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(54) Title: TOOL CHANGER FOR EXPLOSIVE ENVIRONMENT

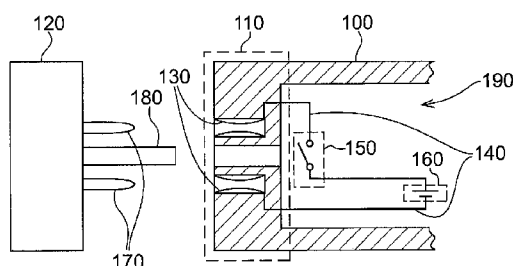


Fig . 1a

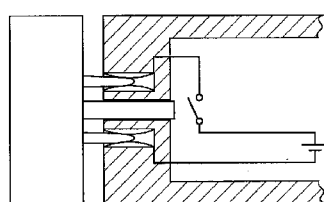


Fig . 1b

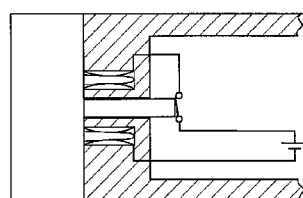


Fig . 1c

(57) Abstract: A robot for explosive environments comprises a purge area (90) configured to comprise a non-explosive gas, and a tool changer (110) configured to receive and withdraw a tool (120). The tool changer (110) is adapted for operating in an explosive environment by providing a switch (150) for switching on and off a supply of electrical power to the tool (120), and by arranging the switch (150) within the purge area (190).

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Tool changer for explosive environment

TECHNICAL FIELD

The present invention relates to an industrial robot adapted for operating in an explosive environment. The adaptation
5 concerns especially a tool changer comprised in the robot.

BACKGROUND ART

Tool changers are used when a robot does several tasks with different tools. A tool changer basically consists of a master plate mounted on a robot arm, the master plate being
10 configured to receive tool plates on which the different tools are mounted. The tool plates can be attached to the master plate with mechanical or pneumatic means. Pressurized air and other fluids can be passed through the tool changer from the robot arm to the tool. Also electrical power and
15 signals for actuators and sensors are passed on to the tool through the tool changer.

US 4,990,022 discloses a tool changer with an interface comprising fluid ports, optical fibers and electrical terminals. When the tool is received, the electrical
20 terminals on the master plate are pressed against the electrical terminals on the tool plate, and a supply of electrical power to the tool is thereby obtained. Using this kind of tool changer may not be allowable in an explosive environment since sparks may be generated at the interfaces
25 between the electrical terminals when the tool is received or withdrawn. The problem can be circumvented by using solely intrinsically safe signals, such as very low voltage signals or fluid signals, to operate the tool. The application of the robot is however radically limited if no
30 electrically operated tools can be used.

According to US 2007/0276538, robot tools may be powered wirelessly, but the system is sophisticated and therefore expensive. Generally, it is not common to use tool changers in potentially explosive environments, and it is not known
5 whether tool changers certified for such use exist.

SUMMARY OF THE INVENTION

One objective of the invention is to provide a robot with a tool changer passing electrical power or signals in a safe and cost effective manner adapted for operation in an
10 explosive environment.

A further objective of the invention is to provide an improved method for changing a robot tool in an explosion safe manner .

These objectives are achieved by the device according to
15 appended claim 1 and the method according to appended claim 10 .

The invention is based on the realization that an electric circuit which supplies electrical power to the tool needs to be closed within a purge area of the robot in order to
20 prevent an eventual spark from igniting a surrounding explosive gas.

According to a first aspect of the invention, there is provided a robot for explosive environments. The robot comprises a purge area configured to comprise a non-
25 explosive gas, a tool changer configured to receive and withdraw a tool, and a first switch for switching on and off a supply of electrical power to the tool. The first switch is arranged within the purge area.

By arranging the first switch within the purge area, an
30 electric circuit which supplies electrical power to the tool

can be closed within the purge area. Consequently, an eventual spark occurring when the electric circuit is closed is prevented from igniting a surrounding explosive gas.

According to one embodiment of the invention, the tool
5 changer comprises a primary terminal, and the tool comprises a secondary terminal, the terminals being configured to be connected when the tool is received, and disconnected when the tool is withdrawn, and wherein the robot comprises a mechanism preventing the terminals from being connected or
10 disconnected when the supply of electrical power to the tool is switched on. By providing the robot with such mechanism the tool changer is prevented from being unintentionally operated in a way that can cause an explosion.

According to one embodiment of the invention, the robot
15 comprises an engagement mechanism for preventing a tool from being received or withdrawn when the supply of electrical power to the tool is switched on. Such engagement mechanism further ensures that the switch is actively controlled before reception or withdrawal of the tool.

20 According to one embodiment of the invention, the engagement mechanism and the first switch are configured to be actuated simultaneously via a mechanical connection between the two. A mechanical connection provides a simple and reliable dependency between the states of the engagement mechanism
25 and the first switch.

According to one embodiment of the invention, the engagement mechanism is operated electrically. Electrical operation of the engagement mechanism is flexible and readily controllable .

30 According to one embodiment of the invention, the first switch is configured to switch on and off a supply of

electrical power to the engagement mechanism. When the electrical power is supplied through a single switch both to the tool and to the engagement mechanism, a simple and reliable dependency between the switching statuses of the
5 both is achieved.

According to one embodiment of the invention, the electrical power is prevented from being supplied to the engagement mechanism and to the tool simultaneously. This measure further prevents reception or withdrawal of the tool when
10 electrical power is supplied to it.

According to one embodiment of the invention, a second switch is configured to switch on and off a supply of electrical power to the engagement mechanism, and the status of the second switch depends on the status of the first
15 switch. A more flexible system is achieved when the electrical power is supplied through separate switches to the tool and to the engagement mechanism. The dependency of the statuses is an obvious requirement for ensuring that connection and disconnection of the terminals is always
20 prevented when the electrical power to the tool is switched on.

According to one embodiment of the invention, a dependency between the statuses of the first and second switches is defined by a computer program. A flexible system is achieved
25 by making the dependency programmable.

According to a second aspect of the invention, there is provided a method for changing a robot tool in an explosion safe manner. The method comprises the steps of: providing a switch within a purge area for switching on and off a supply
30 of electrical power to the tool; actuating the switch to switch off the supply of electrical power to the tool;

changing the tool; and actuating the switch to switch on the supply of electrical power to the tool.

By switching off the supply of electrical power to the tool during the tool change, and by switching the supply of
5 electrical power back on using a switch within the purge area, sparks are prevented from occurring in direct contact with an atmosphere surrounding the robot. Supposing the surrounding environment is explosive, an ignition and a consequent explosion is prevented.

10 BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be explained in greater detail with reference to the accompanying drawings, wherein

figure 1 shows an embodiment without an engagement mechanism,

15 figure 2 shows an embodiment with a manual engagement mechanism, and

figure 3 shows an embodiment with an electrical engagement mechanism.

DESCRIPTION OF PREFERRED EMBODIMENTS

20 Referring to figure 1, a robot arm 100 of an industrial robot is illustrated. At its free end the robot arm 100 comprises a tool changer 110 with an interface for receiving a tool 120. The interface comprises two primary terminals 130 to which electrical connectors 140 are coupled. Via a
25 switch 150, the electrical connectors 140 couple the primary terminals 130 with a direct current (DC) source 160. The tool 120 comprises two secondary terminals 170 which connect with the primary terminals 130 when the tool 120 is received. The secondary terminals 170 are coupled with an

electrical device (not shown) at the tool 120. The electrical device can be an electrical actuator configured to accomplish a desired effect such as a movement, or it can be a sensor or the like. The tool 120 further comprises a
5 pin 180 which actuates the switch 150 after the terminals 130, 170 have been connected. Consequently, the electric circuit providing electrical power to the tool 120 is closed only after connecting the terminals 130, 170.

Closing an electric circuit may generate a spark between
10 contacting surfaces at an instant before a full contact. Let's now assume that the electrical device is such that the electric circuit automatically closes when the tool 120 is received. Without the switch 150, an eventual spark would occur at terminal surfaces which are in direct contact with
15 an atmosphere surrounding the robot. Supposing the surrounding environment is explosive, a risk for spark is not allowed. The switch 150, on the other hand, is arranged within a purge area 190 of the robot, i.e. an area protected from the explosive environment. Typically, the purge area
20 190 comprises a substantially closed volume within which a non-explosive gas is kept at a pressure which is slightly above the surrounding pressure. Consequently, even if a spark would occur when closing the electric circuit, it could not ignite the surrounding gas causing an explosion.
25 Respectively, when the tool 120 is withdrawn, the switch 150 is actuated to open the electric circuit before disconnecting the terminals 130, 170. The terminals 130, 170 are therefore prevented from being connected or disconnected when the electrical power to the tool 120 is switched on.

30 Referring to figure 2, the tool 120 comprises an engagement key 200 which has to be aligned with a key hole 210 in order to allow the tool 120 to be received or withdrawn. The tool 120 is received with a linear movement 220 according to

figure 2a, and after connecting the terminals 130, 170 a rotating movement 230 is applied to the engagement key 200 as illustrated in figure 2b. The rotation of the engagement key 200 engages the tool 120 with the tool changer 110 simultaneously as it actuates the switch 150 to close the electric circuit. The engagement key 200 thereby prevents the tool 120 from being received or withdrawn, and at the same time the terminals 130, 170 from being connected or disconnected, when the electrical power to the tool 120 is switched on.

Referring to figure 3, the engagement function may be operated electrically. The tool changer 110 comprises an electrical engagement key 240 which, according to figure 3a, is designed to be aligned with a key hole 210 at the tool 120 when electrical power is supplied to it. The same switch 150 which switches on and off a supply of electrical power to the tool 120 also switches on and off a supply of electrical power to the electrical engagement key 240. The switch 150 is actuated by means of a controller 250. When the tool 120 is fully received and the terminals 130, 170 are connected, as illustrated in figure 3b, the switch 150 is actuated. According to figure 3c, the electrical power is now supplied to the tool 120 instead of the electrical engagement key 240. The electrical engagement key 240 is designed to be engaged with the tool 120 when electrical power is not supplied to it. The configuration of the switch 150 prevents the electrical power from being supplied to the electrical engagement key 240 and to the tool 120 simultaneously. Consequently, the terminals 130, 170 are prevented from being connected or disconnected when the electrical power to the tool 120 is switched on.

Instead of using a single switch 150, the electrical engagement key 240 may as well have an additional switch

- (not shown) for switching on and off a supply of electrical power to it. Obviously, the different switches need to be controlled appropriately to make sure that the electrical engagement key 240 is always engaged with the tool 120 when electrical power to the tool 120 is switched on. In other words, the statuses of the two switches must be dependent on each other. The dependency may be defined by means of a computer program running within a controller 250 actuating the switches.
- 10 An electrical device at the tool 120, an electrical engagement key 240, or an additional switch may eventually also generate sparks. The purge area 190 should obviously be extended to cover all the components which potentially can cause an explosion.
- 15 The invention is not limited to the embodiments shown above, but the person skilled in the art may, of course, modify them in a plurality of ways within the scope of the invention as defined by the claims.

CLAIMS

1. A robot for explosive environments, the robot comprising :
 - a purge area (190) configured to comprise a non-explosive gas,
 - a tool changer (110) configured to receive and withdraw a tool (120), and
 - a first switch (150) for switching on and off a supply of electrical power to the tool (120),**characterized in that** the first switch (150) is arranged within the purge area (190) .
2. A robot according to claim 1, wherein the tool changer (110) comprises a primary terminal (130), and the tool (120) comprises a secondary terminal (170), the terminals (130, 170) being configured to be connected when the tool (120) is received, and disconnected when the tool (120) is withdrawn, and wherein the robot comprises a mechanism preventing the terminals (130, 170) from being connected or disconnected when the supply of electrical power to the tool (120) is switched on .
3. A robot according to any of the preceding claims, wherein the robot comprises an engagement mechanism (200, 240) for preventing the tool (120) from being received or withdrawn when the supply of electrical power to the tool (120) is switched on.
4. A robot according to claim 3, wherein the engagement mechanism (200) and the first switch (150) are configured to be actuated simultaneously via a mechanical connection between the two.

5. A robot according to claim 4, wherein the engagement mechanism (240) is operated electrically.
6. A robot according to claim 5, wherein the first switch (150) is configured to switch on and off a supply of electrical power to the engagement mechanism (240).
7. A robot according to claim 6, wherein the electrical power is prevented from being supplied to the engagement mechanism (240) and to the tool (120) simultaneously.
8. A robot according to claim 5, wherein a second switch is configured to switch on and off a supply of electrical power to the engagement mechanism (240), and the status of the second switch depends on the status of the first switch (150) .
9. A robot according to claim 8, wherein a dependency of the statuses between the first and second switches is defined by a computer program.
10. A method for changing a robot tool (120) in an explosion safe manner, the method comprising the steps of:
 - providing a switch (150) within a purge area (190) for switching on and off a supply of electrical power to the tool (120),
 - actuating the switch (150) to switch off the supply of electrical power to the tool (120),
 - changing the tool (120), and
 - actuating the switch (150) to switch on the supply of electrical power to the tool (120).

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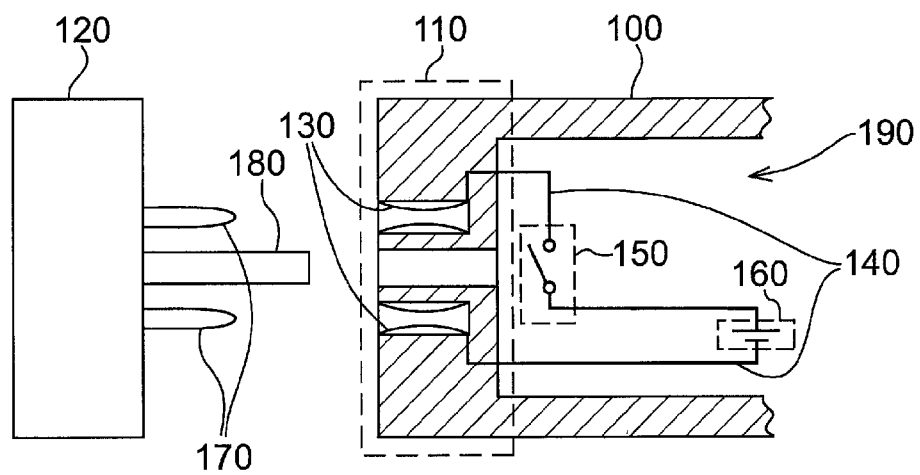


Fig .1a

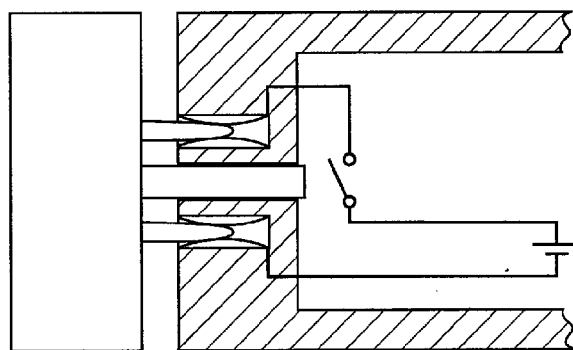


Fig .1b

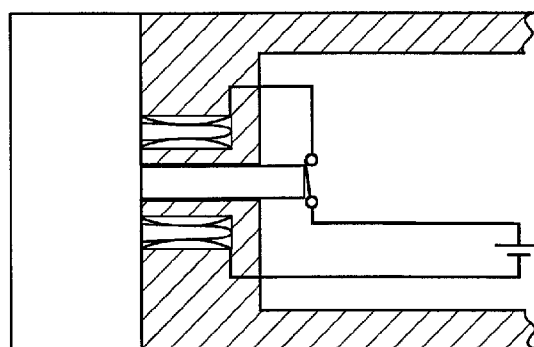


Fig .1c

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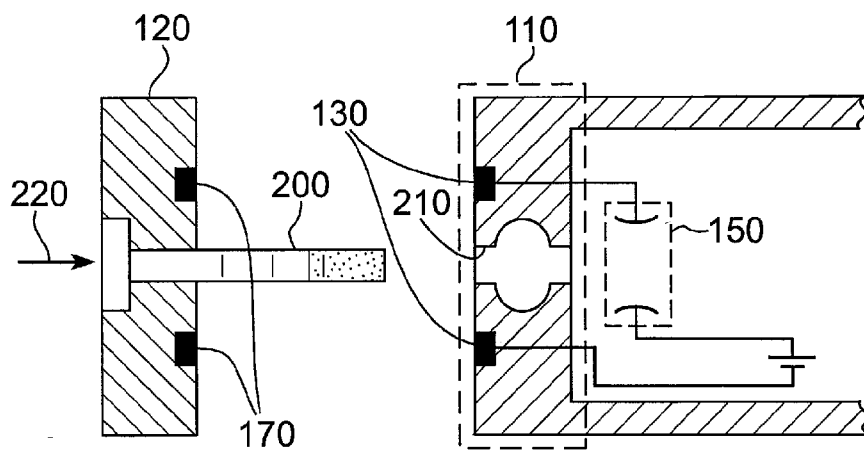


Fig .2a

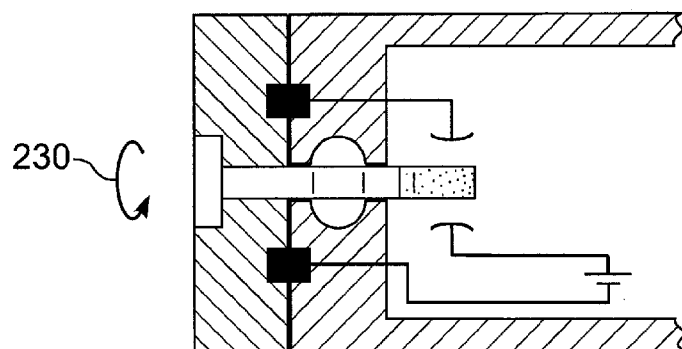


Fig .2b

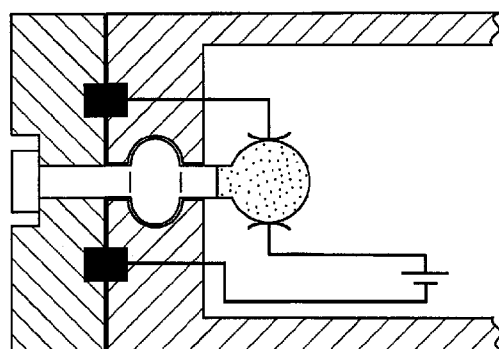


Fig .2c

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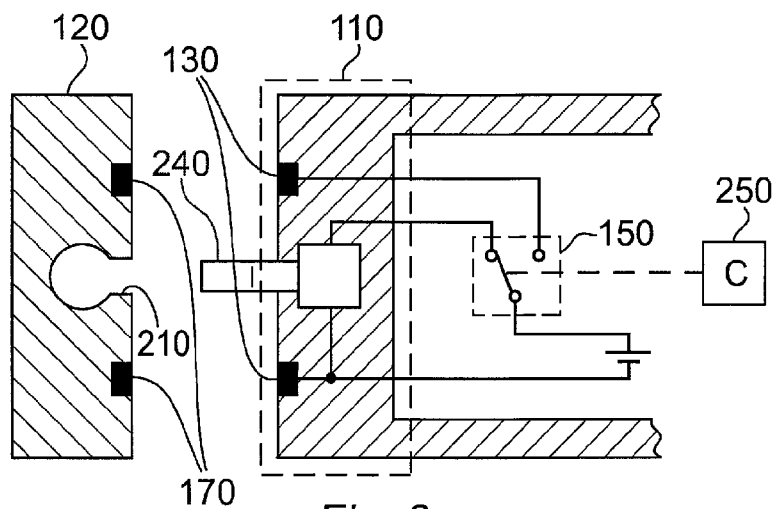


Fig .3a

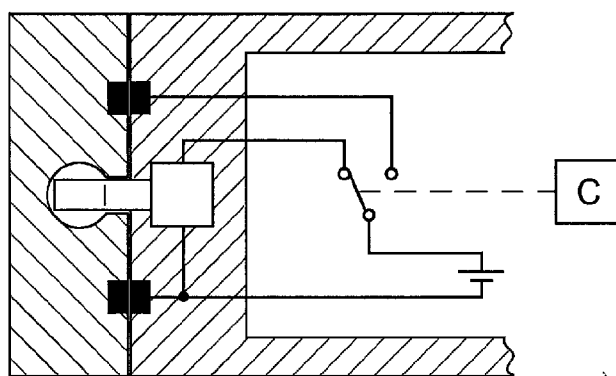


Fig .3b

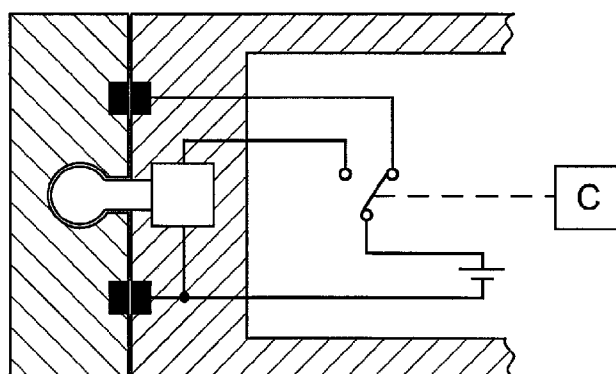


Fig .3c

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/052552

A. CLASSIFICATION OF SUBJECT MATTER
INV. B25J15/04 B25J19/00
ADD.

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)
B25J

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

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

EPO-Internal , WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 2 335 286 A (ALVIS LOGISTICS LIMITED [GB] ALVIS LOGISTICS LTD [GB] ; REMOTEC UK LTD) 15 September 1999 (1999-09-15) the whole document -----	1-10
A	US 4 990 022 A (WATANABE SHINPEI [JP] ET AL) 5 February 1991 (1991-02-05) the whole document -----	1-10
A	W0 2005/059666 AI (ABB RESEARCH LTD [CH] ; GENTZELL TOBIAS [SE] ; KJELLSSON JIMMY [SE] ; STR) 30 June 2005 (2005-06-30) the whole document -----	1-10
A	FR 2 624 422 AI (ROCHE JEAN [FR] ; MENANT DANIEL [FR]) 16 June 1989 (1989-06-16) page 2, line 21 - line 27 -----	1-10



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2011/052552

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 2335286	A	15-09-1999	NONE
US 4990022	A	05-02-1991	NONE
WO 2005059666	A1	30-06-2005	EP 1695426 A1 30-08-2006 EP 1749249 A1 07-02-2007 JP 2007514558 A 07-06-2007 SE 0303445 A 18-06-2005 WO 2005060068 A1 30-06-2005 US 2007276538 A1 29-11-2007 US 2011208353 A1 25-08-2011
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