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[Continued on next page]

(54) Title: PISTON STROKE SENSOR ARRANGEMENT FOR A BRAKE UNIT

(57) Abstract: A piston stroke sensor arrangement for a brake unit includes a brake unit including a piston and a piston tube, and a proximity sensor supported on the brake unit. The proximity sensor may determine the location of the piston within the brake unit based on the position of the piston tube relative to the proximity sensor. The proximity sensor may be an inductive proximity sensor. A groove may be defined in an outer circumferential surface of the piston tube. When the brake unit is in a non-applied position, the proximity sensor may detect metal of the piston tube. When the brake unit is in an applied position, the proximity sensor may not detect the metal of the piston tube.

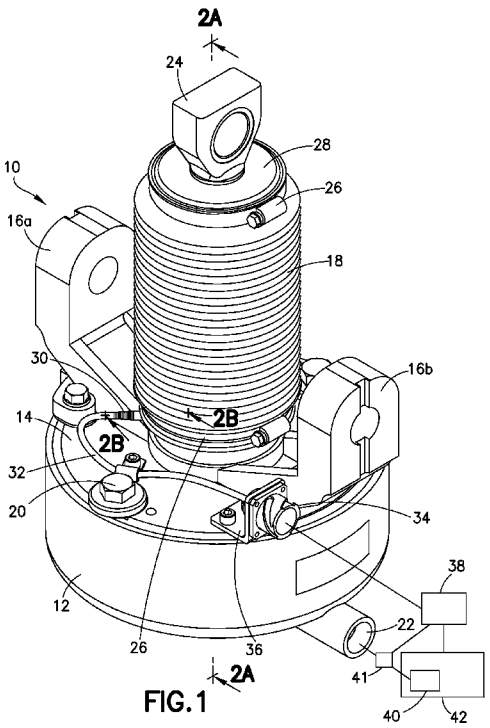

FIG. 1

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PISTON STROKE SENSOR ARRANGEMENT FOR A BRAKE UNIT

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] This disclosure relates generally to piston stroke sensor arrangements and, more particularly, to a piston stroke sensor arrangement for a brake unit of a railway vehicle.

Description of Related Art

[0002] Federal regulations for the inspection of brake units on railway vehicles now mandate that each commuter and short-distance intercity passenger train shall receive a Class I brake test at least once during each calendar day that the train is placed or continues in service. Operators must apply pressurized fluid to the braking system and ensure that the brake pads on the calipers of the disc brake units properly contact the disc surface of the discs of the railway vehicle. Train operators must walk the length of the train and visually verify pad-to-disc contact. During these inspections, it is often difficult for the operator to see and properly identify brake application, especially on cars in which the disc brake units are located in-board of the railway vehicle. When the brake units are positioned in-board of the railway vehicle, it is often necessary for the operator to inspect the brake units using a pit or maintenance facility to gain access to the in-board portion of the railway vehicle.

[0003] In view of the foregoing, a need exists for an arrangement that provides an indication of the operation of the brake units to the train operator using electronic signals. A need exists for an arrangement that identifies whether the brake unit is in an applied or released position. A further need exists to provide an alternate means for performing visual pre-trip brake function inspections.

SUMMARY OF THE INVENTION

[0004] In one embodiment, a piston stroke sensor arrangement for a brake unit includes a brake unit including a piston and a piston tube, and a proximity sensor supported on the brake unit. The proximity sensor may determine the location of the piston within the brake unit based on the position of the piston tube relative to the proximity sensor.

[0005] The proximity sensor may be an inductive proximity sensor. A groove may be defined in an outer circumferential surface of the piston tube. When the brake unit is in a non-applied position, the proximity sensor may detect metal of the piston tube. When the brake unit is in an applied position, the proximity sensor may not detect the metal of the piston tube. When the brake unit is in an applied position, the proximity sensor may be directed towards the groove

on the piston tube. When the brake unit is in a non-applied position, the proximity sensor may be directed towards a portion of the piston tube that does not include the groove. A protrusion may be provided on an outer circumferential surface of the piston tube. When the brake unit is applied, the proximity sensor may be directed towards the protrusion on the piston tube. When the brake unit is not applied, the proximity sensor may not be directed towards the protrusion on the piston tube. An air pressure indicator may be positioned in fluid communication between a fluid source and the brake unit. A notification device may be connected to the proximity sensor and the air pressure indicator. The air pressure indicator may be configured to send information to the notification device identifying the amount of air pressure being supplied to the brake unit. Information from the proximity sensor may be directed to the notification device to identify a position of the piston in the brake unit. The brake unit may be a disc brake unit. The proximity sensor may be configured to detect when the piston of the brake unit is positioned in an over-stroke position. The brake unit may include an anchor flange that supports the piston and piston tube. The proximity sensor may be positioned in the anchor flange adjacent the piston tube.

[0006] In another embodiment, a railway vehicle with a piston stroke sensor arrangement includes a railway vehicle including a brake unit, the brake unit including a piston and a piston tube, and a proximity sensor positioned on the brake unit. The proximity sensor may determine the location of the piston within the brake unit based on the position of the piston tube relative to the proximity sensor.

[0007] The proximity sensor may be an inductive proximity sensor. A groove may be defined in an outer circumferential surface of the piston tube. When the brake unit is in a non-applied position, the proximity sensor may detect metal of the piston tube. When the brake unit is in an applied position, the proximity sensor may not detect the metal of the piston tube. When the brake unit is in an applied position, the proximity sensor may be directed towards the groove on the piston tube. When the brake unit is in a non-applied position, the proximity sensor may be directed towards a portion of the piston tube that does not include the groove. A protrusion may be provided on an outer circumferential surface of the piston tube. When the brake unit is applied, the proximity sensor may be directed towards the protrusion on the piston tube. When the brake unit is not applied, the proximity sensor may not be directed towards the protrusion on the piston tube. An air pressure indicator may be positioned in fluid communication between a fluid source and the brake unit. A notification device may be connected to the proximity sensor and the air pressure indicator. The air pressure indicator may be configured to send information to the notification device identifying the amount of air pressure being supplied to

the brake unit. Information from the proximity sensor may be directed to the notification device to identify a position of the piston in the brake unit. The brake unit may be a disc brake unit. The proximity sensor may be configured to detect when the piston of the brake unit is positioned in an over-stroke position. The brake unit may include an anchor flange that supports the piston and piston tube. The proximity sensor may be positioned in the anchor flange adjacent the piston tube.

[0008] In a further embodiment, a method of determining a piston stroke position for a brake unit includes the steps of: providing a brake unit including a piston and a piston tube, and a proximity sensor positioned on the brake unit; emitting a detection signal from the proximity sensor to the piston tube; and determining the position of the piston within the brake unit based on the position of the piston tube relative to the detection signal emitted from the proximity sensor. A groove may be defined in an outer circumferential surface of the piston tube. When the brake unit is applied, the detection signal emitted from the proximity sensor may be directed towards the groove on the piston tube. When the brake unit is not applied, the detection signal emitted from the proximity sensor may be directed towards a portion of the piston tube that does not include the groove.

[0009] Further details and advantages will be understood from the following detailed description read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] **FIG. 1** is a front perspective view of a piston stroke sensor arrangement for a brake unit in accordance with one embodiment of the present disclosure;

[0011] **FIG. 2A** is a cross-sectional view of the brake unit of **FIG. 1** along line **2A-2A**;

[0012] **FIG. 2B** is a cross-sectional view of the brake unit of **FIG. 1** along line **2B-2B**;

[0013] **FIG. 3** is a front perspective view of a piston tube in accordance with one embodiment of the present disclosure;

[0014] **FIG. 4** is a side view of the piston tube of **FIG. 3**;

[0015] **FIG. 5** is a sectional view depicting a proximity sensor and piston tube in a non-applied position in accordance with the present disclosure;

[0016] **FIG. 6** is a sectional view of the proximity sensor and piston tube of **FIG. 5** in an applied position;

[0017] **FIG. 7** is a sectional view of the proximity sensor and piston tube of **FIG. 5** in an over-stroke position; and

[0018] **FIG. 8** is a side view of a piston tube in accordance with another embodiment of the present disclosure.

DESCRIPTION OF THE DISCLOSURE

[0019] For purposes of the description hereinafter, spatial orientation terms, as used, shall relate to the referenced embodiment as it is oriented in the accompanying drawings, figures, or otherwise described in the following detailed description. However, it is to be understood that the embodiments described hereinafter may assume many alternative variations and configurations. It is also to be understood that the specific components, devices, features, and operational sequences illustrated in the accompanying drawings, figures, or otherwise described herein are simply exemplary and should not be considered as limiting.

[0020] The present disclosure is directed to, in general, a piston stroke sensor arrangement for a brake unit and, in particular, to a piston stroke sensor arrangement for a disc brake unit including a proximity sensor. Certain preferred and non-limiting embodiments of the components of the piston stroke sensor arrangement are illustrated in **FIGS. 1-8**.

[0021] With reference to **FIGS. 1-2B**, a brake unit **10** is shown. In one embodiment, the brake unit **10** may be a part of a disc brake unit commonly used on railway vehicles. It is to be understood, however, that alternative types of brake units may be used, including disc brake units used in conjunction with bicycles, cars, buses, and other types of vehicles that use brake discs for effecting a braking force to a wheel. The brake unit **10** includes a cylinder **12**, an anchor flange **14**, first and second extension members **16a**, **16b**, and bellows **18**. The cylinder **12** and anchor flange **14** are secured to one another using a retaining ring **21** and a plurality of fasteners **20**. As shown in **FIG. 2A**, the retaining ring **21** is positioned between the cylinder **12** and anchor flange **14** and the fasteners **20** lock the cylinder **12** and anchor flange **14** in a secure connection. An inlet **22** extends outwardly from the cylinder **12** and is configured to supply pressurized fluid from a fluid source **40** on a railway vehicle **42** to the brake unit **10**. An air pressure indicator **41** may be positioned in fluid communication between the fluid source **40** and the inlet **22** to measure the air pressure being supplied to the brake unit **10**. In one embodiment, the air pressure indicator **41** may be a pressure transducer. The extension members **16a**, **16b** are configured for connection to a caliper assembly (not shown) of a disc brake unit (not shown).

[0022] A proximity sensor **30** may be inserted through an opening defined in the anchor flange **14**. The proximity sensor **30** may be used to detect the presence of nearby objects and, in particular, metallic objects without any physical contact with the objects. The proximity

sensor **30** emits a detection signal **S** and identifies changes in the return signal. Depending on the value of the return signal and the air pressure being supplied to the brake unit **10**, a notification device **38** determines the position of the target object. Many different types of proximity sensors may be used with the brake unit **10**, including a capacitive displacement sensor, an optical sensor, an eddy-current sensor, an inductive sensor, a laser sensor, a magnetic sensor, a radar sensor, a sonar sensor, or an ultrasonic sensor, among others. In one preferred embodiment, an inductive proximity sensor is used. The proximity sensor **30** may be cylindrical in shape and is held in the anchor flange **14**. It is also to be understood that the proximity sensor **30** may have a trapezoidal, triangular, rectangular, or oval cross-sectional shape. The proximity sensor **30** may be threaded into the anchor flange **14** with a lock nut (not shown) used to secure the proximity sensor **30** in place. The proximity sensor **30** may also be installed using a friction fit, but it is also contemplated that the proximity sensor **30** may be installed using fasteners and a flange or an adhesive. A cable **32** connects the proximity sensor **30** to a connector **34**. The connector **34** is secured to the anchor flange **14** by a flange **36**. The proximity sensor **30** sends the positional output information to the notification device **38** via the connector **34**. The air pressure indicator **41** may also be in communication with the notification device **38** to send air pressure information to the notification device **38**. The notification device **38** may be an indicator panel provided directly on the brake unit **10**, a remote handheld unit held by an operator of the railway vehicle, a control panel of the railway vehicle, or a control panel and/or a central processing unit (CPU) provided in a railway monitoring station. It is to be understood that the connector **34** may send the signal information through a wired connection or remotely. The connector **34** may be connected to a remote signal emitting device (not shown) or hard-wired into a control panel and/or CPU.

[0023] As shown in **FIGS. 2A** and **2B**, the brake unit **10** houses a piston assembly configured to apply a braking force to the brake disc of a railway vehicle. As discussed hereinabove, a spindle head **24** may be connected to a caliper assembly that applies a braking force to the brake disc of the railway vehicle. The spindle head **24** may be threadedly secured to the spindle **44** that is housed within the brake unit **10**. The spindle **44** is movable along a longitudinal axis **L** of the brake unit **10**. The bellows **18** may extend from the anchor flange **14** to a spindle cover **28**. The bellows **18** are secured to the brake unit **10** with clamp rings **26**. It is to be understood that the bellows **18** may be secured using other methods, such as adhesives, fasteners, cable ties, or welding. The spindle cover **28** may be provided on one end of the spindle **44** near the spindle head **24**. As shown in **FIG. 2A**, the spindle cover **28** may be retained between the spindle head **24** and a spindle **44**.

[0024] A collet support **46** is also provided in the brake unit **10**. One end of the collet support **46** encircles the spindle **44** and an opposing end of the collet support **46** is connected to an end of the anchor flange **24**. The collet support **46** and the anchor flange **14** include correspondingly threaded ends that are connected to one another. A biasing member **48** is positioned in one end of the collet support **46**. A first collet **50** is also positioned in the collet support **46** and is positioned around the spindle **44**. As the biasing member **48** is compressed by the first collet **50**, the biasing member **48** creates a biasing force against the first collet **50**.

[0025] A second collet **52** is positioned around a lower portion of the spindle **44** and is provided inside of a piston tube **54** of the brake unit **10**. The piston tube **54** effects the movement of the second collet **52** during operation of the brake unit **10**. The proximity sensor **30** is positioned in the anchor flange **14** adjacent the piston tube **54**.

[0026] A groove **56** is defined in the outer surface of the piston tube **54**. The groove **56** may be a cut or depression formed in the piston tube **54**. The groove **56** may extend around the entire outer circumferential surface of the piston tube **54**. The groove **56** may be defined on the piston tube **54** adjacent the position of the proximity sensor **30** provided in the anchor flange **14**. The groove **56** may be defined around the outer surface of the piston tube **54** because the piston tube **54** may rotate during operation of the brake unit **10**. Regardless of the angular orientation of the piston tube **54** relative to the proximity sensor **30**, the proximity sensor **30** is capable of taking a positional reading of the piston tube **54**. It is also to be understood that instead of using the groove **56**, a protrusion **57** may extend from the outer circumferential surface of the piston tube **54** (see **FIG. 8**). The protrusion **57** may be squared to ensure an accurate reading from the proximity sensor **30**. Additional details regarding the groove **56** are provided hereinbelow.

[0027] Although the groove **56** is used with the piston tube **54**, it is also contemplated that a hole may be provided in the piston tube **54** instead. Unlike the piston tube **54** of the brake unit **10**, which may experience rotational movement during operation of the brake unit **10**, some piston tubes may move in only a linear direction without rotational movement. Since the piston tube may not rotate during this operation, it is unnecessary to provide a groove around the entire outer circumferential surface of the piston tube. Therefore, a hole or plurality of holes may be drilled into a portion of the linear piston tube adjacent the proximity sensor.

[0028] The cylinder **12** of the brake unit **10** defines a first cavity **58** and a second cavity **59** therein and houses a biasing member **60** and a piston **62**. The biasing member **60** may be provided in the second cavity **59**. The piston tube **54** and the piston **62** may be welded together. During operation of the brake unit **10**, pressurized fluid is provided to the first cavity **58** via

inlet **22**. The pressurized fluid acts against one side of the piston **62**, thereby compressing the biasing member **60**. As the biasing member **60** is compressed, a biasing force is created against the piston **62**. As the piston **62** is moved further into the brake unit **10**, the piston **62** and the piston tube **54** move upward along the longitudinal axis **L** of the brake unit **10**. The piston tube **54** moves towards and contacts the second collet **52**. As the piston tube **54** moves upward, the second collet **52** begins to grip the spindle **44** to move the spindle **44** upward in the brake unit **10**. The spindle **44** is moved along the longitudinal axis **L** of the brake unit **10**, thereby moving the spindle head **24** further out of the brake unit **10**. As the spindle head **24** is moved further out of the brake unit **10**, a pivoting force is applied to the caliper assembly (not shown), which applies pressure to the brake discs of the railway vehicle via the brake pads. During this movement, the piston tube **54** moves within the anchor flange **14** along the longitudinal axis **L** of the brake unit **10** relative to the proximity sensor **30**.

[0029] With reference to **FIGS. 3** and **4**, a more detailed description of the groove **56** of the piston tube **54** is provided. As shown, the groove **56** is defined in the piston tube **54** and extends around the outer circumferential surface of the piston tube **54**. The groove **56** may be provided on the entire outer circumferential surface of the piston tube **54** or only a portion of the outer circumferential surface of the piston tube **54**. A leading edge **64** of the groove **56** and a trailing edge **66** of the groove **56** are provided on the piston tube **54**. The leading edge **64** of the groove **56** is positioned closer to the spindle head **24**, and the trailing edge **66** of the groove **56** is positioned closer to the cylinder **12** (see **FIG. 2A**).

[0030] With reference to **FIGS. 2a**, **2b**, and **5-7**, a description of a method of determining the position of a piston in a brake unit is provided. Upon activation of the proximity sensor **30**, a detection signal **S** is emitted from the proximity sensor **30**. As described above, the detection signal **S** may be any type of feedback signal, including sonar, radar, laser, magnetic, or any other electronic signal. In one embodiment, the proximity sensor **30** is an inductive proximity sensor **30** that is configured to detect the presence of metallic objects, such as the piston tube **54**, via the use of a magnetic field. The proximity sensor **30** emits a detection signal **S** configured to determine the location of the piston **62** and piston tube **54** within the brake unit **10** based on the position of the piston tube **54** relative to the detection signal **S** emitted from the proximity sensor **30** and the amount of air pressure provided to the brake unit **10**. As shown in **FIGS. 1**, **2A**, and **5**, when the piston tube **54** is positioned at a non-applied position, the detection signal **S** contacts the outer circumferential surface of the piston tube **54**. In one embodiment, the detection signal **S** detects metal on the piston tube **54**. Based on the detection of metal, the detection signal **S** relays positional output information back to the notification

device **38** that the proximity sensor **30** is detecting the presence of a metallic object. The air pressure indicator **41** will also send air pressure information to the notification device **38**. In a non-applied position of the brake unit **10**, the proximity sensor **30** will detect a metallic object and the air pressure indicator **41** will indicate no air pressure being supplied to the brake unit **10**. The notification device **38** may then activate an indicator light or alert signal that the brake unit **10** is not applied.

[0031] As the brake unit **10** is applied, the piston **62** and piston tube **54** are moved along the longitudinal axis **L** of the brake unit **10**. As shown in **FIGS. 1**, **2A**, and **6**, when the brake unit **10** is applied, the leading edge **64** of the groove **56** is moved past the detection signal **S** and the groove **56** will align with the detection signal **S** emitted from the proximity sensor **30**. The detection signal **S** detects the absence of metal in the groove **56** and provides this positional output information to the notification device **38**. The air pressure indicator **41** will also send air pressure information to the notification device **38** indicating that air pressure is being provided to the brake unit **10**. Due to the absence of metal and the supply of air pressure to the brake unit **10**, the notification device **38** identifies that the brake unit **10** is in an applied position. As will be understood by one of skill in the art, the groove **56** may be cut to the appropriate depth and width so when the piston tube **54** is in the non-applied position, the proximity sensor **30** detects metal on the piston tube **54** and, when the piston tube **54** is in the applied position, the proximity sensor **30** detects the absence of metal on the piston tube **54**. It is to be understood that the proximity sensor **30** may not be configured to detect metal. Instead, the proximity sensor **30** may be configured to detect a solid object, such as the piston tube **54**, and the absence of a solid object, such as the groove **56**.

[0032] As shown in **FIGS. 1**, **2A**, and **7**, when the brake unit **10** is over-stroked, the leading edge **64** and trialing edge **66** of the groove **56** are moved past the detection signal **S** towards the spindle head **24**. During operation, the brake unit **10** may become over-stroked due to a loss of brake pads (not shown) or an internal failure in the brake unit **10**. This situation can cause the piston tube **54** to be pushed past the desired position into an over-stroke position. It is beneficial to the operator of the vehicle to be aware of this situation so repairs and maintenance may be made to the appropriate structure of the brake unit **10**. As the trailing edge **66** moves past the detection signal **S**, the proximity sensor **30** will again detect the metal of the piston tube **54** and will send this positional output information back to the notification device **38**. The air pressure indicator **41** will send air pressure information to the notification device **38** indicating that air pressure is being supplied to the brake unit **10**. Based on the proximity sensor **30** detecting a metallic object and the air pressure indicator **41** indicating that air pressure is

being applied, the notification device **38** may identify that the brake unit **10** is in an over-stroked position.

[0033] As will be readily apparent to one of skill in the art, the position of the piston tube **54** in the brake unit **10** may be determined by providing the protrusion **57** on the piston tube **54**. This method is similar to that used with the groove **56** on the piston tube **54**. When the brake unit **10** is applied, the detection signal **S** emitted from the proximity sensor **30** may be directed towards the protrusion **57** on the piston tube **54**. When the brake unit **10** is not applied, the detection signal **S** emitted from the proximity sensor **30** may not be directed towards the protrusion **57** on the piston tube **54**. The detection signal **S** may be directed towards another portion of the piston tube **54**.

[0034] By using this piston stroke sensor arrangement on the brake unit, it is no longer necessary to inspect the brake units from underneath of or below the railway vehicle. The brake unit may be tested remotely or directly from the outside of the railway vehicle without the need for a pit or maintenance facility to inspect an in-board brake unit. This arrangement also assists in identifying an over-stroke condition for the brake unit **10** so that corrective action may be taken swiftly and promptly.

[0035] While an embodiment of a piston stroke sensor arrangement for a brake unit is shown in the accompanying figures and described hereinabove in detail, other embodiments will be apparent to, and readily made by, those skilled in the art without departing from the scope and spirit of the invention. Accordingly, the foregoing description is intended to be illustrative rather than restrictive. The invention described hereinabove is defined by the appended claims and all changes to the invention that fall within the meaning and the range of equivalency of the claims are to be embraced within their scope.

THE INVENTION CLAIMED IS:

1. A piston stroke sensor arrangement for a brake unit, comprising:

a brake unit comprising a piston and a piston tube; and

a proximity sensor supported on the brake unit,

wherein the proximity sensor determines the location of the piston within the brake unit based on the position of the piston tube relative to the proximity sensor.

2. The piston stroke sensor arrangement as claimed in claim 1, the proximity sensor further comprising an inductive proximity sensor.

3. The piston stroke sensor arrangement as claimed in claim 2, wherein a groove is defined in an outer circumferential surface of the piston tube, and

wherein, when the brake unit is in a non-applied position, the proximity sensor detects metal of the piston tube, and

wherein, when the brake unit is in an applied position, the proximity sensor does not detect the metal of the piston tube.

4. The piston stroke sensor arrangement as claimed in claim 1, wherein a groove is defined in an outer circumferential surface of the piston tube, and

wherein, when the brake unit is in an applied position, the proximity sensor is directed towards the groove on the piston tube, and

wherein, when the brake unit is in a non-applied position, the proximity sensor is directed towards a portion of the piston tube that does not include the groove.

5. The piston stroke sensor arrangement as claimed in claim 1, wherein a protrusion is provided on an outer circumferential surface of the piston tube, and

wherein, when the brake unit is applied, the proximity sensor is directed towards the protrusion on the piston tube, and

wherein, when the brake unit is not applied, the proximity sensor is not directed towards the protrusion on the piston tube.

6. The piston stroke sensor arrangement as claimed in claim 1, further comprising an air pressure indicator in fluid communication between a fluid source and the brake unit, and

a notification device connected to the proximity sensor and the air pressure indicator,

wherein the air pressure indicator is configured to send information to the notification device identifying the amount of air pressure being supplied to the brake unit, and

wherein information from the proximity sensor is directed to the notification device to identify a position of the piston in the brake unit.

7. The piston stroke sensor arrangement as claimed in claim 1, the brake unit further comprising a disc brake unit.

8. The piston stroke sensor arrangement as claimed in claim 1, wherein the proximity sensor is configured to detect when the piston of the brake unit is positioned in an over-stroke position.

9. The piston stroke sensor arrangement as claimed in claim 1, the brake unit further comprising an anchor flange that supports the piston and the piston tube,

wherein the proximity sensor is positioned in the anchor flange adjacent the piston tube.

10. A railway vehicle with a piston stroke sensor arrangement, comprising:

a railway vehicle comprising a brake unit, the brake unit comprising a piston and piston tube; and

a proximity sensor positioned on the brake unit,

wherein the proximity sensor determines the location of the piston within the brake unit based on the position of the piston tube relative to the proximity sensor.

11. The railway vehicle as claimed in claim 10, the proximity sensor further comprising an inductive proximity sensor.

12. The railway vehicle as claimed in claim 11, wherein a groove is defined in an outer circumferential surface of the piston tube, and

wherein, when the brake unit is in a non-applied position, the proximity sensor detects metal of the piston tube, and

wherein, when the brake unit is in an applied position, the proximity sensor does not detect the metal of the piston tube.

13. The railway vehicle as claimed in claim 10, wherein a groove is defined in an outer circumferential surface of the piston tube, and

wherein, when the brake unit is applied, the proximity sensor is directed towards the groove on the piston tube, and

wherein, when the brake unit is not applied, the proximity sensor is directed towards a portion of the piston tube that does not include the groove.

14. The railway vehicle as claimed in claim 10, wherein a protrusion is provided on an outer circumferential surface of the piston tube, and

wherein, when the brake unit is applied, the proximity sensor is directed towards the protrusion on the piston tube, and

wherein, when the brake unit is not applied, the proximity sensor is not directed towards the protrusion on the piston tube.

15. The railway vehicle as claimed in claim 10, further comprising an air pressure indicator positioned in fluid communication between a fluid source and the brake unit, and

a notification device connected to the proximity sensor and the air pressure indicator,

wherein the air pressure indicator is configured to send information to the notification device identifying the amount of air pressure being supplied to the brake unit, and

wherein information from the proximity sensor is directed to the notification device to identify a position of the piston in the brake unit.

16. The railway vehicle as claimed in claim 10, the brake unit further comprising a disc brake unit.

17. The railway vehicle as claimed in claim 10, wherein the proximity sensor is configured to detect when the piston of the brake unit is positioned in an over-stroke position.

18. The railway vehicle as claimed in claim 10, the brake unit further comprising an anchor flange that supports the piston and piston tube,

wherein the proximity sensor is positioned in the anchor flange adjacent the piston tube.

19. A method of determining a piston stroke position for a brake unit, comprising the steps of:

a) providing a brake unit comprising:

a piston and a piston tube; and

a proximity sensor positioned on the brake unit;

b) emitting a detection signal from the proximity sensor to the piston tube; and

c) determining the position of the piston within the brake unit based on the position of the piston tube relative to the detection signal emitted from the proximity sensor.

20. The method of determining a piston stroke position for a brake unit as claimed in claim 19, wherein a groove is defined in an outer circumferential surface of the piston tube,

wherein, when the brake unit is applied, the detection signal emitted from the proximity sensor is directed towards the groove on the piston tube, and

wherein, when the brake unit is not applied, the detection signal emitted from the proximity sensor is directed towards a portion of the piston tube that does not include the groove.

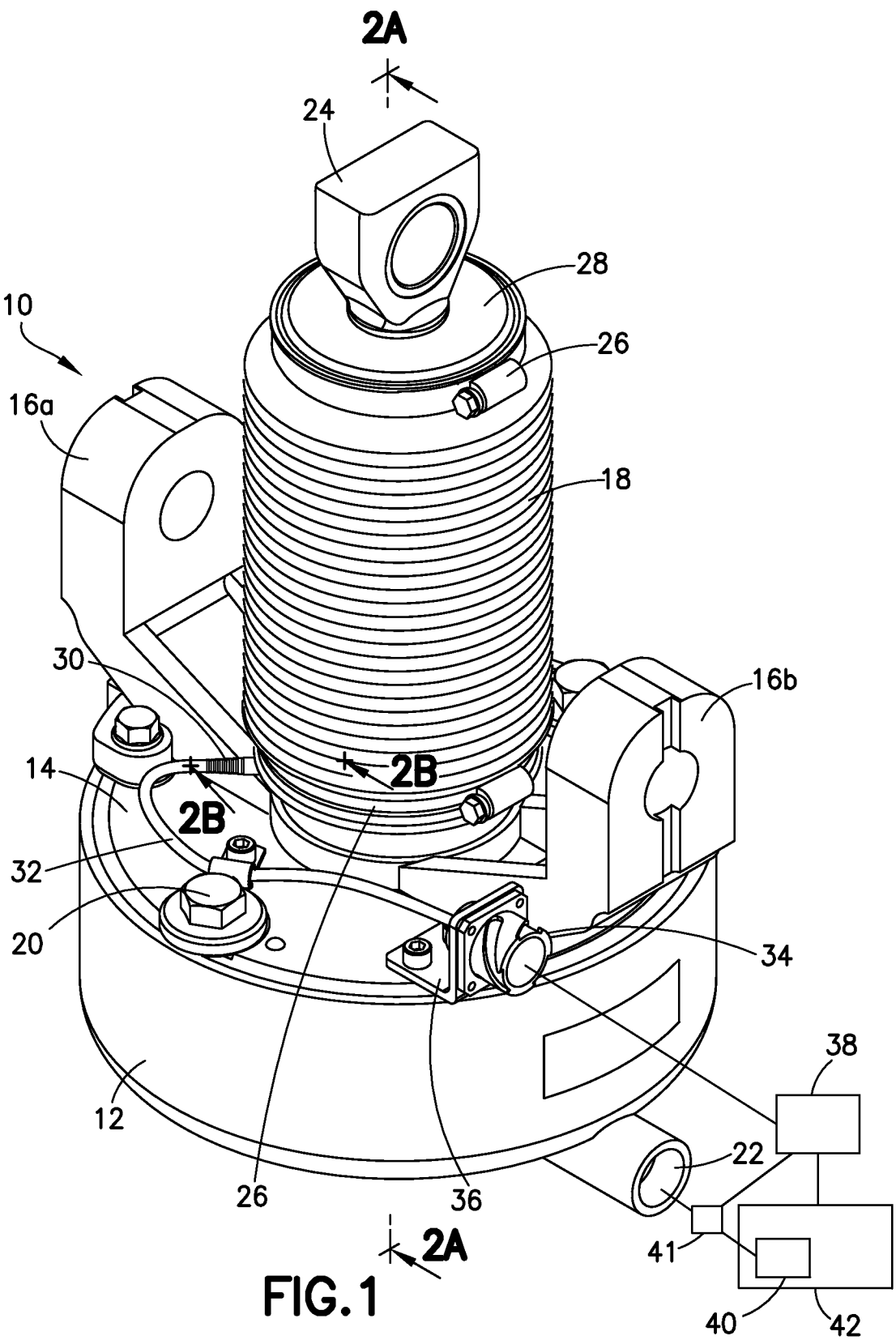
2A
24
28
10
26
16a
18
30
16b
14
2B
2B
32
20
34
38
12
22
26
36
2A
41
40
42

FIG. 1

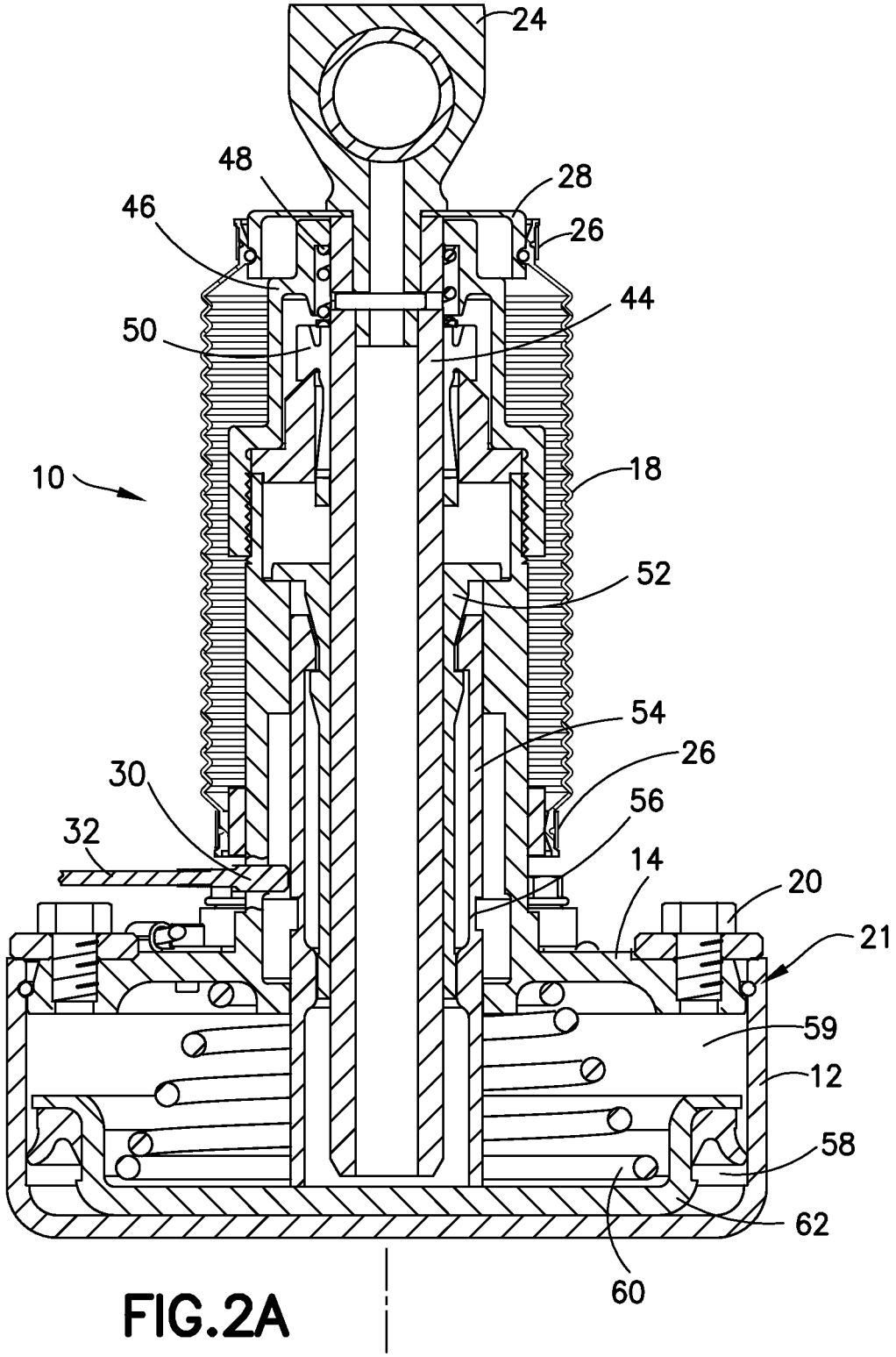

FIG.2A

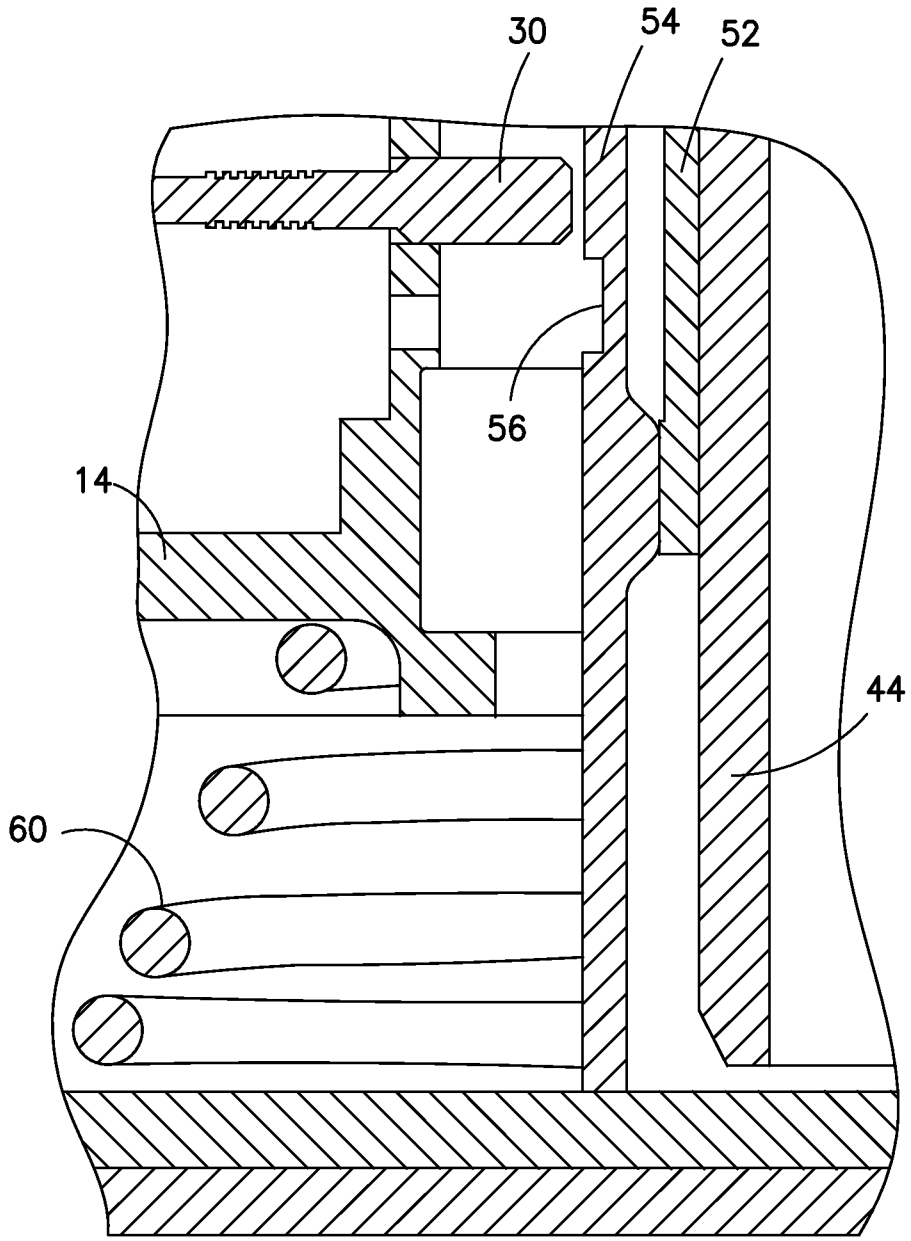

FIG.2B

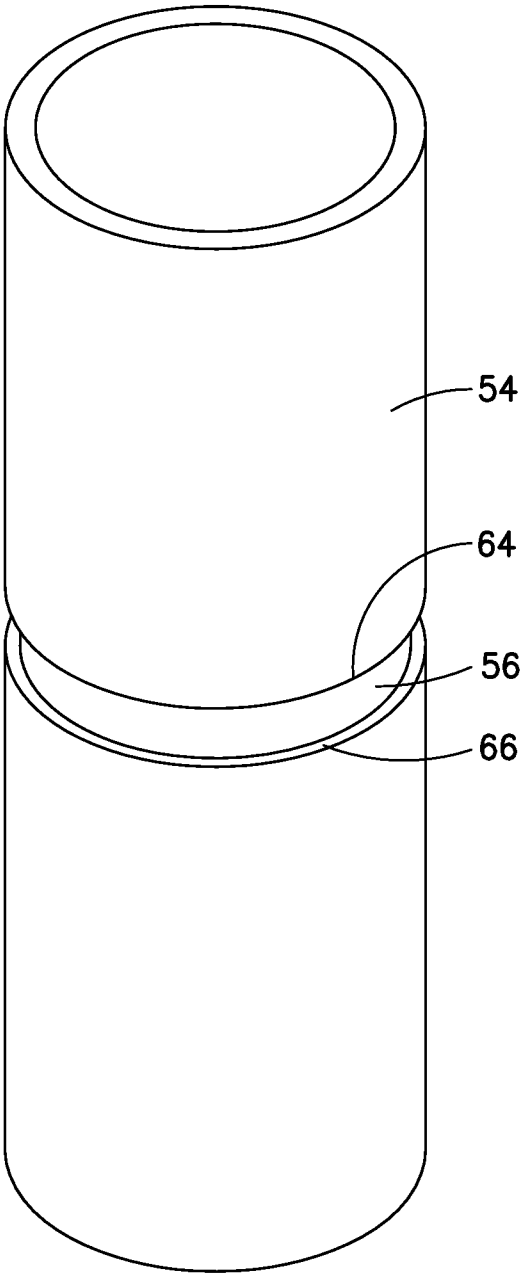

FIG.3

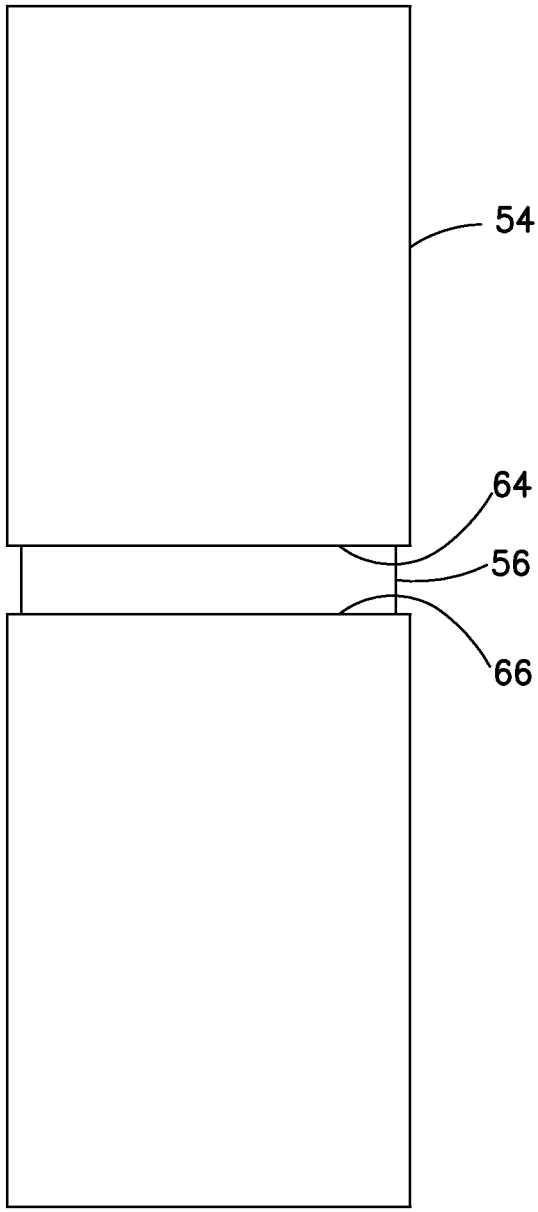

FIG.4

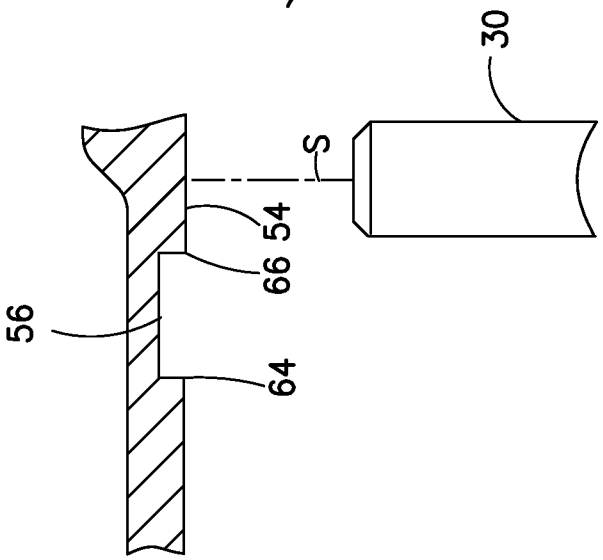

FIG.7

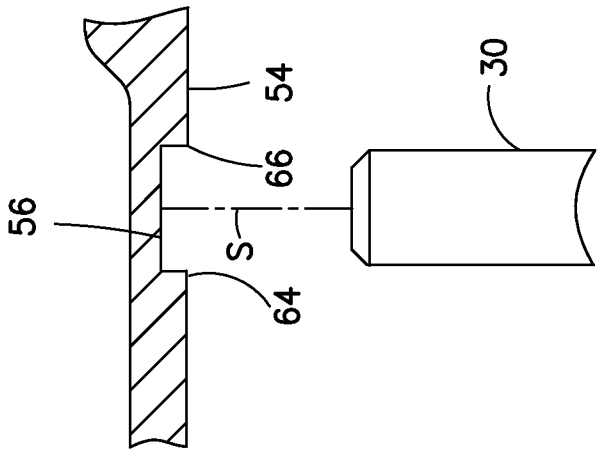

FIG.6

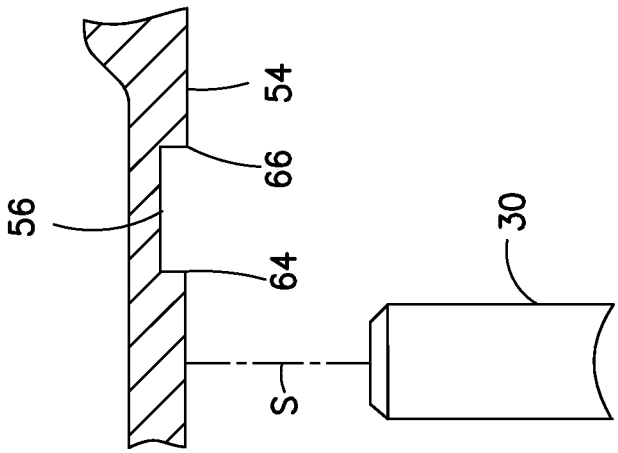

FIG.5

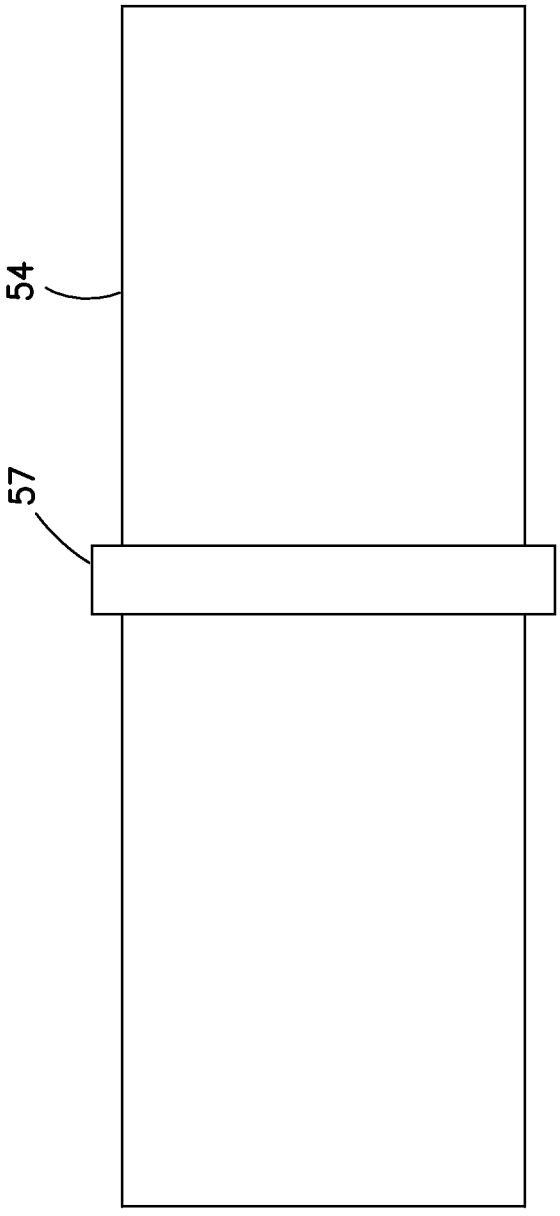

FIG.8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/049109

A. CLASSIFICATION OF SUBJECT MATTER

G01V 3/08(2006.01)i, G01D 5/20(2006.01)i, B61H 13/00(2006.01)i, B61H 5/00(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G01V 3/08; B60Q 1/44; F16D 66/00; F04B 49/00; B60T 13/58; B60T 13/128; G01D 5/20; B61H 13/00; B61H 5/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & keywords: brake unit, stroke sensor, piston, tube, over-stroke and biasing

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011-0308897 A1 (WALLACE et al.) 22 December 2011 See abstract, paragraphs [0018]-[0032], claims 1, 2, 11 and figures 1-6.	1-20
A	US 6352137 B1 (STEGALL et al.) 05 March 2002 See abstract, column 4, line 32 - column 5, line 64 and figures 1, 2.	1-20
A	US 6501375 B1 (WEANT et al.) 31 December 2002 See abstract, column 3, line 54 - column 8, line 12 and figures 2-14.	1-20
A	US 5816778 A (ELSEY, JR. et al.) 06 October 1998 See abstract, column 3, line 65 - column 8, line 20 and figures 1-12.	1-20
A	US 2012-0091787 A1 (NISHINO et al.) 19 April 2012 See abstract, paragraphs [0013]-[0029] and figures 1, 2.	1-20

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

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 December 2015 (22.12.2015)	**22 December 2015 (22.12.2015)**

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2015/049109

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