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CERTIFICATION

This is to certify that the attached translation is, to the best of my knowledge and belief, a true and accurate translation from Japanese into English of the attached Japan Patent Application Public Disclosure No.: S58-46923.

Robert Adler, Project Manager
Geotext Translations, Inc.

Sworn to and subscribed before me

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SPECIFICATION

1. Title of the Invention
Endoscope

2. Claims

1. An endoscope characterized in that [it] contains a path that guides to the other end a manipulation tool inserted at one end and a heating means that is provided in the vicinity of the other end of the said path and that heats the manipulation tool,
the manipulation tool contains a shape-memory alloy that memorizes a first shape adapted to the use state, and
the aforementioned heating means heats the manipulation tool, which was transformed to a second shape different from the first shape, to at least the reverse-transformation temperature of the said shape-memory alloy, to restore the first shape.

2. An endoscope characterized in that, in the endoscope described in Claim 1, the aforementioned shape-memory alloy is such that the reverse-transformation temperature is virtually equal to the temperature of the body in which the aforementioned manipulation tool is used, and the aforementioned heating means heats the said manipulation tool to at least the body temperature.

3. An endoscope characterized in that, in the endoscope described in Claim 1, the aforementioned path contains a cooling means that maintains the manipulation tool inserted into the said path at or below the reverse-transformation temperature of the shape-memory alloy of the said manipulation tool.

3. Detailed Explanation of the Invention

The present invention relates to an endoscope, and particularly [relates] to an endoscope equipped with a manipulation tool, such as forceps, a treatment tool, etc.

Conventionally, in the observation and treatment of a body cavity or internal organ by means of an endoscope, the usual [procedure] is to insert a manipulation tool (e.g., forceps, treatment tool) via a forceps hole penetrated by the endoscope, excise tissue from the body cavity or internal organ, and perform treatment. These variously shaped forceps and treatment tools include the biopsy forceps, basket forceps, high-frequency snare, three-nail forceps, alligator forceps, coagulation electrode, washing tube, cytology brush, etc. However, certain shapes and sizes are required for the respective applications. Furthermore, these forceps and treatment tools are hereinafter collectively called "manipulation tools."

On the one hand, however, to minimize pain experienced by a patient as well as the insertion resistance when inserting an endoscope into the living body and particularly the body cavity of the patient, there is demand for minimizing the outside diameters of the endoscope head and junctions. Consequently, the diameter of the forceps hole into which a manipulation tool is inserted and guided into a body cavity also preferably is small.

An endoscope equipped with a conventional manipulation tool cannot simultaneously satisfy these conflicting requirements, so some degree of compromise has been required. For example, a basket forceps, etc., is inserted into a forceps hole by deforming within the elastic limit of its material, so the insertion resistance is high. Also, in a side-view endoscope, in order to stand these manipulation tools in the usable state, [they] are oriented almost vertically relative to the lengthwise direction of the endoscope, so they are equipped at their head with a forceps standing table operated by means of a wire from the operating portion. The provision of such a movable portion at the endoscope head increases the size of the head and junctions, thereby reducing the reliability of the mechanically operated device.

The present invention eliminates such conventional technical drawbacks, and aims at providing an endoscope that subjects the patient to little pain during insertion.

Another purpose of the present invention is to provide an endoscope with high reliability that is capable of extracting or inserting, without resistance, the manipulation tool with the required shape and size in the use state.

According to the present invention, these purposes are achieved by an endoscope such as the following. That is, this endoscope contains a path that guides to the other end a manipulation tool inserted at one end and a heating means that is provided in the vicinity of the other end of the said path and that heats the manipulation tool; this manipulation tool contains a shape-memory alloy that memorizes a first shape adapted to the use state; and a heating means heats the manipulation tool, which was transformed to a second shape different from the first shape, to at least the reverse-transformation temperature of the shape-memory alloy, to restore the first shape.

The shape-memory alloy of the manipulation tool may be set such that the reverse-transformation temperature becomes virtually equal to the body temperature at which the manipulation tool is used, and the heating means may be set such that the manipulation tool is heated to at least the body temperature

The path that guides the manipulation tool also may be equipped with a cooling means that maintains the manipulation tool inserted therein at or below the reverse-transformation temperature of the shape-memory alloy.

Next, an embodiment of the endoscope based on the present invention will be explained in detail, with reference to the appended drawings. Furthermore, in the present specification, the endoscope includes not only those used in a living body, but also industrial [endoscopes] used within the internal cavities of devices, etc.

Figure 1, a partially cutaway side-view of the endoscope based on the present invention, shows the part of the endoscope inserted into a body cavity (i.e., its head). This head has a cylindrical sheath 10 composed of a plastic or a plastic-coated metal, and at the end thereof is provided a forceps hole 14 that performs suction or through which is passed a manipulation tool 12 (e.g., the basket forceps shown in the drawing or other forceps or a treatment tool). The forceps hole 14 is connected to a tube-shaped path 16 that guides the manipulation tool 12, and a heating means 18 is provided in a shape that surrounds the periphery of the path 16, at the junction between the forceps hole 14 and the path 16 of the sheath 10.

The heating means 18 is a resistance heating element composed of a carbon fixed resistor, a wire-wound resistor, etc., shaped so as to surround the periphery of the tube-shaped path 16, and it is connected via a lead wire 20 to an external power supply (not shown). Within the sheath 10 are provided the additional mechanisms required by the endoscope; for example, an objective lens 22 and an image bundle 24 composed of optical fiber. To simplify the drawings, other mechanisms (e.g., the light guide, air line, water line) have been omitted from the drawings.

As is commonly known, the basket forceps 12 captures and removes from the body calculi within body cavities, for example. In the use state, the form shown in the drawings is adopted. According to the present invention, the basket forceps 12 are composed of a so-called "shape-memory alloy."

As is commonly known, a "shape-memory alloy" is an alloy that, when heated to at least a certain temperature (i.e., the reverse-transformation temperature), loses existing plastic deformation-induced strain. More specifically, the crystal structure of the high-temperature phase called the mother phase or the beta phase is formed by heating to at least the transformation temperature a shape-memory alloy formed into a certain shape. Next, when this is rapidly cooled to or below the transformation temperature, the martensitic crystal structure results. Suppose that, however, stress is applied to the alloy in this state, thereby deforming [the alloy] into a shape different from the original shape. The strain resulting from this deformation is maintained, but if this is heated to or above the reverse-transformation temperature, this strain is eliminated and the original shape is restored. It is said that this is because the martensitic structure reverse-transforms to the mother phase.

The manipulation tool 12, such as a basket forceps, of the endoscope of the present invention is composed of this shape-memory alloy. To explain the basket forceps 12 shown in Figure 1, for example, [it] is shaped into the shape shown in Figure 1, and it is heated to at least its transformation temperature and then rapidly cooled. To insert such forceps 12 into the tube-shaped path 16 via the forceps insertion hole (not shown) of the operation portion of the endoscope and guide [it] smoothly into the forceps hole 14 of the head, it is preferable to insert [it] into the path 16, after temporarily deforming [it] into a shape long in the lengthwise direction, which is shown in Figure 2. The basket forceps 12 deformed thus is heated to at least the reverse-transformation temperature of this shape-memory alloy by passing electric current through the heating means 18 provided near the forceps hole 14, thereby restoring [it] to its original shape (i.e., the shape of the basket forceps 12 in the use state).

Examples of shape-memory alloys used as the manipulation tool 12 include Ti-Ni, Ag-Cd, Au-Cd, Cu-Al-Ni, Cu-Al-Zn, Cu-Zn, Ni-Al, etc. However, Ti-Ni, Cu-Al-Zn, etc., are particularly useful.

In the case of an endoscope inserted into a body cavity, it is preferable to set the reverse-transformation temperature near this body temperature, after appropriately selecting the composition of the shape-memory alloy of the manipulation tool 12. It is preferable to use a heating means 18 because considerable response time might be required to restore the manipulation tool 12 to its original shape by means of natural heating by body temperature. By using the heating means 18, it is possible to set a high reverse-transformation temperature for restoring the manipulation tool 12 to its original shape. This increases the range (i.e., freedom) in selecting the composition of the shape-memory alloy of the manipulation tool 12. However, it is preferable to avoid inflicting lesions or pain in a living body as a result of the increased temperature caused by the heating means, when the endoscope is used in a living body. For the aforementioned reasons, therefore, it is effective to heat to a temperature slightly higher than the temperature of the living body. In the case of Cu-Al-Zn, for example, it is possible to set the martensitic transformation starting temperature to 38 °C in a composition composed of 74% Cu, 8% Al, and 18% Zn. So, according to the present invention, it normally is preferable to set such that reverse-transformation occurs at a temperature between a temperature slightly higher than the normal temperature and a temperature that does not inflict a lesion or pain in a living body (i.e., 30-50 °C). If the reverse-transformation temperature is low, the manipulation tool 12 is cooled in advance, and during use it is immediately inserted into the tube-shaped path 16, via the forceps insertion hole (not shown) of the endoscope operation portion. It also is possible to configure the endoscope so as to maintain the manipulation tool 12 at or below the reverse-transformation temperature of this shape-memory alloy, by cooling the surroundings of the tube-shaped path 16 with a water line, etc.

Such a shape-memory alloy also has so-called "pseudoelasticity" or "superelasticity," so the endoscope of the present invention is advantageous, also, when extracting in the original direction a manipulation tool 12 that returned to its original shape, via the tube-shaped path 16, after insertion. "Pseudoelasticity" or "superelasticity" indicates a property such that, even if stress is applied in excess of the normal elastic limit, strain occurs as if it were subjected to plastic deformation, but when the stress is eliminated, the original shape is restored, so there is no residual permanent strain. Therefore, in the endoscope of Figure 1, a basket forceps 12 that uses such a shape-memory alloy returns to the shape of the usable state, and after a calculus, etc., is captured within a body cavity, [it] is removed smoothly from the forceps insertion hole (not shown) of the endoscope operation portion, in the direction opposite to insertion into the path 16. Such a manipulation tool 12 withstands repeated use any number of times, so it has a long life.

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In addition to basket forceps, forceps for scraping out calculi, which are shaped as shown in Figures 3(A), (B), and (C), exist as such a manipulation tool 12. All of these are formed of a Ti-Ni or another shape-memory alloy, for example, and the shapes of the use states shown in the figures are memorized. When [it] is inserted into an endoscope, it is deformed into a linear shape, such as that shown in Figure 4. In this manner, it is possible to rapidly and smoothly insert [it] into the path 16, and near the opening 14 [it] is heated by the heating means 18, thereby restoring its original shape (i.e., the shape shown in Figure 3), resulting in the usable state.

Another embodiment of the endoscope of the present invention is shown in Figure 5. Unlike the straight-view endoscope, this is an example of a side-view endoscope shown in Figure 1. The structural elements identical to those shown in Figure 1 are labeled identically. The head of this endoscope is partitioned into two chambers by a partition 30. The right side of the partition 30 in the same figure is completely waterproof, and it houses, for example, a tube-shaped path 16 that guides the manipulation tool 32 (e.g., biopsy forceps) shown as an example, as well as the objective lens 22, mirror or prism 34, imaging lens 36, and image bundle 24 composed of optical fiber. In addition, a light guide 38 is shown as an example of a mechanism required in the endoscope, and as shown in the figure, this passes through the partition 30 and extends to the window 40 at the top of the left chamber. At the left end of the tube-shaped path 16, an opening 42 is formed in the partition 30, and as shown in the figure a heating element 18 is provided. This may be the same as [that of] the embodiment shown in Figure 1. An opening 44 is formed in the side of the head sheath 10 (i.e., at the top in Figure 5), and this forms a rectangle that is long in the lengthwise direction of the endoscope, when viewed from above the figure. Other mechanisms required by an endoscope are omitted from the drawings for the sake of drawing simplicity.

In the use state, a treatment tool 32 or self-standing forceps (e.g., the biopsy forceps in the figure) or a cannulation tube passes through the opening 42 at the left end of the tube-shaped path 16 and curves upward, after which [it] exits to the exterior via the rectangular opening 44. The neck portion 46 of the biopsy forceps 32 shown as an example is composed of a coil-shaped shape-memory alloy or a linear or tube-shaped shape-memory alloy, as shown in the figure, and the use state shape, such as that shown in the figure, is memorized. That is, it is formed into a shape like that in the figure, heated to at least the transformation temperature, and cooled rapidly. If necessary, it is cooled, and as in the case shown in Figure 4, it is formed into a linear shape. Then it is inserted into the tube-shaped path 16 via the forceps insertion hole of the endoscope operation portion, after which it is heated to at least the reverse-transformation temperature by means of the heating means 18, thereby restoring the original shape shown in the figure, which results in the usable state.

In the embodiment shown in Figure 5, the mechanisms required in a conventional endoscope (e.g., the forceps standing table required for standing in the usable state the standing-type forceps, the wire that operates this, etc.) are not required. Therefore, the size of the endoscope itself shrinks and the mechanical operation portions become fewer, so device reliability also improves.

By configuring as aforementioned the endoscope of the present invention, it is possible to smoothly insert and extract a manipulation tool with the shape and size necessary in the use state. Consequently, it is possible to narrow the diameter of the endoscope relatively to the size and shape required by the manipulation tool, so it is possible to reduce the pain inflicted on a patient. Also, even when a self-standing manipulation tool is used in a side-view endoscope, it is possible to configure so as to minimize the mechanical, movable parts, which improves device reliability.

4. Brief Explanation of the Drawings

Figure 1 is a partially cross-sectional side view showing an embodiment of the endoscope of the present invention.

Figures 2–4 are diagrams showing the shape of the manipulation tool used in the endoscope of the present invention.

Figure 5 is a partially cross-sectional view showing another embodiment of the endoscope of the present invention.

<u>Explanation of Symbols for Main Components</u>

12 Manipulation tool 16 Tube-shaped path
18 Heating means

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