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(71) Applicant: **Kieser Training AG**
8005 Zürich (CH)

(72) Inventor: **Kieser, Werner**
8006 Zürich (CH)

(74) Representative: **Werner, André**
Jean Hunziker AG,
Schwäntenmos 14
8126 Zumikon (CH)

(54) **Exercise machine**

(57) The present invention relates to an exercise machine utilising the weight of the user as a source of resistance for exercise. The exercise machine comprises at least one curved track (1) having a first section (AB) with curvature of a first sign and a second section (BC) with curvature of opposite sign to that of the first section (AB), and a carriage mounted movably on the at least one track. This enables tailoring of exercise resistance profiles to a variety of different exercise movements.

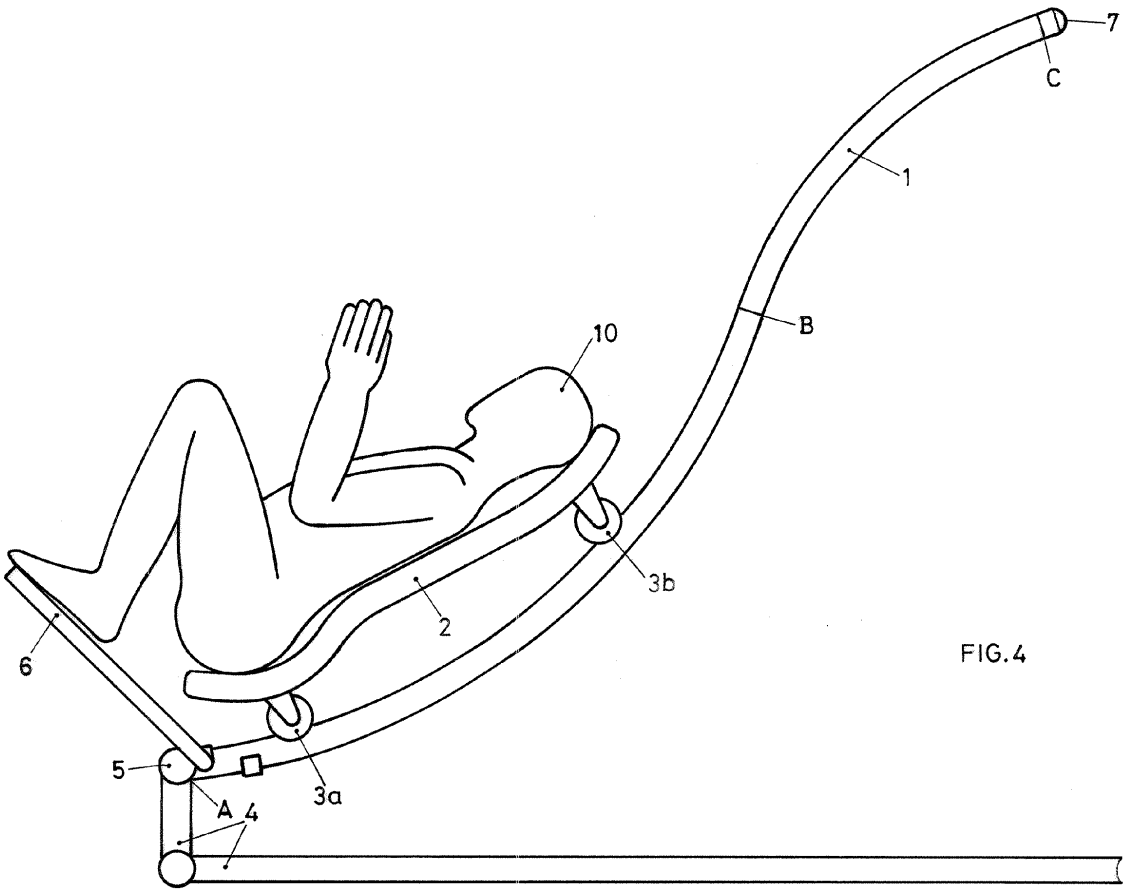

FIG. 4

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Description

[0001] The present invention relates to an exercise machine utilising the weight of the user as a source of resistance for exercise.

[0002] Many such machines are known in the prior art: US 6,244,995, for instance, discloses an exercise machine in which a carriage is movably mounted on a concave-up curved track. A user lies on the carriage and then exercises by means of pushing and/or pulling against various handles, footrests, pulleys, etc, causing the carriage to rise up the curved track. The resistance to the exercise movement at any given point on the track is proportional to the weight of the user and to the sine of the angle of the tangent to the track at that point. Since the curvature of the track is concave-up, i.e. concave with respect to the carriage, the resistance increases as the exercise movement progresses. The intensity of the resistance profile (i.e. the resistance to exercise in dependence of position along the track) may be varied by adjusting the angle of the track.

[0003] This resistance profile is particularly suited to press exercises such as leg presses. However, when used with certain pulling exercises, it may overstress the muscle groups being exercised, potentially causing injury, and it may also present such a degree of resistance that certain exercise movements cannot be performed to completion.

[0004] The object of the invention therefore is to provide an exercise machine of the above-mentioned type exempt from the above-mentioned problems, and thereby enable optimal exercising with a greater variety of exercises than is possible with the exercise machine of US 6,244,995.

[0005] This object is achieved by an exercise device comprising:

- at least one curved track comprising a first section with curvature (κ_1) of a first sign, that is to say the least one curved track curves in a first direction, i.e. is either concave or convex, or in other words curves either up or down. By "curvature of a first sign", the meaning of "sign" is meant in its mathematical sense, i.e. $\kappa_1>0$ [positive sign] or $\kappa_1<0$ [negative sign], as is discussed in greater detail below.

- a carriage mounted movably on the at least one track and adapted to support the body of a user, upon which the user can sit, kneel or lie when using the exercise device.

[0006] According to the invention, the curved track further comprises a second section with curvature (κ_2) of opposite sign to the first curvature (if the curvature of the first section k1<0 [negative sign] then curvature of the second section k2>0 [positive sign] and vice-versa), i.e. of opposite curvature thereto, the second section following the first section, i.e. adjacent thereto or separated by an extra connecting section which may be straight or even curved in a different manner to the first and the second sections. In other words, the track presents a dual curvature, this dual curvature being thus "s" or "reverses" shaped. It should be noted that the two curvatures κ_1, κ_2 do not have to be constant, i.e. do not have to represent circular arcs.

[0007] As in the prior art, the section of the track having a curvature which causes increasing resistance as an exercise motion progresses, i.e. the "concave up" section, is optimal for press exercises such as leg presses, bench presses and so on. Advantageously, the section with the opposite curvature, i.e. the section with "convex up" curvature, is optimal for pulling exercises such as a row, chin-ups, pulldowns, leg curls, tricep extensions and so on. This is because, on the "convex up" curvature, as the exercise movement progresses, the resistance decreases, enabling the exercising to take place with an appropriate resistance profile, reducing the risk of injury. As a result, a greater variety of exercise movements can be carried out in an optimal fashion on a single exercise device than is possible with prior art exercise devices.

[0008] In an embodiment, one of the first section and the second section is concave with respect to the carriage, and the other of the first section and the second section is convex with respect to the carriage. Preferably, the first curvature is concave with respect to the carriage, and the second curvature is convex with respect to the carriage.

[0009] In an embodiment, the second section is adjacent to the first section, i.e. the two sections are contiguous and adjoining, which permits a rapid transition from increasing resistance to decreasing resistance as the carriage travels along the track.

[0010] In an embodiment, the first section, the second section, or both describe circular arcs, i.e. follow the arc of a circle. This enables simple manufacture since circular arcs have a constant curvature and thus easy to manufacture.

[0011] In an embodiment, the magnitude of the curvature of the second section ($|\kappa_2|$) is greater than the magnitude of the curvature of the first section ($|\kappa 1|$), i.e. $|\kappa_2| > |\kappa_1|$. In other words, the second section has a tighter curvature than the first section, and thus the change in resistance as an exercise progresses happens more rapidly. This is particularly advantageous in the case in which the second section has a convex curvature with respect to the carriage and is used for pulling-type exercises such as chin-ups. The resistance profile for such exercises can thus be tailored independently of the resistance profile for exercises taking place on the first section, such as leg presses.

[0012] In an embodiment, a foot rest is provided at or in proximity to the free end of the first section. The footrest can be provided joined directly to the track at the free end of the first section, or to supporting frame to which the track is mounted. Since a footrest by definition has to be suitable for a user to rest his or her foot or feet

thereupon, the first section is thus defined as the lower section in the orientation which the exercise device will take when in use, i.e. the first section is the section nearest the ground.

[0013] In an embodiment, the exercise device further comprises a support structure, such as a support frame, for supporting the track and hinged thereto at or proximate to the free end of the first section. This enables the inclination of the track to be varied, and thereby the intensity of the resistance profile and thus the intensity of exercises performed on the exercise device to be adjusted, since the track can thus be rotated about the hinge.

[0014] In an embodiment, the first section is longer than the second section, which enables the relation between the length of track available for an exercise being performed on the first section to be tailored with regard to that being performed on the second section. Preferably, the length of the second section is between 30% and 70%, preferably between 40% and 60%, further preferably between 45% and 55% of the length of the first section.

[0015] In an embodiment, the track is a solid structure comprising: at least one tube with round, oval, or square structure; or a flat track with at least one flange; or at least one V-groove track; or at least one girder-type track. These provide various forms for the track.

[0016] The invention will be further described with relation to nonlimiting embodiments illustrated in the figures, which show:

Figure 1: a schematic representation of the mechanical principle behind the invention;

Figure 2: an illustration of the concept of curvature as it applies to the exercise device of the invention;

Figure 3: a schematic graph of the curvature k of the curve ABC of figure 2;

Figure 4: a schematic representation of an exercise device constructed according to the invention, at the start of a leg-press exercise;

Figure 5: a schematic representation of the situation at the end of a leg-press exercise;

Figure 6: a schematic representation of the situation at the start of a chin-up exercise;

Figure 7: a schematic representation of the situation at the end of a chin-up exercise;

Figure 8: a schematic graph of a resistance profile for an exercise device according to the invention.

[0017] In the figures, like reference signs represent like parts.

[0018] Figure 1 shows in schematic form the mechanical principle exploited by the invention. Curved track 1, here represented by a single line of constant radius (i.e. an arc of a circle), has a carriage 2 rolling thereupon by means of rollers 3a, 3b. The weight of a user and the weight of the carriage together are represented in figure 1 by force arrow mg. Tangent T is tangential to curved track 1 at a point equidistant between rollers 3a, 3b, and makes an angle θ With the horizontal. Ignoring friction and assuming that the user effectively applies a force F at a point on carriage 2 equidistant between the rollers 3a, 3b and tangential to the carriage 2, to balance the forces and thus overcome the resistance due to gravity, the magnitude of force F is given by:

$$F = mg.\sin\theta$$

[0019] Thus, as θ increases, e.g. as carriage 2 moves up curved track 1, F and thus the resistance to exercise increases, and likewise, as θ decreases, e.g. as carriage 2 moves down curved track 1, F and thus the resistance to exercise decreases.

[0020] Figure 2 illustrates the concept of curvature as it applies to the present invention. In this figure, track 1 is schematically represented by a curve ABC of dual curvature passing through points A, B and C. The section AB is considered here as being a first section, and the section BC is considered as being a second section. In both of the first section and the second section, the curve follows an arc of a circle of radius R_1, R_2 respectively. The relation between R_1 and R_2 has been exaggerated for the purposes of illustration. In this case, Curvature κ in its most general, scalar, form is defined as the inverse of the radius R, i.e.:

$$\kappa = 1 / R$$

[0021] The curvature of the first section AB is thus:

$$\kappa_1 = 1 / R_1$$

and the curvature of the second section BC is thus:

$$\kappa_2 = 1 / R_2$$

[0022] In the more complex case of a non-circular curve, the curvature κ at any given point is given by the inverse of the radius of curvature at that point.

[0023] However, simple scalar curvature is insufficient to adequately express the S-shaped track of the invention, thus the concept of signed curvature must be intro-

duced to distinguish between convex and concave curves. Mathematically, to determine signed curvature, the curve must be parametrised and expressed as a function of a parameter. The sign of the signed curvature κ indicates the direction in which the unit tangent vector rotates as a function of the parameter along the curve: if the unit tangent T rotates anticlockwise, then $\kappa > 0$ (positive sign), whereas if the unit tangent T rotates clockwise, then $\kappa < 0$ (negative sign). Since any given curve can be parametrised in opposite orientations, the definition of positive and negative curvature thus depends on the particular parametrisation chosen, in the same way that concave and convex depends on the frame of reference chosen. In more simple terms, the sign of the curvature κ can be determined by looking at on which side of the curve the centre of the radius of curvature lies and defining one side of the curve as "positive" and the other side as "negative".

[0024] In relation to the illustration of figure 2, the curvature of curve ABC can be described as follows:

1. By parametrisation:

   Curve ABC is parametrised such that as the parameter increases, the curve is described from A, through B, to C.
   Thus, as the parameter increases, unit tangent T rotates anticlockwise from A to B, and then rotates clockwise from B to C. Thus in this frame of reference, $\kappa_{AB} = 1 / R_1$, and
   $\kappa_{BC} = -1 / R_2$. At the point of inflection B, $\kappa_B = 0$, since at that point the unit tangent vector is not rotating. In the case of the opposite parametrisation, the opposite relations will hold, reversing the signs of the curvatures.

2. Position of the centre of the radius of curvature:

   Defining the centre of the radius of curvature as being "above" the curve as it is illustrated in figure 2, it is self-evidently clear that $\kappa_{AB} = 1 / R_1$, and $\kappa_{BC} = -1 / R_2$,
   and at the point of inflection B, $\kappa_B = 0$. Likewise defining the frame of reference in the opposite manner reverses the signs of the curvatures.

[0025] Figure 3 illustrates a qualitative, not to scale graph of the curvature κ of the curve ABC of figure 2. The horizontal axis represents the distance d along the curve and the vertical axis represents the signed curvature κ of the curve. Exactly at the point B, curvature κ is zero.

[0026] In qualitative terms, the curvature can also be described as follows:

In the view of figure 2, defining "up" as it is presented in the figure, the first section of the curve (AB) as illustrated may be described as "concave up" or "convex down", and likewise the second section of the curve (BC) may be described as "convex up" or "concave down".

Alternatively, the curvature may be referenced to the carriage 2. In this case, in the illustrated situation, the first section of the curve (AB) is concave with respect to the carriage 2, and the second section of the curve (BC) is convex with respect to the carriage 2.

[0027] Additionally, the overall shape of curve ABC can be described as "S-shaped", whereas its mirror image can be described as "reverse-S-shaped".

[0028] Figure 4 illustrates schematically an exercise device constructed according to the invention. Curved track 1 is mounted on a support structure 4 which may be of any type. In the illustration, the bottom free end of curved track 1 is hinged to the support structure 4 at hinge 5. The curved track 1 is further supported by non-illustrated supporting means which preferably permit the angle of the curved track 1 to be varied. While the curved track 1 is schematically illustrated in figure 4 as a single track, it may be of any conventional type such as a flat track with at least one flange, a V-groove track, a single girder-type track, multiple tubular tracks, multiple-groove or girder-type tracks or similar. See, for instance, US 4,176,836, US 6,244,995 and US 2002/0132706 for examples.

[0029] Carriage 2 is mounted movably on curved track 1 so as to permit the carriage 2 to move along the curved track 1, e.g. by means of rollers illustrated as 3a and 3b. The skilled person understands how to arrange the carriage 2 on any given track arrangement to permit it to move along the track but not to fall off, e.g. by means of opposed rollers, rollers arranged in grooves in the track (s) and so on: this need not be discussed further.

[0030] Carriage 2 is shaped so as to support the body of a user of the exercise device, and should preferably be able to support the user's body in a near-vertical position.

[0031] A foot rest 6 is provided, illustrated as being attached to a point close to the bottom end of the track 1, however foot rest 6 may be arranged in any convenient manner, e.g. on support structure 4. Furthermore, various handles, bars, pulley systems and so on (not illustrated) may be provided as required to permit a range of exercises to be performed on the exercise device. Examples of such handles etc. are illustrated e.g. in US 6,244,995, and need not be discussed further.

[0032] Curved track 1 is divided into a first section AB extending from point A to point B, and a second section BC extending from point B to point C. The track 1 may be constructed in a single piece or multiple pieces as required. The track 1 is terminated by an optional end cap 7. In the illustrated embodiment, the first section is at the lower end of track 1, nearest the ground, when the exercise device is in its position of use, and the second

section is at the upper end of track 1. As a possible variation, an extra section, e.g. a straight section, may be included between the first section and the second section. As illustrated, the first section from A to B is concave with respect to the carriage 2, i.e. has "concave up", or "positive" curvature ($\kappa>0$) as defined above in reference to figure 2. User 10 is illustrated in figure 4 as being in start position for a leg press exercise, with his feet resting on foot rest 6. Due to the aforementioned positive curvature, as the user performs the leg press exercise, the carriage 2 will rise up the curved track 1 at an ever-increasing angle, thus the resistance to the exercise will increase until the point at which the exercise is complete, as illustrated in figure 5. Although in figure 5 the upper roller 3b has transitioned onto the second section of the curved track 1, the angle of travel of the carriage has increased up to the position illustrated in figure 5.

[0033] In the illustrated embodiment, the second section BC of the curved track 1 has the opposite curvature to the first section AB, i.e. has a "convex up", or "negative" ($\kappa<0$) curvature as defined as above. The overall curve ABC as illustrated goes through a point of inflection at point B, i.e. there is no discontinuity in the curve ABC that would cause the user to experience a "bump" in the transition from the first section AB to the second section BC.

[0034] Figures 6 and 7 illustrate how the second section BC is used during a chin-up exercise. Figure 6 shows the situation at the start of the chain-up exercise. User 10 holds at least one handle or bar represented schematically at 8 as being attached to the free end of curved track 1, although they may be attached in any convenient manner e.g. to a support frame (not illustrated). Pulling on the handle or bar 8 with sufficient force to overcome gravity causes carriage 2 to move up onto the second section BC up to the position illustrated in figure 7 which represents the end of the exercise. As the carriage rises from the position illustrated in figure 6 to that illustrated in figure 7, the angle of travel of the carriage reduces, thereby reducing the resistance to the exercise. This provides a more optimal resistance profile through the illustrated exercise movement for a pulling-type exercise such as the illustrated chin-up exercise.

[0035] Figure 8 shows schematically a graph of the resistance profile dependent on carriage position along the track for an exercise device of the type and general arrangement of that illustrated in figures 4-7. From position 81 to position 82, the resistance increases due to the track being concave with respect to the carriage; from position 82 to position 83 the resistance decreases due to the track being convex with respect to the carriage. The exact shape of the resistance curve 80 and the exact locations of positions 81, 82, and 83 depend on the shape of the curved track 1, the design of the carriage 2, and the position of footrests, bars, handles, etc. In principle, the region from position 81 to position 82 is particularly suited for pushing-type exercises like the leg-press exercise illustrated in figures 4 and 5, and the region from position 82 to position 83 is particularly suitable for pulling exercises such as a row, chin-ups, pulldowns, leg curls, tricep extensions and so on. If desired, particular exercises may involve overlapping at least part of both regions.

[0036] The skilled person can choose the exact shape of the curved track 1, the lengths of the first and second sections, and position of handles, bars, pulleys etc to suit the user, and to engineer the exercise device for desired resistance profiles for various exercises. In the illustrated example, both the first section AB and the second section BC are conformed as arcs of circles, meeting tangentially at B. However, other curved shapes are possible, such as x^2, exponential, logarithmic, sections of sinusoids, and so on as desired. In the embodiment illustrated in figures 4-7, the curvature of the second section BC of curved track 1 is greater than that of the first section AB, and the length of the second section BC is approximately 50% of that of the first section AB. Alternatively, both sections may be of the same length, or the second section may be longer than the first section.

[0037] As a further alternative, although the lower section AB of curved track 1 has been illustrated as being concave with respect to carriage 2 and the upper section BC of curved track 1 has been illustrated as being convex with respect to carriage to 2, the opposite arrangement is also possible if desired, i.e. the first, lower section AB being convex with respect to carriage 2 and the second, upper section BC being concave with respect to carriage 2.

[0038] Although the invention has been described above in terms of specific embodiments, variations thereto are possible while still remaining within the scope of the appended claims.

Claims

1. Exercise device comprising at least one curved track (1) comprising a first section (AB) with curvature of a first sign; a carriage (2) mounted movably on the at least one track (1) and adapted to support the body of a user (10); **characterised in that** the curved track (1) comprises a second section (BC) with curvature of opposite sign to the first sign, the second section (BC) following the first section (AB).

2. Exercise device according to the preceding claim, wherein one of the first section (AB) and the second section (BC) is concave with respect to the carriage (2), and the other of the first section (AB) and the second section (BC) is convex with respect to the carriage (2).

3. Exercise device according to the preceding claim, wherein the first section (AB) is concave with respect to the carriage (2), and wherein the second section (BC) is convex with respect to the carriage (2).

4. Exercise device according to any preceding claim, wherein the second section (BC) is adjacent to the first section (AB).

5. Exercise device according to any preceding claim, wherein the first section (AB) and/or the second section (BC) describe circular arcs.

6. Exercise device according to any preceding claim, wherein the magnitude of the curvature of the second section (BC) is greater than the magnitude of the curvature of the first section (AB).

7. Exercise device according to any preceding claim, further comprising a footrest (6) provided at or in proximity to the free end of the first section (AB).

8. Exercise device according to any preceding claim, further comprising a support structure (3) for supporting the track and hinged thereto at or proximate to the free end of the first section (AB).

9. Exercise device according to any preceding claim, wherein the first section (AB) is longer than the second section (BC).

10. Exercise device according to the preceding claim, wherein the length of the second section (BC) is between 30% and 70%, preferably between 40% and 60%, further preferably between 45% and 55%, of the length of the first section (AB).

11. Exercise device according to any preceding claim, wherein the track (1) is a solid structure comprising: at least one tube with round, oval, or square structure; or a flat track with at least one flange; or at least one V-groove track; or at least one girder-type track.

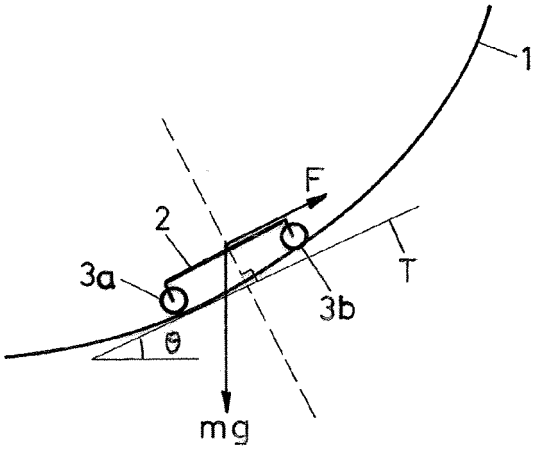

FIG.1

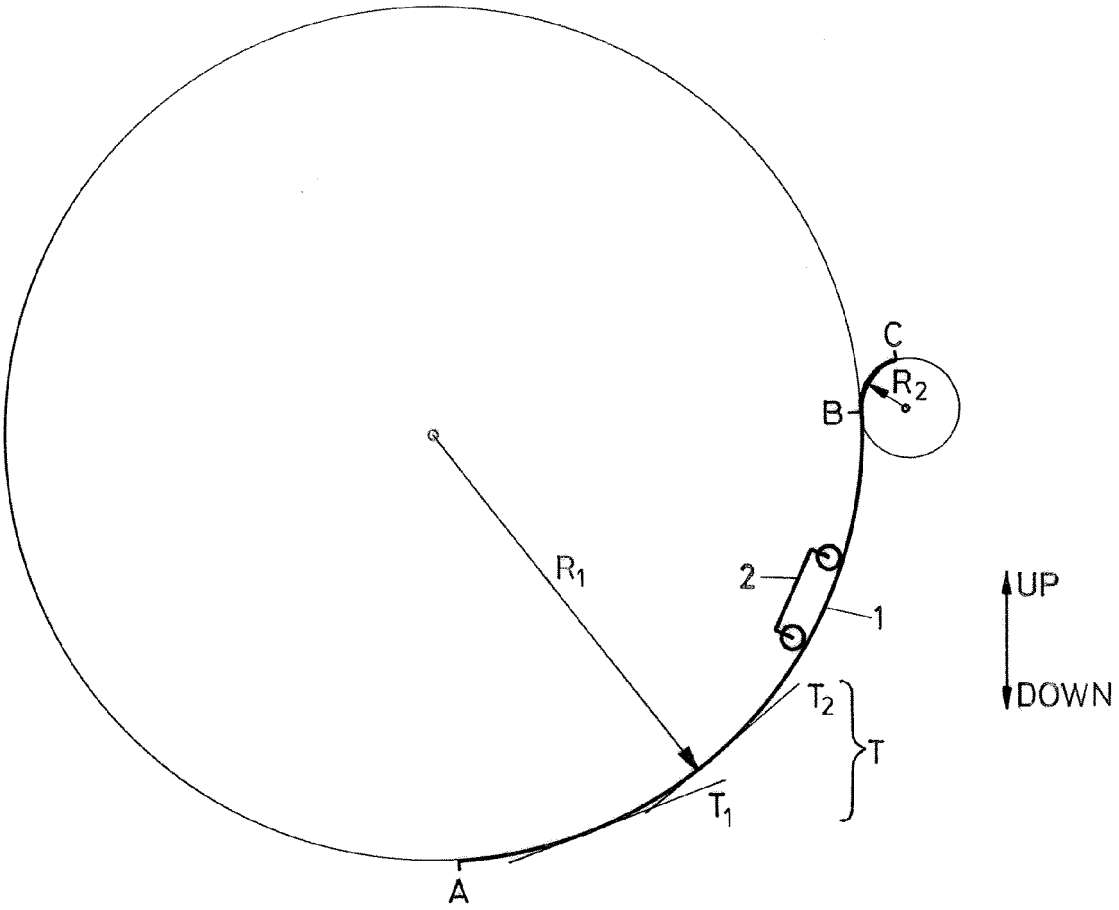

FIG. 2

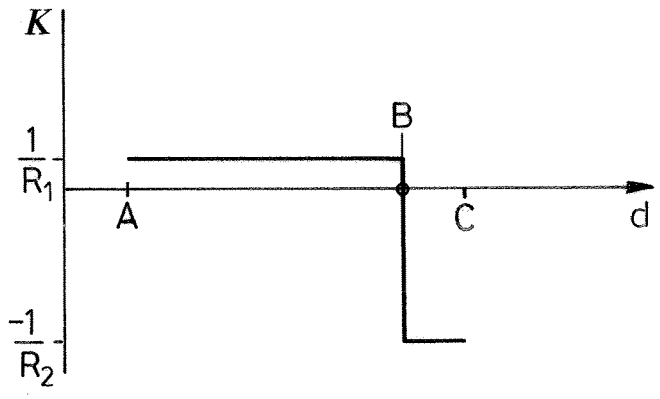

FIG. 3

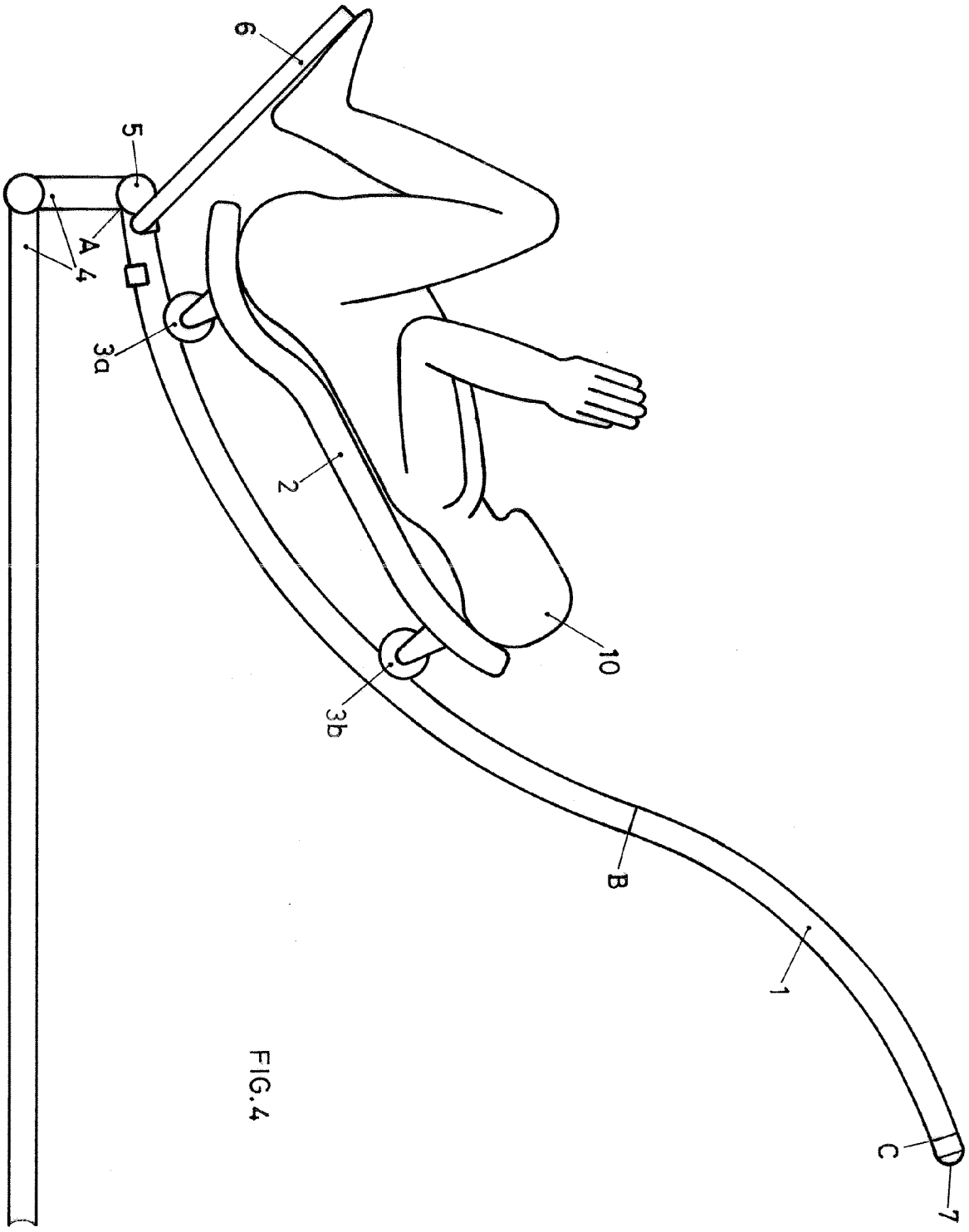

FIG.4

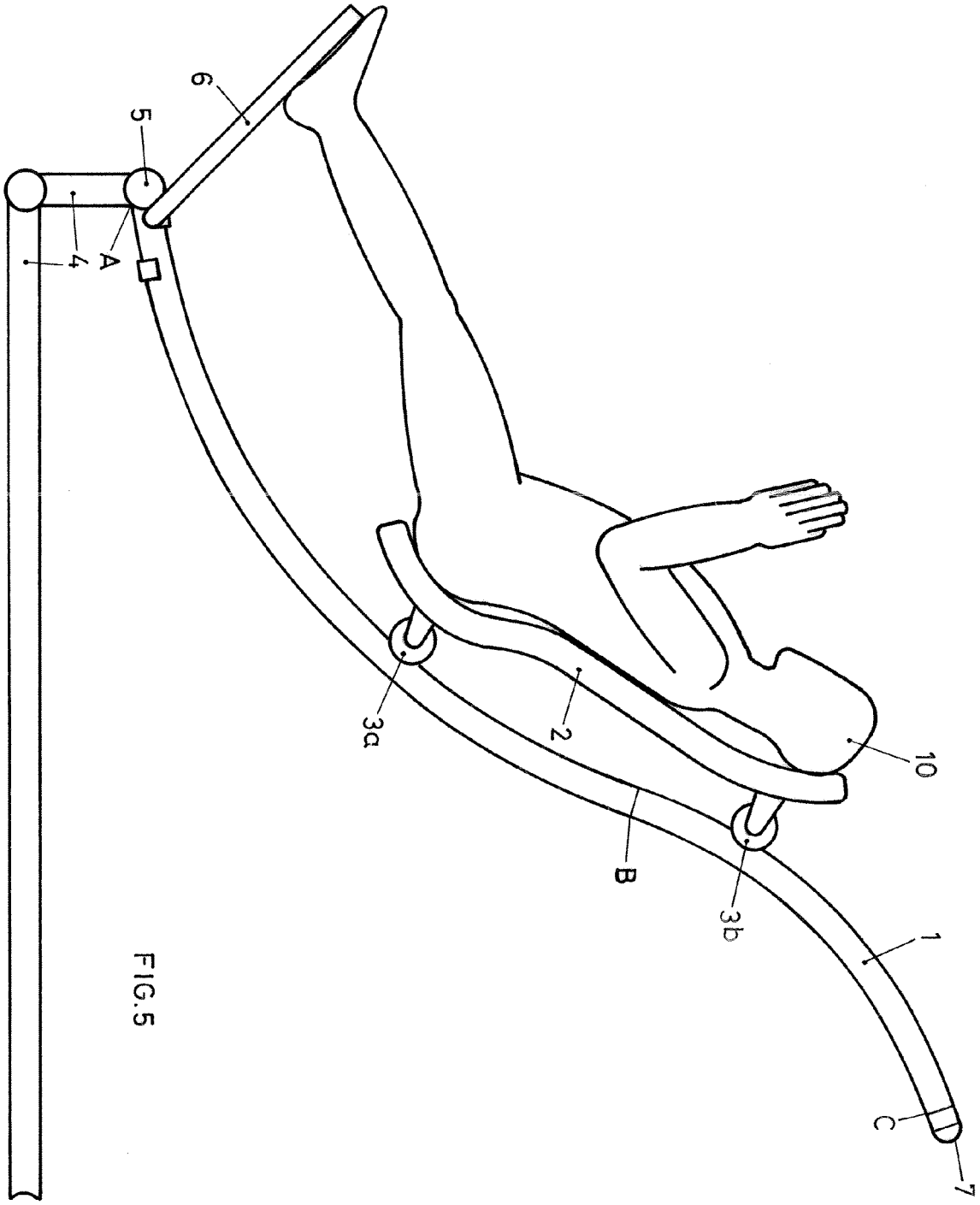

FIG.5

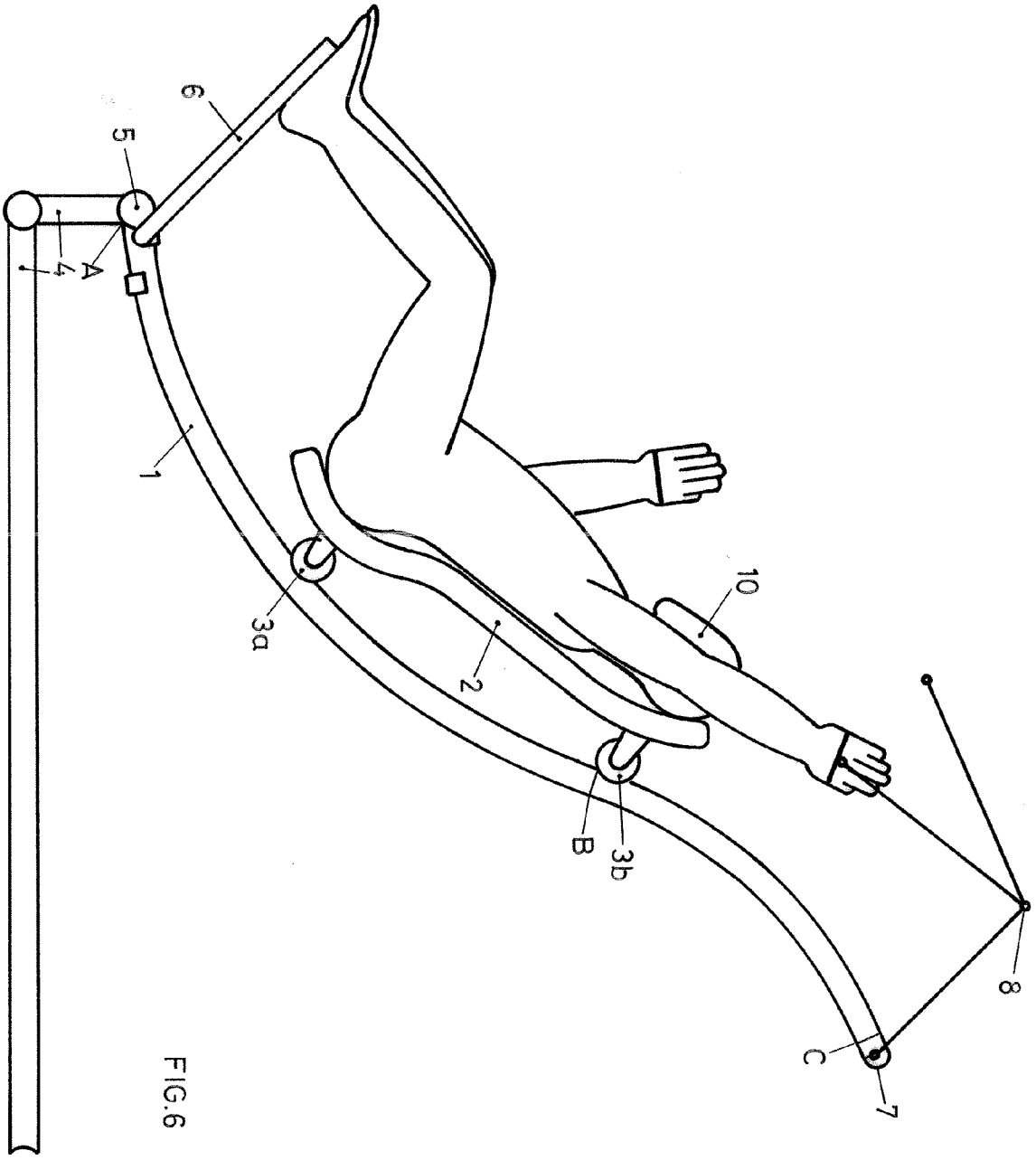

FIG.6

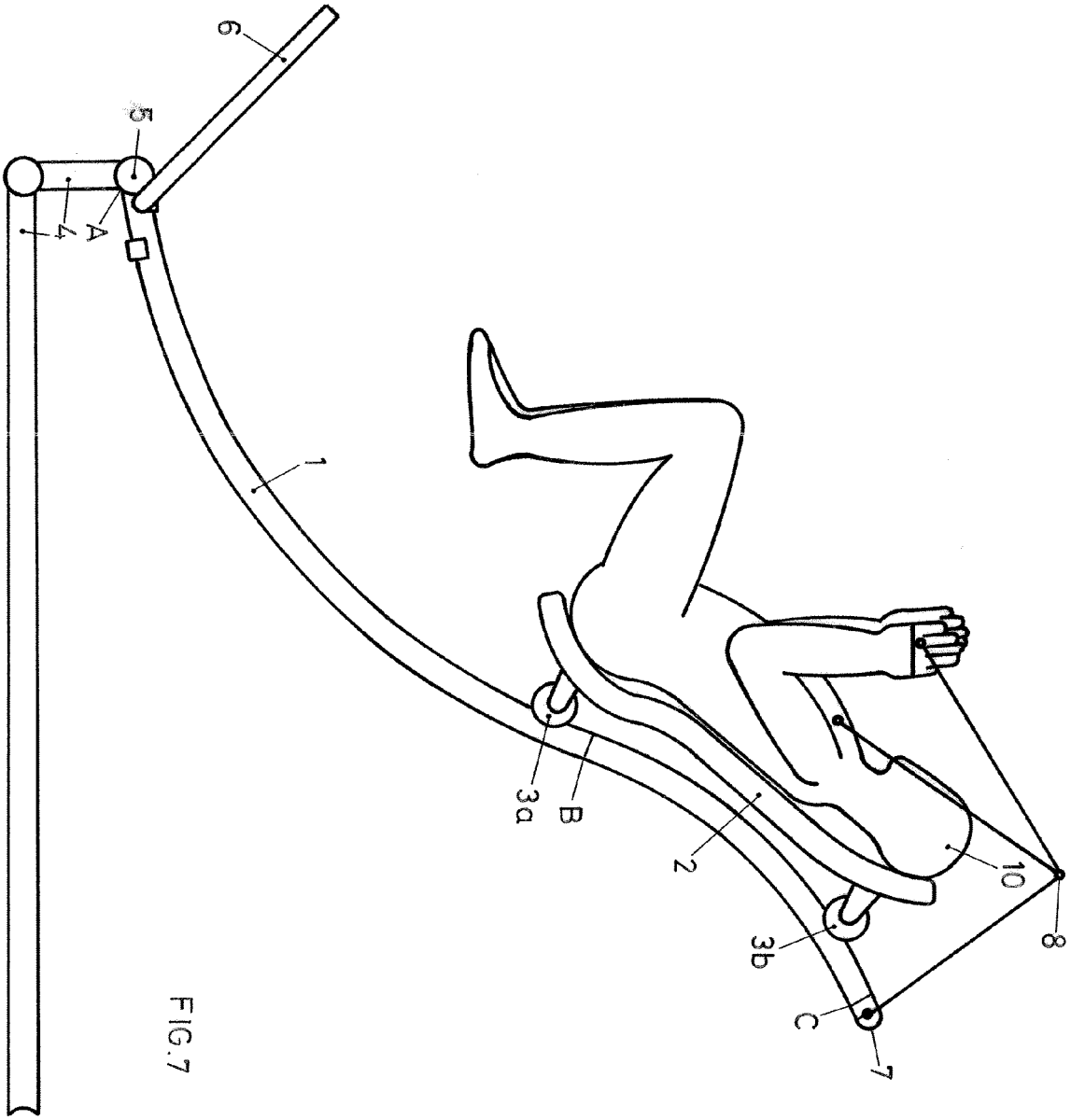

FIG.7

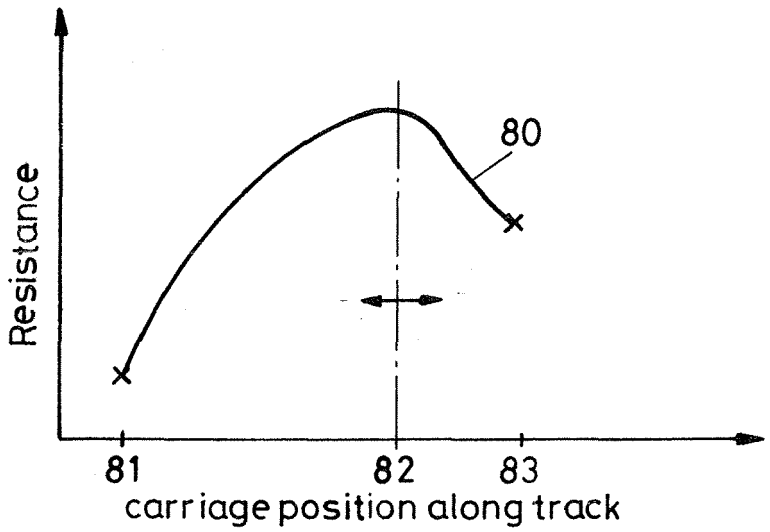

FIG. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 12 16 8043

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	8 November 2012	Borrás González, E

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