

TITLE

Measuring instrument reader and automatic control system

TECHNICAL FIELD

[0001] The invention relates to a measuring instrument reader and an automatic control system that can acquire a measurement value which is measured with a measuring instrument such as an analog flowmeter, an analog manometer, or an analog speedometer.

BACKGROUND ART

[0002] An automatic reader that images an indicator and a scale of an analog measuring instrument such as an analog flowmeter and reads a scale indicated by the indicator as a measurement value on the basis of the captured image is known (see Japanese Unexamined Patent Publication No. 2006-84418 and Japanese Unexamined Patent Publication No. 2011-163856). When measurement values of a plurality of measuring instruments are read with such a type of automatic reader, a plurality of cameras are installed and a measurement value for each measuring instrument is acquired, or the plurality of measuring instruments are imaged at a time with one camera and a plurality of measurement values are acquired through image processing.

SUMMARY

[0003] However, for example, when a plurality of measuring instruments such as analog flowmeters are imaged with one camera, distances or directions of the measuring instruments with respect to the camera are not constant and thus some measuring instruments may be out of focus and blurred. Accordingly, there is a likelihood of a decrease in accuracy at the time of acquiring measurement values.

[0004] The invention has been made to solve the aforementioned problem and an objective thereof is to provide a measuring instrument and an automatic control system that can acquire a plurality of measurement values accurately and efficiently from a plurality of measuring instruments.

[0005] According to the invention, there is provided a measuring instrument reader that acquires a measurement value from a measuring instrument in which a value indicated by a movable portion moving along a scale is the measurement value, the measuring instrument reader including: an imaging unit configured to image a plurality of measuring instruments which are located within an imageable range; and a data acquiring unit configured to acquire the measurement values from an image captured by the imaging unit. The imaging unit focuses on each of the measuring instruments separated into a plurality of groups to capture an image of the measuring instruments for each group. The data acquiring unit acquires the measurement values from a plurality of images captured by the imaging unit.

[0006] With the measuring instrument reader, the imaging unit captures an image of the measuring instruments for each group with a focus on the measuring instruments for each group instead of imaging a plurality of measuring instruments within the imageable range at a time. Accordingly, in comparison with a case in which a plurality of measuring instruments are imaged at a time, the captured image of the measuring instruments is less likely to be blurred. As a result, the data acquiring unit can accurately acquire a plurality of measurement values. With the measuring instrument reader, since an operation of moving the

imaging unit to change the position or the like for each measuring instrument is not necessary for the measuring instruments within the imageable range, the measuring instrument reader is advantageous for automation and can efficiently acquire the measurement values.

5 Accordingly, with the measuring instrument reader, it is possible to accurately and efficiently acquire a plurality of measurement values from a plurality of measuring instruments.

[0007] According to the invention, there is also provided an automatic control system that automatically controls a measuring object state, the
10 automatic control system including: a measuring instrument including a movable portion moving along a scale, in which a value of the scale indicated by the movable portion is a measurement value indicating the measuring object state; an adjustment unit configured to change the measuring object state; a measuring instrument reading unit configured
15 to acquire the measurement value of the measuring instrument; and a control unit configured to compare the measurement value acquired by the measuring instrument reading unit with a reference value and to control the adjustment unit such that a difference between the measurement value and the reference value decreases. The measuring

20 instrument reading unit includes an imaging unit configured to image a plurality of measuring instruments which are located within an imageable range and a data acquiring unit configured to acquire the measurement values from an image captured by the imaging unit. The imaging unit focuses on each of the measuring instruments separated
25 into a plurality of groups to capture an image of the measuring instruments for each group. The data acquiring unit acquires the

measurement values from a plurality of images captured by the imaging unit.

[0008] With the automatic control system, it is possible to efficiently and accurately acquire measurement values from a plurality of measuring instruments and to automatically control a measuring object state on the basis of the measurement values.

[0009] According to the invention, it is possible to accurately and efficiently acquire a plurality of measurement values from a plurality of measuring instruments.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 is a perspective view schematically illustrating a measuring instrument reader according to an embodiment;

FIG. 2 is a diagram schematically illustrating a configuration of the measuring instrument reader;

FIG. 3 is a diagram illustrating an example of a position information table of analog flowmeters;

FIG. 4 is a flowchart illustrating a process flow of acquiring measurement values of a plurality of analog flowmeters;

FIG. 5 is a flowchart illustrating a process flow of acquiring a measurement value of a first analog flowmeter;

FIG. 6 is a diagram illustrating analog flowmeters within an imageable range and an image in a state in which one analog flowmeter is in focus;

FIG. 7 is a diagram illustrating an example of a table on which measurement values of a plurality of analog flowmeters are recorded;

FIG. 8 is a diagram illustrating a state in which a plate is

installed behind analog flowmeters;

FIG. 9 is a diagram illustrating an image of a state in which a plurality of analog flowmeters in a group are in focus;

FIG. 10 is a diagram illustrating an image of analog speedometers which are other measuring instruments; and

FIG. 11 is a diagram schematically illustrating a configuration of an automatic control system according to the embodiment.

DETAILED DESCRIPTION

[0011] An embodiment of an aspect provides a measuring instrument reader that acquires a measurement value from a measuring instrument in which a value indicated by a movable portion moving along a scale is the measurement value, the measuring instrument reader including: an imaging unit configured to image a plurality of measuring instruments which are located within an imageable range; and a data acquiring unit configured to acquire measurement values from an image captured by the imaging unit. The imaging unit focuses on each of the measuring instruments separated into a plurality of groups to capture an image of the measuring instruments for each group. The data acquiring unit acquires the measurement values from a plurality of images captured by the imaging unit.

[0012] With the measuring instrument reader, the imaging unit captures an image of the measuring instruments per group, focused on the measuring instruments per group instead of imaging a plurality of measuring instruments within the imageable range together. Accordingly, in comparison with a case in which a plurality of measuring instruments are imaged at a time, the captured image of the

measuring instruments is less likely to be blurred. As a result, the data acquiring unit can accurately acquire a plurality of measurement values. With the measuring instrument reader, since an operation of moving the imaging unit to change the position or the like for each measuring instrument is not necessary for the measuring instruments within the imageable range, the measuring instrument reader is advantageous for automation and can efficiently acquire the measurement values. Accordingly, with the measuring instrument reader, it is possible to accurately and efficiently acquire a plurality of measurement values from a plurality of measuring instruments.

[0013] In the measuring instrument reader, each group may include one measuring instrument, and the imaging unit may sequentially capture an image focused on the measuring instrument per group. The imaging unit of the measuring instrument reader sequentially captures an image with a focus on one measuring instrument out of a plurality of measuring instruments in the imageable range. As a result, the captured images of the plurality of measuring instruments are less likely to be blurred and it is possible to accurately acquire a plurality of measurement values.

[0014] In the measuring instrument reader, the imaging unit may include a measuring instrument identifying unit configured to identify one or more measuring instruments belonging to each group and an automatic focusing unit configured to capture an image with a focus on the movable portion and the scales of the one or more measuring instruments belonging to each group. One or more measuring instruments belonging to one group can be identified by the measuring

instrument identifying unit. By capturing an image focused on the movable portion and the scales of one or more measuring instruments identified by the measuring instrument identifying unit, it is possible to accurately acquire the measurement values.

5 [0015] In the measuring instrument reader, the measuring instrument may be an analog flowmeter. The analog flowmeter may be an area flowmeter. The measuring instrument reader is advantageous for digitalizing measurement values while enjoying superiority of an analog flowmeter such as an area flowmeter.

10 [0016] In the measuring instrument reader, a measuring object which is measured by the measuring instrument may be a flow rate of a gas. The flow rate of a gas may be a flow rate of a hydrocarbon-based gas. With the measuring instrument reader, it is possible to accurately measure a flow rate of a gas such as a flow rate of a hydrocarbon-based
15 gas.

 [0017] The invention also provides an automatic control system that automatically controls a measuring object state, the automatic control system including: a measuring instrument including a movable portion moving along a scale, in which a value of the scale indicated by the
20 movable portion is a measurement value indicating the measuring object state; an adjustment unit configured to change the measuring object state; a measuring instrument reading unit configured to acquire the measurement value of the measuring instrument; and a control unit configured to compare the measurement value acquired by the
25 measuring instrument reading unit with a reference value and to control the adjustment unit such that a difference between the measurement

value and the reference value decreases. The measuring instrument reading unit includes an imaging unit configured to image a plurality of measuring instruments which are located within an imageable range and a data acquiring unit configured to acquire the measurement values from an image captured by the imaging unit. The imaging unit focuses on each of the measuring instruments separated into a plurality of groups to capture an image on the measuring instruments for each group. The data acquiring unit acquires the measurement values from a plurality of images captured by the imaging unit.

[0018] With the aforementioned automatic control system, it is possible to efficiently and accurately acquire measurement values of a plurality of measuring instruments and to automatically control a measuring object state on the basis of the measurement values.

[0019] Hereinafter, an embodiment of the invention will be described in detail with reference to the accompanying drawings.

[0020] A measuring instrument reader according to an embodiment is a device that can image a plurality of analog flowmeters and acquire measurement values of the individual measuring instruments as data on the basis of image data acquired through the imaging. The analog flowmeter is an example of a measuring instrument and is, for example, an area flowmeter. Analog flowmeters and a gas supply line in which the analog flowmeters are installed will be first described below.

[0021] As illustrated in FIGS. 1 and 2, an analog flowmeter (hereinafter referred to as a “flowmeter F”) is installed in a gas supply line NL that supplies a gas to a heater B. The gas supply line NL includes a gas header T, a manometer P, and various flow rate adjustment valves V. A

measuring object which is measured by the flowmeter F is an amount of supplied gas and is a flow rate of a hydrocarbon-based gas.

[0022] The flowmeter F includes a cylindrical casing C of which a cylinder axis is parallel to a vertical direction, a scale M which is formed on the outer surface of the casing C by printing, marking, or the like, and an indicator K (a movable portion) which is formed of a rotor type float accommodated in the casing C. The scale M is expressed as scale lines, for example, in which a maximum scale line Mb is provided on the uppermost part, and a minimum scale line Ma is provided on the lowermost part, and a plurality of scale lines are provided at equal intervals between the maximum scale line Mb and the minimum scale line Ma. The indicator K can employ various shapes and a shape capable of easily identifying a position of an indicated scale line can be preferably employed. In this embodiment, the upper end of the indicator K indicates a measurement value.

[0023] A measuring instrument reader 1 includes an imaging unit 2 including an imaging element such as a CCD or a CMOS and a data acquiring unit 3 that acquires a measurement value of a flowmeter F on the basis of an image captured by the imaging unit 2. The imaging unit 2 or the data acquiring unit 3 may be connected to a host computer in a central control room which is not illustrated, or the function of the data acquiring unit 3 which will be described later may be provided in the host computer. The data acquiring unit 3 is an example of a data acquiring unit.

[0024] The imaging unit 2 images a plurality of flowmeters F which are located within an imageable range Ar. In this embodiment, for

example, eight (a plurality of) flowmeters F are arranged in a lateral line (see FIG. 1), and two (a plurality of) imaging units 2 are provided for the plurality of flowmeters F. The first imaging unit 2A is provided, for example, such that four flowmeters F on the left side in FIG. 1 are
5 located within the imageable range Ar, and the second imaging unit 2B is provided such that four flowmeters F on the right side are located within the imageable range Ar. Here, the technical significance of the flowmeters F being located within the imageable range Ar of the imaging unit 2 is that the flowmeters F are arranged at positions at
10 which the indicator K and the scale M can be in the focus of the imaging unit 2 fixed to a predetermined position without moving the imaging unit 2.

[0025] Four flowmeters F arranged within the imageable range Ar of the first imaging unit 2A are partitioned into a plurality of groups. For
15 example, in this embodiment, it is assumed that one flowmeter F belongs to each group. A plurality of flowmeters F may be set to belong to one group. For example, setting may be performed such that four flowmeters F are partitioned into two groups, two flowmeters F belong to a first group, and two remaining flowmeters F belong to a
20 second group.

[0026] A monitoring camera or the like can be appropriately used as the imaging unit 2, and the imaging unit 2 includes a lens, an imaging element, a CPU such as a DSP, and a memory as physical elements. The imaging unit 2 includes, as functional elements, a position
25 information storage unit 21 that stores position information of the scales M of the flowmeters F, a measuring instrument identifying unit 22 that

identifies the flowmeters F belonging to the first to fourth groups, and an automatic focusing unit 23 that captures an image focused on the scale M and the indicator K of the flowmeter F identified by the measuring instrument identifying unit 22. The imaging unit 2 is
5 fixedly installed at a predetermined position, and it is not assumed that the imageable range Ar is changed by moving the imaging unit 2.

[0027] Position information of the first, second, third, and fourth flowmeters Fa, Fb, Fc, and Fd is stored in the position information storage unit 21. For example, a position information Table Ta (see
10 FIG. 3) is stored in the position information storage unit 21. Position information is stored in the position information table Ta in correlation with the identification information of the flowmeters F, for example, identification information "1" indicates the first flowmeter Fa, and position information thereof is "A." Identification information "2"
15 indicates the second flowmeter F and position information thereof is "B." Identification information "3" indicates the third flowmeter F and position information thereof is "C." Identification information "4" indicates the fourth flowmeter F and position information thereof is "D."

[0028] There are various methods of acquiring position information. For example, first, position information of the scales M of each of a plurality of flowmeters F may be manually acquired and the acquired position information may be stored. Map information in which
20 relative positions between the positions of the scales M of a plurality of flowmeters F and the installation position of the imaging unit 2 are defined may be stored.
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[0029] An example in which the position information is manually acquired will be described below. First, automatic focusing is performed with a direction of a lens of the imaging unit 2 roughly focused on the first flowmeter Fa. When the scale M and the indicator K of the first flowmeter Fa are focused on, this position is stored as position information of the scale M and the indicator K of the first flowmeter Fa. On the other hand, when the scale M and the indicator K of the first flowmeter Fa are not focused on, adjustment is manually performed such that the scale M and the indicator K of the first flowmeter Fa are focused on, and the in-focus position is stored as position information of the scale M and the indicator K of the first flowmeter Fa. The position information of the scale M and the indicator K of the first flowmeter Fa is a value indicating the direction of the lens of the imaging unit 2, a degree of zoom, a degree of focusing, or the like and widely includes various types of information that can functionally realize focus on the scale M of the first flowmeter Fa. The position information of the second to fourth flowmeters Fb, Fc, and Fd can be acquired in the same way.

[0030] The position information of the first to fourth flowmeters Fa, Fb, Fc, and Fd is based on the premise that the scales M and the indicators K of the first to fourth flowmeters Fa, Fb, Fc, and Fd can be focused on without moving the imaging unit 2. When the scale M and the indicator K of a certain flowmeter F (for example, the fourth flowmeter Fd) cannot be focused on, the flowmeter F cannot be said to be included in the imageable range Ar of the imaging unit 2.

[0031] The measuring instrument identifying unit 22 identifies a

flowmeter F of which the measurement value is to be acquired on the basis of information stored in the position information storage unit 21. For example, when the measurement value of the first flowmeter Fa is to be acquired, the measuring instrument identifying unit 22 reads the position information corresponding to the first flowmeter Fa from the position information storage unit 21. When the measurement values of the second to fourth flowmeters Fb, Fc, and Fd are to be acquired, the measuring instrument identifying unit 22 reads the position information corresponding to the second to fourth flowmeters Fb, Fc, and Fd from the position information storage unit 21. That is, in this embodiment, identifying a flowmeter F means that the position information for focusing on the scale M and the indicator K of the flowmeter F is acquired.

[0032] The automatic focusing unit 23 captures an image with a focus on the scale M and the indicator K of the flowmeter F identified by the measuring instrument identifying unit 22. That is, the automatic focusing unit 23 performs automatic focusing on the basis of the position information acquired by the measuring instrument identifying unit 22, and images the scale M and the indicator K of the flowmeter F in this state to acquire an image.

[0033] The data acquiring unit 3 will be described below. The data acquiring unit 3 includes a CPU, a memory, and a monitor as physical elements, for example, operates in accordance with a program stored in the memory, and performs a function of acquiring a measurement value from an image captured by the imaging unit 2.

[0034] The data acquiring unit 3 includes, as functional elements, a

storage unit 31 that stores various types of basic data or measurement values acquired by a data processing unit 32, the data processing unit 32 that processes a plurality of images captured by the imaging unit 2 and acquires measurement values from the images, and an output unit 33 that outputs measurement value information based on the measurement values acquired by the data processing unit 32.

[0035] In the storage unit 31, for example, an image pattern (an initial image pattern) of a binary image in a state in which the indicator K is located at the minimum scale line Ma on each of the first to fourth flowmeters Fa, Fb, Fc, and Fd may be stored as the basic data. In the storage unit 31, coordinate information of the scale lines (particularly, the minimum scale line Ma or the maximum scale line Mb) with respect to the initial image pattern, a measurement value, and the like may be stored as the basic data. The measurement values of the first to fourth flowmeters Fa, Fb, Fc, and Fd acquired by the data processing unit 32 may be stored in the storage unit 31.

[0036] The data processing unit 32 performs an image processing process of generating a binary image of a flowmeter F which is a measuring object, a detection process of acquiring coordinate information of the indicator K on the basis of the image pattern of the binary image generated in the image processing process, and an arithmetic operation process of acquiring the measurement value indicated by the indicator K.

[0037] An example of the image processing process will be described below. For example, the data processing unit 32 acquires a gray-scale image from the image of the scale M and the like of the flowmeter F

captured by the imaging unit 2. A threshold value is set in advance in the data processing unit 32, and the data processing unit 32 acquires a binary image in which luminance values of pixels are assigned to black and white with a threshold value as a boundary for the gray-scale image.

5 The threshold value is set to, for example, a value for distinguishing the indicator K or the scale M from other areas (an area between the lines of the scale M or the background). As a result, for example, pixels indicating the indicator K or the scale M are likely to be expressed in black, and the other pixels are likely to be expressed in white. The data processing unit 32 acquires an image pattern based on the shapes of black and white areas in the acquired binary image. The binary image for the initial image pattern stored in advance in the storage unit 31 can be acquired by causing the imaging unit 2 to capture an image in a state in which the indicator K is located at the minimum scale line Ma and performing the aforementioned process on the captured image.

10 [0038] Then, the data processing unit 32 performs a process of detecting the indicator K. Detection of the indicator K can be performed using various known image processes. For example, the data processing unit 32 reads the initial image pattern stored in the storage unit 31, compares the read initial image pattern with the currently acquired image pattern of the binary image, and calculates a difference between pattern data. The result of calculation is a two-dimensional arrangement, and a place in which a difference occurs in the arrangement is detected as the position of the indicator K.

20 [0039] When a difference does not occur (when the difference is equal to or less than a threshold value for an error range), the indicator K in

the currently acquired binary image indicates the minimum scale line Ma. When a difference occurs, the indicator K indicates a position other than the minimum scale line Ma. For example, an upper end of the indicator K according to this embodiment indicates the measurement value and thus the uppermost coordinate out of coordinates at which the difference occurs is the coordinate indicating the measurement value.

[0040] Then, the data processing unit 32 performs the arithmetic operation process of acquiring the measurement value indicated by the indicator K. The arithmetic operation process of acquiring the measurement value indicated by the indicator K can be performed by various known arithmetic operations based on a binary image. For example, the data processing unit 32 can read coordinate information of the scale lines stored in the storage unit 31 and acquire the measurement value by comparing the coordinate information of the scale lines with the coordinate information of the indicator K.

[0041] Specifically, by calculating a ratio of a distance from the minimum scale line Ma of the scale M of the flowmeter F to the upper end of the indicator K to a distance from the minimum scale line Ma to the maximum scale line Mb, it is possible to calculate what % in a measuring range the indicator K indicates. The measurement value when the minimum scale line Ma is indicated and the measurement value when the maximum scale line Mb is indicated are stored, for example, in the storage unit 31. The data processing unit 32 can read the measurement value when the minimum scale line Ma is indicated and the measurement value when the maximum scale line Mb is indicated from the storage unit 31 and acquire the measurement value

indicated by the indicator K from the % value in the measuring range.

[0042] The output unit 33 outputs measurement value information based on the measurement value acquired by the data processing unit 32. The measurement value information is, for example, information which is visibly displayed on a monitor or the like. The measurement value information widely includes histories of the measurement values indicating changes over time of the measurement values (numerical values) which are displayed in correlation with the first to fourth flowmeters Fa, Fb, Fc, and Fd or alarm information (including text information or voice information) which is displayed when the measurement value is less than a lower-limit threshold value or when the measurement value is greater than an upper-limit threshold value.

[0043] The method of acquiring a measurement value of a flowmeter F which is performed by the measuring instrument reader 1 will be described below with reference to FIGS. 4 and 5. FIG. 4 is a flowchart illustrating a process flow of acquiring measurement values of a plurality of flowmeters F. FIG. 5 is a flowchart illustrating a process flow of acquiring a measurement value of a first flowmeter Fa.

[0044] Measuring times or measuring intervals are set in advance, and the imaging unit 2 sequentially starts measurement from the first flowmeter Fa at a predetermined measuring time. For example, the first measuring times of the first to fourth flowmeters Fa, Fb, Fc, and Fd are set to “9:30 a.m.,” “9:31 a.m.,” “9:32 a.m.,” and “9:33 a.m.,” respectively. As illustrated in FIG. 4, the measuring instrument reader 1 acquires the measurement value of the first flowmeter Fa at “9:30 a.m.” (S1), acquires the measurement value of the second flowmeter Fb

at “9:31 a.m.” (S2), acquires the measurement value of the third flowmeter Fc at “9:32 a.m.” (S3), and acquires the measurement value of the fourth flowmeter Fd at “9:33 a.m.” (S4). For example, only the measuring time of the first flowmeter Fa and the measurement order of the other flowmeters F may be set and measurement of the subsequent flowmeter F may be started when acquisition of the measurement value of the previous flowmeter F has been completed. The order of the flowmeters F of which the measurement values are acquired may be changed every measurement or acquisition of the measurement values of some flowmeters F may be omitted.

[0045] The method of acquiring the measurement value of the first flowmeter Fa will be described below with reference to FIG. 5. Since the methods of acquiring the measurement values of the second to fourth flowmeters Fb, Fc, and Fd are substantially the same, the method of acquiring the measurement value of the first flowmeter Fa will be representatively described and the methods of acquiring the measurement values of the other flowmeters Fb, Fc, and Fd will be omitted.

[0046] For example, the first measuring time of the first flowmeter Fa is set to “9:30 a.m.” The measuring instrument identifying unit 22 of the imaging unit 2 starts the process of acquiring the position information of the first flowmeter Fa at the measuring time (S11). That is, the measuring instrument identifying unit 22 acquires the identification information “1” of the first flowmeter Fa which is set in correlation with “9:30 a.m.” Then, the measuring instrument identifying unit 22 acquires the position information of the first

flowmeter Fa (such as the direction of the lens, the degree of zoom, and the degree of focusing) with reference to the position information table Ta (see FIG. 3) stored in the position information storage unit 21.

[0047] Then, the automatic focusing unit 23 of the imaging unit 2 performs an automatic focusing process on the basis of the position information of the first flowmeter Fa acquired by the measuring instrument identifying unit 22 (S12). That is, the automatic focusing unit 23 automatically focuses on the scale M and the indicator K of the first flowmeter Fa. For example, in FIG. 6(a), the first to fourth flowmeters Fa, Fb, Fc, and Fd included in the imageable range Ar are illustrated and a target area Xa which is automatically focused on is illustrated by an alternate long and short dash line. In FIG. 6(a), the scale M and the indicator K of the first flowmeter Fa are focused on. For reference, in FIG. 6(b), a state in which the scale M and the indicator K of the second flowmeter Fb are focused on is illustrated, and a target area Xb which is automatically focused on is illustrated by an alternate long and short dash line.

[0048] Then, the automatic focusing unit 23 performs an image acquiring process (S13). That is, the automatic focusing unit 23 images the scale M and the indicator K of the first flowmeter Fa in an in-focus state and acquires an image of the first flowmeter Fa. In the image acquiring process, for example, the automatic focusing unit 23 acquires an image illustrated in FIG. 6(c). FIG. 6(c) illustrates an image in which the first flowmeter Fa is in focus and the second flowmeter Fb adjacent thereto is out of focus. For reference, FIG. 6(d) illustrates an image in which the second flowmeter Fb is in focus. The

automatic focusing unit 23 may output the acquired image to the data acquiring unit 3 or may store the acquired image in the position information storage unit 21.

[0049] Then, the data processing unit 32 of the data acquiring unit 3 generates a binary image from the image acquired by the imaging unit 2 and acquires an image pattern by performing the image processing process (S14). Then, the data processing unit 32 acquires the position (coordinate information) of the indicator K by performing the process of detecting the indicator K (S15). Then, the data processing unit 32 acquires the measurement value indicated by the indicator K by performing the arithmetic operation process (S16). The data processing unit 32 stores the acquired measurement value in the storage unit 31 in correlation with the first flowmeter Fa, the measuring time, and the like. The measurement value acquired by performing the arithmetic operation process may be displayed on the output unit 33.

[0050] The process flow of acquiring the measurement value of the first flowmeter Fa is completed by ending the arithmetic operation process, then the measurement value of the second flowmeter Fb is acquired, then the measurement value of the third flowmeter Fc is acquired, and then the measurement value of the fourth flowmeter Fd is acquired. The measurement values acquired by the imaging unit 2 and the data acquiring unit 3 are stored in the storage unit 31, for example, as illustrated in FIG. 7. FIG. 7 illustrates an example of a table Tb in which the identification information of the first to fourth flowmeters Fa, Fb, Fc, and Fd, the measuring times, and the measurement values are stored in correlation.

[0051] The aforementioned embodiment is based on the premise that an object serving as an obstacle at the time of generating a binary image is not provided behind the first to fourth flowmeters Fa, Fb, Fc, and Fd. However, when the flowmeters F are transparent and an object with luminance close to the indicator K is provided behind them, there is a likelihood that the indicator K will not be able to be distinguished at the time of generating a binary image from the captured image. In this case, for example, as illustrated in FIG. 8, a measuring instrument reader 1 including a white plate 5 provided behind the flowmeters F may be used.

[0052] Operations and advantages of the measuring instrument reader 1 according to this embodiment will be described below. With the measuring instrument reader 1 according to this embodiment, since the imaging unit 2 images a plurality of flowmeters F, it is advantageous for efficient acquisition of a plurality of measurement values. Particularly, since the measuring instrument reader 1 can automatically and accurately acquire the measurement values, it is possible to decrease a human burden and it is very advantageous particularly when the number of flowmeters F which are measuring objects is large (several tens to several hundreds).

[0053] For example, when a comparative example is supposed for the aforementioned embodiment and all the first to fourth flowmeters are simultaneously imaged, some flowmeters are likely to be out of focus. Particularly, even when it is intended to acquire a measurement value by performing image processing in a measuring instrument such as a flowmeter, the accuracy of the original image is poor and thus the

accuracy of the measurement value is not stable. When it is intended to image each flowmeter by moving the imaging unit, a driving mechanism for the imaging unit is necessary and the device configuration is likely to be complicated, which is not efficient.

5 [0054] In comparison with the comparative example, with the measuring instrument reader 1 according to this embodiment, the imaging unit 2 captures an image of the flowmeters F for each group with a focus on flowmeters F for each group instead of imaging a plurality of flowmeters F in the imageable range Ar at a time.

10 Accordingly, in comparison with a case in which a plurality of flowmeters F are imaged at a time, the captured image of the flowmeters F is less likely to be blurred. As a result, the data acquiring unit 3 can accurately acquire a plurality of measurement values. With the measuring instrument reader 1, an operation of moving the imaging
15 unit 2 to change the position or the direction thereof for each flowmeter F is not necessary for the flowmeters F which are within the imageable range Ar. As a result, the measuring instrument reader 1 is advantageous for automation and can efficiently acquire the measurement values. Accordingly, with the measuring instrument
20 reader 1, it is possible to accurately and efficiently acquire a plurality of measurement values from a plurality of flowmeters F.

[0055] With the measuring instrument reader 1 according to this embodiment, one flowmeter F belongs to one group and the imaging unit 2 sequentially captures an image with a focus on the flowmeters F
25 for each group. That is, the imaging unit 2 sequentially captures an image with a focus on one flowmeter F for a plurality of flowmeters F

in the imageable range Ar. As a result, the captured images of a plurality of flowmeters F are less likely to be blurred and it is possible to accurately acquire a plurality of measurement values.

[0056] A plurality of flowmeters F (measuring instruments) may belong to one group. In this case, the automatic focusing unit 23 of the imaging unit 2 focuses on the scales M and the indicators K of the plurality of flowmeters F belonging to one group. For example, the first flowmeter Fa and the second flowmeter Fb may belong to one group as illustrated in FIG. 9(a), and the third flowmeter Fc and the fourth flowmeter Fd may belong to another group as illustrated in FIG. 9(b).

[0057] In this case, for example, a position information table in which position information corresponding to the first flowmeter Fa and the second flowmeter Fb and position information corresponding to the third flowmeter Fc and the fourth flowmeter Fd are defined is stored in the position information storage unit 21 of the imaging unit 2. The measuring instrument identifying unit 22 reads the position information table in the position information storage unit 21 and first acquires the position information corresponding to the first flowmeter Fa and the second flowmeter Fb. Then, the automatic focusing unit 23 captures an image with a focus on the scales M and the indicators K of the first flowmeter Fa and the second flowmeter Fb on the basis of the acquired position information. That is, the imaging unit 2 acquires an image with a focus on the first flowmeter Fa and the second flowmeter Fb (see FIG. 9(a)). Then, the data acquiring unit 3 acquires measurement values of the first flowmeter Fa and the second flowmeter Fb on the

basis of the image acquired by the imaging unit 2.

[0058] Then, the imaging unit 2 acquires the position information of the third flowmeter Fc and the fourth flowmeter Fd and captures an image with a focus on the scales M and the indicators K of the third flowmeter Fc and the fourth flowmeter Fd. That is, the imaging unit 2 acquires an image with a focus on the third flowmeter Fc and the fourth flowmeter Fd (see FIG. 9(b)). Then, the data acquiring unit 3 acquires measurement values of the third flowmeter Fc and the fourth flowmeter Fd on the basis of the image acquired by the imaging unit 2.

[0059] In the measuring instrument reader 1, the flowmeters F are measured as a measuring object. In the case of the flowmeters F, predetermined skill or proficiency is necessary for visually reading and accurately identifying the scale M indicated by the indicator K, and the accuracy of the measurement value is likely to decrease. Here, measurement values can be efficiently and accurately acquired using the measuring instrument reader 1, which is superior.

[0060] In this embodiment, a measuring object which is measured from each flowmeter F is a flow rate of a gas and is particularly a flow rate of a hydrocarbon-based gas. When a flow rate of a hydrocarbon-based gas is measured, an area flowmeter is generally used. The main reason is that the area flowmeter requires a low cost, is suitable for measuring a small flow rate, and is less affected by foreign matter in a fluid such as a liquid component in the hydrocarbon-based gas.

[0061] On the other hand, when a measurement value of an area flowmeter is output as an electrical signal, the structure thereof is complicated and requires a high cost. However, with the measuring

instrument reader 1 according to this embodiment, it is possible to advantageously digitize a measurement value which is accurately acquired by the area flowmeter. That is, with the measuring instrument reader 1 according to this embodiment, it is possible to facilitate digitalization of measurement values while utilizing superiority of an analog flowmeter such as an area flowmeter.

[0062] In the aforementioned embodiment, a flowmeter F or an area flowmeter has been described as an example of a measuring instrument, but the measuring instrument may be, for example, a manometer, a speedometer, or a torque meter (see FIG. 10). For example, a speedometer FA includes a scale MA that is marked in a circular shape and a pointer KA that extends radially from the center of the scale MA. The pointer KA (a movable portion) is rotatable about the center of the scale MA, and a value of a scale line of the scale MA indicated by the pointer KA is a measurement value. That is, the pointer KA is an example of a movable portion that moves along the scale M. The data processing unit 32 of the data acquiring unit 3 generates a binary image from an image captured by the imaging unit 2 and acquires, for example, coordinate information of the tip of the pointer KA. Then, the data processing unit 32 can calculate a rotation angle on the basis of the coordinate information of the tip of the pointer KA and acquire a measurement value with reference to a relationship between the scale M and the coordinate information. FIG. 10 illustrates an image which is captured focused on a center speedometer FA among three speedometers FA in an imageable range Ar.

[0063] An automatic control system 100 according to an embodiment

will be described below with reference to FIG. 11. The automatic control system 100 according to this embodiment includes a heater B, a gas supply line NL that supplies a gas to the heater B, and a control device 10 that automatically controls the gas supplied to the heater B via the gas supply line NL.

[0064] The gas supply line NL includes pipes Na that connect the heater B to a gas header T and through which a gas passes, flowmeters F that measure an amount (a flow rate) of supplied gas passing through the corresponding pipe Na, and adjustment units CT that change the corresponding amount of supplied gas. Each adjustment unit CT includes various types of flow rate adjustment valves V. In the automatic control system 100 according to this embodiment, each flowmeter F is an example of a measuring instrument, and the gas is an example of a measuring object which is measured by the measuring instrument. Each adjustment unit CT can change a measuring object state by changing the corresponding amount (flow rate) of supplied gas. The gas may be a hydrocarbon-based gas.

[0065] The control device 10 includes a measuring instrument reading unit 1A that acquires measurement values of the flowmeters F and a control unit 6 that controls the adjustment units CT on the basis of the measurement values acquired by the measuring instrument reading unit 1A. Since the measuring instrument reading unit 1A includes a physical structure or a functional configuration which is substantially common to the aforementioned measuring instrument reader 1, the common physical structure or functional element will be referred to by the same reference signs and description thereof will be omitted, and

differences will be mainly described below.

[0066] The measuring instrument reading unit 1A includes an imaging unit 2 and a data acquiring unit 3, and acquires measurement values sequentially from the first flowmeter Fa to the fourth flowmeter Fd.

5 The measuring instrument reading unit 1A outputs the acquired measurement values to the control unit 6. The control unit 6 includes a CPU and a memory and is connected to the adjustment units CT such that a control signal can be transmitted to and received from the adjustment units CT in a wireless or wired manner. The control unit 6
10 performs predetermined functions, for example, on the basis of a program stored in the memory.

[0067] The control unit 6 compares an acquired measurement value with a preset reference value when the measurement value is acquired from the measuring instrument reading unit 1A, and transmits a control
15 signal for decreasing a difference between the measurement value and the reference value to the adjustment units CT when there is the difference therebetween. The adjustment units CT are provided in the gas supply lines NL which are installed in each of the first to fourth flowmeters Fa, Fb, Fc, and Fd. Accordingly, the control unit 6
20 transmits the control signal to the adjustment unit CT of the gas supply line NL corresponding to the flowmeter F from which the measurement value has been acquired.

[0068] When a control signal from the control unit 6 is received, the adjustment unit CT controls driving of a pump P or a flow rate
25 adjustment valve V in accordance with the control signal and controls the flow rate such that it approaches the reference value.

[0069] With the automatic control system 100, it is possible to accurately and efficiently acquire measurement values of a plurality of flowmeters F and to automatically control an amount of supplied gas on the basis of the measured values.

5 [0070] While the measuring instrument reader 1 and the automatic control system 100 have been described above on the basis of an embodiment, the invention is not limited to the embodiment. For example, the method of acquiring measurement values from a plurality of images captured by the imaging unit is not limited to the acquisition method based on generation of a binary image, and other image processing may be used to acquire an image. The measuring object of the automatic control system is not limited to an amount of supplied gas, and the automatic control system can be applied to, for example, a system in which a user visually acquires a measurement value measured from a measuring instrument and adjusts a flow rate or the like by an operation based on the measurement value.

15 [0071] Reference signs list

1... Measuring instrument reader

2, 2A, 2B... Imaging unit

20 22... Measuring instrument identifying unit

23... Automatic focusing unit

3... Data acquiring unit

6... Control unit

100... Automatic control system

25 CT... Adjustment unit

F, Fa, Fb, Fc, Fd... Analog flowmeter (measuring instrument)

FA... Speedometer (measuring instrument)

M, MA... Scale

K... Indicator (movable portion)

KA... Pointer (movable portion)

WHAT IS CLAIMED IS:

1. A measuring instrument reader that acquires a measurement value from a measuring instrument in which a value indicated by a movable portion moving along a scale is the measurement value, the measuring instrument reader comprising:

an imaging unit configured to image a plurality of measuring instruments which are located within an imageable range; and

a data acquiring unit configured to acquire the measurement values from an image captured by the imaging unit,

wherein the imaging unit focuses on each of the measuring instruments separated into a plurality of groups to capture an image of the measuring instruments for each group, and

wherein the data acquiring unit acquires the measurement values from a plurality of images captured by the imaging unit.

2. The measuring instrument reader according to claim 1, wherein each group includes one measuring instrument, and

wherein the imaging unit sequentially captures an image focused on the measuring instrument per group.

3. The measuring instrument reader according to claim 1 or 2, wherein the imaging unit includes a measuring instrument identifying unit configured to identify one or more measuring instruments belonging to each group and an automatic focusing unit configured to capture an image focused on the movable portion and the scale of the one or more measuring instruments belonging to each group.

4. The measuring instrument reader according to any one of claims 1

to 3, wherein the measuring instrument is an analog flowmeter.

5. The measuring instrument reader according to claim 4, wherein the analog flowmeter is an area flowmeter.

6. The measuring instrument reader according to any one of claims 1 to 5, wherein a measuring object which is measured by the measuring instrument is a flow rate of a gas.

7. The measuring instrument reader according to claim 6, wherein the flow rate of a gas is a flow rate of a hydrocarbon-based gas.

8. An automatic control system that automatically controls a measuring object state, the automatic control system comprising:

a measuring instrument including a movable portion moving along a scale, in which a value of the scale indicated by the movable portion is a measurement value indicating the measuring object state;

an adjustment unit configured to change the measuring object state;

a measuring instrument reading unit configured to acquire the measurement value of the measuring instrument; and

a control unit configured to compare the measurement value acquired by the measuring instrument reading unit with a reference value and to control the adjustment unit such that a difference between the measurement value and the reference value decreases,

wherein the measuring instrument reading unit includes an imaging unit configured to image a plurality of measuring instruments which are located within an imageable range and a data acquiring unit configured to acquire the measurement values from an image captured by the imaging unit,

wherein the imaging unit captures an image of the measuring instruments for each group which is obtained by partitioning the plurality of measuring instruments into a plurality of groups with a focus on the measuring instruments for each group, and

5 wherein the data acquiring unit acquires the measurement values from a plurality of images captured by the imaging unit.