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Inventor(s)	Anderson; Micah et al.

Vehicular pedal assembly

Abstract

A vehicular pedal assembly includes a pedal housing, a pedal shaft supported by the pedal housing for rotation about a pedal axis, a pedal arm coupled to the pedal shaft pivotable to drive the pedal shaft to rotate about the pedal axis, and a position sensor assembly coupled to the pedal shaft to determine a rotational position of the pedal shaft. The position sensor assembly includes a target element, a sensor circuit that senses the target element and generates a signal, and a sensor shaft fixed for corotation with the pedal shaft. The target element is positioned on the sensor shaft and rotates with the sensor shaft about a sensor axis to move the target element with respect to the sensor circuit and change the signal generated by the sensor circuit. The pedal shaft is movable along the pedal axis relative to the sensor shaft.

Inventors: **Anderson; Micah (Mishawaka, IN), Wolschlager; Kevin (Elkhart, IN), Clark; John (Granger, IN)**

Applicant: **CTS CORPORATION** (Lisle, IL)

Family ID: **1000008747651**

Assignee: **CTS CORPORATION (Lisle, IL)**

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Primary Examiner: Yabut; Daniel D

Attorney, Agent or Firm: Michael Best & Friedrich LLP

Background/Summary

BACKGROUND

(1) The present invention relates to vehicle pedal assemblies and, more specifically, to sensors for determining a position of a pedal.

SUMMARY

(2) Control-by-wire vehicle pedals use sensors that determine the position of the pedal for the purpose of controlling the vehicle. For example, brake-by-wire pedals determine the position of the pedal for the purpose of electro-mechanically applying and releasing the brakes of the vehicle via an actuator not mechanically coupled to the pedal.

(3) In one aspect, the invention provides a vehicular pedal assembly including a pedal housing configured for mounting within a vehicle, a pedal shaft supported by the pedal housing for rotation about a pedal axis, a pedal arm coupled to the pedal shaft and configured to pivot in response to input from a driver to drive the pedal shaft to rotate about the pedal axis, and a position sensor assembly coupled to the pedal shaft to determine a rotational position of the pedal shaft and generate a signal based on the rotational position. The position sensor assembly includes a target element, a sensor circuit configured to sense the target element and generate the signal, and a sensor shaft configured to rotate about a sensor axis and fixed for corotation with the pedal shaft. The target element is positioned on the sensor shaft and is configured to rotate with the sensor shaft about the sensor axis to move the target element with respect to the sensor circuit and change the signal generated by the sensor circuit. The pedal shaft is movable along the pedal axis relative to the sensor shaft.

(4) In another aspect, the invention provides a vehicular pedal assembly for a vehicle, the vehicular pedal assembly including a pedal housing configured for mounting in the vehicle, a pedal shaft supported by the pedal housing for rotation about a pedal axis, a pedal arm drivably engaged with the pedal shaft, and a position sensor assembly coupled to the pedal shaft and configured to determine a rotational position of the pedal shaft and generate a signal based on the rotational position. The pedal shaft extends along the pedal axis between a first end and a second end, and the position sensor assembly is coupled to the first end of the pedal shaft. The pedal arm includes a footpad configured to be engaged by a driver to pivot the pedal arm and rotate the pedal shaft about the pedal axis. The position sensor assembly includes a sensor housing coupled to the pedal housing and containing a sensor circuit, a sensor shaft configured to rotate about a sensor axis and fixed for corotation with the pedal shaft, and a target element positioned on the sensor shaft, wherein the sensor circuit is configured to sense the target element and generate the signal. The vehicular pedal assembly further includes a spacer positioned between the sensor shaft and the first end of the pedal shaft to transmit rotation from the pedal shaft to the sensor shaft. The spacer is configured to absorb movement of the pedal shaft along the pedal axis to axially isolate the sensor shaft.

(5) Other aspects of the invention will become apparent by consideration of the detailed description and accompanying drawings.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) The accompanying figures, where like reference numerals refer to identical or functionally similar elements throughout the separate views, together with the detailed description below, are incorporated in and form part of the specification, and serve to further illustrate examples, instances, and/or aspects of concepts that include the claimed subject matter, and explain various principles and advantages of examples, instances, and/or aspects.

(2) FIG. **1** is a schematic side view of a vehicle with portions of the driver's side removed, the vehicle including a brake pedal and an accelerator pedal.

(3) FIG. **2** is a perspective view of a pedal assembly according to one embodiment for use with the vehicle of FIG. **1**.

(4) FIG. **3** is an exploded view of the pedal assembly of FIG. **2** including a pedal shaft.

(5) FIG. **4** is a perspective view of a joint of the pedal shaft of FIG. **3**, and a coupling between the pedal shaft and a sensor shaft.

(6) FIG. **5** is a cross-sectional view of the joint of the pedal shaft of FIG. **4**, taken along line **5-5** of FIG. **4**.

(7) FIG. **6** is a cross-sectional view of the coupling of FIG. **4**, taken along the line **6-6** of FIG. **4**.

(8) FIG. **7** is a cross-sectional view of the pedal assembly of FIG. **2** taken along the line **7-7**, including the pedal shaft and the sensor shaft.

(9) FIG. **8** is a cross-sectional view of an alternate embodiment of a position sensor assembly for use in the pedal assembly of FIG. **2**.

(10) FIG. **9** is a perspective view of an alternative coupling between the pedal shaft and the sensor shaft of the pedal assembly of FIG. **2** according to a first embodiment.

(11) FIG. **10** is a perspective view of an alternative coupling between the pedal shaft and the sensor shaft of the pedal assembly of FIG. **2** according to a second embodiment.

(12) FIG. **11** is a side view of the coupling of FIG. **10**.

(13) FIG. **12** is a cross-sectional view of the coupling of FIG. **10** taken along line **12-12** of FIG. **11**.

(14) FIG. **13** is a perspective view of a pedal assembly according to another embodiment for use with the vehicle of FIG. **1**.

(15) FIG. **14** is a cross-sectional view of the pedal assembly of FIG. **13** taken along line **14-14** of FIG. **13**.

(16) FIG. **15** is an exploded view of the pedal shaft of the pedal assembly of FIG. **13**.

DETAILED DESCRIPTION OF THE DRAWINGS

(17) Before any embodiments of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the accompanying drawings. It should be understood that the description of specific embodiments is not intended to limit the disclosure from covering all modifications, equivalents, and alternatives falling within the spirit and scope of the disclosure. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The invention is capable of other embodiments and of being practiced or of being carried out in various ways.

(18) Unless the context of their usage unambiguously indicates otherwise, the articles “a,” “an,” and “the” should not be interpreted as meaning “one” or “only one.” Rather these articles should be interpreted as meaning “at least one” or “one or more.” Likewise, when the terms “the” or “said” are used to refer to a noun previously introduced by the indefinite article “a” or “an,” “the” and “said” mean “at least one” or “one or more” unless the usage unambiguously indicates otherwise.

(19) FIG. **1** illustrates a motor vehicle **10**, such as a car, including a body **14** defining an interior compartment **18**, a set of wheels **22** coupled to the body **14**, and an engine **26** operably coupled to at least one of the front or rear sets of wheels **22** to propel the vehicle **10** to move. The vehicle **10** is controlled by a driver located in a driver's seat **30** in the interior compartment **18**. A set of controls

is positioned around the driver on a dashboard and in a footwell **38**. The controls include, among other things, a steering wheel **34** for steering the direction of the front wheels **22**, an accelerator pedal **42** located in the footwell **38**, and a brake pedal **46** located adjacent the accelerator pedal **42** in the footwell **38**. In a typical vehicle configuration, the accelerator pedal **42** may be positioned to the driver's right of the brake pedal **46**. The driver alternately presses the accelerator pedal **42** and the brake pedal **46** to control motion of the car. The accelerator pedal **42** communicates with the engine **26** to provide more torque to the wheels **22**. The brake pedal **46** communicates with one or more braking elements **50** (e.g., brake calipers) positioned adjacent one or more of the wheels **22**. Each braking element **50** selectively engages a rotor rotatable with the wheel **22** to slow the rotation of the wheel **22** and thus slow the movement of the vehicle **10**. In the illustrated embodiment, at least one of the accelerator pedal **42** or the brake pedal **46** includes a control-by-wire system. In the illustrated embodiment, the brake pedal **46** may be brake-by-wire control. Brake-by-wire brake pedals do not mechanically actuate a hydraulic system for braking. Instead, the movement of the brake pedal **46** caused by the driver is measured by a sensor assembly and electronically communicated to a brake controller and one or more remote actuators in control of the braking elements **50** on or adjacent the wheels **22** of the vehicle **10**.

(20) FIGS. **2-7** illustrate a vehicular pedal assembly **100** according to a first embodiment. The pedal assembly **100** is a brake-by-wire pedal assembly that may be coupled to the vehicle **10** as the brake pedal **46**. In the illustrated embodiment, the pedal assembly **100** is mounted to the body **14** of the vehicle **10** in the footwell **38** in front of the driver's seat **30**. In some embodiments, the pedal assembly **100** may additionally or alternatively be used as the accelerator pedal **42** of the vehicle **10**. In some embodiments, the pedal assembly **100** may be coupled to the vehicle **10** in different locations based on the type of vehicle **10**.

(21) As seen in FIG. **2**, the pedal assembly **100** includes a pedal housing **104** and a pedal arm **108** extending from the pedal housing **104**. The pedal housing **104** may include one or more bracket portions **112** including mounting features for securing the pedal housing **104** in the vehicle **10**. For example, the bracket portion(s) **112** may be used to secure the pedal assembly **100** to the body **14** of the vehicle **10** (e.g., at the front bulkhead between the engine bay and the interior compartment **18**). The pedal arm **108** extends between an upper end **116** (or first end **116**), and a lower end **120** (or second end **120**), opposite the upper end **116**. The upper end **116** of the pedal arm **108** is coupled to the pedal housing **104** by a pedal shaft **124** (FIG. **4**). The pedal shaft **124** is rotatable about a pedal axis **126** and the pedal arm **108** is pivotable relative to the pedal housing **104** between a fully depressed position and a rest position. A biasing member (not shown) may be coupled between the pedal housing **104** and the pedal arm **108** to bias the pedal arm **108** toward the rest position.

(22) A footpad **128** (e.g., a brake footpad), is coupled to the lower end **120** of the pedal arm **108**. In some embodiments, the footpad **128** may be integrally formed with the lower end **120** of the pedal arm **108**. In other embodiments, the footpad **128** may be a separate component affixed to the lower end **120**. The footpad **128** is fixed for movement with the lower end **120** of the pedal arm **108**. A driver input force (F) may be applied to the footpad **128**, causing the pedal arm **108** to rotate about the pedal axis **126** in a first direction R**1**, toward the fully depressed position. In other words, the pedal arm **108** pivots in response to an input of the driver on the footpad **128**. As discussed, upon removal of the force (F) the biasing member may rotate the pedal arm **108** in a second direction (R**2**) opposite the first direction. In some embodiments the pedal arm **108** may include at least one curved portion creating an offset in one or multiple directions to increase access to the footpad **128** by the driver. The pedal arm **108** is rotatably fixed to the pedal shaft **124** so that movement of the pedal arm **108** in response to the input force F drives the pedal shaft **124** to rotate about the pedal axis **126**.

(23) The pedal assembly **100** includes at least one position sensor assembly (PSA) **132** coupled to the pedal housing **104**. The PSA **132** determines the travel of the pedal arm **108** between the rest

position and the fully depressed position by determining the rotational position of the pedal shaft **124**. The PSA **132** generates a signal corresponding to the sensed rotational position of the pedal shaft **124**. In some embodiments, the signal generated by the PSA **132** is a preliminary signal that is communicated to a controller which generates a further braking signal to be sent to the braking elements **50**. The controller may perform comparisons or calculations on the preliminary signal in order to generate the further braking signal. For example, the controller may compare the current value of the preliminary signal to stored information (e.g., values that correspond to the signals generated by the PSA **132** when the pedal arm **108** is in the rest position and the fully depressed position, respectively). In another example, the controller may compare a current value of the preliminary signal to a prior value of the preliminary signal. As seen in FIG. **3**, in the illustrated embodiment, the pedal assembly **100** includes a first PSA **132***a* and a second PSA **132***b* coupled to the pedal housing **104** on either side of the pedal arm **108**. In some embodiments, the controller may perform comparisons or calculations on the preliminary signal from the first PSA **132***a* and the preliminary signal from the second PSA **132***b* to generate the further braking signal. In other embodiments, the controller may be configured to process data from the PSA(s) **132** in other ways.
(24) As mentioned above, the illustrated embodiment includes a pair of PSAs including the first PSA **132***a* and the second PSA **132***b*. In some embodiments, the pair of PSAs **132***a*, **132***b* are structurally mirror images of each other and may include similar or the same components in a sensor circuit. In some embodiments, the pair of PSAs **132***a*, **132***b* are mirror images but include different components in each sensor circuit. In other embodiments, the pair of PSAs **132***a*, **132***b* may be both structurally and electronically different.
(25) As seen best in FIG. **3**, the pedal assembly **100**, with the exception of the bracket portion **112** of the pedal housing **104** and the pedal arm **108**, is generally symmetrical such that one side is a mirror image of the other side. Like components use like reference numbers. The instances of the components on the first side of the pedal assembly **100** are labeled with the reference number followed by an ‘a’ (e.g., **132***a*) and on the second side of the pedal assembly **100** with the reference number followed by an ‘b’ (e.g., **132***b*). Features described with reference to one side of the assembly can generally be assumed to apply to the other side of the assembly unless otherwise specified. Generally, when describing the assembly, “inward” refers to a direction toward the symmetrical center and “outward” refers to a direction toward the edges.
(26) With reference to FIG. **3**, the pedal housing **104** incudes a pair of sidewalls **136***a*, **136***b* extending parallel to each other and defining a recess **140** therebetween. The pair of sidewalls **136***a*, **136***b* (also referred to herein as supports **136***a*, **136***b*) are spaced apart by a sufficient distance such that the recess **140** is wider than the upper end **116** of the pedal arm **108**. Each sidewall **136***a*, **136***b* includes a shaft bore **144** extending from the recess **140** through the sidewall **136***a*, **136***b* to a reference surface **148** on the outer side of the sidewall **136***a*, **136***b*. The shaft bore **144** of the first sidewall **136***a* and the shaft bore **144** of the second sidewall **136***b* extend along and are generally aligned with the pedal axis **126**.
(27) The upper end **116** of the pedal arm **108** includes a through bore **152** extending along the pedal axis **126** and having a non-circular profile. In the illustrated embodiment, the upper end **116** includes a pair of flanges **156***a*, **156***b* each having a noncircular opening **160***a*, **160***b* defining the through bore **152** therebetween. In some embodiments, the upper end **116** of the pedal arm **108** may be solid and the openings **160***a*, **160***b* may be positioned at either end of the through bore **152**. In the illustrated embodiment, each opening **160***a*, **160***b* includes a “double D-shaped” profile (i.e., a circle or oval with parallel flattened edges). In other embodiments, other non-circular profiles may be used (e.g., D-shape, star, keyway, notched circle, square, etc.). In some embodiments, the openings **160***a*, **160***b* are identical in shape and orientation. In other embodiments, the opening **160***a* may have a different profile or different orientation from the opening **160***b*.
(28) With continued reference to FIG. **3**, the pedal assembly **100** includes the pedal shaft **124** supported for rotation about the pedal axis **126**. In the illustrated embodiment the pedal shaft **124** is

formed from a pair of shaft portions including a first shaft portion **164***a* and a second shaft portion **164***b*. In the illustrated embodiment, the first shaft portion **164***a* and the second shaft portion **164***b* are first and second halves of the pedal shaft **124** having identical constructions. In other embodiments, the first shaft portion **164***a* and the second shaft portion **164***b* have unique constructions. The shaft portions **164***a*, **164***b* are coupled by a joint **168** (FIG. **4**) to form the pedal shaft **124**.

(29) FIG. **4** illustrates the pedal shaft **124** in more detail. The pedal shaft **124** extends between a first end **172** and a second end **176** along the pedal axis **126**. The first shaft portion **164***a* includes a bearing hub **180***a* having an outer end **184***a*, a mounting hub **188***a* extending inwardly from the bearing hub **180***a*, and a ratchet portion **192***a* (or a joint portion **192***a*) extending inwardly from the mounting hub **188***a*. The second shaft portion **164***b* similarly includes a bearing hub **180***b* having an outer end **184***b*, a mounting hub **188***b* extending inwardly from the bearing hub **180***b*, and a ratchet portion **192***b* extending inwardly from the mounting hub **188***b*. When assembled, the outer end **184***a* of the first shaft portion **164***a* corresponds to the first end **172** of the pedal shaft **124** and the outer end **184***b* of the second shaft portion **164***b* corresponds to the second end **176** of the pedal shaft **124**. As seen in FIG. **4**, the first shaft portion **164***a* is coupled to the second shaft portion **164***b* by the joint **168** (also referred to herein as the shaft coupling **168**). In the illustrated embodiment, the joint **168** is a snap connection, and more specifically, a ratchet rivet connection. Each ratchet portion **192***a*, **192***b* includes a set of ratchet fingers **196***a*, **196***b* extending from the mounting hub **188***a*, **188***b*. In the illustrated embodiment, the first shaft portion **164***a* is identical to the second shaft portion **164***b* and may be rotationally offset to allow the ratchet portion **192***a* to engage the ratchet portion **192***b*. For example, in the illustrated embodiment, the second shaft portion **164***b* is rotated about 90 degrees with respect to the first shaft portion **164***a*.

(30) With reference to FIG. **5**, in the illustrated embodiment, the ratchet fingers **196***a* of the first shaft portion **164***a* are evenly spaced circumferentially about the ratchet portion **192***a*. In other words, the pair of ratchet fingers **196***a* are spaced apart by 180 degrees about the pedal axis **126**. Each ratchet finger **196***a* includes a pair of toothed surfaces **200***a* (also referred to herein as ratchet surfaces) extending lengthwise along the ratchet finger **196***a*, generally along the pedal axis **126**, as seen in FIG. **4**. As seen in FIG. **5**, looking down the length of the ratchet finger **196***a* (or at the cross-section of the ratchet portion **192***a*), each toothed surface **200***a* is oriented radially with respect to the pedal axis **126**. In some embodiments, the ratchet portion **192***a* may include three or more ratchet fingers **196***a*. In some embodiments, the toothed surfaces **200***a* of each ratchet finger **196***a* may be angularly spaced by approximately 360 degrees divided by twice the number of ratchet fingers **196***a*, **196***b* on the ratchet portions **192***a*, **192***b*. For example, in the illustrated embodiment, the toothed surfaces **200***a* of each ratchet finger **196***a* are spaced by approximately 90 degrees, which is 360 degrees divided by four. In the illustrated embodiment, each ratchet finger **196***a* includes an arcuate outer surface **204** and a flat lower surface **208** extending between the pair of toothed surfaces **200***a*. In other embodiments, the upper and lower surfaces of the ratchet fingers **196***a* may be shaped differently. The ratchet fingers **196***b* of the second shaft portion **164***b* are similarly constructed and each of the ratchet fingers **196***b* includes a pair of toothed surfaces **200***b* in the same arrangement as the toothed surfaces **200***a*.

(31) With continued reference to FIG. **5**, the joint **168** is formed by engaging the ratchet fingers **196***a* of the first shaft portion **164***a* with the ratchet fingers **196***b* of the second shaft portion **164***b*. The first ratchet fingers **196***a* are positioned between the second ratchet fingers **196***b*, such that each toothed surface **200***a* is engaged with the toothed surface **200***b* of the second ratchet finger **196***b* directly adjacent. As seen best in FIG. **4**, the teeth on the toothed surfaces **200***a*, **200***b* are shaped to allow axial joining of the shaft portions **164***a*, **164***b* (e.g., movement of the shaft portions **164***a*, **164***b* along the pedal axis **126** in an inward direction and toward each other), but inhibit axial separation of the shaft portions **164***a*, **164***b* (e.g., movement of the shaft portions **164***a*, **164***b* along the pedal axis **126** in an outward direction and away from each other). The joint **168** axially secures

the first shaft portion **164***a* and the second shaft portion **164***b* against separation or uncoupling by the engagement of the toothed surfaces **200***a*, **200***b* along the pedal axis **126**. Additionally, the joint **168** rotationally couples the first shaft portion **164***a* and the second shaft portion **164***b* through the circumferential engagement of the ratchet fingers **196***a*, **196***b* seen in FIG. **5**. Thus, the first shaft portion **164***a* and the second shaft portion **164***b* may be coupled together by the joint **168** to form the pedal shaft **124** that rotates about the pedal axis **126**.

(32) With reference to FIG. **4**, the mounting hub **188***a*, **188***b* of each shaft portion **164***a*, **164***b* has a cross-sectional profile that corresponds to the profile of the openings **160***a*, **160***b* to the through bore **152** in the pedal arm **108**. In the illustrated embodiment, each mounting hub **188***a*, **188***b* includes a "double D-shaped" profile corresponding to the "double D-shaped" profile of the openings **160***a*, **160***b*. In embodiments where the openings **160***a*, **160***b* have different profiles, the mounting hubs **188***a*, **188***b* may each have a matching profile with the associated opening **160***a*, **160***b*. As seen in FIG. **4**, each shaft portion **164***a*, **164***b* has a generally stepped configuration. With reference to the first shaft portion **164***a*, the bearing hub **180***a* has a generally cylindrical surface and a width (e.g., the largest dimension measured perpendicular to the axis **126**) of the bearing hub **180***a* generally corresponds to a diameter of the surface. The width of the bearing hub **180***a* is larger than a width (e.g., the largest dimension measured perpendicular to the axis **126**) of the mounting hub **188***a*. Finally, the width of the mounting hub **188***a* is larger than a width (e.g., the largest dimension measured perpendicular to the axis **126**) of the ratchet portion **192***a*. In embodiments where each ratchet finger **196***a*, **196***b* includes the arcuate outer surface **204**, the width of the ratchet portion **192***a* may generally correspond to a diameter of the resulting outer profile (FIG. **5**). When assembled, the shaft **124** therefore has an overall 'V' shape or 'hourglass' shape, where the first end **172** and the second end **176** have generally similar widths, which are larger than a width near a center or a middle portion of the shaft **124**, adjacent the joint **168**.

(33) Returning to FIG. **3**, the pedal shaft **124** is supported in the pedal housing **104** for rotation by a pair of bearings **212***a*, **212***b* that engage the bearing hubs **180***a*, **180***b* of the pedal shaft **124**. Each bearing **212***a*, **212***b* includes an insert ring **216** for engaging the shaft bore **144** of the respective sidewall **136***a*, **136***b*, and a bearing flange **220** that abuts an inner side of the sidewall **136***a*, **136***b* to locate the bearing **212***a*, **212***b* within the respective shaft bore **144** adjacent the recess **140**. As discussed above, the first and second PSAs **132***a*, **132***b* have similar or identical constructions in the illustrated embodiment. The first PSA **132***a* includes a sensor housing **224***a*, a sensor circuit **228***a* (FIG. **7**) for sensing a target element **232***a* and generating the preliminary signal, a sensor shaft **236***a*, and a spacer **240***a* positioned between the sensor shaft **236***a* and the pedal shaft **124**. The sensor shaft **236***a* is rotatable with respect to the sensor housing **224***a* about a sensor axis **242** (FIG. **4**). In the illustrated embodiment, the sensor axis **242** is coaxial with the pedal axis **126** when the pedal assembly **100** is assembled (see FIG. **7**). In other embodiments, the sensor axis **242** may be offset from and parallel to the pedal axis **126**. Similarly, the second PSA **132***b* includes a sensor housing **224***b*, a sensor circuit **228***b* (FIG. **7**) that senses a target element **232***b*, a sensor shaft **236***b* configured to rotate about a sensor axis **242**, and a spacer **240***b*. The first PSA **132***a* is coupled to the first end **172** of the pedal shaft **124** (i.e., the outer end **184***a* of the first shaft portion **164***a*) to determine a rotational position of the pedal shaft **124** and generate a first preliminary signal based on the sensed position. The second PSA **132***b* is coupled to the second end **176** of the pedal shaft **124** (i.e., the outer end **184***b* of the second shaft portion **164***b*) to determine a rotational position of the pedal shaft **124** and generate a second preliminary signal based on the sensed position. In some embodiments, the PSAs **132***a*, **132***b* are both used to add redundancy to the system. In some embodiments, one of the PSAs **132***a*, **132***b* may be used as a primary sensing unit and the other of the PSAs **132***a*, **132***b* may be used as a backup sensing unit.

(34) The sensor shaft **236***a*, **236***b* of each PSA **132***a*, **132***b* is fixed for corotation with the pedal shaft **124** by a coupling **244***a*, **244***b* formed between the pedal shaft **124** and the sensor shaft **236***a*, **236***b*. Each coupling **244***a*, **244***b* transmits rotation from the pedal shaft **124** to the respective sensor

shaft **236***a*, **236***b* to fix the shafts for corotation. Additionally, each coupling **244***a*, **244***b* axially isolates the sensor shaft **236***a*, **236***b* from movement of the pedal shaft **124** along the pedal axis **126**. In other words, each sensor shaft **236***a*, **236***b* is translationally decoupled from the pedal shaft **124** by the coupling **244***a*, **244***b* formed between the pedal shaft **124** and the sensor shaft **236***a*, **236***b*. The axial isolation of the sensor shafts **236***a*, **236***b* from the pedal shaft **124** increases the accuracy of the sensor circuits **228***a*, **228***b* as described in more detail further below.

(35) Turning to FIG. **4**, the coupling **244***b* between the pedal shaft **124** and the sensor shaft **236***b* is isolated and illustrated in more detail. While not described in detail, the coupling **244***a* is substantially the same as the coupling **244***b* and includes the same components and interactions. Each shaft portion **164***a*, **164***b* includes a set of first projections **248** (also referred to herein as drive projections **248**) extending axially outward from the outer end **184***a*, **184***b*. In the illustrated embodiment, each shaft portion **164***a*, **164***b* includes three of the drive projections **248** circumferentially spaced evenly about the pedal axis **126**. With reference to FIG. **4**, the sensor shaft **236***b* includes a main hub **252** having a cylindrical outer surface, a flange **256** extending from an outer side of the main hub **252**, and a set of second projections **260** (also referred to herein as driven projections **260**) axially extending from an inner end of the main hub **252**. In the illustrated embodiment, the sensor shaft **236***b* includes three of the driven projections **260** circumferentially spaced evenly about the sensor axis **242**.

(36) As seen in FIG. **6**, a cross section of the coupling **244***b* illustrates the spacer **240***b* including an inner hub **264** and a set of spurs **268** extending radially outward from the inner hub **264**. The spurs **268** are circumferentially spaced evenly about the inner hub **264**. A window **272** (FIG. **3**) is formed by the space between each adjacent pair of the spurs **268**. In the illustrated embodiment, the spacer **240***b* includes six of the spurs **268** and six of the windows **272**. The spacer **240***b* is positioned between the sensor shaft **236***b* and the pedal shaft **124** such that the driven projections **260**, the drive projections **248**, and the spurs **268** axially overlap. In other words, the driven projections **260**, the drive projections **248**, and the spurs **268** occupy a common axial span **276** (FIG. **4**) along the pedal axis **126** and engage each other to form the coupling **244***b*. This means that when viewed perpendicular to the pedal axis **126**, the drive projections **248**, the driven projections **260**, and spurs **268** overlap each other in an axial direction along the pedal axis **126** and are visible in a cross-section taken through the common axial span **276**, as seen in FIG. **6**.

(37) With continued reference to FIG. **6**, the cross section of the coupling **244***b* through the common axial span **276** shows that, when coupled, the drive projections **248** are received in alternating windows **272** of the spacer **240***b* and the driven projections **260** are received in the remaining windows **272** between the spurs **268**. When the coupling **244***b* is viewed in cross-section, the outer end **184***b* of the pedal shaft **124**, the sensor shaft **236***b*, and the spacer **240***b* all have similar sizes and outer diameters such that the drive projections **248**, the driven projections **260**, and the spurs **268** all radially overlap (i.e., occupy a common radial span **280**). The radial overlap and the axial overlap of the drive projections **248**, the driven projections **260**, and the spurs **268** causes circumferential engagement during rotation and couples the sensor shaft **236***b* to rotate with the pedal shaft **124**. In other words, the coupling **244***b* between the drive projections **248** and the driven projections **260** transmits rotation from the pedal shaft **124** to the sensor shaft **236***b* through the spacer **240***b*. The sensor shaft **236***b* is driven to corotate with the pedal shaft **124**, so that rotation of the sensor shaft **236***b* is simultaneous with and the same amount as the pedal shaft **124**. While specific amounts and spacings of projections and spurs are disclosed, in other embodiments, different amounts or configurations of drive projections **248**, driven projections **260**, and spurs **268** may be used to form the couplings **244***a*, **244***b*. For example, the drive projections **248**, the driven projections **260**, and the spurs **268** may be unevenly circumferentially spaced with complementary configurations. In another example, the outer end **184***b* includes only two of the drive projections **248**, the sensor shaft **236***b* includes only two of the driven projections **260**, and the spacer **240***b* includes four of the spurs **268**.

(38) In the illustrated embodiment, the spacer **240***b* is formed from a compliant material that has a low stiffness in the axial direction and is axially deformable (e.g., along the pedal axis **126**). The compliant material may also have a high resilience such that the spacer **240***b* is biased to return to its original shape. In some embodiments, the spacer **240***b* is formed and shaped so that the rotational stiffness is higher than the axial stiffness. For example, during forming of the spacer **240***b* the structure of the material may be oriented so the lowest stiffness is in the axial direction, or the spacer **240***b* may have increased thicknesses at certain spots to increase the rotational stiffness, or the spacer **240***b* may be assembled in a certain way to increase the rotational stiffness. In some embodiments, the spacer **240***a* may be generally rigid and may not be axially deformable. In some embodiments the coupling **244***a* may be configured differently from the coupling **244***b*. Additional variations may exist and may be incorporated into the design.

(39) Returning again to FIG. **3**, each sensor shaft **236***a*, **236***b* is fixed for corotation with the pedal shaft **124** by the couplings **244***a*, **244***b*. Each sensor shaft **236***a*, **236***b* includes the target element **232***a*, **232***b* positioned at an outer side of each main hub **252** and positioned for use with the sensor circuits **228***a*, **228***b*. The target elements **232***a*, **232***b* each rotate with the respective sensor shaft **236***a*, **236***b* to move relative to the adjacent sensor housing **224***a*, **224***b*. In some embodiments, the target elements **232***a*, **232***b* is embedded in the sensor shafts **236***a*, **236***b*. For example, the sensor shaft **236***a*, **236***b* may be formed through a molding process, and the target element **232***a*, **232***b* may be embedded in the main hub **252** during the forming process. In some embodiments, a recess is positioned on the outer side of the main hub **252** and the target element **232***a*, **232***b* is positioned within the recess and carried by the sensor shaft **236***a*, **236***b* to rotate therewith. In other embodiments, the target element **232***a*, **232***b* is otherwise coupled to the main hub **252** of the sensor shaft **236***a*, **236***b*. Each sensor housing **224***a*, **224***b* includes an inner housing **284** and a cover **288** removably coupled to the inner housing **284**. The inner housing **284** includes a bearing surface **292** facing inward when assembled.

(40) Turning to FIG. **7**, the sensor circuits **228***a*, **228***b* each have a sensor **296***a*, **296***b* positioned within the respective inner housing **284**. As seen with respect to the first PSA **132***a*, at least a portion of the sensor circuit **228***a* is positioned in the sensor housing **224***a*. For example, a portion of the sensor circuit **228***a* may be positioned on a printed circuit board (PCB) mounted in the inner housing **284**. In some embodiments, the sensor circuit **228***a* may include components electrically connected to the PCB but external to the sensor housing **224***a*, such as a vehicle controller, the braking elements **50**, etc. The PCB and the sensor **296***a* may be accessible by removing the cover **288** from the inner housing **284**. The sensor circuit **228***a* uses the sensor **296***a* to sense the associated target element **232***a* and generate the preliminary signal. The signal varies based on the movement of the target elements **232***a* about the sensor axis **242**, as determined by the rotational position of the pedal shaft **124**. In the illustrated embodiment, the sensor **296***a* includes a proximity sensor such as a Hall sensor or an inductive sensor. The sensor **296***a* may utilize magnetic or electric fields to determine a position of the target element **232***a*. In embodiments where the sensor **296***a* includes a Hall sensor, the target element **232***a* may include a magnet with rotationally varying flux patterns. In embodiments where the sensor **296***a* includes an inductive sensor, the target element **232***a* may include a metallic element configured to interact with a magnetic field generated by the sensor **296***a*. In other embodiments, the sensor **296***a* may include another type of proximity sensor or a different type of rotational position sensor. The sensor **296***a* may be positioned on the PCB and may be positioned adjacent a side of the bearing surface **292** opposite the target element **232***a* on the sensor shaft **236***a*. In some embodiments the sensor **296***a* may be a dual die sensor and may include multiple sensing elements configured to sense the target element **232***a*. In some embodiments, the sensor shaft **236***a* may include multiple target elements **232***a* and the sensor circuit **228***a* may include multiple sensors **296***a* each associated with one of the multiple target elements **232***a*. The sensor circuit **228***b* of the second PSA **132***b* is generally similar to the sensor circuit **228***a*.

(41) As discussed above, in the illustrated embodiment the first PSA **132***a* and the second PSA **132***b* are structurally mirror images. In some embodiments, the PSAs **132***a*, **132***b* are electronically identical and the sensor **296***a* of the first PSA **132***a* and the sensor **296***b* of the second PSA **132***b* are the same type of sensor. For example, in one embodiment, the first PSA **132***a* and the second PSA **132***b* both include Hall sensors. In other embodiments, the PSAs **132***a*, **132***b* are electronically different and the first PSA **132***a* includes a first type of sensor and the second PSA **132***b* includes a second type of sensor, different from the first type of sensor. For example, in one embodiment, the first PSA **132***a* includes a Hall sensor, and the second PSA **132***b* includes an inductive sensor.
(42) FIG. **7** illustrates a cross section of the pedal assembly **100** with the pedal arm **108**, the pedal shaft **124**, and the PSAs **132***a*, **132***b* assembled to the pedal housing **104**. To assemble the pedal assembly **100**, the bearings **212***a*, **212***b* are each coupled to the pedal housing **104** by press-fitting the insert ring **216** into the shaft bore **144** on the respective sidewall **136***a*, **136***b* until the bearing flange **220** abuts the sidewall **136***a*, **136***b*. The upper end **116** of the pedal arm **108** is received in the recess **140** defined between the sidewalls **136***a*, **136***b* such that the through bore **152** (and the openings **160***a*, **160***b*) are generally aligned with the shaft bores **144** along the pedal axis **126**.
(43) As discussed above, the pedal shaft **124** is formed by the pair of shaft portions **164***a*, **164***b* coupled by the joint **168**. In some embodiments, the shaft portions **164***a*, **164***b* may be part of a set of shaft portions having different features and the shaft portions **164***a*, **164***b* may each be selected based on the needs of the respective side of the assembly (e.g., the diameter of the shaft bore, the type of sensor assembly, the type of coupling between the pedal shaft and sensor shaft, etc.). For example, the first shaft portion **164***a* may be selected based on the situation of the first side of the pedal assembly **100** and the first PSA **132***a*, and the second shaft portion **164***b* may be selected based on the situation of the second side of the pedal assembly **100** and the second PSA **132***b*. The joint **168** allows for greater adaptability of the pedal shaft **124** as compared to a unitary pedal shaft.
(44) Once selected, the first shaft portion **164***a* is inserted into the shaft bore **144** of the first sidewall **136***a* from the outside, adjacent the reference surface **148**. The first shaft portion **164***a* is moved along the pedal axis **126** toward the recess **140**. As the first shaft portion **164***a* translates, the ratchet portion **192***a* passes through the opening **160***a* and into the through bore **152** of the pedal arm **108**. If needed, the first shaft portion **164***a* is rotated to align the mounting hub **188***a* with the opening **160***a* in the pedal arm **108**. The mounting hub **188***a* is press fit into the through bore **152** of the pedal arm **108** to couple the first shaft portion **164***a* to the pedal arm **108**. The press fit (or interference fit) between the mounting hub **188***a* and the opening **160***a* axially and rotationally couples the first shaft portion **164***a* to the pedal arm **108**. The bearing hub **180***a* of the first shaft portion **164***a* is supported in shaft bore **144** extending through the sidewall **136***a* of the pedal housing **104**. The bearing hub **180***a* is supported for rotation about the pedal axis **126** through contact with the insert ring **216** of the bearing **212***a*.
(45) Similar to the first shaft portion **164***a*, the second shaft portion **164***b* is inserted into the shaft bore **144** of the sidewall **136***b* and moved along the pedal axis **126** until the ratchet portion **192***b* passes into the through bore **152** of the pedal arm **108**. The mounting hub **188***b* is aligned with the opening **160***b* and press fit therein. In the illustrated embodiment, the “double D-shape” of the first opening **160***a* is oriented differently from the “double D-shape” of the second opening **160***b*. Specifically, the first opening **160***a* is offset by 90 degrees from the second opening **160***b*. Therefore, when the mounting hub **188***b* is aligned with the opening **160***b*, the ratchet portion **192***b* is also aligned with the ratchet portion **192***a*. More specifically, the ratchet fingers **196***a* are positioned between the ratchet fingers **196***b* and the toothed surfaces **200***a*, **200***b* of each are engaged, as seen in FIG. **6**. As the second shaft portion **164***b* is press fit and travels toward the first shaft portion **164***a*, the teeth on the toothed surfaces **200***a*, **200***b* ramp against each other causing the ratchet fingers **196***a*, **196***b* to deflect slightly radially outward from the pedal axis **126**, allowing the second shaft portion **164***b* to continue axially joining with the first shaft portion **164***a* and translating along the pedal axis **126**. Thus, the joint **168** is coupled at the same time and by the

same motion as the press fit between the shaft portion **164***b* and the pedal arm **108**. Once the joint **168** is connected, the teeth on the toothed surfaces **200***a*, **200***b* lock against each other to prevent axial separating of the shaft portions **164***a*, **164***b* (e.g., movement of the shaft portions **164***a*, **164***b* away from each other along the pedal axis **126**). The toothed surfaces **200***a*, **200***b* extend along the ratchet fingers **196***a*, **196***b* of each shaft portion **164***a*, **164***b* such that the joint **168** is formed once the shaft portions **164***a*, **164***b* are a first distance apart from each other (e.g., when three teeth of each toothed surface **200***a*, **200***b* are engaged). Once the joint **168** is formed, axial separation is inhibited by the toothed surfaces **200***a*, **200***b*. The toothed surfaces **200***a*, **200***b* extend along the ratchet fingers **196***a*, **196***b* in the direction of the pedal axis **126** such that the shaft portions **164***a*, **164***b* may continue to travel toward each other, engaging more teeth, until the resulting pedal shaft **124** is the correct length, or the remaining components are correctly positioned. For example, the shaft portions **164***a*, **164***b* may be moved toward each other until an end of the bearing hubs **180***a*, **180***b* from which the mounting hubs **188***a*, **188***b* extend abuts the flanges **156***a*, **156***b* of the pedal arm **108**. The joint **168** therefore allows the pedal shaft **124** to be used with pedal arms **108** having different spacing between the flanges **156***a*, **156***b* or in pedal housings **104** with different spacing between the sidewalls **136***a*, **136***b*, which increases the adaptability of the pedal shaft **124** compared to a unitary pedal shaft.

(46) The pedal shaft **124** is therefore coupled to the pedal arm **108** and to the pedal housing **104** in order to support the pedal arm **108** for rotation about the pedal axis **126** relative to the pedal housing **104**. The pedal arm **108** is drivably engaged with the pedal shaft **124** and the openings **160***a*, **160***b* cooperate with the mounting hubs **188***a*, **188***b* to transmit rotation therebetween. The bearing flange **220** of each of the bearings **212***a*, **212***b* may contact the upper end **116** of the pedal arm **108** to decrease wear as the pedal arm **108** rotates. The pedal shaft **124** is supported with the drive projections **248** at the first end **172** extending within the shaft bore **144** in the first sidewall **136***a*, and the drive projections **248** at the second end **176** extending within the shaft bore **144** in the second sidewall **136***b*. In the illustrated embodiment, the first PSA **132***a* is coupled to first end **172** of the pedal shaft **124** and the second PSA **132***b* is coupled to the second end **176** of the pedal shaft **124**.

(47) To assemble the first PSA **132***a* to the pedal housing **104**, the spacer **240***a* is positioned adjacent the outer end **184***a* of the first shaft portion **164***a* of the pedal shaft **124**, and the drive projections **248** are press fit into alternating windows **272** between the spurs **268**, so that the drive projections **248** and the spurs **268** occupy the common axial span **276** along the pedal axis **126**. The sensor shaft **236***a* is then positioned in the shaft bore **144** of the first sidewall **136***a*, with the driven projections **260** extending toward the first end **172** of the pedal shaft **124**. The sensor shaft **236***a* is moved within the shaft bore **144** toward the first end **172** of the pedal shaft **124** until the driven projections **260** axially overlap with the spurs **268** and the drive projections **248**. The driven projections **260** are press fit into the remaining windows **272** between the spurs **268**. The drive projections **248**, driven projections **260** and spurs **268** are positioned within the common axial span **276** (FIG. **4**) of the pedal axis **126**. The sensor axis **242** is aligned with the pedal axis **126**. The spacer **240***a* is positioned axially between the pedal shaft **124** and the sensor shaft **236***a* and circumferentially between the drive projections **248** and the driven projections **260**. The spacer **240***a* transmits rotation between the pedal shaft **124** and the sensor shaft **236***a* and axially isolates the sensor shaft **236***a* from axial movement of the pedal shaft **124**.

(48) The sensor shaft **236***a* is inserted into the shaft bore **144** until the flange **256** of the sensor shaft **236***a* abuts the reference surface **148** of the first sidewall **136***a* of the pedal housing **104**, limiting axial movement of the sensor shaft **236***a* in the direction toward the pedal arm **108**. A small gap is left between the inner ends of the driven projections **260** and the outer end **184***a* of the shaft portion **164***a*. The target element **232***a* is coupled to the outer end of the sensor shaft **236***a*, if not already provided therein. The sensor housing **224***a* is then mounted to the pedal housing **104**, for example, by threaded fasteners. The sensor housing **224***a* secures the flange **256** of the sensor shaft **236***a*

between the reference surface **148** and the bearing surface **292** of the inner housing **284**, limiting axial movement of the sensor shaft **236***a* in the direction away from the pedal arm **108**. The sensor shaft **236***a* is therefore axially constrained against the reference surface **148** by the sensor housing **224***a* to axially fix the sensor shaft **236***a* (and thus the target element **232***a*) with respect to the sensor **296***a* of the sensor circuit **228***a*. In the context of this disclosure, axially fixed means that the sensor shaft **236***a* is inhibited from any excess movement along the pedal axis **126** relative to the sensor housing **224***a*. In other words, a small amount of axial clearance may exist between the flange **256** and the pedal housing **104** and/or the sensor housing **224***a* due to manufacturing and assembly tolerances that allow for rotation of the sensor shaft **236***a* with respect to the sensor housing **224***a*, however, this axial clearance is minimized. The sensor shaft **236***a* is therefore axially limited with respect to the pedal housing **104** and the sensor housing **224***a*. Any movement of the sensor shaft **236***a* along the pedal axis **126** occurs within a range of axial motion that is smaller than the range of axial motion of the pedal shaft **124** along the pedal axis **126**. The sensor **296***a* and a portion of the sensor circuit **228***a* (e.g., the PCB) are positioned within the sensor housing **224***a*. The cover **288** is coupled to the inner housing **284** to enclose the electronic components in the sensor housing **224***a*. The sensor **296***a* is supported in the sensor housing **224***a* adjacent the bearing surface **292**, and therefore adjacent the target element **232***a*.

(49) The second PSA **132***b* is assembled to the pedal housing **104** in the same way as the first PSA **132***a*, and the details are not repeated for the sake of brevity. The order in which the assembly steps are disclosed is not intended to limit a method of assembling the pedal assembly **100**. The order in which the components are coupled together can be altered without departing from the scope of the disclosure.

(50) During operation of the pedal assembly **100**, a driver applies an input force F (FIG. **2**) to the footpad **128**. The pedal arm **108** is pivoted by the force F and drives the pedal shaft **124** to rotate about the pedal axis **126**. Specifically, the press-fit connection between the mounting hubs **188***a*, **188***b* and the openings **160***a*, **160***b* in the pedal arm **108** transmits the rotation from the pedal arm **108** to the pedal shaft **124**. Rotation of the pedal shaft **124** about the pedal axis **126** is transmitted to the sensor shafts **236***a*, **236***b* by the couplings **244***a*, **244***b*. For the sake of brevity, operation is described with reference to the first side of the assembly **100**, however, the second side operates similarly and simultaneously with the first side. The pedal shaft **124** is driven to rotate the drive projections **248** of the first shaft portion **164***a* about the pedal axis **126**. The drive projections **248** are circumferentially engaged with the spurs **268** of the spacer **240***a*, which are in turn circumferentially engaged with the driven projections **260** on the sensor shaft **236***a*. The spurs **268** transmit the rotation from the drive projections **248** to the driven projections **260**. As discussed above, the spacer **240***a* has a high rotational stiffness. In the illustrated embodiment, the press-fit between the drive projections **248**, the driven projections **260**, and the spurs **268** may deform the spurs **268** near the elastic deformation limit. Thus, rotation is transmitted through the spurs **268** without loss due to rotational deformation of the spacer **240***a*, and the sensor shaft **236***a* co-rotates with the pedal shaft **124**. In other words, the sensor shaft **236***a* rotates the same amount and at the same time as the pedal shaft **124** so that the rotational position of the sensor shaft **236***a* is indicative of the rotational position of the pedal shaft **124**. The sensor shaft **236***a* rotates about the sensor axis **242**. In the illustrated embodiment, the pedal axis **126** and the sensor axis **242** are co-axial. The rotation of the sensor shaft **236***a* about the sensor axis **242** causes the target element **232***a* to rotate with respect to the sensor circuit **228***a* in the sensor housing **224***a*. The sensor circuit **228***a* varies the preliminary signal based on the rotational position of the target element **232***a*, and by extension the position of the pedal arm **108**. A controller processes the preliminary signal from the sensor circuits **228***a*, **228***b* and instructs associated elements of the vehicle **10** (e.g., braking elements **50**) to activate in response to the movement of the pedal arm **108**.

(51) As discussed above, the couplings **244***a*, **244***b* axially isolate the PSAs **132***a*, **132***b* from the pedal shaft **124**, which increases accuracy of the sensor circuits **228***a*, **228***b*. For example,

sometimes, during operation, the force F applied to the pedal arm **108** may cause the pedal arm **108** to shift laterally (e.g., from side to side) in the recess **140**. This translation or lateral displacement of the pedal arm **108** is transmitted to the pedal shaft **124** by the press fit connections between the mounting hubs **188***a*, **188***b* and the openings **160***a*, **160***b* of the through bore **152**. In one example, the pedal shaft **124** is translated along the pedal axis **126** toward the first PSA **132***a*. The translation of the pedal shaft **124** moves the first end **172** of the pedal shaft **124** toward the sensor shaft **236***a*. The pedal shaft **124** applies a force along the pedal axis **126** to the spacer **240***a*, and the spacer **240***a* deforms (i.e., compresses) in response to absorb the movement of the pedal shaft **124** along the pedal axis **126**, axially isolating the sensor shaft **236***a*. Therefore, the pedal shaft **124** moves along the pedal axis **126** relative to the sensor shaft **236***a*. In some embodiments, instead of relying on axial deformation of the spacer **240***a*, the drive projections **248** and/or the driven projections **260** may be slidably coupled to the spacer **240***a* and configured to slide within the windows **272** such that the pedal shaft **126***a* is axially translatable with respect to the sensor shaft **236***a*. Those embodiments may include embodiments where the spacer **240***a* is generally rigid or embodiments where the spacer **240***a* is axially deformable. The sensor shaft **236***a* is isolated from the translation of the pedal shaft **126***a*. The sensor shaft **236***a* is further inhibited from moving along the pedal axis **126** and is axially limited by the pedal housing **104** and the sensor housing **224***a*. The flange **256** of the sensor shaft **236***a* is axially constrained against the reference surface **148** of the pedal housing **104** by the bearing surface **292** of the sensor housing **224***a* to axially fix the sensor shaft **236***a* with respect to the sensor housing **224***a*. Any axial force applied to the sensor shaft by the spacer **240***a* is transmitted through the flange **256** and absorbed by the connection between the pedal housing **104** and the sensor housing **224***a*. Therefore, the sensor shaft **236***a* (and the target element **232***a* carried thereon) is axially limited with respect to the sensor housing **224***a* and the sensor **296***a* therein, inhibiting any decrease in accuracy of the sensor **296***a* that would occur if the translation of the pedal shaft **124** were transmitted to the sensor shaft **236***a*.

(52) Thus, the pedal assembly **100** described herein provides greater precision and accuracy of position sensing. The precision and accuracy of the sensor circuits **228***a*, **228***b* in determining the rotational position of the pedal shaft **124** is greatly improved if the proximity of the target element **232***a*, **232***b* to the sensor **296***a*, **296***b* is only varied by the rotation of the shaft **124** and not by any translational movement. In other words, axial movement of the target elements **232***a*, **232***b* (e.g., along the pedal axis **126**) can decrease the accuracy of the PSAs **132***a*, **132***b*. Therefore, the pedal assembly **100** described herein axially fixes the target element **232***a*, **232***b* with respect to the sensor circuit **228***a*, **228***b* in the sensor housing **224***a*, **224***b* by axially constraining the sensor shaft **236***a*, **236***b* with respect to the sensor housing **224***a*, **224***b* and the pedal housing **104**, and by translationally decoupling (i.e., axially isolating) the sensor shafts **236***a*, **236***b* with respect to the pedal shaft **124**. Each spacer **240***a*, **240***b*, and more broadly each coupling **244***a*, **244***b*, is designed to simultaneously i) maintain a connection for corotation and transmit rotation between the pedal shaft **124** and the sensor shaft **236***a*, **236***b*, and ii) axially isolate the sensor shaft **236***a*, **236***b* by allowing the pedal shaft **124** to move along the pedal axis **126** with respect to the sensor shaft **236***a*, **236***b*. Therefore, the proposed design offers improved accuracy and precision in determining the rotational position of the pedal shaft **124**.

(53) In the embodiment illustrated in FIGS. **2-7**, the sensor shafts **236***a*, **236***b* are each axially constrained with respect to the sensor circuits **228***a*, **228***b* by constraining the flange **256** of each sensor shaft **236***a*, **236***b* against the pedal housing **104** and mounting the sensor housing **224***a*, **224***b* to the pedal housing **104** to pin or sandwich the flange **256** between the bearing surface **292** of the adjacent sensor housing **224***a*, **224***b* and the reference surface **148** of the respective sidewall **136***a*, **136***b* of the pedal housing **104**. In other embodiments, the sensor shafts **236***a*, **236***b* may be axially constrained or fixed using different means.

(54) For example, FIG. **8** illustrates an alternative embodiment of the pedal assembly **100′** including a position sensor assembly **132′** in which the sensor shaft **236′** (including the target

element **232′**) is axially constrained directly by the sensor housing **224′**. The flange **256′** of the sensor shaft **236′** is rotatably received in a groove **304** (or track) formed partly or entirely by the sensor housing **224′** adjacent the bearing surface **292′**. The sensor shaft **236′** is therefore supported adjacent the sensor circuit **228′** and is axially constrained with respect to the sensor circuit **228′** and the sensor **296′**. The sensor housing **224′** is then secured to the pedal housing **104′**, and the sensor shaft **236′** is coupled to the pedal shaft **124′** for corotation therewith. The target element **232′** is axially fixed with respect to the sensor housing **224′** and thus is rotated relative to the sensor circuit **228′** without translating axially with respect to the sensor circuit **228′**. The sensor circuit **228′** generates a signal indicative of the position of the pedal shaft **124′** as indicated by the position of the target element **232′**. Other embodiments may include still further methods of axially constraining the sensor shaft(s) **236***a*, **236***b* and target element(s) **232***a*, **232***b* with respect to the sensor circuit(s) **228***a*, **228***b*.

(55) With reference back to the pedal assembly **100** of FIGS. **2-7**, and as discussed above, the jointed shaft design allows for greater adaptability and modularity, allowing the pedal shaft **124** to be easily customized based on the specific requirements of the situation. Additionally, the pedal shaft **124** of the pedal assembly **100** illustrated in FIGS. **2-7** offers increased ease of installation compared to previous pedal assembly designs. Previous designs included a single unitary shaft (often carrying one or more sensor targets) for mounting the pedal arm to the housing, however, such designs often required difficult or complex press fits through multiple components in order to properly support the pedal arm in the housing. One common issue results from the differing widths of the various bores. For example, a press fit may be more secure when made with a smaller opening, however, rotational support of a shaft may be easier when made with a larger opening, meaning that the portions of the shaft configured to be supported in the housing is often wider than the portion between the supports which is configured to couple (e.g., via press fit) to the pedal shaft. Complex geometry or press-fits may be required to properly support and couple the pedal arm to the housing when using a standard unitary pedal shaft design.

(56) In the embodiment illustrated in FIGS. **2-7**, the joint **168** in the pedal assembly **100** allows each of the shaft portions **164***a*, **164***b* of the pedal shaft **124** to be separately coupled through the outside of the pedal housing **104** and press fit into the openings **160***a*, **160***b* of the through bore **152**. The bearing portions **180***a*, **180***b*, which are the wider portions of the shaft, are supported in the housing **104** on both sides of the pedal arm **108**, and the mounting hubs **188***a*, **188***b*, which are narrower than the bearing portions **180***a*, **180***b*, are press fit in the openings **160***a*, **160***b* and coupled to the pedal arm **108**. The joint **168** is easily connected within the through bore **152** without additional tools, components, or actions. The axial movement needed to join the shaft portions **164***a*, **164***b* and couple the joint **168** occurs as part of the process of press fitting the shaft portions **164***a*, **164***b* to the pedal arm **108**. Therefore, the shaft **124** is formed from the shaft portions **164***a*, **164***b* during assembly without adding a separate motion or step to the process. The ratchet rivet style of the joint **168** allows each shaft portion **164***a*, **164***b* to be formed as a single piece and the joint **168** does not require additional components or pre-assembly of any parts. The joint **168** of the illustrated embodiment offers additional simplicity since the first shaft portion **164***a* and the second shaft portion **164***b* are identical, meaning the number of distinct components in the pedal assembly **100** is not increased by replacing the unitary shaft with the pedal shaft **124** with the joint **168**.

(57) In addition to the ease of assembly, the joint **168** provides secondary or backup locating features that axially and rotationally fix the first shaft portion **164***a* with respect to the second shaft portion **164***b*. In the pedal assembly **100** described herein, the shaft portions **164***a*, **164***b* are each separately press fit to the pedal arm **108**, and therefore the shaft portions **164***a*, **164***b* are each axially fixed with respect to the pedal arm **108** and therefore to each other. Additionally, each shaft portion **164***a*, **164***b* is separately driven to rotate about the pedal axis **126** by the engagement between the openings **160***a*, **160***b* and the mounting hubs **188***a*, **188***b*, resulting in simultaneous

rotation of the shaft portions **164***a*, **164***b*. The press fits may serve as the primary system for locating (e.g., fixing the location of) the shaft portions **164***a*, **164***b* with respect to the pedal arm **108** and to each other. However, even without the press fit between the shaft portions **164***a*, **164***b* and the pedal arm **108**, the joint **168** acts as a backup locating system for maintaining the shaft portions **164***a*, **164***b* with respect to each other. Therefore, in assemblies where only one shaft portion **164***a*, **164***b* is press fit (or otherwise axially and rotationally fixed) with the pedal arm **108**, both shaft portions **164***a*, **164***b* are still rotated and translated simultaneously. Rotationally locating the shaft portions **164***a*, **164***b* with respect to each other allows the shaft portions **164***a*, **164***b* to act together as the pedal shaft **124** so that in embodiments with both the first PSA **132***a* and the second PSA **132***b*, the sensor shafts **236***a*, **236***b* are driven to rotate by the pedal shaft at the same time and to the same degree, resulting in consistent measuring between the first PSA **132***a* and the second PSA **132***b*.
(58) For example, if during operation, only the first shaft portion **164***a* is axially fixed to the pedal arm **108** (e.g., by the press fit between the mounting hub **188***a* and the opening **160***a*), and the second shaft portion **164***b* attempts to axially separate from (i.e., move axially outward with respect to) the first shaft portion **164***a*, the joint **168** would inhibit axial separation. Specifically, the toothed surfaces **200***a* of the ratchet fingers **196***a* would engage the toothed surfaces **200***b* of the ratchet fingers **196***b* and would lock against each other, stopping movement of the toothed surfaces **200***a*, **200***b* relative to each other, and thereby inhibiting axial separation of the shaft portions **164***a*, **164***b*. Thus, if the pedal arm **108** translates laterally, as discussed above, the translation would be transmitted through the press fit to the first shaft portion **164***a* and then through the joint **168** to the second shaft portion **164***b*. The translation is then inhibited from transmitting to the sensor shafts **236***a*, **236***b* by the couplings **244***a*, **244***b*. Axially locating the shaft portions **164***a*, **164***b* prevents the pedal shaft **124** from changing in length, which may adversely affect the spacing in the couplings **244***a*, **244***b* and the effectiveness of the spacers **240***a*, **240***b*. Additionally, if only the first shaft portion **164***a* is rotationally fixed with the pedal arm **108** (e.g., by the press fit between the mounting hub **188***a* and the opening **160***a*), and the pedal arm **108** is rotated about the pedal axis, then the pedal arm **108** drives the first shaft portion **164***a* to rotate about the pedal axis **126**, and the joint **168** transmits the rotation from the first shaft portion **164***a* to the second shaft portion **164***b*. Specifically, the circumferential engagement of the toothed surfaces **200***a*, **200***b* due to the axial and radial overlap of the ratchet fingers **196***a*, **196***b* transmits the rotation between the shaft portions **164***a*, **164***b*. Rotation of the shaft portions **164***a*, **164***b* is transmitted to the sensor shafts **236***a*, **236***b* through the couplings **244***a*, **244***b* and both of the sensor circuits **228***a*, **228***b* can detect the resulting movement of the target elements **232***a*, **232***b* and generate the signal indicating the movement of the pedal shaft **124** and pedal arm **108**. Thus, rotationally locating the shaft portions **164***a*, **164***b* with respect to each other ensures that the pedal shaft **124** can be consistently sensed by either of the sensor circuits **228***a*, **228***b*.
(59) As discussed above, in the pedal assembly **100** the press fits between the mounting hubs **188***a*, **188***b* and the openings **160***a*, **160***b* are designed to act as the primary locating feature to determine the positioning of the shaft portions **164***a*, **164***b* with respect to each other, and the joint **168** is used as a backup system to support the press fits. In some embodiments, the backup locating features of the joint **168** may be used alongside a detection system or regular maintenance that would monitor the primary locating system, or in other words, ensure both shaft portions **164***a*, **164***b* are press fit to the pedal arm **108**.
(60) Overall, the joint **168** offers the pedal shaft **124** increased adaptability and ease of assembly without increasing the complexity of the design or negatively impacting the function thereof and offers support to the primary locating features (e.g., the press fits of the shaft portions **164***a*, **164***b*).
(61) In the pedal assembly **100**, as illustrated in FIGS. **2-7**, the pedal shaft **124** includes both the joint **168** and at least one isolating coupling **244***a*, **244***b* for connecting to the sensor shaft **236***a*, **236***b*. However, in other embodiments a pedal assembly may include only one of the joint or the

coupling(s). For example, a pedal assembly may include a unitary pedal shaft configured to couple to at least one position sensor assembly by an axially isolating coupling. Alternately, a pedal assembly may include a jointed pedal shaft having portions of the position sensor assembly(ies) integrated with the pedal shaft (for example, the pedal assembly **800** illustrated in FIGS. **13-15**). The features are therefore independent, and each offer their own advantages, which may be increased when combined into a single assembly, as shown in the pedal assembly **100** shown in FIGS. **2-7**.
(62) FIG. **9** illustrates a first embodiment of an alternate coupling **544** between a sensor shaft **536** and a pedal shaft **424**. The alternate coupling **544** may be incorporated into the pedal assembly **100** in place of one or both of the couplings **244*a***, **244*b***. The alternate coupling **544** transmits rotation between the sensor shaft **536** and the pedal shaft **424** and allows for axial movement of the pedal shaft **424** along the pedal axis **126**. In the illustrated embodiment, the coupling **544** includes a pair of drive projections **548** extending from an outer end **484** of the pedal shaft **424**. The drive projections **548** are slidably received in a set of slots **560** on the sensor shaft **536**. In the illustrated embodiment, the pedal shaft **424** includes the projections **548** and the sensor shaft **536** includes the slots **560**, however, in other embodiments this may be reversed and the pedal shaft **424** may include slots for receiving the projections of the sensor shaft **536**. The circumferential engagement of the projections **548** in the slots **560** transmits rotation between the pedal shaft **424** and the sensor shaft **536**. The drive projections **548** are axially slidable within the slots **560** to allow the pedal shaft **424** to translate relative to the sensor shaft **536** along the pedal axis **126**. Biasing members **540** may be positioned axially between an end surface **549** of the drive projections **548** and a rear wall **561** of the slots **560** to bias the pedal shaft **424** and the sensor shaft **536** apart. When the coupling **544** is incorporated in a pedal assembly, the biasing members **540** of the coupling **544** retain the target element (not shown) on the end of the sensor shaft **536** in close axial proximity to the sensor circuit in the sensor housing (not shown). As mentioned above, the alternate coupling **544** may be used in place of the couplings **244*a***, **244*b*** between one or both of the sensor shafts **236*a***, **236*b*** and the pedal shaft **124**. In some embodiments, the shaft portions **164*a***, **164*b*** may be selected based on the desired coupling and the configuration of the sensor shaft.
(63) FIGS. **10-12** illustrate a second embodiment of an alternate coupling **744**. The alternate coupling **744** can be incorporated into the pedal assembly **100** and replace one or both of the couplings **244*a***, **244*b***. The coupling **744** connects the sensor shaft **736** with the pedal shaft **624** and transmits rotation therebetween. The coupling **744** also allows movement of the pedal shaft **624** with respect to the sensor shaft **736**. In the illustrated embodiment, the pedal shaft **624** is rotatable about a pedal axis **126**. The sensor shaft **536** is rotatable about a sensor axis **742**. The coupling **744** transmits rotation of the pedal shaft **624** about the pedal axis **126** and drives the sensor shaft **736** to rotates about the sensor axis **742**. The coupling **744** isolates the sensor shaft **736** from axial and radial movement of the pedal shaft **624**. The pedal shaft **624** includes a pair of drive projections **748** extending from an outer end **684**. The sensor shaft **736** similarly includes a pair of driven projections **760** axially extending along the sensor axis **742**. The coupling **744** includes a spacer **740** having an inner hub **764** (FIG. **12**), four spurs **768** extending radially outward from the inner hub **764**, and four windows **772** positioned circumferentially between the spurs **768**. When the pedal shaft **624** and sensor shaft **736** are coupled, the spurs **768** are interspersed between the drive projections **748** and driven projections **760**. In other words, the drive projections **748** and driven projections **760** are received in alternating windows **772** of the spacer **740**.
(64) With reference to FIG. **11**, in the illustrated embodiment, the spacer **740** is configured to axially isolate the sensor shaft **736** from the pedal shaft **624** in a similar way to the spacer **240*b*** of the coupling **244*b*** shown in FIGS. **4** and **6**. The spacer **740** is positioned axially between the pedal shaft **624** and the sensor shaft **736**. The spacer **740** may be formed of a compliant material and may be deformable in an axial direction (e.g., along the pedal axis **126**). In an axially neutral position, shown in FIG. **11**, the driven projections **760** may be spaced from the outer end **684** of the pedal

shaft **624**, and therefore the pedal shaft **624** is able to slide with respect to the sensor shaft **736** in either direction from the neutral position along the pedal axis **126**. The translation of the pedal shaft **624** toward the sensor shaft **736** is absorbed by the spacer **740** and is not transmitted to the sensor shaft **736**. The spacer **740** therefore axially isolates the sensor shaft **736** from the pedal shaft **624**. The spurs **768**, the drive projections **748**, and the driven projections **760**, are all positioned in a common axial span **776** along the pedal axis **126** and a common radial span **780** (FIG. **12**) such that the spurs **768**, the drive projections **748**, and the driven projections **760** are all circumferentially engaged to transmit rotation.
(65) With reference to FIG. **12**, the sensor shaft **736** and the pedal shaft **624** are each radially movable with respect to each other and with respect to the spacer **740**. As discussed above, the drive projections **748** and driven projections **760** are received in the windows **772**, and more specifically, may be press fit with the spacer **740** to position the components in the common axial span **776** and create circumferential engagement therebetween. In a radially neutral position (also referred to as an aligned position), shown in FIG. **12**, the sensor axis **242** is aligned with the pedal axis **126**. A pair of first gaps **308** are formed between the inner hub **764** and each of the drive projections **748**. The drive projections **748** are directly opposite each other across the pedal axis **126**, therefore, the pair of first gaps **308** are similarly formed in windows **772** directly opposite each other. The pair of first gaps **308** are aligned along a first axis (e.g., the X-axis of FIG. **12**). Thus, one of the pair of first gaps **308** is adjacent the inner hub **764** in a first direction along the X-axis (a first radial direction) and the second of the pair of first gaps **308** is adjacent the inner hub **764** in a second direction along the X-axis, opposite the first direction (a third radial direction). The pedal shaft **624** is able to radially deflect and move along the X-axis in the first and second directions relative to the spacer **740** (and therefore the sensor shaft **736**), such that the pedal axis **126** is offset from the sensor axis **742** creating a misalignment of the pedal shaft **624** and the sensor shaft **736**. Similarly, a pair of second gaps **312** is formed adjacent the inner hub **764** along a second axis (e.g., the Y-axis of FIG. **12**), between the inner hub **764** and each of the driven projections **760**. The pedal shaft **624** and the spacer **740** are movable relative to the sensor shaft **736** in a first direction along the Y-axis (a second radial direction) and in a second direction along the Y-axis, opposite the first direction (a fourth radial direction), such that the pedal axis **126** is offset from the sensor axis **742** creating a misalignment of the pedal shaft **624** and the sensor shaft **736**.
(66) The gaps **308**, **312** are smaller than a radial width of the projections **748**, **760** such that at least a portion of the projections **748**, **760** remains radially overlapped with the spurs **768**. In other words, the drive projections **748**, the driven projections **760**, and the spurs **768** remain within the common radial span **780** during misalignment. The coupling **744** therefore maintains the circumferential engagement within the common axial span **776** that transmits rotation, even when the pedal axis **126** is offset from the sensor axis **742**. The coupling **744** maintains a connection for corotation between the pedal shaft **624** and the sensor shaft **736** regardless of axial or radial movement of the pedal shaft **624** relative to the sensor shaft **736**. In other words, the coupling **744** is able to tolerate misalignment between the pedal shaft **624** and the sensor shaft **736** and continue to transmit rotation therebetween. The sensor shaft **736** may be radially constrained with respect to the sensor housing such that during operation, the pedal shaft **624** may deflect radially and move radially along the X and Y axes relative to the sensor shaft **736** and only rotation of the pedal shaft **624** is transmitted to the sensor shaft **736**, maintaining a connection for corotation with the pedal shaft **624** during misalignment. Thus, when the coupling **744** is incorporated into a pedal assembly, the sensor shaft **736** maintains alignment and rotates about the sensor axis **742** with respect to the sensor housing and the target element (coupled to the sensor shaft **736**) does not move axially or deflect radially with respect to the sensing circuit (not shown). In some embodiments, the gaps **308**, **312** may be used alongside or replaced by a low radial stiffness of the spacer **740**. For example, one of the projections **748** may move through one of the first gaps **308** to allow radial deflection of the pedal shaft **624**, and/or the projection **748** may engage the inner hub **764** adjacent the window **772**

and the inner hub **764** may deform to allow for radial deflection of the pedal shaft **624** with respect to the sensor shaft **736**. The directions of movement are discussed with reference to an X-Y coordinate system as applied to FIG. **12**. The references to X and Y axes are not intended to limit the discussed movement to horizontal and vertical axes, and the coordinate system shown in FIG. **12** would rotate along with the coupling **744**. As discussed above, the coupling **744** may replace either coupling **244***a*, **244***b* in the pedal assembly **100** and the shaft portions **164***a*, **164***b* may be selected based on the desired coupling and configuration of the sensor shaft **736**.
(67) With reference to FIGS. **13-15**, an alternative pedal assembly **800** is shown. As discussed above, the benefits of the jointed pedal shaft may be incorporated into pedal assemblies not including translational decoupling of the target element and the pedal shaft. The pedal assembly **800** includes a pedal shaft **824** having a first shaft portion **864***a* and a second shaft portion **864***b* coupled by a joint **868**. The joint **868** is a one-way ratchet joint that is substantially similar to the joint **168** and only differences between the joints are described herein. As seen best in FIG. **15**, the first shaft portion **864***a* includes a pair of ratchet fingers **896***a* and the second shaft portion **864***b* includes a pair of ratchet fingers **896***b*. Each ratchet finger **896***a*, **896***b* includes an axial slot extending lengthwise from a distal end of the ratchet finger along the pedal axis **126**. In the illustrated embodiment, each axial slot **897** may extend partially into the mounting hub **888***a*, **888***b*. Each axial slot **897** subdivides the ratchet finger **896***a*, **896***b* such that a first portion **898** is deflectable with respect to a second portion **899**. The ratchet fingers **896***a*, **896***b* each include a pair of toothed surfaces **900***a*, **900***b*. For example, one of the ratchet fingers **896***a* includes a first one of the toothed surfaces **900***a* on the first portion **898** and a second one of the toothed surfaces **900***a* on the second portion **899**. During the coupling of the joint **868**, the axial slots **897** provide the ratchet fingers **896***a*, **896***b* with greater flexibility to deform relative to the pedal axis **126** and decrease the force required to axially couple the shaft portions **864***a*, **864***b*. Specifically, the first portions **898** and second portions **899** of each ratchet fingers **896***a*, **896***b* may deflect inward (e.g., toward the axial slot **897**), as the teeth on the toothed surfaces **900***a*, **900***b* ramp against each other. When the ratchet fingers **896***a*, **896***b* are engaged, the toothed surface **900***a* on the first portion **898** transmits the rotation to the corresponding toothed surface **900***b* on the first portion **898** of the ratchet finger **896***b* and the toothed surface **900***a* on the second portion **899** transmits rotation to the corresponding toothed surface **900***b* on the second portion **899** of the ratchet finger **896***b*.
(68) With reference to FIG. **14**, in the illustrated embodiment, the first shaft portion **864***a* and the second shaft portion **864***b* are structurally unique. The first shaft portion **864***a* includes a target element **932***a* coupled to the outer end **884***a* of the bearing hub **880***a* (FIG. **15**). In the illustrated embodiment, the target element **932***a* is a metal element configured for use with an inductive position sensor of a sensor circuit **928***b*. The second shaft portion **864***b* includes a target element **932***b* positioned in a flared portion of the bearing hub **880***b*, adjacent the outer end **884***b*. In the illustrated embodiment, the target element **932***b* is a ring-shaped magnet for use with a Hall sensor of a sensor circuit **928***b*. In the illustrated embodiment, the target elements **932***a*, **932***b* are integrated (e.g., embedded) into the shaft portions **864***a*, **864***b*. In other embodiments, the target elements **932***a*, **932***b* may be coupled to a recess on the outer end **884***a*, **884***b*. The target elements **932***a*, **932***b* rotate with the pedal shaft **824** and the sensor circuits **928***a*, **928***b* are able to sense the position of the target elements **932***a*, **932***b* and generate a signal corresponding to a rotational position of the pedal shaft **824**. As discussed above, the joint **868** in the pedal shaft **824** increases the ease of assembly and the modularity of the pedal assembly **800**. In the illustrated embodiment, each shaft portion **864***a*, **864***b* may be selected based on the type of sensor used in the sensor circuit **928***a*, **928***b*, the configuration of the housing **804**, the type of target element **932***a*, **932***b* coupled to the shaft portion **864***a*, **864***b*, and other considerations for each side of the pedal assembly **800**. Additionally, the ratchet style joint **868** provides backup or secondary axial and radial locating of the shaft portions **864***a*, **864***b* independent from and capable of supporting the press fit between the pedal arm **808** and the mounting hubs **888***a*, **888***b* of the pedal shaft **824**. The joint **868** increases

the modularity of the system and adds backup locating features while maintaining an assembly that is easy to manufacture and assemble.
(69) The embodiments described above and illustrated in the figures are presented by way of example only and are not intended as a limitation upon the concepts and principles of the present invention. As such, it will be appreciated that various changes in the elements and their configuration and arrangement are possible without departing from the spirit and scope of the present invention. Accordingly, the specification and figures are to be regarded in an illustrative rather than a restrictive sense, and all such modifications are intended to be included within the scope of present teachings.
(70) The benefits, advantages, solutions to problems, and any element(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential features or elements of any or all the claims. The invention is defined solely by the appended claims including any amendments made during the pendency of this application and all equivalents of those claims as issued.
(71) The Abstract of the Disclosure is provided to allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In addition, in the foregoing Detailed Description, it may be seen that various features are grouped together in various examples for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed examples require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed example. Thus, the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separately claimed subject matter.
(72) Various features and advantages of the invention are set forth in the following claims.

Claims

1. A vehicular pedal assembly comprising: a pedal housing configured for mounting within a vehicle; a pedal shaft supported by the pedal housing for rotation about a pedal axis; a pedal arm coupled to the pedal shaft and configured to pivot in response to input from a driver to drive the pedal shaft to rotate about the pedal axis; and a position sensor assembly coupled to the pedal shaft to determine a rotational position of the pedal shaft and generate a signal based on the rotational position, wherein the position sensor assembly includes a target element, a sensor circuit configured to sense the target element and generate the signal, and a sensor shaft configured to rotate about a sensor axis and fixed for corotation with the pedal shaft, wherein the target element is positioned on the sensor shaft and is configured to rotate with the sensor shaft about the sensor axis to move the target element with respect to the sensor circuit and change the signal generated by the sensor circuit, wherein a coupling between the pedal shaft and the sensor shaft is configured to simultaneously transmit rotation and absorb movement of the pedal shaft along the pedal axis to axially isolate the sensor shaft.
2. The vehicular pedal assembly of claim 1, wherein the sensor shaft is constrained against a reference surface of the pedal housing to axially fix a position of the target element with respect to the sensor circuit.
3. The vehicular pedal assembly of claim 1, wherein the position sensor assembly further includes a sensor housing coupled to the pedal housing, the sensor circuit positioned in the sensor housing, and the sensor shaft includes a flange configured to be constrained between the sensor housing and the pedal housing to axially fix the sensor shaft and the target element with respect to the sensor housing.
4. The vehicular pedal assembly of claim 1, wherein the coupling includes a spacer positioned axially between the pedal shaft and the sensor shaft and the spacer transmits rotation between the

pedal shaft and the sensor shaft.
5. The vehicular pedal assembly of claim 4, wherein the spacer includes an inner hub and a spur extending radially outward from the inner hub.
6. The vehicular pedal assembly of claim 5, wherein the spur transmits rotation from the pedal shaft to the sensor shaft and the spacer is configured to simultaneously transmit rotation and absorb movement of the pedal shaft along the pedal axis to axially isolate the sensor shaft.
7. The vehicular pedal assembly of claim 1, wherein the pedal shaft extends along the pedal axis between a first end and a second end, the position sensor assembly is a first position sensor assembly coupled to the first end of the pedal shaft, and the vehicular pedal assembly includes a second position sensor assembly coupled to the second end of the pedal shaft.
8. The vehicular pedal assembly of claim 7, wherein one of the first and second position sensor assemblies includes a hall sensor configured to sense the target element and the other of the first and second position sensor assemblies includes an inductive sensor configured to sense the target element.
9. The vehicular pedal assembly of claim 1, wherein the coupling includes a first projection of the pedal shaft and a second projection of the sensor shaft.
10. The vehicular pedal assembly of claim 9, wherein the coupling is configured to allow the pedal shaft to move relative to the sensor shaft along a pair of axes perpendicular to each other and perpendicular to the pedal axis.
11. The vehicular pedal assembly of claim 1, wherein the coupling between the pedal shaft and the sensor shaft is configured to tolerate misalignment between the pedal shaft and the sensor shaft and maintain a connection for corotation between the pedal shaft to the sensor shaft.
12. The vehicular pedal assembly of claim 1, wherein the vehicular pedal assembly is a brake pedal, and the pedal arm is coupled to a brake footpad configured to be engaged by the driver to pivot the pedal arm and actuate one or more braking elements.
13. A vehicular pedal assembly for a vehicle, the vehicular pedal assembly comprising: a pedal housing configured for mounting in the vehicle; a pedal shaft supported by the pedal housing for rotation about a pedal axis, the pedal shaft extending along the pedal axis between a first end and a second end; a pedal arm drivably engaged with the pedal shaft, the pedal arm having a footpad configured to be engaged by a driver to pivot the pedal arm and rotate the pedal shaft about the pedal axis; a position sensor assembly coupled to the first end of the pedal shaft and configured to determine a rotational position of the pedal shaft and generate a signal based on the rotational position, wherein the position sensor assembly includes a sensor housing coupled to the pedal housing and containing a sensor circuit, a sensor shaft configured to rotate about a sensor axis and fixed for corotation with the pedal shaft, and a target element positioned on the sensor shaft, wherein the sensor circuit is configured to sense the target element and generate the signal; and a spacer positioned between the sensor shaft and the first end of the pedal shaft to transmit rotation from the pedal shaft to the sensor shaft, the spacer configured to absorb movement of the pedal shaft along the pedal axis to axially isolate the sensor shaft.
14. The vehicular pedal assembly of claim 13, wherein rotation of the sensor shaft moves the target element relative to the sensor circuit and changes the signal generated by the position sensor assembly.
15. The vehicular pedal assembly of claim 13, wherein the sensor shaft is constrained between the sensor housing and the pedal housing to axially fix a position of the sensor shaft with respect to the sensor housing.
16. The vehicular pedal assembly of claim 15, wherein the position sensor assembly is a first position sensor assembly coupled to the first end of the pedal shaft and the vehicular pedal assembly includes a second position sensor assembly coupled to the second end of the pedal shaft.
17. The vehicular pedal assembly of claim 13, wherein the first end of the pedal shaft includes a first projection extending from the first end along the pedal axis, the sensor shaft includes an inner

end having a second projection extending from the inner end along the sensor axis, and the first projection, the second projection, and the spacer are all positioned within a common span of the pedal axis.
18. The vehicular pedal assembly of claim 17, wherein the spacer includes an inner hub and a spur extending radially outward from the inner hub, the spur is positioned circumferentially between the first projection and the second projection, and the spur is configured to transmit rotation of the pedal shaft between the first projection and the second projection to rotate the sensor shaft with the pedal shaft.
19. The vehicular pedal assembly of claim 18, wherein a first gap is disposed adjacent the inner hub and the first projection is configured to move within the first gap along a first axis to allow movement of the pedal shaft with respect to the sensor shaft along the first axis, and a second gap is disposed adjacent the inner hub and the second projection is configured to move within the second gap along a second axis to allow movement of the pedal shaft with respect to the sensor shaft along the second axis.
20. The vehicular pedal assembly of claim 13, wherein a coupling includes the pedal shaft, the sensor shaft, and the spacer and the coupling is configured to tolerate misalignment between the pedal shaft and the sensor shaft and maintain a connection for corotation between the pedal shaft to the sensor shaft.