US 20110185835A1

(19) United States

(12) Patent Application Publication

Bergamasco et al.

(10) Pub. No.: US 2011/0185835 A1

(43) Pub. Date: Aug. 4, 2011

(54) METHOD FOR REMOTE MECHANISM ACTUATION AND EXOSKELETON APTIC INTERFACE BASED THEREON

(75) Inventors: **Massimo Bergamasco**, Castelmaggiore-Calci (IT); **Fabio Salsedo**, Pisa (IT); **Marco Fontana**, Pisa (IT)

(73) Assignee: **SCUOLA SUPERIORE DI STUDI UNIVERSITARI S. ANNA**, Pisa (IT)

(21) Appl. No.: **13/059,589**

(22) PCT Filed: **Aug. 31, 2009**

(86) PCT No.: **PCT/IB09/06283**

§ 371 (c)(1), (2), (4) Date: **Mar. 1, 2011**

(30) **Foreign Application Priority Data**

Oct. 31, 2008 (DE) 20 2008 014 487.6

Publication Classification

(51) **Int. Cl.**
B25J 13/02 (2006.01)

(52) **U.S. Cl.** .... **74/471 R**

(57) **ABSTRACT**

A method for actuating a mechanism imposing a prefixed relative movement between a first and a second rigid link and a hand exoskeleton obtained by utilizing the method. The mechanism includes revolute joints and may be a parallelogram mechanism, a pantograph remote center of rotation mechanism, or a multiple-degrees-of-freedom mechanism. The method provides coaxially arranging at one or more selected revolute joints a number of idle pulleys which are greater than the number of degrees of freedom of the mechanism, the first of the selected revolute joints preferably having its rotation axis fixed with respect to the rigid link; the method also provides arranging an inextensible cable between a traction point and a terminal point on the mechanism or on the second rigid link. By pulling the inextensible cable at the traction point, a multiplied torque is produced which is the sum of singular torques produced by the inextensible cable at each idle pulley, the multiplied torque causing a relative movement between the links.

Fig. 1

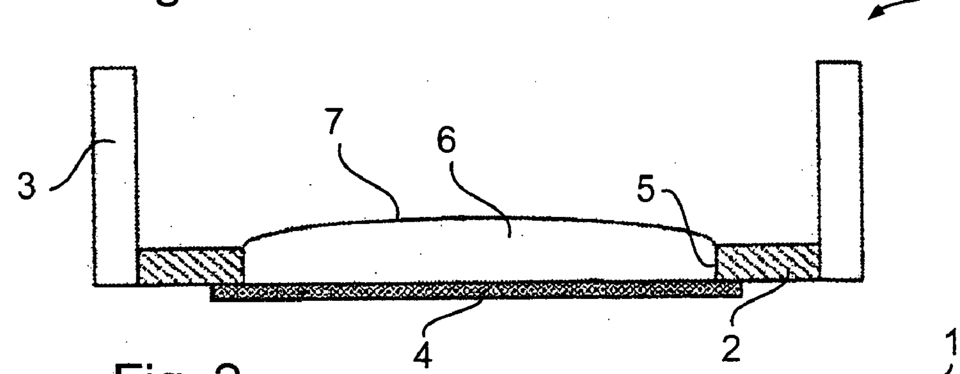


Fig. 2

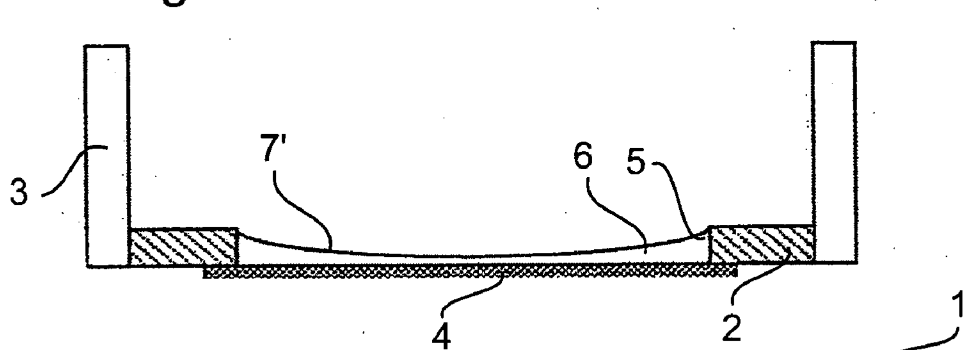


Fig. 3

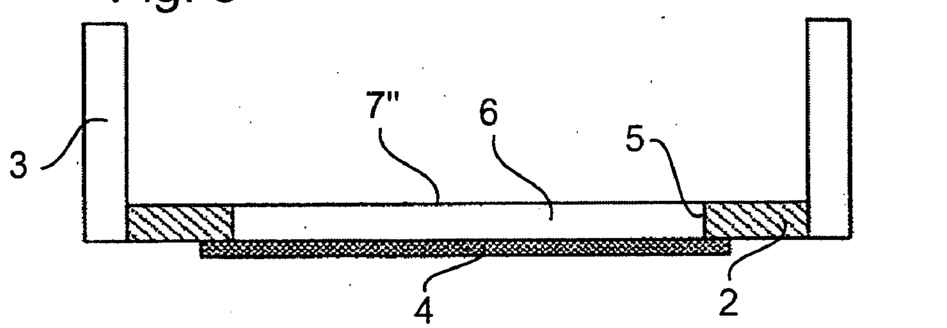


Fig. 4

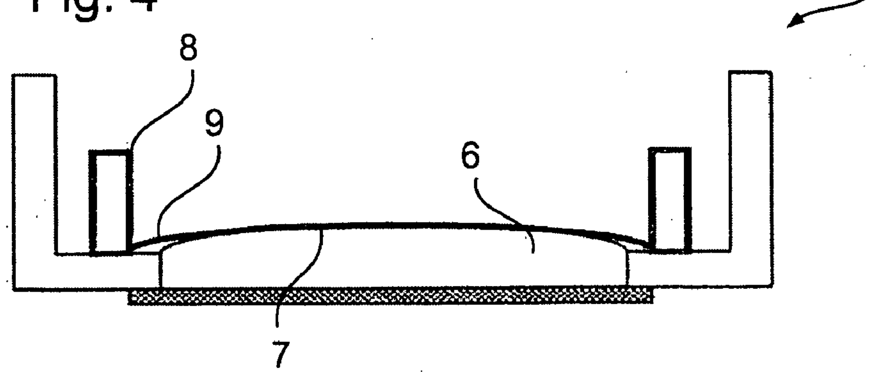
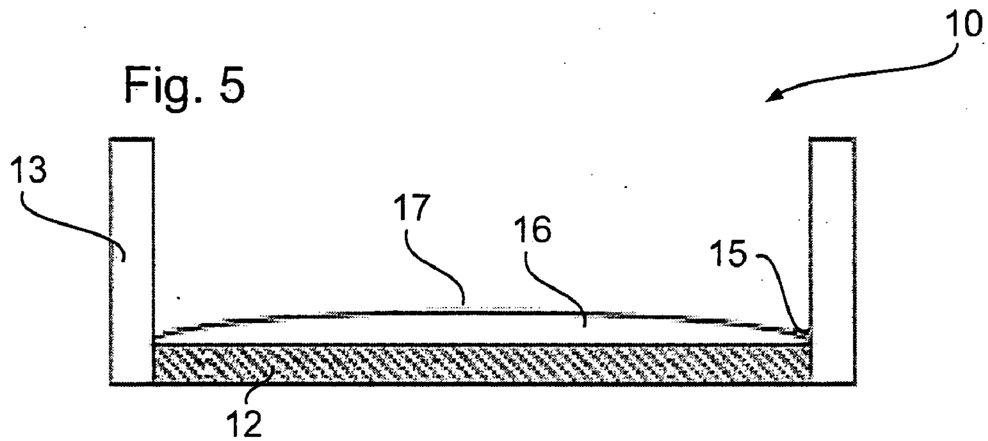


Fig. 5



METHOD FOR REMOTE MECHANISM ACTUATION AND EXOSKELETON APTIC INTERFACE BASED THEREON

FIELD OF THE INVENTION

[0001] The present invention concerns a Petri dish for cell cultivation and microscopy, which can be utilized for cultivating cells as well as for observing the cultivated cells under a microscope, and which is particularly suited for performing laser dissection microscopy.

PRIOR ART

[0002] Hitherto, a combination of a silicone-coated glass Petri dish and a foil-covered metal ring was used for micro-dissection of living cells. The cells were cultivated in the membrane ring, then the ring was placed into the Petri dish and inserted into the microscope. The cells to be extracted were cut around their periphery by micro-dissection, and the ring was subsequently removed from the Petri dish. The cut-out cells remained in the Petri dish and were then further cultivated there.

[0003] The ring disclosed in DE 20 2004 001 703 U1 is to be mentioned as an example of a ring covered with a thin membrane, which in addition may comprise a protective membrane provided beneath the thin membrane and made of Teflon, for example.

[0004] The overall thickness of the bottom of the Petri dish having the ring and inserted into the microscope for laser micro-dissection is approximately two millimetres, a value which is borderline even for long distance objectives (20×, 40×). Further, standard Petri dishes made of glass present strong geometric tolerances and, thus, strongly varying bottom thicknesses. Moreover, there is no controlled manufacturing process for silicone-filled glass Petri dishes that is capable to provide a precisely defined silicone insert and, thus, pre-determinable optical properties. Hence, this results in very bad microscopic properties of the silicone-filled glass Petri dishes so that these either cannot be used at all for modern microscopic methods such as phase contrast microscopy, fluorescence microscopy or DIC, or can only be used with strong restrictions on quality. Plastic Petri dishes that can be manufactured more easily and more precisely cannot be used for laser micro-dissection due to their poor UV transparency. Finally, a further problem consisted in the adhesion of the membrane on the silicone filling, which was either not present or not present over the entire surface.

SUMMARY OF THE INVENTION

[0005] Therefore, it is an object of the present invention to provide a dish for cell cultivation and microscopy, which offers exactly definable optical properties of its base and is suitable both for cell cultivation and for laser dissection microscopy as well. This object is achieved by means of a dish for cell cultivation and microscopy according to claim **1** or claim **8**. Further preferred optional features are defined in the dependent claims.

SHORT DESCRIPTION OF THE FIGURES

[0006] FIG. **1** shows a dish of the invention having a ring and a convex adhesive filling;

[0007] FIG. **2** shows a dish having a ring and a concave adhesive filling;

[0008] FIG. **3** shows a dish having a ring and a flat adhesive filling;

[0009] FIG. **4** shows a dish according to the present invention, into which a laser micro-dissection membrane ring was inserted; and

[0010] FIG. **5** shows a dish according to an alternative embodiment of the invention, which comprises a full-width base and a filling having a convex surface.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0011] In FIG. **1**, an inventive Petri dish **1** according to a first embodiment of the invention is illustrated. The dish comprises a ring **2** forming a part of the base, to which an outer ridge or rim **3** of the dish, extending on the outside and upwardly in an axial direction, is connected. The ring and the outer ridge are preferably made from an optically transparent material such as silica glass (fused quartz glass) or an optically transparent plastic and may be manufactured in one piece (integrally), or separately and then joined. In particular if the ring and/or the outer ridge are made of plastic, a high manufacturing precision and a constant product quality may be achieved by injection molding, for example, which are a pre-requisite for using the dish in microscopy. The thickness of the ring is preferably around one millimetre, which corresponds to the thickness of conventional microscope object slides.

[0012] At the bottom side of the ring **2** a bottom membrane **4** is attached, the thickness of which is substantially smaller than the thickness of the bottom ring **2**, and which closes off the ring opening from below. The bottom membrane is made of a material transparent for UV radiation, such as special compositions of polystyrene and polypropylene. Preferably, the membrane may also be a cover glass that may be made of ultrapure silica glass (fused quartz glass), for example. The thickness of the membrane **4** or the cover glass is preferably less than 500 μm, and is preferably 100 μm.

[0013] The inner side **5** of the ring forms, together with the bottom membrane **4**, a recess, the depth of which corresponds to the thickness of the ring and is, thus, about 1 mm. The recess is filled with an adhesive filling **6** transparent to UV radiation and preferably made of silicone so that a preferably slightly convex surface **7** is formed. In this way, a transparent bottom surface is formed which, on the one hand, is adapted to the thickness of microscope object slides, is optically highly transparent and at the same time maximizes the adhesion surface with a membrane ring to be placed into the dish by virtue of its convex configuration. As the adhesive filling **6** is spatially defined by the recess, easy manufacturing is ensured. Besides, in this way the thickness of the bottom layer may be adapted to the thickness of standardized microscope object slides so that the inventive dish may be utilized directly with conventional microscope objectives. The UV transparency of the filling and the membrane or cover glass is, in particular, necessary for procedures in which the dissected objects are cut from samples held in the dish by means of a UV laser.

[0014] FIGS. **2** and **3** show alternative embodiments of the inventive Petri dish, wherein the surface **7'** of the adhesive filling in FIG. **2** is concave and the surface **7"** in FIG. **3** is flat. While the concave filling is particularly suited for applications in which low amounts of buffer are necessary, the flat filling lends itself for applications in which only shallow (narrow) depths of field, preferably at large microscopic magnifications, are allowed and a curvature of the sample is, thus, disadvantageous.

[0015] In the embodiments of FIGS. **1** to **3**, the thickness of the filling approximately corresponds to the one of the recess, i.e. about 1 millimetre, though this is strictly true only for the flat embodiment of FIG. **3** and, for the embodiments of FIGS. **1** and **2**, variations of this thickness in a radial direction of the dish due to the surface shape (convex or concave) need to be taken into account, so that a variation in the range of 500 μm to 1,200 μm is to be considered.

[0016] In FIG. **4**, the inventive dish having a convex filing and a laser micro-dissection (LMD) membrane ring **8** placed therein is shown. As can be seen from the figure, the LMD membrane **9** is tensioned (spanned) over the convex-shaped surface **7** of the adhesive filling **6** and therefore adheres to it over its entire surface. Hence, due to the adhesion the cells present on the cut LMD membrane after laser cutting cannot be displaced so that a higher degree of referenceability is achieved.

[0017] Finally, FIG. **5** shows an embodiment in which a Petri dish **10** comprises a base (bottom) **12** and an outer ridge or rim **13** of the dish, extending upward at its rim in an axial direction. Here, the base and the outer ridge are made of plastic, the latter being transparent for the base and, according to the specific application, transparent or opaque for the outer ridge. Together with the inner side **15** of the outer ridge, the base forms thus a recess which, like in the above embodiments, is filled with an adhesive filling **16** transparent to UV radiation and preferably made of silicone, so that a preferably slightly convex surface **17** is created. The thickness of the base and filling together is less than about 1 mm. The transparent bottom surface formed in this way provides the same advantages as the embodiment of FIG. **1**, but can be manufactured even more easily.

[0018] The dishes described in the above embodiments are particularly suitable for interference contrast microscopy, phase contrast microscopy, fluorescence methods and laser micro-dissection.

1. A method for actuating a mechanism (**10***a*,**10***c*,**11**,**81**,**90**), said mechanism having a predetermined number of degrees of freedom, said mechanism comprising a plurality of revolute joints, each revolute joint having a rotation axis, said mechanism (**10***a*,**10***c*,**11**,**81**,**90**) connected to a first rigid link (**3**) and a second rigid link (**5**), and said mechanism (**10***a*,**10***c*,**11**,**81**,**90**) adapted to impose a prefixed relative movement between said first rigid link (**3**) and said second rigid link (**5**), said method comprising the steps of:

selecting a subset of one or more revolute joint/s (**37***a-e*, **47***b-c*) among said plurality of revolute joints of said mechanism (**10***a*,**10***c*,**11**,**81**,**90**);

rotatably arranging respective idle pulleys (**32***a-e*, **42***a-f*) about the axis of said revolute joint/s (**37***a-e*, **47***b-c*) of said subset;

arranging an inextensible cable (**33**,**43**) according to a prefixed routing, said routing extending between a traction point (**34**,**44**) on said cable upstream of said first idle pulley (**32***a*, **42***a*) and a terminal point (**36**,**46**) fixed on one of said links (**3**,**5**) or on said mechanism (**10***a*,**10***c*, **11**,**81**,**90**); and said routing comprising respective contact arcs of said inextensible cable (**33**,**43**) about said idle pulleys (**32***a-e*, **42***a-f*);

characterized in that the number of idle pulleys (**32***a-e*, **42***a-f*) that are arranged at said revolute joint/s (**37***a-e*, **47***b-c*) of said subset is greater than the number of said degree/s of freedom, such that by pulling said inextensible cable (**33**,**43**) at said traction point (**34**,**44**) a multiplied torque is produced which is the sum of singular torques produced by said inextensible cable (**33**,**43**) at each idle pulley, said multiplied torque causing a relative movement between said links (**3**,**5**).

2. A method according to claim **1**, wherein a first revolute joint (**37***a*) of said subset has its respective rotation axis fixed with respect to said first link (**3**).

3. A method according to claim **1**, wherein said subset comprises at least two revolute joints, and the distance between any couple of consecutive revolute joints (**37***a-e*, **47***b-c*) of said subset is unchanged during any movement of said mechanism (**10***a*,**10***c*,**11**,**81**,**90**).

4. A method according to claim **1**, wherein for a given movement of said mechanism (**10***a*,**10***c*,**11**,**81**,**90**) all said contact arcs increase in length, or they all decrease in length.

5. A method according to claim **1**, wherein said subset of one or more revolute joint/s is a first subset of one or more revolute joint/s, in which said inextensible cable, said respective routing, said traction point and said terminal point are respectively a first inextensible cable (**33**,**43**), a first routing a first traction point (**34**,**44**) and a first terminal point (**36**,**46**), the following further steps are provided:

selecting a second subset of one or more revolute joint/s among said plurality of revolute joints of said mechanism (**81**);

rotatably arranging respective idle pulleys (**32***a-c*,**42***a-f*) about the axis of said revolute joint/s of said second subset;

arranging a second inextensible cable (**53**,**63**) according to a prefixed second routing, said second routing extending between a second traction point (**54**,**64**) on said second cable upstream of said first idle pulley (**32***a*, **42***a*) and a second terminal point (**36**,**46**) fixed on one of said links (**3**,**5**) or on said mechanism (**81**); and said second routing comprising respective contact arcs of said second inextensible cable (**53**,**63**) partially wound about said idle pulleys (**32***a-c*, **42***a-f*);

wherein the number of idle pulleys (**32***a-c*, **42***a-f*) that are arranged at said revolute joint/s of said second subset is greater than the number of said degree/s of freedom, such that said mechanism (**81**) is bilaterally actuated by pulling said first and said second inextensible cables (**53**,**63**) at said respective first and second traction points (**54**,**64**), i.e. opposite torques/forces are selectively applied to said mechanism (**81**) which causes corresponding opposite relative movements between said first and said second links (**3**,**5**).

6. A method according to claim **4**, wherein a first revolute joint of said second subset has its respective rotation axis fixed with respect to said first link (**3**).

7. A method according to claim **4**, wherein

said first and said second subsets of one or more revolute joint/s coincide with each other,

said first and said second inextensible cables (**53**,**63**) form on each of said pulleys (**32***a-c*, **42***a-f*) respective first and second contact arcs such that the first contact arcs vary in an opposite way with respect to said second contact arcs during said movements of said mechanism (**81**), i.e. when said first contact arcs increase, said second contact arcs decrease by a same length.

8. A method according to claim **1**, wherein a plurality of idle pulleys (**32***a-c* are rotatably arranged about said axis of a revolute joint (**37***a*) selected among said revolute joint/s of said subset, and a deflecting pulley (**68**) is arranged preferably with its axis (**69**) parallel to the axis of said selected revolute joint (**37***a*) at a prefixed distance from said selected revolute joint (**37***a*), said inextensible cable (**33**) forming redundant contact arcs (**62**) with each idle pulley of said plurality of idle pulleys (**32***a-c*), and deflection arcs (**67**) about said deflecting pulley (**68**), said deflection arcs (**67**) alternate to said redundant contact arcs (**62**) along said inextensible cable (**33**).

9. A method according to claim **1**, wherein said mechanism is a serial mechanism (**10***c*,**81**,**90**) having at least two-degrees-of-freedom and comprises a proximal mechanism part (**10***a*,**11**) and a distal mechanism part (**10***b*,**15**,**17**), wherein a cable portion of said routing that moves the distal mechanism part (**10***b*,**15**,**17**) is wound also on idle pulleys (**42***a*, **42***f*, **42***a-c*) of said proximal mechanism part (**10***a*,**11**) such that said proximal mechanism part (**10***a*,**11**) is unaffected by said cable portion.

10. A method according to claim **8**, wherein:

said cable portion of said routing that moves said distal mechanism part (**10***b*,**15**,**17**) and that is wound about the idle pulleys (**42***a*, **42***f*, **42***a-c*) of said proximal mechanism part (**10***a*,**11**) have an overall length unchanged during any movement of said proximal mechanism part (**10***a*,**11**);

the radiuses of said idle pulleys (**42***a*, **42***f*, **42***a-c*) of said proximal mechanism part (**10***a*,**11**) on which said cable portion is wound have opposite sign depending on whether said respective contact arcs increase or decrease in length during a movement of said proximal mechanism part (**10***a*,**11**), and said radiuses have sum equal to zero.

11. A mechanism (**10***a*,**10***c*,**11**,**81**,**90**) actuated by means of the method according to claim **1**, in particular a remote centre of rotation mechanism based on a pantograph mechanism (**11**,**81**,**90**), or a parallelogram mechanism (**10***a*,**10***c*).

12. A hand exoskeleton, comprising:

a base link (**3**) arranged in use substantially integral to the back of a hand of a user,

at least one finger exoskeleton (**80**), comprising a mechanism (**81**,**90**) having two or more degrees of freedom, said finger exoskeleton (**80**) comprising:

a proximal link (**87**) connected to said base link (**3**) by means of a proximal remote centre of rotation mechanism (**11**), in particular a pantograph mechanism, which has a rotation axis (**12**) substantially aligned with the flexion/extension joint between the finger (**100**) proximal phalanx and the metacarpus,

a medial link (**95**) connected to said proximal link (**87**) by means of a medial remote centre of rotation mechanism (**13**), in particular a pantograph mechanism, which has a rotation axis (**14**) substantially aligned with the flexion/extension joint between the finger (**100**) medial and proximal phalanges,

characterized in that a remote centre of rotation mechanism of said remote centre of rotation mechanisms (**11**,**13**) is actuated by the method according to claim **1**.

13. A hand exoskeleton according to claim **11**, wherein said finger (**100**) mechanism (**81**) comprises a distal link (**5**) arranged in use in contact with the palm side of the distal phalanx of said finger (**100**), said distal link connected to said medial link (**95**) by means of a distal mechanism part (**15**,**17**) having one rotational degree of freedom, said distal link mechanism having a rotation axis (**16**) substantially aligned with the flexion/extension joint between the finger (**100**) distal and medial phalanges, said distal mechanism part (**15**,**17**) selected from the group consisting of:

a remote centre of rotation mechanism (**17**), based on a pantograph mechanism, forming together with said proximal and medial mechanisms (**11**,**13**) a three-degrees-of-freedom mechanism (**90**) that is actuated by the method, and

a simple crossed quadrilateral mechanism (**15**,**79**), actuated by a rotation of said medial link (**95**) with respect to said proximal link (**87**).

14. A hand exoskeleton according to claim **11**, wherein

said medial mechanism (**13**) is actuated by means of an inextensible cable (**53**,**63**) which forms contact arcs on said idle pulleys (**42***a-c*) of said proximal mechanism (**11**), said cable producing in said idle pulleys (**42***a-c*) of said proximal mechanism (**11**) a couple that has a non-zero resultant torque value during a movement of said medial mechanism (**13**), and/or

said distal mechanism part (**17**) is actuated by means of a further inextensible cable having parts that are wound about said idle pulleys (**42***a-f*) of said proximal and/or medial mechanism (**11**,**13**), said further cable producing at said idle pulleys (**42***a-f*) of said medial and/or proximal mechanism (**11**) torques that have a non-zero resultant torque value during a movement of said distal mechanism part (**17**).

* * * * *