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(71) **Applicant and**
(72) **Inventor: SARLIS, Andreas** [GR/GR]; 4, Spefsippou St., GR-106 73 Athens (GR).

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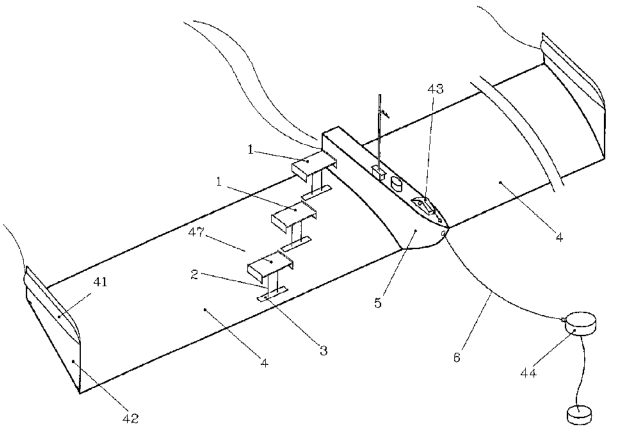
(54) **Title:** FLOATING SYSTEM FOR ELECTRIC POWER PRODUCTION FROM SEA WAVES



(57) **Abstract:** The invention refers to a floating system for electric power production from sea waves consisting of a steel vessel (5) that is fitted with specially designed submerged wings (4) on its sides, on which fixed winches (3) are mounted, fitted with reel drums. These drums are connected with wire cables (2) and put in motion by oscillating floats (1) remaining on the sea surface. Said oscillating floats (1) move over during wave passing and then go back to their original position, being connected with return counterbalance weights. The movement of reel drums is transmitted through a fixed direction mechanism, gearbox and flywheel to submerged AC generators. The wings (4) generate artificially smooth reduction of the sea depth, forcing waves to act as if approaching the shore, reducing their length and increasing their height, while in the open sea. The electric current that is produced by the rotating movement of the drums to the generators is transferred to the vessel, rectified, namely converted to direct and then converted again to 3-phase alternating by means of inverter and transmitted ashore through submerged cable. The entire system is held in place by a mooring buoy (44) and anchored on anchoring weight laid on the sea bottom. The arrangement of the floating electric power production system, the mode of mooring on the buoy and the shape of oscillating floats steer the system so that its wings remain vertical to the wave direction.

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FLOATING SYSTEM FOR ELECTRIC POWER PRODUCTION FROM SEA WAVES

This invention refers to a floating system for electric power production from sea waves. The system consists of a steel vessel, on which two, specially designed, submerged wings are fitted. On said wings, submerged AC generators are firmly mounted. The generators are put in motion by oscillating floats, which remain floating on the sea surface, held in place by means of wire cables on equal in number reel drums and return mechanisms. Wings create an artificially smooth reduction of the sea depth, forcing waves to act as if approaching the shore, reducing their length and increasing their height, while in the open sea. The electric current produced from the oscillating floats and the rotating movement of the drums on the generators is then transferred to the vessel, rectified, namely converted into direct current, after which it is again converted into 3-phase alternating by means of inverter and finally transmitted through submerged cable ashore. The entire system is held in place on a mooring buoy, which is anchored on sea bed by an anchor weight.

The exploitation of sea wave energy for power production has been studied to a considerable extent and there is associated literature available. Power stations for the production of electric power by recovering sea wave energy have already been constructed, without broad application though, because of their disadvantages. Specifically, sea waves cause considerable stress to the floating structures utilized until now, resulting to damages to the structures thus taking them out of operation before long, requiring extensive repairs. On the other hand, the facilities settled ashore could not be exploited but to the minimum extent since there is only a small number of shores that could accommodate such facilities. Apart from that, facilities integrated into sea-walls are very costly, let aside the fact that they should be combined with relevant port works (public works procedures); and fixed sea-bottom structures demand shallow waters. The object of this invention is to create a power production system according to the foregoing that would produce power directly and exclusively from sea wave energy exploitation. Contrary to standing views, the system could be easily positioned, even in relatively deep waters, and transported from one position to another. Said system would be subject reduced sea wave forces, since the main structure would be submerged, requiring low installation costs and application of well known and broadly utilized technology.

According to the invention, this could be achieved through the system referred to in the previous sections, by way of connecting oscillating floats with the generators so that oscillation produced on each float by sea waves through two wire cables and equal number of reel drums would rotate a shaft which, through a revolution increasing gearbox, would give motion to the generator, thus resulting to the production of electric power directly from sea wave energy. The process of converting the unstable-flow electric current produced into 3-phase alternating current suitable for consumption would be effected via the electric equipment installed onboard the vessel.

The invention is described herein below with an example and reference to the drawings attached, in which:

Drawing 1 illustrates the general arrangement of the power production floating system in accordance with this invention

Drawing 2 illustrates system side view.

Drawing 3 illustrates system plan view.

Drawing 4 illustrates system cross-section.

Drawing 5 illustrates the detailed layout of the electric power generator the connection with the winch, the wire cables, the reel drums, the gearboxes and the return mechanism.

Drawing 6 illustrates the oscillating float attached by wires to the winch which is integrated in the wing

Drawing 7 illustrates the side buoyancy float and it's connection to the edge of the submerged wing.

Drawing 8 illustrates the general view of the floating system positioned in the open sea.

Drawing 1 illustrates the general arrangement of the floating system for power production from sea waves. This system consists of the vessel (5), the side buoyancy floats (41) and the specially designed wings (4), which are creating an artificially smooth reduction of the sea depth, thus forcing waves to act as if approaching the shore, reducing their length and increasing their height, while in the open sea. The winches (3) are mounted on the wings (4) and fitted with wire rope (2) reel drums, which are put in motion by oscillating floats (1) that in turn put generators in motion. The steel vessel (5) is equipped with ballast tanks and pumps to ensure system floating at load line when idle at a still water. The wings (4) are fitted with integrated buoyancy tanks that ensure their neutral flotation when the system is still. Drawing 2 shows the spindle-shaped side buoyancy floats (41) that are connected to the tips of wings (4) by means of wire cables and flexible partition wall (42). Said floats have dual function. They reduce rolling during system operation on one hand, ensuring stability and, coupled with the wing tip by means of partition wall; and having been fitted with a back blade (40), prevent waves from escaping sideways, thus enhancing system performance, on the other. The mooring mechanism (43), the chain (6), the mooring buoy (44) and the anchoring weight (21) holding the floating system of power production in place. The shape and mode of anchoring have been designed to hold wings vertical to the wave transmission direction, so that the system recovers the maximum possible wave energy. On the plan view illustrated in Drawing 3, one may see the steel vessel (5), the side buoyancy float (41), the oscillating floats (1), the wings (4) and the mooring mechanisms (43) that together with mooring chain (6) attach the system to the mooring buoy (44), which is anchored at the bottom of the sea by means of cables and holds the electric power floating system in place, so it would not drift because of the waves, sea currents and winds.

The wings are made of steel and synthetic material and are highly resistant in alternant stresses. The integrated buoyancy tanks provide a total buoyancy equated with the weight of the wings and equipment they support (wings, reel drums, shafts and generators), ultimately resulting to the neutral flotation of wings. During system operation, certain buoyancy tanks are ballasted so that the wing weight increases, leading to partially counterbalance the increased buoyancy of oscillating floats caused by the waves. The increase of wing weight during strong waves reduces wing stresses that are due to the forces transferred from oscillating floats through the wire cables to the wings, whereas flotation on water line is ensured by deballasting equal water quantity from vessel (5) ballast tanks. The wings are relatively flexible due to their length. However, their shape in connection with the water resistance restricts their vertical movement, despite the extremely strong forces exercised on the wire cables. The wing (4) dimensions and strength are defined by the number and dimensions of oscillating floats carried on the wing, In the example, each of the two wings carries six oscillating floats. Said floats are positioned by twos in various distances from the front edge of the wing so that the concurrent charging of the wing during the passing of wave crest is avoided.

Drawing 4 of the example illustrates the wing (4) cross-section and the integrated buoyancy tanks (23). Because of their shape, wings create an artificially smooth reduction in sea depth, forcing the waves to act as if approaching the shore and when the wave crest passes from the system, its characteristics change, namely wave height increases and their length decreases, thus enhancing system performance. The oscillating floats (1) are made of steel and synthetic material, their weight being as low as possible. Each oscillating float is coupled by means of wire cables (2) with two reel drums (38) attached to a winch (3) that is placed on the wing (4). In Drawing 5, one may see the wire cables (2) that are connected to the oscillating float and the reel drums (38) that are located on the other edge. Because of this connection, in case the oscillating float is heaved by a wave, the reel drums (38) rotate, turning the shaft (46), thence the shaft drives the generator (33) through the coupling (36) and the gearbox (34). The wire cables are reversely reeled on the drums (38); an inertia damping mechanism (45) and a counterbalance weight (8) are held on the drums. The mechanism and the counterbalance tend to bring the float back to its previous balance/ idle point. Because of the fact that each float is connected with two wire cables on two reel drums coupled on the same shaft; with the cables remaining always in tension, the float is not rotating. Instead, it remains in position with its bow always heading to the same direction. As it has been experimentally confirmed, float movement is elliptic and its direction remains parallel to the wave transmission direction.

The layout that is consistent to the example and illustrated in Drawing 5, consisting of the winch (3), the reel drums (38) put in motion by oscillating floats via wire cables (2) and turning the shaft (46), comprise the basic unit of wave energy conversion into mechanical energy. The rotating movement of the reel drums (38) by means of shaft (46) rotating on highly resistant, both radial (37) and thrust (39) hydro-lubricated bearings, is transferred to the generator through a gearbox (34). The generator and the gearbox are confined in watertight shell (17). A sealing device (35) is fitted at the shaft entering point to the gearbox. The shaft (46) revolutions increase through the gearbox (34). There are also an integrated one way rotation mechanism and a flywheel. The direction of the shaft motion is alternant since when a wave passes the shaft rotates driven by the drums put in motion by the oscillating float movements upwards and aft on one hand; and to the opposite direction when the drums rotate driven by counterbalance weights. In the example, the fixed rotation direction mechanism is positioned on the gearbox. However, such mechanisms may be positioned on the reel drums. When drums move to the reverse direction by the return counterbalance weight, the mechanism releases the shaft and the drum motion from the shaft is thus decoupled. In such case, the system efficiency is better; the construction, however, requires that structures are watertight at the points of reel drum rotation on the shaft, and this leads to a more sophisticated structure.

The AC generator (33) is positioned at the gearbox (34) exiting point and the power produced is then transferred by means of a cable (31) via the necessary sealing devices to the steel vessel (5). The alternating current produced by each generator is then converted, namely rectified to direct current. Then this direct current is connected in parallel to the main electric panel of the system onboard. Following that, the current is again converted into alternating by means of an inverter. Finally, it is transferred to the consumption through submerged cable.

The oscillating floats (1) illustrated in Drawing 6, are oblong in shape, their bow being slightly elevated. Each float is fitted with vertical blades (47) on the sides, which extending beneath and above the float body encasing the wave so it would not escape sideways and prevent wave from rising over the float while its front upper bow part is above water level. The vertical blades (47) of the oscillating floats enhance system performance, compared to the force exercised on the same float without the blades, increasing the force exercised on the float during the wave passing. Moreover, they ensure the maintenance of the float direction; and prevent irregular water flow during the wave passing from the system.

Drawing 7 illustrates the side buoyancy float (41) that is connected to the end of the wing (4) by means of wire cables and flexible synthetic partition wall (42). The float is spindle-shaped, fitted with a back blade (40). This back blade and the partition wall prevent waves from escaping sideways.

The buoyancy float lessens the side rolling of the system and tends to bring the system back to horizontal position.

In the example, the dimensions selected pertain to systems that could be used in the Greek seas. The final dimensions of each system shall be determined following the study of the wave spectrum of the specific area, where the system will be placed. A major factor to be taken into consideration during studies is the resistance to the maximum potential wave, so that the cables connecting the oscillating floats to the winches would not break, on one hand; and the entire system would not be swept by the waves. The distance of the wing upper part from the sea level is determined by the waves that prevail in the area where the system shall be anchored. This distance should be as short as possible, excluding however the contact of the oscillating float (1) to the wing (4), even in the most high waves. In our example, the distance is four meters.

Once the wave spectrum of the area, where the power production system from sea waves is to be positioned, has been studied, the float size shall be determined. In the example, floater dimensions are breadth: sixteen meters; length: eight meters; and height: one and a half meters, giving maximum buoyancy per float weighing approximately two hundred tons. Winch revolutions depend on the reel drum diameter. The cables should not reel around the drum many times. In the example, the reel drum diameter is one meter and the oscillating float is allowed six meters free movement. This means that the number of reeling is less than two, up to the point the wire rope is secured on the reel drum.

In order to deal with extremely adverse weather conditions prevailing in major ocean systems (such as the passing of a typhoon), the floats may be fitted with a system that would allow them sink and remain sunk upon the wings (4) as long as it would be needed, until such adverse weather conditions cease to exist. In these systems, the geometry of the steel vessel (5) and the side floats (41) would be different in order to permit the system to float on a water line of greater draught, than the balance / operation water line.

Once the wave spectrum of the area, where the power production system from sea waves is to be positioned, has been studied, the float size shall be determined. In the example, floater dimensions are breadth: sixteen meters; length: eight meters; and height: one and a half meters, giving maximum buoyancy per float weighing approximately two hundred tons. Winch revolutions depend on the reel drum diameter. The cables should not reel around the drum many times. In the example, the reel drum diameter is one meter and the oscillating float is allowed six meters free movement. This means that the number of reeling is less than two, up to the point the wire rope is secured on the reel drum.

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CLAIMS

1. System for electric power production from sea waves, consisting of steel vessel (5) equipped with integrated ballast tanks, electrical and mechanical equipment as well as anchoring system (43) on mooring buoy (44). On vessel (5) sides and beneath water line wings (4) are connected, on which submerged winches (3) are mounted. The winches are put in motion by the oscillating floats (1) and transmit motion to AC production generators. Side buoyancy floats (41) are connected to the wing ends providing system stability. The electric current produced by the floats oscillation (1) and the rotating movement of winches (3) on the generators is transferred to the vessel (5), where it is converted into 3-phase alternating current by means of an electrical device and then transferred ashore through submerged cable.

2. System for electric power production from sea waves, which according to claim 1 is defined by the wings (4) that remain under the sea level and create artificially smooth reduction of the sea depth, forcing waves to act as if approaching the shore, reducing their length and increasing their height.

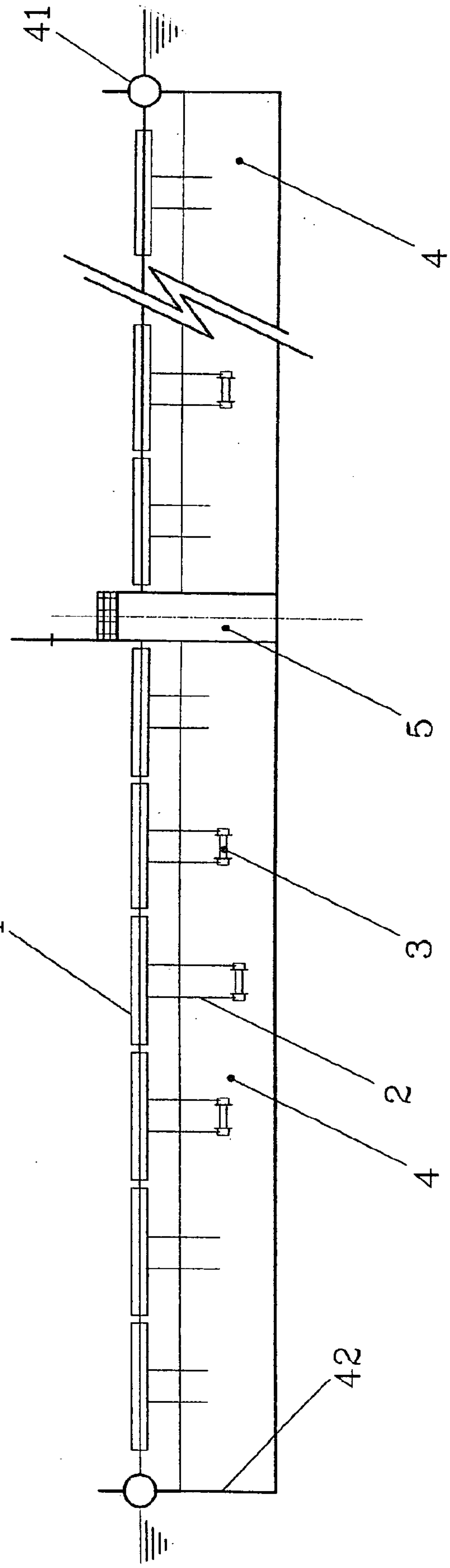
3. System for electric power production from sea waves, which according to claim 2, is defined by the shape of its wings (4). This shape is selected in a way to optimize energy recovery by oscillating floats (1); and the wing strength is determined by the number and size of the oscillating floats (1) carried on.

4. System for electric power production from sea waves, which according to claim 3, is defined by its wings (4), which remain vertical to the direction of wave propagation. This is achieved by the system arrangement and the anchoring mode that keep system wings vertical to the direction of wave propagation, which in turn results to improved energy recovery from oscillating floats (1). When the wave direction changes, the system turns itself under the impact of such waves until it is finally positioned with its wings vertical to the direction of wave propagation.

5. System for electric power production from sea waves, which according to claim 4, is defined by oscillating floats (1), which are made from steel and synthetic material, their shape being similar to that of oscillating floats of the example; and are fitted with vertical blades (47) on their sides. The oscillating float (1) size is determined in accordance to the wave spectrum study in the area where the system is positioned.

6. System for electric power production from sea waves energy, which according to claim 5, is defined by the connection, of each oscillating float (1) on the corresponding winch (3) positioned on a wing, by means of two highly

resistant flexible wire cables (2) reeled on drums (38) so that the one end of cable (2) is held on the oscillating float (1) and the other end is reeled on the drum. A return counterbalance weight (8) and a damping mechanism (45) are in similar way connected by means of wire rope to the reel drum. Because of this connection, when the wave elevates oscillating float (1), the reel drum (38) rotates to one direction and once the wave has passed, the counterbalance (8) draws the float downwards and to the balance position, rotating the reel drum to the opposite direction. The rotating movement of the reel drum (38) through the winch shaft, the fixed direction mechanism, the gearbox and the throttle is transmitted to the submerged generator producing electric current by converting the wave energy into electric energy.



Drawing 1
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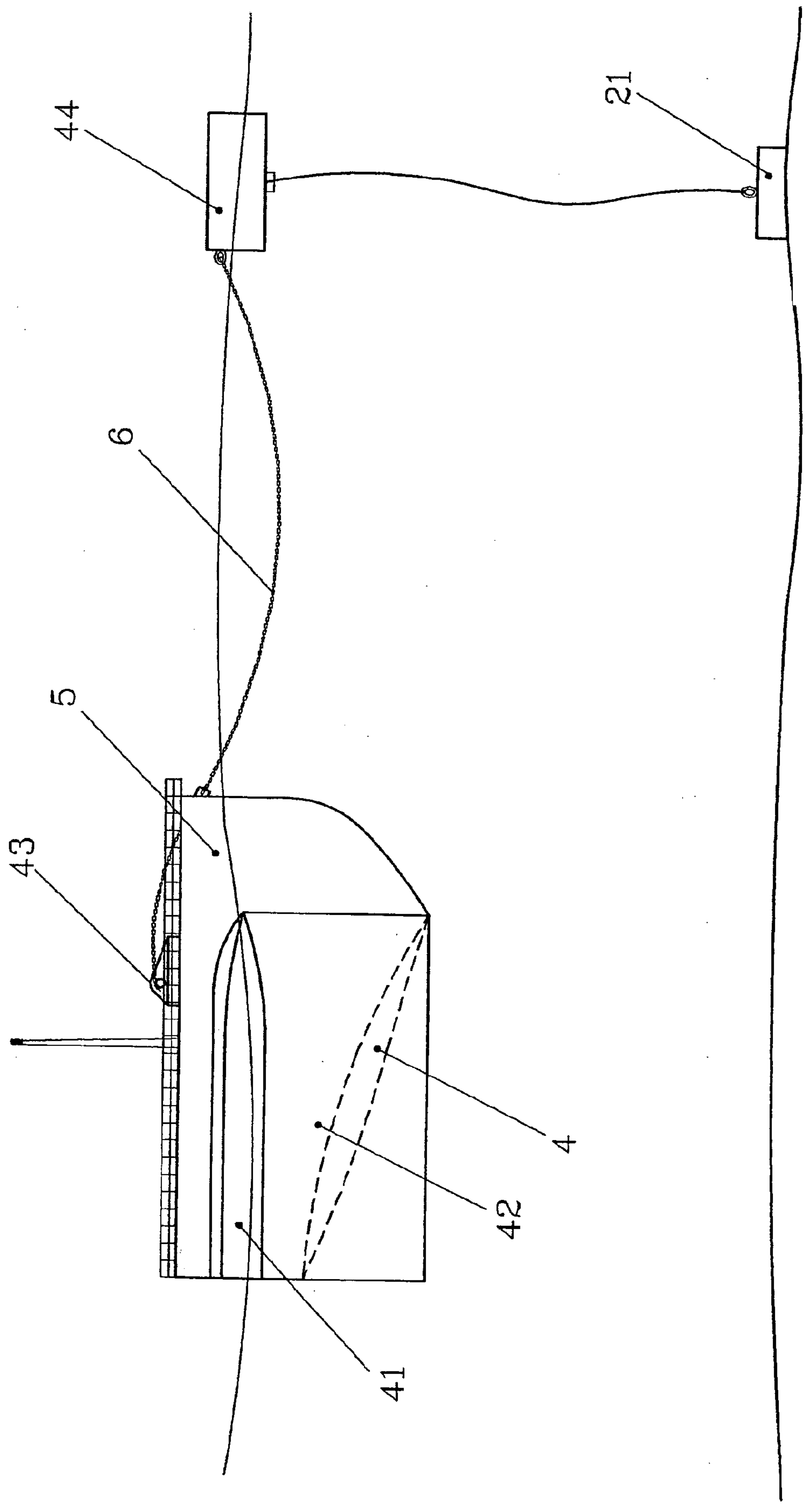
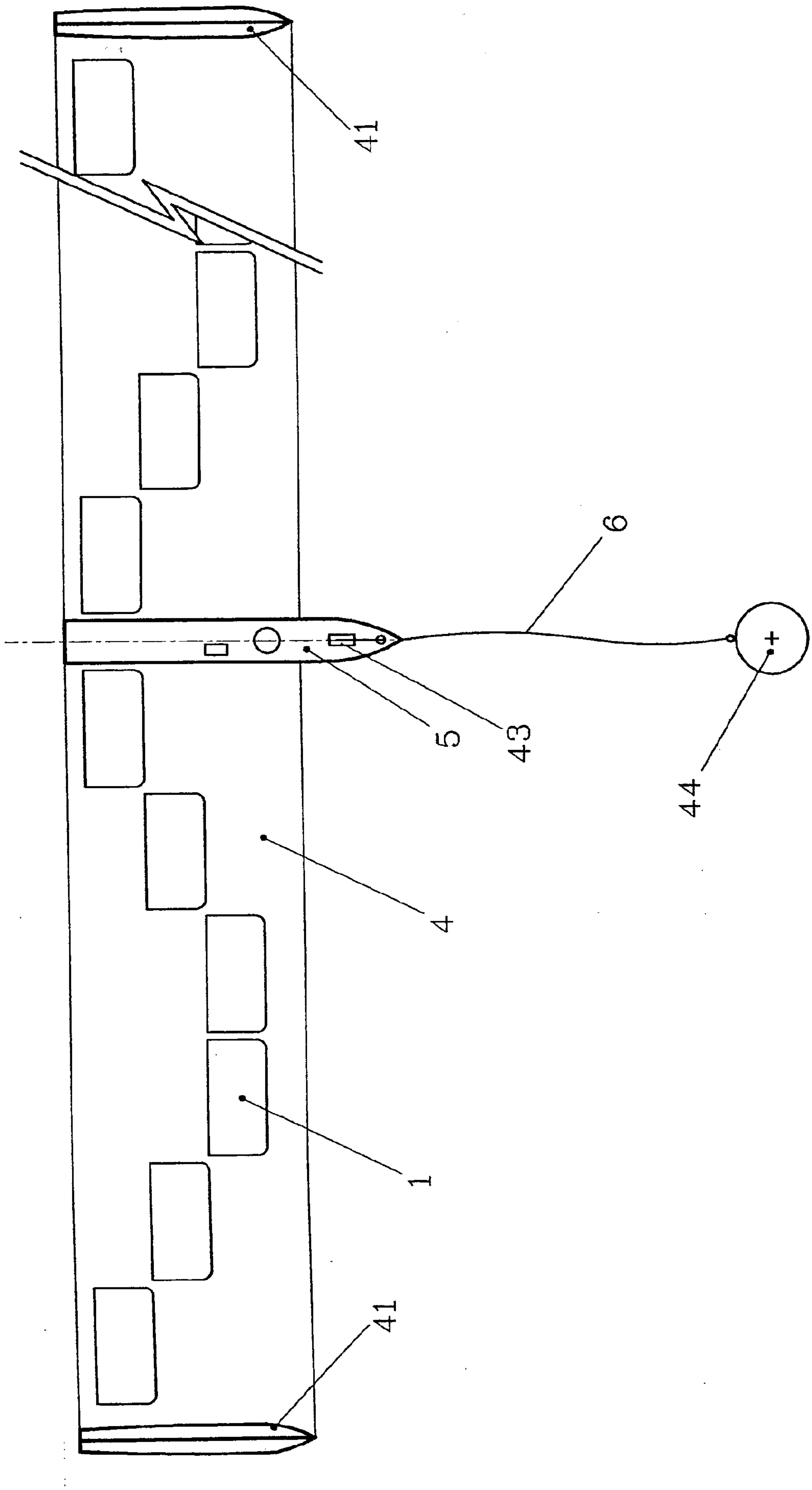
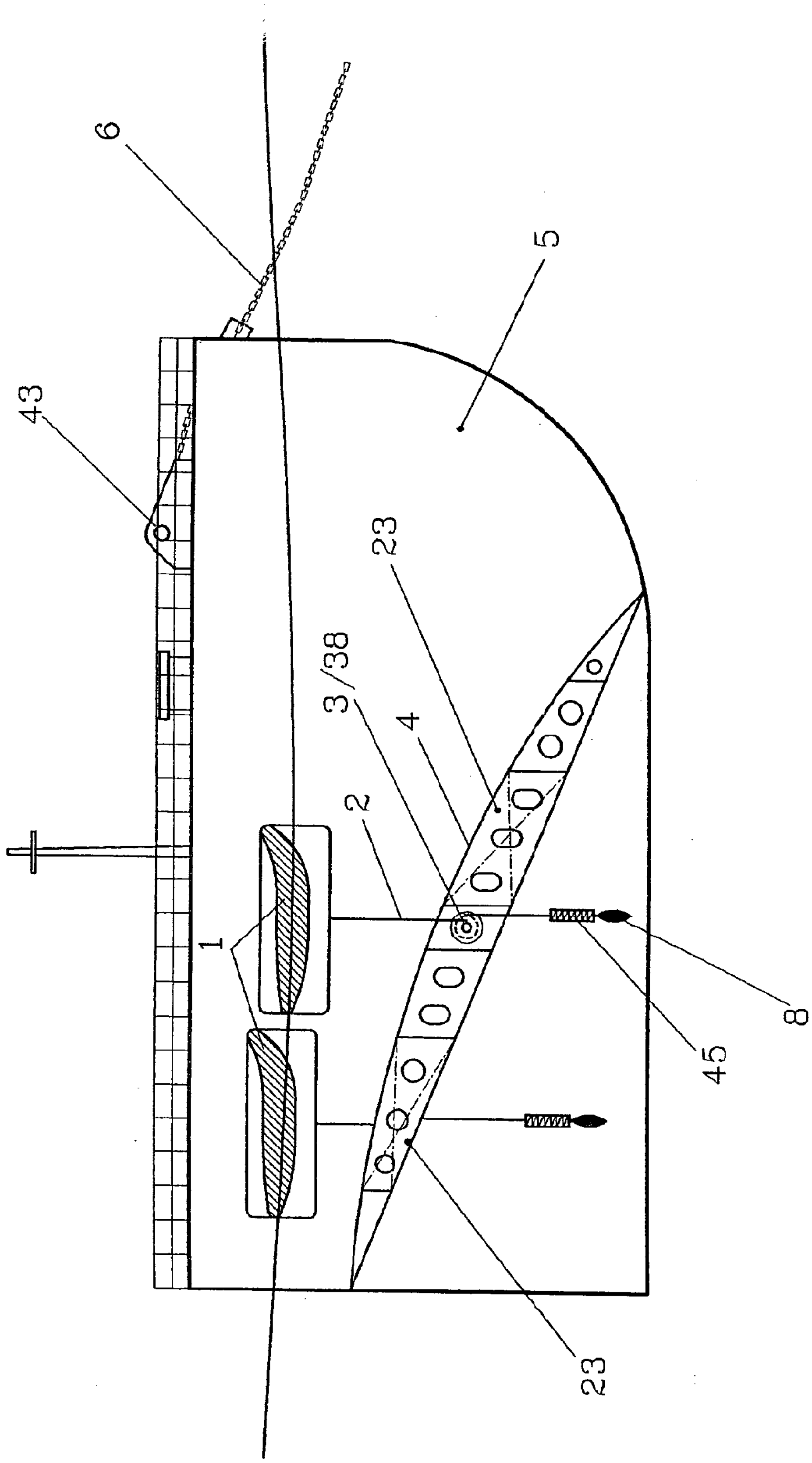


Drawing 2
SCALE 1/500



Drawing 3
SCALE 1/750



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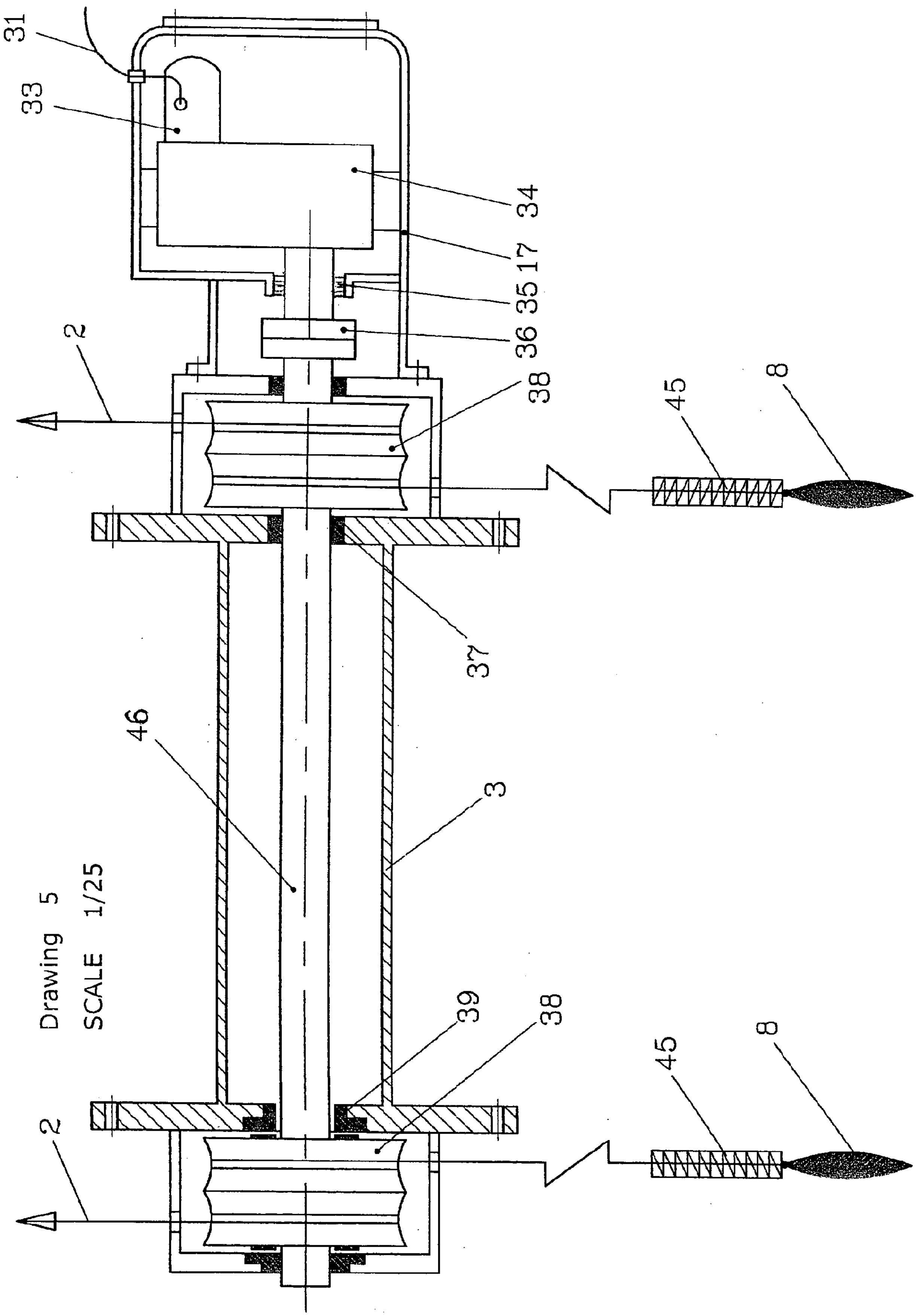
SCALE 1/250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SCALE 1/25
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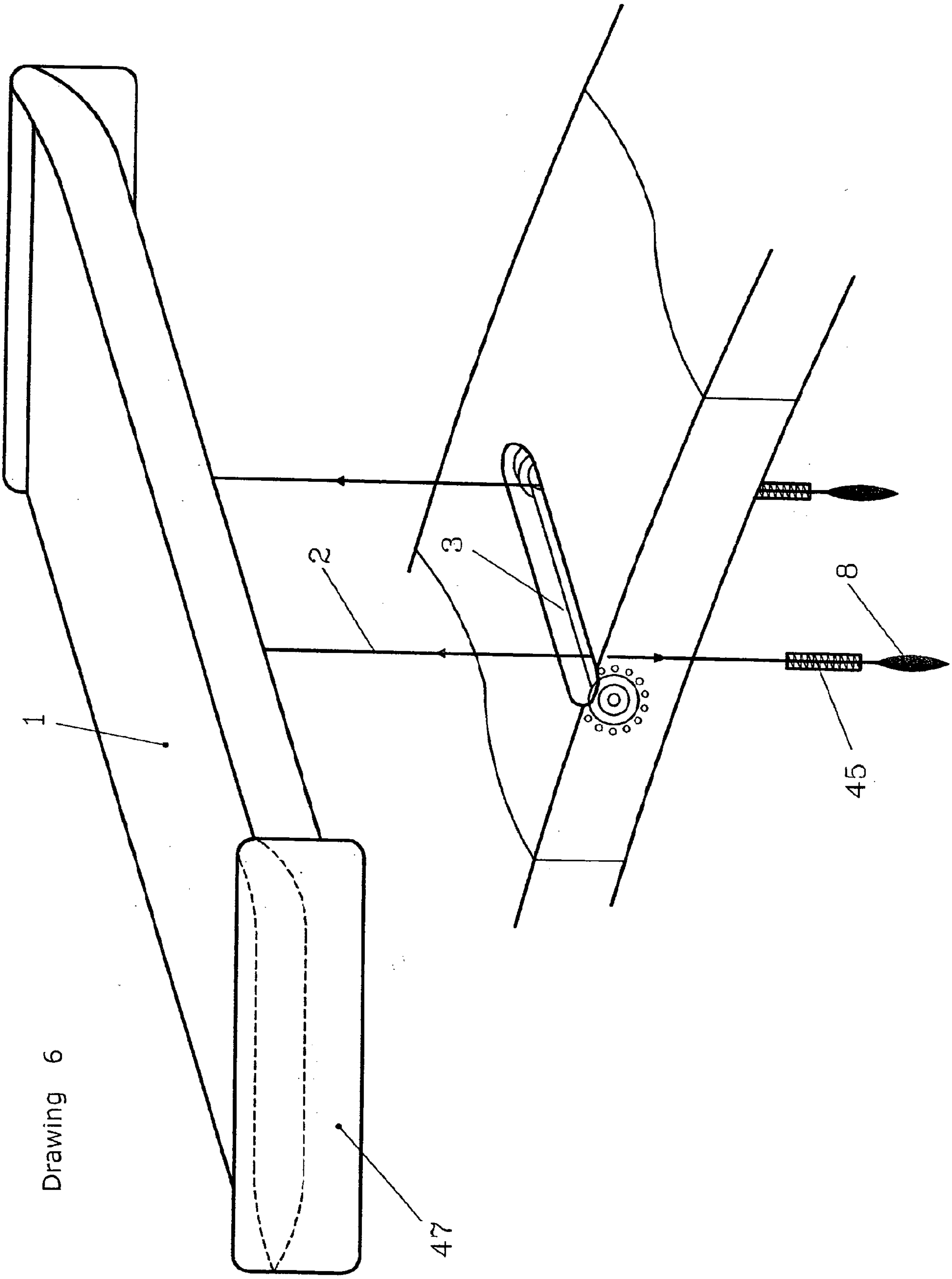
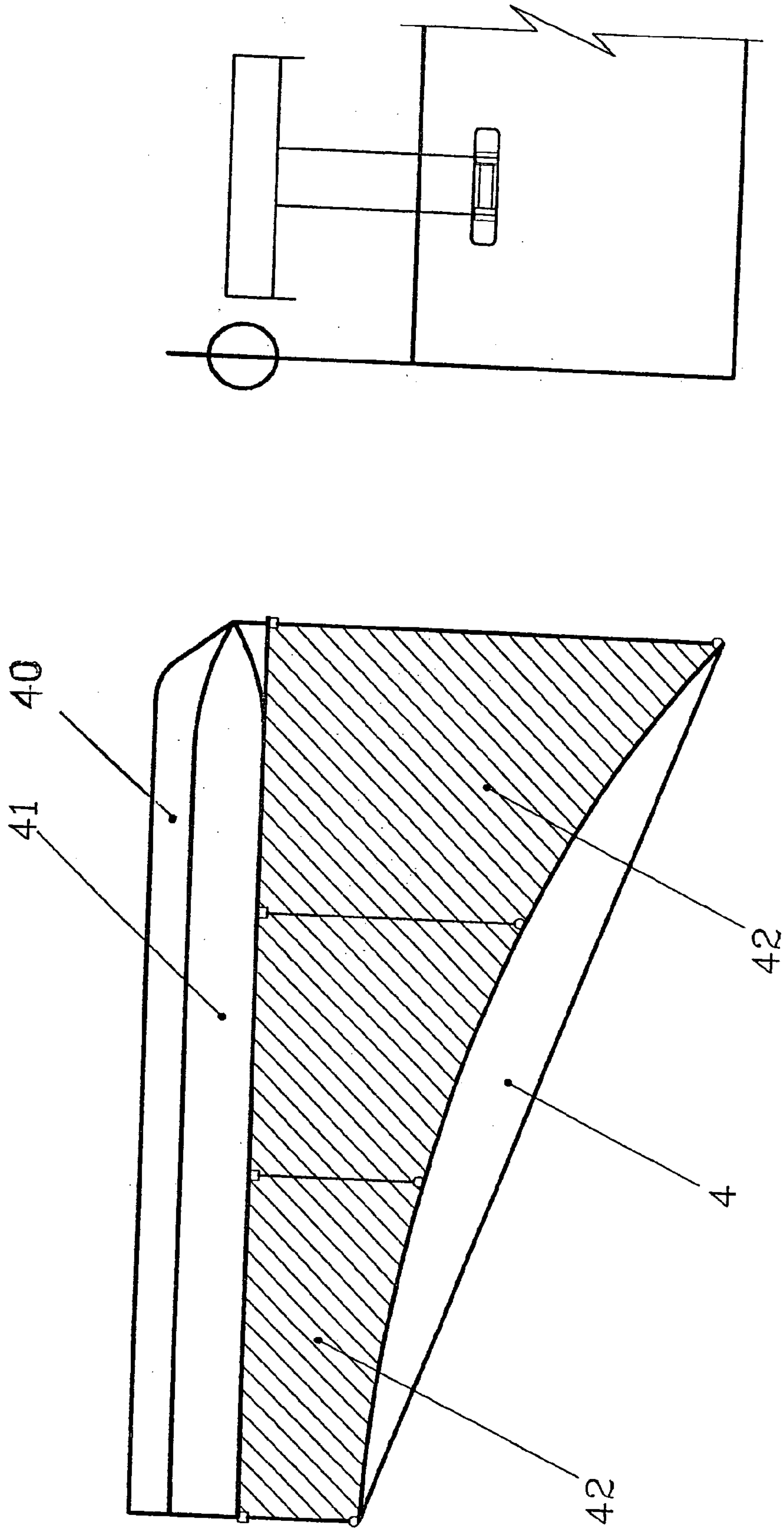
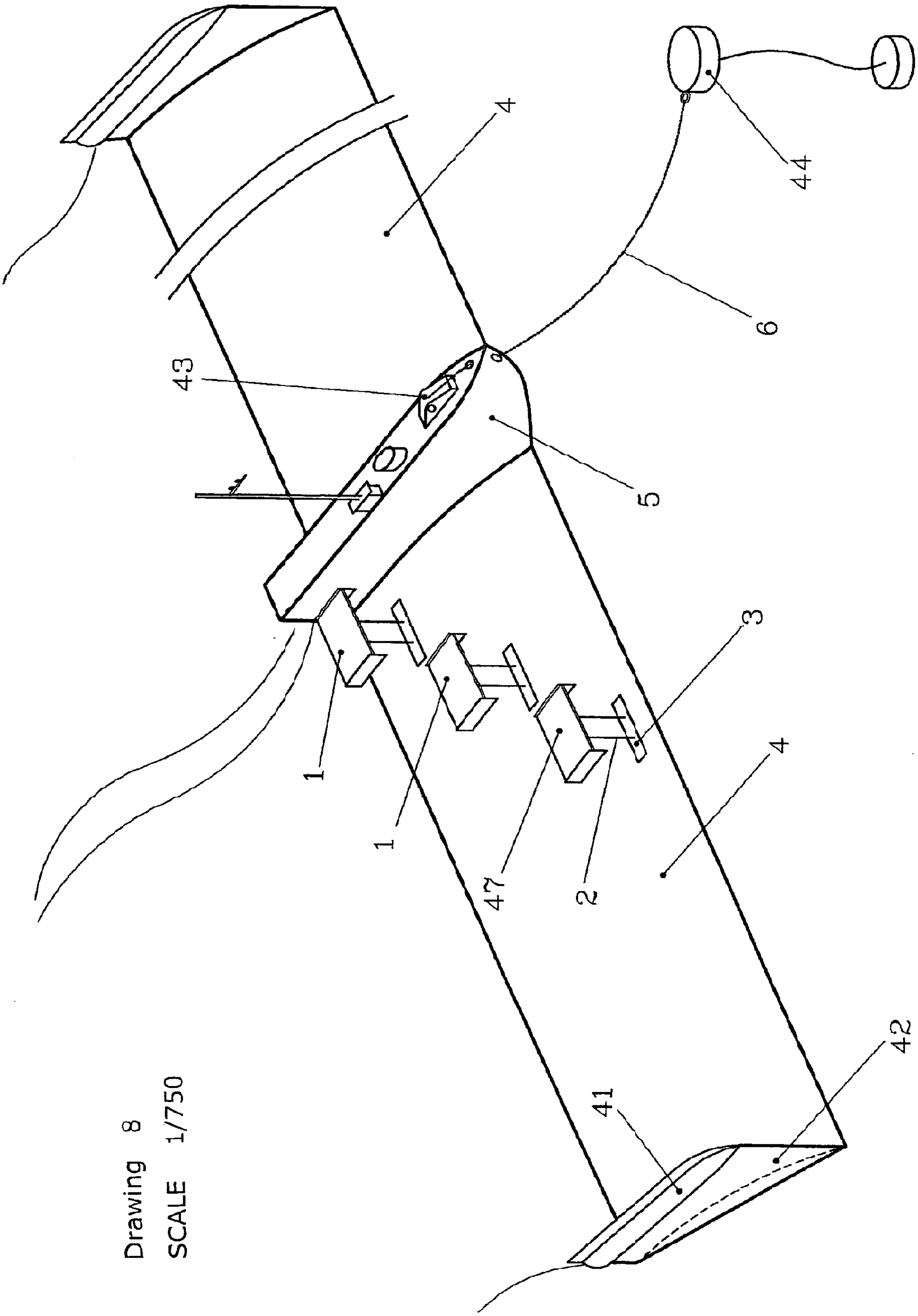


Drawing 6



Drawing 7
SCALE 1/250



Drawing 8
SCALE 1/750

INTERNATIONAL SEARCH REPORT

International application No
PCT/GR2007/000040

A. CLASSIFICATION OF SUBJECT MATTER
INV. F03B13/18

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)
F03B

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

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[X] Further documents are listed in the continuation of Box C

[X] See patent family annex

* Special categories of cited documents

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Date of the actual completion of the international search	Date of mailing of the international search report
7 November 2007	23/11/2007

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
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4

INTERNATIONAL SEARCH REPORT

Information on patent family members

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