ROBOT COMPRISING SERIES-ARRANGED DELTA ASSEMBLIES

The present invention relates to a robot comprising a delta assembly provided with controllable actuators, arms which are hinged to the controllable actuators, which arms are each at least partially built up of hinged elements forming a parallelogram, and an effector which is in hinged contact with said last-mentioned elements.

The present invention further relates to a device provided with legs to enable movement of the device, said legs being provided with the abovementioned robot.

Such a robot is known by the name “delta robot” and is disclosed in WO-87/03528. The known robot comprises a frame with three hinge pins which are arranged at 120 degrees to one another and around which arm portions can hinge. Said arm portions have outwardly hinging end portions which are connected to parallel, hinged elements forming a parallelogram which are rotatably connected to an end effector by means of which, for example, components can be placed in the relevant space or products or articles can be manipulated. A telescopic central arm can be used, if necessary, to rotate the end effector.

A drawback of the known robot is the amount of space taken up around it, in particular if substantial differences in height are involved when manoeuvring the robot.

It is an object of the present invention to provide an improved robot which takes up less surrounding space, even if the distance or differences in height to be bridged by the robot are substantial.

To achieve this, the robot according to the invention is characterized in that the robot comprises at least one additional delta assembly which is provided with arms which are hingedly coupled at least to said effector, and which are each at least partially built up of hinged elements forming a parallelogram, and an end effector which is in hinged contact with said last mentioned elements.

An advantage of the robot according to the invention resides in that by superimposing a number of delta assemblies and coupling them to one another in the manner described hereinabove, a slender robot is obtained the end effector of which can bridge larger differences in height in combination with a reduced lateral space occupation. The robot according to the invention is slender and remains slender also when the end manipulator bridges comparatively large differences in height, which can be attributed to the fact that that each of the delta assemblies arranged in succession, i.e. in practice they are generally arranged one on top of the other, only occupies a limited part of the lateral space required according to the prior art. This becomes apparent in particular when the end effector is moved upwards.

Besides, the robot according to the present invention can move further in all directions than the delta robot according to the prior art.

This has the additional advantage that a larger number of robots, as compared to the prior art, can be disposed next to one another, and operated, enabling a greater number and even more demanding operations for handling objects, products or articles to be carried out at the same or different height levels.

An embodiment of the robot is characterized according to the invention in that the abovementioned delta assemblies form a series of two, three or more series-arranged delta assemblies.

An advantage of this embodiment resides in that it offers greater freedom of design because the application of a number of series-arranged delta assemblies combines a greater range with an increasingly narrower robot, and vice versa. Advantageously, the actuators are not placed in all arms, but only at the front part of the first delta assembly, so that high velocities of the robot according to the invention remain possible.

A further embodiment of the robot is characterized according to the invention in that the effector of one delta assembly forms a ring-shaped body through which the scissor mechanism connected at least to said body projects, said scissor mechanism being formed by the hinged elements of the further delta assembly.

Advantageously, a very compact robot is obtained whose required lateral space during the handling operations it performs is limited and confined by the ring-shaped body within which the scissor mechanism remains at all times.

Further detailed, possible embodiments, which are set forth in the remaining claims, are mentioned together with the associated advantages in the following description.

The robot according to the invention will now be explained in greater detail with reference to the figures mentioned below, in which corresponding parts are indicated by means of the same reference numerals. In the Figures:

Figure 1 shows a possible embodiment of a robot according to the invention; and

Figure 2 shows a further possible embodiment of a robot according to the invention.

Figure 1 shows a robot 1 which, in general, is composed of two or more delta assemblies 2 which successively drive one another mechanically. In figure 1, a robot 1 is shown comprising three assemblies which are arranged in series as it were. The topmost assembly 2-1, which is known per se, comprises in this case three sections arranged at 120 degrees with respect to each other. Each section is provided with an actuator 3, here comprising an individually controllable motor which is connected to a gearbox or other member 4, by means of which, in particular, the velocity and the outward torque can be influenced of a rotatable arm 5 which is connected to the actuator 3 and to which parallelogram-forming elements 6-1, 6-2 are connected. Both elements, briefly indicated by means of reference numeral 6, are connected by means of ball joints 7 to T-shaped end portions of the rotatable arm 5. Via said ball joints, the lower end portions of the elements 6 engage an effector 8. By suitably driving the motors 3, the effector 8 moves in a desired direction, wherein, as is customary in the field of delta robot control, the orientation of the effector remains unchanged. By virtue thereof, the end effector 8 can be moved to any point within a certain range of movement.

As shown in each of the embodiments of figures 1 and 2, the robot 1 is also provided with at least one additional delta assembly 2-2. This assembly 2-2 is also provided with arms 5 and elements 6 which are hinged to said effector 8. The elements 6-1, 6-2 are each built up, at least partially, in the form of a parallelogram, whereby, in the situation shown here, the horizontal position of the end effector 8 moved by said elements is maintained. If the assembly 2-2 were the lowermost part of the robot 1, then the elements would engage the effector 8 in a hinging manner, which effector then forms the end effector 8. In figure 1, the robot 1 comprises in fact three, shown, series-arranged assemblies 2-1, 2-2 and 2-3.

If more than one assembly 2 is applied, then, with the exception of the assembly 2-3 connected to the end effector 8, the other assemblies 2-1, 2-2 comprised in the plurality of assemblies each comprise at least one coupling element 9, which is disposed in a hinging manner at least between the successive effectors 8. In practice, to achieve a symmetric distribution of forces, each of the three sections of said other assemblies will be provided with such a coupling element 9.

With reference to figure 1, said coupling element 9 is hinged, on the one hand, to the vertically movable arm 5 and, on the other hand, to the arm 5 of the underlying assembly, which is a radial tumbler 5-1 which can rotate around a respective part of the effector 8. Said respective part has a diagrammatically indicated shaft 10 whose centreline touches a circle which extends around the imaginary longitudinal axis of the robot 1. The often ball-jointed end portions of successive coupling rods 9 are capable of hinging at positions of the radial tumbler parts 5-1 where the height range of the intermediate effector 8 and, eventually, the end effector 8 can be influenced. In this respect, if the scale of figure 1 is taken into account, each coupling rod 9 in a successive assembly 2-1, 2-2 amplifies the movement by a factor of 2. The three assemblies shown increase the total travel, i.e., the eventual movement distance of the robot. With equal lengths of the arms and rods with respect to the preceding effector, each effector 8 makes the same movement as the first effector, with respect to a fixed point. This advantageously only requires the respective arm 5 at one assembly to be driven at comparatively low power, which results in amplification and acceleration of the movement, while the robot’s movement only takes up a limited amount of space, and the robot can be of light construction.

Figure 2 shows an embodiment of the robot 1 in which the at least one additional delta assembly 2-2 forms a scissor mechanism which is built up of one more series arranged sections. This enables the same advantages to be achieved as described hereinbefore. This scissor mechanism 2-2 also forms a rotatable assembly whose arm 5-1 is hinged, via a rotatable block 11, effector 8 and hinged elements 6-1, 6-2, to the controllable actuators 3. Both elements are also in the shape of a parallelogram. Arm 5-2 of the scissor mechanism is connected to a frame of the robot 1. The lower side of the scissor mechanism 2-2 rotatably engages the end effector 8, whose angular position remains accurate also in the case of movement of the combined scissor mechanisms 2-2. The figure shows that during said movement the scissor mechanism 2-2 remains within the ring-shaped effector 8.

When possible, the abovementioned hinged arms, rods and elements can be replaced by one or more cables, such as Bowden cables. Said cables will then be coupled with spring means to pull back the cables, since cables can only take up tensile forces, not compressive forces. The function of a rod can thus be completely taken over by two cables which are each disposed on either side of a respective hinge point.

The robots elucidated hereinabove are used for many applications. A non-limitative enumeration includes: tower wagons, material processing machines such as milling machines, 3D printers, cranes, dyeing machines, graphic plotters, welding robots, spraying robots, excavators, pick and place machines such as used in the food processing industry, and, in general, devices, which are generally fixedly arranged, by means of which objects are moved and subsequently placed in an oriented manner. The robot elucidated hereinabove can also be accommodated in the legs of an automotive device, because as a result of the increased height range, higher steps will not form a problem.

CLAIMS

1. A robot comprising a delta assembly provided with:

- controllable actuators,
- arms which are hinged to the controllable actuators, which arms are each at least partially built up of hinged elements forming a parallelogram, and
- an effector which is in hinged contact with said elements,

characterized in that the robot comprises at least one additional delta assembly which is provided with:

- arms which are in a hinging manner coupled at least to said effector, and which are each at least partially built up of hinged elements forming a parallelogram, and
- an end effector which is in hinged contact with said last-mentioned elements.

2. The robot according to claim 1, characterized in that the abovementioned delta assemblies form a series of two, three or more series-arranged delta assemblies.

3. The robot according to claim 1 or 2, characterized in that, with the exception of the assembly contacting the end effector, the other successive assemblies each comprise at least one coupling element which is disposed in a hinging manner at least between the successive effectors.

4. The robot according to claim 3, characterized in that a coupling element is provided parallel to all hinged elements, of the other delta assemblies, which form a parallelogram.

5. The robot according to claim 3 or 4, characterized in that the coupling element is a coupling rod and in that the at least one coupling rod can hinge, at each end portion

thereof, around a shaft whose centreline touches a circle which extends around the longitudinal axis of the robot.

6. The robot according to claim 5, characterized in that the end portions of successive coupling rods are capable of hinging at positions of radial arm portions, which positions are chosen such that the height range of the end effector can be influenced.

7. The robot according to claim 1, characterized in that the hinged elements of the at least one additional delta assembly form a scissor mechanism which is built up of one more series-arranged sections.

8. The robot according to claim 7, characterized in that the effector of one delta assembly forms a ring-shaped body through which the scissor mechanism projects.

9. The robot according to claim 7 or 8, characterized in that the scissor mechanism is also hinged to the robot.

10. The robot according to any one of claims 1 to 9, characterized in that the hinged elements are cables and/or hinged rods.

11. A device provided with legs to enable movement of the device, each leg being provided with a robot according to any one of claims 1 to 10.

ABSTRACT

A description is given of a robot comprising a delta assembly provided with controllable actuators, arms which are hinged to the controllable actuators, which arms are each at least partially built up of hinged elements forming a parallelogram, and an effector which is in hinged contact with said elements. The robot comprises at least one additional delta assembly, which is provided with arms which are hinged at least to said effector and which are each at least partially built up of hinged elements forming a parallelogram, and an end effector which is in hinged contact with said last-mentioned elements. The robot built up of serially arranged delta assemblies takes up less surrounding space, even if the distances or differences in height to be bridged by the robot are substantial.