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Arai et al.

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[45] **Date of Patent: Oct. 5, 1999**

[54] **SHAPE INPUT DEVICE**

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[73] Assignees: **Olympus Optical Co.**, Tokyo; **Susumu Tachi**, Tsukuba, both of Japan

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[30] **Foreign Application Priority Data**

Dec. 18, 1996 [JP] Japan 8-338529

[51] **Int. Cl.**[6] **G01B 11/24**; G01B 5/34; G01B 11/02; G06F 15/00

[52] **U.S. Cl.** **356/376**; 356/379; 356/383; 356/384; 364/406; 250/231

[58] **Field of Search** 364/406, 806; 340/209; 414/5; 356/376, 379, 383, 384

[56] **References Cited**

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5-113327	5/1993	Japan .
5-149706	6/1993	Japan .
6-3465	1/1994	Japan .
7-184882	7/1995	Japan .

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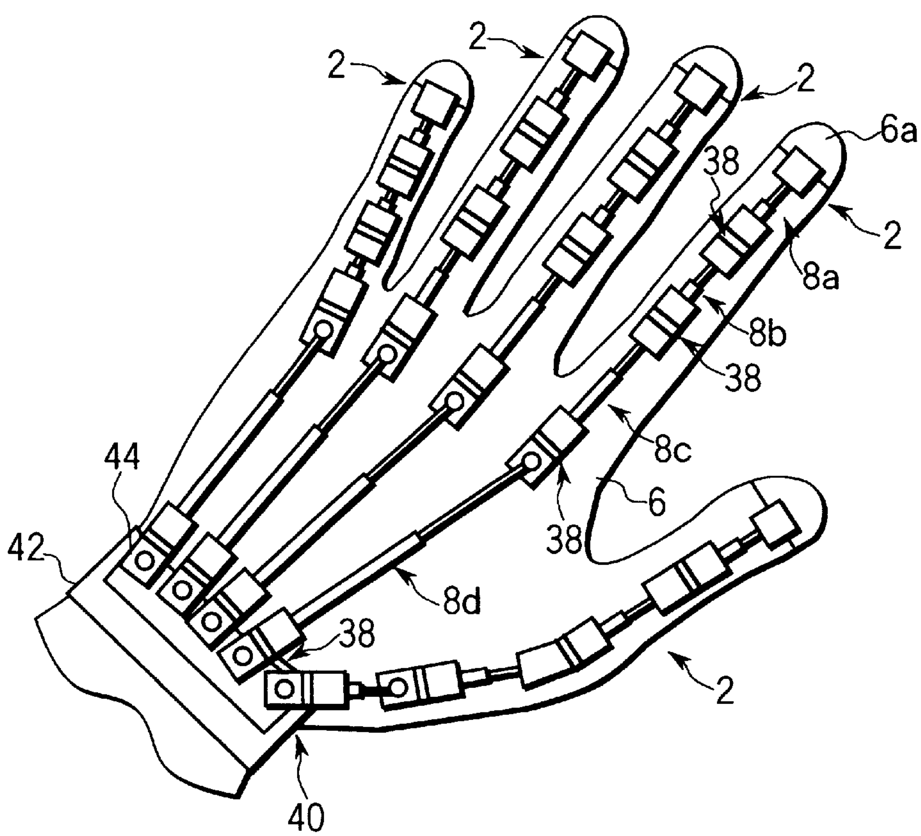
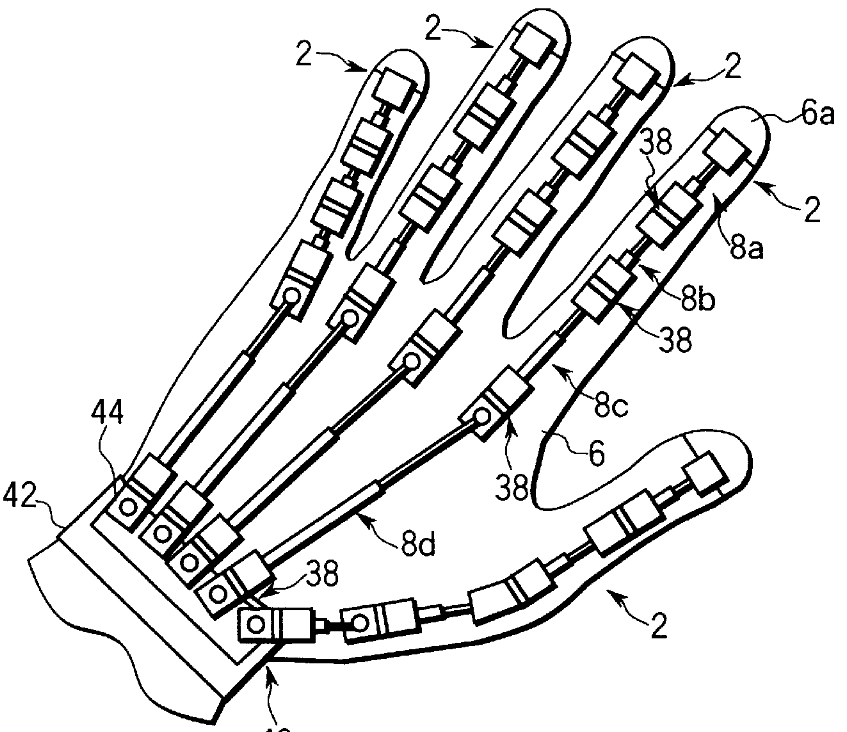
Assistant Examiner—Roy M. Punnoose
Attorney, Agent, or Firm—Frishauf, Holtz, Goodman, Langer & Chick, P.C.

[57] **ABSTRACT**

A device for inputting a shape of an object includes a base mounted on the object, a flex detecting unit for detecting an amount of flex of the object, and a stretch detecting unit, coupled to the base and to the flex detecting unit, for detecting an amount of stretch between the base and the flex detecting unit which corresponds to an amount of stretch of the object. The stretch detecting unit includes a stretch mechanism which is expanded or contracted in accordance with the stretch of the object, and the amount of stretch of the object is detected based on a detected amount of stretch of the stretch mechanism. The flex detecting unit includes a member which is deformable in an amount corresponding to the amount of flex of the object, and the amount of flex of the object is detected based on a detected amount of deformation of the deformable member.

20 Claims, 5 Drawing Sheets




2
2
2
6a
38
2
8a
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8b
38
8c
44
6
42
38
8d
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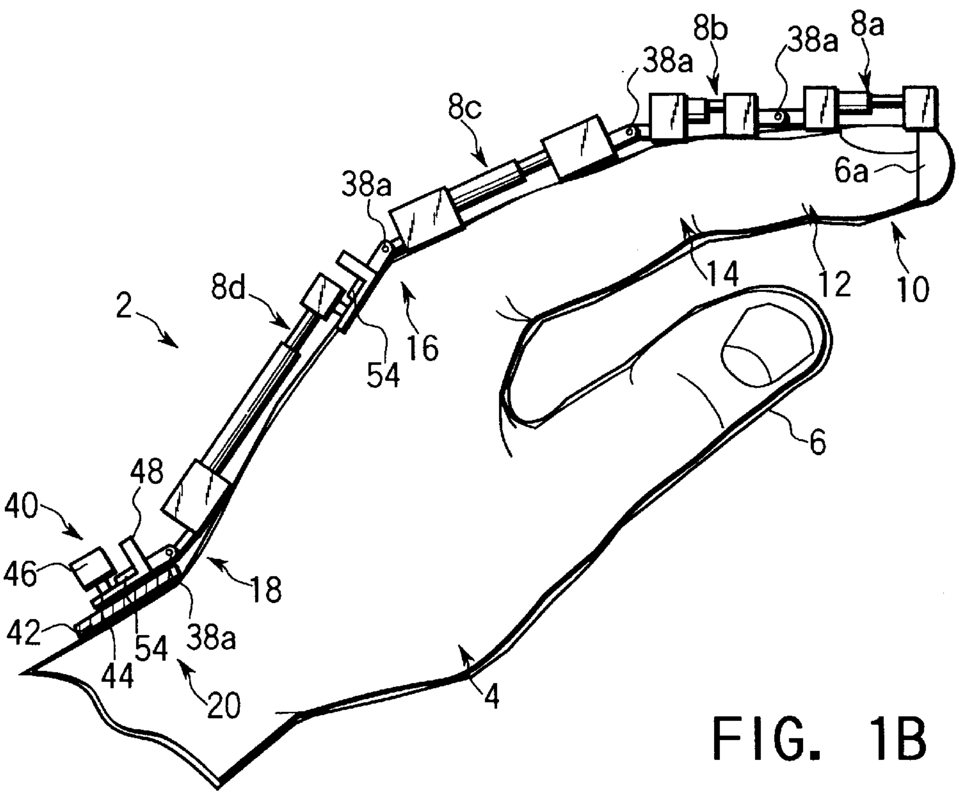
2
40

FIG. 1A


8b
8a
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6a
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12
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8d
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46
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54
38a
44
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4

FIG. 1B

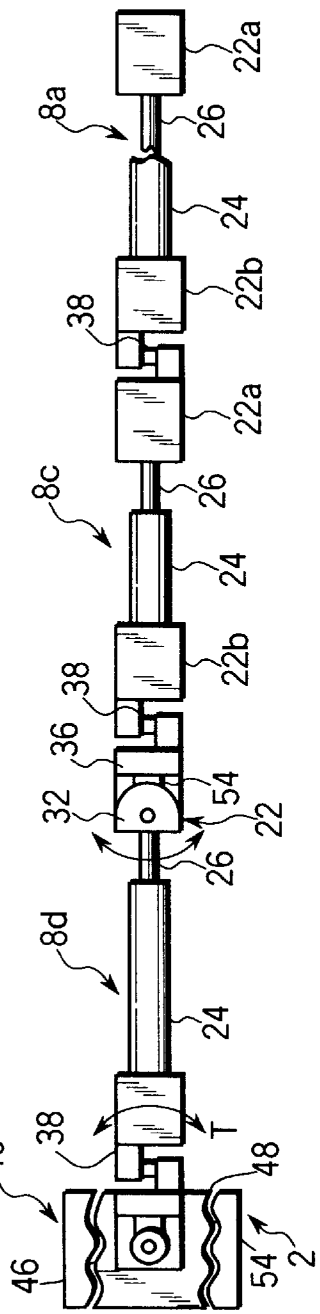


FIG. 2A

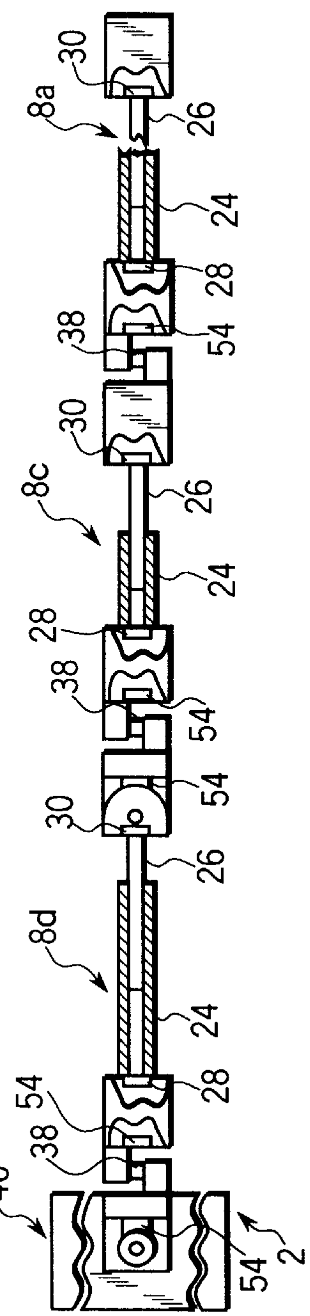


FIG. 2B

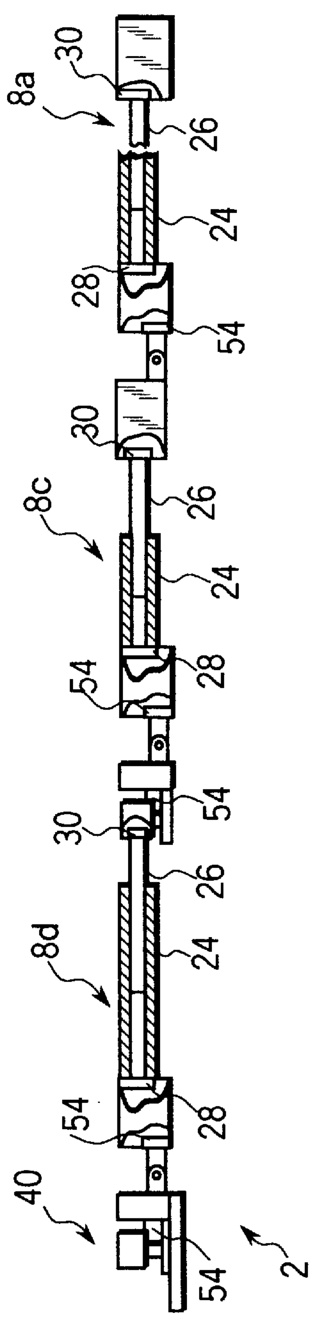


FIG. 2C

FIG. 3A

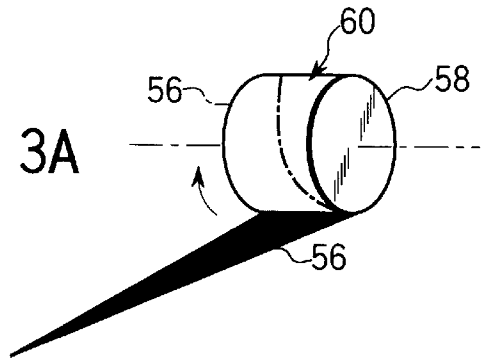
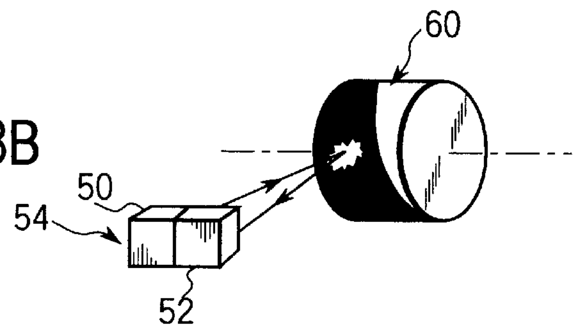


FIG. 3B



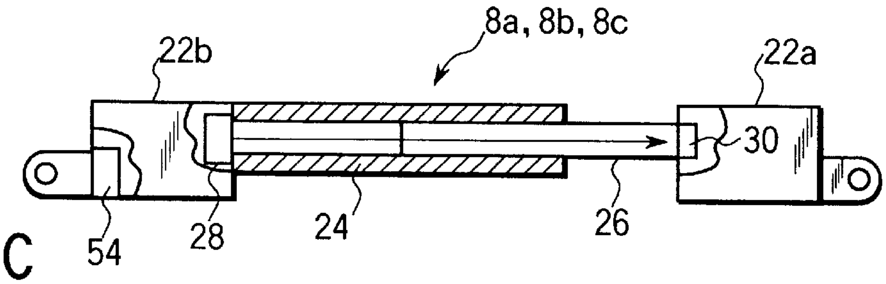
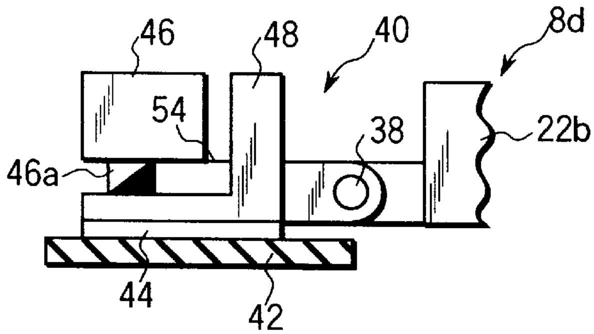


FIG. 3C

FIG. 3D



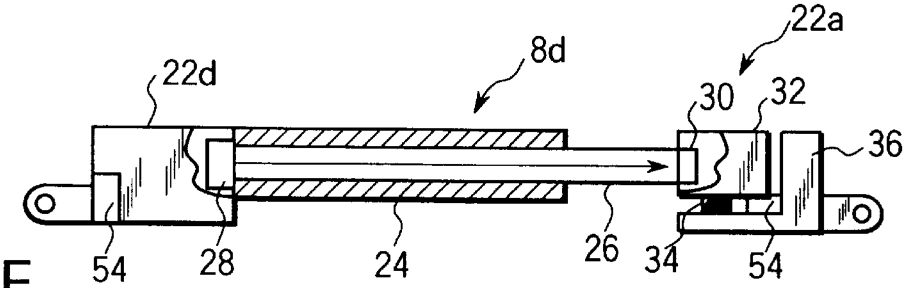


FIG. 3E

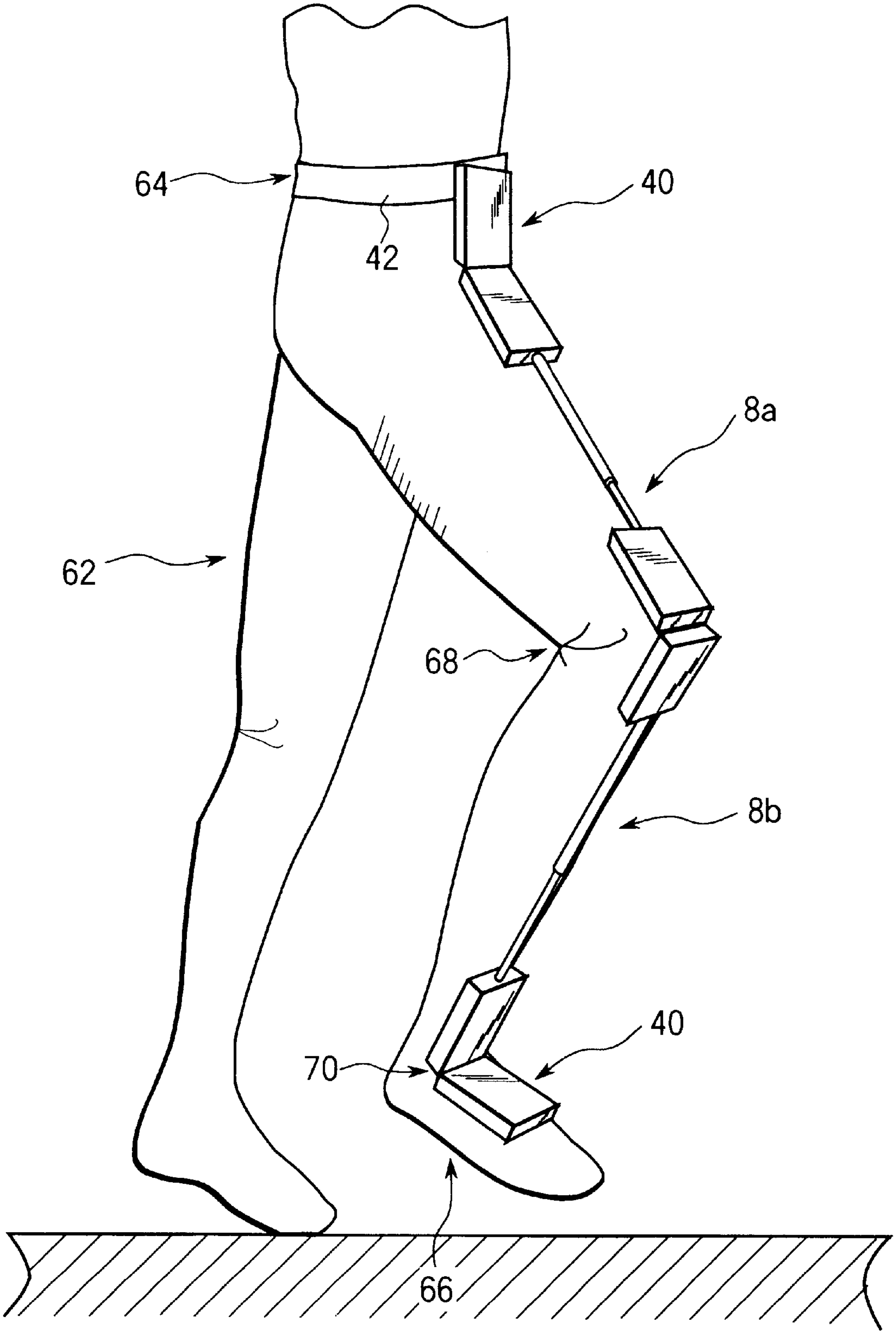


FIG. 4

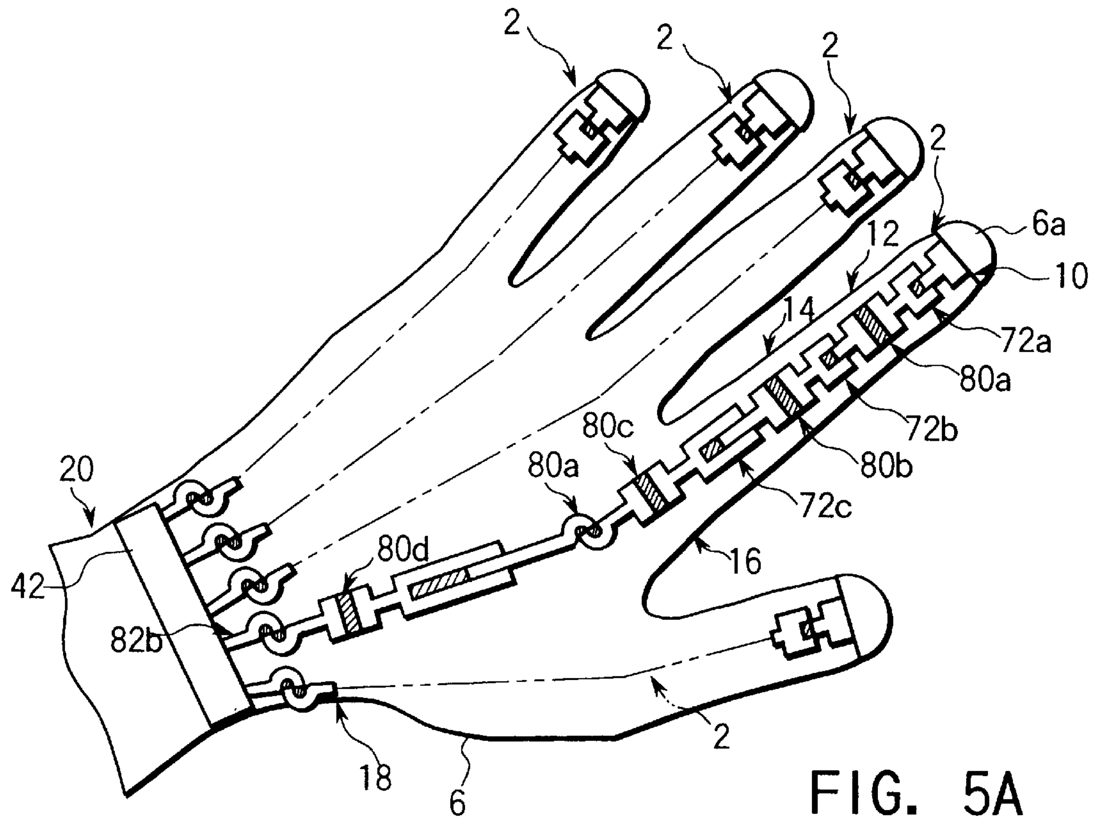


FIG. 5A

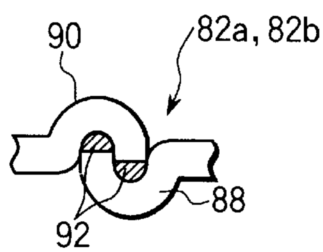


FIG. 5B

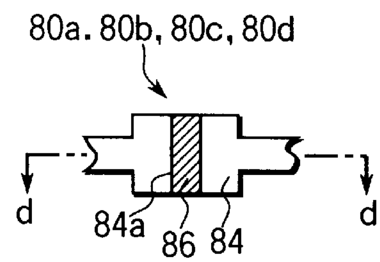


FIG. 5C

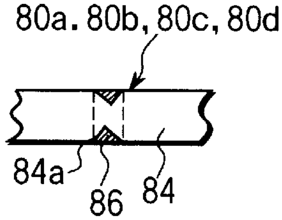


FIG. 5D

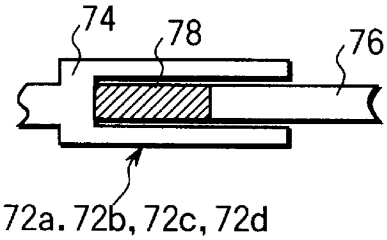


FIG. 5E

SHAPE INPUT DEVICE

BACKGROUND OF THE INVENTION

The present invention relates to a shape input device which can measure any change in shape of a target object and can input measurement information to, e.g., a measuring instrument.

Conventional shape input devices are disclosed in, e.g., Jpn. Pat. Appln. KOKOKU Publication No. 1-56684 and Jpn. Pat. Appln. KOKAI Publication Nos. 5-113327 and 7-184882. All of these shape input devices have a rod member which can be pivotally set along the joint of, e.g., a wrist or arm, and a detection means which can detect the pivot angle of this rod member. The shape change state of the joint is recognized based on the pivot angle of the rod member which is detected by the detection means when the shape of the joint changes.

A change in joint shape is not a simple shape change component which can be specified by only a change in pivot angle of the rod member. In particular, since motion of the hand or finger is a complicated combination of rotational motion and expanding/contracting motion, it is difficult to obtain the shape change state of the joint of the hand or finger with an angle detection unit having a simple arrangement as described above.

For example, Jpn. Pat. Appln. KOKAI Publication Nos. 5-149706 and 6-3465 disclose a shape input device which can detect the shape change of a hand or finger consisting of a plurality of joints.

The shape input device disclosed in Jpn. Pat. Appln. KOKAI Publication No. 5-149706 has a bend sensor which extends along each finger portion of a flexible glove and the resistance of which changes in accordance with the flexing amount of the corresponding joint of the hand or finger. A change in shape of the hand or finger which is apparently bent the most largely can be detected based on a change in resistance of the bend sensor (this will be called the first prior art).

The shape input device disclosed in Jpn. Pat. Appln. KOKAI Publication No. 6-3465 has conductive gel which is applied on each joint portion of a flexible glove and the resistance of which changes in accordance with the flexing amount of the corresponding joint of the hand or finger. A change in shape of the hand or finger can be detected based on a change in resistance of each conductive gel (this will be called the second prior art).

In the above described first and second prior art references, the bend sensor or conductive gel is directly provided on the flexible glove. Accordingly, when a certain joint flexes, this flexing motion is transmitted to another joint portion through the flexible glove to undesirably change the resistance of the bend sensor or conductive gel at this other joint portion. In particular, in the second prior art reference, the influence of the relative translating displacements of the respective conductive gels, which occur upon flexure of the joints, and the influence of strain produced by the flexing displacements of the joints sometimes mix in the detected resistance. As a result, it is sometimes difficult to precisely input a change in shape of the hand or finger. In this case, a change in shape of the hand or finger may be accurately reproduced by signal processing of input data. With this method, however, the lengths of the respective joints of the hand or finger or the link must be measured in advance in units of users, or the input program must be reset in units of users.

BRIEF SUMMARY OF THE INVENTION

The present invention has been made in order to solve these problems, and has as its object to provide a shape input device which can easily input a change in shape of the target object with high precision.

In order to achieve the above object, according to the present invention, there is provided a shape input device comprising stretch detecting means for detecting an amount of a stretch of the object; flex detecting means for detecting an amount of a flex of the object; and connecting means for jointing the stretch detecting means and the flex detecting means corresponding to the shape of the object.

Additional object and advantages of the invention will be set forth in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention. The object and advantages of the invention may be realized and obtained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate presently preferred embodiments of the invention, and together with the general description given above and the detailed description of the preferred embodiments given below, serve to explain the principles of the invention.

FIG. **1A** is a plan view schematically showing the arrangement of a shape input device according to the first embodiment of the present invention;

FIG. **1B** is a partially sectional side view of FIG. **1A**;

FIG. **2A** is a plan showing the practical arrangement of the shape input assembly of the shape input device shown in FIGS. **1A** and **1B**;

FIG. **2B** is a partially cross-sectional view of FIG. **2A**;

FIG. **2C** is a partially longitudinally sectional view of FIG. **2A**;

FIGS. **3A** and **3B** are perspective views showing the arrangement of the detection means of the shape input device shown in FIGS. **1A** and **1B**;

FIG. **3C** is a partially sectional view showing the arrangement of the first to third expansion/contraction amount detection units of the shape input device;

FIG. **3D** is a partially sectional view showing the arrangement of the support assembly of the shape input device;

FIG. **3E** is a partially sectional view showing the arrangement of the fourth expansion/contraction amount detection unit of the shape input device;

FIG. **4** is a perspective view showing a state wherein the shape input device shown in FIGS. **1A** and **1B** is attached to a human leg;

FIG. **5A** is a plan view schematically showing the arrangement of a shape input device according to the second embodiment of the present invention;

FIG. **5B** is a view showing the arrangement of the first and second pivot amount detection units of the shape input device;

FIG. **5C** is a view showing the arrangement of a connecting means incorporated with a flexing amount detection unit;

FIG. **5D** is a sectional view taken along the line d—d of FIG. **5C**; and

FIG. **5E** is a view showing the arrangement of the first to fourth expansion/contraction amount detection units of the shape input device.

DETAILED DESCRIPTION OF THE INVENTION

A shape input device according to the first embodiment of the present invention will be described with reference to FIGS. **1A** and **1B**, FIGS. **2A** to **2C**, and FIGS. **3A** to **3E**.

The shape input device according to this embodiment has at least one shape input assembly **2** which can detect a change in shape of a target object the shape of which changes, and can be detachably attached to the target object. The shape input assembly **2** is formed with at least one expansion/contraction amount detection unit which can detect the extraction/contraction amount of the target object, at least one flexing amount detection unit which can detect the flexing amount of the target object, and a connecting means which can combine the expansion/contraction amount detection unit and the flexing amount detection unit in accordance with the size and shape of the target object.

The shape input device according to this embodiment is formed with a tight-contact means for bringing the shape input assembly **2** into tight contact with the target object. An example of the target object to which the shape input device can be applied includes, e.g., a human hand, finger, and leg, and various types of other variable-shape objects. As an example, this embodiment is applied to a human hand **4** (see FIG. **1**B). In this case, as the tight-contact means, a flexible glove **6** (e.g., a silicone rubber glove) is employed which elastically deforms in accordance with the size or shape of the human hand **4** to bring the shape input assembly **2** into tight contact with the human hand **4**.

As shown in FIG. **1**A, in the shape input device of this embodiment, five shape input assemblies **2** extending from the wrist along five fingertips are detachably attached to the flexible glove **6**. Since these shape input assemblies **2** have the same arrangement except that their sizes differ from one finger to another, in the following description, the arrangement of only the shape input assembly **2** (see FIG. **1**B) extending along the forefinger will be explained as an example.

As shown in FIG. **1**B and FIGS. **2**A to **2**C, the shape input assembly **2** is formed with first to fourth expansion/contraction amount detection units **8*a***, **8*b***, **8*c***, and **8*d*** arranged among the respective joints of the hand **4**. More specifically, the first expansion/contraction amount detection unit **8*a*** is arranged between a fingertip **10** and a first joint **12**, the second expansion/contraction amount detection unit **8*b*** is arranged between the first joint **12** and a second joint **14**, the third expansion/contraction amount detection unit **8*c*** is arranged between the second joint **14** and a third joint **16**, and the fourth expansion/contraction amount detection unit **8*d*** is arranged between the third joint **16** and a wrist joint **18**. In this embodiment, the joints will be numbered as the first joint **12**, the second joint **14**, and the third joint **16** from the fingertip **10** toward a wrist **20**.

As shown in FIGS. **2**A to **2**C and FIG. **3**C, each of the first to third expansion/contraction amount detection units **8*a***, **8*b***, and **8*c*** has a pair of bases **22*a*** and **22*b***, an expansion/contraction mechanism supported between the bases **22*a*** and **22*b***, and a detection means capable of optically detecting the expansion/contraction amount of this expansion/contraction mechanism. In this embodiment, of the pair of bases **22*a*** and **22*b***, one on the fingertip side is called the front base **22*a***, and one on the wrist side is called the rear base **22*b***. In FIGS. **2**A to **2**C, the second expansion/contraction amount detection unit **8*b*** is omitted.

The expansion/contraction mechanism has a hollow guide member **24** extending from the rear base **22*b***, and a hollow slidable member **26** extending from the front base **22*a*** and slidable in the guide member **24**. When the slidable member **26** slides along the guide member **24** relative to it, the distance between the front base **22*a*** and rear base **22*b*** changes relatively. These front and rear bases **22*a*** and **22*b*** are detachably attached to the flexible glove **6** with attaching means (not shown). As the attaching means, for example, an adhesive or Velcro tape can be used.

The detection means has a light-emitting element **28** incorporated in the rear base **22*b***, and a light-receiving element **30** incorporated in the front base **22*a*** and capable of outputting an electric signal corresponding to the received light amount. The light-emitting element **28** and light-receiving element **30** are arranged to oppose each other such that light emitted by the light-emitting element **28** passes through the guide member **24** and slidable member **26** and enters the light-receiving element **30**. The light emission amount of the light-emitting element **28** is preset to a predetermined level so that even when the distance between the front base **22*a*** and rear base **22*b*** becomes the largest, light having a sufficiently large light amount reaches from the light-emitting element **28** to the light-receiving element **30**.

According to this detection means, when the expansion/contraction mechanism operates in accordance with a change in shape of the hand **4** and the distance between the front base **22*a*** and rear base **22*b*** changes relatively, the optical characteristics (e.g., the light amount) of light detected by the light-receiving element **30** change. At this time, the relative distance between the front base **22*a*** and rear base **22*b*** is measured by detecting the electric signal output from the light-receiving element **30**. The expansion/contraction amounts among the respective joints of the hand **4** can be detected separately based on this relative distance.

The front bases **22*a*** and rear bases **22*b*** of the first to third expansion/contraction amount detection units **8*a***, **8*b***, and **8*c*** are respectively detachably attached to the back of the hand of the flexible glove **6** with attaching means (not shown). The front base **22*a*** of the first expansion/contraction amount detection unit **8*a*** is detachably attached to a fingertip holding portion **6*a*** (see FIGS. **1**A and **1**B) of the flexible glove **6** that holds the fingertip **10**. As the attaching means, for example, an adhesive or Velcro tape can be used. When fixing the front bases **22*a*** and rear bases **22*b*** to the flexible glove **6**, for example, a fixing adhesive may be used as the attaching means.

As shown in FIG. **3**E, the fourth expansion/contraction amount detection unit **8*d*** is formed such that it can follow the expanding/contracting motion of the back of the hand, and its front base **22*a*** has a pivot base **32**, a pivot shaft **34**, and a fixed base **36**. The pivot base **32** supports the hollow slidable member **26**. The pivot shaft **34** is integrally formed on the pivot base **32** to project from it and extends in a direction perpendicularly intersecting the axis of the slidable member **26**. The fixed base **36** pivotally supports the pivot shaft **34**. The rear base **22*b*** and fixed base **36** of the fourth expansion/contraction amount detection unit **8*d*** are detachably attached to the back of the hand of the flexible glove **6** with the attaching means. Accordingly, the fourth expansion/contraction amount detection unit **8*d*** can pivot in the direction of an arrow S (see FIG. 2A) about the pivot shaft **34** as the center. Since the other arrangements of the fourth expansion/contraction amount detection unit **8*d*** are the same as those of the first to third expansion/contraction amount detection units **8*a***, **8*b***, and **8*c***, they are denoted by the same reference numerals as those of the first to third expansion/contraction amount detection units **8*a***, **8*b***, and **8*c***, and a detailed description thereof will be omitted.

These first to fourth expansion/contraction amount detection units **8*a***, **8*b***, **8*c***, and **8*d*** are pivotally connected to each other with four connecting means **38**. The respective connecting means **38** are positioned to correspond to the first joint **12**, the second joint **14**, the third joint **16**, and the wrist joint **18** (see FIG. **1**B).

As shown in FIG. **1**B and FIGS. **2**A to **2**C, each connecting means **38** is formed with a connecting shaft **38***a* extending in a direction perpendicularly intersecting the axis of the guide member **24** and slidable member **26**.

More specifically, in the first and second expansion/contraction amount detection units **8***a* and **8***b*, the rear base **22***b* of the first expansion/contraction amount detection unit **8***a* and the front base **22***a* of the second expansion/contraction amount detection unit **8***b* are connected to each other through the corresponding connecting shaft **38***a*, so that they can pivot relative to each other about the connecting shaft **38***a* as the center in accordance with the flexing state of the first joint **12**. Similarly, in the second and third expansion/contraction amount detection units **8***b* and **8***c*, the rear base **22***b* of the second expansion/contraction amount detection unit **8***b* and the front base **22***a* of the third expansion/contraction amount detection unit **8***c* are connected to each other through the corresponding connecting shaft **38***a*, so that they can pivot relative to each other about the connecting shaft **38***a* as the center in accordance with the flexing state of the second joint **14**. In the third and fourth expansion/contraction amount detection units **8***c* and **8***d*, the rear base **22***b* of the third expansion/contraction amount detection unit **8***c* and the fixed base **36** of the fourth expansion/contraction amount detection unit **8***d* are connected to each other through the corresponding connecting shaft **38***a*, so that they can pivot relative to each other about the connecting shaft **38***a* as the center in accordance with the flexing state of the third joint **16**. The fourth expansion/contraction amount detection unit **8***d* is pivotally supported by a support assembly **40** (to be described later) through the corresponding connecting shaft **38***a* arranged on the wrist joint **18**.

As shown in FIG. **3**D, the support assembly **40** has a support reference holder **42**, a fixed base **44**, and a pivot base **48**. The support reference holder **42** is detachably attached to the wrist **20** (see FIG. **1**B) of the flexible glove **6** with an attaching means (not shown). The fixed base **44** is formed on the support reference holder **42** on the side of the back of the hand. The pivot base **48** is pivotally supported on the fixed base **44** with a fixing pin **46** perpendicularly intersecting the corresponding connecting shaft **38***a*. The pivot base **48** is connected to the rear base **22***b* of the fourth expansion/contraction amount detection unit **8***d* through the corresponding connecting shaft **38***a*. Accordingly, the fourth expansion/contraction amount detection unit **8***d* can pivot in the direction of an arrow T (see FIG. **2**A) about the fixing pin **46** as the center so as to follow the stretching expanding/contracting motion of the back of the hand. As the attaching means, for example, an adhesive or Velcro tape can be used.

With the arrangement described above, in accordance with the flexing change of the first joint **12**, the second joint **14**, the third joint **16**, and the wrist joint **18**, the first to fourth expansion/contraction amount detection units **8***a*, **8***b*, **8***c*, and **8***c* pivot relative to each other about the connecting shafts **38***a* of the respective connecting means **38** described above as the center.

The flexing amount detection unit incorporated in this embodiment has a detection means that can optically detect the flexing change of the respective joints **12**, **14**, **16**, and **18** of the hand based on the pivot amounts of the connecting shafts **38***a*.

As shown in FIGS. **2**A to **2**C and FIGS. **3**A to **3**E, the detection means of the flexing amount detection unit has a light-receiving/emitting unit **54** (see FIG. **3**B) and a light amount changing means. The light-receiving/emitting unit **54** is incorporated in the rear base **22***b* of each of the first to fourth expansion/contraction amount detection units **8***a*, **8***b*, **8***c*, and **8***d* and is formed by integrating a light-emitting element **50** and a light-receiving element **52**. The light amount changing means changes the optical characteristics (e.g., the light amount) of the reflected light in accordance with the pivot amount of the corresponding connecting shaft **38***a*. This light amount changing means is pattern-printed on the circumference surface of the corresponding connecting shaft **38***a* in advance.

As shown in, e.g., FIGS. **3**A and **3**B, the light amount changing means is formed by printing a density pattern **60**, which is identical to a density region formed when a black right-angled triangular paper piece **56** is wound on a white cylindrical member **58**, on the outer circumferential surface of each connecting shaft **38***a*.

In this flexing amount detection unit, light emitted by the light-emitting element **50** is reflected by the density pattern **60** and is received by the light-receiving element **52**. In this state, when the respective connecting shafts **38***a* pivot in accordance with the flexing changes of the respective joints of the hand, the density patterns **60** printed on the respective connecting shafts **38***a* move in the same manner, and the optical characteristics (e.g., the light amount) of the light reflected by the density patterns **60** change. The pivot amounts of the respective connecting shafts **38***a* are detected based on the changes in light amount of the reflected light received by the light-receiving elements **52**. The flexing amounts of the first joint **12**, the second joint **14**, the third joint **16**, and the wrist joint **18** are detected separately based on the pivot amounts of the respective connecting shafts **38***a*.

As shown in FIGS. **3**D and **3**E, this embodiment has a pivot amount detection unit for optically detecting the pivot amount of the fourth expansion/contraction amount detection unit **8***d* obtained upon the expanding/contracting motion of the back of the hand. This pivot amount detection unit can separately detect the pivot amount of the pivot base **32** formed on the front base **22***a* of the fourth expansion/contraction amount detection unit **8***d* and the pivot amount of the pivot base **48** of the support assembly **40**.

More specifically, the pivot shaft **34** formed on the pivot base **32** of the fourth expansion/contraction amount detection unit **8***d* to project from it has a light amount changing means (see FIG. **3**A) similar to that described above, and the fixed base **36** for pivotally supporting this pivot shaft **34** has a light-receiving/emitting unit **54** similar to that described above. The pivot amount of the pivot shaft **34** is detected based on a change in light amount of the light amount changing means detected by this light-receiving/emitting unit **54**. The fixing pin **46** for pivotally supporting the pivot base **48** of the support assembly **40** has a light amount changing means (see FIG. **3**A) like that described above on its fixed shaft **46***a*, and a light-receiving/emitting unit **54** similar to that described above is arranged on the pivot base **48**. The pivot amount of the pivot base **48** with respect to the fixing pin **46** is detected based on a change in light amount of the light amount changing means detected by this light-receiving/emitting unit **54**.

In this manner, according to the shape input device of this embodiment, complicated stretching expanding/contracting motion, pivot motion, and flexing motion that occur upon a change in shape of the hand **4** can be detected separately, so that changes in shape of the hand **4** can be input highly precisely and accurately.

The present invention is not limited to the arrangement of the above embodiment, and various changes and modifications may be made within the scope which includes no new matter. For example, the above embodiment exemplifies a case wherein a change in shape of the left hand is to be input. However, if the device of the present invention is attached to the right hand, each of the right and left hands, or one finger according to each application purpose, a change in shape of the right hand, the right and left hands, or one finger can be input. In the above embodiment, the device according to the present invention is attached to the hand **4** through the flexible glove **6**. However, this device can be directly attached to the hand **4** without using a flexible glove **6** but with, e.g., a Velcro tape.

As a modification of the detection means that detect the expansion/contraction amounts of the first to fourth expansion/contraction amount detection units **8**a, **8**b, **8**c, and **8**d, for example, if light-receiving/emitting units **54** similar to that shown in FIG. **3**B are used in place of the light-emitting element **28**, reflection type detection means can be employed. In this case, it is preferable to remove the light-receiving elements **30** and employ columnar slidable members **26** and to form reflection films on the distal end faces (surfaces facing the light-receiving/emitting units **54**) of the slidable members **26**. According to this modification, when irradiating light to the reflection films, the relative distance between the front base **22**a and rear base **22**b is measured by detecting the change in light amount of light reflected by these reflection films.

Changes in relative distance between the front bases **22**a and rear bases **22**b of the respective pairs may be measured by, e.g., linear encoders, and the expansion/contraction amounts of the first to fourth expansion/contraction amount detection units **8**a, **8**b, **8**c, and **8**d may be detected based on the obtained pulse counts of the linear encoders obtained by measurement. When the pulse counts are counted in this manner, changes in relative distance can be measured without being influenced by noise.

The resistive force may be indicated to the device user by feeding a fluid, e.g., positive or negative pressure air or oil, from a compressor into the guide members **24** and slidable members **26** of the first to fourth expansion/contraction amount detection units **8**a, **8**b, **8**c, and **8**d. In this case, force sensors that measure the force acting in the guide members **24** and slidable members **26** from the pressure of the fluid may be provided, and the output information from the power sensors may be subjected to predetermined arithmetic processing, so that force information can be indicated to the device user.

Furthermore, each expansion/contraction mechanism constituted by the guide member **24** and slidable member **26** may be formed with, e.g., an air valve, and the resistive force may be indicated to the device user by opening/closing this air valve.

As shown in FIG. **4**, the shape input device according to the present invention may be attached to a human leg **62**, so that a change in shape of the leg **62** can be input. In this case, a support assembly **40** is attached to a support reference holder **42** attached to a human waist **64**, and another support assembly **40** is attached to the instep of a human foot **66**. For example, a first expansion/contraction amount detection unit **8**a is arranged to extend from the human waist **64** to a knee joint **68** and, for example, a second expansion/contraction amount detection unit **8**b is arranged to extend from the knee joint **68** to an ankle joint **70**. The support assemblies **40** and the first and second expansion/contraction amount detection units **8**a and **8**b are connected to each other with connecting means. With this arrangement, complicated stretching expanding/contracting motion and flexing motion that accompany a change in shape of the leg **62** can be detected separately, so that changes in shape of the leg **62** can be input highly precisely and accurately.

A shape input device according to the second embodiment of the present invention will be described with reference to FIGS. **5**A to **5**E. In the description of the second embodiment, portions that are identical to those shown in the first embodiment are denoted by the same reference numerals as in the first embodiment, and a detailed description thereof will be omitted.

As shown in FIG. **5**A, the shape input device of this embodiment is adapted to a human hand (see reference numeral **4** of FIG. **1**B) as the target object, in the same manner as in the first embodiment, and five shape input assemblies **2** extending from a wrist **20** along five fingertips **10** are brought into tight contact with the hand with a flexible glove **6** (e.g., a silicone rubber glove). Since these shape input assemblies **2** have the same arrangement except that their sizes differ from one finger to another, in the following description, the arrangement of only the shape input assembly **2** extending along the forefinger will be explained as an example.

The shape input assembly **2** is formed with first to fourth expansion/contraction amount detection units **72**a, **72**b, **72**c, and **72**d arranged among the respective joints of the hand. More specifically, the first expansion/contraction amount detection unit **72**a is arranged between the fingertip **10** and a first joint **12**, the second expansion/contraction amount detection unit **72**b is arranged between the first joint **12** and a second joint **14**, the third expansion/contraction amount detection unit **72**c is arranged between the second joint **14** and a third joint **16**, and the fourth expansion/contraction amount detection unit **72**d is arranged between the third joint **16** and a wrist joint **18**. In this embodiment, although an actual hand is not disclosed in FIG. **5**A, assuming that a hand is placed in the flexible glove **6** to be in tight contact with it, the joints will be numbered as the first joint **12**, the second joint **14**, and the third joint **16** from the fingertip **10** toward the wrist **20**.

As shown in FIG. **5**E, each of the first to fourth expansion/contraction amount detection units **72**a, **72**b, **72**c, and **72**d has an expansion/contraction mechanism which expands/contracts in accordance with a change in shape of the hand, and a detection means which can electrically detect the expansion/contraction amount of this expansion/contraction amount.

The expansion/contraction mechanism has a bottomed cylindrical guide member **74** (to be referred to as a guide member hereinafter) and a columnar slidable member **76** (to be referred to as a slidable member hereinafter) which can slide in the guide member **74**. The guide member **74** and slidable member **76** are attached to the flexible glove **6** such that they linearly move relative to each other without rotation. The slidable member **76** of the first expansion/contraction amount detection unit **72**a is detachably attached to a fingertip holding portion **6**a (see FIG. **5**A) of the flexible glove **6** that holds the fingertip **10**.

The detection means has a conductive elastic member **78** (e.g., a conductive rubber member). The conductive elastic member **78** is accommodated in the guide member **74** so as to connect the guide member **74** and slidable member **76** to each other. When the conductive elastic member **78** is elastically deformed in accordance with the relative sliding state of the slidable member **76**, its resistance changes.

With this arrangement, when the guide member **74** and slidable member **76** linearly move, upon a change in shape of the hand, in directions to separate relative to each other, a tensile force or compression force acts on the conductive elastic member **78**. At this time, the relative distance between the guide member **74** and slidable member **76** is measured by detecting the resistance of the conductive elastic member **78** which changes in accordance with the tensile force or compression force. The expansion/contraction amounts among the respective joints of the hand can be detected separately based on this relative distance.

The first to third expansion/contraction amount detection units **72***a*, **72***b*, and **72***c* are integrally connected to each other through first to third connecting means **80***a*, **80***b*, and **80***c*, and the fourth expansion/contraction amount detection unit **72***d* is supported through first and second pivot amount detection units **82***a* and **82***b* that pivot upon stretching expanding/contracting motion of the back of the hand. More specifically, the slidable member **76** of the fourth expansion/contraction amount detection unit **72***d* is pivotally connected to the third connecting means **80***c* through the pivot amount detection unit **82***a*, and the guide member **74** of the fourth expansion/contraction amount detection unit **72***d* is pivotally connected to the second pivot amount detection unit **82***b* through a fourth connecting means **80***d*. The second pivot amount detection unit **82***b* is integrally supported by a support reference holder **42**, detachably attached to the wrist **20** of the flexible glove **6**, with an attaching means (not shown).

The first to fourth connecting means **80***a*, **80***b*, **80***c*, and **80***d* are positioned to correspond to the first joint **12**, the second joint **14**, the third joint **16**, and the wrist joint **18**, respectively, and can elastically deform in accordance with the flexing amounts of the respective joints of the hand.

Flexing amount detection units are incorporated in this embodiment to electrically detect the flexing amounts of the respective joints of the hand based on the elastic deformation amounts of the respective connecting means.

As shown in FIGS. **5**C and **5**D, each of the connecting means **80***a*, **80***b*, **80***c*, and **80***d* in which the flexing amount detection unit is incorporated has an elastic member **84**, e.g., a resin member. Notched portions **84***a* each having a triangular section are formed at substantially the central portion of the elastic member **84**. The two sides of the elastic member **84** are elastically deformed relative to each other about the notched portions **84***a* as the center. FIG. **5**D is a sectional view taken along the line d—d of FIG. **5**C.

Each flexing amount detection unit has detection means incorporated in the notched portions **84***a*. The detection means have conductive elastic members **86** (e.g., conductive rubber members). When the conductive elastic members **86** elastically deform in accordance with the shape change state of the elastic member **84**, their resistance change.

With this arrangement, when the elastic member **84** relatively and elastically deforms about the notched portions **84***a* as the center upon a change in shape of the hand, a tensile force or compression force acts on the conductive elastic members **86**. At this time, the deformation amount of the elastic member **84** is measured by detecting the resistance of each conductive elastic member **86** that changes in accordance with the tensile force or compression force. The flexing amount of each joint of the hand can be detected separately based on this deformation amount.

As shown in FIG. **5**B, each of the first and second pivot amount detection units **82***a* and **82***b* has first and second first hook members **88** and **90** interlocked with each other, and a detection means for pivotally connecting the first and second first hook members **88** and **90** to each other. This detection means has a conductive elastic member **92** (e.g., a conductive rubber member). When the conductive elastic member **92** elastically deforms in accordance with the pivot state of the first and second first hook members **88** and **90**, its resistance changes. More specifically, the first hook member **88** of the first pivot amount detection unit **82***a* is integrally connected to the third connecting means **80***c*, and the second hook member **90** of the first pivot amount detection unit **82***a* to the slidable member **76** of the fourth expansion/contraction amount detection unit **72***d*. The first hook member **88** of the second pivot amount detection unit **82***b* is integrally connected to the fourth connecting means **80***d*, and the second hook member **90** of the second pivot amount detection unit **82***b* to the support reference holder **42**.

With this arrangement, when the first and second hook members **88** and **90** pivot relative to each other upon a change in shape (stretching expanding/contracting motion) of the hand, a tensile force or compression force acts on the conductive elastic member **92**. At this time, the pivot amounts of the first and second first hook members **88** and **90** are measured by detecting the resistance of the conductive elastic member **92** that changes in accordance with the tensile force or compression force. The pivot amounts of the respective joints of the hand obtained upon a change in shape of the hand can be detected separately based on this pivot amounts.

In this manner, according to the shape input device of this embodiment, complicated stretching expanding/contracting motion, pivot motion, and flexing motion that occur upon a change in shape of the hand can be detected separately, so that changes in shape of the hand can be input highly precisely and accurately.

The present invention is not limited to the arrangement of the above embodiment, and various changes and modifications may be made within the scope which includes no new matter. For example, the above embodiment exemplifies a case wherein a change in shape of the left hand is to be input. However, if the device of the present invention is attached to the right hand, each of the right and left hands, or one finger according to the application purpose, a change in shape of the right hand, the right and left hands, or one finger can be input. In the above embodiment, the device according to the present invention is attached to the hand through the flexible glove **6**. However, this device can be directly attached to the hand without using a flexible glove **6** but with, e.g., a Velcro tape.

Additional advantages and modifications will readily occur to those skilled in the art. Therefore, the invention in its broader aspects is not limited to the specific details and representative embodiments shown and described herein. Accordingly, various modifications may be made without departing from the spirit or scope of the general inventive concept as defined by the appended claims and their equivalent.

We claim:

1. A device for inputting a shape of an object, comprising:

a base mounted on the object;

flex detecting means for detecting an amount of flex of the object; and

stretch detecting means, coupled to the base and to the flex detecting means, for detecting an amount of stretch between the base and the flex detecting means which corresponds to an amount of stretch of the object.

2. The device of claim **1**, wherein the stretch detecting means includes a stretch mechanism which is expanded or contracted in accordance with the stretch of the object, and wherein the amount of stretch of the object is detected based on a detected amount of stretch of the stretch mechanism.

3. The device of claim **2**, wherein the stretch mechanism includes a guide member and a member slidable along the guide member.

4. The device of claim **3**, wherein the guide member includes a light source at an end thereof and the slidable member includes a photo-detector at an end thereof for receiving light from the light source, and wherein the amount of stretch of the object is detected based on a position of the slidable member determined in accordance with a signal from the photodetector.

5. The device of claim **2**, wherein the stretch mechanism includes a member which is deformable in accordance with the amount of stretch of the object, and wherein the amount of stretch of the object is detected based on a detected amount of deformation of the deformable member.

6. The device of claim **5**, wherein the deformable member comprises a conductive elastic member, and wherein the amount of stretch of the object is detected based on a change of resistance of the conductive elastic member.

7. The device of claim **1**, wherein the flex detecting means includes a member which is deformable in an amount corresponding to the amount of flex of the object, and wherein the amount of flex of the object is detected based on a detected amount of deformation of the deformable member.

8. The device of claim **7**, wherein the deformable member comprises a conductive elastic member, and wherein the amount of flex of the object is detected based on a change of resistance of the conductive elastic member.

9. The device of claim **7**, wherein the deformable member includes a first shaft having a rotation axis with a pattern on a surface thereof and a second shaft pivotally connected to the rotation axis, and wherein the amount of flex of the object is detected using the pattern.

10. The device of claim **1**, further comprising rotation detecting means for detecting a rotation of the object in a direction different from a direction of the flex of the object, said rotation detecting means being serially connected to the flex detecting means and the stretch detecting means.

11. The device of claim **10**, wherein the rotation detecting means includes a member which is deformable in an amount corresponding to an amount of the rotation of the object, and wherein the amount of rotation of the object is detected based on a detected amount of deformation of the deformable member.

12. The device of claim **11**, wherein the deformable member comprises a conductive elastic member, and wherein the amount of rotation of the object is detected based on a change of resistance of the conductive elastic member.

13. A device for inputting a shape of an object, comprising:

two flex detecting means for detecting an amount of flex of the object; and

stretch detecting means, connected between the two flex detecting means, for detecting an amount of stretch between the two flex detecting means which corresponds to an amount of stretch of the object.

14. The device of claim **13**, wherein the stretch detecting means includes a stretch mechanism which is expanded or contracted in accordance with the stretch of the object, and wherein the amount of stretch of the object is detected based on a detected amount of stretch of the stretch mechanism.

15. The device of claim **14**, wherein the stretch mechanism includes a guide member and a member slidable along the guide member.

16. The device of claim **14**, wherein the stretch mechanism includes a member which is deformable in accordance with the amount of stretch of the object, and wherein the amount of stretch of the object is detected based on a detected amount of deformation of the deformable member.

17. The device of claim **13**, wherein the flex detecting means includes a member which is deformable in an amount corresponding to the amount of flex of the object, and wherein the amount of flex of the object is detected based on a detected amount of deformation of the deformable member.

18. The device of claim **17**, wherein the deformable member comprises a conductive elastic member, and wherein the amount of flex of the object is detected based on a change of resistance of the conductive elastic member.

19. The device of claim **13**, further comprising rotation detecting means for detecting a rotation of the object in a direction different from a direction of the flex of the object, said rotation detecting means being serially connected to the flex detecting means and the stretch detecting means.

20. The device of claim **19**, wherein the rotation detecting means includes a member which is deformable in an amount corresponding to an amount of the rotation of the object, and wherein the amount of rotation of the object is detected based on a detected amount of deformation of the deformable member.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 5,963,331

DATED : October 5, 1999

INVENTOR(S) : ARAI et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On the title page,

Item [73] Assignees, after "Olympus Optical Co.,"
insert --Ltd.--.

Signed and Sealed this

Twentieth Day of February, 2001

Attest:

NICHOLAS P. GODICI

Attesting Officer

Acting Director of the United States Patent and Trademark Office