



(72) KROGEDAL, ARNULF, NO

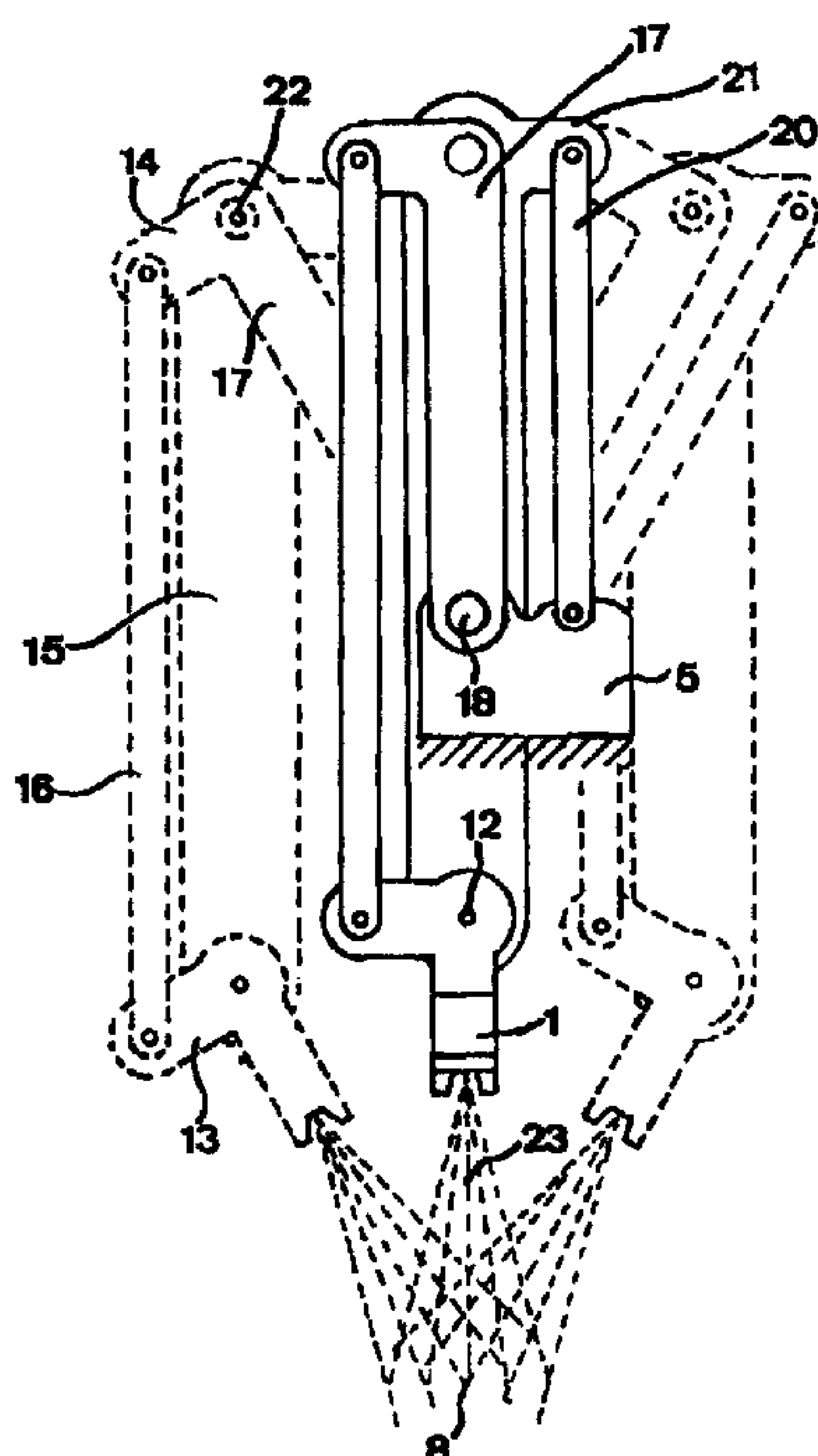
(71) ABB FLEXIBLE AUTOMATION A/S, NO

(51) Int.Cl.⁶ B05B 13/04

(30) 1997/10/24 (9703877-2) SE

(54) **DISPOSITIF DESTINE A FAIRE PIVOTER UNE BUSE DE
PULVERISATION DISPOSEE SUR UN BRAS-ROBOT**

(54) **A DEVICE FOR PIVOTING A SPRAY NOZZLE ARRANGED AT
A ROBOT ARM**



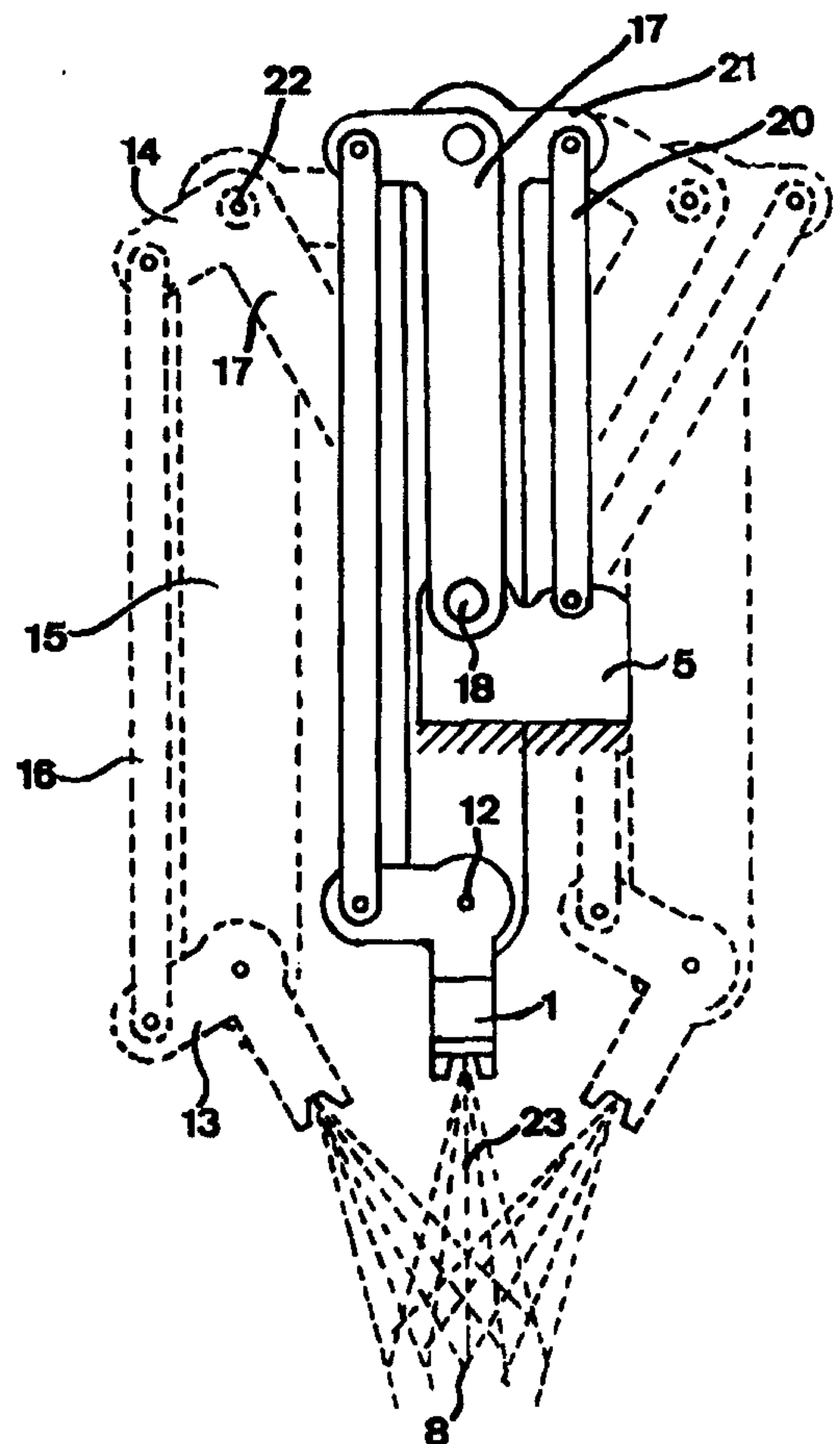
(57) Dispositif permettant de faire pivoter une buse (1) de pulvérisation, disposée sur un bras-robot en vue de la pulvérisation automatique de peinture sur un objet, autour d'un axe (12) pratiquement perpendiculaire à l'extension longitudinale du bras. Ledit dispositif possède un mécanisme permettant de rendre une position de la buse de pulvérisation dans un plan pratiquement perpendiculaire à cet axe dépendante d'un mouvement de pivotement de ladite buse autour de cet axe de manière qu'il en résulte un mouvement de translation simultané de la buse dans ce plan, tout en compensant au moins partiellement un mouvement d'un point (8) du jet de pulvérisation situé à une distance déterminée de la buse dans ce plan lorsque la buse de pulvérisation pivote sans mouvement de translation.

(57) In a device for pivoting a spray nozzle (1) arranged at a robot arm for automatical spray application of paint on an object, about an axis (12) being substantially perpendicular to the longitudinal extension of the arm, an arrangement is arranged to make a position of the spray nozzle in a plane substantially perpendicular to said axis depending on a pivoting of the nozzle about said axis in such a way that such pivoting results in a simultaneous translation movement of the nozzle in this plane while at least partly compensating a movement of a point (8) of the spray nozzle jet located at a determined distance from the spray nozzle in this plane when pivoting the spray nozzle without any translation movement.

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International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : B05B 13/04	A1	(11) International Publication Number: WO 99/21660 (43) International Publication Date: 6 May 1999 (06.05.99)
(21) International Application Number: PCT/IB98/01629 (22) International Filing Date: 19 October 1998 (19.10.98) (30) Priority Data: 9703877-2 24 October 1997 (24.10.97) SE (71) Applicant (for all designated States except US): ABB FLEXI- BLE AUTOMATION A/S [NO/NO]; P.O. Box 265, N-4341 Bryne (NO). (72) Inventor; and (75) Inventor/Applicant (for US only): KROGEDAL, Arnulf [NO/NO]; Jaerveien 295, N-4300 Sandnes (NO).		(81) Designated States: CA, JP, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report.</i>
(54) Title: A DEVICE FOR PIVOTING A SPRAY NOZZLE ARRANGED AT A ROBOT ARM (57) Abstract In a device for pivoting a spray nozzle (1) arranged at a robot arm for automatical spray application of paint on an object, about an axis (12) being substantially perpendicular to the longitudinal extension of the arm, an arrangement is arranged to make a position of the spray nozzle in a plane substantially perpendicular to said axis depending on a pivoting of the nozzle about said axis in such a way that such pivoting results in a simultaneous translation movement of the nozzle in this plane while at least partly compensating a movement of a point (8) of the spray nozzle jet located at a determined distance from the spray nozzle in this plane when pivoting the spray nozzle without any translation movement.		



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A DEVICE FOR PIVOTING A SPRAY NOZZLE ARRANGED AT A ROBOT ARM

10 **FIELD OF THE INVENTION AND PRIOR ART**

The present invention relates to a device for pivoting a spray
nozzle arranged at a robot arm for automatical spray application
of paint on an object, about an axis being substantially perpen-
15 dicular to the longitudinal extension of the arm.

In this connection, the word "robot arm" is given a broad sense
and includes an arm even in the form of a beam or the like of
any type of apparatus for automatical spray application of paint
20 on an object. The word "paint" is also given a broad sense
herein and comprises all types of paints and colours appropriate
for spray application.

Such a device may be designed for a number of different fields
25 of use, but for illuminating, but not in any way restricting the in-
vention, the use of such a device for spraying on objects in the
form of vehicle bodies will mainly be discussed from now.

In a device of this type already known used in connection with
30 automatical spray application of paint to pivot the nozzle when
the same is to spray the curved passage between the roof and
the side of the vehicle a problem appears, which is illustrated in
the appended fig 3, which in a very schematic way shows such a
device already known. In the spray application itself it is desir-
35 able to have substantially the same distance between the spray
nozzle and the object sprayed all the time, to achieve the best

possible final result with a uniform paint surface on the vehicle body. In devices of this type already known a problem arises during said pivoting, which is illustrated in fig 3. When the nozzle 1 is pivoted, which takes place by acting thereupon via lever components and lever arms 2-4, this takes place in relation to a carrier 5. This carrier 5 is usually arranged displaceable in relation to a robot arm 6 in the horizontal direction (se X in fig 1 and 2), said robot arm being displaceable in the vertical direction Z in relation to a frame 7 and in the longitudinal direction Y in relation to the same frame via appropriate driving members and guides. When the nozzle 1 is pivoted for spraying a passage mentioned and the carrier 5 itself is not moved in relation to the robot arm 6 and this is not moved in relation to the frame 7, the point 8 of the spray nozzle jet, which has the desired distance to the object, will then be moved both in X- and Z-direction, which is illustrated by its new position 8' in fig 3. This movement of said point have to be compensating for so as to achieve a good result of the spraying, which in apparatuses already known is tried to obtain by moving the carrier itself, which means in practice its main axis 9 in X- and Z-direction by displacing the carrier along the robot arm 6 and the robot arm 6 along the frame 7, respectively. However, depending on inertial forces present, when a reasonable high spraying rate is required it is nearly impossible to compensate for this effect in this way. Thus, it is a risk that the result of the spraying will be deficient or the spraying of these parts will take to long time.

Another disadvantage with such devices already known concerns that in dimensioning of the spraying cabin it must be taken into consideration that the demand for these additional movements of the carrier of the spray nozzle in the border of the spraying cabin, in which said passages being sprayed, because of the necessity of these compensating movements therein, which make that the spraying cabin have to be given a proportionately large extension therein.

SUMMARY OF THE INVENTION

The object of the present invention is to provide a device of the type referred to in the introduction, which to a large extent
5 solves the problems mentioned above in such devices already known.

This object is obtained according to the invention by providing such a device with an arrangement arranged to make a position
10 of the spray nozzle in a plane substantially perpendicular to said axis depending on a pivoting of the nozzle about said axis in such a way that such pivoting results in a simultaneous translation movement of the nozzle in this plane while at least partly compensating a movement of a point of the spray nozzle yet located at a determined distance, preferably substantially corresponding to the appropriate distance between the spray nozzle
15 and the object during the spray application, from the spray nozzle in this plane when pivoting the spray nozzle without any translation movement.

20 By arranging such an arrangement it is possible to compensate for the movement of said point, illustrated in fig 3, when pivoting the spray nozzle, so that at least the distance this point is moving in said plane, while the carrier is stationary, is less and
25 therefore it will be possible to completely compensate for this movement, by decreasing the inertial forces mentioned above considerably, by an appropriate moving of the robot arm and/or the carrier along the robot arm. Thus, it will be possible to all the time achieve a substantially perpendicular angle between
30 the spray nozzle jet and a surface of an object that recently have been sprayed and a determined spraying distance together with a substantially constant reciprocal velocity between the nozzle and the object.

35 According to a preferred embodiment of the invention said arrangement comprises members arranged to guide the spray

nozzle during pivoting thereof to move along a path extending in two dimensions in said plane, in which said members preferably are arranged to guide the pivot axis of the spray nozzle to move along a circular arc and it is especially advantageous if the members are arranged to guide the pivot axis of the nozzle to move along a circular arc having said point as the centre point of the circle. In the latter case the fact is that full compensating for a movement, occurring in another case, of said point in said plane will be effected without any movement of the robot arm itself or any carrier along the same. This means that without any problems, i.e. without any requirements to take into account any inertial forces, it is achieved that during such pivoting of the spray nozzle for spraying the passages mentioned above the paint jet always may be kept substantially perpendicular to the surface that is sprayed and with the nozzle at a determined distance from this surface during a constant reciprocal velocity between the object, in this case the vehicle body, and the spray nozzle. This means in turn that the spraying cabin may be made smaller, since the compensating is done within the device itself without any requirements for movements of any carrier of the spray nozzle or any robot arm at opposite ends of the spraying cabin, so that the spraying cabin may be made more narrow with a factor twice the movement in the horizontal direction (X-direction according to above) that should be required in a device according to prior art.

According to another preferred embodiment of the invention said arrangement comprises a set of link arms pivotably arranged about axes being substantially parallel to said axis and arranged to connect the spray nozzle with a carrier, and the length of these link arms and the distance between the pivot axes of the latter's are so dimensioned that said compensating is achieved. In this way it is possible, with simple means, to achieve a very reliable function and a path of movement of the spray nozzle exactly defined when pivoting thereof in a defined dependence of the pivot motion.

According to another preferred embodiment of the invention the device comprises a first quadrangle formed by four link arms pivotably connected to each other at their ends about axes being substantially parallel to said axis, said spray nozzle being attached to a first of these link arms, it comprises an additional link arm arranged to connect the quadrangle of link arms with a carrier and which is pivotably connected to the carrier about an axis substantially parallel to said axes, and said first quadrangle of link arms being carried in relation to the robot arm by said additional link arm and carrier and being movable in relation to the carrier by pivoting the additional link arm about the axis connecting it with the carrier to cause pivoting of the first link arm with the spray nozzle during translation movement of the same in said plane. In this way it's possible to realise an arrangement for said dependence by simple means. Thus, by pivoting said first additional link arm the spray nozzle is brought to perform a translation movement in relation to said carrier and by that in said plane when pivoting the nozzle to compensate for a movement of said point of the paint jet.

According to another preferred embodiment of the invention, which constitutes a further development of the embodiment last mentioned, said additional link arm is a part of a second quadrangle of link arms with a second additional link arm arranged opposite to said additional link arm and pivotably connected with the carrier about an axis substantially parallel to said axes, and a third additional link arm of the second quadrangle is formed by the carrier and a fourth additional link arm of the second quadrangle is rigidly connected with a third link arm of the first quadrangle. In this way the compensating movement of the spray nozzle may be controlled in an exact way without any risk that the force of gravity or the inertial forces on the different link arms will affect the movement path of the nozzle.

According to another preferred embodiment of the invention the link arms of the quadrangles form substantially a parallelogram, which makes it possible to achieve complete compensation of above mentioned kind if so is required in an easy way.

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Further advantages of and favourable features of the invention appear from the following description and the other dependent claims.

10 BRIEF DESCRIPTION OF THE DRAWINGS

With reference to the appended drawings, below follows a description of preferred embodiments of the invention cited as examples.

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In the drawings:

Fig 1 illustrates in a schematic way a possible application of a device according the invention in connection with spray painting of a vehicle body in a spraying cabin from the side,

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Fig 2 is a simplified view of the plant in fig 1 and illustrating this from above,

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Fig 3 is a very schematic view illustrating the principle of function for a device according to prior art,

Fig 4 is a view corresponding to fig 3 of a device according to a first preferred embodiment of the invention as viewed in the direction of the pivot axis of the spray nozzle, a base position being shown by unbroken lines and dashed lines are used to show two of an infinite number of positions of the nozzle located on both sides of the base position,

30

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Fig 5 is a partly cut view of the device according to fig 4 in a direction substantially perpendicular to said pivot axis and as viewed from left in fig 4, and

- 5 Fig 6 is a view corresponding to fig 4 of a device according to a second preferred embodiment of the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

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A spraying cabin 10 for spray painting of vehicle bodies 11 is illustrated in a very schematic way in fig 1, said spray painting regarding at least roof and the passage between roof and sides being done via a spray nozzle, not shown in fig 1 and 2, arranged on a carrier 5, thus making the possibilities to movement that have been described in the introduction feasible, i.e. in X-, Z- and Y-direction and also a rotation of the arm 6 about an horizontal axis extending in the longitudinal direction of the arm, which is illustrated by the arrows R. The possibility to pivot the spray nozzle is indicated by A. Through these different possibilities to movements of the spray nozzle arbitrary patterns of movement may be formed by suitably combining, in which the following examples may be mentioned: Z-R-X, Z-R-X-A, Z-Y-R-X and Z-Y-R-X-A.

25

A device according to the invention, which is directed to the movement A, is achieved by a so-called spray nozzle tipping/wrist mechanism. It is illustrated in fig 4 how such a movement is achieved in an advantageous way. The device shown therein according to a first preferred embodiment of the invention will now be described while simultaneously referring to fig 5.

30

There is illustrated how the spray nozzle 1 is arranged pivotably about an axis 12, that forms a corner in a quadrangle formed of four link arms, which constitutes a parallelogram. This quadrangle comprises a first short link arm 13, on which the spray nozzle

35

zle is attached, a second link arm 14 opposite to the first link arm, a third link arm 15 and a fourth link arm 16 opposite to the third link arm.

- 5 A first additional link arm 17 is rigidly connected to the second link arm 14, and this additional link arm is pivotably connected at its second end with a carrier or carriage 5 about an axis 18 substantially parallel to said axis 12, which carrier may be moved along the robot arm 6, illustrated in fig 1 and 2, for
10 movement of the device in X-direction. Thus, said first quadrangle of link arms is via the first additional link arm 17 connected to the carrier 5 and movable in relation to the same through pivoting of the link arm 17. A power member 19, indicated in fig 5, is designed to turn the axis 18 so as to in that way pivot the link
15 arm 17 and therethrough the spray nozzle 1.

The device further comprises a second quadrangle, more precisely a parallelogram, of link arms, in which the first additional link arm 17 is a part of, and this further shows a second additional
20 link arm 20 arranged opposite thereto, which is pivotably connected with the carrier 5 about an axis substantially parallel to the axis 12, a third additional link arm formed by the carrier 5 and a fourth additional link arm 21, which is rigidly connected with the third link arm 15 of the first parallelogram of link arms.

25

The arrangement of the link arm 20 in parallel with the link arm 17 will ensure that the third link arm 15 of the first parallelogram always is in a vertical position.

- 30 Preferably, the distance between the pivot axis of the first additional link arm 18 at the carrier and the pivot axis 22 thereof at the third link arm of the first quadrangle is substantially equal to the distance between the pivot axis 12 of the nozzle and said point 8, at which point it is desired to have the centre point of
35 the paint jet 23 of the nozzle at an optimal spray distance between the nozzle and the object during painting. If this is the

case and said both quadrangles form exact parallelograms, pivoting of the spray nozzle 1 by turning the axis 18 and therefore pivoting of the first additional link arm 17 the pivot axis 12 of the spray nozzle 1 will move along a circle arc of a circle having
5 said point 8 as the centre point of the circle, so that this point is stationary. This means that no compensating movement is required, either in Z- or X-direction when spraying the vehicle roof in the passage between roof and side. Thus, the width of the spraying cabin itself may be decreased with two times the
10 movement in X-direction otherwise required. The radius of the circle in occurring cases of vehicle painting may typically be about 300 mm.

A device according to another preferred embodiment of the invention is very schematically illustrated in fig 6 and is intended
15 to work according to the same principle that the device shown in fig 4, and of which it is intended that a spray nozzle is arranged on an arm 24, that is movable in a corresponding circle arc path when pivoting a second arm 26 pivotably connected with a carrier in a pivot centre 25. There is a link arm 27 arranged between the both arms 24 and 26 to transmit the pivot movement
20 of the arm 26 to a pivot movement of the nozzle arranged on a plate 28 indicated, while a link arm 29 is arranged, upon pivoting the second arm 26, to bring the pivot axis of the nozzle arranged on the first arm 24 to move according to a path of a circle arc to keep a desired centre point of the paint jet in substantially the same position during pivoting of the spray nozzle.
25

It is then possible to dimension the different arms of the embodiment according to fig 6 so that complete or partly compensating according to above is achieved.
30

The same is also true for the embodiment according to fig 4, wherein it is in principle possible to not make the distances between the two pivot centres 18 and 22 and the pivot centre 12
35 and said point 8 equal in size or not make any or both said

- quadrangles so that these form completed parallelograms, and achieve a partial compensating of the movement of said point otherwise occurring when pivoting the spray nozzle. Such a partial compensating may perhaps, in some cases, be desired or in any case for different reasons one may be forced to accept this and complete compensating is still achieved by combining this partial compensating with a movement of the carrier of the device in X- and/or Z-direction.
- 10 The invention is of course not in any way restricted to the preferred embodiments described above, but many possibilities to modifications thereof will be apparent for a man skilled in the art, without departing from the basic idea of the invention as defined in the claims.
- 15 For example the nozzle could be arranged pivotably in relation to a robot arm arranged in another way than in the figures, and the field of use could be another than what is described above.

Claims

1. A device for pivoting a spray nozzle (1) arranged at a robot arm (6) for automatical spray application of paint on an object, about an axis (12) being substantially perpendicular to the longitudinal extension of the arm, characterized in that the device comprises an arrangement arranged to make a position of the spray nozzle in a plane substantially perpendicular to said axis depending on a pivoting of the nozzle about said axis (12) in such a way that such pivoting results in a simultaneous translation movement of the nozzle in this plane while at least partly compensating a movement of a point (8) of the spray nozzle jet located at a determined distance, preferably substantially corresponding to the appropriate distance between the spray nozzle and the object during the spray application, from the spray nozzle in this plane when pivoting the spray nozzle without any translation movement.
2. A device according to claim 1, characterized in that said arrangement comprises members (13-22, 24-29) arranged to guide the spray nozzle during pivoting thereof to move along a path extending in two dimensions in said plane.
3. A device according to claim 2, characterized in that said members are arranged to guide the pivot axis (12) of the spray nozzle to move along a circular arc.
4. A device according to claim 3, characterized in that the members are arranged to guide the pivot axis (12) of the nozzle to move along a circular arc having said point (8) as the centre point of the circle.
5. A device according to any of claims 1-4, characterized in that said arrangement comprises a set of link arms pivotably arranged about axes being substantially parallel to said axis

and arranged to connect the spray nozzle with a carrier, and that the length of these link arms and the distance between the pivot axes of the latter's are so dimensioned that said compensating is achieved.

5

6. A device according to claim 5, characterized in that said dimensioning is such that complete compensating is achieved, so that said point (8) remains stationary when the spray nozzle (1) is pivoted about said axis (12).

10

7. A device according to any of claims 1-6, characterized in that it comprises a first quadrangle formed by four link arms (13-16) pivotably connected to each other at their ends about axes being substantially parallel to said axis (12), that the spray nozzle is attached to a first (13) of these link arms, that it comprises an additional link arm (17) arranged to connect the quadrangle of link arms with a carrier (5) and which is pivotably connected to the carrier about an axis substantially parallel to said axes, and that said first quadrangle of link arms is carried in relation to the robot arm by said additional link arm and carrier and is movable in relation to the carrier by pivoting the additional link arm about the axis connecting it with the carrier to cause pivoting of the first link arm (13) with the spray nozzle (1) during translation movement of the same in said plane.

15

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8. A device according to claim 7, characterized in that said additional link arm (17) is through one end rigidly connected to a link arm (14) of said first quadrangle of link arms.

30

9. A device according to claim 8, characterized in that the additional link arm (17) is rigidly connected to a second link arm (14) of said quadrangle, said second link arm being opposite to the first link arm.

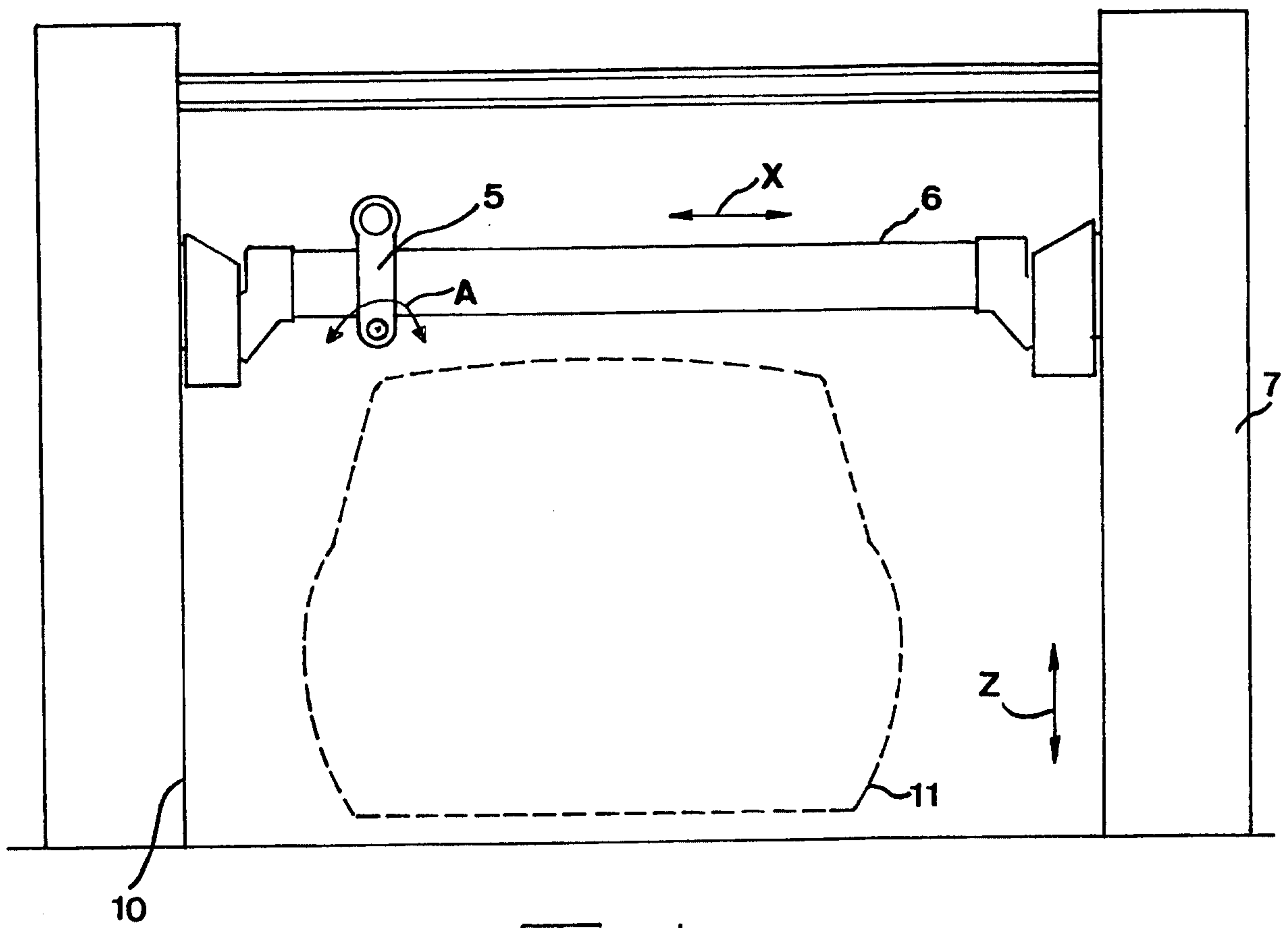
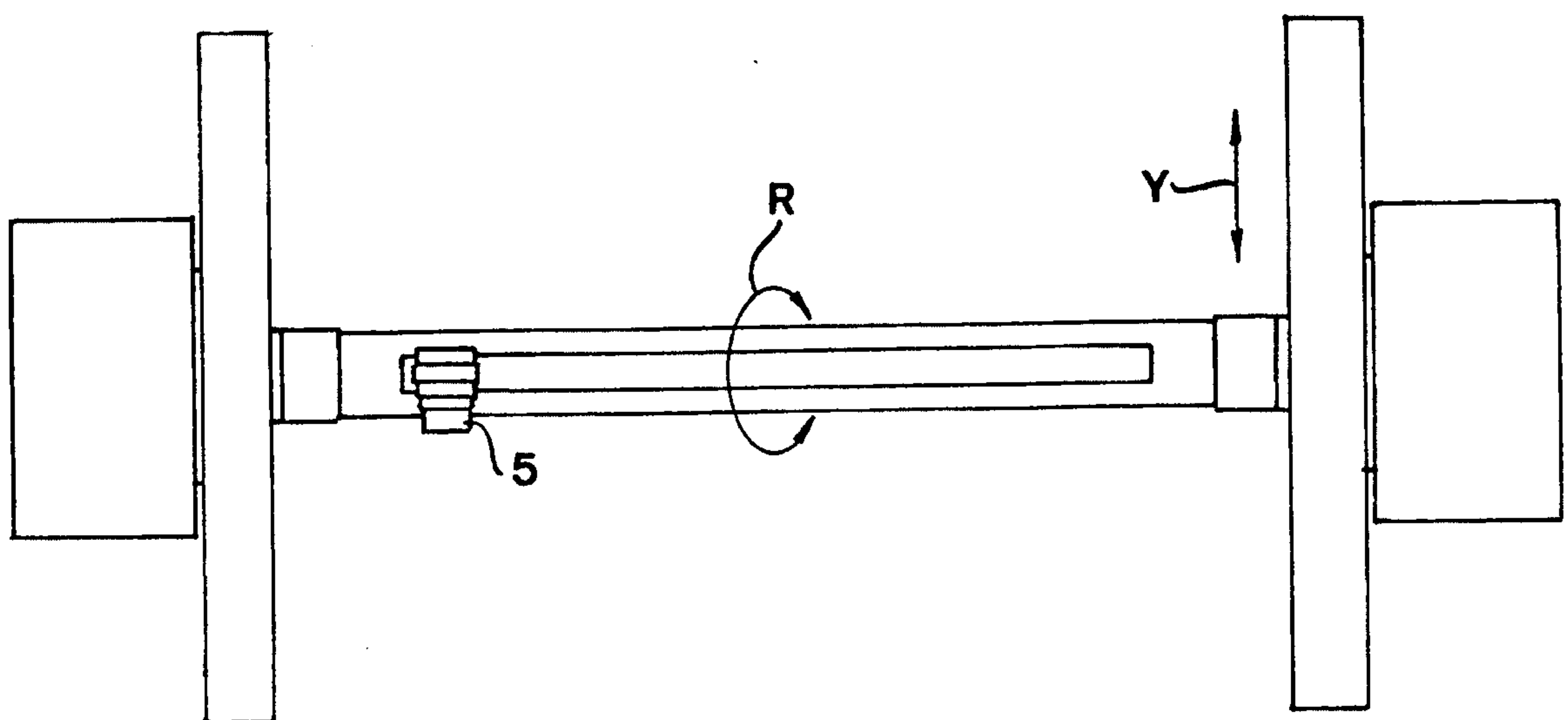
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10. A device according to any of claims 7-9, characterized in that said additional link arm (17) is a part of a second quadrangle of link arms with a second additional link arm (20) arranged opposite to said additional link arm and pivotably connected with the carrier about an axis substantially parallel to said axes, and that a third additional link arm of the second quadrangle is formed by the carrier (5) and a fourth additional link arm (21) of the second quadrangle is rigidly connected with a third link arm (15) of the first quadrangle.
11. A device according to any of claims 7-10, characterized in that the link arms of the first quadrangle form substantially a parallelogram.
12. A device according to claim 10, characterized in that the link arms of the second quadrangle form substantially a parallelogram.
13. A device according to any of claims 7-12, characterized in that the distance between the pivot axis (18) of the first additional link arm (17) at the carrier and the pivot axis (22) thereof at a link arm of the first quadrangle, is substantially equal to the distance between the pivot axis (12) of the nozzle and said point (8).
14. A device according to claim 13, characterized in that the pivot axis (12) of the nozzle is arranged at a corner of said first quadrangle, and that the first additional link arm (17) is pivotably connected with a third link arm (15) of the first quadrangle, which connects the second link arm (14) and the first link arm (13) at the pivot axis of the spray nozzle.
15. A device according to any of claims 1-14, characterized in that it comprises a link arm (17), pivotably connected with a carrier (5) about an axis substantially parallel to said pivot axis (12) of the nozzle (1) and arranged to cause pivoting of

the spray nozzle about the pivot axis thereof during pivoting of this link arm about the axis (18) thereof at the carrier, and that the device comprises a power member (19) arranged to pivot said link arm about the pivot axis at the carrier for piv-
5 oting the spray nozzle about the pivoting axis thereof.

16.A device according to any of claims 1-15, characterized in that it is designed to be arranged at a robot arm of a mechanism for painting vehicle roofs from above by a spray nozzle
10 moving to and fro.

1/3

Fig 1Fig 2

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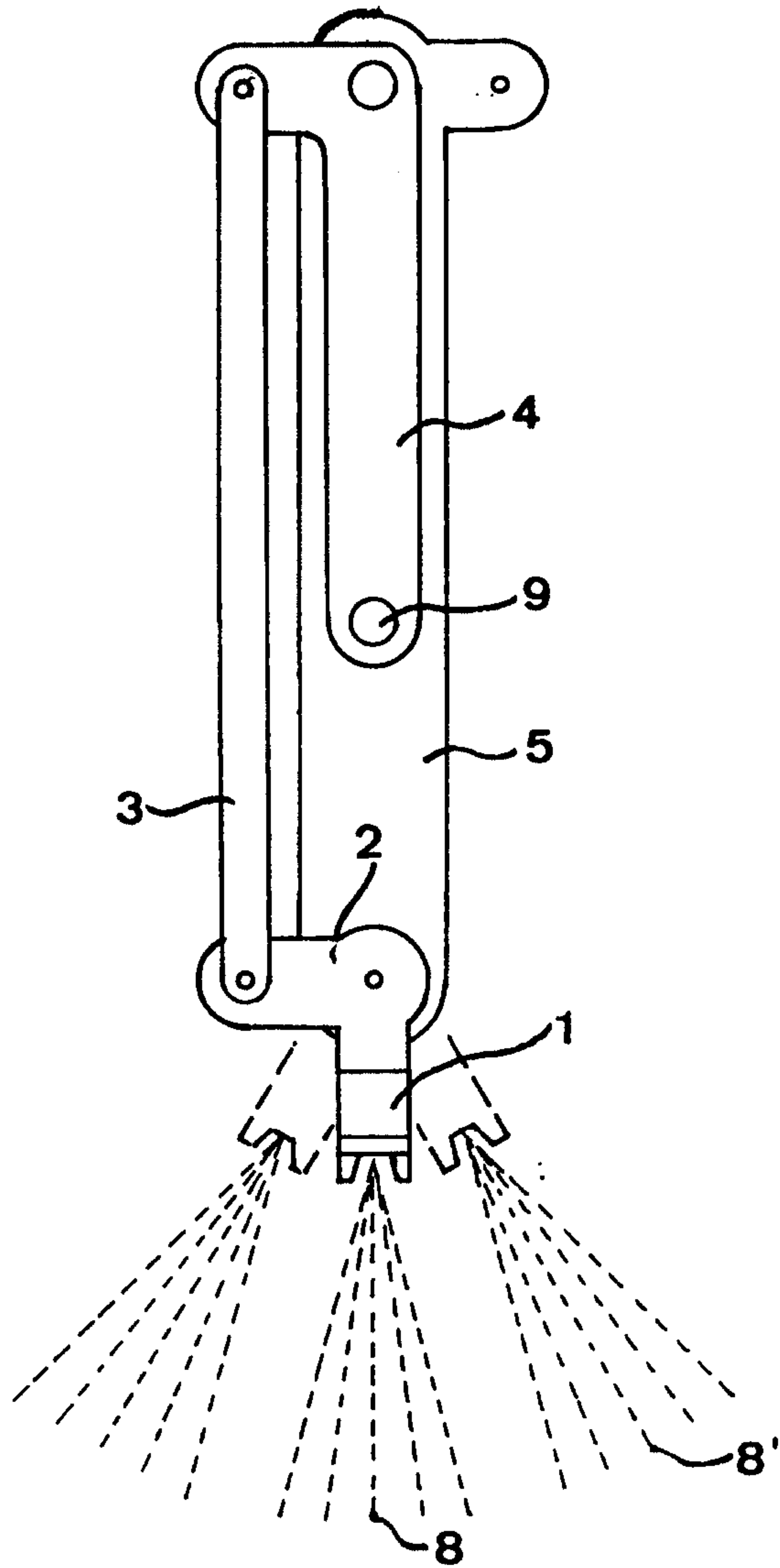


Fig 3

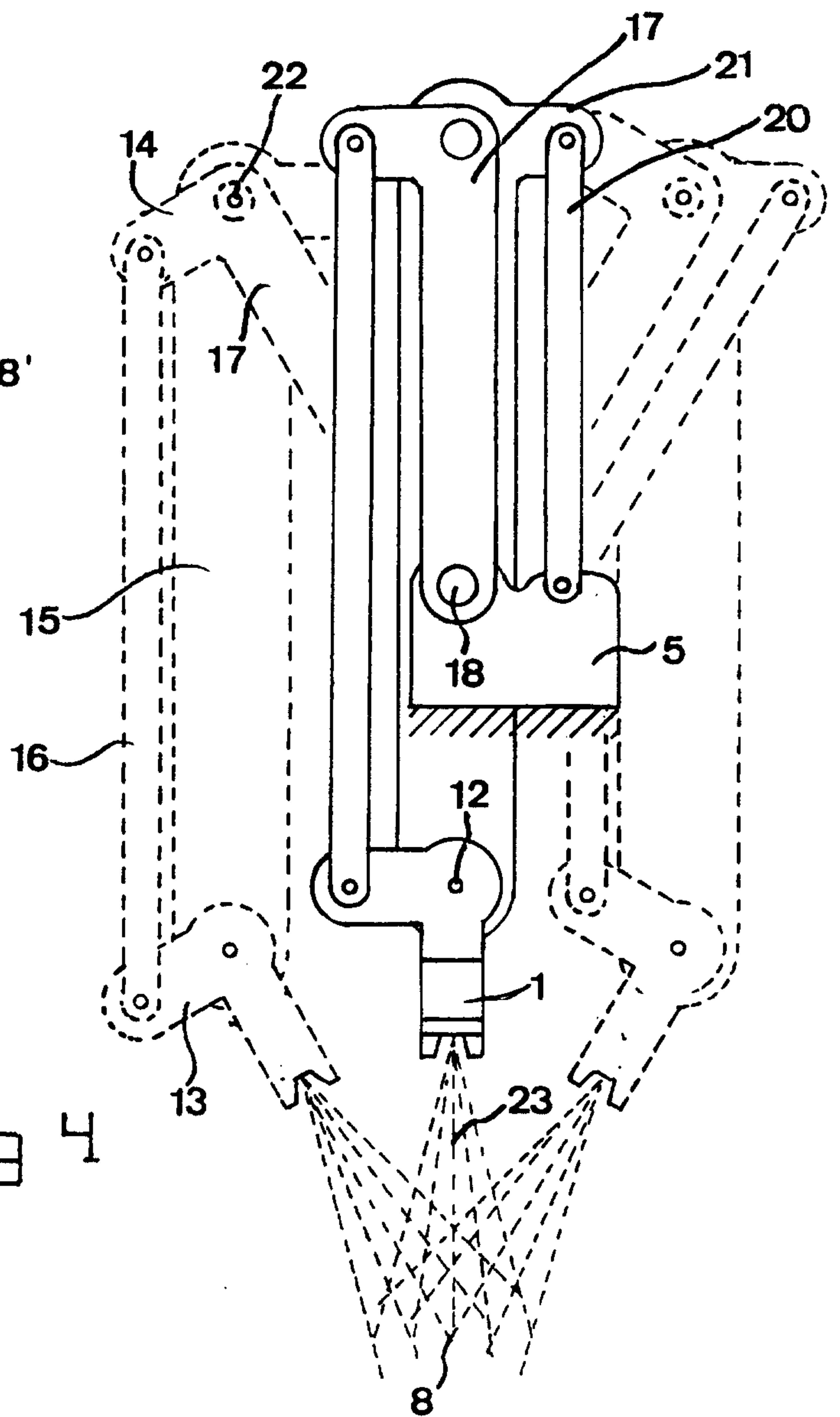


Fig 4

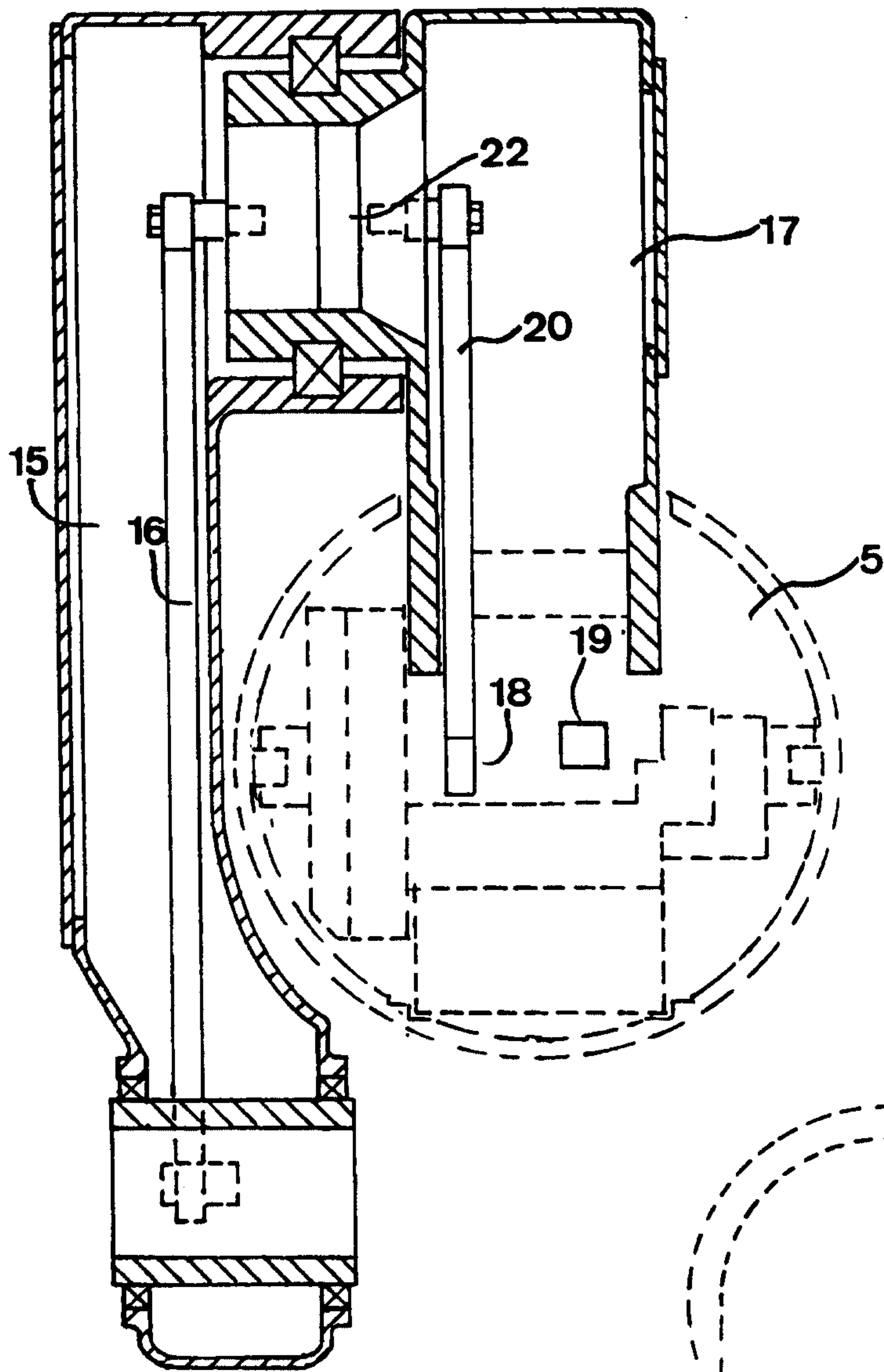


Fig 5

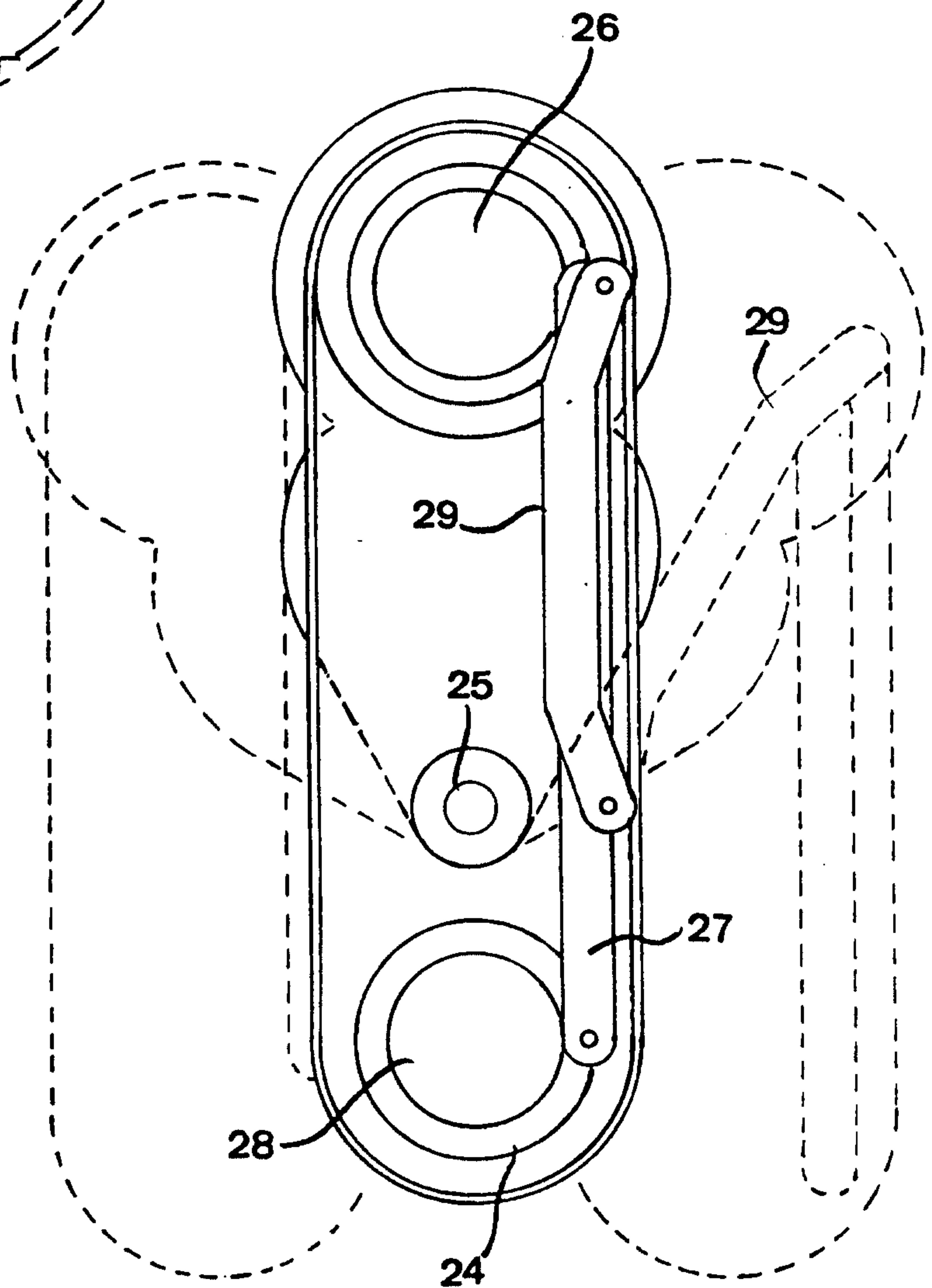


Fig 6