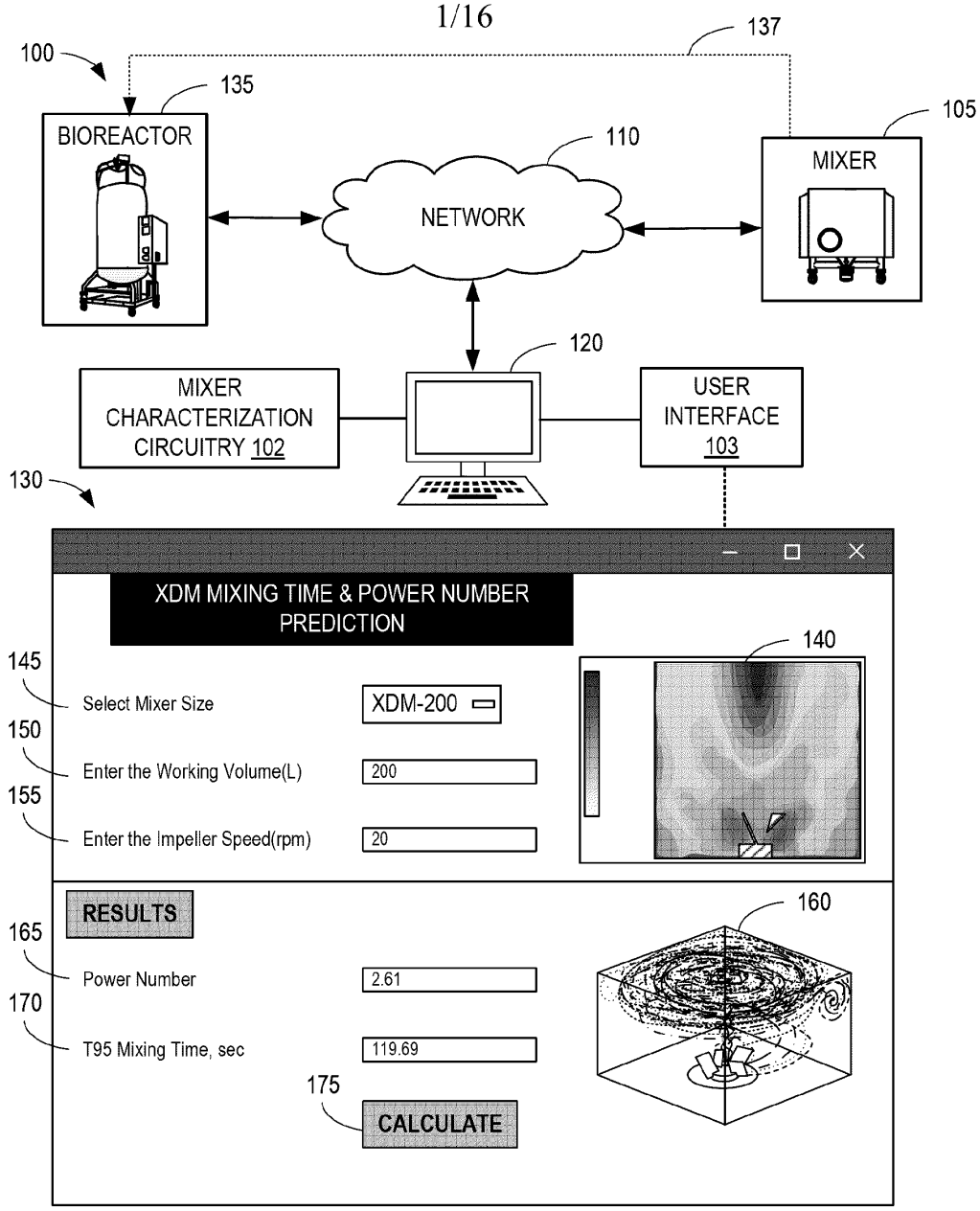

100
135
137
105
BIOREACTOR
110
NETWORK
MIXER
120
MIXER CHARACTERIZATION CIRCUITRY 102
USER INTERFACE 103
130
XDM MIXING TIME & POWER NUMBER PREDICTION
140
145
Select Mixer Size
XDM-200
150
Enter the Working Volume(L)
200
155
Enter the Impeller Speed(rpm)
20
RESULTS
160
165
Power Number
2.61
170
T95 Mixing Time, sec
119.69
175
CALCULATE

FIG. 1

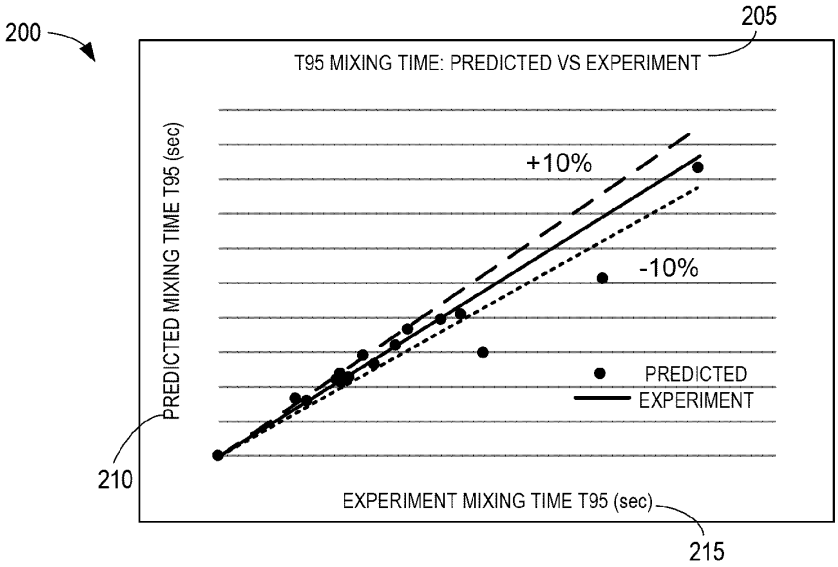

200
205
T95 MIXING TIME: PREDICTED VS EXPERIMENT
PREDICTED MIXING TIME T95 (sec)
+10%
-10%
PREDICTED
EXPERIMENT
210
EXPERIMENT MIXING TIME T95 (sec)
215

FIG. 2

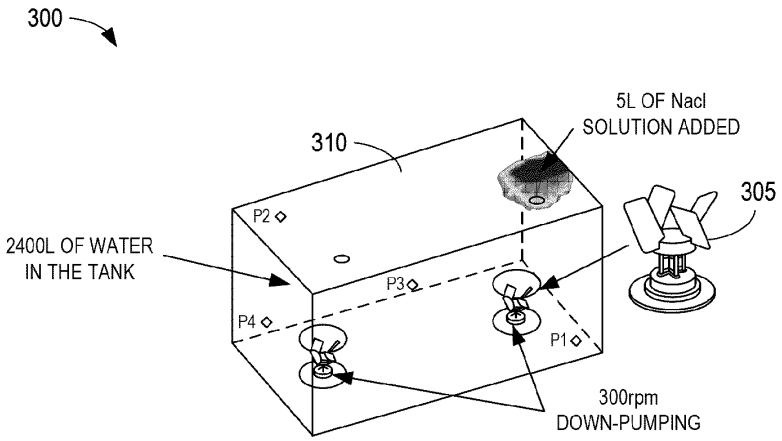

300
5L OF Nacl
SOLUTION ADDED
310
305
P2
2400L OF WATER
IN THE TANK
P3
P4
P1
300rpm
DOWN-PUMPING

FIG. 3

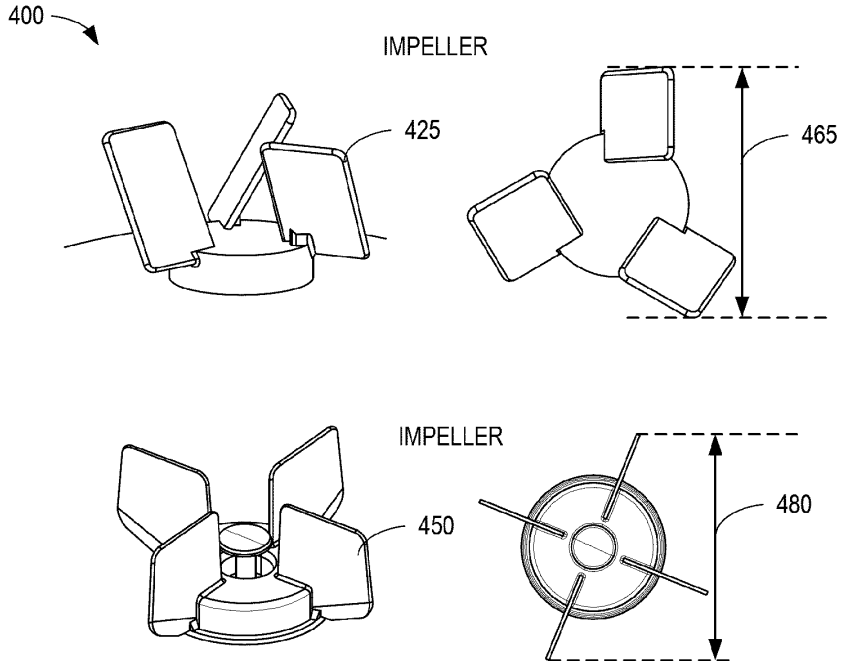

400
IMPELLER
425
465
IMPELLER
450
480

FIG. 4

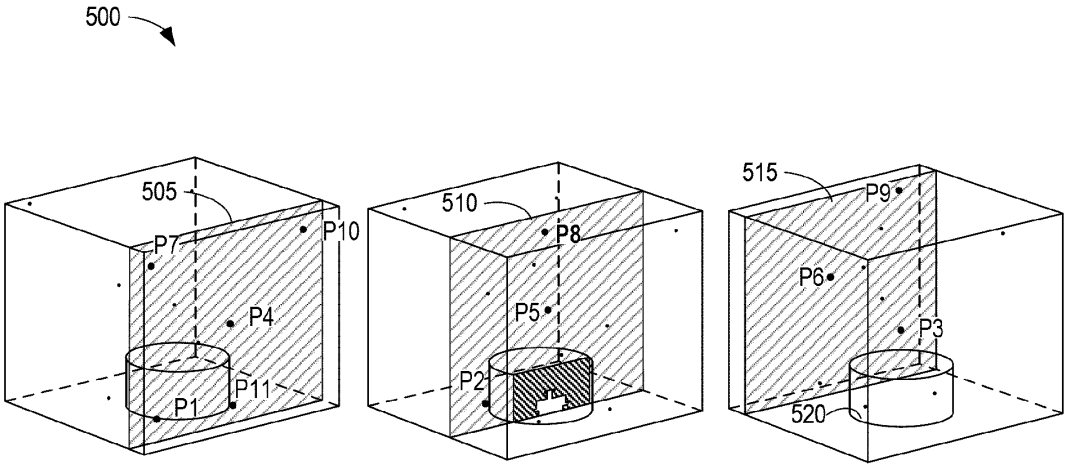

500
505
P7
P10
P4
P11
P1
510
P8
P5
P2
515
P9
P6
P3
520

FIG. 5

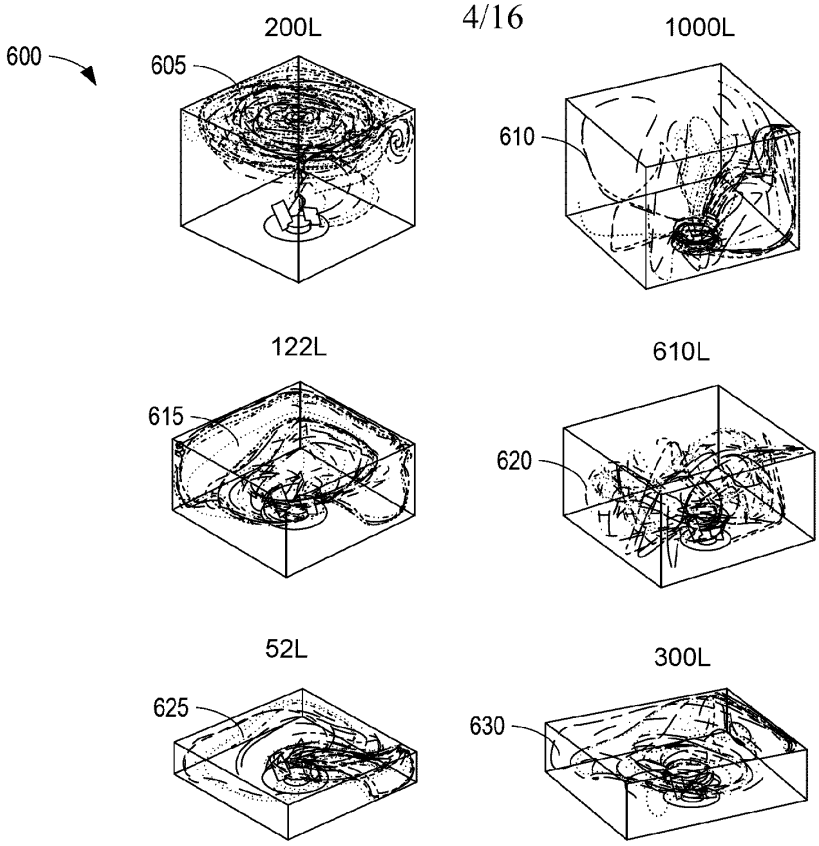

600
200L
605
1000L
610
122L
615
610L
620
52L
625
300L
630

FIG. 6

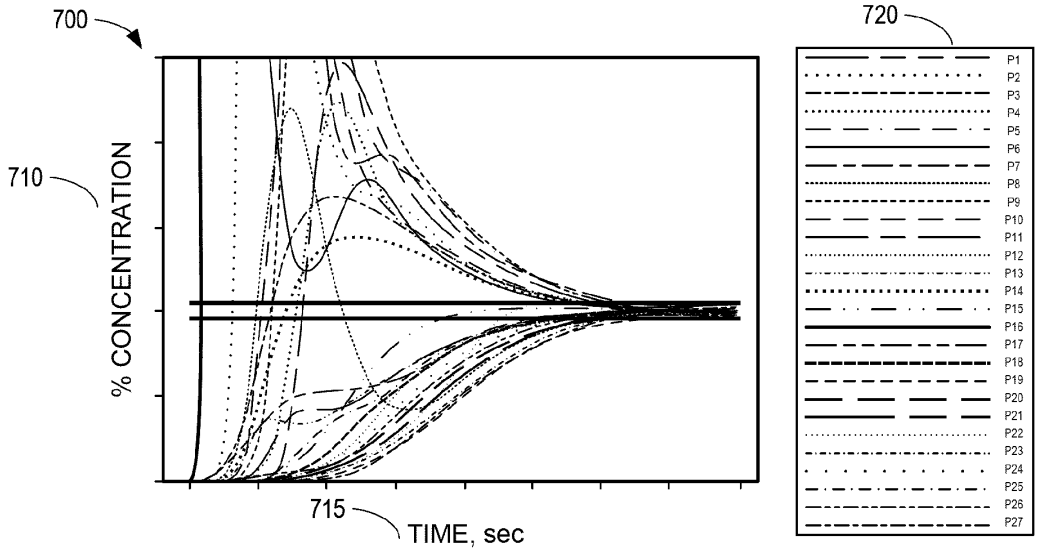
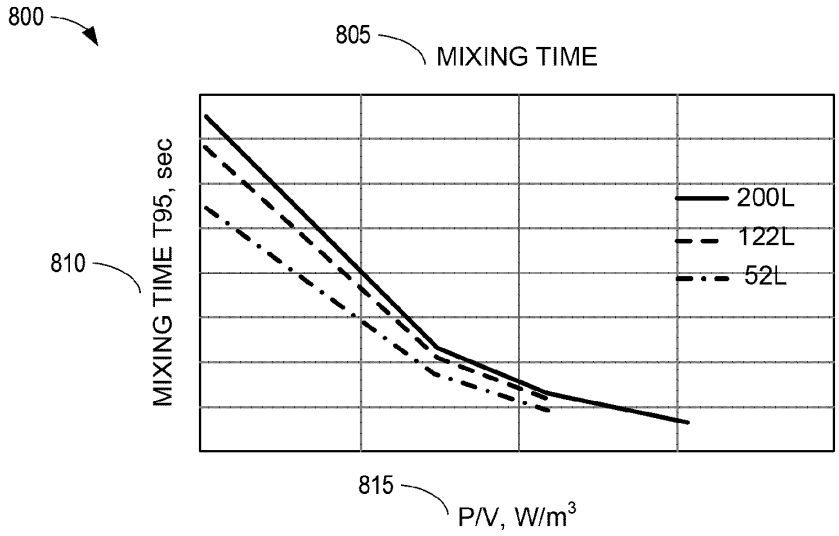

700
710
% CONCENTRATION
715
TIME, sec
720
P1
P2
P3
P4
P5
P6
P7
P8
P9
P10
P11
P12
P13
P14
P15
P16
P17
P18
P19
P20
P21
P22
P23
P24
P25
P26
P27

FIG. 7


800
805
MIXING TIME
MIXING TIME T95, sec
810
200L
122L
52L
815
P/V, W/m3

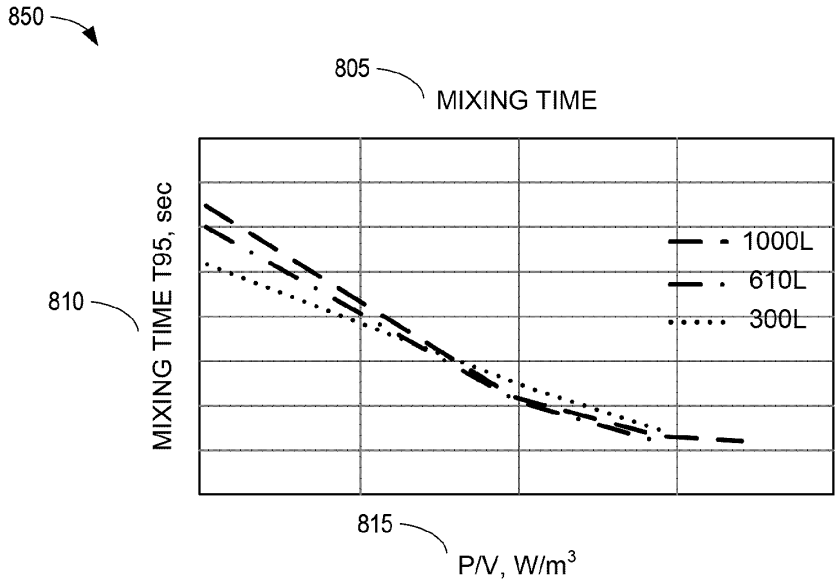

850
805
MIXING TIME
MIXING TIME T95, sec
810
1000L
610L
300L
815
P/V, W/m3

FIG. 8

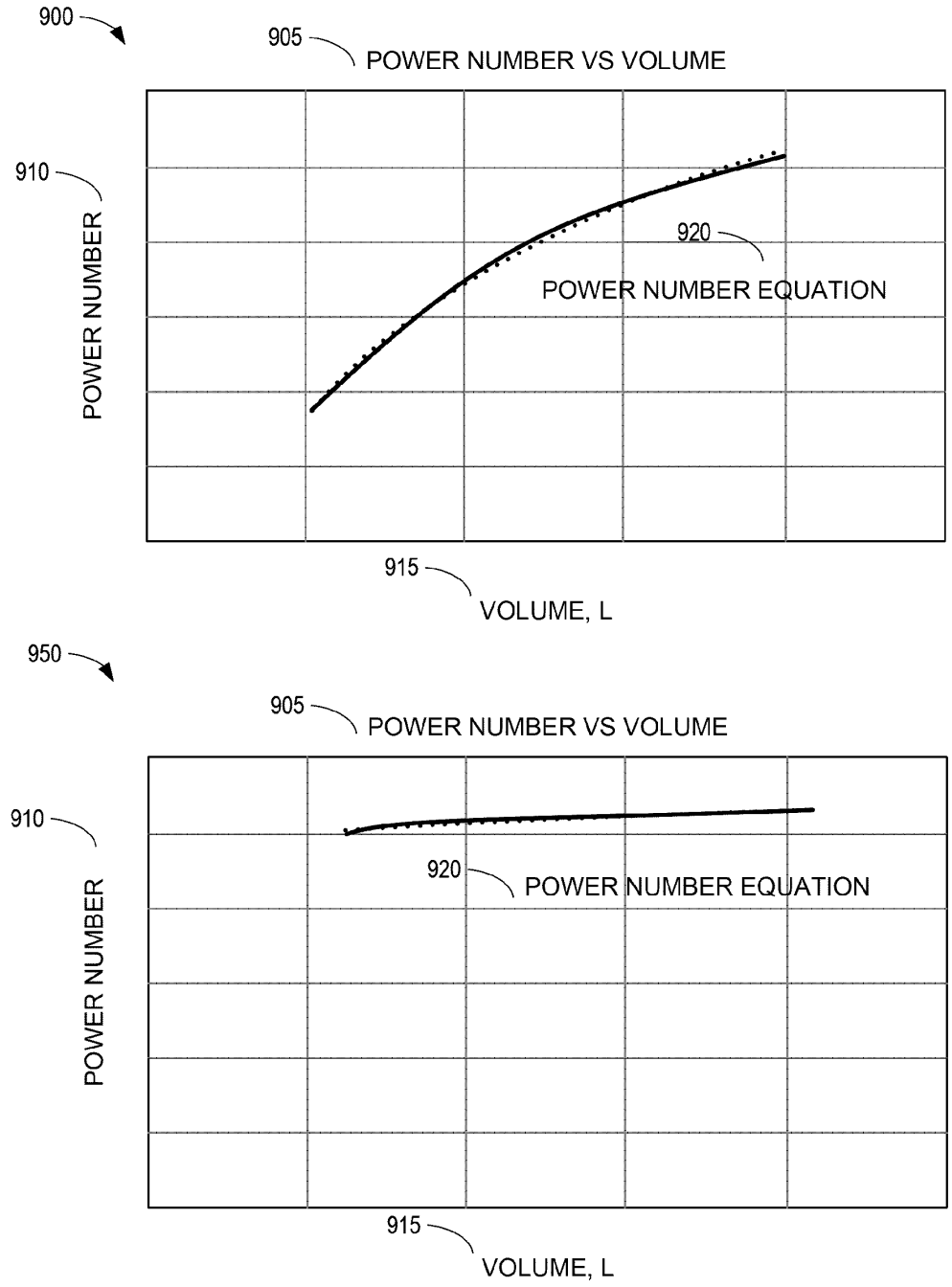

900
905
POWER NUMBER VS VOLUME
910
POWER NUMBER
920
POWER NUMBER EQUATION
915
VOLUME, L
950
905
POWER NUMBER VS VOLUME
910
POWER NUMBER
920
POWER NUMBER EQUATION
915
VOLUME, L

FIG. 9

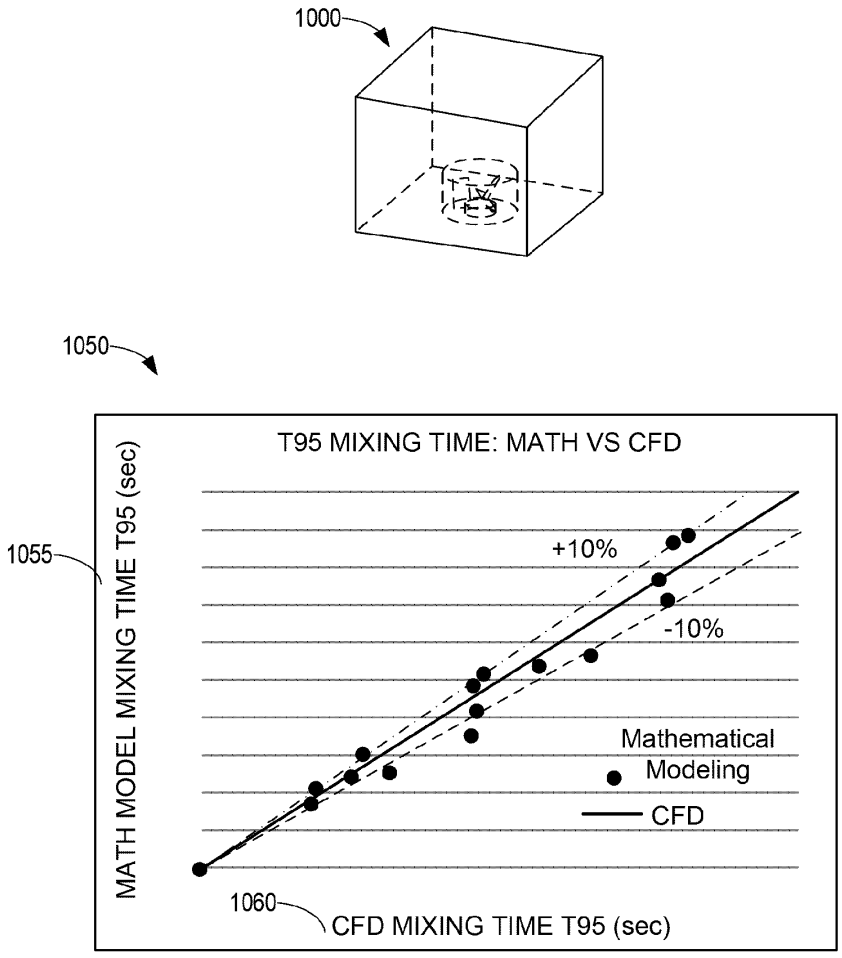

1000
1050
T95 MIXING TIME: MATH VS CFD
1055
MATH MODEL MIXING TIME T95 (sec)
+10%
-10%
Mathematical Modeling
CFD
1060
CFD MIXING TIME T95 (sec)

FIG. 10

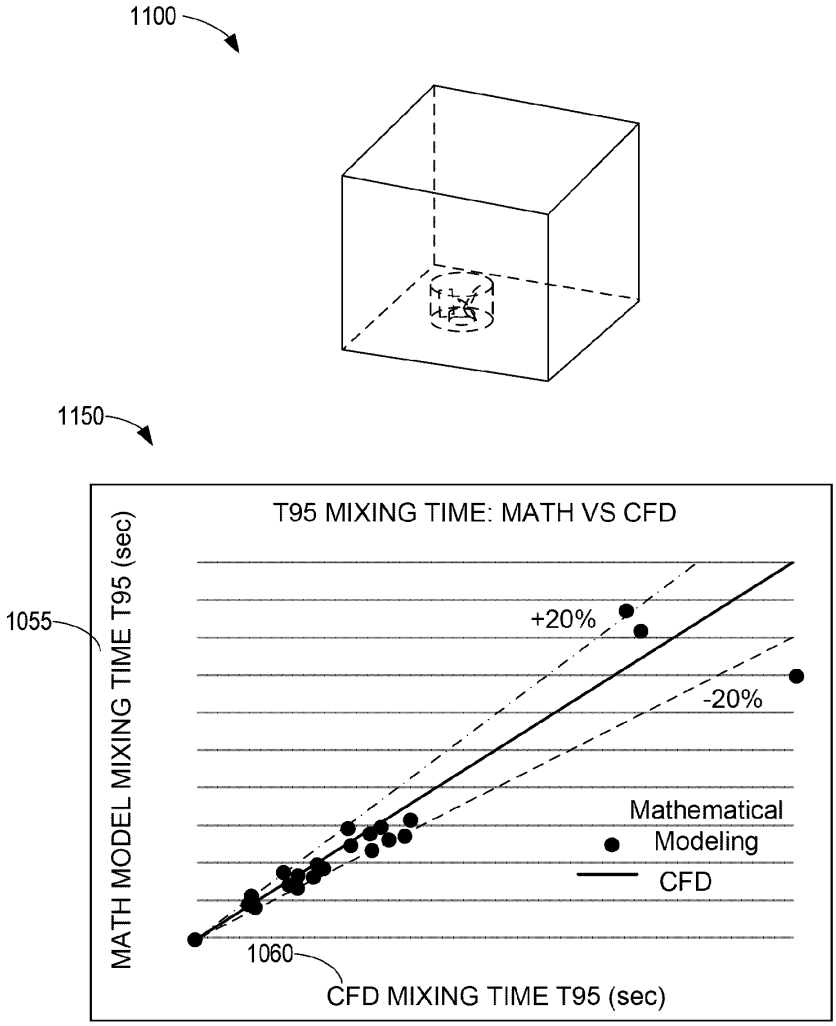

1100
1150
T95 MIXING TIME: MATH VS CFD
1055
MATH MODEL MIXING TIME T95 (sec)
+20%
-20%
Mathematical
Modeling
CFD
1060
CFD MIXING TIME T95 (sec)

FIG. 11

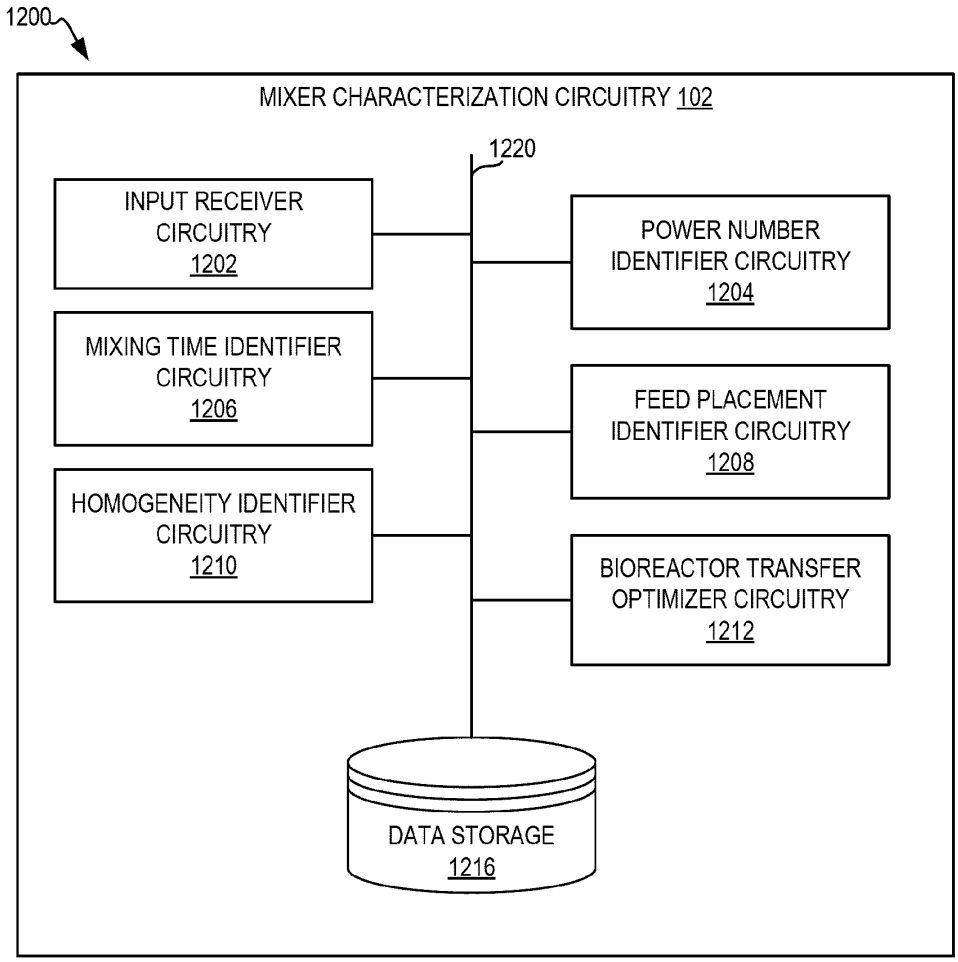

1200
MIXER CHARACTERIZATION CIRCUITRY 102
1220
INPUT RECEIVER CIRCUITRY 1202
MIXING TIME IDENTIFIER CIRCUITRY 1206
HOMOGENEITY IDENTIFIER CIRCUITRY 1210
POWER NUMBER IDENTIFIER CIRCUITRY 1204
FEED PLACEMENT IDENTIFIER CIRCUITRY 1208
BIOREACTOR TRANSFER OPTIMIZER CIRCUITRY 1212
DATA STORAGE 1216

FIG. 12

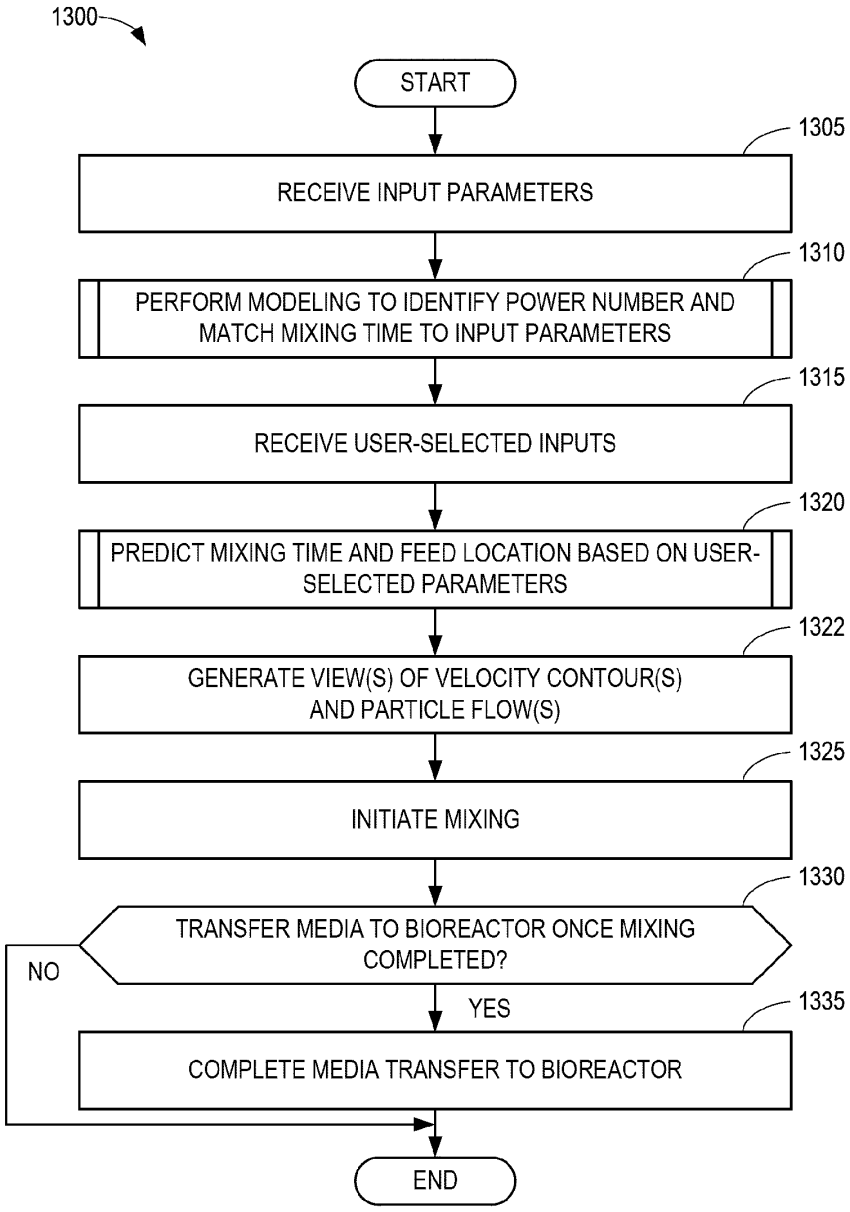

1300
START
1305
RECEIVE INPUT PARAMETERS
1310
PERFORM MODELING TO IDENTIFY POWER NUMBER AND MATCH MIXING TIME TO INPUT PARAMETERS
1315
RECEIVE USER-SELECTED INPUTS
1320
PREDICT MIXING TIME AND FEED LOCATION BASED ON USER-SELECTED PARAMETERS
1322
GENERATE VIEW(S) OF VELOCITY CONTOUR(S) AND PARTICLE FLOW(S)
1325
INITIATE MIXING
1330
TRANSFER MEDIA TO BIOREACTOR ONCE MIXING COMPLETED?
NO
YES
1335
COMPLETE MEDIA TRANSFER TO BIOREACTOR
END

FIG. 13

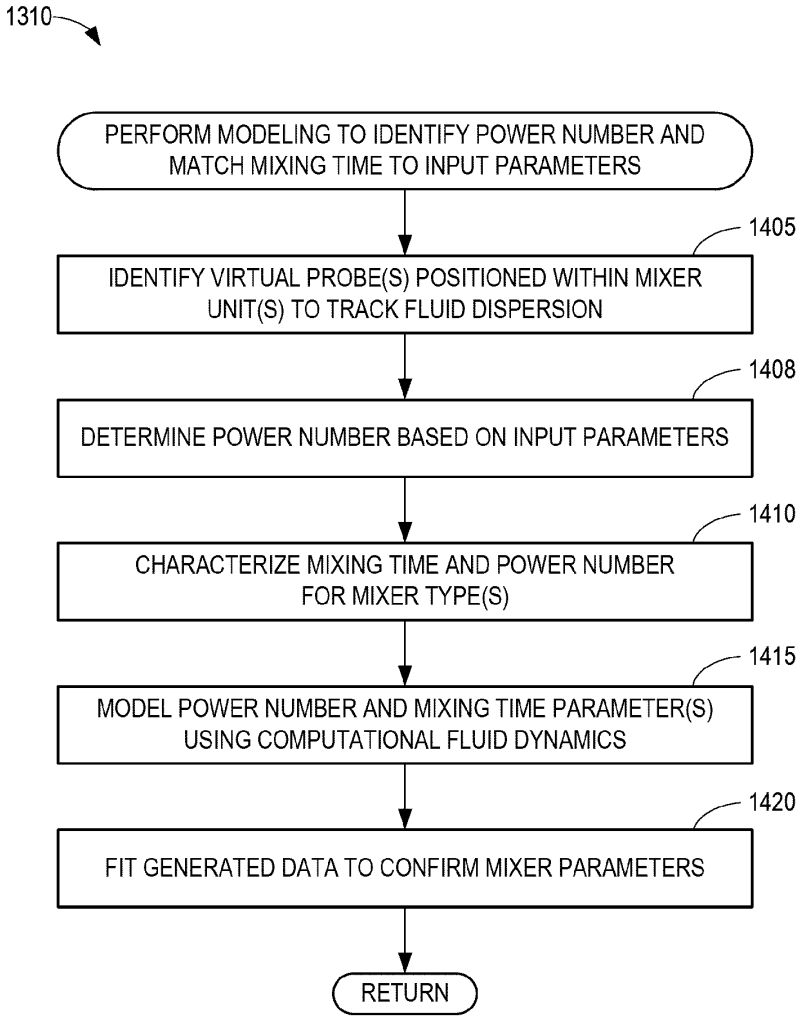

1310
PERFORM MODELING TO IDENTIFY POWER NUMBER AND MATCH MIXING TIME TO INPUT PARAMETERS
1405
IDENTIFY VIRTUAL PROBE(S) POSITIONED WITHIN MIXER UNIT(S) TO TRACK FLUID DISPERSION
1408
DETERMINE POWER NUMBER BASED ON INPUT PARAMETERS
1410
CHARACTERIZE MIXING TIME AND POWER NUMBER FOR MIXER TYPE(S)
1415
MODEL POWER NUMBER AND MIXING TIME PARAMETER(S) USING COMPUTATIONAL FLUID DYNAMICS
1420
FIT GENERATED DATA TO CONFIRM MIXER PARAMETERS
RETURN

FIG. 14

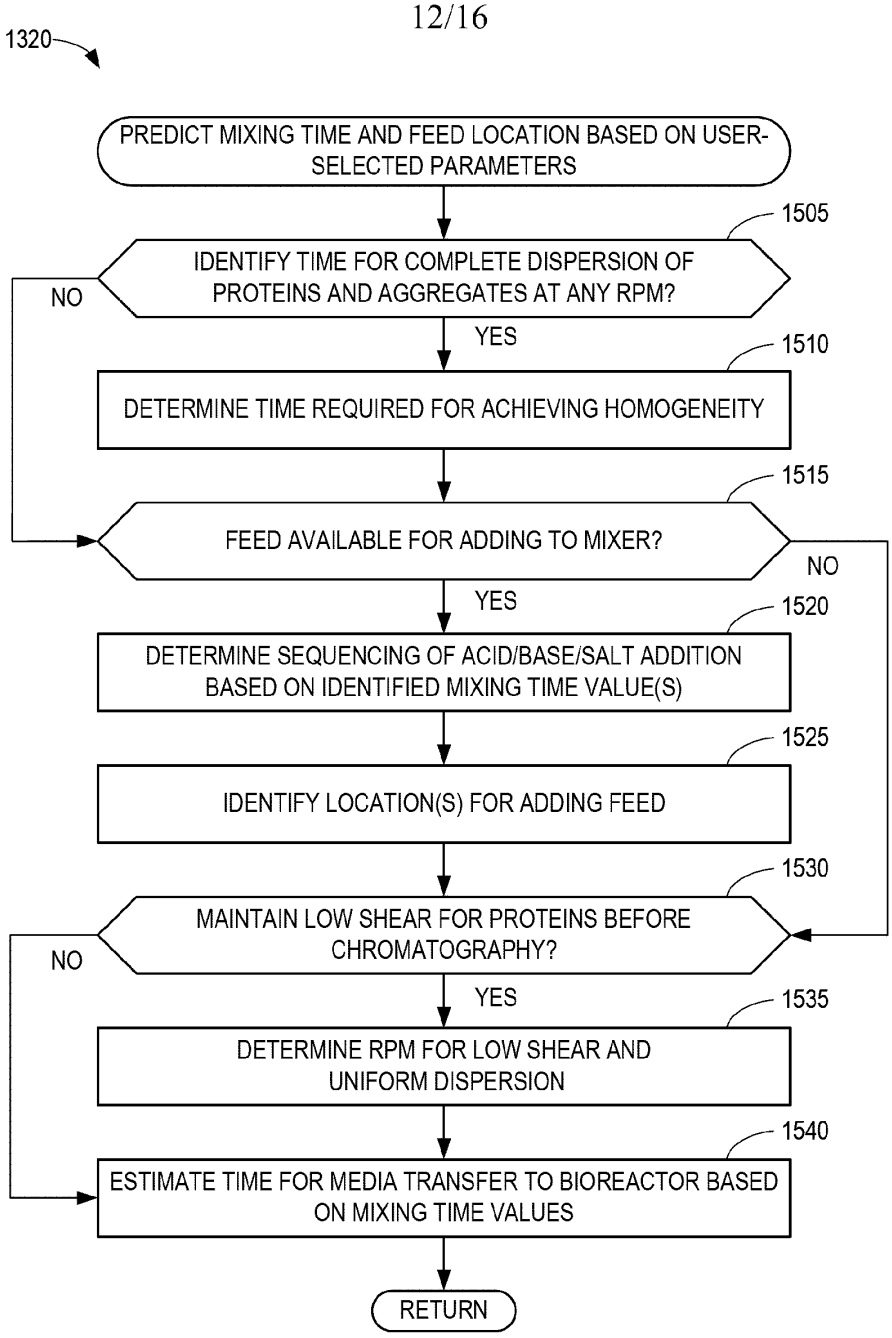

1320
PREDICT MIXING TIME AND FEED LOCATION BASED ON USER-SELECTED PARAMETERS
1505
IDENTIFY TIME FOR COMPLETE DISPERSION OF PROTEINS AND AGGREGATES AT ANY RPM?
NO
YES
1510
DETERMINE TIME REQUIRED FOR ACHIEVING HOMOGENEITY
1515
FEED AVAILABLE FOR ADDING TO MIXER?
NO
YES
1520
DETERMINE SEQUENCING OF ACID/BASE/SALT ADDITION BASED ON IDENTIFIED MIXING TIME VALUE(S)
1525
IDENTIFY LOCATION(S) FOR ADDING FEED
1530
MAINTAIN LOW SHEAR FOR PROTEINS BEFORE CHROMATOGRAPHY?
NO
YES
1535
DETERMINE RPM FOR LOW SHEAR AND UNIFORM DISPERSION
1540
ESTIMATE TIME FOR MEDIA TRANSFER TO BIOREACTOR BASED ON MIXING TIME VALUES
RETURN

FIG. 15

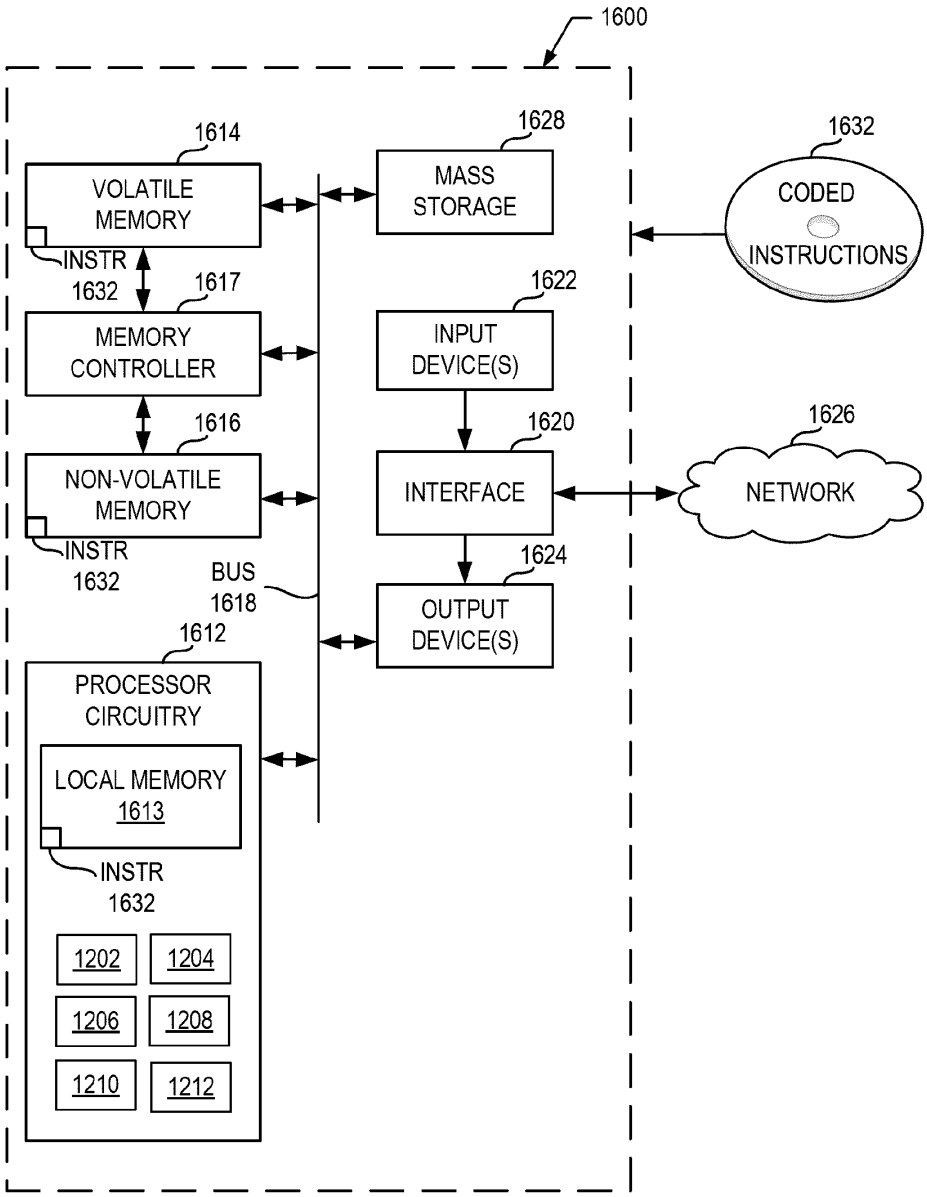

1600
1614
VOLATILE MEMORY
INSTR 1632
1617
MEMORY CONTROLLER
1616
NON-VOLATILE MEMORY
INSTR 1632
BUS 1618
1612
PROCESSOR CIRCUITRY
LOCAL MEMORY 1613
INSTR 1632
1202
1204
1206
1208
1210
1212
1628
MASS STORAGE
1622
INPUT DEVICE(S)
1620
INTERFACE
1624
OUTPUT DEVICE(S)
1632
CODED INSTRUCTIONS
1626
NETWORK

FIG. 16

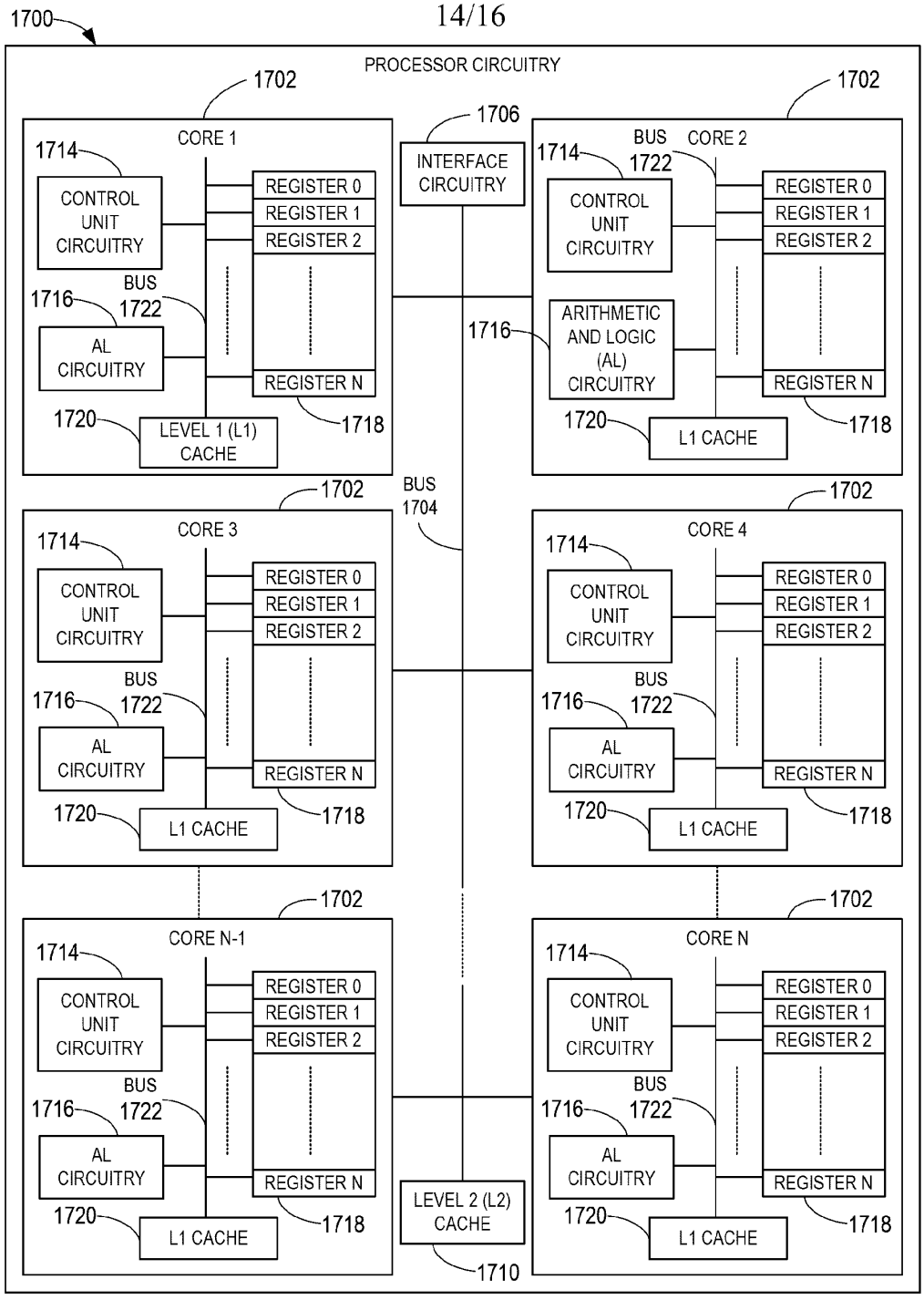

1700
PROCESSOR CIRCUITRY
1702
CORE 1
1714
CONTROL UNIT CIRCUITRY
REGISTER 0
REGISTER 1
REGISTER 2
REGISTER N
BUS
1722
1716
AL CIRCUITRY
1720
LEVEL 1 (L1) CACHE
1718
1706
INTERFACE CIRCUITRY
CORE 2
ARITHMETIC AND LOGIC (AL) CIRCUITRY
L1 CACHE
BUS 1704
CORE 3
CORE 4
CORE N-1
CORE N
LEVEL 2 (L2) CACHE
1710

FIG. 17

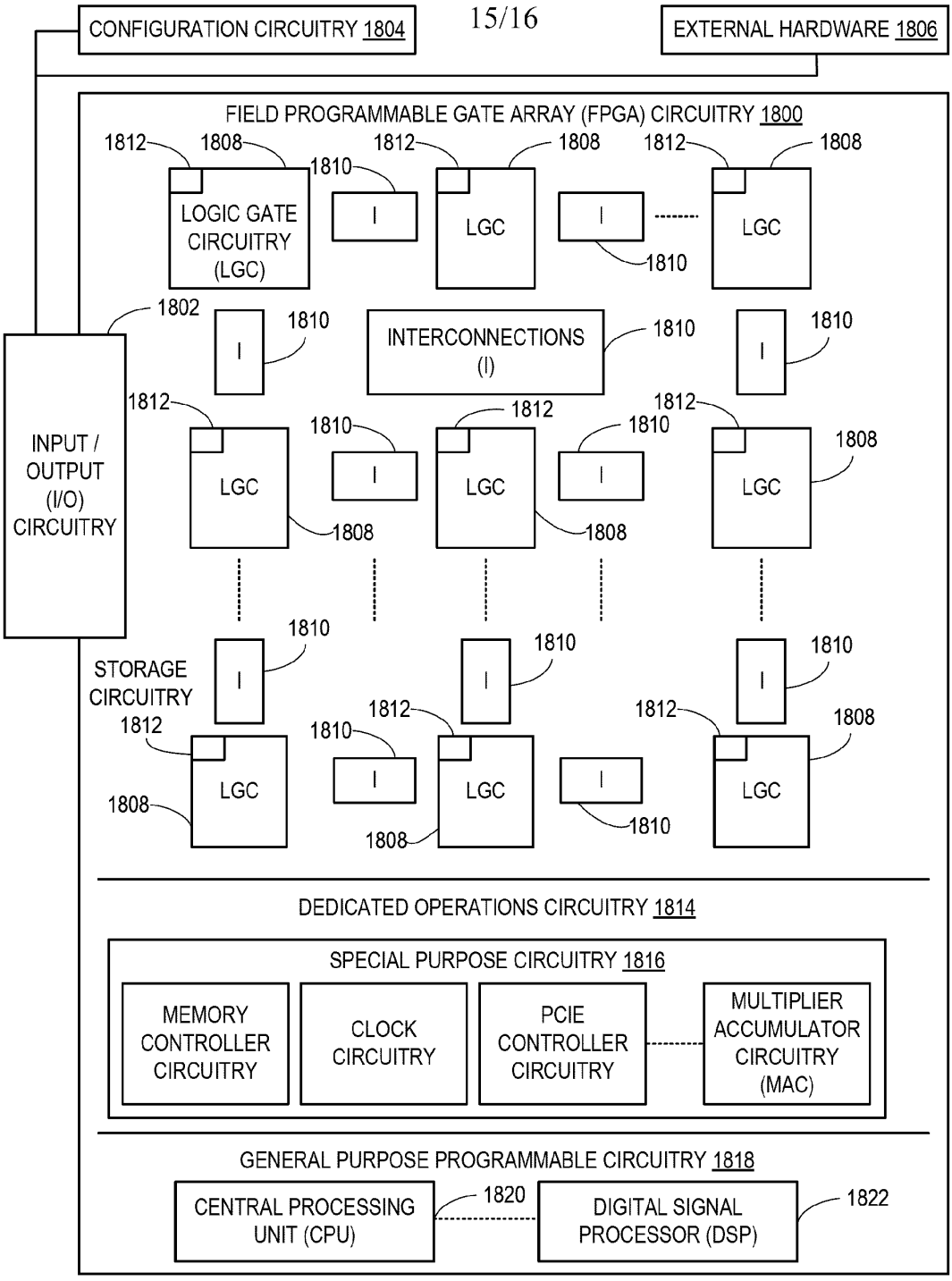

CONFIGURATION CIRCUITRY 1804
EXTERNAL HARDWARE 1806
FIELD PROGRAMMABLE GATE ARRAY (FPGA) CIRCUITRY 1800
LOGIC GATE CIRCUITRY (LGC)
LGC
I
INTERCONNECTIONS (I)
INPUT / OUTPUT (I/O) CIRCUITRY
STORAGE CIRCUITRY
1802
1808
1810
1812
DEDICATED OPERATIONS CIRCUITRY 1814
SPECIAL PURPOSE CIRCUITRY 1816
MEMORY CONTROLLER CIRCUITRY
CLOCK CIRCUITRY
PCIE CONTROLLER CIRCUITRY
MULTIPLIER ACCUMULATOR CIRCUITRY (MAC)
GENERAL PURPOSE PROGRAMMABLE CIRCUITRY 1818
CENTRAL PROCESSING UNIT (CPU)
1820
DIGITAL SIGNAL PROCESSOR (DSP)
1822

FIG. 18

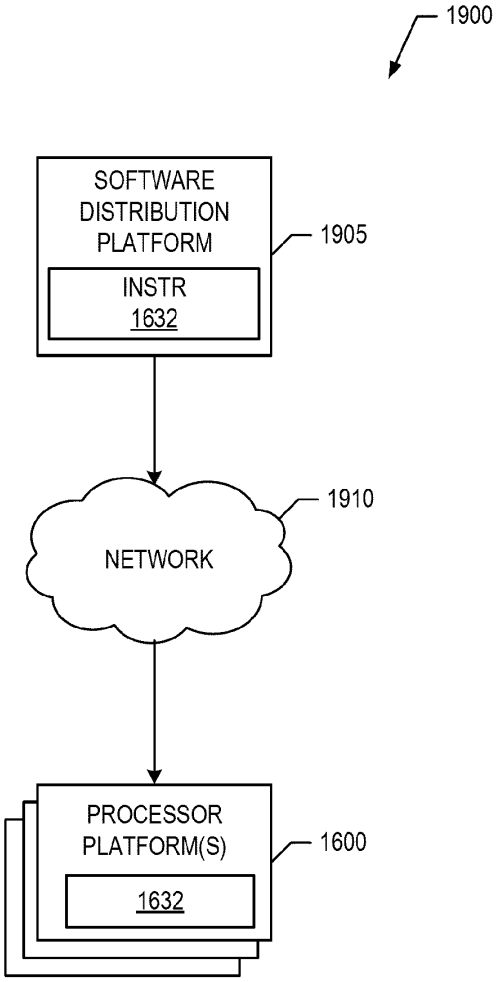

1900
SOFTWARE DISTRIBUTION PLATFORM
1905
INSTR 1632
1910
NETWORK
PROCESSOR PLATFORM(S)
1600
1632

FIG. 19