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(54) **FORCE SENSOR**

(76) Inventor: **Terry L. Zahuranec**, North Olmsted, OH (US)

Correspondence Address:
PATENT GROUP 2N
JONES DAY
NORTH POINT
901 LAKESIDE AVENUE
CLEVELAND, OH 44114 (US)

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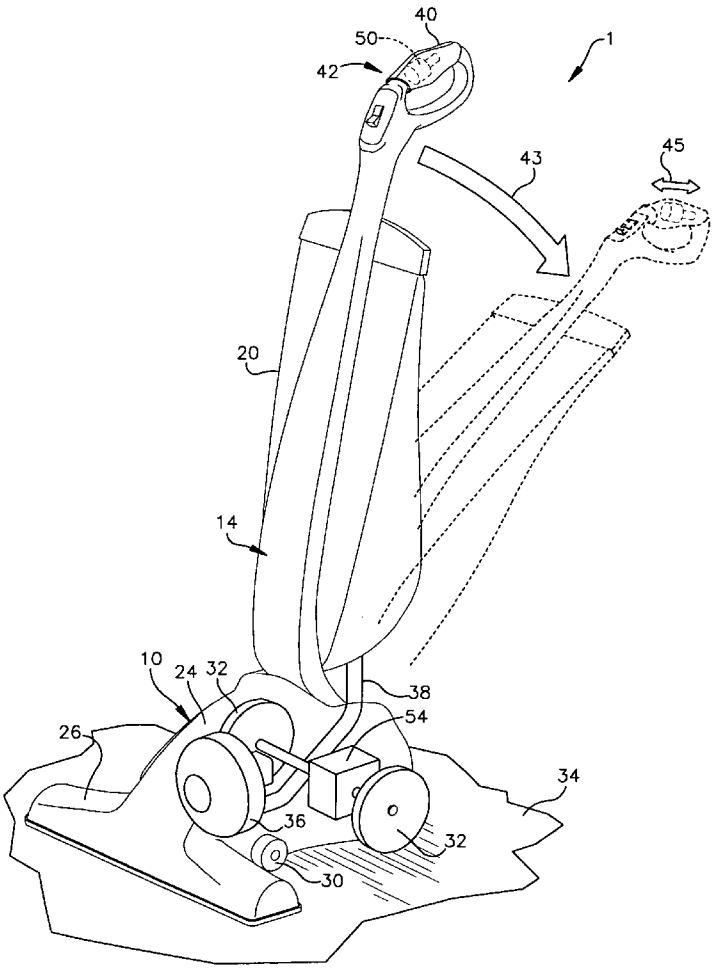
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(57) **ABSTRACT**

A force measuring apparatus includes a housing located with respect to an axis and having axially front and rear sections. A plunger is centered on the axis, supported by the housing for axial movement, and has axially front and rear spring supports. A load cell is fixed to the housing behind the rear spring support. A front spring structure is compressed between the front section of the housing and the front spring support of the plunger, urging the plunger rearward. A rear spring structure is compressed between the load cell and the rear spring support. The rear spring structure urges the plunger forward and applies against the load cell a force that is measurable by the load cell.



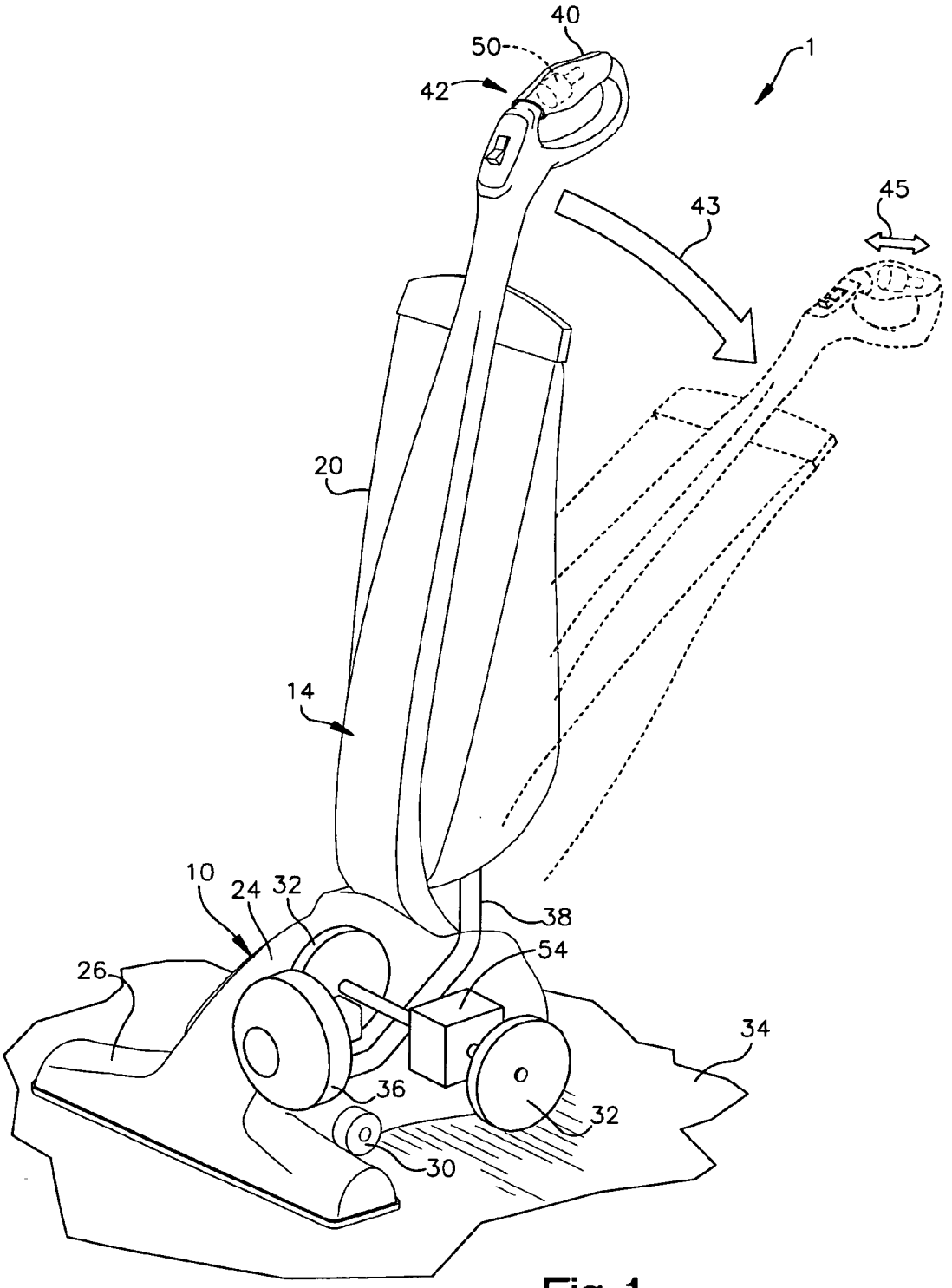


Fig. 1

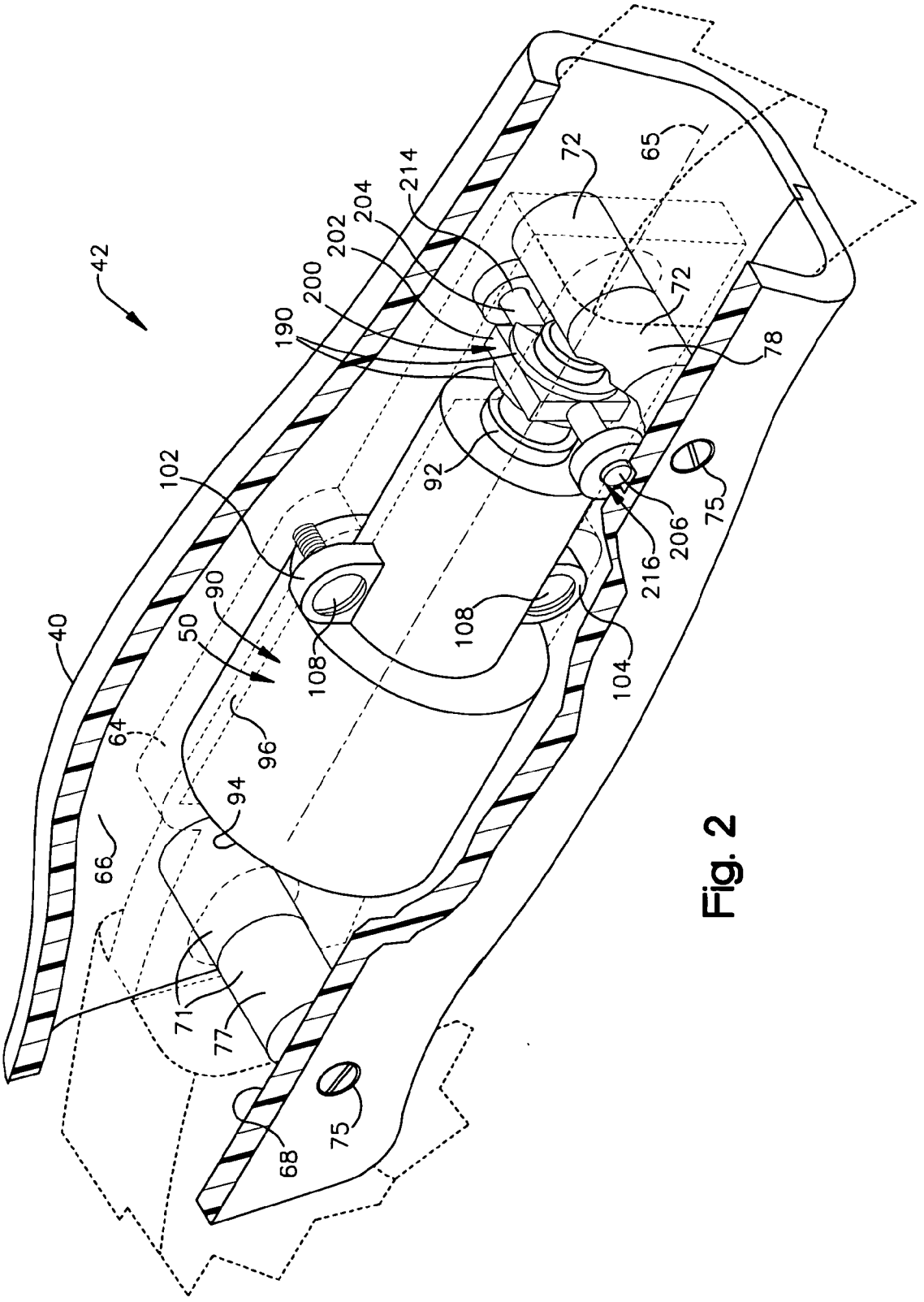

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Fig. 2

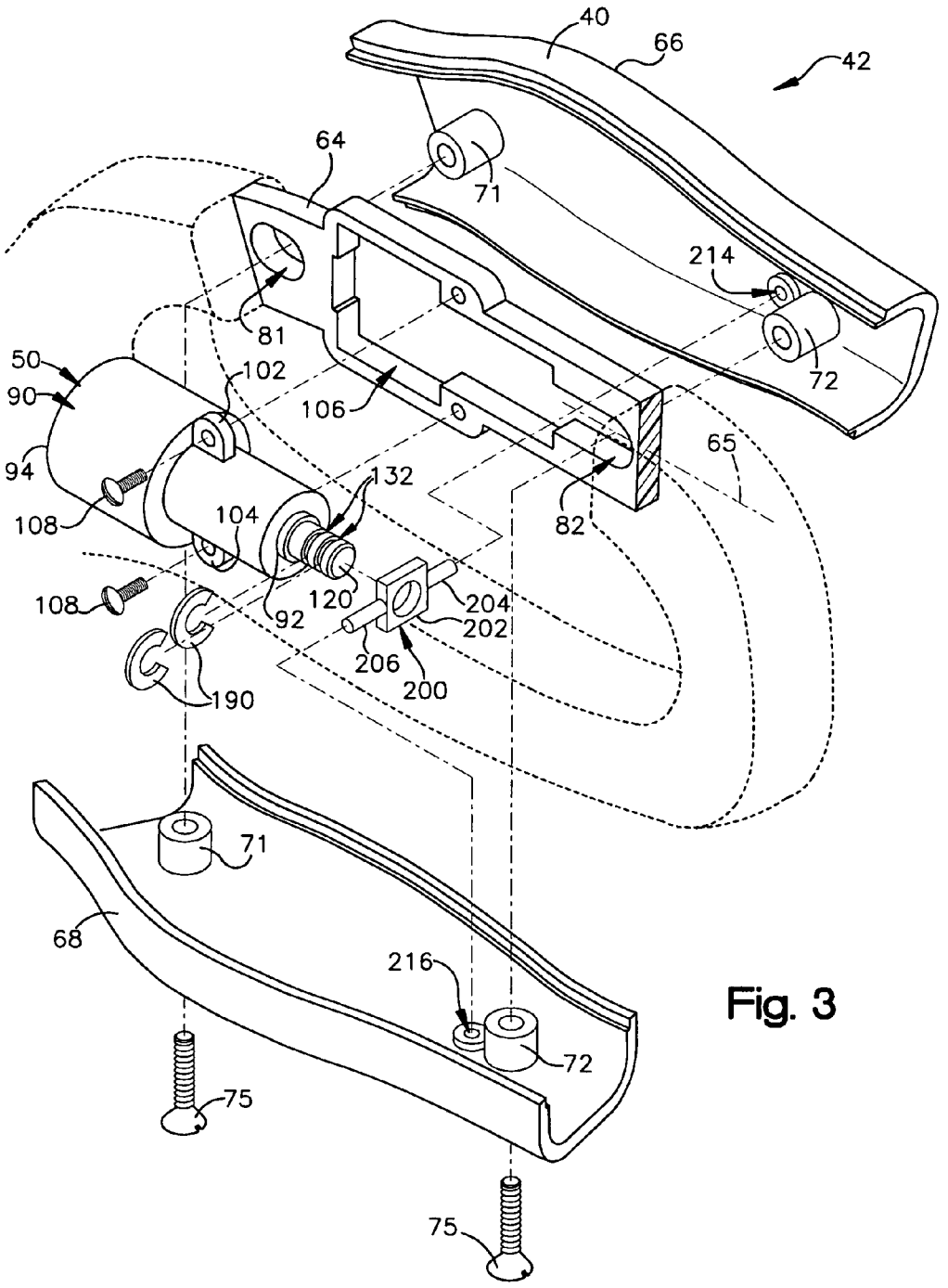

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Fig. 3

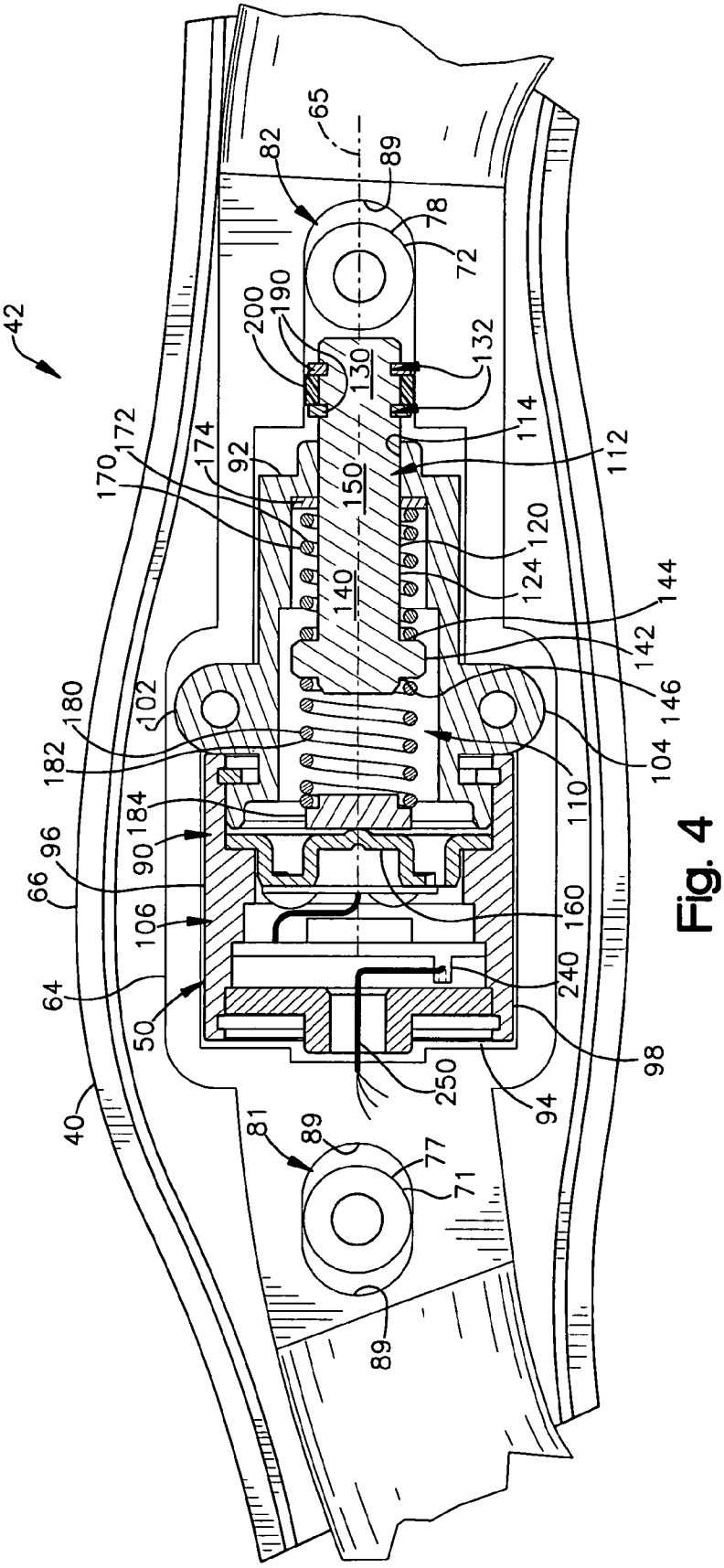

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Fig. 4

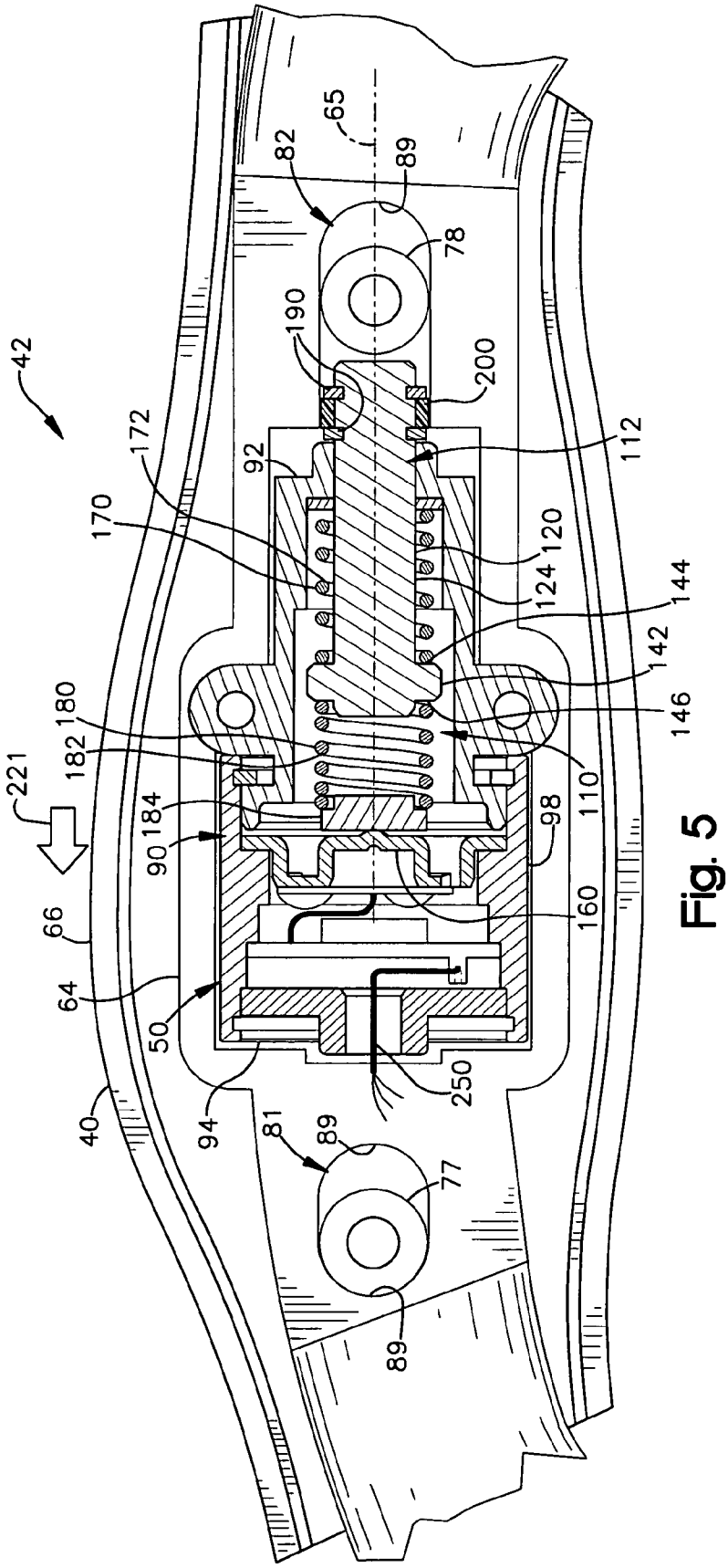

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Fig. 5

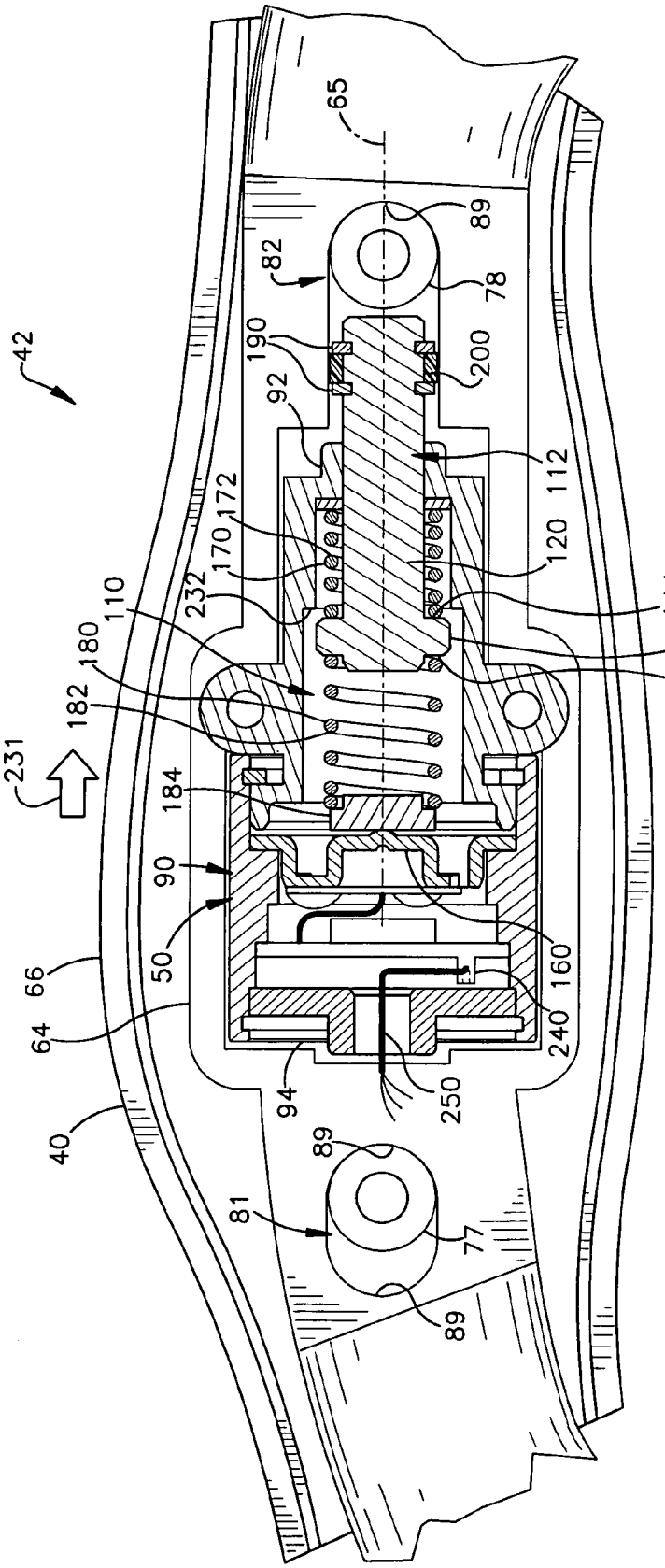

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Fig. 6

FORCE SENSOR

TECHNICAL FIELD

[0001] This application relates to force sensors.

BACKGROUND

[0002] A force sensor includes a housing and a plunger projecting from the housing. The sensor outputs an electrical signal that is a function of a force applied to the plunger relative to the housing.

SUMMARY

[0003] A force measuring apparatus includes a housing located with respect to an axis and having axially front and rear sections. A plunger is centered on the axis, supported by the housing for axial movement, and has axially front and rear spring supports. A load cell is fixed to the housing behind the rear spring support. A front spring structure is compressed between the front section of the housing and the front spring support of the plunger, urging the plunger rearward. A rear spring structure is compressed between the load cell and the rear spring support. The rear spring structure urges the plunger forward and applies against the load cell a force that is measurable by the load cell.

[0004] Preferably, the spring structures together bias the plunger into a neutral position. From the neutral position, an external rearward force applied to the plunger will move the plunger rearward and increase the measurable force, and an external forward force applied to the plunger will move the plunger forward and decrease the measurable force. An extension limiting structure limits forward movement of the plunger to prevent full compression of the front spring structure. A retraction limiting structure limits rearward movement of the plunger to prevent full compression of the rear spring structure. The housing encases the front and rear support structures of the plunger, and a front section of the plunger is located in front of the housing. Prongs are attached to the plunger and project radially outward from the plunger. A device has pockets that rotatably capture the prongs to couple the plunger to the device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] FIG. **1** is a schematic perspective view of a vacuum cleaner including a handle;

[0006] FIG. **2** is a breakaway view of an upper portion of the handle, including a force sensor;

[0007] FIG. **3** is an exploded view of the upper portion of the handle;

[0008] FIG. **4** is a sectional view of the upper portion of the handle, with a plunger of the sensor shown in a neutral position;

[0009] FIG. **5** is a view similar to FIG. **4**, with the plunger shown in a retracted position; and

[0010] FIG. **6** is a view similar to FIG. **4**, with the plunger shown in an extended position.

DESCRIPTION

[0011] The apparatus **1** shown in FIG. **1** has parts that are examples of the elements recited in the claims. The apparatus **1** thus includes examples of how a person of ordinary skill in the art can make and use the claimed invention. It is described here to meet the requirements of enablement and best mode without imposing limitations that are not recited in the claims.

[0012] The apparatus **1** is a vacuum cleaner. It includes a base **10**, a handle **14** extending upward from the base **10**, and a filter bag **20** suspended from the handle **14**. The base **10** includes a housing **24** defining a nozzle **26**. Front and rear wheels **30** and **32** are rotatably connected to the housing **24** to enable wheeling the base **10** over a floor **34**. A fan **36** in the housing **24** drives a flow of air that carries dirt from the floor **34**, through the nozzle **26**, the fan **36** and a fill tube **38**, into the filter bag **20**.

[0013] To move the base **10** about the floor **34**, a handgrip **40** of an upper section **42** of the handle **14** is grasped by hand. The handle **14** is pivoted backward as indicated by arrow **43**. A forward or rearward force is manually applied to the handgrip **40**, as indicated by arrow **45**, to push the base **10** forward or pull the base **10** rearward. A force sensor **50** within the handgrip **40** outputs a signal indicative of the direction and magnitude of the force applied to the handle **14**. An electrically powered drive assembly **54** in the base housing **24** receives the signal. The drive assembly **54** rotates the rear wheels **32** in a direction corresponding to the direction of the force applied to the handle **14**, with a torque and speed that are positively related to the magnitude of the force. The drive assembly **54** thus uses electrical power to assist the user in propelling the base **10** over the floor **34**.

[0014] The upper section **42** of the handle **14** is shown in FIGS. **2-3**. It includes the handgrip **40** and a stem **64**. The stem **64** is in the form of a metal bar extending along an axis **65**. The handgrip **40** surrounds the stem **64** and is axially slidable along the stem **64**.

[0015] The handgrip **40** comprises two side sections **66** and **68**. Each side section **66** and **68** includes first and second tubular bosses **71** and **72**. The first bosses **71** are aligned with each other, abut each other, and are secured together by a screw **75**. The first bosses **71** thus together comprise a first prong **77** (FIG. **2**) extending from one side **66** of the handgrip **40** to the other side **68** of the handgrip **40**. Similarly, the second bosses **72** are aligned with each other, abut each other, and are secured together by a screw **75** extending through second bosses **72**. The second bosses **72** thus comprise a second prong **78** extending from one side **66** of the handgrip **40** to the other side **68** of the handgrip **40**.

[0016] As shown in FIG. **4**, the first and second prongs **77** and **78** extend through corresponding first and second slots **81** and **82** in the stem **64**. The first and second slots **81** and **82** are elongated in the axial direction and are sized with respect to the prongs **77** and **78** to enable axial movement of the prongs **77** and **78** relative to the stem **64** while preventing transverse movement of the prongs **77** and **78** relative to the stem **64**. The prongs **77** and **78** and slots **81** and **82** together thus enable axial movement of the handgrip **40** relative to the stem **64** while preventing transverse movement of the handgrip **40**. The range of axial movement is limited by abutment of the prongs **77** and **78** with axial ends **89** of the slots **81** and **82**.

[0017] The sensor **50** includes a housing **90** centered on the axis **65**, with axially front and rear sections **92** and **94**,

a top **96** and a bottom **98**. Upper and lower tabs **102** and **104** extend respectively upward from the top **96** and downward from the bottom **98**. The housing **90** is located in a central slot **106** in the stem **64** and is secured in place by screws **108** (FIG. **3**) that fasten the tabs **102** and **104** to the stem **64**.

[**0018**] The sensor housing **90** defines a chamber **110**. A front channel **112** extends forward from the chamber **110** through the front section **92** of the housing **90**. The front channel **112** is bounded by a cylindrical bearing surface **114** of the housing **90**.

[**0019**] A plunger **120**, centered on the axis **65**, projects forward from the housing **90**. The plunger **120** has a cylindrical side surface **124**. An axially front section **130** of the plunger **120** is located in front of the housing **90** and has two annular grooves **132** extending circumferentially about the cylindrical side surface **124**. An axially rear section **140** of the plunger **120** is located in the chamber **110** and includes a flange **142** extending radially outward from the cylindrical side surface **124**. The flange **142** has front and rear spring support surfaces **144** and **146**.

[**0020**] An axially middle section **150** of the plunger **120** includes a portion of the cylindrical side surface **124**. The side surface **124** of the middle section **150** is diametrically the same size as, closely received by, and slidable relative to the bearing surface **114** of the housing **90**. The bearing surface **114** enables axial movement of the plunger **120** while preventing radial movement of the plunger **120**, to keep the plunger **120** centered on the axis **65**. The plunger **120** is thus supported by the housing **90** for axial movement.

[**0021**] A load cell **160** is fixed to the rear section **94** of the housing **90**. The load cell **160** is located in the chamber **110**, rearward from the rear spring support surface **146** of the plunger **120**. The load cell **160** outputs an electrical signal that is a function of a force applied to it.

[**0022**] A front spring structure **170** in the chamber **110** includes a front coil spring **172** and a metal washer **174**. The coil spring **172** is compressed between the washer **174** and the front spring support surface **144** of the plunger **120**. Accordingly, the front spring structure **170** is compressed between the front section **92** of the housing **90** and the front spring support surface **144** of the plunger **120**. The front spring structure **170** thus urges the plunger **120** rearward. The front coil spring **172** is coiled about the plunger **120**, which helps keep the spring **172** radially centered on the axis **65**.

[**0023**] A rear spring structure **180** in the chamber **110** includes a rear coil spring **182** and a metal plug **184** that abuts the load cell **160**. The rear coil spring **182** is compressed between the metal plug **184** and the rear support surface **146** of the plunger **120**. Accordingly, the spring support structure **180** is compressed between the load cell **160** and the rear support surface **146** of the plunger **120**. The rear spring structure **180** thus urges the plunger **120** forward and applies, against the load cell **160**, a force that is measurable by the load cell **160**. The spring structures **170** and **180** together bias the plunger **120** to an axially neutral position relative to the housing **90**. The coil springs **172** and **182** and the plunger **120** are centered on the axis **65**.

[**0024**] As shown in FIGS. **2-3**, two C-clamps **190** are clipped into the two plunger grooves **132**. Closely captured by and between the C-clamps **190** is a coupling bracket **200**. The bracket **200** includes a rectangular plate **202** that closely receives the plunger **120**. Two cylindrical prongs **204** and **206** project transversely outward from transversely opposite sides of the plate **202**. The prongs **204** and **206** are thus attached by the plate **202** to the plunger **120** and project radially outward in diametrically opposite directions. The two prongs **204** and **206** are rotatably captured in respective pockets **214** and **216** in the respective handgrip sections **66** and **68**. The bracket **200** thus couples the plunger **120** to the handgrip **40**, for the plunger **120** to move in unison with the handgrip **40**. Accordingly, the biasing of the plunger **120** toward its neutral position relative to the sensor housing **24** biases the handgrip **40** toward a neutral position relative to the handle stem **64**.

[**0025**] In this example, the sensor housing **90** is connected to the handle stem **64**, and the plunger **120** is connected to the handgrip **40**. Alternatively, the sensor housing **90** can be connected to the handgrip **40**, and the plunger **120** can be connected to the handle stem **64**.

[**0026**] In FIG. **5**, the plunger **120** is shown in a retracted position, displaced axially inward from its neutral position. The plunger **120** is retracted by applying a manual force **221** to the handgrip **40**, against the bias of the sensor **50**, toward the front of the vacuum cleaner **1** (FIG. **1**). In turn, the handgrip **40** applies a force, which is external with respect to the sensor **50**, to the plunger **120**, pushing the plunger **120** axially inward against the bias of the rear spring structure **180**. This increases the force that is applied by the rear spring structure **180** against the load cell **160** and measured by the load cell **160**.

[**0027**] The retracted position of the plunger **120** in FIG. **5** is a fully retracted position in that further axially inward movement of the plunger **120** is prevented by abutment of the first handgrip prong **77** against an end surface **89** of the first slot **81**. Accordingly, the first prong **77** and the end surface **89** comprise a retraction limiting structure that limits axially inward movement of the plunger **120**. Axially inward movement is also prevented by abutment of one of the C-clamps **190** against the front **192** of the sensor housing **90**. Accordingly, the C-clamp **190** and the front **192** of the housing **90** comprise another retraction limiting structure. The retraction limiting structures prevent full compression of the rear coil spring **182** and thus the rear spring structure **180**. They also protect the load cell **160** from overload force by limiting the force the rear spring **182** can apply to the load cell **160**. The retraction limiting structures are located outside the housing **90** in this example, but can be located in the housing **90**.

[**0028**] In FIG. **6**, the plunger **120** is shown in an extended position, displaced axially outward from its neutral position. The plunger **120** is extended by applying a manual force **231** to the handgrip **40**, against the bias of the sensor **50**, away from the front of the vacuum cleaner **1** (FIG. **1**). In turn, the handgrip **40** applies a force, which is external with respect to the sensor **50**, to the plunger **120**, pulling the plunger **120** axially outward against the bias of the front spring structure **170**. This decreases the force that is applied by the rear spring structure **180** against the load cell **160** and measured by the load cell **160**.

[**0029**] The extended position of the plunger **120** in FIG. **6** is a fully extended position in that further axially outward movement of the plunger **120** is prevented by abutment of the first and second handgrip prongs **77** and **78** against end surfaces **89** of respective slots **81** and **82**. Accordingly, the first prong **77** and an end surface **89** of the first slot **81** comprise a first extension limiting structure. Similarly, the second prong **78** and an end surface **89** of the second slot **82** comprise a second extension limiting structure. Each exten-

sion limiting structure limits axially outward movement of the plunger **120** to prevent full compression of the front coil spring **172** and the front spring structure **170**. Even in the absence of the first and second extension limiting structures, full compression of the front coil spring **172** would be prevented by abutment of the plunger flange **142** against a shoulder **232** of the housing **90**. Accordingly, the plunger flange **142** and the shoulder **232** comprise a third extension limiting structure, located in the housing **90**.

[**0030**] A processor **240** in the housing **24** communicates with the load cell **160** to output the signal that is indicative of the force externally applied to the plunger **120**. In this example, the signal is analog, with a range of 0-5V, and 2.5 volts being output when the plunger **120** is in its neutral position. The output voltage will increase in response to increasing force applied by the rear spring structure **180** against the load cell **160** due to increasing axially inward force externally applied to the plunger **120**. Conversely, the output voltage will decrease in response to decreasing force applied by the rear spring structure **180** against the load cell **160** due to increasing axially outward force externally applied to the plunger **120**. The drive assembly **54** (FIG. **1**) receives the analog signal though wires **250** and drives the rear wheels **32** in a direction and with a force and speed based on the signal as explained above.

[**0031**] Alternatively, the signal that is output by the processor **240** to the drive assembly **54** can be digital. The range can be 0-255 counts, with 128 counts being output when the plunger **120** is in its neutral position. The counts will increase with increasing axially inward force externally applied to the plunger **120**, and will decrease with increasing axially outward force externally applied to the plunger **120**.

[**0032**] This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to make and use the invention. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal language of the claims.

1. A force measuring apparatus comprising:

a housing located with respect to an axis and having axially front and rear sections;

a plunger centered on the axis, supported by the housing for axial movement, and having axially front and rear spring supports;

a load cell fixed to the housing behind the rear spring support;

a front spring structure compressed between the front section of the housing and the front spring support of the plunger, urging the plunger rearward; and

a rear spring structure compressed between the load cell and the rear spring support, urging the plunger forward and applying against the load cell a force that is measurable by the load cell.

2. The apparatus of claim 1 wherein the spring structures together bias the plunger into a neutral position from which an external rearward force applied to the plunger will move the plunger rearward and increase the measurable force and an external forward force applied to the plunger will move the plunger forward and decrease the measurable force.

3. The apparatus of claim 1 wherein the plunger has a radially outwardly extending flange with front and rear surfaces that respectively comprise the front and rear spring supports.

4. The apparatus of claim 1 wherein the front spring structure includes a coil spring surrounding the plunger.

5. The apparatus of claim 1 further comprising an extension limiting structure that limits forward movement of the plunger to prevent full compression of the front spring structure.

6. The apparatus of claim 1 further comprising a retraction limiting structure that limits rearward movement of the plunger to prevent full compression of the rear spring structure.

7. The apparatus of claim 1 wherein the housing encases the spring supports of the plunger.

8. The apparatus of claim 1 wherein a front section of the plunger is located in front of the housing.

9. The apparatus of claim 1 wherein the front section of the housing defines an axially extending channel that closely receives the plunger so as to enable axial movement of the plunger while preventing radial movement of the plunger.

10. The apparatus of claim 1 further comprising prongs attached to the plunger and projecting radially outward from the plunger.

11. The apparatus of claim 10 further comprising a device with pockets that rotatably capture the prongs to couple the plunger to the device.

12. The apparatus of claim 10 further comprising a plate by which the prongs are attached to the plunger, that closely receives the plunger and from which the prongs project radially outward.

13. The apparatus of claim 1 further comprising a vacuum cleaner handle including a handle stem and a handgrip slidably attached to the stem, one of the stem and the handgrip being fixed to the housing, and the other of the stem and the handgrip being fixed to the plunger, for the force measurable by the load cell to be indicative of a force manually applied to the handgrip relative to the stem.

14. A force measuring apparatus comprising:

a housing located with respect to an axis and having axially front and rear sections;

a plunger centered on the axis, supported by the housing for axial movement, and having a spring support;

a load cell fixed to the housing behind the rear spring support;

a spring structure compressed between the load cell and the spring support of the plunger, urging the plunger forward and applying against the load cell a force that is measurable by the load cell; and

a retraction limiting structure that limits rearward movement of the plunger to prevent full compression of the rear spring structure.

15. The apparatus of claim 14 wherein the housing encases the spring support of the plunger.

* * * * *