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**Declarations under Rule 4.17:**

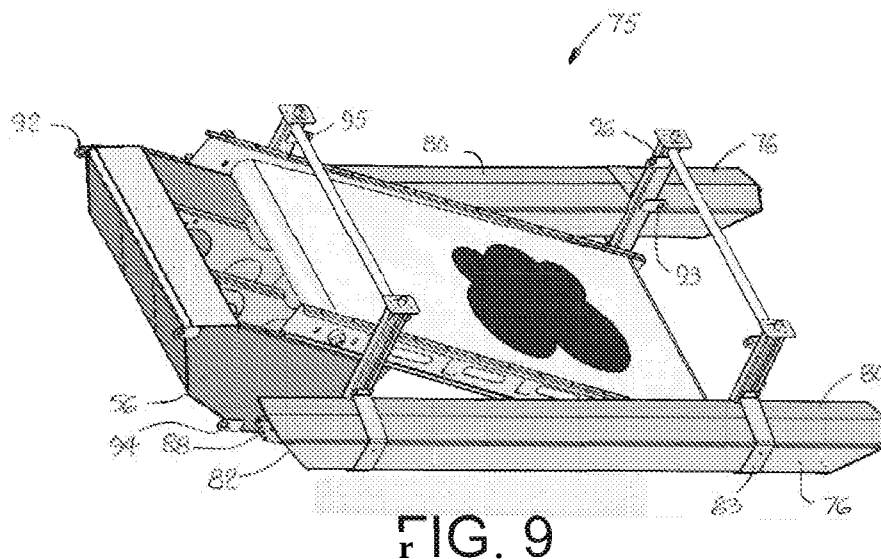
- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(H))
- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(Hi))

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- with international search report (Art. 21(3))

[Continued on next page]

(54) Title: SKIMMER



(57) Abstract: A self-floating skimmer that can operate remotely from a vessel. Pontoons allow the skimmer to float at the surface of a body of water. An inclined belt conveyor whose lower end is submerged just below the surface of the water conveys material to be collected up the incline to the upper end where it is dumped from the surface of the belt into a collection tank below. For convenience in storage or transit, the skimmers can be stacked atop one another. The belt conveyor can include a bidirectional conveyor belt that is driven in either direction by a selectively reversible drive motor.

- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

## Skimmer

### BACKGROUND

The invention relates generally to skimmers and more particularly to floating skimmers using conveyor belts to skim oil, vegetation, or floating debris from the surface of a body of water.

Skimmers are used to collect aquatic vegetation or to clean up oil spills or floating debris. In the case of oil spills, skimmers skim oil floating at the surface of a body of water and collect the oil in a reservoir for disposal or processing. Belt conveyors extending into the water are often used to catch the oil and convey it to a reservoir. Similarly, belt conveyors are also used to drag vegetation or solid floating debris out of a body of water. Many of these belt skimmers are affixed to a powered vessel, such as a boat. The skimmer is deployed from the boat. Because the boat provides the flotation for these skimmers, the amplitude of the up-and-down motion of the skimmer due to wave action can be significant because of the length and width, or beam, of the boat. This up-and-down motion can cause the skimmer to rise out of the water and miss oil, vegetation, or debris to be skimmed. Furthermore, when deployed from a large boat with a deep draft, the skimmer is unable to operate in shallow or confined areas.

### SUMMARY

These shortcomings are overcome by a skimmer embodying features of the invention. Such a skimmer comprises a frame and a pair of floats mounted on opposite outer sides of the frame. The floats have parallel float axes defining a horizontal plane when floating in a body of water. A belt conveyor is mounted to the frame between the pair of floats and defines a conveying path inclined relative to the horizontal plane between a lower end and an upper end. The belt conveyor includes a rotating drive element at the upper end of the belt conveyor, a reversing element at the lower end of the belt conveyor, and an endless conveyor belt trained around the rotating drive element and the reversing element and driven by the rotating drive element along the conveying path, which includes an underwater portion at the lower end of the conveyor at which material to be skimmed is captured. A trough is positioned below the conveyor belt to catch skimmed material falling

off the conveyor belt. In the case of an oil skimmer, a scraper contacting the conveyor belt proximate the trough scrapes excess oil from the conveyor belt and directs the oil into the trough.

Another version of a skimmer comprises a frame and a pair of floats mounted on opposite outer sides of the frame. The floats have parallel float axes defining a horizontal plane when floating in a body of water. A belt conveyor is mounted to the frame between the pair of floats and defines a conveying path inclined relative to the horizontal plane between a lower end and an upper end. The belt conveyor includes an endless conveyor belt arranged to advance along the conveying path including an underwater portion at the lower end of the belt conveyor at which material to be skimmed is captured. A selectively reversible motor selectively drives the conveyor belt in either direction along the conveying path. A trough positioned below the conveyor belt catches skimmed material falling off the conveyor belt.

#### BRIEF DESCRIPTION OF THE DRAWINGS

These features of the drawings, as well as its advantages, are better understood by referring to the following description, appended claims, and accompanying drawings, in which:

FIG. 1 is an isometric view of a floating skimmer embodying features of the invention;

FIG. 2 is a side elevation view of the skimmer of FIG. 1;

FIG. 3 is a top plan view of the skimmer of FIG. 1;

FIG. 4 is a bottom isometric view of the skimmer of FIG. 1;

FIG. 5 is an isometric view of the belt conveyor frame of the skimmer of FIG. 1;

FIG. 6 is a side elevation view of the belt conveyor frame of FIG. 5;

FIG. 7 is an isometric view of the collection trough in the skimmer of FIG. 1;

FIG. 8 is an isometric view of a pair of skimmers as in FIG. 1 stacked one atop the other;

FIG. 9 is an oblique view of another version of a floating skimmer embodying features of the invention;

FIG. 10 is a side elevation view of the skimmer of FIG. 9;

FIG. 11 is a front elevation view of the skimmer of FIG. 9; FIG. 12 is a bottom perspective view of the skimmer of FIG. 9;

FIG. 13 is a side elevation view of the conveyor portion of a skimmer as in FIG. 1 or 9 with the trough replaced by a separate barge to collect skimmed vegetation, such as duckweed, or floating debris;

FIG. 14 is a side elevation view of the conveyor portion of a skimmer as in FIG. 1 or 9 with the deep trough replaced by a shallower collection trough and the skimmer traveling in reverse during oil skimming; and

FIG. 15 is a side elevation view of the conveyor portion of a skimmer as in FIG. 1 or 9 with the conveyor belt driven in reverse to collect oil from the bottom of the conveyor.

#### DETAILED DESCRIPTION

A floating skimmer embodying features of the invention is shown in FIGS. 1-4. The skimmer 10 includes an inclined belt conveyor 12 having a conveyor belt 14 advancing upward along an upper run 16 from a lower end 18 of the conveyor to an upper end 19. As shown in FIG. 4, the conveyor belt returns along a return run 17 on the bottom side of the skimmer. The conveyor 12 is mounted in a frame that includes on the outer sides 20, 21 of the conveyor two lower posts 22 near the lower end of the conveyor and two upper posts 23 near the upper end. Cross-braces 24 connect between top ends 26, 27 of the lower posts and the upper posts for stability. Floats, such as pontoons 28, are also mounted to the posts near their bottom ends 30, 31. The pontoons shown are in the form of hexagonal tubes having parallel float axes 32 that define a horizontal plane 34, for example, at the water line as in FIG. 2, when the oil skimmer is deployed in a body of water. The floats and other frame elements can be made of lightweight aluminum for easier handling.

The endless conveyor belt 14 is trained around a rotating drive element 36 at the upper end 19 of the conveyor 12 and a reversing element 38 at the lower end 18. The upper and lower runs and the paths the belt follows around the drive and reversing elements constitute a conveying path, a portion of which is underwater during deployment to capture floating material to be collected. As shown in FIGS. 5 and 6, the drive element is realized in this example as a set of sprockets 40 or pulleys mounted on a shaft 41 whose ends are

supported in bearing blocks 43 mounted to side frames 42 of the conveyor. A motor 44, such as a hydraulic motor or an electric motor, is coupled to the shaft by a gearbox 46. Teeth on the sprockets engage structure in the inner side of the conveyor belt to positively drive it in a direction of belt travel 48 up the incline on the top run 16, as shown in FIGS. 1 and 3. A

5 modular plastic conveyor belt, which has inner-side drive structure that allows it to be positively driven, is preferable to a flat belt, which is friction driven and may tend to slip in an oily environment. One example of a lightweight modular plastic conveyor belt that could be used is the INTRALOX® Series 1600 Open Hinge Flat Top belt manufactured and sold by Intralox, L.L.C. of Harahan, Louisiana 70123 and described in U.S. Patent Publication

10 No. 2006/0278500 to Kevin W. Guernsey, "Plastic Conveyor Belts and Modules with Lateral Channels," published December 14, 2006. The disclosure of that publication is incorporated into this description by reference. Modular plastic conveyor belts are constructed of a series of rows of one or more conveyor belt modules linked together at hinge joints. The modules are typically injection-molded out of a thermoplastic polymer, such as polypropylene or  
15 polyethylene. The reversing element 38 at the lower end is realized in this example as a set of idle rollers 50 rotatably mounted on a fixed shaft 52 spanning the width of the conveyor 12, as shown in FIGS. 5 and 6. The top run of the conveyor belt is supported on transverse Z-shaped supports 54, whose corners would be rounded more than shown to prevent catching structure in the inner side of the conveyor belt.

20 A collection trough 56 is attached to the conveyor frame by a pair of short posts 58, as shown in FIGS. 1-4. The trough is positioned below the upper end 19 of the top run 16 of the conveyor so that oil 60 gathered at the submerged lower end 18 of the conveyor and adhering to the outer surface of the belt drops from the belt into the trough as it rounds the rotating drive element. As shown in FIG. 7, a scraper bar 62 extending from a lip of the  
25 trough 56 scrapes residual skimmed material, such as oil, vegetation, or debris, from the belt and directs it into the trough. Panels 64 in the trough give it stability. Openings 66 in the bottoms of the panels allow collected oil to seek a common level across the width of the trough. The bottom 68 of the trough extends below the horizontal plane 34 defined by the float axes 32 of the floats 28. The trough serves as additional flotation means for the skimmer  
30 and provides stability.

As shown in FIG. 8, the top ends of the posts 22, 23, 58 are topped with flat plates 70, 71 for seating the bottoms of the corresponding posts of another skimmer. In this way, skimmers can be stacked one atop the other for convenience during storage or out-of-water transit. Convenient and compact storage can be important because a large supply of skimmers is often needed only during catastrophes, such as oil spills. For the majority of the time, the skimmers have to be kept in storage. Pins 72 upstanding from the longer posts 22, 23 restrict the lateral motion of the stacked skimmers to prevent their posts from accidentally disengaging.

Another version of a skimmer is shown in FIGS. 9-12. The skimmer 75 is similar to that of FIG. 1. But this skimmer has floats, or pontoons 76, that have U-shaped hulls 78, instead of the hexagonal shape of the pontoon of FIG. 1. The pontoon includes a peaked lid 80 and flat end panels 82. The pontoon is shown in this example attached to the lower and upper posts 22, 23 by straps 83. The end panels are angled to connect from the ends of the lid to the shorter bottom of the U-shaped hull. The angled panels help prevent the skimmer from diving underwater when hit by waves or while being pushed or towed in the skimming direction 84 or towed trough-first in the reverse direction 85 when not skimming. The force of the water 86, 86' acting on the angled end panels at the leading end of the skimmer during towing tends to push the leading end of the pontoon upward and prevent diving. Attached to the end panels of the pontoons are attachment members 88 having a number of holes 90 for conveniently attaching fenders 97 or oil-funneling booms (not shown) to the oil skimmer by ropes 87 through the holes 90 or through holes 89 in the straps 83. Eyes 92 at the upper end of the oil-collection trough 56 are provided to lash the skimmer to a boat pushing the skimmer through the water in the skimming direction 84. Eyes 93 on the lower post 22 at about the level of the top of the pontoon are provided for tow lines (not shown) pulling the skimmer in the towing direction 84. Eyes 94 at the bottom of the trough 56 are provided for lines used to tow the skimmer in the reverse direction 85.

The skimmer has a grooved flat hull 91 that is attached to the bottom of the trough 56 and extends almost to the lower posts 22 at the lower end of the conveyor. A cross-beam 100 connects the hull to the frame. Openings across the width of the cross-beam channel water along the length of the hull. Besides protecting the belt in the conveyor return run, the flat

hull allows the skimmer to skim across the waves as it is being towed trough-first at high speed in transit to another location. The trough-formed bow gives the skimmer stability for high-speed towing. The low tow point, together with the flat hull that is below the bottom of the pontoons' hulls, keeps the bow formed by the angled-bottom trough 56 elevated, with the pontoons generally completely above the water line. The sides of the flat hull, except at the end attached to the bottom of the trough and where attached to the cross-beam 100, are not attached to any part of the skimmer's frame. Consequently, water can enter the space 99 above the hull up to the water line when the hull is submerged during skimming and flotation is being provided by the pontoons. Only when the skimmer is being towed trough-first at a speed high enough for the hull to ride atop the waves will water not fill the space above the flat hull. Inverted V-shaped grooves 102 running the length of the flat hull form openings along the end of the hull attached to the trough. The openings at the grooves allow air to enter the space and help push water off the top side 104 of the hull. The openings also allow air and water to drain at the trough end when the oil skimmer is pitched forward. The hull is tangent to the bottom of the lower post 22. Diverter shields 106 mounted to the frame just above the ends of the hull proximate the lower end of the conveyor direct the flow of water from the top side of the hull away from the bottom ends of the posts 22 and the lower end of the conveyor. Additional eyes 95, 96 on the upper and lower posts provide additional attachment points for securing the skimmer. Oil or water may be drained from the trough 56 through a drain hole 98 on the bottom of the trough. Like the posts in the skimmer of FIG. 1, the upper posts 23 in the skimmer of FIGS. 9-12 are shown vertically offset above the level of the lower vertical posts 22. Because the upper and lower posts are the same length, skimmers can be stacked atop one another as in FIG. 8. Any of the features shown in the skimmer 75 of FIGS. 9-12 could be implemented in the skimmer 10 of FIG. 1, and vice versa.

FIGS. 13-15 show three modes of operation of the skimmers. In FIG. 13, the conveyor belt 14 is driven up the inclined upper run 16 by the counterclockwise rotation of the drive sprockets 40 driven by the conveyor motor 44 (FIG. 3). The skimmer is stationary or advances in the forward direction 84. It is shown with a scraper 110 directing skimmed material 112 into a separate collection barge 114 that can replace the collection troughs of the skimmers in FIGS. 1 and 9. This mode of operation (belt moving up incline and skimmer

moving forward) is preferred for collecting thick mats of oil-laden material, floating debris, or vegetation, such as duckweed, from the water surface 116. The mode of operation shown in FIG. 14 works well with thin oil slicks 118. In this mode, the conveyor belt advances up the inclined upper run 16, but the skimmer is stationary or advances in the reverse direction

5 85 to first contact the oil slick on the lower belt run 17. The oil follows the belt downward below the water surface 116, adheres to the belt, and is carried up the inclined upper run to the drive sprockets 40, where the oil can be scraped from the belt by a scraper 110 and directed into a shallow collection tank 120. Unlike the deep collection troughs 56 of the skimmers shown in FIGS. 1 and 9, the shallow collection tank does not extend below the

10 waterline 116 so as not to deflect the oil slick away from the lower run of the conveyor belt. Furthermore, the hull 91 of the skimmer of FIG. 9 and the lateral conveyor supports 54 (FIG. 5) below the waterline are removed to avoid intercepting the oil slick with any structure other than the belt. In this example, the pontoons (28 in FIG. 1 and 76 in FIG. 9) serve as a catamaran-like hull for the skimmer. In a third mode of operation, shown in

15 FIG. 15, the skimmer advances in the forward direction 84, but the belt 14 is driven down the inclined upper run 16 as indicated by the clockwise rotation 122 of the drive sprockets 40. This is also an effective way to collect thin layers of floating oil. The lower end 18 of the conveyor is driven into the slick 124, and the clockwise rotation of the belt at the lower end drags the oil underwater to the lower run 17 of the belt. The oil adheres to the belt and is

20 conveyed upward along the lower run 17 to a scraper 126, which scrapes the oil from the belt into a collection trough (not shown). The conveyor belt can be made bidirectional to operate in any of the three modes by using a selectively reversible conveyor motor (44 in FIG. 3) to drive it. The direction of belt travel can be selected by a switch or the like. Thus, the mode of operation can be changed to adapt the skimmer to various collection

25 scenarios—thin oil slicks, thick, aerated oil clumps, floating debris, or vegetation, such as duckweed.

Although the invention has been described in detail with reference to a couple of versions, others are possible. For example, the floats could be made of foam rather than the hollow pontoons shown. Or the pontoons could be foam-filled to make them leak-proof. The

30 pontoons could be shaped other than hexagonal or U-shaped; they could square, oval,

circular, or octagonal, for example. And the bottom of the trough could be smoothly curved rather than angled. Furthermore, the pontoons could be made shorter, extending from the lower end of the conveyor a shorter distance back toward the upper end.

What is claimed is:

## CLAIMS

1. A skimmer comprising:

a frame;

a pair of floats mounted on opposite outer sides of the frame and having parallel float

5 axes defining a horizontal plane when floating in a body of water;

a belt conveyor mounted to the frame between the pair of floats and defining a

conveying path inclined relative to the horizontal plane between a lower end and an upper end, wherein the belt conveyor includes:

a rotating drive element at the upper end of the belt conveyor;

10 a reversing element at the lower end of the belt conveyor;

an endless conveyor belt trained around the rotating drive element and the reversing element and driven by the rotating drive element along the conveying path including an underwater portion at the lower end of the belt conveyor at which material to be skimmed is captured;

15 a trough positioned below the conveyor belt to catch skimmed material falling off the conveyor belt.

2. A skimmer as in claim 1 wherein the trough has a bottom that extends below the horizontal plane and floats in the body of water.

3. A skimmer as in claim 2 wherein the bottom of the trough is angled to form a bow for  
20 the skimmer.

4. A skimmer as in claim 1 wherein the floats are hexagonal tubes.

5. A skimmer as in claim 1 wherein the floats have a U-shaped hull.

6. A skimmer as in claim 1 wherein the floats have angled end plates to prevent diving.

7. A skimmer as in claim 1 wherein the frame includes vertical posts attached to the outer  
25 sides of the frame and having plates at top ends of the posts for stacking skimmers atop each other.

8. A skimmer as in claim 1 further comprising a pair of lower vertical posts attached to the frame on opposite sides of the conveyor belt near the lower end of the belt conveyor and a pair of upper vertical posts attached to the frame on opposite sides of the conveyor belt

near the upper end of the belt conveyor, wherein the lower vertical posts are vertically offset from the upper vertical posts.

9. A skimmer as in claim 8 further comprising a flat horizontal plate at a top end of each of the upper and lower vertical posts.

5 10. A skimmer as in claim 1 wherein the belt conveyor further includes a plurality of Z-shaped transverse supports supporting the conveyor belt between the upper and lower ends of the belt conveyor.

11. A skimmer as in claim 1 further comprising a grooved flat hull attached to the trough and extending below the belt conveyor to the lower end, wherein the flat hull is below  
10 the bottoms of the pair of floats.

12. A skimmer as in claim 1 wherein the trough does not extend below the horizontal plane.

13. A skimmer as in claim 1 comprising a selectively reversible conveyor motor rotating the rotating drive element and selectively changing the direction of travel of the conveyor belt along the conveying path.

15 14. A skimmer as in claim 1 further comprising a scraper contacting the conveyor belt proximate the trough to scrape skimmed material from the conveyor belt and direct the skimmed material into the trough.

15. A skimmer comprising:

a frame;

20 a pair of floats mounted on opposite outer sides of the frame and having parallel float axes defining a horizontal plane when floating in a body of water;

a belt conveyor mounted to the frame between the pair of floats and defining a conveying path inclined relative to horizontal plane between a lower end and an upper end, wherein the belt conveyor includes:

25 an endless conveyor belt arranged to advance along the conveying path including an underwater portion at the lower end of the belt conveyor at which material to be skimmed is captured;

a selectively reversible motor to selectively drive the conveyor belt in either direction along the conveying path;

a trough positioned below the conveyor belt to catch skimmed material falling off the conveyor belt.

16. A skimmer as in claim 15 wherein the trough has a bottom that extends below the horizontal plane and floats in the body of water.

5 17. A skimmer as in claim 16 wherein the bottom of the trough is angled to form a bow for the skimmer.

18. A skimmer as in claim 15 wherein the floats are hexagonal tubes.

19. A skimmer as in claim 15 wherein the floats have a U-shaped hull.

20. A skimmer as in claim 15 wherein the floats have angled end plates to prevent diving.

10 21. A skimmer as in claim 15 wherein the frame includes vertical posts attached to the outer sides of the frame and having plates at top ends of the posts for stacking skimmers atop each other.

22. A skimmer as in claim 15 further comprising a pair of lower vertical posts attached to the frame on opposite sides of the conveyor belt near the lower end of the belt conveyor and  
15 a pair of upper vertical posts attached to the frame on opposite sides of the conveyor belt near the upper end of the belt conveyor, wherein the lower vertical posts are vertically offset from the upper vertical posts.

23. A skimmer as in claim 22 further comprising a flat horizontal plate at a top end of each of the upper and lower vertical posts.

20 24. A skimmer as in claim 15 wherein the belt conveyor further includes a plurality of Z-shaped transverse supports supporting the conveyor belt between the upper and lower ends of the belt conveyor.

25 25. A skimmer as in claim 15 further comprising a grooved flat hull attached to the trough and extending below the belt conveyor to the lower end, wherein the flat hull is below the bottoms of the pair of floats.

26. A skimmer as in claim 15 wherein the trough does not extend below the horizontal plane.

30 27. A skimmer as in claim 15 further comprising a scraper contacting the conveyor belt proximate the trough to scrape skimmed material from the conveyor belt and direct the skimmed material into the trough.

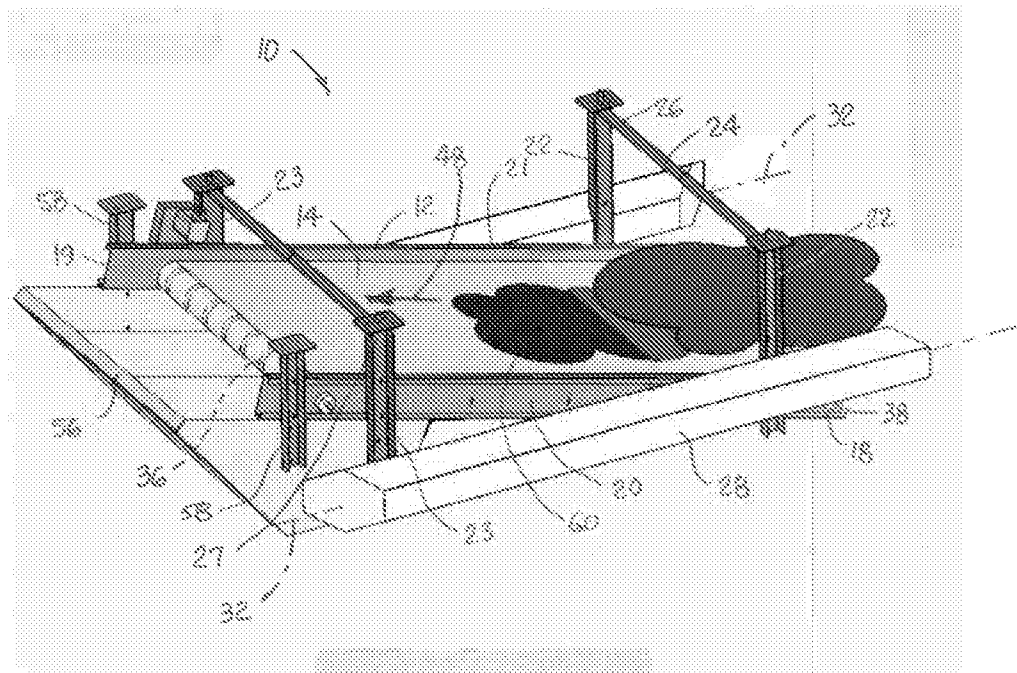


FIG. 1

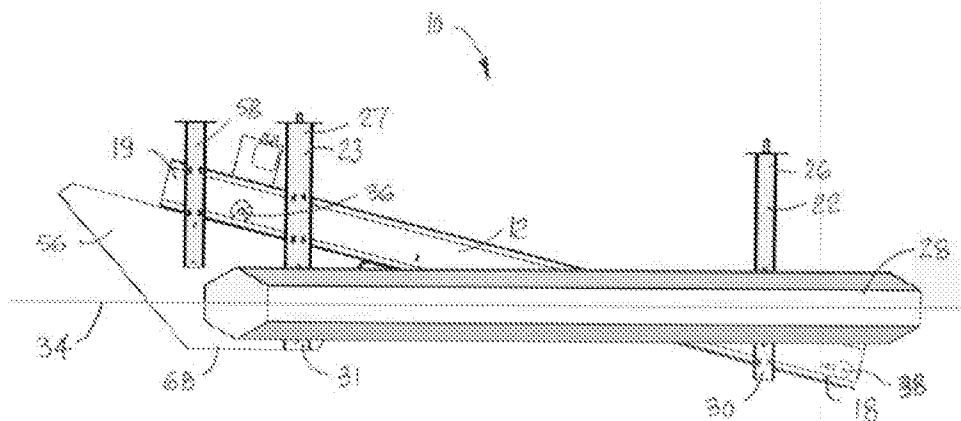


FIG. 2

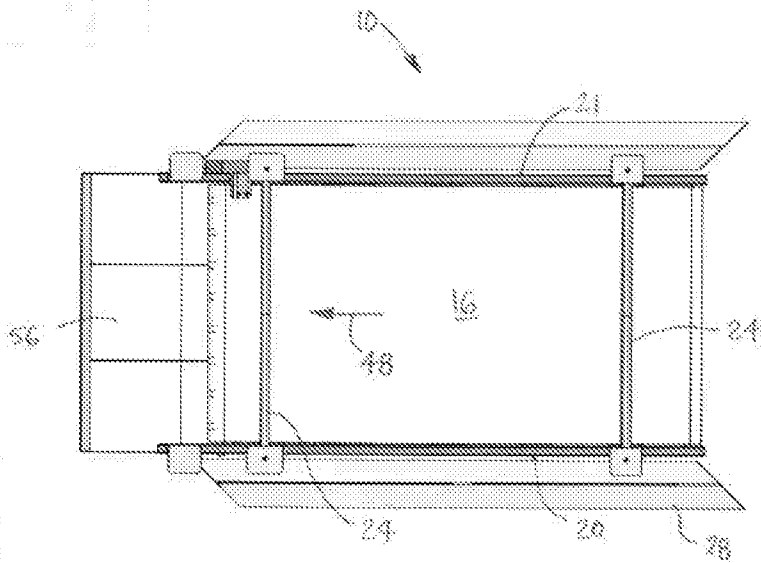


FIG. 3

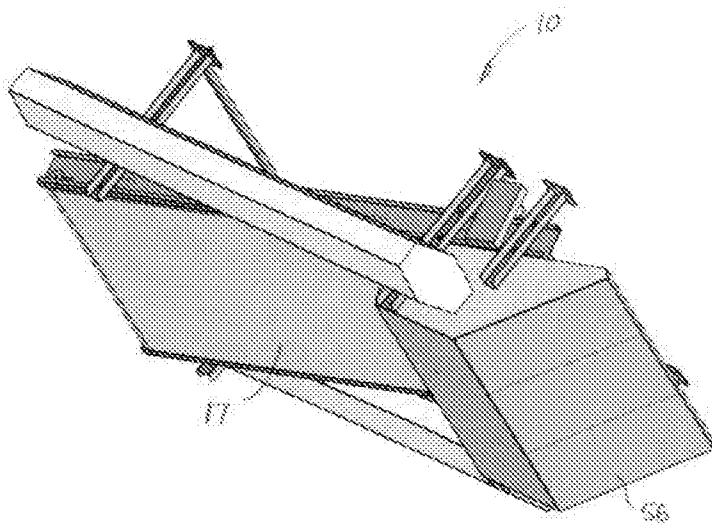


FIG. 4

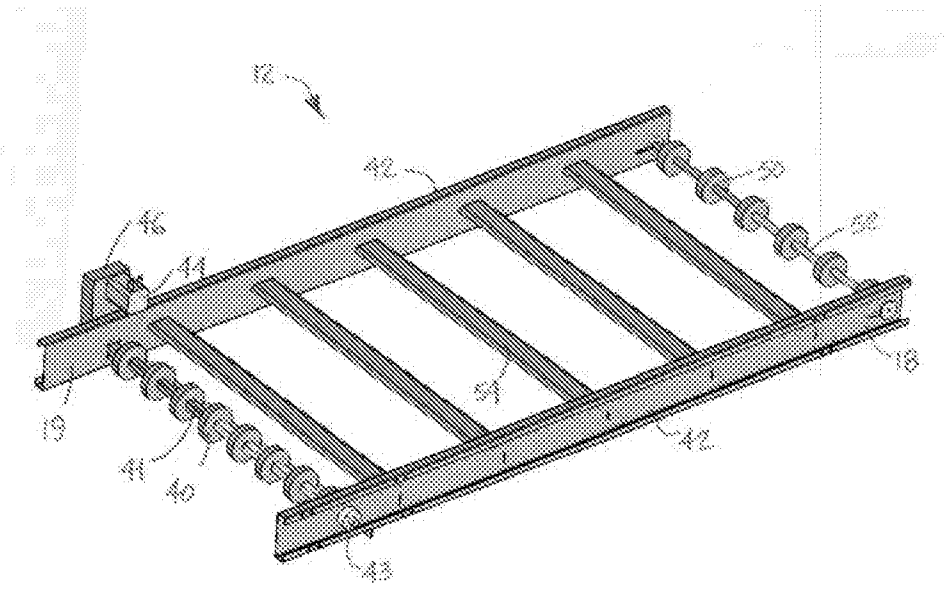


FIG. 5

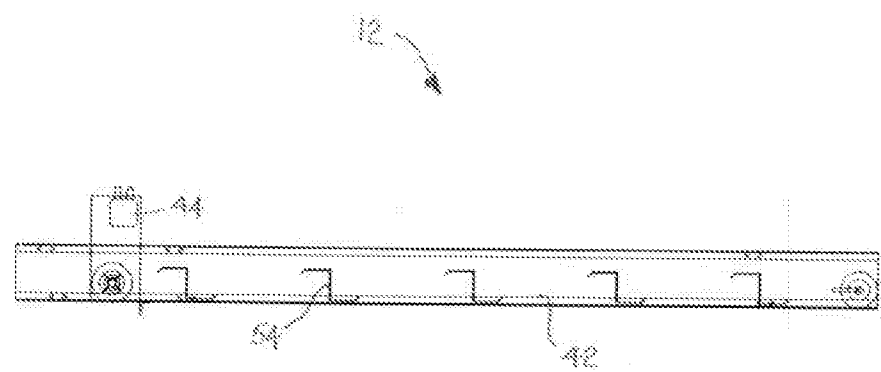


FIG. 6

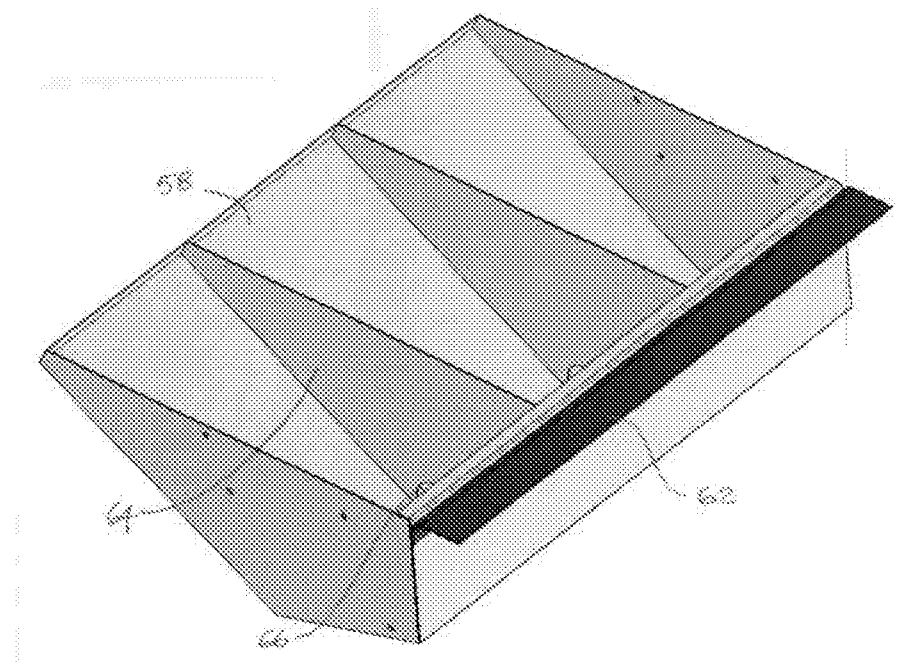


FIG. 7

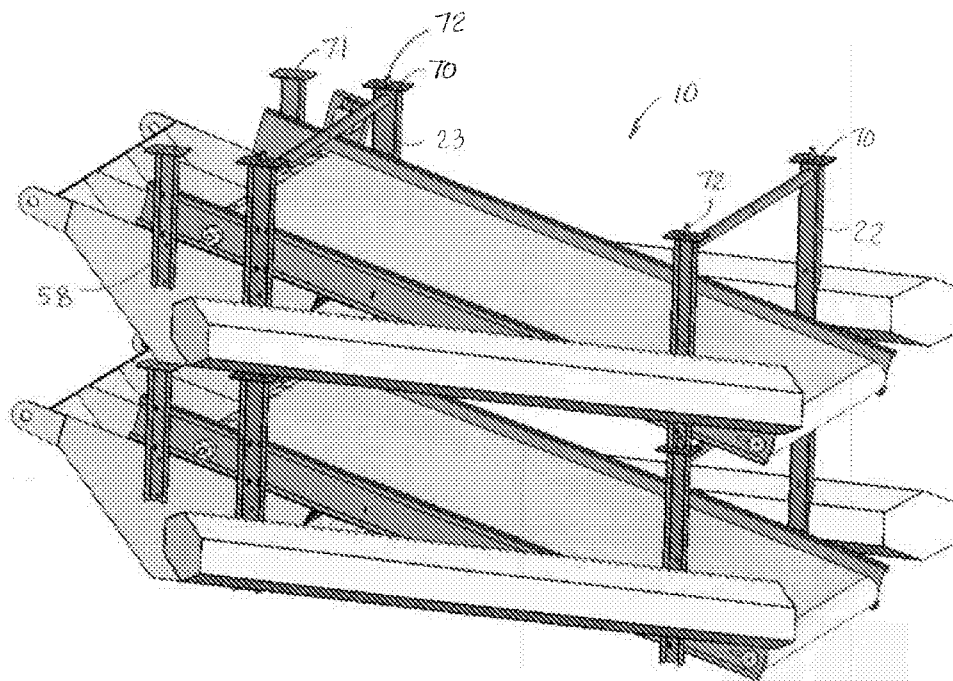


FIG. 8

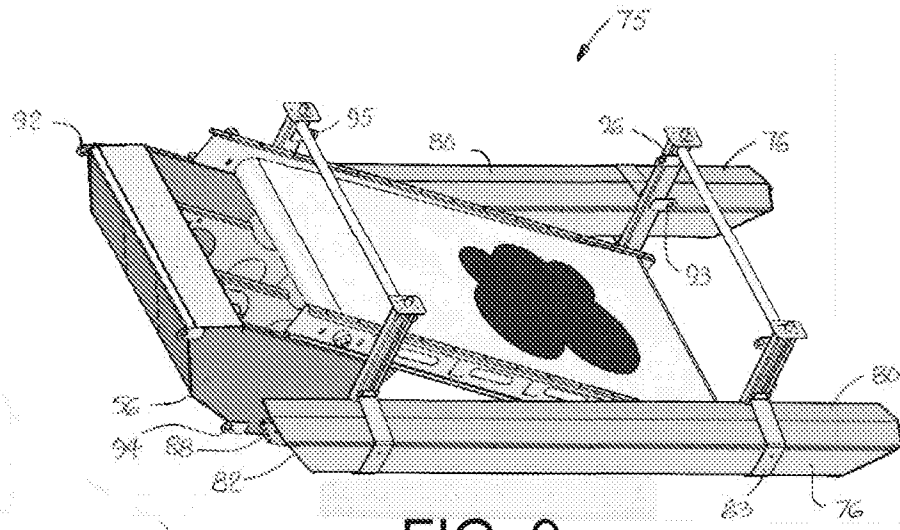


FIG. 9

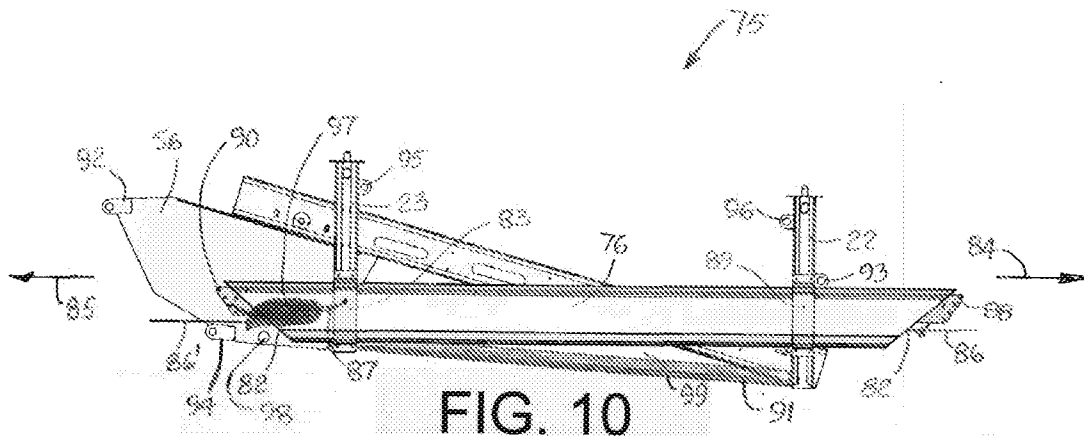
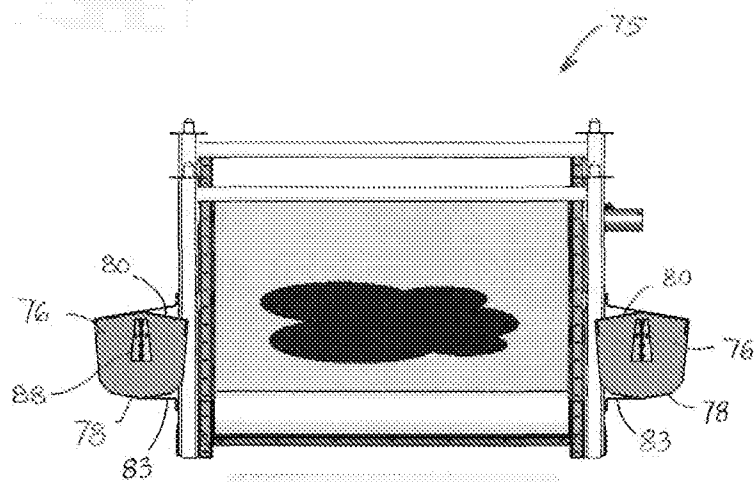


FIG. 10



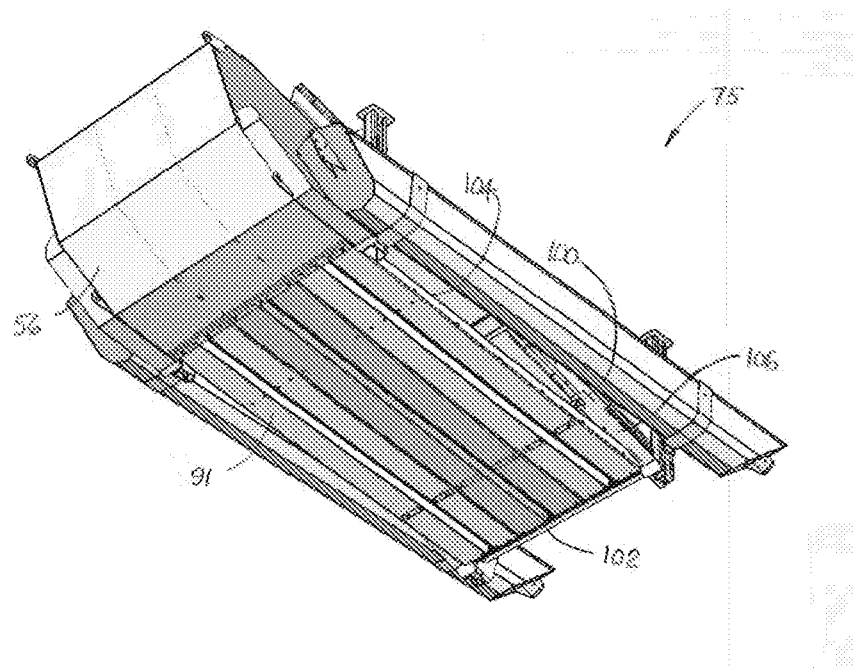


FIG. 12

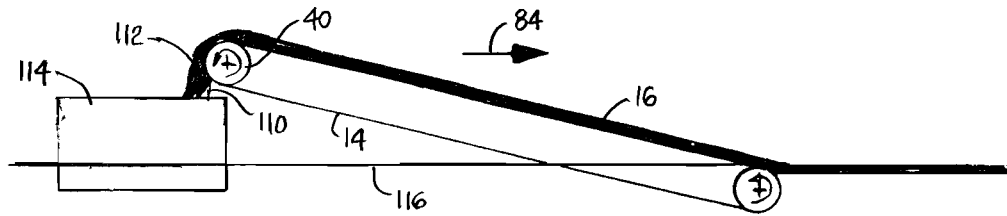


FIG. 13

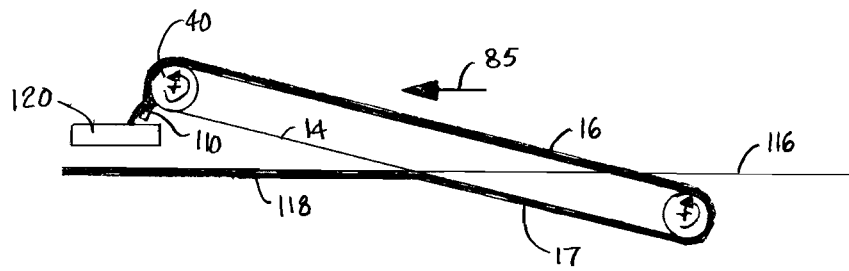


FIG. 14

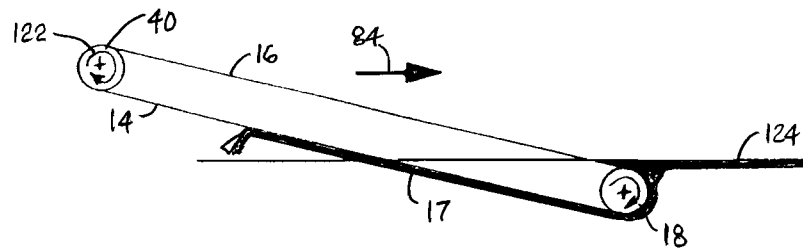


FIG. 15

# INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 1/43194

## A. CLASSIFICATION OF SUBJECT MATTER

**IPC(8) - E02B 15/04 (2011.01)**

**USPC - 210/242.3: 210/923**

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)

USPC - 210/242.3; 210/923

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

USPC - 210/242.3; 210/923 (keyword delimited) DialogPro: Chemical Engineering and General Research

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WEST: US Patents full-text; US PGPubs full-text; EPO Abstracts; and JPO Abstracts; Google

Search Terms Used: Skimmers, oil spills, floats (pontoon), frame, belt conveyor, scraper, trough, rotating drive, shaft, gear box, sprocket

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No.       |
|-----------|------------------------------------------------------------------------------------|-----------------------------|
| X         | US 5,753,108 A (Haynes et al.) 19 May 1998 (19.05.1998); See cols 1-14             | 1,4-9,12-15,18-23, 26, 27   |
| Y         |                                                                                    | 2, 3, 10, 11,16, 17, 24, 25 |
| Y         | US 5,362,391 A (Stephens) 08 November 1994 (08.11.1994); cols 5-8                  | 2, 3, 10, 11,16, 17, 24, 25 |
| Y         | US 7,410,577 B2 (Broje) 12 August 2008 (12.08.2008); col 6, Ins 30-33              | 11, 25                      |

☐ Further documents are listed in the continuation of Box C.

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Date of the actual completion of the international search

28 Nov. 2011 (28.11.2011)

Date of mailing of the international search report

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