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Rigid Endoscope

Description:

The invention is based on an endoscope with the characteristics contained in the preamble to claim 1. Such an endoscope is known from DE 38 18 104 A1 (see figures 23 and 8 therein). The known endoscope has a slender shaft in the form of a rigid jacket tube in which two parallel guide tubes are provided that run from two lenses that are located at the distal end of the shaft all the way to a headpiece that is located at the proximal end of the shaft, and that have adjacent to each other two oculars or matching optics for an image taking or imaging device, particularly for a CCD camera. The two guide tubes each contain an optical transmission system with several bar lenses in succession. Bar lenses are, as their term suggests, bar-shaped lenses that consist either of a base bar with flat end faces, in which case a lens, if necessary a multiple lens, is bonded to one or both of the end faces, or they consist of a bar that has a spherical or an aspherical curved surface, or a spherical or an aspherical curved surface at one end and a flat surface at the opposite end, to which a lens may be bonded. The known endoscope allows stereoptic observation of objects. Because the two guide tubes lie immediately adjacent to each other, they must, in order to make stereoptic observation possible, both be adjusted to eye distance by means of the beam paths that pass through them, or pass through a subsidiary imaging device such as a CCD camera at a preset distance from each other. To this end, two pairs of prisms are provided in the headpiece, which collect the light beams emitted by both transmission systems in the guide tubes and then direct them to the oculars that are provided at a larger interval.

This has the disadvantage that compared to a monocular endoscope without parallel beam displacement but that is otherwise identically designed and in which identical optical elements are provided, additional glass pathways and additional refractive surfaces are introduced, which decrease image brightness and sharpness as a result of additional absorption and reflection loss. In addition, the prisms inserted into the beam path of a monocular endoscope with a straight beam path require recalculation of the optical system.

The object of the present invention is to improve a rigid endoscope of the aforementioned type such that the bends in its beam path needed to achieve beam displacement are associated with less loss in image brightness and sharpness.

This object is solved by means of an endoscope with the characteristics listed in claimed 1. The advantageous developments of the invention are the subject of the dependent claims.

In contrast to prior art, the invention teaches that the beam path through the endoscope is not bent by providing two individual prisms that are provided as an additional element between the ocular and the optical transmission system, which creates the optical connection between the lens and the ocular. Rather, the provision of prisms according to the invention is a component of a bar lens of the optical transmission system. The bar lens in this case can take the form of a base bar with two flat end surfaces that run at a right angle to the longitudinal axis of the base bar, a prism being attached, in particular bonded, to each end surface at its one incident face or emergent face, respectively, if necessary with the insertion of a spacing piece. This results in twofold beam deviation, which makes beam displacement possible. It is, however, also possible to provide a prism only at one end of the base bar. The simple beam deviation that results can be used in a monocular endoscope to take the ocular out of the shaft alignment, thereby creating place for instruments that can be guided straight through the shaft, and which can be operated in the space behind the proximal end of the shaft.

Instead of the ocular, matching optics may be provided for imaging or image creation devices such as cameras that are associated with the endoscope. The term ocular is used in a general sense to include such matching optics as well.

However, twofold beam deviation can also be achieved with bar lenses that have a prism only at one end of their base bar when such bar lenses are arranged successively in the beam path.

Instead of attaching special prisms to the base bar of the bar lens, the base bar can itself be formed as a prism by having its end faces slanted to the longitudinal axis of the base bar instead of at right angles. This has the advantage that the prisms need not be specially produced and bonded to the base bar, but that one can simply fit the base bar with one or several lenses that turn it into a bar lens, similar to an endoscope with a completely straight light path.

In all cited cases, the bar lens that is designed as a deviating prism can be designed in such a way that when observing the beam that runs along the optical axis, the incident beam and the emergent beam lie along the same plane and deviation occurs at a right angle. It is equally possible to deviate the beam at angles other than 90° and/or to allow the incident beam and the emergent beam to run along different planes.

The invention has the following advantages:

1.

Because the deviating prisms are integrated into the bar lens that is necessary in any case, no additional refractory faces are needed in comparison with an endoscope with a straight beam path and a comparable optical system. Beam deviation therefore entails no particular loss in reflection, so that the usual decreases in image brightness and quality are avoided.

2.

Because the deviating prisms are integrated into the bar lens that is necessary in any case, no additional beam path is required in the glass; rather, the beam path needed for beam deviation can (when prisms are attached to the base bar of the bar lens, this is the beam path that runs through the prisms) the taken into consideration before hand when measuring the length of the base bar, so that in contrast to prior art in which deviation prisms are add-on elements between the optical transmission system, consisting of bar lenses and the ocular, respectively, the invention teaches that no lengthening of the beam path in the glass is needed. As a result, beam deviation entails no absorption losses, and therefore no resultant decreases in image brightness and quality, which is extremely important for endoscopes in which no beam cross-sections are being attempted.

3.

Existing optical transmission systems with bar lenses that have been designed and built with a straight beam path for endoscopes can be integrated without further calculation and few additional construction costs into endoscopes in which beam deviation, in particular beam displacement, is desired, both in stereoscopic endoscopes and monocular endoscopes. This represents a significant cost advantage.

Recalculation of an optical system that is to be transposed from an endoscope with a straight beam path to one with beam deviation is indispensable because the arrangement of prisms responsible for the beam deviation is a component of a bar lens of the optical transmission system, for which the calculation already exists. Whether a bend occurs in the base bar of the bar lens or in prisms set into the base bar is irrelevant for the calculation of the bar lens, at least to the extent that the beam path in the bar lens is not significantly lengthened or shortened. This is the case when the length of the beam path in the base bar and prism combination is between 65% and 150% of the length of the base bar of the bar lens, which assumes an existing straight-line bar lens system that is to be modified without recalculation for the purpose of beam deviation or beam displacement, respectively.

Of course it is important that the material used for the prisms is not different from that used for the base bar of the bar lens or that it be at least similar in its optical properties not only when the base bar of the bar lens is in itself in the form of a prism (claim 3), but also when the prisms are bonded to the face of base bar as special elements, in order that there be no significant loss of quality in the optical data of the entire optical transmission system if this is not recalculated.

4.

As a result of the integration of the prisms into a bar lens, the dimensions of the optical system can be kept small, which is particularly important for an endoscope.

Because the prisms are integrated into a bar lens, they don’t have to be adjusted separately when installing them into the endoscope housing, which greatly facilitates assembly. An endoscope with beam displacement according to the invention does not contain more separate components than does a comparable endoscope without beam displacement.

There are no particular limits to the type of prism that can be used. Triangular prisms, pentagonal prisms, rhomboidal prisms, Wollaston prisms, Porro prisms, and other prisms can all be used, in which case rhomboidal prisms and rhomboid-like prisms are particularly preferable. The incident face and the emergent face of the prisms are preferably rectangular or quadratic, because then production, mounting in the endoscope housing, and adjustment are facilitated.

The embodiments of the invention are schematically depicted in the attached diagrams.

Figure 1 shows a longitudinal section of a stereoendoscope,

Figure 2 shows a side view of a bar lens according to the invention with beam deviation only had one end,

Figure 3 shows a top view of the bar lens in Figure 2,

Figure 4 shows a left frontal view of the bar lens from the view in Figure 3,

Figure 5 shows a modification of the diagram in Figure 4 with a larger lens,

Figure 6 shows a modification of the diagram in Figure for with a smaller lens,

Figure 7 shows a top view of an example of a bar lens according to the invention with beam deviation at both ends,

Figure 8 shows a side view of the bar lens in Figure 7,

Figure 9 shows a frontal view of the bar lens from the view in Figure 7,

Figure 10 shows a modification of the diagram in Figure 9 with smaller lenses,

Figure 11 shows a modification of the diagram in Figure 9 with larger lenses,

Figure 12 shows a frontal view of further embodiment of a bar lens according to the invention the base bar of which has a hexagonal cross-section,

Figure 13 shows a side view in the direction of arrow A in Figure 12 of a section of the bar lens in Figure 12,

Figure 14 shows a modification of the bar lens depicted in Figure 12, the base bar of which has the form of a circular face in cross-section,

Figure 15 shows an oblique view of a further embodiment of a bar lens according to the invention, in which the incident beam and the emergent beam lie on a common plane,

Figure 16 shows an oblique view of a further embodiment of a bar lens according to the invention, in which the incident beam and the emergent beam lie on different planes,

Figure 17 shows a view of the bar lens in Figure 16 in the direction of arrow B toward its one front side,

Figure 18 shows a top view of a further embodiment of a bar lens according to the invention with a round base bar and attached prisms,

Figure 19 shows section XIX-XIX as shown in Figure 18,

Figure 20 shows section XX-XX as shown in Figure 18,

Figure 21 shows top view of a further embodiment of a bar lens according to the invention with a round base bar,

Figure 22 shows section XXII-XXII as shown in Figure 21,

Figure 23 shows an optical transmission system consisting of bar lenses for a stereoendoscope, that has been modified from Figure 1, and

Figure 24 shows a very simplified monocular endoscope with beam displacement.

The same reference numbers are used in the various embodiments to represent the same or corresponding parts.

Figure 1 shows a stereoendoscope with a rigid, cylindrical shaft 1 that culminates at its proximal end 2 in a headpiece 3, the diameter of which is significantly larger than the diameter of the shaft 1. There are two lenses 5 and 6 at the distal end 4 of the shaft that are only depicted schematically as lenses. Two guide tubes 7 and 8 run in parallel to each other in shaft 1, in which are arranged in succession several bar lenses 9 and 10 and 9a and 10a, respectively, which belong to two optical transmission systems 9 to 11 and 9a to 11a, respectively, through which the beams entering both lenses 5 and 6 are transmitted to two oculars or matching optics 12 and 13 for a subsidiary imaging or image taking device that is located in the headpiece 3.

In shaft 1 both optical transmission systems have only a small distance b between their optical axes 14 and 15, whereas the optical axes 16 and 17 of the oculars have a larger distance, such as the distance between the eyes or a common distance that is set for a subsidiary image taking or imaging device such as a camera. Because of this, the endoscope must be provided with a beam displacement mechanism. To this end, a further bar lens 11 or 11a is provided in at least one of the two beam paths, in the diagrammed example according to Figure 1 in each of the two beam paths in headpiece 3, in which an array of prisms is integrated that ensures a twofold right-angle beam deviation and therefore parallel beam displacement.

The two beam paths in the endoscope are mirror images of each other: to this end, lenses 5 and 6, the bar lenses 9 and 9 a, bar lenses 10 and 10a, bar lenses 11 and 11a, and oculars 12 and 13 are configured identically to each other, and bar lenses 11 and 11a are situated in a mirror relationship to each other. The bar lenses in the shaft 1 each consist of one cylindrical base bar 18 with flat end faces, on which a simple lens 19 is bonded to one side and a twofold lens 20 is bonded to the opposite side. This arrangement is only depicted as an example, and other arrangements of bar lenses are certainly possible.

Bar lens 11 has, for example, one base bar 21 with a rectangular cross-section and flat end faces 22 and 23 that are parallel to one another. A simple lens 25, the optical axis of which is coincident with the optical axis 16 of the ocular 12, is bonded to the circumferential surface 24 that lies opposite to the end face 22. A twofold lens 27, the optical axis of which coincides with the optical axis 15 of the shaft 1, is bonded to the circumferential surface 26 of the base bar 21 that is opposite to the end face 23.

A light beam entering lens 5 passes through bar lenses 9 and 10 as well as the twofold lens 27, is reflected by the diagonal end face 23 and again by the diagonal end face 22, passes through the simple lens 25 and reaches the ocular 12. Another light beam enters the other lens 6 and reaches ocular 13 in a corresponding way.

Instead of oculars 12 and 13, matching optics could also be provided with which the stereoendoscope could be connected to a camera. The term ocular is here meant in a general sense to include such matching optics that connects to a camera other imaging method.

Figures 2 to 6 show examples of bar lenses that only cause beam deviation at one of their ends. The bar lens depicted in Figures 2 to 4 has a rectangular base bar 21 the end face 22 of which is diagonal to the longitudinal axis of the base bar, and the other end face 23 of which runs at right angles to the longitudinal axis 28 of the base bar. Of the circumferential surface is of the base bar 21, at least circumferential surface 24 is polished; and face 22 is preferably mirrored. The circumferential surface 24 that is opposite to end face 22 has a simple lens 25 that is circular in cross-section; the opposite end face 23 has a twofold lens 27. Lenses 25 and 27 are bonded to the base bar.

Lenses 25 and 27 preferably have a diameter that is congruent with the lateral length of the cross-section of the base bar. However, it is also possible to select one or another lens, particularly the lens 25 attached to the circumferential surface, that is larger (Figure 5) or smaller (Figure 6); this can be advantageous in assembling the endoscope housing or in calibration.

Figures 7 to 11 show an embodiment of bar lenses with twofold beam deviation. The bar lens depicted in figures 7 to 9 is constructed as it is used in an endoscope according to Figure 1, bar lenses 11 and 11a. Bar lens 11 has a base bar 21 with two flat end surfaces 22 and 23 that are preferably mirrored and that are parallel to each other and run diagonal to the longitudinal axis 28 of the base bar. A simple lens 25 is bonded to the circumferential surface 24 that is opposite the end face 22. A twofold lens 27 is bonded to the circumferential surface 26 that is opposite and surface 23. At least the areas of circumferential surfaces 24 and 26 that lie below lenses 25 and 27 are polished. The other circumferential surfaces do not need to be polished.

Lenses 25 and 27 are circular in cross-section and have a diameter that is equal to the lateral length of the rectangular cross-section of base bar 21. Here, too, modifications are possible in which lenses 25 and 27 are smaller (Figure 10) or larger (Figure 11).

The base bar of the bar lens according to the invention does not need to be rectangular or square in cross-section, but can have other cross-sectional forms. One example of a cross-section in the form of a regular hexagon is shown in figures 12 and 13 with one or two slanting end faces 22 that are preferably mirrored, and another with a lens 25 that is circular in cross-section that is bonded to circumferential surface that is opposite the slanted end face. Instead of a regular hexagon, other regular or irregular cross-sectional forms may be used. These are particularly suitable for variants in which the beam not only passes in parallel through the plane that is formed by the optical axes 14 and 15 in shaft 1 of the stereoendoscope (see Figure 15), but is also deviated at an angle to this plane (see figures 16 and 17).

The bar lens depicted in Figure 15 differs from the bar lens in Figure 7 in that the base bar 21 has two end faces to each of which is bonded a triangular prism 29 and 30, and that run vertical to the longitudinal axis 28. The prisms are positioned such that when observing the principal beam, the incident beam 31 and the emergent beam 32 lie on a common plane E. However, if the prism 30 is rotated around the longitudinal axis 28 of the base bar by angle x (Figure 17) then the emergent beam 32 no longer lies along the plane E, but rises above plane E by angle x. If one places two such bar lenses as depicted in figures 16 and 17 in succession in the beam path, the emergent beam then runs along a plane that is parallel to plane E, i.e., not only can the beam be displaced parallel laterally but also parallel in another plane.

This type of displacement may be achieved both with base bars that are canted in cross-section as well as with those that are round or semicircular in cross-section.

Figures 18 to 22 show embodiments of bar lenses according to the invention with base bars that are round in cross-section. Figures 18 to 20 show a bar lens with a cylindrical base bar 21 that has two end faces to each of which has been bonded a triangular prism 29 and 30, respectively, to each of which in turn has been bonded a twofold lens 27 or a single lens 25, respectively, and that runs vertical to the longitudinal axis of the base bar. The prisms each have a rectangular cross-section of incidence and cross-section of emergence 33 the lateral length of which is congruent with the diameter of the base bar 21. In the embodiment depicted in figures 21 and 22 a bar lens has a cylindrical base bar 21 with end faces 22 and 23 that are preferably mirror images and that are parallel to each other and flat, and that are slanted to the longitudinal axis 28 of the base bar. Corresponding polished cylindrical lenses 25 and 27, respectively, are bonded to the cylindrical circumferential surfaces 24 and 26 that lie opposite to these surfaces, and the diameter of which is preferably congruent with the diameter of the base bar 21, but can also be modified such that it is smaller or larger.

Figure 14 shows a modification of the example from Figure 21 such that instead of a cylindrical base bar 21 a base bar is used that has the form of a circular section in cross-section, in which case a lens 25 is bonded to the flat section of the circumferential surface that is opposite to slanted end face 22.

Figure 23 shows an example for a stereoendoscope in which three bar lenses, 41, 42, and 43, and 41a, 42a, and 43a, respectively, are provided in each of the two beam paths in the shaft, and two other bar lenses 44 and 45, and 44a and 45a, respectively are provided in the headpiece, between each of which one bar lens 11 and 11a, respectively, is situated with an integrated arrangement of prisms.

The invention is not only suitable for stereoendoscopes, but for a monocular endoscopes as well. One such example is shown in Figure 24. The shaft 1 of this endoscope is bent at a right angle, in which case a bar lens 11 according to the invention is provided to bend the beam path 33, for which only the position is indicated in Figure 24. A free space 34 in the anterior area of the endoscope is gained by this right-angle bend, in which instruments can be operated that are passed through a working channel 35 in the shaft.

Claims:

1. Rigid endoscope

having a shaft in which at least one lens and bar lenses of an optical transmission system that are connected with it are provided at the distal end,

and having a headpiece at the proximal end of the shaft with at least one ocular or one matching optic for an image taking or imaging device subordinate to the endoscope, in which case the optical axis of the ocular or of the matching optic, respectively, does not coincide with the optical axis of the associated transmission system in the shaft,

for which reason, an arrangement of prisms for bending the beam path is provided in the headpiece between the optical system in the shaft and the ocular,

characterized in that the arrangement of prisms is a component of a bar lens (11, 11a).

2. Endoscope according to claim 1, **characterized in that** the bar lens (11, 11a), the component of which is the prism arrangement, has a base bar (21) with two flat end faces that run at a right angle to its longitudinal axis (28), and in that a prism (29, 30) is provided, and in particular bonded, at one or both end faces with one of its incident or emergent faces (33), respectively, and in which a lens (25, 27) is provided, and in particular bonded, to one or both prisms (29, 30) at its or their other incident or emergent face (33).

3. Endoscope according to claim 1, **characterized in that** the bar lens (11, 11a), the component of which is the prism arrangement, has a base bar (21) with one or two flat end faces (22, 23) that are, in particular, parallel, and that are diagonal to its longitudinal axis (28), and in that a lens (25, 27) is attached, in particular bonded, to the bordering circumferential surface (24, 26) of the base bar (21) that lies opposite to one or both end faces (22, 23).

4. Endoscope according to one of the previous claims, **characterized in that** the prisms are triangular prisms, rhomboidal prisms, or rhomboid-like prisms.

5. Endoscope according to one of the previous claims, **characterized in that** the arrangement of prisms is selected such that when observing a principal beam, the incidence beam (31) and the emergent beam (32) pass along different planes.