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## (54) Towed underwater sledge.

(57) A sledge on which a diver can be towed underwater by a vessel comprises a sledge wing (1), on which the diver lies, holding himself in place by gripping a thigh grip post (26). Two towing lines (4,5) are attached at one end to the sledge just in front of the laterial centre of pressure and the centre of gravity of the sledge, and at the other end to a towing foil (6), from which a towing line (7) leads to the towing vessel. The diver can manoeuvre the sledge by moving control rods (17,18) which move elevons (21,22) at the rear of the sledge. Transparent upper and lower screens (8,10) deflect the water flow past the sledge and, in combination with a viewing section (9) through the sledge wing (1), allow the diver to see clearly forwards and downwards in a natural sweep of the eyes for optimum visibility.

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# TOWED UNDERWATER SLEDGE

The invention relates to a sledge on which a diver can be towed underwater by a vessel particularly, but not exclusively, to enable the diver to observe the sea bed.

In many situations there are advantages in having a diver towed by a vessel. A vessel can tow the diver at greater speeds and over greater distances than a diver can swim. Furthermore, the diver remains in contact with the vessel.

Sledges known in the prior art were originally made of wood and were large and heavy, making them awkward to handle on land and difficult to manoeuvre in the water. In use they became saturated with water and lost buoyancy, making them unsuitable for long periods of use. A wooden screen was fitted to the front of the sledge, to deflect the water flow over the diver riding on the sledge, which greatly restricted the visibility for the diver. Lighter sledges of metal tubing frames with transparent screens, as described in US patent number 3931777, are also known but these still have the problem of restricted visibility due to the buoyancy material and the material used for fastening the screens to the sledge. These sledges also lack manoeuvrability and stability when towed by a vessel. Additionally it is difficult for a diver to keep himself on the sledge underwater and it is very dangerous for a diver to be tied to a sledge or attached by any means that is not instantly releasable if necessary.

The object of the invention is to provide a sledge, on which a diver can be towed underwater by a vessel, which provides good visibility down towards the sea bed.

The sea bed is here taken to include the bed of any body of water through which the sledge can be towed eg sea, lake or river.

It is a further object of the invention to provide such a sledge which is lightweight, portable, easily manoeuvrable in water and which does not lose buoyancy during use.

A sledge, on which a diver can be towed underwater by a vessel, comprising:

a) a sledge wing;

b) means to attach the sledge to a towing vessel;

c) steering and elevation means;

d) a transparent upper deflector screen at the front of and extending above the said sledge wing;

e) a tranparent lower deflector screen at the front of and extending below the said sledge wing; characterised in that the sledge wing is positively buoyant, the means to attach the sledge to a towing vessel includes two towing lines from the sledge attached one on each side of the sledge wing at a point forward of the lateral centre of pressure and the centre of gravity of the sledge, a viewing section is provided through the said sledge wing at its forward end and means are provided by which the diver can hold his body on the sledge.

Preferably there is provided a keel on the underside of the sledge wing, running fore to aft. Advantageously there are also provided two skegs, parallel to and on either side of the keel. The keel and skegs provide directional stability. Preferably the keel and skegs extend below the steering and elevation means such that when the sledge is out of the water and lying flat, it rests on the keel and one of the skegs and thus avoids the risk of damaging the steering and elevation means on the ground.

Advantageously the keel and skegs are formed in one piece with the wing. Alternatively they may be attached to the wing.

The upper deflector screen deflects the flow of water over the diver while the sledge is being towed. Preferably the upper screen is of a size such as to ensure that the pressure of the water flow is kept off the diver's body at the maximum desired towing speed. Advantageously the upper screen keeps the water flow pressure off the body of the diver up to a speed of at least 5 knots. Above the maximum design speed, turbulence will begin to affect the diver.

The lower deflector screen deflects the flow of water under the sledge, creating an area of low pressure (hereinafter referred to as a "moonpool") beneath the viewing section down through which the diver can then see clearly. Preferably the lower deflector screen is secured to the lower edge of the upper deflector screen. The securing means should such that it does not adversely affect the diver's visibility. Preferably the lower screen extends far enough down to create a moonpool up to the maximum desired speed. Preferably the lower deflection screen does not extend below the keel and skegs so that it is protected from damage and does not adveresly affect the flow of water past the keel and skegs.

Advantageously the screens are made of a strong transparent plastics material such as perspex (R.T.M.) or any other suitable strong, transparent material.

Preferably the screens are curved to form a more hydrodynamic shape and to avoid problems caused by flexing which occurs when a flat screen is subjected to the pressure of the water flow.

Preferably the screens are detachable for easier transportation of the sledge on land.

Advantageously the sledge wing is a "dished delta" shape in that it is wider at the rear than at the front and is curved upwards towards the sides.

Preferably the sledge wing is made of plastics material and is hollow. Preferably it is filled with a high density, buoyancy foam material. Advantageously the plastics material is glass reinforced plastics (GRP). Alternatively the wing may be made out of kevlar (R.T.M.) or any other suitable material. The material must be suitable for forming the sledge wing and must be able to withstand the environment of use without damage such as corrosion. The high water pressures experienced by the sledge at depth mean that it is very difficult to make a completely leak-free sledge, however the foam filling ensures that not much water can enter the wing body and hence that the sledge does not lose its buoyancy.

Advantageously the wing contains one or more drain holes and plugs such that any water which has been forced in under pressure while the sledge is underwater can be allowed to drain out when the sledge is removed from the water. Conveniently the keel and skegs also contain drain plugs.

Preferably the wing is of a length and width to enable a diver to lie comfortably on it. Conveniently, so as to retain maximum strength of the wing material if a material such as GRP is used, the wind shape is such that all the surfaces are in shear stress and not in tension stress.

Preferably the means to attach the sledge to a towing vessel comprises two towing lines from the sledge to a towing foil and then towing lines from the foil to the vessel. Preferably there is one line from the foil to the vessel. Preferably the towing foil is positively buoyant to compensate for the weight of the tow line. Preferably the towing foil is made of hollow glass reinforced plastics and is advantageously filled with a high density, buoyancy foam material. Conveniently the foil has about 1kg reserve buoyancy. Advantageously the towing lines are attached to towing brackets mounted on either side of the sledge wing. Preferably the attachment points are just in front of the lateral centre of pressure and of the centre of gravity of the sledge. Preferably the towing position is such as to give maximum controllability of the sledge. Preferably the distance apart of the two towing points on the towing foil is the same as the distance apart of the towing points on the sledge.

Preferably the steering and elevation means comprise elevons controlled ny means of control rods. Advantageously there are two elevons controlled by means of two control rods. Preferably the elevons are at the rear of the sledge and are connected by means of linkages to the control rods at the front of the sledge. Conveniently the elevons are attached to the sledge wing by means of steerng gear brackets.

Advantageously the elevons have a hydrodynamic form. Conveniently they are made of plastics material, advantageously GRP. Advantageously the elevons are hollow and holed and are free-flooding. Preferably the linkages are made of stainless steel and advantageously they are formed of hollow tubing, where possible, to increase the buoyancy of the sledge.

Preferably the control rods control the elevons such that pushing the control rods forward causes the sledge to dive, pulling them back causes it to climb and pushing one forward and pulling the other back causes it to bank. In this way the diver can control the steering and elevation of the sledge. This steering arrangement is simple and cheap to make and fit to the sledge. It can also be used for long periods of time by the diver without being over tiring.

Alternatively steering may be by means of a single joystick control connected by means of linkages to the elevons at the rear of the sledge. This arrangement has the advantage that the diver is left with one hand free for other purposes.

Preferably the diver holds his body on the sledge by means of a thigh grip post on the sledge wing. Preferably the post is moveable in various positions along the length of the sledge so that it can be adjusted to the most comfortable position for the diver to grip with his legs to hold himself on the sledge.

Conveniently the post is moveable in three positions. It has been found that a range of about 20cm between the foremost and the rearmost positions will enable most divers to grip the post comfortably.

The thigh post has a additional advantage in that it is easy for the diver to release his grip on the post if he wishes to leave the sledge.

Alternatively a foot rest can be provided in the form of a bar across the rear of the sledge under which the diver can position his feet.

Preferaby the sledge is ballasted such that it has a desired amount of reserve buoyancy. Preferably the reserve buoyancy is about 10kg. Normally a diver is weighted to zero buoyancy so he will not affect the buoyancy of the sledge. Conveniently the ballast is used to trim the sledge. Advantageously the ballast is secured to the steering gear at the rear of the sledge. Conveniently the ballast comprises lead weights.

Preferably there is included a grab rail at the front of the sledge to protect the upper deflector screen. Additionally the grab rail enables the sledge to be steadied on land or when it is placed

in the water without the upper deflector screen being held, which would bring the risk of damaging the upper deflector screen. Preferably the grab rail is of hollow tubing. Preferably it is of glass reinforced plastics material and conveniently it is filled with a high density, buoyant foam material. Conveniently the rail is detachable for easier transportation of the sledge on land.

Preferably the lower deflector screen does not extend below the level of the keel.

Preferably there are provided crash/skid bars at the front of the sledge to protect the sledge and the lower deflector screen on land or if the sledge should hit an obstacle in the water. The crash/skid bars cause the sledge to slide over an obstacle, reducing the chance of damage to the sledge or injury to the diver.

Preferably a communication device is provided to enable the diver to communicate with the towing vessel. Conveniently a voice communication device is provided between the diver and the vessel. Alternatively the communication device may comprise a push-button type switch on one of the control rods and a continuous cable link to the surface vessel terminating in an indicator unit. Conveniently communication may be by means of a simple code of the number of signals sent from the diver to the vessel. The indicator unit is conveniently arranged to display the signals by means of visual or audible signal displays.

Conveniently there are hoisting points on the sledge so that it may easily be lowered to and lifted from the water surface. Preferably the hoisting points comprise four "D" rings attached to the sledge wing to which ropes or other lifting means may be fastened. Advantageously the "D" rings are attached one on each towing bracket and one on each outboard bracket of the stern steering gear. Conveniently the "D" rings are made of welded stainless steel.

Advantageously the "D" rings on the stern steering gear brackets may also be used as anchor points for detachable straps to hold the elevons in a "tail up" attitude to prevent the sledge from diving so that it can be towed along the surface without a diver on board.

Conveniently the sledge may also carry marker floats, with sinkers, which the diver on the sledge can deploy whilst submerged or on the surface so that he can mark a particular spot for himself or for future divers.

Advantageously a miniature closed circuit television camera may be mounted on the sledge. Conveniently the monitor is on the towing vessel. This will enable people on the surface to view pictures on the sea bottom, controlled by the diver on the sledge.

So that the time taken to reach the diving area can be reduced, the sledge can preferably be adapted so that a diver can ride on it, in the manner of water skiing, on the surface. Preferably a quick release rein is attached to the towing brackets on the sledge wing. The diver holds onto this rein while standing up as the sledge is towed by the towing vessel. Conveniently the rein is removed from the sledge once the diving area has been reached.

In order that the invention may be more fully understood, it will now be described, by way of example only, with reference to the attached drawings on which:

Figure 1 is a plan view of a sledge accordng to the invention;

Figure 2 is a cross-section along the line X-X on the sledge shown in Figure 1;and

Figure 3 is an end view of the steering gear at the rear of the sledge, as shown in Figures 1 and 2.

Referring to Figures 1 and 2, a sledge according to the invention is shown. The sledge body comprises a solid wing 1 which is of a "dished delta" shape in that it is wider at the rear than at the front end and is curved up towards the edges. A "dished delta" shape has advantages over a flat, rectangular shape for stability both on and below the water surface.

Towing brackets 2,3 are attached one on each side of the wing 1 at a position forward of the laterial centre of pressure and of the centre of gravity of the sledge. If the towing position is too far forward the sledge will not be manoeuvrable and it will be very difficult to make it dive. The further forward the towing point is, the greater will be the tendency for the sledge to rise towards the surface when it is towed, which makes it very difficult to control. On the other hand, if the towing position is behind the lateral centre of pressure or the centre of gravity of the sledge, the sledge will tend to stall and will dive vertically in the water.

Towing lines 4,5 are attached to the brackets 2,3 and terminate at a towing foil 6. A single towing line 7 passes from the foil 6 to a towing vessel (not shown).

An upper deflector screen 8 of transparent plastics material is attached at the front of the wing 1. This screen 8 deflects the water flow over a diver riding on the sledge but still allows forward visibility. A viewing section 9 is formed in the front of the wing 1, down through which a diver on the sledge can view towards the seabed.

Attached to the lower edge of the upper deflector screen 8 is a lower deflector screen 10. This screen 10 deflects the water flow below the viewing section 9 leaving an area of low pressure beneath the viewing section 9 where the water is still and

clear, like a "moonpool". This allows the diver to see clearly downwards. The screens 8,10 are curved so that they do not deflect under the pressure of the water flow. With flat screen the water flow causes then to deflect and this may cause them to break, particularly in colder water where the plastics material may become more brittle. The curving gives maximum strength for minimum weight of the screens. The viewing section 9 combined with the deflection screens 8,10 encourage the diver to look forward and down in a natural sweep of the eyes for optimum visibility.

Crash/skid bars 11,12,13 extend in front of and below the wing 1 to protect the sledge in the event of a collision with an obstacle.

A grab rail 14, supported by bars 15,16, is positioned over the top of the upper screen 8 to protect it and to enable the sledge to be steadied when it is placed in the water, without risk of damaging the upper screen 8.

Referring now to Figure 3 as well, control rods 17,18 at the front of the sledge are connected by means of linkages 19,20 to elevons 21,22 mounted at the rear of the wing 1. The control rods 17,18 are pivoted on the cross-bar 23 such that pushing the control rods 17,18 forward pulls the linkages 19,20 forward, which rotates the elevons 21,22 clockwise to a "tail-down" position via the linkages 24,25, thus causing the sledge to dive. Pulling the control rods 17,18 backwards pushes the linkages 19,20 back, thus rotating the elevons 21,22 in an anti-clockwise direction to a "tail-up" position and hence causing the sledge to climb. Banking to port or starboard is effected by pushing one control rod, 17 or 18, forward and pulling the other back. The elevons 21,22 are of a hydrodynamic shape so that they reduce the hydrodynamic perfomance of the sledge by as little as possible.

A thigh grip post 26 is positioned along the centre line of the wing 1. When a diver lies on the sledge he grips the post 26 between his legs and this enables him to remain in bodily contact with the sledge. A support 27 assists in holding his legs in place. If the diver wishes to bale out from the sledge he need only release his legs from the post 26 and float away from the sledge. The sledge buoyancy will then cause it to float to the surface.

The post 26 can be positioned in any one of three holes 28a,b,c in the wing 1 so that it is in the most comfortable position for the diver.

A keel 29 extends below the wing 1 and two skegs 30,31 run parallel to the keel 29 along the wing 1. The keel 29 and skegs 30,31 provide directional stability for the sledge. The depth of the skegs is such that when the sledge is on land it will rest in the keel 29 and one skeg, 30 or 31, such that the steering gear does not touch the ground, as indicated by the dotted line 32. Additionally the lower deflection screen 10 does not extend below the keel 29 or the skegs 30,31 and thus there is no interference in the flow of water between the keel 29 and skegs 30,31 so that the directional stability and manoeuvrability of the sledge are maintained.

The elevons 21,22 are attached to the rear of the wing 1 by means of brackets 33,34,35,36. Ballast, in the form of lead weights, can be attached to the wing 1 at the mounting points 37,38,39,40.

The wing 1, keel 29 and skegs 30,31 are made of glass reinforced plastics filled with a high density foam material 41.

Hoisting rings 42,43,44,45 are attached to the sledge on the towing brackets 2,3 and the steering gear brackets 33,36 for easier lifting and lowering of the sledge from and onto the water surface.

The sledge of the invention has many advantages over the prior art in that is is very controllable, manoeuvrable and stable. It has good hydrodynamic properties and is easy, comfortable and non-tiring to ride and steer. It is protected against damage on land or the seabed. It is very robust and easy and cheap to maintain.

The sledge is ideal for use in searching or scientific observation of the seabed, for wreck searching and surveying or for pleasure use such as looking at, for example, coral reefs. A vessel can tow the sledge faster and over greater distances than a diver can swim by himself and also has the advantage, particularly for less experienced divers, of continuous contact between the diver and the towing vessel.

The thigh post device by which the diver holds himself on the sledge is easy to release should it be necessary for the diver to leave the sledge suddenly. This increases the safety of using the sledge as it can be very dangerous for a diver to be tied or otherwise attached to the sledge by a means that is not instantly releasable. The buoyancy of the sledge means that it will return to the surface making it easy to retrieve.

One or more sledges can be towed by the vessel and the sledge can also be adapted to carry more than one diver.

## Claims

1. A sledge, on which a diver can be towed underwater by a vessel, comprising:
a) a sledge wing (1);
b) means to attach the sledge to a towing vessel;
c) steering and elevation means;
d) a transparent upper deflector screen (8) at the front of and extending above the said sledge wing;
e) a tranparent lower deflector screen (10) at the front of and extending below the said sledge wing (1);

characterised in that the sledge wing (1) is positively buoyant, the means to attach the sledge to a towing vessel includes two towing lines (4,5) from the sledge attached one on each side of the sledge wing at a point forward of the lateral centre of pressure and the centre of gravity of the sledge, a viewing section (9) is provided through the said sledge wing (1) at its forward end and means are provided by which the diver can hold his body on the sledge.

2. A sledge according to claim 1 characterised in that there is provided a keel (29) on the underside of the sledge wing, running fore to aft.

3. A sledge according to claim 2 characterised in that there are provided two skegs (30,31), parallel to and on either side of the keel.

4. A sledge according to claim 3 characterised in that the keel and skegs extend below the steering and elevation means such that when the sledge is out of the water and lying flat, it rests on the keel and one of the skegs.

5. A sledge according to any one of the preceding claims characterised in that the lower deflector screen (10) deflects the flow of water under the sledge, creating an area of low pressure beneath the viewing section (9).

6. A sledge according to any one of the preceding claims characterised in that the screens (8,10) are detachable.

7. A sledge according to any one of the preceding claims characterised in that the sledge wing (1) is a "dished delta" shape in that it is wider at the rear than at the front and is curved upwards towards the sides.

8. A sledge according to any one of the preceding claims characterised in that the sledge wing (1) is made of plastics material and is hollow.

9. A sledge according to claim 8 characterised in that the sledge wing (1) is filled with a high density, buoyant foam material (41).

10. A sledge according to any one of the preceding claims characterised in that the wing contains one or more drain holes and plugs.

11. A sledge according to any one of the preceding claims characterised in that the means to attach the sledge to a towing vessel comprises two towing lines (4,5) from the sledge to a towing foil (6) and then towing lines (7) from the foil (6) to the vessel.

12. A sledge according to any one of the preceding claims characterised in that the attachment points (2,3) of the towing lines (4,5) to the sledge are just in front of the lateral centre of pressure and of the centre of gravity of the sledge.

13. A sledge according to any one of the preceding claims characterised in that the steering and elevation means comprise elevons (21,22) controlled by means of control rods (17,18).

14. A sledge according to claim 13 characterised in that the elevons (21,22) are at the rear of the sledge and are connected by means of linkages (19,20) to the control rods (17,18) at the front of the sledge.

15. A sledge according to claim 13 or claim 14 characterised in that the elevons (21,22) are hollow and holed and are free flooding.

16. A sledge according to any one of the preceding claims characterised in that the diver holds his body on the sledge by means of a thigh grip post (26) on the sledge wing (1).

17. A sledge according to claim 16 characterised in that the post (26) is moveable in various positions along the length of the sledge so that it can be adjusted to the most comfortable position for the diver to grip with his legs to hold himself on the sledge.

18. A sledge according to claims 1 to 15 characterised in that the diver holds himself on the sledge by means of a foot rest in the form of a bar across the rear of the sledge under which he can position his feet.

19. A sledge according to any one of the preceding claims characterised in that there are provided crash/skid bars (11,12,13) at the front of the sledge to protect the sledge and the lower deflector screen (10).

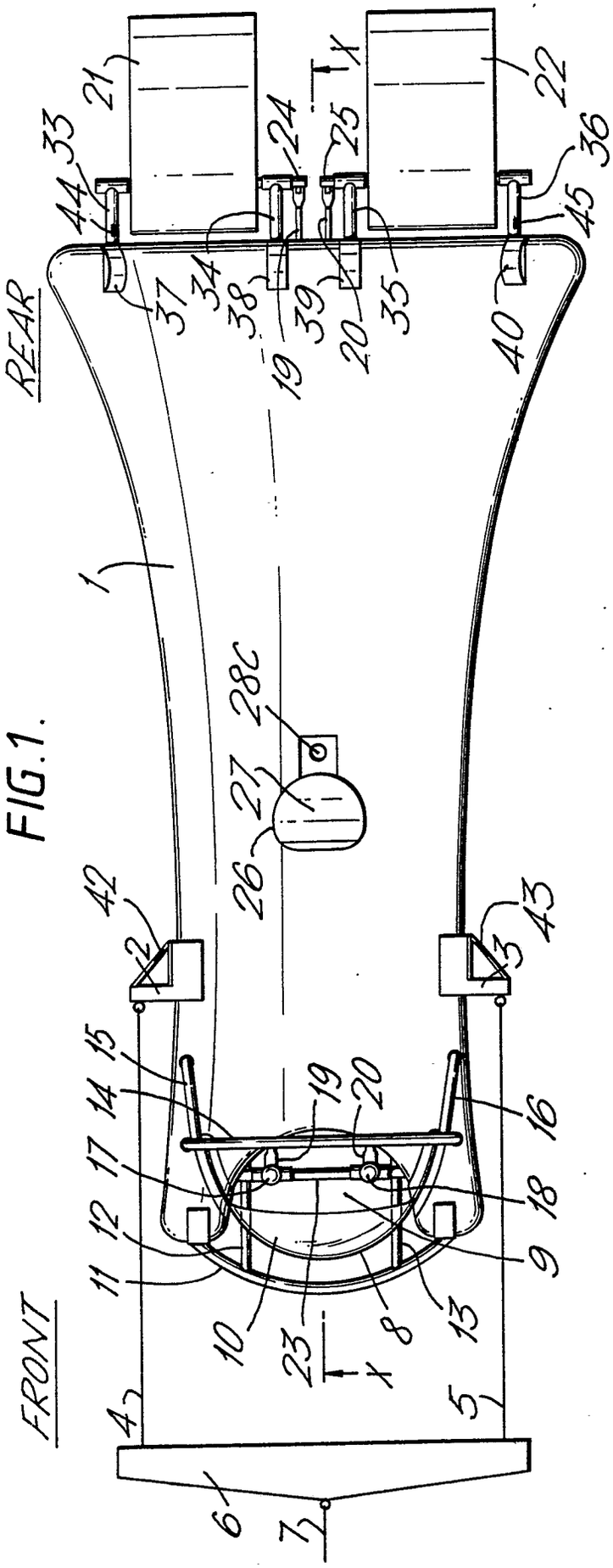
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FIG.1.

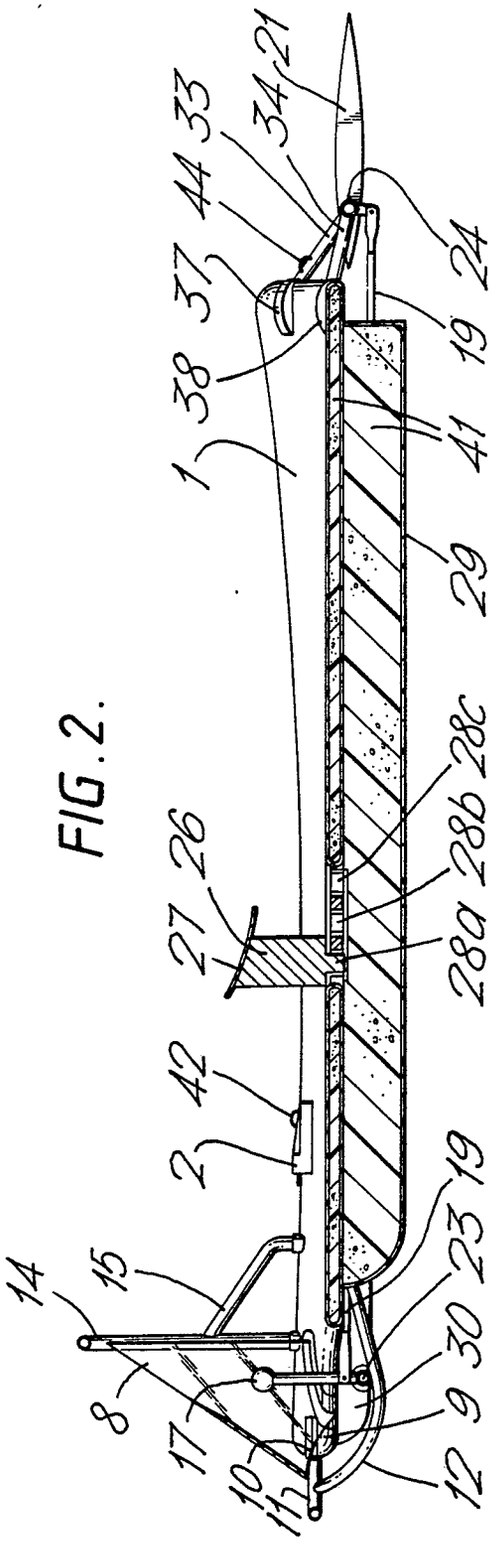
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FIG. 2.

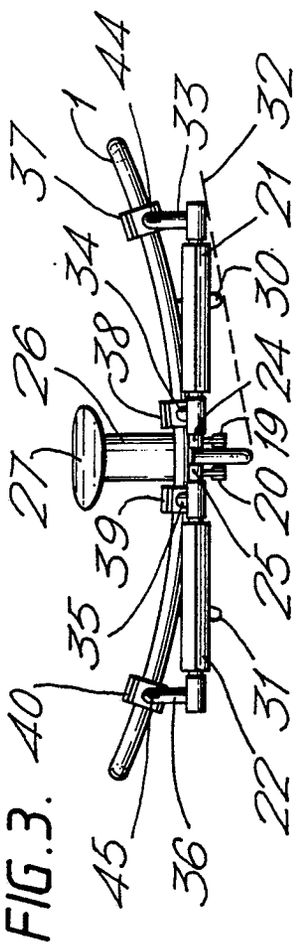
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FIG. 3.

European Patent Office

# EUROPEAN SEARCH REPORT

Application number

EP 87 30 4406

## 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.4) |
|---|---|---|---|
| Y | US-A-2 843 860 (R.L. GROOTVELD)<br>* Whole document * | 1 | B 63 C 11/46 |
| A | | 3,11-15,18,19 | |
| | --- | | |
| Y | FR-A-2 467 139 (E. DE CANECAUDE)<br>* Page 1, lines 1-5; claim 1; figures 1,2 * | 1 | |
| A | | 8,10 | |
| | --- | | |
| A | FR-A-1 499 380 (M.F. JANIERE)<br>* Page 1, lines 43-50; page 2, lines 36-43; figure 3 * | 1,2,13 | TECHNICAL FIELDS SEARCHED (Int. Cl.4) |
| | --- | | B 63 C |
| A | DE-A-1 949 858 (HAUSER)<br>* Page 1, lines 1-5; page 5, lines 20-25; page 6, lines 5-19 * | 1,5,8,13 | |
| | --- | | |
| A | US-A-3 139 055 (R.M. NUTTING)<br>* Column 1, lines 7-10; column 3, line 48 - column 4, line 4; figures 1,4 * | 1,16,17 | |
| | ----- | | |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| THE HAGUE | 18-08-1987 | VURRO,L. |

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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