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(54) ENDOSCOPY IMAGING SYSTEM INCLUDING IN-LINE DUAL CAMERA 3D ENDOSCOPY CANNULA ASSEMBLY

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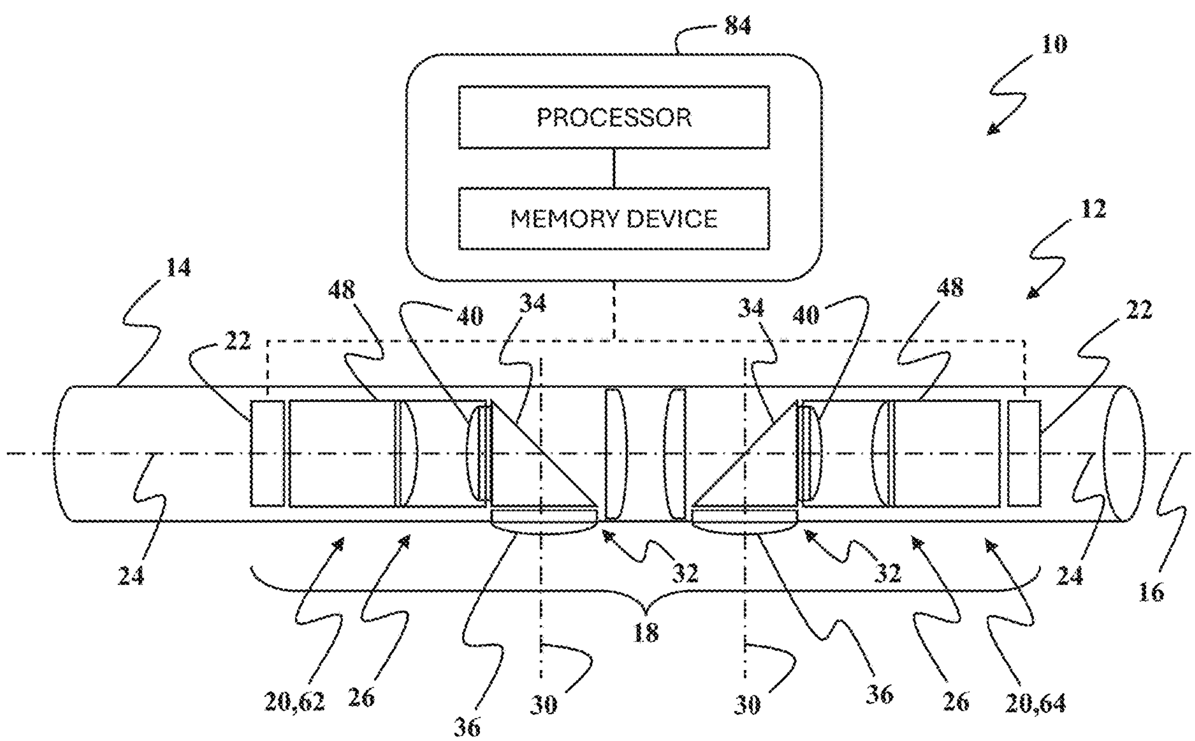
(57) **ABSTRACT**

An endoscopy cannula assembly is described herein. The endoscopy cannula assembly includes a cannula extending along a longitudinal axis and a 3D imaging system positioned within the cannula. The 3D imaging system includes a pair of imaging modules orientated in an opposing mirrored relationship along the longitudinal axis. Each imaging module includes a camera sensor orientated along a first optical axis and an optical engine configured to receive light rays through an opening defined along a sidewall of the cannula along a second optical axis and direct the received light rays along the first optical axis towards the camera sensor.



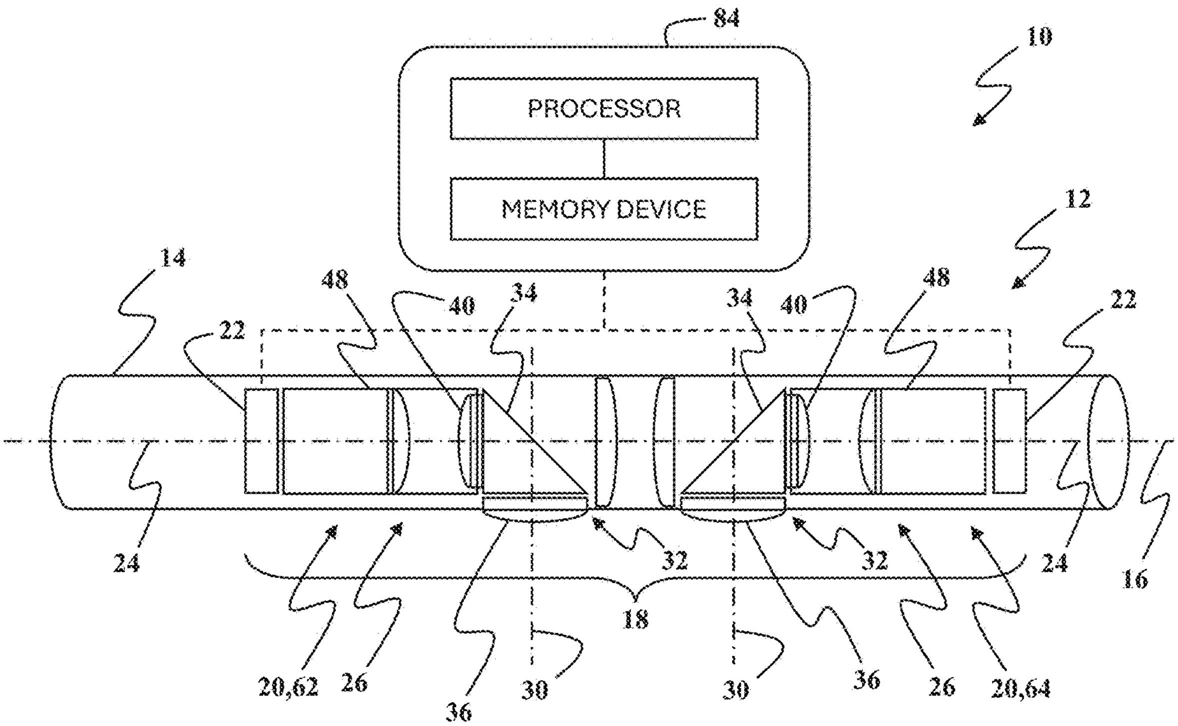

84
10
PROCESSOR
MEMORY DEVICE
12
14
48
40
34
34
40
48
22
22
24
32
32
24
16
18
20,62
26
36
30
30
36
26
20,64

FIG. 1

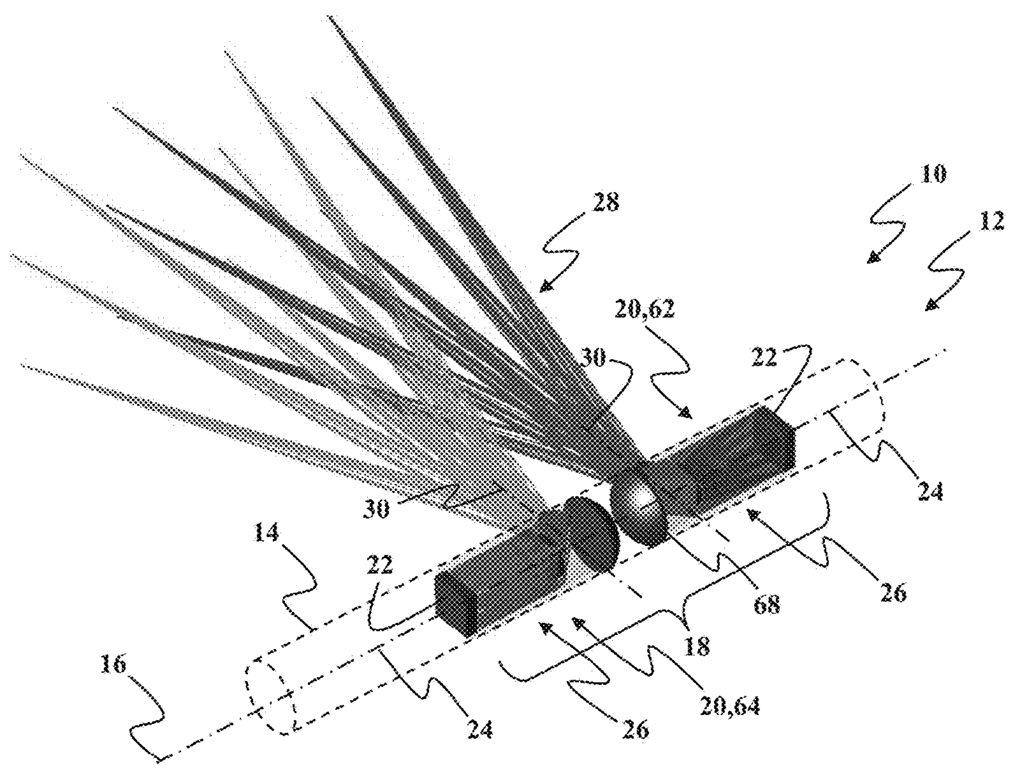

28
10
12
20,62
30
22
24
30
14
22
68
26
18
16
24
26
20,64

FIG. 2

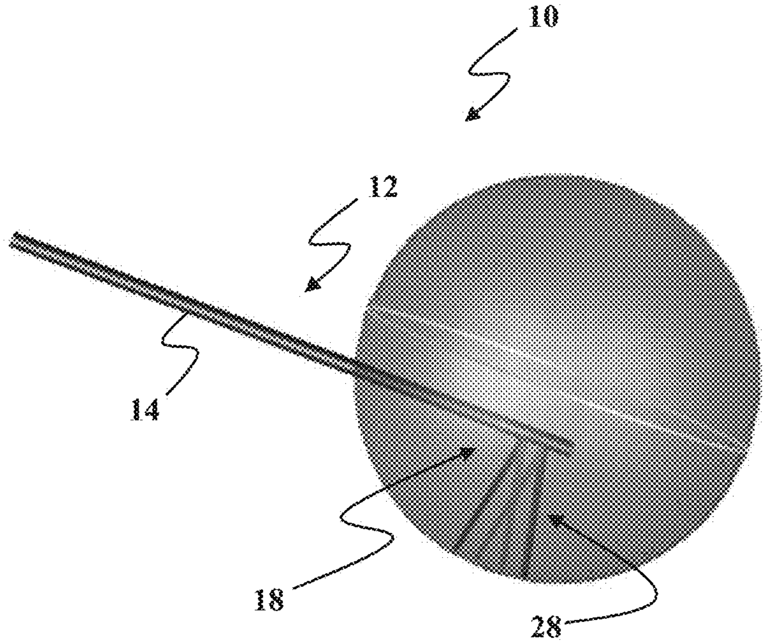


FIG. 3

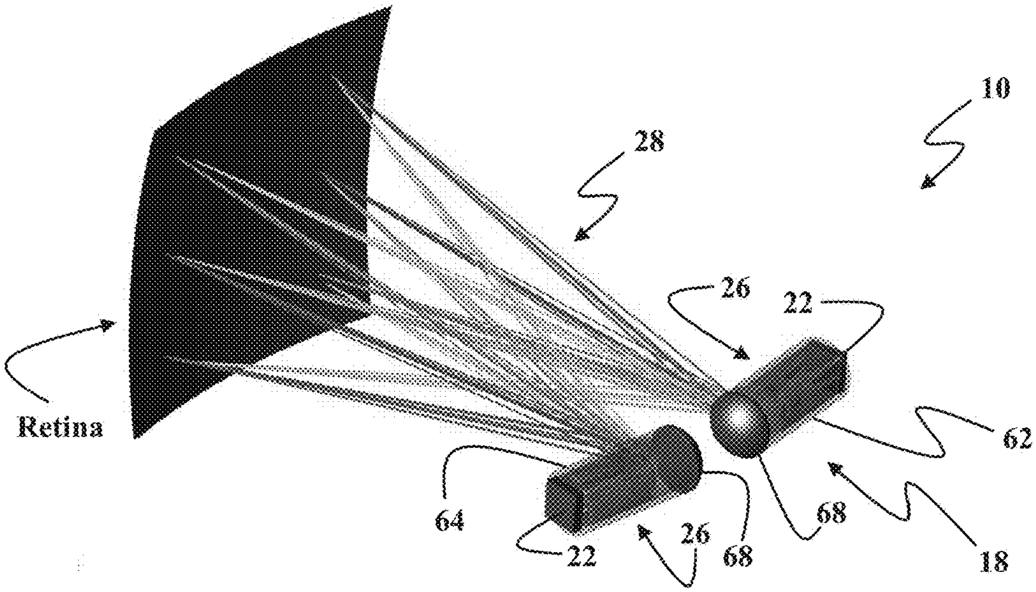

10
28
26
22
Retina
62
64
68
68
22
26
18

FIG. 4

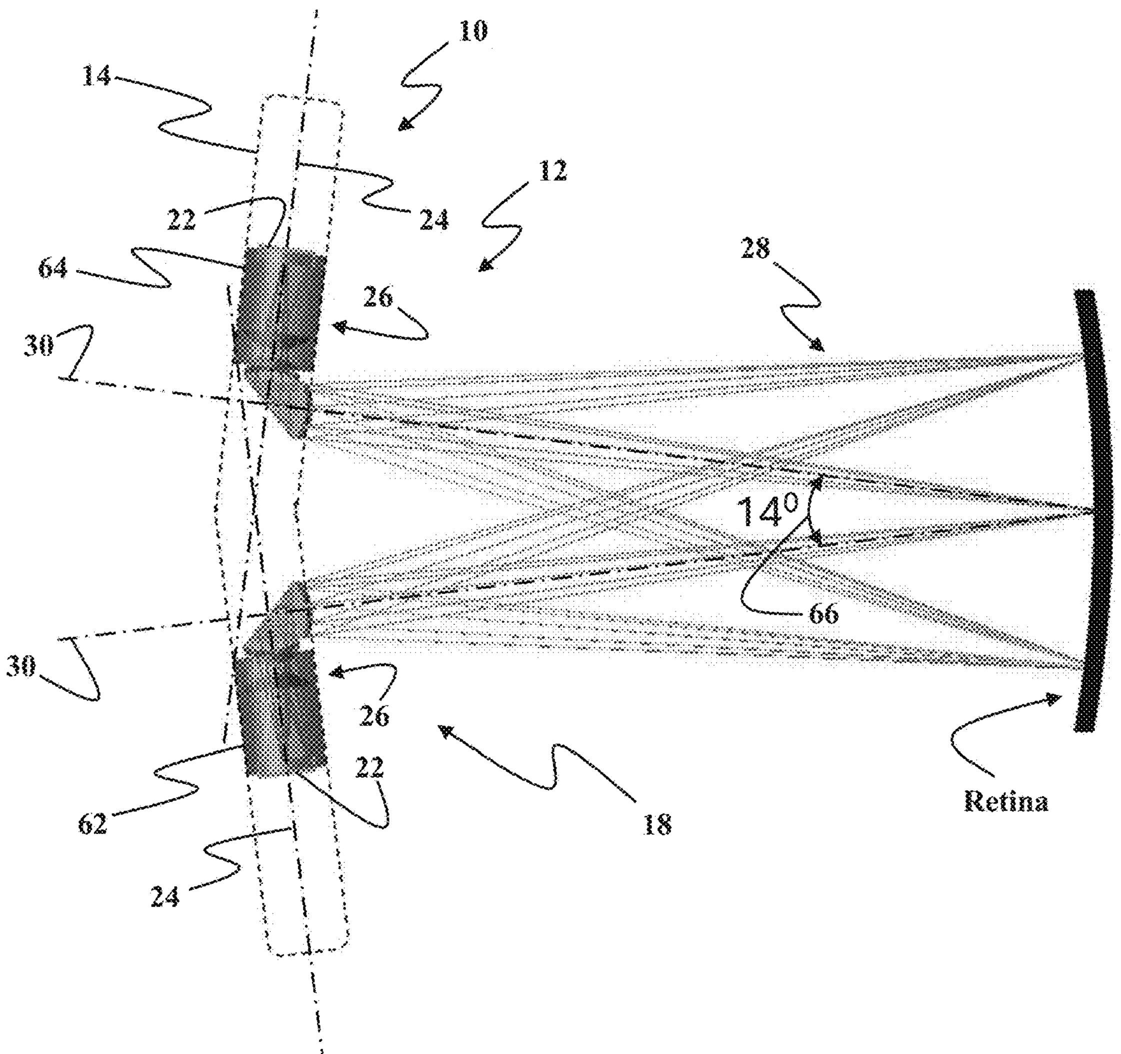

10
14
12
24
22
64
26
28
30
14°
66
30
26
22
62
18
24
Retina

FIG. 5

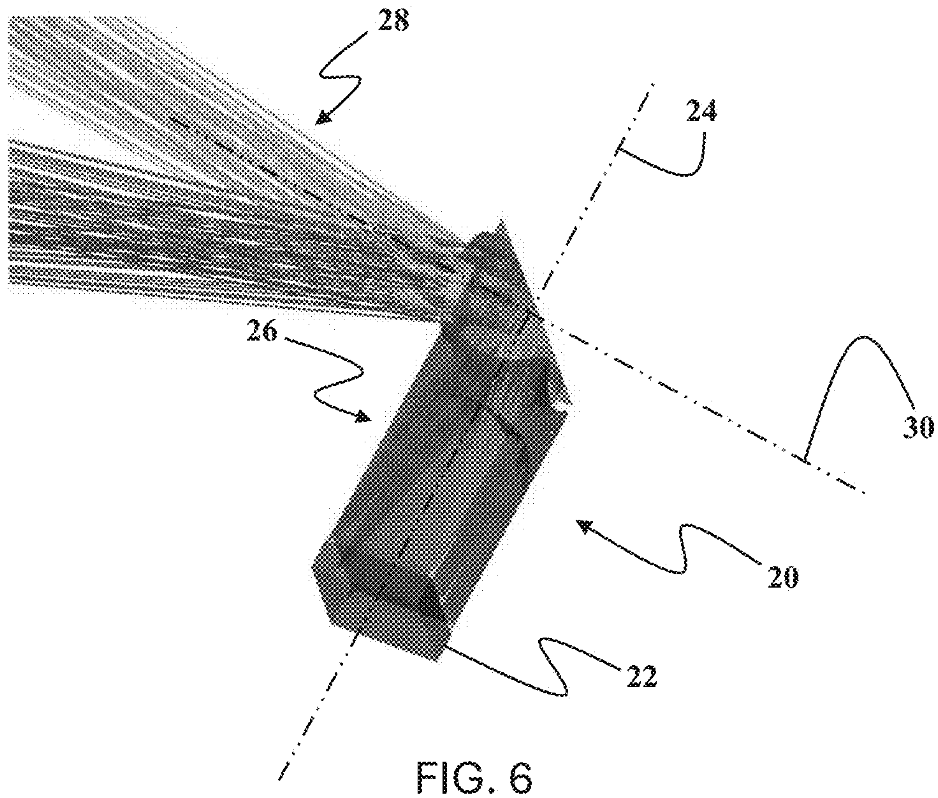


FIG. 6

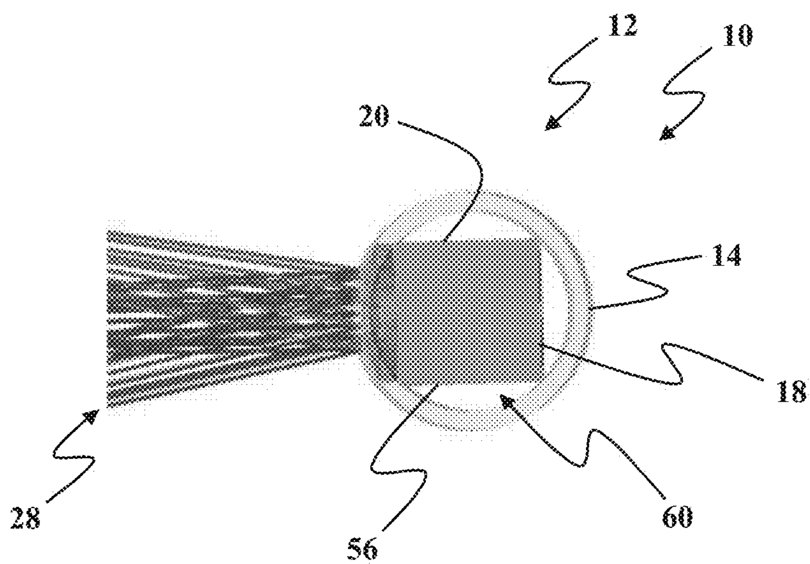
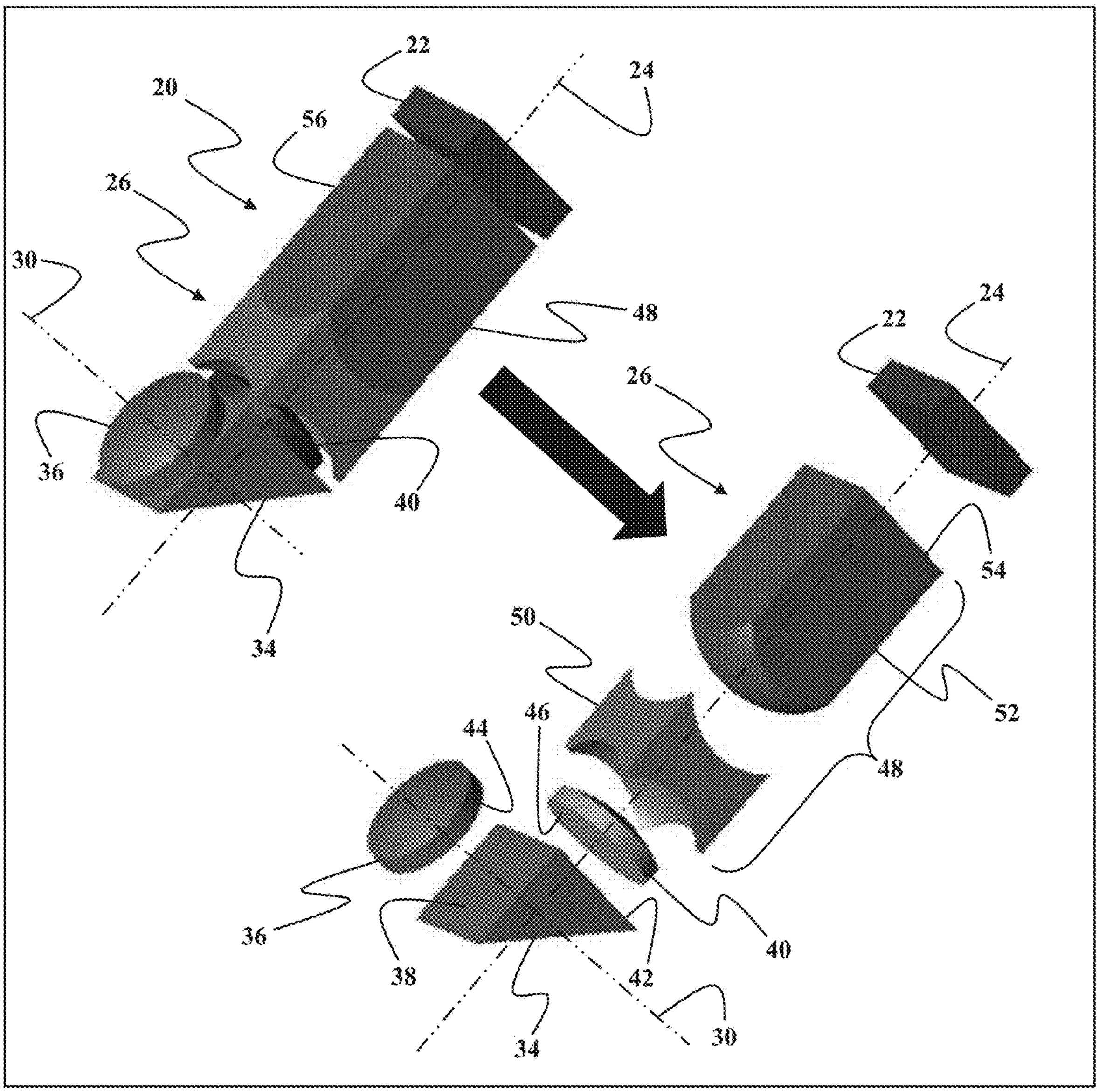


FIG. 7


22
24
20
56
26
30
48
22
24
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36
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34
54
50
52
44
46
48
36
40
38
42
34
30

FIG. 8

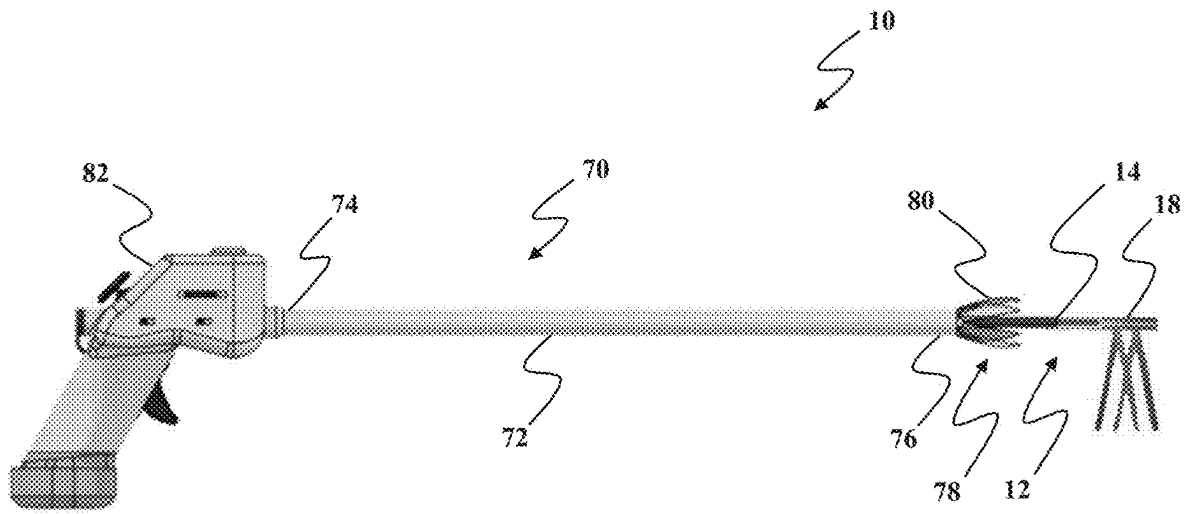

FIG. 9

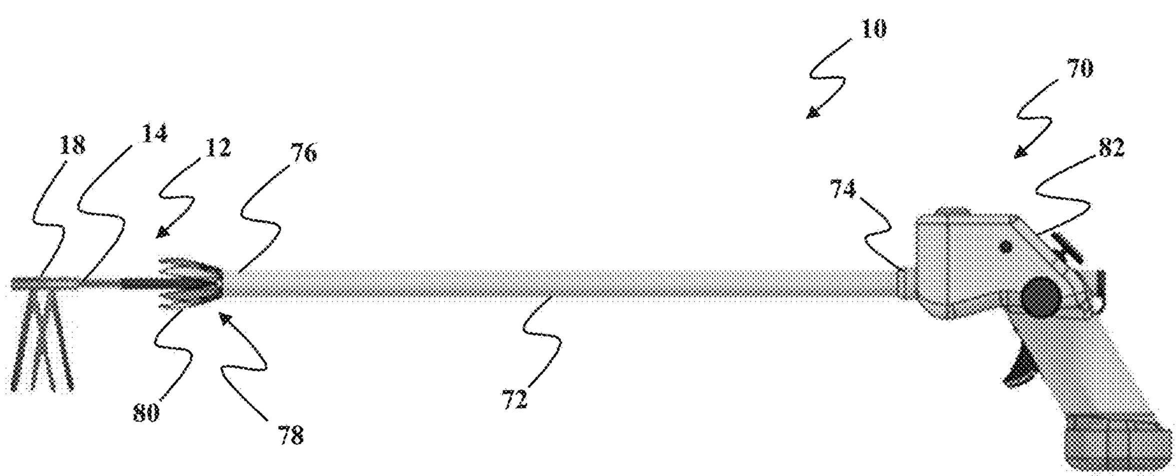

FIG. 10

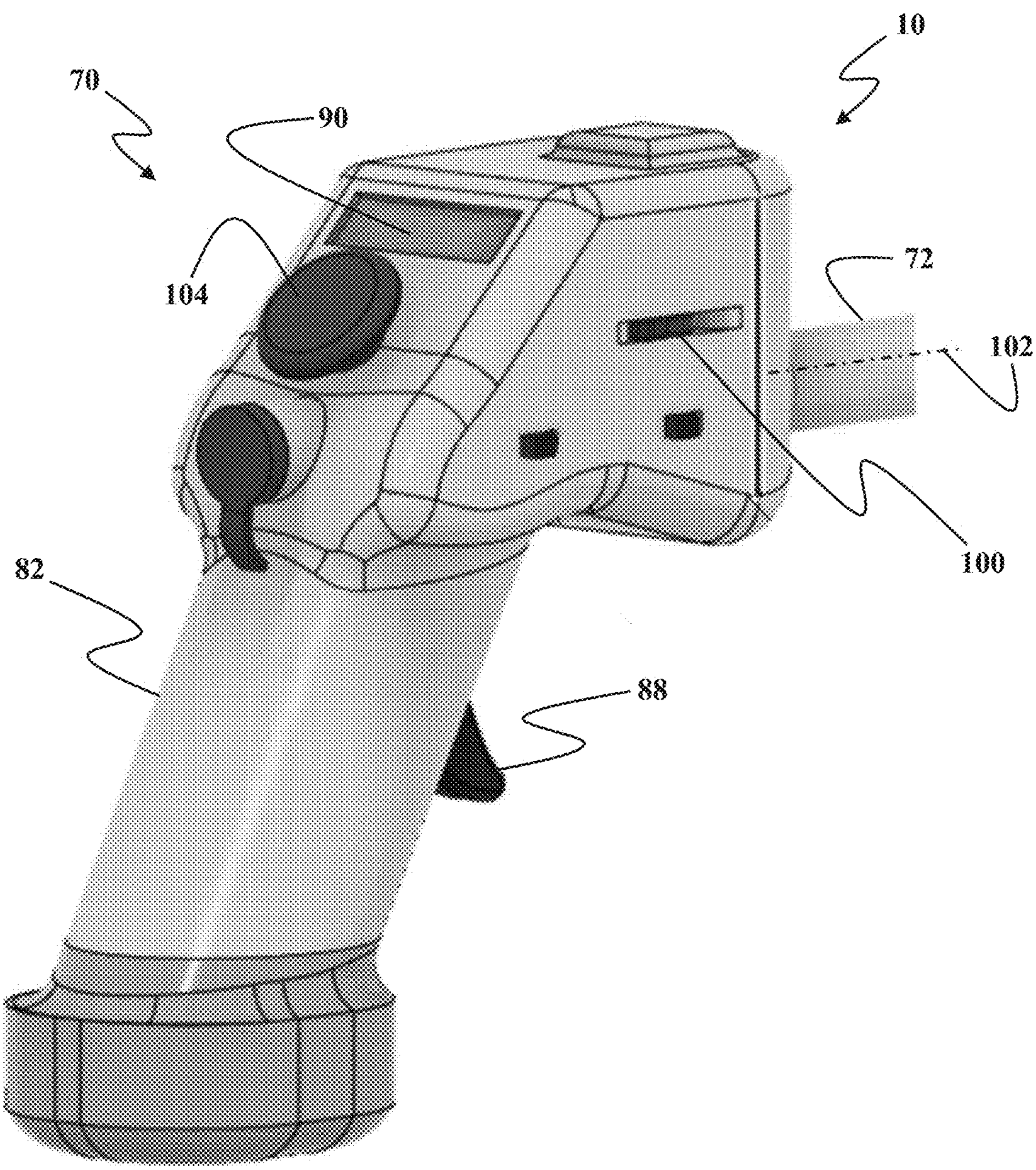

FIG. 11

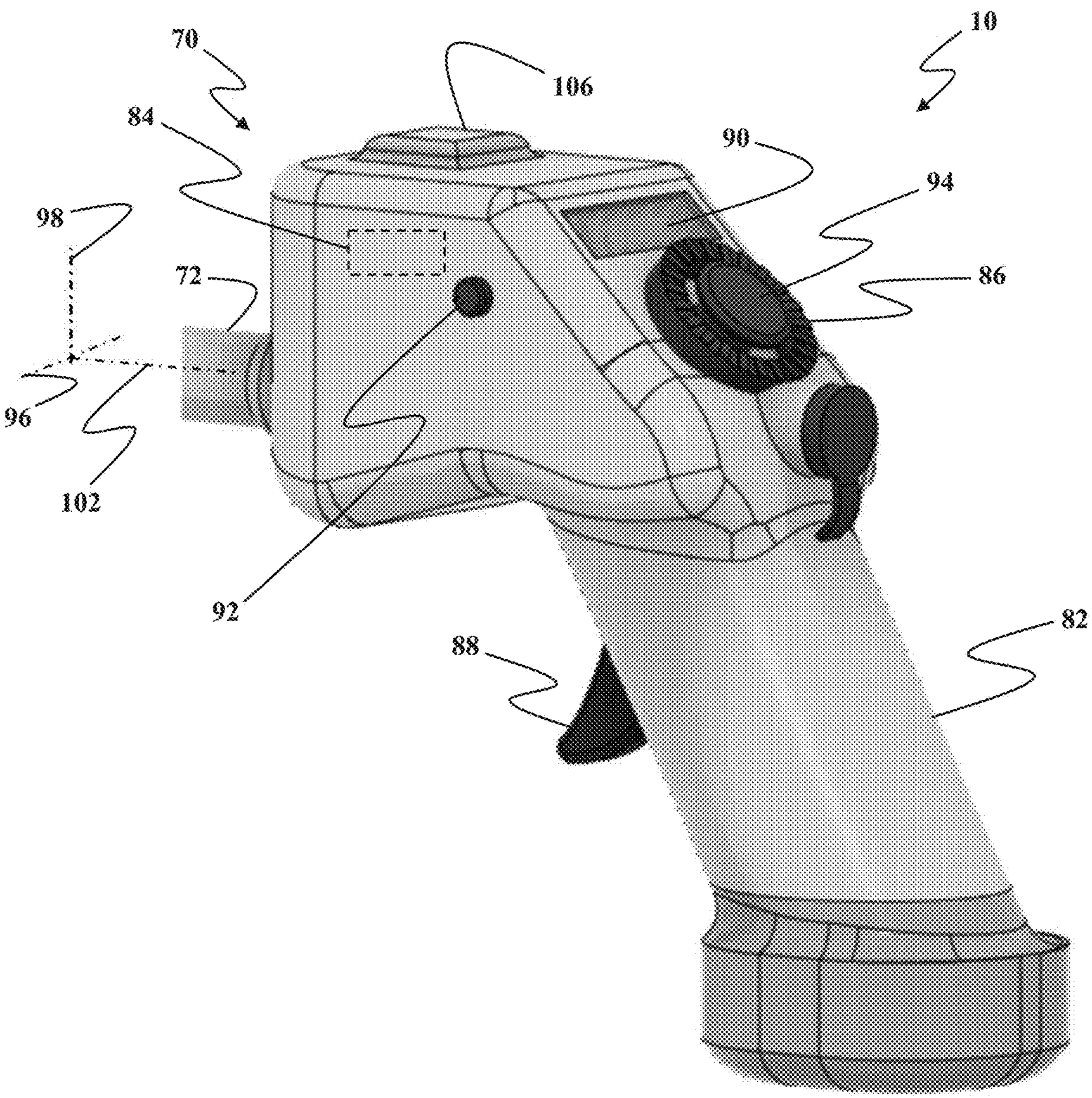

FIG. 12

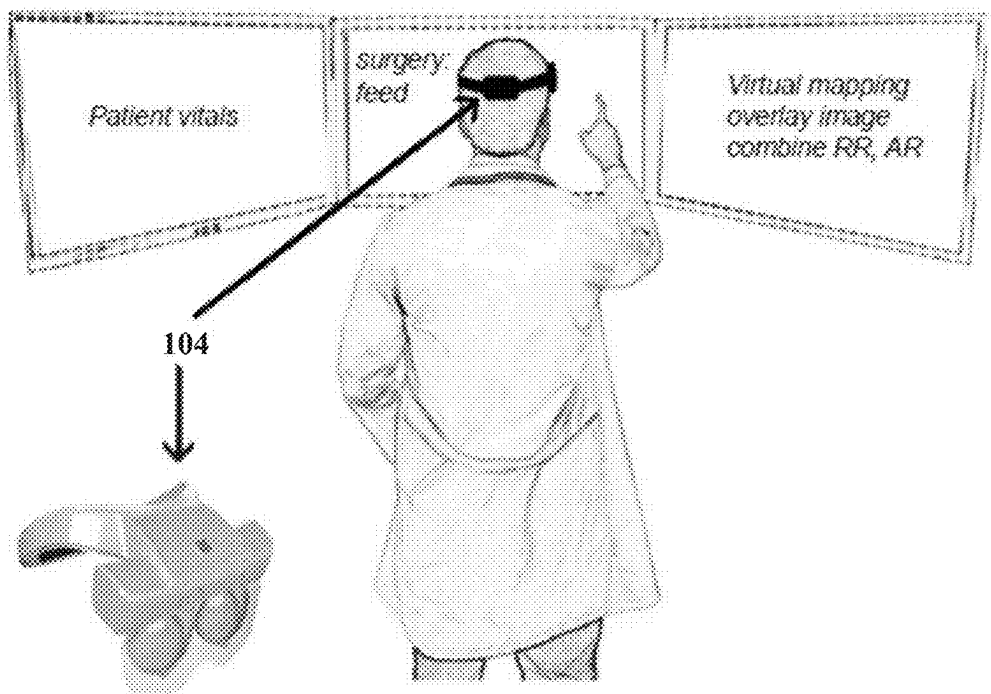
Patient vitals
surgery feed
Virtual mapping overlay image combine RR, AR
104

FIG. 13

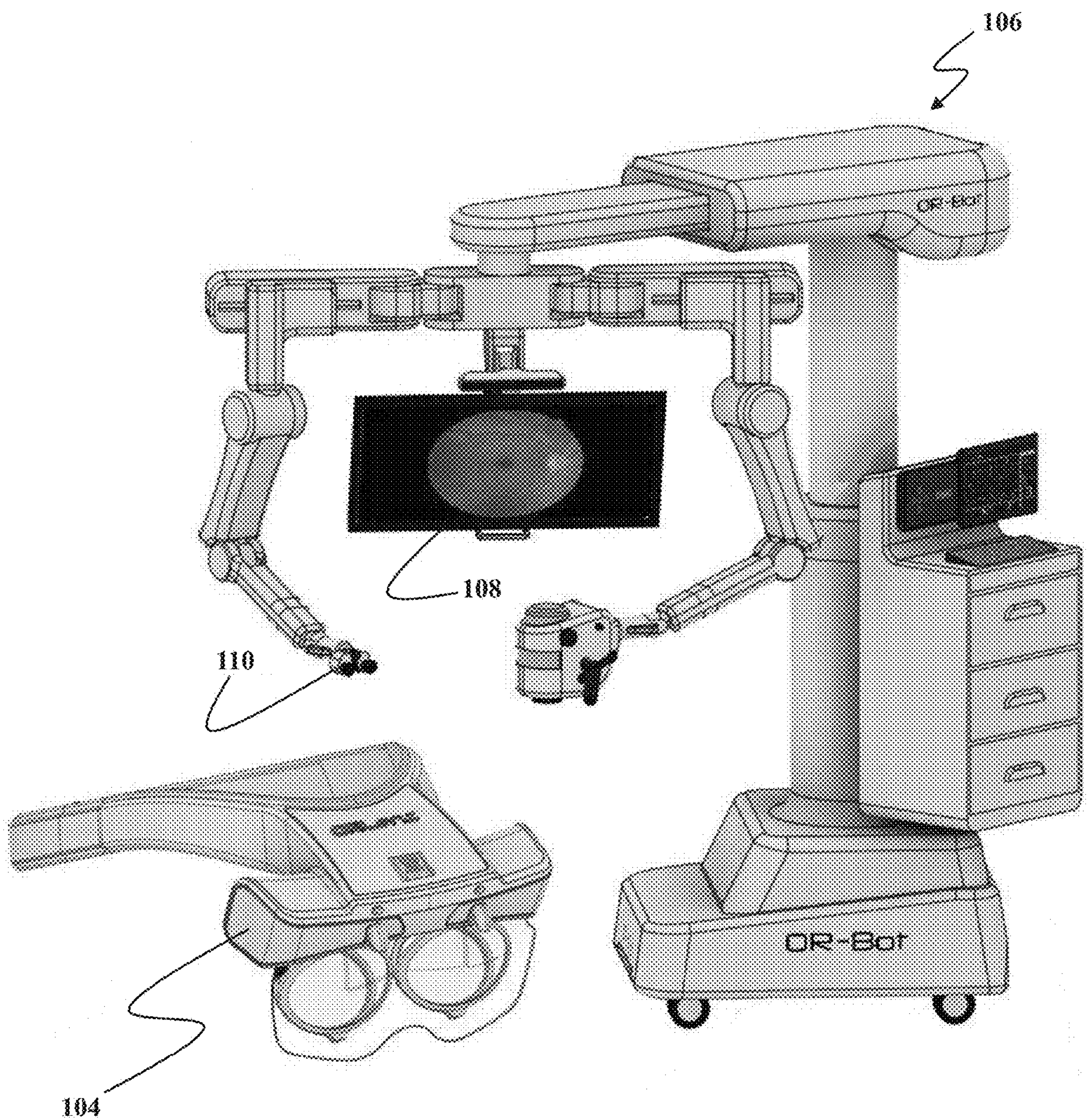

FIG. 14

ENDOSCOPY IMAGING SYSTEM INCLUDING IN-LINE DUAL CAMERA 3D ENDOSCOPY CANNULA ASSEMBLY

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional application Ser. No. 63/551,928, filed on Feb. 9, 2024, the disclosures of which are hereby incorporated by reference in their entirety and for all purposes.

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TECHNICAL FIELD

[0003] The present disclosure generally relates to cannulas for use in endoscopes and, more specifically, to endoscopy imaging systems including endoscopy cannula assemblies with in-line dual camera 3D imaging for use in ocular endoscopy.

BACKGROUND OF THE INVENTION

[0004] There are three major categories in endoscopy in general: 1) Fiber based-camera at the proximal end and fibers are used for imaging and illumination with some having these features: a) Low gauge (such as in laparoscopic endoscopy), b) Flexible, c) Illumination provided inside the cannula, d) 3D available in some as side by side double apertures, e) Zoom is provided by some, and f) Variable focusing may be available; 2) Rigid Hopkins relay based-camera at the proximal end with some having these features: a) Bendable tips available, b) Zooming, c) Variable focusing, and d) Large field-of-view (FOV); and 3) Digital camera at the distal tip, Mono only (no 3D).

[0005] Currently the preferred gauges in Ocular Endoscopy are 23 (0.6 mm) 25 (0.5 mm) and 27 (0.45 mm) which do not necessitate stitches upon removal. At these sizes, 3D based on two lenses side by side is not possible since such an arrangement does not provide enough base distance for good stereopsis. A common convergence angle is 60 mm IPD over 10 inches which is about 14°. If the intraocular working distance is say 10 mm, the "IPD" at the distal tip would be 2.4 mm to provide 14° convergence.

[0006] In addition, at least some known ophthalmic optical coherence tomography (OCT) scans use small diameter which do provide depth info but which have issues like color, lag, registration, and FOV.

[0007] The present invention solves one or more of the problems identified above.

SUMMARY OF INVENTION

[0008] In one aspect of the present invention, an endoscopy cannula assembly is provided. The endoscopy cannula assembly includes a cannula extending along a longitudinal axis and a 3Dimensional (3D) imaging system positioned within the cannula. The 3D imaging system includes a pair of imaging modules orientated in an opposing mirrored relationship along the longitudinal axis. Each imaging module includes a camera sensor orientated along a first optical axis and an optical engine configured to receive light rays through an opening defined along a sidewall of the cannula along a second optical axis and direct the received light rays along the first optical axis towards the camera sensor.

[0009] In another aspect of the present invention, an endoscopic imaging apparatus is provided. The endoscopic imaging apparatus includes a handle subsystem including a control handle configured for attachment and actuation of endoscopic tools, a shaft extending outwardly from the handle subsystem between a proximal end opposite a distal end, and an endoscopic tool. The endoscopic tool includes a trocar piercing tip coupled to the distal end of the shaft and movable between an open position and a closed position and an endoscopy cannula assembly positioned within the shaft and extendable through the trocar piercing tip. The endoscopy cannula assembly includes a cannula extending along a longitudinal axis and a 3D imaging system positioned within the cannula. The 3D imaging system includes a pair of imaging modules orientated in an opposing mirrored relationship along the longitudinal axis. Each imaging module includes a camera sensor orientated along a first optical axis and an optical engine configured to receive light rays through an opening defined along a sidewall of the cannula along a second optical axis and direct the received light rays along the first optical axis towards the camera sensor.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Non-limiting and non-exhaustive embodiments of the present invention are described with reference to the following figures. Other advantages of the present disclosure will be readily appreciated, as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

[0011] FIG. **1** is a schematic view of an endoscopy cannula assembly, according to embodiments of the present invention;

[0012] FIGS. **2-7** are partial perspective views of the endoscopy cannula assembly shown in FIG. **1** including a 3D imaging system including a pair of imaging modules, according to embodiments of the present invention;

[0013] FIG. **8** is an exploded view of an imaging module shown in FIGS. **2-7**;

[0014] FIGS. **9-12** are perspective views of an endoscopic imaging apparatus including the endoscopy cannula assembly, according to embodiments of the present invention; and

[0015] FIGS. **13-14** are schematic views of a visualization theater that may be used with the endoscopic imaging apparatus show in FIGS. **8-12**, according to embodiments of the present invention.

[0016] Corresponding reference characters indicate corresponding parts throughout the drawings.

DETAILED DESCRIPTION

[0017] With reference to the figures, and in operation, the present invention is directed towards an endoscopic imaging apparatus including an endoscopy cannula assembly that includes an in-line dual camera 3D imaging system for use in ocular endoscopy.

[0018] Currently, known ocular endoscopy using high gauge/small diameter cannulas are mono-scopes since the common 3D capture is done by two side by side cameras which is impossible with small diameter cannulas. The endoscopy cannula assembly of the present invention provides the combination of a small diameter cannula and 3D capture with two in-line cameras. The stereoscopic in-line arrangement provides 3D capture with two in line cameras and the small diameter cannulas (e.g., 0.8 mm).

[0019] For example, the cannula may be Gauge 23 and may be disposable, include a disposable cover, or be autoclavable. The 3D imaging system may include 3D with adjustable IPD for 2 to 4 mm, dual in line cameras rotatable about z-axis. The 3D imaging system may also include 3D on a bendable distal head, All digital with >10,000 pixels, and variable focus (e.g., piezos). The 3D imaging system may also include a FOV with 32 degrees on the diagonal, 22.5×22.5 degrees, with 5 mm for the working distance, and a convergence angle of 14 degrees which will provide good stereopsis. For example, the 3D imaging system may be designed for 5 mm working distance from the retina during ocular endoscopy. This design is for a field of view of 22.5×22.5 degrees inside the eyeball.

[0020] In some embodiments, the 3D imaging system **18** may include two modules that are co-linear (shown in FIG. **2**), so the field of view is partially 3D flanked by two 2D domains. In other embodiments, the 3D imaging system may include two modules that are angled so the full retina field is in 3D (shown in FIGS. **4** and **5**). In addition, the optics apertures may be 0.35×0.35 mm and the camera sensors may be 0.35×0.35 mm, and are inside the inner diameter of the cannula of 0.5 mm with an external diameter of 0.6 mm. Between the optics and the cannula there is room for wires.

[0021] The following is a detailed description of the preferred embodiments of the disclosure, reference being made to the figures in which the same reference numerals identify the same elements of structure in each of the several figures.

[0022] Referring to FIGS. **1-14**, in the illustrated embodiment, the endoscopic imaging apparatus **10** includes an endoscopy cannula assembly **12** including a cannula **14** extending along a longitudinal axis **16** and an in-line dual camera 3D imaging system **18** positioned within the cannula **14**. The 3D imaging system **18** includes a pair of imaging modules **20** orientated in an opposing mirrored relationship along the longitudinal axis **16**.

[0023] In the illustrated embodiment, each imaging module **20** includes a camera sensor **22** orientated along a first optical axis **24** and an optical engine **26** configured to receive light rays **28** along a second optical axis **30** and direct the received light rays along the first optical axis **24** towards the camera sensor **22**. For example, the cannula **14** may include one or more openings **32** defined along a sidewall of the cannula **14**. The optical engine **26** receives the light rays **28** through the one or more openings **32** defined along the cannula **14** along the second optical axis **30** and directs the received light rays along the first optical axis **24** towards the camera sensor **22**.

[0024] In the illustrated embodiment, the optical engine **26** includes a folding prism **34** spaced a distance from the camera sensor **22** along the first optical axis **24**. The folding prism **34** is configured to direct the light rays received along the second optical axis **30** towards the camera sensor **22**. In this way, the second optical axis **30** may be orientated perpendicular to the first optical axis **24** such the 3D imaging system **18** may include dual in-line opposing camera sensors **22** positioned within the cannula **14**.

[0025] The optical engine **26** also includes a first plano aspheric lens **36** positioned adjacent to an entrance face **38** of the folding prism **34** and a second plano aspheric lens **40** positioned adjacent an exit face **42** of the folding prism **34**. The entrance face **38** of the folding prism **34** is defined along the second optical axis **30**. The first plano aspheric lens **36** is orientated along the second optical axis **30** such that a flat surface **44** of the first plano aspheric lens **36** is adjacent to the entrance face **38** of the folding prism **34**. In some embodiments, the flat surface **44** of the first plano aspheric lens **36** is cemented to the entrance face **38** of the folding prism **34**.

[0026] The exit face **42** of the folding prism **34** is defined along the first optical axis **24**. The second plano aspheric lens **40** is orientated along the first optical axis **24** such that a flat surface **46** of the second plano aspheric lens **40** is adjacent to the exit face **42** of the folding prism **34**. In some embodiments, the flat surface **46** of the second plano aspheric lens **40** is cemented to the exit face **42** of the folding prism **34**.

[0027] The optical engine **26** also includes a doublet **48** orientated along the first optical axis **24** and positioned between the second plano aspheric lens **40** and the camera sensor **22**. The doublet **48** includes a bi-concave aspheric lens **50** and a plano convex lens **52** positioned between the bi-concave aspheric lens **50** and the camera sensor **22**, with a flat surface **54** of the plano convex lens **52** orientated towards the camera sensor **22**. In some embodiments, the bi-concave aspheric lens **50** is cemented to the plano convex lens **52** to form the doublet **48**. For example, as shown in FIG. **8**, the two plano aspheric lenses **36**, **40** are cemented to the folding prism **34**, and the bi-concave aspheric lens **50** and the plano convex lens **52** are cemented to form a doublet **48**.

[0028] In the illustrated embodiment, the doublet **48** includes a substantially rectangular body **56** extending along the first optical axis **24** such that a gap **60** is defined between the inner surface of the cannula **14** and the doublet body **56**. The gap **60** is sized and shaped to accommodate communication and/or power wires connected to the camera sensor **22**. For example, the optics apertures may be 0.35×0.35 mm and are inside the inner diameter of the cannula of 0.5 mm, with an external diameter is 0.6 mm, forming the gap **60** between the optics and the cannula for room for wires.

[0029] In some embodiments, the pair of imaging modules **20** includes a first imaging module **62** that is axially aligned with a second imaging module **64**. For example, as shown in FIG. **2**, the 3D imaging system **18** may include the first imaging module **62** axially aligned with the second imaging module **64** such that the first optical axis **24** of each imaging module **62**, **64** is co-axial, and the second optical axis **30** of each imaging module **62**, **64** is substantially parallel to each other.

[0030] In other embodiments, for example, as shown in FIGS. **4-5**, the first imaging module **62** may be obliquely aligned with the second imaging module **64** such that the first optical axis **24** of each imaging module **62**, **64** are obliquely orientated to each other, and the second optical axis **30** of each imaging module **62**, **64** intersect to form a convergence angle **66**. For example, as shown in FIG. **5**, the convergence angle **66** formed by the two intersecting second optical axes **30** defines a convergence angle **66** equal to about 14 degrees, which is also the angle a normal 65 mm human interpupillary distance (IPD) will suspend when looking at an object at 10". In some embodiments, the endoscopy cannula assembly **12** may include a piezo motor and/or gimble assembly coupled to the pair of imaging modules **20** to change a position of the pair of imaging modules **20** over couple of mm of focusing with a slight change in sensor axial position.

[0031] In some embodiments, each imaging module **20** may include an end cap **68** positioned adjacent to the folding prism **34** to facilitate preventing light rays from entering the opposing imaging module **20**.

[0032] Referring to FIGS. **9-12**, in the illustrated embodiment the endoscopic imaging apparatus **10** also includes a handle subsystem **70**, a shaft **72** extending outwardly from the handle subsystem **70** between a proximal end **74** and an opposite a distal end **76**, and an endoscopic tool **78**. The endoscopic tool **78** includes a trocar piercing tip **80** coupled to the distal end **76** of the shaft **72** and movable between an open position and a closed position, and the endoscopy cannula assembly **12** positioned within the shaft **72** and extendable through the trocar piercing tip **80**.

[0033] The handle subsystem **70** includes a control handle **82** that is configured for attachment and actuation of endoscopic tool **78**. The control handle **82** includes a controller **84** coupled to the camera sensors **22**, and including a memory device coupled to one or more processors that are programmed to receive image data from the camera sensors **22** and store the received image data in the memory device.

[0034] The handle subsystem **70** includes with one or more batteries, controllers, circuit boards and wireless modules, camera modules (sensor, camera, and circuit/power board and lens), and antennas for sending and receiving data and video. The control handle **82** may also house and control all the subsystems related to the endoscopic tool **78** manipulation. For example, the control handle **82** may include a control roll wheel **86** disposed on the side of control handle **82** and a safety trigger **88**. The roll wheel **86** can be used to roll the endoscopic tool **78** 360 degrees about the longitudinal axis **16**. The safety trigger **88** provides a mechanical interlock for roll wheel **86** rotation, locked in position unless safety trigger **88** is actuated.

[0035] The control handle **82** may also include a digital display **90** providing a readout panel for display of information on instrument configuration and positioning. The digital display **90** may indicate tool extension distance, such as in Imperial or SI Units. For example, when in piercing tool mode, the digital display **90** can show the percentage for tool opening. Units of measurement, such as Imperial or SI Units, can be selected using a units button **92** as a type of control toggle.

[0036] The control handle **82** may also include a joystick control **94** that can be used to control movement of the endoscopic tool **78** about an x-axis **96** and/or a y-axis **98**. The joystick control **94** can be enabled by actuating safety trigger **88**. The control handle **82** may also include an extension wheel **100** that can be used to move the endoscopy cannula assembly **12** forward or backward along a z-axis **102** defined along a direction of the shaft **72**.

[0037] Additional details of the handle subsystem **70**, which may be used in the present invention, are described in U.S. patent application Ser. No. 17/473,689 to David Street et al., filed Sep. 13, 2021, titled "Wireless Laparoscopic Device with Gimballed Camera", which is incorporated herein by reference in its entirety.

[0038] Referring to FIGS. **13-14**, in some embodiments, the handle subsystem controller **84** may be coupled in communication with a wearable augmented/extended reality (AXR) headset **104** adapted to be worn by a user. For example, the control handle **82** may include a wireless transceiver **106** coupled to the controller **84** for use in wirelessly transmitting the image data received from the camera sensors **22** to the AXR headset **104** for viewing by the user. Additional details of the AXR headset **104**, which may be used in the present invention, are described in U.S. patent application Ser. No. 17/139,167 to David Kessler et al., filed Dec. 31, 2020, titled "Wearable Pupil-Forming Apparatus"; and U.S. patent application Ser. No. 18/531,248 to David Kessler et al., filed Dec. 6, 2023, titled "Augmented Reality Near-Eye Pupil-Forming Catadioptric Optical Engine in Glasses Format", which are incorporated herein by reference in their entirety. The AXR headset **104** may be, for example, the ORLenz™ Extended Reality Visualization headset sold by Ocutrx™.

[0039] In some embodiments, the controller **84** may be coupled in communication with a controller of an All-Digital Multi-Option 3D Viewing Theatre (ADMO3DV) system **106** including a 3D autostereoscopic monitor (3DAM) **108**, a 3D digital viewport (3DDV) device **110**, and the AXR headset **104**. The controller **84** may be programmed to transmit the image data received from the camera sensors **22** to the controller of the ADMO3DV system **106** to display the received images on the 3D autostereoscopic monitor **108**, the 3D digital viewport device **110**, and/or the AXR headset **104**.

[0040] Additional details of the All-Digital Multi-Option 3D Viewing Theatre system **106**, which may be used in the present invention, are described in U.S. patent application Ser. No. 18/450,997 to Michael H. Freeman et al., filed Sep. 6, 2023, titled "Surgery Visualization Theatre", which is incorporated herein by reference in its entirety. The All-Digital Multi-Option 3D Viewing Theatre system **106** may be, for example, the OR-Bot™ sold by Ocutrx™.

[0041] A controller, computing device, or computer, such as described herein, includes at least one or more processors or processing units and a system memory. The controller typically also includes at least some form of computer readable media. By way of example and not limitation, computer readable media may include computer storage media and communication media. Computer storage media may include volatile and nonvolatile, removable and non-removable media implemented in any method or technology that enables storage of information, such as computer readable instructions, data structures, program modules, or other data. Communication media typically embody computer readable instructions, data structures, program modules, or other data in a modulated data signal such as a carrier wave or other transport mechanism and include any information delivery media. Those skilled in the art should be familiar with the modulated data signal, which has one or more of its characteristics set or changed in such a manner as to encode information in the signal. Combinations of any of the above are also included within the scope of computer readable media.

[0042] The order of execution or performance of the operations in the embodiments of the invention illustrated and described herein is not essential, unless otherwise specified. That is, the operations described herein may be performed in any order, unless otherwise specified, and embodiments of the invention may include additional or fewer operations than those disclosed herein. For example, it is contemplated that executing or performing a particular operation before, contemporaneously with, or after another operation is within the scope of aspects of the invention.

[0043] In some embodiments, a processor, as described herein, includes any programmable system including systems and microcontrollers, reduced instruction set circuits (RISC), application specific integrated circuits (ASIC), programmable logic circuits (PLC), and any other circuit or processor capable of executing the functions described herein. The above examples are exemplary only, and thus are not intended to limit in any way the definition and/or meaning of the term processor.

[0044] This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Other aspects and features of the present invention can be obtained from a study of the drawings, the disclosure, and the appended claims. The invention may be practiced otherwise than as specifically described within the scope of the appended claims. It should also be noted that the steps and/or functions listed within the appended claims, notwithstanding the order of which steps and/or functions are listed therein, are not limited to any specific order of operation.

[0045] Although specific features of various embodiments of the invention may be shown in some drawings and not in others, this is for convenience only. In accordance with the principles of the invention, any feature of a drawing may be referenced and/or claimed in combination with any feature of any other drawing.

[0046] The invention has been described in detail with particular reference to a presently preferred embodiment, but it will be understood that variations and modifications can be effected within the spirit and scope of the disclosure. The presently disclosed embodiments are therefore considered in all respects to be illustrative and not restrictive. The scope of the invention is indicated by any appended claims, and all changes that come within the meaning and range of equivalents thereof are intended to be embraced therein.

What is claimed is:

1. An endoscopy cannula assembly, comprising:

a cannula extending along a longitudinal axis; and

a 3-dimensional imaging system positioned within the cannula and including:

a pair of imaging modules orientated in an opposing mirrored relationship along the longitudinal axis, each imaging module including:

a camera sensor orientated along a first optical axis; and

an optical engine configured to receive light rays through an opening defined along a sidewall of the cannula along a second optical axis and direct the received light rays along the first optical axis towards the camera sensor.

2. The endoscopy cannula assembly of claim **1**, wherein the optical engine includes:

a folding prism spaced a distance from the camera sensor along the first optical axis and configured to direct the light rays received along the second optical axis towards the camera sensor.

3. The endoscopy cannula assembly of claim **2**, wherein the optical engine includes:

a first plano aspheric lens adjacent an entrance face of the folding prism defined along the second optical axis; and

a second plano aspheric lens adjacent an exit face of the folding prism defined along the first optical axis.

4. The endoscopy cannula assembly of claim **3**, wherein the optical engine includes:

a flat surface of the first plano aspheric lens cemented to the entrance face of the folding prism; and

a flat surface of the second plano aspheric lens cemented to the exit face of the folding prism.

5. The endoscopy cannula assembly of claim **3**, wherein the optical engine includes:

a doublet positioned between the second plano aspheric lens and the camera sensor.

6. The endoscopy cannula assembly of claim **5**, wherein the optical engine includes:

the doublet including a bi-concave aspheric lens cemented to a plano convex lens positioned between the bi-concave aspheric lens and the camera sensor.

7. The endoscopy cannula assembly of claim **6**, wherein a flat surface of the plano convex lens is orientated towards the camera sensor.

8. The endoscopy cannula assembly of claim **5**, wherein the doublet includes a substantially rectangular body extending along the first optical axis.

9. The endoscopy cannula assembly of claim **1**, wherein the pair of imaging modules includes a first imaging module axially aligned with a second imaging module.

10. The endoscopy cannula assembly of claim **1**, wherein the pair of imaging modules includes a first imaging module obliquely aligned with a second imaging module.

11. An endoscopic imaging apparatus comprising:

a handle subsystem including a control handle configured for attachment and actuation of endoscopic tools;

a shaft extending outwardly from the handle subsystem between a proximal end opposite a distal end; and

an endoscopic tool including:

a trocar piercing tip coupled to the distal end of the shaft and movable between an open position and a closed position; and

an endoscopy cannula assembly positioned within the shaft and extendable through the trocar piercing tip, the endoscopy cannula assembly including:

a cannula extending along a longitudinal axis; and

a 3-dimensional imaging system positioned within the cannula and including:

a pair of imaging modules orientated in an opposing mirrored relationship along the longitudinal axis, each imaging module including:

a camera sensor orientated along a first optical axis; and

an optical engine configured to receive light rays through an opening defined along a sidewall of the cannula along a second optical axis and direct the received light rays along the first optical axis towards the camera sensor.

12. The endoscopic imaging apparatus of claim **11**, wherein the optical engine includes:

a folding prism spaced a distance from the camera sensor along the first optical axis and configured to direct the light rays received along the second optical axis towards the camera sensor.

13. The endoscopic imaging apparatus of claim **12**, wherein the optical engine includes:

a first plano aspheric lens adjacent an entrance face of the folding prism defined along the second optical axis; and

a second plano aspheric lens adjacent an exit face of the folding prism defined along the first optical axis.

14. The endoscopic imaging apparatus of claim **13**, wherein the optical engine includes:

a flat surface of the first plano aspheric lens cemented to the entrance face of the folding prism; and

a flat surface of the second plano aspheric lens cemented to the exit face of the folding prism.

15. The endoscopic imaging apparatus of claim **13**, wherein the optical engine includes:

a doublet positioned between the second plano aspheric lens and the camera sensor.

16. The endoscopic imaging apparatus of claim **15**, wherein the optical engine includes:

the doublet including a bi-concave aspheric lens cemented to a plano convex lens positioned between the bi-concave aspheric lens and the camera sensor.

17. The endoscopic imaging apparatus of claim **16**, wherein a flat surface of the plano convex lens is orientated towards the camera sensor.

18. The endoscopic imaging apparatus of claim **15**, wherein the doublet includes a substantially rectangular body extending along the first optical axis.

19. The endoscopic imaging apparatus of claim **11**, wherein the pair of imaging modules includes a first imaging module axially aligned with a second imaging module.

20. The endoscopic imaging apparatus of claim **11**, wherein the pair of imaging modules includes a first imaging module obliquely aligned with a second imaging module.

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