

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
21 March 2002 (21.03.2002)

PCT

(10) International Publication Number
WO 02/22443 A1

(51) International Patent Classification⁷: **B64G 1/64**

(21) International Application Number: PCT/SE01/01884

(22) International Filing Date:
5 September 2001 (05.09.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0003315-9 18 September 2000 (18.09.2000) SE

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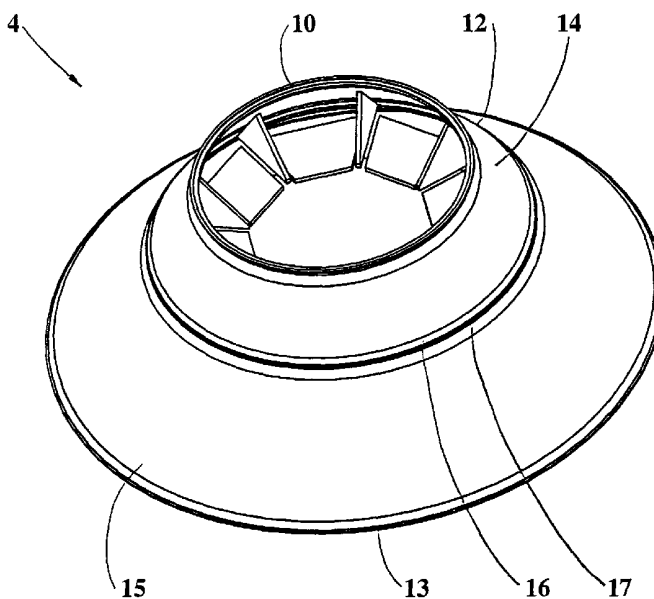
(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, CZ (utility model), DE, DE (utility model), DK, DK (utility model), DM, DZ, EC, EE, EE (utility model), ES, FI, FI (utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (utility model), SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— with international search report

[Continued on next page]

(54) Title: DEVICE AND METHOD FOR A SPACECRAFT



(57) **Abstract:** The invention presented here relates to a device in a spacecraft comprising a carrier rocket, a satellite and a detachable adapter (4) for connecting a satellite to the carrier rocket, where the adapter (4) comprises a wall structure (14, 15) for supporting the satellite on the carrier rocket, and is fixed at its lower rim to the carrier rocket and is fixed at its upper rim to the satellite. The device is characterised in that the adapter (4) is divided essentially across the longitudinal direction of the spacecraft and that both of the adapter parts (12, 13) are detachably connected to each other. The invention comprises the said adapter design and a method for separating the invented device.



WO 02/22443 A1



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Device and method for a spacecraft

TECHNICAL FIELD

5 The present invention relates to a device in a spacecraft comprising a first craft part, a second craft part with its payload, and a detachable adapter for connecting the second craft part to the first craft part.

The invention also involves the design of the said adapter, as well as a method for
10 separating the craft parts in the invented device.

STATE OF THE ART

A carrier rocket is used for launching craft such as satellites into space. The carrier
15 rocket consists of several engines, which one at a time propel the rocket so as to carry it to an orbital point where the satellite is separated from the carrier rocket. During launching, when one rocket carrier engine is expended the next one takes over, whereupon a part of the carrier rocket comprising the expended engine detaches from the rest of the carrier rocket.

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By means of a bolt connection, a carrier rocket adapter is mounted above the engine which powers the rocket carrier the final part of its path towards the orbital point where the satellite is to be detached. The carrier rocket adapter acts as an interface between the carrier rocket and cylindrical structural parts of the satellite, whereby a
25 clamp comprising shoes and a band provide a detachable connection between a carrier rocket adapter and a satellite. In the assembled state the shoes bear on cylindrical structural parts of the satellite and the carrier rocket's adapter, at the same time as the band is pre-stressed around the shoes so that these exert compressive forces on the structural parts and the adapter. During satellite separation an opening
30 mechanism in the clamp is activated, whereby the clamp opens and the satellite is released from the carrier rocket adapter with the aid of separating springs. The carrier rocket adapter has the shape of an envelope surface of a straight cylinder, or the envelope surface of a straight truncated, straight, circular cone, one rim of which, as described above, is mounted above the upper engine by means of, for example, a

bolt connection, while the other ribbed rim is prevented by the clamp fitting from moving relative to the ribbed circular structural parts of the satellite.

5 An arrangement involving a smaller satellite between the carrier rocket adapter and the main satellite is also known. This smaller satellite may extend down into the adapter's internal space. The smaller satellite is detachable from the main satellite and can be separated from it after carrier rocket separation.

DESCRIPTION OF INVENTION

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One embodiment of the present invention provides a device for a spacecraft, comprising a first craft part, a second craft part with its payload, and a detachable adapter for connecting the second craft part to the first craft part, where the adapter contains a wall structure which supports the second craft part on the first craft part and is fixed at its lower rim to the first craft part and has at its upper rim a detachable connection with the second craft part. The device is characterised in that the adapter is divided across the longitudinal direction of the spacecraft and that the adapter parts are detachably connected to each other. In one preferred embodiment the the adapter is divided into two adapter parts. In another embodiment the adapter is divided across the longitudinal direction of the spacecraft in several places and thus consists of several adapter parts detachably connected to each other.

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Moreover, the invention relates to the said adapter as well as a method for separating the craft parts within the device, which involves the second craft part detaching from the spacecraft after which the adapter part fitted to the second craft part is detached from the remaining spacecraft.

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The first craft part is preferably a carrier rocket and the second craft part is preferably a satellite.

30

In one embodiment the above-mentioned adapter part(s) not connecting to the carrier rocket has (have) internally dedicated positions for equipment for space operation of the adapter part, such as solar panels, power systems, control systems, and on-board computers, but even payloads such as hardware and software for execution of one or

more tasks. Thereby the adapter part can operate as a separate independent satellite. In an alternative embodiment, the spaces are occupied by equipment for space operation in the form of small independent satellites designed to release from the above-mentioned adapter part after separation. In a further embodiment, the two
5 above-mentioned embodiments are combined.

The device and the method represented by the invention have several advantages compared with previously known technology. The invention device allows at least one extra satellite to be launched with each rocket firing without needing to modify
10 either the structure of the carrier rocket intended for fitting to the adapter or equivalent structure on the satellite. The influence of the additional satellite on the main satellite during the launching phase and the separation phase is negligible. Furthermore, a greater payload volume can be sent up with every rocket firing, without impacting on the original payload volume. The usefulness of the device is
15 also greater with regard to weight, as the adapter is included in the spacecraft irrespective of whether or not it is used as a satellite structure after satellite separation.

DESCRIPTION OF DRAWINGS

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Fig. 1 illustrates schematically an example of a spacecraft.

Fig. 2 is a perspective drawing of an adapter in the spacecraft in Fig. 1.

Fig. 3 is a perspective drawing of a part of the adapter in Fig. 2.

Fig. 4 shows a cross-sectional view of a clamp fitting on the spacecraft.

25 Fig. 5A shows the adapter part in Fig 3 from above and Fig 5B shows the corresponding adapter part in an alternative embodiment, also viewed from above.

PREFERRED EMBODIMENTS

30 In Fig 1 the number 1 denotes a spacecraft comprising a carrier rocket 2 and a detachable craft part 3, in the form of a satellite in the example here. The carrier rocket 2 is constructed of several engines (not shown), which one at a time power the space craft 1 so as to carry it to an orbital point where the satellite 3 is separated from the carrier rocket 2. During launching, when one rocket carrier engine is expended,

the next one takes over, whereupon a part of the carrier rocket comprising the expended engine detaches from the rest of the carrier rocket. An adapter 4 is mounted above the carrier rocket 2 engine, which propels the spacecraft 1 the final part of its course towards the orbital point where the satellite 3 is to be detached.

5 The satellite 3 is mounted above the adapter 4; the adapter 4 acts as an interface between the carrier rocket 2 and the satellite 3. The adapter 4 comprises an upper adapter part 12, which, as will be described below in more detail, is detachably fitted to cylindrical structural parts 11 of the satellite 3, and a lower adapter part 13 fitted, for example by bolting, riveting, gluing, or a combination of these, above the last
10 engine section of the carrier rocket.

Each carrier rocket part 12, 13 in Fig. 2 comprises a wall 14, 15 in the shape of an envelope surface of a straight truncated, straight, circular cone, where the radius of the wall of the upper adapter part's 12 lower rim 16 essentially coincides with the
15 wall radius of the lower adapter part's 13 upper rim 17. In the example shown, the angle of incline of the upper adapter wall 14 is greater than the angle of incline of the lower adapter wall 15. In an alternative embodiment, the angles of incline of both adapter walls 14, 15 are equally big, while in a further embodiment the angle of incline of the upper adapter wall 14 is less than the angle of incline of the lower
20 adapter wall 15. In the example shown, the lower adapter wall 15 is longer than the upper; in an alternative embodiment, the adapter walls are the same lengths and in a further embodiment, the upper adapter wall is longer than the lower. As well as the adapter 4 being divided, it is constructed according to conventional measurements in order to fit to the carrier rocket and standard interfaces with satellites, and with the
25 same performance as regards strength, etc as existing conventional adapters.

In Fig. 4, the upper adapter part's 12 wall 14 at its lower rim 16 is furnished with a flange 6 constructed either integrated with the wall 14 as one part, or as a separate part, which is fixed, by riveting for example, to the lower rim 16 of the wall 14.
30 Similarly, the lower adapter part's 13 wall 15 at its upper rim 17 is furnished around the outside with a flange 7. A clamp 8 comprising flanged 6,7 shoes 10 positioned at regular intervals and a band 9 surrounding the shoes join the parts 12, 13 of the adapter 4. An opening mechanism (not shown) in the clamp, on being activated, is

arranged to open the clamp, so that the adapter parts 12, 13 have a detachable connection with each other.

5 The upper rim 10 shown in Fig. 2 also has a flange around the outside and the cylindrical structural parts 11 of the satellite 3 are supplied with flanges. A clamp such as the one described in connection with Fig. 4 forms a detachable connection between the satellite and the adapter part 12, with the shoes resting against the satellite's cylindrical structural parts 11 and the adapter part 12, at the same time as a band is pre-stressed around the shoes so that these exert compressive forces on the
10 satellite and the adapter, thus preventing them from moving in relation to one another.

In Fig. 3 and 5A, the adapter part 12 has internally dedicated attachment positions 18 for various equipment. The amount and complexity of equipment may vary, and
15 may, for example, include all the equipment needed for an independent satellite, such as solar panels, propulsion systems, control systems and on-board computers. Those attachment positions 18 not required for satellite operation may be used for payload, for example hardware and software for executing one or more tasks. Fig 5B shows an alternative configuration of positions 18 in the adapter part; the only limitation
20 being that the positions 18 must not encroach on the space reserved for parts such as protruding parts of the satellite and/or the carrier rocket. In an alternative embodiment, each of several mounting positions 18 is occupied by a small, independent satellite, so that after clamp separation the adapter part 12 is used as a "dispenser" for releasing small satellites. The adapter part 12 preferably has a control
25 system and a propulsion system for driving the adapter part 12 to a position that is specific for each small satellite and where the satellite is released. Apart from acting as an interface between the carrier rocket's upper engine module and the satellite 3, as well as being a load carrying structure for the satellite 3, a part 12 of the adapter 4 together with the equipment contained therein constitutes an independent spacecraft
30 after clamp separation.

The above-described spacecraft is designed to operate as follows. When the last carrier rocket engine is expended and the satellite 3 has adopted its desired course, an opening mechanism in the clamp between the satellite and the upper adapter part is

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activated, whereby the clamp opens and the satellite 3 is released from the adapter 4, thus rendering it free to adopt its course in space. Thereafter, the clamp joining the adapter parts opens, whereupon the adapter part 12 is able to leave the carrier rocket and adopt a course in space aided by the equipment in the dedicated positions.

5

CLAIMS

1. A device in a spacecraft (1), comprising a first craft part (2), a second craft part (3) with its payload, and a detachable adapter (4) for connecting the second craft part (3) to the first craft part (2), where the adapter (4) comprises a wall structure (14, 15) which supports the second craft part (3) on the first craft part, and is fixed at its lower rim to the first craft part and is fixed at its upper rim to the second craft part, **characterised in** that the adapter (4) is divided in at least one place across the longitudinal direction of the spacecraft and that the adapter parts (12, 13) are detachably connected to each other.
2. A device as in claim 1, **characterised in** that one adapter part (12) of the adapter (4) is detachably connected to the second craft part (3)
3. A device as in claim 1, **characterised in** that the adapter part (12) has internally dedicated positions (18) for equipment for space operation.
4. A device as in claim 1, **characterised in** that the wall structure (14, 15) is constructed as a truncated cone.
5. A method for separating the craft parts within the device as in claim 1, **characterised in** that the second craft part (3) detaches from the spacecraft (1) after which the adapter part (12) is detached from the remaining spacecraft.
6. An adapter for a spacecraft (1) designed to detachably join a first craft part (2) with a second craft part (3) with its payload, where the adapter (4) comprises a wall structure (14, 15) for supporting the second craft part (3) on the first craft part (2), and where the wall structure (14, 15) at its lower rim is designed to be fixed to the first craft part and at its upper rim to be fixed to the second craft part, **characterised in** that adapter (4) is divided essentially across the longitudinal direction of the spacecraft and that both of the adapter parts (12, 13) are detachably connected to each other.

7. A device in a spacecraft (1), comprising a carrier rocket (2), a satellite (3) and a detachable adapter (4) for connecting the satellite (3) to the carrier rocket (2), where the adapter (4) comprises a wall structure (14, 15) for supporting the satellite (3) on the carrier rocket (2), and is fixed at its lower rim to the carrier
5 rocket and is fixed at its upper rim to the satellite, **characterised in** that the adapter (4) is divided essentially across the longitudinal direction of the spacecraft and that both of the adapter parts (12, 13) are detachably connected to each other.
- 10 8. A device as in claim 1, **characterised in** that one adapter part (12) of the adapter (4) is detachably connected to the satellite (3).
9. A device as in claim 1, **characterised in** that the adapter part (12) has internally dedicated positions (18) for equipment for space operation.
- 15 10. A device as in claim 1, **characterised in** that the wall structure (14, 15) is constructed as a truncated cone.
11. A method for separating the craft parts within the device as in claim 7,
20 **characterised in** that the satellite (3) detaches from the spacecraft (1) after which the adapter part (12) is detached from the remaining spacecraft.
12. An adapter for a spacecraft (1) designed to detachably join a carrier rocket (2) with a satellite (3), where the adapter (4) comprises a wall structure (14, 15) for
25 supporting the satellite (3) on the carrier rocket (2), and where the wall structure (14, 15) at its lower rim is designed to be fixed to the carrier rocket and at its upper rim to be fixed to the satellite, **characterised in** that the adapter (4) is divided essentially across the longitudinal direction of the spacecraft and that both of the adapter parts (12, 13) are detachably connected to each other.
- 30 13. A device in a spacecraft, comprising a first craft part, a second craft part with its payload, and an adapter for detachably connecting the second craft part to the first craft part,

- said adapter comprising a wall structure which supports the second craft part on the first craft part, said wall structure being fixed at its lower rim to the first craft part and being fixed at its upper rim to the second craft part, and
- said adapter being divided across the longitudinal direction of the spacecraft in at least one place into adapter parts detachably connected to each other.

14. A device in a spacecraft, comprising a carrier rocket, a satellite and an adapter for detachably connecting the satellite to the carrier rocket,

- said adapter comprising a wall structure for supporting the satellite on the carrier rocket, said wall structure being fixed at its lower rim to the carrier rocket and being fixed at its upper rim to the satellite and
- said adapter being divided essentially across the longitudinal direction of the spacecraft into a first and a second adapter part detachably connected to each other.

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15. A device as in claim 14, wherein the first adapter part of the adapter is detachably connected to the satellite.

16. A device as in claim 15, wherein the first adapter part has internally dedicated positions for equipment for space operation.

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17. An adapter for a spacecraft designed to detachably join a first craft part with a second craft part comprising payload, where the adapter comprises a wall structure for supporting the second craft part on the first craft part, and where the wall structure at its lower rim is designed to be fixed to the first craft part and at its upper rim to be fixed to the second craft part, the adapter being divided essentially across the longitudinal direction of the spacecraft into adapter parts detachably connected to each other.

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18. An adapter for a spacecraft designed to detachably join a carrier rocket with a satellite, where the adapter comprises a wall structure for supporting the satellite on the carrier rocket, and where the wall structure at its lower rim is designed to be fixed to the carrier rocket and at its upper rim to be fixed to the satellite, the

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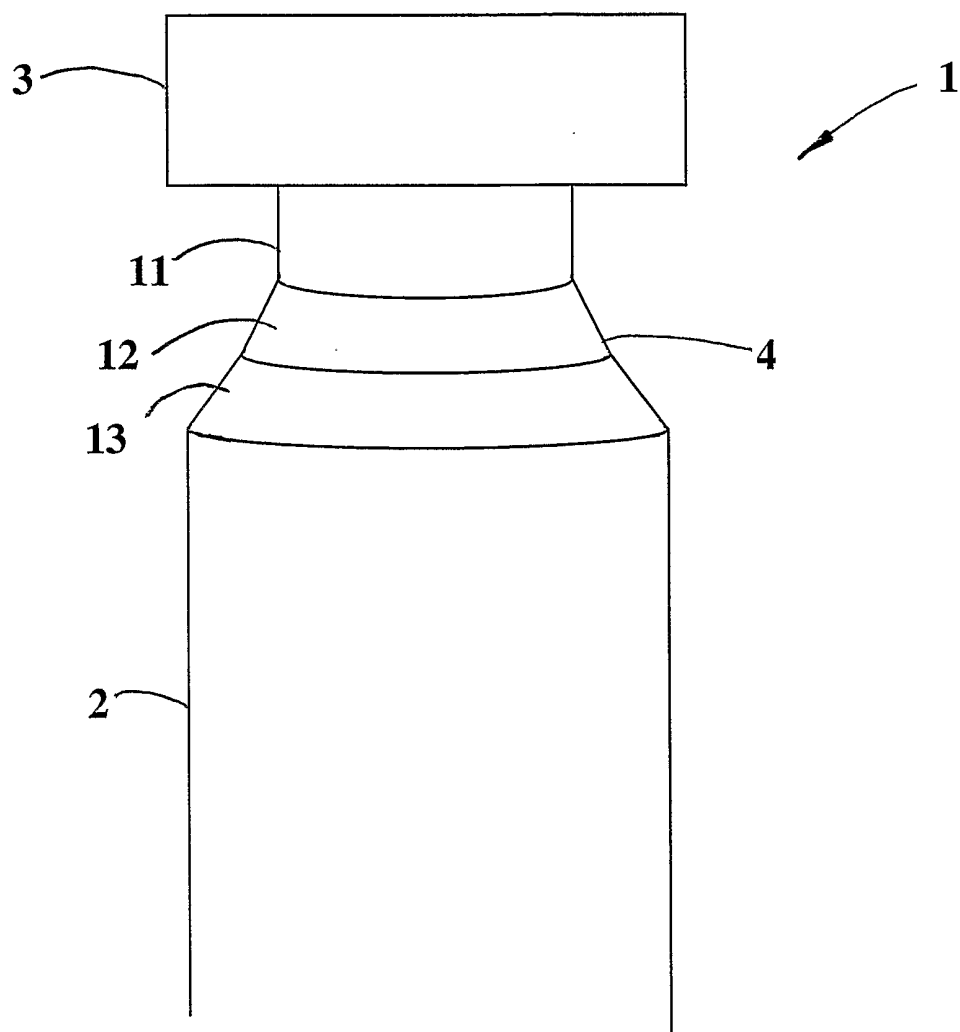
adapter being divided essentially across the longitudinal direction of the spacecraft into adapter parts detachably connected to each other.

19. A method for separating a first craft part from a second craft part of a space craft,
5 wherein an adapter detachably connects the second craft part to the first craft part, said adapter being divided across the longitudinal direction of the spacecraft in at least one place into adapter parts detachably connected to each other, the method comprising the steps of detaching the second craft part from an upper part of the adapter and then detaching said upper adapter part from the
10 remaining spacecraft.

20. A method for separating a carrier rocket from a satellite, wherein an adapter detachably connects the satellite to the carrier rocket, said adapter being divided across the longitudinal direction into an upper adapter part facing the satellite and
15 a lower adapter part facing the carrier rocket, said adapter parts being detachably connected to each other, the method comprising the steps of detaching the satellite from the upper part of the adapter and then detaching said upper adapter part from the lower adapter part.

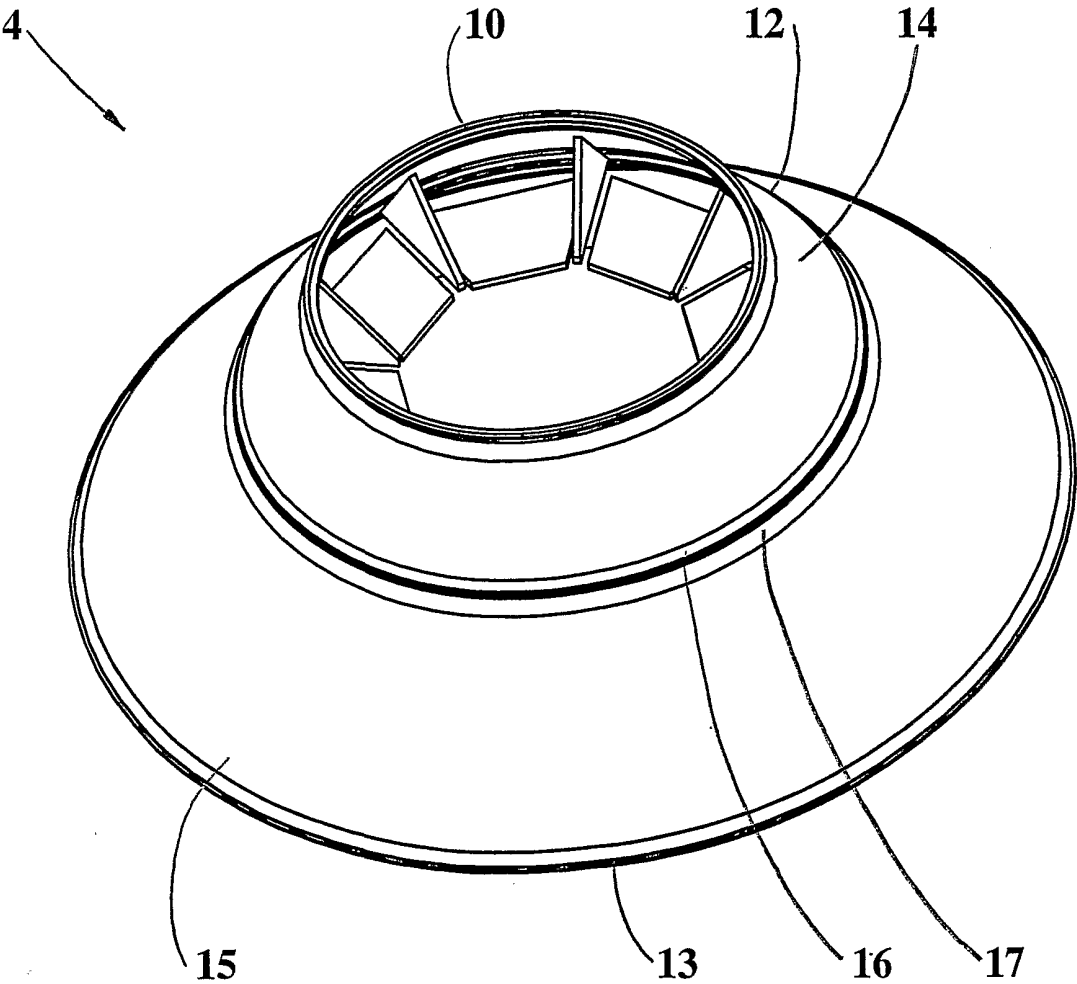
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FIG 1



2/4

FIG 2



3/4

FIG 3

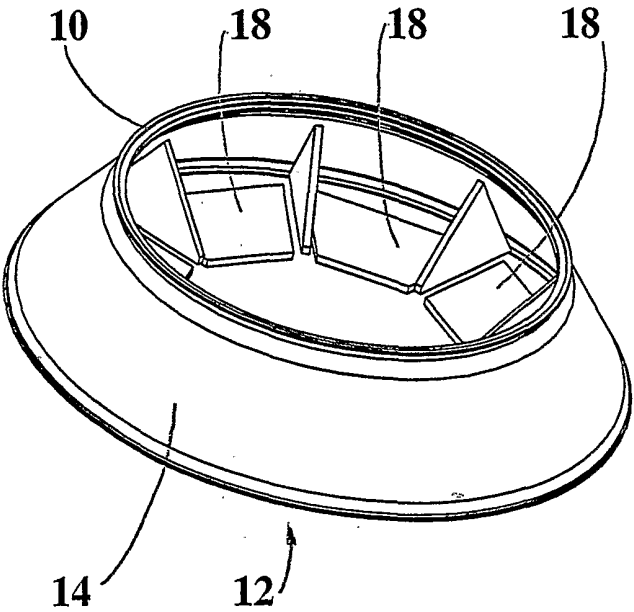


FIG 4

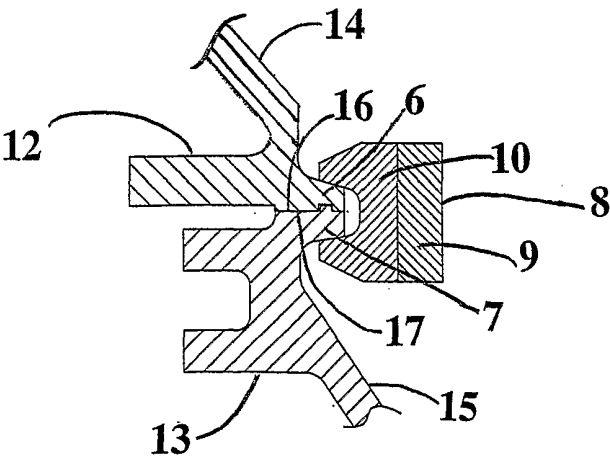


FIG 5A

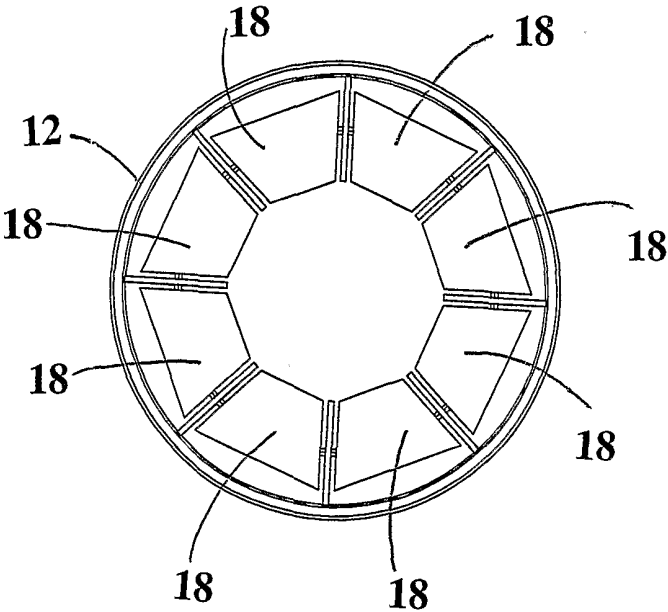
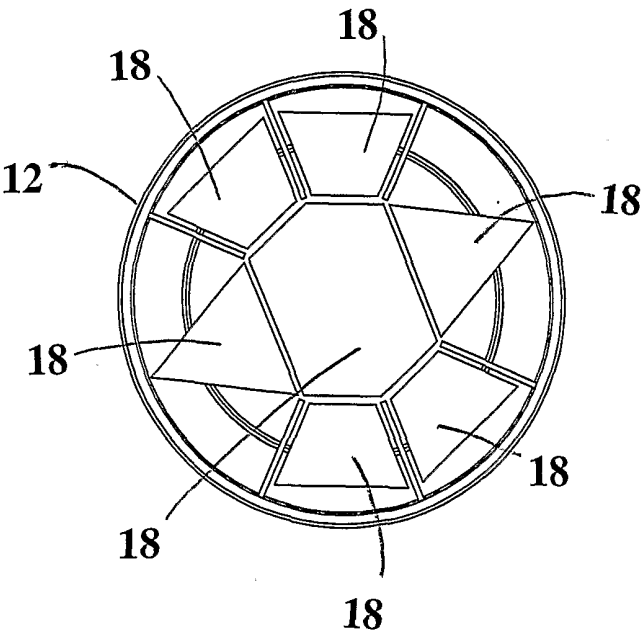


FIG 5B



INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 01/01884

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: B64G 1/64

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: B64G

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 DATA

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 1002717 A2 (CONSTRUCCIONES AERONAUTICAS, S.A.), 24 May 2000 (24.05.00), column 4, line 29 - line 51; column 6, line 50 - column 7, line 8, figures 1-3, abstract --	1-20
A	US 5271582 A (PERKINS ET AL), 21 December 1993 (21.12.93), column 6, line 39 - line 51; column 7, line 36 - line 55; column 8, line 22 - line 37, figures 2-6, abstract --	1-20
A	EP 0905022 A1 (CONSTRUCCIONES AERONAUTICAS, S.A.), 31 March 1999 (31.03.99), figures 1,2, abstract -----	1-20

☐ 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

19 December 2001

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

International application No.

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