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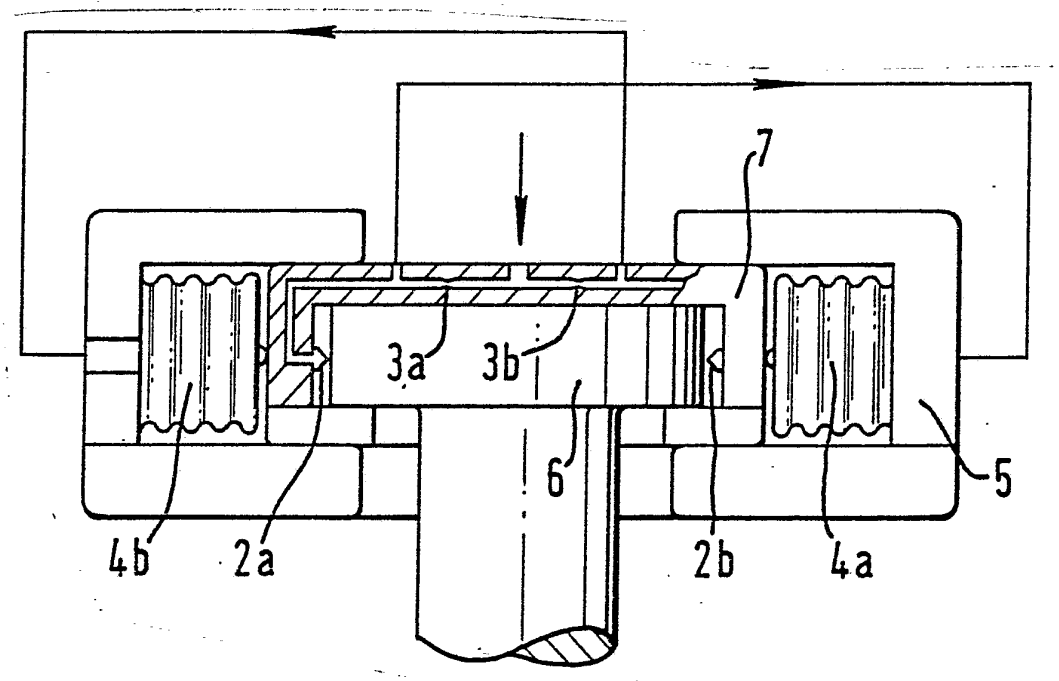
(54) Title: A MANIPULATING UNIT



(57) Abstract

A manipulating unit comprising a housing (5) in which there are a) position sensing means (7, 2a, 2b, 2c, 2d, 3a, 3b, 3c, 3d) for sensing the position of a member in the housing, which member is coupled locally to gripping means, and b) actuating means (4a, 4b, 4c, 4d) coupled to the sensing means and the member for producing movements of the member within the housing.

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A MANIPULATING UNIT

The present invention relates to a manipulating unit, for example for use in an industrial robot or a co-ordinate table.

In positioning systems comprising a robot arm and a robot gripper, there are known devices, called Remote Complicance Centres, which are placed between the robot arm and the robot gripper to provide the robot gripper with the compliance necessary to realise insertions of components in required locations. However, these devices are passive, i.e. they are provided with no sensing means to monitor the misalignments, nor with motors or other forms of actuators to realise the necessary adjustments.

High positioning accuracy is required in particular when robots are used for automatic assembly. Some work undertaken by research groups is attempting to sense the misalignment of components and correct it by adjusting the position of the robot arm.

Because robot arms are relatively heavy, it is difficult to make minute adjustments ranging from a few hundredths of millimetres up to a few millimetres.

According to the present invention, there is provided a manipulating unit comprising a housing in which there are a) position sensing means, for sensing the position of a member in the housing, which member is coupled locally to gripping means, and

b) actuating means coupled to the sensing means and the member for producing movements of the member within the housing.

The activating and sensing means could be fluidic or electrical actuating and sensing means.

For fluidic implementation, the position sensing means may conveniently comprise a nozzle, which is supplied with a gas through a first gas line via constricting means, the nozzle being disposed opposite the member whose position is to be sensed, and a second gas line, connected to the first gas line between the nozzle and said constricting means, and coupled to the actuating means, the arrangement being such that, when the member moves towards or away from the nozzle, the gas pressure at said constricting means increases or decreases respectively, causing gas to flow towards or away from the actuating means via the second gas line. In this case the actuating means may comprise bellows, or a pliable capsule, connected to the second gas line to allow the passage of gas into and out of the bellows, and which abuts the member to cause movement thereof.

For electrical implementation, the positioning sensing means may comprise electrical sensors which are capable of sensing contact forces between abutting members. Conveniently, the electrical sensors are strain gauges.

The examples of the present invention to be described with reference to the accompanying drawings each includes an adaptable unit which is capable of both a sensing and an actuating function. The unit is mounted at the end of the robot arm and provides the base for the robot hand (gripper). The unit, equipped with sensing means, itself realises the corrective movements without resorting to using the arm's actuators. The unit may comprise: an inner member which acts as a base for the gripper;

a sensor member; and an outer member. Because much smaller weights are manipulated than in the case of adjusting the whole robot arm, it is easier to realise minute adjustments required for the alignment of a component held by the robot hand.

In the units described below, misalignment of components between the inner member and the sensor member is sensed, whilst the correction action is generated between outer sensors and the sensor member. The sensor member therefore acts as a mediator between the inner and outer members. The units shown in Figures 3a, 3b, 5 and 6 use air for both the sensing and actuating means, but similar units could be realised instead as shown in Figures 8a and 8b which use sensors (capacitive, inductive etc.) and electrical actuation means utilising, for example, solenoids electromagnets or stepper motors.

The present invention will now be described, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 is a diagram for explaining the principle of examples of the invention;

Figures 2 and 4 show different kinds of misalignment which can be compensated for by different examples of the invention;

Figures 3a and 3b are respectively a partially cut-away side view and a plan view of an example of the invention for compensating for types of misalignments according to Figure 2;

Figure 5 is a partially cut-away side view of an example of the invention for compensating for types of misalignments according to Figure 4;

Figure 6 is a side view of another example of the invention for compensating for types of misalignments according to Figure 4;

Figure 7 shows an alternative embodiment of the actuating means; and

Figures 8a and 8b show a plan view and cut-away side view respectively of an electrical implementation of the invention.

The examples of the present invention shown in Figures 3a, 3b, 5 and 6, use the principle of a 'back pressure sensor' in conjunction with a pneumatic actuator - see Figure 1. The position of a component is monitored by a face 1. A nozzle 2 is supplied with air from a constant supply at pressure Ps via an orifice 3. When the face 1 moves closer to the nozzle 2, the pressure in the conduit downstream of the orifice 3 is increased and consequently causes expansion of a bellows 4 providing an acutator.

Several sensor-actuator units based on the above principle can be combined together to cater for both linear and angular adjustments in more than one direction.

In the case of the insertion of a pin into a hole, a possible misalignment which may occur is shown in Figure 2. The misalignment where the pin makes a contact with the chamfer of the hole may be cured by the type of unit shown in Figures 3a and 3b. In the unit of Figures 3a and 3b, an outer member 5 is mounted on the robot arm whilst a most inner member 6 provides a base for the robot hand (gripper). The member 6 can slide freely in a horizontal plane inside a sensor member 7 which in turn may be moved in any horizontal direction by two pairs of bellows 4a, 4b and 4c, 4d mounted inside the outer member 5. If, for example, the pin, when being pushed by the gripper into the hole, makes a first contact with the right-hand side of the chamfer, the member 6 would tend to slide to the left and close a nozzle 2a which in turn would cause an increase of pressure in the right-hand bellows 4a. At the same time, the inner member 6 would open a nozzle 2b connected to the left-hand bellows 4b thus reducing its pressure.

As a result of this, the sensor member 7 would be moved by the pair of bellows 4a, 4b to the left, carrying the inner member 6 and thus correcting the misalignment of the pin. The movement of the member 6 inside the sensor member 7 is only a few tenths of a millimetre, whilst the movement of the sensor member 7 inside the outer member 5 is much larger, of the order of a few millimetres. Similarly, another pair of sensing nozzles 2c, 2d and the pair of bellows 4c, 4d can realise adjustment in the perpendicular direction. Thus, misalignments in any direction in the plane of the unit can be catered for.

Angular misalignment (Figure 4) may be corrected by a unit shown in Figure 5. The inner member 6 is in this case a part which is in the form of a part-spherical joint which can rotate, within a limited angle, in the sensor member 7. The sensing nozzles 2a, 2b monitor any deviation from a vertical position. For example, if the inclination of the pin is in the clockwise direction from vertical, the nozzle 2a at the left would close, thus increasing the pressure in the conduit which is connected to the bellows 4a on the right; simultaneously, the nozzle 2b would open, thus reducing the pressure in the bellows 4b on the left. Consequently, the bellows 4a would expand, pushing the member 6 to the left thus reducing and eventually eliminating the inclination. Again, another pair of sensing nozzles and another pair of bellows realise adjustments relative to a perpendicular axis.

A correction of angular misalignments can also be made by the unit shown in Figure 6 where, instead of making adjustments (by the bellows) in a horizontal plane as previously, they would be realised by rotating the member 6 inside the outer member 5. In this case, all the relative movements between the members

would be rotational instead of, as previously, some or all or them being linear. Again, another pair of sensing nozzles and another pair of bellows realise adjustments about a perpendicular axis.

It should be understood that in each of the above-described examples, the unit has two degrees of freedom, containing two pairs of sensing nozzles and two pairs of actuator-bellows, the pairs being arranged to form a cross to cater for alignments in two perpendicular directions or around two perpendicular axes.

It is possible to use three sensing nozzles and three bellows only, in each case offset by 120° relative to each other, to realise either planar or angular alignment.

It may be necessary in some cases to use up to four degrees of freedom to provide total freedom for adjustments. In such a case, a unit according to Figures 3a and 3b and a unit according to Figure 6 could be mounted on each other, the inner member of one unit being fixed to the outer member of the other unit, thus providing two linear and two rotational adjustments.

As it is advantageous that the above manipulating units are as compact and as small as possible, the bellows, which may take up a relatively large space can be replaced by capsules moulded from a pliable material such as, for example, synthetic rubber. In all other respects, the configuration of the unit will remain the same. Figure 7 shows such a capsule 10 moulded inside the outer member 5 in order to actuate the sensor member 7. The expanding side of the capsule can move the base of the robot hand in order to make the necessary adjustments.

Figures 8a and 8b show an example of a 2 degree of freedom electrical sensing unit. In this case,

instead of using minute displacements to sense the misalignment of components, the unit is equipped with strain-gauge elements 8 which sense directly the contact forces between the mated members. Any misalignments encountered are demonstrated by an imbalance of the monitored contact forces.

In this example, the sensor member 7 and the inner member 6 are connected by a cross-bridge 9 thus forming one module.

In the case of using electrical sensing and actuating means, the signals from the electrical sensor(s) are easily processed in a computer which instructs the actuators to make the necessary corrections and optimises the action of the electrical actuator(s). The same may be achieved with a pneumatic unit provided that the pneumatic signals are converted to electrical and/or vice versa. Combined electrical sensing and pneumatic actuation or pneumatic sensing and electrical actuation may also be used in a unit according to the invention.

CLAIMS

1. A manipulating unit comprising a housing in which there are a) position sensing means, for sensing the position of a member in the housing, which member is coupled locally to gripping means, and b) actuating means coupled to the sensing means and the member for producing movements of the member within the housing.

2. A manipulating unit as claimed in claim 1, wherein the position sensing means comprises a nozzle, a first gas line with constricting means for supplying gas to the nozzle via the constricting means, the nozzle being disposed opposite the member whose position is to be sensed, and a second gas line, connected to the first gas line between the nozzle and said constricting means, and coupled to the actuating means, the arrangement being such that, if the member moves towards or away from the nozzle, the gas pressure at said constricting means increases or decreases respectively, causing gas to flow towards or away from the actuating means via the second gas line.

3. A manipulating unit as claimed in claim 2, wherein said constricting means comprises an orifice.

4. A manipulating unit as claimed in claim 2 or 3, wherein the actuating means comprises bellows, which are connected to the second gas line to allow the passage of gas into and out of the bellows, and which abuts the member to cause movement thereof.

5. A manipulating unit as claimed in claim 2 or 3, wherein the actuating means comprises a pliable capsule, which is connected to the second gas line to allow the passage of gas into and out of the capsule, and which abuts the member to cause movement thereof.

6. A manipulating unit as claimed in claim 5, wherein the capsule is made of a synthetic rubber.

7. A manipulating unit as claimed in claim 1,

wherein the position sensing means comprises electrical sensing means capable of sensing contact forces between abutting members.

8. A manipulating unit as claimed in claim 7, wherein the electrical sensing means comprises at least one strain gauge.

9. A manipulating unit as claimed in claim 7 or 8, wherein the actuating means comprises electromagnetic means.

FIG. 1.

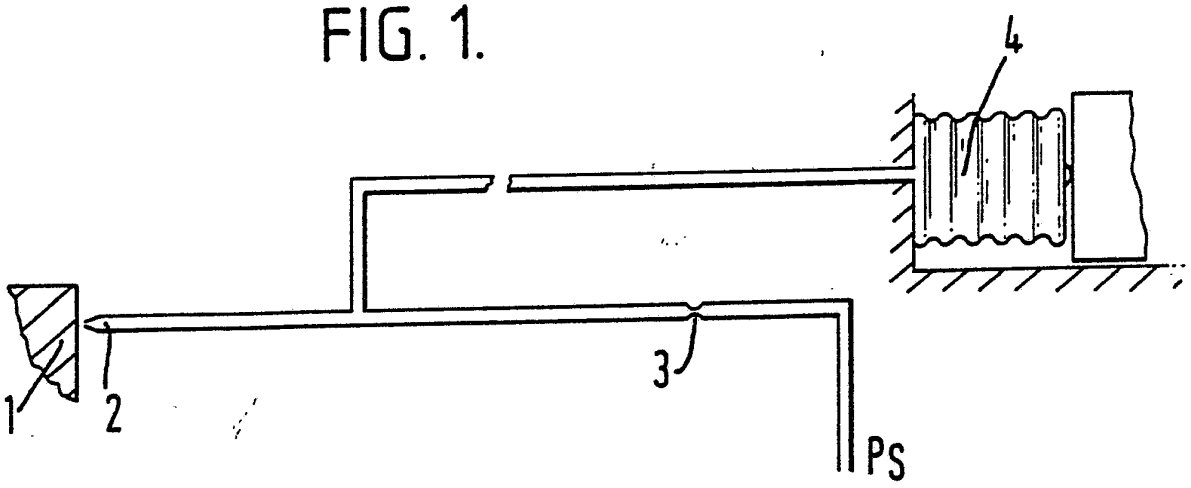


FIG. 2.

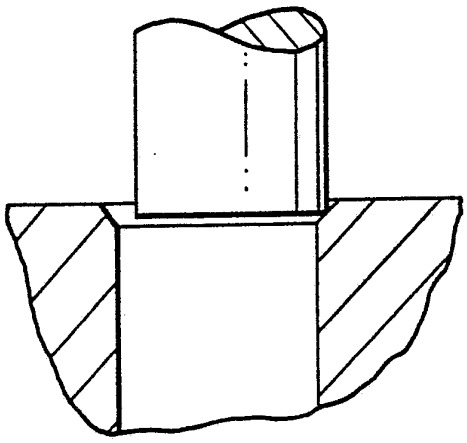


FIG. 4.

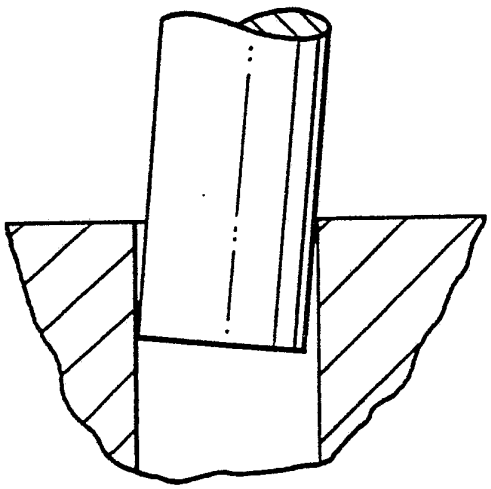


FIG. 3a.

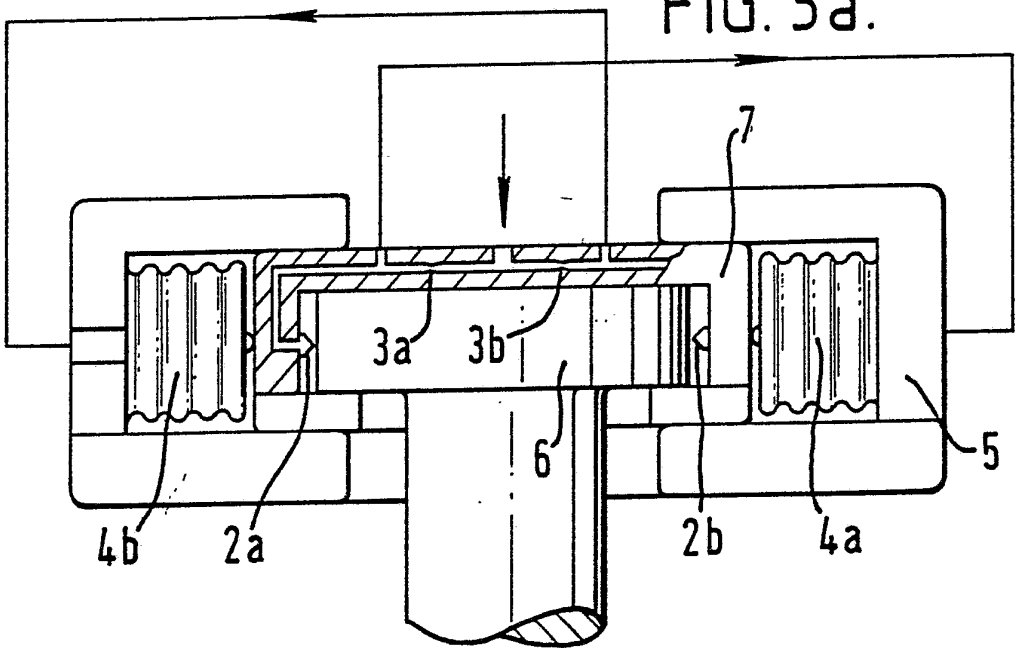


FIG. 3b.

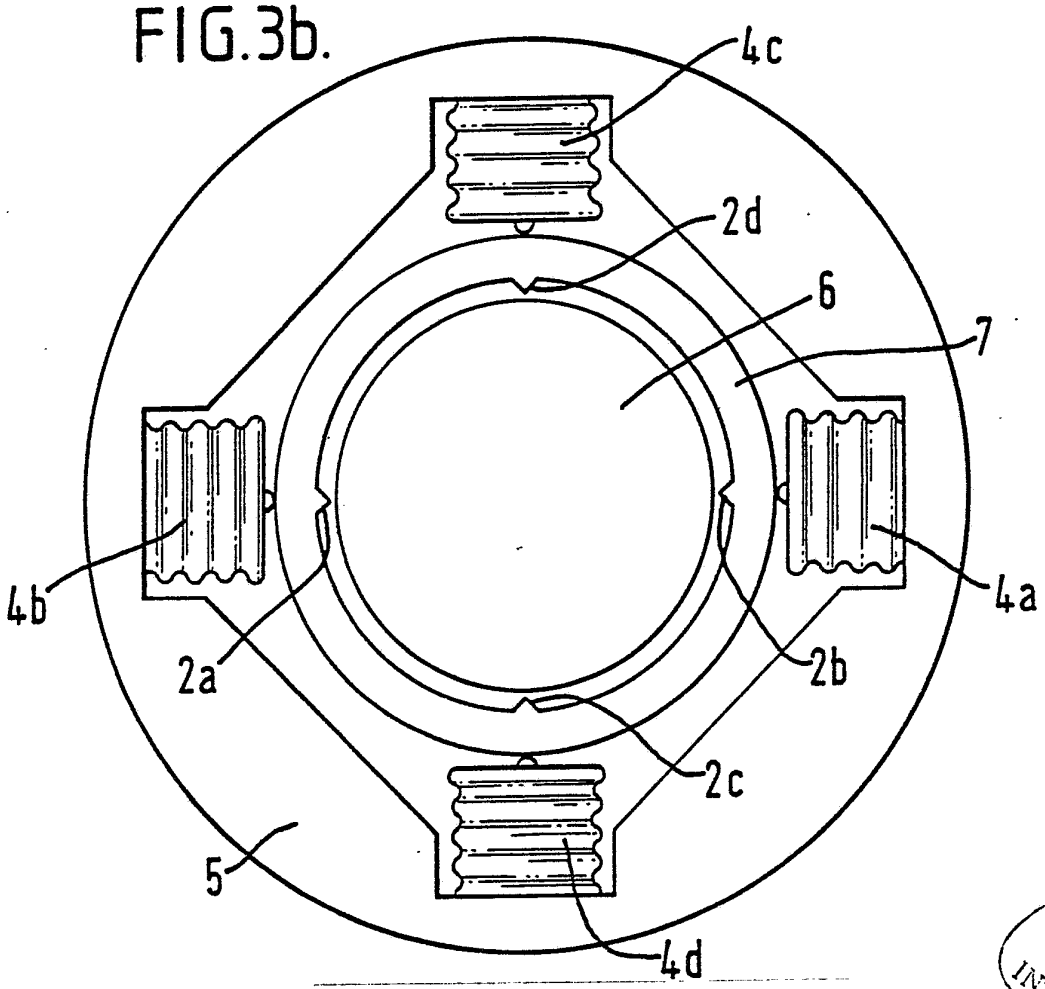


FIG. 5.

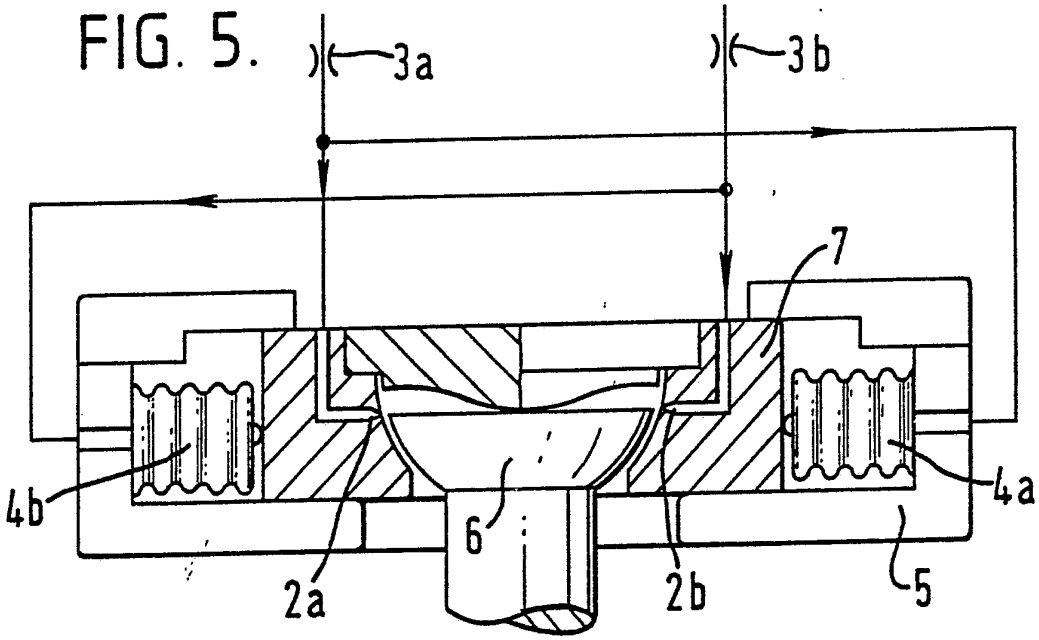
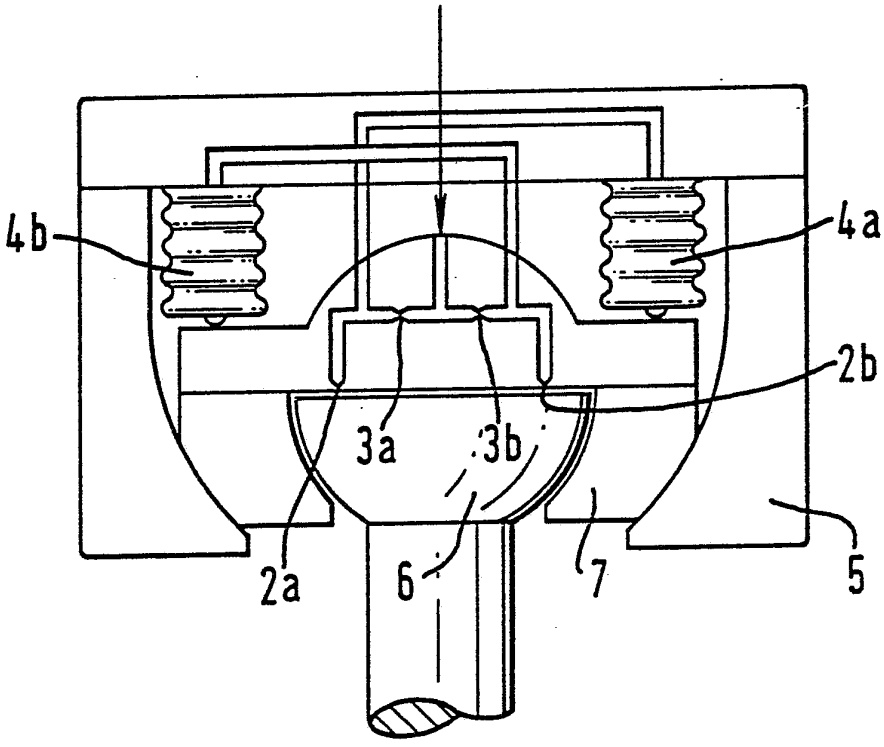


FIG. 6.



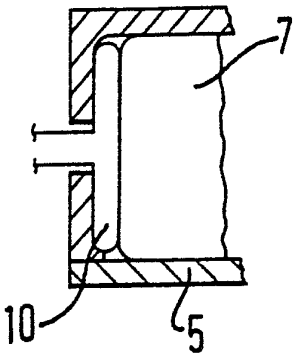


FIG. 7.

FIG. 8a.

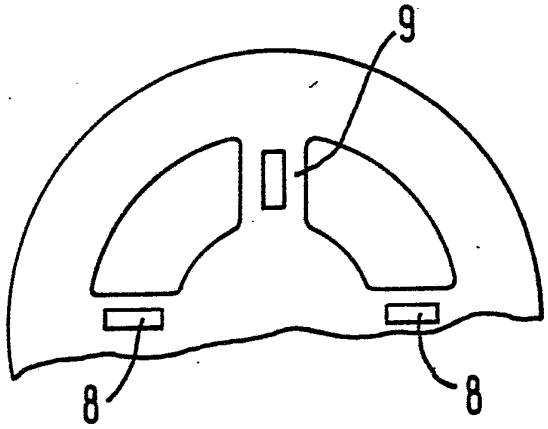
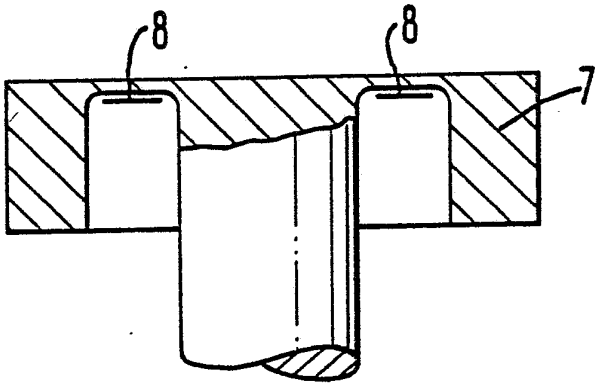


FIG. 8b.



INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 83/00075

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[3]: B 25 J 15/00; B 25 J 19/00; B 23 P 19/00

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
IPC[3]	B 25 J 15/00; B 25 J 19/00; B 23 P 19/00

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
X	EP, A, 0015618 (LEUVEN RESEARCH & DEVELOPMENT V.Z.W.) 17 September 1980, see claim 1; page 4, lines 17-28 --	1
Y	US, A, 3893217 (EDMOND) 8 July 1975, see column 5, line 48 to column 6, line 54 --	1
Y	EP, A, 0067882 (FANUC) 29 December 1982, see claims 1,3,4 --	1,8
A	GB, A, 2022550 (SHIROYAMA KOGYO) 19 December 1979, see page 1, line 113 - page 2, line 27	2

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IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
13th June 1983	29 JUIN 1983
International Searching Authority [1]	**Signature of Authorized Officer [20]**
EUROPEAN PATENT OFFICE	G.L.M. Kruycenberg

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON

INTERNATIONAL APPLICATION NO. PCT/GB 83/00075 (SA 4884)

This Annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 21/06/83

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Patent document cited in search report	Publication date	Patent family member(s)		Publication date
EP-A- 0015618	17/09/80	NL-A-	7901956	16/09/80
		JP-A-	55129809	08/10/80
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