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(54) **Title**: APPARATUS AND ARTIFICIAL REEF FOR AFFECTING SURFACE WAVES

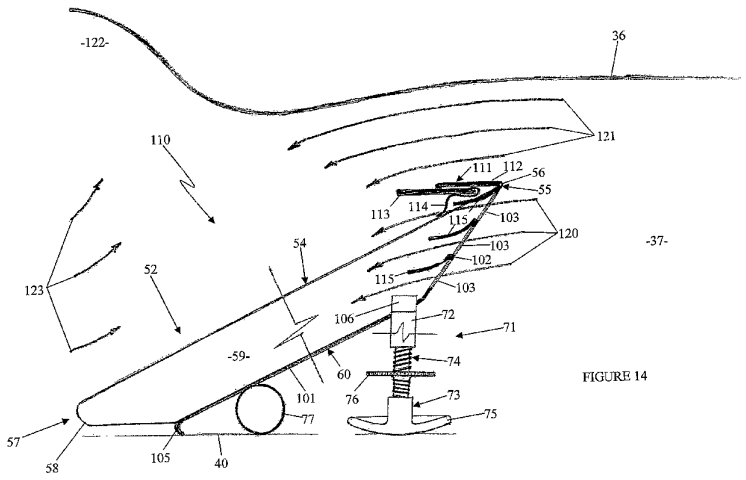


FIGURE 14

(57) **Abstract**: An artificial reef (110) for affecting surface waves (122) propagating along a surface (36) of a body of water (37) comprises an inclined upper surface (54) including a plurality of baffles (59). The reef (110) is submergible in a the body of water (37) such that the waves (122) are able to propagate over the reef (110), and such that the upper surface (54) faces towards the waves (122) as the waves (122) propagate towards the reef (110).

WO 2009/132378 A1

APPARATUS AND ARTIFICIAL REEF FOR AFFECTING SURFACE WAVES

Field of the Invention

The present invention relates generally to apparatus and artificial reefs for affecting surface waves which propagate along the surface of a body of water.

Although the present invention will be described with particular reference to affecting surface waves which propagate along the sea or ocean surface, it will be appreciated that the invention may be used to affect surface waves in other environments. For example, it may be used to affect surface waves which propagate along the surface of a pool or lake.

Background to the Invention

An artificial reef is a man-made, underwater reef structure. Some artificial reefs are built in the ocean for the purpose of promoting marine life in areas where the ocean bottom is generally featureless, while others are built for the purpose of improving hydrodynamics for surfing or to control beach erosion.

Artificial reefs can be built in the ocean using a number of different methods. Many reefs are built by deploying existing materials in order to create a reef. This can be done by sinking oil rigs, scuttling ships, or by deploying rubble, tyres, or construction debris. Other artificial reefs are purpose-built structures which are constructed using plastic, concrete or other materials.

An example of a purpose-built artificial reef for improving hydrodynamics for surfing is disclosed in the published international patent application whose international publication number is WO 03/092460 (Surf Pools Limited). The artificial reef is in the form of a variable floor for a body of water. The variable floor includes a base portion for location on or within a fixed floor of the body of water, and means to adjust the slope of the upper surface of the variable floor relative to the fixed floor or base portion in one or both of a first direction transverse to the direction of travel of waves and in a second direction transverse to the first direction.

The artificial reef disclosed in the aforementioned patent application suffers

from a number of deficiencies, including that it is extremely complex and expensive, and that it requires a significant amount of energy to operate.

It would therefore be desirable to provide an improved artificial reef for improving hydrodynamics for surfing which overcomes or ameliorates one or more of the deficiences of the aforementioned purpose-built artificial reef.

Summary of the Invention

It is an object of the present invention to overcome, or at least ameliorate, one or more of the deficiencies of the prior art mentioned above, or to provide the consumer with a useful or commercial choice.

Other objects and advantages of the present invention will become apparent from the following description, taken in connection with the accompanying drawings, wherein, by way of illustration and example, a preferred embodiment of the present invention is disclosed.

According to a first broad aspect of the present invention there is provided an artificial reef for affecting surface waves propagating along a surface of a body of water, the reef being submergible in the body of water such that the waves are able to propagate over the reef.

According to a second broad aspect of the present invention there is provided an apparatus for affecting surface waves propagating along a surface of a body of water, the apparatus comprising an artificial reef for affecting the waves, the reef being submergible in the body of water such that the waves are able to propagate over the reef.

The artificial reef is able to affect one or more characteristics of the waves as they propagate over the reef. For example, the artificial reef may affect the height of the waves, the shape of the waves, or the rate at which they peel or break.

Advantageously, the reef may affect the waves in a manner which makes the waves more suitable for surfers and the like. For example, the reef may affect the shape of the waves so that the waves have a tubular shape in which the lip of the wave falls forward of the base of the wave. This is particularly advantageous because, for surfers, one of the most sought after or desired positions or manoeuvres when surfing

a wave is to ride inside the tube of the wave as it breaks.

Moreover, the reef is able to cause a wave which propagates over the reef to break after it passes over the reef. This is a significant safety feature of the reef because if a surfer, for example, who is riding the wave wipes out or falls off the wave while riding it, this will tend to occur in deeper water where they will not contact the reef or the floor of the body of water in which the reef is submerged.

Preferably, the reef includes an inclined upper surface, and the reef is able to be submerged in the body of water such that the upper surface faces towards the waves as the waves propagate towards the reef.

It is preferred that the upper surface includes a plurality of baffles. It has been found that the baffles are able to affect the waves by inhibiting the base of each wave from spreading or widening as it propagates over the reef. For surfers, this has the desirable effect of increasing the height of each wave, and of generally improving the overall quality of the waves, including their shape, for surfing.

The baffles may be arranged in any suitable manner. Preferably, the upper surface includes an upper end, and a lower end, and the baffles extend from the upper end to the lower end. Preferably, the baffles are parallel to each other. It is also preferred that the baffles are spaced apart from each other. In a particular preferred form, the baffles are spaced apart from each other at regular intervals.

Each baffle may have any suitable profile. In a preferred form, each of the baffles has an identical profile. Preferably, the baffles are hollow. It is particularly preferred that each baffle has a profile selected from the group comprising: a straight linear profile; a T-shaped profile; a profile including a circular portion and a straight linear portion extending from the circular portion; a triangular profile; a circular profile; and a rectangular or square profile. In a particular preferred form, each of the baffles includes a pipe or tube. The pipe or tube is preferably a heavy duty pipe or tube.

Preferably, the upper surface also includes a floor, and the baffles extend from the floor. Preferably, the floor includes a lower portion, and an upper portion which is inclined relative to the lower portion. The floor is preferably a panel. It is particularly preferred that the floor is a rubber panel or membrane. Advantageously,

the floor is fabricated from a rubber conveyor belt.

In a preferred form, the artificial reef also includes a ramp secured relative to the upper surface such that the ramp is able to be moved relative to the upper surface between a raised position and a lowered position. Advantageously, when the ramp is in the raised position, the ramp may lift a wave as the wave propagates over the reef so as to thereby increase the height of the wave. When the ramp is in the lowered position, the ramp is preferably inhibited from impeding outflowing water from flowing over the reef.

Preferably, the ramp is able to be moved to the raised position as a wave propagates over the reef. It is also preferred that the ramp is able to be moved to the lowered position as outflowing water flows over the reef. In a particular preferred form, the ramp is hinged relative to the upper surface of the artificial reef such that the ramp is able to be pivoted relative to the upper surface between the raised position and the lowered position.

The ramp may comprise a single section hinged relative to the upper surface. However, it is particularly preferred that the ramp includes a first section hinged relative to the upper surface, and a second section hinged relative to the first section. In a particular preferred form, the first section and the second section are thin boards. Preferably, the second section is tethered relative to the upper surface of the artificial reef so as to limit the movement of the second section relative to the upper surface.

It is preferred that the upper surface of the artificial reef includes at least one opening for permitting water to flow through the reef, and at least one valve for preventing inflowing water from flowing through the at least one opening, and for allowing outflowing water to flow through the at least one opening. As a wave propagates forward towards the reef, the at least one valve closes the at least one opening so that inflowing water is forced to flow up and over the reef. Outwardly flowing water is able to cause the at least one valve to open so that the outflowing water is able to flow through the reef.

The at least one opening may be any suitable shape. Preferably, the at least one opening is rectangular.

The at least one valve may be any suitable type of valve. Preferably, the at

least one valve is a flap. In a particular preferred form, the at least one valve is a rubber flap.

Preferably, the at least one opening and the at least one valve are located between the baffles of the upper surface, adjacent to the upper end thereof, and beneath the ramp.

The artificial reef may include a skirt for inhibiting water from flowing beneath the reef. It is preferred that the skirt extends downwardly from the lower end of the upper surface of the artificial reef. Preferably, the skirt is a rubber skirt.

Preferably, the depth of the upper surface below the surface of the body of water is able to be adjusted. It is particularly preferred that the reef includes a support for supporting the upper surface relative to a floor of the body of water, the support being operable to adjust the depth of the upper surface below the surface of the body of water. The support allows the depth of the upper surface below the surface of the body of water to be adjusted to suit the size of the waves propagating along the body of water.

Preferably, the inclination of the upper surface relative to the surface of the body of water is able to be adjusted. It is preferred that the support is also operable to adjust the inclination of the upper surface relative to the surface of the body of water. For example, operating the support to decrease the depth of the upper surface below the surface of the body of water may also increase the inclination of the upper surface relative to the surface of the body of water. Conversely, operating the support to increase the depth of the upper surface below the surface of the body of water may also decrease the inclination of the upper surface relative to the surface of the body of water.

The support preferably includes at least one adjustable leg for adjusting the depth of the upper surface relative to the surface of the body of water. Preferably, the length of the at least one adjustable length is able to be adjusted. It is preferred that the at least one adjustable leg includes a top portion secured relative to the upper surface, a bottom portion for resting on the floor of the body of water, and a threaded shaft extending between and engaged with the top portion and the bottom portion such that the length of the at least one adjustable leg is able to be adjusted by rotating the

shaft relative to the top portion and the bottom portion. The bottom portion preferably includes a dish-shaped portion for resting on the floor of the body of water. The shaft preferably includes a flange for use in rotating the shaft relative to the top portion and the bottom portion.

It is particularly preferred that the support includes a plurality of adjustable legs. Preferably, the length of each leg is able to be adjusted independently of the other legs. Each leg is preferably located adjacent to the upper end of the upper surface.

It is preferred that the support includes a sliding member for sliding over the floor of the body of water. The sliding member is preferably located adjacent to the lower end of the upper surface. In a particular preferred form, the sliding member is a pipe.

Preferably, the artificial reef includes a limb for affecting the waves, wherein the angle of the limb relative to a wave front of the waves is able to be adjusted. The rate at which the waves peel or break as they propagate over the reef may be altered by adjusting the angle of the limb relative to the wave front. For example, the rate at which the waves peel or break as they propagate over the reef may be decreased by increasing the angle of the limb relative to the wave front. Conversely, the rate at which the waves peel or break as they propagate over the reef may be increased by decreasing the angle of the limb relative to the wave front.

It is preferred that the limb includes the upper surface of the artificial reef.

In a preferred form, the limb includes a leading edge and a trailing edge.

Preferably, the artificial reef also includes a base which the limb is hinged relative to such that the angle of the limb relative to the wave front is able to be adjusted by pivoting the limb relative to the base. It is preferred that the reef includes a pliable panel or membrane for hinging the limb to the base. In a particular preferred form, the reef includes a rubber membrane for hinging the limb to the base.

In a particular preferred form, the artificial reef includes a pair of the limbs, wherein the limbs are able to be pivoted relative to each other to thereby adjust the angle of either one of the limbs relative to the wave front of the waves. Preferably, a linkage couples the limbs together such that the angle of each limb relative to the

wave front is able to be adjusted simultaneously. In a particular preferred form, the linkage includes a first arm hinged to one of the limbs, and a second arm hinged to the other limb and to the first arm.

The artificial reef may include a securing means for securing the artificial reef relative to a floor of the body of water. Preferably, the securing means includes an elongate member for securing the reef relative to the floor. The elongate member may for example, be a chain, cable or rope. Preferably, the securing means also includes an anchor for securing the elongate member relative to the floor. The anchor preferably includes a plurality of augers for embedding into the floor of the body of water.

Preferably, the artificial reef includes a moving mechanism for moving the artificial reef relative to the floor of the body of water. This allows the depth of the reef below the surface of the body of water to be adjusted, and in the case where that depth changes, enables the reef to be maintained at a consistent depth. For example, if the reef is submerged in the ocean adjacent to a beach, the reef may be moved closer to the beach when the tide is coming in, and further away from the beach when the tide is going out, so as to maintain the reef at a substantially consistent depth below the surface of the water. Maintaining the reef at a consistent depth enables the reef to have a more consistent effect on the waves as they propagate over the reef. In particular, it enables the reef to produce surf in a range of conditions and not just during favourable wave and tide conditions.

The moving mechanism preferably includes a winding mechanism, and a flexible member coupled to the reef and the winding mechanism, wherein the winding mechanism is operable to wind the flexible member in or out to thereby move the artificial reef relative to the floor of the body of water. The winding mechanism may be a manually operated winding mechanism such as a manually operated windlass, or a motor driven winding mechanism such as a winch, for example.

The artificial reef may be moved manually relative to the floor of the body of water, or it may be moved automatically. For example in the case of automatic movement of the reef, it may be moved automatically in response to a change in the depth of the reef below the surface of the body of water, such as would occur if the

reef was, for example, submerged in a tidal area of the ocean or sea adjacent to a beach.

It is preferred that the apparatus also includes at least one channel/wave corral for channelling/herding the waves towards the artificial reef. Preferably, the at least one channel includes a pair of channel walls. It is particularly preferred that each of the channel walls includes a float for floating on the surface of the body of water, a wall panel secured to the float, a weight secured to the wall panel, and an anchor for anchoring the weight relative to the floor of the body of water. The float is preferably an air-filled tube or pipe. The wall panel is preferably a solid rubber membrane or panel. It is particularly preferred that the wall panel is fabricated from a rubber conveyor belt or a geotextile membrane. The ballast is preferably a concrete-filled tube or pipe. In a preferred form the anchor includes an auger for embedding in the floor of the body of water.

Brief Description of the Drawings

In order that the invention may be more fully understood and put into practice, a preferred embodiment thereof will now be described with reference to the accompanying drawings, in which:

Figure 1 is a plan view of a preferred embodiment of an apparatus according to one aspect of the present invention;

Figure 2 is an end elevation of one of the channel walls of the apparatus depicted in figure 1;

Figure 3 is an enlarged plan view of a first preferred embodiment of an artificial reef according to another aspect of the present invention, wherein the reef is part of the apparatus depicted in figure 1;

Figure 4 is a side elevation of the artificial reef depicted in figure 3;

Figure 5 is a front elevation of the artificial reef depicted in figure 3;

Figure 6 is a rear elevation of the artificial reef depicted in figure 3;

Figure 7 depicts the profile of a first type of upper surface for the artificial reef illustrated in figure 3;

Figure 8 depicts the profile of a second type of upper surface for the artificial

reef illustrated in figure 3;

Figure 9 depicts the profile of a third type of upper surface for the artificial reef illustrated in figure 3;

Figure 10 depicts the profile of a fourth type of upper surface for the artificial reef illustrated in figure 3;

Figure 11 depicts the profile of a fifth type of upper surface for the artificial reef illustrated in figure 3;

Figure 12 is a rear elevation of a portion of a limb of a second preferred embodiment of an artificial reef according to one of the aspects of the present invention;

Figure 13 is a cross-sectional side elevation of the portion of the limb of the artificial reef depicted in figure 12 taken along the line 13 – 13;

Figure 14 depicts a cross-sectional side elevation of a portion of a limb of a third preferred embodiment of an artificial reef according to one of the aspects of the present invention, and also depicts outflowing water flowing through and over the reef as a wave surge approaches the reef in the opposite direction to the outflowing water;

Figure 15 depicts the artificial reef illustrated in figure 14 as the outflowing water abates and as the approaching wave moves closer to the reef;

Figure 16 depicts the artificial reef illustrated in figure 14 as the wave approaches even closer to the reef; and

Figure 17 depicts the artificial reef illustrated in figure 14 as the wave breaks after passing over the reef.

Detailed Description of the Drawings

Referring to figure 1, an apparatus 30 according to a preferred embodiment of one aspect of the present invention is able to affect surface waves in a body of water such as for example, the ocean, sea, a pool, or a lake.

Apparatus 30 includes an artificial reef 31 according to a first preferred embodiment of another aspect of the present invention, and a plurality of channels/wave corrals 32 located in front of the reef 31.

Reef 31 is submerged in a body of water such as for example, the ocean, sea,

a pool, or a lake, such that surface waves which propagate along the surface of the body of water are able to propagate over the reef.

Reef 31 is preferably located adjacent to a shore of the body of water in which the reef 31 is submerged. For example, if the reef 31 is submerged in the ocean or sea, it may be located adjacent to a beach which is part of a shoreline of the ocean or sea.

Channels 32 include a plurality of channel walls 33 which are substantially submerged in the body of water. Channels 32 are located in front of the artificial reef 31 so that surface waves which propagate towards the reef 31 will encounter the channels 32 before they propagate over the reef 31.

Referring to figure 2, each channel wall 33 includes a float 34 comprising an elongate air-filled tube or pipe 35. Due to its buoyancy, the float 34 remains afloat on the surface 36 of the body of water 37 in which the reef 31 and the channel walls 33 are submerged.

A wall panel 38 is secured relative to the float 34 such that the wall panel 38 is suspended in the water beneath the float 34. Panel 38 may for example be a geotextile or rubber membrane. If the panel 38 is a rubber membrane, it may for example be a recycled rubber conveyor belt.

A weight 39 is secured relative to a lower end of the wall panel 38. Weight 39 functions as ballast and rests on the floor 40 of the body of water 37. Weight 39 includes an elongate tube or pipe 41 which is filled with concrete 42.

A plurality of anchors 43 are each secured to the weight 39 by a respective shackle 44. The anchors 43 are secured at different locations along the length of the weight 39. Each anchor 43 is in the form of an auger, and is embedded in the floor 40. The anchors 43 anchor or secure the weight 39 relative to the floor 40 so that the channel wall 33 is maintained in the desired position in the body of water 37 relative to the artificial reef 31.

Referring to figures 3 to 6, the artificial reef 31 includes a base 50 which in use rests on the floor 40 of the body of water 37. Base 50 includes a rectangular tongue portion 51 which is normally the first part of the reef 31 to meet a wave surge traveling towards the reef 31 from the channels 32 of the apparatus 30.

Two elongate limbs 52 are hinged relative to the base 50 such that each limb 52 is able to be pivoted relative to the base 50. In particular, each limb 52 is hinged to the base 50 by a respective pliable rubber membrane 53.

Each limb 52 includes an upper surface 54 which faces towards the waves as they propagate towards the reef 31 from the channels 32, and which is inclined relative to the surface 36 of the body of water 37. Each limb 52 also includes a trailing edge 56, and a leading edge 58.

Upper surface 54 includes a plurality of parallel and regularly spaced baffles 59 extending from the upper end 55 of the upper surface 54 to the lower end 57 of the upper surface 54.

The baffles 59 may have any suitable profile. Figures 7 to 11 depict various exemplary profiles that the upper surface 54 and its baffles 59 may have. The baffles 59 depicted in figure 7 have a straight linear profile, and they all extend perpendicularly from a floor 60 which is also part of the upper surface 54 and which is actually a recycled rubber conveyor belt.

The baffles 59 depicted in figure 8 have a T-shaped profile, and they also extend perpendicularly from the floor 60.

With reference to figure 9, the baffles 59 include a hollow circular portion 61 provided by the profile of a hollow tube or pipe, and a straight linear portion 62 extending perpendicularly from the floor 60 to the circular portion 61.

In figure 10, the baffles 59 have a triangular profile, and they extend upwardly from the floor 60. Unlike the baffles 59 depicted in figures 7, 8, 9 and 11, the baffles 59 depicted in figure 10 are not spaced apart from each other. Consequently, the floor 60, which is located beneath the baffles 59, does not actually form part of the upper surface 54.

The baffles 59 depicted in figure 11 have a circular profile. Each baffle 59 is a hollow pipe or tube 63 which is secured to the floor 60.

With particular reference to figures 4 and 6, each of the limbs 52 also includes a support 70 for supporting the upper surface 54 of the limb 52 relative to the floor 40. The support 70 is operable to adjust the depth of the upper end 55 of the surface 54 and trailing edge 56 below the surface 36 of the body of water 37, and the

inclination of the upper surface 54 relative to the surface 36.

Each support 70 includes a plurality of adjustable legs 71 for adjusting the depth of the upper surface 54 below the surface 36, and for adjusting the inclination of the upper surface 54 relative to the surface 36. The legs 71 are secured relative to the upper surface 54 of each limb 52, and are located adjacent to the upper end 55 of the upper surface 54 of each limb 52. The length of each leg 71 is able to be adjusted independently of the other legs 71.

Each leg 71 includes a top portion 72 secured relative to the upper surface 54, a bottom portion 73 for resting on the floor 40, and a threaded shaft 74 extending between and engaged with the top portion 72 and the bottom portion 73 such that the length of the leg 71 is able to be adjusted by rotating the shaft 74 relative to the top portion 72 and the bottom portion 73. The bottom portion 73 includes a dish-shaped foot 75 which rests on the floor 40, and which is able to slide over the surface of the floor 40. The shaft 74 includes a flange 76 for use in rotating the shaft 74 relative to the top portion 72 and the bottom portion 73.

Although not depicted in the drawings, stiff and elongate members that are preferably fabricated from steel, interconnect the bottom portions 73 so that the bottom portions 73 of the legs 71 are prevented from rotating while their shafts 74 are being rotated.

The support 70 of each limb 52 also includes a sliding member in the form of a pipe 77 which is secured relative to the upper surface 54 of the limb 52 such that the pipe 77 is located adjacent to the lower end 57 of the upper surface 54 of the limb 52. Pipe 77 rests on the floor 40, and is able to slide over the surface of the floor 40.

The support 70 allows the depth of the upper surface 54 below the surface 36 of the body of water 37 to be adjusted to suit the size of the waves propagating along the body of water 37. For example, if the waves are 1 metre high, the support 70 may be adjusted so that the upper end 55 and trailing edge 56 of the upper surface 54 associated with the support 70 are at a depth of 1 metre below the surface 36. As another example, if the waves are 2 metres high, the support 70 may be adjusted so that the upper end 55 and trailing edge 56 are at a depth of 2 metres below the surface 36.

Adjusting the depth of the upper end 55 and trailing edge 56 of either of the upper surfaces 54 below the surface 36 also has the effect of changing the inclination of the upper surface 54 relative to the surface 36. If the support 70 is adjusted to decrease the depth of the upper surface 54 below the surface 36, the inclination of the upper surface 54 relative to the surface 36 will increase. Conversely, if the support 70 is adjusted to increase the depth of the upper surface 54 below the surface 36, the inclination of the upper surface 54 relative to the surface 36 will decrease.

It has been found that the effect that the reef 31 has on waves which propagate over it can be changed by raising and lowering the upper surfaces 54 of the reef 31 relative to the surface 36. By adjusting the supports 70 to increase the depth of the upper surfaces 54 and trailing edges 56 of the reef 31 relative to the surface 36, the effect of the reef 31 on the waves is to make the waves wider or fatter with a small lip curling down. On the other hand, if the support 70 is adjusted to decrease the depth of the upper surfaces 54 and trailing edges 56 of the reef 31 relative to the surface 36, the effect of the reef 31 on the waves is to make the waves more hollow and tube-like.

The limbs 52 are coupled together by a linkage 80 such that the angle of each limb 52 relative to a wave front of a wave propagating towards the reef 31 is able to be adjusted simultaneously. In particular, the linkage 80 allows both of the limbs 52 to be simultaneously swept further back away from or towards an approaching wave front. When the limbs 52 are swept back away from the approaching wave front, the angle of the limbs 52 relative to the wave front increases. When the limbs 52 are swept forward towards the approaching wave front, the angle of the limbs 52 relative to the wave front decreases. Linkage 80 includes a first arm 81 hinged to one of the limbs 52 at 82, and a second arm 83 hinged to the other limb 52 at 84 and to the first arm at 85.

A wave which propagates over the reef 31 such that it moves over the leading edges 58 of the reef 31 followed by the trailing edges 56 of the reef 31, will tend to break along or just past the trailing edges 56 of the reef 31.

Each limb 52 of the reef 31 is able to produce a separate surf break. The breaks produced by the limbs 52 peel from the base 50 of the reef 31 to the distal ends of the limbs 52.

The rate at which an approaching wave peels or breaks as it propagates over the reef 31 can be altered by adjusting the angle of each limb 52 relative to the wave front. For example, the rate at which the wave peels or breaks as it propagates over the reef 31 can be decreased by increasing the angle of the limb 52 relative to the wave front or, in other words, by sweeping the limbs 52 backwards and away from the approaching wave front so that the angle of each limb 52 relative to the wave front increases. Conversely, the rate at which the wave peels or breaks as it propagates over the reef 31 can be increased by sweeping the limbs 52 forward towards the approaching wave front so that the angle of each limb 52 relative to the wave front decreases.

The artificial reef 31 may include a sweeping mechanism (not depicted) which includes the linkage 80 and which enables the position of the limbs 52 to be adjusted from a remote location such as, for example, from a shore which is located adjacent to the reef 31. The sweeping mechanism may be a manually or automatically operated mechanism.

The adjustability of the depth of the artificial reef 31 below the surface 36 of the body of water 37, and the adjustability of the angle of each limb 52 of the reef 31 relative to an approaching wave front enables the artificial reef 31 to be adjusted to produce a broad range of surf and wave types for surfers who have different surfing styles and different levels of skill, ability and experience. For example, the artificial reef 31 may be adjusted to produce surf which is suitable for long board surfing, short board surfing, body boarding, body surfing, or ski surfing.

As mentioned above, a wave which propagates over the reef 31 will break along or just past the trailing edges 56 of the reef 31. Consequently, if a surfer falls off their surfboard while riding the wave, it is unlikely that the surfer will hit the reef 31 as they will tend to fall off beyond the trailing edges 56 of the reef 31 and into the deeper water beyond the reef 31. In safety terms, this is a major improvement over other reefs which are more likely to be struck by a surfer if they fall off their surfboard.

Referring to figures 1 and 3, the artificial reef 31 also includes a securing means 90 for securing the artificial reef 31 relative to the floor 40 to inhibit the reef 31

from unintentionally moving relative to the floor 40. Securing means 90 includes an elongate member 91 for securing the reef 31 relative to the floor 40. Elongate member 91 may for example be a chain, cable, rope or an elongate track. With particular reference to figure 1, one end 92 of the member 91 is secured to an ocean anchor 93. Anchor 93 secures end 92 of the elongate member 91 relative to the floor 40. Anchor 93 includes three augers 94 that are embedded in the floor 40 so that the anchor 93 is secured relative to the floor 40. The other end 95 of the member 91 is secured to a beach anchor (not depicted) which is secured relative to a beach (not depicted) which the apparatus 30 is located adjacent to.

The artificial reef 31 may also include a moving mechanism (not depicted) for moving the artificial reef 31 as a whole relative to the floor 40 of the body of water 37. The moving mechanism allows the depth of the reef 31 below the surface 36 of the body of water 37 to be adjusted, and in the case where that depth changes, enables the reef 31 to be maintained at a consistent depth so that the reef 31 is able to produce consistent surf 31 in a range of conditions, and not just in favourable wave and tide conditions. For example, if the reef 31 is submerged in the ocean adjacent to a beach, the reef 31 may be moved closer to the beach at or near high tide or when the tide is coming in, and further away from the beach at or near low tide or when the tide is going out, so as to maintain the reef 31 at a substantially consistent depth below the surface 36 of the water. Thus, the mobility of the reef 31 enables it to be moved to follow the tide in and out so that the reef 31 can continuously produce surf while there is a swell running.

Figures 12 and 13 depict a portion of an arm 52 of an artificial reef 100 according to a second preferred embodiment of one of the aspects of the present invention. For convenience, like features of the artificial reefs 31 and 100 are referenced with like reference numerals.

Reef 100 is identical to the reef 31 except that the upper surface 54 of each arm 52 of the reef 100 includes a floor 60 having a lower portion 101 and an upper portion 102 which is inclined relative to the lower portion 101.

Each baffle 59 of the reef 100 is a heavy duty hollow pipe or tube which is secured relative to the floor 60, and which extends between the upper end 55 and the

lower end 57 of the upper surface 54. The baffles 59 are parallel to each other and are also spaced apart from each other at regular intervals.

The upper portion 102 of the floor 60 includes a plurality of rectangular openings 103 located between each adjacent pair of baffles 59. Openings 103 permit water to flow through the reef 100.

The upper portion 102 also includes a plurality of valves in the form of rubber flaps (not depicted) which only allow outflowing water (i.e. water flowing towards the reef 100 in the direction indicated by arrows 104) to flow through the openings 103. The flaps prevent inflowing water (i.e. water flowing in the opposite direction to that indicated by the arrows 104) from flowing through the openings 103, so that the inflowing water is forced to flow up and over the surface 54 of the reef 100.

Each limb 52 of the artificial reef 100 also includes a skirt 105 for inhibiting water from flowing underneath the reef 100. Skirt 105 extends from the lower end 57 of the upper surface 54 down to the floor 40.

The support 70 of each arm 52 of the reef 100 also includes an elongate frame member 106 which is secured to the floor 60 of the upper surface 54 of the arm 52 and to the top portions 72 of the legs 71.

Figure 14 depicts an arm 52 of an artificial reef 110 according to a third preferred embodiment of one of the aspects of the present invention when the reef 110 is submerged below the surface 36 of a body of water 37 and resting on the floor 40 of the body of water 37. For convenience, like features of the artificial reefs 100 and 110 have been referenced with like reference numerals.

Reef 110 is identical to the reef 100 except that the reef 110 also includes a ramp 111 located adjacent to the upper end 55 of the upper surface 54. Ramp 111 is hinged along the trailing edge 56 relative to the upper surface 54 such that the ramp 111 is able to be pivoted relative to the upper surface 54 between a raised position and a lowered position which is depicted in figure 14. Ramp 111 includes a first section 112 which is in the form of a thin board, and a second section 113 which is also in the form of a thin board. The first section 112 and the second section 113 are hinged to each other so that they are able to pivot relative to each other. The second section 113

is tethered relative to the upper surface 54 of the reef 110 by a tether 114 such that movement of the second section 113 relative to the upper surface 54 is limited by the tether 114. Tether 114 may, for example, be a pliable rubber membrane.

Reef 110 includes valves in the form of rubber flaps 115 for controlling the flow of water through the openings 103 in the upper portion 102 of the upper surface floor 60 of the reef 110. Flaps 115 allow outflowing water to flow through the openings 103 and, hence, through the reef 110. Flaps 115 inhibit inflowing water from flowing through the openings 103 and, hence, through the reef 110. Figure 14 depicts outflowing water flowing past the reef 110 such that some of the outflowing water flows over the reef 110 as depicted by arrows 120, and such that some of the outflowing water flows through the openings 103 in the reef 110 as depicted by the arrows 121.

At the same time that the outflowing water flows past the reef 110 as depicted by the arrows 120 and 121, a wave surge approaches the reef 110. The wave surge comprises a wave 122 and an accompanying inflow of water flowing in the direction depicted by the arrows 123. The outflowing water depicted by the arrows 120, 121 is actually a result of the wave 122 drawing water from in front of it as it approaches the shallower water in front of it, which has the effect of increasing the size of the wave 122.

In figure 14, the force exerted on the ramp 111 by the outflowing water which flows over the reef 110 in the direction indicated by the arrows 120 is sufficiently great to maintain the ramp 111 in the lowered position. When it is in the lowered position, the ramp 111 is inhibited from impeding the outflowing water depicted by the arrows 120 from flowing over the reef 110.

Referring to figure 15, as the wave 122 propagates over the reef 110, the inflow of water which accompanies the wave 122 flows along the upper surface 54, and the outflow of water in the direction indicated by the arrows 120 and 121 abates. Also, the force of the inflowing water causes the ramp 111 to move towards the raised position, and the flaps 115 to begin closing so that they are able to inhibit the inflowing water from flowing through the openings 103. By inhibiting the inflowing water from flowing through the openings 103, the flaps 115 are able to force the

inflowing water to move upwards along the upper surface 54 to increase the volume of the wave 122, and are also able to prevent the wave 122 from breaking prematurely (i.e. before the trailing edge 56).

As the wave 122 propagates further over the reef 110 and the inflowing water flows further along the upper surface 54 as shown in figure 16, the ramp 111 moves further towards the raised position, and the flaps 115 continue to close. Also, the wave 122 begins to curl over and form a lip 124.

With reference to figure 17, the wave 122, which has a tube-like shape that is attractive to surfers, begins to break as it propagates past the trailing edge 56 of the reef 110. At this stage, the ramp 111 is in the fully raised position, and the flaps 115 are fully closed. When the ramp 111 is in the fully raised position, the tether 114 is stretched taught so that it limits the movement of the second section 113 of the ramp 111 relative to the first section 112 of the ramp 111.

When the ramp 111 is in the raised position, it interacts with the outflow of water indicated by the arrows 120 and the inflow of water indicated by the arrows 123 to lift or increase the height of the wave 122 as it propagates over the reef 110.

After the wave 122 passes the reef 110, and the strength of the outflowing water increases, the ramp 111 moves back to the lowered position, and the flaps 115 open so that the outflowing water can again flow through the openings 103. The cycle repeats as another wave and an accompanying inflow of water approach the reef 110.

Throughout the specification and the claims, unless the context requires otherwise, the term "comprise", or variations such as "comprises" or "comprising", will be understood to apply the inclusion of the stated integer or group of integers but not the exclusion of any other integer or group of integers.

Throughout the specification and claims, unless the context requires otherwise, the term "substantially" or "about" will be understood to not be limited to the value for the range qualified by the terms.

It will be appreciated by those skilled in the art that variations and modifications to the invention described herein will be apparent without departing from the spirit and scope thereof. The variations and modifications as would be apparent to persons skilled in the art are deemed to fall within the broad scope and

ambit of the invention as herein set forth.

It will be clearly understood that, if a prior art publication is referred to herein, that reference does not constitute an admission that the publication forms part of the common general knowledge in the art in Australia or in any other country.

CLAIMS:

1. An artificial reef for affecting surface waves propagating along a surface of a body of water, the reef comprising an inclined upper surface including a plurality of baffles, the reef being submergible in the body of water such that the waves are able to propagate over the reef, and such that the upper surface faces towards the waves as the waves propagate towards the reef.

2. The artificial reef of claim 1, wherein the upper surface includes an upper end, and a lower end, and wherein the baffles extend from the upper end to the lower end.

3. The artificial reef of any one of the preceding claims, wherein the baffles are parallel to each other.

4. The artificial reef of any one of the preceding claims, wherein the baffles are spaced apart from each other.

5. The artificial reef of claim 4, wherein the baffles are spaced apart from each other at regular intervals.

6. The artificial reef of any one of the preceding claims, wherein the baffles are hollow.

7. The artificial reef of any one of the preceding claims, wherein each of the baffles has a profile selected from the group comprising: a straight linear profile; a T-shaped profile; a profile including a circular portion and a straight linear portion extending from the circular portion; a triangular profile; a circular profile; and a rectangular or square profile.

8. The artificial reef of any one of the preceding claims, wherein each of the baffles includes a pipe or tube.

9. The artificial reef of any one of the preceding claims, wherein the upper surface includes a floor, and the baffles extend from the floor.

10. The artificial reef of claim 9, wherein the floor includes a lower portion, and an upper portion which is inclined relative to the lower portion.

11. The artificial reef of any one of the preceding claims, wherein the reef includes a ramp secured relative to the upper surface such that the ramp is able to be moved relative to the upper surface between a raised position and a lowered position.

12. The artificial reef of claim 11, wherein the ramp includes a first section hinged relative to the upper surface, and a second section hinged relative to the first section.

13. The artificial reef of any one of the preceding claims, wherein the upper surface includes at least one opening for permitting water to flow through the reef, and at least one valve for preventing inflowing water from flowing through the at least one opening, and for allowing outflowing water to flow through the at least one opening.

14. The artificial reef of claim 13, wherein the at least one valve is a flap.

15. The artificial reef of any one of the preceding claims, wherein the reef includes a support for supporting the upper surface relative to a floor of the body of water, the support being operable to adjust the depth of the upper surface below the surface of the body of water.

16. The artificial reef of claim 15, wherein the support includes at least one adjustable leg.

17. The artificial reef of claim 16, wherein the at least one adjustable leg includes a top portion secured relative to the upper surface, a bottom portion for resting on the floor of the body of water, and a threaded shaft extending between and engaged with the top portion and the bottom portion such that the length of the at least one adjustable leg is able to be adjusted by rotating the shaft relative to the top portion and the bottom portion.

18. The artificial reef of any one of claims 15 to 17, wherein the support includes a sliding member for sliding over the floor of the body of water.

19. The artificial reef of any one of the preceding claims, wherein the reef includes a pair of limbs for affecting the waves, each limb including a respective one of the upper surface, wherein the angle of each limb relative to a wave front of the waves is able to be adjusted.

20. The artificial reef of any one of the preceding claims, the reef including a moving mechanism for moving the artificial reef relative to a floor of the body of water.

21. An apparatus for affecting surface waves propagating along a surface of a body of water, the apparatus comprising the artificial reef of any one of claims 1 to 20.

22. The apparatus of claim 21, wherein the apparatus further comprises at least one channel for channelling the waves towards the artificial reef.

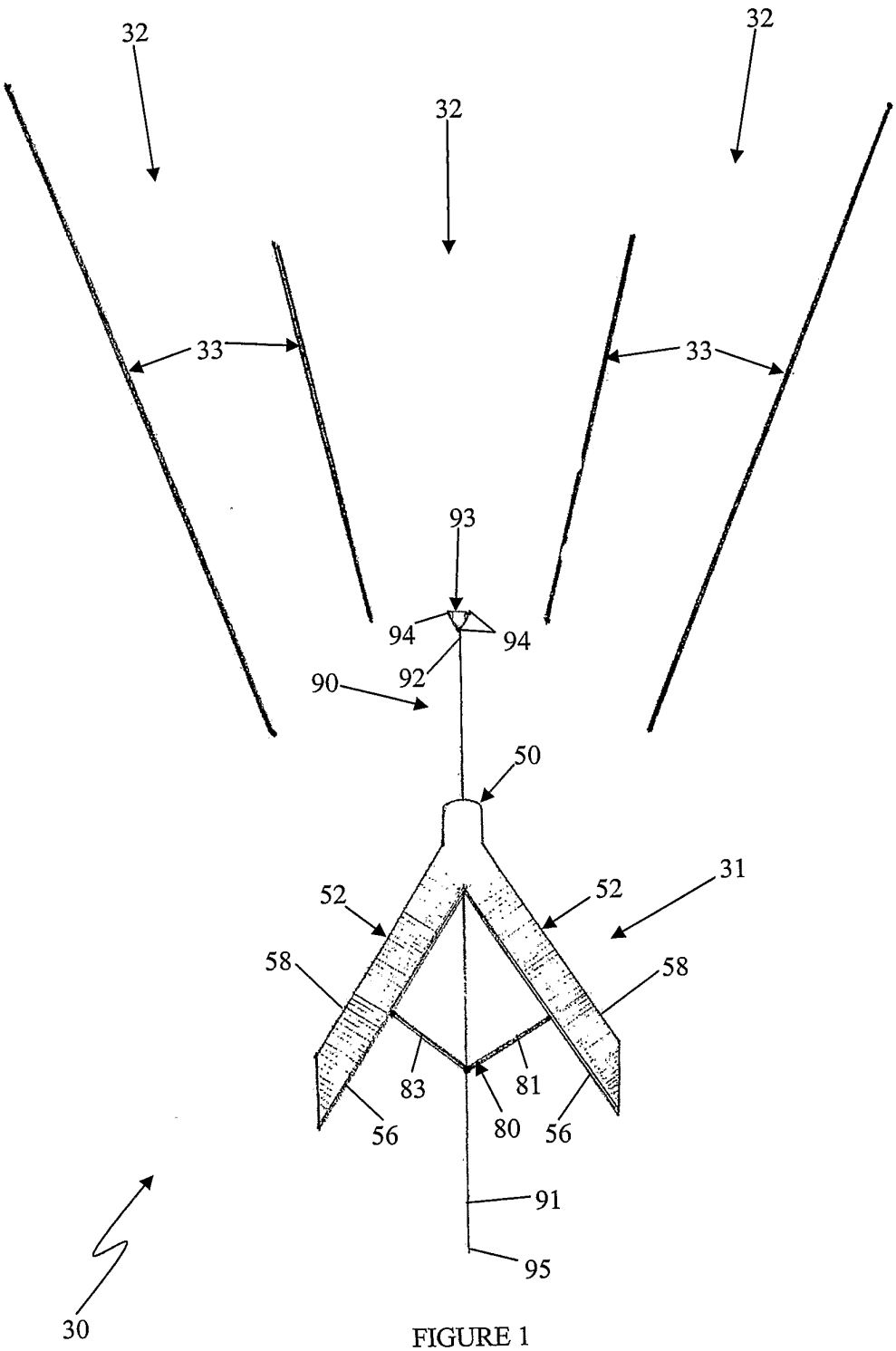
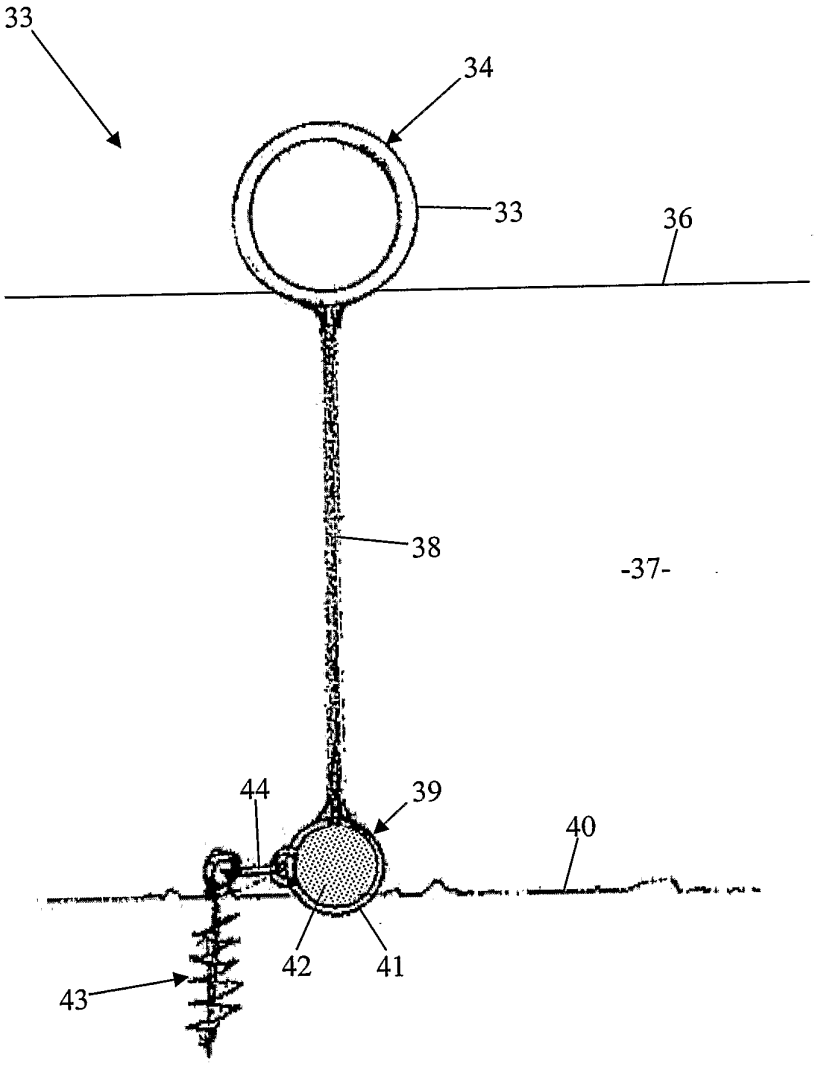


FIGURE 1



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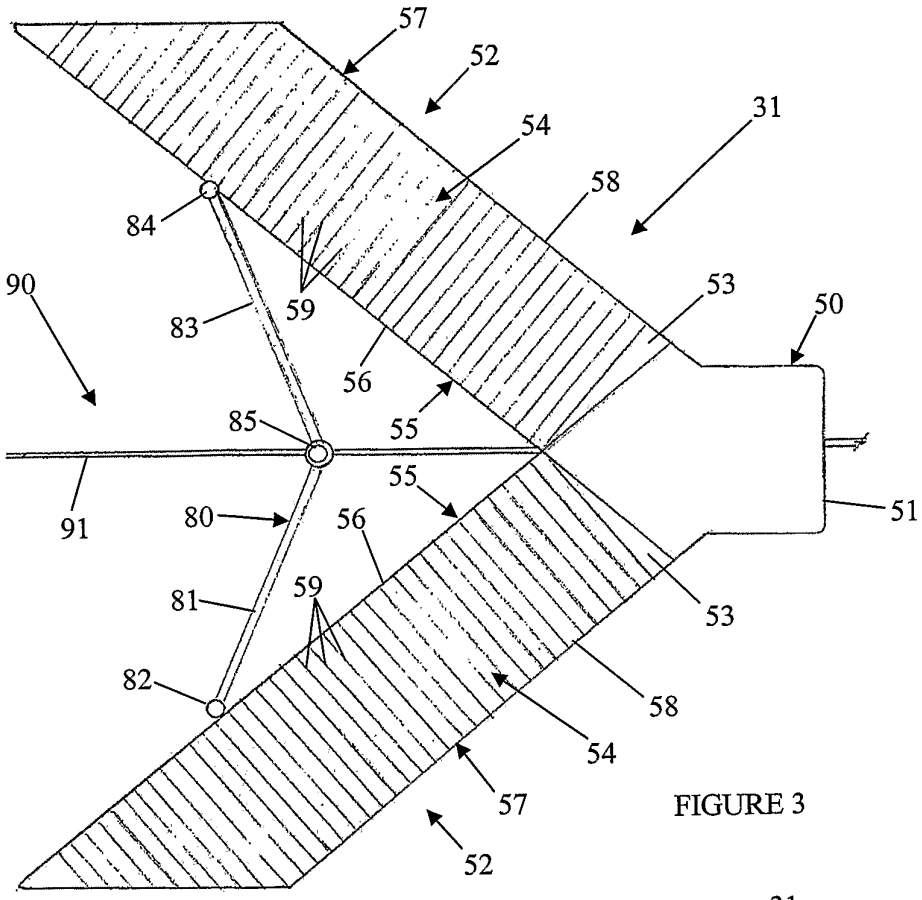

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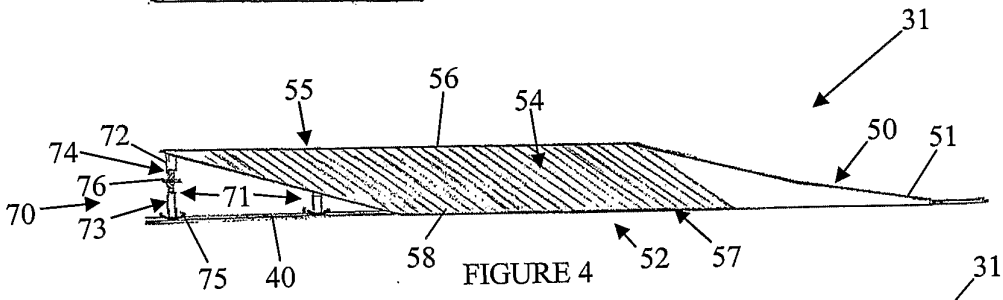

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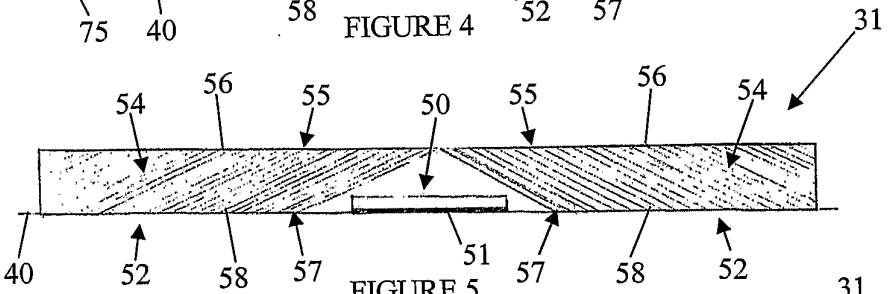

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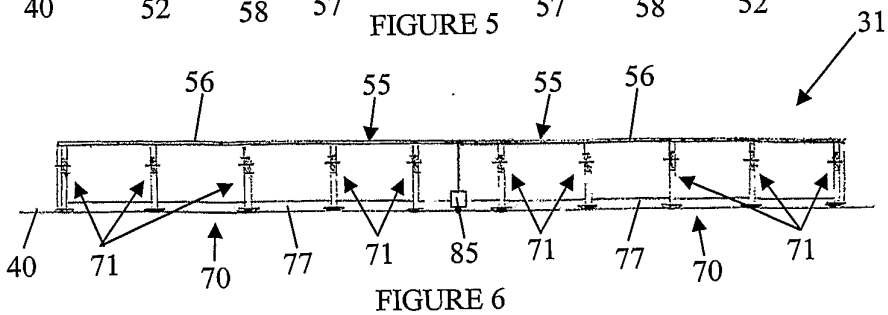

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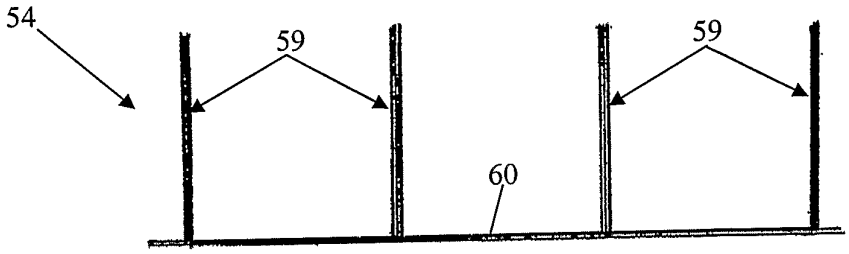

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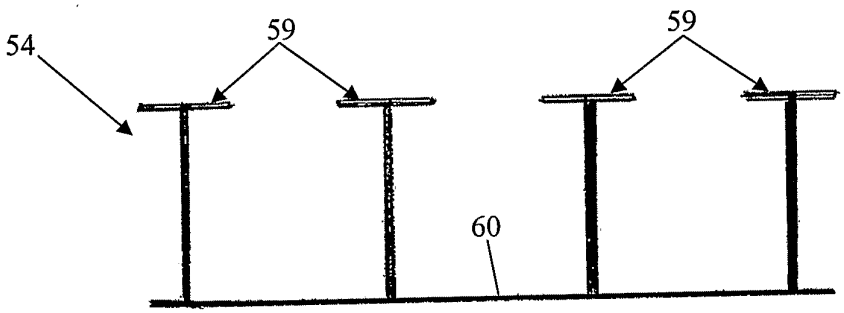

FIGURE 8

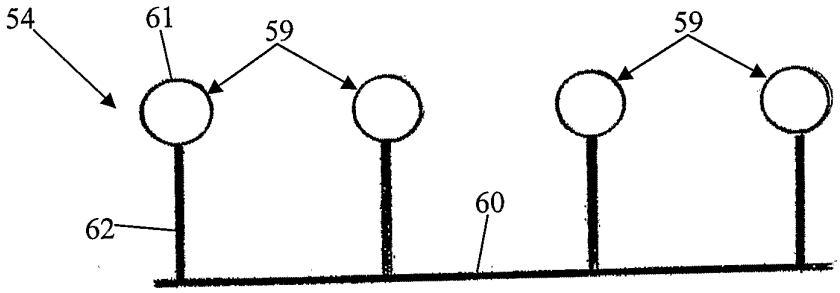

FIGURE 9

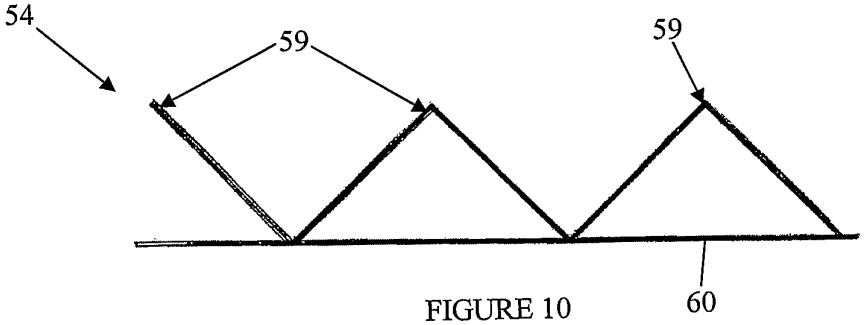

FIGURE 10

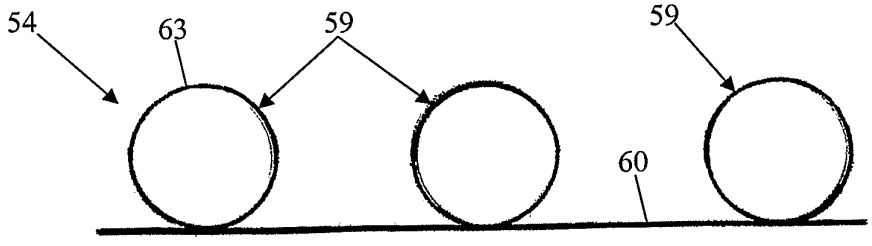

FIGURE 11

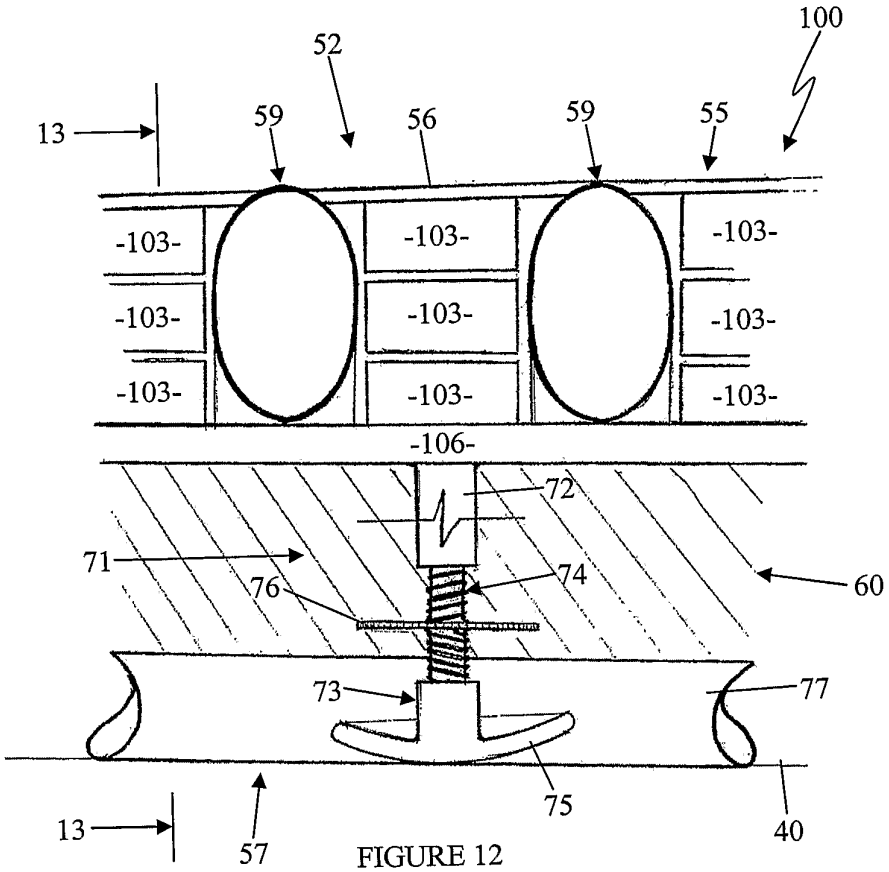

FIGURE 12

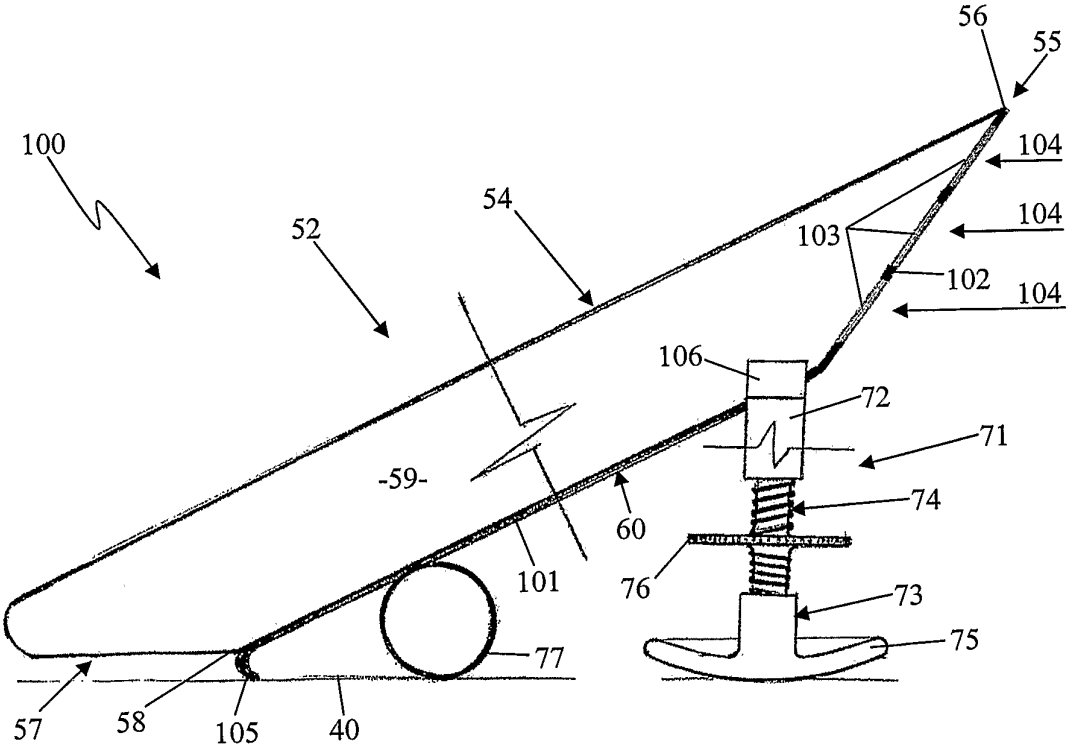

FIGURE 13

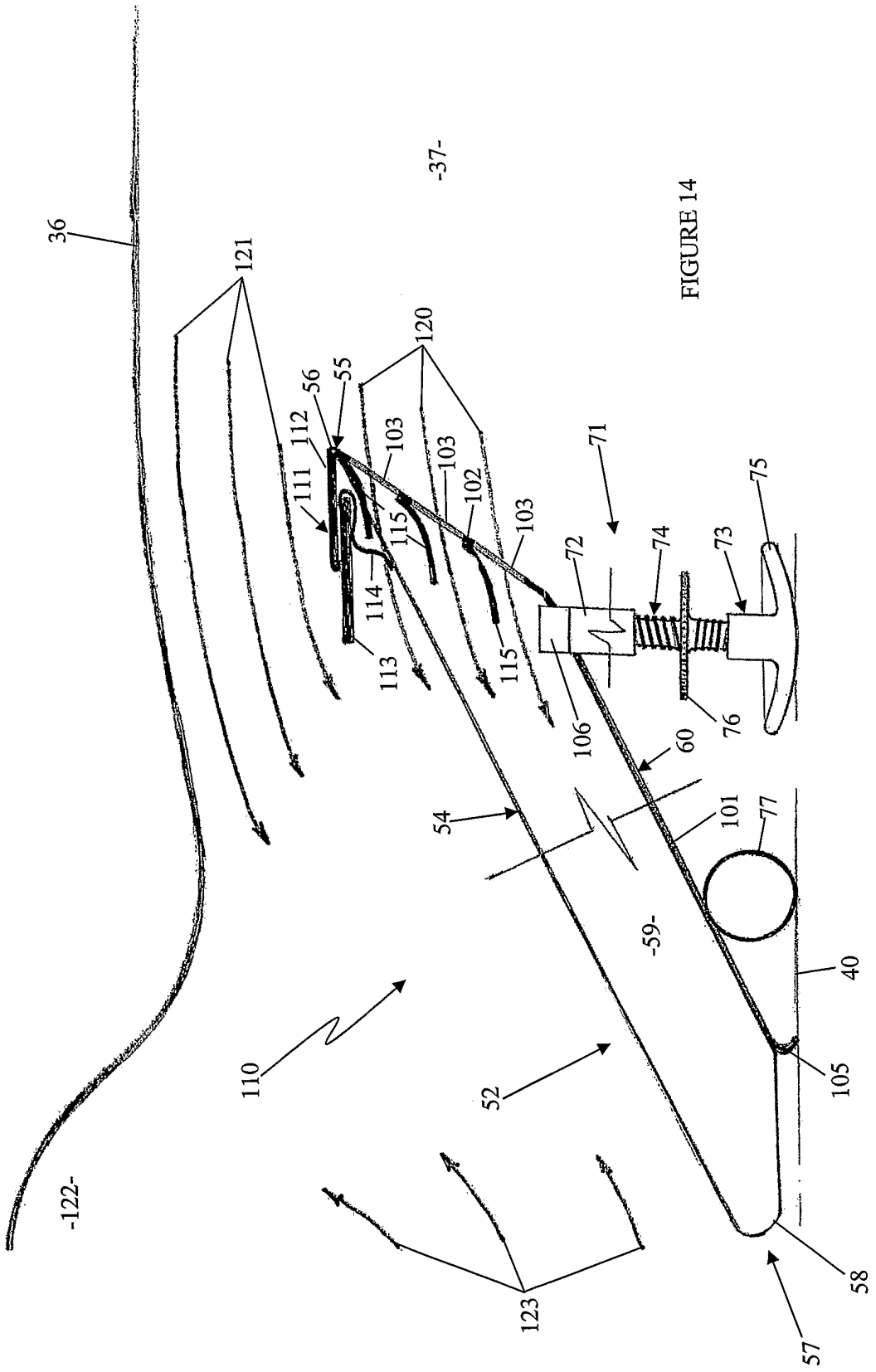
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FIGURE 14

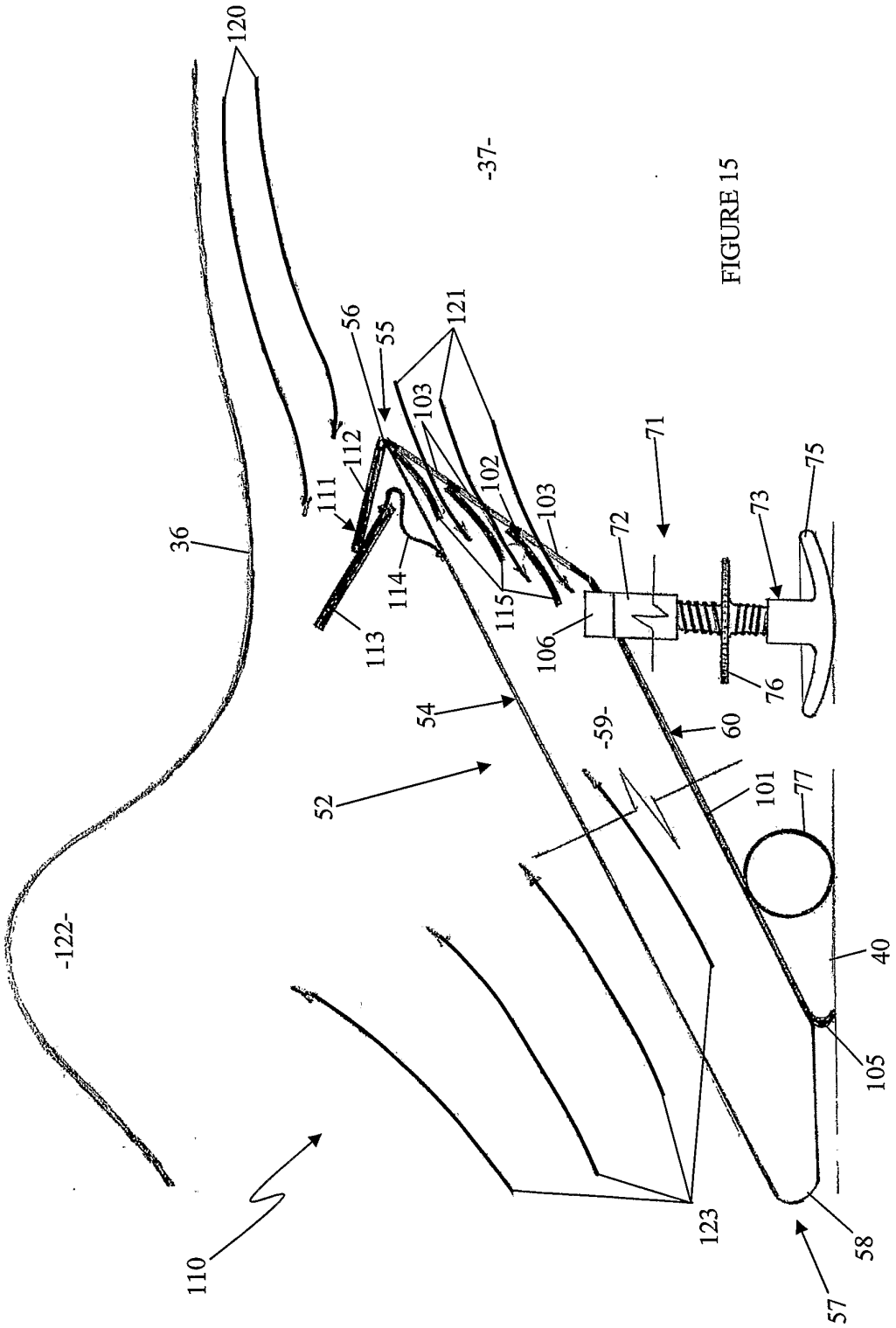
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FIGURE 15

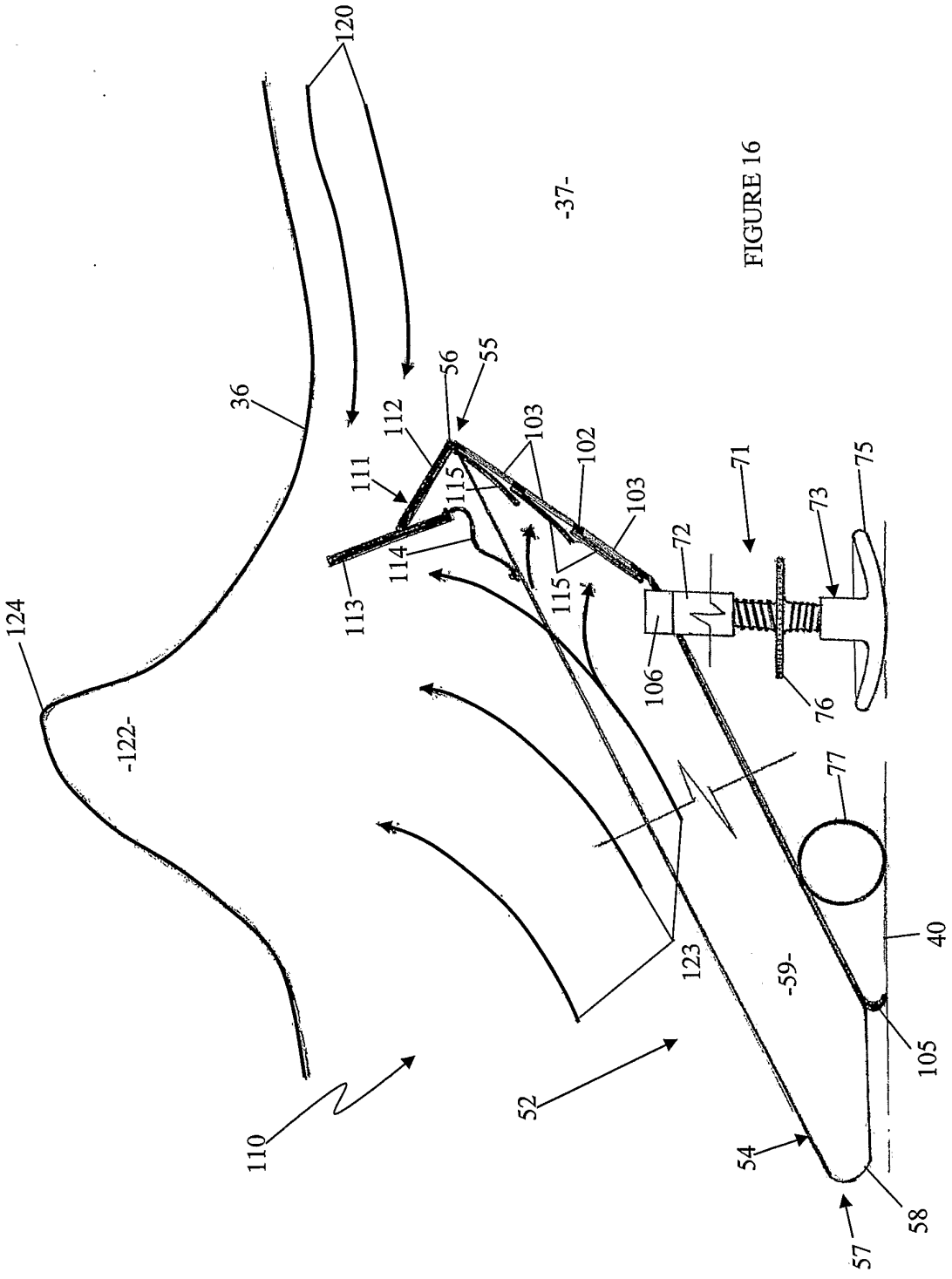
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FIGURE 16

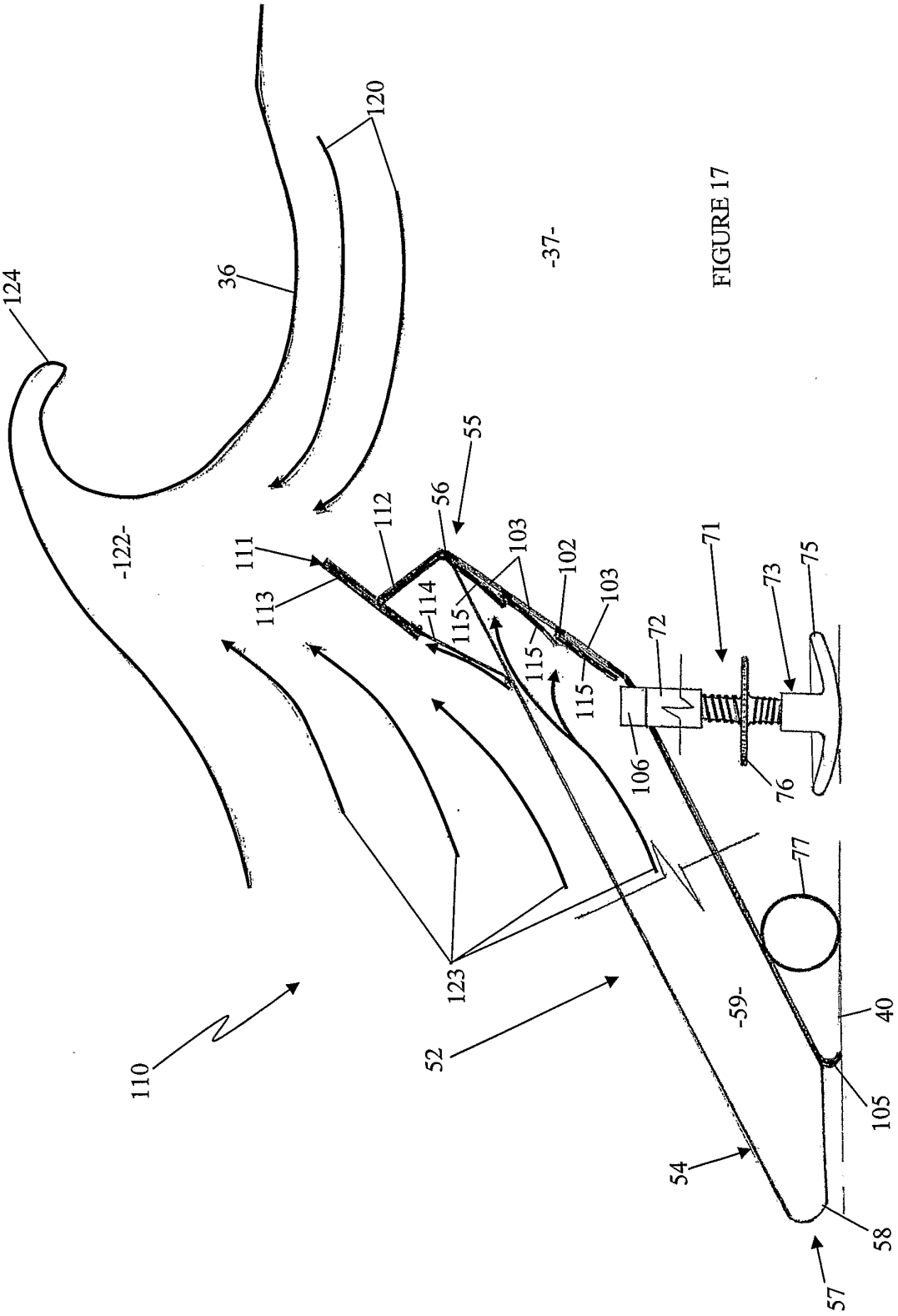
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FIGURE 17