

IPR2021-00311

Petitioner Ocado Group plc's Demonstrative Exhibits

*U.S. Patent No. 10,474,140
March 28, 2022*

'140 Patent Claims a Robot Used to Access Bins in a Storage Grid

Claim 1(preamble)

"1. A remotely operated vehicle for picking up storage bins from an underlying storage system, comprising:"

Claim 1(a)

"a vehicle lifting device for lifting the storage bin from the underlying storage system,"

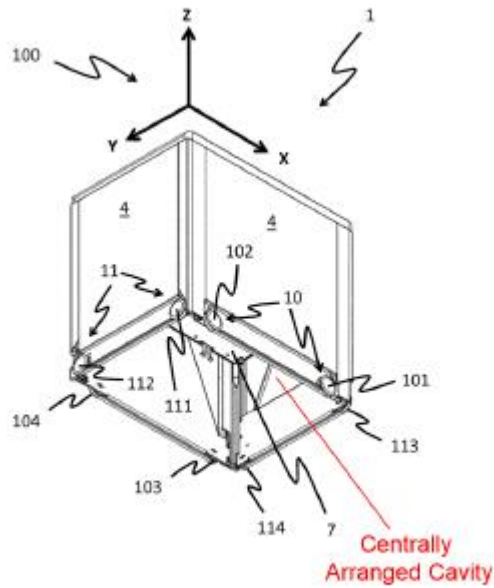


FIG. 3

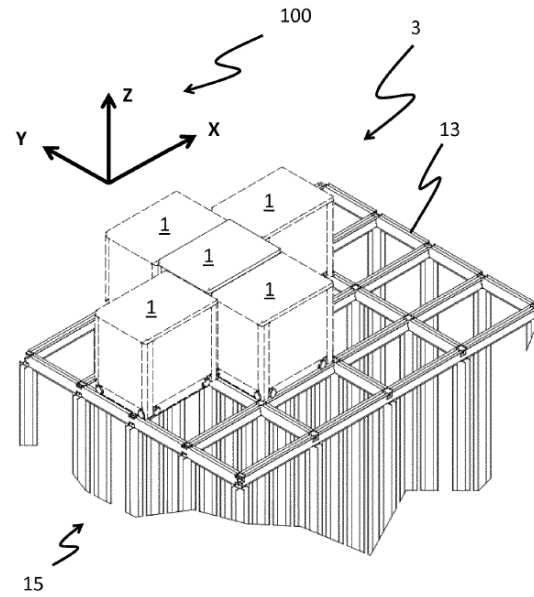


FIG. 5

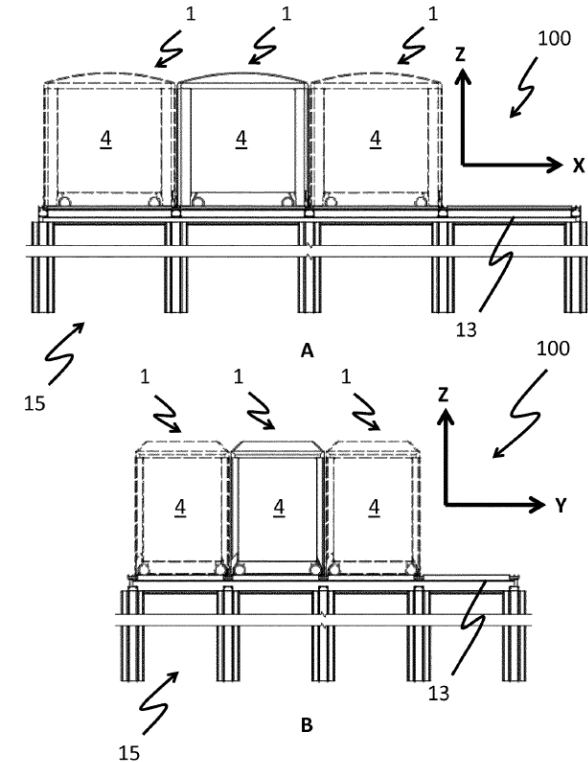
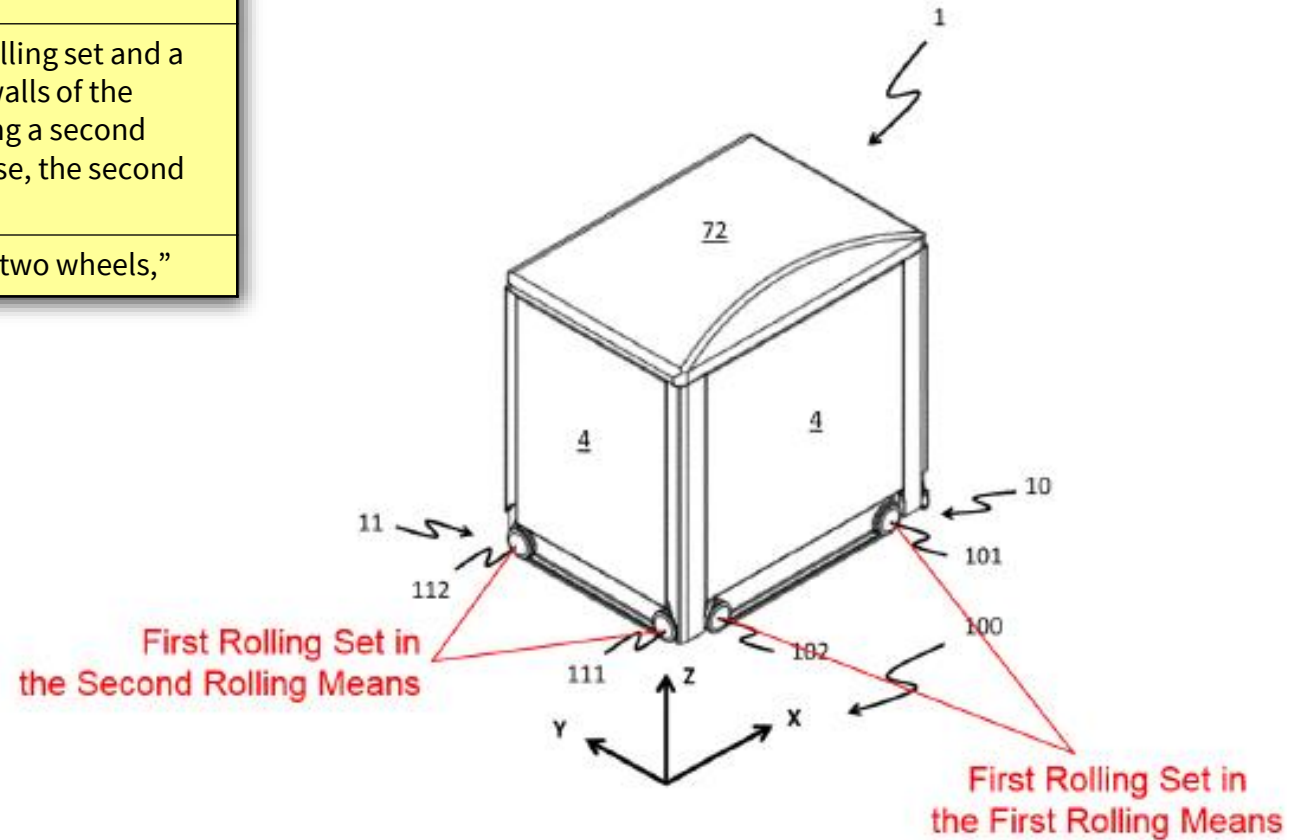


FIG. 6

Robot of '140 Patent Has Two Rolling Means and Four Rolling Sets

Claim 1(b)	“a first vehicle rolling means comprising a first rolling set and a second rolling set arranged at opposite facing side walls of a vehicle body, allowing movement of the vehicle along a first direction on the underlying storage system during use, and”
Claim 1(c)	“a second vehicle rolling means comprising a first rolling set and a second rolling set arranged at opposite facing side walls of the vehicle body, allowing movement of the vehicle along a second direction on the underlying storage system during use, the second direction being perpendicular to the first direction,”
Claim 1(d)	“wherein each of said rolling sets comprises at least two wheels,”



Robot of '140 Patent Has In-Wheel Motors Configured to Provide a Rolling Set Specific Driving Force and Motor Control Electronics

Claim 1(e)	“wherein the vehicle further comprises: a first driving means situated at or at least partly within the first vehicle rolling means for providing rolling set specific driving force to the vehicle in the first direction,”
Claim 1(f)	“a second driving means situated at or at least partly within the second vehicle rolling means for providing rolling set specific driving force to the vehicle in the second direction and”
Claim 1(g)	“motor control electronics arranged within the volume between two of the wheels of each rolling set, which motor control electronics are configured to supply electric power to the first and second vehicle rolling means.”

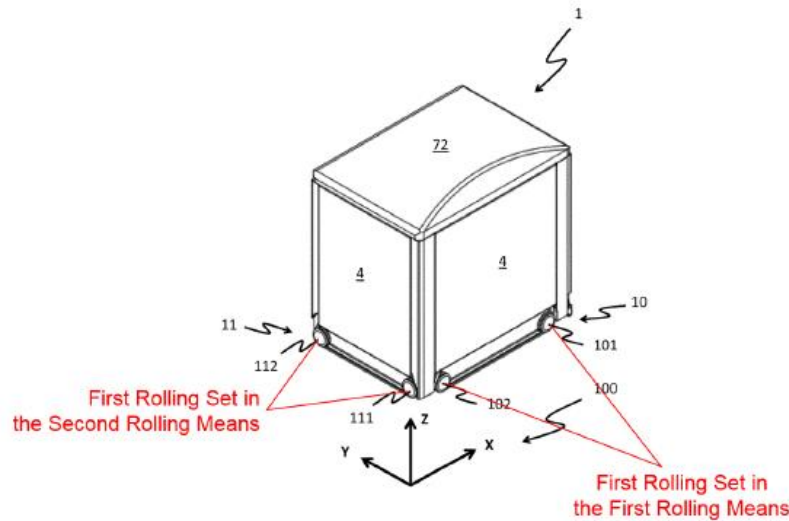


FIG. 2

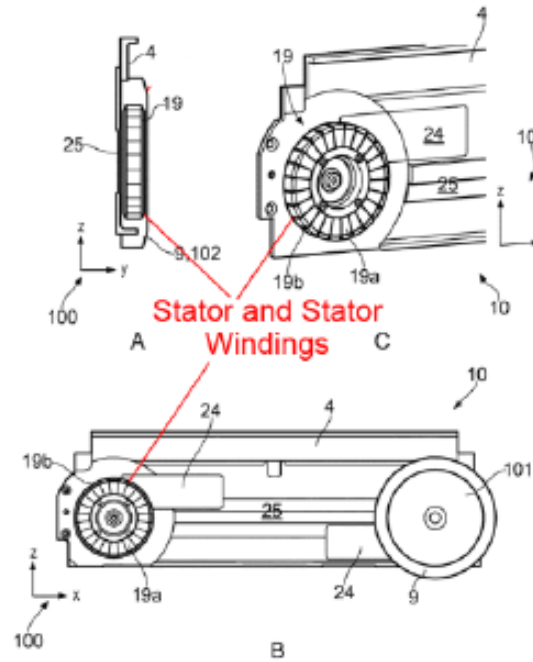


FIG. 9

Claims 2-4 and 11-14 are directed to an “outer rotation” in-wheel motor, with rotor magnets outside the stator/stator windings.

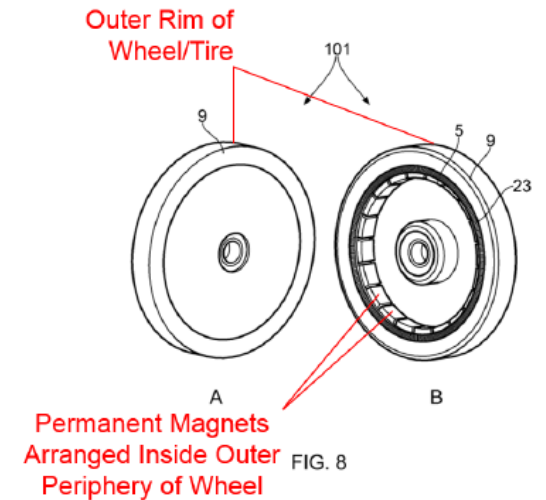


FIG. 8

Agreed-Upon Claim Constructions

Claim Term	Construction
“rolling set specific driving force” (RSSDF)	“driving force that is specific to a rolling set”
“motor control electronics” (MCE)	“electronics that control a motor”

Prior Art

- There is no dispute about whether the asserted references are prior art

Jan. 25, 2011
EP/052 filing date
(Ex. 1004)

Jun. 19, 2013
Farag publicly
available
(Ex. 1006; Ex. 1007;
Ex. 1010; Ex. 1035)

Jul. 22, 2014
Christensen
publicly available
(Ex. 1005; see Ex. 1008;
Ex. 1009)

Jul. 24, 2014
WO/055 filing date
(Ex. 1003)

Jan. 28, 2015
'140 Patent Foreign
Priority Date
(Ex. 1001)

2011

2012

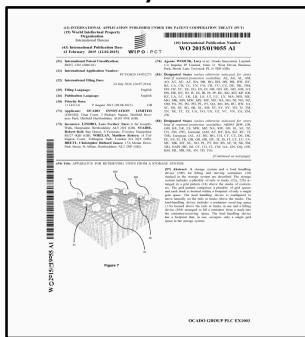
2013

2014

2015

All of the Challenged Claims Rendered Obvious by WO/055 in Light of EP/052 and Christensen

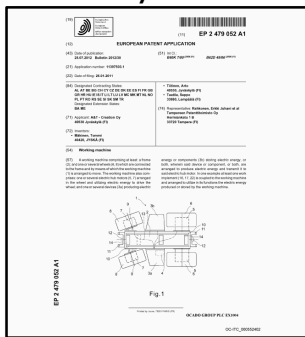
WO/055



WO/055 discloses a single-space, central-cavity robot with rolling set specific driving force (“RSSDF”)

- Discloses all elements of claim 1 except 1(g)
- Teaches a robot design with in-wheel motors that is lighter and achieves a smaller horizontal footprint
- Does not disclose placement of MCE with in-wheel motors, or structure of in-wheel motors

EP/052



EP/052 teaches placement of MCE entirely between the wheels for a smaller and lighter robot

- Discloses location of motor control electronics for in-wheel motors
- Teaches that a robot with in-wheel motors that has batteries and MCE between the wheels will be lighter and have a smaller footprint
- Does not disclose structure of in-wheel motors

Christensen



Christensen teaches that an outer-rotation motor is the most efficient in-wheel motion and how to use it

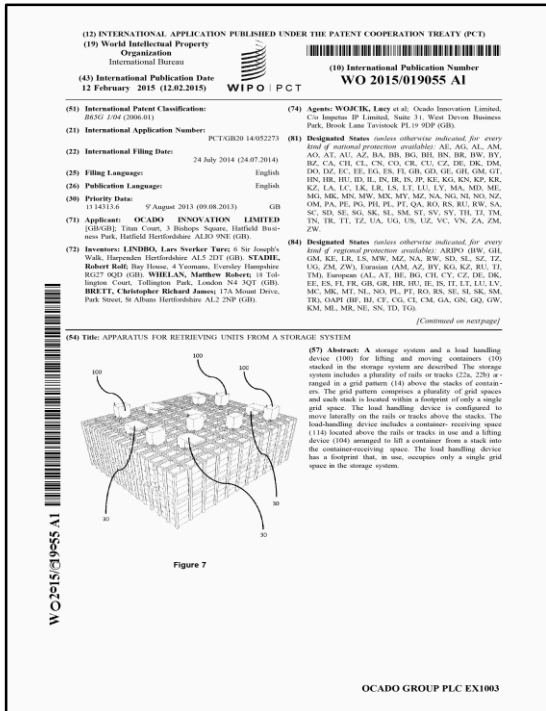
- Discloses outer-rotation motor as the best implementation of in-wheel motor suggested by WO/055
- Discloses remaining claims in combination with WO/055 and EP/052



Lindbo WO/055

Patent Owner Does Not Dispute That WO/055 Discloses All But Two Limitations of Claim 1 of the '140 Patent

WO/055



The two limitations Patent Owner says are not disclosed by WO/055:

Claim 1(e)-(f)

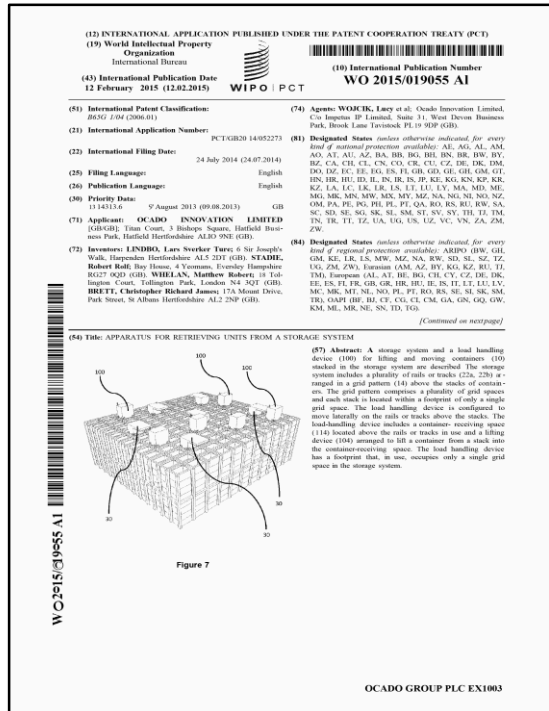
“... a first driving means situated at or at least partly within the [first/second] vehicle rolling means for providing rolling set specific driving force to the vehicle in the [first/second] direction,”

Claim 1(g)

“motor control electronics arranged within the volume between two of the wheels of each rolling set, which motor control electronics are configured to supply electric power to the first and second vehicle rolling means.”

WO/055 Discloses the Four-Wheel Rolling Means and Two-Wheel Rolling Sets of Claim 1 of the '140 Patent

WO/055



“Rolling Means” comprise two “rolling set[s] arranged at opposite facing side walls of a vehicle body”

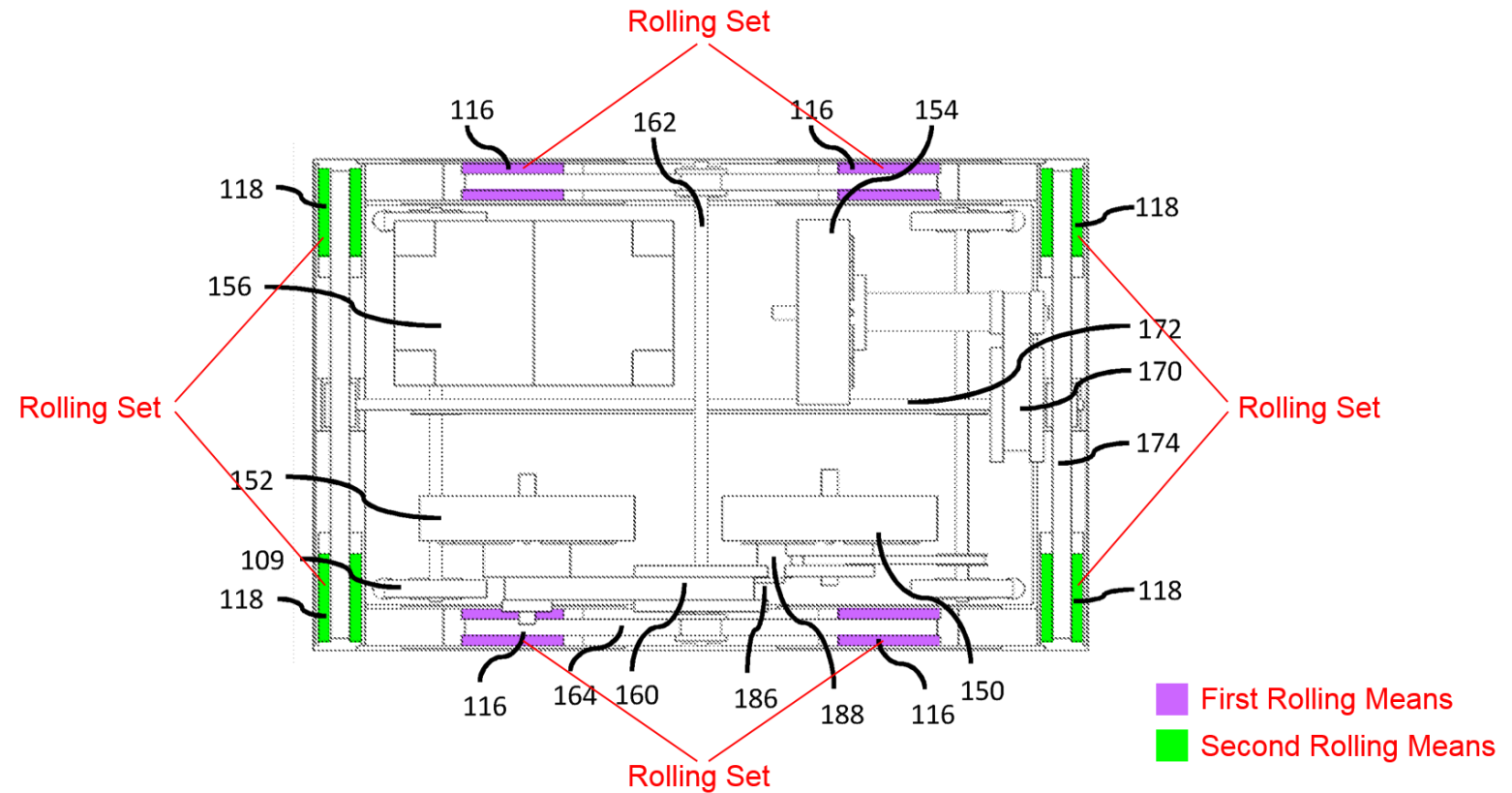
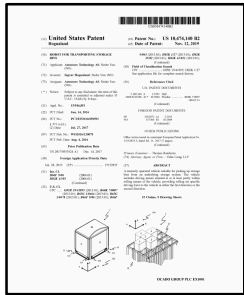


Figure 10

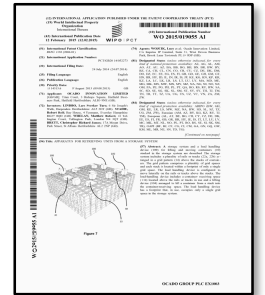
WO/055 and '140 Patent Disclose RSSDF for Their In-Wheel Motor Embodiments in the Same Way

'140 Patent



- Both patents describe two embodiments: a drive-belt embodiment and an in-wheel motor embodiment (Ex. 1036, ¶¶ 6-7)
- Both patents use equating language (“[a]lternativ[e],” “interchangeable,” “Likewise”) to mean that the in-wheel motor embodiment should be configured the same way as drive-belt embodiment (Ex. 1036, ¶¶ 6-7, 10)

WO/055



For example, when four belts are applied in order to drive the inventive vehicle in the X and Y-directions, a total of four motors may be installed in operative engagement with each of the four belts, thereby achieving the desired rolling set specific driving force. Likewise, when eight wheels are applied in order to drive the vehicle in the X- and Y-directions, a total of eight motors may be installed in operative engagement with each of the eight wheels, thereby achieving the desired rolling set specific driving force.

Alternatively, the wheels may include integrated motors, for example motors integrated within the wheel hubs. In this way, each wheel is a self-container drive unit, and drive belts are not required. This arrangement is advantageous as it reduces the size of the load-handling device and facilitates servicing.

It will be appreciated that features described in relation to one particular embodiment are interchangeable with features described in relation to the other embodiments. For example, the motorised hub wheels described in relation to Figure 17 could be used on any of the other embodiments and/or the batteries could be located low down adjacent the container-receiving space in any of the embodiments to improve stability and increase acceleration/deceleration. Other variations and modifications not explicitly described above will also be apparent to the skilled reader.

WO/055's Discloses Wheels in a Rolling Set Connected to Motor By a Drive Belt, and Thus Discloses RSSDF

WO/055

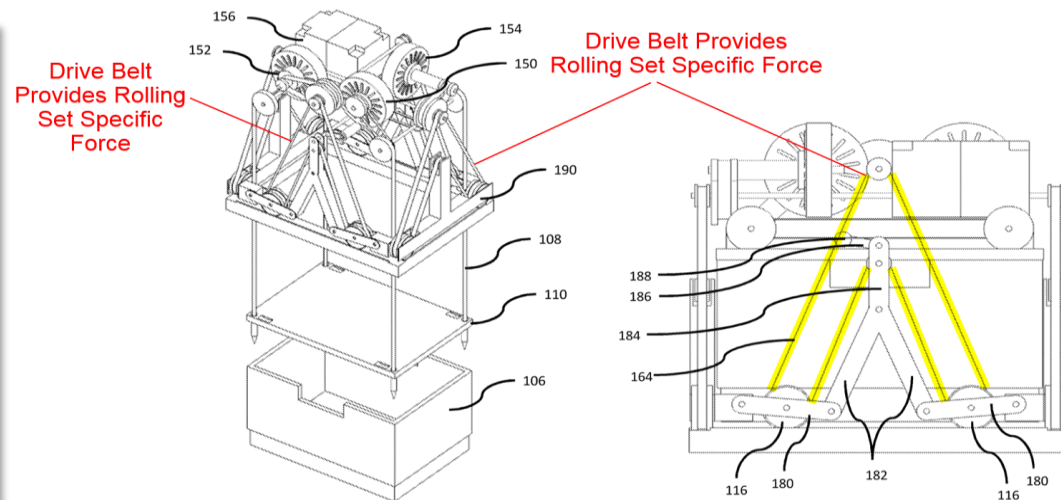
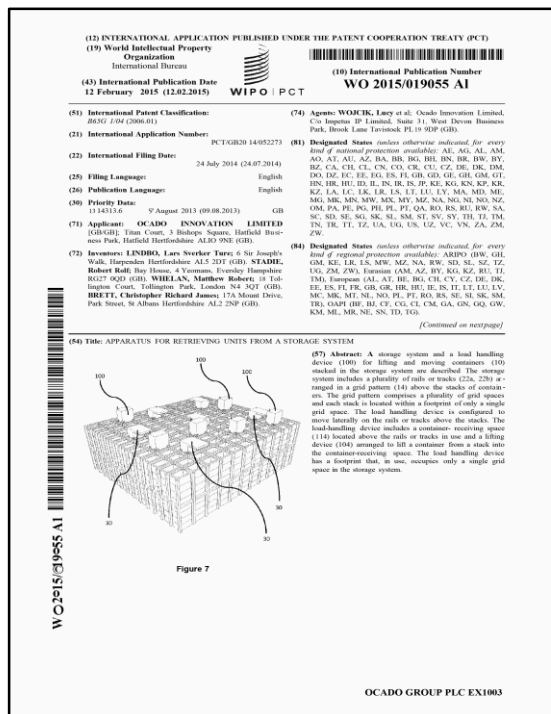
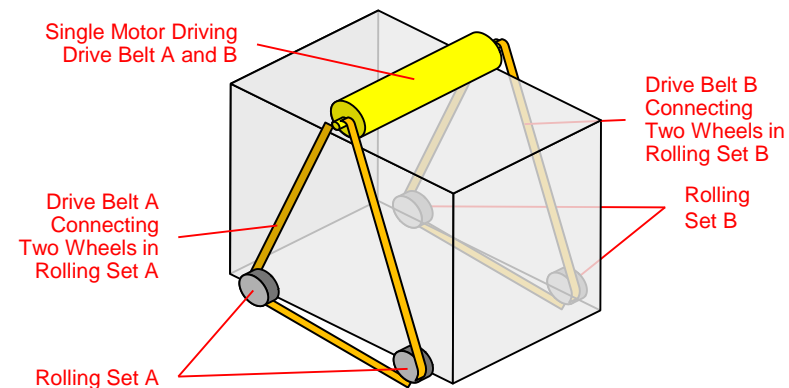


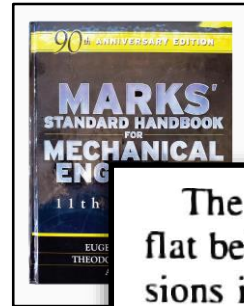
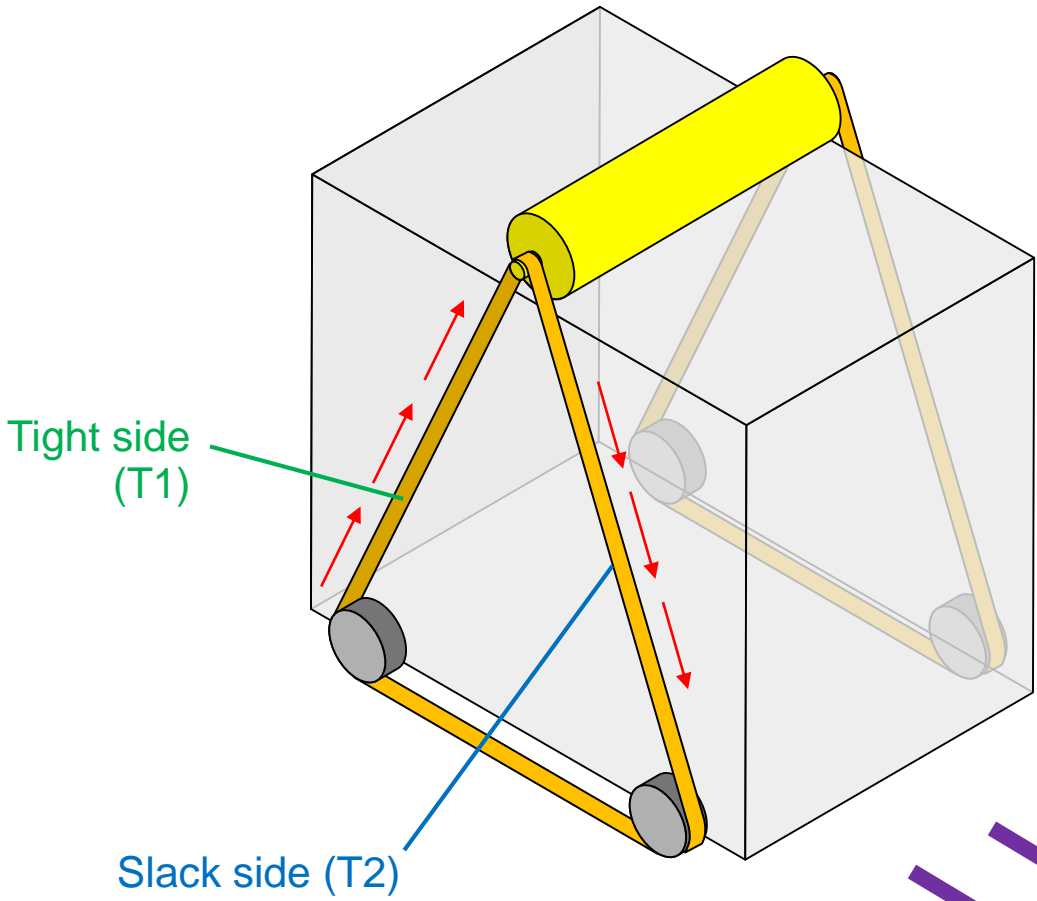
Figure 11

Figure 12

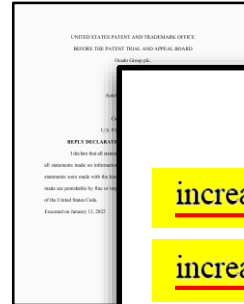


Y motor). (*Id.*, 12:22-25.) Each rolling set is thus controlled and coordinated separately, by a separate drive belt, even though the driving force originates from the same motor. (*Id.*, Figs. 9, 11.) In other words, **the motor delivers force that is specific to each rolling set** because the force is imparted to each rolling set individually by a separate drive belt. (*Id.*; EX2023, 41:13-42:12; EX1001, 3:37-45.)

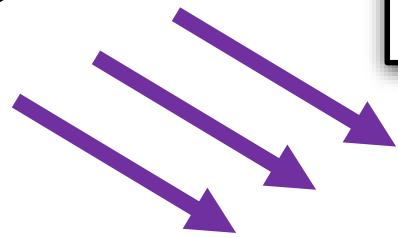
WO/055 Discloses Providing a Different RSSDF to Each Rolling Set



The turning force (tangential) on the rim of a pulley driven by a flat belt is equal to $T_1 - T_2$, where T_1 and T_2 are, respectively, the tensions in the driving (tight) side and following (slack) side of the belt.



24. In the drive belt embodiment of WO/055, as the load on a rolling set is increased (because of the uneven weight distribution) the tension in the drive belt increases to provide the greater driving force necessary to overcome the forces resisting rotation of the wheels of that rolling set, which causes the wheels in the rolling set to rotate at the rate required by their mechanical connection to the motor.



AutoStore Admitted (Twice) That WO/055's Drive Belt Embodiment Discloses a RSSDF

February 25, 2021 Agreed Construction:

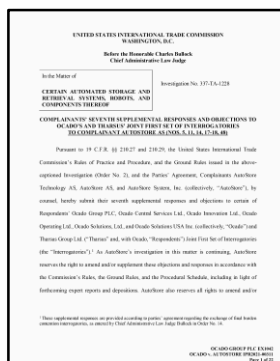
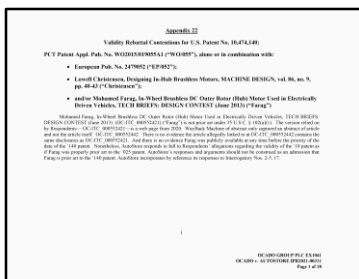
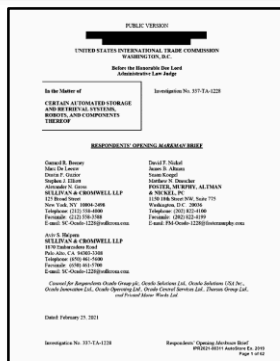
Claim Term	Relevant Patent(s)/Claim(s)	Agreed-Upon Construction
“rolling set specific driving force”	'140 Patent: Claim 1	“driving force that is specific to a rolling set”

March 8, 2021 Admission:

“for providing rolling set specific driving force”: AutoStore does not dispute that the embodiment of figures 11 and 12 may result in a rolling set specific driving force. But that embodiment does not meet the “driving means situated at or at least

May 5, 2021 Admission:

“for providing rolling set specific driving force”: AutoStore does not dispute that the embodiment of figures 11 and 12 may result in a rolling set specific driving force. But that embodiment does not meet the “driving means situated at or at least



Dr. Pfeifer's Testimony About RSSDF Is Consistent

- Dr. Pfeifer's testimony about RSSDF has been consistent: a RSSDF is provided where the wheels in each rolling set are controlled and coordinated together, as a rolling set, and not on some other basis. (*E.g., Ex. 1036, ¶¶ 6, 9-10; see also Ex. 2023, 47:2-7, 90:6-16, 262:6-12*)
- Because the wheels in the rolling set are controlled and coordinated together using a drive belt, they move at the same rate, as Dr. Pfeifer explained at his deposition:
 - If weight is distributed equally across the robot, providing an RSSDF using a belt may result in the same driving force to each rolling set, or to each wheel in the rolling set
 - Unequal weight distribution will result in a different driving force to each wheel in the rolling set (*E.g., Ex. 2023, 47:18-48:12; Ex. 1036, ¶¶ 14, 17, 19, 24*)

Q. In a rolling set, if wheel A is set to 50 Newtons and wheel B is set to 75 Newtons, that can still be a rolling set specific driving force?

A. Yes, they can -- I don't know if the term "set to" is proper here, but each of the two wheels can provide a different force, and that might be because of the belt drive and the different distribution of weight. It might be what is needed based on the acceleration and the movement of the vehicle, of the robot. But, yes, the different wheels can provide different forces. It's just a matter that they are commanded together to accomplish the task.



EP/052

WO/055 and EP/052 Relate to the Same Field of Endeavor

- **Same field of endeavor:** robotic vehicles with in-wheel motors
 - WO/055 teaches a remotely controlled vehicle (Ex. 1003, 5:5-8), with in-wheel motors (Ex. 1015 ¶¶ 143-44)
 - EP/052 teaches a “remote control” vehicle (Ex. 1004, 4:36-45, 5:20-39), with in-wheel motors (Ex. 1036, ¶¶ 34-42)

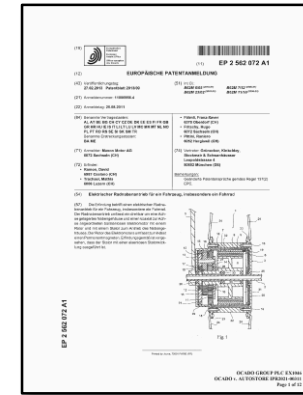
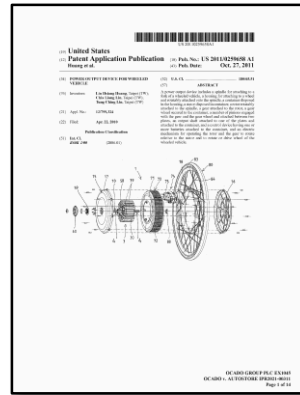
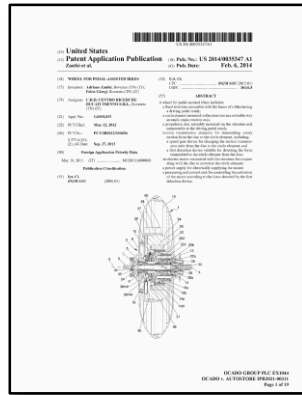
- **Both seek to satisfy known design objectives in industry:** make the robot smaller and lighter while maintaining stability (Ex. 1036, ¶ 36)
 - WO/055 teaches that the robot “takes up the minimum possible amount of space in the X-Y plane” and “can also offer . . . reduced weight compared to the cantilever-type prior art.” (Ex. 1003, 11:36-40, 12:6-10)
 - EP/052 seeks to “attain a lighter drive unit” and places components in side compartments to attain a “low structure.” (Ex. 1004, 3:46-48, 8:56, see also 2:13-16)

WO/055 and EP/052 Are Reasonably Pertinent to Same Problem

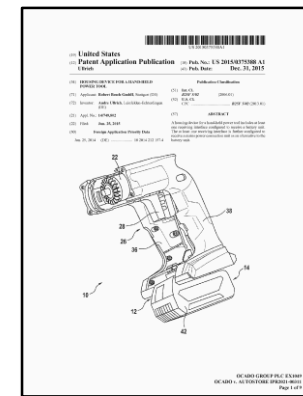
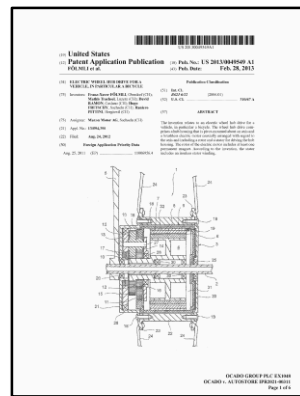
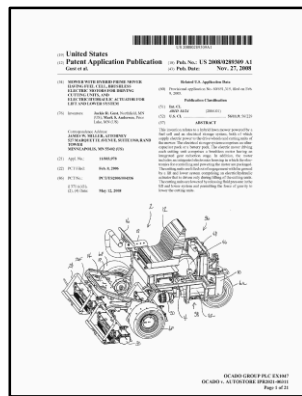
- Both references address the problem of reducing robot size and weight while still maintaining stability (*Ex. 1036, ¶¶ 36-42*)
 - **WO/055** teaches the use of in-wheel motors to **make the robot lighter, save space, and achieve a smaller horizontal footprint** on the grid:
 - **EX1003, 5:15-39:** “For high-volume systems in which speed of operation is critical, it is important to maximise the performance of each of the load handling devices, in terms of speed of operation, battery life, reliability, lifting capacity, stability and so on. It may therefore be desirable to provide load-handling devices that offer improved performance in one or more of these areas.”
 - **EX1003, 12:6-9:** “The load handling devices 100 of the invention can also offer improved stability, increased load handling capacity and reduced weight compared to the cantilever-type prior art load handling devices 30, because in the invention the load of the containers is suspended between the pairs of wheels on each side of the vehicle.”
 - **EP/052** also teaches the use of in-wheel motors—as well as batteries and MCE between the wheels—to **make the vehicle lighter** and **achieve a smaller vertical footprint**
 - **EX1004, Abstract, 10:30, 3:46-48, 8:56, see also 1:47-50, 2:15-16:** teaching the use of “one or several electric hub motors,” which make “it . . . possible to attain a lighter drive unit when compared to work implements of prior art, as well as better efficiency,” and that storing batteries and MCE in between the wheels allows it to attain a “low structure.”

During Prosecution, Patent Owner and Examiner Recognized a Broad Range of Analogous Prior Art

■ Patent Owner Cited Bicycle Patents



■ Examiner Cited Lawn Mower, Bicycle, and Handheld Power Tool Patents



A POSITA Would Have Been Motivated to Combine WO/055 and EP/052



- WO/055 suggests MCE should be kept in close proximity to the batteries (power components) and in-wheel motors (drive components) (*Ex. 1003, 11:32-34, Ex. 1036, ¶¶ 27-28, 39-41*)

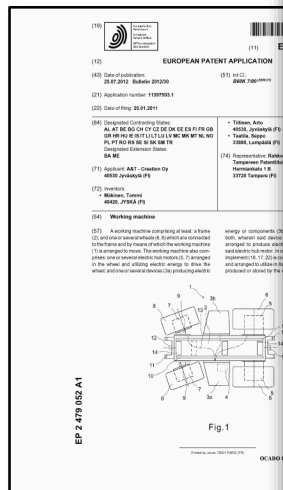
handling device, as shown in Figure 6(c). The upper part 112 houses the battery and associated electronics, controllers and communications devices, motors for driving the wheels 116, 118, motors for driving the crane mechanism 104, and other sensors and systems.

and other components”). WO/055 explains that locating these components near each other in one location is advantageous because “the footprint of the [robot] is reduced” compared to prior art robots, and the reduced footprint allows “the efficiency of operation of the storage system” as a whole to be improved. (EX1003, 6:20-29; *see also id.*, 6:12-14, 11:32-34, 12:16-18.) From these teachings, a POSITA would understand that these components should remain together in the other embodiments, too.

- But WO/055 does not disclose MCE location in embodiments with in-wheel motors and battery in the lower side walls (*Ex. 1036, ¶¶ 28, 39*)
- A POSITA would recognize the need to move MCE in robot with in-wheel motors because it avoids:
(*Ex. 1036, ¶¶ 32, 39-41*)
 - Inefficient and more complex design
 - Longer cabling
 - Increased risk of electronic interference
- MCE in that location would be protected from collisions with the wheels acting as a buffer (*Ex. 1036, ¶ 32*)

EP/052 Teaches Placing the MCE and Batteries in the Volume Between the Wheels of the Rolling Sets (In Units 3a and 3b)

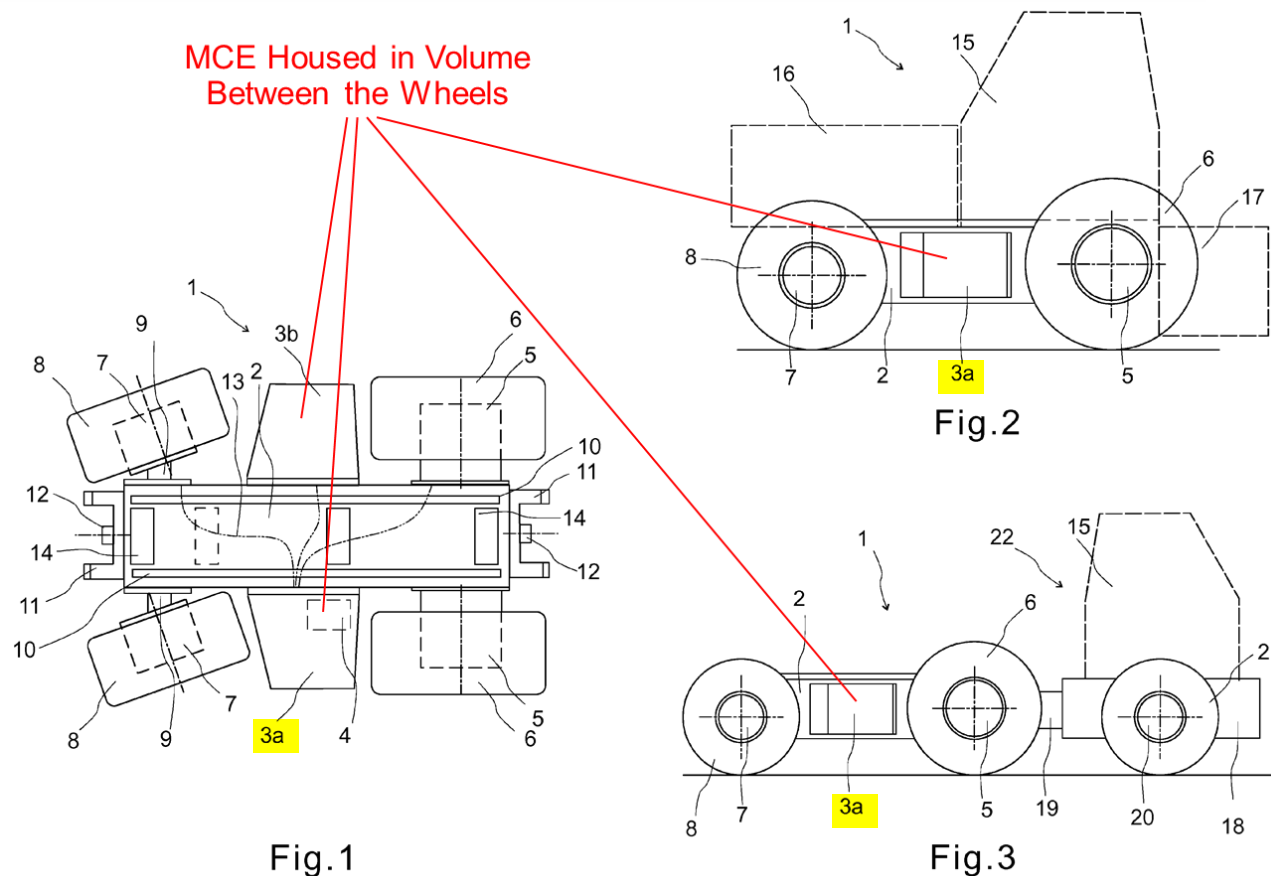
EP/052



[0038] According to Fig. 1 at least one component storing electric energy is placed in the unit 3b. According to one example the unit 3a comprises a battery or a capacitor storing electric energy. Another component that stores electric energy may be placed in the unit 3a. The number and dimensioning of components storing electric energy depends on the planned need for electric energy. The unit 3b can be removed for maintenance or replacement. Another component that stores electric energy may also be placed on top of the frame 2, for example in the module 16, or even in the work implement 22 shown in Fig. 3.

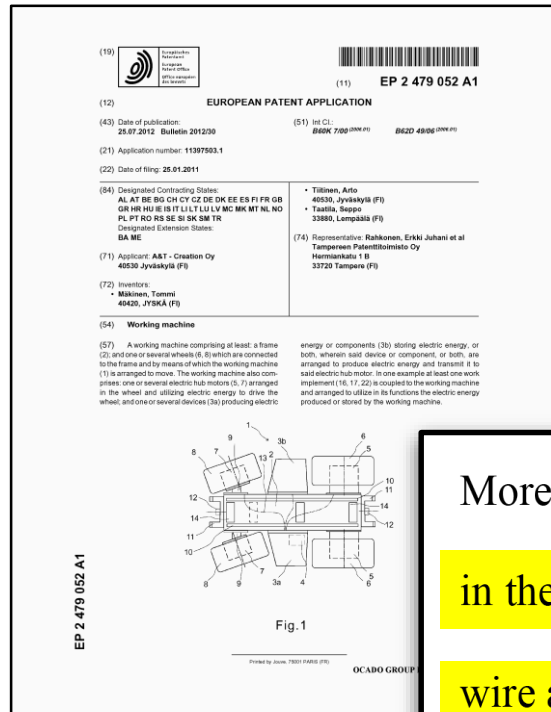
[0041] It is possible to place other components required by the drive unit 1 inside the frame 2. The cables 13 illustrate the transmission of data, signals and electric power between the modules and the different units. It is possible to control the function of the drive unit 1, the modules and the units by means of one or several electric control units or control devices, which are illustrated by means of a control device 4, which can be placed for example in the frame 2 or in the unit 3a or 3b. If necessary,

MCE Housed in Volume Between the Wheels



EP/052 Teaches Placing MCE in the Volume Between Wheels of Each Rolling Set

EP/052



- In implementing this solution in WO/055, a POSITA would understand that the MCE should not be wired *across* the cavity to motors on the other side of the robot
 - Wiring could interfere with lifting a storage bin into the cavity
 - POSITA would instead locate separate control units on each side of the robot so no cross-cavity wiring needed

Moreover, as I stated above, a POSITA seeking to implement the solution of EP/052 in the cavity robot of WO/055 would understand that it would not be reasonable to wire a single control unit across the cavity to control the motors on the other side of the robot. Doing so would interfere with lifting a storage bin into the cavity, or it would require substantially longer cables, increasing the risk of interference.

EP/052 Discloses Placing the MCE Entirely Within the Volume Between the Wheels

- “In an obviousness inquiry, **we do not require a prior art reference to adopt the same terminology** as used in the challenged patent.”

Wright Med. Tech., Inc. v. Univ. of N. Carolina, IPR2014-00626, Paper 9 at 14 (PTAB Oct. 7, 2014)

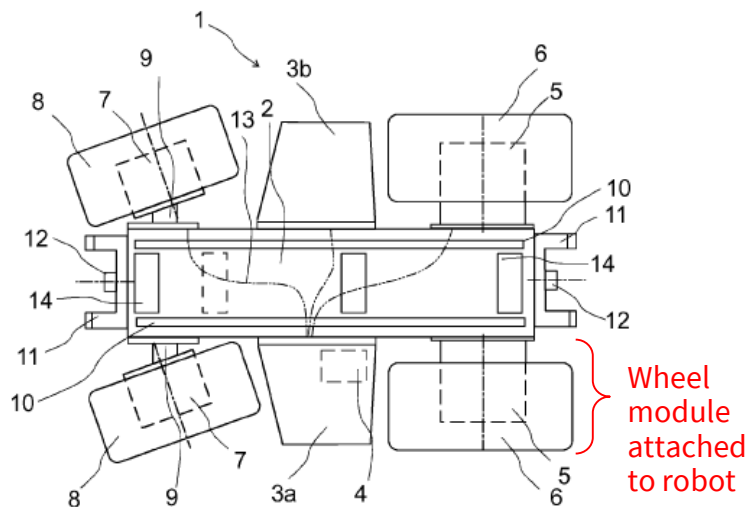


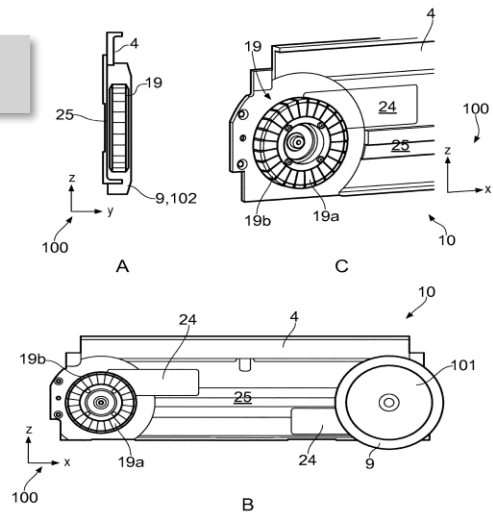
Fig. 1

- The “wheels” referred to in WO/055 and ’140 Patent have the **same** structure as the “wheel modules” of EP/052 (tire + hub motor)
 - **’140 Patent**: “Each of the wheels may comprise a plurality of rotor magnets . . . and a plurality of stators” (Ex. 1001, 3:22-25)
 - **WO/055**: “[E]ach wheel 256 having a motor integrated within a hub 260 of the wheel 256.” (Ex. 1003, 14:27-28, 7:7-8)
 - **EP/052**: “[E]ach wheel module comprises one wheel 6 and an electric hub motor 5 belonging to the same and driving the wheel 6.” (Ex. 1004, [0028])

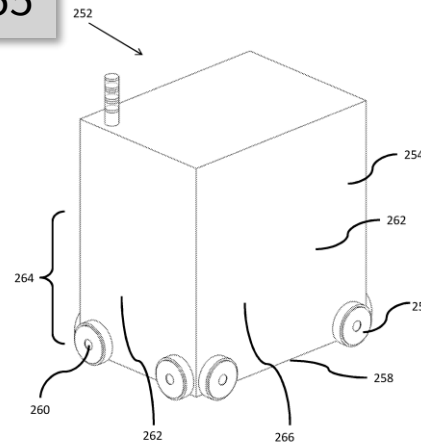
Patent Owner Incorrectly Defines Claimed Volume by Tire, Not Wheel

- Defining volume by wheel or wheel module achieves all of the benefits described by Dr. Janét (which are not actually described by the '140 Patent)
 - “[T]he biggest issue here is the **efficient use of space**” (Ex. 1040, 58:22-23)
 - “overall maximizes the number of simultaneously operating vehicles through, among other things, potentially **reducing the cross-sectional area. The footprint**” (Ex. 1040, 45:17-23)
 - **Less** “opportunity for **electromagnetic interference** from other data lines” (Ex. 1040, 58:7-12)
- Defining volume by tire ignores that both MCE and wheels must be attached to robot body

'140 Patent

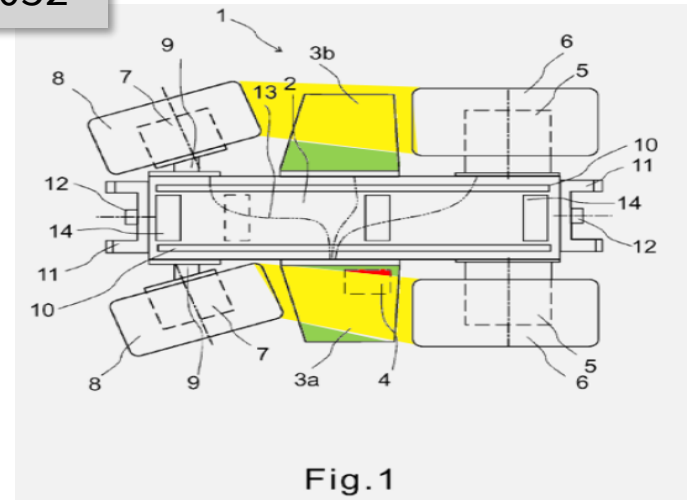


WO/055



EP/052

Dr. Janét's "volume"



A POSITA Would Have a Reasonable Expectation of Success in Combining WO/055 and EP/052

- Janét wrongly argues that the MCE would “likely extend beyond the wheels and prevent the robot from passing robots on adjacent grid spaces” (*Ex. 2021, ¶¶ 84, 93; POR 29, 36*)
 - No such disclosure in WO/055 (*Ex. 1036, ¶ 42*)

- Janét asserts that (i) wheels on WO/055 are “thin” and (ii) the MCE circuit boards were “pretty bulky” (*Ex. 1040, 68:9-16*)
 - There are no such disclosures in WO/055 (*Ex. 1036, ¶ 42*)
 - “Bulky components” refers to motors and batteries
 - Dr. Janét’s only basis for asserting that WO/055’s MCE must be bulky is because they are stored in the vehicle module above the cavity, which says nothing about the size of the MCE. (*Ex. 1036, ¶ 33, Ex. 1040, 71:7-17*)
 - Dr. Janét admits that MCE are “generally circuit boards” (*Ex. 1040, 78:2-13*)
 - Pfeifer testified that a POSITA would understand that circuit boards are generally thin and flat (*Ex. 1036, ¶ 33*)



Christensen

Claims 2-15 Require an Outer Rotation In-Wheel Motor

'140 Patent – Claims 2-4

(12) **United States Patent**
Hogeland

(13) Patent No.: **US 10,474,140 B2**
(45) Date of Patent: **Nov. 12, 2019**

(54) **REBOT FOR TRANSPORTING STORAGE BINS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **15546451**

(86) PCT Filed: **Jan. 14, 2016**

(87) PCT No.: **PCT/EP2016/06691**
§ 371 (c)(1), (2) Date: **Jul. 27, 2017**

(87) PCT Pub. No.: **WO2016128075**
PCT Pub. Date: **Aug. 4, 2016**

(45) **Prior Publication Data**
US 2017035124 A1 Dec. 14, 2017

(36) **Foreign Application Priority Data**
Jan. 28, 2015 (EP) 15112353

(51) Int. Cl. (2006.01) **B66F 17/08**
H02A 47/03 (2006.01)

(52) U.S. Cl. (2013.01) **G01B 21/00**
G01B 21/00 (2013.01); *H02G 1/04* (2013.01); *H02G 1/06* (2013.01); *H02G 1/08* (2013.01); *H02G 1/10* (2013.01); *H02G 1/12* (2013.01); *H02G 1/14* (2013.01); *H02G 1/16* (2013.01); *H02G 1/18* (2013.01); *H02G 1/20* (2013.01); *H02G 1/22* (2013.01); *H02G 1/24* (2013.01); *H02G 1/26* (2013.01); *H02G 1/28* (2013.01); *H02G 1/30* (2013.01); *H02G 1/32* (2013.01); *H02G 1/34* (2013.01); *H02G 1/36* (2013.01); *H02G 1/38* (2013.01); *H02G 1/40* (2013.01); *H02G 1/42* (2013.01); *H02G 1/44* (2013.01); *H02G 1/46* (2013.01); *H02G 1/48* (2013.01); *H02G 1/50* (2013.01); *H02G 1/52* (2013.01); *H02G 1/54* (2013.01); *H02G 1/56* (2013.01); *H02G 1/58* (2013.01); *H02G 1/60* (2013.01); *H02G 1/62* (2013.01); *H02G 1/64* (2013.01); *H02G 1/66* (2013.01); *H02G 1/68* (2013.01); *H02G 1/70* (2013.01); *H02G 1/72* (2013.01); *H02G 1/74* (2013.01); *H02G 1/76* (2013.01); *H02G 1/78* (2013.01); *H02G 1/80* (2013.01); *H02G 1/82* (2013.01); *H02G 1/84* (2013.01); *H02G 1/86* (2013.01); *H02G 1/88* (2013.01); 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Claims 2-15 Require an Outer Rotation In-Wheel Motor (cont'd)

'140 Patent – Claims 11-15

US 10,474,140 B2

110 Patent No. US 10,474,140 B2
 (45) Date of Patent: Nov. 12, 2019

5. The vehicle in accordance with claim 1, wherein at least one of the first and second driving means comprises an electric motor comprising a rotor and a stator and that the vehicle further comprises means for measuring back electromotive force, the means being in signal communication with one of the stator and the rotor, allowing rolling out specific velocity regulation of the vehicle during operation.

6. The vehicle in accordance with claim 1, wherein the vehicle comprises a rotary encoder associated to at least one of the first and second vehicle rolling means, allowing angular position feedback during operation.

7. The vehicle in accordance with claim 6, wherein the rotary encoder is of type optical encoder.

8. The vehicle in accordance with claim 6, wherein the rotary encoder is a rotary encoder disk arranged within the outer periphery of the at least one of the first and second vehicle rolling means.

9. The vehicle in accordance with claim 1, wherein: at least one of the first and second driving means comprises an electric motor comprising a rotor and a stator and that the vehicle further comprises an accelerometer that assures acceleration of at least one of the first and second vehicle rolling means, the accelerometer being in signal communication with the stator.

10. The vehicle in accordance with claim 9, wherein the accelerometer comprises at least one of a piezoelectric sensor and an inductive sensor.

11. The vehicle in accordance with claim 1, wherein the first vehicle rolling means comprises four first-direction-wheels having their direction of revolution in the first direction and the second vehicle rolling means comprises four second-direction-wheels having their direction of revolution in the second direction, wherein each of the first-direction-wheels and each of the second-direction-wheels is drivingly connected to the first driving means and the second driving means, respectively.

12. The vehicle in accordance with claim 11, wherein, for each wheel, at least part of the driving means is arranged within the wheels outer periphery.

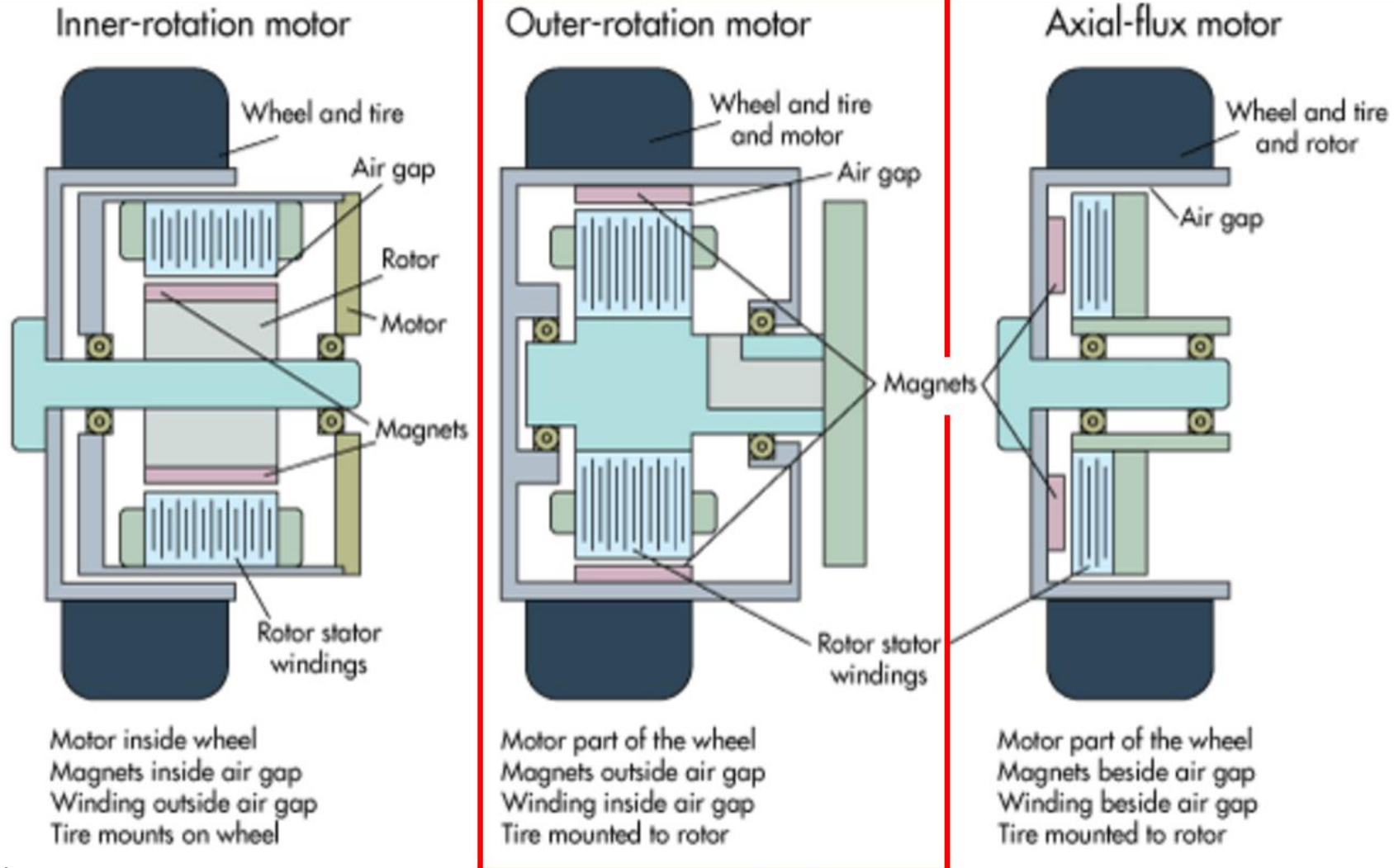
13. The vehicle in accordance with claim 11, wherein each of the wheels has a plurality of rotor magnets arranged within the inner radial surface of the wheels outer periphery and a plurality of stator field windings arranged at least partly within the vehicle body.

14. The vehicle in accordance with claim 13, wherein the stator field windings are following the outer periphery of the wheels.

15. A storage system for storage of bins, the storage system comprising: a bin storing structure comprising a plurality of storage columns, wherein each storage column is arranged to accommodate a vertical stack of storage bins, and a remotely operated vehicle in accordance with claim 1 arranged on top of the bin storing structure.

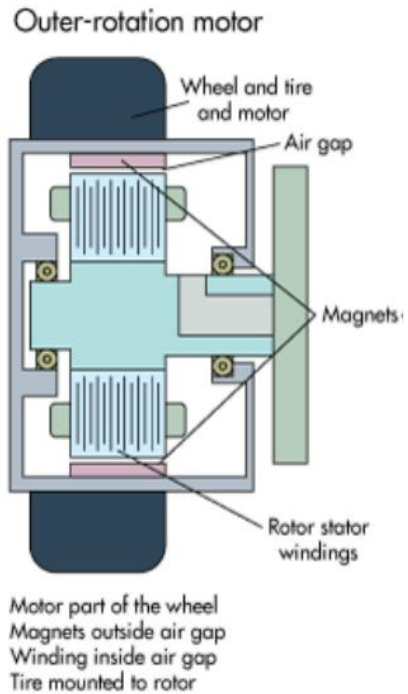
Claim 11(a)	“11. The vehicle in accordance with claim 1,”
Claim 11(b)	“wherein the first vehicle rolling means comprises four first-direction-wheels having their direction of revolution in the first direction and”
Claim 11(c)	“the second vehicle rolling means comprises four second-direction-wheels having their direction of revolution in the second direction,”
Claim 11(d)	“wherein each of the first-direction-wheels and each of the second-direction-wheels is drivingly connected to the first driving means and second driving means, respectively.”
Claim 12(a)	“12. The vehicle in accordance with claim 11,”
Claim 12(b)	“wherein, for each wheel, <u>at least part of the driving means is arranged within the wheels outer periphery.</u> ”
Claim 13(a)	“13. The vehicle in accordance with claim 11,”
Claim 13(b)	“wherein each of the wheels has <u>a plurality of rotor magnets arranged within the inner radial surface of the wheels outer periphery</u> and a plurality of stator field windings arranged at least partly within the vehicle body.”
Claim 14(a)	“14. The vehicle in accordance with claim 13,”
Claim 14(b)	“wherein the <u>stator field windings are following the outer periphery of the wheels.</u> ”
Claim 15(a)	“15. A storage system for storage of bins, the storage system comprising:”
Claim 15(b)	“a bin storing structure comprising a plurality of storage columns, wherein each storage columns [sic] is arranged to accommodate a vertical stack of storage bins, and”
Claim 15(c)	“a remotely operated vehicle in accordance with claim 1 arranged on top of the bin storing structure.”

Christensen Discloses an “Outer-Rotation” In-Wheel Motor Design

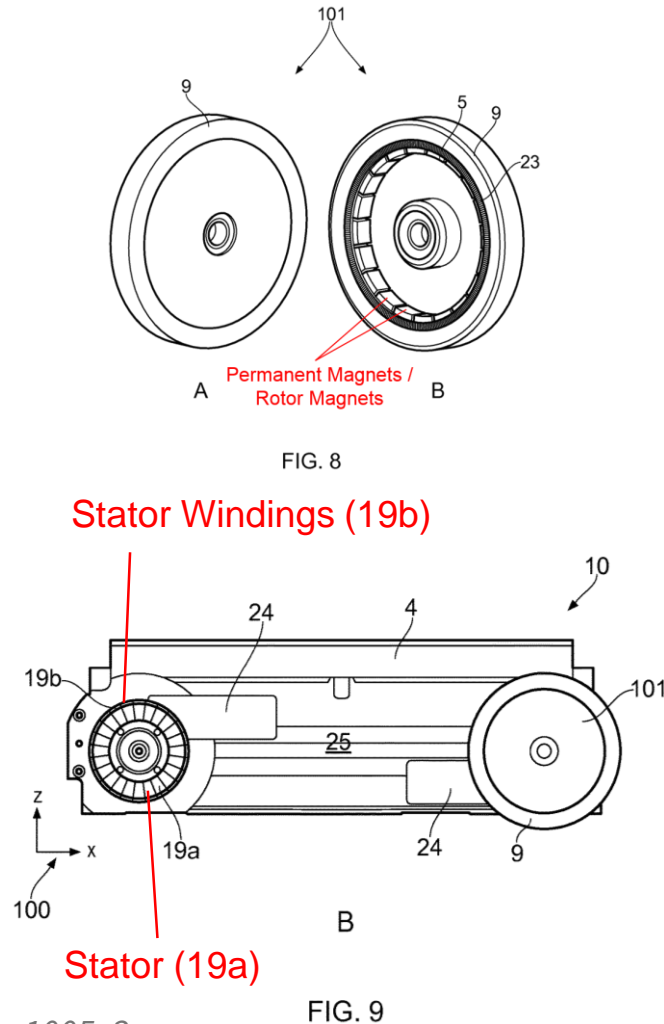


There Is No Dispute That Christensen Discloses the Same “Outer-Rotation” In-wheel Motor Structure Described and Claimed in the ’140 Patent

Christensen



'140 Patent



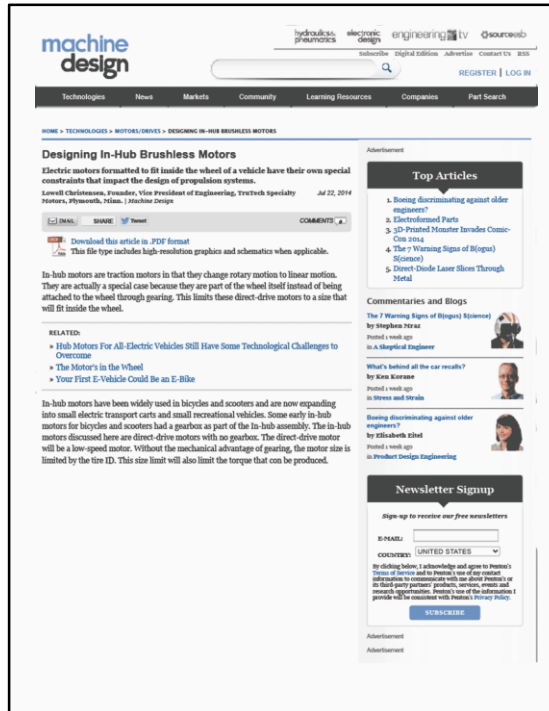
'140 Patent, Claim 2

2. The vehicle in accordance with claim 1, wherein at least one of the first and second driving means comprises rotor magnets arranged at the inner surface of the outer periphery of the vehicle rolling means.

Pfeifer:

157. One of the three in-hub motors disclosed in the article is an outer-rotation motor. In that configuration, “the rotor sits outside the stator and rotates around it.” (*Id.* at 3) The “rotor is formed as the tire rim and the tire will directly mount to the motor rotor.” (*Id.*) As seen in the figure below, the motor has permanent magnets that are attached to the inner periphery of the rotor/wheel. (*Id.* at 4 (“[M]agnets on [the] outer-rotation motor lie near the motor’s outer diameter.”).) Additionally, the motor is located inside the wheel and does not “protrude from the wheel.” (*Id.* at 3.)

Christensen Discloses Outer Rotation In-Wheel Motors for Use in Automated Storage And Retrieval Systems



Nevertheless, it looks as though in-hub motors will have a bright future where there is a need for smaller traction motors. They probably will not replace traction motors in locomotives or trucks, but smaller applications will be fair game. The absence of a gearbox and the accompanying potential for oil leakage will make them attractive for use in autonomous or guided carts used to move supplies in hospitals and factories. These applications also will be required to operate on batteries and as battery technology improves, the range of applications for in-hub motors will also increase.

All in all, this analysis shows that the outer-rotation motor gives a simpler design in that the wheel/tire is part of the motor and the motor can have a shorter stack than the inner rotation case. The shorter magnet and stator in the outer-rotation motor would also cost less.

Dr. Janét's Opinion That a POSITA Would Not Choose an Outer Rotation Motor for WO/055 Is Baseless

Dr. Janét relies entirely on statements in WO/055 that do not support his claim that wheels are “small” and load is “large” in comparison:

- **Ex. 1003, 13:18:** “wheel design is compact”
 - This out-of-context disclosure only relates to specific drive-belt wheel embodiment
(See Ex. 1003, 13:14-19)
 - Patent Owner clips quote: “This wheel design is compact”
- **Ex. 1003, 5:15-18:** “For high-volume systems in which speed of operation is critical, it is important to maximize the performance of each of the load handling devices, in terms of speed of operation, battery life, reliability, lifting capacity, stability and so on.”
- **Ex. 1003, 12:6-7:** “The load handling devices 100 of the invention can also offer improved stability, increased load handling capacity”

Dr. Janét's Undisclosed Wheel-Width Calculation Should Not Be Credited

Dr. Janét (*Ex. 2021*, ¶ 107 n.2):

This estimate is based in part on Figure 7, which shows the WO/055 next to a prior art AutoStore Red Line R5 robot (i.e., the “known load handler devices”). WO/055 at Fig. 7, 10:20–30. From this, I was able to determine the size of the WO/055 robot given that it was designed to operate on the same (or similar) grid system as the AutoStore R5.

- No indication of what other evidence was relied on (*Ex. 1036*, ¶ 54 n.3)
- No indication that Figure 7 is drawn to scale (*Ex. 1036*, ¶ 54; *Ex. 1040*, 190:2-196:6)
- Bases undisclosed wheel-width calculation of 1-2 inches on wrong robot (*Ex. 1036*, ¶ 54)
 - WO/055 cites NO/366 (*Ex. 1043*) — filed in **1999** — as the prior art cantilever robot depicted (*Ex. 1003*, 3:21-24, 10:20-22)
 - R5 robot was only released in 2011 (*Ex. 2015*, 11)

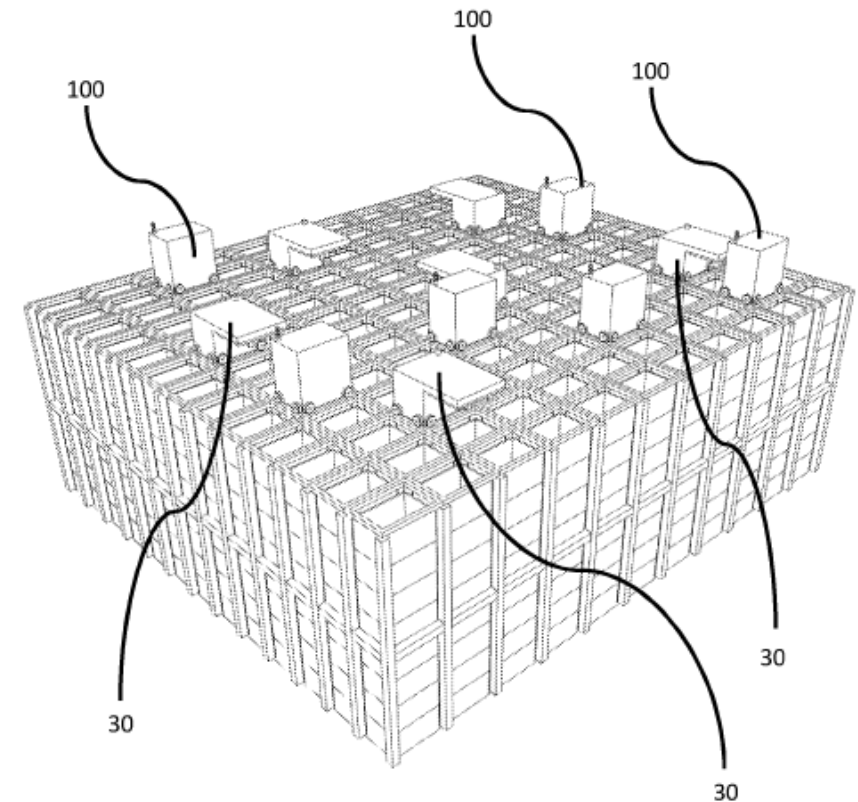


Figure 7

Christensen Compared Inner- and Outer-Rotation Motors and Determined That Outer-Rotation Motors Were Better for the WO/055 Application

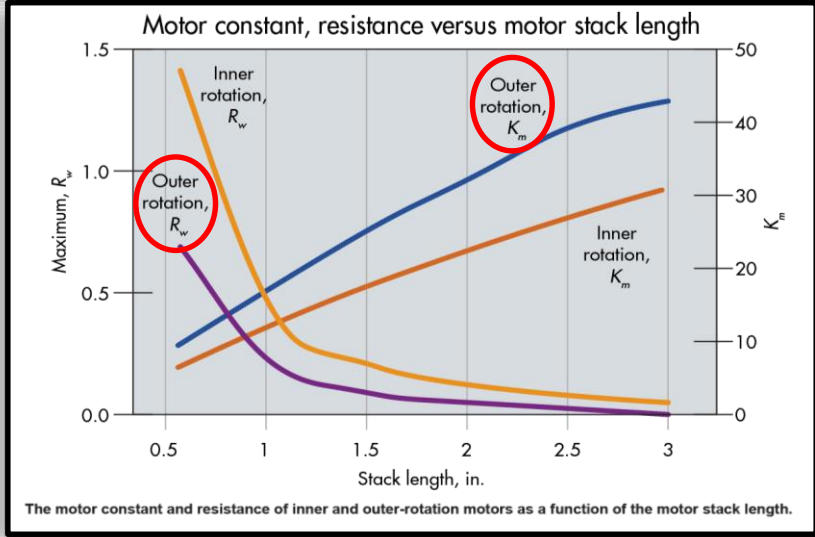
- Janét opines that WO/055 in-wheel motor width is 1-2 inches
- Christensen discloses that outer rotation motor is better for a motor width of 1-2 inches:

58. Christensen discloses that for any motor in this range, including motors with a width from 1-2 inches, the outer-rotation motor is both substantially more efficient and has higher thermal capacity than the inner-rotation motor. (Id.) Far

- K_m = The motor constant
 - Measure of motor's thermal capacity
 - Higher K_m means greater thermal capacity
- R_w = motor's resistance to electric current, and thus its efficiency
 - Lower R_w means a more efficient motor

EXAMPLE PARAMETERS, IN-HUB MOTOR-POWERED VEHICLE		
Parameter	Units	Value
Weight/wheel	lb	250
Minimum buss voltage	V	48
Friction coefficient	Unitless	0.02
Maximum acceleration time	Sec	5
Gravitational constant	ft/ss	32.2
Maximum climb speed	mph	15
Maximum flat speed	mph	20
Maximum climb angle	deg	15
Minimum climb angle	deg	2

Vehicle parameters used for an example of specifying an in-hub motor.



Paper: Reply 23-25

Source: Ex. 1005, 4-5; Ex. 1036, ¶ 58

WO/055 and Christensen Disclose and Render Obvious Stator and Field Windings “at Least Partly Within Vehicle Body” as Required by Claims 4, 12

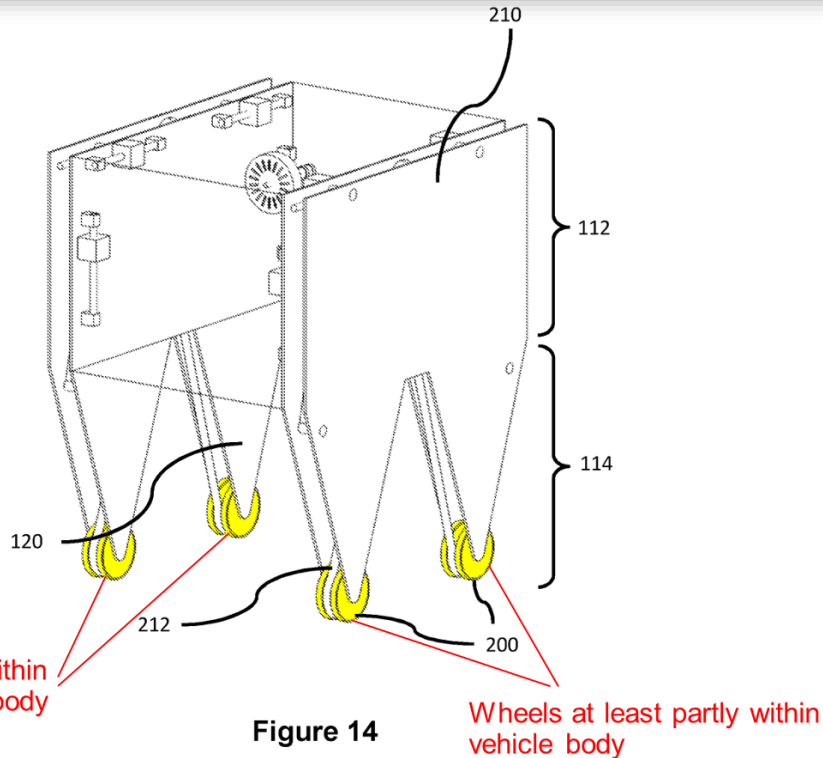
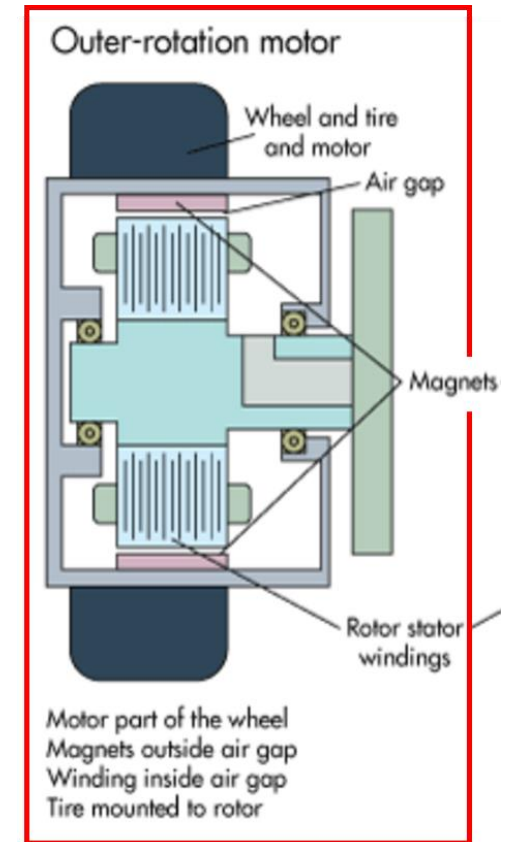


Figure 14

- WO/055 teaches embodiments where the wheels are within the vehicle body, like Figure 14 (EX1036, ¶ 62)
- WO/055 also states that “motorised hub wheels described in relation to Figure 17 could be used on any of the other embodiments,” like Figure 14 (EX1003, 15:14-17; EX1036, ¶ 62; see also EX1003, 13:28-29)

- Christensen teaches that the motor components, including the stator and stator windings, should not extend past the outer surface of the wheel, suggesting that, if larger motor is needed, it should extend past inner surface into vehicle body (Ex. 1005, 2; Ex. 1036, ¶ 61)
- Motivation to combine
 - Larger container-receiving space while minimizing footprint of the robot (Ex. 1003, 6:20-29, 11:23-25)
 - Protecting motors in the wheels from “damage from road debris and other such factors” (Ex. 1036, ¶ 62; Ex. 1005, 3)



WO/055 Discloses Stator and Field Windings “at Least Partly Within Vehicle Body”

- Patent Owner argues that WO/055 is not compatible with placing wheels within the side walls, but it later contradicts its own argument

Moreover, the embodiment with in-wheel motors in the WO/055 (shown in Figure 17 and described in detail in column 14, line 18 through line 39) is not compatible with placing the wheels within the walls. As described above, the space in the walls behind the wheels is already occupied by batteries. WO/055 at 14:31–

already located there.” Reply, 10. But Dr. Pfeifer acknowledges that nothing in WO/055 teaches that the batteries occupy the entire side wall. Ex. 2027, 24:14–25:22. Indeed, he acknowledges that, to the extent the batteries do not “take up the entire portion of the sidewalls, then it would be possible to put [the motor control electronics] there[.]” *Id.* Operating under the assumption that Petitioner would like

- Patent Owner claims that “replacing the belt drive results in the wheel motor being outside the vehicle body, as shown in Figure 17,” even though Figure 14 discloses the wheels within the side walls (*POSR 20*)
 - Contrary to WO/055’s statement that “motorised hub wheels described in relation to Figure 17 could be used on any of the other embodiments” (*Ex. 1003, 15:14-17*)