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(54) **FUEL SUPPLY SYSTEM**

(57) A fuel supply system includes a fuel supplier 10 including a cylinder 30 attachable to a mating portion of a blast tube 4 of a blast furnace 1; a hollow rotary member 40 rotatably disposed in the cylinder 30 and having a base end through which fuel is to be fed in the internal space of the rotary member 40; a pipe 20 fixed to an end, adjacent to the blast furnace 1, of the rotary member 40 and having a front end through which fuel is to be fed into the blast furnace 1; and a driving unit (for example, a hollow stepping motor 90) rotating the rotary member 40; and a control unit 102 disposed separate from the fuel supplier 10 and controlling the driving unit of the fuel supplier 10 to rotate the rotary member 40 and the pipe 20.

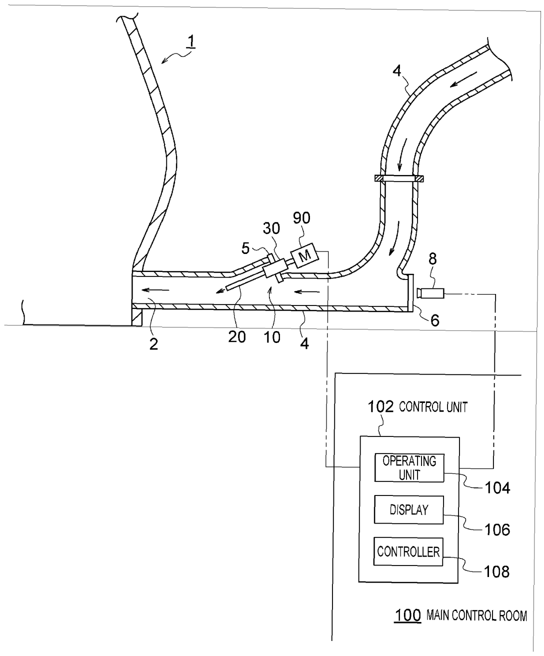

FIG. 2

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Description

TECHNICAL FIELD

[0001] The present invention relates to a fuel supply system including a fuel supplier, such as a burner, for injecting fuel, such as pulverized coal, from a blast furnace tuyere to the interior of the furnace.

BACKGROUND ART

[0002] For a reduction in the amount of coke to be used, fuel, such as pulverized coal, heavy oil, or waste plastic is injected from a blast furnace tuyere and burned in the furnace. The fuel, such as pulverized coal, is injected together with a hot blast of air into the furnace through a pulverized coal (PC) burner (hereinafter, also simply referred to as "burner") extending through a blast tube fixed to the tuyere.

[0003] A traditional burner is made of, for example, a stainless steel or any other special metal that has high thermal resistance because the burner is exposed to a high temperature. Unfortunately, such a traditional burner still causes troubles, such as thermal deformation of a lance pipe, which may damage the tuyere or reduce the combustion efficiency, for example. To avoid these troubles, the traditional burner requires replacement of the damaged lance pipe with a new one after every deformation, resulting in an increase in consumption of lance pipes. In addition, the burner should be replaced under a weak blast of air during the suspension of the operation of the blast furnace. This requirement leads to an increase in cost.

[0004] To address these problems, a burner disclosed in Japanese Patent No. 5105293 includes a deformable lance pipe that can be rotated around the axis with a reduced spring force. The lance pipe of the burner can be appropriately rotated at the beginning of the thermal deformation under an airtight condition so that the deformed portion is moved to a different position. Such a rotation can prevent further deformation in the same direction of the deformed portion of the lance pipe and keep the lance pipe in a substantially linear shape for a long time, and thus can efficiently prevent damage to the tuyere and a decrease in combustion efficiency.

SUMMARY OF INVENTION

[0005] A site worker directly observes the condition of the lance pipe of the burner according to Japanese Patent No. 5105293 through an inspection window at the site of the blast furnace. If the lance pipe is deformed, the site worker manually rotates the lance pipe to displace the deformed portion. Unfortunately, such an operation at the site of the blast furnace is troublesome for the site worker and increases the workload for the site worker. In detail, rotation of the lance pipe of the burner according to Japanese Patent No. 5105293 requires loosening of the screws fastening the flange and the sleeve. Loosening of the screws fastening the flange and the sleeve allows rotation of the adapter around the axis. Thus, the adapter can be rotated by a predetermined angle. This causes rotation of the lance pipe. After rotation of the lance pipe by a predetermined angle, the screws on the flange are tightened. That is, the sleeve is rotated and the screws are tightened to fasten the sleeve and the flange. Displacement of the deformed portion through manual rotation of the lance pipe by a site worker at the site of the blast furnace is unfortunately a troublesome operation for the site worker.

[0006] An object of the present invention, which has been made in view of such a problem, is to provide a fuel supply system including a controller separately disposed from a fuel supplier. The controller can control a driving unit to rotate a pipe. Thus, the site worker needs not to manually rotate the pipe at the site of the blast furnace and thus reduces the workload for the site worker.

[0007] A fuel supply system of the present invention includes: a fuel supplier including: a cylinder attachable to a mating portion of a blast tube of a blast furnace; a hollow rotary member rotatably disposed in the cylinder and having a base end through which fuel is to be fed in the internal space of the rotary member; a pipe fixed to an end of the rotary member and having a front end through which fuel is to be fed into the blast furnace, the end being adjacent to the blast furnace; and a driving unit rotating the rotary member; and a control unit disposed separate from the fuel supplier and controlling the driving unit of the fuel supplier to rotate the rotary member and the pipe.

[0008] The fuel supply system of the present invention may further include an image capturing device capturing an image of the pipe of the fuel supplier disposed in the blast tube of the blast furnace.

[0009] In this case, the control unit may include: a controller controlling the driving unit of the fuel supplier; a display displaying the image of the pipe captured at the image capturing device; and an operating unit operated by an operator. The controller may control the driving unit of the fuel supplier to rotate the rotary member and the pipe in response to an instruction for rotating the pipe inputted from the operating unit.

[0010] In the fuel supply system of the present invention, the control unit may determine whether the pipe is under a predetermined condition based on the image of the pipe of the fuel supplier captured at the image capturing device. If the control unit determines that the pipe of the fuel supplier is not under the predetermined condition, the control unit may control the driving unit of the fuel supplier to rotate the rotary member and the pipe.

[0011] Further, the control unit may control the driving unit of the fuel supplier to rotate the rotary member and the pipe by a predetermined angle at predetermined time intervals.

[0012] Also, the driving unit may include a hollow stepping motor, and an actuator disposed on the rotary member of the fuel supplier may be disposed in a hollow portion of the hollow stepping motor to rotate the rotary member by the hollow stepping motor.

BRIEF DESCRIPTION OF DRAWINGS

[0013]

Fig. 1 is a schematic configurational view of a blast furnace and a main control room according to an embodiment of the present invention.

Fig. 2 is a configurational view of a fuel supply system supplying fuel, such as pulverized coal, to the blast furnace illustrated in Fig. 1.

Fig. 3 is a side view of an example configuration of the fuel supplier of the fuel supply system illustrated in Fig. 2.

Fig. 4 is an enlarged longitudinal cross-section of the internal configuration of the fuel supplier illustrated in Fig. 3.

Fig. 5 is an exploded view of the components of the fuel supplier illustrated in Fig. 3.

Fig. 6 is a perspective view of the fuel supplier illustrated in Fig. 3 before a cap is fixed to a cylinder.

Fig. 7 is a perspective view of the fuel supplier illustrated in Fig. 3 after the cap is fixed to the cylinder.

Fig. 8 is a longitudinal cross-section of the fuel supplier illustrated in Fig. 3 including a pipe having a deformed end in the tuyere of the blast furnace.

Fig. 9 is a perspective view of the configuration of a hollow stepping motor of the fuel supplier illustrated in Fig. 3.

Fig. 10 is a longitudinal cross-section of another example configuration of a fuel supplier of the fuel supply system illustrated in Fig. 2.

DESCRIPTION OF EMBODIMENTS

[0014] Embodiments of the present invention will now be described with reference to the accompanying drawings. Figs. 1 to 9 illustrate a fuel supply system according to an embodiment and a blast furnace which is to be supplied with fuel, such as pulverized coal, from the fuel supply system. Fig. 1 is a schematic configurational view of a blast furnace and a main control room according to the embodiment. Fig. 2 is a configurational view of the fuel supply system feeding fuel, such as pulverized coal, to the blast furnace illustrated in Fig. 1. Fig. 3 is a side view of an example configuration of a fuel supplier of the fuel supply system illustrated in Fig. 2. Fig. 4 is an enlarged longitudinal cross-section of the internal configuration of the fuel supplier illustrated in Fig. 3. Fig. 5 is an exploded view of the components of the fuel supplier illustrated in Fig. 3. Fig. 6 is a perspective view of the fuel supplier illustrated in Fig. 3 before a cap is fixed to a cylinder. Fig. 7 is a perspective view of the fuel supplier illustrated in Fig. 3 after the cap is fixed to the cylinder. Fig. 8 is a longitudinal cross-section of the fuel supplier illustrated in Fig. 3 including a pipe having a deformed end in the tuyere of the blast furnace. Fig. 9 is a perspective view of the configuration of a hollow stepping motor of the fuel supplier illustrated in Fig. 3.

[0015] The configuration of a blast furnace 1, which is to be supplied with fuel, such as pulverized coal, from the fuel supply system according to the embodiment, is now described with reference to Fig. 1. The blast furnace 1 is a vertically cylindrical structure having an outer face covered with a steel plate and an inner face lined with a refractory. The blast furnace 1 includes about 20 to 50 tuyeres 2 radially extending from the side face of the hearth of the blast furnace 1. Hot blasts of air passing through hot air-blast stoves 3 and blast tubes 4, such as hot-air tubes, are blown through the water-cooled copper tuyeres 2 into the blast furnace 1. A tap port for discharging molten iron and a slag port for discharging molten slag are separately disposed below the tuyeres 2. The fuel supplier (PC burner) 10 (described below) is configured to inject fuel, such as pulverized coal, into the furnace through the tuyeres 2. In detail, each tuyere 2 of the blast furnace 1 is provided with the corresponding blast tube 4, and a pipe 20 (described below) of the fuel supplier 10 is configured to be disposed in the blast tube 4 such that the front end portion of the pipe 20 extends from the tuyere 2 to the interior of the furnace, as illustrated in Fig. 2.

[0016] More specifically, each blast tube 4 is provided with a mating portion 5, such as a flange, to receive projections 32 (described below) of the fuel supplier 10. Fixing the projections 32 of the fuel supplier 10 to the mating portion 5 causes the pipe 20 (described below) of the fuel supplier 10 to be disposed in the blast tube 4, as illustrated in Fig. 2. The blast tube 4 is provided with an inspection window 6 composed of a transparent glass through which the inside of the blast tubes 4 can be observed. An image capturing device 8, such as a CCD camera for capturing internal images of the blast tubes 4 is disposed on the outer face of the inspection window 6. The image capturing device 8 also captures images of the pipe 20 of the fuel supplier 10 disposed in the blast tube 4. Still and video images captured at the image capturing device 8 are sent to a controller 108 of a control unit 102 described below.

[0017] With reference to Figs. 1 and 2, the control unit 102 controlling the fuel supplier 10 is disposed in a main control room 100 disposed at a site other than that of the blast furnace 1. The control unit 102 includes an operating unit 104, such as a keyboard, a display 106, such as a large panel, and the controller 108, such as a CPU. The still and video images captured by the image capturing device 8 appear on the display 106 of the control unit 102. In this embodiment, about 20 to 50 tuyeres 2 radially extend from the side face of the hearth of the blast furnace 1, and the blast tubes 4 disposed on the tuyeres 2 respectively are provided with image capturing devices 8. The display 106 of the control unit 102 simultaneously or alternatingly displays multiple still or video images captured at the image capturing devices 8. The site worker can operate the operating unit 104 and input various commands to the controller 108.

[0018] The configuration of the fuel supplier (PC burner) 10 of the fuel supply system according to the embodiment will now be described with reference to Figs. 3 to 9. The fuel supplier 10 according to the embodiment includes a cylinder (sleeve) 30 attachable to the mating portion 5, such as a flange, of the blast tube 4 of the blast furnace 1, a hollow rotary member (adaptor) 40 rotatably disposed in the cylinder 30 and having a base end through which fuel is to be fed into the rotary member 40, a pipe (lance pipe) 20 detachably fixed to the end (adjacent to the blast furnace 1) of the rotary member 40 and having a front end through which fuel is to be fed into the blast furnace 1, and a cap 60 detachably fixed to the cylinder 30 and holding the rotary member 40 in the cylinder 30. A spring 50 is disposed in the cylinder 30 and functions as an urging member biasing a second sealing face 44 (described below) of the rotary member 40 to a first sealing face 34 (described below) of the cylinder 30. An actuator 70 for rotating the rotary member 40 is fixed, for example, by welding, to the rotary member 40. These components of the fuel supplier 10 are described in detail below.

[0019] The pipe (lance pipe) 20 is a long thin pipe made of a heat-resistant material, such as stainless steel. The base end portion (fixed to the rotary member 40) of the pipe 20 has a thread ridge or an external thread 22 (second engaging portion) on the outer periphery (refer to Fig. 4). The front end portion (adjacent to the blast furnace 1) of the hollow rotary member 40 (described below) has a tapped hole or internal thread 42 (second engaged portion) on the inner periphery. The thread ridge or external thread 22 of the pipe 20 is screwed into the internal thread 42. The pipe 20 is thus detachably fixed to the end, adjacent to the blast furnace 1, of the rotary member 40. Fixing the pipe 20 to the rotary member 40 brings the internal space of the pipe 20 into communication with the internal space of the rotary member 40.

[0020] Several, for example, three projections 32 radially extend from the outer periphery of the cylinder or sleeve 30 substantially at an end, adjacent to the blast furnace 1, of the cylinder. The projections 32 facilitate fixation of the cylinder 30 to the mating portion 5, such as a flange, of the blast tube 4 of the blast furnace 1. The projections 32 of the cylinder 30 are inserted in the holes in the mating portion 5 and then rotated to fix the cylinder 30 to the blast tube 4 of the blast furnace 1. When fixing the cylinder 30 to the blast tube 4 of the blast furnace1, in place of the insertion and rotation of the projections 32 in the holes of the mating portion 5, the cylinder 30 may be fixed to the blast tube 4 of the blast furnace 1 with keys, such as cotters. Several, for example, four fins 38 radially extend from the outer periphery of the cylinder 30. The cylinder 30 has a first sealing face 34 along its entire inner periphery. The first sealing face 34 is tapered in the longitudinal direction (i.e., the horizontal direction in Figs. 4 and 5) of the cylinder 30. The cylinder 30 has two locking holes 39 on the outer periphery near its base end (remote from the blast furnace 1). The cap 60 engaging with the cylinder 30 is secured to the cylinder 30 with a rod-like locking pin 66 extending through the locking holes 39 (refer to Figs. 6 and 7).

[0021] With reference to Figs. 4 and 5, the hollow rotary member (adaptor) 40 has a second sealing face 44 along its outer periphery in the middle of the longitudinal direction. Accommodating the rotary member 40 in the cylinder 30 brings the second sealing face 44 into sealing contact with the first sealing face 34. The second sealing face 44 is tapered in the longitudinal direction (i.e., the horizontal direction in Figs. 4 and 5) of the rotary member 40. The close contact of the second sealing face 44 of the rotary member 40 accommodated in the cylinder 30 with the first sealing face 34 of the cylinder 30 can prevent leakage of gases and dusts from a gap between the cylinder 30 and the rotary member 40 to the exterior of the cylinder 30. The base end (remote from the blast furnace 1) of the rotary member 40 is fixed, for example, by welding, to the actuator 70 (described below). The rotary member 40 can be rotated in the cylinder 30 by the actuator 70.

[0022] The cap 60 is detachably fixed to the base end (remote from the blast furnace 1) of the cylinder 30. Fixing the cap 60 to the cylinder 30 holds the rotary member 40 in the cylinder 30. In detail, the cap 60 has a thread ridge or an external thread (first engaging portion) 62 on the outer periphery of the front end portion (adjacent to the blast furnace 1), as illustrated in Figs. 5 and 6. The cylinder 30 has a tapped hole or an internal thread (first engaged portion) 36 on the inner periphery of the base end portion. The external thread 62 of the cap 60 is screwed into the internal thread 36 of the cylinder 30. The cap 60 is thus detachably fixed to the base end of the cylinder 30. After the engagement of the cap 60 to the cylinder 30, the locking pin 66 is inserted through the two locking holes 39, and the cap 60 is thereby secured to the cylinder 30, as illustrated in Fig. 7. In the embodiment, the locking holes 39 and the locking pin 66 function as a locking mechanism for securing the cap 60 engaging with the cylinder 30 to the cylinder 30.

[0023] With reference to Fig. 4, the spring 50 is disposed around the rotary member 40 in the cylinder 30. The spring 50 is in contact with the cap 60 at one end. Accommodating the rotary member 40 and the spring 50 in the cylinder 30 and engaging the cap 60 with the base end of the cylinder 30 bring the spring 50 into a compressed state. The resilient force of the spring 50 from the compressed state urges the rotary member 40 to the left in Fig. 4. The second sealing face 44 of the rotary member 40 is thereby biased to the first sealing face 34 of the cylinder 30, and the first sealing face 34 is in closer contact with the second sealing face 44. In other words, the spring 50 functions as an urging member biasing the second sealing face 44 of the rotary member 40 to the first sealing face 34 of the cylinder 30. Such a spring 50 brings the second sealing face 44 into closer contact with the first sealing face 34 and thus can prevent leakage of gases and dusts from a gap between the first sealing face 34 and the second sealing face 44 with more certainty.

[0024] The actuator 70 is hollow and is fixed, for example, by welding to the base end (remote from the blast furnace 1) of the rotary member 40. The internal space of the actuator 70 is in communication with the internal space of the rotary member 40. A hollow stepping motor 90 is fixed to the actuator 70, as illustrated in Fig. 9. The hollow stepping motor 90 rotates the actuator 70. In detail, the actuator 70 has a power transmitter 72 having a circular cross-section. The power transmitter 72 is disposed in the hollow portion 92 of the hollow stepping motor 90. The hollow stepping motor 90 thereby rotates the power transmitter 72 of the actuator 70. The hollow stepping motor 90 is connected to the controller 108 of the control unit 102 via signal lines. Control signals sent from the controller 108 to the hollow stepping motor 90 instruct the hollow stepping motor 90 to rotate the power transmitter 72 of the actuator 70. The actuator 70 is connectable to a fuel supply hose 80 through which fuel, such as pulverized coal, is to be fed in the internal space of the actuator 70. The actuator 70 may be directly connected to the hose 80 or may be connected to the hose 80 with a hollow tube. Alternatively, the actuator 70 may be connected to the hose 80 with a valve. The actuator 70 may be directly connected to a flexible hose through which fuel is to be fed in the internal space of the actuator 70.

[0025] The hollow stepping motor 90 serving as a driving unit to rotate the actuator 70 fixed to the rotary member 40 can control the precise alignment of the pipe 20 and the rotary member 40. The hollow stepping motor 90 can clockwise or counterclockwise rotate the pipe 20, the rotary member 40, and the actuator 70. The hollow stepping motor 90, which is disposed around the power transmitter 72 of the actuator 70, contributes to design of a fuel supplier 10 having reduced dimensions.

[0026] A process of assembling the fuel supplier 10 will now be described with reference to Figs. 5 to 7. For simplicity, the pipe 20 and the hose 80 are not depicted in Figs. 6 and 7.

[0027] At the start of the assembly of the fuel supplier 10, the rotary member 40 and the spring 50 are accommodated in the cylinder 30 such that the spring 50 is disposed around the rotary member 40. Fig. 6 illustrates the cylinder 30 accommodating the rotary member 40 and the spring 50. The cap 60 is then fixed to the base end of the cylinder 30 to prevent detachment of the rotary member 40 and the spring 50 from the base end to the exterior of the cylinder 30. In detail, the external thread 62 of the cap 60 is screwed into the internal thread 36 of the cylinder 30. After the engagement of the cap 60, the actuator 70 in connection with the fuel supply hose 80 is fixed, for example, by welding to the base end of the rotary member 40. Fig. 7 illustrates the cylinder 30 with the cap 60 fixed to the base end of the cylinder 30. At the end of the assembling process, the base end of the pipe 20 is fixed to the front end of the rotary member 40. In detail, the external thread 22 of the pipe 20 is screwed into the internal thread 42 of the rotary member 40. The fuel supply system 10 illustrated in Figs. 3 and 4 is assembled through the process described above.

[0028] The fuel supply system according to the embodiment includes the fuel supplier 10, the image capturing device 8, and the control unit 102 to inject fuel, such as pulverized coal, from the tuyere 2 of the blast furnace 1 to the interior of the furnace.

[0029] Now described is how to use the fuel supplier 10. Before the start of feed of fuel, such as pulverized coal, into the blast furnace 1 with the fuel supplier 10, the projections 32 of the cylinder 30 are fixed to the mating portion 5, such as a flange, of the blast tube 4 of the blast furnace 1 such that the pipe 20 of the fuel supplier 10 is inserted into the blast tube 4 of the tuyere 2 of the blast furnace 1 and the front end portion of the pipe 20 extends from the tuyere 2 to the interior of the furnace. Fuel, such as pulverized coal, is fed through the fuel supply hose 80 in the internal space of the actuator 70, so that the fuel passes through the internal space of the actuator 70, the internal space of the rotary member 40, and the internal space of the pipe 20, in this order, and is injected through the front end of the pipe 20 in the blast furnace 1.

[0030] After a long-term use of the pipe 20 of the fuel supplier 10, the pipe 20 may be thermally deformed, as illustrated in Fig. 8, causing a risk of contact with the tuyere 2 or any other component. To avoid the risk in this embodiment, the still and video images of the pipe 20 captured at the image capturing device 8, such as a CCD camera, appear on the display 106 of the control unit 102 disposed in the main control room 100 so that the site worker can detect the beginning of deformation of the pipe 20. Upon such detection, the site worker can operate the operating unit 104 of the control unit 102 to input an instruction for driving the hollow stepping motor 90, so that the hollow stepping motor 90 rotates the actuator 70. The pipe 20 and the rotary member 40 are thereby rotated together to expose the front end portion of the pipe 20 to heat at a different position. Such an appropriate rotation of the pipe 20 by the operating unit 104 of the control unit 102 operated by the site worker enables uniform thermal application to the entire periphery of the pipe 20, preventing deformation, such as flexure in one direction, of the pipe 20 under its own weight in a high temperature environment.

[0031] A process will now be described for maintenance of the fuel supply system 10. The fuel supplier 10 according to the embodiment requires occasional replacement of the pipe 20 because the front end portion of the pipe 20 is prone to be thermally damaged in the blast furnace 1. Since the pipe 20 is detachable from the rotary member 40, the replacement of the pipe 20 does not involve detachment of the cap 60 from the cylinder 30. Only the pipe 20 can be detached while the rotary member 40 resides in the cylinder 30. In other words, the pipe 20 can be replaced with a new one while the first sealing face 34 of the cylinder 30 is in close contact with the second sealing face 44 of the rotary member 40. This configuration can prevent deposition of dusts onto the first sealing face 34 and the second sealing face 44 and scratches on the first sealing face 34 and the second sealing face 44.

[0032] The rotary member 40 of the fuel supplier 10 according to the embodiment wears and needs to be replaced with a new one once a year, in general. Since the cap 60 is detachable from the cylinder 30, the replacement of the rotary member 40 requires detachment of only the cap 60 from the cylinder 30. This configuration can eliminate workload for the site workers in association with the replacement of the cylinder 30.

[0033] In the fuel supply system according to the embodiment having the configuration described above, the pipe 20 of the fuel supplier 10 having a front end through which fuel is to be fed into the blast furnace 1 is fixed to an end, adjacent to the blast furnace 1, of the hollow rotary member 40. The rotary member 40 rotatably resides in the cylinder 30. The rotary member 40 is rotationally driven by the hollow stepping motor 90. The control unit 102, disposed separately from the fuel supplier 10, controls the hollow stepping motor 90 to rotate the rotary member 40 and the pipe 20. In such a fuel supply system, the hollow stepping motor 90 can rotate the pipe 20 at the beginning of the thermal deformation of the pipe 20 under an airtight condition so that the deformed portion is moved to a different position. Such a rotation can keep the pipe 20 in a substantially linear shape for a long time, and thus can efficiently prevent damage to the tuyere 2 of the blast furnace 1 and a decrease in combustion efficiency. The control unit 102, disposed separately from the fuel supplier 10, can control the hollow stepping motor 90 to rotate the pipe 20. Thus, the site worker needs not to manually rotate the pipe 20 at the site of the blast furnace and thus reduces the workload for the site worker. In particular, the control unit 102 disposed in the main control room 100 can be operated by a site worker to remotely control the rotation of the pipe 20 of the fuel supplier 10.

[0034] As described above, the fuel supply system according the embodiment includes the image capturing device 8 for capturing images of the pipe 20 of the fuel supplier 10 disposed in the blast tube 4 of the blast furnace 1. This configuration enables monitoring of the condition of the pipe 20 of the fuel supplier 10 disposed in the blast tube 4 of the blast furnace 1.

[0035] As described above, the control unit 102 of the fuel supply system according to the embodiment includes the controller 108 controlling the hollow stepping motor 90 of the fuel supplier 10, the display 106 displaying images of the pipe 20 captured at the image capturing device 8, and the operating unit 104 operated by an operator, such as a site worker. The controller 108 controls the hollow stepping motor 90 of the fuel supplier 10 to rotate the rotary member 40 and the pipe 20 in response to an instruction for rotating the pipe 20 inputted from the operating unit 104. In this way, the site worker can observe the images of the pipe 20 captured at the image capturing device 8 appearing on the display 106 of the control unit 102 to confirm the condition of the pipe 20. If the site worker detects deformation of the pipe 20, he or she can operate the operating unit 104 of the control unit 102 to input an instruction for driving the hollow stepping motor 90. In response, the hollow stepping motor 90 rotates the actuator 70 and thereby the pipe 20 and the rotary member 40 rotate together. This exposes a different position of the front end portion of the pipe 20 to heat. In the embodiment, the term "images" appearing on the display 106 refers to not only still images of the pipe 20 but also video images (moving images) of the pipe 20.

[0036] In the fuel supplier 10 of the fuel supply system according to the embodiment, the hollow rotary member 40 having a base end through which fuel is to be fed in the internal space rotatably resides in the cylinder 30, the pipe 20 having a front end through which the fuel is to be fed into the blast furnace 1 is detachably fixed to an end (adjacent to the blast furnace 1) of the rotary member 40, and the cap 60 holding the rotary member 40 in the cylinder 30 is detachably fixed to the cylinder 30. In this configuration, the pipe 20 can be replaced without involving exposure of the sealing faces (in specific, the first sealing face 34 and the second sealing face 44) between the cylinder 30 fixed to the mating portion 5, such as a flange, of the blast tube 4 of the blast furnace 1 and the rotary member 40. Such replacement can reduce the workload of the site worker. In other words, the cap 60 functions as a protective cover for the first sealing face 34 and the second sealing face 44.

[0037] The embodiment described above should not be construed to limit the scope of the present invention, and various modifications can be made on the fuel supply system.

[0038] For example, the driving unit rotating the actuator 70 of the fuel supplier 10 should not be limited to the hollow stepping motor 90. Any other driving unit that can rotate the actuator 70 may be used. For example, the power transmitter 72 of the actuator 70 may be serrated and rotated by a rack-and-pinion driving unit.

[0039] The image capturing device 8 should not be limited to a CCD camera. Any image capturing device 8 may be used to capture images of the pipe 20 of the fuel supplier 10 disposed in the blast tube 4, besides a CCD camera.

[0040] The control unit 102 should not be limited to that including the operating unit 104, such as a keyboard, and the display 106, such as a large panel. Alternatively, the control unit 102 may include a touch panel functioning as both the operating unit 104 and the display 106. The control unit 102 may be disposed at any location besides the main control room 100. For example, the control unit 102 may be disposed near the blast tube 4 in site of the blast furnace 1. Alternatively, the control unit 102 may be a portable information terminal, such as a smart phone or a tablet PC.

[0041] In the embodiment described above, the controller 108 controls the hollow stepping motor 90 of the fuel supplier 10 to rotate the rotary member 40 and the pipe 20 in response to an input of an instruction for rotating the rotary member 40 and the pipe 20 via the operating unit 104. Alternatively, the hollow stepping motor 90 of the fuel supplier 10 may be controlled through any other scheme. For example, the controller 108 may determine whether the pipe 20 is under a predetermined condition (in specific, extending in a linear shape) on the basis of images of the pipe 20 of the fuel supplier 10 captured at the image capturing device 8, even without an instruction from the operating unit 104 operated by an operator, such as a site worker. If the controller 108 determines that the pipe 20 of the fuel supplier 10 is not under the predetermined condition, the controller 108 may automatically drive the hollow stepping motor 90 of the fuel supplier 10. In specific, if the controller 108 determines the beginning of deformation of the pipe 20 on the basis of images of the pipe 20 of the fuel supplier 10 captured at the image capturing device 8, the controller 108 may automatically drive the hollow stepping motor 90 of the fuel supplier 10. In detail, the control unit 102 is provided with a memory unit (not shown) for storing images of the pipe 20 of the fuel supplier 10 disposed in the blast tube 4 under a predetermined condition (i.e., extending in a linear shape). The controller 108 compares the images of the pipe 20 of the fuel supplier 10 captured at the image capturing device 8 and the images of the pipe 20 stored in the memory unit and, if the compared images significantly differ, determines that the pipe 20 of the fuel supplier 10 is not under the predetermined condition (i.e., is at the beginning of deformation). Such a control process does not require the control unit 102 to be provided with the operating unit 104 and the display 106.

[0042] As another scheme of controlling the hollow stepping motor 90 of the fuel supplier 10, the control unit 102 may control the hollow stepping motor 90 of the fuel supplier 10 to rotate the rotary member 40 and the pipe 20 by a predetermined angle at predetermined time intervals, even without an instruction from the operating unit 104 operated by an operator, such as a site worker. In specific, the control unit 102 controls the hollow stepping motor 90 of the fuel supplier 10 to rotate the rotary member 40 and the pipe 20, for example, by 30 every 24 hours. In this way, the hollow stepping motor 90 rotates the pipe 20 by a predetermined angle at predetermined time intervals to move the deformed portion to a different position, even without management of the operator, such as the site worker. Such rotation can keep the pipe 20 in a substantially linear shape for a long time. Such a control process does not require the control unit 102 to be provided with the operating unit 104 and the display 106 and allows omission of the image capturing device 8.

[0043] The fuel supplier of the fuel supply system according to the embodiment should not be limited to that illustrated in Figs. 3 to 7. Another embodiment of the fuel supply system will now be described with reference to Fig. 10. Fig. 10 is a longitudinal cross-section of another example configuration of a fuel supplier of the fuel supply system illustrated in Fig. 2.

[0044] A fuel supplier (PC burner) 201 illustrated in Fig. 10 includes a pipe (lance pipe) 202 composed of a thin linear tube disposed in the central portion of the fuel supplier 201, a lance pipe guide (not shown) disposed on the exterior of the pipe 202, and a sheath (not shown) disposed on the lance pipe guide on the section rearward of the intermediate portion in the longitudinal direction. A connector 205 is disposed at the rear end of the fuel supplier 201.

[0045] The pipe 202 is a thin pipe composed of a heat resistant material, such as stainless steel. Projections 207 are radially disposed on the pipe 202 in the intermediate portion to support the pipe 202 in the central portion of the lance pipe guide. Fixing the projections 207 of the fuel supplier 201 to the mating portion 5, such as flange, of the blast tube 4 causes the pipe 202 of the fuel supplier 201 to be disposed in the blast tube 4, thereby causing the front end portion of the pipe 202 to extend from the tuyere 2 to the interior of the blast furnace 1.

[0046] The rear end of the pipe 202 is connected to the connector 205, as illustrated in Fig. 10. The connector 205 includes a sleeve 210, a pipe flange 212, and an adapter 214. The inner face of the sleeve 210 has an internal thread 210a in which the pipe flange 212 is screwed.

[0047] The pipe flange 212 has a central through-hole having a diameter larger than that of the pipe 202 and has a collar 216 at the front end of the pipe flange 212. The collar 216 is integrated with a threaded cylinder 217 disposed on the rear of the collar 216. The threaded cylinder 217 has an external thread 217a that is screwed into the internal thread 210a of the sleeve 210.

[0048] The adapter 214 is equivalent to a typical reducer. The adapter 214 has a through-hole 218 in the center and a flaring portion 214a from which the pipe 202 is fitted, on the front end. The through-hole 218 is tapered from the intermediate portion in the longitudinal direction to the rear portion such that the diameter increases toward the rear portion. The rear end of the adapter 214 has a large-diameter opening 214b connectable to a hose 230 for feeding a raw material or pulverized coal.

[0049] The outer circumference of the front end of the adapter 214 has a flange 214c. A spring 222 is fit around the adapter 214 between the flange 214c and the rear end of the sleeve 210 to bias the adapter 214 forward (leftward in Fig. 10). In the embodiment illustrated in Fig. 10, the adapter 214 is movable in the front-rear direction inside the sleeve 210. A thrust bearing 220 is fit to the outer circumference of the adapter 214, as illustrated in Fig. 10. The thrust bearing 220 prevents the adapter 214 and the sleeve 210 from rotating together.

[0050] A chamfered face 225 is disposed along the entire outer circumference of the front end of the adapter 214. A chamfered face 226 is disposed on the entire inner circumference of the rear end of the threaded cylinder 217 of the pipe flange 212. The chamfered faces 225 and 226 are sealing faces in close contact with each other and serve as a sealing member (metal packing) for preventing flow of gases. Alternatively, a chamfered face may be provided on the inner circumference of the adapter 214 and another chamfered face may be provided on the outer circumference of the pipe flange 212, to constitute a sealing member (metal packing) having male and female components opposite to those of the former sealing member. The rear portion of the adapter 214 is connectable to the hose 230 for feeding pulverized coal.

[0051] In an assembled state as illustrated in Fig. 10, the back face of the collar 216 of the pipe flange 212 is in contact with the front end face of the sleeve 210 and the rear end of the pipe flange 212 is in contact with the front end of the adapter 214. In this state, the chamfered face 226 of the pipe flange 212 comes into close contact with the chamfered face 225 of the adapter 214 along the entire circumference, to prevent flow of gases and dusts.

[0052] In the assembled state, the urging force of the spring 222 maintains the close contact between the adapter 214 and the pipe flange 212. The thrust bearing 220, which is disposed as illustrated in Fig. 10, transfers the urging force of the spring 222 to the adapter 214.

[0053] During operation of the blast furnace 1, fuel, such as pulverized coal, heavy oil, or waste plastic, is fed through the pipe 202 and injected into the furnace together with a blast from the interior of the blast tube 4.

[0054] The adapter 214 includes a hollow stepping motor 290, which has a configuration similar to that of the hollow stepping motor 90 illustrated in Fig. 9. The hollow stepping motor 290 rotates the adapter 214. In detail, the adapter 214 includes a power transmitter 214d having a circular cross-section. The power transmitter 214d is disposed in the hollow portion of the hollow stepping motor 290. This configuration enables the hollow stepping motor 290 to rotate the power transmitter 214d of the adapter 214. The hollow stepping motor 290 is connected to the controller 108 of the control unit 102 via signal lines. Control signals sent from the controller 108 to the hollow stepping motor 290 instruct the hollow stepping motor 290 to rotate the power transmitter 214d of the adapter 214.

[0055] In such a fuel supplier 201, the control unit 102 disposed separately from the fuel supplier 201 controls the hollow stepping motor 290 to rotate the adapter 214 and the pipe 202, like the fuel supplier 10 illustrated in Figs. 3 to 7. In such a fuel supply system, the control unit 102 disposed separately from the fuel supplier 201 can control the hollow stepping motor 290 to rotate the pipe 202. Thus, the site worker needs not to manually rotate the pipe 202 at the site of the blast furnace and thus bears a reduced workload.

Claims

1. A fuel supply system comprising:

    a fuel supplier comprising:

        a cylinder attachable to a mating portion of a blast tube of a blast furnace;
        a hollow rotary member rotatably disposed in the cylinder and having a base end through which fuel is to be fed in the internal space of the rotary member;
        a pipe fixed to an end of the rotary member and having a front end through which fuel is to be fed into the blast furnace, the end being adjacent to the blast furnace; and
        a driving unit rotating the rotary member; and

    a control unit disposed separate from the fuel supplier and controlling the driving unit of the fuel supplier to rotate the rotary member and the pipe.

2. The fuel supply system according to claim 1, further comprising an image capturing device capturing an image of the pipe of the fuel supplier disposed in the blast tube of the blast furnace.

3. The fuel supply system according to claim 2, wherein the control unit comprises:

    a controller controlling the driving unit of the fuel supplier;
    a display displaying the image of the pipe captured at the image capturing device; and
    an operating unit operated by an operator, and the controller controls the driving unit of the fuel supplier to rotate the rotary member and the pipe in response to an instruction for rotating the pipe inputted from the operating unit.

4. The fuel supply system according to claim 2, wherein the control unit determines whether the pipe is under a predetermined condition based on the image of the pipe of the fuel supplier captured at the image capturing device, and, if the control unit determines that the pipe of the fuel supplier is not under the predetermined condition, controls the driving unit of the fuel supplier to rotate the rotary member and the pipe.

5. The fuel supply system according to claim 1, wherein the control unit controls the driving unit of the fuel supplier to rotate the rotary member and the pipe by a predetermined angle at predetermined time intervals.

6. The fuel supply system according to any one of claims 1 to 5, wherein the driving unit comprises a hollow stepping motor, and an actuator disposed on the rotary member of the fuel supplier is disposed in a hollow portion of the hollow stepping motor to rotate the rotary member by the hollow stepping motor.

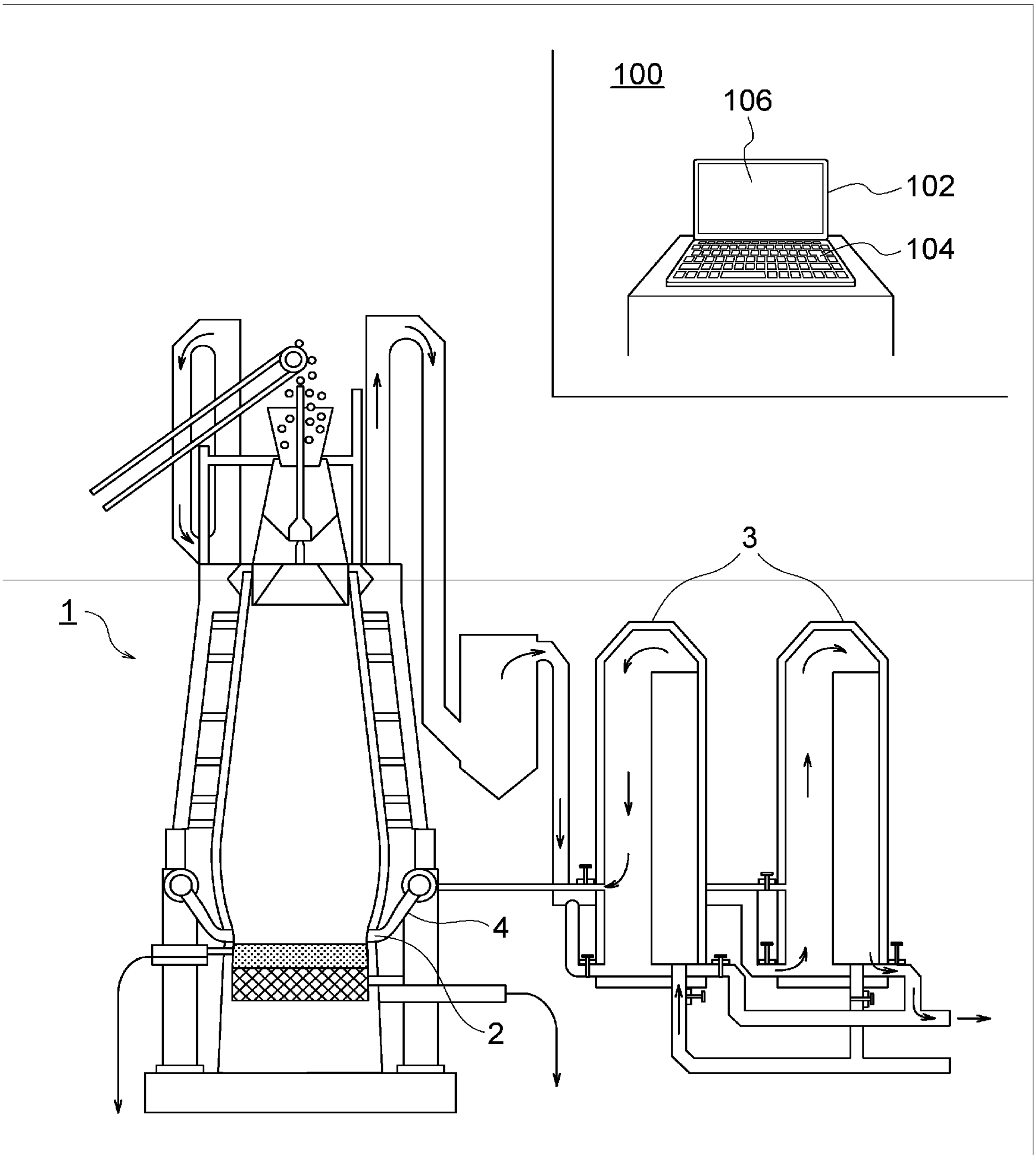

FIG. 1

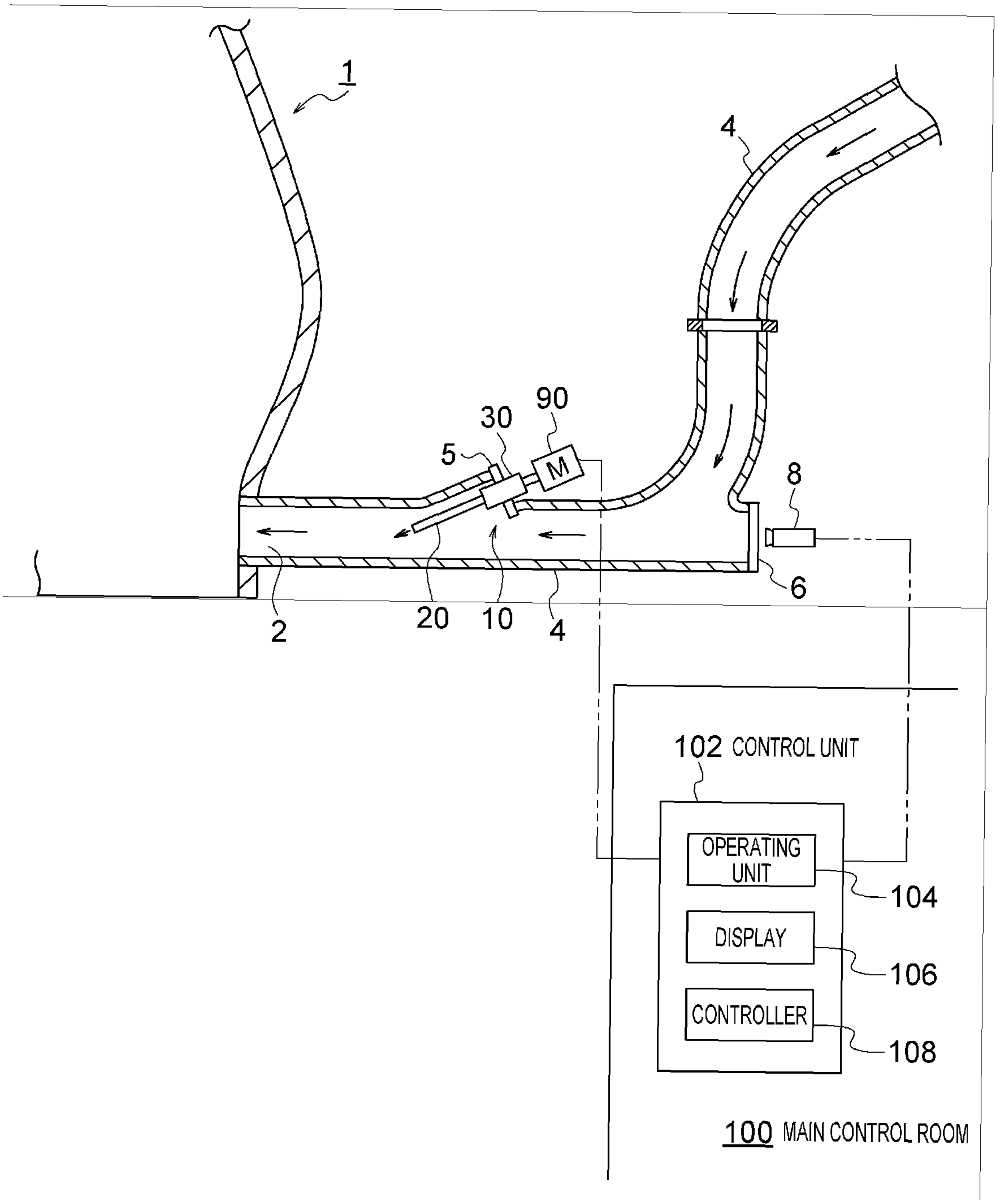
1
4
90
30
5
M
8
6
2
20
10
4
102 CONTROL UNIT
OPERATING UNIT
104
DISPLAY
106
CONTROLLER
108
100 MAIN CONTROL ROOM

FIG. 2

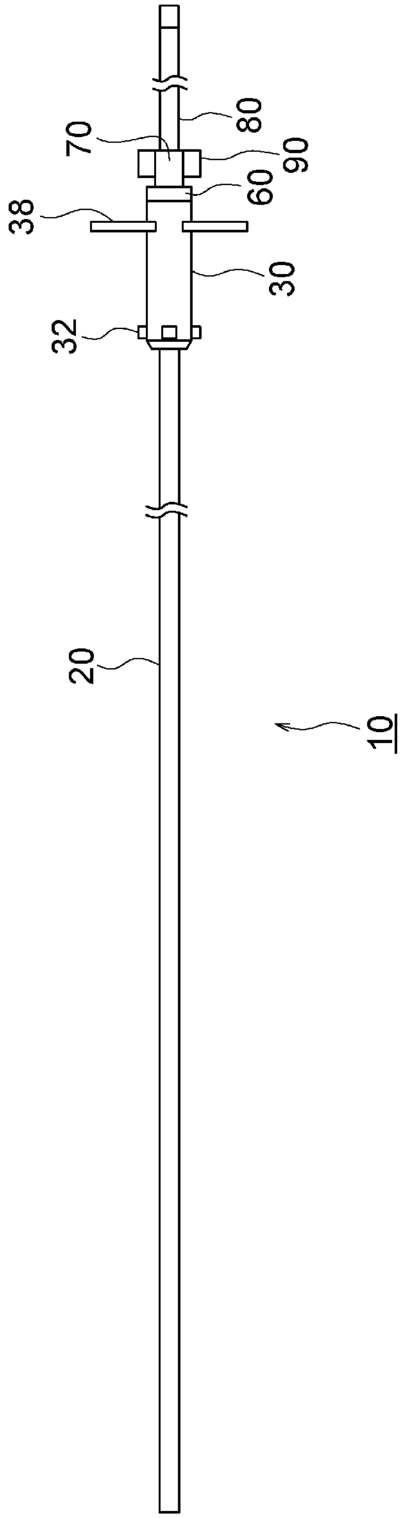

FIG. 3

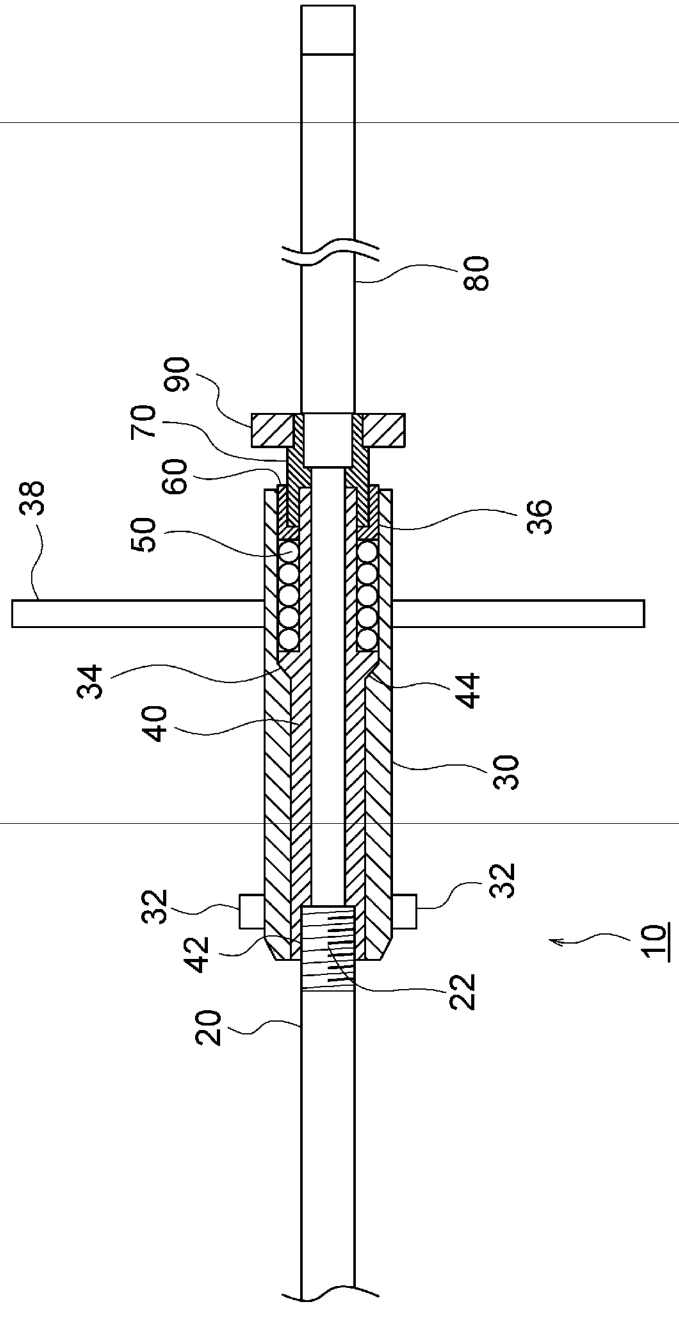

FIG. 4

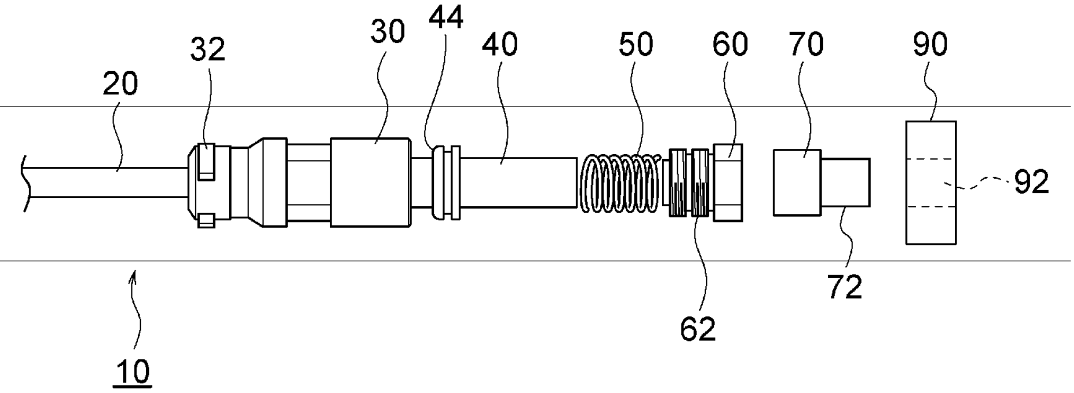

FIG. 5

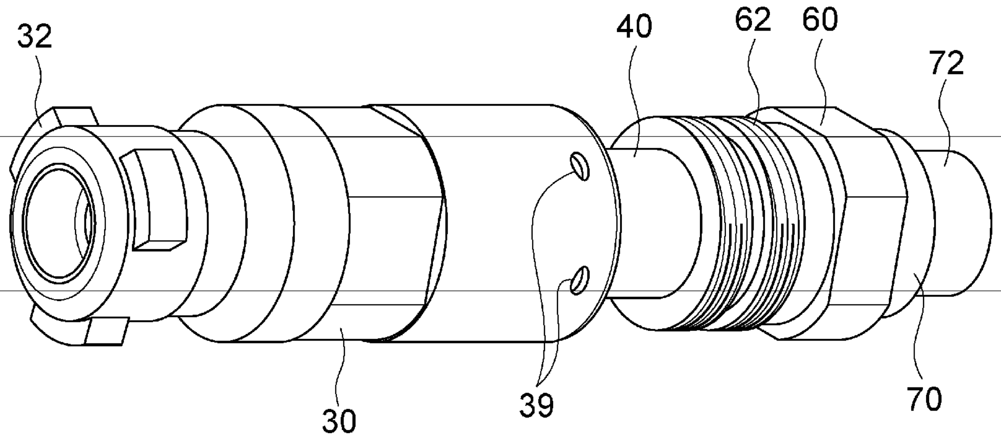

FIG. 6

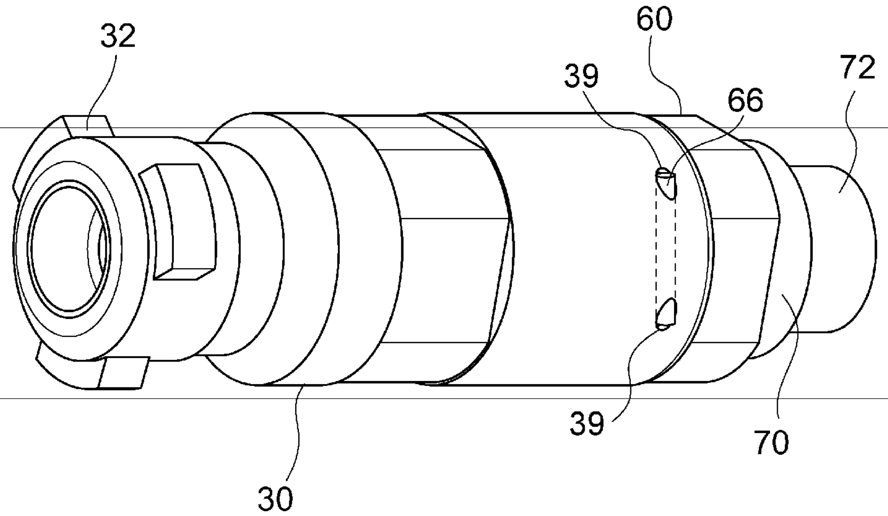

FIG. 7

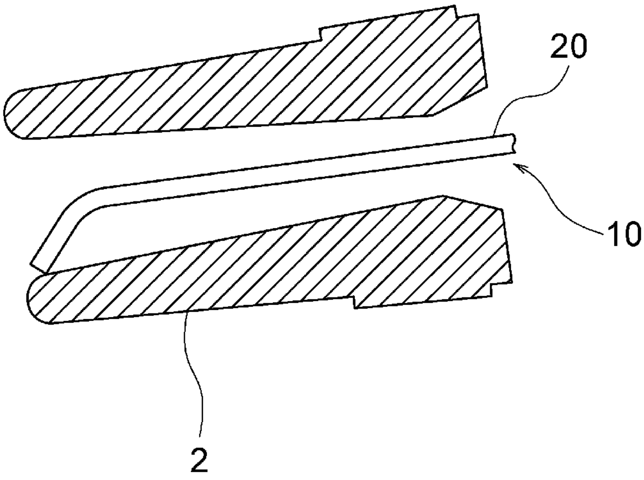

FIG. 8

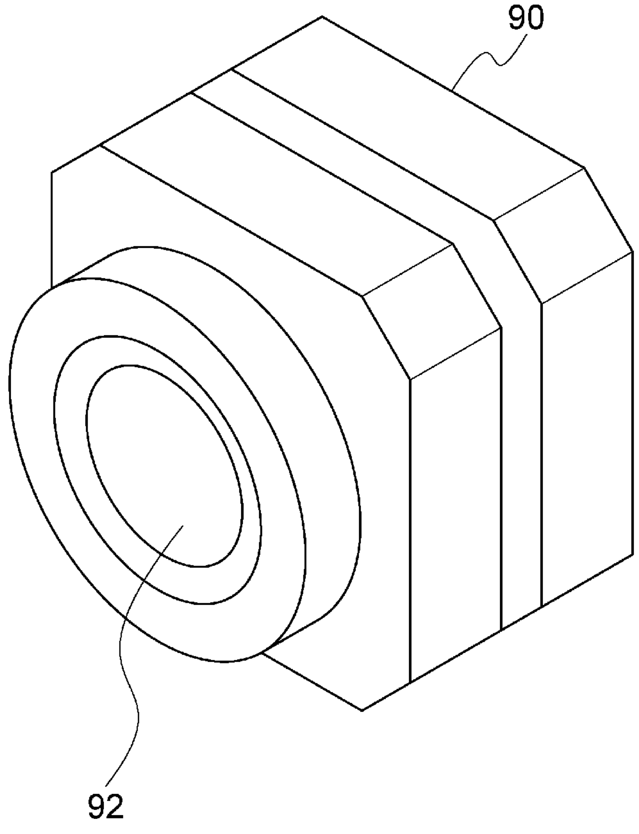

FIG. 9

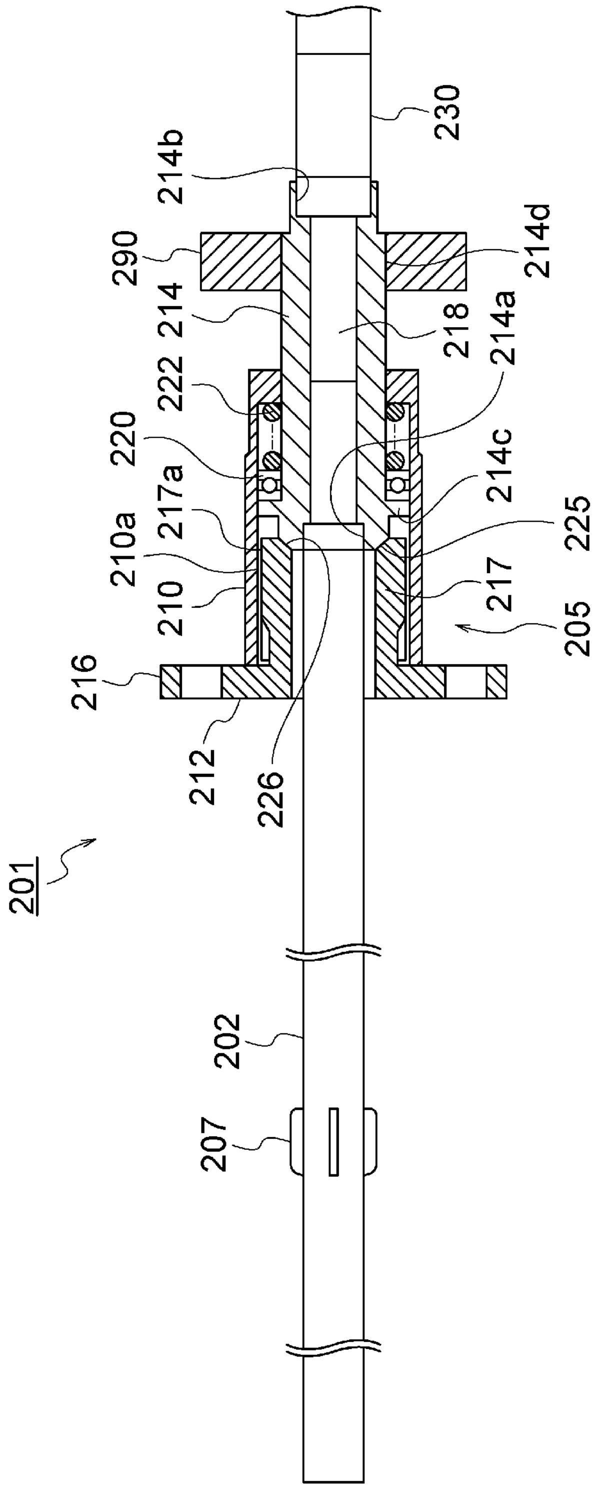
230
214b
290
214d
214
218
214a
222
220
214c
217a
225
210a
217
210
205
216
212
226
201
202
207

FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/087385

A. CLASSIFICATION OF SUBJECT MATTER
C21B7/00(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)
C21B5/00-C21B7/24

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2017
Kokai Jitsuyo Shinan Koho	1971-2017	Toroku Jitsuyo Shinan Koho	1994-2017

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2015-21151 A (Nippon Steel & Sumitomo Metal Corp.), 02 February 2015 (02.02.2015), paragraphs [0023] to [0031]; fig. 1 to 5 (Family: none)	1-2,5-6
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 154560/1988(Laid-open No. 74350/1990) (Nippon Steel Corp.), 06 June 1990 (06.06.1990), page 4, line 14 to page 7, line 10; fig. 1 (Family: none)	1-2,5-6

☒ Further documents are listed in the continuation of Box C.   ☐ See patent family annex.

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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
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06 February 2017 (06.02.17)	14 February 2017 (14.02.17)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/087385

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2015-25188 A (JFE Steel Corp.), 05 February 2015 (05.02.2015), paragraphs [0010] to [0045]; fig. 1 to 14 & US 2016/0148365 A1 paragraphs [0038] to [0102]; fig. 1 to 23 & WO 2015/015936 A1 & EP 3029160 A1 & TW 201518511 A & CN 105392904 A & KR 10-2016-0020574 A	2
A	JP 2000-129320 A (NKK Corp.), 09 May 2000 (09.05.2000), paragraphs [0010] to [0018]; fig. 1 to 2 (Family: none)	1-6
A	JP 2012-219336 A (Tritech Inc.), 12 November 2012 (12.11.2012), paragraphs [0018] to [0039]; fig. 1 to 8 (Family: none)	1-6

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 5105293 B **[0004] [0005]**