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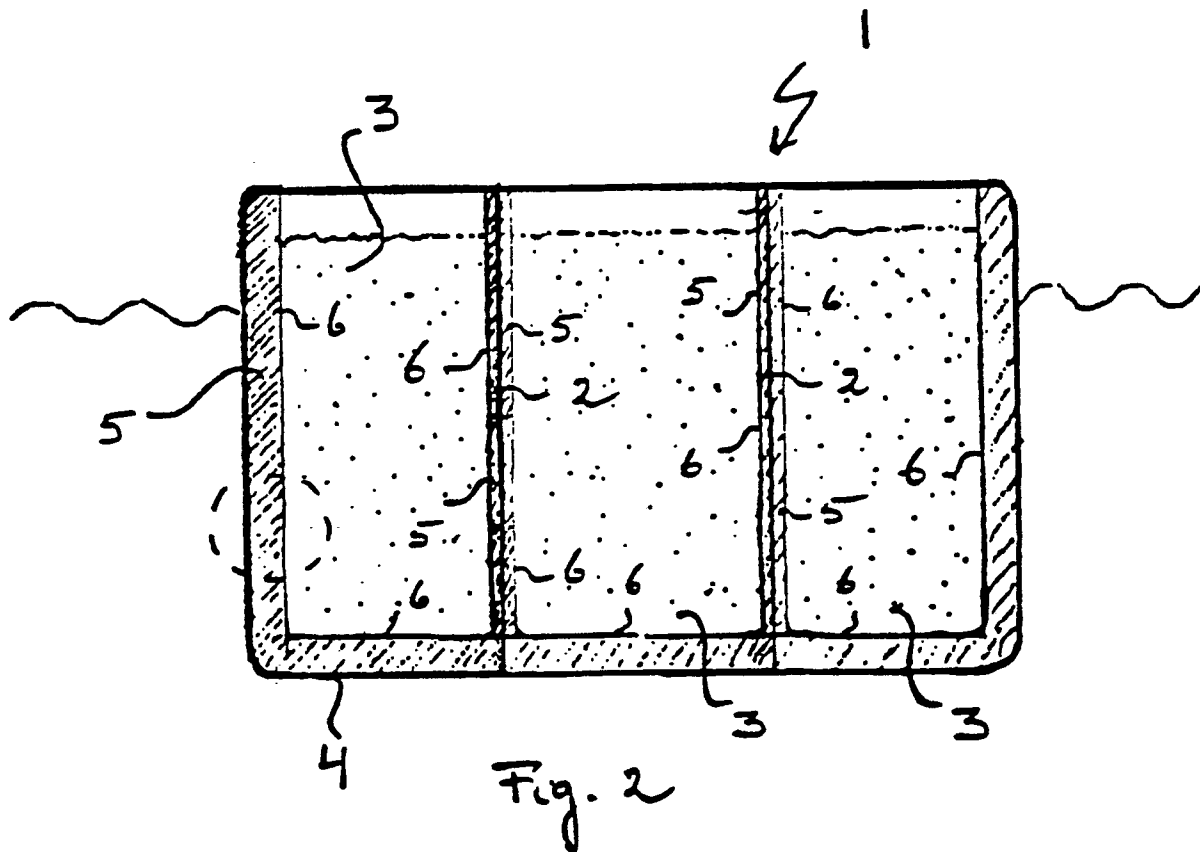
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(54) **Vessel for conveying a liquid cargo.**

(57) A vessel comprising at least one cargo hold provided with a rigid outer wall (4), a flexible, liquid-tight container (6) so being present within said outer wall for conveying a liquid cargo therein, whereby the rigid outer wall is at least partially provided at its inner side with a layer (5) which is substantially made of a material having a pressure distributing property.



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VESSEL FOR CONVEYING A LIQUID CARGO

The invention relates to a vessel comprising at least one cargo hold provided with a rigid outer wall, a flexible, liquid-tight container so being present within said outer wall for conveying a liquid cargo therein.

Such a vessel is known from Dutch Patent Specification No. NL 72.05209, wherein a bag which, when filled with liquid, will fill the cargo hold forms the flexible, liquid-tight container. This known vessel has been designed in order to minimize the risk of leaking cargo holds, e.g. caused by a collision, whereby the liquid cargo, such as oil, may escape. Such a flexible bag is much better able to resist deformations, without actually tearing, than the rigid steel construction. At the same time the use of such bags renders the partial or complete cleaning of the interior of the cargo holds redundant. The bags may be adapted for relatively easy replacement, and the same bags may be used repeatedly for the same type of liquid, e.g. oil. In particular in cargo holds in which two or more bags are provided it will be possible to carry several types of oil or other liquids, whereby each time the same bag is used for the same type of liquid, so that cleaning becomes substantially redundant.

A drawback of the known vessel is that in the event that the vessel is seriously damaged it is not excluded that after the rigid outer wall of the cargo hold has been breached, as a result of a calamity, also the bags in which the cargo is stored will tear. It stands to reason that a free outflow of the cargo, e.g. oil or chemicals, may cause enormous damage to the environment.

The object of the present invention is to provide a vessel for conveying a liquid cargo, whereby the risk of leaking cargo holds, e.g. as a consequence of a collision, is excluded or at least minimized.

In order to accomplish that objective a vessel of the kind mentioned in the preamble is characterized in that the rigid outer wall is at least partially provided at its inner side with a layer which is substantially made of a material having a pressure distributing property. The strength properties of this material are such that in the event of e.g. a collision the forces exerted on the rigid outer wall are distributed by said layer, so that the occurrence of high local stresses, which might constitute a risk for the flexible, liquid-tight container, is prevented. The strength properties of the material are furthermore such that in the event that the sheet steel bends inwards the layer will remain sufficiently intact, so that any contact between sharp steel edges of the damaged rigid outer wall and the flexible liquid-tight container is avoided. Said container is for example made of a polymer, e.g. polyethylene, which is sufficiently flexible and which is able to resist the corrosiveness of e.g. crude oil for the life span of a vessel. It is noted that the term rigid outer wall - besides the ship's skin - is also meant to comprise upright inner side walls of the cargo hold.

One embodiment of a vessel according to the invention is characterized in that the material of which the layer is substantially made has a high energy dissipating power. When besides the rigid outer wall and the flexible, liquid-tight container also the material of the layer has an energy dissipating power, the risk that the container will tear, e.g. in the event of a collision, will practically be excluded.

Another embodiment of a vessel according to the invention is characterized in that the layer is substantially made up by a foam layer. Said foam layer is preferably a synthetic foam layer of preferably polyurethane resin or polyethylene, or a natural material with the same pressure distributing property.

Another embodiment of a vessel according to the invention is characterized in that the layer is a first layer, which is at least partially provided at its inner side with a reinforced second layer, whereby an elastic/plastic third layer is provided on at least part of the inner side of said second layer. Because of this it is prevented that, even in the event of extreme calamities, the ship's cargo can leak out.

Another embodiment of a vessel according to the invention is characterized in that the wall of the flexible, liquid-tight container bears against the layer substantially made of a material having a pressure distributing property or against the elastic/plastic layer, as the case may be, so as to form a lining.

The invention will be explained in more detail with reference to a few figures illustrated in a drawing, wherein:

- figures 1 and 2 very diagrammatically illustrate a cargo hold of a vessel according to the invention;
- figure 3 illustrates a detail, indicated by means of a dotted circle, of figure 1;
- figure 4 shows several steps in the phenomenon of collision with a synthetic double hull;
- figure 5 illustrates energy absorption for different double hull concepts versus the penetration depth in case of collision; and
- figure 6 shows a comparison of criteria for the different double hull concepts.

In figure 1 a cargo hold 1 of a vessel according to the invention can be distinguished, said cargo hold 1 being subdivided into several compartments 3 by means of inner side walls 2. Said cargo hold 1 contains a rigid outer wall, a ship's skin 4 in this case, at the inner side of which a foam layer 5 is provided, which is made of a material having a high (enough) compressive strength and as high an energy dissipating power as possible. A flexible, liquid-tight container bears against the foam layer 5 so as to form an (inner) lining 6.

The foam layer 5 and the inner lining 6 preferably have the following properties.

	<u>foam layer</u>	<u>inner lining</u>
5		
	specific gravity	50 - 1000 500 - 3000 kg/m ³
	max. compr. stress	>3 MPa
10	tensile strength	40 - 70 MPa
	stretch	>50

The thickness of the foam layer 5 and the inner lining 6 varies, dependent on e.g. the type and the size of the vessel, and ranges from 0.5 - 3 m for the foam layer and from 1 - 5 cm for the inner lining.

15 A combination of this foam layer 5 and the flexible inner lining 6 easily yields along with the movements of the ship's skin 4. There are several possibilities of providing the combination of the foam layer 5 and the flexible inner lining 6:

20 1. The foam layer 5 and the inner lining 6 are only provided along the ship's skin 4, whereby the attachment of the flexible inner lining 6 to the inner side walls 2 of the cargo hold 1 requires additional provisions (figure 1).

2. The foam layer 5 and the flexible inner lining 6 are provided along the ship's skin and the upright inner side walls 2 of the cargo hold 1. The foam layer 5 bearing against the inner side walls 2 may be much thinner than the foam layer 5 bearing against the inner side of the ship's skin 4 (figure 2).

The foam layer 5 has a fourfold function:

- 25 a. Distributing the force which is exerted on the ship's skin in the event of a calamity, as a result of which the occurrence of local high peak tensions on the inner lining 6 is prevented;
 b. Effecting a spacing between the ship's skin 4 (breaching sheet steel!) and the flexible inner lining 6;
 c. Maintaining said spacing when, e.g. in the event of a collision, the ship's skin moves inwards; and
 d. Dissipating (part) of the energy which is transferred to the ship's skin, e.g. in the event of a collision.

30 In the event of a collision between an object and a vessel having a cargo hold 1 the following stages can in principle be distinguished:

- The object penetrates the steel ship's skin.
- The object penetrates into the ship's hold, whereby the foam layer 5 protects the inner lining 6. Because the volume of the cargo hold 1 is becoming smaller, the pressure in the cargo hold 1 will increase very fast, whereby air present above the cargo escapes until a maximum pressure in the cargo hold 1 is exceeded.
- The steel deck or other partitions become deformed and break if no measures have been taken to prevent this. The foam layer 5 is loaded at the maximum pressure now and the penetrating object is halted.
- The penetrating object and the vessel become detached from one another. The foam layer 5 and the inner lining 6 are tensioned in front of the opening caused by the collision and prevent the cargo from flowing/leaking out (see figure 4). The effect of the pressure distributing layer, in combination with a flexible inner tank (possibly protected by a glass fibre layer (or otherwise) at the outside, so that in the event of a collision or of the vessel running aground the inner tank remains intact) is to a considerable degree caused by the energy absorbing capacity which is created as a result of a pressure build-up in the collided tank, and of the resulting deformation of the inner walls of said tank. This phenomenon does not occur with a single or double steel skin, since the tank will start to leak, so that no pressure is built up and no energy can dissipate as a result of the deformation of the tank walls. This energy absorbing effect was calculated, and is illustrated in figure 5 as compared to steel skins. Figure 6 shows the results of the feasibility study that has been carried out, i.e. the effect of the decrease of the cargo volume per dwt ship capacity, the cost and the critical energy supply.

50 Since the foam layer 5 is less elastic than the inner lining 6, said foam layer 5 might become breached in case of very extreme calamities, as a result of which the flexible inner lining 6 might run the risk of tearing as yet, resulting in the cargo leaking out. As a safeguard against such extreme calamities a special feature of a vessel according to the invention is that at its inner side the foam layer 5 is provided with a reinforced layer 7 of synthetic fibres (or any other material resistant to shock), on the inner side of which an elastic/plastic layer 8 is provided. In that case the flexible inner lining 6 bears against said elastic/plastic layer 8 (figure 3). Said layers may also be combined to form one composite layer, of course. Also another sequence of layers fall within the scope of the invention, for example a sequence corresponding to the above described sequence on the

understanding that the positions of the foam layer 5 and the elastic/plastic layer 8 are mutually exchanged. The use of several layers of synthetic fibres instead of the use of one synthetic layer is of course also possible.

The advantage of vessel according to the invention in comparison with the vessel described in Dutch Patent Specification No. NL 72.05209 is not only that the risk of leaking cargo holds is excluded/minimized, but also that the cargo is insulated by the foam layer 5, so that an energy saving is realized. The use of polyurethane resin to form the foam layer moreover has the advantage that there is less internal corrosion in the cargo hold 1, and that - because of its low specific weight - there is hardly an increase in the weight of the vessel. A final advantage of the vessel according to the invention is that there is substantially no loss of cargo capacity, which is to a substantial degree the case with a vessel according to the above-mentioned Dutch Patent Specification. Indeed, with this known vessel a relatively large spacing between the ship's skin and the inner tank is required, due to the necessity of offsetting the power transmitting effects of the connections between the ship's skin and the inner tank occurring in the event of a collision. The space between the ship's skin and the inner tank with this known vessel may furthermore form an explosion space, in case explosive gases are released into this space as a result of e.g. a fire which has broken out on said vessel.

It is noted that in the event that the vessel according to the invention runs aground, as a result of a collision with e.g. a rock projecting from the bottom of the sea, said rock will cause less damage to the vessel, because on the one hand the relative movement of the rock will be braked very strongly by the foam layer 5, and on the other hand there are no fixed, rigid connections between the ship's skin 4 and the flexible inner lining 6. This in contrast to that which is described in Dutch Patent Specification No. NL 72.05209, wherein fixed connections are present between the ship's skin and the inner tank.

Claims

1. A vessel comprising at least one cargo hold provided with a rigid outer wall, a flexible, liquid-tight container so being present within said outer wall for conveying a liquid cargo therein, characterized in that the rigid outer wall is at least partially provided at its inner side with a layer which is substantially made of a material having a pressure distributing property.
2. A vessel according to claim 1, characterized in that the material of which the layer is substantially made has a high energy dissipating power.
3. A vessel according to claim 1 or 2, characterized in that the layer is substantially made up by a foam layer.
4. A vessel according to claim 1, 2 or 3, characterized in that the layer is a first layer, which is at least partially provided at its inner side with a reinforced second layer, whereby an elastic/plastic third layer is provided on at least part of the inner side of said second layer. Because of this it is prevented that, even in the event of extreme calamities, the ship's cargo can leak out.
5. A vessel according to any one of the preceding claims, characterized in that the wall of the flexible, liquid-tight container bears against the layer substantially made of a material having a pressure distributing property or against the elastic/plastic layer, as the case may be, so as to form a lining.

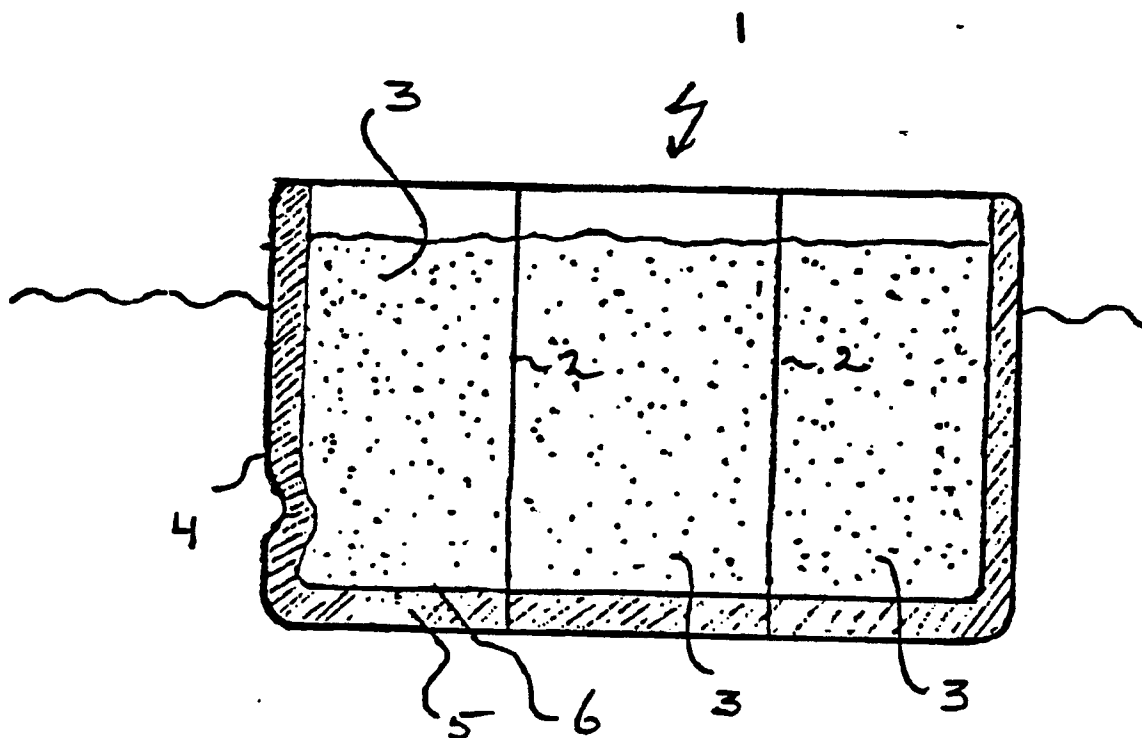


Fig. 1

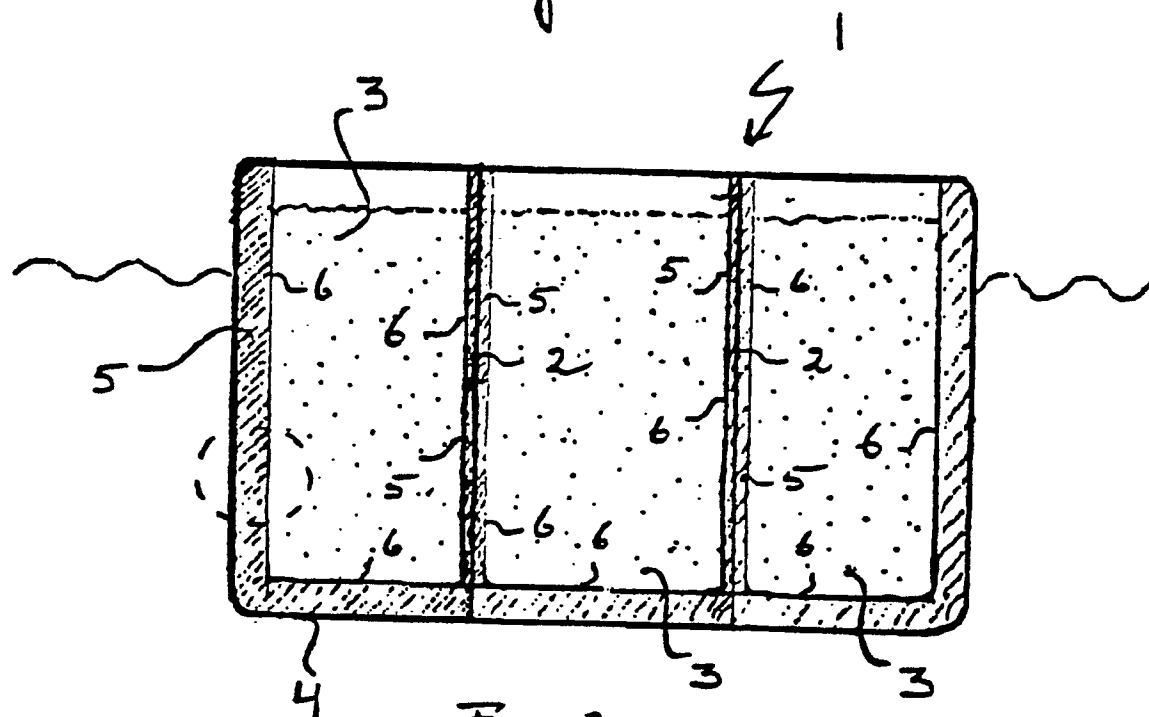


Fig. 2

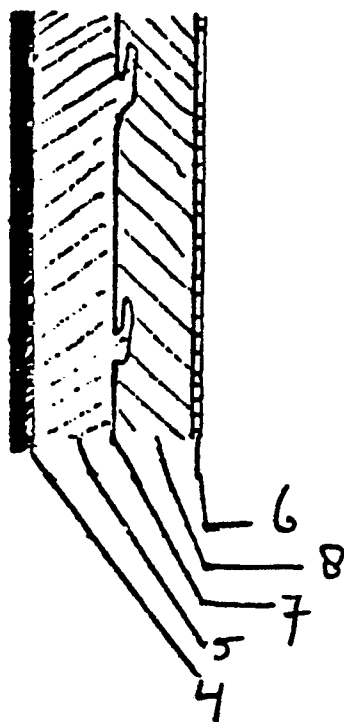


Fig. 3

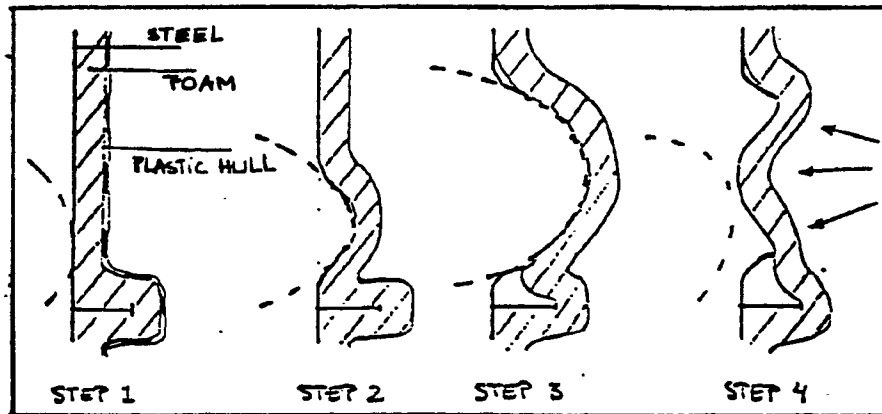


Fig. 4 Several steps in the phenomenon of collision with a synthetic double hull.

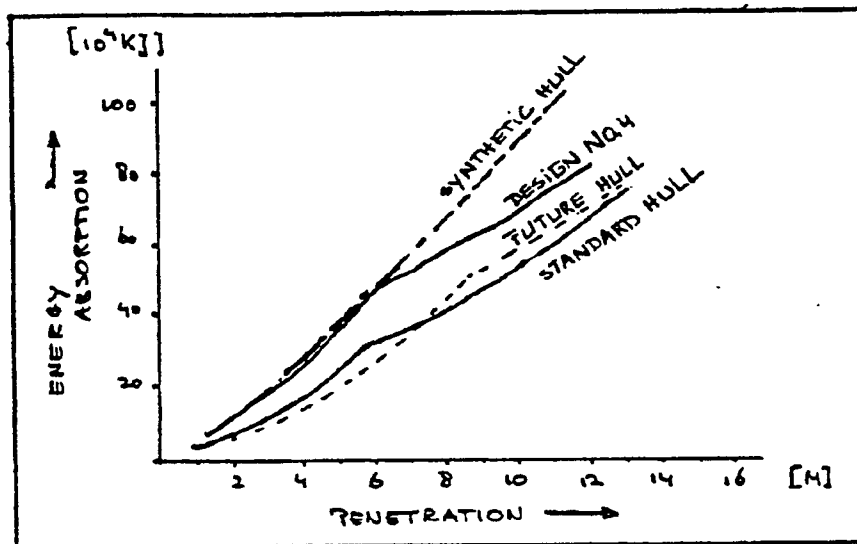


Fig. 5 Energy absorption for the different double hull concepts versus the penetration depth in case of collision.

	standard steel DH	future steel DH	design no. 4	synthetic DH case 1	synthetic DH case 2
cargo vol.	100 %	70 %	90 %	90 %	75 %
weight	100 %	105 %	106 %	110 %	120 %
costs	100 %	106 %	107 %	108 %	118 %
critic energy	100 %	160 %	150 %	> 100 %	> 100 %

Fig. 6 Comparison of criteria for the different double hull concepts.



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EUROPEAN SEARCH REPORT

Application Number

EP 91 20 0490

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	US-A-3 272 373 (ALLEAUME) * Claims; figure 1 * ---	1-5	B 63 B 11/04 B 63 B 25/12
A	US-A-4 135 465 (DUDLEY) * Abstract; figures 1,2 * -----	1-5	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			B 63 B
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 28-05-1991	Examiner DE SCHEPPER H.P.H.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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