optical axis; an aperture stop; and a fourth optical element with input and output surfaces having rotational symmetry and centered on the optical axis.

[0006a] According to one aspect, there is provided an optical imaging assembly, comprising: an optical axis; an object axis defined by an object being imaged; an aperture stop disposed on the optical axis; a light-transmissive sleeve enclosing the object axis, being telecentric in object space, such that a ray leaving the object travels in a direction substantially parallel to the optical axis, and passes substantially through a center of the aperture stop; and at least three refractive lens elements being arranged between the object and the aperture stop without any other intervening optical component, at least one of said elements having surfaces having at least one of cylindrical and acylindrical prescription, with an image plane, wherein the object being imaged lies within the sleeve.

[0006b] According to another aspect, there is provided an imaging assembly, comprising: an optical axis; an object axis defined by an object being imaged; an aperture stop disposed on the optical axis; four lens elements disposed on the optical axis, at least three of said four lens elements being arranged between the object and the aperture stop without any other intervening optical component; and a light-transmissive sleeve being telecentric in object space, such that a ray leaving the object travels in a direction substantially parallel to the optical axis, and passes substantially through a center of the aperture stop, wherein the imaging assembly has an optical speed f-number of 1.5 or less, two of said four lens elements have aspherical prescriptions, and the other two of said four lens elements have acylindrical surfaces, and wherein said two acylindrical surfaces are separated from one another.

[0006c] According to yet another aspect, there is provided an imaging assembly configured for removing optical distortion from an image generated by an object located within a transparent sleeve, said assembly comprising: a first optical element having a first input surface and a first output surface, said first input surface having a substantially planar surface, said first output surface having a cylindrical or acylindrical surface; and a second optical element having a second input surface and a second output surface, said second input surface having the substantially planar surface, said second output surface

having the cylindrical or acylindrical surface, wherein both said first and second optical elements are arranged without any other intervening optical component such that said first and second output surfaces acting in conjunction remove the optical distortion from the image generated by the object.

[0007] ~~More specifically, a~~An optical imaging assembly is provided, including an optical axis, with an object axis, having a light-transmissive sleeve enclosing the object axis, telecentric in object space, having at least three refractive lens elements, in two of the lens elements, at least one of said elements having surfaces with at least one of cylindrical and acylindrical prescription, with an image plane, wherein the object being imaged lies within the sleeve.

[0008] In one embodiment, an assembly includes four lens elements arranged in a manner such that the resulting optical imaging assembly is able to correct for large amounts of optical distortion, is telecentric in object space, has an f-number of 1.5 or less. Two of the lens elements have aspherical prescriptions, and the other two lens elements have acylindrical surfaces, wherein the two acylindrical surfaces are separated from one another. The optical imaging assembly is well adapted for use in a liquid flowmeter system in which the fluid flows in a series of droplets enclosed in a drip chamber.

[0009] In another embodiment, an imaging assembly is configured for removing optical distortion from an image generated by an object located within a light transmissive sleeve. The assembly includes a first optical element acting in conjunction with a second optical element; both optical elements have cylindrical and/or acylindrical surfaces that together remove optical distortion from the image.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The nature and mode of operation of the present optical imaging assembly will now be more fully described in the following detailed description taken with the accompanying drawing figures, in which:

[0011] Figure 1 is a schematic top-view of the present optical imaging assembly;

CLAIMS

What is claimed is:

1. An optical imaging assembly, comprising: an optical axis; an object axis; a light-transmissive sleeve enclosing the object axis, being telecentric in object space, having at least three refractive lens elements, at least one of said elements having surfaces having at least one of cylindrical and acylindrical prescription, with an image plane, wherein the object being imaged lies within the sleeve.

2. The assembly as set forth in claim 1 wherein the distance between the at least one of cylindrical and acylindrical prescription is greater than 1.0mm.

3. The assembly as set forth in claim 1 wherein the input surface of a first lens element is planar.

4. The assembly as set forth in claim 1 wherein at least one of the refractive lens elements has a surface having radial symmetry.

5. The assembly as set forth in claim 4 wherein the surface having radial symmetry is a spherical surface.

6. The assembly as set forth in claim 4 wherein the surface having radial symmetry is an aspherical surface.

7. The assembly as set forth in claim 1 wherein at least one of the refractive lens elements is made from a polymer material.

8. The assembly as set forth in claim 1 wherein at least one of the refractive lens elements is fabricated with a molding process.

9. The assembly as set forth in claim 1 wherein the object being imaged is a liquid.

10. The assembly as set forth in claim 9 wherein the liquid object is a pendant drop.

11. The assembly as set forth in claim 1 wherein the system is telecentric in object space.

12. The assembly as set forth in claim 1 wherein the system has an f-number of 2.0 or less.

13. The assembly as set forth in claim 1 wherein a distance from the object plane to the image plane is 200mm or less.

14. The assembly as set forth in claim 1 in wherein the magnitude of the magnification is less than 1.0.

15. An imaging assembly, comprising: four lens elements arranged in a manner such that the resulting optical imaging assembly is able to correct for large amounts of optical distortion; is telecentric in object space; has an f-number of 1.5 or less; two of said lens elements have aspherical prescriptions, and the other two of said lens elements have acylindrical surfaces; wherein said two acylindrical surfaces are separated from one another.

16. An imaging assembly configured for removing optical distortion from an image generated by an object located within a transparent sleeve, said assembly comprising: a first optical element acting in conjunction with a second optical element; both said optical elements have cylindrical and/or acylindrical surfaces that together remove optical distortion from the image.

What is claimed is:

1. An optical imaging assembly, comprising:

an optical axis;

an object axis defined by an object being imaged;

an aperture stop disposed on the optical axis;

a light-transmissive sleeve enclosing the object axis, being telecentric in object space, such that a ray leaving the object travels in a direction substantially parallel to the optical axis, and passes substantially through a center of the aperture stop; and

at least three refractive lens elements being arranged between the object and the aperture stop without any other intervening optical component, at least one of said elements having surfaces having at least one of cylindrical and acylindrical prescription, with an image plane,

wherein the object being imaged lies within the sleeve.

2. The assembly as set forth in claim 1 wherein a thickness of each refractive lens along the optical axis is greater than or equal to 4.0 mm.

3. The assembly as set forth in claim 1 wherein the input surface of a first lens element is planar.

4. The assembly as set forth in claim 1 wherein at least one of the refractive lens elements has a surface having radial symmetry.

5. The assembly as set forth in claim 4 wherein the surface having radial symmetry is a spherical surface.

6. The assembly as set forth in claim 4 wherein the surface having radial symmetry is an aspherical surface.

7. The assembly as set forth in claim 1 wherein at least one of the refractive lens elements is made from a polymer material.

8. The assembly as set forth in claim 1 wherein at least one of the refractive lens elements is fabricated with a molding process.

9. The assembly as set forth in claim 1 wherein the object being imaged is a liquid.

10. The assembly as set forth in claim 9 wherein the liquid object is a pendant drop.

11. The assembly as set forth in claim 1 wherein the assembly has an f-number of 2.0 or less.

12. The assembly as set forth in claim 1 wherein a distance from the object plane to the image plane is 200 mm or less.

13. The assembly as set forth in claim 1 in wherein the magnitude of the magnification is less than 1.0.

14. An imaging assembly, comprising:

an optical axis;

an object axis defined by an object being imaged;

an aperture stop disposed on the optical axis;

four lens elements disposed on the optical axis,

at least three of said four lens elements being arranged between the object and the aperture stop without any other intervening optical component; and

a light-transmissive sleeve being telecentric in object space, such that a ray leaving the object travels in a direction substantially parallel to the optical axis, and passes substantially through a center of the aperture stop,

wherein the imaging assembly has an optical speed f-number of 1.5 or less, two of said four lens elements have aspherical prescriptions, and the other two of said four lens elements have acylindrical surfaces, and

wherein said two acylindrical surfaces are separated from one another.

15. An imaging assembly configured for removing optical distortion from an image generated by an object located within a transparent sleeve, said assembly comprising:

a first optical element having a first input surface and a first output surface, said first input surface having a substantially planar surface, said first output surface having a cylindrical or acylindrical surface; and

a second optical element having a second input surface and a second output surface, said second input surface having the substantially planar surface, said second output surface having the cylindrical or acylindrical surface,

wherein both said first and second optical elements are arranged without any other intervening optical component such that said first and second output surfaces acting in conjunction remove the optical distortion from the image generated by the object.