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Patents Form 1

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Request for grant of a patent

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Application number GB1819511.5

| | | | |
|---|---|----------------------------------|--|
| 1. Your reference | 27027 | | |
| 2. Full name, address and postcode of the applicant or of each applicant | <u>Köppen, Rob</u> Anton Philipslaan 125 Eindhoven 5616 TW Netherlands | | |
| Patents ADP number (<i>if you know it</i>) | 12373965001 | | |
| Full name, address and postcode of the applicant or of each applicant | <u>van der Stel, Sander</u> Annabijnspad 55 Middelharnis 3241 DP Netherlands | | |
| Patents ADP number (<i>if you know it</i>) | 12373973001 | | |
| 3. Title of the invention | REMOTE CONTROLLED CRAWLING DEVICE | | |
| 4. Name of your agent (<i>if you have one</i>) | Gallafents Ltd | | |
| "Address for service" to which all correspondence should be sent. This may be in the European Economic area or Channel Islands (see warning note below) (<i>including the postcode</i>) | 1 Sans Walk London EC1R 0LT United Kingdom | | |
| Patents ADP number (<i>if you know it</i>) | 0000729001 | 11699626001 | |
| 5. Priority declaration: Are you claiming priority from one or more earlier-filed patent applications? If so, please give details of the application(s) | | | |
| | Country | Application number | Date of filing |
| 6. Divisionals etc: Is this application a divisional application, or being made following resolution of an entitlement dispute about an earlier application. If so, please give the application number and filing date of the earlier application | | | PDAS Access Code |
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| 7. Inventorship: (Inventors must be individuals not companies) | | | |
| Are all the applicants named above also inventors? | Yes | | |
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Description: **11**

Claim(s): **n/a**

Abstract: **n/a**

Drawing(s): **3**

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Priority documents: **0**

Statement of inventorship and right to grant of a patent

(Patents Form 7): **0**

Request for search (Patents Form 9A): **0**

Request for substantive examination (Patents Form 10): **0**

Any other documents (please specify): **PDAS Registration Form**

11. I/We request the grant of a patent on the basis of this application.

Date: **30 Nov 2018**

12. Name, e-mail address, telephone, fax and/or mobile number, if any, of a contact point for the applicant

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REMOTE CONTROLLED CRAWLING DEVICE

The present invention relates to a remote-controlled device capable of crawling along cables, seamless pipes and cylindrical bars (hereafter
5 “cable/pipe/bar”), that are positioned horizontally, vertically, or at an incline, whilst simultaneously pushing or pulling significant amounts of weight in the form of accessories or appendages.

It is particularly directed to crawlers for remote inspection and optionally
10 cleaning or lubrication of tensioned steel cables. Examples of such are cables that add stability to free-standing structures, such as towers, masts or poles, chimneys and flare stacks, often referred to as “guys”. Guys are generally continuously under considerable stress, and are exposed to harsh environmental conditions for the duration of their use. Periodic examination
15 and maintenance are essential to ensure a guy safely fulfils its maximum service life.

BACKGROUND

20 Traditional guy maintenance used to consist of a visual inspection and simultaneous lubrication by a technician suspended from the guy in a man-basket. This unsafe method was replaced by employing a rope access technician or a technician suspended in a basket from a crane. Aside from the high degree of risk posed to the technician, as well as the considerable
25 expense of using a crane, this inspection method proved of limited efficacy. First, these methods make it difficult for a technician to inspect the full circumference of a guy; second, the guy can only be inspected from the outside, meaning approximately ninety percent is missed. Furthermore, if the guy was attached to a gas flare stack this had to be shut down during the
30 work.

A method has been developed which uses two manual winches to pull cleaning, lubrication, and Magnetic Flux Leakage (MFL) inspection devices up and down a guy. Whilst this approach saves the expense of using a crane, it is very labour intensive and if the guy is attached to a flare stack, that still has to be shut down. The method is also prone to cause excess grease to spill from the guy as it is almost impossible to match the correct flow of grease with the winch speed.

Whilst an MFL device can inspect one hundred percent of a guy (exterior and interior), it requires being driven along the guy at a constant speed for accurate results. This is extremely difficult to achieve using manual winches.

Using a motorised wheeled robot (which engages with the guy surface with much higher friction than the MFL inspection device), enables an MFL inspection device to be driven at a steady speed, which greatly improve the inspection results, but wheeled robots suffer from some limitations, including not having enough contact area on the guy, which meant that a grease deposit could render the robot immobile. Additionally, a wheeled robot is restricted in the amount of weight it can pull, and/or the amount of frictional force it can overcome, which means that when cleaning and lubrication devices (which generally give rise to frictional forces between the guy and such devices much greater than those arising when using an MFL inspection device) are to be applied, a labour intensive, manual winch system still has to be used.

The present invention seeks to develop a remote controlled device capable of inspecting, cleaning and lubricating guys.

PRIOR ART PATENT DISCLOSURES

Published US Patent specification 2015360736 describes a mobile robot that employs multiple caterpillar type movements to drive along the surface of a

cable for the purposes of maintenance and inspection. The tracks are toothed belts, driven by similarly toothed pulleys, to prevent slippage. Caterpillars are positioned at equal circumferential angles to ensure the robot is held onto the cable. The tracks are made from rubber and have tensioners that keep the belts taut. A polyethylene resin panel that supports the caterpillar to maintain constant contact between the full length of the belt and cable. There is a distance adjuster that maintains sufficient contact between caterpillars and the cable, which can also be adjusted to allow different sized cables to be driven along. The main advantage of a tracked design over wheeled is that the caterpillars provide more contact between the drive mechanism and cable, thereby improving traction. However, the traction this existing robot design generates is limited and so can only carry a maximum payload of 30kg, which limits its ability to push and pull appendages.

French Patent specification 2526842 describes a device for the maintenance of guys on radio communications pylons, with wire brushes for cleaning and painting operations within two hinged semi-cylindrical assemblies, and that is pulled along a guy manually by a winch-operated cable.

The present invention is directed to a crawler which, operating by remote control, acts as a tractor to push/pull large payloads such as inspection and maintenance appendages for inspecting, cleaning and lubricating guys, along a cable.

GENERAL DESCRIPTION OF THE INVENTION

The crawler of the present invention comprises two diametrically opposed continuous track systems (upper and lower) that when assembled together have a channel through the centre which partially envelops the cable/pipe/bar. This channel maximizes the track contact surface and also has a layer of material to increase grip. A single motor may provide direct drive to the lower track and indirect drive to the upper track. Tension

adjusters fixed between the upper and lower halves allow the clamping force – and therefore traction – to be increased or decreased as required, whilst moving along the cable. The drive from the motor to the endless track systems is preferably a chain drive.

5

The crawler is preferably constructed so that majority of its weight is underneath the cable/pipe/bar, which maintains the crawler in an upright position as it moves along. Maintenance and inspection appendages may be connected to the crawler by a quick release coupling.

10

The crawler is typically dimensioned to enable it to move along a cable/pipe/bar of any diameter greater than 20mm. The nature of the continuous track drive mechanism is such that each crawler is capable of moving along cables of a range of diameters, above or below which a larger or smaller sized continuous track may be needed.

15

Certain crawler component characteristics will vary slightly depending on the required application. For instance, the size and/or quantity of the track shoes may vary depending on the requirement. The track saddles are suitably made of aluminium on smaller diameter cable/pipe/bars or steel on larger sizes. The material lining the track saddles may need to be harder or softer, thinner or thicker, more hard wearing, or oil resistant. The track drive chain typically consists of a double chain, however when the device is to be used on larger sized cable/pipe/bar, triple or quadruple chains could be used. The tension adjusters may be actuators or pneumatic/hydraulic cylinders. Motor power can be supplied by hard wired cable or battery.

20

25

30

By way of illustration, the following is a description of one embodiment of a crawler according to the present invention, the embodiment being specifically designed for remote inspection and optionally cleaning or lubrication of tensioned steel cables. The operator mounts the crawler and a maintenance or inspection device attached or linked to it on the guy and then drives the

assembly along the guy by remote control. The crawler may push or pull the maintenance or inspection device.

In the accompanying drawings:

5

Figure 1 is a diagrammatic perspective view showing the essential components of a remote-controlled crawler according to the present invention;

10 Figure 2 is a diagrammatic section through the crawler in a plane perpendicular to the axis of a guy on which it is set; and

Figure 3 is a diagrammatic perspective view of the drive mechanism of the crawler engaged on a guy, showing the essential components of the
15 continuous track drives;

The crawler comprises two separate aluminium housings 1, 2 accommodating drive mechanisms that, when fixed together, clamp around a guy 35 and which allows the device to move along the guy. Each housing
20 contains a drive mechanism 3, the two mechanisms comprising two separate continuous track systems positioned opposite each other. Mounted inside each housing 1, 2 is a drive shaft 7, 15 and an axle 11, 18, on each of which are positioned track sprockets 29 over which run endless track chains 30.

25 The upper housing 1 and lower housing 2 are mounted together by sliding four guide rods 27 fixed in the lower housing 2 into four guide bearings 28 fixed in the upper housing 1, and sliding the two housings towards each other. The guide rod bearings constrain the movement between the upper and lower housings to a single plane in which the tension can be adjusted,
30 thereby keeping the two continuous track drives properly aligned. Two actuator pistons 22 are arranged to slot into fixing points in the lower housing 23 which keeps the upper and lower housings coupled together and which

can act to increase or decrease the grip exerted by individual track saddles 32, each mounted on tracking 31 connected to the track chains 30, which increase or decrease the surface area in contact with the guy. The track saddles are lined with track pads 33 which are made from a material that improves traction, such as polyurethane, rubber, or a silicone compound. The continuous track system mounted in the lower housing acts together with the continuous track system mounted in the upper housing so that the track saddles simultaneously clamp on to the guy 35 from opposing sides. A motor 4 is arranged to drive both lower and upper continuous track systems in order to move the crawler along the guy.

The lower housing 2 on to which the motor 4 is attached, and other components weigh substantially more than the upper housing 1 and the components attached to housing 1. During mounting, the lower housing is positioned on the guy to ensure that the centre of gravity of the assembled crawler is directly underneath the guy. This keeps the crawler upright when going along the guy, i.e. it does not rotate around the guy as it goes along.

The lower and upper continuous track systems are driven by the single electrical motor 4 to which power is supplied via a cable in Figure 1. The direct drive to the lower continuous track system is via a motor shaft 5, a motor drive sprocket 6 on shaft 5 and a lower drive shaft 7 and a lower drive sprocket 8 on shaft 7 and a lower drive chain 9 running over both of sprockets 6 and 8.

The upper continuous track system is driven by power transmitted from the lower drive to the upper drive by a pair of spur gears 12, 13 that reverse the direction of the lower drive so the facing sections of the upper and lower continuous tracks move in the same direction. The lower drive shaft gear 12 meshes with the upper drive shaft gear 13 on which is fixed a drive sprocket over which runs an upper drive chain 17, which then runs over an idler sprocket 14 and then runs over an upper drive shaft sprocket 16 and lastly

runs over a tensioning sprocket 19. A sprung tensioner 20 automatically adjusts the tension of the upper drive chain, and the idler sprocket 14 provides clearance for the sprung tensioner 20 to function. The upper drive shaft sprocket 16 is positioned on the upper drive shaft which provides the driving force to the upper continuous track system.

In the space between the track sprockets 29 adjacent the side of each track chain 30 opposite the side in contact with the guy, is a support block 34 connected to both sides of each housing A and B in such a position that it keeps the portion of the track chain running over it pressed against the surface of the guy, thereby maintaining a constant clamping force over the full length of each continuous track. The support block is made from a hard-wearing material with a low coefficient of friction (such as Nylon) so that minimal drive motor power is lost.

A key function of the crawler is the ability to adjust the tension between the upper and lower housings and thereby adjust the amount of grip the continuous tracks have. Guys do not have a uniform inclination as the upper portions are naturally more steep than the lower portions, which means greater tension is required to traverse upper portions than the lower portions. Guys may be narrower in some places than in others, and narrowness below a certain threshold will cause the crawler to lose grip and can prevent it from traversing further. Grease on the surface of the guy will also reduce traction and may also prevent the crawler moving along it. By supplying current to two linear actuator power connections 24, the actuator motors 21 may be made to retract the piston rods 22, thereby squeezing the lower and upper housings more closely together and thus compressing both continuous drive tracks more strongly against the guy, thereby increasing traction and allowing the crawler to continue moving along the guy.

Conversely, guys may be thicker or more rough in some locations than in others which means the grip could become too great and the crawler would

be unable to move further. By reducing the current to the actuator the piston rods will extend, thereby reducing the clamping force exerted by both continuous drive tracks on the guy and allowing the crawler to continue moving along the guy. Additionally, in case of failure of motor 4, the tension
5 can be fully released allowing the crawler to be retrieved for repair.

Some guys are in the form of a rope that is formed by weaving individual wire strands in a single direction. If an individual wire on the surface breaks a loose end may rise up a few millimetres from the surface of the guy, pointing
10 in the weave direction. Such an obstruction might prevent the crawler from moving further, but this can be remedied by extending the actuator piston rods so that the continuous track can pass over the obstruction.

If a crawler is to be used on a guy which may have undergone significant
15 surface damage, for example resulting in multiple loose wire strands creating an obstruction that even loosening the traction would not be able to overcome, and which might potentially get caught in the continuous track drive mechanism thereby rendering the crawler immobile and potentially unable to be retrieved, it is desirable to fix cameras to the front and rear of
20 the crawler or any appendage attached to it so that video images of the guy surface can be recorded and wirelessly streamed to a screen on the ground so the operator has a live visual as the crawler moves along. This should allow the operator to identify potentially unpassable obstructions and avoid the crawler becoming irretrievably stuck.

25

The power supply for the crawler may be a 230V or 380V mains supply, which is hard wired by cable to the crawler, or from batteries placed inside the crawler. If the actuators need a different operating voltage, this may be derived from a transformer, which may be located in the controller or in the
30 crawler depending on whether current will be sufficient when the crawler is at its maximum distance from the operator for the actuator to function.

The crawler may be operated from a remote controller connected to crawler by cable or wireless with commands transmitted by RF with the following functions:

- 5 i. Button for crawler power On/Off
- ii. Button to switch motor phase and reverse the direction the crawler is traversing in
- 10 iii. Frequency controller to adjust the motor speed and thus the crawler speed along the guy
- iv. Power cable runs from actuator power connection 24 to PLC in control panel with touchscreen having programmed commands to control the
15 actuators and change the clamping force on the guy.

At the front and rear ends of the crawler and of any appendage to one or other end of the crawler, return switches may be provided arranged to signal the motor to go into reverse when it reaches the end of the guy so the
20 crawler will automatically return to its starting place.

Inspection and maintenance appendages may be connected to the front or rear of the crawler by a quick release coupling. Such appendages may be an MFL inspection appendage, a lubricating appendage that pumps a fixed
25 amount of grease on to the guy and removes any excess; and a cleaning appendage to remove grease, fouling deposits painted and preservative coatings, and lubricants. Such a cleaning appendage can be used simultaneously with the lubricating appendage to pump degreasing agent, if required.

30

In the drawings, the numbering of the components shown is as follows:

1. Upper housing
2. Lower housing
3. Drive mechanism
4. Motor
- 5 5. Motor shaft
6. Motor drive sprocket
7. Lower drive shaft
8. Lower drive shaft sprocket
9. Lower drive chain
- 10 10. Bearing
11. Lower axle
12. Lower drive shaft gear
13. Upper drive shaft gear
14. Idler sprocket
- 15 15. Upper drive shaft
16. Upper drive shaft sprocket
17. Upper drive chain
18. Upper axle
19. Upper drive chain tensioning sprocket
- 20 20. Sprung tensioner
21. Linear actuator
22. Piston rod
23. Piston lower housing fixing
24. Actuator power connection
- 25 25. Actuator reinforcement bridge
26. Manual tension adjuster
27. Guide rod
28. Guide bearing
29. Track sprocket
- 30 30. Track chain
31. Track bracket
32. Track saddle

- 33. Track pad
- 34. Track support
- 35. Guy

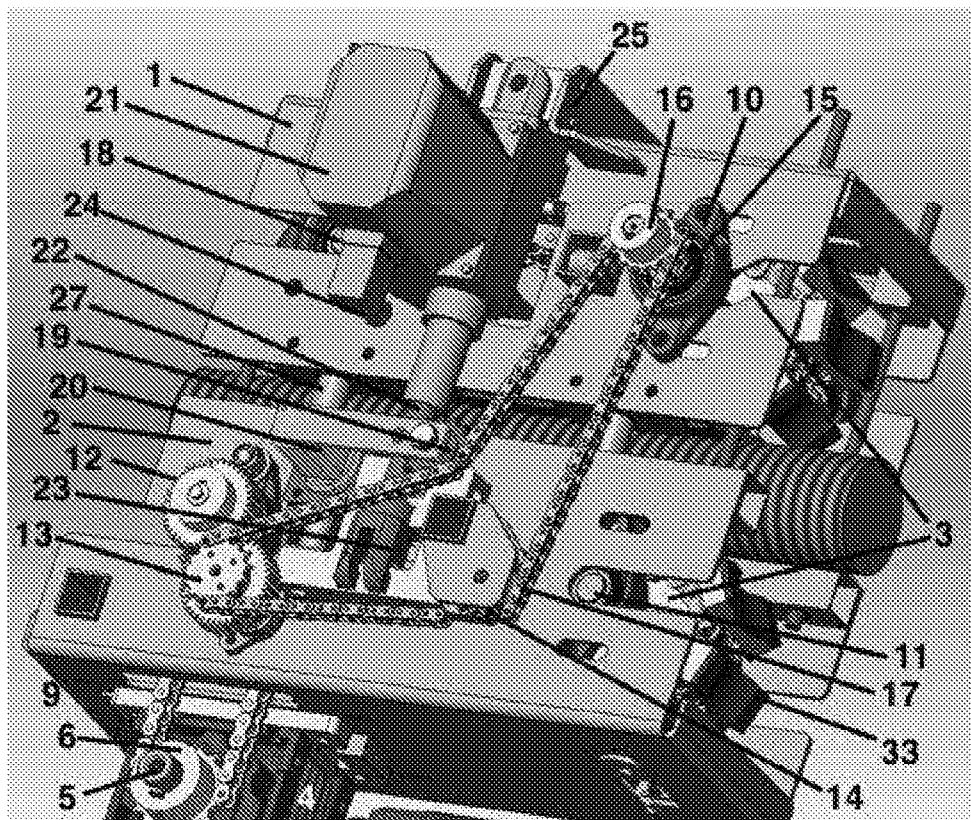


Fig.1

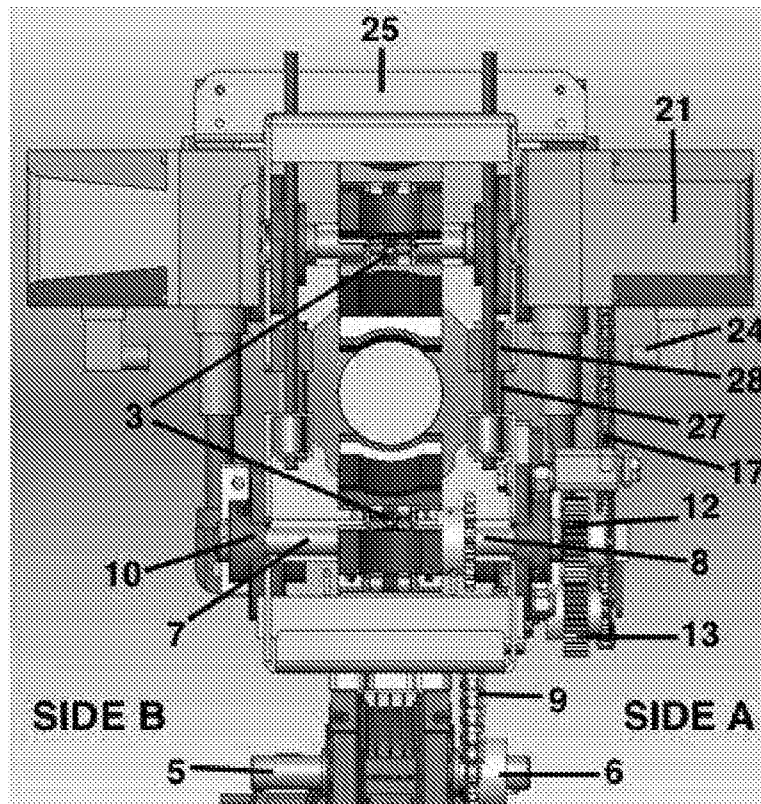


Fig. 2

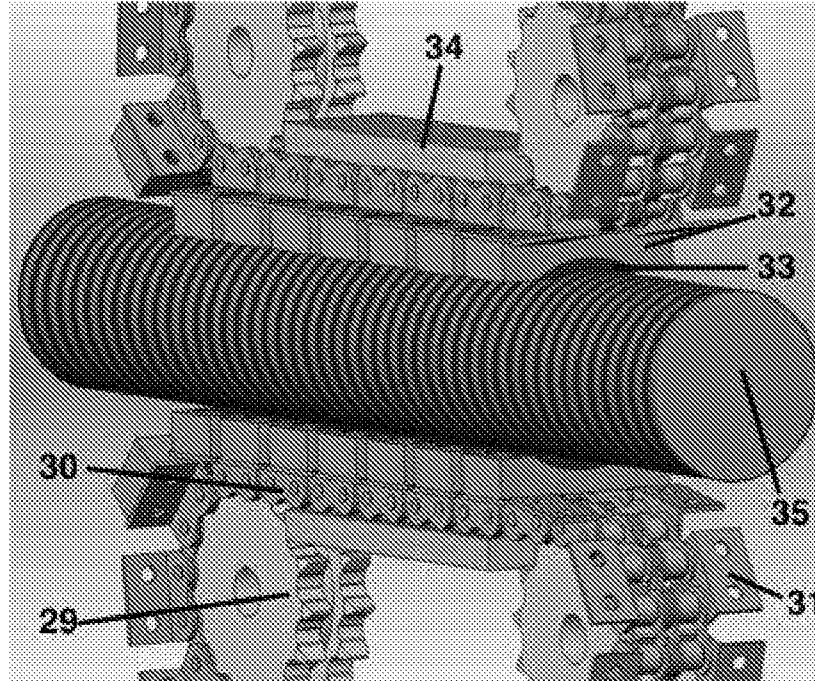


Fig. 3