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(54) **APPARATUS FOR ISOLATING A SENSOR FROM VIBRATION**

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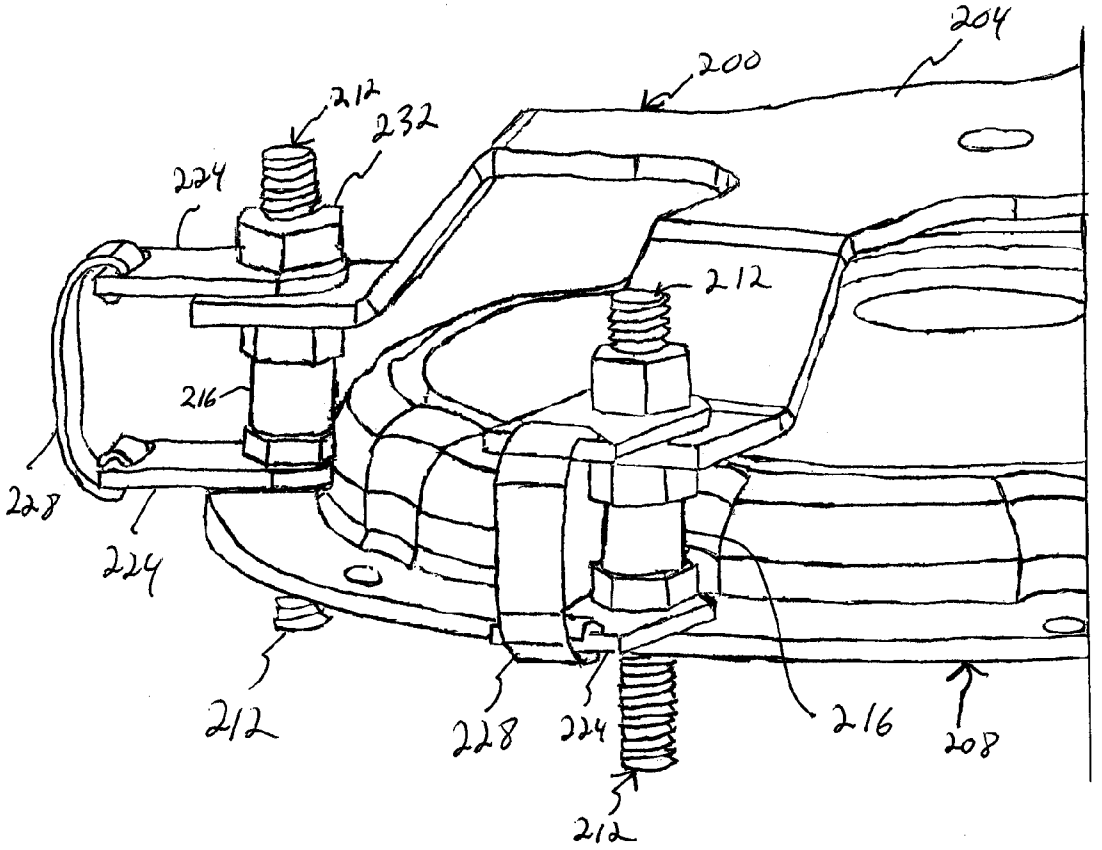
(57) **ABSTRACT**

A sensor bracket that isolates a sensor from mechanical vibrations of an associated component extends the operational lifetime, for example, of a wheel-mounted sensor on a vehicle. The bracket includes a multi-legged bracket to decrease the dynamic instability induced by using highly compliant isolating elements on a rotating wheel. Multiple isolating elements provide a reduction in the vibration impinging on a sensor while still maintaining rotational stability of the assembly on the wheel. In some aspects, an intrinsic, fail-safe feature is included in the sensor mounting bracket and isolating element design.



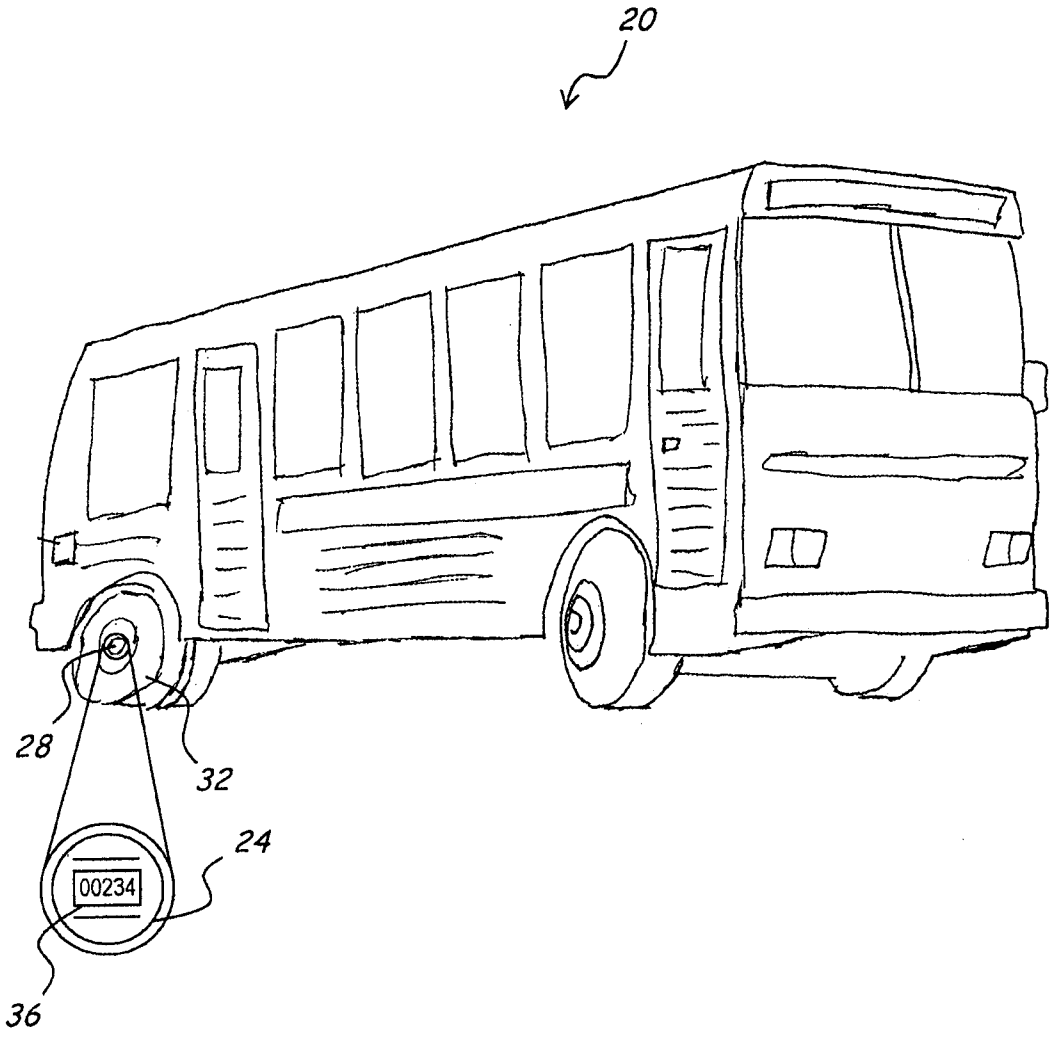


FIG.1

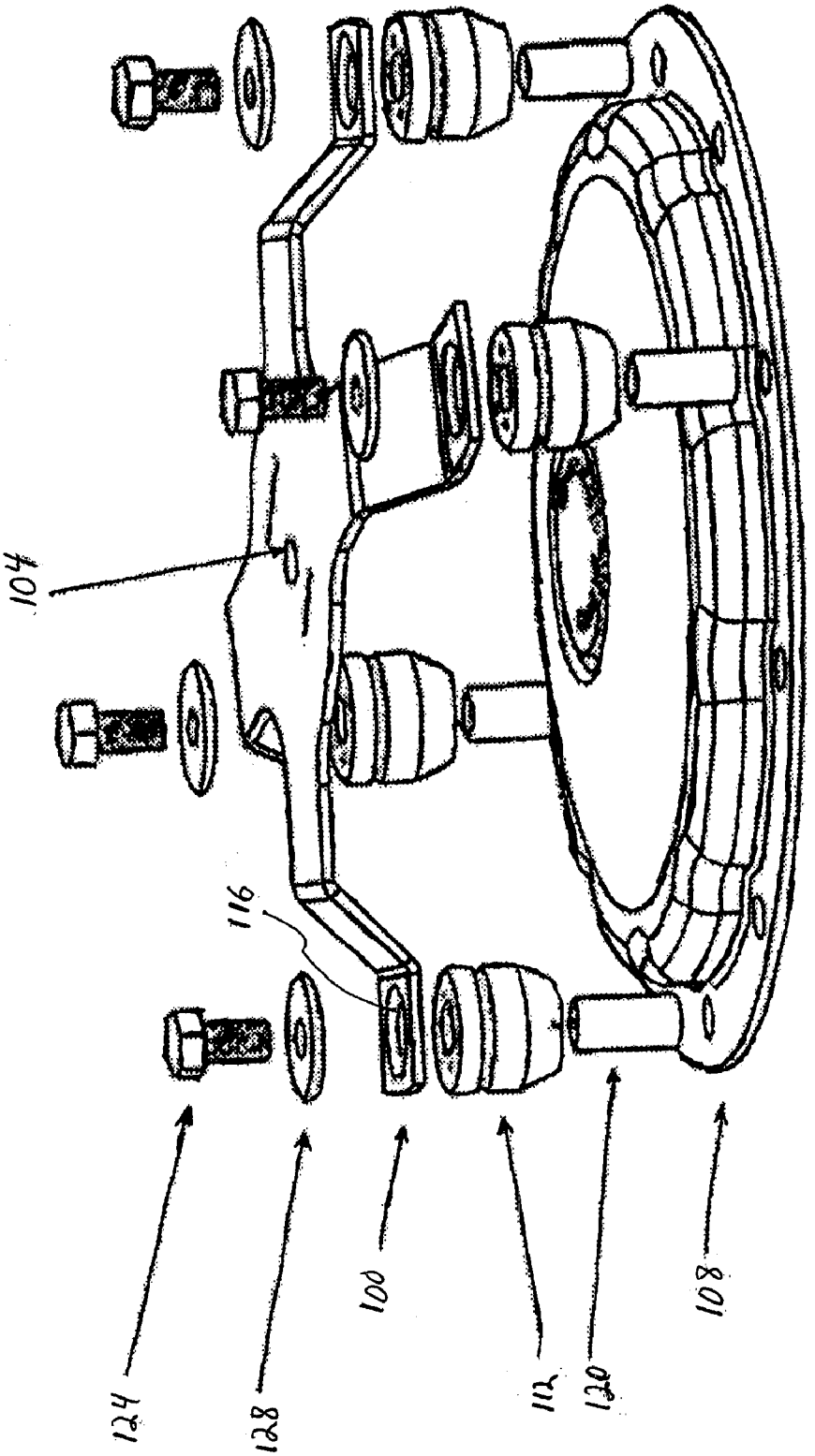


Fig. 2

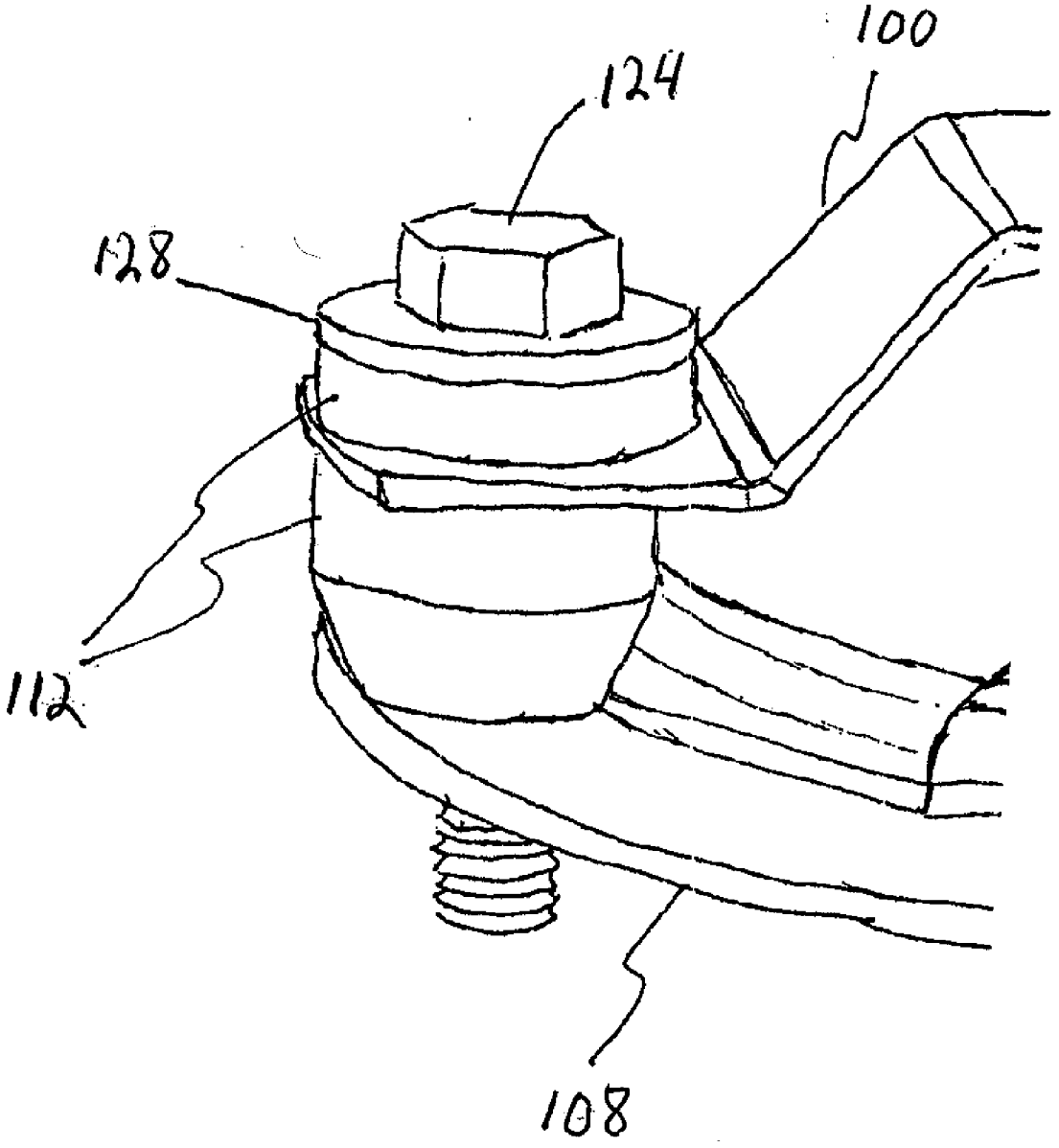


Fig. 3

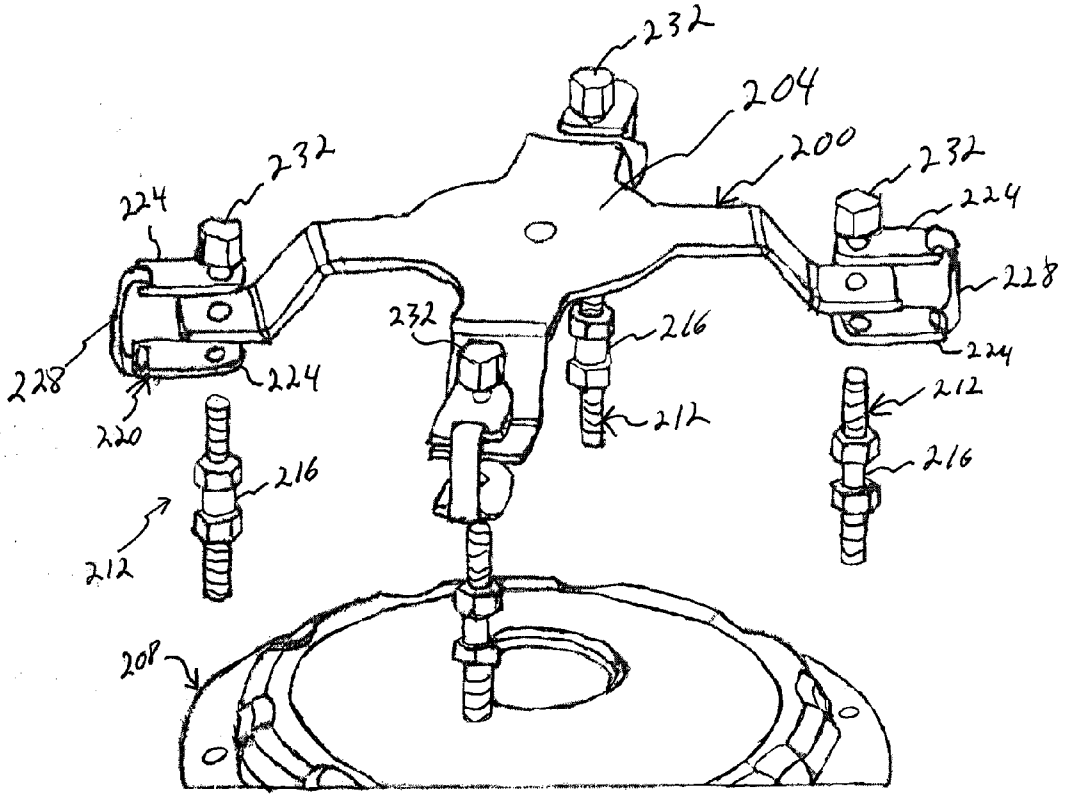

232
204
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Fig. 4

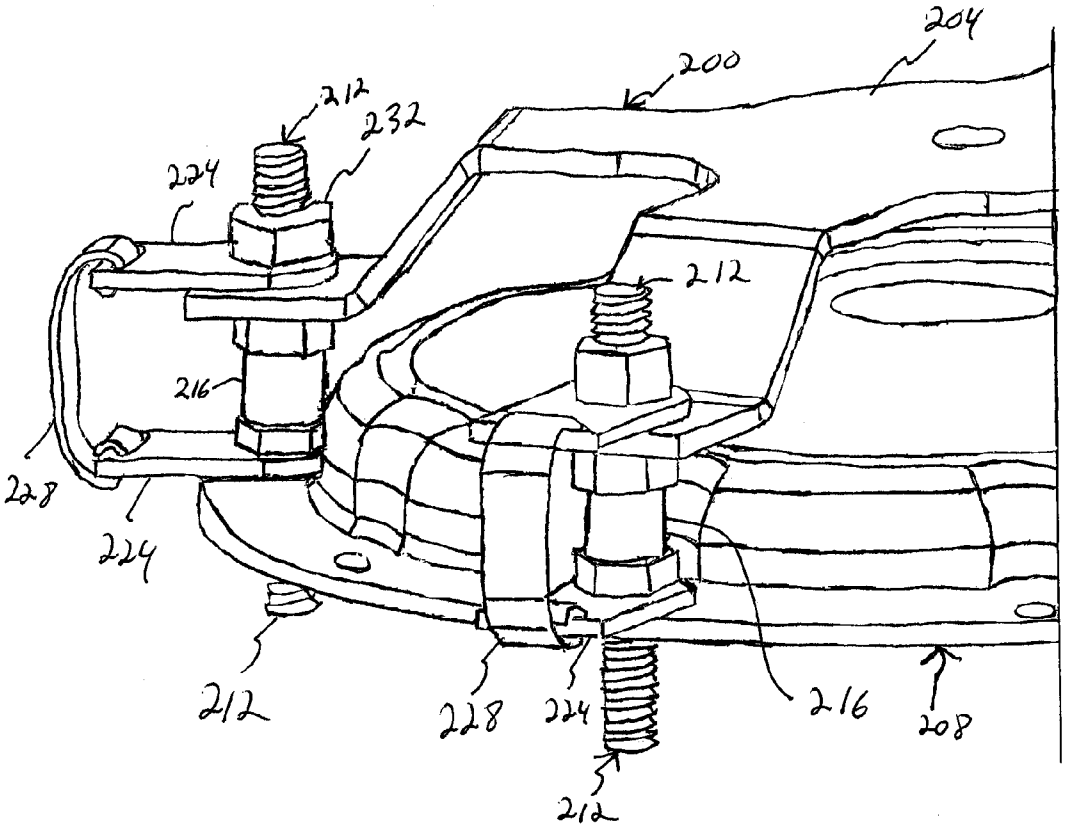

Fig. 5

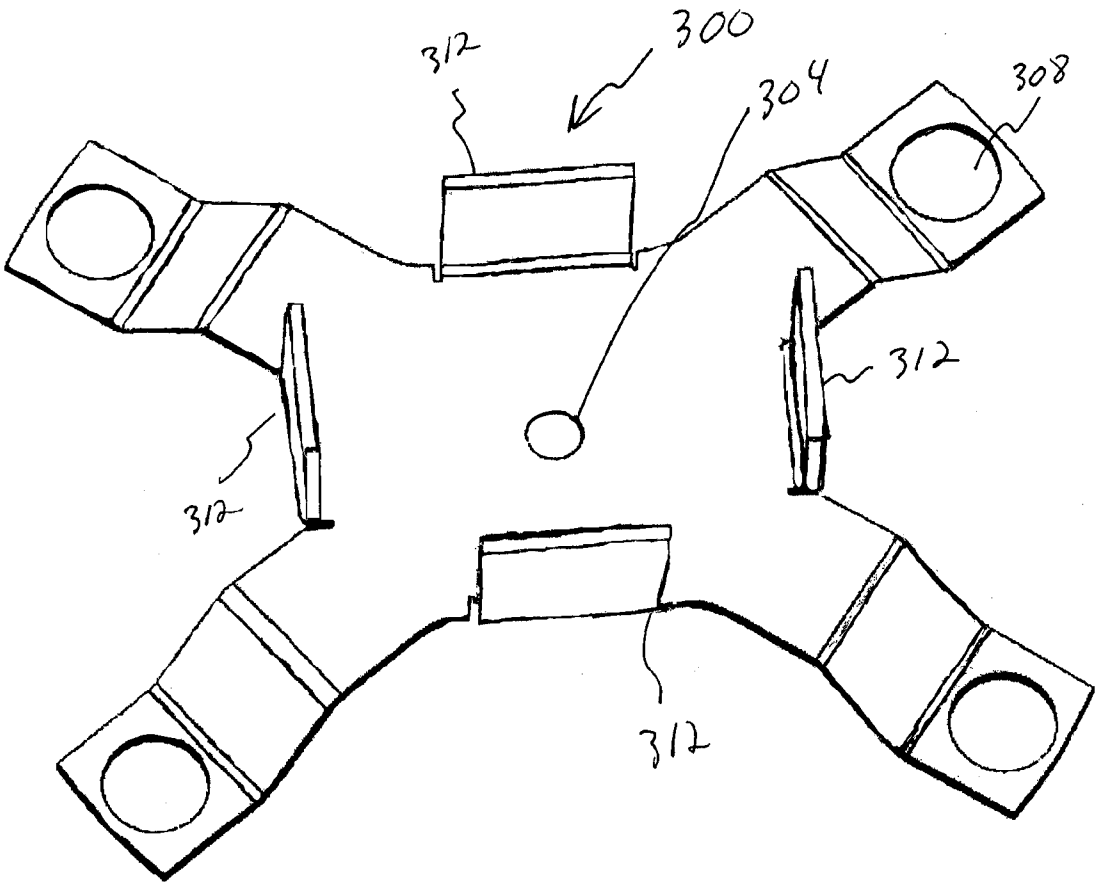

Fig. 6

APPARATUS FOR ISOLATING A SENSOR FROM VIBRATION

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. provisional patent application No. 61/029,414, filed on Feb. 18, 2008 entitled "Apparatus for Isolating a Sensor From Vibration," the entire disclosure of which is incorporated herein by reference.

FIELD

[0002] The present invention is related to mechanically isolating vehicle sensors from vehicle vibrations, and, more specifically, an isolation bracket that isolates a vehicle sensor from vibrations of the vehicle.

BACKGROUND

[0003] Vehicle sensors are often mounted to vehicle components such that information directly related to the associated component may be relayed to an interested party. For example, odometers may be placed on a wheel hub to measure the revolutions of the associated wheel. The measured revolutions, along with information related to the wheel diameter, may be used to calculate a distance traveled by the associated wheel, and therefore a distance traveled by the associated vehicle. Such a device is well known, and is commonly referred to as a hubodometer. A hubodometer is one example of a sensor that may be mounted to a vehicle. Other types of sensors or devices may also be attached to a vehicle, such as, for example, tire pressure sensors, weight sensors, temperature sensors, location sensors, and communications devices, to name but a few.

SUMMARY

[0004] Embodiments disclosed herein provide a sensor bracket that isolates a sensor from mechanical vibrations of an associated component. Mounting brackets of various embodiments extend the operational lifetime, for example, of a wheel-mounted sensor on a truck, trailer or bus. Mounting brackets of various aspects accomplish this by protecting the mounted sensor from damaging shock and vibration. The sensor could be an electronic mileage counter such as an electronic hubodometer, a mechanical mileage counter such as a mechanical hubodometer, a tire pressure monitor, and/or a lubricant fluid sensor, to name a few. The shock and vibration impinging on a wheel-mounted sensor may result from poor road conditions such as potholes, washboard, gravel, expansion joints, and/or dislocations associated with the roadway. The shock and vibration impinging on a wheel-mounted sensor also may result from poor driving skill, resulting in excessive encounters with shoulder/centerline 'rumble strip' cut outs/protrusions, curbs, foreign objects, and the like. The shock and vibration impinging on a wheel-mounted sensor also may result from poor vehicle maintenance, resulting in, for example, excessive 'wheel hop' on braking. The shock and vibration impinging on a wheel-mounted sensor further may be the result of high levels of vibration generated by the internal gearing of the axle on which the sensor is mounted. In other vehicles, such as rail vehicles, vibration may result from axle gearing, track conditions, and the like. The present disclosure provides isolating mounting brackets that reduce the vibration transmitted to a vehicle sensor. In some embodiments, provided is a provision of a 'fail-safe' attachment method, which prevents the bracket and sensor assembly from being launched from the wheel during operation of the vehicle should a failure of isolating elements occur.

[0005] Provided in various aspects of the present disclosure are: a sensor-mounting system, designed for the purpose of extending the operational life of a wheel-mounted sensor by protecting it from harmful shock and vibration; use of a multi-legged bracket to decrease the dynamic instability induced by using highly compliant isolating elements on a rotating wheel; implementation of wide temperature range, multiple isolating elements to provide a reduction in the vibration impinging on a sensor while still maintaining rotational stability of the assembly on the wheel; and/or implementation of an intrinsic, fail-safe feature in the sensor mounting bracket and isolating element design.

[0006] In one aspect this disclosure provides a bracket for isolating a sensor from vibration, comprising: (a) a sensor mount adapted to receive a sensor; (b) a plurality of legs extending from the sensor mount; and (c) an isolating element that engages with a distal end of each leg and adapted to receive an attachment element that secures the respective leg, through the isolating element, to a wheel hub. The sensor mount, in an embodiment, comprises a plate having a mounting hole therein that is adapted to receive a sensor. The sensor mount may also include tabs extending from the plate that cover a portion of a sensor when mounted to said plate and provide a shield for the sensor. The plurality of legs, in an embodiment, include holes that receive said isolating elements. The isolating elements may be formed of silicone rubber elements that are substantially cylindrical and include a reduced diameter slot that is captured by a matching hole a respective leg. The isolating elements also include, in some embodiments, a spacer that is inserted into the center thereof. The isolating elements are adapted to receive an attachment bolt used for securing the leg to a wheel hub. The isolating elements may also be molded directly onto said legs, and may include a spacer molded into the material of the isolating element.

[0007] In another aspect, provided is a bracket for isolating a sensor from vibration, comprising: (a) a sensor mount adapted to receive a sensor; (b) a plurality of legs extending from the sensor mount; and (c) a dual stud isolator that engages with a distal end of each leg and adapted secure each leg to a vehicle wheel hub. The dual stud isolator may comprise a first threaded stud having an elastomeric element bonded thereto and a second threaded stud bonded to the elastomeric element opposite the first stud. The studs, in an embodiment, comprise hex bolts with the elastomeric element bonded to the hex head of the hex bolts. The bracket may also include a lanyard assembly coupling the first and second threaded studs of each dual stud isolator.

[0008] A further aspect of the disclosure provides an apparatus for mounting a sensor to a vehicle, comprising: (a) a mounting plate that receives a sensor; (b) a securement assembly that secures the mounting plate to a vehicle; and (c) an isolation element coupled to the securement assembly between the securement assembly and vehicle. The securement assembly, in some embodiments, includes a plurality of legs that extend from said mounting plate. The mounting plate may comprise a plate and a plurality of tabs extending from the plate to at least substantially cover a portion of a sensor when mounted to the plate. The isolation element, in some

embodiments, is substantially cylindrical and includes a reduced diameter slot that is captured by a matching hole in the securement assembly.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. **1** is a perspective view of a vehicle of one embodiment;

[0010] FIG. **2** is a perspective view of an exploded mounting bracket assembly of an embodiment;

[0011] FIG. **3** is a perspective view of an assembled mounting bracket assembly of the embodiment of FIG. **2**;

[0012] FIG. **4** is a perspective view of an exploded mounting bracket assembly of another embodiment;

[0013] FIG. **5** is a perspective view of an assembled mounting bracket assembly of the embodiment of FIG. **4**; and

[0014] FIG. **6** is a perspective view of a mounting bracket of another embodiment.

DETAILED DESCRIPTION

[0015] For a more complete understanding of this invention, reference is now made to the following detailed description of several embodiments as illustrated in the drawing figures, in which like numbers represent the same or similar elements. Various embodiments are described herein, with specific examples provided in many instances to serve to illustrate and discuss various concepts included in the present disclosure. The specific embodiments and examples provided are not necessarily to be construed as preferred or advantageous over other embodiments and/or examples.

[0016] With reference to FIG. **1**, a vehicle **20** is illustrated for one embodiment as a bus that may be used in public transit. While the vehicle **20** of FIG. **1** is illustrated as a public transit bus, it will be readily understood that this example is for purposes of illustration and discussion, and that methods, systems and apparatuses of the present disclosure may be used for any type of vehicle, including, for example, automobiles, trucks, semi tractor/trailers, and school buses. Furthermore, the systems and apparatuses of the present disclosure may also be used with other types of vehicles, including rail vehicles, aircraft, and/or watercraft. In the embodiment of FIG. **1**, an odometer **24** is mounted to a wheel hub **28** of a set of rear wheel **32**. Typically wheel **32** includes a set of dual wheels, although the present disclosure is equally applicable to any wheel configuration. Such an odometer **24** is often referred to as a "hubodometer," and these devices are commonly used in situations where the mileage of the wheel **32** may not necessarily be tracked by an odometer within the vehicle **20** itself, and/or in situations where it is convenient to view a mileage reading without having to access an interior of the vehicle **20**. For example, in the example of buses used in public transit, it may be more efficient for personnel to view the mileage of a bus on such a hubodometer **24** rather than having to open a door to the bus, climb into the bus, read a mileage from an odometer on the interior instrument panel, exit the bus, and close the door. Furthermore, in many cases digital odometers on the instrument panel may not be active unless the vehicle is turned on, thus making such checking of mileage even more inefficient. The odometer **24** of the embodiment of FIG. **1** includes a display **36** that displays the distance traveled, such as total miles since the odometer's **24** installation, of the vehicle **20**. Such an odometer **24** may record and output on display **36** the distance traveled since a particular event, such as vehicle **20** maintenance or wheel **32** replacement, instead of or in addition to the total distance recorded since the installation of the odometer. In the embodiment of FIG. **1**, the odometer **24** is an electronic hubodometer that measures distance traveled according to a number of revolutions detected by an accelerometer within the hubodometer and a size of the wheel **32** that is programmed into the hubodometer. The odometer **24** may also include an RF circuit that operates to transmit an information signal modulated onto an RF signal that includes an identification for the odometer **24** and the current value of the distance that has been measured by the odometer **24**.

[0017] Traditionally, a solid metallic flat or formed (commercial steel with rust resistant treatment or stainless steel) bracket is used to attach an odometer to the wheel end of the vehicle or trailer. This bracket is rigidly mounted to the wheel, utilizing the existing hubcap bolts, drive axle cover-plate retainer bolts, or, in some cases, the actual lug nuts that attach the wheel to hub. The present disclosure recognizes that the mounting techniques just described provide little, if any, attenuation of the shock/vibration transmitted from the wheel to an odometer. It is recognized that such shock/vibration may have a detrimental effect on a hubodometer, or any other type of sensor associated with a wheel end, including failure of the component. The present disclosure provides for the shock/vibration transmitted to the sensor to be reduced to a level that is within a sensor's fragility limit. To achieve reduced shock and vibration impinging on the sensor, a bracket, as will be described in more detail for some exemplary embodiments, is mounted to the wheel end utilizing isolating elements such as elastomeric (elastomeric refers to a relatively highly pliable material or rubber-like substance, such as neoprene or silicone-based rubber) elements. The assembly is designed so that the vibration from the hub to the bracket and sensor must be transmitted through the isolating element to the sensor and bracket. The isolating elements and bracket combination is designed, in various embodiments, to tailor the mechanical resonances so that they do not occur in close proximity (in the frequency domain) to the operational vibration frequencies in the axle.

[0018] As mentioned above, vehicles, as they travel over roadways, rails, etc. may experience a variety of different vibrations. Such vibrations may be caused by roadway surfaces, environmental factors such as wind, and/or by the vehicle itself as different mechanical components of the vehicle operate and generate vibration. For example, some vehicles have planetary gearing that is located at the end of a vehicle axle, which may cause vibrations in the wheel hub. Other drive train components may cause vibration as well, such as the engine and transmission. Various embodiments disclosed herein provide an isolation bracket that operates to isolate vibrations from a sensor.

[0019] In one embodiment, illustrated in FIGS. **2** and **3**, a hubodometer (not shown) may be mounted to a bracket **100** via a sensor mount **104** that in the embodiment of FIGS. **2** and **3** is a center, ½ inch diameter hole, using a standard washer and locknut (not shown). The bracket **100** is mounted to a axle hub cover plate **108**, the cover plate **108** being associated with a wheel hub of a vehicle (not shown). The bracket **100** is isolated from vibrations of the wheel hub through isolating elements **112**, which in the embodiment of FIGS. **2** and **3** are four silicone rubber, single-piece, elastomeric elements **112** that are inserted into associated holes **116** in the bracket **100**. A spacer **120** is inserted into the center of each of the isolating elements **112**. The assembly is secured to the cover plate **108**

using an attachment bolt **124** and a washer **128**. In the embodiment of FIGS. **2** and **3**, four, longer length bolts **124** and larger OD washers **128**, the assembly is mounted in the specified manner on the cover plate **108**. The associated wheel hub may be associated, for example, with a MAN planetary gear reduction axle, which is used in a large percentage of New Flyer, 40 foot transit buses. In an exemplary embodiment, the elastomeric element **112** is a single-piece design, molded from silicone or neoprene rubber. The element **112** has a reduced diameter slot that is captured by a matching hole **116** in the bracket **100**. In other embodiments, isolating elements may be molded directly onto the bracket, thereby becoming an integral part of the bracket. Additionally, other embodiments may have the steel spacer molded into such an isolating element when the isolating element is molded directly onto the bracket, thereby forming a bracket assembly that would require fewer individual parts to assemble when mounted to a vehicle.

[0020] Another embodiment of an isolating bracket is illustrated in FIGS. **4** and **5**. In this embodiment, as will be described in more detail, an elastomeric element is created by bonding rubber directly to threaded studs. As illustrated in FIGS. **4** and **5**, a hubodometer (not shown) may mounted to a bracket **200** via a sensor mount **204** that in the embodiment of FIGS. **4** and **5** is a center, ½" diameter hole, using the standard washer and locknut (not shown). The bracket **200** is mounted to a axle hub cover plate **208**, the cover plate **208** being associated with a wheel hub of a vehicle (not shown). The bracket **200** is isolated from vibrations of the wheel hub through a dual stud isolator **212**. In this embodiment elastomeric element **216** is created by bonding rubber directly to threaded studs. The studs may be, for example, off-the-shelf hex bolts. The hex head has the advantage of providing an easy method of tightening the fastener into the wheel hub on one end and then providing for nut attachment to the bracket **200** on the other end. This system is made fail-safe by adding a lanyard assembly **220** made from steel end pieces **224** and a lanyard **228** of Nylon or Kevlar, for example, that connects the end pieces **224**. The dual stud isolator **212** is assembled with the lanyard assembly **220** and the bracket **200** is secured with locknut **232** inserted into associated holes in the bracket **200**. The associated wheel hub may be associated, for example, with a MAN planetary gear reduction axle, which is used in a large percentage of New Flyer, 40 foot transit buses.

[0021] Another embodiment of an isolating bracket is illustrated in FIG. **6**. In this embodiment, a sensor such as a hubodometer (not shown) may mounted to a bracket **300** via a sensor mount **304** that in the embodiment of FIG. **6** is a center, ½" diameter hole, using the standard washer and locknut (not shown). The bracket **300**, similarly as described above, may be mounted to a axle hub cover plate associated with a wheel hub of a vehicle (not shown). The bracket **300** may be isolated from vibrations in a manner similar as described above, such as through elastomeric isolating elements that are inserted into associated holes **308** in the bracket **300**. In the embodiment of FIG. **6**, tabs **312** are provided that provide protection to the sensor from foreign objects and/or road debris when the vehicle is in motion. The height of the tabs **312** is selected such that each tab **312** is higher than the height of the mounted sensor or hubodometer. In such a manner, any flying rocks, sticks, small and medium-sized mammals, etc. may be deflected by the tabs **312** and provide an additional degree of protection to the sensor. In this embodiment, the elastomeric isolating elements provide shock protection to the sensor in a similar manner as described above in that they provide isolation to the sensor from axle-borne shocks due to pot-holes and the other road hazards.

[0022] In a still further embodiment, sensor vibration isolation is obtained by manufacturing the actual bracket from a high-damping material or laminate composite that substantially reduces the vibration transmitted to the sensor due to the energy absorbing damping in the bracket construction. Elastomeric elements need not be used in this embodiment, and the bracket is bolted directly to the hub. For example, the bracket material is made from Constrained Layer Damping (CLD) steel. This is a sandwich-type (laminated) construction where two layers of steel are bonded together with an high damping elastomeric layer in the center (similar to automotive windshield construction). The laminate, in other embodiments, may also be formed with multiple layers of steel and damping layers thereby creating more damping and higher structural rigidity. In yet another embodiments, the bracket is fabricated from aluminum, magnesium, injection molded plastic or carbon fiber-reinforced polymer that may be substituted for the steel components in the laminate construction. Bracket construction using a high damping material that has been described here would be inherently fail-safe, as separate isolating elements such as elastomeric elements are not required.

[0023] While embodiments described herein are described with respect to a four-legged bracket that may be affixed to a vehicle wheel of an over the road vehicle, it will be understood that numerous other configurations and applications are within the scope of this disclosure. For example, as briefly mentioned above, isolation devices may be used in rail vehicle applications. In such applications, it may be desirable to provide vibration isolation in order to extend the lifetime of a sensor. In certain embodiments, a three-legged bracket with isolating elements for each leg may be affixed to a rail vehicle wheel in a similar manner as described above. Numerous other applications and configurations of brackets will be readily recognized by one of skill in the art.

[0024] The previous description of the disclosed embodiments is provided to enable a person skilled in the art to make or use the present invention. Various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without departing from the spirit or scope of the invention. Thus, the present invention is not intended to be limited to the embodiments shown herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

What is claimed is:

1. A bracket for isolating a sensor from vibration, comprising:

a sensor mount adapted to receive a sensor;

a plurality of legs extending from said sensor mount; and

an isolating element that engages with a distal end of each leg and adapted to receive an attachment element that secures the respective leg, through said isolating element, to a wheel hub.

2. The bracket of claim **1**, wherein said sensor mount comprises a plate having a mounting hole therein that is adapted to receive a mounting element of a sensor.

3. The bracket of claim **1**, wherein said sensor mount comprises a plate and a plurality of tabs extending from said plate to at least substantially cover a portion of a sensor when mounted to said plate.

4. The bracket of claim **1**, wherein said plurality of legs include holes that receive said isolating elements.

5. The bracket of claim **1**, wherein said isolating elements comprise silicone rubber elements.

6. The bracket of claim **5**, wherein said isolating elements are substantially cylindrical and comprise a reduced diameter slot that is captured by a matching hole a respective leg.

7. The bracket of claim **5**, wherein said isolating elements further comprise a spacer that is inserted into the center thereof.

8. The bracket of claim **5**, wherein said isolating elements are adapted to receive an attachment bolt thereby securing said leg to a wheel hub.

9. The bracket of claim **1**, wherein said isolating elements comprise an elastomeric material and are molded directly onto said legs.

10. The bracket of claim **9** wherein said isolating elements further comprise a spacer molded into said elastomeric material.

11. A bracket for isolating a sensor from vibration, comprising:

a sensor mount adapted to receive a sensor;

a plurality of legs extending from said sensor mount; and

a dual stud isolator that engages with a distal end of each leg and adapted secure each leg to a vehicle wheel hub.

12. The bracket of claim **11**, wherein said dual stud isolator comprises a first threaded stud having an elastomeric element bonded thereto and a second threaded stud bonded to said elastomeric element opposite said first threaded stud.

13. The bracket of claim **12**, wherein said studs comprise hex bolts and said elastomeric element is bonded to the hex head of said hex bolts.

14. The bracket of claim **12**, further comprising a lanyard assembly coupling said first and second threaded studs.

15. An apparatus for mounting a sensor to a vehicle, comprising:

a mounting plate that receives a sensor;

a securement assembly that secures said mounting plate to a vehicle; and

an isolation element coupled to said securement assembly between said securement assembly and vehicle.

16. The apparatus of claim **15**, wherein said securement assembly comprises a plurality of legs that extend from said mounting plate.

17. The apparatus of claim **15**, wherein said mounting plate comprises a plate and a plurality of tabs extending from said plate to at least substantially cover a portion of a sensor when mounted to said plate.

18. The apparatus of claim **15**, wherein said isolation element comprises a silicone rubber element.

19. The apparatus of claim **18**, wherein said isolation element is substantially cylindrical and includes a reduced diameter slot that is captured by a matching hole in said securement assembly.

20. The apparatus of claim **15**, wherein said isolation element comprises an elastomeric material that is molded directly onto said securement assembly.

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