



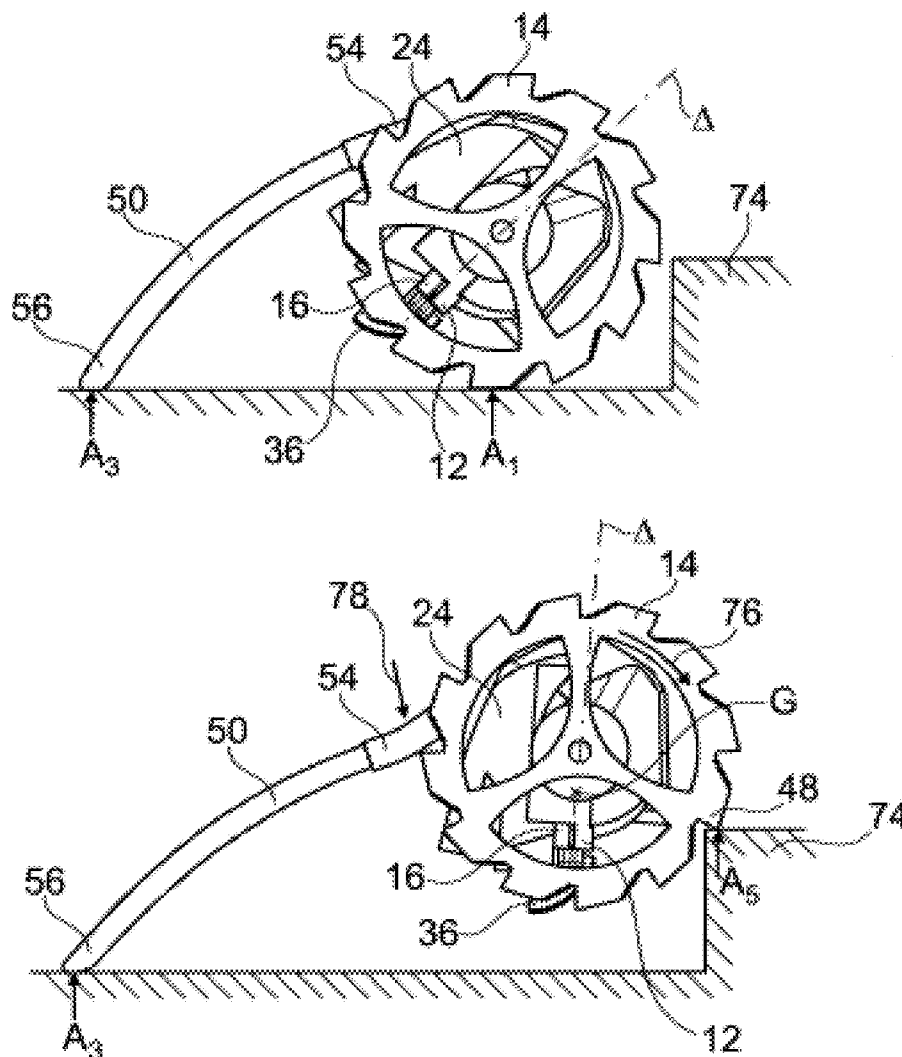
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(19) **United States**(12) **Patent Application Publication**
Barse(10) **Pub. No.: US 2016/0184721 A1**(43) **Pub. Date: Jun. 30, 2016**(54) **ROLLING AND JUMPING ROBOT WITH AN
INCREASED OBSTACLE PASSING ABILITY**(52) **U.S. Cl.**CPC *A63H 11/06* (2013.01); *A63H 17/262*
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901/01 (2013.01)(71) Applicant: **PARROT, Paris (FR)**(72) Inventor: **Thomas Barse, Aichi (JP)**(21) Appl. No.: **14/979,891**(22) Filed: **Dec. 28, 2015**(30) **Foreign Application Priority Data**

Dec. 29, 2014 (FR) 1463364

Publication Classification(51) **Int. Cl.***A63H 11/06* (2006.01)*A63H 33/00* (2006.01)*A63H 17/26* (2006.01)(57) **ABSTRACT**

This robot includes a body with a carriage (12) and a pair of wheels (14), as well as a sliding part (16) supporting a contact pad (36) allowing, through abrupt liberation of the energy stored in a spring, to cause a leap of the robot above the ground. It further includes a tail stand (50), fastened to the robot body at a fixation point located remote from the sliding part and in a region (24) at the opposite from the ground according to the main direction (Δ) of the carriage. The tail stand forms at its distal end (56) an alternative ground-bearing point (A_3), in a region located beyond the circumference of the wheels (14). The tail stand is at least partially elastically deformable by bending so as to allow under stress a moving of its distal end (56) closer to or away from the point (58) of fixation to the robot body.



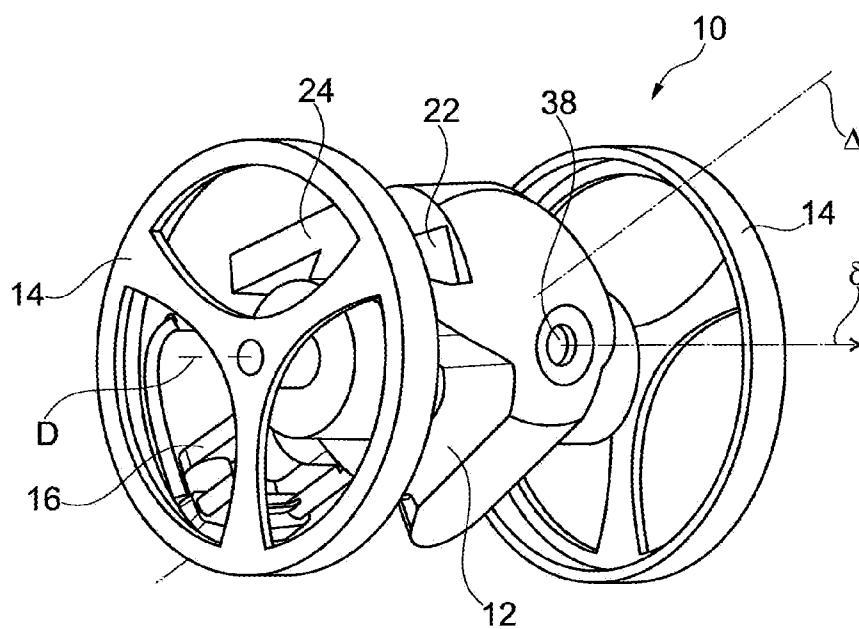


Fig. 1

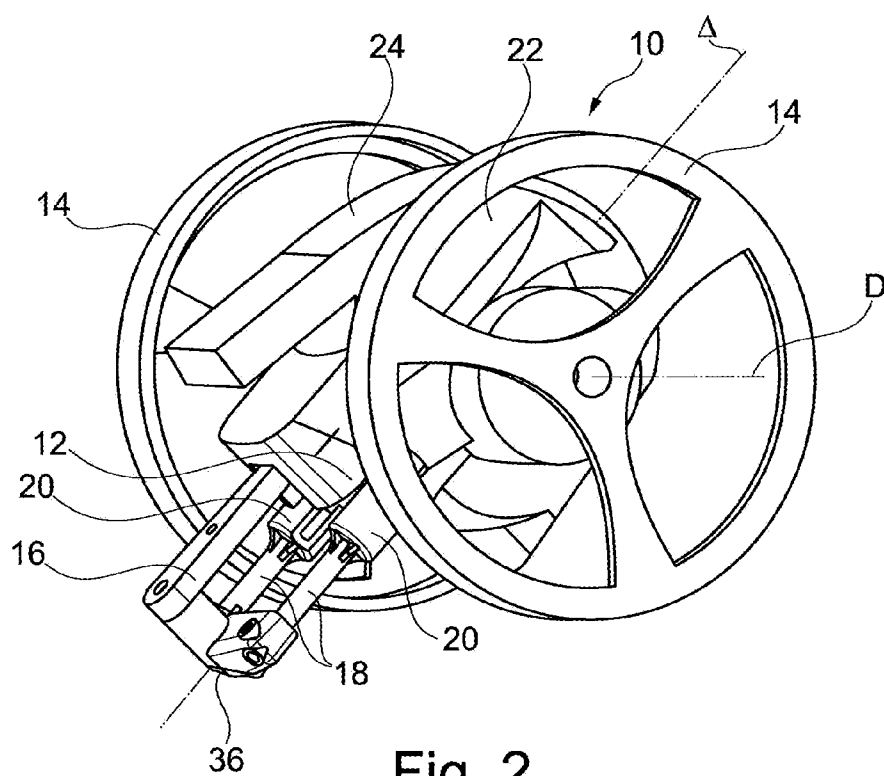


Fig. 2

Fig. 3a

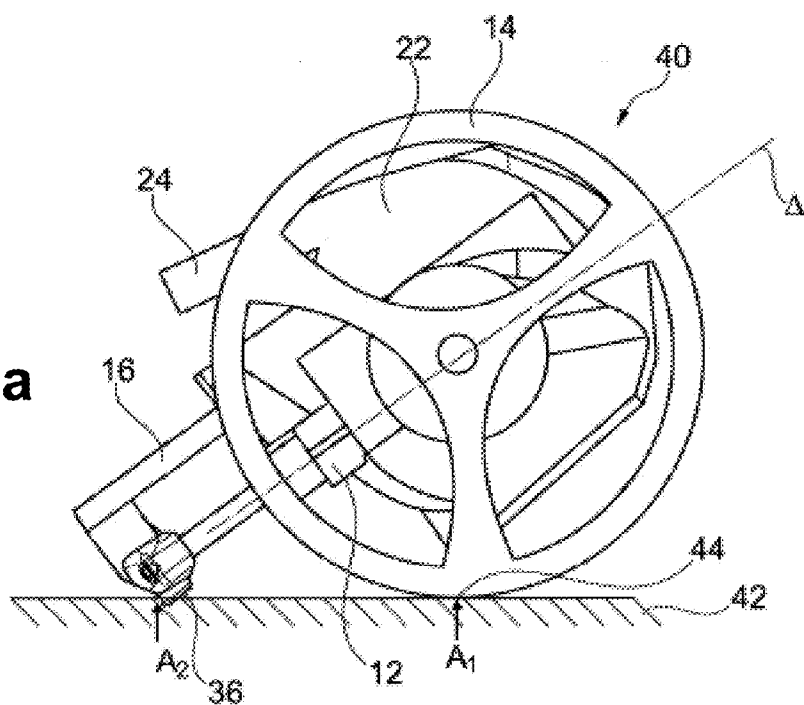
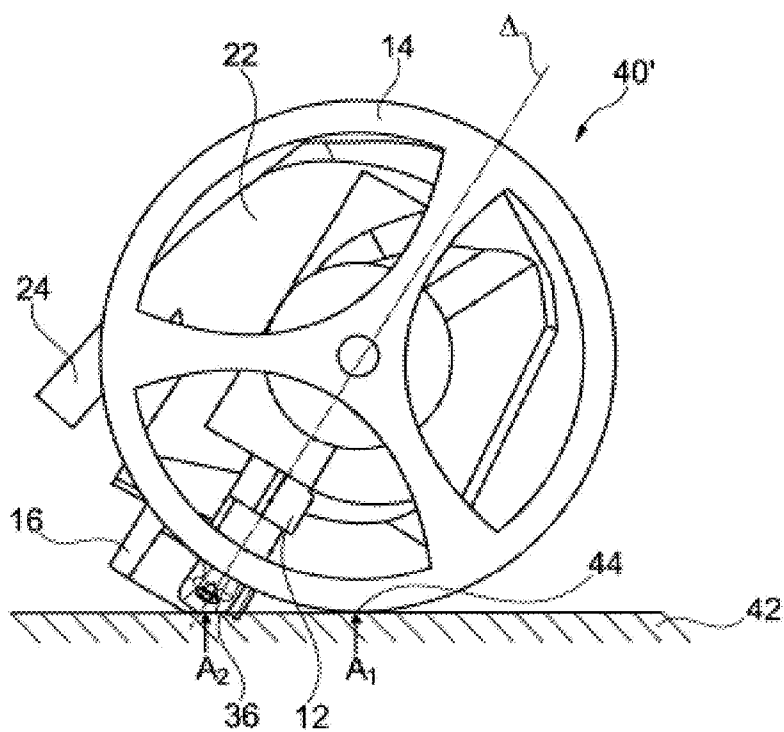


Fig. 3b



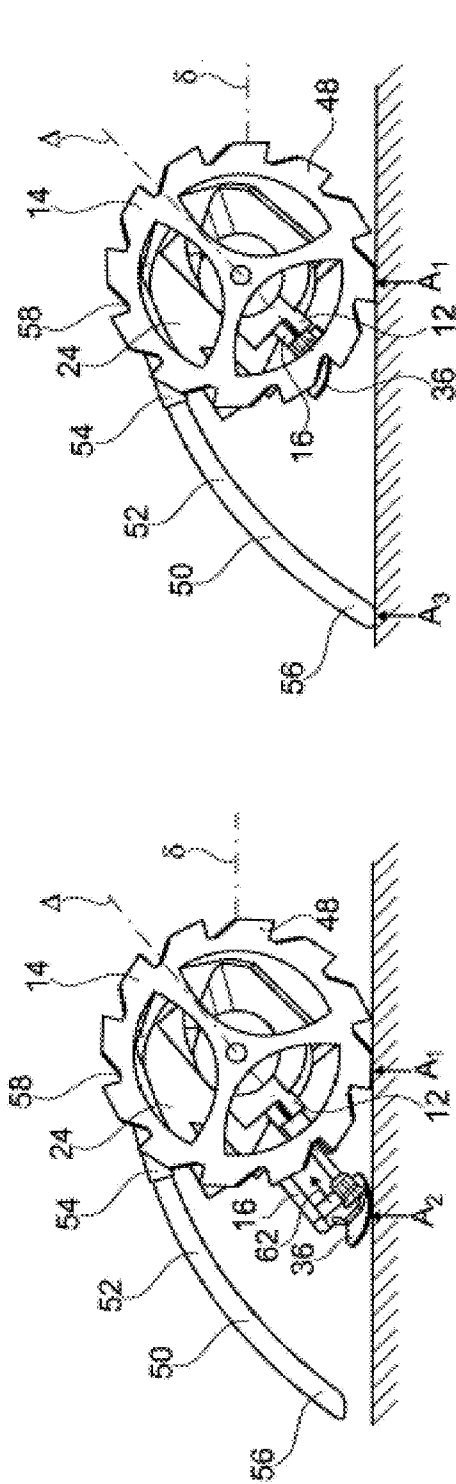


Fig. 4b

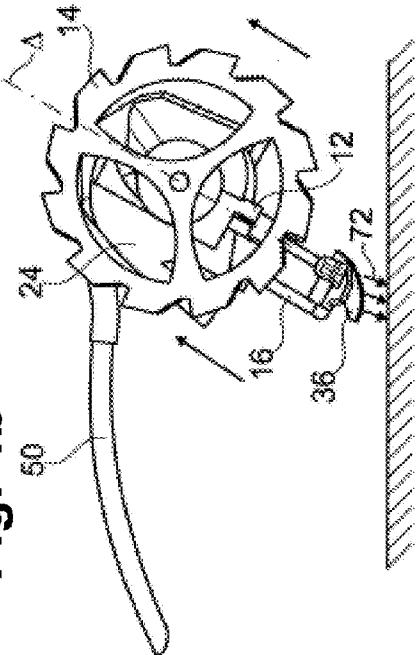


Fig. 4d

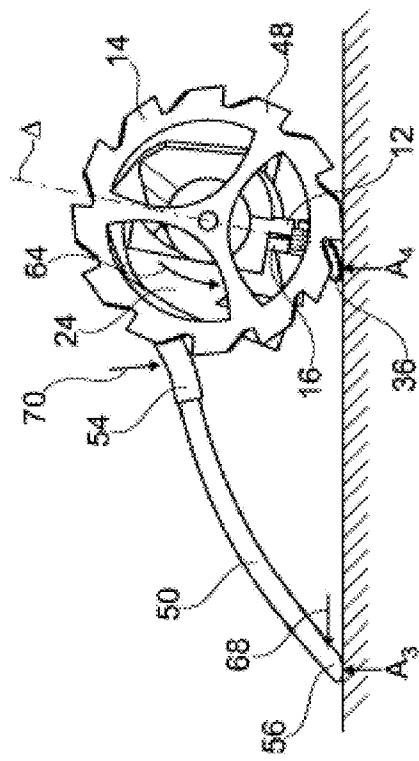


Fig. 4c

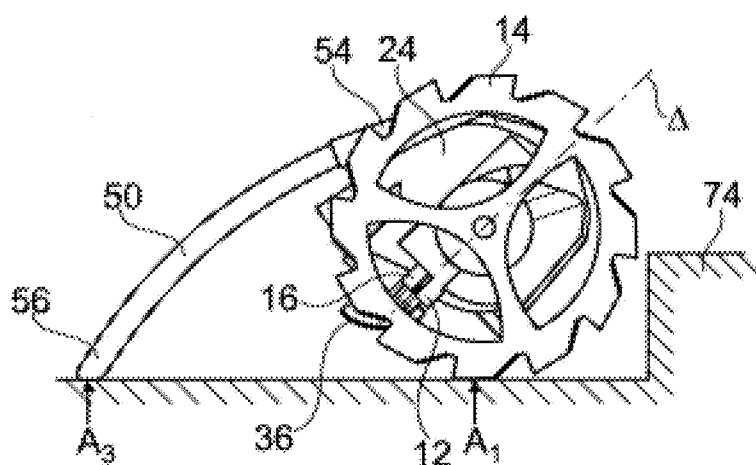


Fig. 5a

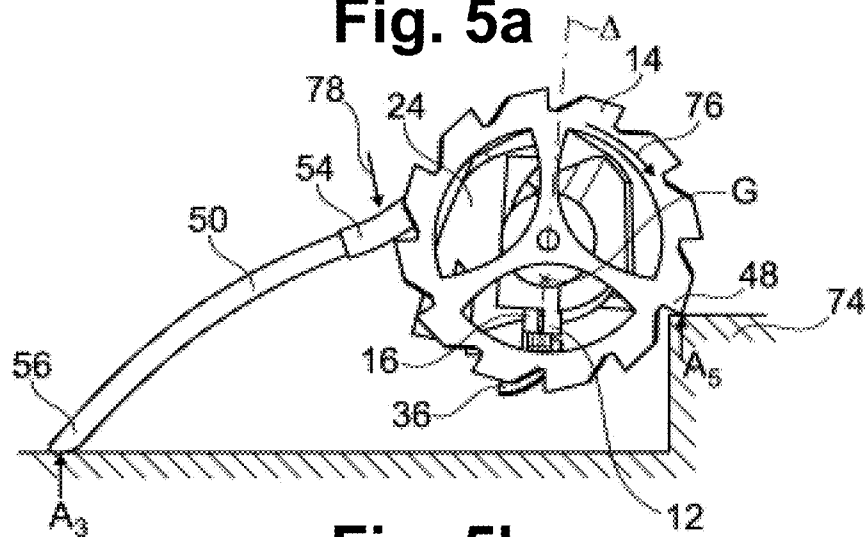


Fig. 5b

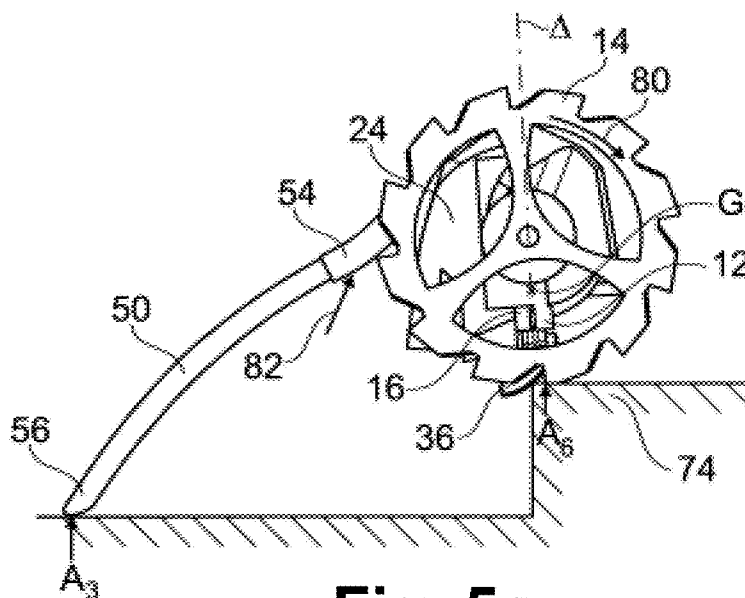


Fig. 5c

ROLLING AND JUMPING ROBOT WITH AN INCREASED OBSTACLE PASSING ABILITY

[0001] The invention relates to a rolling and jumping robot including a pair of wheels arranged on either side of a robot body.

[0002] Such a type of robot is described for example in the JP 2011/41696 A (Barse) as well as in the EP 2 862 606 A1 (published on 22 Apr. 2015), corresponding to the product marketed under the name "Jumping Sumo" by Parrot SA, Paris, France.

[0003] It is a remote-controlled rolling and jumping object mounted on two independent wheels, each provided with its own motor, which allows the robot to move forward, to move rearward, to take a jumping position, etc. The robot body includes a frame or carriage connected to the wheels and a sliding part guided on slides, with a spring interposed between the carriage and the sliding part. A motor moves the sliding element closer to the carriage, which has for effect to progressively compress the spring and hence accumulate therein an elastic potential energy. The unit is maintained in this position by a locking system, which may be liberated to abruptly release the spring and to throw the robot above the ground by transformation of the potential energy of the spring into kinetic energy, the impact of the sliding part against the ground producing, by reaction, the desired leaping effect. The jump height may be adjusted by a variable compression of the spring, so as to deliver a more or less significant energy at the time of the jump.

[0004] The object of the present invention is, while keeping this base structure and this jumping function, to improve the robot and to add it functionalities of aid to obstacle passing, in particular when it is used in "cross-country", or to get over steps, pavement edges, etc., for example, and this with a minimum of complementary physical means added to the base structure.

[0005] The invention applies to a robot of the above-mentioned type, i.e. comprising more precisely and in a manner known per se, in particular from the above-mentioned JP 2011/41696 A:

[0006] a body comprising a carriage and a pair of wheels arranged on either side of the carriage, the wheels being rotationally mounted with respect to the carriage about a common axis perpendicular to the main direction of the carriage;

[0007] a sliding part, mobile in guided translation along the carriage between two extreme positions, respectively extended and contracted, of this sliding part;

[0008] releasable means for locking the sliding part at the contracted position;

[0009] first motor means, adapted to drive the wheels in rotation with respect to the carriage;

[0010] second motor means, adapted to move the sliding part in translation with respect to the carriage, up to the contracted position;

[0011] a spring member stressed between the carriage and the sliding part; and

[0012] means for controlling the spring member, adapted i) to progressively store a mechanical energy in the spring member by moving the sliding part towards the contracted position under the action of the second motor means, and ii) to liberate the thus-stored energy, hence driving the sliding part towards the extended position following the releasing of the locking means, so as to

cause a leap of the robot above the ground under the effect of the sliding part expansion.

[0013] The sliding part includes a protruding distal end supporting a contact pad such that, in the contracted position, the contact pad is located near the perimeter of the wheels, and that the expansion of the sliding part is transmitted by the contact pad. Characteristically, the robot further includes a tail stand extending in a vertical plan and fastened to the robot body at a fixation point located remote from the sliding part and in a region at the opposite from the ground according to the main direction of the carriage. The tail stand forms at its distal end an alternative ground-bearing point, in a region located beyond the circumference of the wheels. Moreover, this tail stand is at least partially elastically deformable by bending so as to allow under stress a moving of the contact pad closer to or away from the surface of contact with the ground.

[0014] The wheels are advantageously wheels that are notched at their periphery.

[0015] In a preferential embodiment, the robot further comprises jump-control means, adapted to modify the configuration of the robot, successively between:

[0016] a) said extended position, where the robot rests in stable equilibrium on the two wheels and the contact pad;

[0017] b) said contracted position, where the robot rests in stable equilibrium on the two wheels and the alternative bearing point at the distal end of the tail stand, this tail stand being not under bending stress;

[0018] c) a jump-preparation position, where, after stressing of the first motor means towards the tilting rearward of the carriage, the pad comes into contact with the ground, the tail stand being then under bending stress; and

[0019] d) a jumping position, where the robot takes off from the ground after releasing of the locking means.

[0020] According to various advantageous characteristics:

[0021] the alternative bearing point is configured with respect to the tail stand so that the passage from the extended position to the contracted position is made with no change of inclination of the main direction of the carriage with respect to the ground;

[0022] the fixation point of the tail stand to the robot body is located, in the radial direction, in the inner vicinity of the periphery of the wheels;

[0023] the length of the tail stand is comprised between 1 and 3 times the diameter of the wheels;

[0024] the tail stand comprises an elongated, rigid distal portion, linked to the robot body by an elastically deformable member;

[0025] the rigid distal portion is a curved portion whose concavity is turned towards the ground;

[0026] the contact face of the pad turned towards the ground is a convex rounded face;

[0027] the distal end of the tail stand further comprises means for mounting an accessory providing the robot with an additional functionality, and/or the rigid portion of the stand is removable and replaceable by an accessory providing the robot with an additional functionality.

[0028] An exemplary embodiment of the invention will now be described, with reference to the appended drawings in which the same numeral references denote identical or functionally similar elements throughout the figures.

[0029] FIG. 1 is a general three-quarter front view of a known robot.

[0030] FIG. 2 is a general three-quarter rear view of the robot of FIG. 1, showing more precisely the different elements of this known robot that, combined together, ensure the jumping function.

[0031] FIGS. 3(a) and (b) are side views illustrating the known robot of FIGS. 1 and 2, with the sliding part in the extended position and the contracted position, respectively.

[0032] FIGS. 4(a) to (d) illustrate a robot of the type illustrated in the preceding Figures, but modified according to the teachings of the invention, as it is in four successive positions, i.e.: extended, contracted, jump preparation and jump triggering.

[0033] FIGS. 5(a) to (c) illustrate the robot according to the invention of FIG. 4, as it is at three successive steps of passing an obstacle such as a step.

[0034] FIGS. 1, 2 and 3 illustrate a robot of a known type, such as that described in the above-mentioned EP 2 862 606 A1.

[0035] In these Figures, the reference 10 generally denotes the robot, which comprises a carriage 12 supported by two wheels 14. The wheels 14 are mounted on the carriage 12 so as to pivot about a common axis D, and they are driven independently by individual electric motors (not shown), piloted by suitable circuits allowing the robot, according to the direction and speed of rotation of the wheels, to progress along a straight line, to move rearward, to turn about itself or to turn along a curve, etc., such different moves being controlled by the user by means of a suitable remote-control.

[0036] The carriage 12 extends following a main direction A, perpendicular to the pivot axis D of the wheels, and it supports a sliding part 16 movable in translation parallel to the axis A under the effect of a suitable motor, piloted by the robot control circuits. This sliding part 16 comprises for example two parallel rods 18 guided by these respective cylinders 20 integral with the carriage 12, with interposition between the rods 18 and the cylinders 20 of one or several helical springs (not visible in the Figures) serving as energy storage means, with compression of the spring when the sliding part 16 is moved closer to the carriage 12, and conversely returning to the sliding part 16 of the energy stored by these springs when the sliding part 16 is released towards an extended position of the carriage/sliding part unit. This mechanism is described in particular in the EP 2 952 236 A1 (published on 9 Dec. 2015).

[0037] It will be noted that, in the fully extended position of the sliding part 16 (position illustrated in FIGS. 1, 2 and 3(a)), the distal end of this part protrudes beyond the circumference of the wheels 14, and may hence come into contact with the ground. This distal end comprises for that purpose an added element or a surface forming contact pad 36, liable to form a ground-bearing point for the robot (point denoted A₂ in FIGS. 3(a) and (b)).

[0038] The robot may also be provided with one or several optical devices 38 (FIG. 1), such as a camera or a light, whose optical axis 8 forms a fixed angle with respect to the main direction A of the carriage and of the robot body integral with this carriage. This device allows for example, when the robot rolls, to light in front of the robot and/or to pick up a video image of the manoeuvre ground, viewed from the robot.

[0039] FIGS. 3(a) and (b) illustrate the robot in two positions hereinafter referred to as “extended” 40 and “contracted” 40' positions, corresponding to the two extremes

positions of the sliding part 16 in its guided movement in translation with respect to the carriage 12.

[0040] In either one of these positions 40 and 40', the robot rests on the ground 42 through three bearing points: in 44, at the contact of the wheels (point A₁) with the ground, and through the contact pad 36 at the distal end of the sliding part 16 (point A₂).

[0041] As indicated hereinabove, the sliding part 16 forms a telescopic unit with the carriage 12, and may hence move in translation between the extended position 40 (FIG. 3(a)) and the contracted position 40' (FIG. 3(b)) under the action of a motor specifically piloted to ensure this translation.

[0042] The extended position of FIG. 3(a) allows in particular the rolling on the ground, the rotations, etc.

[0043] The moving of the sliding part 16 towards the contracted position produces a moving of the ground-bearing point A₂ of the pad 36 and, correlatively, a modification of the inclination of the axis A of the carriage, and hence of the robot inclination.

[0044] The contracted position of FIG. 3(b) forms the jump-preparation position, which will occur through abrupt liberation of the energy of the previously-compressed springs, this energy being transmitted via the pad 36, by inertia and reaction of the ground, to the body 22 of the robot, to cause the latter to leap.

General Structure of the Robot According to the Invention

[0045] FIGS. 4 and 5 illustrate a robot such as that just described with reference to the state of the art, after having been modified according to the teachings of the invention.

[0046] FIG. 4 will explain how is kept the (pre-existing) jumping function that has been described hereinabove, whereas FIG. 5 will illustrate the (new) obstacle passing function.

[0047] To allow this new function, the robot is provided with wheels 14, which are notched wheels, i.e. provided at their periphery, on the tire tread, with reliefs, notches or grousers 48 or other similar means (grousers added to or integral with the wheel, deep sculptures, etc.) providing a high adhesion on irregular grounds, for example, as illustrated in FIGS. 5(b) and (c), on the edge of a step, or on natural, stony grounds, with branches, etc., by minimising the risk of skidding of the robot. An alternative to notched wheels consists, equivalently, in making these wheels from a very soft material, able to conform, through its deformation, the irregularities of the ground on which the robot evolves.

[0048] Characteristically of the invention, the robot is provided with a tail stand 5 fastened to the robot body. In the illustrated example, this stand 50 is formed of an elongated rigid element 52 linked to the robot body by an elastically deformable member 54 such as an helical spring or an elastic sleeve.

[0049] The distal end 56 of the tail stand 50 is intended to form an alternative bearing point for the robot body. The size and shape of the tail stand are chosen so that this end 56 is located beyond the periphery of the wheels, for example at a distance from the rotation axis comprised between typically 1 and 3 times the diameter of the wheels. On the proximal side, the tail stand 50 is fastened to the body (by the elastic element 54 in the illustrated example) at a fixation point 58 located in the radial direction remote from the sliding part 16 and in a region of the robot body located at the opposite from the ground according to the main direction A of the carriage, in

particular on the protruding excrescence **24** in the upper part of the robot body, in the inner vicinity of the periphery of the wheels.

[0050] The tail stand **50**, that extends in a vertical plan, is a flexible stand due to the elastic member **54** that links the elongated rigid element to the robot body at the fixation point **58**. More precisely, this flexibility must permit a bending deformation allowing, under stress, a moving of the contact pad (**36**) closer to or away from the surface of contact with the ground. The general configuration of the tail stand and the size thereof are such that, when the sliding part is in the extended position (configuration of FIG. **4(a)**, itself corresponding to the configuration of FIG. **3(a)**), the only bearing points that maintain the robot and that support the weight thereof in this case remain the sliding part (at A_2) and the wheels (at A_1). It may possibly remain, as in the example of FIG. **5**, an interval between the surface of the ground and the distal end **56** of the tail stand **50**, but in any case, even if this end **56** touches the ground, it does not form a real bearing point when the sliding part is extended, due to the flexibility of the stand **50**.

[0051] On the other hand, in the contracted position of the sliding part **16** (configuration of FIGS. **4(b)** and **5(a)**, corresponding to the configuration of FIG. **3(b)**), the distal end **56** comes into contact with the ground, the robot then resting on its two wheels (points A_1) and on the end **56** of the tail stand (point A_3), instead of resting on its two wheels (points A_1) and on the pad **36** (point A_2). FIGS. **4(b)** and **3(b)** will be compared in this respect.

[0052] Advantageously, the size and shape of the tail stand are chosen so that this change of bearing point upon the passage of the sliding part to the concentrated position is made with no modification of the general direction of the axis Δ of the carriage, and hence of the axis δ of the robot camera with respect to the ground (or with a slight modification, due to the weight of the robot and of the flexible portion, causing a slight bending of the stand). This will avoid a tilting of the image of the scene picked-up by this camera, as it was the case with the known robot illustrated in FIG. **3**, where the passage from the position of FIG. **3(a)** to that of FIG. **3(b)** was made with a tilting upward of the axis Δ , and hence of the viewing direction **8** of the camera. The tail stand **50** has advantageously a curved shape, whose concavity is turned towards the ground, which allows with a shorter stand to better control the position of the robot body.

[0053] As indicated, the end **56** of the tail stand has for main function to form an alternative bearing point for the robot in conditions that will be exposed hereinafter. But, subsidiary, this end may also serve to the fixation of an accessory providing the robot with an additional functionality, for example by mounting a float, a brush, a catapult, spikes, etc., either by mounting directly the accessory on the tail stand, or by replacing all or part of the rigid portion **52** of the stand by a replacement element carrying the accessory in question.

Kinematics of the Jumping Function

[0054] As will be seen with reference to FIGS. **4(a)** to **(d)**, the jumping function of the known device (exposed hereinabove with reference to FIG. **3**) is kept with the structure according to the invention, where the robot is provided with the tail stand **50**.

[0055] At the first step, illustrated in FIG. **4(a)**, the sliding part **16** is in the extended position, and the robot rests on its two wheels (point A_1) and on the pad **36** (point A_2). The end

56 of the tail stand **50** is remote from the ground. This configuration is not different from that illustrated in FIG. **3a** for a device according to the prior art.

[0056] After retraction of the sliding part **16** (arrow **62**), the configuration is that illustrated in FIG. **4(b)**. The sliding part **16** is then in the contracted position, with compression of the springs, as in the above-described configuration of FIG. **3(b)**. However, unlike FIG. **3(b)**, due to the presence of the tail stand **50**, the third bearing point becomes the end **56** of the stand (alternative bearing point A_3), the pad **36** being then located above the level of the ground. It will be moreover noted that, in this position of FIG. **4(b)**, the flexible stand **50** is not, or almost not, under bending stress.

[0057] This contracted position may be kept, waiting for a latter jump, wherein the robot can continue to evolve on the ground with an increased stability, in particular on an uneven ground, thanks to the grousers **48** of the wheels **14**, but above all, to the greater distance between the points of contact A_1 of the wheels and the third bearing point, i.e. the alternative bearing point A_3 , which defines a larger lift triangle than in the preceding case.

[0058] When the user wants to trigger the jump, the control circuit of the driving motors of the wheels sends to these latter an acceleration impulse that causes a tilting rearward of the robot body (arrow **64**, FIG. **3(c)**), with for consequence the moving backward of the alternative bearing point A_3 (arrow **68**) and the bending (schematised by the arrow **70**) of the elastic element **54** of the tail stand. The acceleration impulse imparted to the robot and the bending of the tail stand **50** have for effect to press the pad **36** to the ground. When the pad **36** touches the ground (point A_4), then the control circuit releases the locking means of the sliding part, which has for effect to cause the abrupt expansion of this sliding part and the leap of the robot above the ground, through the pad **36** (arrow **72**, FIG. **4(d)**).

[0059] In practice, the releasing of the locking means is caused at the suitable time by adjustment between the instant of this releasing (unlocking) and the duration of the impulse of acceleration of the wheels. This ensures a jump in the best conditions, with direct and immediate transmission of the energy liberated at the time of the unlocking.

Kinematics of the Obstacle Passing Function

[0060] We will now describe, with reference to FIGS. **5(a)** to **(c)**, how the adding of the tail stand **50** provides a new function of obstacle passing.

[0061] The obstacle is, in this example, a step **74** in front of which the robot is located, in the configuration illustrated in FIG. **5(a)**.

[0062] This configuration is in any point identical to that of FIG. **4(b)** described hereinabove, i.e. with the robot resting on the ground through its two wheels (bearing point A_1) and the end **56** of the tail stand **50** (alternative bearing point A_3). The sliding part **16** is in the contracted position (and it will stay therein for all the duration of the obstacle passing), i.e. the pad **36** is in the inner vicinity of the periphery of the wheels **14**.

[0063] At the following step, illustrated in FIG. **5(b)**, the wheels **14** of the robot have moved forward (arrow **76**) and they enter into contact with the obstacle **74** and, thanks to the grousers **48**, engage with a protruding part of this obstacle, for example the nose of the step **74**. The robot is then in rest on the points A_5 of contact of the wheels with the obstacle, and the alternative bearing point A_3 that is still in contact with the ground.

[0064] Under the effect of the robot weight, whose centre of gravity G is located between the points A_5 and A_3 , the tail stand 50 is put under elastic stress, with bending of the deformable elastic element 54 (bending schematised by the arrow 78).

[0065] At the following step, illustrated in FIG. 5(c), the rotation of the wheels is continued (arrow 80). The robot and the wheels thereof pass the obstacle, whereas the alternative bearing point A_3 , still in contact with the ground, prevents the tilting rearward of the robot. The stress exerted by the tail stand, which is under bending stress (schematised by the arrow 82), has moreover a tendency to push the robot towards the front of the obstacle.

[0066] After the centre of gravity G of the robot has passed the obstacle, i.e., in the example illustrated, when the pad 36 arrives at the nose of the step 74 (bearing point A_6), then the robot can carry on its way, the tail stand 50 ensuring the stability of the mobile unit during this transitory phase. The contact face of the pad 36 turned towards the ground is preferably a convex, rounded face, in order not to get caught on the obstacle and to allow the later to be passed with no trouble.

[0067] It will be noted that this obstacle passing functionality requires no run-up to be given to the robot, wherein the configuration illustrated in FIG. 5(a) can be a configuration in which the robot is stopped, simply in front of the obstacle.

1. A rolling and jumping robot resting on the ground, including:

a body (22) comprising a carriage (12) and a pair of wheels (14) arranged on either side of the carriage, the wheels being rotationally mounted with respect to the carriage about a common axis (D) perpendicular to the main direction (A) of the carriage;

a sliding part (16), mobile in guided translation along the carriage between two extreme positions, respectively extended and contracted;

releasable means for locking the sliding part at the contracted position;

first motor means, adapted to drive the wheels in rotation with respect to the carriage;

second motor means, adapted to move the sliding part in translation with respect to the carriage, up to the contracted position;

a spring element stressed between the carriage and the sliding part; and

means for controlling the spring member, adapted i) to progressively store a mechanical energy in the spring member by moving the sliding part towards the contracted position under the action of the second motor means, and ii) to liberate the thus-stored energy, hence driving the sliding part towards the extended position following the releasing of the locking means, so as to cause a leap of the robot above the ground under the effect of the sliding part expansion,

said robot being characterized in that:

the sliding part (16) includes a protruding distal end supporting a contact pad (36);

in the contracted position, the contact pad is located near the perimeter of the wheels;

the expansion of the sliding part is transmitted by the contact pad (36);

the robot further includes a tail stand (50) extending in a vertical plan and fastened to the robot body (22) at a fixation point (58) located remote from the sliding part and in a region (24) at the opposite from the ground according to the main direction (A) of the carriage;

the tail stand forms at its distal end (56) an alternative ground-bearing point (A_3), in a region located beyond the circumference of the wheels (14); and

the tail stand is at least partially elastically deformable by bending so as to allow under stress a moving of the contact pad (36) closer to or away from the surface of contact with the ground.

2. The robot of claim 1, wherein the wheels (14) are wheels that are notched (48) at their periphery.

3. The robot of claim 1, further comprising jump-control means, adapted to modify the configuration of the robot, successively between:

a) said extended position, where the robot rests in stable equilibrium on the two wheels (14, A_1) and the contact pad (36, A_2);

b) said contracted position, where the robot rests in stable equilibrium on the two wheels (14, A_1) and the alternative bearing point (A_3) at the distal end of the tail stand (50), this tail stand being not under bending stress;

c) a jump-preparation position, where, after stressing of the first motor means towards the tilting rearward of the carriage, the pad (36) comes into contact (A_4) with the ground, the tail stand being then under bending stress; and

d) a jumping position, where the robot takes off from the ground after releasing of the locking means.

4. The robot of claim 3, wherein the alternative bearing point (A_3) is configured with respect to tail stand (50) so that the passage from the extended position to the contracted position is made with no change of inclination of the main direction (Δ) of the carriage with respect to the ground.

5. The robot of claim 1, wherein the fixation point (58) of the tail stand (50) to the robot body (22) is located, in the radial direction, in the inner vicinity of the periphery of the wheels (14).

6. The robot of claim 1, wherein the length of the tail stand (50) is comprised between 1 and 3 times the diameter of the wheels (14).

7. The robot of claim 1, wherein the tail stand comprises an elongated, rigid distal portion (52), linked to the robot body by an elastically deformable member (54).

8. The robot of claim 7, wherein the rigid distal portion (52) is a curved portion whose concavity is turned towards the ground.

9. The robot of claim 1, wherein the contact face of the pad (36) turned towards the ground is a convex rounded face.

10. The robot of claim 1, wherein the distal end (56) of the tail stand further comprises means for mounting an accessory providing the robot with an additional functionality.

11. The robot of claim 7, wherein the tail stand (50) is a stand whose rigid portion (52) is removable and replaceable by an accessory providing the robot with an additional functionality.

* * * * *