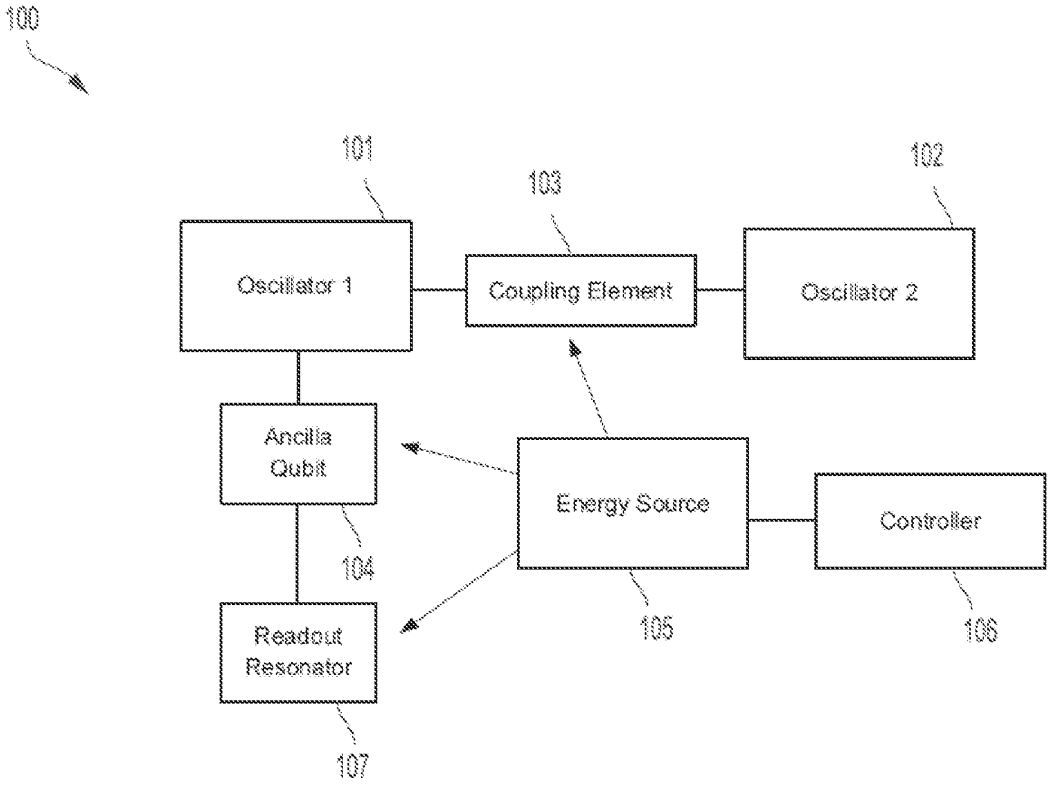

100
101
103
102
Oscillator 1
Coupling Element
Oscillator 2
Ancilla Qubit
Energy Source
Controller
104
Readout Resonator
105
106
107

FIG. 1

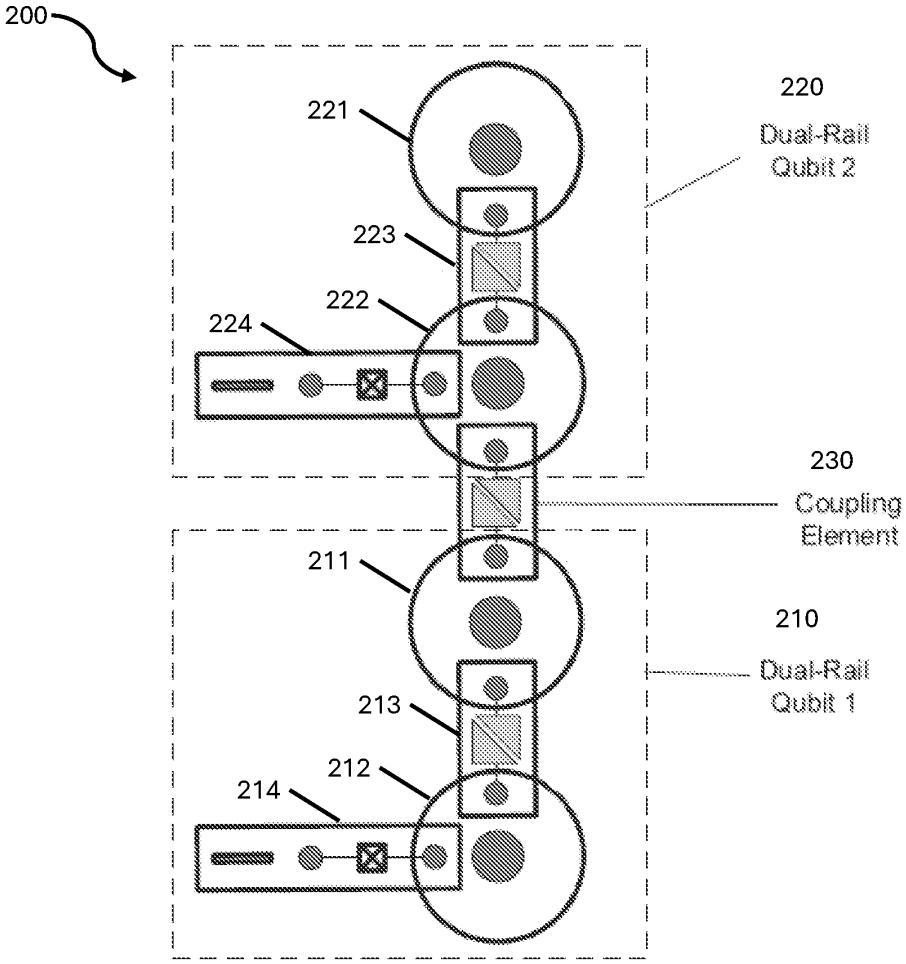

200
221
220
Dual-Rail
Qubit 2
223
222
224
230
Coupling
Element
211
210
Dual-Rail
Qubit 1
213
212
214

FIG. 2

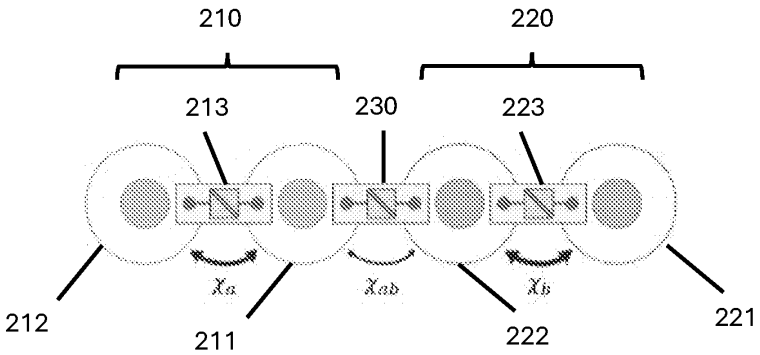


FIG. 3

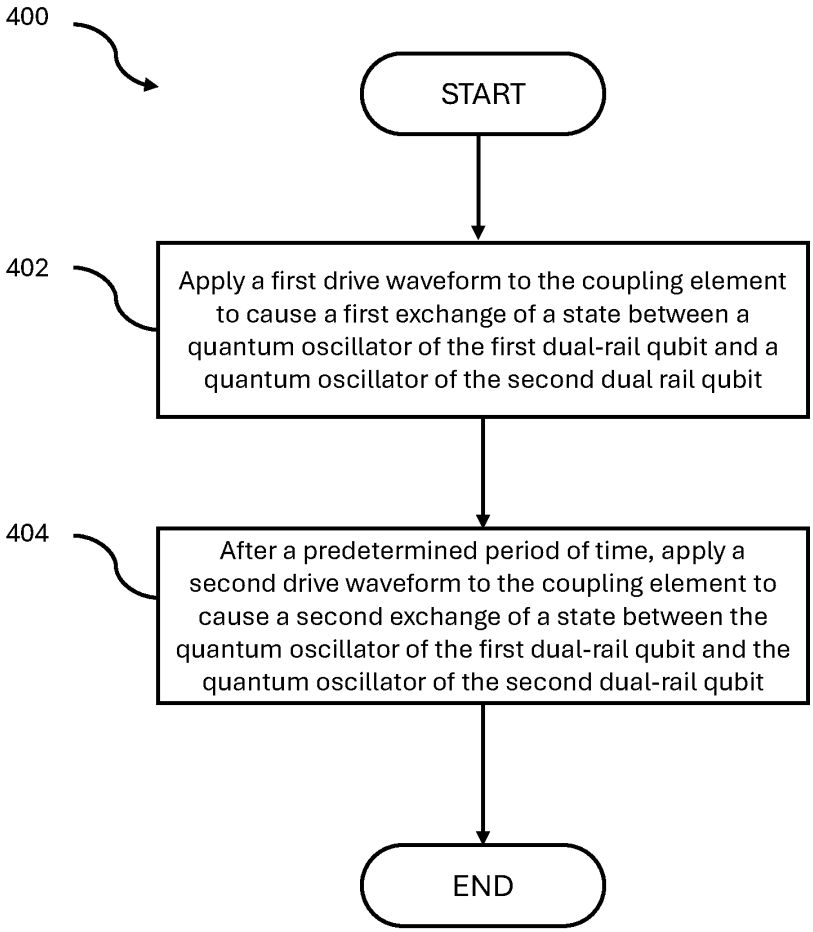

400
START
402
Apply a first drive waveform to the coupling element to cause a first exchange of a state between a quantum oscillator of the first dual-rail qubit and a quantum oscillator of the second dual rail qubit
404
After a predetermined period of time, apply a second drive waveform to the coupling element to cause a second exchange of a state between the quantum oscillator of the first dual-rail qubit and the quantum oscillator of the second dual-rail qubit
END

FIG. 4

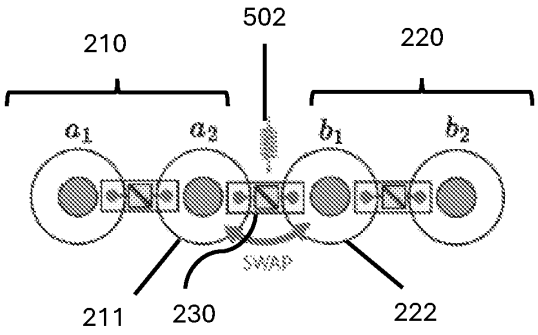


FIG. 5A-1

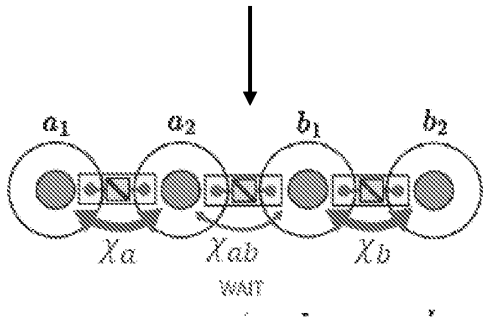


FIG. 5A-2

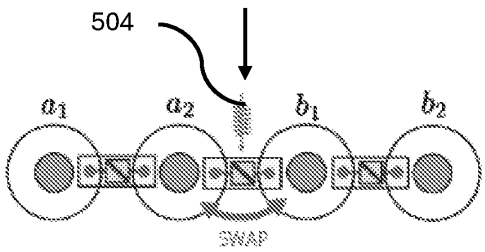


FIG. 5A-3

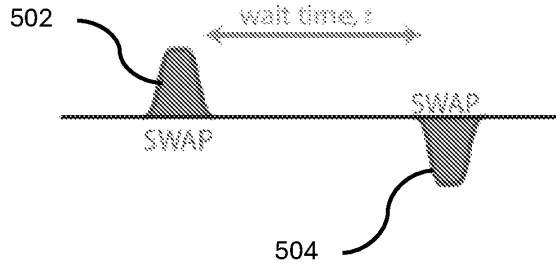


FIG. 5B

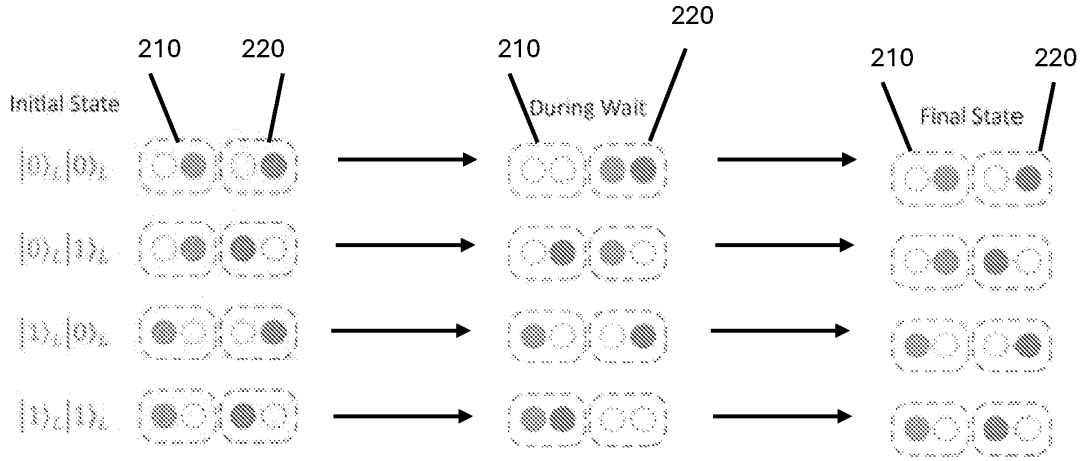

210
220
210
220
210
220
Initial State
During Wait
Final State
$|0\rangle_L|0\rangle_L$
$|0\rangle_L|1\rangle_L$
$|1\rangle_L|0\rangle_L$
$|1\rangle_L|1\rangle_L$

FIG. 5C

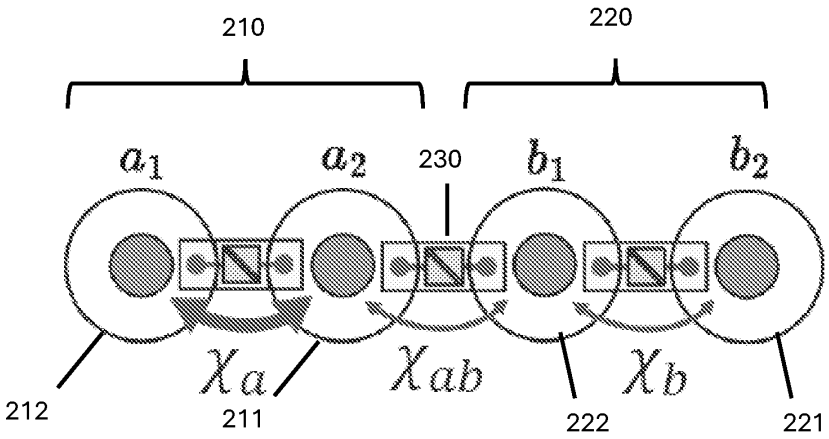

210
220
a_1
a_2
230
b_1
b_2
χ_a
χ_{ab}
χ_b
212
211
222
221

FIG. 6A

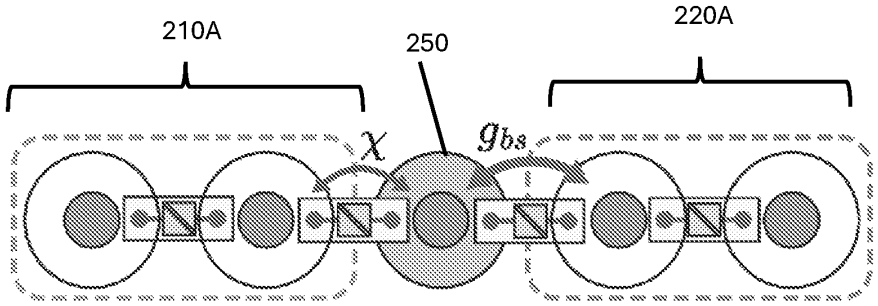
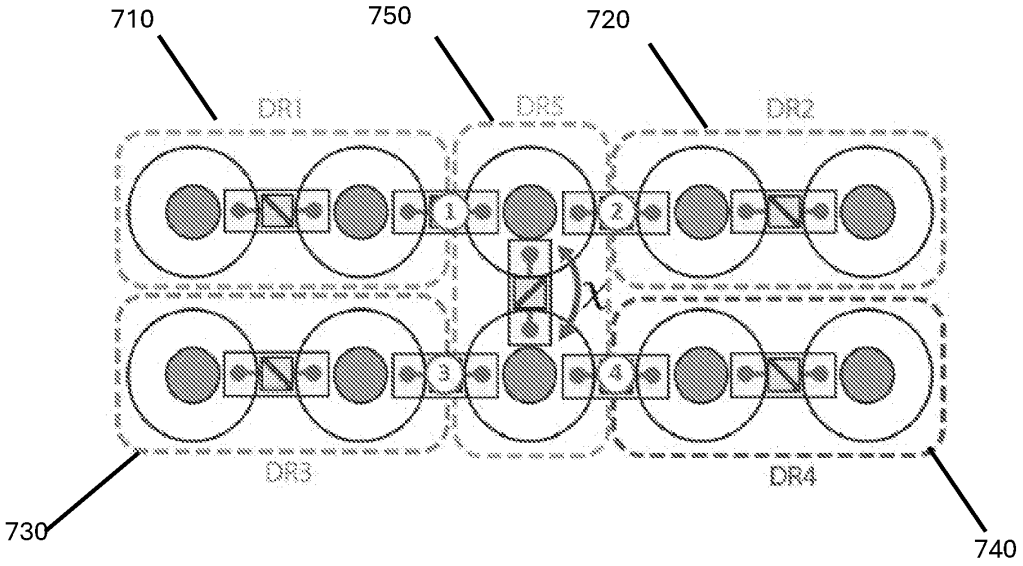

210A
250
220A
χ
g_{bs}

FIG. 6B


710
750
720
DR1
DR5
DR2
1
2
5
χ
3
4
DR3
DR4
730
740

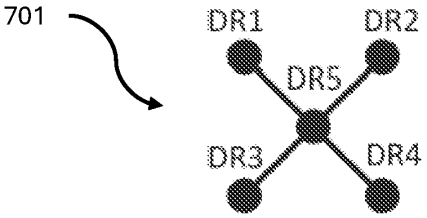
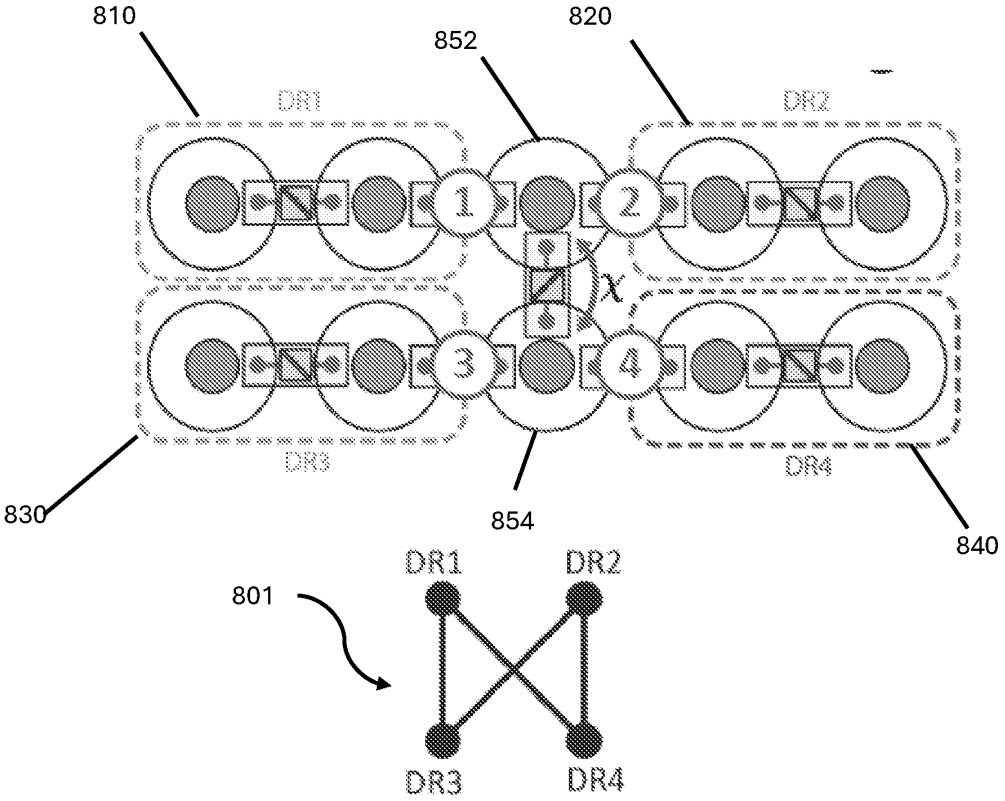

701
DR1
DR2
DR5
DR3
DR4

FIG. 7


810
852
820
DR1
DR2
1
2
χ
3
4
DR3
DR4
830
854
840

801
DR1
DR2
DR3
DR4

FIG. 8A

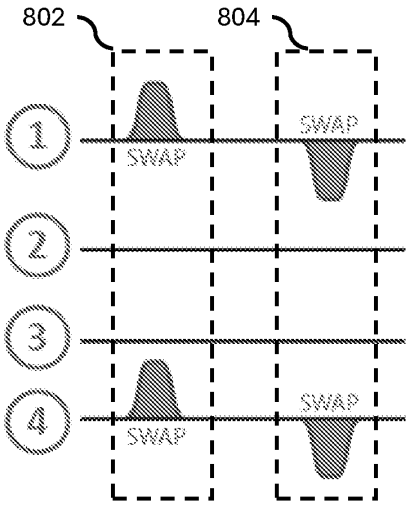

802
804
1
SWAP
SWAP
2
3
4
SWAP
SWAP

FIG. 8B

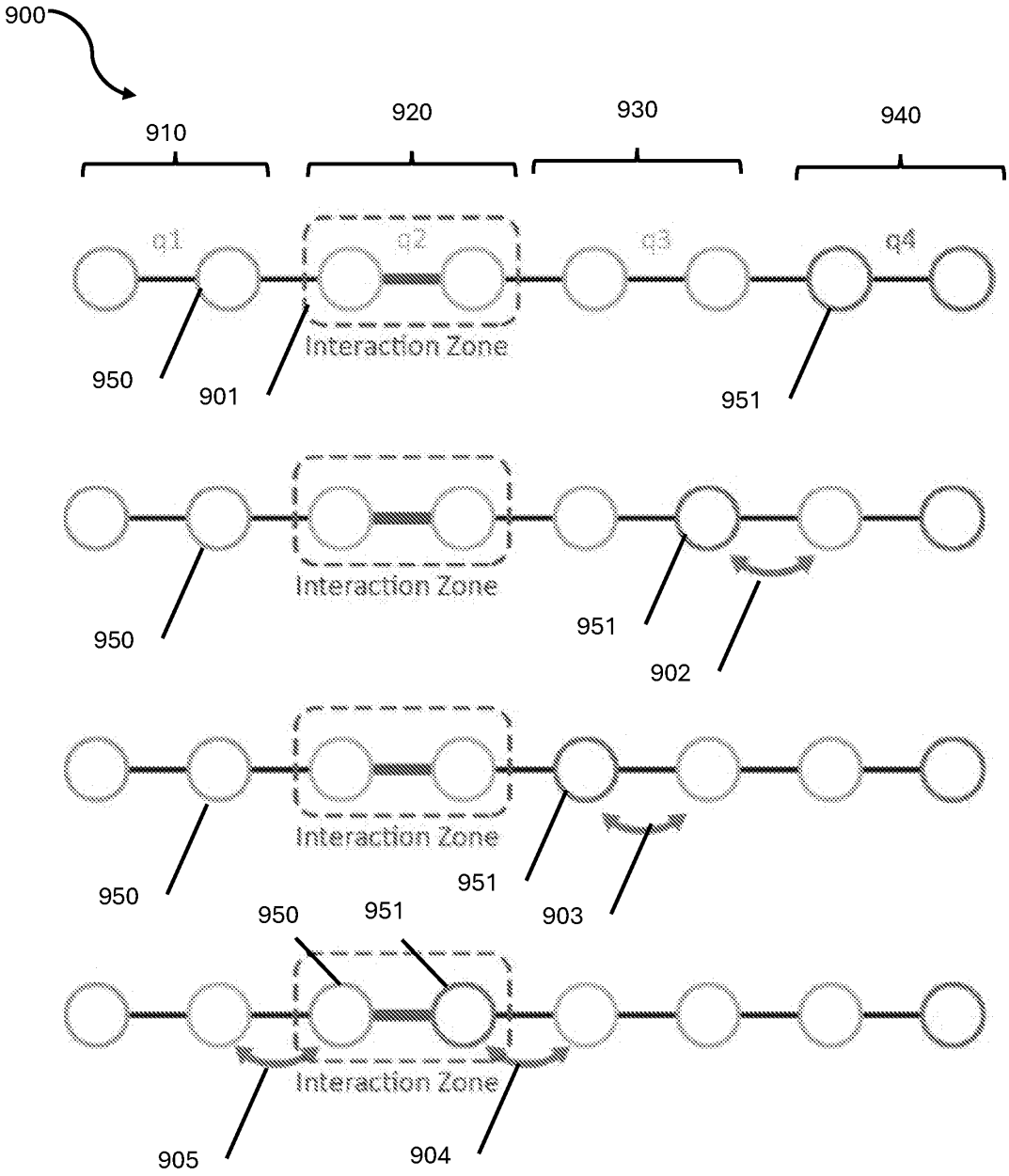

900
910
920
930
940
q1
q2
q3
q4
Interaction Zone
950
901
951
Interaction Zone
950
951
902
Interaction Zone
950
951
903
950
951
Interaction Zone
905
904

FIG. 9

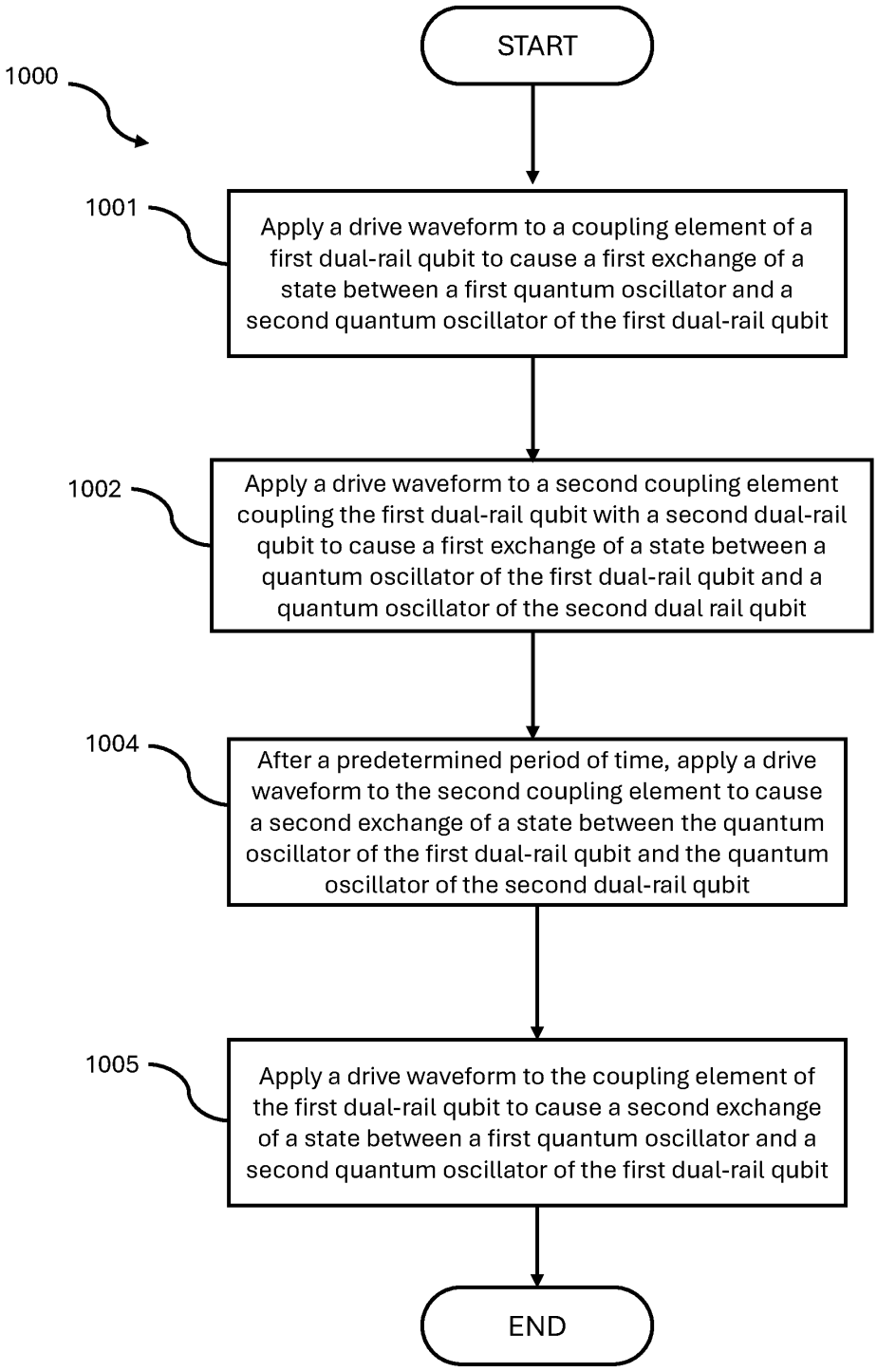

START
1000
1001
Apply a drive waveform to a coupling element of a first dual-rail qubit to cause a first exchange of a state between a first quantum oscillator and a second quantum oscillator of the first dual-rail qubit
1002
Apply a drive waveform to a second coupling element coupling the first dual-rail qubit with a second dual-rail qubit to cause a first exchange of a state between a quantum oscillator of the first dual-rail qubit and a quantum oscillator of the second dual rail qubit
1004
After a predetermined period of time, apply a drive waveform to the second coupling element to cause a second exchange of a state between the quantum oscillator of the first dual-rail qubit and the quantum oscillator of the second dual-rail qubit
1005
Apply a drive waveform to the coupling element of the first dual-rail qubit to cause a second exchange of a state between a first quantum oscillator and a second quantum oscillator of the first dual-rail qubit
END

FIG. 10

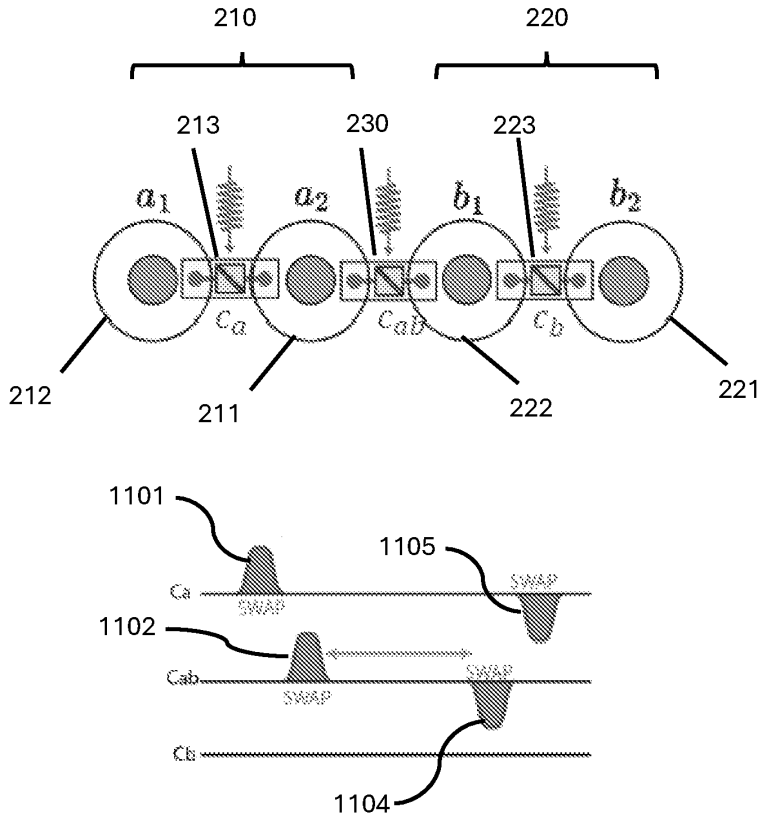

210
220
213
230
223
a_1
a_2
b_1
b_2
c_a
c_{ab}
c_b
212
211
222
221
1101
1105
Ca
SWAP
SWAP
1102
Cab
SWAP
SWAP
Cb
1104

FIG.11

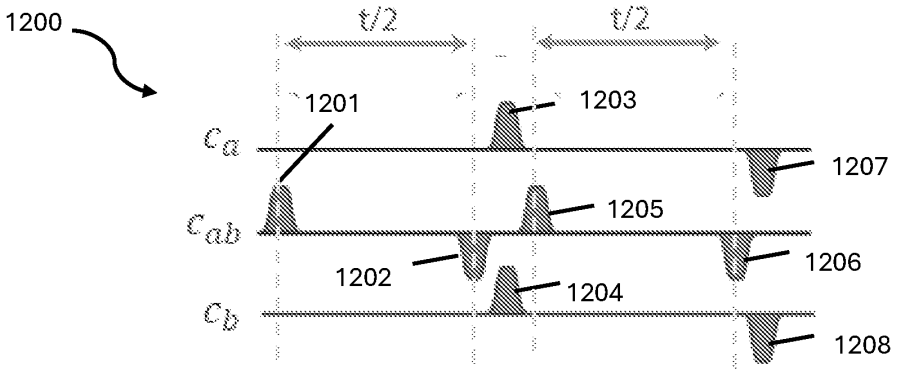


FIG. 12A

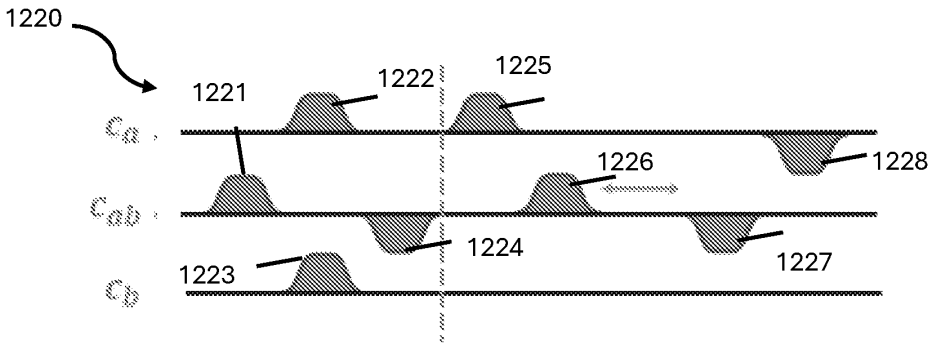


FIG. 12B

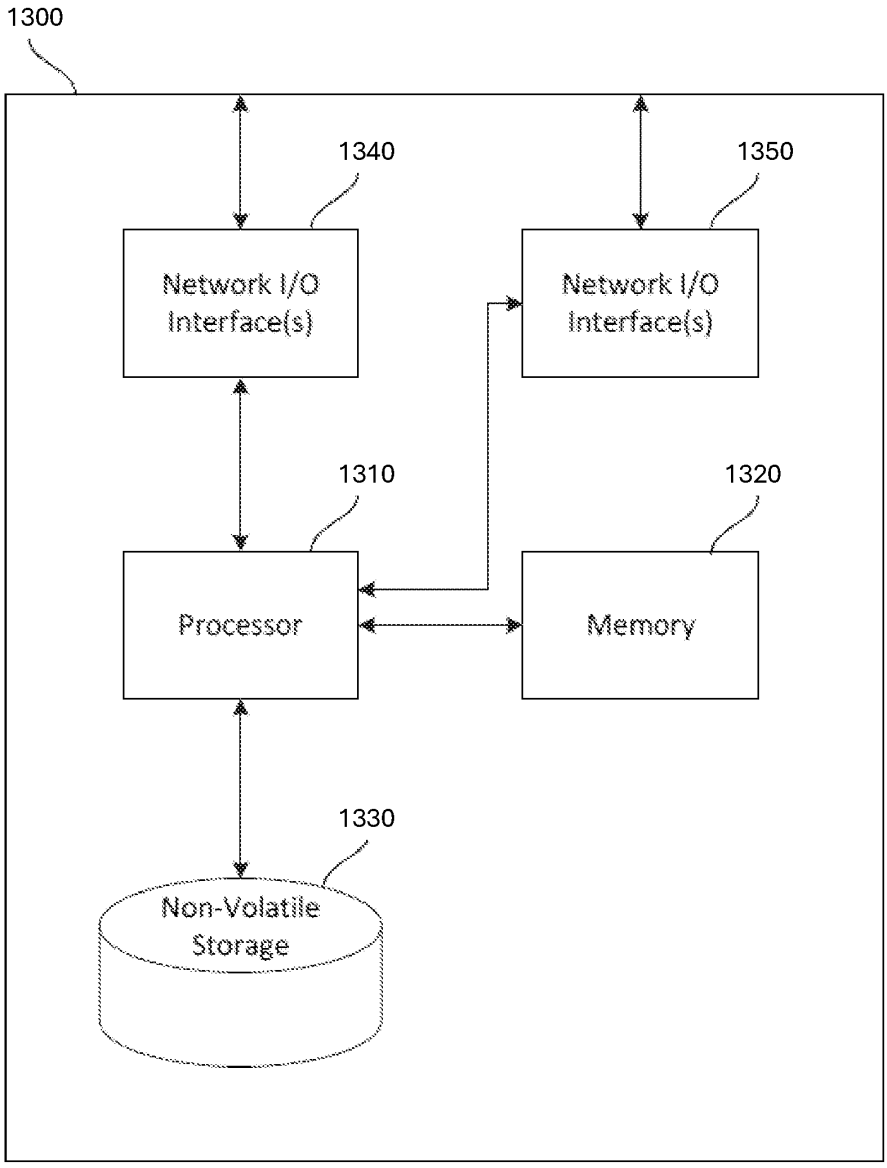

1300
1340
1350
Network I/O Interface(s)
Network I/O Interface(s)
1310
1320
Processor
Memory
1330
Non-Volatile Storage

FIG. 13