AUSTRALIA
PATENTS ACT 1990
NOTICE OF ENTITLEMENT

We, **ABB Trallfa Robot A/S**, the applicant/Nominated Person in respect of Application No. 49852/93 state the following:-

The Nominated Person is entitled to the grant of the patent because the Nominated Person would, on the grant of a patent for the invention to the inventor, be entitled to have the patent assigned to the Nominated Person.

DATED this EIGHTH day of JANUARY 1996

.....
a member of the firm of
DAVIES COLLISON CAVE
for and on behalf of the
applicant(s)

(DCC ref: 1786407)

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WALL INTEGRATED ROBOT PAINTER

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(56) Prior Art Documents
US 5213620
WO 87/04968

(57) Claim

1. A robot installation for painting objects inside a cabin having walls isolating the object to be painted from the surroundings, said installation comprising at least one robot shaft associated with a painting tool and protruding through at least one slot penetrating the cabin walls for servo-controlled movements along said slot and servo-drive means controlling said robot shaft movements in accordance with a preprogrammed motional pattern for said painting tool, characterised in that said slot is disposed on a rotatable element supported in or on the cabin walls, the servo-drive means comprising means for controlling the rotational movements of said rotatable element in accordance with said preprogrammed motional pattern.

3. A robot installation as claimed in claim 1, characterised in that said rotatable element is a circular disc disposed for rotational movements in a plane identical or parallel with the plane of a cabin wall.

5. A robot installation as claimed in claim 1, characterised in that said rotatable element is disposed for rotational movements about an axis in or parallel with one of the cabin walls, said robot shaft protruding through at least one slot substantially parallel with said rotational axis.

6. A robot installation as claimed in claim 5, wherein the rotatable element comprises a hollow cylinder

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7. A robot installation as claimed in claim 6, wherein the cylinder is disposed for rotational movements about a vertical axis.

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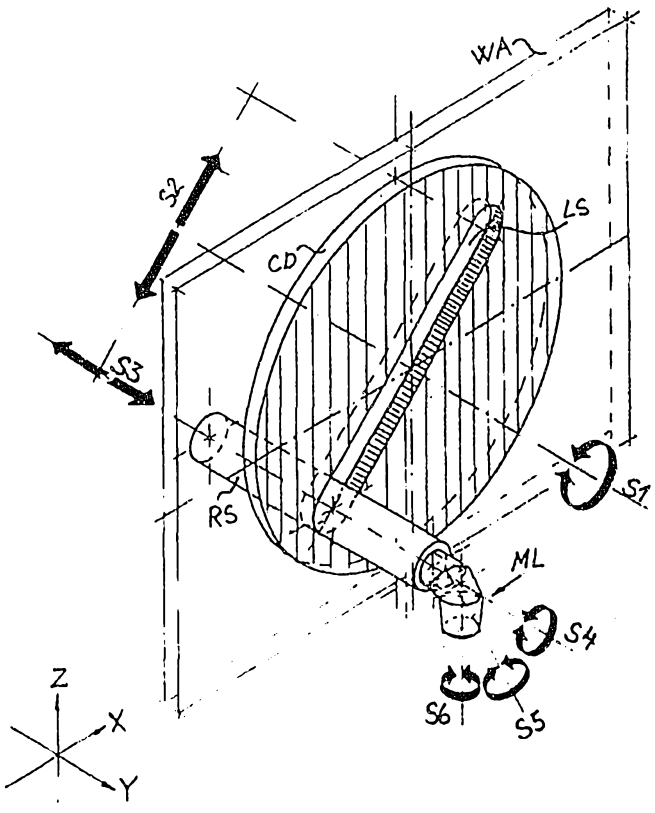
(54) Title: WALL INTEGRATED ROBOT PAINTER

(57) Abstract

A robot installation for painting objects inside a cabin (CA) having walls (WA, WB) isolating the object (AU) to be painted from the surroundings, is suitably integrated in the cabin walls in order to save interior cabin space and achieve a robot operation better adapted to the painting process. The installation comprises at least one main robot shaft (RS) associated with a painting tool and protruding through at least one slot (LS) penetrating the cabin walls for servo-controlled movements along such slots and possibly also in the direction of and/or about the axis of said shaft. Servo-drive means are disposed for controlling said robot shaft movements in accordance with a preprogrammed motional pattern for said painting tool, including tracking of a travelling object to be painted. Said slot is disposed on a rotatable element (CD, SC) suppported in or on the cabin walls, and the servo-drive means comprise means for controlling the rotational movements of the rotatable element in accordance with said preprogrammed motional pattern. The rotatable element may be a circular disc (CD) disposed for rotational movements in a plane identical or parallel withthe plane of a cabin wall (WA), the slot (LS) extending preferably along a diameter of said disc. Alternatively said rotatable element may be a hollow cylinder (SC) disposed for rotational movements about a vertical axis in or parallel with one of the cabin walls, said robot shaft protruding through at least one slot (LS) substantially parallel with said rotational axis. In practice the robot shaft is normally connected with the painting tool through manipulator link means (ML) having at least one and preferably three or more axes of motion.



WALL INTEGRATED ROBOT PAINTER

The present invention is related to a robot installation for painting objects inside a cabin having walls isolating the object to be painted from the surroundings.

Programmable robots are generally known in the art and well described in the litterature. Special types of such robots are designed to be used for painting of certain objects, e.g. motor cars, and a robot of this type may be "taught" or preprogrammed by a skilled operator to perform the appropriate movements of a painting tool in order to apply a prescribed layer of paint to a selected part of the motor car body.

Painting of motor cars in industrial scale usually takes place in painting cabins, through which the car bodies are moved on conveyors in line succession. Such cabins may secure sufficient isolation of the health injurous painting areas from the environments.

For external painting of car bodies in such cabins simple and ecconomical resiprocators or the like are usually used. Apparatus of this type may have a sufficient range of resiprocical motion in the vertical direction, but rather limited possibilities of motion in the transversal dimention of the painting cabin, and practically no option for tracking the object to be painted in the direction of the conveyor motion through the cabin. Several such resiprocators having overlapping working ranges along the length direction of the cabin must then be used to maintain a reasonable conveyor speed and paint coverage.

In order to achieve an uniform layer of paint and optimum painting quality, the paint must be sprayed from the painting tool in a controlled manner normally to the surface to be covered. The motional pattern of the tool must then be correspondingly programmed in relation to the curved surfaces and edges of the car body. This can only be accomplished by

means of robot manipulators with six or more axes of motion, which also would allow efficient tracking of the object to be painted and higher conveyor speed through the painting cabin. Such robots must then be located in the painting cabin itself, which would require considerably wider cabins than with the resipocator embodiment discussed above.

Wider cabins would, however, require larger volume flow of venting air through the cabins, and the extended movements of the manipulator parts of robots with many axes of motion, which are located within the cabin, may well set up tubulations in the air flow.

It is, however, essential that the flow of air along the object to be painted is uniform, in order not to disturb the dispersed atomized paint particles directed from the painting tool towards the surfaces to be uniformly painted.

As explained above, both the use of wall mounted resiprocator and location of advanced robots within the painting cabin have certain disadvantages. It is therefore a main object of the present invention to provide a robot installation that to a great extent would overcome all such disadvantages.

It should be noted, however, that the present invention is solely directed to the mounting and installation for robots for the above and similar purposes and is not concerned with the design or construction of the paiting robots per se, or with the programming of robots for efficient and satisfactory painting operations in agreement with the form and movements of the objects to be painted.

Such design and programming are well described elsewhere, e.g. in GB Patent No. 1.431.413 and US Patent No. 4.920.500 issued to the present applicant.

Thus, the invention concerns a robot installation for painting objects inside a cabin having walls isolating the object to be

painted from the ~~sourroundings~~ surroundings, said installation comprising at least one robot shaft associated with a painting tool and protruding through at least one slot penetrating the cabin walls for servo-controlled movements along said slot and possibly also in the direction of and/or about the axis of said shaft, and servo-drive means controlling said robot shaft movements in accordance with a preprogrammed motional pattern for said painting tool.

On this background of the known prior art the robot installation according to the invention has the characterizing feature that said slot is disposed on a rotatable element supported in or on the cabin walls, the servo-drive means comprising means for controlling the rotational movements of said rotatable element in accordance with said preprogrammed motional pattern.

Said rotatable element may be a circular disc disposed for rotational movements in a plane identical or parallel with the plane of a cabin wall, the slot extending preferably along a diameter of said disc, or alternatively a preferably hollow cylinder disposed for rotational movements about a preferably vertical axis in or parallel with one of the cabin walls, said robot shaft protruding through at least one slot substantially parallel with said rotational axis. In both cases efficient tracking in the travelling direction of the object to be painted is achieved by rotation of the rotatable element, possibly in combination with the movements of the robot shaft in the slot.

Advantageously, servo-drive means may be located within said hollow cylinder for actuating the movements of said robot shaft in the slot by means of pivotal motions about at least two axes.

Also, in practice the robot shaft may be connected with the painting tool through manipulator link means having at least one and preferably three or more axes of motion.

The robot installation according to the invention will now be further explained by means of exemplified embodiments with reference to the accompanying drawings, whereon:

Fig. 1 shows schematically a prior art painting cabin having four painting robots mounted inside the cabin,

Fig. 2 shows ~~schematically~~ schematically a painting cabin having wall integrated robots according to the invention.

Fig. 3 shows in principle the wall integration of a rotatable, slotted element with protruding robot shaft according to the invention in a first embodiment, in which said element is a slotted disc, and

Fig. 4 - 6 show in principle the wall integration of rotatable slotted elements with protruding robot shaft according to the invention in further embodiments, in which said elements are slotted cylinders.

As the present invention is not concerned with the design and construction of robot manipulators or their component parts per se, but merely with suitable cabin wall integration of certain movable robot elements, only the elements involved in such integration being illustrated in principle in the figures and described below.

In Fig. 1 it is shown schematically in section a top plane view of a conventional painting cabin CA having side walls WA and end walls WB, and a motor car body AU situated centrally in said cabin. Also four painting robots PR are suitably located in the cabin along the side walls for efficient painting of the motor car body. These robots are advanced robot manipulators having a large numer of axes of motion and are consequently able to efficiently perform detailed painting operations in accordance with a "pre-taught" painting program adapted to the particular type of motor car body in question.

Motor car bodies of this type are then moved in succession on a conveyor (indicated by a thick arrow in the figure) into and through the painting cabin CA, having inlet and outlet opening CI, CO for this purpose, the intermittent conveyor speed being adapted to the painting program of the robot manipulators PR for allowing uniform paint coverage and optimum tracking of the moving car bodies AU by the painting robots.

As evident from Fig. 1, the painting robots PR are in this conventional embodiment occupying an unduly large portion of the cabin volume. Also the large moving parts of the robot manipulators and their extensive movements are likely to set up turbulations in the flow of venting air through the cabin, which may negatively affect the uniformity of the layer of paint sprayed onto the car body surface in atomized form.

These disadvantages may be overcome to a large extent by means of a narrower cabin provided with simple reciprocators for the painting of the motor cars by means of painting tools mounted on arms extending through narrow slots in the cabin walls and disposed for vertical reciprocating movements along the slots, as discussed above.

However, with such a solution the quality of the painting would be largely degraded, which is not feasible in many cases, where uniform paint coverage and an always reliable painting process are primary requirements.

Hence, in order to combine a narrow cabin with robot manipulators able to produce high quality painting with reduced venting air agitation, it is suggested according to the invention to integrate the robots with the cabin walls.

Such a painting cabin CA with wall integrated robot installations IR is illustrated inFig. 2, in which a cabin of the same general design as the one in Fig. 1 is shown in the same format and with the same reference characters indicating corresponding components. Here a cabin embodiment with two

wall integrated robots and a shorter cabin is shown in upper portion of the figure, whereas an embodiment with three wall integrated robots and extended cabin length is shown in the lower portion. In both cases the operating fields of the various robots are indicated with the designation N. In this manner robot installations with wide operation fields and ample tracking abilities are realized in combination with reduced cabin dimensions.

One way of integrating a robot manipulator in a cabin wall is illustrated in Fig. 3. Here it is indicated that a ~~cicular~~ circular disc CD having a diametrical slot LS is rotatably supported in the cabin wall WA. Such rotatable support may be realized by any suitable means known in the art. The range of rotation may be a full revolution or a suitable fraction of the same, e.g. a half or a quarter of a revolution. The main manipulator shaft RS is protruding through the diametrical slot and is disposed for translational motions along the slot and in the axial direction of the shaft.

Thus, by means of the slotted disc CD and the protruding shaft three axes of motion may be realized for the robot manipulator, e.i. the rotational axis of the disc, indicated by S1, the translational movement of the shaft along the slot, indicated by S2, and the translational movement of said shaft in the direction of the shaft axis, indicated by S3 in the figure. By these means coarse positioning of the painting tool in accordance with the set painting program may be performed by the servo-controlled drive means of the rotatable disc and the robot shaft in all the three cartesian coordinates x, y and z indicated in Fig. 3, i.e. the length, width and height dimensions respectively, of the painting cabin. An efficient tracking function in the x direction may then be provided by the wall based axis S1, possibly in combination with the other wall based axes of motion S2 and S3.

The finer and exact positioning of the tool is then achieved through the axes of motion S4, S5, S6 provided by the wrist manipulator link ML, which is connecting said robot shaft RS with the painting tool and controlled by the servo-drive means.

Another embodiment of the wall integration of said rotatable element of the painting robot is illustrated in principle in Fig. 4. Here the rotatable element is a hollow slotted cylinder SC supported vertically in the cabin wall for rotational movements about the central axis of the cylinder. The main robot shaft is protruding through a pair of mutually aligned slots LS through the cylinder walls and parallel with the cylinder axis.

The coarse robot movements in the directions of the said coordinates x, y and z corresponding to the cabin dimensions mentioned above, may in this case be realized through the rotation of the cylinder SC about its central axis, indicated by the axis of motion S1, together with translational movements of the main robot shaft RS along and perpendicularly to the slot, corresponding the indicated axis of motion S2 and S3, respectively. Also in this case an efficient tracking function in the x direction may be achieved by means of the wall based axes of motion S1, S2 and S3.

In Fig. 5 it is shown an embodiment of the same type as in Fig. 4, comprising a rotatable cylinder integrated in the cabin wall, the only difference being that the main robot shaft RS is pivotally supported in the cylinder itself, rather than disposed for translational movements along the slot. Thus, the latter translation movement is here substituted by a pivotal movement in a considerably shorter pair of cylinder slots LS, as indicated by the shown rotational axis of motion S2, the other axes of motion S1 and S3 being the same as in Fig. 4.

In this manner the same coarse servo-controlled robot movements along the said cartesian axes x, y and z, and associated object tracking as explained earlier, may be realized.

In Fig. 6 also a wall integrated rotatable element in the form of a hollow cylinder SC is shown. In this case the cylinder is appropriately supported on a more solid base, as the servo-drive machinery is located inside the cylinder itself, the main robot shaft protruding through a single slot in the cylinder wall. Here the wall-based coarse robot movements in the x, y and z directions are realized by means of three rotational axes of motion, S1, S2 and S3, respectively, which also may provide the intended object tracking discussed above.

As in the embodiment shown in Fig. 3, also with the latter embodiments illustrated in the Figs. 4, 5 and 6, the finer servo-controlled movements of the painting tool is performed by means of the additional axes of motion S4, S5 and S6 of the wrist manipulator link ML.

With the wall integrated robot installations according to the invention considerably reduced dimensions of painting cabins are achieved, while maintaining large operational fields for the integrated robot manipulators. Efficient tracking functions are provided in the direction of the conveyor motion (the x direction) even with very narrow cabins. Due to the wall integration of several axes of motion of the robot manipulators, a reduced number and size of movable components would be operating in the interspace between the cabin walls and the object to be painted, e.g. a motor car body, which means less turbulations in the venting air through the cabin and thereby a more uniform paint coverage.

Practical wall integrated test installations have shown that a saving of the order of 10 - 25 % may be achieved in the width dimention of the cabin (the y direction). Due to more efficient tracking, also a cabin length reduction up to 25 %

may be achieved in the length direction (the x direction). Reduction of the order of 10 - 40 % in the cabin volume to be vented are then obtainable, which means less venting air, less air turbulation and less disturbance of the painting process.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A robot installation for painting objects inside a cabin having walls isolating the object to be painted from the surroundings, said installation comprising at least one robot shaft associated with a painting tool and protruding through at least one slot penetrating the cabin walls for servo-controlled movements along said slot and servo-drive means controlling said robot shaft movements in accordance with a preprogrammed motional pattern for said painting tool, characterised in that said slot is disposed on a rotatable element supported in or on the cabin walls, the servo-drive means comprising means for controlling the rotational movements of said rotatable element in accordance with said preprogrammed motional pattern.

2. A robot installation as claimed in claim 1, wherein said slot enables further controlled movements in the direction of and/or about the axis of the shaft.

3. A robot installation as claimed in claim 1, characterised in that said rotatable element is a circular disc disposed for rotational movements in a plane identical or parallel with the plane of a cabin wall.

4. A robot installation as claimed in claim 2, wherein said slot extends along a diameter of said disc.

5. A robot installation as claimed in claim 1, characterised in that said rotatable element is disposed for rotational movements about an axis in or parallel with one of the cabin walls, said robot shaft protruding through at least one slot substantially parallel with said rotational axis.

6. A robot installation as claimed in claim 5, wherein the rotatable element comprises a hollow cylinder.

7. A robot installation as claimed in claim 6, wherein the cylinder is disposed for rotational movements about a vertical axis.

8. A robot installation as claimed in claim 5, characterised in that the robot shaft is disposed for translational movements along the slot, controlled by the servo-drive means.

9. A robot installation as claimed in claim 5, characterised in that the robot shaft is disposed for pivotal movements in the slot, controlled by the servo-drive means.

10. A robot installation as claimed in claim 9, wherein the robot shaft is disposed for pivotal movements about a pivot axis located inside the hollow cylinder.

11. A robot installation as claimed in claim 9, characterised in that servo-drive means are located within said hollow cylinder for actuating the movements of said robot shaft in the slot by means of pivotal motions about at least two axes.

12. A robot installation as claimed in any one of claims 1 to 11, characterised in that the robot shaft is connected with the painting tool through manipulator link means having at least one axis of motion.

13. A robot installation as claimed in claim 12, wherein the manipulator link means has three or more axes of motion.

14. A robot installation substantially as hereinbefore described with reference to the accompanying drawings.

DATED this 21st day of July, 1997
ABB TRALLFA ROBOT A/S
By its Patent Attorneys
DAVIES COLLISON CAVE

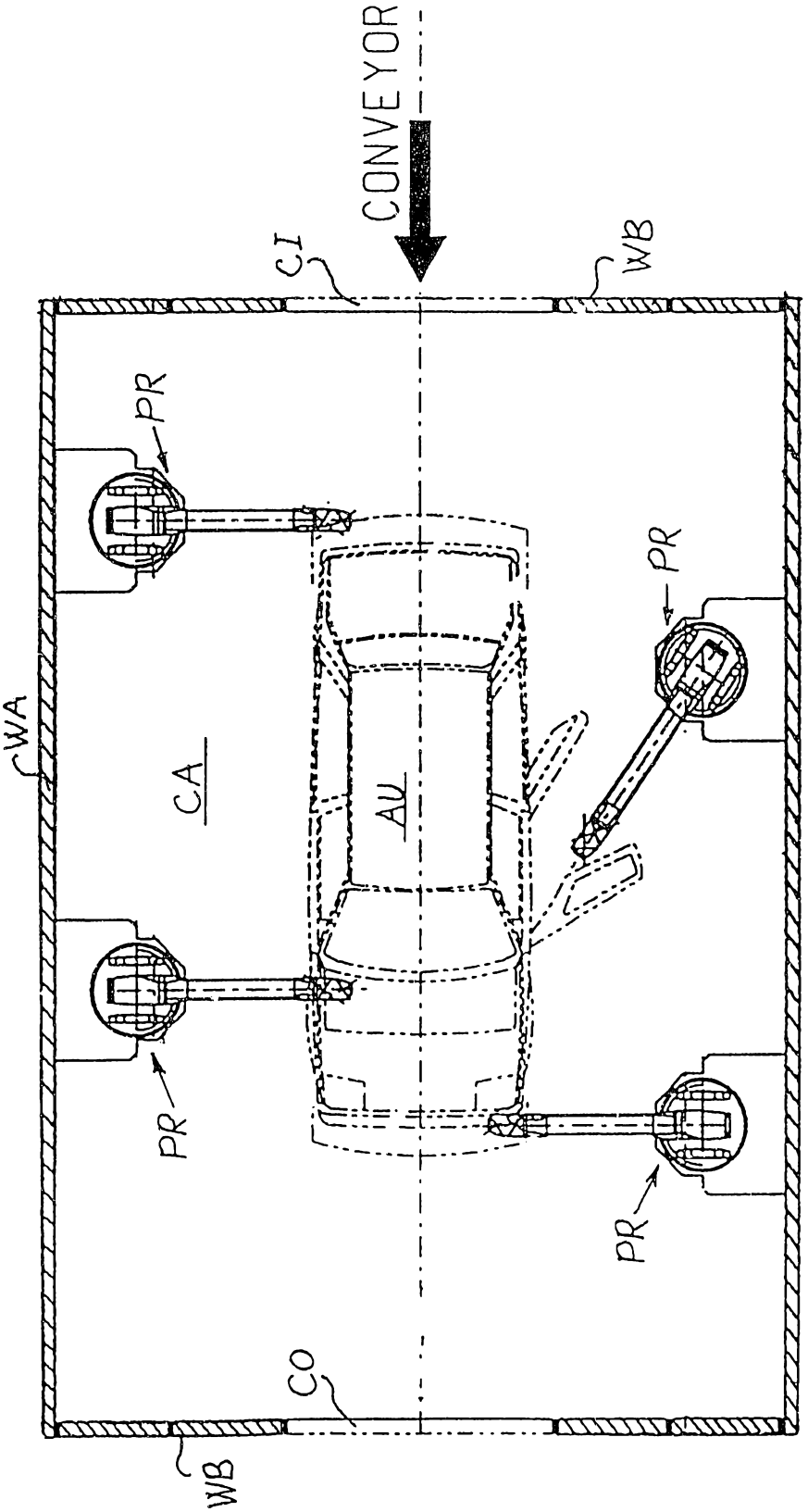


Fig. 1

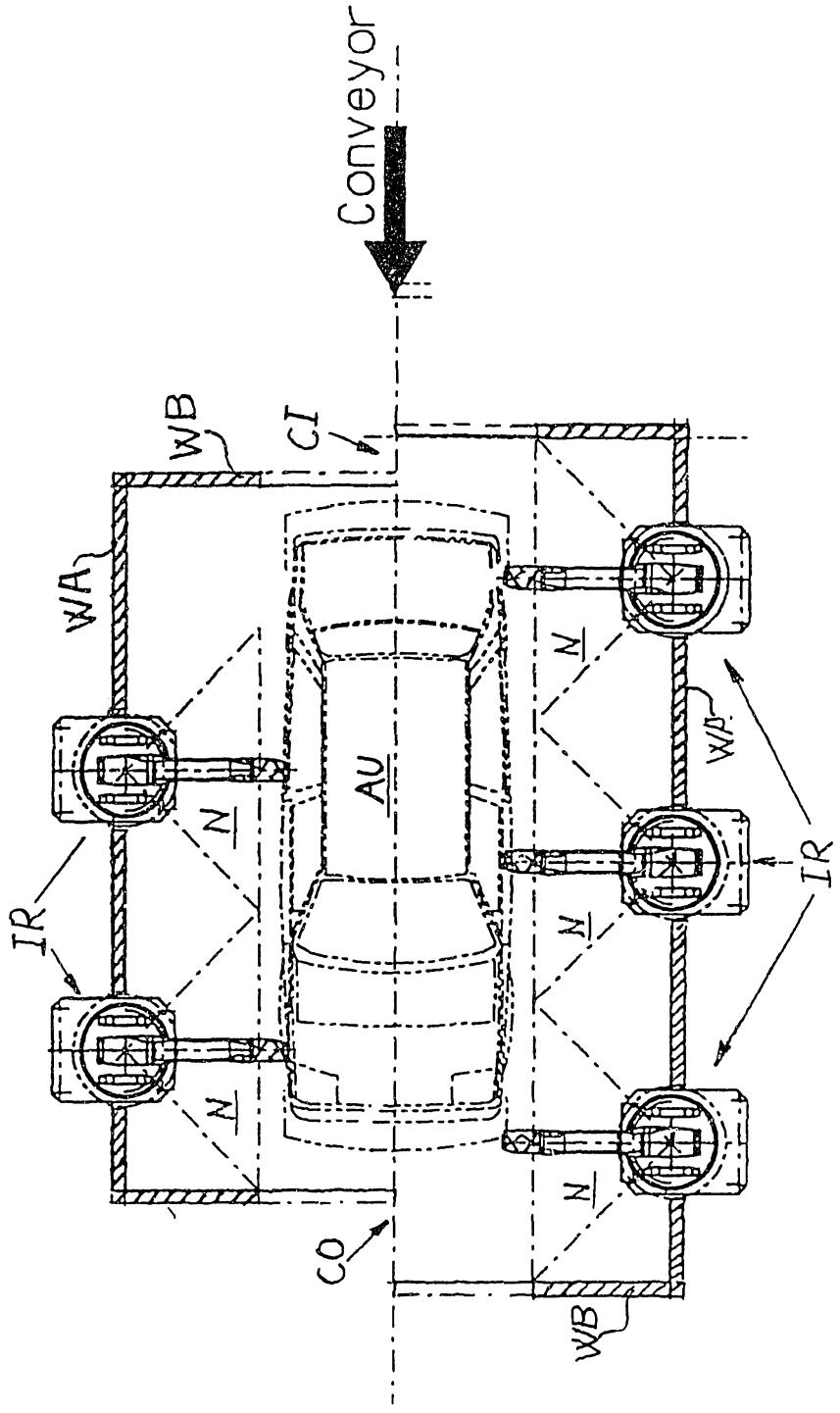


Fig. 2.

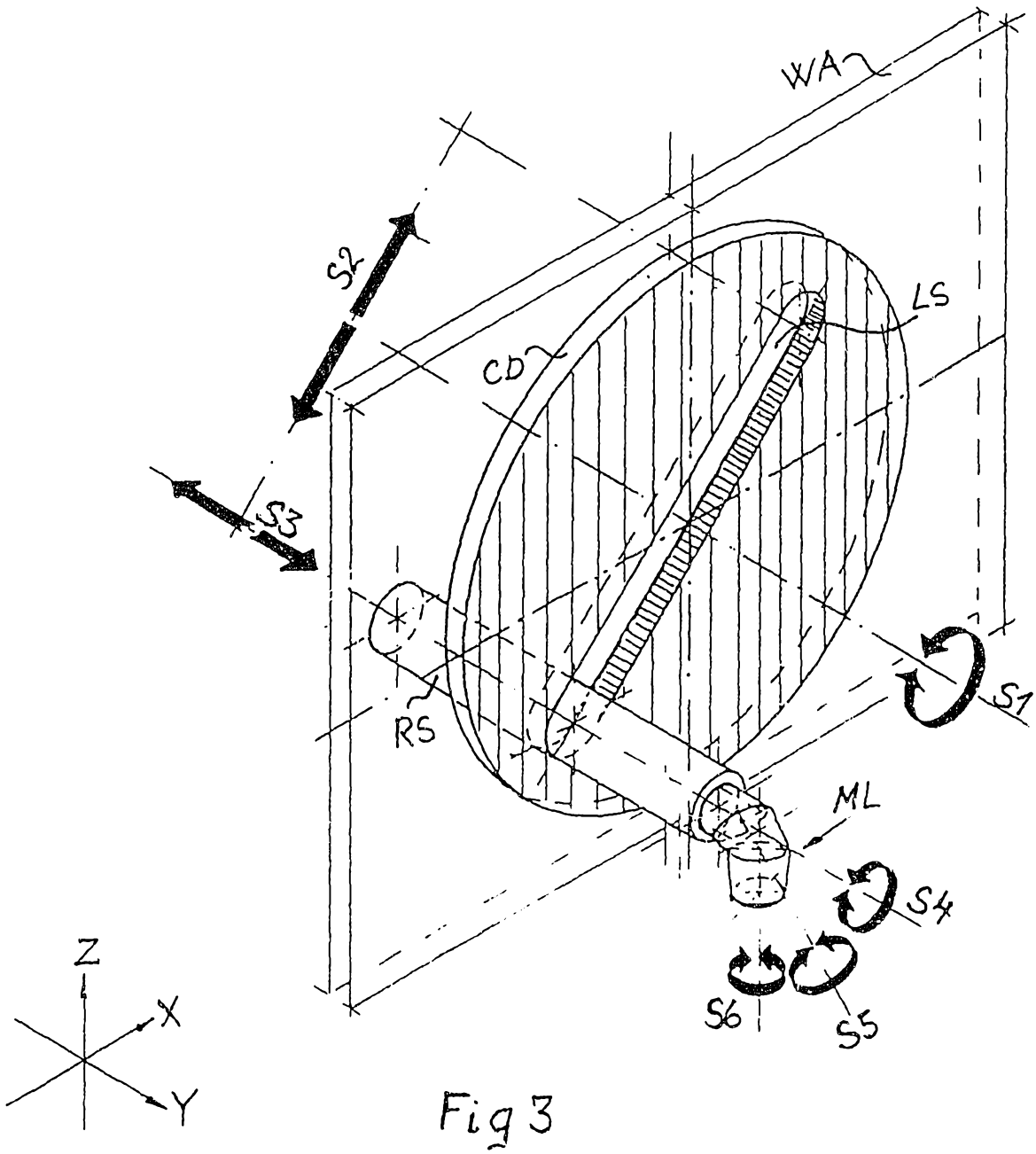


Fig 3

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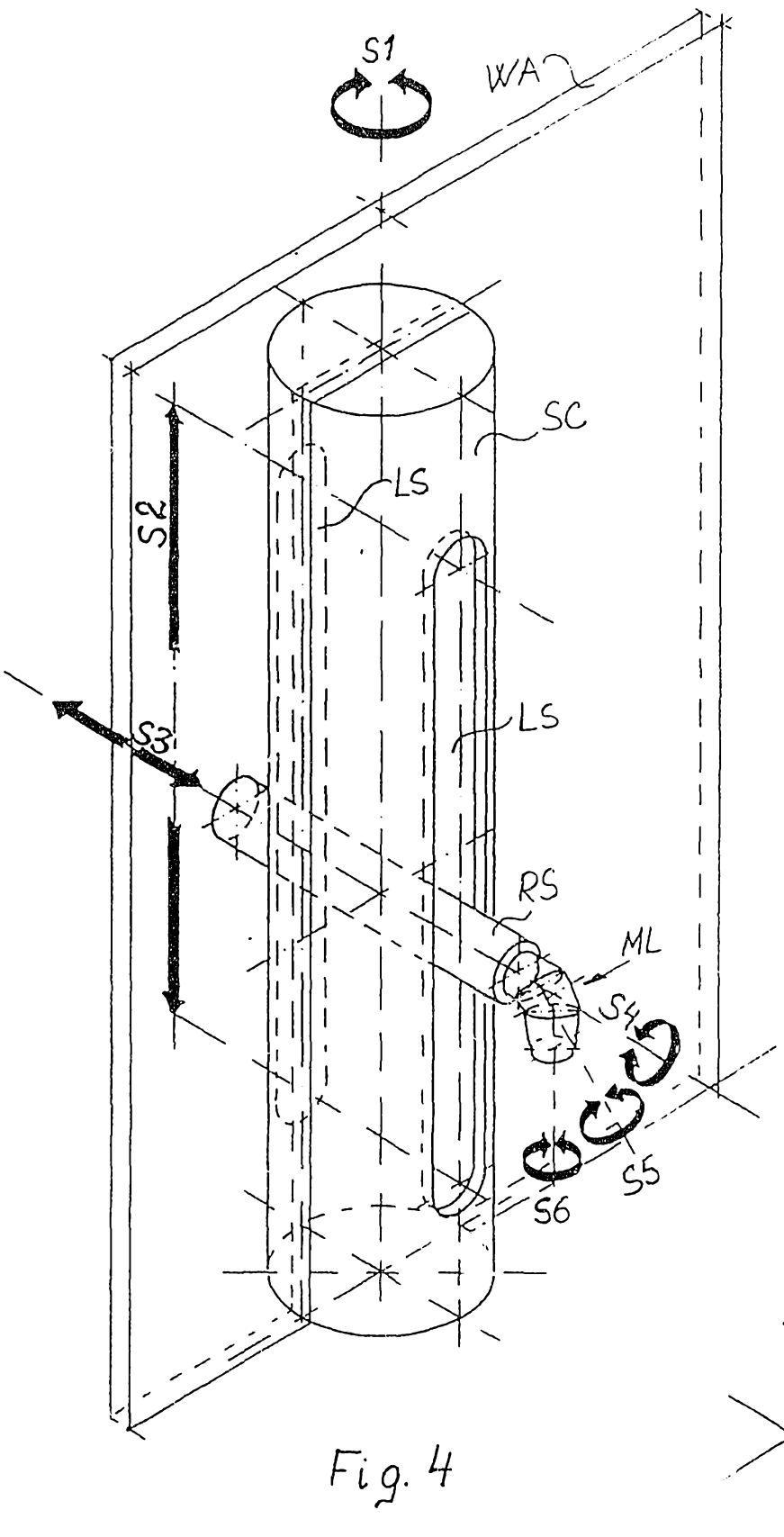

Fig. 4

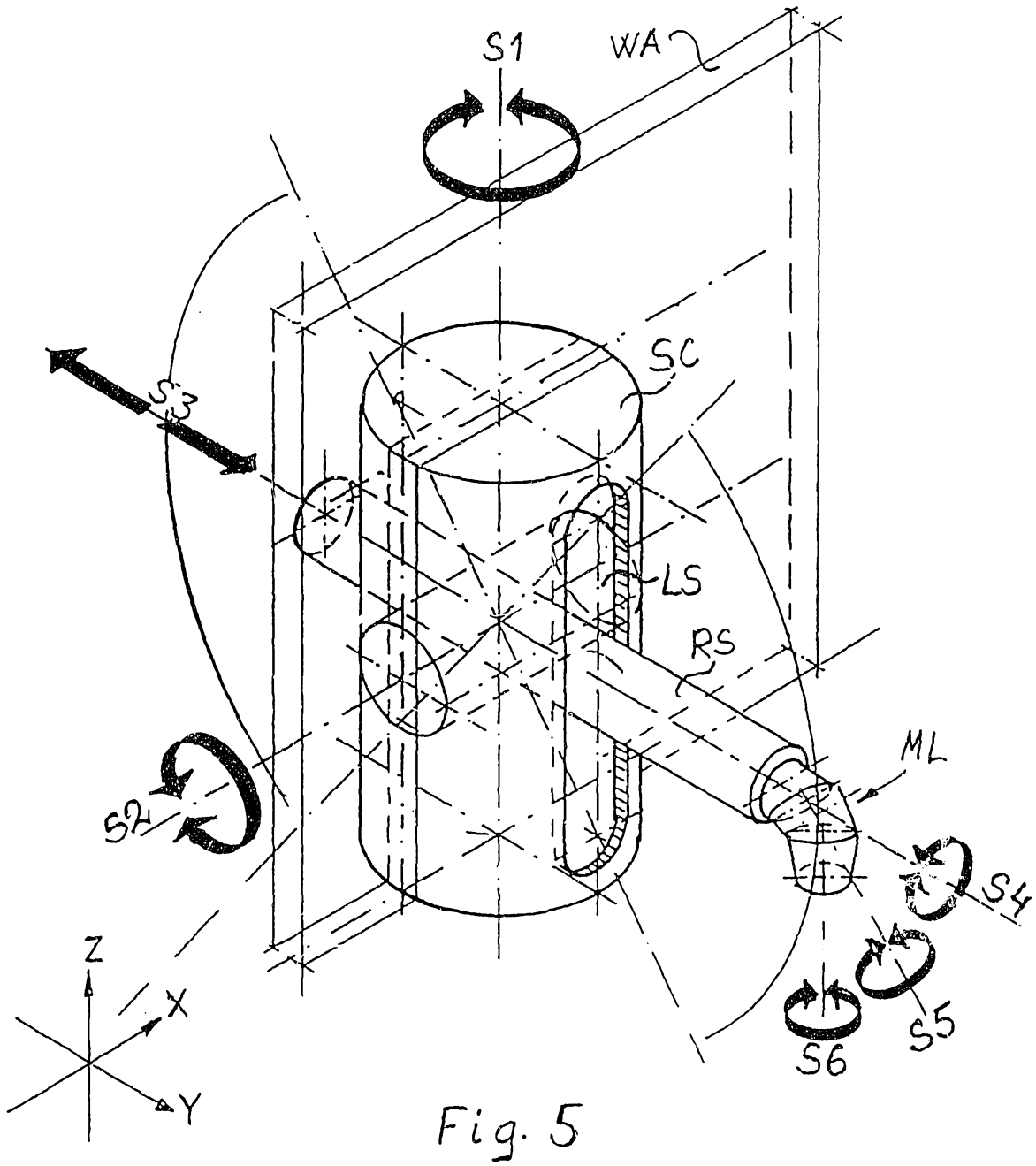

Fig. 5

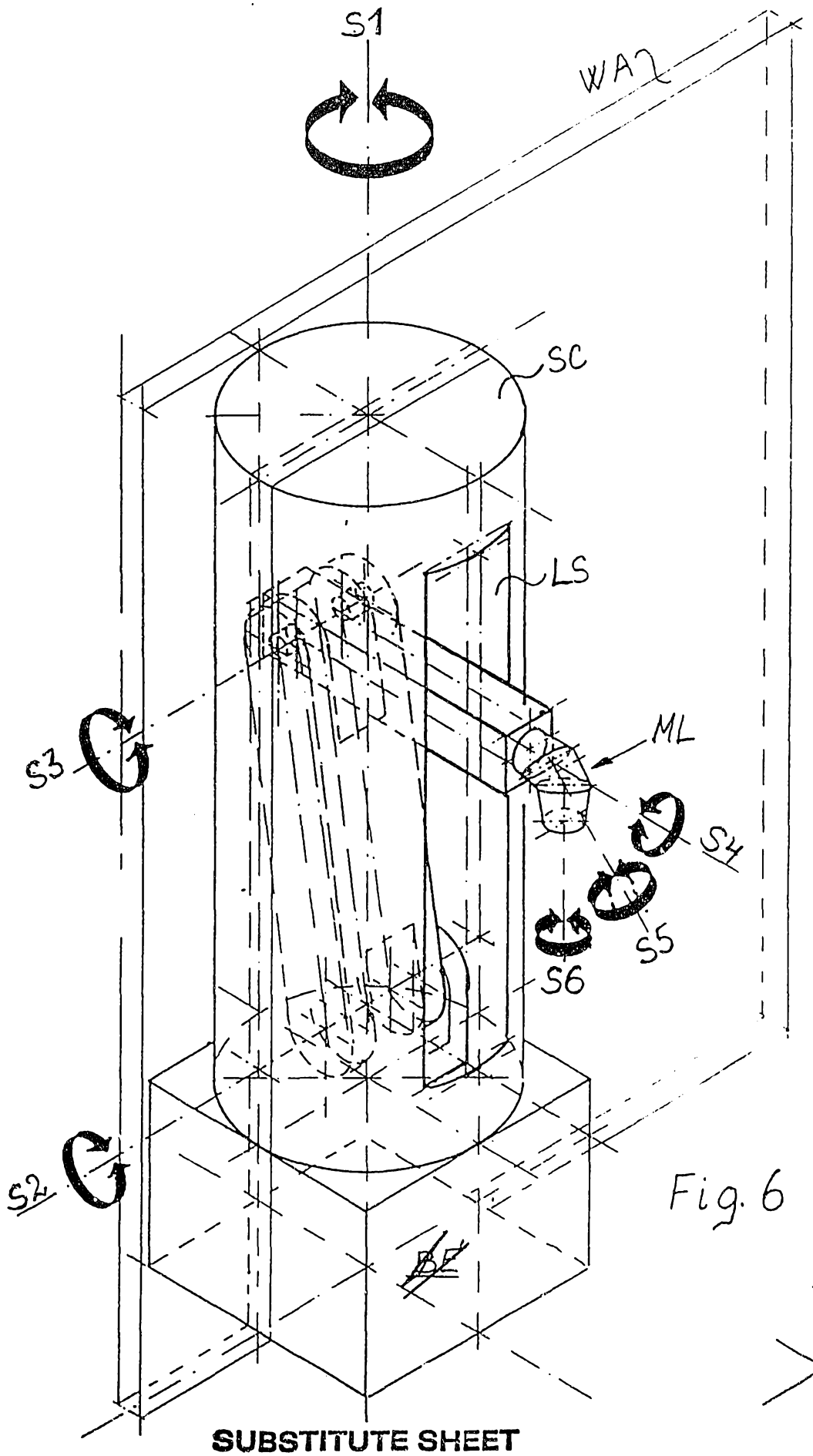

Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 93/00117

A. CLASSIFICATION OF SUBJECT MATTER

IPC5: B05B 13/04
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC5: B05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP, A1, 0536459 (ABB FLÄKT RANSBURG GMBH), 14 April 1993 (14.04.93), column 7, line 4 - line 24, figures 1,5, claims 1-3 --	1,2,3,4
A	WO, A1, 9114509 (ERIC VON GERTTEN AB), 3 October 1991 (03.10.91), page 10, line 23 - line 30, figures 5,8 --	1
A	US, A, 5213620 (ERICH MEYER), 25 May 1993 (25.05.93), column 3, line 51 - line 54, figures 1, 3, abstract --	1

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
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"P" document published prior to the international filing date but later than the priority date claimed
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"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 February 1994	21 -02- 1994
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Johan von Döbeln Telephone No. +46 8 782 25 00

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 93/00117

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 4920500 (AMUND HETLAND ET AL), 24 April 1990 (24.04.90), column 2, line 31 - line 36; column 3, line 34 - line 41, figures 1,4, abstract	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

28/01/94

International application No.
PCT/NO 93/00117

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A1- 0536459	14/04/93	DE-A- 4107094	10/09/92
		EP-A- 0504535	23/09/92
WO-A1- 9114509	03/10/91	AU-A- 7576691	21/10/91
		SE-B,C- 464222	25/03/91
		SE-A- 9000998	25/03/91
US-A- 5213620	25/05/93	EP-A- 0476561	25/03/92
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		CA-A- 1272275	31/07/90
		EP-A,B- 0261106	30/03/88
		SE-T3- 0261106	