device 130 is disposed, via the hollow light guide region 113. The side surface of the objective lens 112 is fixed to the inner wall surface in the vicinity of the distal end portion of the tubular part 111 using an adhesive or the like, and the distal end surface of the insertion unit 110 is thus sealed.

[0027]

The hollow light guide region 113 is a space arranged between the base end portion and distal end portion of the tubular part 111 and serves as a light guide member that guides the light having passed through the objective lens 112 to the imaging device 130.

[0028]

FIG. 2 illustrates a detailed configuration of the illumination device 120 and imaging device 130 of the endoscope device 100. The illumination device 120 has an optical fiber 121, a diffusion layer 122, and a light source unit 123. The optical fiber 121 is led out from the light source unit 123 and fixed to the inner surface of the tubular part 111 with an adhesive or the like and extends to the diffusion layer 122 at the distal end portion of the tubular part 111.

[0029]

The diffusion layer 122 (see FIG. 1) diffuses and outputs the light which is supplied from the light source unit 123 via the optical fiber 121. The diffusion layer 122 is composed, for example, of a diffusing plate or a diffusing lens that diffuses the incident light and outputs the diffused light. The diffusion layer 122 is provided to diffuse the light so as to cover the view angle obtained by the wide-angle objective lens 112.

[0030]

The light source unit 123 supplies light for illuminating the object A to the base end portion of the optical fiber 121. The light source unit 123 comprises a light emitting diode (LED) element 125 and a first driver circuit 126. A xenon lamp can be used as substitute for the LED element 125, but in this case the light source unit 123 is provided separately from the insertion unit 110, and the illumination light is introduced into the insertion unit 110 via a long cord.

[0031]

The LED element 125 incorporates elements that emit light of three colors of red (R), green (G), and blue (B) and irradiates the incident end of the optical fiber 121 with white light obtained by color mixing.

[0032]

The first driver circuit 126 drives the LED element 125 under the control by the control device 140. The first driver circuit 126 performs dimming control of the LED element 125 by

with the naked eye in 2K, but not visible in 8K.) The number of pixels of 8K (about 33 million) is 16 times that of 2K (about 2 million). In the display device 150 (see FIG. 1), the number of pixels is represented by (field of view (monitor area))×(pixel density). For example, if the field of view is quadrupled that of 2K, the pixel density will also be quadrupled that of 2K. Assuming that the view angle when viewing the monitor screen is 30 degrees in 2K, 60 degrees in 4K, and 100 degrees in 8K, the reality is saturated at 100 degrees, so 8K is sufficient if the reality is required.

[0040]

The imaging element 131 may comprise pixels equivalent to or larger than 8K. In real world, even with the number of elements of 8K or less, clear images can be obtained as compared with 4K, so such elements may be put on sale or the like with indication of 8K. It is therefore assumed that "8K equivalent" refers to the number of pixels of 6K or more.

[0041]

FIG. 4 is an external view of the imaging device 130, FIGs. 5A-5C are a set of diagrams illustrating the board arrangement and the housing dimensions of the imaging device 130, and FIGs. 6A and 6B are a set of assembly diagrams of components. FIG. 5A is a front view, FIG. 5B is a plan view, and FIG. 5C is a cross-sectional view along line A–A. FIG. 6A is an exploded view and FIG. 6B is a perspective view of the completed body after assembly. The mounting part 135 has a size of about 80 mm×80 mm×30 mm, and a diaphragm 233 and an imaging substrate (on which the imaging element 131 is mounted) are mounted on the mounting part 135. The eyepiece mount part 114 on which an eyepiece 115 is mounted is attached to the mounting part 135, and the insertion unit 110 is attached to the eyepiece mount part 114. The grasping part 136 has a size of about 60 mm×53 mm×105 mm, which is a size that allows the grasping part 136 to be grasped in a hand. In order to mount the imaging substrate having a size of (pixel pitch)×(number of pixels) required for 8K, the mounting part 135 has a cross-sectional area equal to or larger than the cross-sectional area of the grasping part 136. In FIGs. 5A-5C, reference numeral 137A denotes a Peltier element that cools the substrate on which the imaging device 131 is mounted, reference numeral 137B denotes a Peltier element (which may not be necessary) that cools a control substrate 231 (which may not be necessary) left in the imaging device 130, and reference numeral 232 denotes a circular frame body that is in contact with the frame body of the eyepiece mount part 114 (the same size) and connected to the diaphragm 233. In FIGs. 6A-6B, reference numeral 232 denotes the circular frame body and reference numeral 234 denotes a frame part of the substrate on which the imaging device 131 is mounted.

zoom out to search for the surgical instrument and correct its position. This can shorten the duration of surgery. Thus, when the 8K image display technique and the zoom-in and zoom-out technique are used, the reliability and safety of surgery are enhanced, the duration of surgery can be shortened, and the surgical environment greatly changes. In this way, the creation of a wide surgical space, the digital zooming, and the large screen display significantly change the surgical environment. This improves the medical care to be highly reliable, safe, and secure.

[0061]

The storage unit 143 stores the operation program for the control unit 141, the operation program for the image processing unit 142, the image data received from the transmission unit 134, the frame data reproduced and processed by the image processing unit 142, etc.

[0062]

The input/output IF 144 serves as an interface for transmission and reception of data between the control unit 141 and an external device. The input device 145, which is composed of a keyboard, a mouse, buttons, a touch panel, and other necessary components, supplies an instruction from the user to the control unit 141 via the input/output IF 144.

[0063]

The display device 150, which is composed of a liquid crystal display device or the like having a display pixel number corresponding to 8K, displays an operation screen, a captured image, a processed image, etc. under the control by the control device 140. The 8K allows a large screen monitor to be used as the display device. For example, a large screen monitor of 30 inches or more is used because the storage unit 143 stores images of 7680×4320 pixels. Even a large screen monitor allows for natural viewing. All the persons concerned in the surgery can therefore share the images on one or more large screens to achieve smooth communications. (Surgeons can also view a branched image from the imaging device.)

[0064]

Unlike the cameras for television broadcasting, the endoscope is used in a dedicated facility. The imaging device 130 attached to the insertion unit 110 is therefore connected to the control device 140 via cables 146 (see FIG. 2) of about several meters. The control device 140 and the display device 150 are placed on a table or the like. The illumination device 120, the imaging device 130, and the control device 140 are separated from one another. Accordingly, the structures attached to the insertion unit 110 (the insertion unit 110, the imaging device 130, and the illumination device 120) are reduced in weight and size, and handling of the insertion unit 110 is thus relatively easy. Moreover, the cables 146 connecting the illumination device

The operation of the endoscope device 100 having the above configuration will then be described. When using the endoscope 100, the user (practitioner) operates the input device 145 to input an instruction to turn on the endoscope device 100. In response to this instruction, the control unit 141 turns on the first driver circuit 126 and the second driver circuit 132. The first driver circuit 126 turns on the light source (such as the xenon lamp or the LED element 125), while the second driver circuit 132 starts imaging with the imaging element 131. The white light output from the LED element 125 is guided through the optical fiber 121 and diffused by the diffusion layer 122 for irradiation.

[0068]

The imaging element 131 captures a video footage through the objective lens 112 and the hollow light guide region 113. It has been found that the pitch P of pixels is preferably 2.8 to 3.8 μm from the relationship between the aperture (f value) of the lens system and the pitch P of pixels of the imaging element 131, so a pitch P of pixels within that range was used. This allows for acquisition of bright and high-resolution images.

[0069]

The second driver circuit 132 sequentially reads out the pixel voltages of respective pixels from the imaging element 131, and the read out pixel voltages are converted by the A/D conversion unit 133 into digital image data, which are sequentially transmitted from the transmission unit 134 to the control device 140 via the cables 146.

[0070]

The control unit 141 of the control device 140 sequentially receives the transmitted image data via the input/output IF 144 and in turn stores the image data in the storage unit 143.

[0071]

Under the control by the control unit 141, the image processing unit 142 processes the image data stored in the storage unit 143 to reproduce the frame data and may perform additional processing thereon as appropriate.

[0072]

The control unit 141 appropriately reads out the frame data stored in the storage unit 143 and supplies the frame data to the display device 150 via the input/output IF 144 for display.

[0073]

The user (practitioner) inserts the insertion unit 110 into the body cavity while confirming the display on the display device 150. When the insertion unit 110 is inserted in the body cavity, the object A is illuminated with light from the diffusion layer 122 and the imaging device 131 captures an image of the object A, which is displayed on the display device 150.