DRIP CHAMBER WITH INTEGRATED OPTICS

TECHNICAL FIELD

[0001] The present disclosure relates to a rectangular drip chamber for an infusion tube with integrated optics, in particular, lenses integrated onto one or more walls of the drip chamber. The present disclosure relates to an optical imaging system including the rectangular drip chamber for the infusion tube with integrated optics.

BACKGROUND

[0002] It is known to use lenses, separate from a cylindrical drip chamber, as part of an optical imaging system for an infusion tube. Source light and imaging light must pass through the cylindrical wall of the drip chamber when entering and exiting the drip chamber, respectively, greatly complicating the optical design of both the illumination and imaging sub-systems (lenses, image sensors etc.).

SUMMARY

[0003] According to aspects illustrated herein, there is provided a drip chamber for an infusion tube, including: a first end arranged to receive a drip tube; a second end including an exit port; at least one wall connecting the first and second ends; a space enclosed by the first and second ends and the at least one wall; and at least one lens integral to the at least one wall or directly fixed to the at least one wall.

[0004] According to aspects illustrated herein, there is provided an optical imaging system for use with an infusion device, including: at least one light source for emitting first light; a drip chamber including at least one wall connecting first and second ends of the drip chamber and a space at least partially enclosed by the at least one wall and the first and second ends; and at least one lens integral to the at least one wall or directly fixed to the at least one wall, the at least one lens arranged to: transmit the first light to the space or receive the first light transmitted through the space. The imaging system includes an optics system including at least one image sensor for receiving the first light from the at least one lens and transmitting data characterizing the first light received from the at least one lens; and at least one specially programmed processor configured to generate, using the data, at least one image of the space.

[0005] According to aspects illustrated herein, there is provided a drip chamber for an infusion tube, including: a first end arranged to receive a drip tube; a second end

including an exit port; and first, second, third, and fourth walls connecting the first and second ends. In a cross-section orthogonal to a longitudinal axis for the drip tube, the first, second, third, and fourth walls form a rectangle enclosing a space.

[0006] According to aspects illustrated herein, there is provided a method of forming a drip chamber for an infusion tube, including: forming a first end arranged to receive a drip tube; forming a second end including an exit port; connecting the first and second ends with at least one wall; enclosing a space with the first and second ends and the at least one wall; and integrating at least one lens into the at least one wall; or directly fixing at least one lens to the at least one wall.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Various embodiments are disclosed, by way of example only, with reference to the accompanying schematic drawings in which corresponding reference symbols indicate corresponding parts, in which:

Figure 1 is a schematic side view of an optical imaging system with a rectangular drip chamber;

Figure 2 is a schematic top view of an optical imaging system with a square drip chamber;

Figure 3 is a schematic side view of an optical imaging system with a drip chamber including at least one integrated or directly fixed lens;

Figure 4 is a schematic top view of an optical imaging system with a drip chamber including at least one integrated or directly fixed lens;

Figure 5 is a schematic side view of an optical imaging system with a drip chamber including at least one integrated or directly fixed lens; and

Figure 6 is a schematic top view of an optical imaging system including at least one integrated or directly fixed lens.

DETAILED DESCRIPTION

[0008] At the outset, it should be appreciated that like drawing numbers on different drawing views identify identical, or functionally similar, structural elements of the disclosure. It is to be understood that the disclosure as claimed is not limited to the disclosed aspects.

[0009] Furthermore, it is understood that this disclosure is not limited to the particular methodology, materials and modifications described and as such may, of

course, vary. It is also understood that the terminology used herein is for the purpose of describing particular aspects only, and is not intended to limit the scope of the present disclosure.

[0010] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood to one of ordinary skill in the art to which this disclosure belongs. It should be understood that any methods, devices or materials similar or equivalent to those described herein can be used in the practice or testing of the disclosure.

[0011] Figure 1 is a schematic side view of optical imaging system **100** with rectangular drip chamber **102**.

[0012] Figure 2 is a schematic top view of optical imaging system **100** with square drip chamber **102**. The following should be viewed in light of Figures 1 and 2. Chamber **102** includes end **104** arranged to receive drip tube **106** and end **108** including exit port **110**. Chamber **102** includes walls **112**, **114**, **116**, and **118** connecting ends **104** and **108** and enclosing space **120**. In a cross-section orthogonal to longitudinal axis **LA** for drip tube **106**, for example, as shown in Figure 2, walls **112**, **114**, **116**, and **118** form a rectangle enclosing space **120**. In an example embodiment, the rectangle is a square.

[0013] System **100** includes light source **122**, and optics system **123** with at least one lens **124** and at least one image sensor **126**. In the example of Figures 1 and 2, system **123** includes lenses **124A** and **124B** and image sensors **126A** and **126B**. The light source is arranged to emit light **130**, which is transmitted through space **120** and received by lenses **124A** and **124B**. Lenses **124A** and **124B** focus and transmit the light to image sensors **126A** and **126B**, respectively. Image sensors **126A** and **126B** receive the light from lenses **124A** and **124B**, respectively, and generate and transmit data **132** characterizing the light received from lenses **124A** and **124B**. In the example of Figures 1 and 2, sensors **126A** and **126B** generate and transmit data **132A** and **132B**, respectively. Memory element **133** is configured to store computer executable instructions **134**. Processor **135** is configured to execute instructions **134** to generate, using data **132**, at least one image **136** of space **120**. In the example of Figures 1 and 2, the processor generates images **136A** and **136B** of space **120** from data **132A** and **132B**, respectively.

[0014] By “characterizing,” we mean that the respective data describes, or quantifies, the light, for example, providing parameters enabling generation of an image using the respective data. By “emitting light” we mean that the element in questions

generates the light. By “transmitted by” we mean that light passes through the element in question, for example, light emitted by light source **122** passes through space **120**.

[0015] In an example embodiment, end **E1** of drip tube **106** is located in space **120** and image **136A** includes end **E1**. Processor **135** is configured to execute instructions **134** to analyze image **136A** to determine if drop **138** is pendant at end **E1** and to determine time periods **140** in which drop **138** is or is not pendant at end **E1**. Time periods **140** can be used to identify when a source of fluid, such as medication bag **141**, is empty. In an example embodiment, image **136A** includes an image of drop **138** pendant from end **E1** and processor **135** is configured to execute instructions **134** to calculate volume **142** of the pendant drop **138**, for example, for use in controlling flow through drip chamber **102**.

[0016] In an example embodiment, meniscus **144** for fluid **146** in drip chamber **102** is located in space **120** and is included in image **136B**. Processor **135** is configured to execute instructions **134** to calculate, from image **136B**, position **148** of meniscus **144** within drip chamber **102**. Position **148** can be used to control flow through drip chamber **102**, or if meniscus **144** is determined to be absent, indicating a possible air-in-the-line fault condition, flow through drip chamber **102** can be halted.

[0017] In the example of Figures 1 and 2, two lenses and two image sensors are used. It should be understood that only one or the other of lens/image sensor pairs **124A**/**126A** or **124B**/**126B** can be used in system **100**. It also should be understood that two separate light sources could be used.

[0018] Figure 3 is a schematic side view of optical imaging system **200** with drip chamber **202** including at least one integrated or directly fixed lens.

[0019] Figure 4 is a schematic top view of optical imaging system **200** with drip chamber **202** including at least one integrated or directly fixed lens. The following should be viewed in light of Figures 3 and 4. Chamber **202** includes end **204** arranged to receive drip tube **206** and end **208** including exit port **210**. Chamber **202** includes walls **212**, **214**, **216**, and **218** connecting second ends **204** and **208** and enclosing space **220**. In a cross-section orthogonal to longitudinal axis **LA** for drip tube **206**, for example, as shown in Figure 4, walls **212**, **214**, **216**, and **218** form a rectangle enclosing space **220**. In an example embodiment, the rectangle is a square. Drip chamber **202** includes at least one lens **221** integral to at least one of walls **212**, **214**, **216**, or **218** or directly fixed to at least one of walls **212**, **214**, **216**, or **218**, as further described below.

[0020] System **200** includes light source **222**, and optics system **223** with at least one lens **224** and at least one image sensor **226**. In the example of Figures 3 and 4, system **223** includes lenses **224A** and **224B** and image sensors **226A** and **226B**. The light source is arranged to emit light **230**, which is transmitted through space **220** and received by lenses **224A** and **224B**. Lenses **224A** and **224B** focus and transmit the light to image sensors **226A** and **226B**, respectively. Image sensors **226A** and **226B** receive the light from lenses **224A** and **224B**, respectively, and generate and transmit data **232** characterizing the light received from lenses **224A** and **224B**. In the example of Figures 3 and 4, sensors **226A** and **226B** generate and transmit data **232A** and **232B**, respectively. Memory element **233** is configured to store computer executable instructions **234**. Processor **235** is configured to execute instructions **234** to generate, using data **232**, at least one image **236** of space **220**. In the example of Figures 3 and 4, the processor generates images **236A** and **236B** of space **220** from data **232A** and **232B**, respectively.

[0021] In Figures 3 and 4, at least one lens **221** is integral to or directly fixed to wall **212** or **216**, for example, and performs functions in addition to those described above. At least one lens **221** is arranged to transmit light **230** to space **220**, or receive light **230** transmitted through space **220** and transmit light **230** to lens **224**. In the example of Figures 3 and 4, lens **221A** and **221B** are positioned on wall **216** and arranged to receive light **230** transmitted through space **220** and focus and transmit the received light to lens **224A** and **224B**, respectively.

[0022] In an example embodiment, end **E1** of drip tube **206** is located in space **220** and image **236A** includes end **E1**. Processor **235** is configured to execute instructions **234** to analyze image **236A** to determine if drop **238** is pendant at end **E1** and to determine time periods **240** in which drop **238** is or is not pendant at end **E1**. Time periods **240** can be used to identify when a source of fluid, such as medication bag **241**, is empty. In an example embodiment, image **236A** includes an image of drop **238** pendant from end **E1** and processor **235** is configured to execute instructions **234** to calculate volume **242** of the pendant drop **238**, for example, for use in controlling flow through drip chamber **202**.

[0023] In an example embodiment, meniscus **244** for fluid **246** in drip chamber **202** is located in space **220** and is included in image **236B**. Processor **235** is configured to execute instructions **234** to calculate, from image **236B**, position **248** of meniscus **244** within drip chamber **202**. Position **248** can be used to control flow through drip chamber

202, or if meniscus **244** is determined to be absent, indicating a possible air-in-the-line fault condition, flow through drip chamber **202** can be halted.

[0024] In the example of Figures 3 and 4, two lenses **224** and two image sensors are used. It should be understood that only one or the other of lens/image sensor pairs **224A**/**226A** or **224B**/**226B** can be used in system **100**. It also should be understood that two separate light sources could be used to emit light. In the example of Figures 3 and 4, lenses **221A** and **221B** are shown; however, it should be understood that drip chamber **202** can be equipped only one or the other of lenses **221A** or **221B**.

[0025] In an example embodiment, the portion of the wall to which lenses **221A** and **221B** are integral or attached, for example, portions **216A** and **216B** of wall **216**, are flat. For example, wall **216** includes exterior surface **250** with flat portions **216A** and **216B** and lenses **221A** or **221B** are integral to flat portions **216A** and **216B** or directly fixed to flat portions **216A** and **216B**. In an example embodiment, walls **212** and **216** are flat, substantially parallel to each other, and face in directions **D1** and **D2**, respectively. In an example embodiment, portions **216A** and **216B** and at least portions of wall **212** aligned with portions **216A** and **216B**, orthogonal to longitudinal axis **LA** for the drip chamber, are flat and substantially parallel to each other, for example, along longitudinal axis **LA**. That is, light **230** passing through lenses **221A** and **221B** passes through flat and substantially parallel portions of wall **212**.

[0026] Although walls **214** and **218** are shown as flat forming a square with walls **212** and **216** in Figure 4, it should be understood that walls **214** and **218** are not required to have any particular shape or to form any particular shape of space **220**. It also should be understood that although walls **212** and **216** are shown as flat, the portion of wall **216** not including portions **216A** and **216B**, and the portions of wall **212** not aligned with portions **216A** and **216B** orthogonal to longitudinal axis **LA**, are not required to have any particular shape.

[0027] It should be understood that lens **221A** and/or **221B** can be positioned on wall **212**, in which case, the above discussion regarding wall **216** and wall **212** with portions **216A** and **216B** and lenses **221A** and **221B** is applicable to wall **212** and wall **216** having the lenses and flat portions. It also should be understood that only one of lenses **221A** or **221B** can be positioned on drip chamber **202,** either on wall **212** or on wall **216**. The single lens **221** can be positioned to transmit light to image the drip tube or to transmit light to image the meniscus.

[0028] Figure 5 is a schematic side view of optical imaging system **300** with drip chamber **302** including at least one integrated or directly fixed lens.

[0029] Figure 6 is a schematic top view of optical imaging system **300** with drip chamber **302** including at least one integrated or directly fixed lens. The following should be viewed in light of Figures 5 and 6. Chamber **302** includes end **304** arranged to receive drip tube **306** and end **308** including exit port **310**. Chamber **302** includes walls **312**, **314**, **316**, and **318** connecting ends **304** and **308** and enclosing space **320**. In a cross-section orthogonal to longitudinal axis **LA** for drip tube **306**, for example, as shown in Figure 6, walls **312**, **314**, **316**, and **318** form a rectangle enclosing space **320**. In an example embodiment, the rectangle is a square. Drip chamber **302** includes at least two lenses **321** integral to walls **312** and **318**, or directly fixed to walls **312** and **318**, as further described below. In general, lenses **321** are in pairs (one on side **312** and the other on side **316**) aligned with a line orthogonal to axis **LA**. In Figures 5 and 6, two pairs of lenses, **321A/C** and **321B/D** are shown.

[0030] System **300** includes light source **322**, and optics system **323** with at least one lens **324** and at least one image sensor **326**. In the example of Figures 5 and 6, system **323** includes lenses **324A** and **324B** and image sensors **326A** and **326B**. The light source is arranged to emit light **330**, which is transmitted through space **320** and received by lenses **324A** and **324B**. Lenses **324A** and **324B** focus and transmit the light to image sensors **326A** and **326B**, respectively. Image sensors **326A** and **326B** receive the light from lenses **324A** and **324B**, respectively, and generate and transmit data **332** characterizing the light received from lenses **324A** and **324B**. In the example of Figures 5 and 6, sensors **326A** and **326B** generate and transmit data **332A** and **332B**, respectively. Memory element **333** is configured to store computer executable instructions **334**. Processor **335** is configured to execute instructions **334** to generate, using data **332**, at least one image **336** of space **320**. In the example of Figures 5 and 6, the processor generates images **336A** and **336B** of space **320** from data **332A** and **332B**, respectively.

[0031] In Figures 5 and 6, lenses **321** are integral to or directly fixed to walls **312** and **316** and perform functions in addition to those described above. Pairs of lenses **321** are arranged to transmit light **330** to space **320**, and receive light **330** transmitted through space **320**. In the example of Figures 5 and 6, lens **321A** and **321C** are arranged to receive light **330** from source **322** and transmit light **330** through space **320**; and lenses **321B** and **321D** are arranged to receive light **330** transmitted through space **320** and focus and transmit the received light **320**. Thus, lenses **321A** and **321C** form a pair (the same light

passes through both lenses) and lenses **321B** and **321D** form a pair (the same light passes through both lenses). As shown in Figure 6, axis **LA** is located between lenses **321A** and **321C** and lenses **321B** and **321D** along plane **337** orthogonal to axis **LA**.

[0032] In an example embodiment, end **E1** of drip tube **306** is located in space **320** and image **336A** includes end **E1**. Processor **335** is configured to execute instructions **334** to analyze image **336A** to determine if drop **338** is pendant at end **E1** and to determine time periods **340** in which drop **338** is or is not pendant at end **E1**. Time periods **340** can be used to identify when a source of fluid, such as medication bag **341**, is empty. In an example embodiment, image **336A** includes an image of drop **338** pendant from end **E1** and processor **335** is configured to execute instructions **334** to calculate volume **342** of the pendant drop **338**, for example, for use in controlling flow through drip chamber **302**.

[0033] In an example embodiment, meniscus **344** for fluid **346** in drip chamber **302** is located in space **320** and is included in image **336B**. Processor **335** is configured to execute instructions **334** to calculate, from image **336B**, position **348** of meniscus **344** within drip chamber **302**. Position **348** can be used to control flow through drip chamber **302**, or if meniscus **344** is determined to be absent, indicating a possible air-in-the-line fault condition, flow through drip chamber **302** can be halted.

[0034] In the example of Figures 5 and 6, two lenses **324** and two image sensors are used. It should be understood that only one or the other of lens/image sensor pairs **324A**/**326A** or **324B**/**326B** can be used in system **300**. It also should be understood that two separate light sources could be used to emit light. In the example of Figures 5 and 6, lenses **321A-D** are shown; however, it should be understood that drip chamber **302** can be equipped only one or the other of pair of lenses **321A/C** or **321B/D**.

[0035] In an example embodiment, the portions of the walls to which lenses **321A-D** are integral or attached, for example, portions **312A** and **312B** of wall **312**, and portions **316A** and **316B** of wall **316** are flat. For example, walls **312** and **316** include respective exterior surfaces **350** with flat portions **312A** and **312B** and flat portions **316A** and **316B**, respectively. Lenses **321A** and **321B** are integral to portions **312A** and **312B** or directly fixed to portions **312A** and **312B**, respectively; and lenses **321C** and **321D** are integral to portions **316A** and **316B** or directly fixed to portions **316A** and **316B**, respectively. Portions **312A** and **316A** are substantially parallel to each other and portions **312B** and **316B** are substantially parallel to each other. In an example embodiment, walls

312 and **316** are flat and face in directions **D1** and **D2**, respectively. In an example embodiment, walls **312** and **316** are flat and substantially parallel to each other, for example, substantially parallel to longitudinal axis **LA** for the drip chamber. Although walls **314** and **318** are shown as flat and forming a square with walls **312** and **316** in Figure 6, it should be understood that walls **314** and **318** are not required to have any particular shape or to form any particular shape of space **320**. It also should be understood that although walls **312** and **316** are shown as flat, the portions of wall **312** not including portions **312A** and **312B**, and the portions of wall **316** not including portions **316A** and **316B**, are not required to have any particular shape.

[0036] Advantageously, flat walls for drip chamber **102**, **202**, or **302**, for example, flat walls **112** and **116** for drip chamber **102**, eliminate the problem noted above of source light and imaging light passing through a cylindrical wall of a drip chamber when entering and exiting the drip chamber. Thus, the optical design of both an illumination system, for example, light sources **122**, **222**, or **322**, and an optical system such as system **123**, **223**, or **323**, including components such as lenses **124**, **224**, or **324** and/or imagers **126**, **226**, or **326**, can be advantageously simplified, reducing complexity and cost of systems **100**, **200**, and **300**. For example, drip chamber **302** with a substantially parallel portions **312A/316A** and **312B/316B** reduces optical aberrations such as distortion, astigmatism, and coma.

[0037] Integrally molding lens or lenses **221/321** to drip tubes **206/306**, or attaching lens or lenses **221/321** directly to drip tubes **206/306**, advantageously enables faster speeds for lens or lenses **221/321**, without compromising the performance of lens or lenses **221/321** in other areas. Integrally molding lens or lenses **221/321** to drip tubes **206/306**, or attaching lens or lenses **221/321** directly to drip tubes **206/306** also reduces the parts count, cost, and complexity of systems **200**/**300**. Further, lens or lenses **221/321** enable a reduction in the distance between a backlight such as sources **222**/**323** and an image sensor such as **226**/**326**, advantageously reducing a size of an infusion pump including drip chamber **202** or **302**.

[0038] Installing lens or lenses **221/321** provides an extra degree of freedom in the design of illumination for system **200**/**300**, for example, enabling greater control over spatial and angular flux incident on a pendant drop being illuminated.

[0039] It should be understood that any combination of the drip chamber configurations shown in Figures 1 through 6 can be used in a single drip chamber. For example, drip chamber **202** or **302** can include lens/sensor pair **221A**/**224A/226A** and

lenses/sensor grouping **321B/321D/324B/326B**. For example, drip chamber **200** or **300** can include lens/sensor grouping **221B/224B/226B** and lenses/sensor pair **321A/321C/324A/326A**.

[0040] Light sources **122, 222,** and **322** can be different from each other and can be any light source known in the art, including, but not limited to a light-emitting diode (LED), an array of LEDs, a laser diode, an incandescent lamp, or a fluorescent lamp.

[0041] The following provides further detail regarding drip chambers **102**, **202**, and **302** and/or lenses **221/321**. Lenses **221/321** can be any combination of: positive or negative; spherical or aspherical; rotationally symmetric or asymmetric; or cylindrical. Lens or lenses **221/321** can be Fresnel lenses. Lens or lenses **221/321** can have a diffractive optical element installed onto them or can be replaced by a diffractive optical element. Drip chamber **202/302** with integral lens or lenses **221/321** can be fabricated by injection molding. Drip chamber **202/302** with integral lens or lenses **221/321** can be made from a polymer, such as acrylic, polycarbonate, or polystyrene. A cross section of drip chambers **102**, **202**, or **302** can be circular, elliptical, rectangular, square, or rectangular with radiused corners.

[0042] In an example embodiment, drip chamber **202** or **302** includes installation feature **252** so that the drip chamber can be installed in an infusion pump in only one (desired) way, for example, so that lens or lenses **221** or **321** are properly oriented. In an example embodiment, drip chamber **202** or **302** includes an alignment feature to ensure that when installed, an optical axis of the drip chamber is co-linear with an axis of lens or lenses, such as lens or lenses **221** or **321**, and/or the axis of a light source such as light source **222** or **322** The installation and alignment features can be combined.

[0043] Lens or lenses **221** or **321** can be partially recessed into the walls of drip chamber **202** or **302** so that the overall thickness of the walls are not significantly increased as the thickest part of lens or lenses **221** or **321**. Such a configuration can avoid “sinks” and improve the surface figure of the lens in question.

[0044] In an example embodiment, drip chamber **202** includes installation features, such as features **252A** and/or **252B**. Features **252A** and **252B** are used to precisely locate lenses **221A** and **221B**, respectively, on respective optical axis. The size, shape, and location of features **252A** and/or **252B** are for purposes of illustration only, other sizes, shapes, and locations are possible. The preceding discussion also is applicable to drip chamber **302**.

[0045] Lens or lenses **221** or **321** can be produced as part of the molding process for drip chamber **202** or **302**, or can be fabricated in separate molding processes and subsequently bonded to chamber **202** or **302**. The bonding can be executed with adhesive or through an ultrasonic or thermal bonding process. The respective prescriptions of lens or lenses **221** or **321** can be different, resulting in different imager magnifications. The different magnifications can be matched to various configurations of chamber **202** or **302** to enhance operations such a imaging of drops pendant from drip tube **208** or **308**. Interlock-like features can be integrally molded onto drip chamber **202** or **302**, which can be sensed by an infusion pump, causing the pump to utilize different calibration flow-rate constant according to the sensed magnification. A two-dimensional bar code, such as QR code, can be installed onto a surface of drip chamber **202** or **302** within the field of view of the imager (but not blocking view of areas of interest such as drip tube **208**, or **308**). The code can include information regarding drip chamber **202** or **302** such as: manufacturer, date of manufacture, authentication information, magnification, nominal drip rate of a nozzle.

[0046] It will be appreciated that various of the above-disclosed and other features and functions, or alternatives thereof, may be desirably combined into many other different systems or applications. Various presently unforeseen or unanticipated alternatives, modifications, variations, or improvements therein may be subsequently made by those skilled in the art which are also intended to be encompassed by the following claims.

CLAIMS

1. A drip chamber for an infusion tube, comprising:

a first end arranged to receive a drip tube;

a second end including an exit port;

at least one wall connecting the first and second ends;

a space enclosed by the first and second ends and the at least one wall; and

first and second lenses each directly fixed to said at least one wall.

2. The drip chamber of claim 1, wherein said first and second lenses are each arranged to: transmit light to the space or receive light transmitted through the space.

3. The drip chamber of claim 1, wherein the at least one wall includes a first wall with at least a flat portion and said first and second lenses are directly fixed to the flat portion.

4. The drip chamber of claim 1, wherein the at least one wall includes an exterior surface and said first and second lenses are directly fixed to the exterior surface.

5. The drip chamber of claim 1, further comprising first and second walls with at least first and second flat portions, respectively, substantially parallel to each other, wherein said first and second lenses are directly fixed to only one of the first or second flat portions.

6. The drip chamber of claim 1, wherein the at least one wall forms a rectangle enclosing the space in a cross-section orthogonal to a longitudinal axis of the drip chamber.

7. The drip chamber of claim 1, further comprising first and second walls with at least first and second flat portions, respectively, the first lens is directly fixed to the first flat portion and the second lens is directly fixed to the second first flat portion.

8. The drip chamber of claim 7, wherein a longitudinal axis for the drip chamber is located between the first and second lenses on a line connecting the first and second lenses.

9. An optical imaging system for use with an infusion device, comprising:

at least one light source for emitting first light;

a drip chamber including at least one wall connecting first and second ends of the drip chamber, a space at least partially enclosed by the at least one wall and the first and second ends, and first and second lenses each fixed to the at least one wall, said first and second lenses each arranged to transmit the first light to the space or receive the first light transmitted through the space;

an optics system including at least one image sensor for receiving the first light from said first and second lenses and transmitting data characterizing the first light received from said first and second lenses; and

at least one specially programmed processor configured to generate at least one image of the space using the data.

10. The optical imaging system of claim 9, wherein the at least one wall includes an exterior surface and the said first and second lenses are directly fixed to the exterior surface.

11. The optical imaging system of claim 9, wherein the at least one wall includes at least a flat portion and said first and second lenses are directly fixed to the flat portion.

12. The optical imaging system of claim 9, wherein the first lens is arranged to transmit the first light to the space and the second lens is arranged to receive the first light transmitted by the first lens through the space and transmit the received first light to the at least one image sensor.

13. The optical imaging system of claim 10, wherein the drip chamber includes a drip tube, an end of the drip tube is located in the space, the at least one image including an image of a drop pendant from the end of the drip tube and the at least one specially programmed processor is configured to calculate a volume of the pendant drop from the image of the drop pendant.

14. The optical imaging system of claim 10, wherein a meniscus for fluid in the drip chamber is located in the space and the at least one specially programmed processor is configured to calculate, from the at least one image, a position of the meniscus within the drip chamber.

15. A drip chamber for an infusion tube, comprising:

a first end including a drip tube;

a second end including an exit port;

first, second, third, and fourth walls connecting the first and second ends, wherein, in a cross-section orthogonal to a longitudinal axis of the drip tube, the first, second, third, and fourth walls form a rectangle enclosing a space, wherein one of said first, second, third and fourth walls includes a code integral to said one of said first, second, third and fourth walls, the code including information regarding the drip chamber; and

first and second lenses each directly fixed to one of said first, second, third and fourth walls.

16. A method of forming a drip chamber for an infusion tube, the method comprising:

forming a first end arranged to receive a drip tube;

forming a second end including an exit port;

connecting the first and second ends with at least one wall and enclosing a space with the first and second ends and the at least one wall;

integrally attaching a code to the at least one wall, the code including information regarding the drip chamber; and

directly fixing first and second lenses to the at least one wall.