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(54) **HUB MOTOR WITH INTEGRATED BRAKE**

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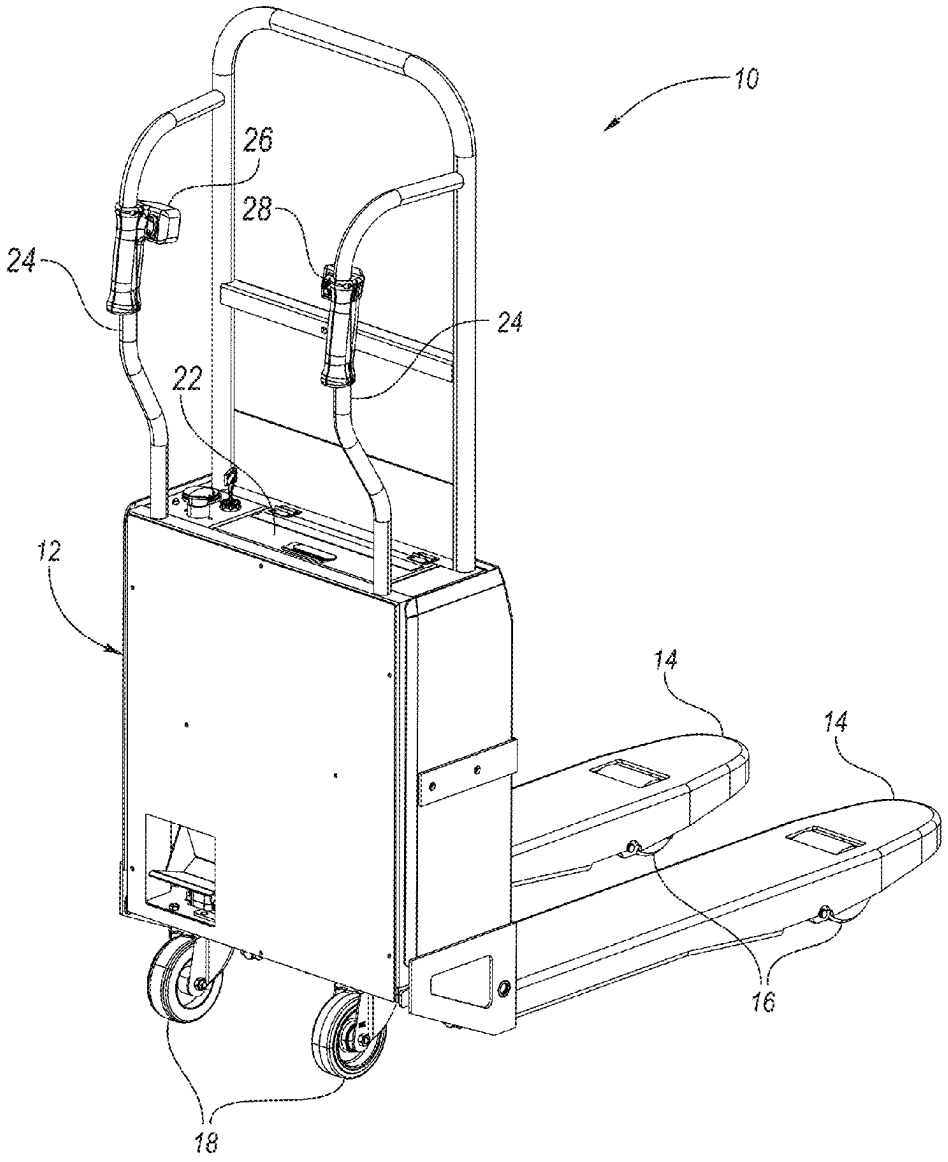
(57) **ABSTRACT**

A hub motor includes a hub motor body, an axle extending into the hub motor body, a rotor coupled to the outer housing, a stator within the rotor and coupled to the axle, and a brake within the hub motor body. The brake may include a brake pad spring-biased into braking engagement and moved out of braking engagement by an electromagnetic coil, such that the brake will fail into a braked state.



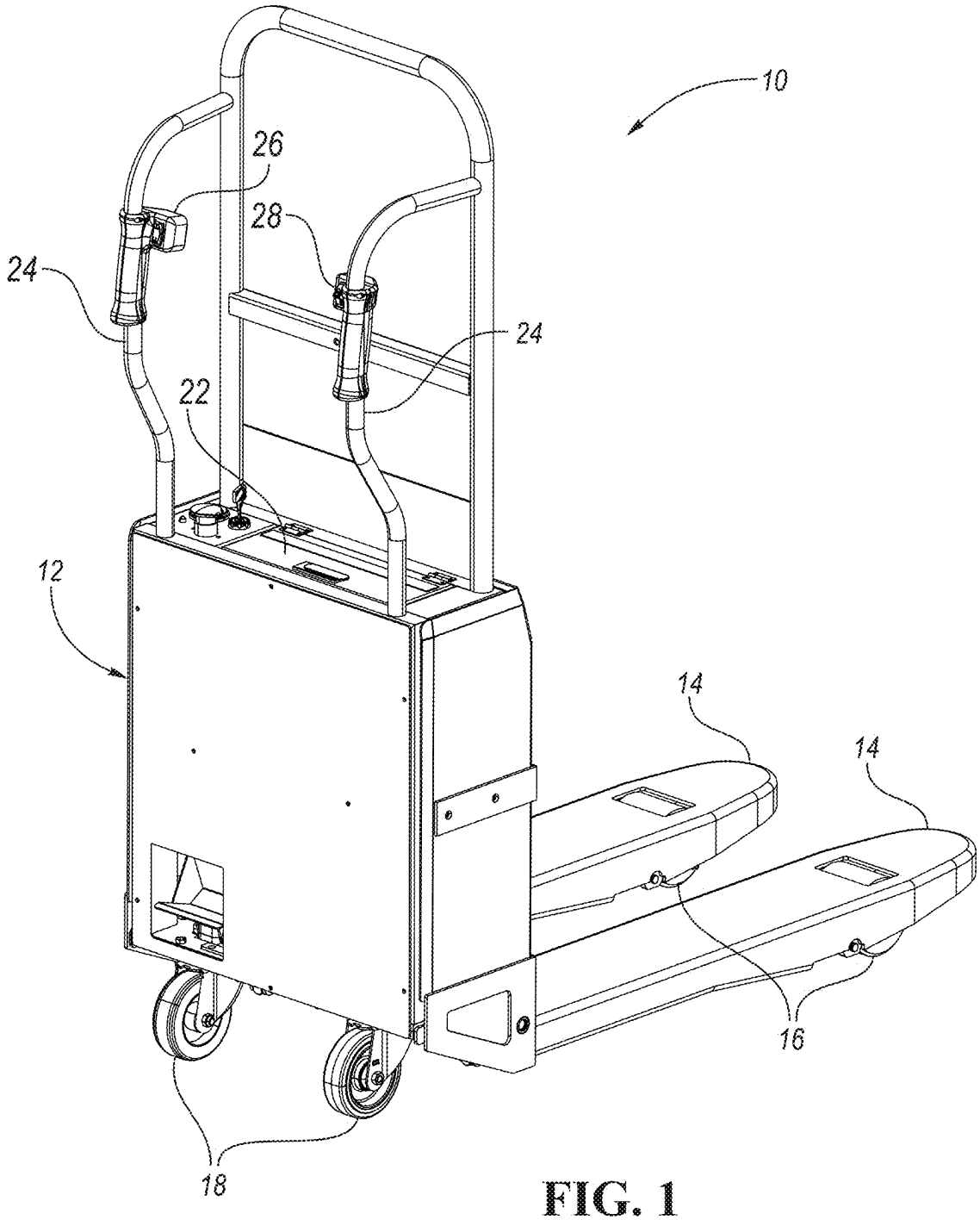



FIG. 1

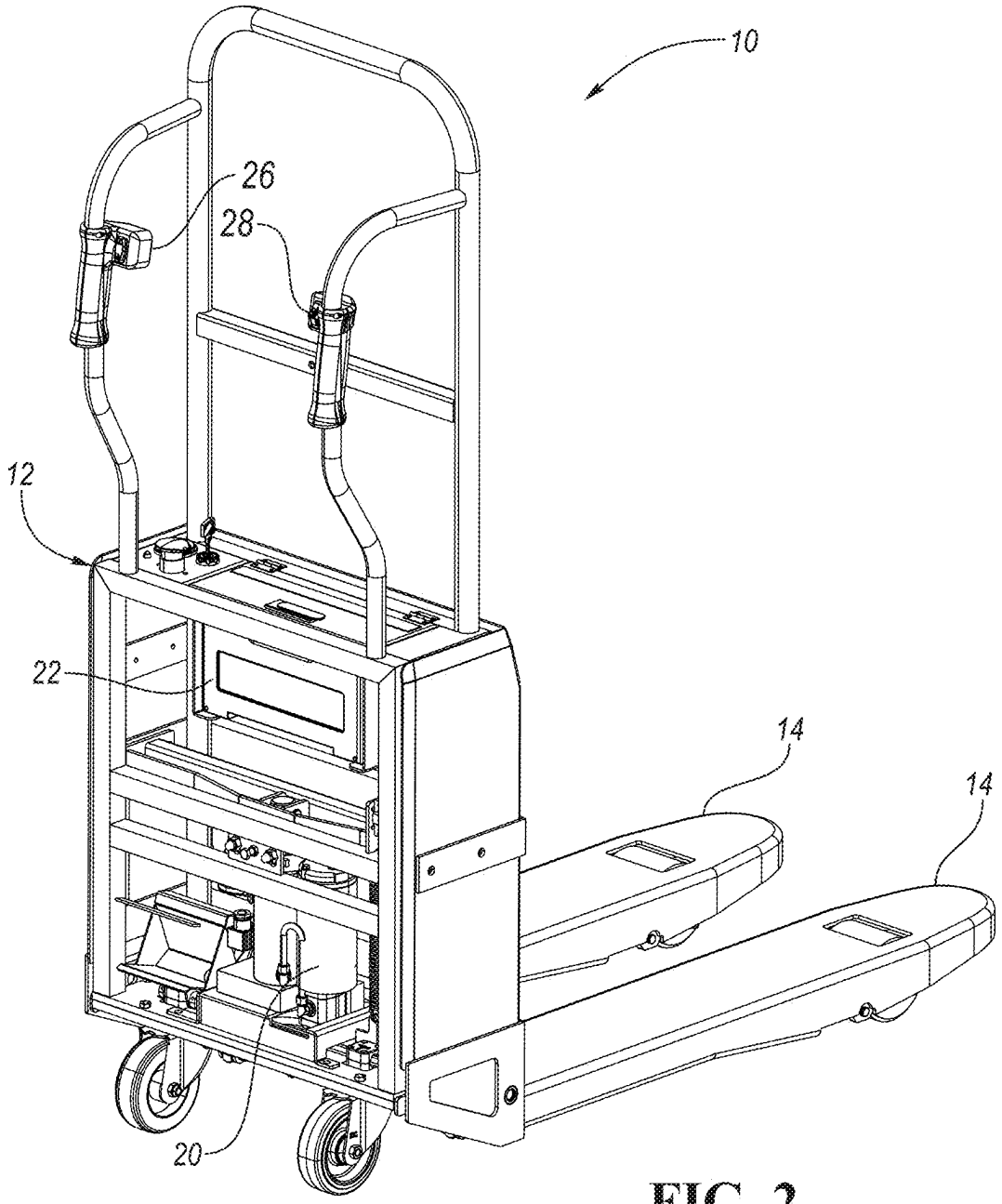



FIG. 2

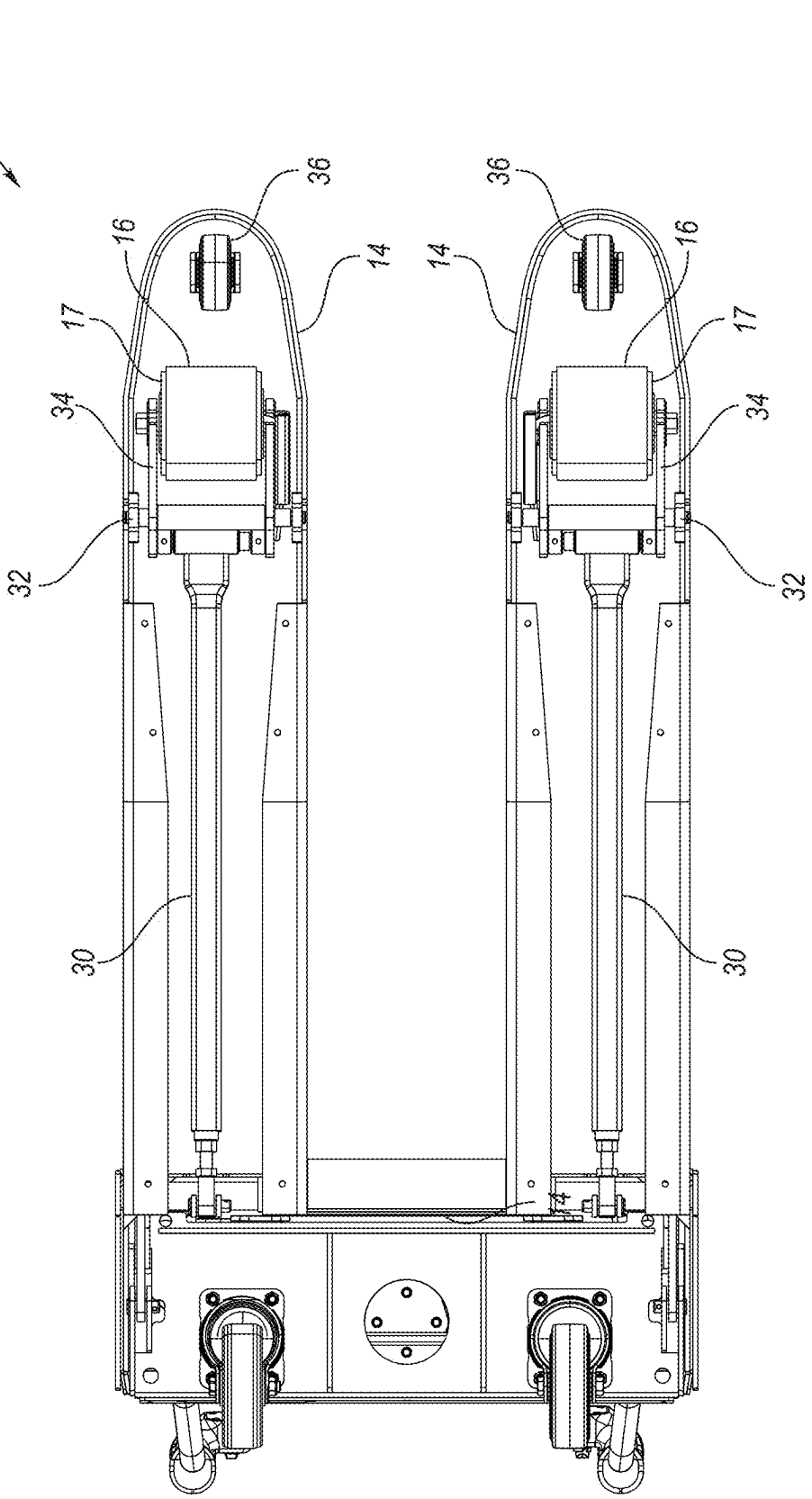



FIG. 3

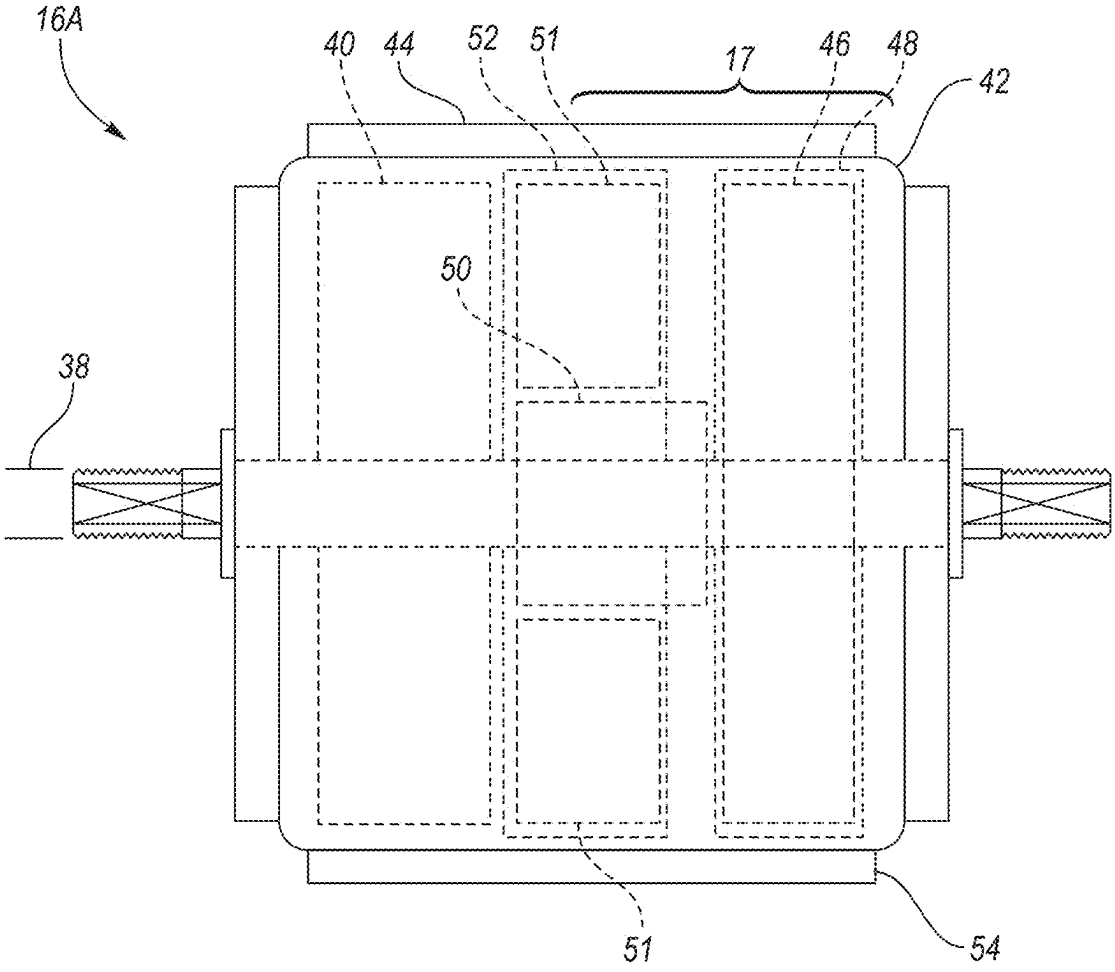



FIG. 4

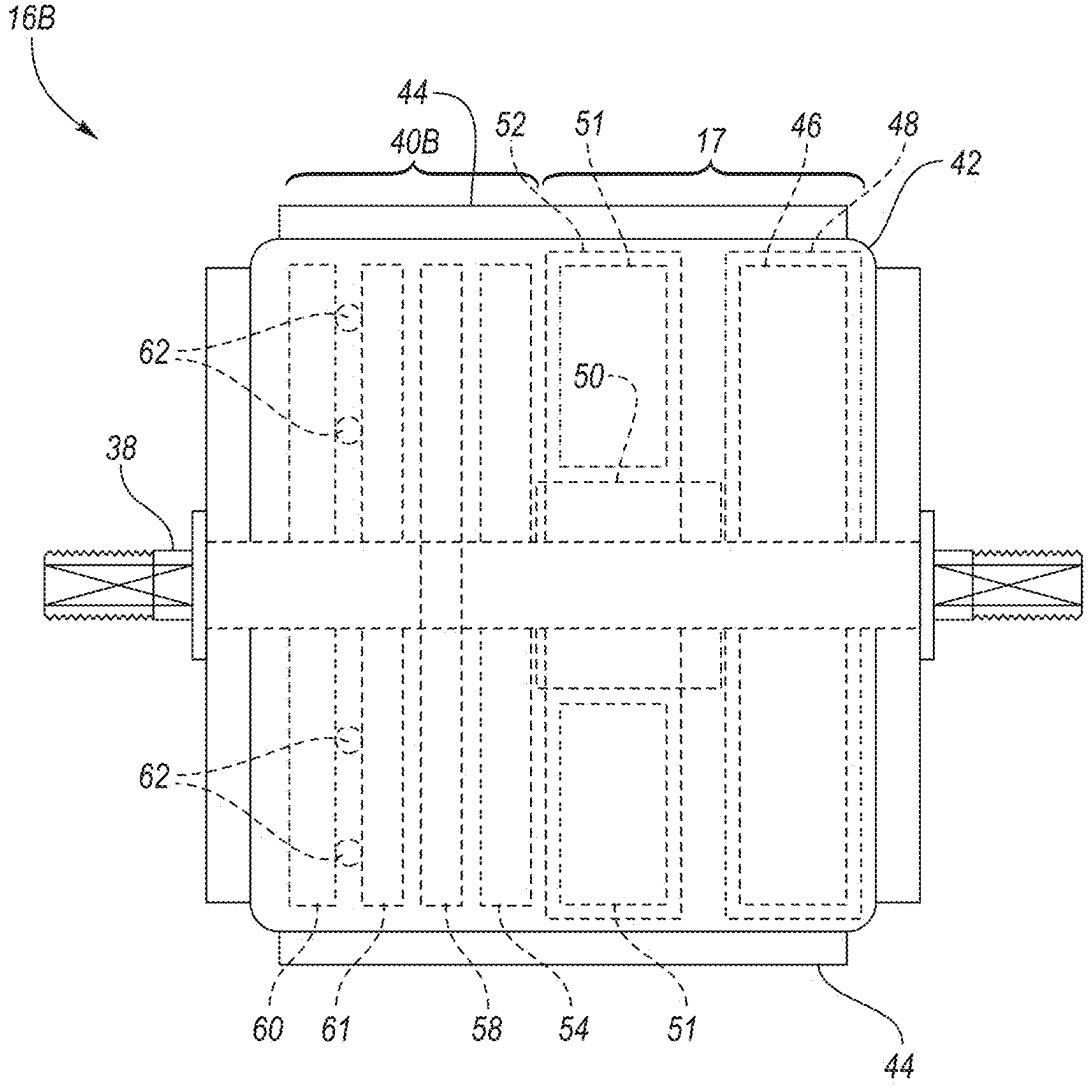



FIG. 5

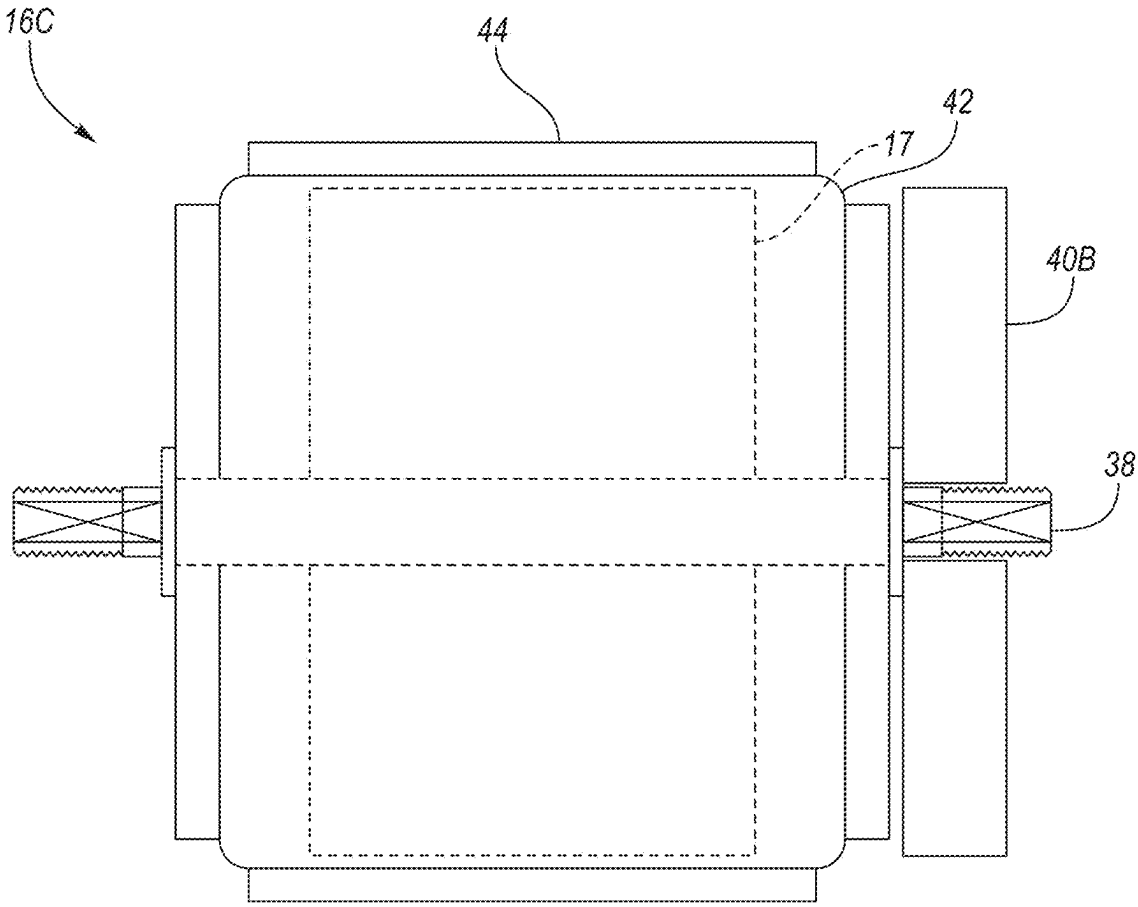



FIG. 6

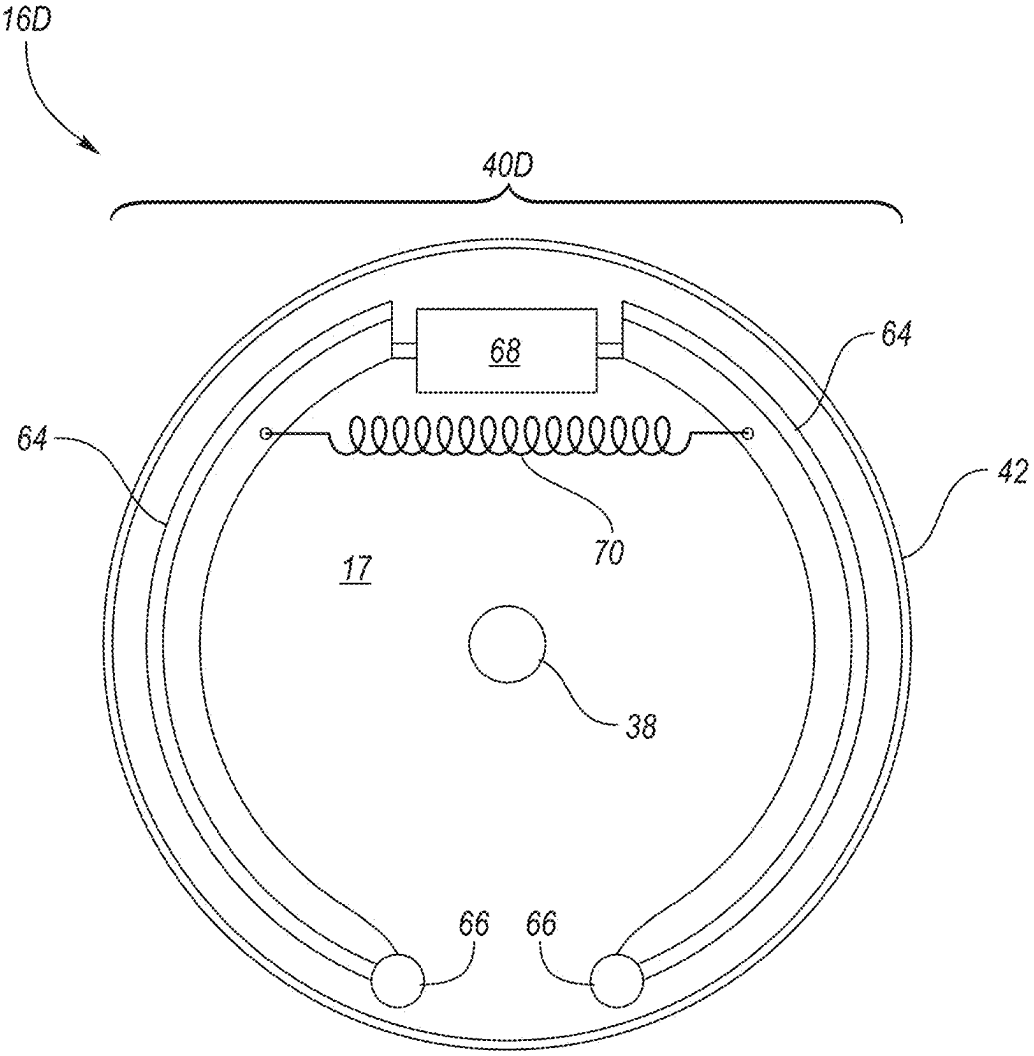



FIG. 7

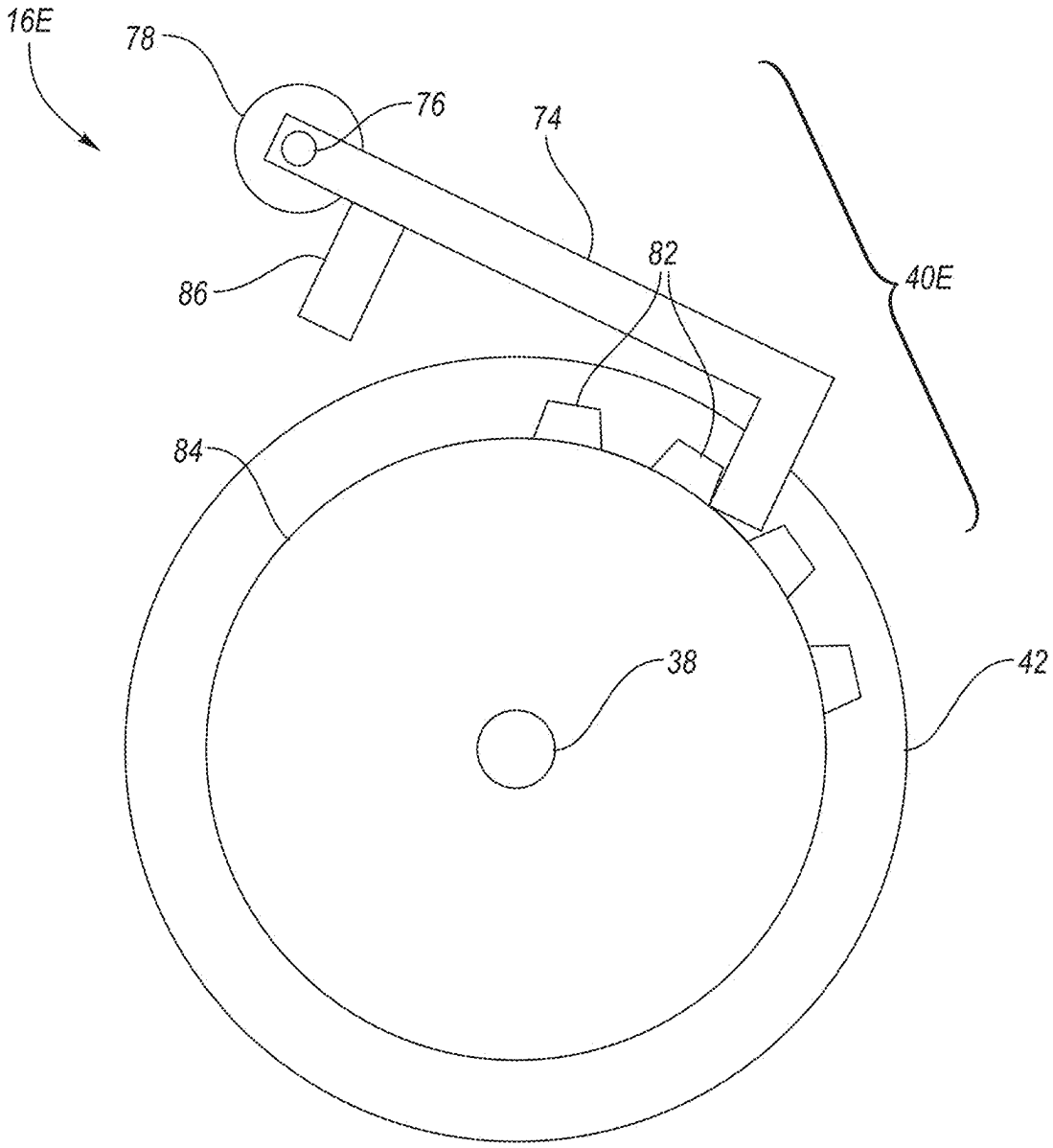



FIG. 8

# HUB MOTOR WITH INTEGRATED BRAKE

## BACKGROUND

**[0001]** A powered delivery sled having a compact electric hub motor is currently being sold by the assignee of the present invention to provide a manual push mode, powered drive assist mode and full powered drive mode to deliver product from a trailer to a store. The current hub motor provides a great solution for delivery but requires a separate parking brake to hold the sled at a standstill when stopped.

**[0002]** The current hub motor has the ability to utilize the electromagnetic windings to apply a brake when powered. However, the current hub motor does not have any sort of integrated parking brake or friction brake feature and typically relies on another system to hold the product at a standstill.

## SUMMARY

**[0003]** Several embodiments disclosed herein build upon the existing hub motor to integrate a parking brake or friction brake into the hub motor to maintain the compact, full power packaging. The integration of the brake gives the compact hub motor package full capability similar to an electric pallet jack drive but in a smaller, lighter weight package.

**[0004]** This allows for lighter, more compact equipment to be more full-featured for deliveries up and down ramps, throughout parking lots, etc. while still being able to get into tight restaurants and coolers.

**[0005]** Optionally, the parking brake may also assist the hub motors in slowing the sled down, e.g. when on ramps.

**[0006]** The parking brake could be electrical, non-electrical, mechanical, internal and/or external to the hub motor. Since making it electrical may be an issue if the battery dies, one option disclosed herein is to automatically apply the parking brake when the unit is without battery, i.e. the brake will fail to the braked status.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0007]** FIG. **1** shows an example pallet sled in which the hub motor brake is used.

**[0008]** FIG. **2** shows the pallet sled of FIG. **1** with a back panel removed.

**[0009]** FIG. **3** is a bottom view of the pallet sled of FIG. **1**.

**[0010]** FIG. **4** shows one arrangement of the wheel assembly with integrated brake that could be used in the pallet sled of FIG. **1**.

**[0011]** FIG. **5** shows one possible specific implementation of the wheel assembly of FIG. **4** with a first example brake assembly.

**[0012]** FIG. **6** shows a second possible implementation of the wheel assembly with integrated brake of FIG. **4**.

**[0013]** FIG. **7** shows a third possible implementation of the wheel assembly with integrated brake of FIG. **4**.

**[0014]** FIG. **8** shows a fourth possible implementation of the wheel assembly with integrated brake of FIG. **4**.

## DETAILED DESCRIPTION

**[0015]** An example of a powered sled **10** for transporting objects such as pallets is shown in FIG. **1**. The sled **10** includes a lift module or base **12** connected to a pair of tines **14** extending forward of the base **12**. The base **12** can raise and lower the tines **14**, such as by leveraging the load wheels **16** supporting outer ends of the tines **14**. Casters **18** may support the base **12**.

**[0016]** A battery **22** is also mounted in the base **12** for driving motors within the load wheels **16**, as will be explained below. Upright handles **24** extend upward from the base **12**. Alternatively, the sled **10** could have a pivotable tiller arm for steering a rear wheel supporting the base, similar to a traditional pallet jack. A lift control lever **26** is connected to the handles **24**. A throttle control lever **28** is also connected to the handles **24**. The load wheels **16** include hub motors. The hub motors selectively receive power from the battery **22** to drive the load wheels **16** rotatably. Both hub motors may be controlled by the single throttle lever **28**. One or more planetary gearsets may connect the hub motor to the load wheel **16**.

**[0017]** FIG. **2** shows the sled **10** with a rear cover removed. The sled **10** that is shown includes an electro-hydraulic pump **20** for raising and lowering the tines **14**. The pump **20** may be powered by the removable battery **22**. Alternatively, a hydraulic foot pump or other mechanism for lifting the tines **14** may be utilized.

**[0018]** FIG. **3** is a bottom view of the sled **10**. Referring to FIG. **3**, each load wheel **16** is mounted at the end of a pair of arms **34**, which are pivotably mounted at opposite ends to the tine **14** at pivot axis **32**. As is well-known, a push rod **30** leverages the arms **34** up and down to raise and lower the load wheels **16**. In this example, the push rods **30** are powered by the pump **20** (FIG. **2**) as controlled by the lift control lever **26** (FIG. **1**).

**[0019]** The load wheels **16** include hub motors **17**. The hub motors **17** selectively receive power from the battery **22** (FIG. **1**) to drive the load wheels **16** rotatably. Both hub motors **17** may be controlled by the single throttle lever **28** (FIG. **1**). Alternatively, dual throttle controls (one for each hub motor **17**) would allow the operator to steer the sled **10**. A free spinning lead wheel **36** is mounted at the front of each tine **14** and spaced above the floor (FIG. **4**) to assist in contact with curbs, ramps, etc. As another alternative, a hub motor **17** may be provided in only one of the load wheels **16**, while the other load wheel is free spinning.

**[0020]** FIG. **4** shows one embodiment of a load wheel **16**A that could be used as one or both of the load wheels **16** in the pallet sled **10** of FIG. **1**. The load wheel **16**A has an axle **38** extending therethrough and integrates a brake assembly **40** within the hub motor body **42** or housing. The brake assembly **40** may be an electric pallet jack (EPJ) style electromagnetic (EM) brake. Alternatively, the brake assembly **40** may be a drum brake or a pawl brake.

**[0021]** There may be a tread **44** on the outer surface of the hub motor body **42**. The hub motor **17** and the brake assembly **40** are both within the hub motor body **42** and within the tread **44**. According to one known configuration, the hub motor **17** includes a stator **46** fixed to the axle **38**. A rotor **48** circumscribes the stator **46** and is rotatable relative to the stator **46**, the axle **38** and the hub motor body **42**. The rotor **48** is connected to a planetary gearset which is in turn coupled to a ring gear **52**, which is fixed to the hub motor body **42**. More specifically, the rotor **48** is fixed to a sun gear **50** which is coupled to a plurality of planet gears **51** (two are illustrated, but three or more would likely be used). The planet gears **51** engage the inner circumference of the ring gear **52**. The ring gear **52** is fixed to the hub motor body **42**.

**[0022]** In use, the hub motor **17** (e.g. one in each load wheel **16**) may have power selectively applied thereto to power the pallet sled **10** (FIG. **1**). More specifically, the stator **46** drives the rotor **48** rotatably about the axle **38**. The rotating rotor **48** drives the sun gear **50**, which is coupled via the planet gears **51** to the ring gear **52**. The ring gear **52** is fixed to the interior of the hub motor body **42**, so the hub motor body **42** is rotatably driven about the axle **38**.

**[0023]** To slow down or provide a controlled descent down a ramp or other incline, the user can apply a braking force to the hub motor body **42** via controlling the stator **46**. When parked or otherwise not rolling, the brake assembly **40** can also be applied. The brake assembly **40** couples the hub motor body **42** to the axle **38**, thereby preventing (or inhibiting) relative rotation between the two. As will be explained below, the brake assembly **40** may have a "fail on" feature, i.e. if power to the brake assembly **40** is disconnected, the brake assembly **40** applies a braking force tending to inhibit rotation of the hub motor body **42** relative to the axle **38**.

**[0024]** FIG. **5** shows a load wheel **16**B which is one specific example implementation of the load wheel **16**A of FIG. **4** in which the brake assembly **40** is a disk brake assembly **40**B. The motor portion of the load wheel **16**B is the same as that of FIG. **4**, i.e. the stator **46**, rotor **48**, sun gear **50**, planet gears **51**, and ring gear **52** are the same as in FIG. **4**.

**[0025]** The brake assembly **40**B includes a friction disk **54**, a brake pad **58** and an electromagnetic pressure plate assembly **60**, each annular in shape so as to be received on the axle **38** of the load wheel **16**A. The friction disk **54** is fixed to the sun gear **50** (or alternatively, the hub motor body **42**) so that it rotates about the axle **38** with the sun gear **50** (or with the hub motor body **42**). The electromagnetic pressure plate assembly **60** is fixed to the axle **38** (and/or fixed to some external structure but fixed relative to the axle **38**). The brake pad **58** is rotatably coupled to the axle **38** and slidable relative to the axle **38** along the axis of the axle **38**. The brake pad **58** is normally slightly spaced away from both the electromagnetic pressure plate assembly **60** and the friction disk **54**.

**[0026]** Within the electromagnetic pressure plate assembly **60**, a plurality of springs **62** bias a pressure plate **61** toward the brake pad **58**. The pressure plate **61** is slidable axially relative to the axle **38**. When permitted, the springs **62** bias the pressure plate **61** into the brake pad **58**, thereby sliding the brake pad **58** forcibly toward the friction disk **54** to lock the hub motor body **42** to the axle **38**. When the electromagnetic pressure plate assembly **60** is activated, the pressure plate **61** is drawn away from the brake pad **58** (e.g. by an electromagnetic coil), thereby compressing the springs **62** such that brake pad **58** is spaced from both the pressure plate **61** and the friction disk **54**. A wire harness connects the electromagnetic pressure plate assembly **60** to a controller of the sled **10** and/or a parking brake button for the user.

**[0027]** The brake assembly **40**B operates as a fail-on brake and utilizes the springs **62** to compress the brake pad **58** against the friction disk **54**, which is fixedly secured to the hub motor body **42**. When the brake assembly **40**B is energized upon turning the sled **10** on or engaging the throttle (for example), the coils in the electromagnetic pressure plate assembly **60** charge and pull the brake pad **58** away from the friction disk **54**, thereby unlocking the hub motor body **42** from the axle **38**, so that the hub motor body **42** can rotate about the axle **38**.

**[0028]** When the user parks the sled **10**, the user can press a button, turn a key, pull a lever, etc, to activate the brake assembly **40**B as a parking brake. The sled **10** disconnects power from the electromagnetic pressure plate assembly **60**, thereby permitting the springs **62** to press the brake pad **58** against the friction disk **54**, thereby locking the hub motor body **42** relative to the axle **38**, i.e. locking the load wheel **16**B against rotation.

**[0029]** This embodiment largely utilizes an electromagnetic brake mechanism but repackaged into the hub motor body **42** (i.e. within the same housing) inline with the hub motor **17** and gearset. Having the brake internalized within the hub motor body **42** allows the load wheel **16**B to have a wider tread **44** to match the overall footprint. The load wheel **16**B of FIG. **5** could be used as the load wheels **16** of FIGS. **1-3**.

**[0030]** If packaging within the hub motor body is an issue, the brake assembly **40**B could be mounted external to the hub motor and still remain inline with the rotation axis, as shown in FIG. **6**. The external brake assembly **40**B may shorten the length of the tread **44** while maintaining the same, wide overall footprint. The load wheel **16**C of FIG. **6** could be used as the load wheels **16** of FIGS. **1-3**.

**[0031]** In another embodiment shown in FIG. **7**, a drum brake assembly **40**D is integrated within the hub motor body **42** of a load wheel **16**D that can be used as the load wheels **16** in the pallet sled **10** of FIGS. **1-4**. The drum brake assembly **40**D could be used as the brake assembly **40** of FIG. **4**, again adjacent the hub motor **17** and within the hub motor body **42**. The drum brake assembly **40**D includes at least one (preferably two) brake shoes **64** pivotably mounted to the pallet sled **10** (i.e. fixed relative to the axle **38**) at two pivot points **66**. An actuator **68** (such as hydraulic, or electric, or manual via linkage, etc) is connected to the opposite ends of the brake shoes **64**. A spring **70** also connects the ends of the brake shoes **64** away from the pivot points **66**. Preferably, the spring **70** biases the brake shoes **64** away from one another, i.e. such that they pivot on the two pivot points **66** into the inner surface of the hub motor body **42**. When activated, the actuator **68** pulls the ends of the brake shoes **64** toward one another, i.e. away from the inner surface of the hub motor body **42**.

**[0032]** The electrically controlled drum brake assembly **40**D holds the hub motor **17** and load wheel **16**D stationary when engaged (i.e. when no power is applied to the actuator **68** to prevent the hub motor **17** and load wheel **16**D from rotating. The drum brake assembly **40**D is mounted within the hub motor body **42** of the hub motor hub motor **17** and uses the actuator **68** to counter the spring **70** that applies the brake shoes **64** radially outward against the inside diameter of the hub motor body **42**, which acts as the brake drum. Again, if power to the actuator **68** is cut, the spring **70** applies the brake.

**[0033]** As in the previous embodiment, the drum brake assembly **40**D could automatically engage and disengage, or be activated by the operator.

**[0034]** In another embodiment, not illustrated, the drum brake assembly **40**D may be integrated external to the hub motor body **42**. This embodiment is similar to the previous embodiment, but the drum brake assembly **40**D is mounted outside the hub motor body **42** of the hub motor **17** and

applies brake shoes or brake pads directly against the outside diameter of the hub motor body **42** tread **44** to prevent the hub motor **17** from rotating.

**[0035]** FIG. **8** shows another embodiment of a hub motor **16**E that could be used in the pallet sled **10** of FIG. **1**. A parking pawl brake assembly **40**E can be integrated with the hub motor body **42**. The parking pawl brake assembly **40**E includes a pawl **74** pivotably coupled to the pallet sled **10** (FIG. **1**) about a pivot point **76**. A spring **78** (such as a torsion spring) biases the pawl **74** in a rotatable direction such that the opposite end of the pawl **74** is biased into engagement with a plurality of teeth **82** on a drum **84** that is coupled to the hub motor body **42**, the sun gear **50** (FIG. **4**), the ring gear **52** (FIG. **4**), or other rotating component. An actuator **86** is configured to pivot the pawl **74** out of engagement. The actuator **86** may be an electric actuator, such that it releases in the absence of power.

**[0036]** The parking pawl brake assembly **40**E locks the hub motor **17** internally when engaged, to prevent the hub motor body **42** from rotating relative to the axle **38** or the remainder of the pallet sled **10**. This is similar to how a parking pawl functions within an automatic transmission by locking the rotation of the output shaft, but the hub motor shaft does not rotate. Therefore, instead, the pawl **74** could engage with the existing sun gear, planet gears or ring gear of the planetary gearset. The pawl **74** could also engage with a new internal component that interacts with the ring gear or directly on notches on the inside diameter of the hub motor body **42**.

**[0037]** The electrically controlled actuator **86** could be configured to automatically engage and disengage the pawl parking brake assembly **40**E based on hub motor body **42** rotation. If the hub motor body **42** is stopped, the pawl parking brake assembly **40**E would automatically be applied by disengaging the actuator **86** and permitting the spring **78** to bias the pawl **74** into the teeth **82**. When the hub motor starts driving, the pawl parking brake assembly **40**E would automatically be disengaged, e.g. by activating the actuator **86** to move the pawl **74** away from the teeth **82**. The pawl parking brake assembly **40**E could also be activated by the operator and controls would be in place to ensure the pawl parking brake assembly **40**E can only be set when the hub motor has stopped rotating.

**[0038]** In accordance with the provisions of the patent statutes and jurisprudence, exemplary configurations described above are considered to represent a preferred embodiment of the invention. However, it should be noted that the invention can be practiced otherwise than as specifically illustrated and described without departing from its spirit or scope.

What is claimed is:

**1**. A hub motor comprising:
- a hub motor body;
- a rotor coupled to the hub motor body;
- a stator within the rotor;
- a planetary gearset coupling the rotor to the hub motor body; and
- a brake within the hub motor body.

**2**. The hub motor of claim **1** wherein the brake includes at least one spring biasing a brake pad into braking engagement.

**3**. The hub motor of claim **2** wherein the brake further includes at least one coil preventing braking engagement of the brake pad when the at least one coil is energized, wherein the at least one coil is positioned within the hub motor body.

**4**. The hub motor of claim **3** further including a tread on an outer surface of the hub motor body, wherein the brake is positioned within the tread.

**5**. The hub motor of claim **1** wherein the brake engages to inhibit relative rotation between the hub motor body and the stator in an absence of power applied to the brake.

**6**. The hub motor of claim **1** wherein the brake includes at least one brake shoe within the hub motor body.

**7**. The hub motor of claim **6** further including at least one spring biasing the at least one brake shoe toward braking engagement to inhibit rotation of the hub motor body relative to the stator, and an actuator configured to move the at least one brake shoe away from braking engagement when activated.

**8**. The hub motor of claim **1** wherein the brake includes at least one pawl selectively engaging teeth to inhibit rotation of the hub motor body relative to the stator.

**9**. The hub motor of claim **8** further including:
- at least one spring biasing the at least one pawl toward braking engagement to inhibit rotation of the hub motor body relative to the stator; and
- an actuator configured to move the at least one pawl away from braking engagement when activated.

**10**. The hub motor of claim **1** further including an axle extending through the hub motor body and protruding from opposite ends of the hub motor body.

**11**. The hub motor of claim **1** wherein the planetary gearset includes a sun gear coupled to the rotor and a ring gear fixed to the hub motor body, the planetary gearset further including planet gears engaging the ring gear and the sun gear.

**12**. The hub motor of claim **11** motor further including a friction disk fixed to one of the sun gear or the hub motor body, the brake including a brake pad coupled to an axle and slidable along an axis of the axle toward and away from the friction disk.

**13**. The hub motor of claim **12** wherein the brake includes at least one spring biasing the brake pad into braking engagement with the friction disk, the brake further includes at least one coil preventing braking engagement of the brake pad with the friction disk when the at least one coil is energized, wherein the at least one coil is positioned within the hub motor body.

**14**. The hub motor of claim **13** further including a tread on an outer surface of the hub motor body, wherein the brake is positioned completely within an envelope defined by the tread.

**15**. A delivery sled including a base and at least one support surface extending forward of the base, the delivery sled further including at least one hub motor of claim **14** powering a wheel supporting the delivery sled.

**16**. A delivery sled including a base and at least one support surface extending forward of the base, the delivery sled further including at least one hub motor of claim **1**.

**17**. A hub motor comprising:
- a hub motor body;
- a rotor coupled to the hub motor body;
- a stator within the rotor; and
- a brake within the hub motor body, wherein the brake includes at least one pawl selectively engaging teeth to inhibit rotation of the hub motor body relative to the stator.

**18**. The hub motor of claim **17** further including:

at least one spring biasing the at least one pawl toward braking engagement to inhibit rotation of the hub motor body relative to the stator; and

an actuator configured to move the at least one pawl away from braking engagement when the actuator is activated.

**19**. The hub motor of claim **17** further including a planetary gearset coupling the rotor to the hub motor body.

**20**. The hub motor of claim **19** wherein the planetary gearset includes a sun gear coupled to the rotor and a ring gear fixed to the hub motor body, the planetary gearset further including planet gears engaging the ring gear and the sun gear.

**21**. A delivery sled comprising:

a base;

at least one support surface extending forward of the base;

a wheel supporting the delivery sled, wherein the wheel includes a hub motor therein, the hub motor including a hub motor body, a rotor and a stator, wherein the stator is within the rotor and the hub motor body;

a planetary gearset coupling the rotor to the hub motor body; and

a brake assembly configured to brake the hub motor body.

**22**. The delivery sled of claim **21** wherein the brake assembly includes a brake shoe.

**23**. The delivery sled of claim **21** wherein the brake assembly is within the hub motor body.

**24**. The delivery sled of claim **21** wherein the brake assembly includes a disk brake.

**25**. The delivery sled of claim **21** wherein the brake assembly includes a pawl.

* * * * *