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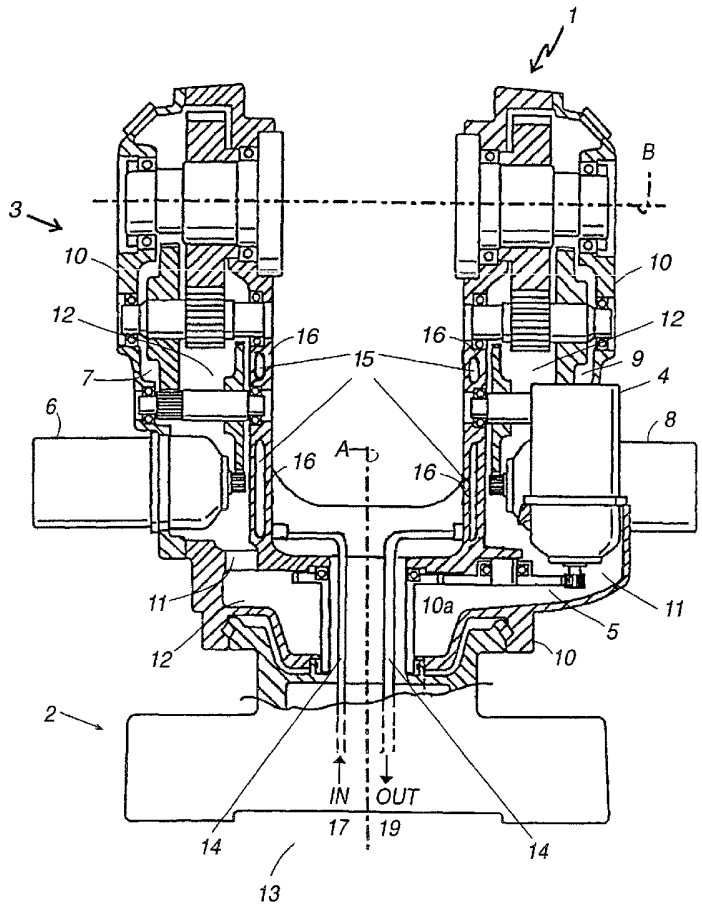
(54) Title: INDUSTRIAL ROBOT COMPRISING A COOLING DEVICE



(57) Abstract: The invention relates to a system comprising an industrial robot comprising a manipulator, the movements of which are provided by of at least one motor-driven gear unit (5, 7, 9) with a gear housing (10) contains a coolant and a lubricant (12) that are circulated by the movement. A cooling device (13) is arranged to transport heat from the coolant and the lubricant (12). The cooling device (13) is arranged outside or inside the gear housing (10). The invention also relates to a method for decreasing the temperature of a coolant and a lubricant (12), circulated by the movement, in a gear housing (10).

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SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Industrial robot comprising a cooling device

TECHNICAL FIELD

The present invention relates to a system comprising an industrial robot with a manipulator comprising a cooler.

BACKGROUND ART

In, for example, six-axis industrial robots, which have a vertical arm articulately connected on a stand, drive means for the arms are placed near the centre of rotation of the arm. The remaining drive means are arranged nearer to the working tools of the robot. Each drive means drives its own axis via a gear and a transmission, and hence attains one degree of freedom. The gear is usually in the form of a toothed gearing built into a gear housing filled with a coolant and lubricant, which usually consists of oil.

US patent US 4,671,732 discloses a six-axis industrial robot with three drive means arranged in the lower part of the robot near the stand. The three drive means are identical, which facilitates the design of and any repair of the robot. The three drive units are completely separated as regards spaces for lubricant.

In operation, the industrial robot is normally included in a production loop with, for example, a press. The robot supplies the press with moulding blanks which arrive at the robot via some form of transport device. The technical development aims at faster presses and also faster transport devices. Thus, the development entails a need of faster robots. It is estimated that the running speed of the robot has increased by a factor of five in fifteen years. This has resulted in a need for the gears included in the robots to attain increasingly higher speeds. Further, there is a need of an increased operating speed in combination with an increased handling weight, which leads to an increased load

and a need of increased supplied power. In a robot comprising, for example, one or more toothed gearings, the high speed as well as the high load lead to increased friction heat on the teeth included in the gear and hence increased generation of heat in the gears.

For the purpose of receiving and discharging heat from the teeth, the gear is surrounded by a coolant and lubricant. Problems arise when the running speed of the robot is so high and the generation of heat so great that the coolant and lubricant does not manage to cool the gear. Then, there is a risk that the coolant and lubricant of the gear, electronics included and seals included may be damaged by the high temperature that is generated in the gears. In the long run, also the teeth risk being damaged. Thus, too high temperatures reduce the service life of the gear very drastically. There is an increased risk of frequent shutdowns and expensive renovations of the robot.

The three lower motors in the robot are activated to differing degrees and the corresponding gears are heated to differing degrees. This leads to an uneven distribution of generated heat, which entails different local thermal expansions of the material/metal in the robot, which in turn leads to deformities in the structure of the robot. The precision of the robot is deteriorated and the robot is unable to fulfil the performance expected by the robot user.

Another problem that arises at high temperatures is that the precision of the work of the robot is lowered. In, for example, a six-axis robot, it is particularly the drive unit, which drives the rotation of the robot around the vertical axis A (Fig. 2), and its gear that are loaded most and have to be run at very high speed. There, the temperature will be very high and causes temperature differences to arise in different regions of the coolant and lubricant in the gear housing of the motor. This, in turn, implies

that a turn disc, arranged in the foot and around which the robot is built and which ensures the rotation around the A axis, is at risk of having an uneven temperature distribution, which influences the precision.

It is known to solve the above-mentioned problems by arranging cooling flanges outside the gear housing. The solution is space-demanding and is not suited for an industrial robot included, for example, in a production line. In addition, cooling flanges do not provide sufficient cooling at high speeds of the robot.

Hence, when manufacturing industrial robots, a need arises of a robot that manages fast running under high loading while maintaining the precision. In addition, it should be simple to give the robot the necessary operational service.

This need cannot be fulfilled by any robots according to the prior art.

SUMMARY OF THE INVENTION

The object of the present invention is to obtain faster robots that correspond to the possibilities of the peripheral equipment and the requirements of the customer. There is also a desire to increase the time between planned service intervals. The object is to achieve a robot comprising at least one motor-driven gear, wherein the gear is arranged such that the requirement for sufficient cooling is fulfilled while at the same time the robot achieves the requirements made for precision and the time for interruption in production, primarily due to servicing, is reduced.

According to a first aspect of the invention, the solution is a system comprising the characteristic features described in the independent device claim 1, and according to a second aspect a method in an industrial robot in accordance

with the characteristic features described in the independent method claim 12.

The gear unit is preferably a compact gear in the form of a toothed gearing or an RW gear. It is part of the solution according to the invention that the gear unit also comprises other types of gears, suitable for the purpose.

A system comprising an industrial robot with a manipulator, the movements of which are provided by at least one motor-driven gear unit with a gear housing containing a coolant and lubricant circulating due to the movement. A cooler is adapted to discharge thermal energy from the circulating cooling and lubricant and hence to cool the same.

It is part of the inventive concept to arrange the cooler externally in relation to the robot. In one embodiment, the cooler is an extra piece of equipment. It is suitable to place the cooler in the form of an extra piece of equipment externally in relation to the gear housing at an insensitive location, on or close to the gear housing. One possible embodiment is that the coolant and lubricant is passed out from the gear housing, to and through the cooler, and back into the gear housing. The coolant and lubricant in the gear housing circulates either by itself or with the aid of a device that facilitates/accelerates the circulation, for example a pump.

It is part of the inventive concept to integrate the cooler into the robot. In one embodiment, it is integrated in at least one wall portion of the gear housing. In another embodiment, the cooler is arranged to be integrated and protruding from a wall portion in a direction towards the internal volume of the gear housing.

It is also part of the inventive concept to arrange the cooler inside the internal volume of the gear housing.

In, for example, welding robots, the coolant is passed to the tool through the robot structure. It is part of the solution according to the invention to combine the cooling of a robot tool with the cooling of the coolant and lubricant. In one embodiment, the cooler according to the invention comprises a cooling coil to a welding tool arranged combined with a cooler, for a gear housing, in the form of a heat exchanger. The heat exchanger contains a coolant that discharges heat from both the welding tool and the gear unit. The coolant consists of a fluid, for example water. Alternatively, one or more cooling coils to or from different robot tools and one or more heat exchanger are connected to a common, central cooling device. A further alternative is that a plurality of heat exchangers are arranged on one or more robots and that these heat exchangers are connected to a common, central cooling device.

In exchangers comprising a coolant and lubricant there is a need to filter away undesired particles from the medium. It is, therefore, part of the inventive concept to arrange at least one filter such that the circulating coolant and lubricant passes through at least one filter.

It is part of the inventive concept that the cooler is a heat exchanger containing a coolant in the form of a fluid. In one embodiment, the coolant is water.

According to a second aspect of the invention, the solution is a method, in a system comprising an industrial robot with a manipulator, the movements of which are provided by at least one motor-driven gear with a gear housing, for reducing the temperature of coolant and lubricant circulating in the gear housing due to the movement. A cooler is arranged, a coolant arranged in the coolant is brought to circulate, heat from the coolant and lubricant is transferred to and discharged by the circulating coolant. In one embodiment of the invention, the circulating coolant and lubricant is brought to be cooled externally in relation to

the gear housing. In another embodiment according to the invention, the circulating coolant and lubricant is brought to be cooled inside the gear housing. The method according to the invention comprises raising the effect of the cooling by increasing the circulation of the coolant and lubricant. The method according to the invention also comprises separating, at the same time, undesired particles from the coolant and lubricant by bringing the circulating coolant and lubricant to pass through a filtering device.

The invention also relates to use of the system according to the invention for common cooling of coolant and lubricant from one or more industrial robots and/or robot tools.

Additional preferred embodiments are clear from the dependent claims and the subsequent description.

BRIEF DESCRIPTION OF THE DRAWING

The invention will be explained in greater detail by description of embodiments with reference to the accompanying drawing, wherein

Figure 1 is a six-axis industrial robot equipped with three drive units in the lower part of the robot.

Figure 2 is an industrial robot equipped with an external heat exchanger in accordance with the present invention.

Figures 3a and 3b are industrial robots equipped with external heat exchangers in accordance with the present invention.

Figure 4 is a cooling device according to the invention arranged in an internal chamber in a gear housing.

Figure 5 is a system of interconnected heat exchangers according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In an industrial robot, comprising a manipulator with a control device (Figure 1), electrically motor-driven gears are arranged in the lower part of the robot at the stand to attend to the movements of the robot arm. Each electric motor transmits rotational movements to a toothed gearing, which usually drives a transmission that transmits movements to the robot arm. Figure 2 shows a six-axis industrial robot 1 with a stand 2 and the robot foot 3 rotatably journalled thereon, where a first drive unit 4 is adapted, via a first toothed gearing 5, to rotate the robot around the vertical axis A. A second drive unit 6 is adapted, via a second toothed gearing 7, to rotate the robot arm around a horizontal axis B, and a third drive unit 8 is adapted, via a third toothed gearing 9, to rotate the robot arm around the horizontal axis C. The first, second and third gearings (Figure 1) are arranged in a common gear housing 10. The gear housing 10 is cast in one piece and for reasons of structural strength the gear housing 10 is divided into several internal chambers 10a, 10b and 10c, which are connected to overflow channels 11. The gear housing 10 is filled with a coolant a lubricant 12, which surrounds the gears 5, 7 and 9. In operation of the robot, the first, second and third motors and their gears operate to a varying degree for the robot to carry out the desired movements. By driving the various gears, the surrounding coolant and lubricant 12 is set in circulation. The coolant and lubricant takes up heat from the teeth and by the circulation in the common gear housing, any temperature differences of the agent 12 are equalized and a uniform temperature is obtained in the entire housing. To facilitate/accelerate the circulation of the agent 12, an external device 13 may be connected to the gear housing, for example from a pump (not shown).

Figure 2 further shows a device 13 adapted to discharge thermal energy from the circulating coolant and lubricant

12. The device comprises cooling ducts 15 which are integrated into internal wall portions 16 of the gear housing 10. A cooling agent 14, for example water, is adapted to circulate in the cooling ducts 15. The cooling agent 14 passes into the robot via a duct 17 from an external heat exchanger 18 (not shown), through the duct 15 and further passes out from the robot via a duct 19 back to the heat exchanger 18.

In Figure 3, a first external duct 20 passes the coolant and lubricant 12 out from the gear housing 10 and further to an external heat exchange 18. The coolant and lubricant 12 passes through the heat exchanger, whereby it is cooled. A second external duct 21 passes the cooled coolant and lubricant 12 out from the heat exchanger 18 and further back to and into the gear housing 10. The heat exchanger comprises a system with the cooling agent 14, which discharges the thermal energy absorbed from the coolant and lubricant 12. Air (Figure 3b) or the alternative cooling agent 14, for example water (Figure 3a), is circulated in the system. Figure 3b further shows an alternative of the invention with a first part 22 of the device 13 arranged to protrude from a wall portion 23 of the gear housing 10 in a direction into one of the internal chambers 10b of the gear housing. Figure 3b shows a further alternative of the invention with a second part 24 of the device 13 arranged inside the internal chamber 10a of the gear housing with only connections and a possible support (not shown) fixed to the chamber wall 25. Figure 4 shows a schematically illustrated second part 24 of the device 13.

It is part of the invention that a plurality of devices 13 comprising heat exchangers 18 are connected to a central cooling device 27 for common cooling of the cooling agent 14. Figure 5 shows a system formed by five heat exchangers and comprising a central cooling device. Figure 5 intends to show five heat exchangers connected to a robot with robot tools, or, alternatively, five heat exchangers connec-

ted to different robots. A filter 28 is arranged in each conduit 20 that conducts the coolant and lubricant to the respective heat exchanger.

The invention is not, of course, in any way limited to the preferred embodiments described above but a plurality of possibilities of modifications thereof are included in the inventive concept, which are described in the appended claims.

CLAIMS

1. A system comprising an industrial robot (1) with a manipulator, the movements of which are provided by means of at least one motor-driven gear unit (5, 7, 9) with a gear housing (10) containing a coolant and lubricant (12) circulating due to the movement, **characterized** in that a cooler (13) is adapted to discharge the thermal energy from the circulating coolant and lubricant (12) and hence to cool the same.

2. A system according to claim 1, wherein the cooler (13) is mounted externally in relation to the gear housing (10).

3. A system according to claim 1, wherein the cooler (13) is arranged to be integrated into the robot.

4. A system according to claim 3, wherein the cooler (13) is arranged to be integrated into at least one wall portion (16) of the gear housing.

5. A system according to claim 4, wherein the cooler (13) comprises a first part (22) arranged to protrude from the wall portion (23) in a direction into the internal chamber (10a, 10b, 10c) of the gear housing.

6. A system according to claim 4, wherein the cooler (13) comprises a second part (24) arranged inside the internal volume (10a, 10b, 10c) of the gear housing.

7. A system according to any of claims 1-5, wherein the cooler (13) is a heat exchanger (18) containing a cooling agent (14).

8. A system according to claim 6, wherein the cooling agent (14) consists of a fluid.

9. A system according to claim 6, wherein the cooling agent (14) consists of water.

10. A system according to any of the preceding claims, wherein a device (26) facilitates/accelerates the circulation of the coolant and lubricant (12).

11. A system according to claim 9, wherein the external device () is in the form of a pump.

12. A method in a system comprising an industrial robot (1), with a manipulator, the movements of which are provided by means of at least one motor-driven gear (5, 7, 9) with a gear housing (10), for reducing the temperature of the coolant and lubricant (12) circulating in the gear housing (10) due to the movement, **characterized** in that the a cooler (13) is arranged, that a cooling agent (14) arranged in the cooler (13) is brought to circulate, and that heat from the coolant and lubricant is transferred to and discharged by the circulating cooling agent (14).

13. A method according to claim 12, wherein the circulating coolant and lubricant (12) is brought to be cooled externally in relation to the gear housing (10).

14. A method according to claim 12, wherein the circulating coolant and lubricant (12) is brought to be cooled inside the gear housing (10).

15. A method according to claim 11, wherein the circulation of coolant and lubricant () is brought to increase with the aid of a pump (26).

16. A method according to any of the preceding claims, wherein the circulating coolant and lubricant () is brought to be filtered.

17. Use of a system according to any of claims 1-11 for common cooling of the coolant and lubricant from one or more industrial robots and/or robot tools.

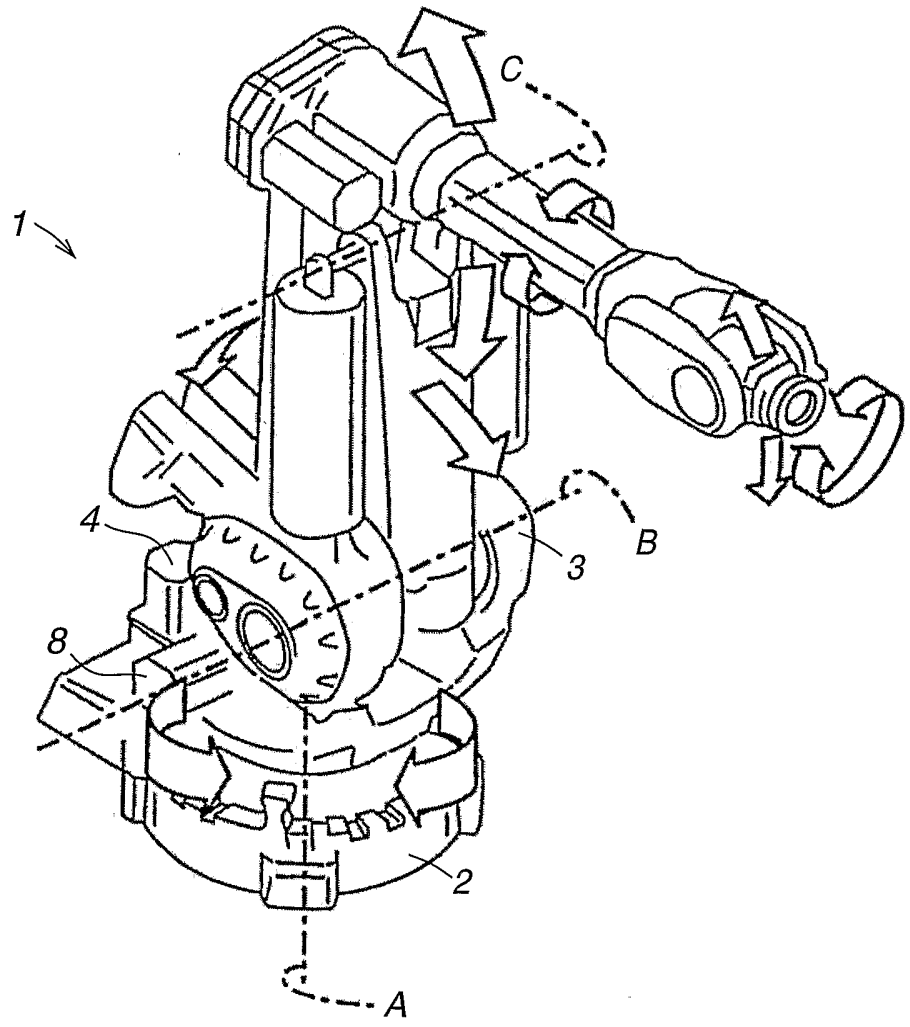

Fig. 1

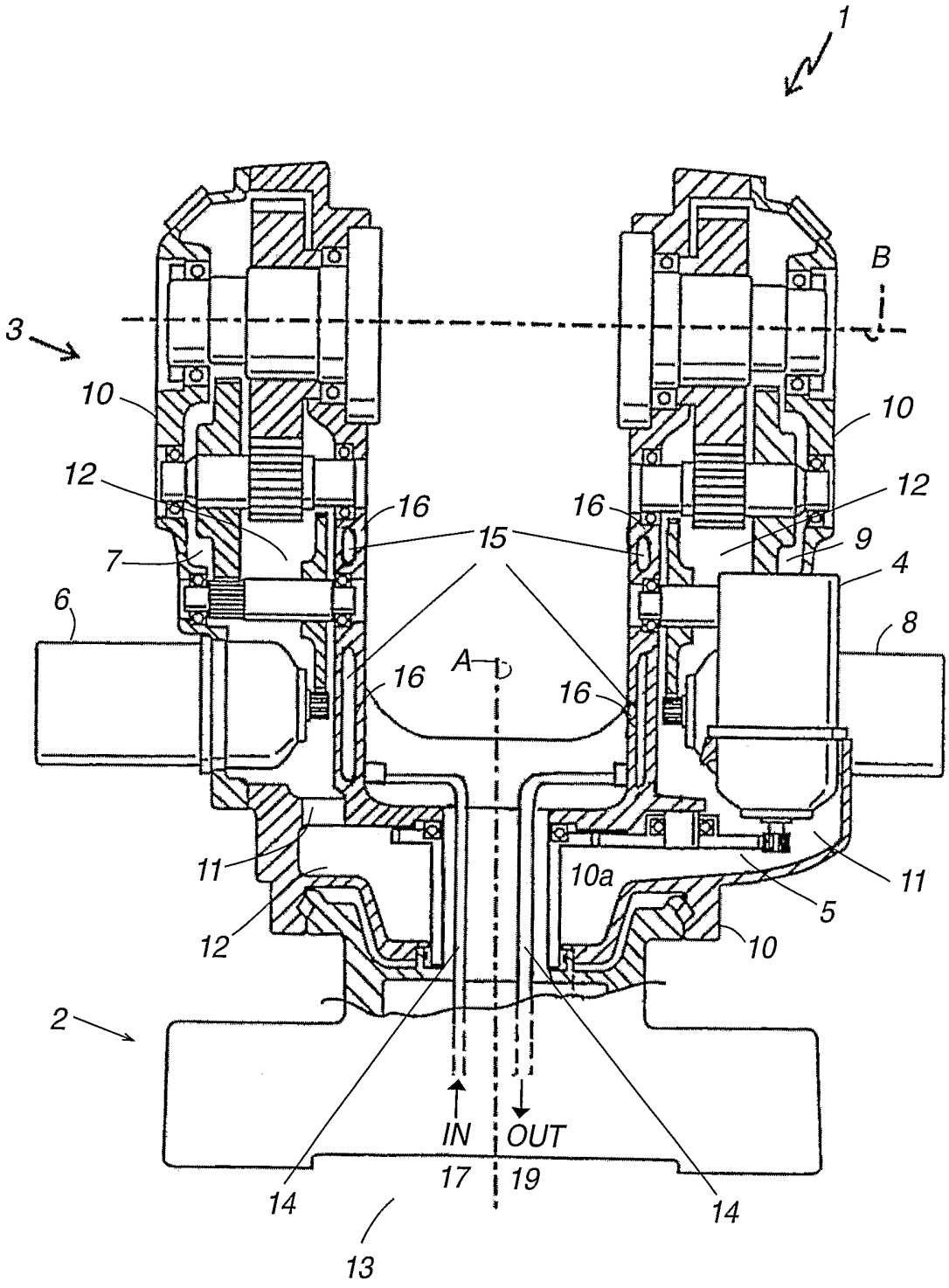

Fig. 2

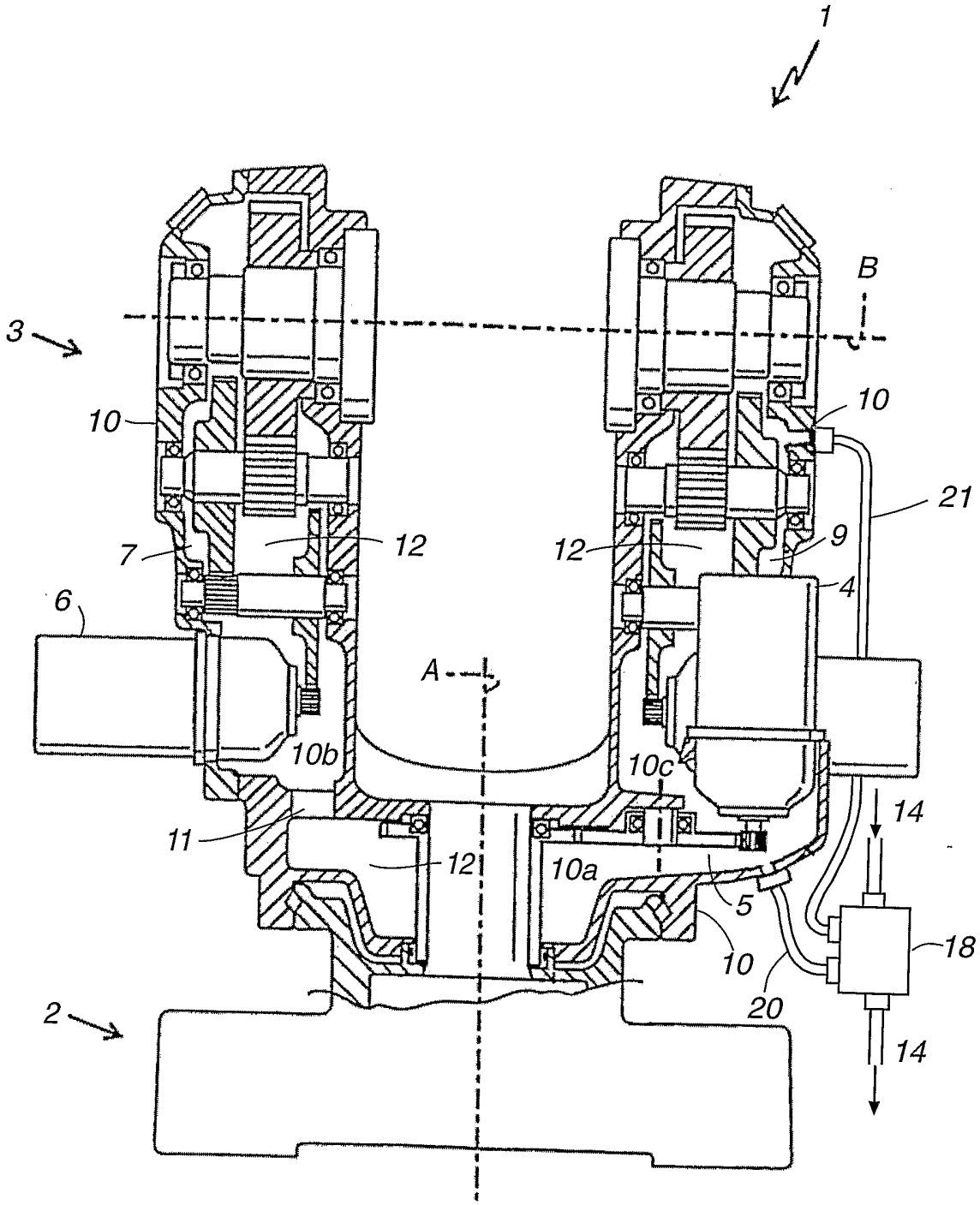

Fig. 3a

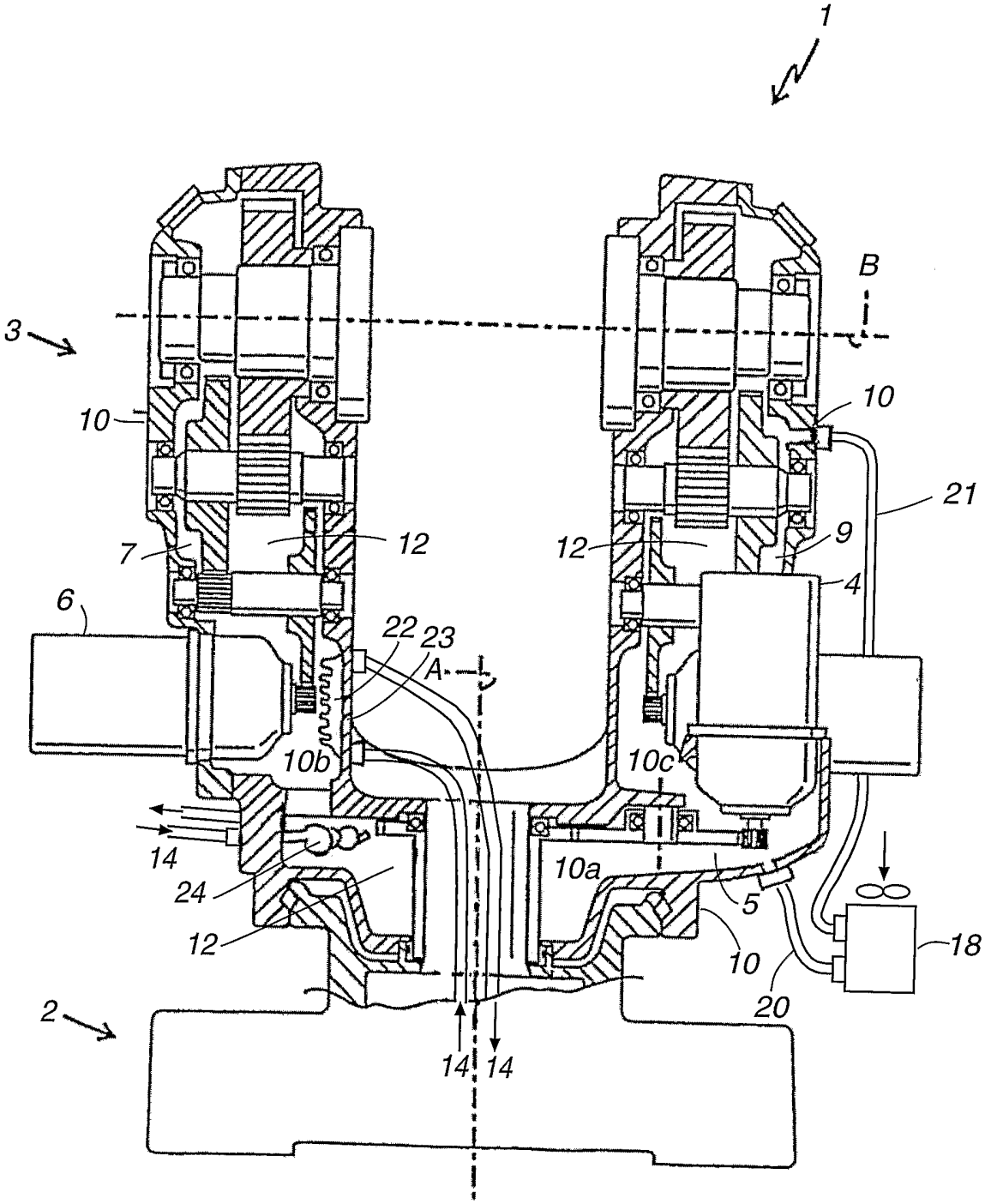

Fig. 3b

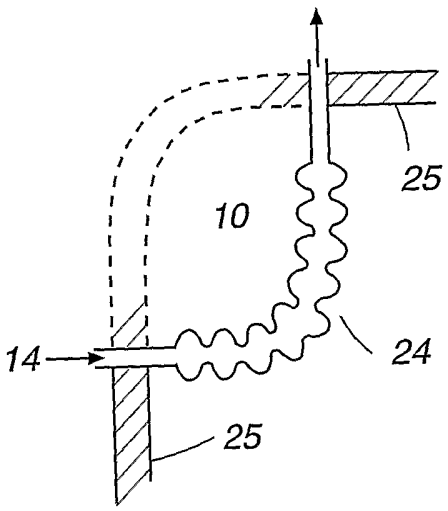

Fig. 4

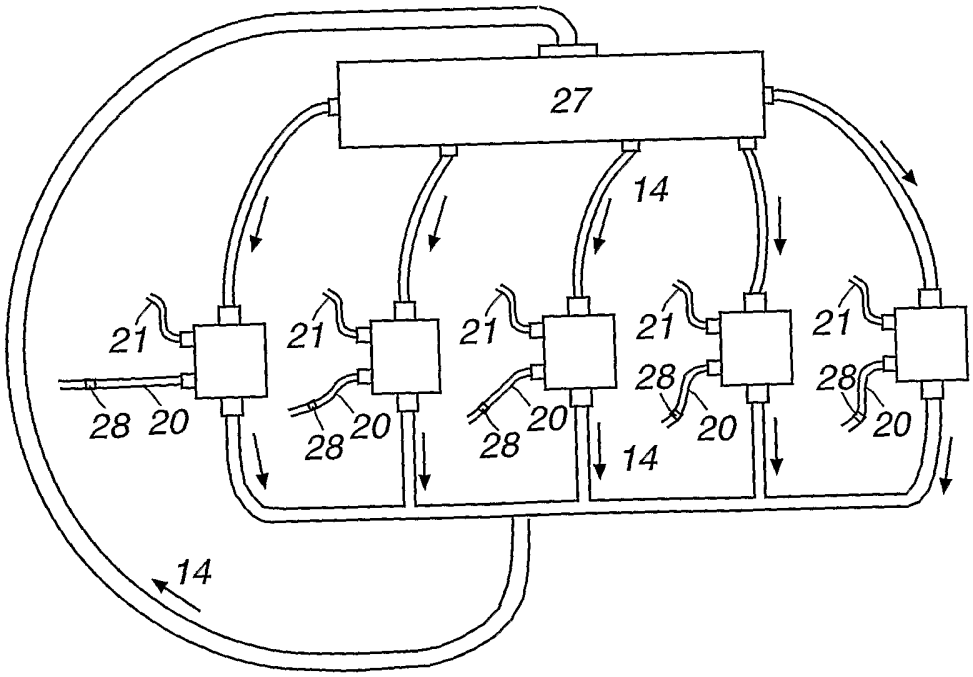

Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 03/01172

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: B25J 19/00
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)

IPC7: B25J

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)

EPO-INTERNAL,WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 0100369 A1 (ABB AB), 4 January 2001 (04.01.01), whole document	1-11
A		12-17
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Y	US 3690410 A (L.J.SIEGHARTNER), 12 Sept 1972 (12.09.72), whole document	1-11
A		12-17
	--	
A	US 4020715 A (M.L.SOLLARS), 3 May 1977 (03.05.77), column 5, line 4 - line 16, figure 1	1-17
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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
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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
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Date of the actual completion of the international search	Date of mailing of the international search report
24 Sept 2003	03 -10- 2003
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 Henrik Eriksson /itw Telephone No. +46 8 782 25 00

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 03/01172

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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