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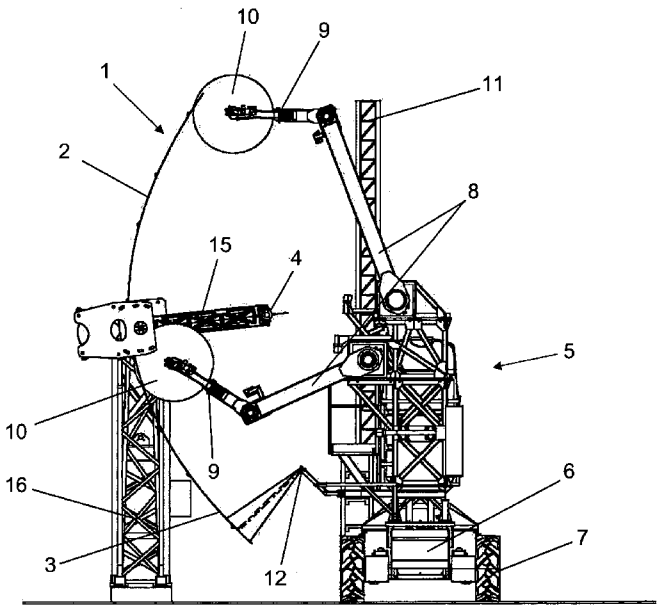

Fig. 4

(57) Abstract: The present invention relates to a cleaning system for cleaning parabolic trough collector plants made up of cleaning vehicles (5) with moving means (7), cleaning means, and operating means thereof. The cleaning vehicles (5) are autonomous and independent of one another, and have navigation means (11,12) guiding and steering the cleaning vehicle (5) in its movement along the plant. The navigation means are made up of a relative navigation system with an inertial unit and distance sensors (12) which measure the distance of the cleaning vehicle (5) to the parabolic trough collector (1), and an absolute navigation system with a GPS positioning sub-system. A control system integrates and controls the cleaning means, operating means, moving means (7) and navigation means (11, 12) of the cleaning vehicles (5).

WO 2012/126559 A2

CLEANING SYSTEM FOR CLEANING PARABOLIC TROUGH COLLECTOR PLANTS AND CLEANING METHOD USING SAID SYSTEM

Technical Field of the Invention

The present invention belongs to the technical field of mechanised cleaning systems for cleaning large surfaces, specifically large reflective surfaces with a noticeable concave curvature, and more specifically to the mechanised cleaning of large parabolic trough collector plants.

Background of the Invention

Many systems and methods for the mechanised cleaning of large surfaces such as buildings, large windows, glass panels, monuments, and specifically heliostats, trackers and photovoltaic solar installations and large parabolic trough collector plants for heating the fluids flowing inside the pipes fixed to said parabolic trough collectors have emerged in the last few years. Articulated arms which apply pressurised water or brushing devices applied by articulated arms stand out among them. The more modern methods try to be as automated as possible for the purpose of reducing labour and human control to achieve the greatest efficiency possible, so many of these systems incorporate robots for cleaning.

In terms of the particular case of parabolic trough collector plants, these need a periodic maintenance for their correct operation and for making the most out of the energy which can be obtained from the same. One of the main maintenance activities which directly influences the energy produced is the reflectivity of the mirrors and the pipe making up the collector. This reflectivity depends on several factors dirt build-up both on the mirrors and on the tube through which the fluid flows being a determining factor. To reduce the dirt and maintain an optimum cleaning rate the periodic programming of cleaning activities is necessary for maintaining the reflectivity of the mirrors in optimum values and the absorbance of the tube and thus obtaining the maximum performance of the plant.

The characteristics of these collector plants are such that they make the cleaning the same a specific problem.

Each collector longitudinally measures more than one hundred meters and has a height of several meters. The collector is divided into symmetrical upper and lower parts, depending on whether the part is above or below its axis. The collectors can have different sizes, but usually each of them can be formed from approximately between several hundred and one thousand square meters of mirror divided into

facets. Each collector has hundreds of facets of mirror with a separation therebetween and organised into rows and columns both in the upper part of the collector and in the lower part.

The shape of the collector is parabolic trough-like, therefore the facets forming it are curved facets, with different angle of curvature according to their arrangement in the collector. In the focal point of the paraboloid a pipe through which a fluid flows which rests on the collector is arranged by means of a structure joining the support of the pipe with the paraboloid in its axis. The cleaning system must therefore be such that the cleaning tool used is capable of adapting to the curvature of the mirrors such that the entire surface of the collector, both the lower and upper parts can be cleaned, overcoming the tube and its support structure, as well as the structure for supporting and actuating the collector assembly.

In the collector cleaning operation, both the mirrors and the pipe must be cleaned. The cleaning of the mirrors is very delicate since they must be cleaned in an efficient manner but without damaging them by wear or breakage, which involves a precise control of the distance of the cleaning tool at all times with respect to the mirror, as well as a careful selection of the cleaning tool material if this is to be performed by contact. The pipe is also very delicate since a breakage thereof would imply serious problems for the plant, since it renders a complete loop of collectors useless and needs the operation for emptying the fluid and repairing said pipe. The arrangement of the pipe also involves controlling the path and position of the cleaning tool and of the arm supporting it to prevent impacts which cause damage to the same.

The parabolic trough collector plants are organised in hundreds of loops, each loop containing several collectors joined linearly and in parallel forming a U. Therefore in each plant the collectors are in the order of hundreds of linear kilometres, and this is a particular characteristic of these plants since the cleaning vehicle which is used to clean them must travel all these kilometres while cleaning hundreds of thousands of square meters of mirrors along the path, which must be done efficiently and quickly. This implies that cleaning a complete plant requires a lot of time and the plant must also be cleaned with a determined frequency for maintaining the reflectivity of the mirrors, therefore if the cleaning system is not capable of covering the entire path in a determined time, more cleaning equipment is needed, implying a greater cost.

The terrain of the plant which is uneven introduces another additional characteristic typical of these plants. Said unevenness must be absorbed by the cleaning system such that the movement of the cleaning tool is not affected by the

same, maintaining the distance relative to the mirrors constant with respect to any unevenness of the terrain. An impact with the mirrors or the pipe causing damage therein is thus prevented. Likewise, in the rainy season the terrain can become muddy and under these circumstances the vehicle must avoid damaging the paths due to its weight as it passes.

The frequency of cleaning is determined by several factors, among them the quality of the cleaning system used. If the cleaning system is not of high quality, the frequency of cleaning must be increased, which results in a greater number of equipment necessary for performing the cleaning and therefore a greater investment cost thereon. If in contrast the cleaning is of quality, the frequency of cleaning is lower, less equipment is needed and the investment is lower. If the cleaning equipment needs human operation of any type the costs of the plant increase due to the personnel cost throughout the service life of the plant. Likewise heavy cleaning equipment damage the terrain of the plant, making the investment on machinery which repairs said terrain of the plant necessary or preventing its use in rainy seasons.

In terms of the cleaning methods implemented for cleaning large surfaces, automatic car wash services stand out where rotating rollers and pressurised water clean the surfaces of the cars for cleaning them. Documents GB1071366, US3481346 and US2004/0064908, for example, show inventions based on moving the object to be cleaned and not on moving the cleaning vehicle which will perform the cleaning as is the case in question. Another type of cleaning devices are those which are intended for cleaning tunnels, walls, panels, etc., such as those shown in documents EP0668400, ES1034481 and EP0874086. All these systems describe the cleaning of large surfaces by means of rollers and pressurised water by means of tools which clean as the vehicle moves and which have a structural shape adapted to the shape of the surface to be cleaned.

In terms of cleaning solar power plants of parabolic trough collectors or solar panels, the method was similar to the usual surface cleaning method, i.e., by using brushes and/or pressurised water for cleaning the mirrors which are on the collectors, as shown by documents ES1069495, WO2010/106195, ES2316317, ES2267393, and WO2010/142837.

In the current cleaning systems for cleaning parabolic trough collectors, the solution to the cleaning problem thereof has been dealt with in different ways, the more common being using a large and heavy vehicle which includes a tool that performs the cleaning on said vehicle. This tool consists of a group of pressurised water dispensers

and can additionally incorporate rotating rollers or brushes for cleaning the mirrors by contact. In both cases the tool adopts the parabolic shape of the collector and its size is determined by the height of said collector, which means heavy tools, affecting the weight of the vehicle. The vehicle usually moves in parallel to the collector while cleaning the same in a longitudinal direction. Each vehicle is provided with one or two tools, such that each cleans one half of the collector (the upper or the lower part). Furthermore, these cleaning vehicles need at least one operator to operate it. These systems have a series of problems, including the low cleaning quality, especially in the cleaning systems for cleaning exclusively with pressurised water, the frequency of cleaning must be increased and therefore the investment on equipment and labour. Furthermore, since the intervention of at least one operator is needed the costs per cleaning operation increase. The heavy vehicles damage the terrain of the plant, and the vehicles which longitudinally clean the collector while moving forward are more susceptible to being affected by the unevenness of the terrain and therefore are more susceptible to damaging the collectors. Another problem is that the cleaning tools which clean as the vehicle moves and which have the shape of the collectors have to perform manoeuvres to overcome the supports of the tube as well as the supports of the collectors themselves and the joints between collectors.

A system which achieved an efficient cleaning of the parabolic trough collectors preventing the drawbacks existing in the systems of the state of the art above was therefore desirable.

Description of the Invention

The present invention solves the problems existing in the state of the art by means of a cleaning system for cleaning parabolic trough collector plants, which is made up of a plurality of cleaning vehicles moving along the plant cleaning the parabolic trough collectors.

The cleaning vehicles used are small and light cleaning vehicles for reducing their impact on the collector plants as much as possible.

Each of these cleaning vehicles has a chassis in which there are arranged moving means for moving the cleaning vehicle, cleaning means for cleaning the parabolic trough collectors, and operating means for operating the cleaning means which position said cleaning means on the surface of the parabolic trough collectors to be cleaned, and move them for cleaning the collectors.

The cleaning vehicles object of the present invention are autonomous and independent of one another, i.e., they do not need an operator to operate them during

the cleaning process, which reduces the operating costs. To that end they additionally have navigation means in their chassis, guiding and steering the cleaning vehicle in its movement along the parabolic trough collector plant. These navigation means consist of a relative navigation system and an absolute navigation system.

The relative navigation system is made up of an inertial unit and a group of distance sensors, which measures the distance of the cleaning vehicle to the parabolic trough collector.

The absolute navigation system has a GPS positioning sub-system. The absolute navigation system can additionally incorporate a wireless communication system for communicating the cleaning vehicles with a determined point of the plant for obtaining a greater precision in the positioning thereof. The cleaning vehicles additionally have a control system integrating and controlling the cleaning means, the operating means thereof and the moving and navigation means of the vehicles for providing the correct movement of the cleaning vehicles and an efficient cleaning of the parabolic trough collectors at the same time.

The operating means for operating the cleaning means have particularly at least one robotic arm to which said cleaning means are fixed.

Furthermore, the cleaning means have at least one distance sensor, which measures the distance of these cleaning means to the surface of the parabolic trough collector.

Thus, as a result of the distance sensors, the cleaning means can be brought precisely and safely closer to the surface of the parabolic trough collector without damaging it. Once positioned, for performing the cleaning tasks, the robotic arm moves the cleaning means in a plane perpendicular to the parabolic trough collector and perpendicular to the direction of the cleaning vehicle, following the surface of said parabolic trough collector, while said cleaning vehicle is stopped. In other words, the vehicle does not move forward and actuates its cleaning means at the same time, as occurs in the systems of the state of the art, but first moves forward, then stops, and then positions the cleaning means and actuates them. When it finishes, it removes the cleaning means and moves again.

Since the movement is in the plane perpendicular to the collector, the supports of the tube fixed thereto are not obstacles for cleaning the collector since they only come into contact with the bristles or hair of the cleaning means and not with any rigid element of the cleaning vehicle, not having to modify the trajectory of the tool in these sections.

The operating means for operating the cleaning means are preferably made up of two robotic arms. A first robotic arm brings the cleaning means closer to the surface of the upper part of the parabolic trough collector and moves them along this surface cleaning this upper part. A second robotic arm brings the cleaning means closer to the surface of the lower part of the parabolic trough collector and moves them along this surface cleaning this lower part.

In terms of the cleaning means, these are particularly made up of a straight and horizontal rotating roller fixed to the end of the robotic arms, which rotates driven by an electric motor, and of a plurality of nozzles connected to a hydraulic system which spray pressurised water. The function of the hydraulic system is to transport the water from the water tank to the nozzles, and is made up of pumps, flow valves, check valves, flow regulating valves, the nozzles and the pipes for its transportation.

Therefore, in this case, the cleaning means do not adopt the parabolic trough shape of the collector as occurs in the systems existing in the state of the art, but it will be a straight tool which will clean the collector from bottom to top or from top to bottom, the trajectory of the robotic arm, not the tool, is that which is adapted to the shape of the collector. It allows optimally sizing the cleaning means, since their length will not thus be conditioned by the height of the collector, and the sizes of these cleaning means may be smaller so the cleaning vehicle may also be smaller and lighter.

According to the particular embodiments of the invention, the cleaning vehicles of the cleaning system can have a locating system for locating broken mirrors in the parabolic trough concentrator as well as a locating system for locating leakages of the fluid flowing inside the pipe fixed to the parabolic trough collector.

An efficient high safety cleaning of the parabolic trough collectors is achieved with this system, since neither the collectors nor the pipes fixed thereto are damaged by accidental impacts from the cleaning means (such as the rollers) or from the operating means (such as the robotic arms), as occurs in other methods existing in the state of the art. Furthermore, since the vehicles are autonomous and independent of one another, the presence of operators for driving them or for the cleaning itself is not necessary, a considerable cost saving being achieved.

Another object of the present invention is a cleaning method for cleaning parabolic trough collector plants which uses the cleaning system described above and which is made up of the following steps:

First, the cleaning vehicles are distributed along the entire plant, positioning each of them at a first end of a parabolic trough collector.

Next the cleaning vehicles are positioned in parallel to the parabolic trough collector by means of their moving means and their navigation means, and the vehicles are stopped.

Once the cleaning vehicles are stopped, the operating means position the cleaning means on the surface of the first section of the parabolic trough collector to be cleaned, and these clean the first section of the parabolic trough collector by means of moving the cleaning means driven by the operating means in a plane perpendicular to the parabolic trough collector and perpendicular to the direction of the cleaning vehicle. Thus, the means follow the surface of the parabolic trough collector, while the cleaning vehicle is stopped. In other words, in this method the vehicle first moves forward, then stops, and then positions the cleaning means and actuates them. When it finishes, it removes the cleaning means and moves again.

The cleaning means are then separated from the surface of the first section of the already cleaned parabolic trough collector, and once these are separated the cleaning vehicles move forward towards the next section of the parabolic trough collector by means of their moving means and their navigation means. Subsequently, the cleaning vehicle stops again to again clean the next section, the different sections of the collector are thus successively cleaned.

Once the last section of the parabolic trough collector is cleaned, the cleaning means are separated from the surface of this last cleaned section, and the cleaning vehicles autonomously move to the next parabolic trough collector to be cleaned, the entire process being repeated again.

According to a particular embodiment of the method, in the step of cleaning the section of the parabolic trough collector, the surface of the collector is sluiced by means of pressurised water sprayed by the nozzles of the cleaning means.

According to an alternative embodiment, in the step of cleaning, the surface of the collector is sluiced by means of pressurised water sprayed by the nozzles of the cleaning means, and the surface of the collector is also sluiced by means of the straight and horizontal rotating roller driven by the operating means. Furthermore, a rinsing is preferably performed after sluicing with the roller.

A high quality high safety cleaning of the parabolic trough collectors is performed by means of this method, since neither the collectors nor the pipes fixed thereto are damaged by accidental impacts from the cleaning means or from the operating means as can occur in other methods existing in the state of the art. Furthermore, since the cleaning method is performed by vehicles which are

autonomous and independent of one another, the presence of operators for driving them or for the cleaning itself is not necessary, a considerable cost saving being achieved.

Description of the Drawings

To facilitate the understanding of the invention an embodiment of the invention will be described below with an illustrative and non-limiting character referring to a set of drawings.

Figure 1 schematically shows a side view of a collector and the pipe with the fluid to be heated fixed thereto.

Figure 2 is an elevational view of the collector and the pipe of the above figure.

Figure 3 is a schematic view of a loop of four collectors of a parabolic trough collector plant.

Figure 4 schematically shows a cleaning vehicle of the cleaning system object of the present invention in the position for cleaning the collector and the pipe of Figures 1 and 2.

Figure 5 is a schematic plan depiction of the cleaning vehicle in the position for cleaning the collector and the pipe.

These drawings refer to a group of elements which are:

1. parabolic trough collectors
2. upper part of the collector
3. lower part of the collector
4. pipe through which the fluid to be heated by the collector flows
5. cleaning vehicles
6. chassis of the cleaning vehicle
7. moving means of the vehicle
8. robotic arm
9. nozzles
10. rotating roller of the cleaning means
11. GPS positioning system
12. distance sensors
13. first end of the parabolic trough collector
14. second end of the parabolic trough collector
15. support of the pipe through which the fluid to be heated flows
16. support of the collector

Description of the Preferred Embodiments of the Invention

The object of the present invention is a cleaning system for cleaning parabolic trough collector plants, which is made up of a group of cleaning vehicles 5 moving along the plant cleaning the parabolic trough collectors 1.

As can be observed in Figures 4 and 5, each of these cleaning vehicles 5 is in turn made up of a chassis 6, in which there are arranged moving means 7 of the cleaning vehicle 5, cleaning means for cleaning the parabolic trough collectors 1, and operating means for operating the cleaning means which position said cleaning means on the surface of the parabolic trough collectors 1 to be cleaned, and move them, thus cleaning the collectors 1.

The chassis 6 is a small and light platform and has the elements necessary for performing the movement for translating and steering the cleaning vehicle 5. It will particularly have rear wheel drive and optionally front wheel drive, and front wheel turning or steering. The systems for actuating both the drive and the direction will be controlled by electric systems, even though the final actuation is of another type, i.e., mechanical, hydraulic, etc. Even though the drive is hydraulic, for example, the instructions are transmitted to valves and pumps by means of an electric system.

The cleaning vehicles 5 are autonomous and independent of one another, therefore they have navigation means 11,12, in their chassis 6 guiding and steering the cleaning vehicle 5 in its movement along the parabolic trough collector plant 1. These navigation means 11,12 are in turn made up of a relative navigation system and an absolute navigation system.

The relative navigation system has an inertial unit (made up of gyroscopes, accelerometers, encoders and odometers), and a group of distance sensors 12 which measures the distance of the cleaning vehicle 5 to the parabolic trough collector 1. These distance sensors are preferably ultrasound sensors.

Furthermore, for facilitating the navigation of the cleaning vehicle 5, it can have obstacle presence sensors arranged in the rear and front part.

In addition, the absolute navigation system has a GPS positioning sub-system 11, which will consist of a GPS antenna and receiver.

Additionally, according to a particular embodiment this absolute navigation system comprises a wireless communication system for communicating the cleaning vehicles 5 with a determined fixed point of the plant, such as for example a radio receiver in each vehicle and a fixed system with radio emitter in the plant, or any wireless system. This additional communication will provide a greater precision in positioning the vehicle.

Furthermore, the cleaning vehicles 5 have a control system integrating and controlling the cleaning means and the operating means for operating them, and the moving means 7 and the navigation means 11,12 for moving the cleaning vehicles 5 and an efficient cleaning of the parabolic trough collectors 1.

The cleaning vehicles 5 can optionally be provided with a communication system with remote operators for remote control thereof.

The operating means for operating the cleaning means of the present invention particularly have a robotic arm 8 to which the cleaning means are fixed.

In this embodiment the cleaning means have at least one distance sensor 12, which measures the distance of said cleaning means to the surface of the parabolic trough collector 1. After the cleaning means are positioned on the surface of the parabolic trough collector 1 for cleaning said collector 1, the robotic arm 8 moves the cleaning means in a plane perpendicular to the parabolic trough collector 1 and perpendicular to the movement direction of the cleaning vehicle 5. The cleaning is thus performed, the cleaning means following the surface of the parabolic trough collector 1, while the cleaning vehicle 5 is stopped. To obtain this movement, the robotic arms 8 have at least two degrees of freedom, and will consist of two metal structures the joints of which have motors or electric servomotors with their reduction gears.

Figures 4 and 5 show a preferred embodiment of the cleaning system for cleaning collector plants based on robotic arms 8 providing the cleaning means with the movement described above. In this preferred embodiment the cleaning means are made up of two robotic arms 8. A first robotic arm 8 brings the cleaning means closer to the surface of the upper part 2 of the parabolic trough collector 1, and moves them along the same cleaning said upper part 2. A second robotic arm 8 brings the cleaning means closer to the surface of the lower part 3 of the parabolic trough collector 1, and moves them along the same cleaning said lower part 3.

In terms of the cleaning means, according to a preferred embodiment of the invention shown in Figures 4 and 5, the cleaning means are made up of a straight and horizontal rotating roller 10 fixed to the end of the robotic arms 8, which rotates driven by an electric motor, and of a group of nozzles 9, which are connected to a hydraulic system and which spray pressurised water for cleaning the collector 1. The pressurised water will be sprayed by the nozzles 9 before the roller 10 passes along the surface to be cleaned and optionally once the roller has passed for rinsing the surface.

The cleaning vehicles 5 preferably have at least one additional nozzle 9 fixed to the chassis 6 and connected to the hydraulic system which sprays pressurised water

towards the pipe 4 fixed to the collector 1 through which the fluid to be heated by said collector flows for cleaning this pipe 4.

As can be observed in Figure 5, according to a preferred embodiment of the operating means, the first and second robotic arms 8 are vertically misaligned to prevent dirtying the one which is on top of the other and wetting the one which is underneath in the cleaning operation.

According to the preferred embodiments of the present invention, the cleaning vehicles 5 can have, performed by means of sensors, a locating system for locating broken mirrors in the parabolic trough concentrator 1, and also a locating system for locating leakages of the fluid flowing inside the pipe 4 fixed to the parabolic trough collector 1.

Another object of the present invention is a cleaning method for cleaning parabolic trough collector plants which uses the cleaning system described above.

In this cleaning method, the first step consists of distributing the cleaning vehicles 5 along the entire plant, positioning each of them at a first end 13 of a parabolic trough collector 1 to be cleaned. This distribution can be done autonomously by the cleaning vehicles 5 or in an assisted manner.

Next the cleaning vehicles 5 are arranged parallel to the parabolic trough collector 1 using their moving means 7 and their navigation means 11,12, and they are then stopped.

Once the cleaning vehicles are stopped, the operating means position the cleaning means on the surface of the first section of the parabolic trough collector 1 to be cleaned, and the first section of the parabolic trough collector 1 is cleaned by means of moving the cleaning means by the operating means. The movement caused by the operating means is in a plane perpendicular to the parabolic trough collector 1 and perpendicular to the direction of the cleaning vehicle 5, travelling the parabolic surface of the collector 1 from top to bottom or of bottom to top. The cleaning means thus follow the surface of the parabolic trough collector 1, as long as said cleaning vehicle 5 is stopped.

When the cleaning of the section has ended, the operating means separate the cleaning means from the surface of the first section of the parabolic trough collector 1, and the cleaning vehicles 5 move forward towards the next section of the parabolic trough collector 1 by means of their moving means 7 and their navigation means 11,12.

The movement is performed maintaining the fixed distance to the collector 1 by means of the distance sensors 12. When the cleaning vehicle 5 has to move along the

collector 1, but the distance sensors 12 can not detect it, either due to the breakage or the gaps between collectors 1, the movement will be performed assisted by the inertial unit. The movement will also be supervised by the absolute navigation system to know for sure when the end of the collectors 1 has been reached and to calibrate the relative positions.

Next the cleaning vehicle 5 is again stopped for subsequently cleaning the next section of the collector 1.

Once the last section of the parabolic trough collector 1 is cleaned, the operating means separate the cleaning means from the surface of said last section of the parabolic trough collector 1, and the cleaning vehicle 5 autonomously moves from the second end 14 of the parabolic trough collector 1 towards the first end 13 of the next parabolic trough collector 1 to be cleaned.

The step of cleaning the section of the parabolic trough collector 1 can particularly consist of sluicing the surface of the collector 1 by means of pressurised water sprayed by the nozzles 9 of the cleaning means.

Alternatively, and preferably, the step of cleaning consists of sluicing the surface of the collector 1 by means of pressurised water sprayed by the nozzles 9 of the cleaning means, and also sluicing the surface of the collector 1 by means of the straight and horizontal rotating roller 10 driven by the operating means which cleans the surface which has previously been sluiced by the water. Additionally, according to a preferred embodiment of the invention, after sluicing by means of the rotating roller 10 a subsequent rinsing of the surface is performed.

While the sluicing is performed by means of the rotating roller 10, the nozzles 9, orientated towards the next section of collector 1, will perform a sluicing by spraying water towards this section which will be sluiced by the roller 10 in the next forward movement of the cleaning vehicle 5.

Furthermore, this step of cleaning can include sluicing the pipe 4 fixed to the parabolic trough collector 1 by means of pressurised water which is sprayed by the additional nozzles 9 fixed to the chassis 6 of the cleaning vehicles 5 for cleaning said pipe 4.

Preferably, in the step of moving the cleaning vehicles 5 forward towards the next section of the parabolic trough collector 1, the pipe 4 fixed to the parabolic trough collector 1 is sluiced by means of pressurised water sprayed by the additional nozzles 9 fixed to the chassis 6 of the cleaning vehicles 5 for cleaning said pipe 4. The pipe 4 is thus cleaned while the cleaning vehicle 5 moves. This does not affect the safety of the

mirrors of the parabolic trough collector 1 because although the sluicing is being performed while the cleaning vehicle 5 moves, there is no risk of the rollers 10 or the robotic arms 8 impacting the parabolic trough collector 1 since these are withdrawn and separated from it, and furthermore, the imperfections that could exist in the terrain are not transmitted to the cleaning means.

Once the invention has been clearly described, it must be stated that the particular embodiments described above are susceptible to detail modifications as long as they do not alter the fundamental principal and the essence of the invention.

CLAIMS

1.- A cleaning system for cleaning parabolic trough collector plants comprising a plurality of cleaning vehicles (5) moving along the plant cleaning the parabolic trough collectors (1), each of these cleaning vehicles (5) comprising

- a chassis (6), in which there are arranged
- moving means (7) of the cleaning vehicle (5),
- cleaning means for cleaning the parabolic trough collectors (1), and
- operating means for operating the cleaning means, which position said cleaning means on the surface of the parabolic trough collectors (1) to be cleaned, and move said cleaning means cleaning the collectors (1),

said cleaning system is characterised in that

- the cleaning vehicles (5) are autonomous and independent of one another, additionally comprising in their chassis (6) navigation means (11,12) guiding and steering the cleaning vehicle (5) in its movement along the parabolic trough collector plant (1), and which in turn comprise
  - a relative navigation system, having
    - an inertial unit, and
    - a plurality of distance sensors (12) which measures the distance of the cleaning vehicle (5) to the parabolic trough collector (1),
  - an absolute navigation system having a GPS positioning sub-system,
- and in that the cleaning vehicles (5) comprise a control system integrating and controlling the cleaning means, the operating means for operating said cleaning means, the moving means (7) and the navigation means (11,12) for moving the cleaning vehicles (5) and cleaning the parabolic trough collectors (1).

2.- The cleaning system for cleaning parabolic trough collector plants according to claim 1, characterised in that

- the operating means for operating the cleaning means comprise at least one robotic arm (8) to which said cleaning means are fixed,
- in that the cleaning means comprise at least one distance sensor (12) which measures the distance of said cleaning means to the surface of the parabolic trough collector (1),
- and in that once the cleaning means are positioned on the surface of the parabolic trough collector (1) for cleaning, the robotic arm (8) moves them in a plane perpendicular to the parabolic trough collector (1) and perpendicular to the direction of

the cleaning vehicle (5), following the surface of said parabolic trough collector (1), while said cleaning vehicle (5) is stopped.

3.- The cleaning system for cleaning parabolic trough collector plants according to the preceding claim, characterised in that the operating means for operating the cleaning means comprise

- a first robotic arm (8) which brings the cleaning means closer to the surface of the upper part (2) of the parabolic trough collector (1) and moves them along the same cleaning said upper part (2),
- a second robotic arm (8) which brings the cleaning means closer to the surface of the lower part (3) of the parabolic trough collector (1) and moves them along the same cleaning said lower part (3).

4.- The cleaning system for cleaning parabolic trough collector plants according to any of claims 2 to 3, characterised in that the cleaning means comprise

- a straight and horizontal rotating roller (10), fixed to the end of the robotic arms (8), which rotates driven by an electric motor, and
- a plurality of nozzles (9) connected to a hydraulic system which spray pressurised water.

5.- The cleaning system for cleaning parabolic trough collector plants according to any of the preceding claims, characterised in that the cleaning vehicles (5) additionally comprise at least one additional nozzle (9) fixed to the chassis (6) connected to the hydraulic system which sprays pressurised water towards the pipe (4) fixed to the collector (1) through which the fluid to be heated by the collector flows, cleaning said pipe (4).

6.- The cleaning system for cleaning parabolic trough collector plants according to any of claims 3 to 5, characterised in that the first and second robotic arms (8) are vertically misaligned.

7.- The cleaning system for cleaning parabolic trough collector plants according to any of the preceding claims, characterised in that the distance sensors (12) are ultrasound sensors.

8.- The cleaning system for cleaning parabolic trough collector plants according to any of the preceding claims, characterised in that it comprises obstacle presence sensors arranged in the rear and front part of the cleaning vehicles (5).

9.- The cleaning system for cleaning parabolic trough collector plants according to any of the preceding claims, characterised in that the absolute navigation system comprises a wireless communication system for communicating the cleaning vehicles

(5) with a fixed point of the plant.

10.- The cleaning system for cleaning parabolic trough collector plants according to any of the preceding claims, characterised in that the cleaning vehicles (5) comprise a locating system for locating broken mirrors in the parabolic trough concentrator (1).

11.- The cleaning system for cleaning parabolic trough collector plants according to any of the preceding claims, characterised in that the cleaning vehicles (5) comprise a locating system for locating leakages of the fluid flowing inside the pipe (4) fixed to the parabolic trough collector (1).

12.- A cleaning method for cleaning parabolic trough collector plants using the cleaning system of claims 1 to 11, characterised in that it comprises the steps of

- distributing the cleaning vehicles (5) throughout the plant, positioning each of them at a first end (13) of a parabolic trough collector (1),
- positioning the cleaning vehicles (5) parallel to the parabolic trough collector (1) by means of their moving means (7) and their navigation means (11,12), and then stopping said cleaning vehicles (5),
- positioning the cleaning means on the surface of the first section of the parabolic trough collector (1) to be cleaned by means of the operating means,
- cleaning the first section of the parabolic trough collector (1) by means of moving the cleaning means by the operating means in a plane perpendicular to the parabolic trough collector (1) and perpendicular to the direction of the cleaning vehicle (5), following the surface of said parabolic trough collector (1) while said cleaning vehicle (5) is stopped,
- separating the cleaning means from the surface of the first section of the cleaned parabolic trough collector (1),
- moving the cleaning vehicles (5) forward towards the next section of the parabolic trough collector (1) by means of their moving means (7) and their navigation means (11,12), and then stopping said cleaning vehicles (5) for subsequently cleaning the next section of the collector (1),
- separating the cleaning means from the surface of said last section of the cleaned parabolic trough collector (1), and autonomously moving the cleaning vehicles (5) from the second end (14) of the parabolic trough collector (1) towards the first end (13) of the next parabolic trough collector (1) to be cleaned once the last section of the parabolic trough collector (1) is cleaned.

13.- The cleaning method for cleaning parabolic trough collector plants

according to the preceding claim, characterised in that in the step of cleaning the section of the parabolic trough collector (1) the surface of the collector (1) is sluiced by means of pressurised water sprayed by the nozzles (9) of the cleaning means.

14.- The cleaning method for cleaning parabolic trough collector plants according to claim 12, characterised in that in the step of cleaning the section of the parabolic trough collector (1) the following is performed

- sluicing the surface of the collector (1) by means of pressurised water sprayed by the nozzles (9) of the cleaning means, and
- sluicing the surface of the collector (1) by means of the straight and horizontal rotating roller (10) driven by the operating means.

15.- The cleaning method for cleaning parabolic trough collector plants according to the preceding claim, characterised in that in the step of cleaning the section of the parabolic trough collector (1), after sluicing the surface of the collector (1) by means of the rotating roller (10) said surface of the collector (1) is rinsed.

16.- The cleaning method for cleaning parabolic trough collector plants according to any of claims 12 to 15, characterised in that in the step of cleaning the section of the parabolic trough collector (1) the pipe (4) fixed to the parabolic trough collector (1) is sluiced by means of pressurised water sprayed by the additional nozzles (9) fixed to the chassis (6) of the cleaning vehicles (5) for cleaning said pipe (4).

17.- The cleaning method for cleaning parabolic trough collector plants according to any of claims 12 to 16, characterised in that in the step of moving the cleaning vehicles (5) forward towards the next section of the parabolic trough collector (1), the pipe (4) fixed to the parabolic trough collector (1) is sluiced by means of pressurised water sprayed by the additional nozzles (9) fixed to the chassis (6) of the cleaning vehicles (5) for cleaning said pipe (4).

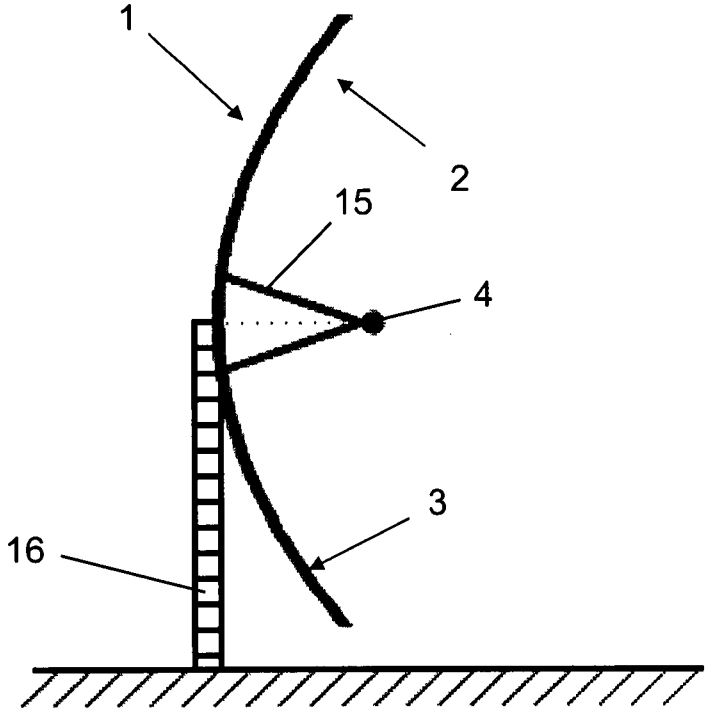

Fig. 1

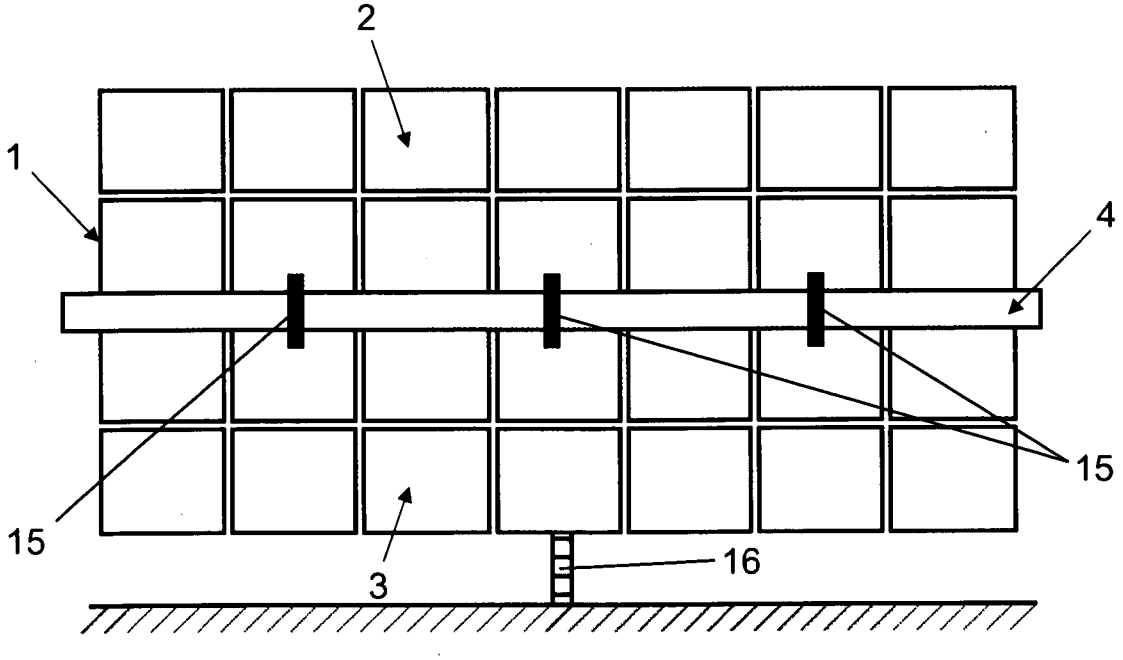

Fig. 2

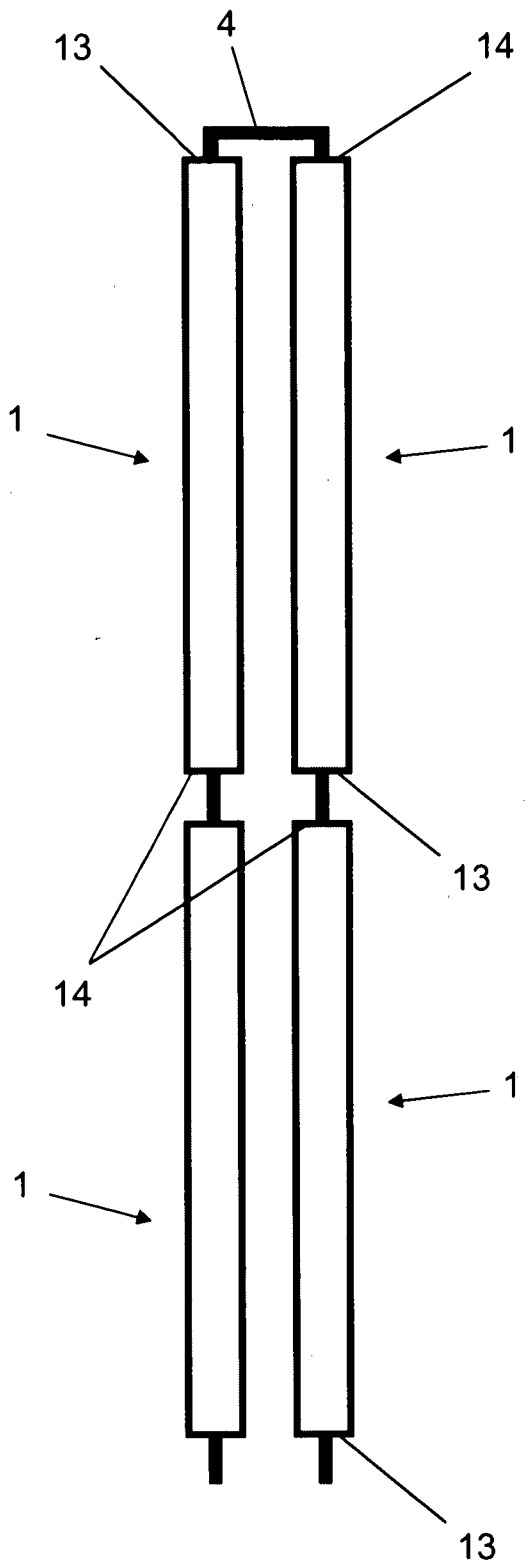

Fig. 3

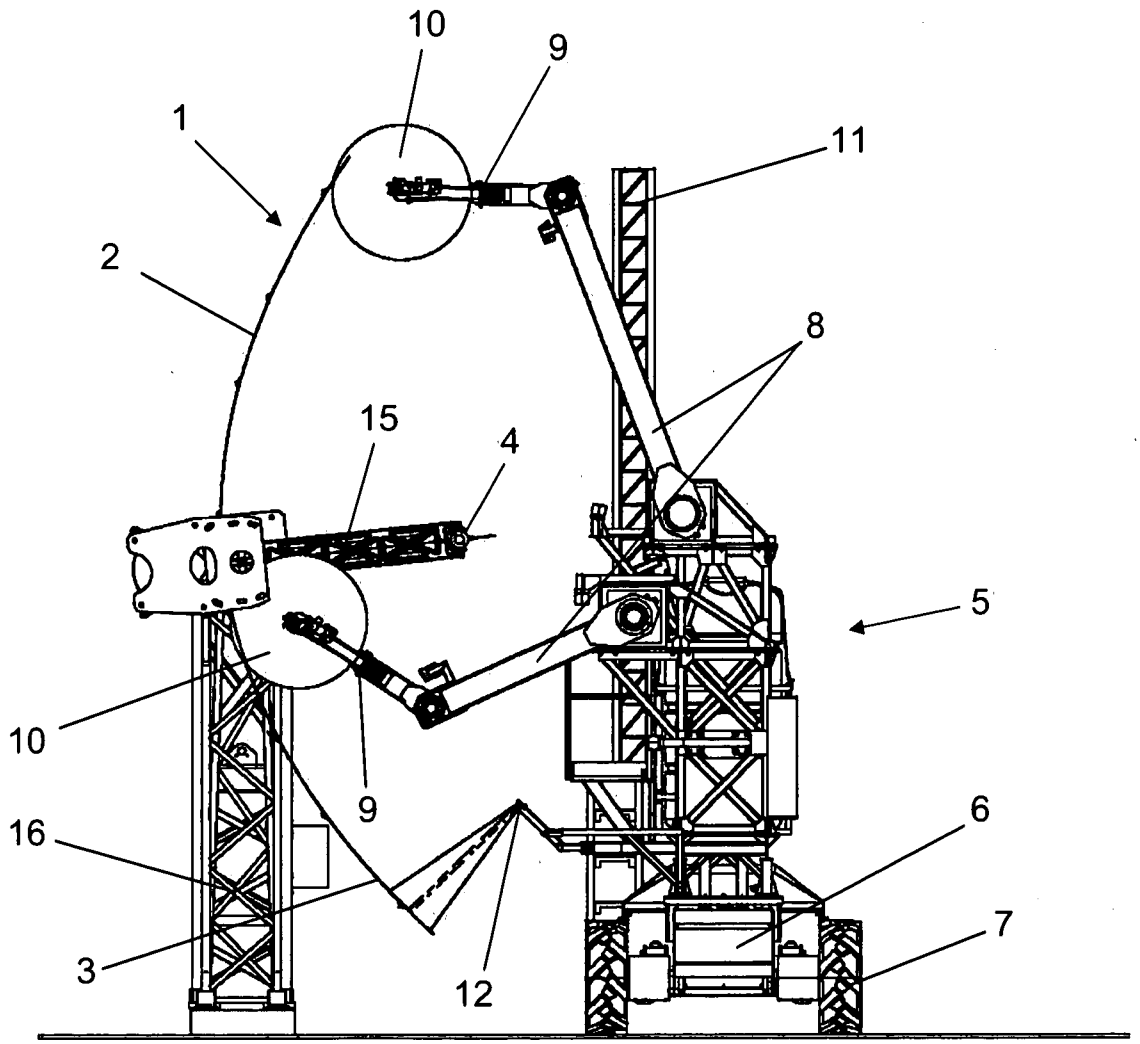

Fig. 4

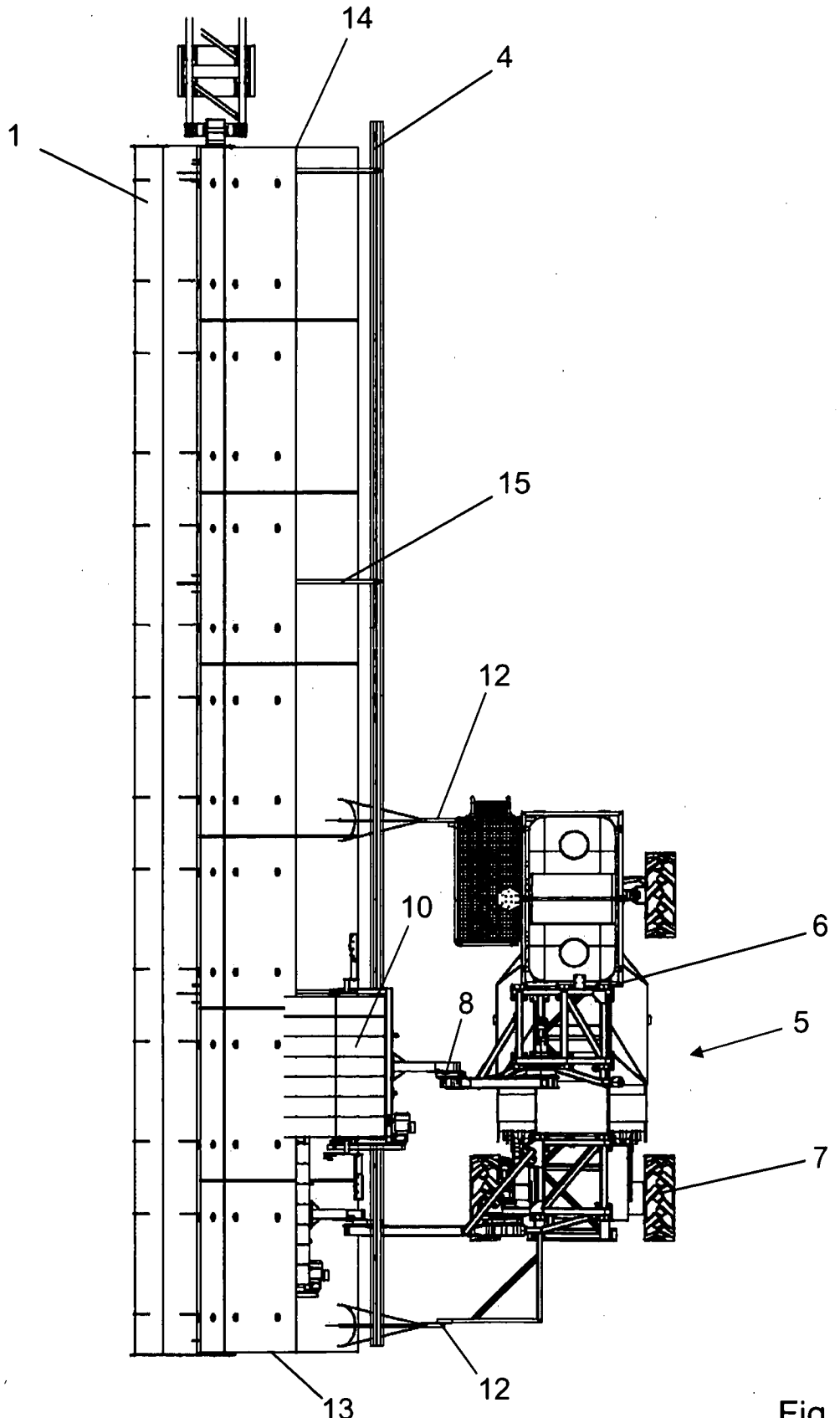

Fig. 5