

FLUID METER OPTICS

FIELD OF THE INVENTION

[0001] This invention relates to fluid meter optics, and more particularly to improved optics for internet of things (IOT) designs for fluid meters.

BACKGROUND OF THE INVENTION

[0002] Fluid meters are devices used to accurately measure the flow of a liquid, such as the common water meter. Historically meters are read manually. Meter readers are responsible for traveling to different residential and commercial locations on assigned routes and gathering accurate data regarding the amount of utilities used. Gas, electric, steam consumption, and water meters all must be read with electronic devices, or the findings must be written down in a route book to enter into the computer at the end of the collection route. Readers drive or walk down specific routes to gather information from each customer on that route. Meter readers are responsible for recognizing an abnormal output of utilities, such as extremely high electricity, gas, or water usage, and for finding the source of the utility leak or problem before repairing it.

[0003] While it is desirable to automate this process, the millions of fluid meters in existence today are not set up to automatically transmit data to remote locations. Further, merely retrofitting such fluid meters with an imaging sensor is insufficient since glint may be a problem when the sensor is exposed to bright ambient light or

1 direct solar illumination. Glint occurs when strong reflection from a curved optical
2 surface above the fluid meter display reaches the imaging sensor. Such glint can
3 degrade the performance of image processing algorithms of IOT devices. Mere
4 blocking out of solar or ambient light by opacity is not possible as there is still a need
5 for a way to manually inspect the fluid meter for meter owners and/or for the
6 operating utility as a backup in case the sensor fails. It would therefore be desirable
7 to provide passive fluid meter optics which allow for both automatic recording of
8 information on the display of the fluid meter, and allow for manual inspection, while
9 also accounting for glint produced from strong solar illumination or other sources of
10 strong ambient light.

11 12 SUMMARY OF THE INVENTION

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14 [0004] In accordance with a first aspect, there is provided fluid meter optics which
15 are adapted to allow for inspection of a display of a fluid meter, and comprise a
16 housing having a first opening adapted to receive light, an imaging sensor for
17 automatic inspection, mounted on the housing, a bandpass filter mounted on the
18 housing, wherein a first band of wavelengths passes from the bandpass filter to the
19 imaging sensor, and a dichroic filter positioned between the first opening and the
20 display and adapted to pass a second range of wavelengths of light reflected from
21 the display through the dichroic filter.

22
23 [0005] From the foregoing disclosure and the following more detailed description of
24 various embodiments it will be apparent to those skilled in the art that the present
25 invention provides a significant advance in the technology of fluid meter optics.

1 Particularly significant in this regard is the potential the invention affords for providing
2 fluid meter optics suitable for use in an IOT application while preserving the ability for
3 manual inspection. Additional features and advantages of various embodiments will
4 be better understood in view of the detailed description provided below.

5 6 BRIEF DESCRIPTION OF THE DRAWINGS

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8 [0006] Fig. 1 is an isometric view of a fluid meter assembly having a fluid meter and
9 fluid meter optics in accordance with one embodiment.

10
11 [0007] Fig.2 is a schematic cross section of the fluid meter optics in accordance with
12 another embodiment, showing a second opening, a second polarizer positioned
13 between a dichroic filter and the display, an imaging sensor positioned over the
14 display, and polarized LEDs.

15
16 [0008] Fig. 3 is a top side schematic view of the fluid meter optics of another
17 embodiment, showing a non-polarized LED with additional (third) polarizer for the
18 LEDs, and ports for additional lighting.

19
20 [0009] It should be understood that the appended drawings are not necessarily to
21 scale, presenting a somewhat simplified representation of various features illustrative
22 of the basic principles of the invention. The specific design features of the fluid meter
23 optics as disclosed here, including, for example, the specific wavelength range of the
24 dichroic filter, will be determined in part by the particular intended application and
25 use environment. Certain features of the illustrated embodiments have been

enlarged or distorted relative to others to help provide clear understanding. In particular, thin features may be thickened, for example, for clarity of illustration. All references to direction and position, unless otherwise indicated, refer to the orientation illustrated in the drawings.

DETAILED DESCRIPTION OF CERTAIN EMBODIMENTS

[0010] It will be apparent to those skilled in the art, that is, to those who have knowledge or experience in this area of technology, that many uses and design variations are possible for the fluid meter optics disclosed here. The following detailed discussion of various alternate features and embodiments will illustrate the general principles of the invention with reference to fluid meter optics suitable for use with a display of a water meter, and can be a retrofit assembly attached to an existing water meter. Other embodiments suitable for other applications will be apparent to those skilled in the art given the benefit of this disclosure. The fluid meter display is preferably illuminated by a narrow band light source (i.e. a light emitting diode, LED 37) whose center wavelength matches that of the transmitted wavelength band of the bandpass filter, for example about between 550 nm to 610 nm . This illuminating light source is orthogonally polarized with respect to the imaging sensor's polarizer to cut off its glint from the curved optical surface of the fluid meter. The imaging sensor sees the depolarized diffused light from the fluid meter display. This narrowband light source can be both polarized and diffused for good meter display illumination. Solar or ambient light passing through the dichroic filter onto the fluid meter display will be of shorter wavelength and outside the transmitted wavelength band of the bandpass filter. Thus such ambient light will not be seen by

1 the imaging sensor. To enhance the cut-off, preferably the dichroic filter is tilted (e.g.,
2 45 degrees). Also another polarizer may be cascaded with the dichroic filter. Both
3 ways can convert the polarization of the solar or ambience light passing through the
4 dichroic filter, into mainly orthogonal polarization with respect to the imaging sensor's
5 polarizer. This further reduces the glint seen by the imaging sensor.

6
7 [0011] Turning now to the drawings, Fig. 1 is an isometric view of a fluid meter
8 assembly 10 having a fluid meter such as water meter 20 and fluid meter optics 30.
9 The fluid meter assembly may be constructed as original equipment, or the fluid
10 meter optics may be added afterwards. A retrofit or aftermarket kit is particularly
11 desirable in places where many water meters are already installed. Typical OEM
12 analog fluid meters are made by *George Kent* Limited, U.K. for example, and are
13 provided with an inspection window 21 and a display 22 behind the inspection
14 window 21. The display can contain numbers of different colours and backgrounds
15 of different colours, such as white numbers on a red background and black letters on
16 a white background. Strong light reaching a top curved optical surface of the
17 inspection window 21 causes the glint which is received by the imaging sensor.

18
19 [0012] The fluid meter optics 30 can be attached as original equipment or retrofitted
20 afterwards. Fluid meter optics 30 are designed to read the display, both
21 automatically and/or manually. In many cases it may be less expensive to merely
22 retrofit an analog fluid meter with fluid meter optics as envisioned herein. As shown
23 in the embodiment of Fig. 2, the fluid meter optics 30 can comprise a housing 31
24 having a first opening 33 on one side remote from the display 22, adapted to receive
25 ambient light (or an external torchlight) and provide a manual inspection port 53, and

1 a second opening 63 on another side, and when the fluid meter optics is assembled
2 together with the fluid meter 20, the second opening is positioned over the display
3 22. Ports 64 (shown in the embodiments of Fig. 1 and Fig. 3) can also provided and
4 used to shine a torchlight when there is insufficient ambient lighting. In some
5 embodiments the second opening 63 may not be present, and the housing of the
6 fluid meter optics may be essentially combined with the housing of the fluid meter.
7 The first opening 33 may optionally be covered with glass or a transparent plastic,
8 thereby allowing light to pass into and out of an interior of the housing of the fluid
9 meter optics. Fig. 2 shows a schematic cross section view of the fluid meter optics
10 30 when attached to a fluid meter 20. The first opening 53 is positioned directly over
11 the display 22, and preferably is large enough to allow for an optical path of light
12 reflected from the display to reach both an imaging camera/sensor 32 for automatic
13 inspection and a manual inspection portion of the first opening 33. The imaging
14 sensor 32 may be mounted inside/on to the housing generally over the display and is
15 operatively connected to a controller 34. Alternatively the imaging sensor 32 may be
16 mounted on the housing at an angle with respect to the display, and/or not directly
17 over the display. The controller in turn is operatively connected to a data collection
18 station (not shown) for remote transmission of data about the display.

19
20 [0013] There often can be situations, especially on bright sunny days, where the glint
21 from ambient light or direct solar illumination makes it difficult for the imaging sensor
22 32 to read the display. This can degrade performance of image processing
23 algorithms used in automatic inspection. In accordance with a highly advantageous
24 feature, several design improvements are added to address this issue. As shown in
25 the embodiment of Fig. 2, a bandpass filter 42 and a polarizer 52 are positioned

1 between the imaging sensor 32 and the second opening 63. The cascade of the
2 bandpass filter and polarizer allows polarized light between two specific wavelengths
3 to pass, but blocks or hinders signals at other wavelengths. The cascade of
4 bandpass filter and polarizer is adapted to receive light reflected up from the display
5 through the second opening 63. Once the light reaches the cascade of bandpass
6 filter 42 and polarizer 52, a first band of wavelengths with a particular polarization
7 passes from the cascade of bandpass filter and polarizer to the imaging sensor.
8 Wavelengths below or above a first band are effectively blocked by the bandpass
9 filter. The bandpass filter 42 can preferably work best at a range of wavelengths
10 where it gives the best image contrast of the fluid meter display. For example, it is
11 not recommended to use a red (>620nm) bandpass filter, as it is difficult for imaging
12 sensor to see white wordings on red background common used on commercially
13 available analog fluid meters. On the other hand, a 580 nm bandpass filter (yellow-
14 orange wavelength) may be used, for example, so that most of the light on a bright
15 sunny day is blocked from reaching the imaging sensor, and only wavelengths near
16 580 nm (roughly 570-590 nm) can pass.

17
18 [0014] Glint caused by solar or ambience light passing through first opening 33,
19 reflected from curved optical surface of fluid meter 21 into the imaging sensor 32,
20 affects image quality and degrade performance of image processing algorithms.
21 Preferably this can be addressed by use of the dichroic filter 35. A dichroic filter
22 (sometimes referred to as an optical thin-film filter, or interference filter) is used to
23 selectively pass light of a range of colors while reflecting other colors. Preferably, in
24 the embodiment of the drawings, the dichroic filter acts to reflect and block higher
25 wavelengths from passing. Sometimes this is referred to as a low pass optical filter

1 that passes light with a wavelength lower than a certain cutoff wavelength (for
2 example, between about 500nm to 550nm). and attenuates (by reflecting away)
3 signals with wavelengths higher than the cutoff wavelength. This dichroic filter
4 removes those wavelength components in the solar light passing through opening
5 33, which otherwise may reach the curved optical surface of fluid meter 21, reflect
6 strongly, and be received by the imaging sensor 32 via bandpass filter 42, to cause
7 glint in the display image.

8
9 [0015] The dichroic filter may be formed as a plate positioned in the housing between
10 the first opening 33 and the second opening 63, along an optical path from the first
11 opening to the display 22 (when assembled to the fluid meter). The dichroic filter is
12 preferably tilted at an angle θ , such as 45 degrees with respect to the second
13 opening 63. This tilting enhances manual viewing clarity and also converts the
14 polarization of the solar or ambient light passing through the dichroic filter principally
15 into light having orthogonal polarization to the imaging sensor's polarizer. This
16 advantageously further reduces the glint seen by the imaging sensor. Optionally,
17 since blocking of high wavelengths is never perfect, a second polarizer 85 may be
18 used positioned generally adjacent the dichroic filter (as shown in Fig. 2) to convert
19 the solar or ambient light passing through the dichroic filter into completely
20 orthogonal polarization with respect to the imaging sensor's polarizer. This
21 significantly reduces glint seen by the imaging sensor. In the embodiment shown
22 here, the 45 degree tilted dichroic filter passes light for wavelength less than 530nm.
23 Manual inspection of the fluid meter display through port 53, relies on ambience light
24 of wavelength less than 530nm transmitting through the dichroic filter. If ambience

light is not bright enough, an external torchlight can be used to shine at fluid meter display through port 53 or ports 64.

[0016] One or more LEDs 37 mounted on and inside the housing 31 may also be provided to illuminate the display 22. See Fig. 3 for a representative mounting pattern for the LEDs. Preferably the LEDs emits diffused light at a wavelength the same as the first band of wavelengths passed by the bandpass filter 42. The LEDs 37 in the embodiment of Fig. 2 can emit polarized light. Optionally, as shown in Fig. 3, a (third) LED polarizer 86 can be positioned between the (nonpolarised) LEDs 137 and the display 21 so as to emit light of orthogonal polarization to the imaging sensor's polarizer 52. This reduces glints from the curved optical surface 21 of the fluid meter display 22 upon LED illumination. The imaging sensor sees the depolarized diffused light from the fluid meter display 22.

[0017] Note that in the fluid meter optics disclosed herein, there can be a pair of separate optical paths, and light which passes through the bandpass filter generally does not pass through the dichroic filter and vice versa. The display is viewable from both the imaging sensor 32 and the manual inspection port 53. Optionally as shown in Fig. 2 the bandpass filter 42 is mounted adjacent the dichroic filter 35 such that where they meet is positioned directly over the display 22 as indicated by dashed line 99. Optionally, imaging sensor 32 can use the light from the fluid meter display reflected by the dichroic filter. Other orientations suitable for providing a pair of optical paths will be readily apparent to those skilled in the art given the benefit of this disclosure.

[0018] The dichroic filter may be positioned at an angle with respect to the display and the second opening 63. In the embodiment shown in the drawings, a bluish-green dichroic filter is mounted at a 10-70 degree angle Θ , most preferably about 45 degrees. This mounted angle may produce a cutoff wavelength of about 530 nm. Generally, titling a dichroic filter will shift the cutoff wavelength towards lower wavelengths. A blackened side or back wall 46 may also be provided cooperating with the dichroic filter to define a manual viewing channel 36. The channel can extend all the way from the first opening to the second opening. The side wall has a first segment 38 and a second segment 39. Preferably the first segment 38 can extend from the first opening generally parallel to the dichroic filter to help reduce reflections, and the second segment 39 can extend at about right angles (perpendicular) to the first segment so as to be generally perpendicular to the dichroic filter. The back wall and side wall are preferably blackened with a matte finish. Optionally, other blackened structure shape or just the blacken wall of casing 83 is sufficient to improve manual viewing clarity.

[0019] From the foregoing disclosure and detailed description of certain embodiments, it will be apparent that various modifications, additions and other alternative embodiments are possible without departing from the true scope of the invention. The embodiments discussed were chosen and described to provide the best illustration of the principles of the invention and its practical application to thereby enable one of ordinary skill in the art to use the invention in various embodiments and with various modifications as are suited to the particular use contemplated. All such modifications and variations are within the scope of the

- 1 invention as determined by the appended claims when interpreted in accordance
- 2 with the breadth to which they are fairly, legally, and equitably entitled.
- 3

CLAIMS

What is claimed is:

1. Fluid meter optics adapted to allow for inspection of a display of a fluid meter comprising:
 - a housing having a first opening adapted to receive light;
 - an imaging sensor for automatic inspection, mounted on the housing;
 - a bandpass filter mounted on the housing, wherein a first band of wavelengths passes from the bandpass filter to the imaging sensor; and
 - a dichroic filter positioned between the first opening and the display and adapted to pass a second range of wavelengths of light reflected from the display through the dichroic filter.
2. The fluid meter optics of claim 1 further comprising a first polariser positioned adjacent the bandpass filter.
3. The fluid meter optics of claim 2 further comprising a second polarizer positioned adjacent to the dichroic filter.
4. The fluid meter optics of claim 3 where the second polarizer transmits light of orthogonal polarization to the first polarizer adjacent to bandpass filter.
5. The fluid meter optics of claim 1 wherein light received by the imaging sensor via the bandpass filter from the display does not pass through the first opening.

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2 6. The fluid meter optics of claim 1 wherein the dichroic filter comprises a plate
3 positioned at an angle with respect to the display.
4

5 7 The fluid meter optics of claim 2 wherein the dichroic filter comprises a plate
6 tilted at an angle with respect to the display, wherein tilting of the dichroic filter
7 results in transmission of at least partially polarized light whose polarization is
8 orthogonal to the first polarizer adjacent to passband filter
9

10 8. The fluid meter optics of claim 6 wherein the angle is 10-70 degrees.
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12 9. The fluid meter optics of claim 1 further comprising a channel between the
13 first opening and the display formed by the dichroic filter and a blackened side wall.
14

15 10. The fluid meter optics of claim 1 further comprising a light source mounted on
16 the housing.
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18 11. The fluid meter optics of claim 10 where the light source is an LED which
19 emits a narrow band of wavelengths in the same range as the first band of
20 wavelengths passed by the bandpass filter.
21

22 12. The fluid meter optics of claim 10 wherein the light source is one of a light
23 source which emits polarized light and a light source which emits light converted to
24 polarized light by a third polarizer.
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1 13. The fluid meter optics of claim 12 wherein polarization of the light from the
2 light source is orthogonal to a first polarizer adjacent to the bandpass filter.

3
4 14. The fluid meter optics of claim 1 where the bandpass filter has a center
5 wavelength of a passband between 550 nm to 610 nm.

6
7 15. The fluid meter optics of claim 1 where the dichroic filter is low pass and has a
8 cut-off wavelength between 500nm to 550nm.