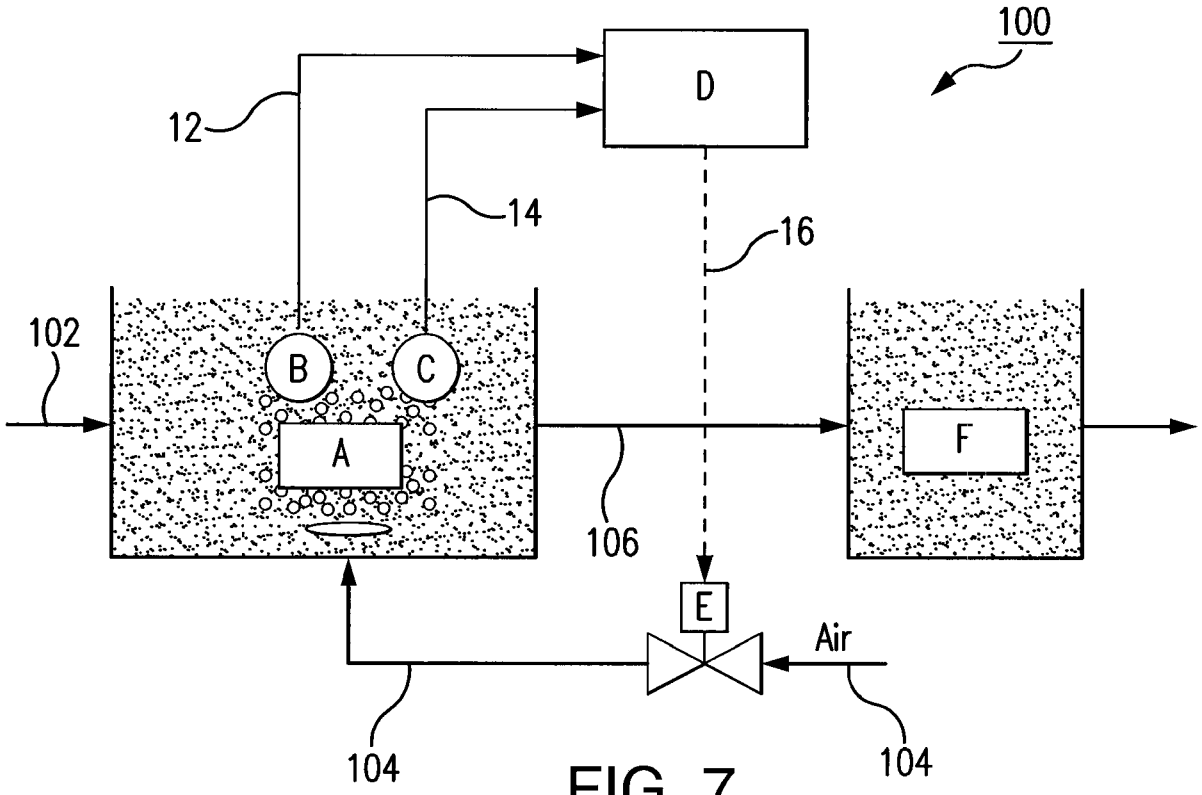
100
D
12
14
16
102
B
C
A
F
106
E
Air
104
104

FIG. 7

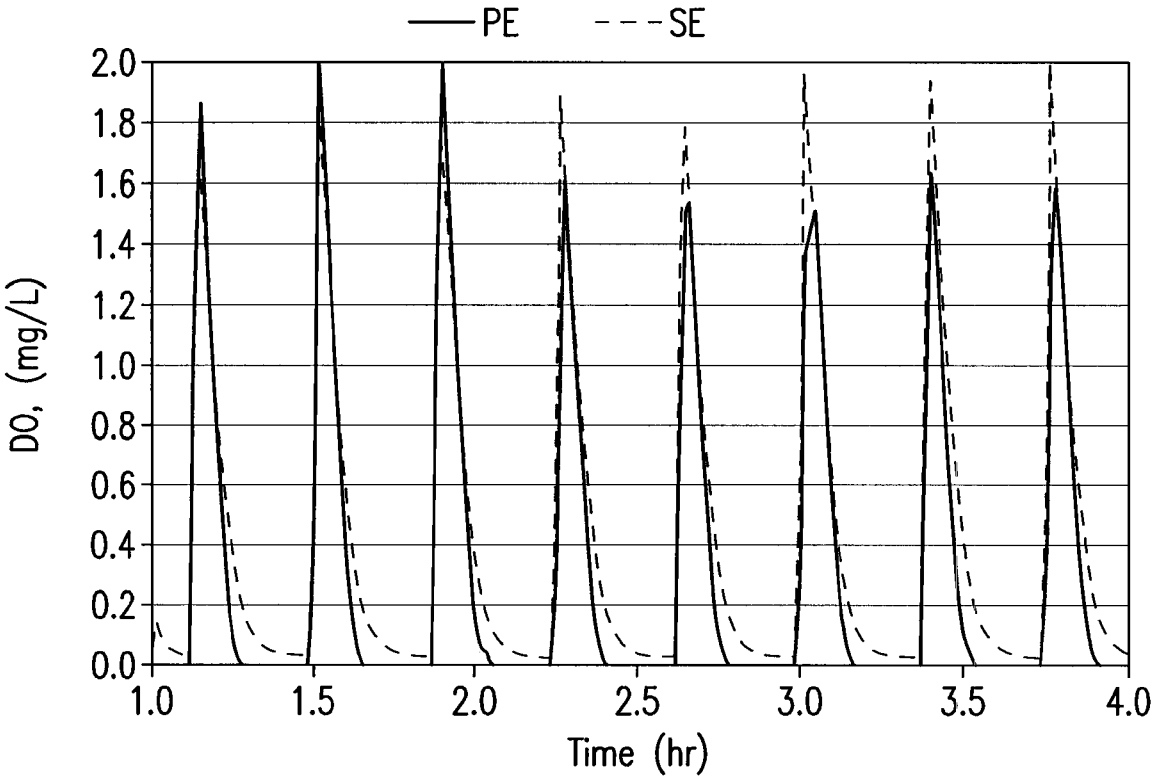
PE
SE
DO, (mg/L)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Time (hr)

FIG. 8

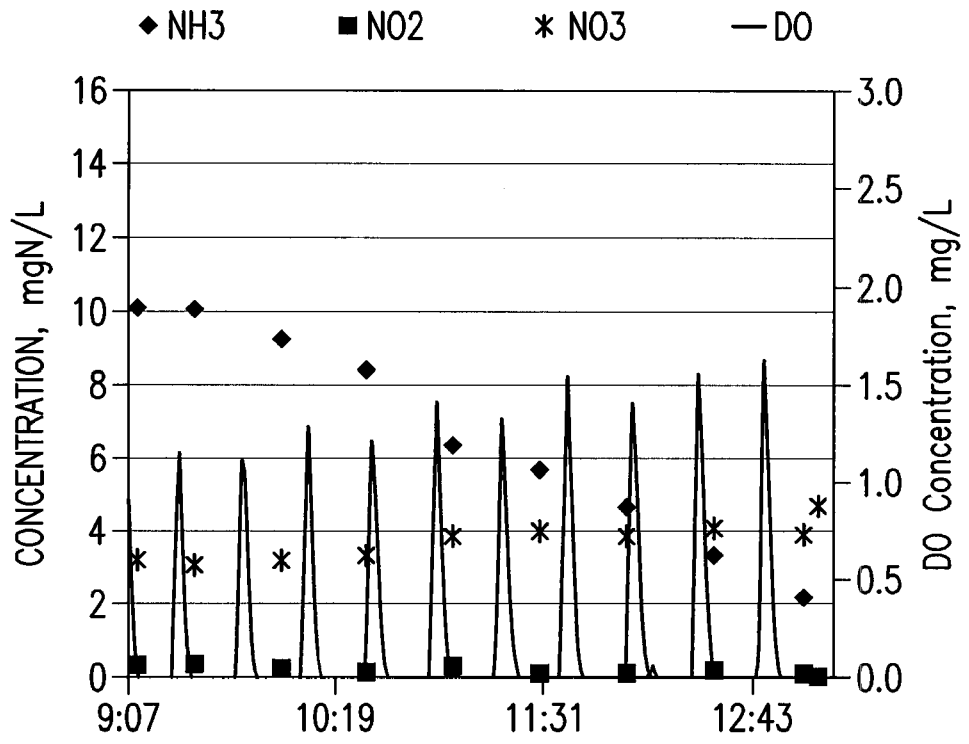
◆ NH3
■ NO2
* NO3
— DO
CONCENTRATION, mgN/L
DO Concentration, mg/L
16
14
12
10
8
6
4
2
0
3.0
2.5
2.0
1.5
1.0
0.5
0.0
9:07
10:19
11:31
12:43

FIG. 9

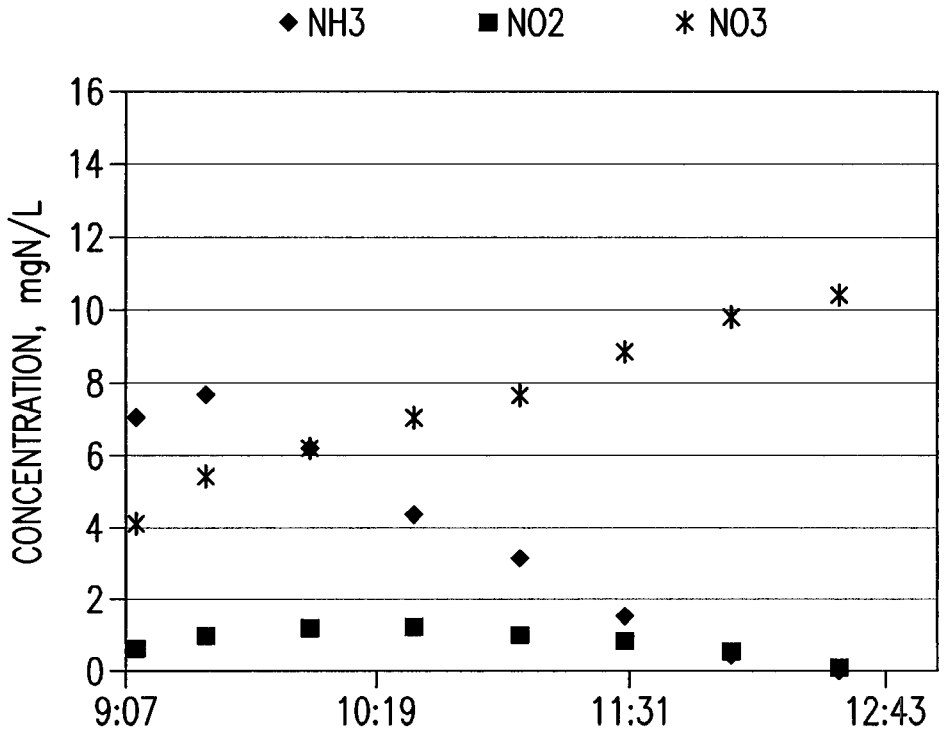
◆ NH3
■ NO2
* NO3
CONCENTRATION, mgN/L
16
14
12
10
8
6
4
2
0
9:07
10:19
11:31
12:43

FIG. 10

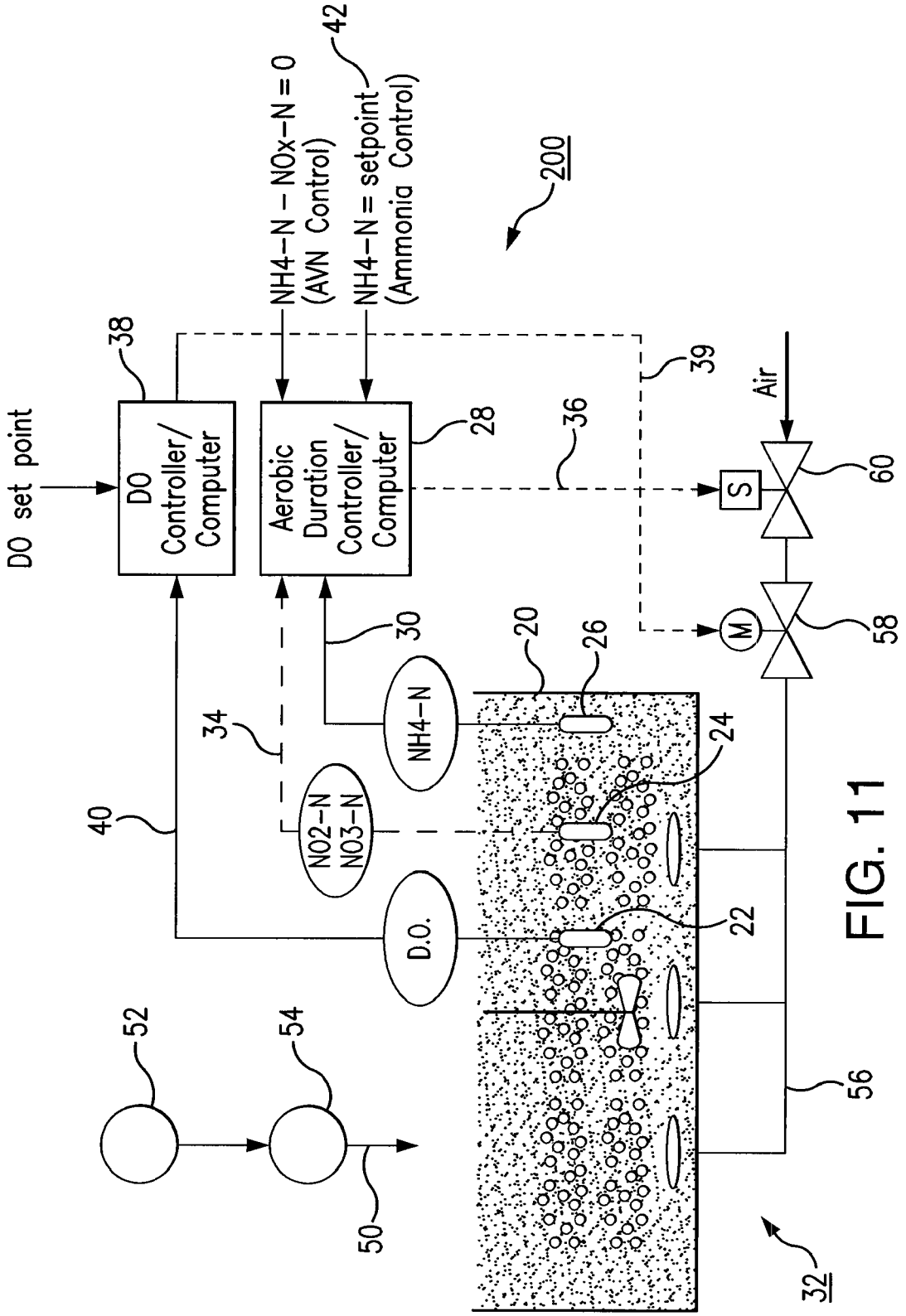
200
DO set point
38
DO Controller/ Computer
NH4–N – NOx–N = 0 (AVN Control)
NH4–N = setpoint (Ammonia Control)
42
Aerobic Duration Controller/ Computer
28
36
39
Air
S
60
M
58
30
20
26
NH4–N
34
NO2–N NO3–N
24
40
D.O.
22
52
54
50
56
32

FIG. 11

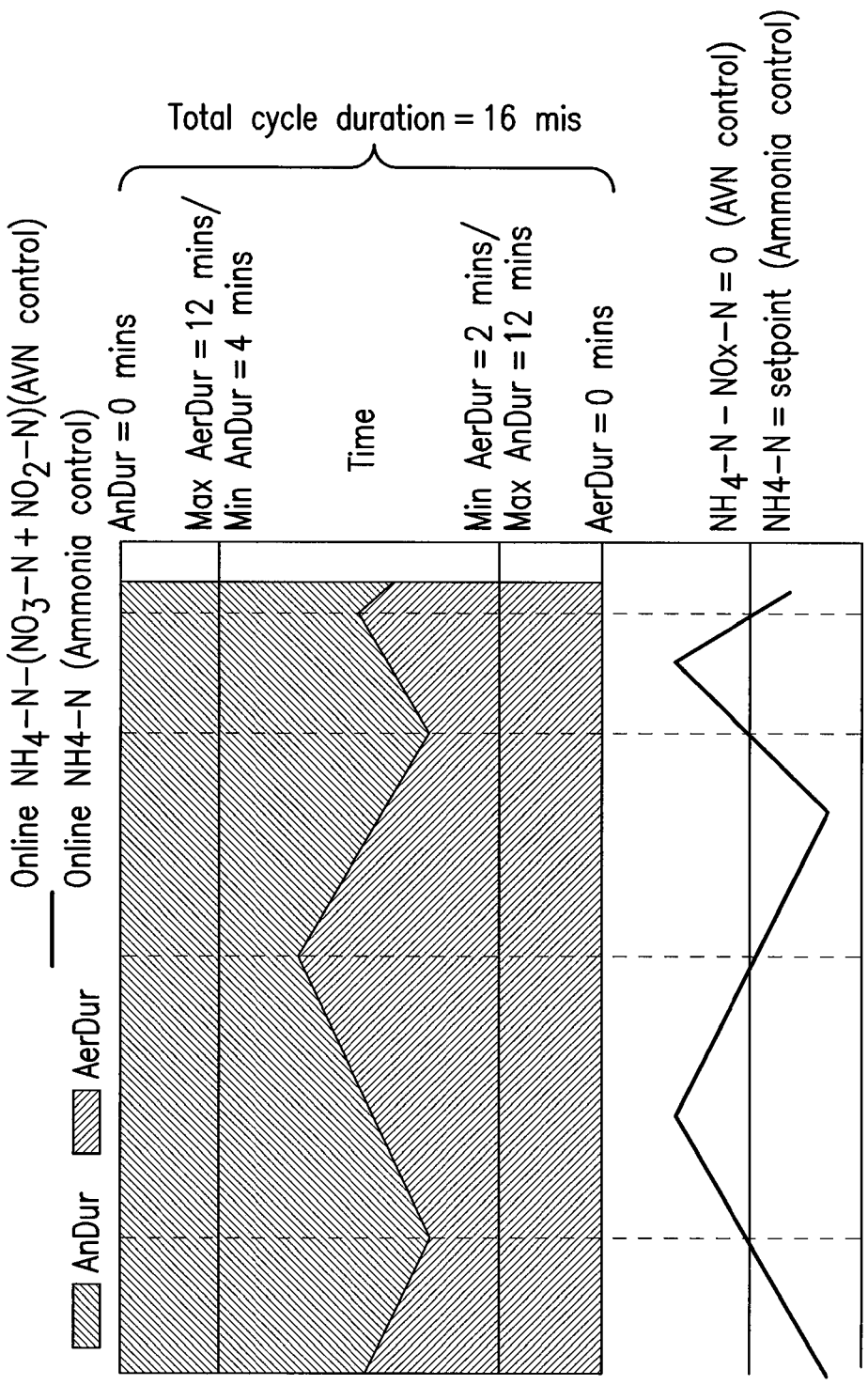
Online NH_4–N–(NO_3–N + NO_2–N)(AVN control)
Online NH4–N (Ammonia control)
AnDur
AerDur
Total cycle duration = 16 mis
AnDur = 0 mins
Max AerDur = 12 mins/
Min AnDur = 4 mins
Time
Min AerDur = 2 mins/
Max AnDur = 12 mins
AerDur = 0 mins
NH_4–N – NOx–N = 0 (AVN control)
NH4–N = setpoint (Ammonia control)
Time scale representing reactions
in nitrite–shunt reactor

FIG. 12

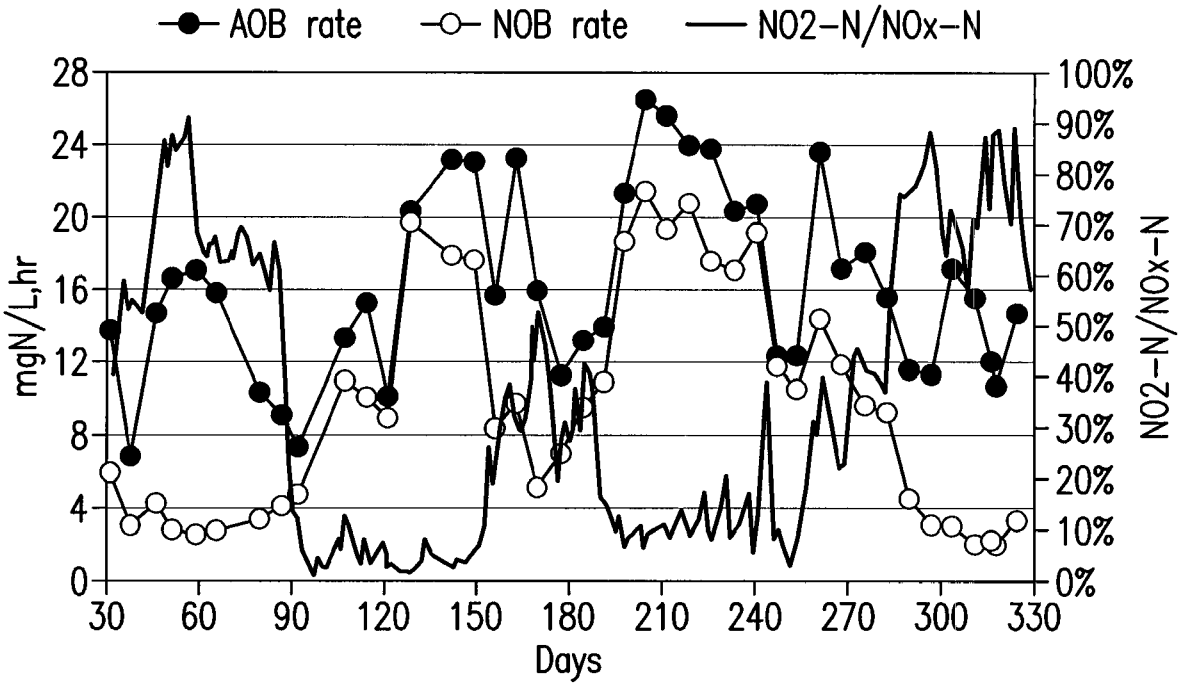
AOB rate
NOB rate
NO2-N/NOx-N
mgN/L,hr
NO2-N/NOx-N
Days
28
24
20
16
12
8
4
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
30
60
90
120
150
180
210
240
270
300
330

FIG. 13

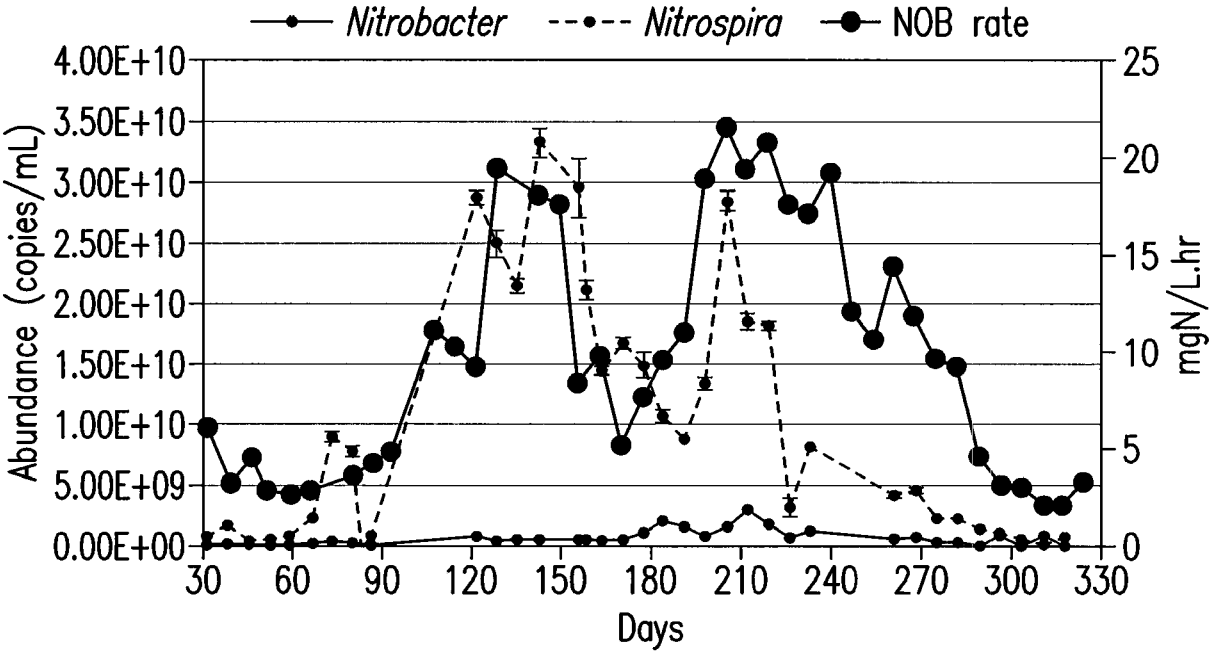
Nitrobacter
Nitrospira
NOB rate
Abundance (copies/mL)
mgN/L.hr
Days
4.00E+10
3.50E+10
3.00E+10
2.50E+10
2.00E+10
1.50E+10
1.00E+10
5.00E+09
0.00E+00
25
20
15
10
5
0
30
60
90
120
150
180
210
240
270
300
330

FIG. 14

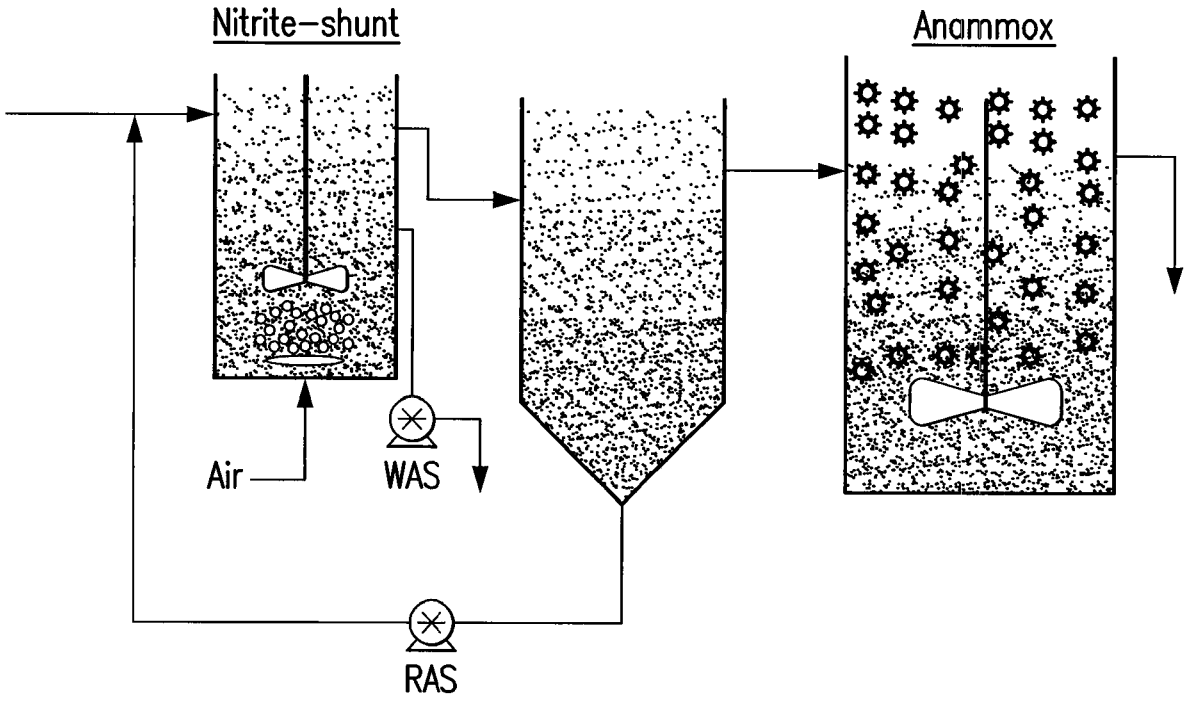
Nitrite-shunt
Anammox
Air
WAS
RAS

FIG. 15

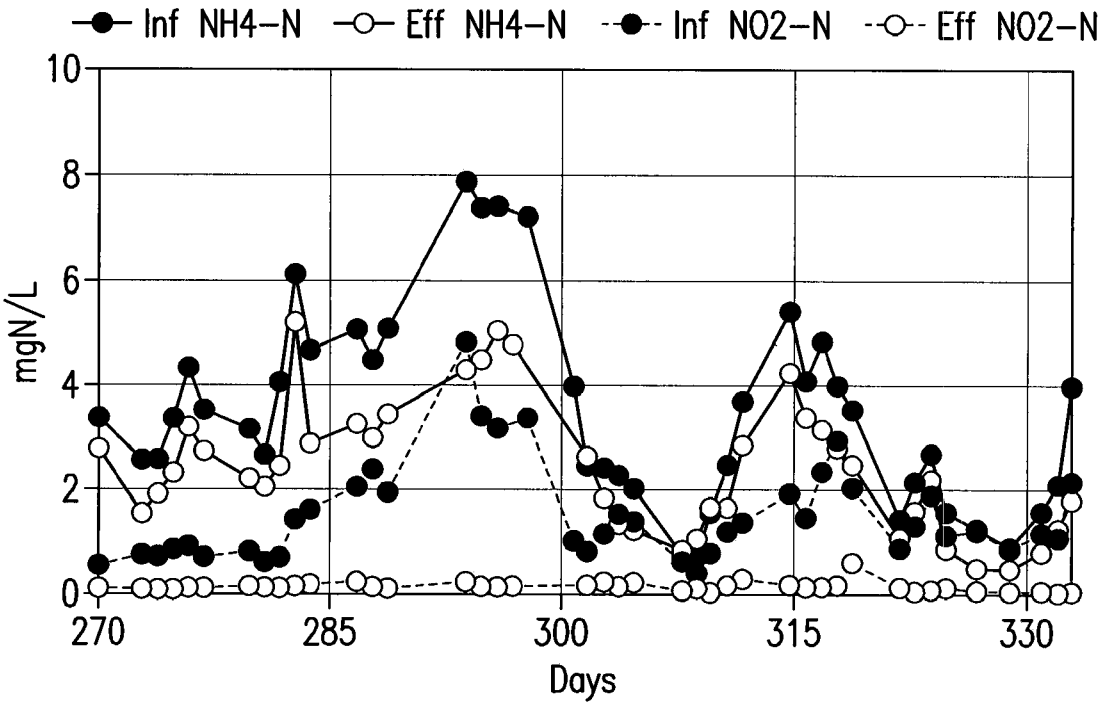
Inf NH4-N
Eff NH4-N
Inf NO2-N
Eff NO2-N
mgN/L
10
8
6
4
2
0
270
285
300
315
330
Days

FIG. 16