

SUMMARY

[0016] According to an exemplary embodiment, there is a streamer for collecting seismic data related to a subsurface of a body of water. The streamer includes a body having a predetermined length; plural detectors provided along the body; and plural birds provided along the body. The birds are configured to float, when deployed under water, at a predetermined depth from a surface of the water such that a first portion of the body has a curved profile while being towed underwater. aspect of the present invention, there is provided a streamer for collecting seismic data related to a subsurface of a body of water, the streamer comprising: a body having a predetermined length; plural detectors provided along the body; and plural birds provided along the body, wherein the birds are configured to float, when deployed under water, at a predetermined depth from a surface of the water such that at least some of the detectors are distributed at different depths from the surface of the water on a non-linear, variable-depth profile while being towed underwater, the non-linear, variable-depth profile being a parameterized curve, wherein the parameterized curve is a parabola.

[0017] According to another exemplary embodiment, there is also disclosed a method for seismic data acquisition related to a subsurface of a body of water. The method includes a step of towing a body having a predetermined length together with plural detectors provided along the body; a step of configuring plural birds provided along the body, to float at a predetermined depth from a surface of the water such that a first portion of the body has a curved profile while being towed underwater; and a step of recording with the plural detectors the seismic data generated in the body of the water while towing the body.

[0018] ~~According to still another exemplary embodiment,~~ there is also disclosed a method for deploying a streamer for seismic data acquisition related to a subsurface of a body of water. The method includes releasing into the body of water, from a vessel, a body having a predetermined length together with plural detectors provided along the body; towing the body and the plural detectors such that the plural detectors are submerged; and configuring plural birds provided along the body, to float at a predetermined depth from a surface of the water such that a first portion of the body has a curved profile while being towed underwater.

[0019] ~~According to still another exemplary embodiment, there is also~~
disclosed a streamer for collecting seismic data related to a subsurface of a body of water. The streamer includes a body having a predetermined length; plural detectors provided along the body; and plural birds provided along the body. The streamer is configured to flow underwater when towed such that the plural detectors are distributed along a curved profile described by (i) a depth z_0 of a first detector, (ii) a slope s_0 of a first portion of the body with an axis parallel with a surface of the body of water, and (iii) a predetermined horizontal distance h_c between the first detector and an end of the curved profile.

[0020] ~~According to yet another exemplary embodiment, there is also~~
disclosed a streamer for collecting seismic data related to a subsurface of a body of water. The streamer includes a body having a predetermined length; plural detectors provided along the body; and plural birds provided along the body. The streamer is configured to flow underwater when towed such that the plural detectors are distributed along a first portion and a second portion of the body. The first portion has a slanted profile with a first slope and the second portion has a slanted profile with a second slope different from the first slope.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate one or more embodiments and, together with the description, explain these embodiments. In the drawings:

[0022] Figure 1 is a schematic diagram of a conventional seismic data acquisition system having a horizontal streamer;

WHAT IS CLAIMED IS:

1. A streamer for collecting seismic data related to a subsurface of a body of water, the streamer comprising:
a body having a predetermined length;
plural detectors provided along the body; and
plural birds provided along the body, wherein the birds are configured to float, when deployed under water, at a predetermined depth from a surface of the water such that at least some of the detectors are distributed at different depths from the surface of the water on a non-linear, variable-depth profile while being towed underwater, the non-linear, variable-depth profile being a parameterized curve,

wherein the parameterized curve is a parabola.

2. The streamer of Claim 1, wherein a first portion of the body has the same non-linear, variable-depth profile while being towed underwater.

~~3. The streamer of Claim 1 or 2, wherein the parameterized curve is a parabola, a circle or a hyperbola.~~

~~4. The streamer of Claim 2, further comprising:~~

~~a second portion having a flat profile connected to the first portion.~~

~~5. The streamer of Claim 2, wherein the non-linear, variable-depth profile is described by $z(h)$, which is a depth of a point of the first portion relative to the surface of the water, and satisfies the following equation:~~

$$~~z(h) = z_0 + s_0 h \left(1 - 0.5 \left(\frac{h}{h_c} \right) \right) \text{ for } h \leq h_c,~~$$

~~where h is a horizontal distance between the point and a first detector provided on the body, z_0 is a depth of the first detector relative to the surface of the water, s_0 is a slope of the body at the first detector of the streamer, and h_c is a~~

~~predetermined horizontal distance between the first detector and an end of the non-linear, variable-depth profile.~~

~~6. The streamer of Claim 5, further comprising:
a second portion, connected to the first portion, the second portion
being described by equation $z(h) = z_0 + s_0 - 0.5 \cdot h_c$ for $h > h_c$.~~

~~7. The streamer of Claim 5, wherein a projection of the entire body on a line substantially parallel to the surface of the water is less than h_c .~~

~~83. The streamer of any one of the preceding claims Claim 1 or 2,
wherein the non-linear, variable-depth profile stays substantially the same
during the towing.~~

~~9. The streamer of Claim 2, further comprising:
a second portion, connected to the first portion, the second portion
having birds and detectors and having a flat profile.~~

~~10. The streamer of Claim 9, wherein the second portion is
substantially parallel to the surface of the water.~~

~~114. The streamer of any one of the preceding claims, wherein the
plural detectors include only hydrophones.~~

425. The streamer of any one of the preceding claims, wherein no portion of the body, detectors or birds is anchored to the subsurface.

~~13. A method for seismic data acquisition related to a subsurface of a body of water, the method comprising:~~

~~towing a body having a predetermined length together with plural detectors provided along the body;~~

~~configuring plural birds provided along the body, to float at a predetermined depth from a surface of the water such that at least some of the detectors are distributed at different depths from the surface of the water on a non-linear, variable depth profile while being towed underwater, the non-linear, variable depth profile being a parameterized curve; and~~

~~recording with the plural detectors the seismic data generated in the body of the water while towing the body.~~

~~14. The method of Claim 13, wherein a first portion of the body has the same non-linear, variable depth profile while being towed underwater.~~

~~15. The method of Claim 13 or 14, wherein the parameterized curve is a parabola, a circle or a hyperbola.~~

~~16. The method of Claim 14, wherein a second portion of the streamer has a flat profile and is connected to the first portion.~~

~~17. The method of Claim 14, wherein the non-linear, variable depth profile is described by $z(h)$, which is a depth of a point of the first portion relative to the surface of the water, and satisfies the following equation:~~

$$z(h) = z_0 + s_0 h \left(1 - 0.5 \left(\frac{h}{h_c} \right) \right) \text{ for } h \leq h_c,$$

where h is a horizontal distance between the point and a first detector provided on the body, z_0 is a depth of the first detector relative to the surface of the water, s_0 is a slope of the body at the first detector of the streamer, and h_c is a predetermined horizontal distance between the first detector and an end of the non-linear, variable-depth profile.

18. The method of Claim 17, further comprising:
towing a second portion, connected to the first portion, the second portion being described by equation $z(h) = z_0 + s_0 \cdot 0.5 \cdot h_c$ for $h > h_c$.

19. The method of Claim 17, wherein a projection of the entire body on a line substantially parallel to the surface of the water is less than h_c .

20. The method of any one of Claims 13-19, wherein the non-linear, variable-depth profile stays substantially the same during the towing.

21. The method of Claim 14, further comprising:
towing a second portion connected to the first portion, the second portion having birds and detectors and having a flat profile.

22. A method for deploying a streamer for seismic data acquisition related to a subsurface of a volume of water, the method comprising:
releasing into the volume of water, from a vessel, a body having a predetermined length together with plural detectors provided along the body;

~~towing the body and the plural detectors such that the plural detectors are submerged; and~~

~~configuring plural birds provided along the body, to float at a predetermined depth from a surface of the water such that at least some of the detectors are distributed at different depths from the surface of the water on a non-linear, variable-depth profile while being towed underwater, the non-linear, variable-depth profile being a parameterized curve.~~