

DESCRIPTION

[Title of Invention] FLOATING DEVICE FOR IN-PIPE INSPECTION, IN-PIPE INSPECTION METHOD AND IN-PIPE INSPECTION SYSTEM

[Technical Field]

[0001]

The present invention relates to a floating device for in-pipe inspection, an in-pipe inspection method, and an in-pipe inspection system for inspecting properties of the insides of sewer pipes.

[Background Art]

[0002]

The sewerage system in Japan is widespread nationwide, the penetration rate of the sewerage system had reached nearly 80% at the time of 2017, and the total length of sewerage pipelines is about 470,000 km, which is very long. However, most of the sewerage pipelines in Japan are aging, and problems such as collapse of roads and clogging of sewers caused by such aging are becoming apparent in many places. For example, it is known that the probability of occurrence of road collapse is high in sewerage pipelines constructed in or before 1975, and countermeasure to aging of sewerage pipelines is an urgent issue.

In order to prevent such road collapse and clogging of sewers and maintain sewerage pipelines, a need for inspecting the properties of the insides of sewerage pipes in the field is increasing more than before (hereinafter, the inspection of the properties of the insides of sewerage pipes will be sometimes referred to as "in-pipe inspection of sewerage pipes" or simply "inspection").

[0003]

Currently, inspection of the insides of sewer pipes is conducted by several methods. In the case of a sewer pipe having a relatively large diameter, for example, a sewer pipe having a diameter (inner diameter) of 800 mm or more, a human (inspector) dives into the pipe and conducts an inspection (diving visual inspection). On the other hand, in the case of a sewer pipe having a relatively small diameter, for example, a sewer pipe having a diameter of less than 800 mm, a pipe opening camera, a self-propelled television camera or the like is inserted into the pipe to conduct an inspection (they will be referred to as "pipe opening camera inspection" and "self-propelled television camera inspection", respectively).

[0004]

In the diving visual inspection, an inspector dives into a pipe from a manhole, and visually inspects the property of the inside of the pipe. The inspector checks

and measures the inside of the pipe using a test hammer, scale, etc., photographs places where abnormalities are found, and stores image data obtained by the photographing. The diving visual inspection is a highly accurate inspection because the inspector directly inspects the inside of the pipe at the site.

[0005]

The pipe opening camera inspection is conducted by using equipment (a pipe opening camera) in which a light and a camera are attached to the tip of an extendable operating rod (not shown). Specifically, the pipe opening camera is inserted into a manhole from the ground, and an inspector captures images of the internal state of the pipe while watching a monitor at hand connected to the pipe opening camera, and records images of places which are judged to be abnormal.

Since the pipe opening camera has a simple structure as compared with a set of self-propelled television cameras (described later), it is higher in portability and easier in operability. Also, since the pipe opening camera inspection is conducted without moving the camera, a daily progress amount (here, indicates the length of a sewerage pipeline that can be inspected per day) can be increased as compared to the self-propelled television camera inspection (described later), which makes the inspection cost relatively low.

[0006]

The self-propelled television camera inspection is an inspection in which an in-pipe propelling body equipped with a camera (for example, see a self-propelled vehicle described in Patent Literature 1) is propelled in the pipe to collect necessary image data instead of human's diving into the pipe in such a case that a sewer pipe under inspection has a certain diameter or more (for example, 150 mm or more) or toxic gas is drifting inside a pipe.

[0007]

Figure 11 shows a schematic diagram for explaining a self-propelled television camera inspection described in Patent Literature 2. Patent Literature 2 shows an example in which the inside of a water supply pipe is inspected, but it describes an example of a self-propelled television camera inspection using an in-pipe propelling body.

A self-propelled television camera 900 as the in-pipe propelling body is equipped with a television camera 913. The self-propelled television camera 900 is connected to a ground controller 950, a manual operation unit 953, and a ground monitor 954 via a remote-control cable 920.

The self-propelled television camera inspection is conducted as follows. An inspection of a sewer pipeline of one span between adjacent manholes (between a manhole 800a and a manhole 800b in the Figure) is set as one step,

the self-propelled television camera 900 is inserted from the upstream manhole 800a into the inside 982 of a sewer pipe 981, and necessary image data are collected while the self-propelled television camera 900 is propelled to the downstream side of the inside 982.

An operator on the ground checks images captured by the television camera 913 on a ground monitor 954 while operating the television camera 913. The television camera 913 mainly reflects the condition in front of the television camera 913 while the self-propelled television camera 900 is running. However, at a place where there seems to be a problem, the self-propelled television camera 900 is temporarily stopped, and the lens of the television camera 913 (not shown) is rotated to check the condition of an inner wall 988, whereby a deterioration condition is determined and necessary imaging is performed.

[0008]

An actual in-pipe inspection of a sewer pipe does not use such a type of in-pipe propelling body as propelled while pushing fluid in a pipe with an impeller (not shown) as described in Patent Literature 2, but use such a type of in-pipe propelling body as propelled while pushing the inner wall by tires (not shown) as described in Patent Literature 1.

In practice, it is general to selectively use inspection methods, for example, a rough screening is

performed while grasping "presence or absence of abnormality" by the pipe opening camera inspection, and if it is suspected that there is an abnormality in the pipe, the self-propelled television camera inspection is conducted for detailed inspection.

[Citation List]

[Patent Literature]

[0009]

[Patent Literature 1] Japanese Patent Laid-Open No. S61-261161

[Patent Literature 2] Japanese Patent Laid-Open No. H10-221257

[Summary of Invention]

[Technical Problem]

[0010]

However, since the diving visual inspection is an inspection relying on a human visual inspection as described above, it cannot completely exclude a risk of oversight. It is also pointed out that the accuracy of the inspection depends on the skill and experience of the inspector. Furthermore, it has been pointed out that this inspection cannot be applied to sewer pipes having small and medium diameters, it is essential to ensure the safety of inspectors, and long inspection time increases

burdens to be imposed on inspectors and makes it difficult to enhance inspection efficiency.

[0011]

The pipe opening camera inspection is an inspection in which the pipe opening camera is fixed to a manhole, and imaging is performed while appropriately using a zoom function. For this reason, with respect to an inner wall at a location far from a pipe opening at which the pipe opening camera is fixed, the state of the inner wall can only be imaged at a shallow angle. Therefore, it is difficult to correctly grasp the deterioration state of the inner wall at the location far from the pipe opening. It is generally said that abnormalities such as breakage are more likely to occur at locations far from a pipe opening, and from this point, there is a risk that abnormalities far from the pipe opening camera are overlooked at the screening stage, and the accuracy of the inspection may be deteriorated as a whole. In addition, it has also been pointed out that the inspection time is long and it is difficult to increase the inspection efficiency because in addition to abnormality diagnosis in the field, abnormality diagnosis is also performed later by checking recorded images indoors.

[0012]

As described above, in the self-propelled television camera inspection, a series of routines for inserting the

self-propelled television camera into a pipe, monitoring the inside of the pipe, manipulating the lens, performing necessary imaging, and withdrawing the self-propelled television camera is repetitively performed span by span, so that the inspection time is long and it is difficult to enhance the inspection efficiency, which make the inspection cost higher. Furthermore, it has also been pointed out that the accuracy of the inspection tends to vary depending on the skill of the operator.

[0013]

The present invention has been made to solve the above-mentioned problems, and has an object to provide a floating device for an in-pipe inspection, an in-pipe inspection method and an in-pipe inspection system that can inspect the inside of a sewer pipe accurately and efficiently as compared with prior arts although they are simple.

[Solution to Problems]

[0014]

[1] A floating device for in-pipe inspection capable of floating in sewage inside a pipe to inspect properties of a pipe inside of a sewer pipe, comprises:

- a light for illuminating the pipe inside;

- a camera for imaging at least an inner wall of the pipe inside and outputting image data obtained by the imaging;

a timer for outputting time data for associating position data of the floating device for in-pipe inspection with each of the image data;

an accelerometer for measuring acceleration of the floating device for in-pipe inspection and outputting acceleration data;

a storage device for storing the time data, the acceleration data, and the image data;

a casing that accommodates at least the camera, the timer, the accelerometer, and the storage device, and defines an outer shape of a main body of the floating device for in-pipe inspection; and

a posture control means.

The casing has an imaging window that is provided to correspond to at least a part of a view angle at which the camera images, and through which light from an outside passes, and the posture control means controls a posture of the main body so that the camera and the imaging window are kept above a water surface of the sewage.

[0015]

[2] In the floating device for in-pipe inspection of another aspect of the present invention, the camera is preferably an omnidirectional camera.

[0016]

[3] In the floating device for in-pipe inspection of another aspect of the present invention, the posture

control means preferably includes at least a rope having one end side connected to a side surface of the main body, and a sea anchor that is connected to the other end side of the rope and flows in the sewage while leading the main body.

[0017]

[4] In the floating device for in-pipe inspection of another aspect of the present invention, the sea anchor is preferably configured to float in the sewage more easily than the main body.

[0018]

[5] In the floating device for in-pipe inspection of another aspect of the present invention, it is preferable that the main body has a spherical shape, the light and the camera are provided inside an upper hemisphere, and the imaging window forms at least a part of an outer shell of the upper hemisphere.

[0019]

[6] The floating device for in-pipe inspection of another aspect of the present invention preferably further comprises a radio wave transmission means for transmitting a radio wave from the floating device for in-pipe inspection to an outside.

[0020]

[7] An in-pipe inspection system according to the present invention is an in-pipe inspection system for inspecting properties of an inside of a sewer pipe in a sewerage

pipeline tracing continuously to at least manholes at three or more places, comprising:

- the floating device for in-pipe inspection described in [6];

- an in-hole antenna arranged in a vertical hole of each of the manholes; and

- a reception device that is connected to the in-hole antenna and receives a radio wave captured by the in-hole antenna,

wherein when passing a vicinity of the manhole, the floating device for in-pipe inspection transmits a radio beacon to an outside by the radio wave transmission means at least, and when receiving the radio beacon, the reception device outputs passage information of the floating device for in-pipe inspection based on reception of the radio beacon.

[0021]

[8] An in-pipe inspection method is an in-pipe inspection method for inspecting properties of an inside of a sewer pipe by using the floating device for in-pipe inspection described above, comprising:

- a step of casting the floating device for in-pipe inspection into the sewer pipe from a manhole;

- a pipe inside image collecting step of illuminating a pipe inside by the light while floating the floating device for in-pipe inspection inside the sewer pipe, imaging at least an inner wall of the pipe

inside by the camera to collect image data, and causing the image data output by the camera to be stored into the storage device together with the time data output by the timer and the acceleration data output by the accelerometer; and

a pipe inside defect analysis step of reading out the image data, the time data, and the acceleration data stored in the storage device, analyzing each of the image data to analyze presence or absence of a defect in the pipe inside and degree of the defect, and based on the position data calculated based on the time data and the acceleration data, specifying a position where a defect exists when it is determined that the defect exists on a screen based on the image data.

[0022]

[9] In the in-pipe inspection method of another aspect of the present invention, it is preferable that the floating device for in-pipe inspection further comprises a radio wave transmission means for transmitting a radio wave to an outside, and each middle manhole located between an upstream manhole and a downstream manhole is provided with an in-hole antenna arranged in a vertical hole of the middle manhole, and a reception device that receives a radio wave captured by the in-hole antenna and is arranged at the manhole,

wherein the in-pipe image collecting step causes the floating device for in-pipe inspection to collect the

image data, and also causes the radio wave transmission means to transmit a radio beacon from the floating device for in-pipe inspection to an outside, and

wherein an existence section grasping step is executed which causes the reception device to capture the radio beacon transmitted from the floating device for in-pipe inspection and output passage information indicating that the floating device for in-pipe inspection has passed a vicinity of the manhole, thereby grasping a section in which the floating device for in-pipe inspection exists.

[0023]

The term of "inspect properties of the inside of a sewer pipe" used here means, specifically, qualitative/quantitative grasping of the degree of deterioration of the sewer pipe such as corrosion, damage, crack, and joint misalignment of the sewer pipe, the presence or absence of protrusion of a mounting pipe and the degree thereof, the degree of vertical slack in the pipe that affects flow capacity, sedimentation state of earth and sand or the like, adherence or non-adherence of mortar, oil and fat or the like to the inner wall, the intrusion of tree roots or groundwater into the pipe, or the like.

For reference, most of sewerage pipelines in Japan are ones of "natural flow-down type", which is prone to suffer the above-mentioned defects.

[Advantageous Effect of Invention]

[0024]

According to the present invention, it is possible to inspect the inside of a sewer pipe accurately and efficiently although simple as compared with a conventional technique of inspecting the inside of a sewer pipe.

[Brief Description of Drawings]

[0025]

[Figure 1] Figure 1 is a schematic diagram showing a configuration of a floating device 1 for in-pipe inspection according to a first embodiment and an example of its use.

[Figure 2] Figure 2 shows a perspective view of a main body 100 of a first embodiment.

[Figure 3] Figure 3 shows a conceptual diagram of a floating device 1 for in-pipe inspection according to the first embodiment.

[Figure 4] Figure 4 shows a schematic diagram of an example of calculating position data based on time data and acceleration data in the first embodiment.

[Figure 5] Figure 5 shows an example of a block diagram of the floating device 1 for in-pipe inspection according to the first embodiment.

[Figure 6] Figure 6 is a schematic view showing a view angle VA at which a camera 130/130a of the first embodiment performs imaging.

[Figure 7] Figure 7 is a schematic diagram showing a configuration of a floating device 2 for in-pipe inspection according to a second embodiment and an example of its use.

[Figure 8] Figure 8 shows a configuration diagram of an in-pipe inspection system 10 according to a third embodiment.

[Figure 9] Figure 9 shows a flowchart of an in-pipe inspection method according to a fourth embodiment.

[Figure 10] Figure 10 shows a cross-sectional view of main bodies 100b and 100c according to another embodiment.

[Figure 11] Figure 11 is a schematic diagram for explaining a self-propelled television camera inspection described in Patent Literature 2.

[Description of Embodiments]

[0026]

Hereinafter, embodiments of a floating device for in-pipe inspection, an in-pipe inspection system, and an in-pipe inspection method of the present invention will be described with reference to the drawings. The embodiments described below do not limit the invention according to the claims. Further, not all of components

and combinations thereof described in each embodiment are essential to the solution of the present invention.

[0027]

[First Embodiment]

A floating device for in-pipe inspection according to a first embodiment of the present invention is configured so that a light, a camera, a device for obtaining position data of the floating device for in-pipe inspection (for example, an accelerometer and a timer), and a storage device are installed in a main body of the floating device (hereinafter, simply referred to as "main body"), for example, configured as a semitransparent spherical casing. When this floating device for in-pipe inspection is cast into a sewer pipe, it floats along with sewage, so that the floating device for in-pipe inspection sequentially captures images of the inner wall and the like inside the pipe by the built-in camera while floating. The details will be described below.

[0028]

1. Configuration of floating device 1 for in-pipe inspection according to first embodiment

Figure 1 is a schematic diagram showing a configuration of a floating device 1 for in-pipe inspection according to the first embodiment and an example of its use. Figure 2 shows a perspective view of a main body 100 of the first embodiment. Figure 3 shows

a conceptual diagram of the floating device 1 for in-pipe inspection according to the first embodiment.

[0029]

(1) Outline of floating device 1 for in-pipe inspection

As shown in Figure 1, the floating device 1 for in-pipe inspection according to the first embodiment is a device which can float in sewage 890 in the pipe inside 811 of a sewer pipe 810 (hereinafter, may be simply referred to as "pipe inside 811") in order to inspect the property of the pipe inside 811. When the floating device 1 for in-pipe inspection is cast into the sewer pipe 810, the floating device 1 floats downstream together with the sewage 890 flowing in the pipe inside 811. In the example of the embodiment, the floating device 1 for in-pipe inspection is roughly divided into a main body 100 and posture control means 200.

[0030]

As shown in Figure 2, the floating device 1 for in-pipe inspection includes a light 120, a camera 130, a timer 162, an accelerometer 140, and a storage device 163, and at least the camera 130, the timer 162, the accelerometer 140 and the storage device 163 are accommodated and packaged inside the casing 110.

Further, the floating device 1 for in-pipe inspection comprises a posture control means 200 (see Figure 1).

[0031]

The casing 110 in the present embodiment is formed by connecting an upper casing 112 constituting an upper hemisphere and a lower casing 114 constituting a lower hemisphere and forms a sphere as a whole. For convenience of description, a boundary portion between the upper hemisphere and the lower hemisphere is referred to as "equator", and when an elevation angle at which the equator is viewed from the center of the sphere is set to 0° , a point at an elevation angle of 90° in the upper hemisphere is referred to as "zenith Z".

The detailed description of each component is continued as follows.

[0032]

(2) Light 120

The light 120 illuminates the pipe inside 811. In the present embodiment, a thin LED (Light Emitting Diode) 120a can be used as the light 120. The LED 120a is of a tape type and is attached to the inner surface of the upper casing 112 made of a transparent material. The LED 120a can project light to the pipe inside 811 (including the inner wall 818) of the sewer pipe to illuminate the pipe inside 811. For example, a plurality of LEDs 120a (for example, 10 LEDs) are arranged above the circumference (edge) near the equator of the upper casing 112 at equal intervals (see Figure 2).

The light 120 is sufficient if it can illuminate the pipe inside 811, and therefore it may be incorporated in

the casing 110 (that is, the main body 100) as shown in Figs. 1 and 2, or arranged outside the casing 110 (not shown).

[0033]

(3) Camera 130

The camera 130 images the state of the pipe inside 811 (at least the inner wall 818), and outputs image data obtained by the imaging. The camera 130 includes an imaging element 132, a lens 134, etc. (see Figure 2). The camera 130 used in the present embodiment is expected to image the state of the pipe inside 811 as broadly as possible. Therefore, the camera 130 is preferably provided with a wide-angle lens. Therefore, the camera 130 is preferably an omnidirectional camera 130a.

[0034]

In the present embodiment, an omnidirectional camera 130a having a fisheye lens 134a is used as the camera 130. As a specification of the omnidirectional camera 130a, for example, when the omnidirectional camera 130a is placed upright with the zenith Z set as the upper side, the omnidirectional camera 130a can capture images while covering one round (360°) along a horizontal line parallel to the equator. In addition, the omnidirectional camera 130a can preferably capture images while covering, for example, an elevation angle range wider than a range of 0° to 90° (for example, from -30° to 90°, that is, from -30° below the horizontal line up to

90° at the zenith) (see also Figure 6 described later in combination).

[0035]

The camera 130 is not limited to the omnidirectional camera 130a as long as it can image the state of the pipe inside 811 in a wide range. For example, a plurality of cameras having relatively narrow-angle lenses may be introduced, and images captured by those cameras may be combined with one another to perform wide-range imaging. Further, it is possible to introduce a method in which a camera having a lens with a relatively narrow angle is used, and the optical axis of the lens of the camera is appropriately scanned, so that a wide range is imaged.

[0036]

(4) Timer 162, accelerometer 140 and storage device 163

For example, GPS radio waves from GPS (Global Positioning Satellite) do not reach the pipe inside 811, so that it is impossible to directly know the position of the camera 130 (imaging position, imaging coordinates), and thus the position of the floating device 1 for in-pipe inspection when imaging is performed in the pipe inside 811.

Therefore, as shown in Figure 3, the imaging position is indirectly calculated by using the timer 162 and the accelerometer 140, and linked with data of the imaging position (position data) corresponding to each image data. Specifically, based on time data obtained by

the timer 162 and acceleration data obtained by the accelerometer 140, position data of the floating device 1 for in-pipe inspection (at least data of an imaging position when the camera 130 performs imaging) can be obtained.

By grasping a time point (or time) at (for) which imaging has been performed, position data can be linked to the image data while also considering acceleration data (details will be described later with reference to Figure 4).

[0037]

The timer 162 is used to associate the position data of the floating device 1 for in-pipe inspection with each image data obtained by the camera 130 imaging the pipe inside 811, and outputs time data (see Figure 3).

Here, the "time data" is data relating to time, and may be, for example, actual time data, or data over a lapse time from the time point when the floating device 1 for in-pipe inspection is cast into the pipe.

The "timer 162" in this case only needs to be able to grasp the time, and it is possible to use any one of an electronic device (RTC 162a) installed in a controller 160 (described later) as shown in Figure 5, a built-in timer in the camera 130 when the camera 130 is incorporated with the built-in timer, a built-in timer in the accelerometer 140 when the accelerometer 140 is incorporated with the built-in timer, and the like.

[0038]

The accelerometer 140 measures the acceleration of the floating device 1 for in-pipe inspection and outputs acceleration data (see Figure 3). The "acceleration data" in this case is data related to acceleration. For example, it may be data representing the value of acceleration itself at a certain specific time point or may be data representing the transition of acceleration with respect to the time axis. Further, the acceleration data may be data representing the value of a velocity obtained by integrating acceleration over time.

[0039]

The storage device 163 stores the above-described time data, acceleration data, and image data (see Figure 3). The storage device 163 may store data other than these data, programs, and the like.

[0040]

(5) Example of calculation of position information based on time information and acceleration information

Figure 4 shows a schematic diagram of an example of calculating position data based on time data and acceleration data in the first embodiment. Specifically, Figure 4 shows a schematic diagram of a sewerage pipeline when the sewerage pipeline is viewed from the sky.

As shown in Figure 4, it is assumed that the floating device 1 for in-pipe inspection is moving from, for example, a manhole 800a to a manhole 800b.

The velocity of the floating device 1 for in-pipe inspection when the floating device 1 has passed a point P1 of the sewer pipe 810 is represented by V_a , the velocity of the floating device 1 when the floating device 1 has passed a point P2 is represented by V_b , the velocity of the floating device 1 when the floating device 1 has passed a point P3 is represented by V_c , the velocity of the floating device 1 when the floating device 1 has passed a point P4 is represented by V_d , the velocity of the floating device 1 when the floating device 1 has passed a point P5 is represented by V_e , and the velocity of the floating device 1 when the floating device 1 has passed a point P6 is represented by V_f .

The velocity at each point can be obtained based on acceleration information output by the accelerometer 140 when the floating device 1 has passed each point. For example, if the acceleration data output by the accelerometer 140 is an acceleration value, the velocity can be obtained by integrating the acceleration value at the time of passing the point by the time t .

If time data output by the timer 162 is an actual time point, a time required for the floating device 1 for in-pipe inspection to move between adjacent points can be obtained by subtracting a passage time point at a just-before passed point from an actual time point at which a point of interest has been passed (see t_1 , t_2 , t_3 , t_4 , t_5 in Figure 4).

The floating device 1 for in-pipe inspection moves at a substantially constant velocity between adjacent points, for example, the length L1 between points P1 and P4 can be calculated by an approximate expression of $L1 \div V_{at1} + V_{bt2} + V_{ct3}$. In other words, "position data" indicating a position (coordinate) offset downstream from the manhole 800a by the length of L1 obtained from $L1 \div V_{at1} + V_{bt2} + V_{ct3}$ can be calculated as the position information of the point P4.

[0041]

Therefore, for example, when the state of the pipe inside 811 is imaged at each of the points P1 to P6 to obtain respective image data, each of the image data can be associated and linked with position data of each of the points P1 to P6 obtained by an equation similar to the above approximate expression.

By performing such association (linkage), for example, when a crack of the sewer pipe 810 is found in image information (photograph) of the point P4, the position of the crack can be specified on the assumption that the crack exists at a position indicated by the position data of the point P4 linked to the image data of the point P4 (a position offset from the manhole 800a by the length L1).

[0042]

(6) Installation of components in floating device 1 for in-pipe inspection

The timer 162, the accelerometer 140, and the storage device 163 may be mounted on a printed circuit board (not shown). Further, the controller 160 may be configured by the timer 162, the storage device 163, etc. (see portions indicated by the dotted lines in the lower hemisphere of Figure 2).

[0043]

Figure 5 shows an example of a block diagram of the floating device 1 for in-pipe inspection according to the first embodiment.

As shown in Figure 5, the controller 160 includes a processor 161, an RTC (Real Time Clock) 162a as the timer 162, a memory 163a as the storage device 163, a transmission circuit 166 constituting a radio wave transmission means 170 described later, a power supply circuit 165, an interface circuit 164 and the like.

[0044]

The camera 130, an acceleration sensor 140a as the accelerometer 140 and an LED 120a as the light 120 are connected to the interface circuit 164. The interface circuit 164 interfaces them with a bus 168.

The interface circuit 164, the memory 163a, the RTC 162a, etc. are connected to the processor 161 via the bus 168. The processor 161 operates based on a program (not shown). The operation by the processor 161 controls, for example, to capture image data from the camera 130 and store the image data in the memory 163a, to capture real-

time data as time data from the RTC 162a in connection with each imaging operation and store the real-time data as an imaging time point in the memory 163a, to capture acceleration data from the acceleration sensor 140a at an appropriate timing and store the acceleration data in the memory 163a, to calculate position data based on time data and acceleration data (for example, see the foregoing), to link position data corresponding to respective image data, etc.

The transmission circuit 166 is a circuit for transmitting radio waves from the floating device 1 for in-pipe inspection to the outside (details will be described later).

The power supply circuit 165 is connected to a battery 150a serving as an electrical storage device 150, and generates power required for the controller 160, the input/output device (the camera 130, the acceleration sensor 140a, the LED 120a, etc.), the transmission circuit 166, etc. to operate.

The acceleration sensor 140a may be mounted on the above-described printed circuit board together with the component group constituting the controller 160 (see Figure 2). Further, as the electrical storage device 150 a capacitor or the like may be used in addition to the battery 150a (so-called primary battery, secondary battery, etc.). Further, the timer 162 to be mounted in

the controller 160 is not limited to the RTC 162a, and a simple clock may be adopted, for example.

The mounting configuration described here is just an example and should not be construed as being limited in the present invention.

[0045]

(7) Casing 110

Next, the casing 110 will be described with reference to Figs. 2 and 6.

The casing 110 accommodates at least the camera 130, the timer 162, the accelerometer 140, and the storage device 163. In the present embodiment, in addition to these components, the casing 110 accommodates the light 120 (LED 120a), the electrical storage device 150 (battery 150a), the radio wave transmission means 170 including the transmission circuit 166, the controller 160, and the like.

[0046]

The casing 110 may be configured to be divided into the upper casing 112 and the lower casing 114 as described above. In the present embodiment, a circular lid-shaped transparent plastic whose outer surface is hemispherical is used as the upper casing 112, and hemispherical polystyrene foam (styrene foam) is used as the lower casing 114.

[0047]

When the upper casing 112 and the lower casing 114 are assembled, the casing 110 in which the space between the upper casing 112 and the lower casing 114 is sealed can be obtained. The inside and the outside of the casing 110 are separated by the casing 110, so that liquid such as sewage does not invade into the casing 110. As a result, the main body 100 produces buoyancy with respect to sewage as a whole.

The specific gravity of the main body 100 is appropriately set to generate buoyancy with respect to the sewage 890. Further, the specific gravity of the main body 100 is appropriately set so that the draft of the main body 100 has a predetermined relationship with the draft of a sea anchor (described later) (details will be described later).

[0048]

The casing 110 is provided with an imaging window 113 which is provided to correspond to at least a part of a view angle at which the camera 130 performs imaging and through which light from the outside passes.

The "imaging window 113" is configured such that reflected light generated when light from the light 120 is reflected from an object in the pipe inside 811 passes (including "is transmitted") through this "window". The camera 130 can capture images of the state of the pipe inside 811 through the "imaging window 113". Conversely, it is preferable that the "imaging window 113" is

configured by a transparent member through which the state of the pipe inside 811 can be imaged.

[0049]

In the present embodiment, the main body 100 has a spherical shape, and includes the light 120 and the camera 130 inside the upper hemisphere (upper casing 112). The imaging window 113 forms at least a part of the outer shell of the upper hemisphere.

[0050]

Figure 6 is a schematic diagram showing a view angle VA at which the camera 130/130a of the first embodiment performs imaging. Specifically, Figure 6 is a diagram when a plane including the optical axis of the omnidirectional camera 130a and the zenith Z of the omnidirectional camera 130a is viewed vertically (that is, the omnidirectional camera 130a is viewed from the lateral side thereof).

As a specification of the omnidirectional camera 130a to be used in the embodiment, if the elevation angle is, for example, -30° to 90° (that is, if imaging can be performed from -30° below the horizontal line up to 90° at the zenith Z), the view angle VA centered on the omnidirectional camera 130a is 240° (see Figure 6).

As a range in which the imaging window 113 is provided, the imaging window 113 may be provided only in a part of the above range of the view angle VA (only a necessary range). It is needless to say that the imaging

window 113 may be provided over a range covering the entire range of the view angle VA (or a range larger than the above range).

In the present embodiment, the whole of the upper casing 112 is made of a transparent material (transparent plastic), and the entire range of the upper casing 112 is set as the imaging window 113 (see an area between A and B in Figs. 2 and 6).

[0051]

The casing 110 defines the outer shape of the main body 100 of the floating device 1 for in-pipe inspection.

It is preferable that the main body 100 whose outer shape is defined by the casing 110 is spherical. In other words, it is preferable that the outer shape has no particular corner (convex portion). In the present embodiment, the outer shape of the main body 100 is approximately a sphere. At this time, the diameter of the main body 100 is selected according to the diameter of a sewer pipe as an inspection target. Specifically, for example, the diameter of the main body 100 is set to 100 mm for the inspection of a sewer pipe having an opening diameter of 200 mm to 350 mm, and the diameter of the main body 100 is set to 150 mm for the inspection of a sewer pipe having an opening diameter of 400 mm to 600 mm.

The outer shape of the main body 100 is not limited to the spherical shape, and may be, for example, a

rectangular parallelepiped shape or an annular shape (donut-like shape).

[0052]

(8) Posture control means 200

The floating device 1 for in-pipe inspection is cast into the pipe inside 811 of a sewer pipe, and images the pipe inside 811 while moving along with the natural flow of sewage 890. Therefore, the posture control of the main body 100 while the main body 100 is drifted by the sewage 890 is extremely important. For example, when the main body 100 has a spherical outer shape as in the present embodiment, the main body 100 is easily rotated by an external force such as the flow of the sewage 890. If the main body 100 rotates, the optical axis along which the camera 130 captures images also rotates accordingly, so that captured images also become images of indefinite angles, which may be recorded as erroneous image data. As a result, it is impossible to appropriately image the pipe inside 811, and it is difficult to specify the position of a damaged portion of the pipe inside 811. Therefore, the floating device 1 for in-pipe inspection comprises a posture control means 200 for controlling the posture of the main body 100.

[0053]

The posture control means 200 controls the posture of the main body 100 to keep the camera 130 and the imaging window 113 above the surface of the sewage 890.

In other words, the posture control means 200 controls the position of the main body 100 so that the imaging surface of the camera 130 faces upwards, and the imaging window 113 is also positioned above the sewage 890 to enable the camera 130 to mainly image an inner wall 818 at an upper side of the pipe inside 811.

[0054]

Although not shown, when the main body 100 is placed upright on a horizontal plane, an axis connecting the zenith Z of the main body 100 and the center of the main body 100 is defined as a first axis, an axis connecting a side portion A of the main body 100 in a flowing direction of the main body 100 (at a forward side of progress), the center of the main body 100 and a side portion B of the main body 100 at a rearward side of progress is defined as a second axis, and an axis which is vertical to the first axis and the second axis and passes through the center of the main body 100 is defined as a third axis (strictly speaking, each axis can be defined while centered on the camera 130. An axis connecting a direction (zenith Z) opposite to a vertical direction with respect to viewing from the camera 130 and the center of the camera 130 may be defined as the first axis, and likewise the second axis and the third axis can be defined while centered on the camera 130.).

When defined in this way, more specifically, the above-mentioned "controlling the posture" means to

control the main body 100 so that with respect to the axis of the sewer pipe 810, the main body 100 rotates about the first axis as less as possible, rotates about the second axis as less as possible, and rotates about the third axis as less as possible.

[0055]

The posture control means 200 may be implemented by using any mechanism and principle as long as it can maintain the posture of the main body 100 as described above. For example, the center of gravity may be located at a position which is as low as possible in the lower casing 114 by making the mass of the lower hemisphere larger than that of the upper hemisphere of the floating device 1 for in-pipe inspection. In that case, the posture control means 200 is the lower hemisphere having a larger mass than the upper hemisphere, or the lower hemisphere having the center of gravity of the floating device 1 for in-pipe inspection.

[0056]

In the present embodiment, as shown in Figure 1, the posture control means 200 is configured by at least a rope 220 having one end side connected to a side surface (a portion indicated by an arrow A) of the main body 100, and a sea anchor which is connected to the other end side of the rope 220 and flows in the sewage 890 while leading the main body 100.

The sea anchor 210 has an elliptic spherical shape (a rugby ball shape) and can move above the main body 100 in the sewage 890 while generating buoyancy with respect to the sewage 890. In other words, the sea anchor 210 is configured to have a lower specific gravity than the main body 100. This point will be described in detail later.

When the main body 100 having a diameter of 150 mm is controlled, the shape of the sea anchor 210 is, for example, a rugby ball shape having a major axis of 30 mm and a minor axis of 10 mm. Further, the length of the rope 220 is set such that the separation distance between the main body 100 and the sea anchor 210 is 500 mm.

[0057]

By configuring the sea anchor 210 so that the sea anchor 210 leads the main body 100 as described above, the sea anchor 210 can tow the main body 100 in the flowing direction of the sewage 890.

[0058]

As described above, in the present embodiment, the sea anchor 210 is configured to float in the sewage 890 more easily than the main body 100.

More specifically, the sea anchor 210 is preferably configured so that it is capable of capturing the flow of the sewage 890 flowing in the pipe inside 811, and the draft d_2 of the sea anchor 210 is set to be different from the draft d_1 of the main body 100 as shown in Figure

1, so that the sea anchor 210 flows antecedent to the main body 100.

When the sewer pipe 810 is cross-sectionally viewed on a plane perpendicular to the axis of the sewer pipe 810, the flow velocity of the sewage 890 varies depending on the place (a place near the water surface, a place under the water surface, a place in contact with the inner wall of the sewer pipe, etc.). In the present embodiment, the draft d2 of the sea anchor 210 is set according to such a difference in flow velocity. For example, the draft d1 of the main body 100 is set so that the contact surface of the main body 100 with the sewage 890 mainly comes into contact with a place where the flow velocity is slow (for example, a deep portion of the sewage 890 with respect to the water surface), while the draft d2 of the sea anchor 210 is set so that the contact surface of the sea anchor 210 with the sewage 890 mainly comes into contact with a place where the flow velocity is high (for example, a shallow portion of the sewage 890 with respect to the water surface).

[0059]

In the present embodiment, the posture control means 200 comprises the rope 220 and the sea anchor 210 connected to the main body 100 via the rope 220. But, the posture control means is not limited to this configuration. For example, the posture control means 200 may be in close contact with the outer surface of the

main body 100 or embedded inside the main body 100 as long as the posture control means 200 can contribute to causing the main body 100 to float while keeping the upper hemisphere at the water surface position of the sewage 890 as much as possible.

[0060]

(9) Radio wave transmission means 170

In addition to the above configuration, the floating device 1 for in-pipe inspection further comprises a radio wave transmission means 170 for transmitting radio waves from the floating device 1 for in-pipe inspection to the outside.

The radio wave transmission means 170 may transmit a radio wave of any specification as long as it can specify a section (place) of a sewerage pipeline in which the floating device 1 for in-pipe inspection currently flows as described later. Further, the circuit configuration and the like may be arbitrary.

[0061]

In the present embodiment, the radio wave transmission means 170 is configured with a beacon that always transmits a predetermined radio wave (radio beacon). As shown in Figure 5, the radio wave transmission means 170 is configured by a transmission circuit 166 for transmitting a radio beacon, and a built-in antenna 167 connected to the transmission circuit 166 to output the radio beacon.

In the present embodiment, the radio wave transmission means 170 is configured to always transmit the radio beacon. But, the radio wave transmission means is not limited to this configuration. The radio wave transmission means 170 may be configured to detect approaching of a manhole 800 by some method and emit a radio wave only while passing the vicinity of the manhole 800.

[0062]

2. How to use floating device 1 for in-pipe inspection according to first embodiment

The floating device 1 for in-pipe inspection can typically be used as follows.

It is assumed that a sewer pipe between an upstream manhole and a downstream manhole will be inspected.

The floating device 1 for in-pipe inspection is cast from the upstream manhole to put the floating device 1 for in-pipe inspection into the pipe inside 811 of the sewer pipe. The floating device 1 for in-pipe inspection floats with the flow of sewage 890. When the floating device 1 for in-pipe inspection floats, the posture of the main body 100 (especially the camera 130) is kept by the posture control means 200. The floating device 1 for in-pipe inspection images the state of the pipe inside 811 (at least the inner wall 818) with the camera 130 while floating, and each image data output by the imaging

is associated (linked) with position data acquired based on time data, acceleration data, and the like.

The floating device 1 for in-pipe inspection is withdrawn at the downstream manhole. Each image data stored in the storage device 163 of the floating device 1 for in-pipe inspection is analyzed to analyze the presence or absence of a defect in the pipe inside 811 and the degree of the defect. When it is determined that a defect exists, a position where the defect exists is specified based on position data associated with the image data of the defect.

[0063]

Further, with respect to a middle manhole located between the upstream manhole and the downstream manhole of the sewerage pipeline as an inspection target, it is detected by capturing a radio beacon transmitted by the floating device 1 for in-pipe inspection that the floating device 1 for in-pipe inspection has passed the vicinity of the middle manhole, thereby grasping a section where the floating device 1 for in-pipe inspection is present, whereby the floating device 1 for in-pipe inspection is steadily withdrawn.

The details will be described with respect to third and fourth embodiments.

[0064]

3. Effect of floating device 1 for in-pipe inspection according to first embodiment

(1) The floating device 1 for in-pipe inspection includes the light 120 for illuminating the pipe inside 811, the camera 130 for imaging the state of the pipe inside 811 (at least the inner wall 818) and outputting image data obtained by the imaging, the timer 162 for outputting time data for associating position data of the floating device 1 for in-pipe inspection with each image data, the accelerometer 140 for measuring acceleration of the floating device 1 for in-pipe inspection and outputting acceleration data, the storage device 163 for storing the time data, the acceleration data and the image data, the casing 110 that accommodates at least the camera 130, the timer 162, the accelerometer 140, and the storage device 163 therein, and defines the outer shape of the main body 100 of the floating device 1 for in-pipe inspection, and the posture control means 200. The casing 110 includes the imaging window 113 which is provided to correspond to at least a part of the view angle at which the camera 130 images and through which light from the outside passes.

The posture control means 200 controls the posture of the main body 100 so that the camera 130 and the imaging window 113 are kept above the water surface of the sewage 890.

[0065]

Since the floating device 1 for in-pipe inspection is configured in this way, buoyancy can be obtained by the casing 110, and when the floating device 1 for in-

pipe inspection is cast into the pipe inside 811, it floats together with the sewage 890. The floating device 1 for in-pipe inspection successively captures images of the state of the pipe inside 811 (at least the inner wall 818) illuminated by the light 120 through the imaging window 113 by the camera 130 while floating, and stores each captured image data into the storage device 163.

Therefore, it is possible to image the state of the pipe inside along natural downflow of the floating device 1 for in-pipe inspection with neither a human's (inspector's) diving into the pipe inside 811 nor manipulation of the camera 130 or the like on the ground.

Therefore, as compared to the conventional technique for inspecting the inside of the sewer pipe, it is possible to conduct a simple and efficient inspection.

[0066]

Further, the posture of the main body 100 (incorporated with the camera 130) can be appropriately maintained by the posture control means 200, the camera 130 can always keep approximately the same angle and the same direction with respect to the axis of the sewer pipe 810 (the downflow direction of the sewage 890), and it is possible to perform stable imaging of the state of the pipe inside under the same condition.

Further, the floating device 1 for in-pipe inspection moves in the pipe inside 811 along with the flow of the sewage 890, and performs imaging sequentially,

and it is possible to image the state of the pipe inside 811 (particularly, the inner wall 818) from a close position. Therefore, it is possible to grasp the presence or absence of a defect (damage, deterioration, or the like) and the degree of the defect with high accuracy, and it is possible to dramatically reduce the risk of overlooking a place where a defect has occurred.

Further, each image data obtained by imaging is associated (linked) with position data calculated by the accelerometer 140, the timer 162, etc. Therefore, even when an analysis of a sewerage pipeline as an inspection target is performed separately, it is possible to easily specify a position of the sewerage pipeline where a defect (damage, deterioration, or the like) exists. In other words, the position of the defective portion can be specified with high accuracy.

Therefore, it is possible to perform a highly accurate inspection as compared with the conventional technique for inspecting the inside of a sewer pipe.

[0067]

According to the floating device 1 for in-pipe inspection of the first embodiment, the inside of the sewer pipe can be inspected accurately and efficiently although it is simple as compared with the prior art.

[0068]

(2) The camera 130 is an omnidirectional camera 130a. Since the omnidirectional camera 130a can obtain image

information in a wide angle range, it is possible to reduce the risk of overlooking defects (damage, deterioration, etc.), and it is possible to enhance the accuracy of confirming the presence or absence of a defect (damage, deterioration or the like) and the degree of the defect.

[0069]

(3) The posture control means 200 is configured by at least the rope 220 having one end side connected to the side surface of the main body 100, and the sea anchor 210 which is connected to the other end side of the rope 220 and flows in the sewage 890 while leading the main body 100.

Since the sea anchor 210 is configured to lead the main body 100 in this way, the sea anchor 210 will unilaterally pull the side surface (near A in Figure 1) of the main body 100. As a result, the main body 100 is towed so that a straight line connecting A and B in Figure 1 is substantially aligned with the axis of the sewer pipe 810 (the downflow direction of the sewage 890) while kept in a substantially horizontal position, and the side surface thereof indicated by A always faces the downflow direction. Therefore, the main body 100 can be more reliably kept in an appropriate posture.

[0070]

(4) The sea anchor 210 is configured to float in the sewage 890 more easily than the main body 100.

With such a configuration, as compared with places of the sewage 890 where the bottom and side surfaces of the main body 100 come into contact with the sewage 890 (places when viewed as a cross-section), the bottom and side surface of the sea anchor 210 can be brought into contact with places of the sewage 890 where the flow velocity of the sewage 890 is relatively high (a shallow portion when viewed from the water surface). Therefore, the sea anchor 210 can lead the main body 100 more appropriately, and the posture of the main body 100 can be kept more appropriately.

[0071]

(5) The main body 100 of the floating device 1 for in-pipe inspection has a spherical shape, and the imaging window 113 is configured to form at least a part of the outer shell of the upper hemisphere of the spherical main body 100.

The main body 100 is spherical and has few hooking portions. Therefore, even if there is an obstacle (earth and sand, mortar, oil and fat, tree root or the like) in the pipe inside 811, the main body 100 (and further the floating device 1 for in-pipe inspection) can be relatively reliably made to flow to a downstream manhole. Furthermore, since at least a part of the outer shell of the upper hemisphere is configured to serve as the imaging window 113, the camera 130 can image the state of

the pipe inside 811 through the imaging window 113 as long as the posture of the main body 100 is maintained.

[0072]

(6) The floating device 1 for in-pipe inspection further includes the radio wave transmission means 170 for transmitting a radio wave from the floating device 1 for in-pipe inspection to the outside.

Since the radio wave transmission means 170 transmits a radio wave to the outside, for example, like a beacon, the existing position of the floating device 1 for in-pipe inspection can be specified at the outside by capturing the radio wave. As a result, it is possible to ensure the withdrawal of the floating device 1 for in-pipe inspection (details on position determination and withdrawal of the floating device for in-pipe inspection will be described later).

[0073]

[Second Embodiment]

Next, a floating device 2 for in-pipe inspection according to a second embodiment will be described.

Figure 7 is a schematic diagram showing a configuration of the floating device 2 for in-pipe inspection according to the second embodiment and an example of its use. In the second embodiment, components having the same basic configurations and characteristics as those of the first embodiment are represented by the

same reference signs as those of the first embodiment, and the description thereof will be omitted.

[0074]

The floating device 2 for in-pipe inspection according to the second embodiment basically has the same configuration as the floating device 1 for in-pipe inspection according to the first embodiment, but is different from the floating device 1 for in-pipe inspection in that it is further provided with an auxiliary light 300.

[0075]

In other words, as shown in Figure 7, in addition to the light 120 (LED 120a) incorporated in the main body 100, the floating device 2 for in-pipe inspection according to the second embodiment includes an auxiliary light 300 separate from the main body 100.

The auxiliary light 300 may be any material as long as it produces buoyancy when it is thrown into the sewage 890 and emits light by itself. For example, a light ball 310 may be adopted.

[0076]

In the floating device 2 for in-pipe inspection, the auxiliary light 300 (light ball 310) is connected to the main body 100, and can float integrally with the main body 100. For example, as shown in Figure 7, the floating device 2 for in-pipe inspection is configured so that the main body 100, the auxiliary light 300, and the

sea anchor 210 are connected in series through the ropes 220 on the front side (downstream side, see reference sign A in Figure 7) of the main body 100.

In addition to this configuration, it is more preferable to further include a configuration in which the main body 100 and the auxiliary light 300 are connected to each other through the rope 220 on the rear side (upstream side, see reference sign B in Figure 7) of the main body 100.

[0077]

The floating device 2 for in-pipe inspection according to the second embodiment has such a configuration, which enables the auxiliary light 300 serving as a light source to float at a position away from the main body 100 in addition to the light 120 (LED 120a) incorporated in the main body 100. As a result, the pipe inside can be illuminated at a position far from the camera 130, and the state of the pipe inside at a position far from the camera 130 can be imaged more clearly, so that the accuracy of inspection can be further enhanced.

[0078]

The floating device 2 for in-pipe inspection according to the second embodiment has basically the same configuration as the floating device 1 for in-pipe inspection according to the first embodiment except that the auxiliary light 300 is further provided. Therefore,

the corresponding effects among the effects of the floating device 1 for in-pipe inspection according to the first embodiment are similarly exhibited.

[0079]

[Third Embodiment]

Next, an in-pipe inspection system 10 according to a third embodiment will be described.

Figure 8 shows a configuration diagram of the in-pipe inspection system 10 according to the third embodiment. Specifically, Figure 8 shows a cross section of an underground condition and an aboveground condition, which is taken in the vertical direction along the axis of the sewerage pipeline. In the third embodiment, the same signs as those in the first and second embodiments are used for the components having the same basic configurations and characteristics as those in the first and second embodiments, and the description thereof will be omitted.

[0080]

1. Configuration of in-pipe inspection system 10 according to third embodiment

As shown in Figure 8, the in-pipe inspection system 10 according to the third embodiment is an in-pipe inspection system for inspecting the properties of the inside of the sewer pipe 810 of a sewerage pipeline tracing continuously to at least manholes at three or

more places (manholes 800x, 800a, 800b, 800c, 800y in Figure 8).

The in-pipe inspection system 10 according to the third embodiment includes the floating devices 1, 2 for in-pipe inspection, in-hole antennas 550, and reception devices 500.

[0081]

Each of the floating devices 1, 2 for in-pipe inspection in this case is assumed to be the floating device 1 for in-pipe inspection according to the first embodiment or the floating device 2 for in-pipe inspection according to the second embodiment, which particularly includes the radio wave transmission means 170.

Each of the floating devices 1, 2 for in-pipe inspection is configured to transmit a radio beacon to the outside by the radio wave transmission means 170 at least when passing the vicinity of the manhole.

[0082]

The in-hole antenna 550 is arranged in a vertical hole 805 of the manhole 800.

In Figure 8, the in-hole antennas 550 are arranged in vertical holes 805 of middle manholes 800a, 800b and 800c located between an upstream manhole 800x from which each of the floating device 1, 2 for in-pipe inspection is cast and a downstream manhole 800y from which each of

the floating devices 1, 2 for in-pipe inspection is withdrawn.

[0083]

The reception device 500 is connected to the in-hole antenna 550 and receives radio waves captured by the in-hole antenna 550. For example, the reception device 500 is arranged on the ground to correspond to each of the middle manholes 800a, 800b, and 800c described above. A set of the in-hole antenna 550 and the reception device 500 may be arranged in the upstream manhole 800x and the downstream manhole 800y.

[0084]

The reception device 500 is configured to output passage information of each of the floating devices 1, 2 for in-pipe inspection based on reception of a radio beacon when receiving the radio beacon.

"Output of passage information" may be performed by any method. For example, the passage information may be output to an indicator, a display unit such as a display panel, a sound device such as a buzzer or the like. In this case, an inspector on the ground can recognize the passage visually or the like, and can grasp which one of sections SC1, SC2, SC3, SC4 each of the floating devices 1, 2 for in-pipe inspection exists in.

Further, "output of passage information" may be output to a centralized management terminal 610 via wireless communication (an example of Figure 8)/wired

communication by a transmission device as described above. In Figure 8, as the reception device 500 is introduced a relay device which includes not only a reception function, but also a transmission device (no reference sign) for transmitting various kinds of information to PC, etc. by communication. Reference signs 510a, 510b, and 510c represent aerial antennas connected to such a transmission device. With this configuration, a section in which each of the floating devices 1, 2 for in-pipe inspection resides can be grasped on the display panel or the like of the centralized management terminal 610 while recognizing the passage each of the floating devices 1, 2 for in-pipe inspection.

[0085]

2. Effect of in-pipe inspection system 10 according to third embodiment

The in-pipe inspection system 10 has the above-mentioned configuration. Therefore, every time each of the floating devices 1, 2 for in-pipe inspection has passed vicinities of the middle manholes 800a, 800b, and 800c, it can be recognized that each of the floating devices 1, 2 for in-pipe inspection has successfully passed the sections SC1, SC2 and SC3 located just before the middle manholes 800a, 800b and 800c, and reached the middle manholes (passage information of the floating device for in-pipe inspection). In other words, it is

possible to grasp which section each of the floating devices 1, 2 is currently located in.

It is possible to take the following countermeasure by actively using the passage information of the floating device for in-pipe inspection. For example, if each of the floating devices 1, 2 for in-pipe inspection cannot be detected at the downstream manhole 800y even after a predetermined time has elapsed, it can be guessed that each of the floating devices 1, 2 for in-pipe inspection resides in any upstream section. At that time, a section in which each of the floating devices 1, 2 for in-pipe inspection resides is specified based on the passage information of the corresponding floating device for in-pipe inspection, a check and a measurement (for example, downflow is forcibly performed in the sewerage pipeline by using a high-pressure injection device or the like) are performed while centered on the specified section, whereby each of the floating devices 1, 2 for in-pipe inspection can be reliably withdrawn.

[0086]

[Fourth Embodiment]

Next, an in-pipe inspection method according to a fourth embodiment will be described.

Figure 9 shows a flowchart of the in-pipe inspection method according to the fourth embodiment. In the following description, not only Figure 9, but also Figure 8 and the like should be appropriately referred to.

Among components of the in-pipe inspection method according to the fourth embodiment, description on those components which are common to the components of the floating device 1 for in-pipe inspection according to the first embodiment, the floating device 2 for in-pipe inspection according to the second embodiment, and the in-pipe inspection system according to the third embodiment cites the descriptions in the first embodiment, the second embodiment and the third embodiment.

[0087]

1. Configuration of in-pipe inspection method according to fourth embodiment

The in-pipe inspection method according to the fourth embodiment is an in-pipe inspection method of inspecting the property of the inside 811 of the sewer pipe 810. The in-pipe inspection method according to the fourth embodiment performs an inspection by using the floating device 1 for in-pipe inspection according to the first embodiment or the floating device 2 for in-pipe inspection according to the second embodiment.

[0088]

As shown in Figure 9, the in-pipe inspection method according to the fourth embodiment includes at least an in-pipe inspection floating device casting step S10, an in-pipe image collecting step S20, and an in-pipe defect analysis step S50. In addition to these steps, an in-pipe inspection floating device withdrawing step S40 may

be included between the in-pipe image collecting step S20 and the in-pipe defect analysis step S50.

[0089]

In the in-pipe inspection floating device casting step S10, each of the floating devices 1, 2 for in-pipe inspection is cast from the upstream manhole (manhole 800x in Figure 8) into the inside 811 of the sewer pipe.

[0090]

In the in-pipe image collecting step S20, the pipe inside 811 is illuminated by the light 120 while each of the floating devices 1, 2 for in-pipe inspection is floated in the inside 811 of the sewer pipe, and at least the inner wall 818 of the pipe inside 811 is imaged by the camera 130 to collect image data, and image data output by the camera 130 are stored in the storage device 163 together with time data output by the timer 162, and acceleration data output by the accelerometer 140.

[0091]

In the in-pipe inspection floating device withdrawing step S40, each of the floating devices 1, 2 for in-pipe inspection that has drifted is withdrawn at the downstream manhole (manhole 800y in Figure 8).

[0092]

The in-pipe defect analysis step S50 reads out the image data, the time data, and the acceleration data stored in the storage device 163 of each of the withdrawn floating devices 1, 2 for in-pipe inspection. Further,

each image data is analyzed to analyze the presence or absence of a defect in the pipe inside 811 and the degree of the defect. In addition, when it is determined that there is a defect on the screen of the image data, a position where the defect exists is specified based on the position data which is data calculated based on the time data and the acceleration data and also is linked to the image data.

[0093]

In addition to the above configuration, the in-pipe inspection method according to the fourth embodiment preferably has the following configuration. In other words, it is preferable that an existence section grasping step S30 is performed in parallel to the in-pipe image collecting step S20 prior to the in-pipe inspection floating device withdrawing step S40 (see Figure 9).

[0094]

This is specifically as follows. First, it is assumed as a premise that each of the floating devices 1, 2 for in-pipe inspection is further provided with radio wave transmission means 170 for transmitting a radio wave to the outside, and at each of the middle manholes 800a, 800b and 800c located between the upstream manhole 800x and the downstream manhole 800y, the in-hole antenna 550 is arranged in the vertical hole 805 of the middle manhole, and the reception device 500 for receiving a

radio wave captured by the in-hole antenna 550 is arranged for each manhole (see Figure 8).

[0095]

At this time, in the in-pipe image collecting step S20, in parallel to causing each of the floating devices 1, 2 for in-pipe inspection to perform image collection, the radio wave transmission means 170 is caused to transmit a radio beacon to the outside from the floating devices 1, 2 for in-pipe inspection.

In parallel to the in-pipe image collecting step S20, the existence section grasping step S30 (see Figure 9) is executed. The existence section grasping step S30 causes the reception device 500 to capture the radio beacon transmitted from each of the floating devices 1, 2 for in-pipe inspection and output passage information representing that each of the floating devices 1, 2 for in-pipe inspection has passed the vicinity of the manhole, thereby grasping the section in which each of the floating devices 1, 2 for in-pipe inspection is present.

Then, in the above-mentioned in-pipe inspection floating device withdrawing step S40, each of the floating devices 1, 2 for in-pipe inspection is withdrawn from the manhole based on the section in which each of the floating devices 1, 2 for in-pipe inspection is present, which is grasped in the existence section grasping step S30.

[0096]

2. Effect of in-pipe inspection method according to fourth embodiment

(1) The in-pipe inspection method according to the fourth embodiment is premised on use of the floating device 1 for in-pipe inspection according to the first embodiment and the floating device 2 for in-pipe inspection according to the second embodiment. Therefore, the in-pipe inspection method according to the fourth embodiment has the corresponding effects among the effects obtained by the floating device 1 for in-pipe inspection according to the first embodiment and/or the floating device 2 for in-pipe inspection according to the second embodiment.

[0097]

(2) Further, in the in-pipe inspection method according to the fourth embodiment, each of the floating devices 1, 2 for in-pipe inspection is provided with the radio wave transmission means 170, and the in-hole antennas 550 and the reception devices 500 are arranged to correspond to the middle manholes 800a, 800b and 800c. Under this arrangement, in the in-pipe image collecting step S20, the radio wave transmission means 170 is caused to transmit the radio beacon, and in the existence section grasping step S30, the reception device 500 is caused to capture the radio beacon and output the passage information indicating that each of the floating devices 1, 2 for in-pipe inspection has passed the vicinity of a manhole of interest (see Figure 8 in combination).

Since the in-pipe inspection method according to the fourth embodiment has such a configuration, every time each of the floating devices 1, 2 for in-pipe inspection has passed the vicinity of the middle manhole 800a, 800b, 800c, it can be recognized that each of the floating devices 1, 2 for in-pipe inspection has successfully passed the section SC1, SC2, or SC3 just before the corresponding middle manhole and reached the corresponding middle manhole (passage information of the floating device for in-pipe inspection). In other words, it is possible to grasp which section each of the floating devices 1, 2 for in-pipe inspection currently resides in.

For this reason, for example, if each of the floating devices 1, 2 for in-pipe inspection cannot be detected at the downstream manhole 800y even after a predetermined time has elapsed, a section in which each of the floating devices 1, 2 for in-pipe inspection resides is specified based on the passage information of the corresponding floating device for in-pipe inspection, and a check and a measurement are performed while centered on the specified section, each of the floating devices 1, 2 for in-pipe inspection can be reliably withdrawn.

[0098]

The in-pipe inspection method based on the radio wave transmission means 170 or the like here is premised

on use of the in-pipe inspection system 10 according to the third embodiment. Therefore, the in-pipe inspection method according to the fourth embodiment likewise has the corresponding effect out of the effects obtained by the in-pipe inspection system 10 according to the third embodiment.

[0099]

[Other embodiments]

The present invention has been described based on the foregoing respective embodiments. But, the present invention is not limited to the above embodiments. The present invention can be implemented in various modes without departing from the spirit of the invention, and for example, the following modifications are possible.

[0100]

The main body 100 of each of the floating devices 1, 2 for in-pipe inspection in each embodiment is configured so that the camera 130 is arranged in the vicinity of the center of the casing 110. However, the present invention is not limited to this configuration. For example, like a main body 100b shown in Figure 10(a), a camera 130b may be arranged such that the lens thereof contacts the inner surface of the canopy-like upper casing 112. In this case, an observation window 113b is configured in a range shown in the figure. Further, as shown in Figure 10(b), the main body 100 may be configured so that a portion obtained by cutting out a part of the canopy-like upper

casing 112c is formed as an observation window 113c, and a lens 134c of a camera 130c is fitted into the cutout portion.

Figure 10 shows cross-sectional views of main bodies 100b and 100c according to other embodiments. Further, in Figs. 10(a) and 10(b), cavities C are formed inside the upper casings 112 and 112c, and the cavities C remain. However, the present invention is not limited to this configuration. For example, a predetermined material may be molded in the portions corresponding to the cavities C. [0101]

The outer shape of the main body 100 of each of the floating devices 1, 2 for in-pipe inspection in each embodiment has been described by exemplifying a substantially spherical shape. However, the present invention is not limited to this configuration. For example, it may have a so-called capsule shape or a so-called donut shape having an annular shape. [0102]

In the description of the in-pipe inspection method according to the fourth embodiment using Figure 8, Figure 9 and the like, the description has been made on the premise that the in-pipe inspection floating device withdrawing step S40 is executed. However, the present invention is not limited to this configuration. An in-pipe inspection method that does not execute the in-pipe inspection floating device withdrawing step S40 can also

be adopted. For example, the present invention may have a configuration in which when each of the floating devices 1, 2 for in-pipe inspection has passed a predetermined manhole, each of the floating devices 1, 2 for in-pipe inspection transmits the above-mentioned image data, time data, and acceleration data to the outside by the radio wave transmission means 170 with the image data, the time data and the acceleration data being carried on radio waves, and the reception device 500 receives the radio waves. By adopting such a configuration, it is possible to extract necessary data when each of the floating devices 1, 2 for in-pipe inspection has passed a predetermined manhole, so that the inspection of the pipe inside can be performed without executing the in-pipe inspection floating device withdrawing step S40.

[Reference Signs List]

[0103]

1, 2... floating device for in-pipe inspection, 10... in-pipe inspection system, 100, 100b, 100c... main body (of floating device for in-pipe inspection), 110... casing, 112... upper casing, 113...imaging window, 113b, 113c... observation window, 114... lower casing, 120... light, 120a... LED, 130, 130b, 130c... camera, 130a... omnidirectional camera, 132... imaging element, 134, 134c... lens, 134a... fisheye lens, 140... accelerometer,

140a... acceleration sensor, 150... electrical storage device, 150a... battery, 160... controller, 161... processor, 162... timer, 162a... RTC, 163... storage device, 163a... memory, 164... interface circuit, 165... power supply circuit, 166... transmission circuit, 167... built-in antenna, 168... bus, 170... radio wave transmission means, 200... posture control means, 210... sea anchor, 220... rope, 300... auxiliary light, 310... light ball, 500... Reception device, 550... in-hole antenna, 610... centralized management terminal, 800, 800a, 800b, 800c, 800x, 800y... manhole, 805... vertical hole (of manhole), 810,981...sewer pipe, 811,982... inside (pipe inside) of sewer pipe, 818,988... inner wall (of sewer pipe), 890...sewage, 900...self-propelled television camera, 913...television camera, 920... remote control cable, 950... ground controller, 953... manual operation unit, 954... ground monitor

Claims

[Claim 1]

A floating device for in-pipe inspection capable of floating in sewage inside a pipe to inspect properties of a pipe inside of a sewer pipe, comprising:

- a light for illuminating the pipe inside;

- a camera for imaging at least an inner wall of the pipe inside and outputting image data obtained by the imaging;

- a timer for outputting time data for associating position data of the floating device for in-pipe inspection with each of the image data;

- an accelerometer for measuring acceleration of the floating device for in-pipe inspection and outputting acceleration data;

- a storage device for storing the time data, the acceleration data, and the image data;

- a casing that accommodates at least the camera, the timer, the accelerometer, and the storage device, and defines an outer shape of a main body of the floating device for in-pipe inspection; and

- a posture control means, wherein the casing has an imaging window that is provided to correspond to at least a part of a view angle at which the camera images, and through which light from an outside passes, and the posture control means controls a posture of the main body

so that the camera and the imaging window are kept above a water surface of the sewage.

[Claim 2]

The floating device for in-pipe inspection of claim 1, wherein the camera is an omnidirectional camera.

[Claim 3]

The floating device for in-pipe inspection of claim 1 or 2, wherein the posture control means includes at least a rope having one end side connected to a side surface of the main body, and a sea anchor that is connected to the other end side of the rope and flows in the sewage while leading the main body.

[Claim 4]

The floating device for in-pipe inspection of claim 3, wherein the sea anchor is configured to float in the sewage more easily than the main body.

[Claim 5]

The floating device for in-pipe inspection of any one of claims 1 to 4, wherein the main body has a spherical shape, the light and the camera are provided inside an upper hemisphere and the imaging window forms at least a part of an outer shell of the upper hemisphere.

[Claim 6]

The floating device for in-pipe inspection of any one of claims 1 to 5, further comprising a radio wave transmission means for transmitting a radio wave from the floating device for in-pipe inspection to an outside.

[Claim 7]

An in-pipe inspection system for inspecting properties of an inside of a sewer pipe in a sewerage pipeline tracing continuously to at least manholes at three or more places, comprising:

the floating device for in-pipe inspection of claim 6;

an in-hole antenna arranged in a vertical hole of each of the manholes; and

a reception device that is connected to the in-hole antenna and receives a radio wave captured by the in-hole antenna, wherein at least when passing a vicinity of the manhole, the floating device for in-pipe inspection transmits a radio beacon to an outside by the radio wave transmission means, and when receiving the radio beacon, the reception device outputs passage information of the floating device for in-pipe inspection based on reception of the radio beacon.

[Claim 8]

An in-pipe inspection method for inspecting properties of an inside of a sewer pipe by using the floating device for in-pipe inspection of any one of claims 1 to 6, comprising:

an in-pipe inspection floating device casting step of casting the floating device for in-pipe inspection into the sewer pipe from a manhole;

a pipe inside image collecting step of illuminating a pipe inside by the light while floating the floating device for in-pipe inspection inside the sewer pipe, imaging at least an inner wall of the pipe inside by the camera to collect image data, and causing the image data output by the camera to be stored into the storage device together with the time data output by the timer and the acceleration data output by the accelerometer; and

a pipe inside defect analysis step of reading out the image data, the time data, and the acceleration data stored in the storage device, analyzing each of the image data to analyze presence or absence of a defect in the pipe inside and degree of the defect, and based on the position data calculated based on the time data and the acceleration data, specifying a position where a defect exists when it is determined that the defect exists on a screen based on the image data.

[Claim 9]

The in-pipe inspection method of claim 8, wherein the floating device for in-pipe inspection further comprises a radio wave transmission means for transmitting a radio wave to an outside, and each middle manhole located between an upstream manhole and a downstream manhole is provided with an in-hole antenna arranged in a vertical hole of the middle manhole, and a

reception device that receives a radio wave captured by the in-hole antenna and is arranged at the manhole,

wherein the in-pipe image collecting step causes the floating device for in-pipe inspection to collect the image data, and also causes the radio wave transmission means to transmit a radio beacon from the floating device for in-pipe inspection to an outside, and

wherein an existence section grasping step is executed which causes the reception device to capture the radio beacon transmitted from the floating device for in-pipe inspection and output passage information indicating that the floating device for in-pipe inspection has passed a vicinity of the manhole, thereby grasping a section in which the floating device for in-pipe inspection exists.