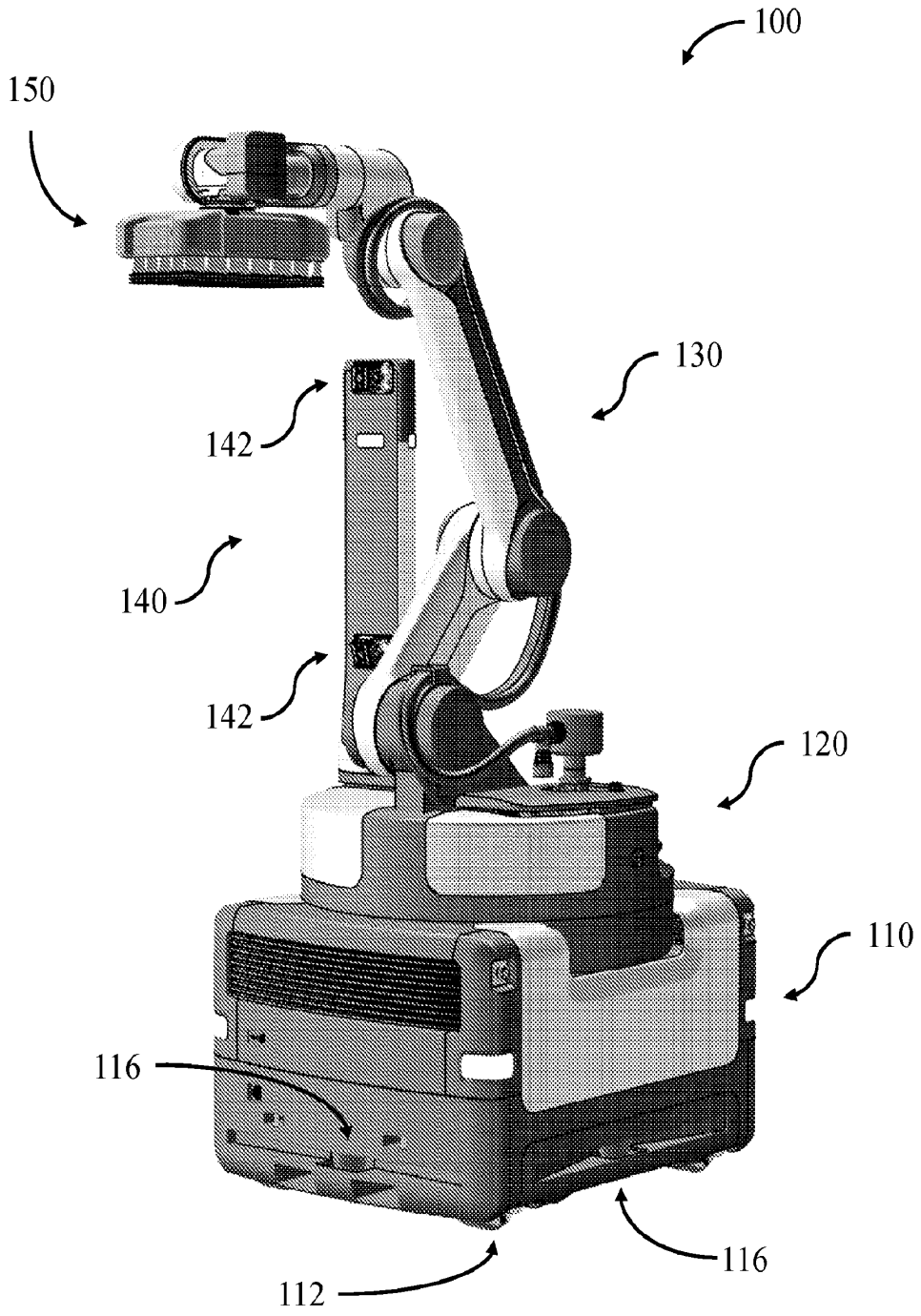


FIG. 1A

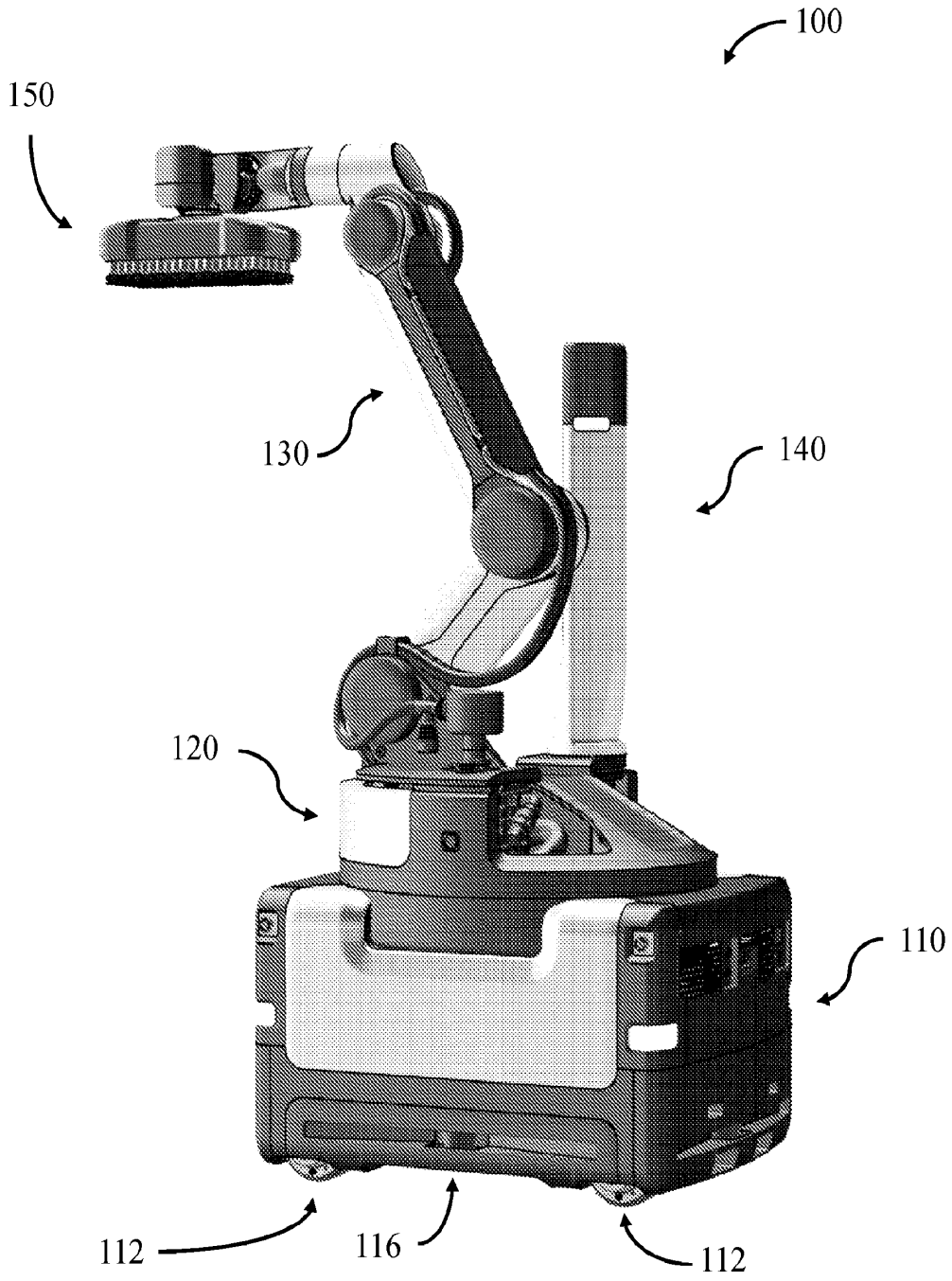


FIG. 1B

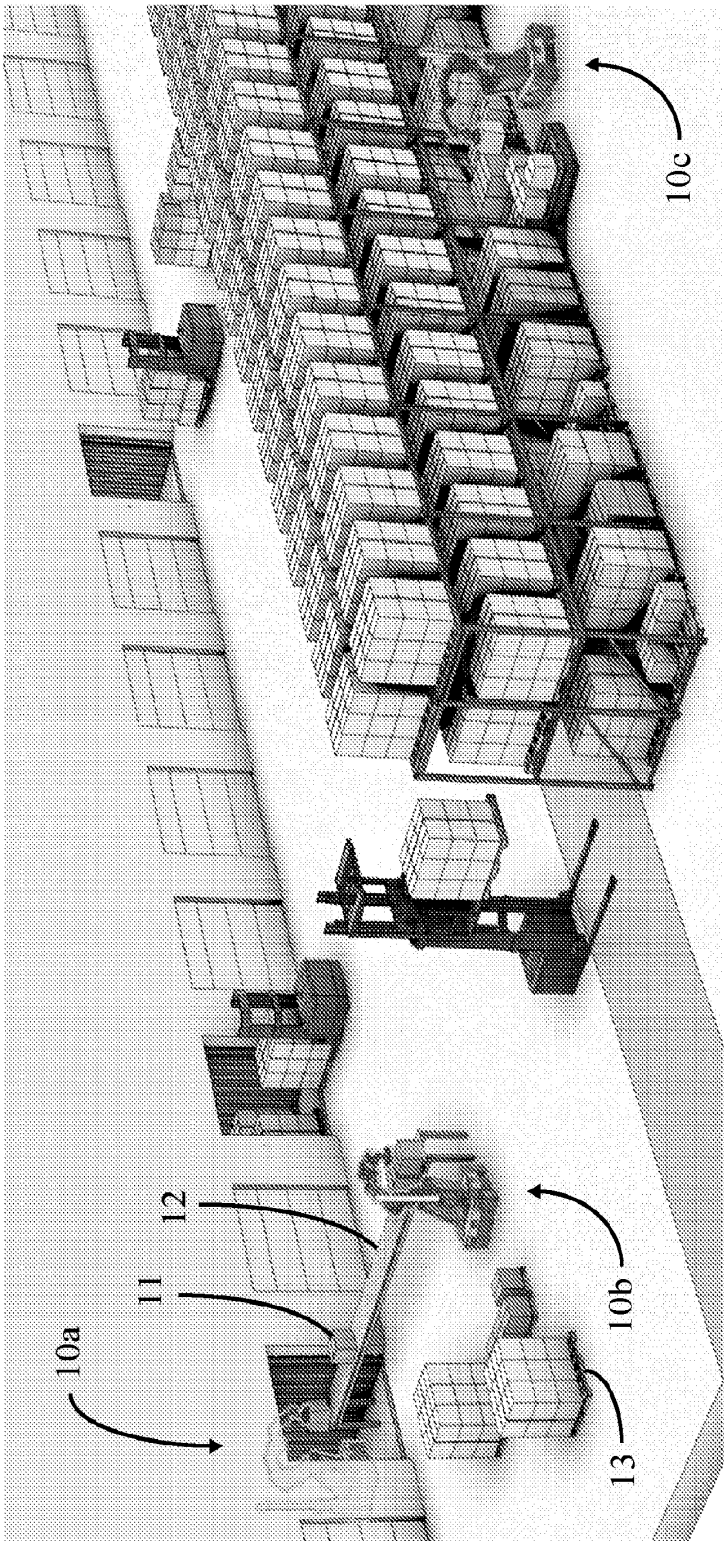


FIG. 2A

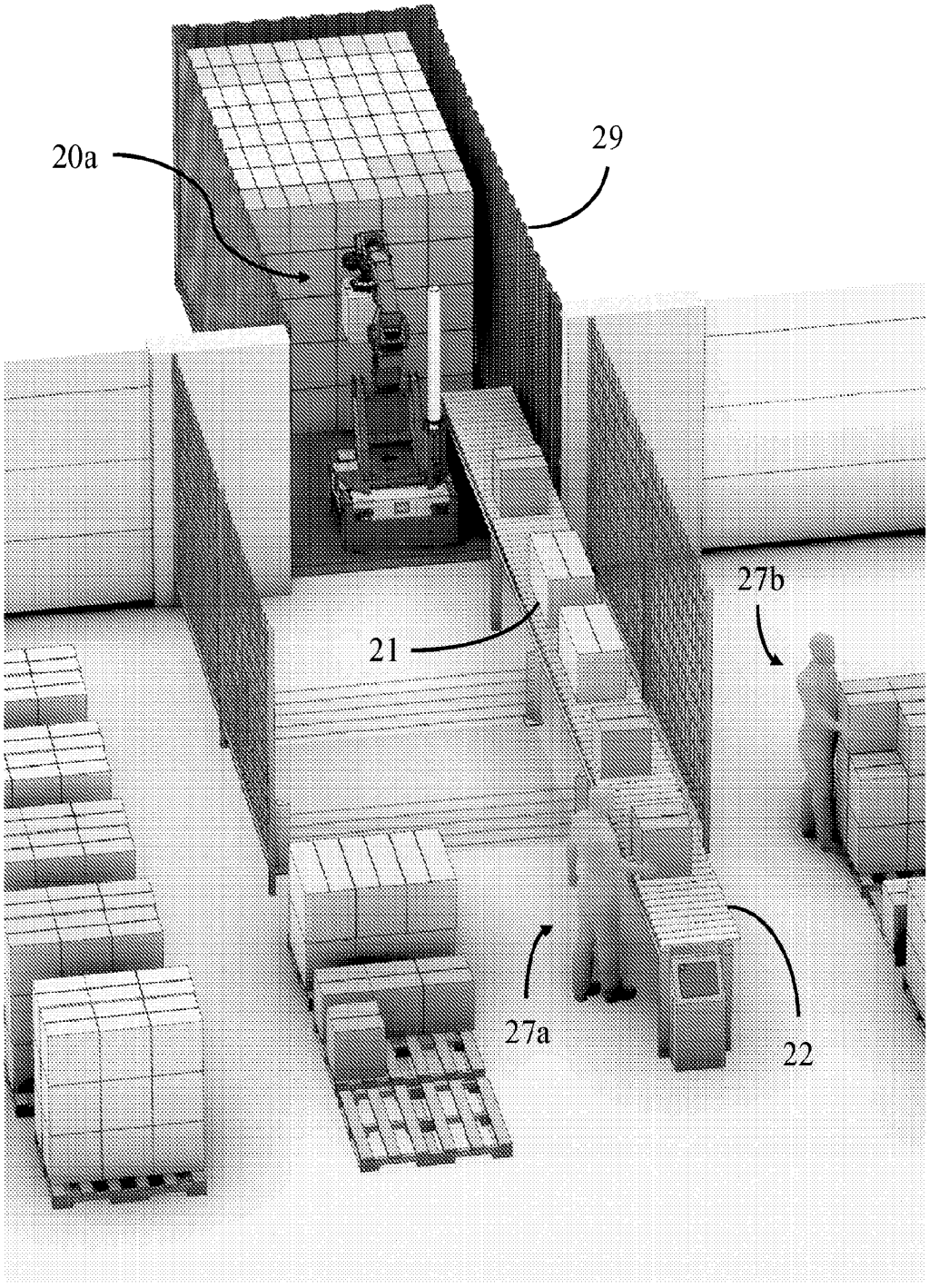


FIG. 2B

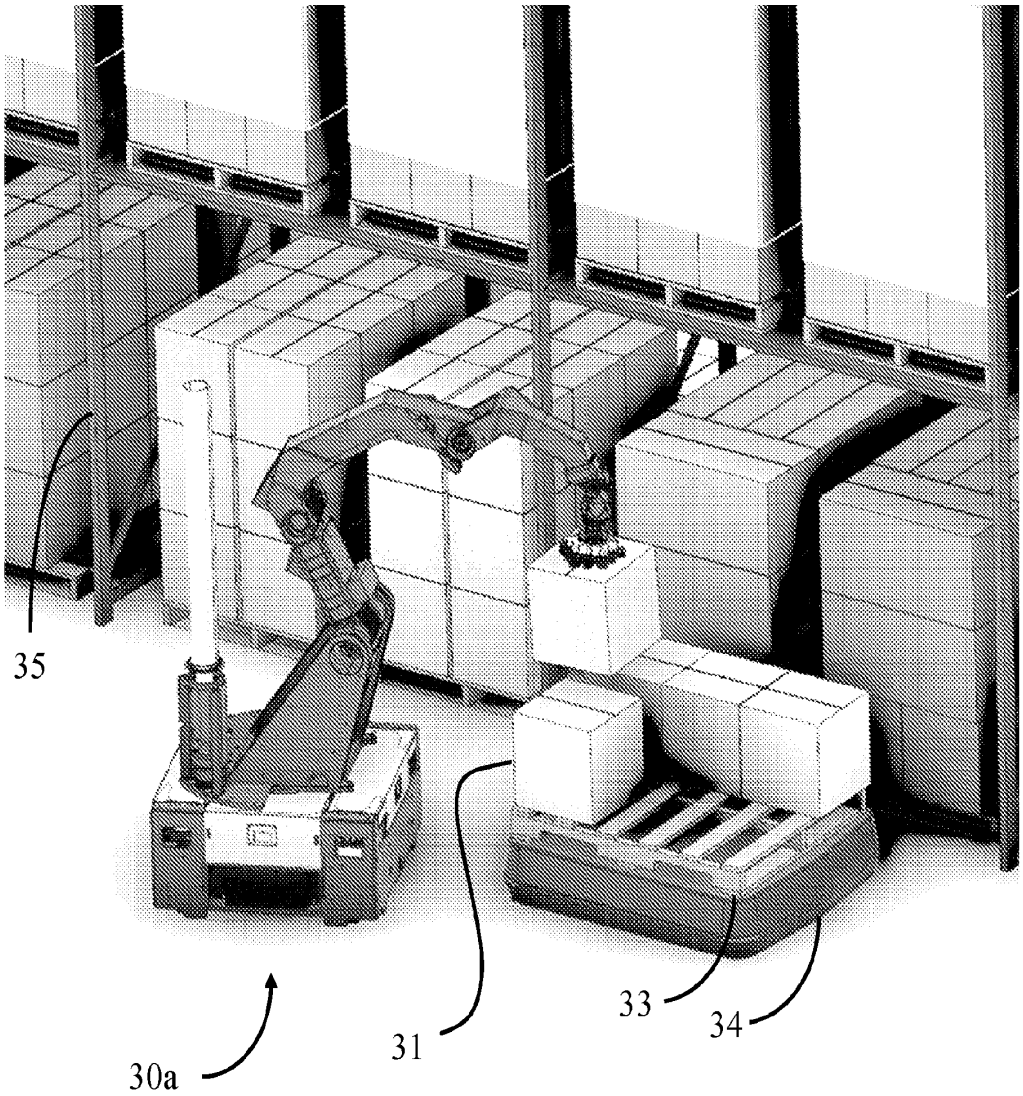


FIG. 2C

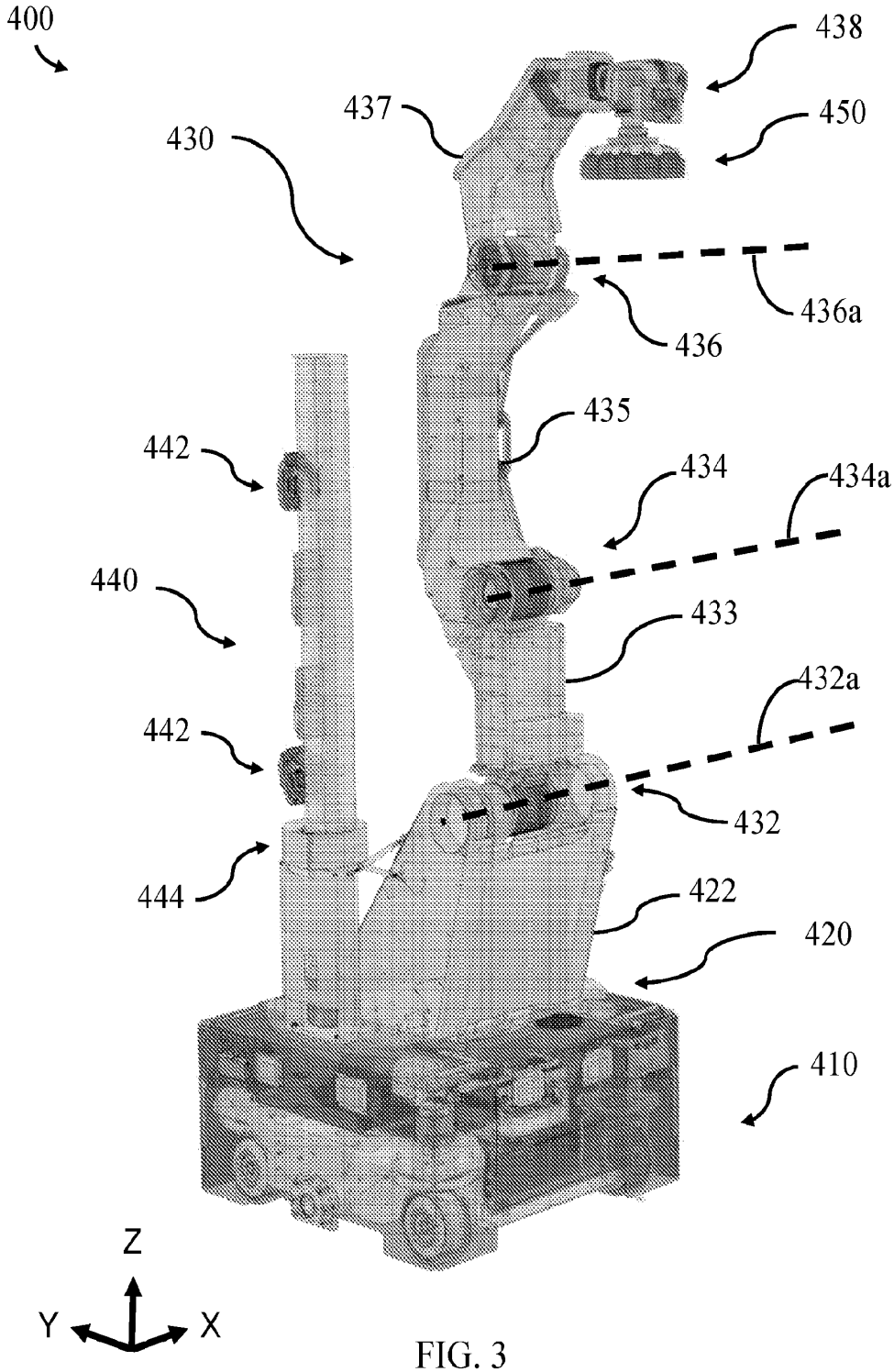

400
438
437
450
430
436a
436
435
442
434
434a
440
433
432a
442
432
444
422
420
410
Z
Y
X

FIG. 3

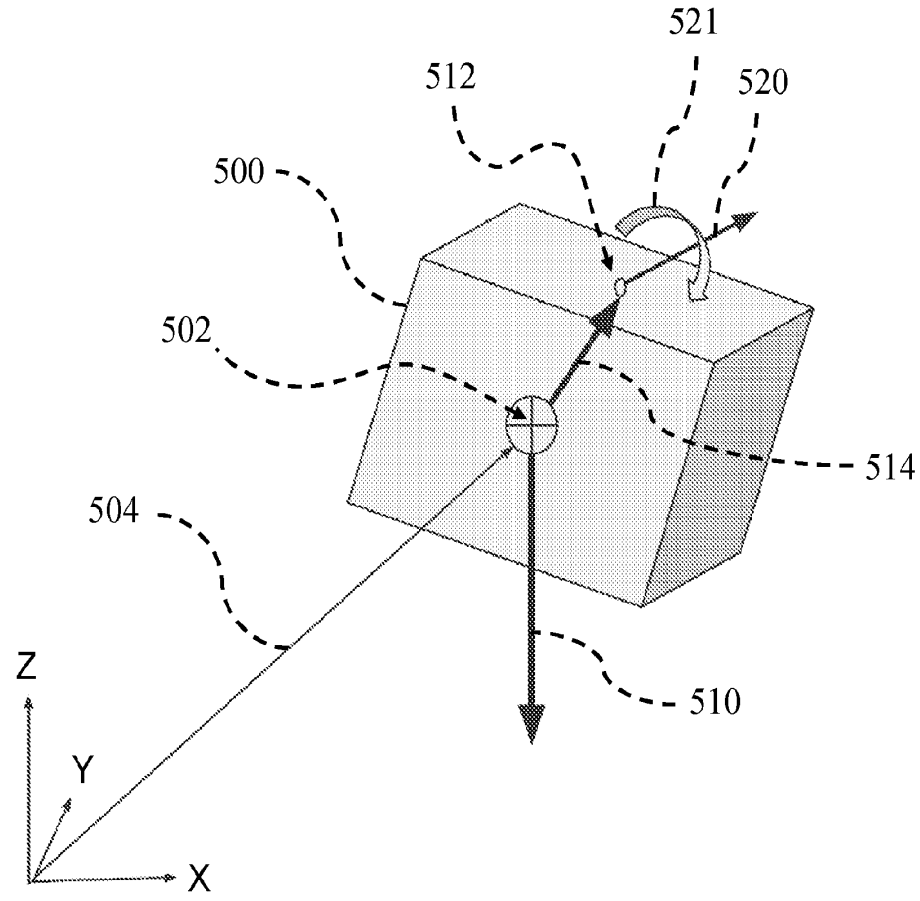

521
512
520
500
502
514
504
510
Z
Y
X

FIG. 4A

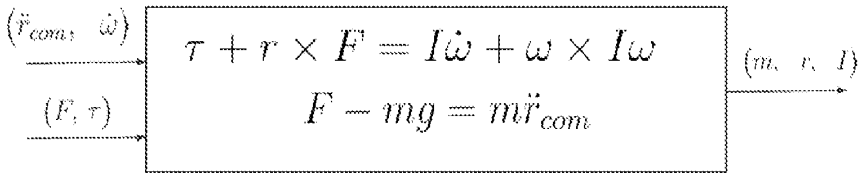

$(\ddot{r}_{com},\ \dot{\omega})$
$(F,\ \tau)$
$\tau + r \times F = I\dot{\omega} + \omega \times I\omega$
$F - mg = m\ddot{r}_{com}$
$(m,\ r,\ I)$

FIG. 4B

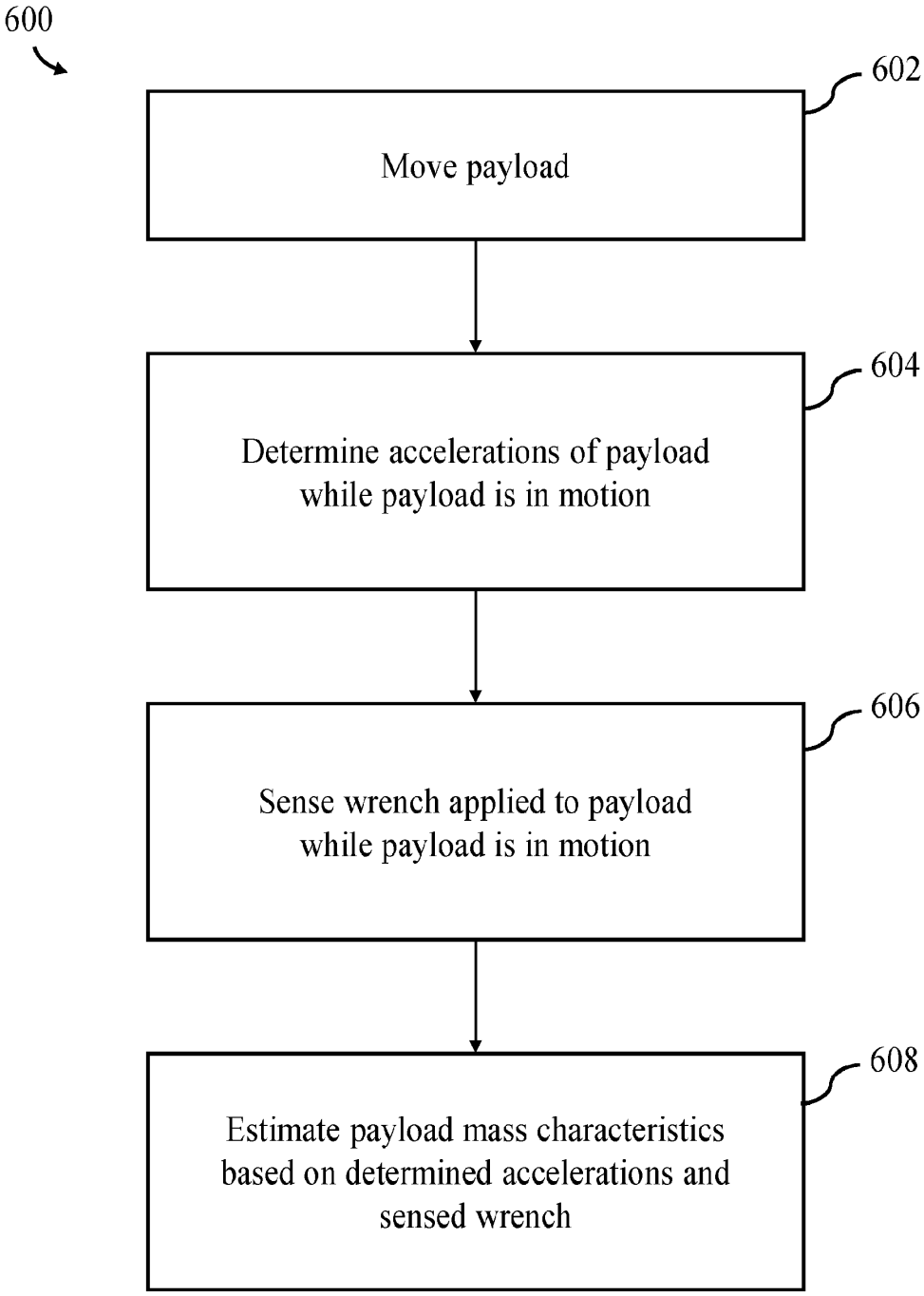

600
602
Move payload
604
Determine accelerations of payload while payload is in motion
606
Sense wrench applied to payload while payload is in motion
608
Estimate payload mass characteristics based on determined accelerations and sensed wrench

FIG. 5

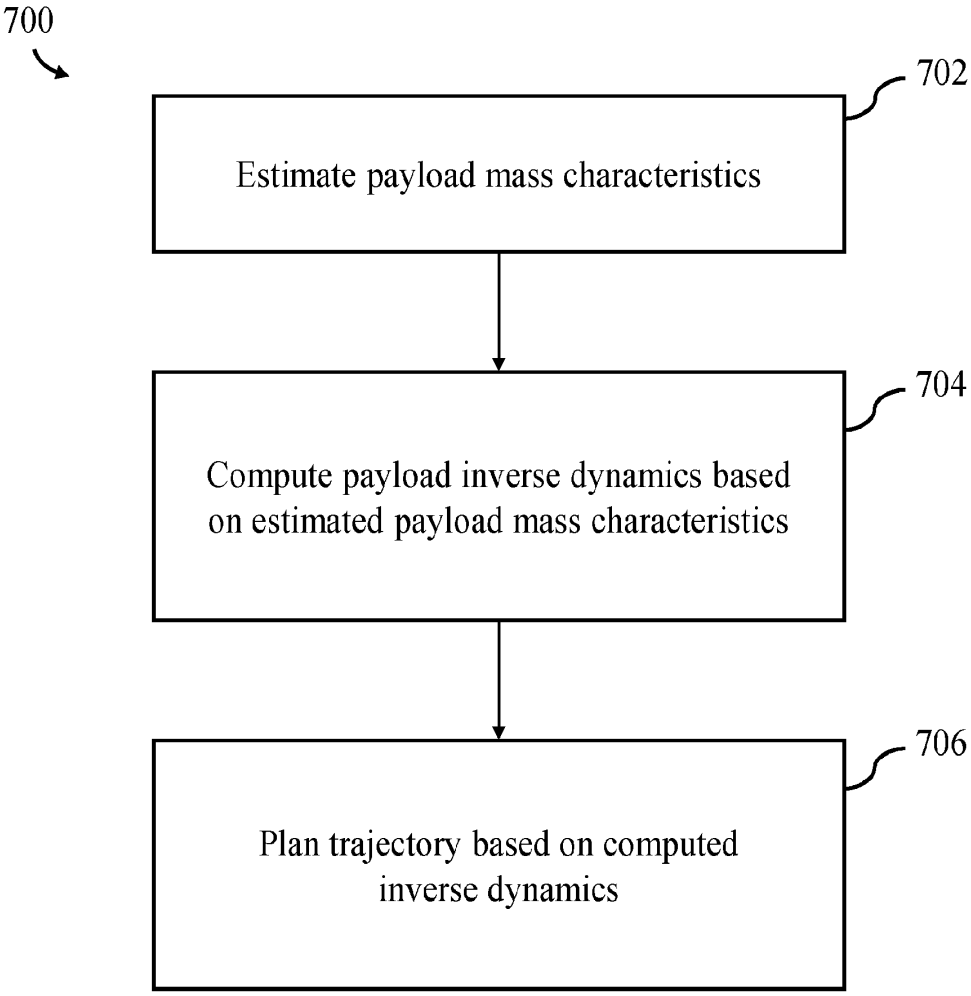

700
702
Estimate payload mass characteristics
704
Compute payload inverse dynamics based on estimated payload mass characteristics
706
Plan trajectory based on computed inverse dynamics

FIG. 6

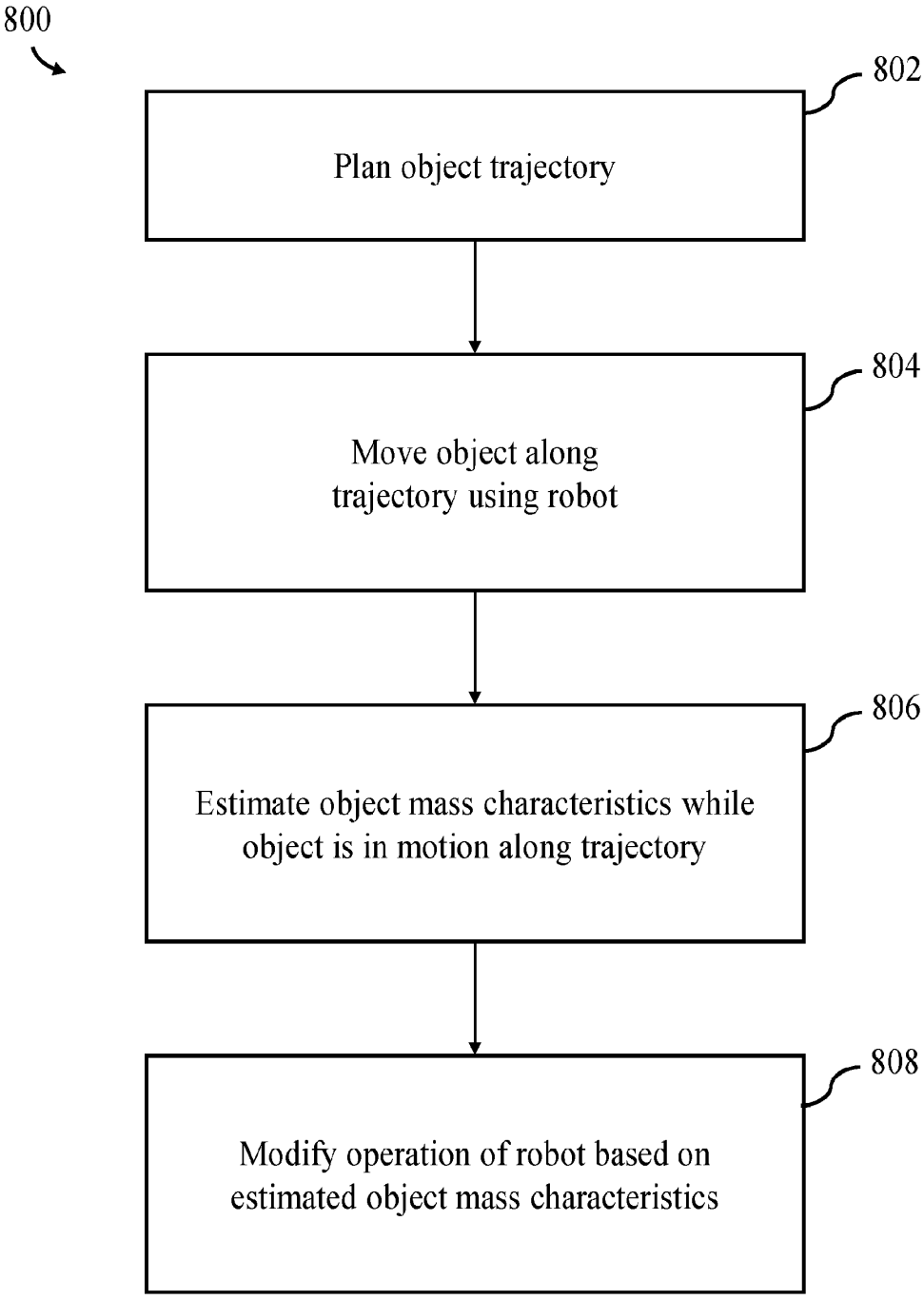

800
802
Plan object trajectory
804
Move object along trajectory using robot
806
Estimate object mass characteristics while object is in motion along trajectory
808
Modify operation of robot based on estimated object mass characteristics

FIG. 7