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Description

The invention relates to a method and a device for protecting persons and stationary or autonomously moving obstacles in front of stationary or autonomously moving handling apparatuses such as manufacturing, transport, inspection or service robots and their manipulators from collisions within their workspace by protective covers including internal pressure sensors and an integrated pressure increasing and pressure maintaining device.

From DE 10 2007 062 245 A1, a collision detection device surrounding the movable elements of the handling apparatus with media storages made of flexible material is known. The media storages are equipped with pressure sensors, which indicate a pressure increase upon collision and can be used to trigger protective circuits.

From EP 1 810 795 A1, a safety device is known, in which elastic, sealed, gas-filled protective covers surround the manipulators of a robot, which are equipped with one or several pressure sensors to be used in conjunction with a reference sensor for triggering protective circuits.

From DE 10 2006 044 071 B4, a robot protection device is known, in which elastic protective covers likewise surround the manipulator(s) to damp impacts, and a change in the pressure of said protective covers in the case of collision is detected by pressure sensors.

All these approaches have in common that they require an external feed source for filling the protective covers with a gas or fluid, thus involving complex hose tubings restricting the mobility of the manipulators, in particular with a plurality of covers. The handleable number of individual protective covers

is thus limited, and hence their application in autonomously moving robots is restricted.

Since a pressure increase upon collision will be more striking in protective covers having small volumes than with large-volume protective covers, the height of the ideal feed pressure of the medium in the protective cover will thus also depend on its size.

It has, therefore, proved to be advantageous to provide a plurality of small protective elements rather than a few large-volume protective covers. This offers the additional advantage that their shapes can be adapted to the shape of the surface of the robot and its manipulators. Also the protection of their extremely collision-endangered zones can be better realized, in particular with autonomous robots.

The size of the protective covers, their shapes and the pressure prevailing in their interiors also defines their dimensional stability.

Since even the shape of the protective elements has a clear impact on the height of the ideal feed pressure of the medium in the protective cover, the subdivision of the protective covers into smaller protective elements will practically only be feasible if each of the protective elements is assigned a pressure ideal for its shape and size.

The invention will be explained in more detail by way of an exemplary embodiment according to the accompanying drawings, wherein:

Fig. 1 depicts protective elements with their base shells, without foam fillings;

Fig. 2 depicts directly mounted protective elements with foam fillings in cross section;

Fig. 3 depicts a directly mounted protective element with a foam filling and laterally arranged sensor and pressure-increasing device in cross section; and

Fig. 4 depicts a directly mounted protective element with a foam filling and the joint lateral arrangement of the sensor and the pressure-increasing device in cross section.

10 According to the invention, the object as illustrated in cross section in Fig. 1 is achieved in that the medium is not supplied to each protective element 1 from outside, but the protective elements in their interiors, in addition to at least one pressure sensor 4, each also comprise a pressure-increasing
15 device 7, which sucks in the medium, preferably ambient air, and generates a pressure in the interior of the protective element, which is adjustable from a control device 8.

As illustrated in Fig. 1, a preferred configuration according to
20 the invention of the device comprising protective elements 1 typically consists of base shells 12 made of plastic, an air inlet and cable passage channel 13 kept clear by spacers 2, the pressure-increasing devices 7, the at least one pressure sensors 4 with or without reference sensors 6, and elastic covers 11 for
25 the protective elements.

In a further preferred configuration according to the invention of the device comprising protective elements 1 as illustrated in Fig. 1, the, for instance piezoelectric, pressure-increasing
30 device 7, the at least one internal pressure sensor 4, and optionally the at least one external pressure sensor 6, are mounted on a mounting plate 3 designed as a printed circuit board and glued into the base shell.

The internal pressure-increasing device 7 also offers some protection against injury to the elastic protective cover 11 of the protective element 1 by automatically compensating for small injuries to the elastic protective cover, or leakages.

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The power supply cable and data lines 5 of the pressure-increasing pump and the pressure sensors are led to the control device 8 in grooves 13 below the base plate via a collective channel.

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The power supply of the integrated pressure-increasing device 7 is preferably effected by electric power fed on demand via a control device 8 arranged outside the protective elements 1.

15 Said control device 8 can be designed as an analog controller or as a digital controller. As appropriate, actuation of the pressure-increasing devices 7 can be effected individually or in groups. The individual combination of actuation algorithms for each of the protective elements is also possible.

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The configuration according to the invention of the protective elements 1 comprising internal pressure-increasing devices 7 can be controlled via the control device 8 according to a default pressure profile or also by a pulsed pressure increase.

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The pressure-increasing device 7 is preferably designed as a piezoelectric pump.

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As illustrated in Fig. 2, the inner fillings 9 of the protective elements 1 in a further preferred configuration can be supplemented with open-pore foam fillers 9 to enhance the dimensional stability and the attenuation effect, thus providing an inherent elasticity of the protective elements 1 at a collision.

Another variant of the configuration of the device comprising protective elements 1 consists in that the foam filling 9 is gas-tightly covered by an outer cover 11 of cured liquid plastic, said cover being applied by painting, spraying or dip-coating. The mounting plate 3 described in the preceding passage, which is designed as a printed circuit board, is subsequently glued into said outer cover 11 together with the piezoelectric pressure-increasing device 7, the internal pressure sensor 4, and optionally the external pressure sensor 6.

The gas-tight outer cover 11 can be made of elastic materials having different properties adapted to the respective application, e.g. high-temperature-resistant, refractory, anti-bacterially coated, or even in different colors for purposes of distinction, alarm or design. Its layer thickness is variable, typically ranging between 20 μm and 2 mm.

In another preferred configuration variant, the parts comprising the protective cover 11 and the foam filling 9 are made of a material forming a gas-tight outer skin with a gas-permeable inner structure in the production, such as microcellular rubber or integral foam.

A further preferred configuration of the device comprising protective elements 1 consists in that a shape adapted to the surface of the robot or manipulator 10 to be protected is used. This configuration can be used for respective surfaces, e.g. as plane or slightly curved flat cushions, half-shells for cladding cylindrical or conical pipe parts, and round manipulator elements. The fastening of the protective elements to the base shells of plastic is effected by gluing, magnetic fastening or fastening lugs for fastening screws.

The design of the protective elements 1 can also be realized as illustrated in cross section in Figs. 3 and 4. There, the internal pressure sensors 4, the external pressure sensors 6 and the pressure-increasing device 7 are arranged laterally on the protective elements 1 either separately or, as illustrated in the cross section of Fig. 4, on a common base plate, which is preferably designed as a printed circuit board.

A further preferred configuration of the device comprising protective elements 1 consists in that it is used as a spherical or mushroom pushbutton for switching operations, e.g., typically an emergency mushroom pushbutton, or in an elongate strip form for safety circuits in clamping strips.

The device and options of combination of its configuration variants in terms of shape and size allow for the control of different counter-measures at a risk of collision by suitably programming the control device 8. In particular, this encompasses emergency shutdowns, proximity control via the pressure gradient, proximity control by capacitive proximity sensors in combination with the protective element according to the invention as a contact sensor, preferably in that the concerned protective element is more strongly inflated while being approached so as to increase the protective effect.

Similarly, the combination of a control of the surface of the manipulator 10 to be protected by the protective elements according to the invention as contact sensor with a three-dimensional camera forming spatial images is envisaged. This, in particular, for securing the final approach distance of the manipulator of about 1 to 3 cm, which cannot or hardly been

seized by a camera forming three-dimensional images, and hence has to be covered by the manipulator at creep speed.

P a t e n t k r a v

- 5 1. Fremgangsmåde til beskyttelse af personer og stationære eller autonomt bevægede forhindringer, der befinder sig foran stationære eller autonomt bevægede håndteringsapparater såsom fremstillings-, transport-, inspektions- eller serviceroboter og deres manipulatorer, mod kollisioner i disse håndteringsapparaters arbejdsområde ved hjælp af beskyttelseselementer, der er udformet som beskyttelseshylstre og kan fyldes med et medium, med en eller flere indvendigt liggende tryksensorer, **kendetegnet ved, at** mediet ikke føres udefra ved et tryk til hvert beskyttelseselement (1), men et overtryk genereres i det indre af beskyttelseselementet og ud over en eller flere tryksensorer (4) også har en indvendigt liggende trykforøgelsesindretning (7).
- 10 2. Fremgangsmåde ifølge krav 1, **kendetegnet ved, at** mediet fortrinsvis er omgivelsesluft og suges ind gennem indsugningskanaler, og mediet genereres i det indre af beskyttelseselementet ved et tryk, som kan indstilles af en styreindretning (8).
- 15 3. Fremgangsmåde ifølge krav 1 og 2, **kendetegnet ved, at** energiforsyningen af denne integrerede trykforøgelsesindretning (7) sikres ved hjælp af elektrisk energi, som ved behov tilføres via en styreindretning (8), der er anbragt uden for beskyttelseselementerne (1).
- 20 4. Fremgangsmåde ifølge et af kravene 2 og 3, **kendetegnet ved, at** styreindretningen (8) er udført som analog styring.
- 25 5. Fremgangsmåde ifølge et af kravene 2 og 3, **kendetegnet ved, at** styreindretningen (8) er udført som digital styring.
- 30 6. Fremgangsmåde ifølge et af kravene 4 til 5, **kendetegnet ved, at** styreindretningen (8) styrer trykforøgelsesindretningerne (7) enkeltvis eller sammenvættet i grupper.

7. Fremgangsmåde ifølge et af kravene 2 til 6, **kendetegnet ved, at** trykforøgelsesindretningerne (7) via styreindretningen (8) også styres på en pulserende måde i henhold til en på forhånd angivet trykforøgelsesprofil.

5 8. Fremgangsmåde ifølge et af kravene 2 til 7, **kendetegnet ved, at** trykforøgelsesindretningen (7) styres via den individuelle kombination af styrealgoritmer pr. beskyttelseselement.

10 9. Fremgangsmåde ifølge et af kravene 1 til 8, **kendetegnet ved, at** kun det berørte beskyttelseselement i kombination med kapacitive nærhedssensorer puster sig mere op ved kollisionsfare og således forstærker beskyttelsesvirkningen.

15 10. Fremgangsmåde ifølge et af kravene 1 til 8, **kendetegnet ved, at** kun det respektivt berørte beskyttelseselement i kombination med digital tredimensionel detektering af overfladeformen af en kollisionsgenstand eller en person puster sig mere op og således forstærker beskyttelsesvirkningen.

20 11. Fremgangsmåde ifølge et af kravene 1 til 8, **kendetegnet ved, at** styreindretningen (8) i kombination med digital tredimensionel detektering af overfladeformen af en kollisionsgenstand eller en person styrer robottens og/eller manipulatorens bevægelser på en sådan måde, at robottens og/eller manipulatorens tilnærmelseshastighed reduceres til et sikkert omfang.

25 12. Indretning til beskyttelse af personer og stationære eller autonomt bevægede forhindringer, der befinder sig foran stationære eller autonomt bevægede håndteringsapparater såsom fremstillings-, transport-, inspektions- eller serviceroboter og deres manipulatorer, mod kollisioner i disse håndteringsapparaters arbejdsområde ved hjælp af beskyttelseselementer, der er udformet
30 som beskyttelseshylstre og kan fyldes med et medium, med indvendigt liggende tryksensorer, **kendetegnet ved, at** mediet ikke føres udefra ved et tryk til hvert beskyttelseselement (1), men et overtryk genereres i det indre af beskyttelseselementet og ud over mindst en tryksensor (4) også har en indvendigt liggende trykforøgelsesindretning (7).

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13. Indretning ifølge krav 12, **kendetegnet ved, at** den indvendige fyldning (9) af beskyttelseselementerne (1) består af åbenporet skummateriale.

5 14. Indretning ifølge et af kravene 12 eller 13, **kendetegnet ved, at** hvert beskyttelseselement har en luftindgangs- og kabel-gennemgangs-kanal (13), som holdes fri ved hjælp af afstandsstykker (2).

10 15. Indretning ifølge et af kravene 12 eller 13, **kendetegnet ved, at** trykforøgelsesindretningen (7), den eller de indvendigt liggende tryksensorer (4) og eventuelt den eller de udvendigt liggende tryksensorer (6) er monteret på en bæreplade (3), der er udformet som en fælles printplade.

15 16. Indretning ifølge et af kravene 13 til 15, **kendetegnet ved, at** skummaterialefyldningen (9) er gastæt indhyllet med en udvendig indhylling (11) af hærdet flydende kunststof, og denne indhylling påstryges, påsprøjtes eller påføres ved en dyppemetode.

20 17. Indretning ifølge et af kravene 13 til 15, **kendetegnet ved, at** skummaterialefyldningen (9) er fremstillet af et materiale, som danner en gastæt udvendig hud ved en gasgennemtrængelig indvendig struktur.

25 18. Indretning ifølge krav 16 eller 17, **kendetegnet ved, at** den gastætte udvendige indhylling (11) består af en højtemperaturfast eller antibakteriel coating.

30 19. Indretning ifølge et af kravene 12 til 18, **kendetegnet ved, at** den anvendes i kugle-, svampeformet eller i aflang udførelse som tast til koblingsprocesser.

Fig. 1

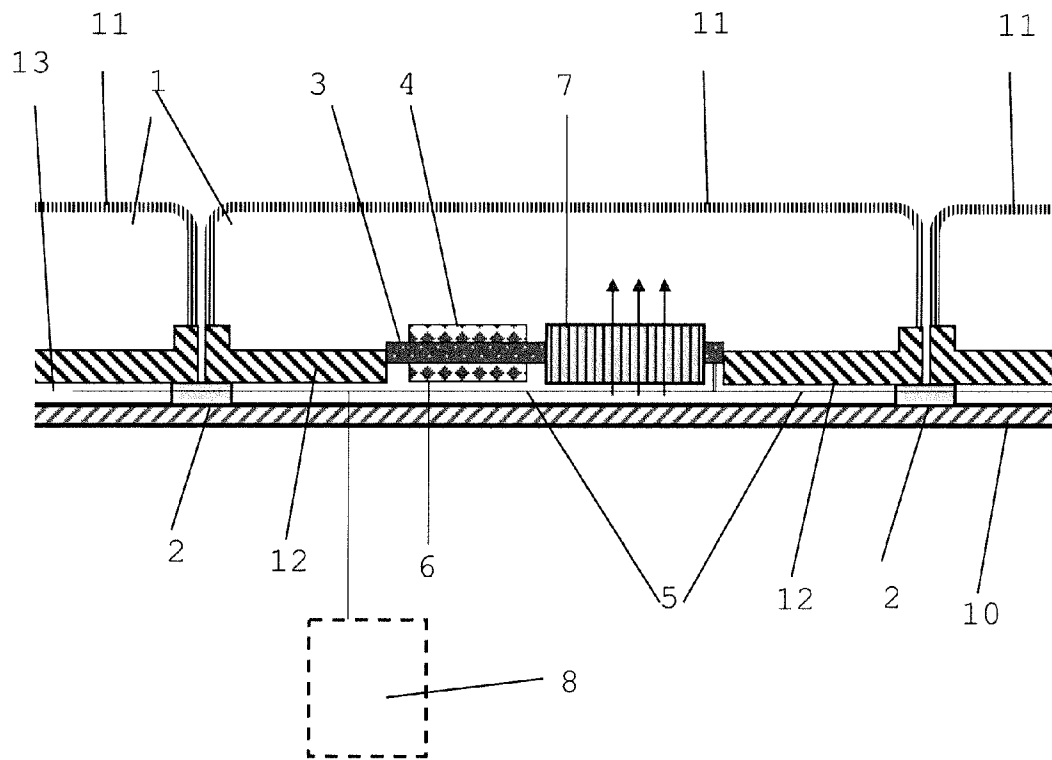


Fig. 1

Fig. 2

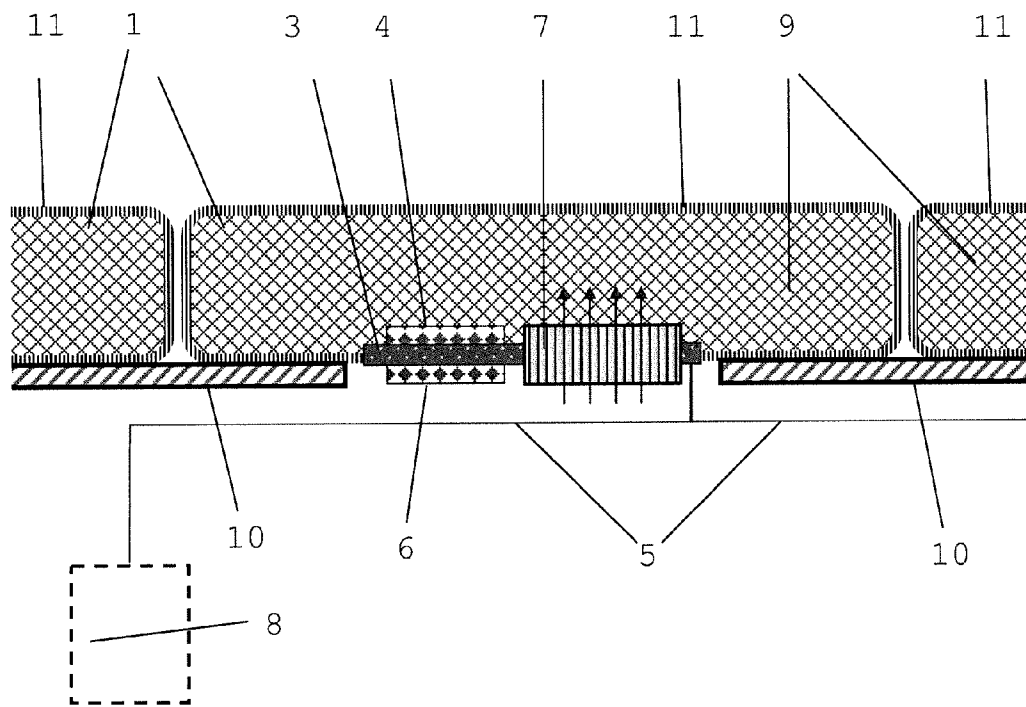


Fig. 2

Fig. 3

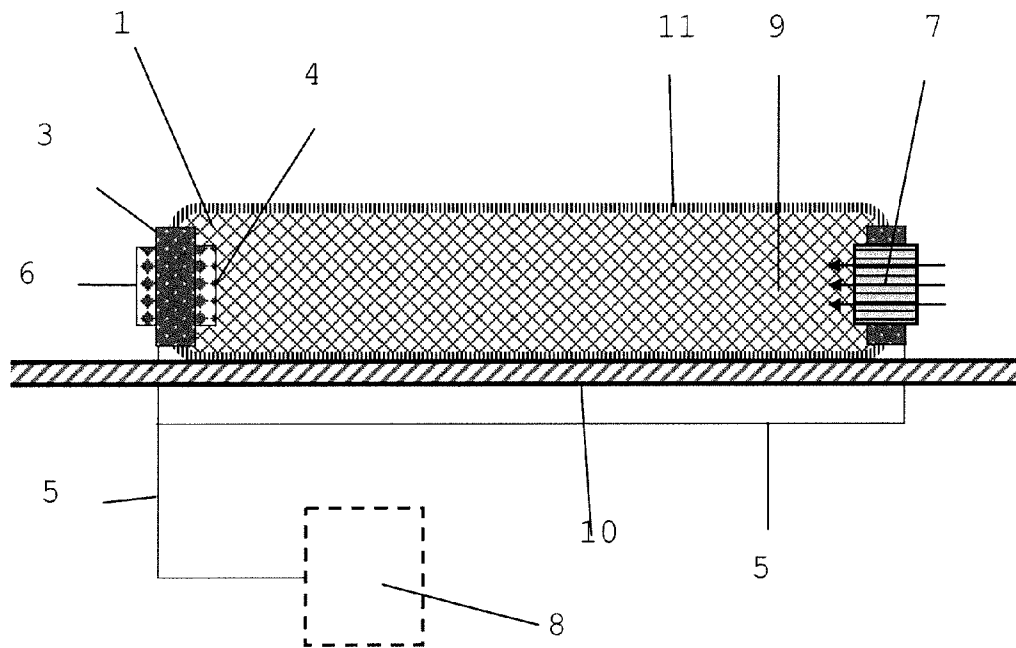


Fig. 3

Fig. 4

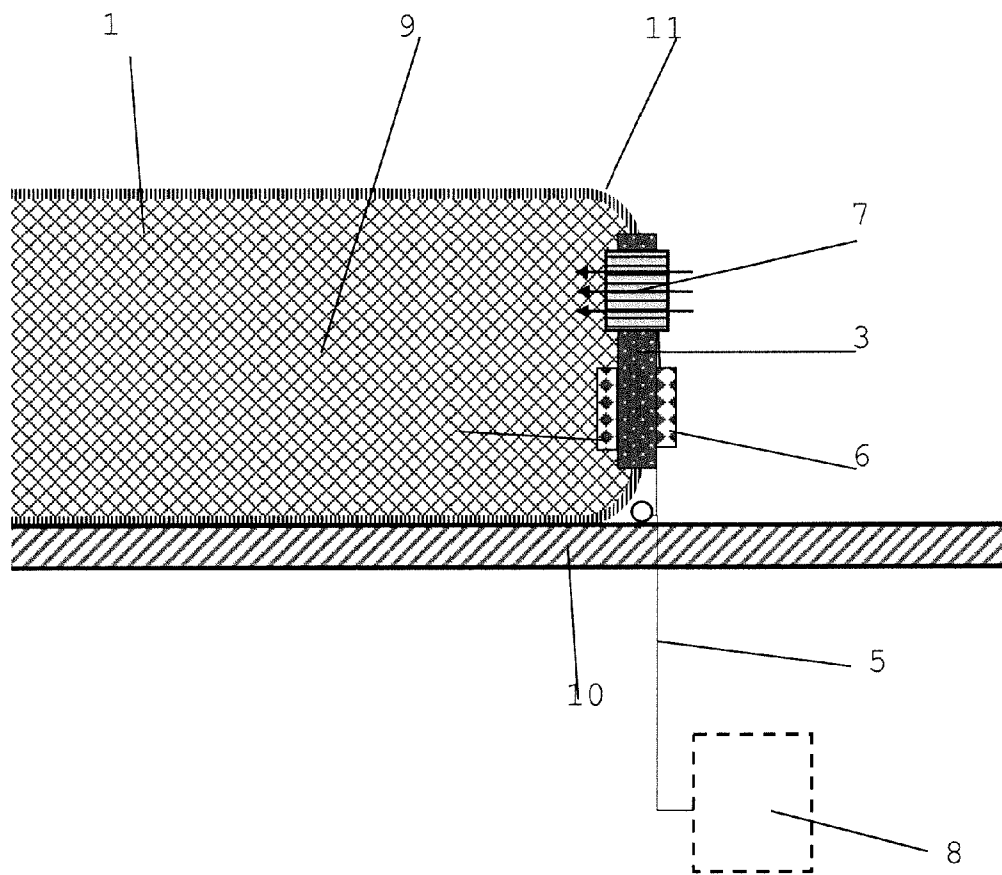


Fig. 4