



(51) International Patent Classification:

*B62K 15/00* (2006.01) *B62K 11/02* (2006.01)  
*B62K 11/00* (2013.01)

(21) International Application Number:

PCT/US2016/042235

(22) International Filing Date:

14 July 2016 (14.07.2016)

(25) Filing Language:

English

(26) Publication Language:

English

(71) Applicant: **FORD GLOBAL TECHNOLOGIES, LLC**  
[US/US]; 330 Town Center Drive, Suite 800, Dearborn, MI  
48126 (US).

(72) Inventors: **VAISHNAV, Dhaval, P.**; 43583 Yorkville Dr.,  
Canton, MI 48188 (US). **PALMA, Rodolfo**; 46143 Han-  
ford Rd., Canton, MI 48187 (US). **GOMEZ MATA, Fran-  
cisco, Javi**; Carretera Mexico Toluca 5454, Cuajimalpa De  
Morelos, DF 05320 (MX).

(74) Agent: **HART, Bryan, T.**; Bejin Bieneman PLC, 300 River  
Place Road, Suite 1650, Detroit, MI 48107 (US).

(81) Designated States (*unless otherwise indicated, for every  
kind of national protection available*): AE, AG, AL, AM,  
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ,  
CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ,  
EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR,  
HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA,  
LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN,  
MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE,  
PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE,  
SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ,  
UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every  
kind of regional protection available*): ARIPO (BW, GH,  
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ,  
UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,  
TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK,  
EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV,  
MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,

(54) Title: FOLDING SCOOTER

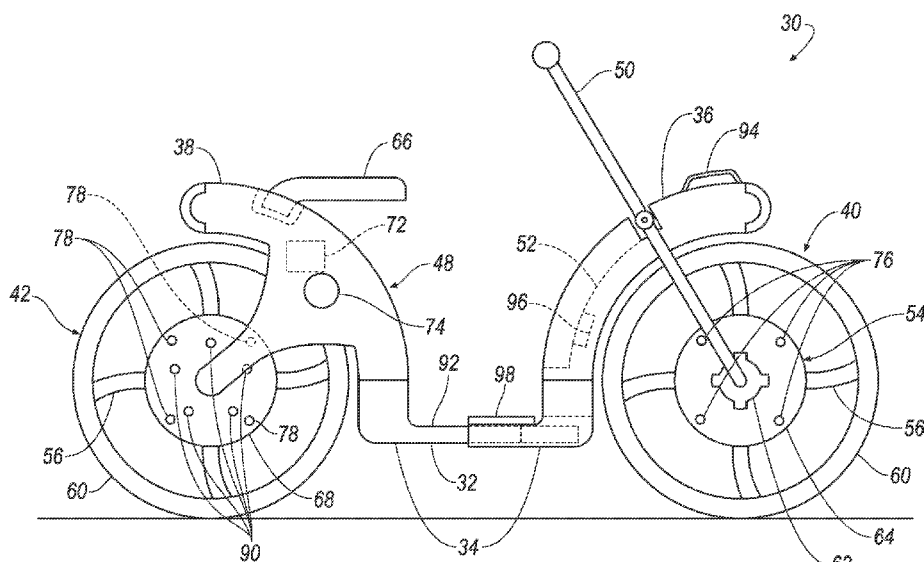


FIG. 1

(57) Abstract: A scooter includes a telescoping beam having two ends spaced from each other. A front frame segment is rotatably coupled to one of the ends, and a rear frame segment is rotatably coupled to the other of the ends. A first wheel is supported by the front frame segment, and a second wheel is supported by the rear frame segment. The telescoping beam is retractable and extendable, and the front and rear frame segments are rotatable, to change the scooter between a riding position and a stowed position. In the stowed position, the scooter may be disposed in a compartment of a vehicle.

TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,  
KM, ML, MR, NE, SN, TD, TG).

**Declarations under Rule 4.17:**

- *as to applicant's entitlement to apply for and be granted a  
patent (Rule 4.17(ii))*
- *of inventorship (Rule 4.17(iv))*

**Published:**

- *with international search report (Art. 21(3))*

## FOLDING SCOOTER

### BACKGROUND

[0001] In urban centers, vehicles such as cars may contribute to and suffer from congestion and gridlock. Waiting in traffic may cost occupants time and fuel. Furthermore, parking may not be available near an occupant's final destination. The occupant must travel the remaining distance from a parking location for the vehicle to the final destination, which is sometimes called the last-mile problem.

[0002] Vehicles may be equipped with a temporary spare tire. The spare tire is used for traveling a small distance relative to the distance traveled over the life of the vehicle.

[0003] Scooters are motorized vehicles with two or three wheels that are designed to transport one or two riders. Scooters can be useful in urban environments because of their small size relative to cars and other motor vehicles. Scooters may more easily navigate through congestion and may be easier to park since they may be able to be parked in smaller curbside spots, on sidewalks, in bike racks, in offices, etc. Scooters may be less useful for long-distance transportation because they have a smaller payload and may expose their riders to the external environment. Also, scooters may be too bulky to transport in vehicles such as cars.

### BRIEF DESCRIPTION OF THE DRAWINGS

[0004] Figure 1 is a side view of a scooter in a riding position.

[0005] Figure 2 is a front view of the scooter in a stowed position.

[0006] Figure 3 is a side view of the scooter in the stowed position.

[0007] Figure 4 is a rear perspective view of a vehicle.

[0008] Figure 5 is a cross-sectional view of wheels of the scooter attached to a wheel hub of the vehicle.

### DETAILED DESCRIPTION

[0009] With reference to the Figures, wherein like numerals indicate like parts throughout the several views, a scooter 30 includes a

telescoping beam 32 having two ends 34 spaced from each other. A front frame segment 36 is rotatably coupled to one of the ends 34, and a rear frame segment 38 is rotatably coupled to the other of the ends 34. A first wheel 40 is supported by the front frame segment 36, and a second wheel 42 is supported by the rear frame segment 38.

**[0010]** The scooter 30 may be folded from a riding position, as shown in Figure 1, into a stowed position, as shown in Figures 2–5. The stowed position reduces the volume occupied by the scooter 30, which allows for easier transportation of the scooter 30, for example, in a vehicle 44. Furthermore, the scooter 30 may be used as a spare tire for the vehicle 44, which may allow the vehicle 44 to carry the scooter 30 instead of a spare tire, saving additional space. Using the scooter 30 instead of the spare tire makes more efficient and frequent use of the weight that would be dedicated to the spare tire. The easier transportation of the scooter 30 allows the scooter 30 to more easily address the last-mile problem.

**[0011]** With reference to Figure 1, the scooter 30 includes a frame 48. The frame 48 includes the telescoping beam 32 and the frame segments 36, 38. The frame 48 may be formed of metal such as aluminum, plastic, or any other suitable material.

**[0012]** The telescoping beam 32 has two ends 34 spaced from each other. The telescoping beam 32 has a modifiable length. The telescoping beam 32 may have an outer telescoping member and an inner telescoping member. The inner telescoping member or a portion thereof extends out of and retracts into the outer telescoping portion. The outer telescoping portion extends fully or partially around the inner telescoping portion. The telescoping beam 32 has a long position, as shown in Figure 1, in which the inner telescoping member extends out of the outer telescoping portion to a maximum extent, and a short position, as shown in Figures 2–5, in which the inner telescoping member retracts into the outer telescoping member to a maximum extent. The telescoping beam 32 may have a flat portion 92 facing upwards.

**[0013]** The flat portion 92 may provide a footrest for a rider. In addition, the outer telescoping portion may include a hinged footrest extension 98.

The hinged footrest extension 98 may rotate from a folded position transverse to the flat portion 92 to an unfolded position coplanar with the flat portion 92. The hinged footrest extension 98 may provide a footrest for a rider while the scooter 30 is in the riding position and reduce the width of the telescoping beam 32 while the scooter 30 is in the stowed position.

**[0014]** The front frame segment 36 is rotatably coupled to one of the ends 34 of the telescoping beam 32. The front frame segment 36 is rotatable relative to the telescoping beam 32 from the riding position to the stowed position. The front frame segment 36 may be curved around a portion of a circumference of the first wheel 40. In the riding position, a plane defined by the front frame segment 36 is aligned with the beam 32, as shown in Figure 1. In the stowed position, the plane defined by the front frame segment 36 is perpendicular to the beam 32, as shown in Figures 2 and 3.

**[0015]** A foldable handlebar 50 may be rotatably attached to the front frame segment 36. The handlebar 50 may be coupled to the first wheel 40. Rotation of the handlebar 50 relative to the front frame segment 36 turns the first wheel 40 in order to steer the scooter 30. The handlebar 50 may fold about a hinge between an unfolded position, upright relative to the front frame segment 36 (as shown in Figure 1), and a folded position, against the front frame segment 36 (as shown in Figure 3).

**[0016]** With continued reference to Figure 1, the front frame segment 36 may include a compartment 52 sized to receive the handlebar 50. In the folded position, the foldable handlebar 50 may be disposed in the compartment 52. In the unfolded position, the foldable handlebar 50 may be spaced from the compartment 52. The compartment 52 may include a cover (not shown). When the foldable handlebar 50 is in the unfolded position, the compartment 52 may provide storage space. The compartment 52 may have a charging outlet 96 electrically connected to a battery 72 (described below) that a user may use to charge a mobile device.

**[0017]** The first wheel 40 is rotatably supported by the front frame segment 36. The front frame segment 36 rotatably supports the first wheel 40 about a rotational axis, about which the first wheel 40 rotates. The first wheel 40

may include a hub 54, spokes 56, a rim 58, and a tire 60. The spokes 56 extend from the hub 54 to the rim 58. The tire 60 extends around the rim 58. The width of the first wheel 40 may be approximately half the width of a wheel 86 of the vehicle 44.

**[0018]** With reference to Figures 1 and 5, the hub 54 of the first wheel 40 is located at the center of the first wheel 40, in other words, at the rotational axis. The hub 54 includes a central portion 62 and a flange portion 64. The flange portion 64 may extend around the central portion 62. The spokes 56 may connect to the flange portion 64. The central portion 62 may be detachable from the flange portion 64. For example, as shown in Figure 1, the central portion 62 is attached to the flange portion 64, and as shown in Figure 5, the central portion 62 is removed from the flange portion 64 when the scooter 30 is used as a spare tire of the vehicle 44, as set forth further below.

**[0019]** The rear frame segment 38 is rotatably coupled to the other of the ends 34 of the telescoping beam 32 than the front frame segment 36. The rear frame segment 38 is rotatable relative to the telescoping beam 32 from the riding position to the stowed position. The rear frame segment 38 may be curved around a portion of a circumference of the second wheel 42. In the riding position, a plane defined by the rear frame segment 38 is aligned with the beam 32, as shown in Figure 1. In the stowed position, the plane defined by the rear frame segment 38 is perpendicular to the beam 32, as shown in Figures 2 and 3.

**[0020]** With continued reference to Figure 1, a seat 66 may be rotatably attached to the rear frame segment 38. The seat 66 may include a padded, curved surface designed to provide support to a sitting rider of the scooter 30. The seat 66 may rotate from an unfolded position extending from the rear frame segment 38 (as shown in Figure 1) to a folded position against the rear frame segment 38 (as shown in Figure 3). In the unfolded position, the seat 66 provides support for a rider. In the folded position, the seat 66 may wrap around the rear frame segment 38.

**[0021]** With continued reference to Figure 1, the second wheel 42 is rotatably supported by the rear frame segment 38. The rear frame segment 38 rotatably supports the second wheel 42 about a rotational axis, about which the

second wheel 42 rotates. The second wheel 42 may include a hub 68, spokes 56, a rim 58, and a tire 60. The hub 68 is located at the rotational axis, in other words, at the center of the second wheel 42. The spokes 56 extend from the hub 68 to the rim 58. The tire 60 extends around the rim 58. The width of the second wheel 42 may be approximately half the width of a wheel 86 of the vehicle 44.

**[0022]** With reference to Figure 5, one of the first wheel 40 and the second wheel 42 includes an electric motor 70. For example, the hub 68 of the second wheel 42 may include the electric motor 70. The electric motor 70 may be drivably connected to the second wheel 42. The electric motor 70 rotates the second wheel 42 with respect to the frame 48.

**[0023]** The battery 72, as identified in Figure 1, may be coupled to the rear frame segment 38 and electrically connected to the electric motor 70. The battery 72 may be of any suitable type for vehicular electrification, for example, lithium-ion batteries, nickel-metal hydride batteries, lead-acid batteries, or ultracapacitors.

**[0024]** With reference to Figure 1, a charging port 74 may be mounted on the rear frame segment 38. The charging port 74 may receive an electrical connector. The charging port 74 may be electrically connected to the battery 72 and may allow the transmission of power from an external source to the battery 72.

**[0025]** With reference to Figure 1, each of the hubs 54, 68 include bolt holes 76, 78 in a common pattern. In other words, each bolt hole 76 in the common pattern in the first wheel 40 can be simultaneously aligned with a bolt hole 78 in the common pattern in the second wheel 42, and vice versa. Said another way, for each bolt hole 76 in the common pattern in the first wheel 40, the second wheel 42 has a bolt hole 78 at the same distance from the rotational axis and the same angles about the rotational axis relative to the other bolt holes 78 in the common pattern. For example, the common pattern may be four bolt holes 76, 78 that are 90° apart relative to the rotational axis at the same distance from the rotational axis. In the first wheel 40, the flange portion 64 may have the bolt holes 76.

**[0026]** A bracket 94 may be rotatably connected to the front frame segment 36. When the scooter 30 is in the stowed position, the bracket 94 may be rotated from an aligned position aligned with the front frame segment 36 to a handle position extending from the front frame segment 36 to the rear frame segment 38. The bracket 94 is releasably attachable to the rear frame segment 38. When the bracket 94 is in the handle position and attached to the rear frame segment 38, the bracket 94 serves as a handle for a user to lift the scooter 30.

**[0027]** A releasable lock (not shown) may be between the telescoping beam 32 and each of the front and rear frame segments 36, 38. The releasable locks may be located at the ends 34 of the telescoping beam 32. The releasable locks may be changeable between a locked and an unlocked position. In the locked position, the releasable locks prevent the frame segments 36, 38 from rotating relative to the telescoping beam 32. In the unlocked position, the releasable locks permit the frame segments 36, 38 to rotate relative to the telescoping beam 32. The releasable lock may be, for example, a pin fitted through holes in the frame segments 36, 38 and the telescoping beam 32 corresponding to the stowed position and the riding position for the frame segments 36, 38; mating elements on the frame segments 36, 38 and the telescoping beam 32 combined with a spring biasing the mating elements together; or any other suitable mechanism.

**[0028]** The scooter 30 is movable between the riding position, shown in Figure 1, and the stowed position, shown in Figures 2 and 3. When the scooter 30 is in the riding position, the telescoping beam 32 is in the long position, the front and rear frame segments 36, 38 are in the riding position, the handlebar 50 is in the unfolded position, and the seat 66 is in the unfolded position. When both frame segments 36, 38 are in the riding position, the planes defined by the frame segments 36, 38 are aligned with the beam 32. The rotational axes of the first wheel 40 and the second wheel 42 are offset from each other in the riding position. The rotational axes may be parallel to each other if the first wheel 40 is steered straight forward or may intersect if the first wheel 40 is turned.

**[0029]** When the scooter 30 is in the stowed position, the telescoping beam 32 is in the short position, the front and rear frame segments 36,

38 are in the stowed position, the handlebar 50 is in the folded position, and the seat 66 is in the folded position. When both frame segments 36, 38 are in the stowed position, the planes defined by the frame segments 36, 38 are perpendicular to the beam 32. The rotational axes of the first wheel 40 and the second wheel 42 are collinear in the stowed position. In other words, the wheels 40, 42 are parallel and next to each other in the stowed position. The common pattern of bolt holes 76, 78 in the first and second wheels 40, 42 are aligned in the stowed position.

**[0030]** To change the scooter 30 from the riding position to the stowed position, a rider folds the handlebar 50 from the unfolded position to the folded position and folds the seat 66 from the unfolded position to the folded position. The rider retracts the telescoping beam 32 from the long position to the short position. The rider rotates the frame segments 36, 38 from the riding position to the stowed position. The rider aligns the bolt holes 76, 78 in the common pattern in the wheels 40, 42 and bolts the wheels 40, 42 to each other through the bolt holes 76, 78. The actions taken by the rider do not need to follow this order.

**[0031]** To change the scooter 30 from the stowed position to the riding position, the rider removes the bolts holding the wheels 40, 42 together from the bolt holes 76, 78. The rider rotates the frame segments 36, 38 from the stowed position to the riding position, and the rider extends the telescoping beam 32 from the short position to the long position. The rider unfolds the handlebar 50 from the folded position to the unfolded position, and the rider unfolds the seat 66 from the folded position to the unfolded position. The actions taken by the rider do not need to follow this order.

**[0032]** The scooter 30 may be used in conjunction with the vehicle 44, for example, a motor vehicle such as an automobile.

**[0033]** With reference to Figure 4, the vehicle 44 may include a compartment 46. The compartment 46 may be sized to receive a spare tire. The compartment 46 may, for example, be disposed in a lining of a trunk 80 of the vehicle 44, or the compartment 46 may be in a separate case fastened to an exterior surface of the vehicle 44, or the compartment 46 may be in another

suitable location in or on the vehicle 44. In the stowed state, the scooter 30 may be disposed in the compartment 46.

**[0034]** With continued reference to Figure 4, the vehicle 44 may include a wheel hub 82 fixed relative to the compartment 46. The wheel hub 82 has bolts. A vehicle wheel 86 may be fixed to the wheel hub 82 via nuts and the bolts 88. The vehicle wheel 86 may be removed from the wheel hub 82 by removing the nuts and sliding the wheel off of the bolts 88.

**[0035]** The first wheel 40 and/or the second wheel 42 of the scooter 30 includes additional bolt holes 90 configured to align with the wheel hub 82 of the vehicle 44, e.g., the second wheel 42 includes the additional bolt holes 90 in Figure 3. The additional bolt holes 90 are aligned in a common pattern with the bolts 88 of the wheel hub 82. The common pattern may be different than the common pattern of bolt holes 76, 78 on the first and second wheels 40, 42.

**[0036]** The first and second wheels 40, 42 may together operate as a spare tire for the vehicle 44. When the scooter 30 is in the stowed position, the scooter 30 may be changed to the spare-tire state. A rider detaches the frame 48 from the first and second wheels 40, 42. Specifically, the rider detaches the central portion 62 of the hub 54 from the flange portion 64 at the first wheel 40, and the rider detaches the rear frame segment 38 from the second wheel 42. The rider may also remove the electric motor 70 from the second wheel 42. The electric motor 70 may be connected to the rear frame segment 38 and detach as a unit with the frame 48. The first and second wheels 40, 42, which are bolted together via the common pattern of bolt holes 76, 78, may now be used as a spare tire. The rider attaches the first and second wheels 40, 42 to the wheel hub 82 through the additional bolt holes 90 and the bolts 88 of the wheel hub 82.

**[0037]** The disclosure has been described in an illustrative manner, and it is to be understood that the terminology which has been used is intended to be in the nature of words of description rather than of limitation. Many modifications and variations of the present disclosure are possible in light of the above teachings, and the disclosure may be practiced otherwise than as specifically described.

## CLAIMS

What is claimed is:

1. A scooter comprising:  
a telescoping beam having two ends spaced from each other;  
a front frame segment rotatably coupled to one of the ends, and a rear frame segment rotatably coupled to the other of the ends; and  
a first wheel supported by the front frame segment, and a second wheel supported by the rear frame segment.
2. The scooter of claim 1, wherein the first wheel and the second wheel each includes a hub, each of the hubs including bolt holes in a common pattern.
3. The scooter of claim 2, wherein the second wheel includes an additional bolt hole configured to align with a wheel hub of a vehicle.
4. The scooter of claim 2, wherein the hub of the first wheel includes a central portion and a flange portion extending around the central portion, the flange portion having the bolt holes and the central portion being detachable from the flange portion.
5. The scooter of claim 1, wherein the front frame segment and the rear frame segment are rotatable relative to the telescoping beam from a riding position to a stowed position, rotational axes of the first wheel and the second wheel are offset from each other in the riding position and collinear in the stowed position, wherein the first wheel and the second wheel each include a bolt hole aligned with each other in the stowed position.
6. The scooter of claim 1, wherein one of the first wheel and the second wheel includes an electric motor.
7. The scooter of claim 1, further comprising a foldable handlebar rotatably attached to the front frame segment.

8. The scooter of claim 7, wherein the front frame segment includes a compartment sized to receive the handlebar.

9. The scooter of claim 8, further comprising a charging outlet disposed in the compartment.

10. The scooter of claim 1, further comprising a seat rotatably attached to the rear frame segment.

11. The scooter of claim 1, further comprising a releasable lock between the telescoping beam and each of the front and rear frame segments.

12. The scooter of claim 1, further comprising a bracket rotatably connected to one of the front frame segment and the rear frame segment and attachable to the other of the front frame segment and the rear frame segment.

13. The scooter of claim 1, further comprising an extension rotatably connected to the telescoping beam about an axis in a direction of the telescoping beam.

14. A vehicle comprising:  
a compartment; and  
a scooter disposed in the compartment;  
the scooter includes a telescoping beam having two ends spaced from each other, a front frame segment rotatably coupled to one of the ends, and a rear frame segment rotatably coupled to the other of the ends, a first wheel supported by the front frame segment, and a second wheel supported by the rear frame segment.

15. The vehicle of claim 14, wherein the first wheel and the second wheel each includes a hub, each of the hubs including bolt holes in a common pattern.

16. The vehicle of claim 15, further comprising a wheel hub fixed relative to the compartment and having a bolt, wherein the second wheel includes an additional bolt hole configured to align with the wheel hub.

17. The vehicle of claim 15, wherein the hub of the first wheel includes a central portion and a flange portion extending around the central portion, the flange portion having the bolt holes and the central portion being detachable from the flange portion.

18. The vehicle of claim 14, wherein the front frame segment and the rear frame segment are rotatable relative to the telescoping beam from a riding position to a stowed position, rotational axes of the first wheel and the second wheel are offset from each other in the riding position and collinear in the stowed position, wherein the first wheel and the second wheel each include a bolt hole aligned with each other in the stowed position.

19. The vehicle of claim 14, wherein one of the first wheel and the second wheel includes an electric motor.

20. The vehicle of claim 14, further comprising a releasable lock between the telescoping beam and each of the front and rear frame segments.

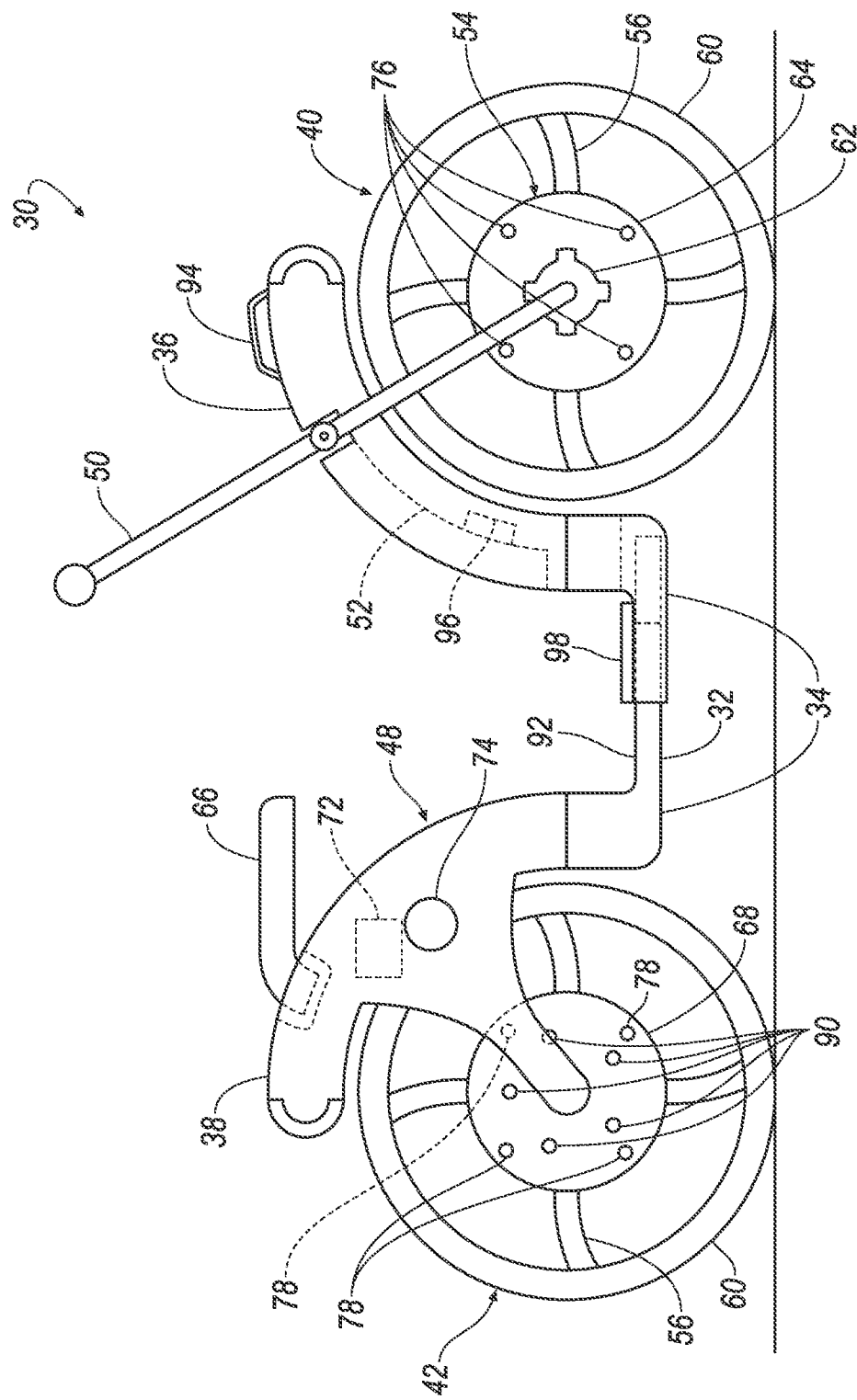


FIG. 1

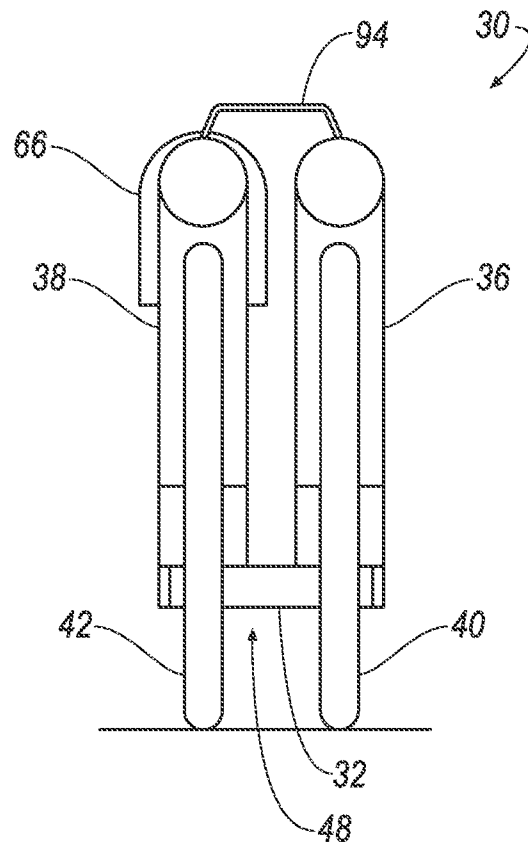


FIG. 2

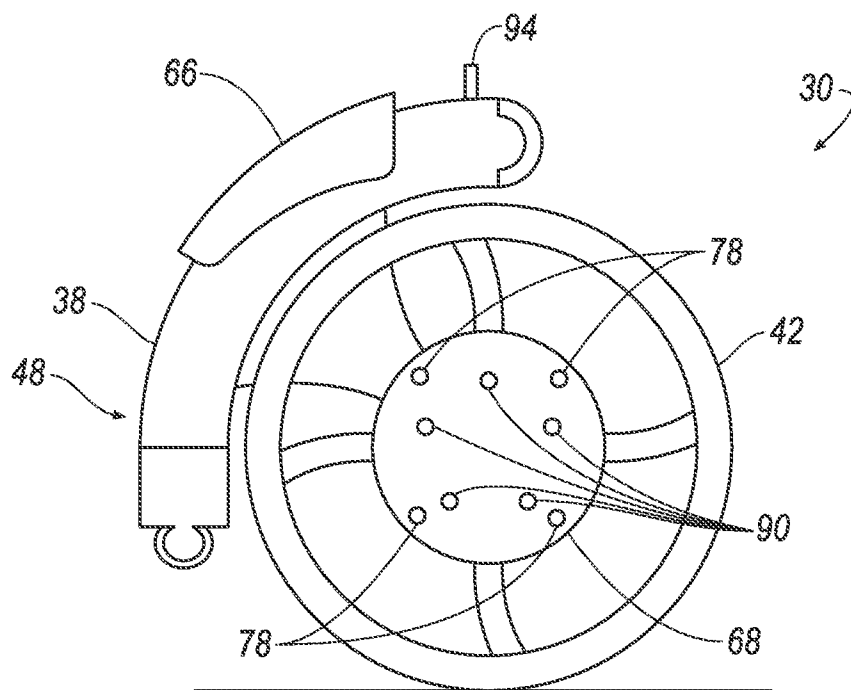
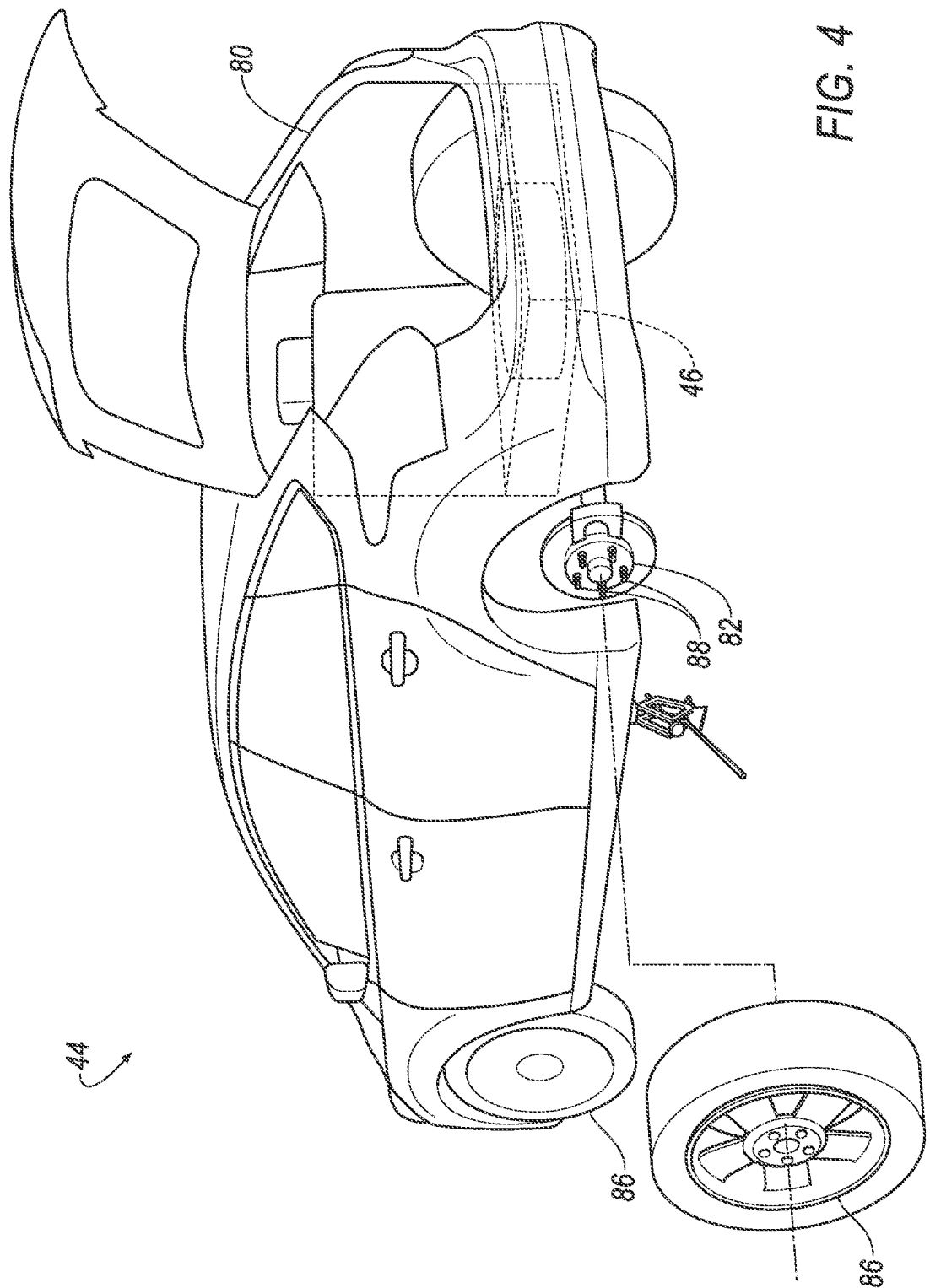


FIG. 3



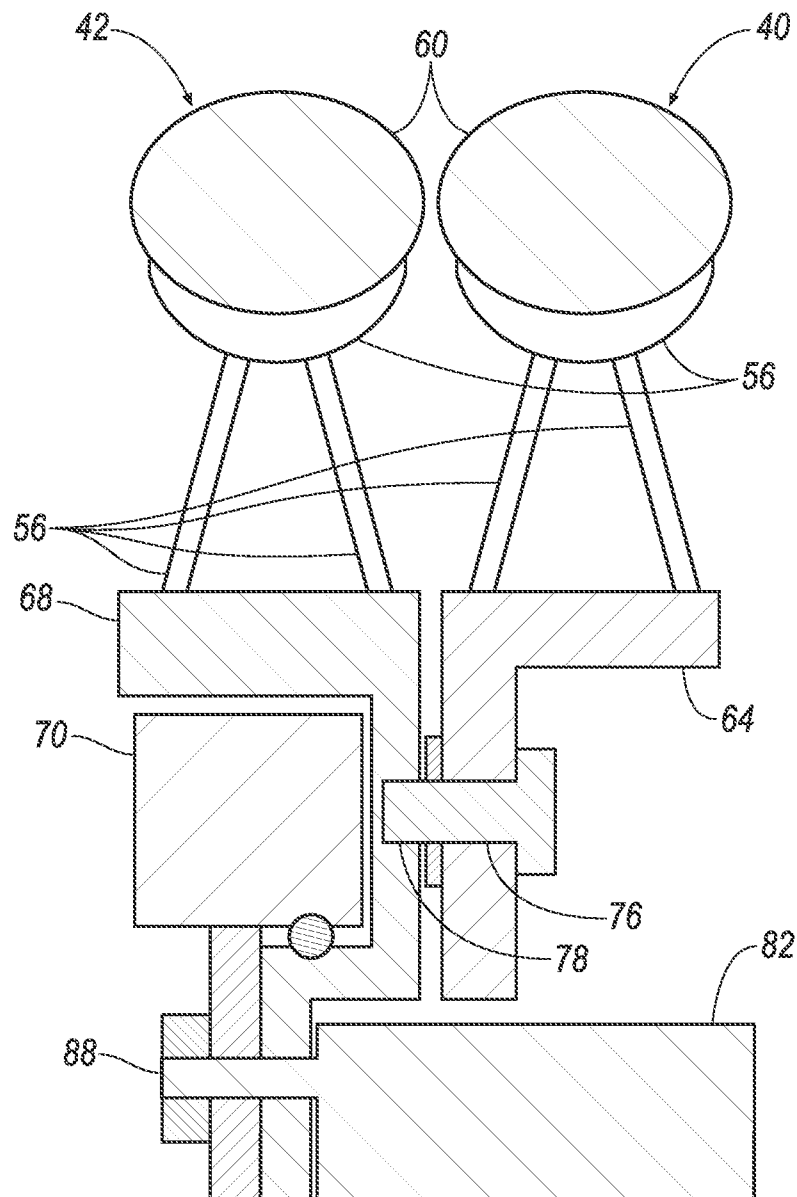


FIG. 5

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 16/42235

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - B62K 15/00, B62K 11/00, B62K 11/02 (2016.01)

CPC - B62K 15/00, B62K 15/006, B62K 11/00, B62K 11/02, B62K 15/008

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC (8): B62K15/00, B62D61/00, B62K11/00 B62K15/\*, B62K11/\*, B62K2202/\*, B62K2204/\* (2016.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

CPC: B62K15/00, B62K15/006, B62K11/00, B62K11/02, B62K15/00, B62K15/006, B62K15/008, B62K2202/00 B62K15/\*, B62K11/\*, B62K15/\*, B62K2202/\*, B62K2204/\*

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Patbase, Google (Web, Patents, Images, Scholar)

Bicycle, scooter, fold, base, electric, telescoping, extend, rotate, small, hinge, engage, retract, wheel, frame, hub, vehicle, spare, tire, brake, carry, retain, bracket, hold clip, internal, stow, handle, compartment,

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category*                     | Citation of document, with indication, where appropriate, of the relevant passages                                                                                    | Relevant to claim No.                                                |
|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|
| X<br>-----<br>Y<br>-----<br>A | CN 104354810 A (XIAO QINGQING) 18 February 2015 (18.02.2015) entire document, especially Title, Abstract, see translation, fig. 1, 4; pg. 4, ln 8-28, pg 5, ln 19-24. | 1, 5-7, 10<br>-----<br>12, 14, 18-19<br>-----<br>2-4, 8-9, 15-17, 20 |
| Y<br>-----<br>A               | US 2015/0266536 A1 (Yap) 24 September 2015 (24.09.2015) entire document, especially Title, Abstract, fig.1, 8-11; para [0027]-[0030], [0033],                         | 1, 11, 13<br>-----<br>2-4, 8-9, 15-17, 20                            |
| Y<br>-----<br>A               | US 2015/0084312 A1 (Schreuder et al.) 26 March 2015 (26.03.2015) entire document, especially Title, Abstract, fig. 1para[0042]; figs. 1, 3B, 5A, 5B.                  | 1, 11, 13<br>-----<br>2-4, 8-9, 15-17, 20                            |
| Y<br>-----<br>Y<br>-----<br>A | US 8,388,015 B2 (Chen) 5 March 2013 (05.03.2013) entire document, especially Title, Abstract, fig.6 col 10, ln 43-52.                                                 | 12<br>-----<br>14, 18-19<br>-----<br>2-4, 8-9, 15-17, 20             |
| A                             | US 2016/0076226 A1 (Aich et al.) 17 March 2016 (17.03.2016)                                                                                                           | 2-4, 8-9, 15-17, 20                                                  |
| A                             | US 8,511,695 B2 (Johnson et al.) 20 August 2016 (20.08.2016)                                                                                                          | 2-4, 8-9, 15-17, 20                                                  |

☐ Further documents are listed in the continuation of Box C.

|                                                                                                                                                                         |                                                                                                                                                                                                                                                  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| * Special categories of cited documents:                                                                                                                                | "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention                                              |
| "A" document defining the general state of the art which is not considered to be of particular relevance                                                                | "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone                                                                     |
| "E" earlier application or patent but published on or after the international filing date                                                                               | "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art |
| "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) | "&" document member of the same patent family                                                                                                                                                                                                    |
| "O" document referring to an oral disclosure, use, exhibition or other means                                                                                            |                                                                                                                                                                                                                                                  |
| "P" document published prior to the international filing date but later than the priority date claimed                                                                  |                                                                                                                                                                                                                                                  |

|                                                                                                                                                                                 |                                                                                            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|
| Date of the actual completion of the international search<br>17 September 2016                                                                                                  | Date of mailing of the international search report<br>06 OCT 2016                          |
| Name and mailing address of the ISA/US<br>Mail Stop PCT, Attn: ISA/US, Commissioner for Patents<br>P.O. Box 1450, Alexandria, Virginia 22313-1450<br>Facsimile No. 571-273-8300 | Authorized officer:<br>Lee W. Young<br>PCT Helpdesk: 571-272-4300<br>PCT OSP: 571-272-7774 |