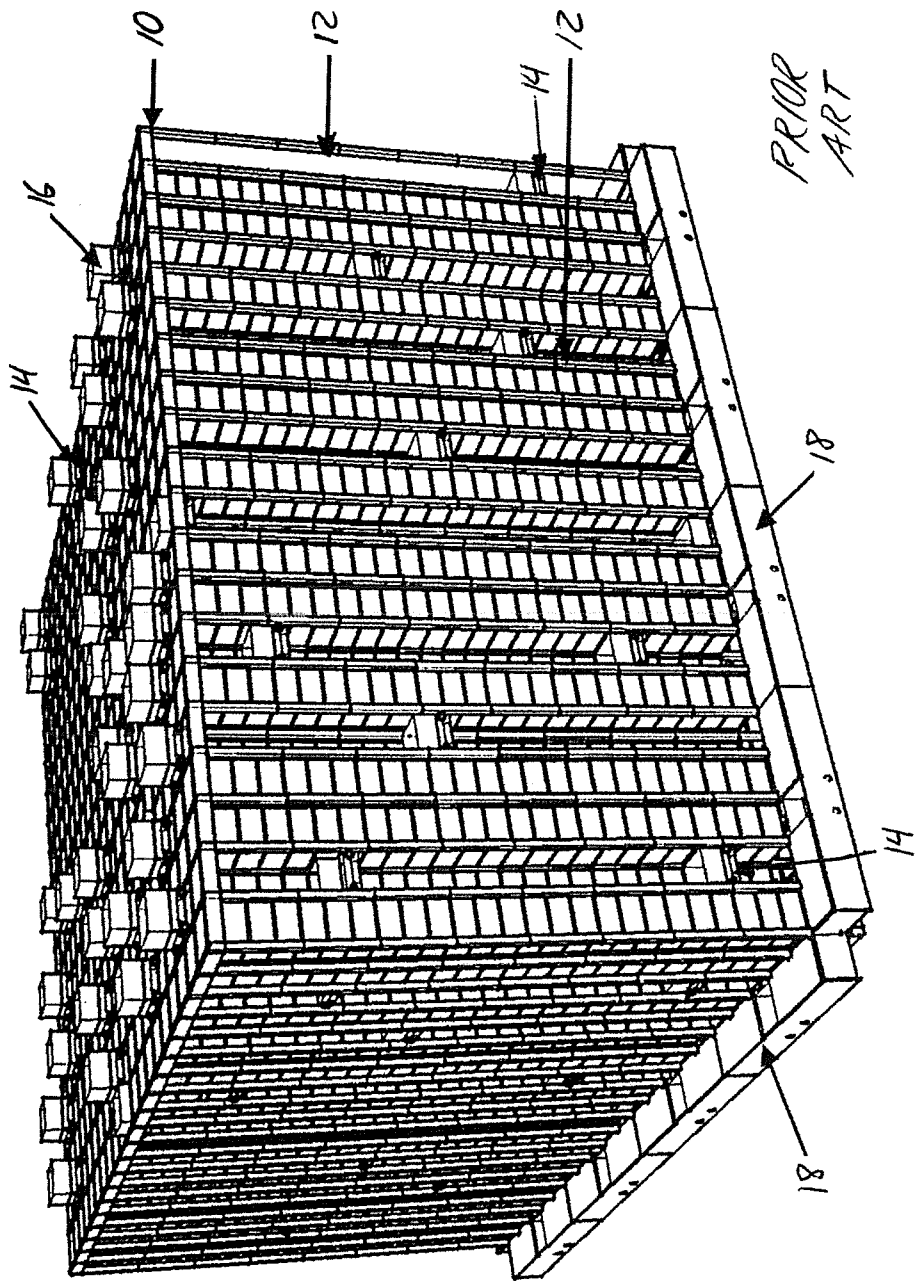


PRIOR ART

FIG. 1

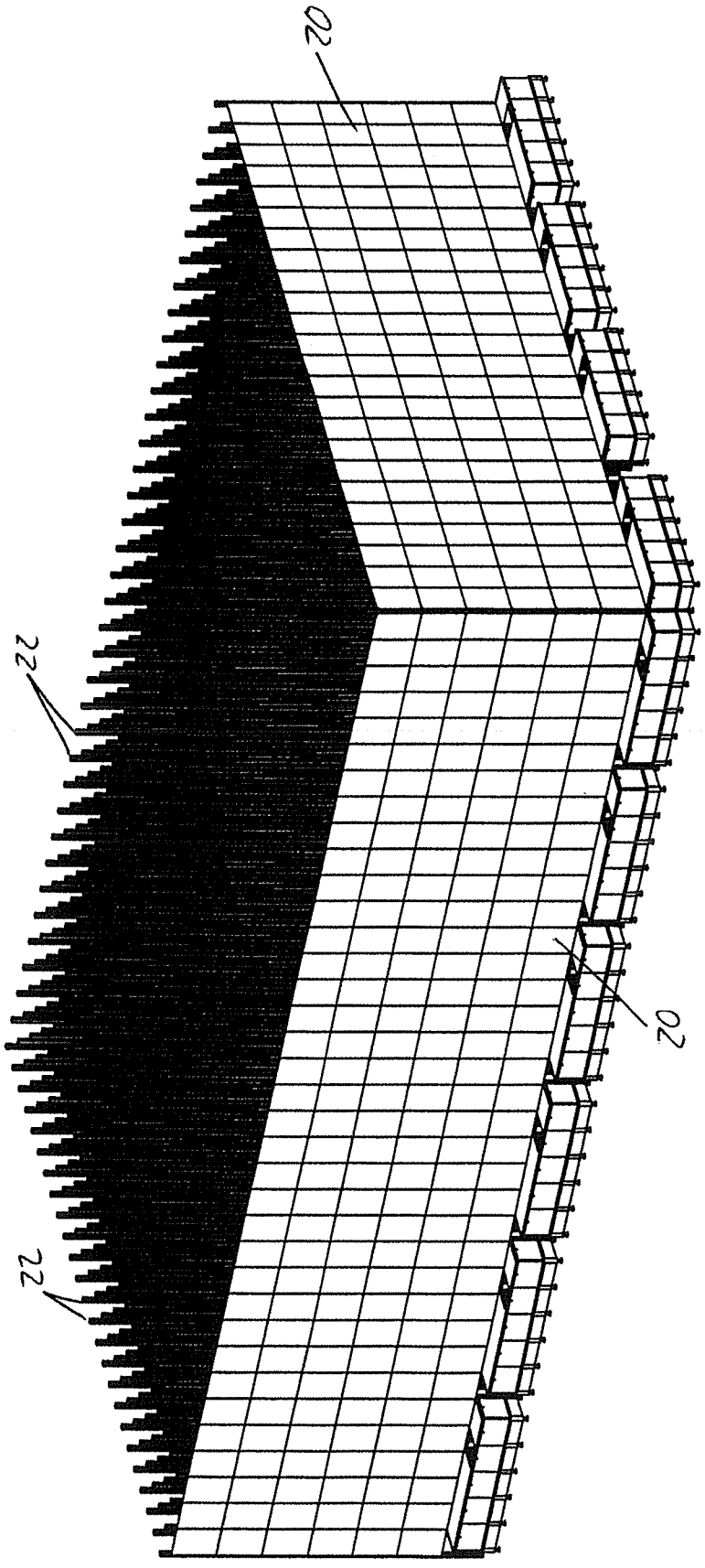


FIG. 2

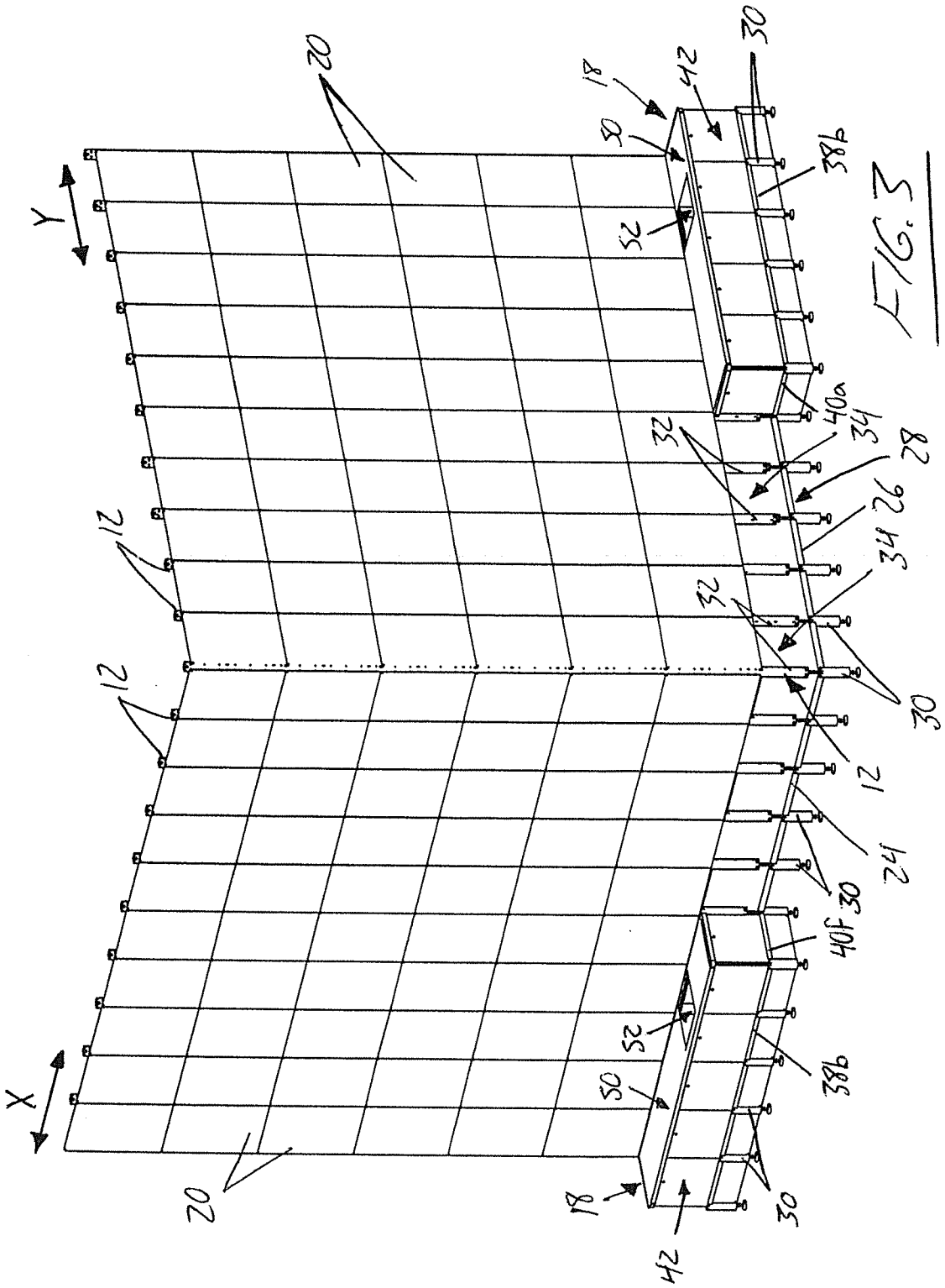


FIG. 3

FIG. 4

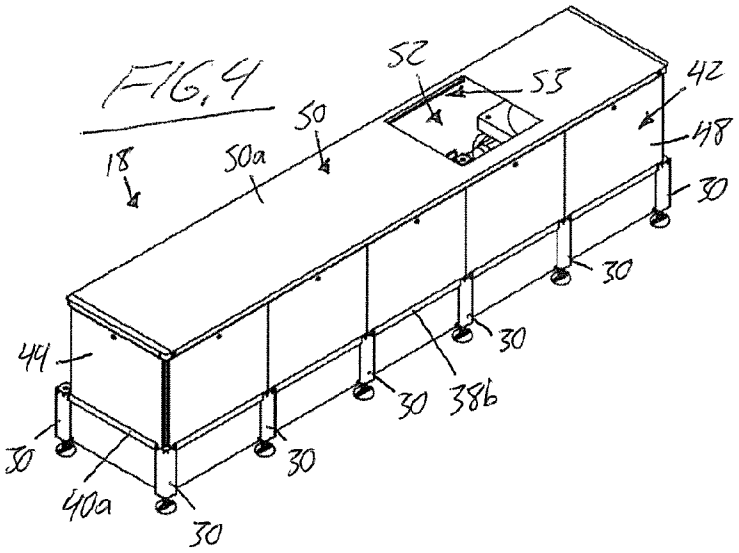


FIG. 5

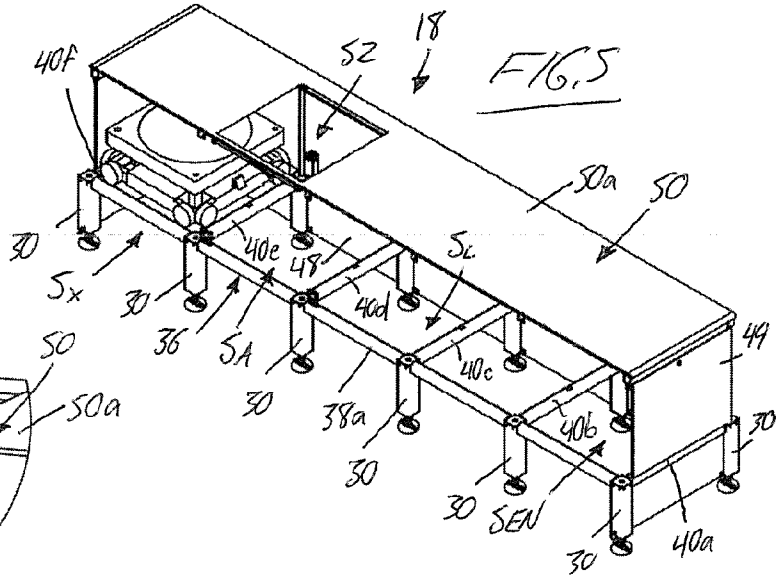
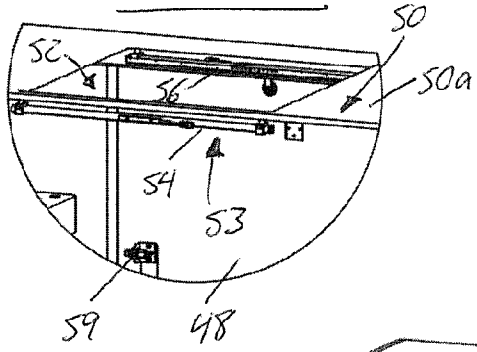


FIG. 6A



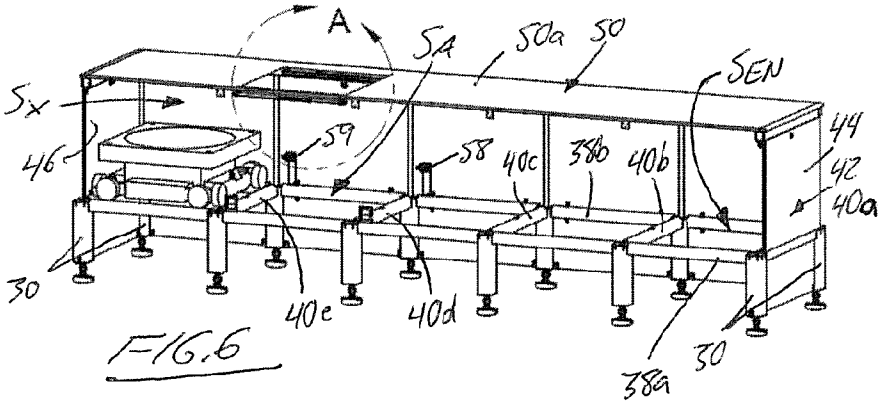


FIG. 6

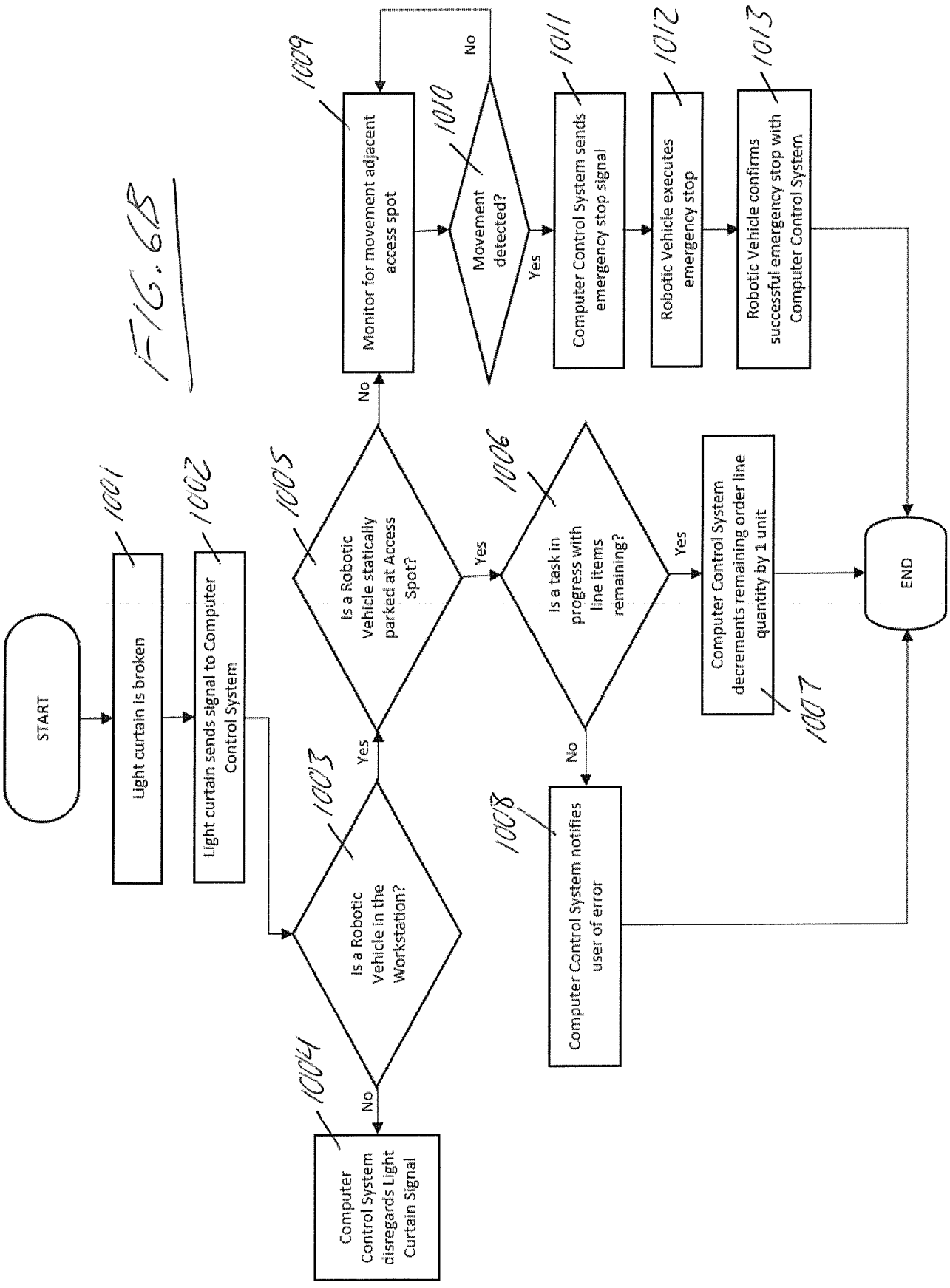

START
Light curtain is broken
1001
Light curtain sends signal to Computer Control System
1002
Is a Robotic Vehicle statically parked at Access Spot?
1005
Yes
No
Is a Robotic Vehicle in the Workstation?
1003
Yes
No
Computer Control System disregards Light Curtain Signal
1004
Is a task in progress with line items remaining?
1006
Yes
No
Computer Control System decrements remaining order line quantity by 1 unit
1007
Computer Control System notifies user of error
1008
END
Monitor for movement adjacent access spot
1009
Movement detected?
1010
No
Yes
Computer Control System sends emergency stop signal
1011
Robotic Vehicle executes emergency stop
1012
Robotic Vehicle confirms successful emergency stop with Computer Control System
1013

FIG. 6B

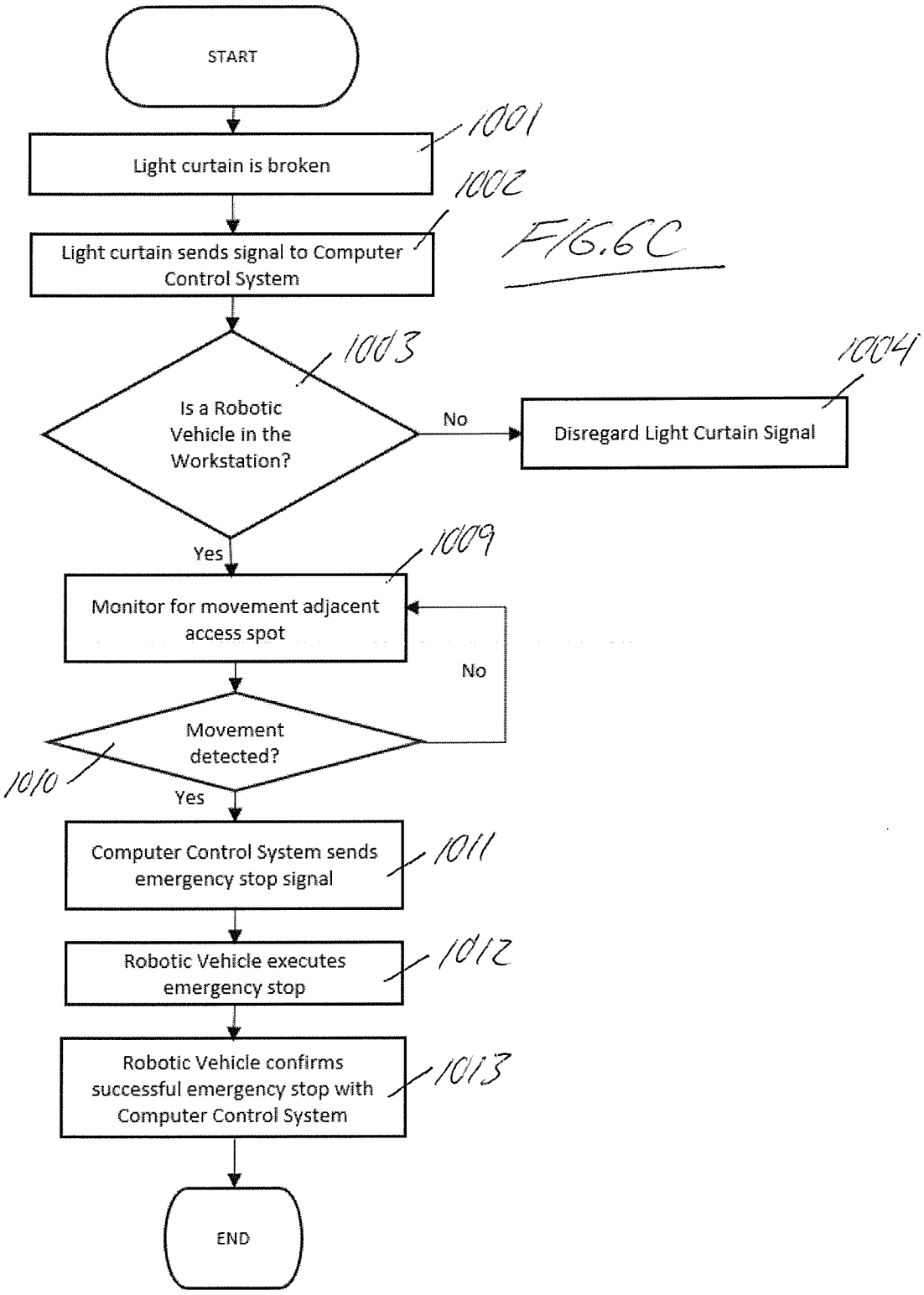

START
Light curtain is broken
1001
Light curtain sends signal to Computer Control System
1002
Is a Robotic Vehicle in the Workstation?
1003
No
Disregard Light Curtain Signal
1004
Yes
Monitor for movement adjacent access spot
1009
No
Movement detected?
1010
Yes
Computer Control System sends emergency stop signal
1011
Robotic Vehicle executes emergency stop
1012
Robotic Vehicle confirms successful emergency stop with Computer Control System
1013
END

FIG.6C

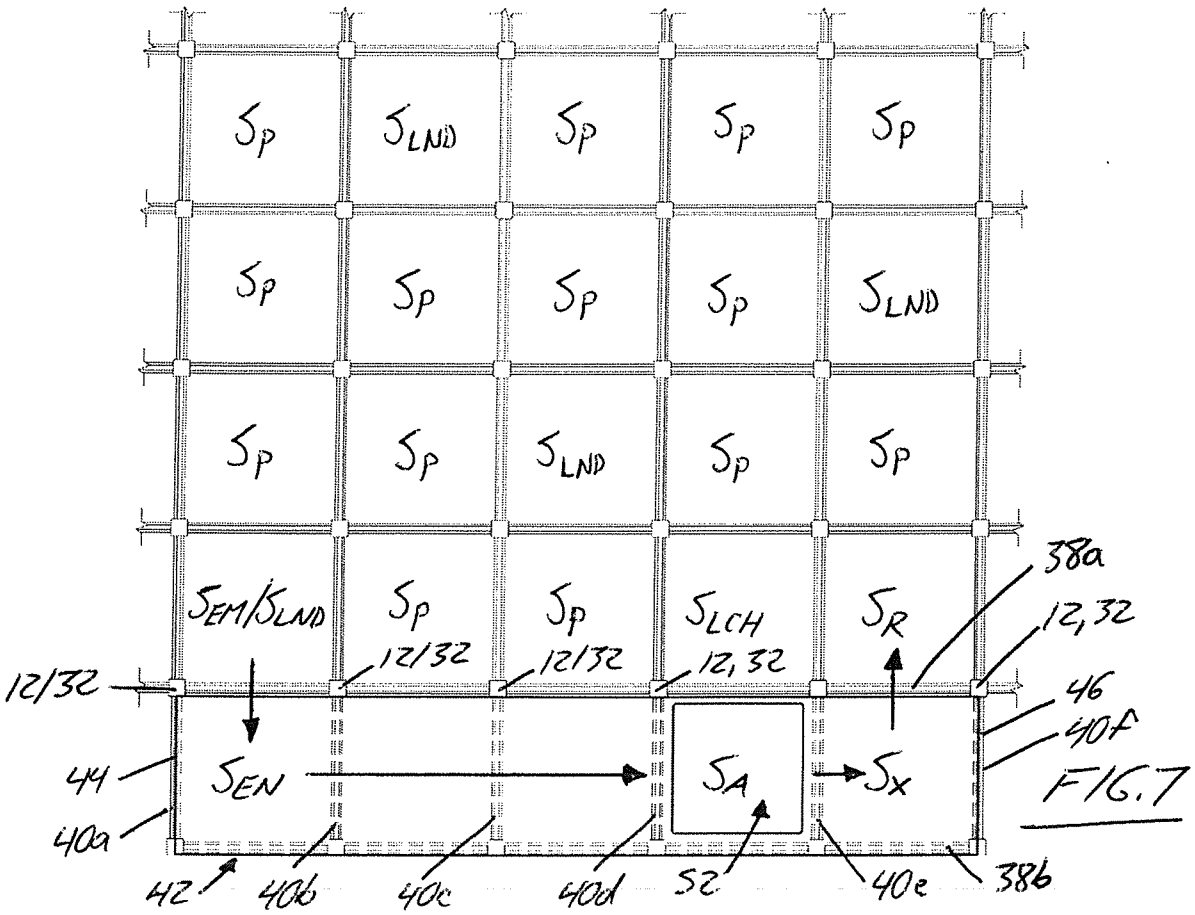

SP
SLND
SEM/SLND
SLCH
SR
SEN
SA
Sx
12/32
38a
46
40f
44
40a
42
40b
40c
40d
52
40e
38b

FIG.7

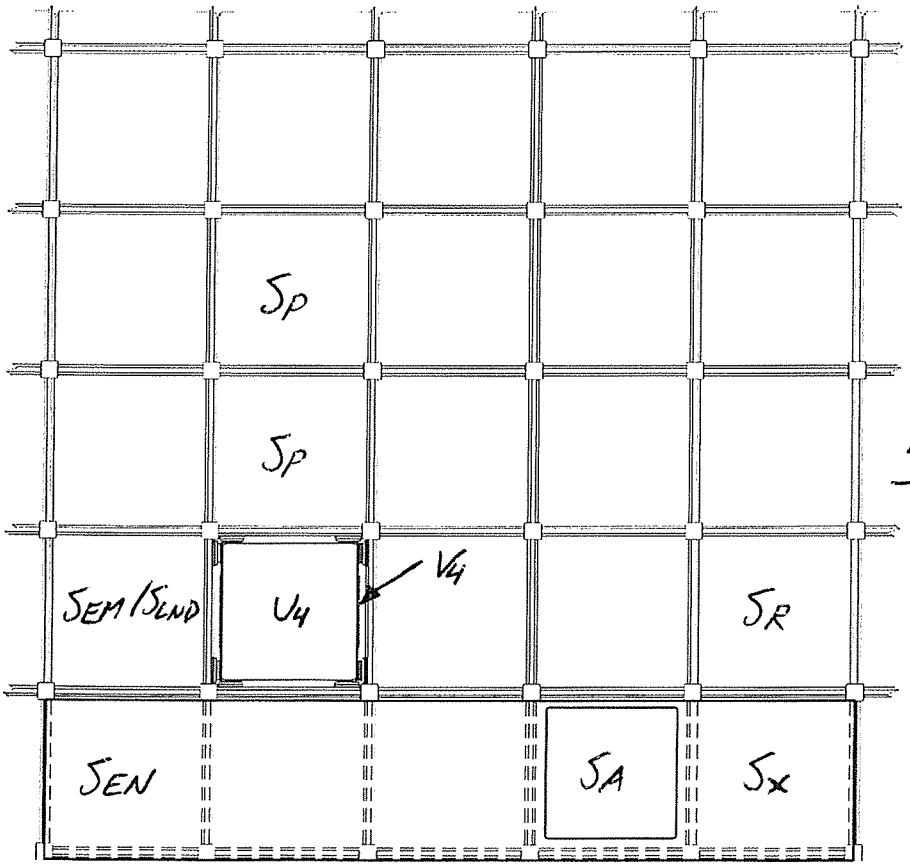

SP
SEM/SLND
U4
V4
SR
SEN
SA
Sx

FIG.7A

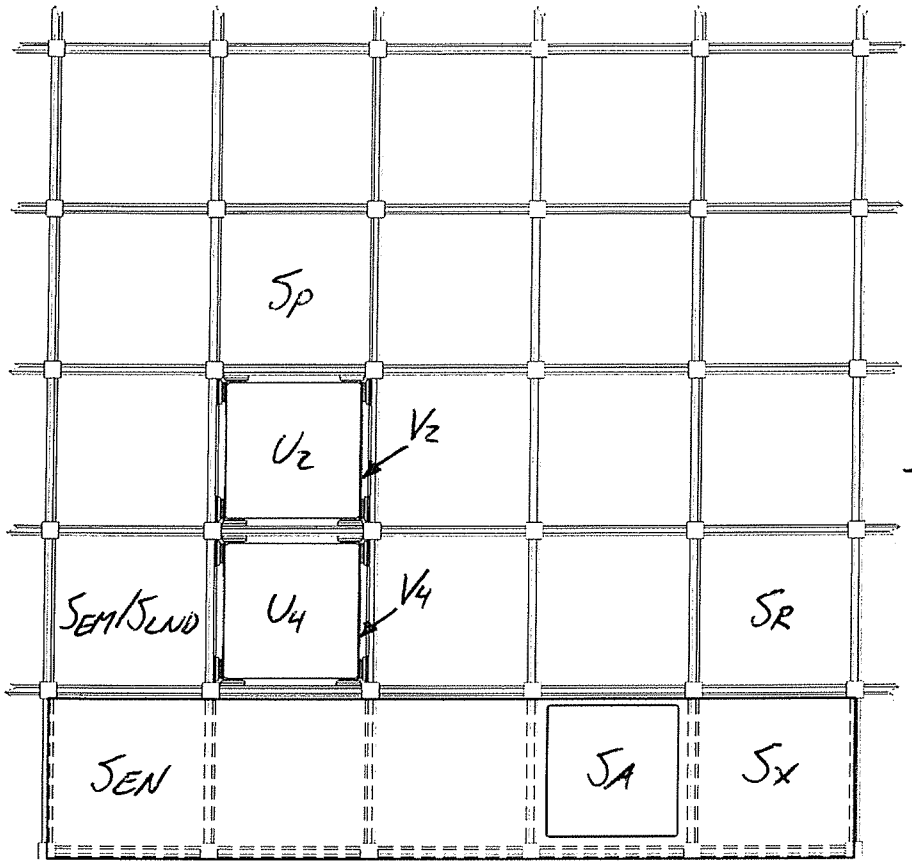

S_P
U_2
V_2
S_{EM}/S_{LND}
U_4
V_4
S_R
S_{EN}
S_A
S_X

FIG. 7B

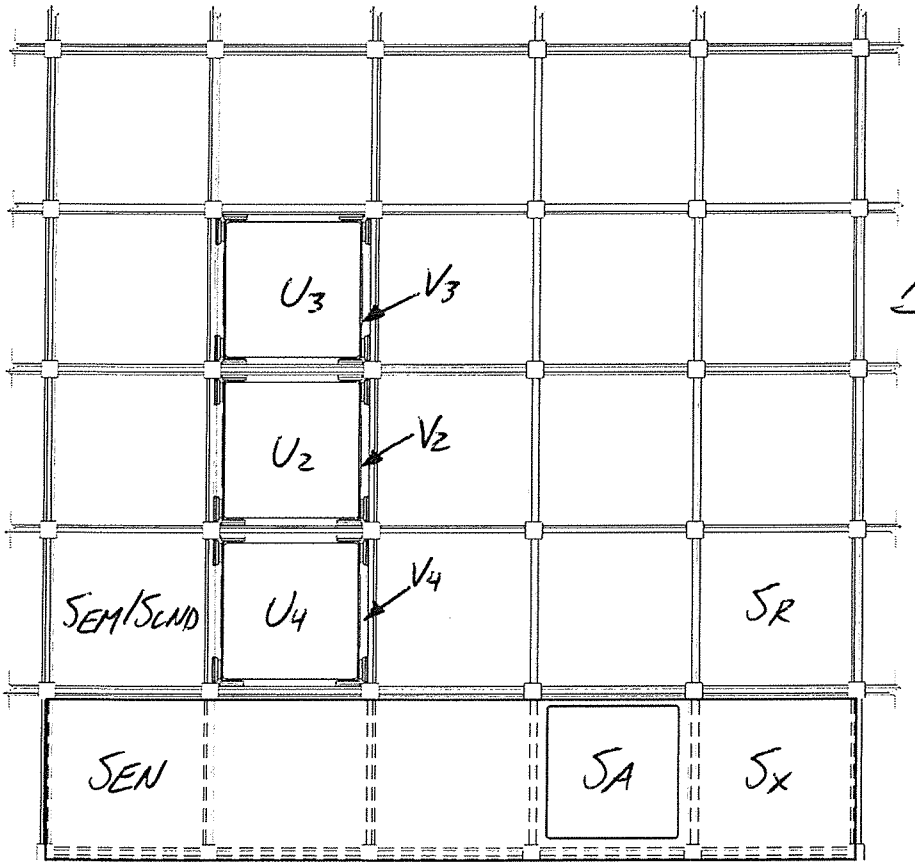

U_3
V_3
U_2
V_2
S_{EM}/S_{LND}
U_4
V_4
S_R
S_{EN}
S_A
S_X

FIG. 7C

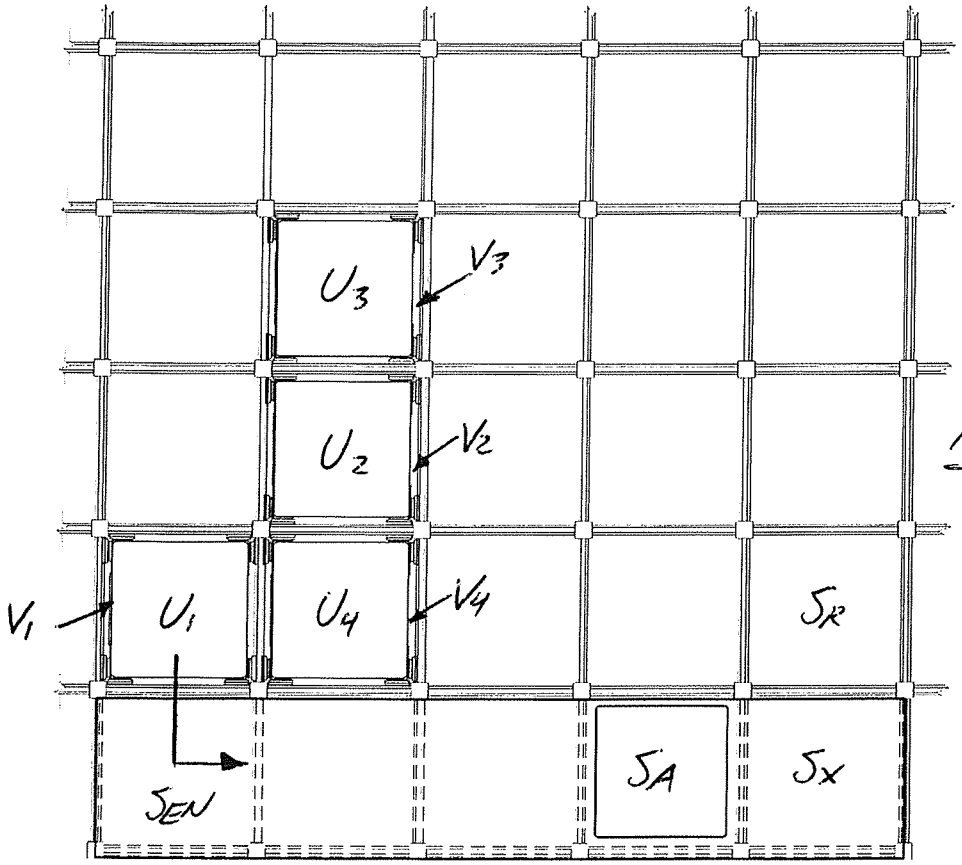

U3
V3
U2
V2
V1
U1
U4
V4
SR
SEN
SA
SX

FIG. 7D

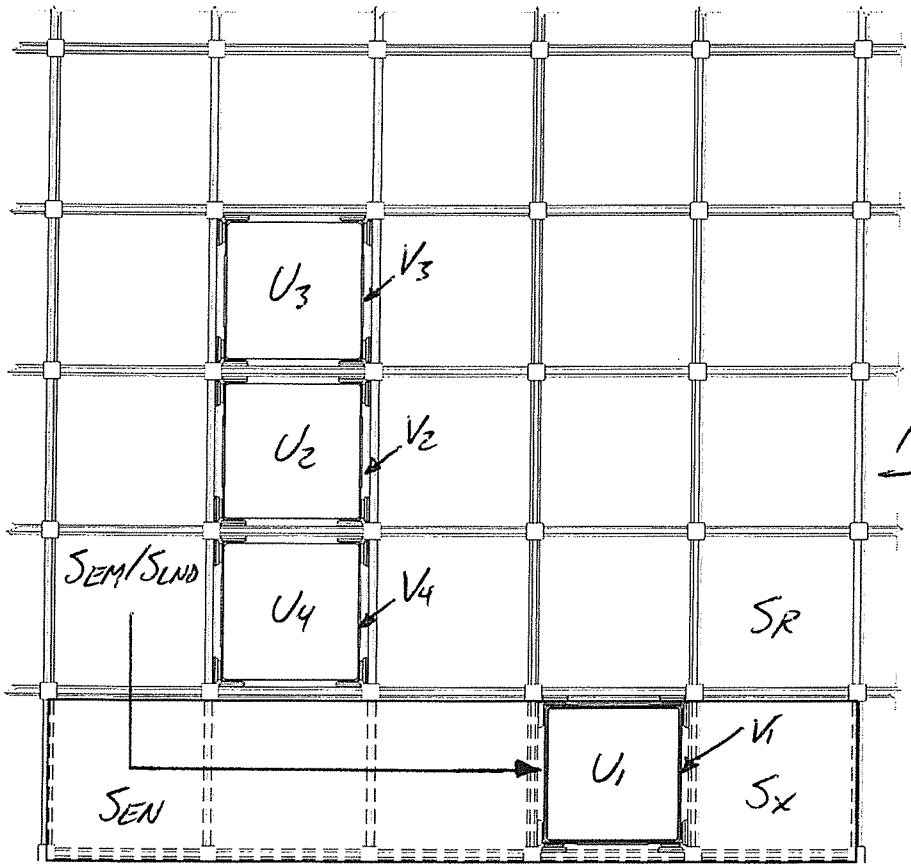

U3
V3
U2
V2
SEM/SLND
U4
V4
SR
U1
V1
SEN
SX

FIG. 7E

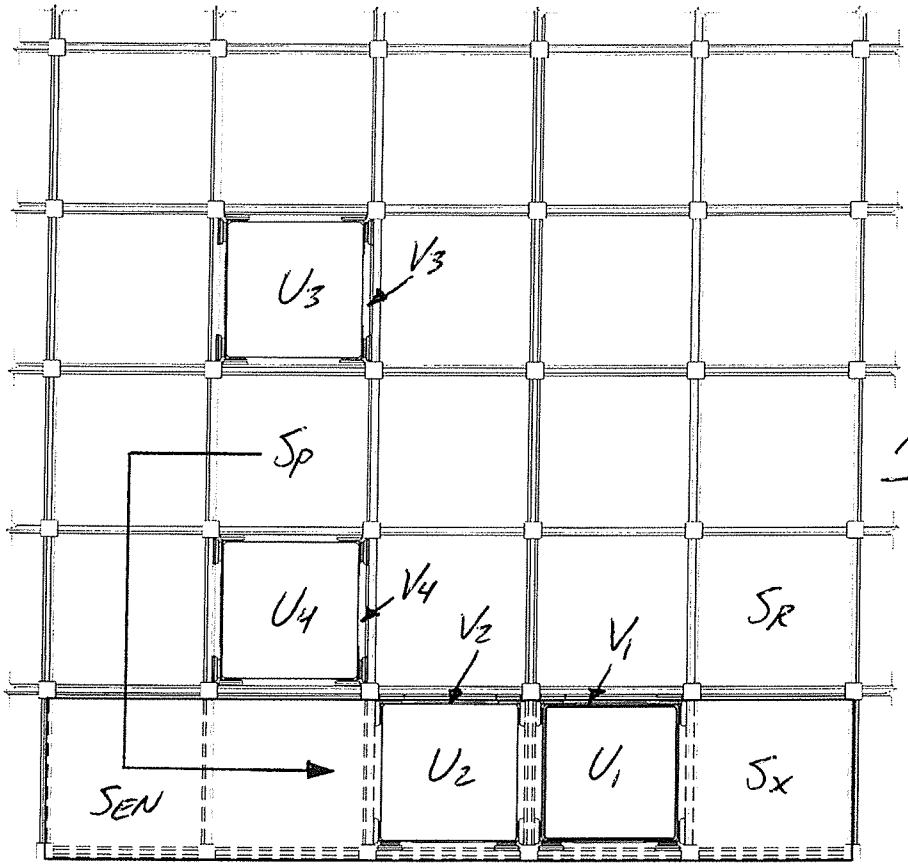

U3
V3
SP
U4
V4
V2
V1
SR
U2
U1
SX
SEN

FIG. 7F

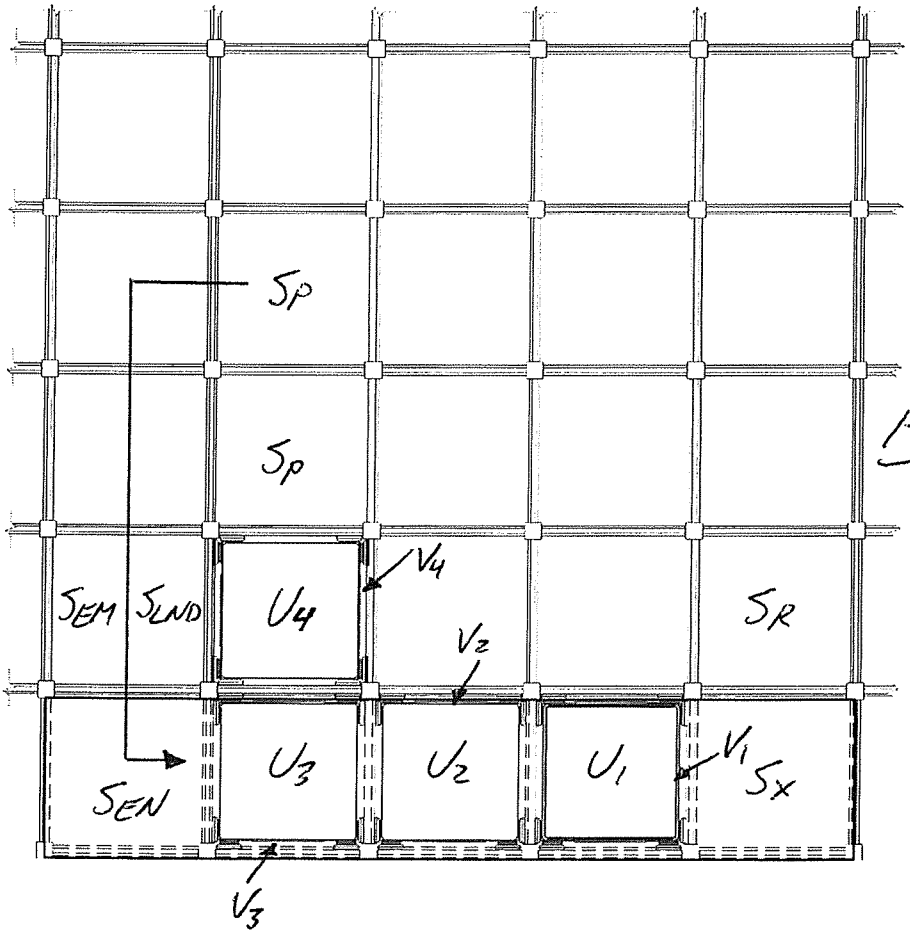

SP
SP
SEM
SLND
U4
V4
V2
SR
U3
U2
U1
V1
SX
SEN
V3

FIG. 7G

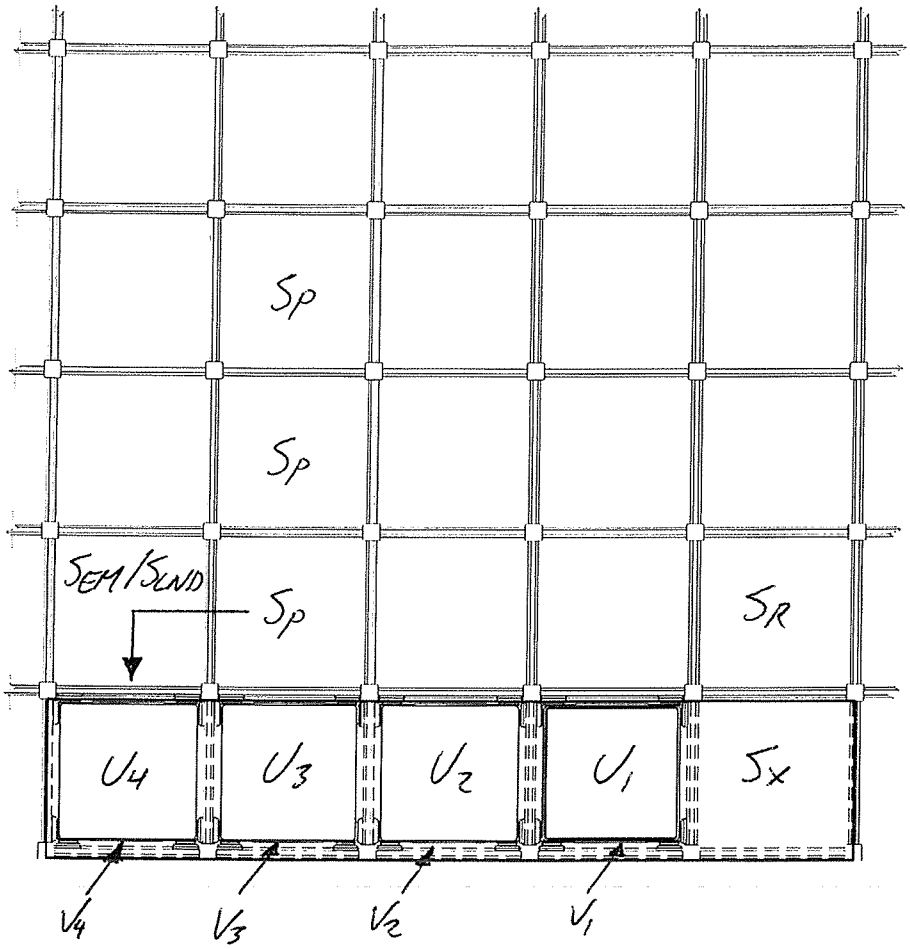


FIG. 7H

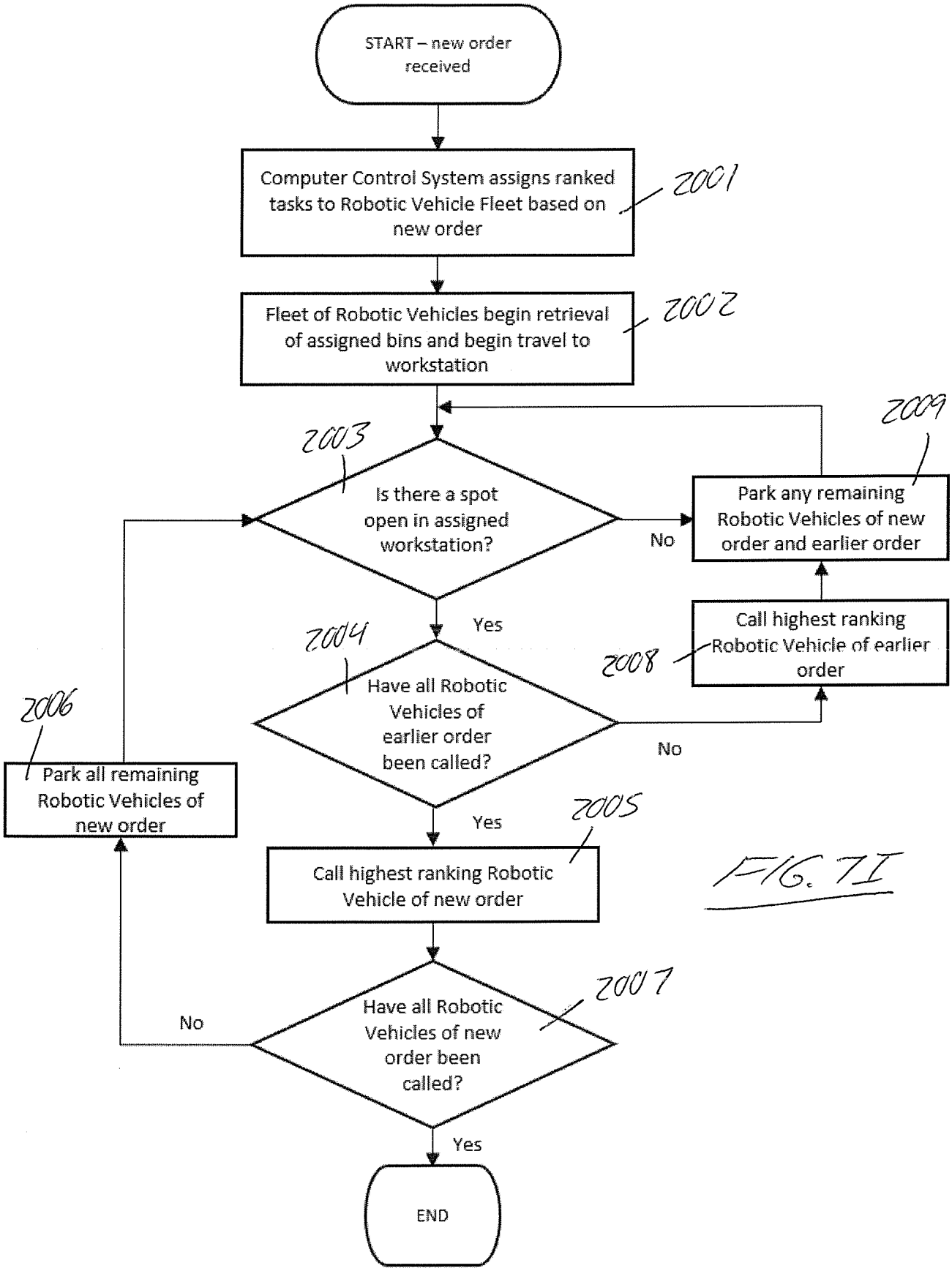

START – new order received
Computer Control System assigns ranked tasks to Robotic Vehicle Fleet based on new order
2001
Fleet of Robotic Vehicles begin retrieval of assigned bins and begin travel to workstation
2002
2003
Is there a spot open in assigned workstation?
No
2009
Park any remaining Robotic Vehicles of new order and earlier order
Yes
2004
Have all Robotic Vehicles of earlier order been called?
2008
Call highest ranking Robotic Vehicle of earlier order
No
2006
Park all remaining Robotic Vehicles of new order
Yes
2005
Call highest ranking Robotic Vehicle of new order
2007
Have all Robotic Vehicles of new order been called?
No
Yes
END

FIG. 7I

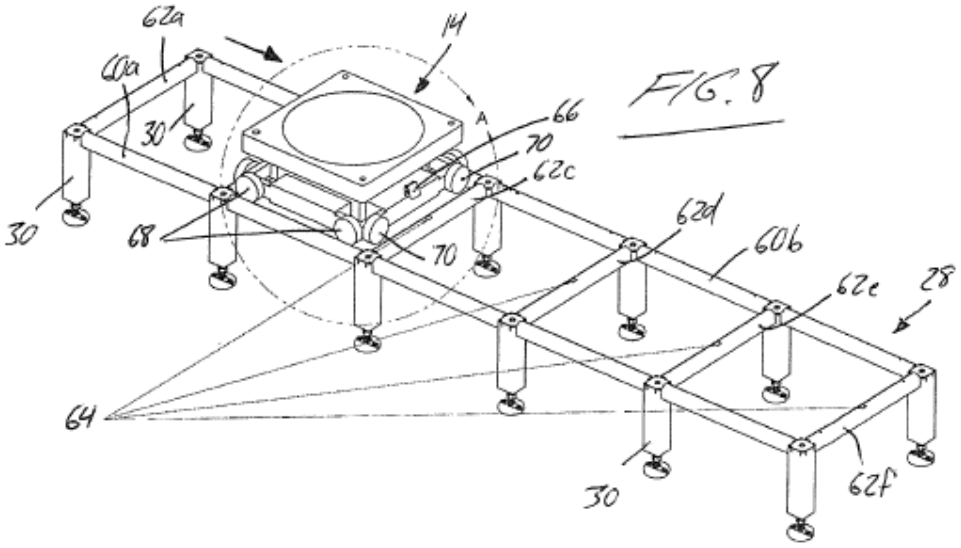

62a
14
60a
30
66
70
62c
62d
60b
62e
28
30
68
70
64
30
62f

FIG. 8

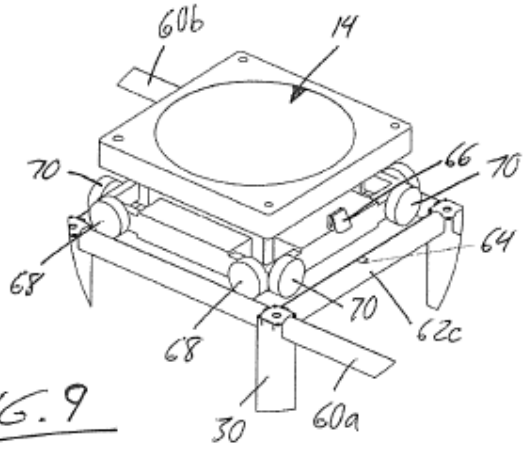
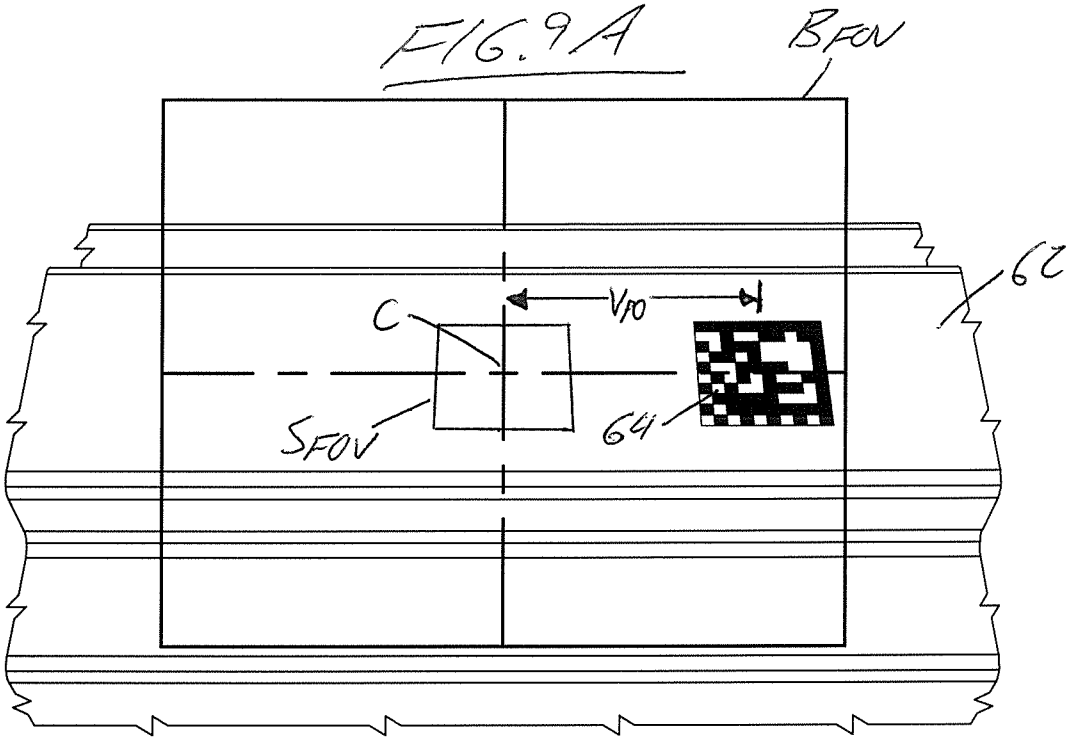

60b
14
70
66
70
64
68
70
62c
68
30
60a

FIG. 9

FIG. 9A



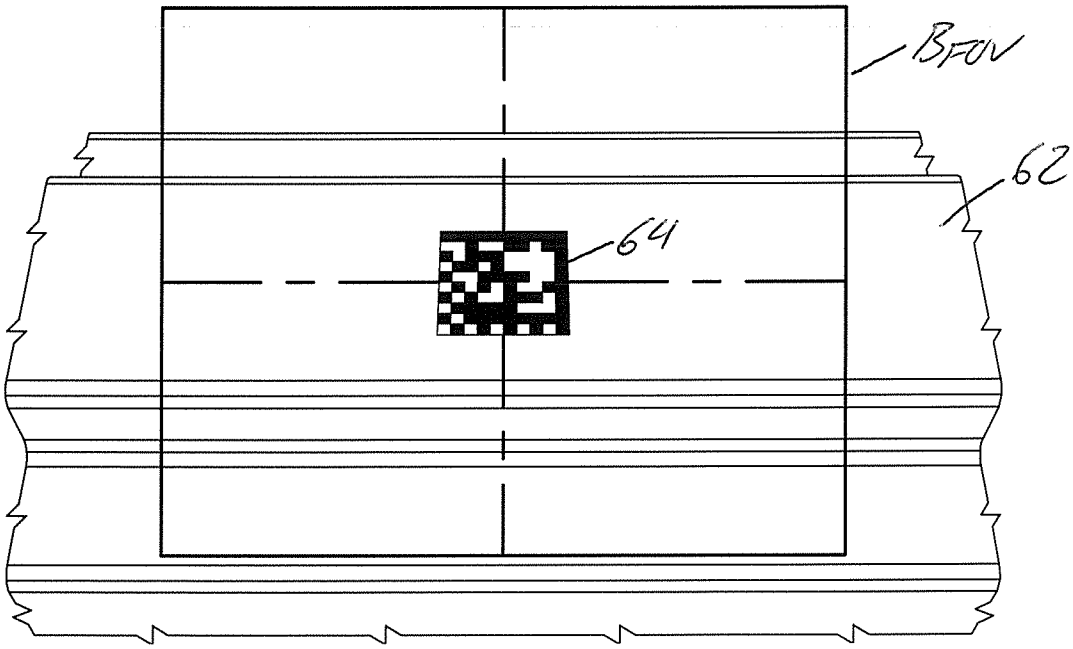


FIG. 9B

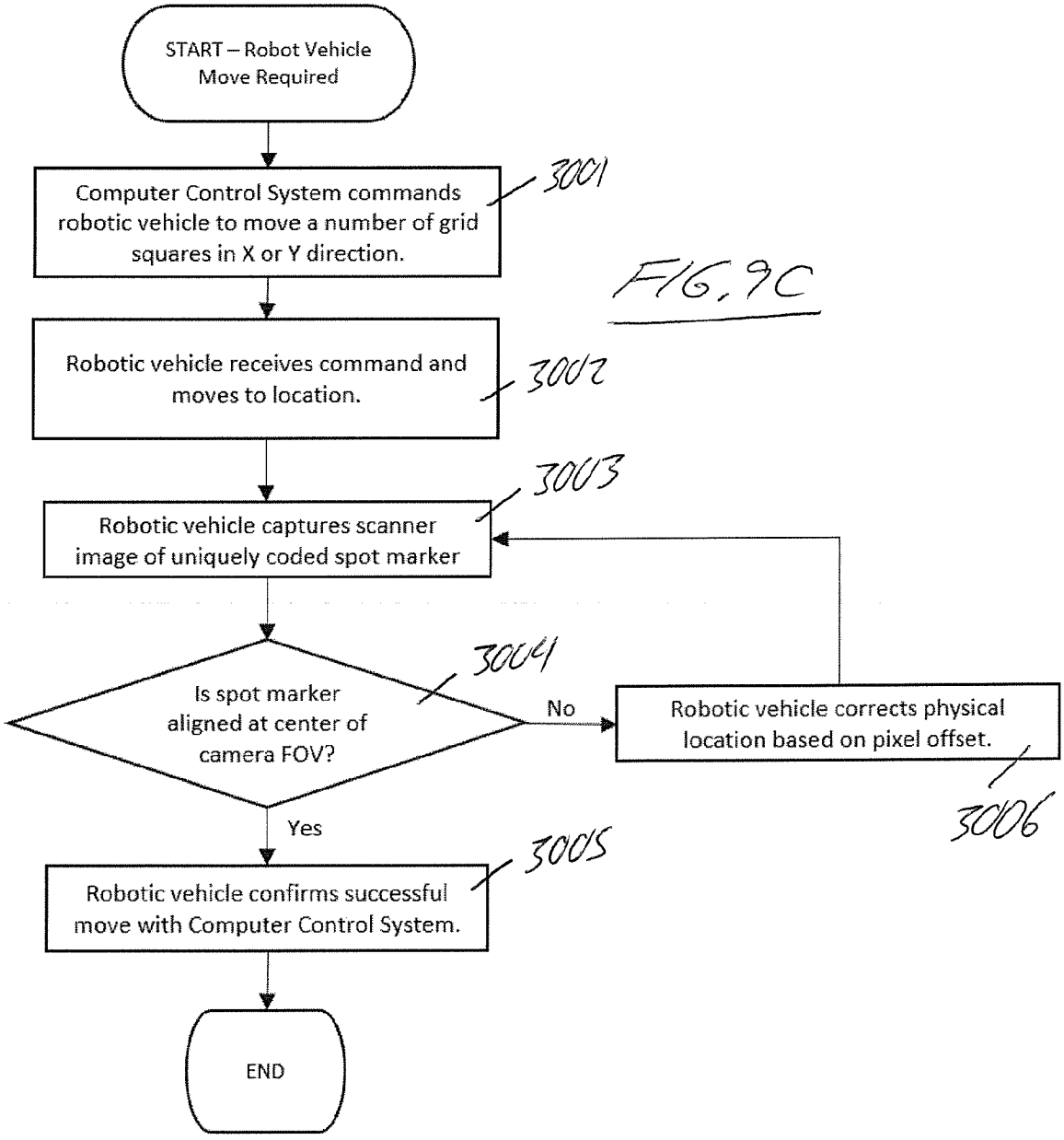

START – Robot Vehicle Move Required
Computer Control System commands robotic vehicle to move a number of grid squares in X or Y direction.
3001
Robotic vehicle receives command and moves to location.
3002
Robotic vehicle captures scanner image of uniquely coded spot marker
3003
Is spot marker aligned at center of camera FOV?
3004
No
Robotic vehicle corrects physical location based on pixel offset.
3006
Yes
Robotic vehicle confirms successful move with Computer Control System.
3005
END

FIG. 9C

FIG.10

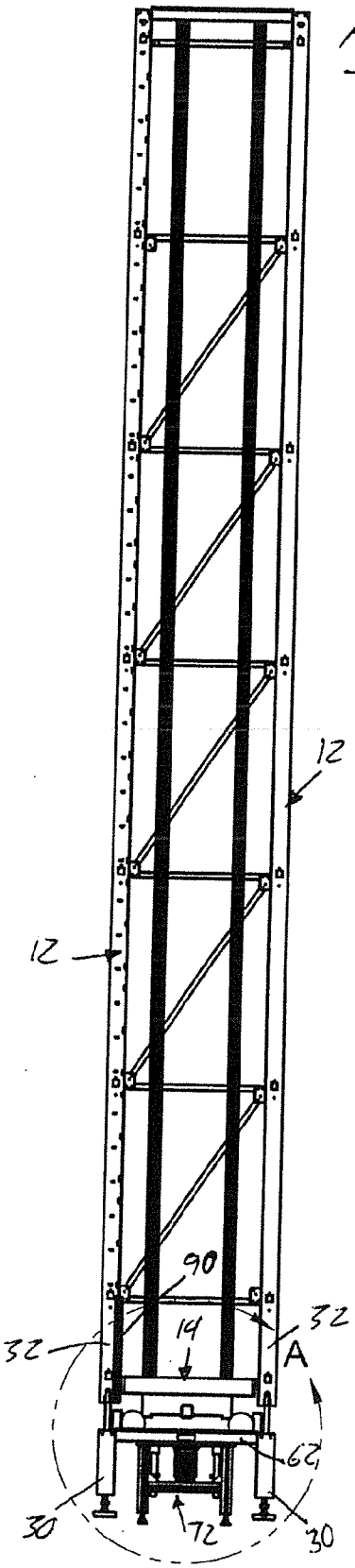
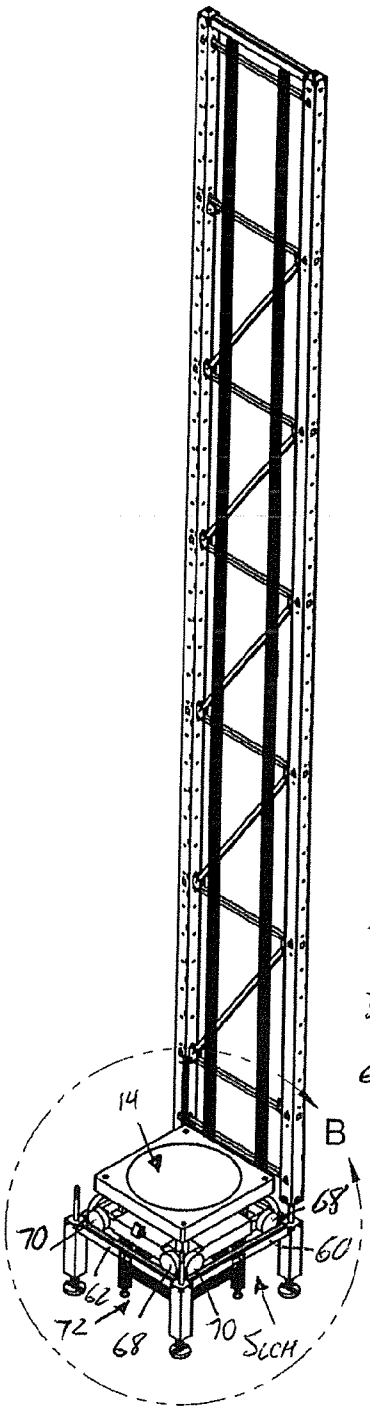


FIG.11



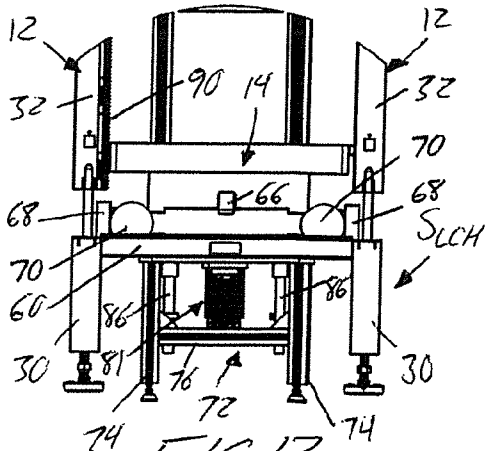


FIG.12

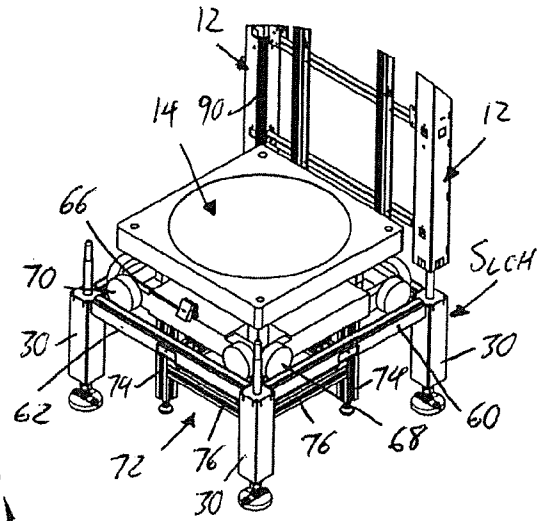


FIG.13

FIG.14

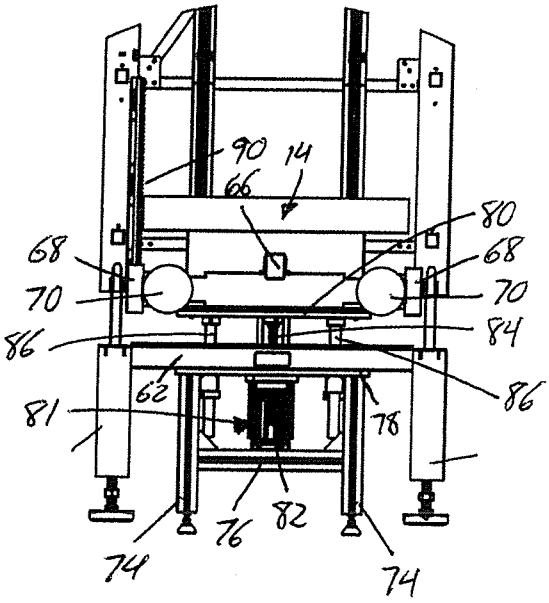


FIG.15

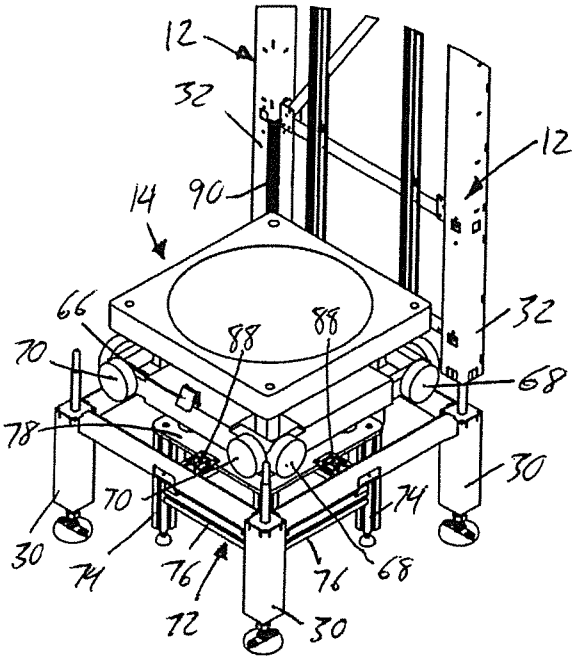


FIG.16

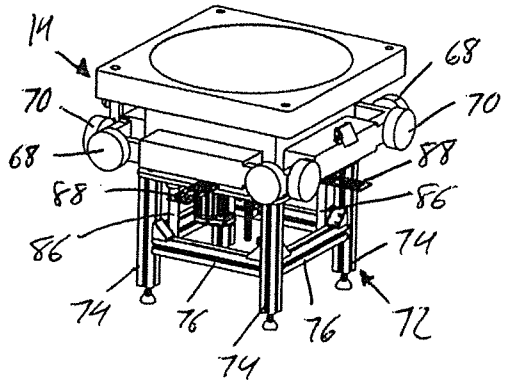
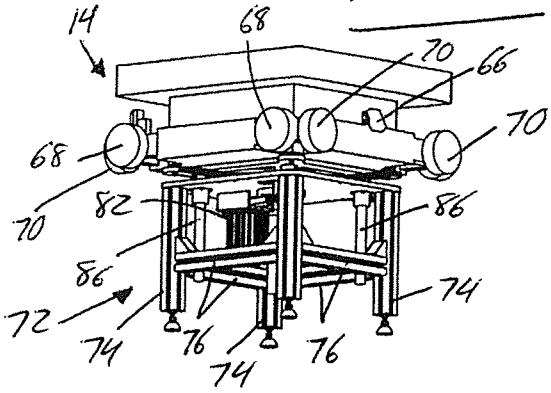


FIG.17



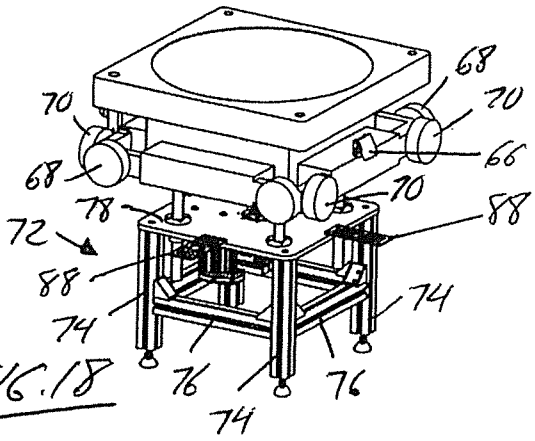


FIG.18

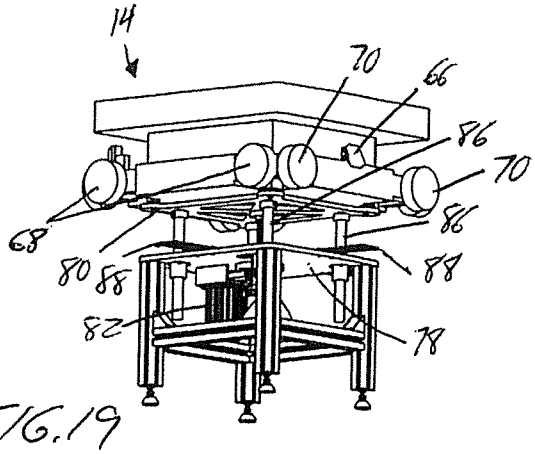


FIG.19

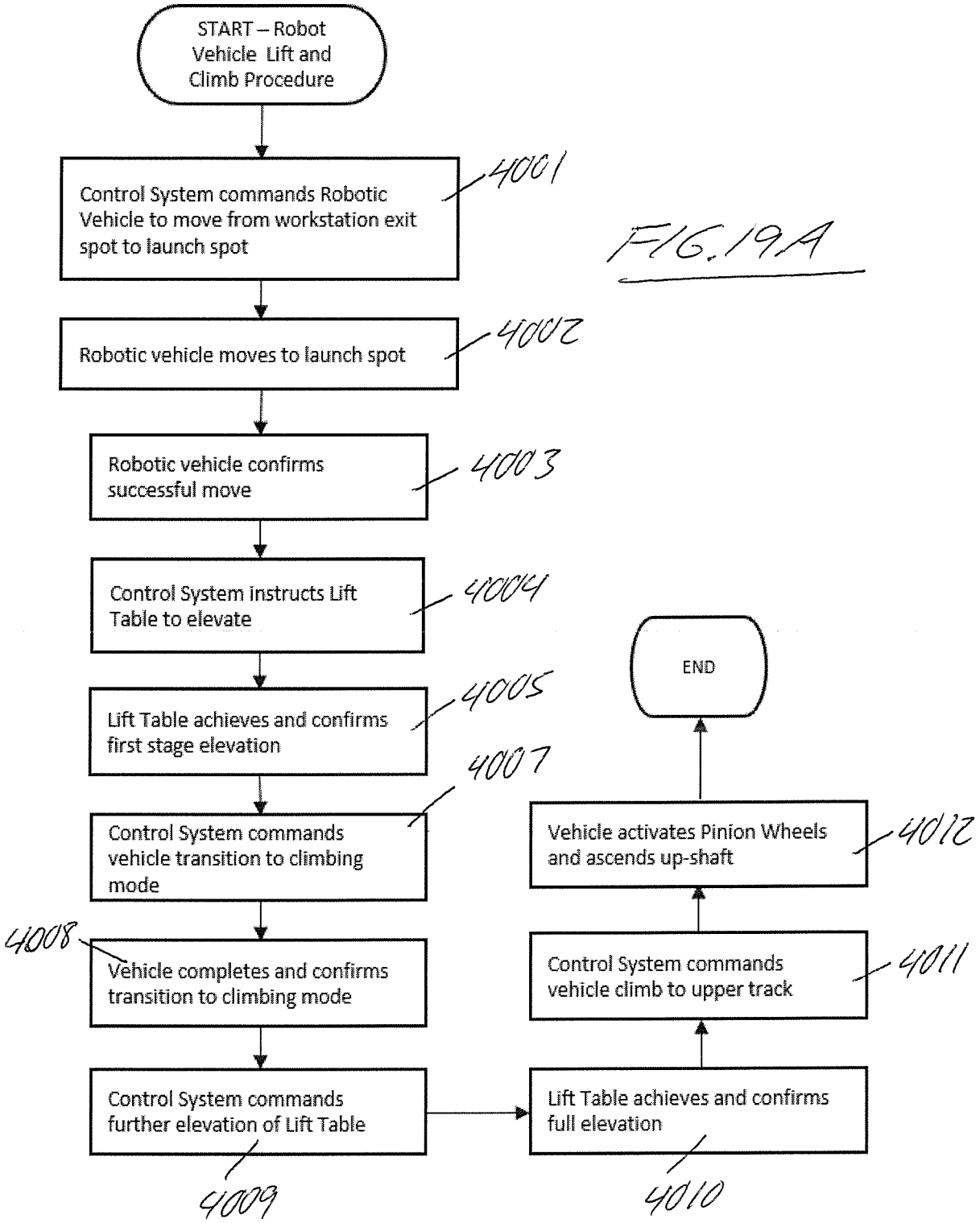

START – Robot Vehicle Lift and Climb Procedure
Control System commands Robotic Vehicle to move from workstation exit spot to launch spot
4001
Robotic vehicle moves to launch spot
4002
Robotic vehicle confirms successful move
4003
Control System instructs Lift Table to elevate
4004
Lift Table achieves and confirms first stage elevation
4005
Control System commands vehicle transition to climbing mode
4007
Vehicle completes and confirms transition to climbing mode
4008
Control System commands further elevation of Lift Table
4009
Lift Table achieves and confirms full elevation
4010
Control System commands vehicle climb to upper track
4011
Vehicle activates Pinion Wheels and ascends up-shaft
4012
END

FIG. 19A

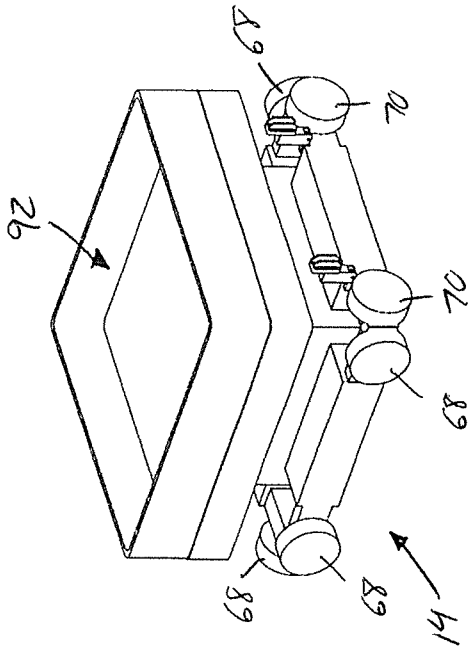


FIG. 21

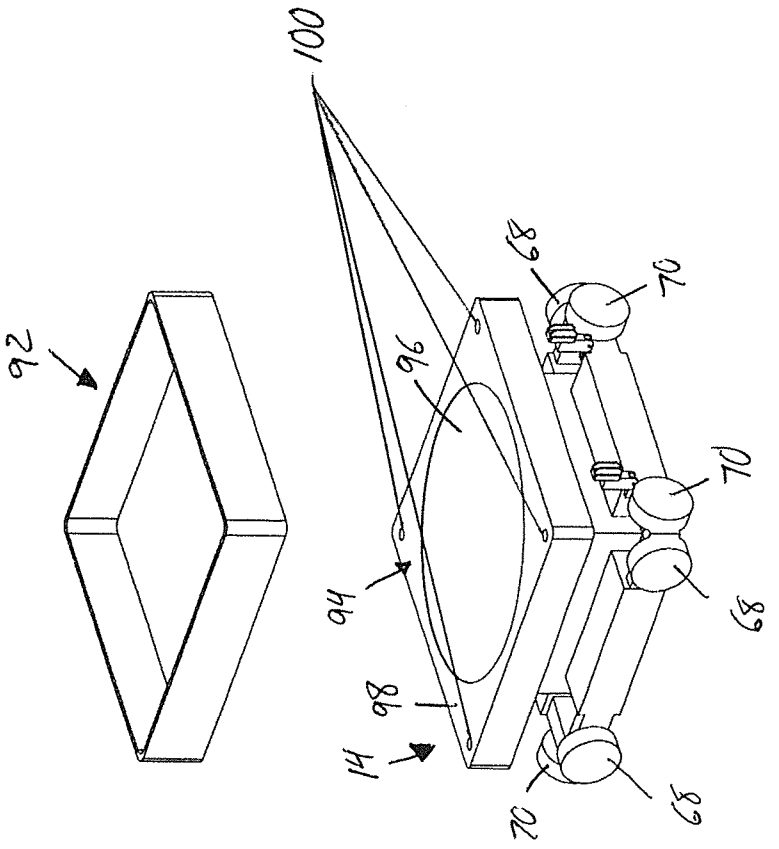


FIG. 20

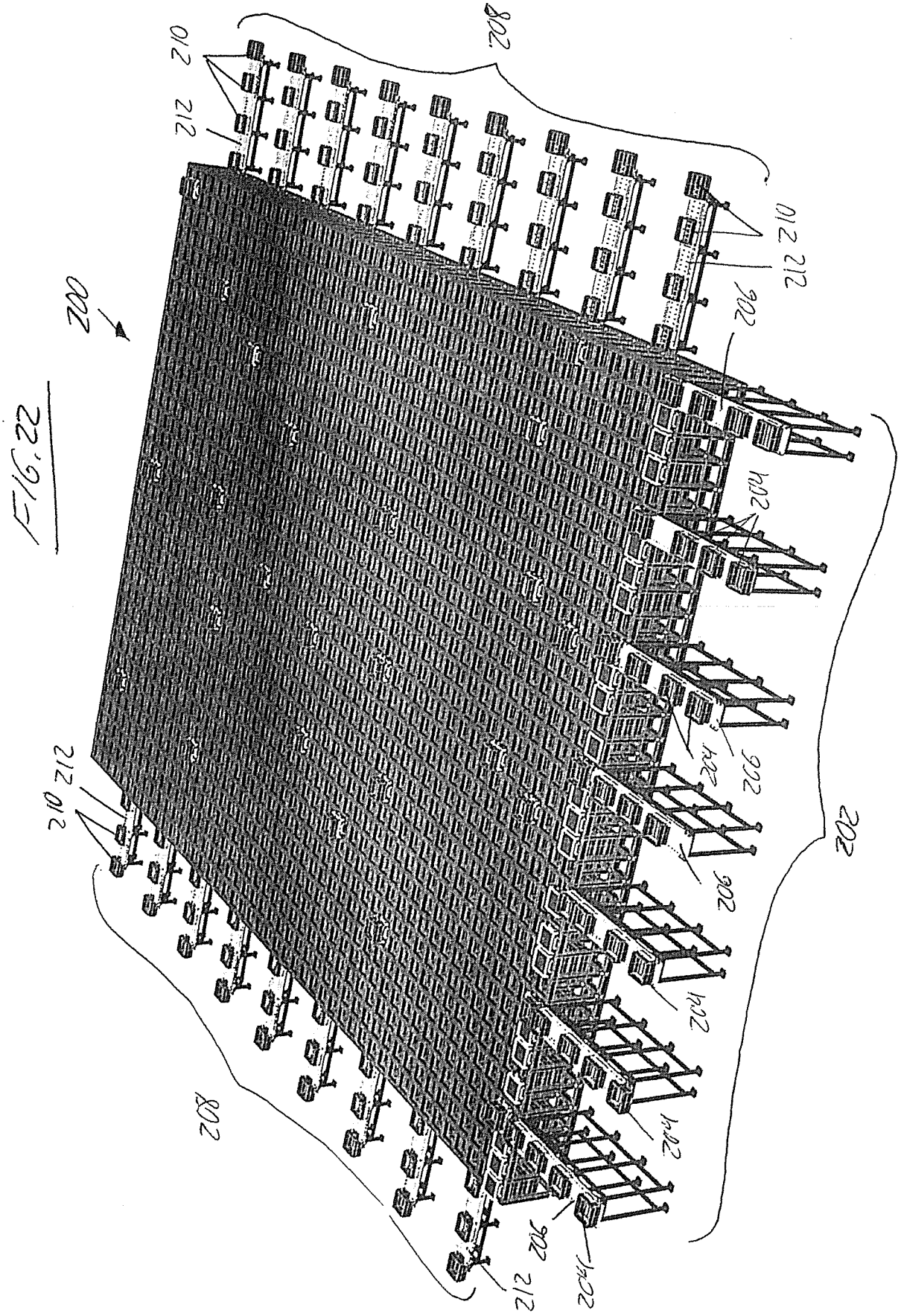


FIG. 22

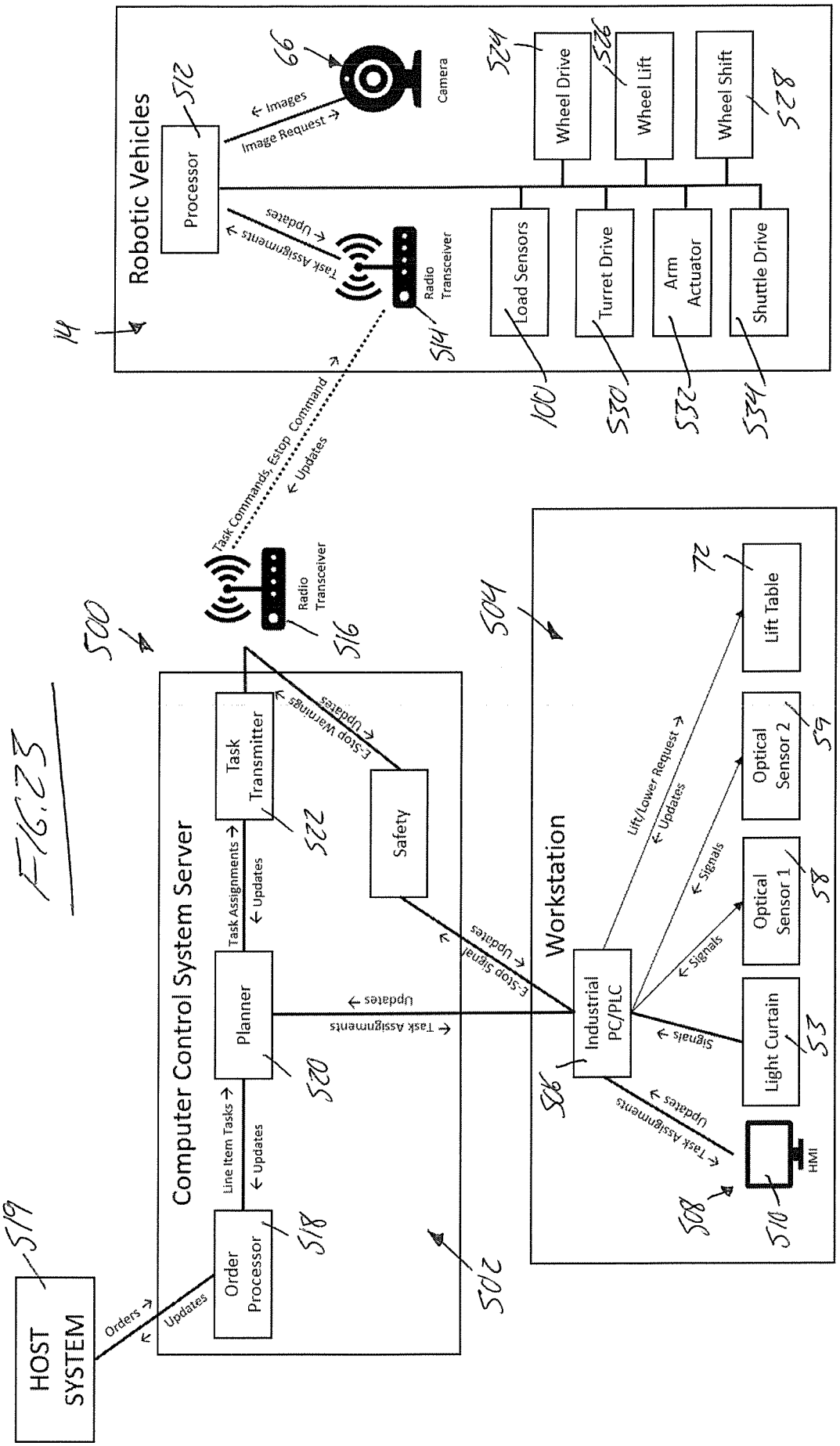

HOST SYSTEM
519
Orders
Updates
Computer Control System Server
Order Processor
518
Line Item Tasks
Updates
Planner
520
Task Assignments
Updates
Task Transmitter
522
E-Stop Warnings
Updates
Safety
E-Stop Signal
Updates
502
500
Task Commands, Estop Command
Updates
Radio Transceiver
516
Workstation
504
Industrial PC/PLC
506
Lift/Lower Request
Updates
Lift Table
72
Signals
Optical Sensor 2
59
Signals
Optical Sensor 1
58
Signals
Light Curtain
53
Task Assignments
Updates
HMI
508
510
Robotic Vehicles
14
Processor
512
Images
Image Request
Camera
66
Task Assignments
Updates
Radio Transceiver
514
Load Sensors
100
Turret Drive
530
Arm Actuator
532
Shuttle Drive
534
Wheel Drive
524
Wheel Lift
526
Wheel Shift
528

FIG. 23