# United States Patent [19]

**Brown**

[11] **3,709,357**

[45] **Jan. 9, 1973**


[54] **FLEXIBLE HELICAL CONVEYOR FOR LIQUIDS**


[76] Inventor: **Kenard D. Brown,** 1227 South Willow Street, Casper, Wyo. 82601



[22] Filed: **May 8, 1970**

[21] Appl. No.: **35,628**

**Related U.S. Application Data**

[63] Continuation-in-part of Ser. No. 808,054, March 18, 1969, abandoned.

[52] **U.S. Cl.** ..... **198/213**

[51] **Int. Cl.** ..... **B65g 33/00**

[58] **Field of Search** ..... 198/213; 417/61; 210/242; 415/72, 73, 74



[56] **References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 3,360,108 | 12/1967 | Voss | 198/213 |
| 1,983,962 | 12/1934 | Barber et al. | 198/213 X |
| 2,438,637 | 3/1948 | Jansen | 198/213 X |
| 2,045,757 | 6/1936 | Constantin | 198/213 |



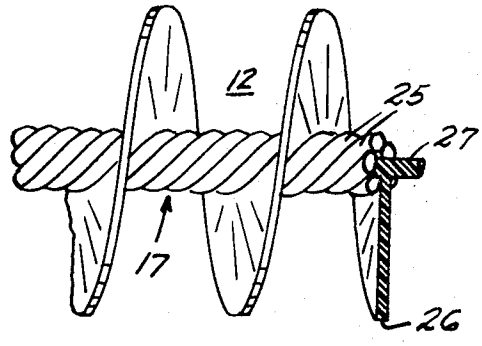
*Primary Examiner*—Richard E. Aegerter
*Assistant Examiner*—Harold S. Lane
*Attorney*—McGrew & Edwards



[57] **ABSTRACT**

A system for removing light fluid such as oil from heavy fluids such as water comprises an extended length of open screw conveyor constructed of material such that it will float on water. The conveyor may comprise a helical fin having a central bead or core about which stranded cables are wound, the stranded cables may be of steel wire or plastic and when the conveyor is required to float on water plastic materials are employed for all parts of the conveyor. The conveyor is connected to two spaced motor vessels one end being pivotally connected to one of the vessels for free rotation and the other end passing up into the other vessel through a surrounding conduit and being rotated by a motor mounted on the other vessel. A reservoir is provided in the other vessel to collect the liquid. During operation the cable is rotated in a direction to draw the liquid toward the reservoir vessel and the two vessels are moved forward to sweep an area covered with oil or other lighter fluid. In another embodiment the flexible helical drive member is housed in a flexible tubing having a longitudinal opening for admitting the lighter liquid from the surface of the body of heavy liquid, the entire assembly thus formed floats on the body of liquid.


**7 Claims, 17 Drawing Figures**



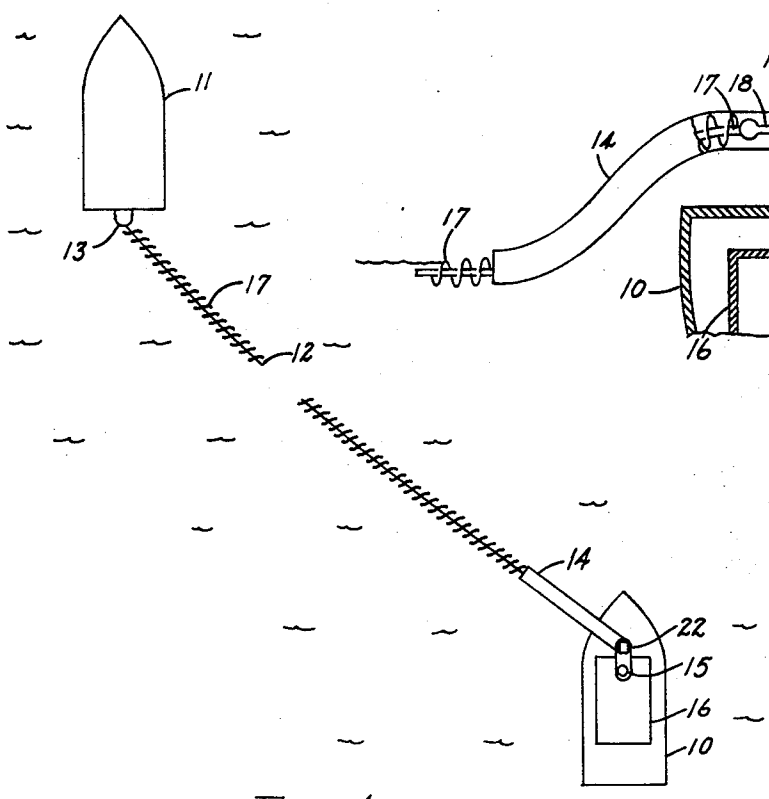



Fig. 1




Fig. 2

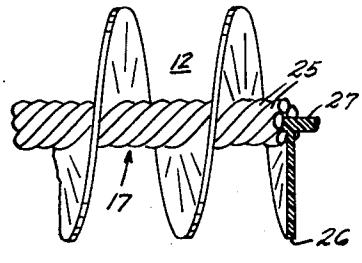



Fig. 3

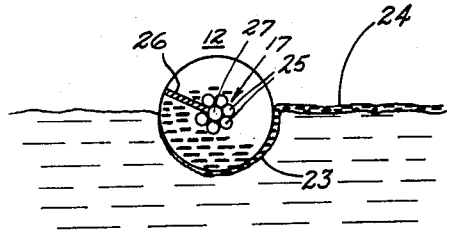



Fig 4

INVENTOR
KENARD D. BROWN

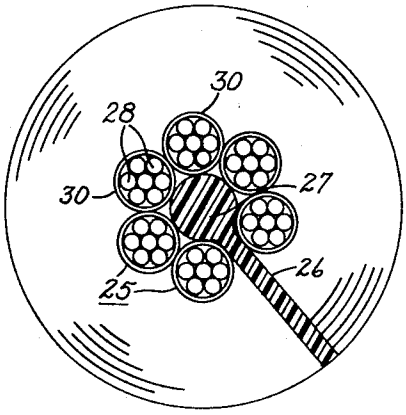



Fig. 5

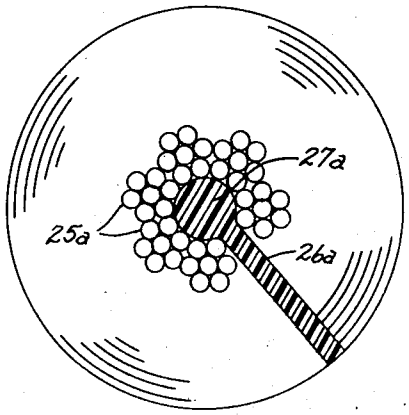



Fig. 6

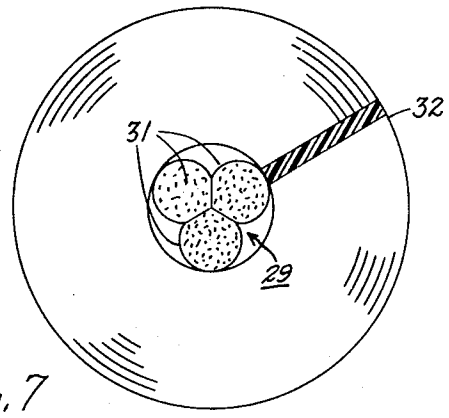



Fig. 7

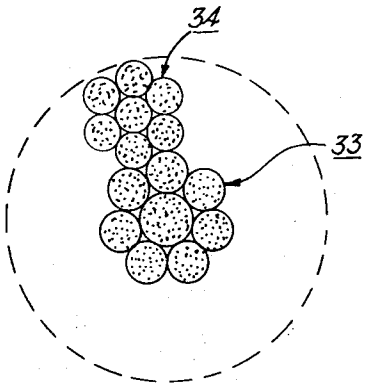



Fig. 8

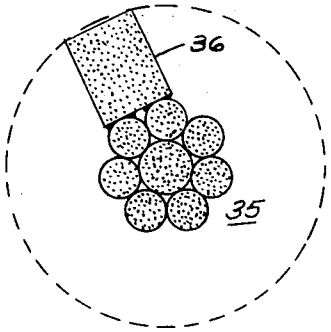



Fig. 9

INVENTOR
KENARD D. BROWN

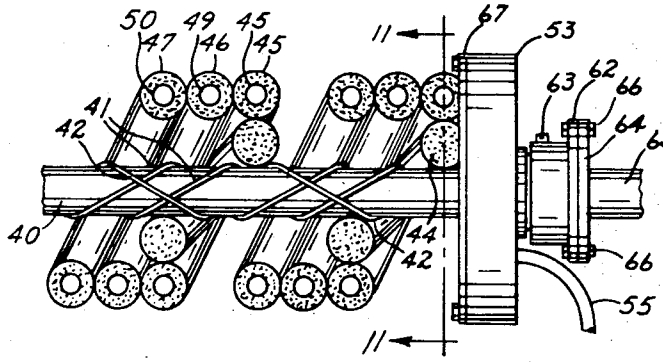



FIG. 10

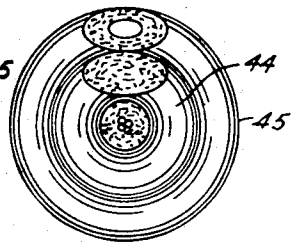



FIG. 11

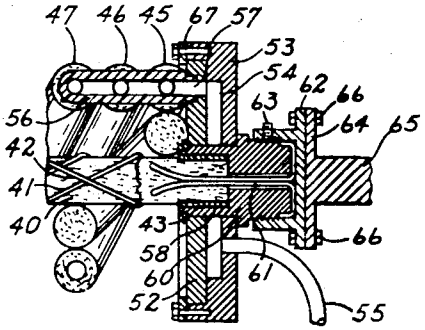



FIG. 12

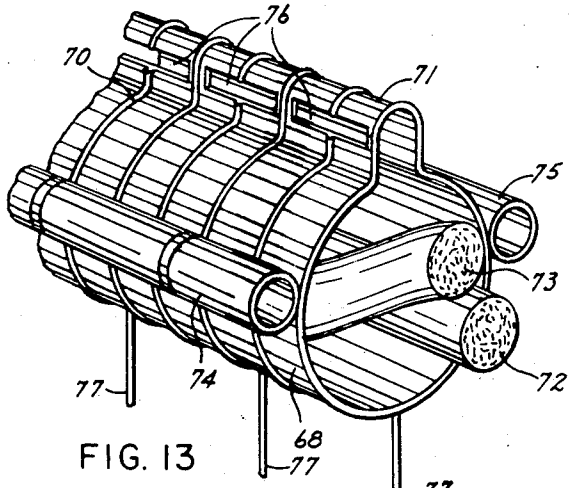



FIG. 13

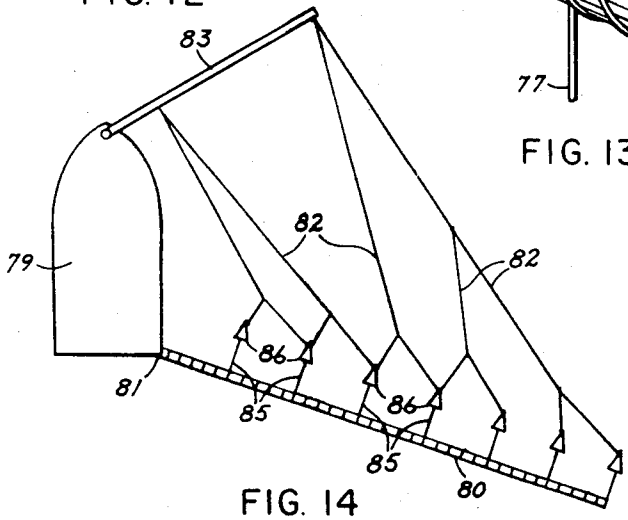



FIG. 14

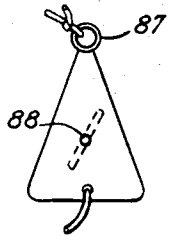



FIG. 15

INVENTOR.
KENARD D. BROWN

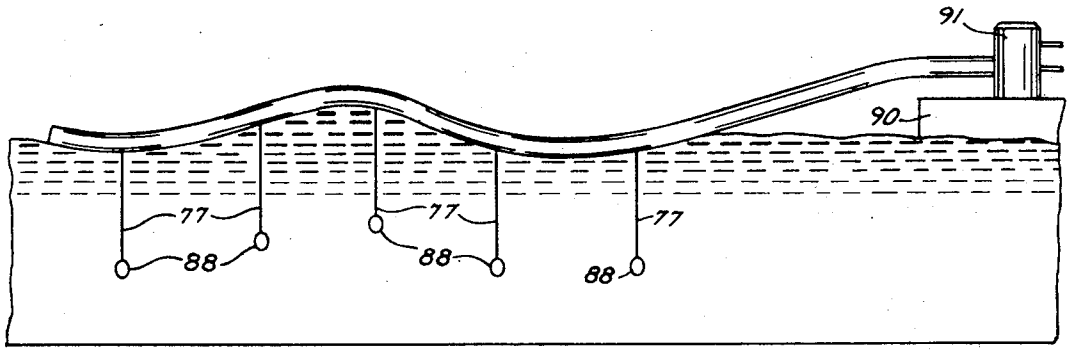



FIG. 16

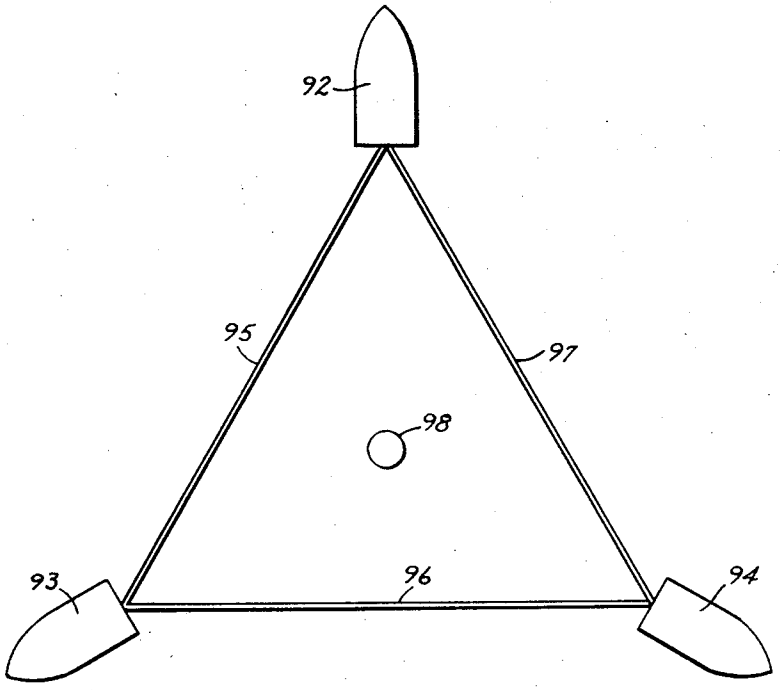



FIG. 17

INVENTOR.
KENARD D. BROWN

# FLEXIBLE HELICAL CONVEYOR FOR LIQUIDS

This application is a continuation-in-part of the applicant's co-pending application, Ser. No. 808,054 filed Mar. 18, 1969, now abandoned.

This invention relates to flexible conveyor systems of the screw type and particularly to an improved system for sweeping the surface of a liquid such as water on which there is a layer of a lighter liquid such as oil.

Various arrangements have been proposed and tried for effecting the removal of oils from the surface of water and particularly for removing large quantities of oil such as are released when a tanker is broken open or an underwater oil well leaks oil. These arrangements have included chains of logs drawn across the water by boats and suction devices for collecting the oil accumulated within the barrier thus formed. Such devices have proved successful to some extent, however, they have not been satisfactory for all applications and the use of vacuum devices for removing oil tends to result in removing substantial amounts of water with the oil, and it is, therefore, necessary to settle out the oil after it has been collected in a reservoir. Furthermore, the procedures embodied thus far have been relatively slow in operation. It is desirable to provide a simple and more effective arrangement for removing a lighter liquid from the surface of a body of heavier liquid and, accordingly, it is an object of the present invention to provide an improved helical conveyor suitable for removing oil or other light liquids from the surfaces of bodies of water or other relatively heavy liquids.

It is another object of this invention to provide an improved flexible screw or helical conveyor suitable for conveying fluid material through flexible tubing.

It is another object of this invention to provide a flexible screw type conveyor which is of rugged but lightweight construction and can float on water.

It is a further object of this invention to provide a flexible screw type conveyor including an improved arrangement for retaining fluids against outward movement during rotation of the conveyor.

It is a still further object of this invention to provide a flexible screw type conveyor capable of floating on water and including an improved arrangement for adjusting the buoyancy thereof.

Briefly, in carrying out the objects of this invention in one embodiment thereof, an extended helical or screw type conveyor is constructed by providing a helical fin formed with a bead or bulb adjacent its center and bound by stranded cables wrapped about the central bead and holding the helical fin securely in position. The resulting conveyor is flexible and by constructing the fin and cable components of suitable high tensile synthetic plastic material the conveyor may be made to float on water. The system eploying this conveyor includes two motor driven vessels between which a length of the conveyor is supported and allowed to float on the water. One end of the conveyor is attached to one of the vessels by a universal pivot, such as a ball joint, and the other end is attached to be driven by a motor in the other vessel. During operation the cable is rotated in a direction to move fluid along the cable toward the driven end of the cable and a reservoir is provided on the vessel at that end of the collection of light fluids flowing toward the cable from the surface of the water. In order to raise the collected oil or other



like fluids to the reservoir the end of the cable near the reservoir vessel is surrounded with a suitable tubing thereby providing a spiral pump to lift the liquid into the vessel and deliver it to the reservoir.

In another embodiment the flexible screw or auger member is enclosed in a flexible tubing having a longitudinal opening facing to one side for admitting to the conveyor light liquid from the surface of the body of heavier liquid.

The features of novelty which characterize this invention are pointed out with particularity in the claims annexed hereto and forming a part of this specification. The invention itself however both as to its organization and method of operation together with further objects and advantages thereof will best be understood upon reference to the following description taken in connection with the accompanying drawings in which:

FIG. 1 is a diagrammatic plan view of the system of sweeping oil from water embodying this invention;

FIG. 2 is an enlarged side elevation view of the reservoir vessel of the system of FIG. 1;

FIG. 3 is an enlarged side elevation of a portion of the conveyor of FIGS. 1 and 2;

FIG. 4 is an enlarged sectional elevation view of the conveyor of FIGS. 1 and 2 shown floating on the surface of a body of water;

FIG. 5 is a somewhat diagrammatic cross sectional view of the helical conveyor of FIG. 1 when constructed entirely of plastic materials;

FIG. 6 is a cross sectional view similar to FIG. 5 illustrating another embodiment of the conveyor construction;

FIGS. 7, 8 and 9 illustrate further embodiments of the conveyor wherein a helical member is bonded to a central tension carrying rope, the helical member in FIGS. 8 and 9 being ropes and the rope of FIG. 9 being of rectangular cross section;

FIG. 10 is a side elevation view partly in section illustrating another embodiment of the invention;

FIG. 11 is a sectional view along the line 11—11 of FIG. 10;

FIG. 12 is a sectional view of the end fitting for the rotor of FIG. 11;

FIG. 13 is a perspective view of a short section of conveyor illustrating another embodiment of the invention;

FIG. 14 is a plan view of a towing system for a conveyor of the type of that of FIG. 13;

FIG. 15 is an enlarged view of a portion of an outrigger float of the conveyor of FIG. 14;

FIG. 16 is a side elevation view of the conveyor of FIG. 13 illustrating its use during wave action; and

FIG. 17 is a plan view of an oil removing system employing conveyors of this invention arranged on a body of water in surrounding relationship to a source of oil or other light liquid.

Referring now to the drawings, there is illustrated in FIG. 1 a system for sweeping a layer of oil from water wherein two power boats 10 and 11 are provided and are positioned to travel along spaced parallel courses. An open or unconfined flexible helical conveyor 12 extends between the boats and moves laterally with respect to the surface of the water. The conveyor 12 is constructed of synthetic plastic materials which are lighter than water so that the conveyor can float on the

water. The lefthand end of the conveyor **12** as viewed in FIG. **1** is connected to the boat **11** by a free swivel connection indicated at **13** and the righthand end of the conveyor is anchored to the boat **10**. The righthand end of the conveyor passes through a tube **14** which extends from the surface of the water up into the boat and a motor **15** is mounted in the boat adjacent the conveyor and is connected to rotate the conveyor in a direction tending to move liquid along the conveyor toward the boat **10**. Liquid moved along the conveyor is confined when it reaches the tubing **14** in which it fits with minimum clearance and is thereby delivered to a reservoir **16** in the boat.

FIG. **2** is a diagrammatic illustration with the conveyor substantially enlarged in cross section and showing the manner in which oil or other fluid collected by the conveyor may be moved up into the boat and thence into the reservoir **16**. This figure also indicates diagrammatically the driving mechanism for the conveyor. The central shaft of the conveyor, indicated at **17**, is securely attached to a shaft **18** rotatably mounted on the boat on a bearing block and spider assembly **19** and having bevel gears **20** and **21** arranged between the block and driven by the motor **15** through a variable speed transmission **22**. The oil pumped by rotation of the conveyor **12** moves upwardly through the tube **14** and past the spider assembly including the gears **20** and **21** and thence to the reservoir **16**, as indicated by arrows. The conveyor tube **14** is rotatable about the vertical axis of the gear **21**, so that it may be swung to desired positions around the bow of the boat **10**.

The conveyor as illustrated in FIG. **2** is rotated in a counterclockwise direction as viewed from the left end of the conveyor. The conveyor floats on the water and when it is rotated forms a trough **23**, as indicated in FIG. **4**. Oil or other light liquid floating on the surface of the water, as indicated at **24**, flows into this trough and as the conveyor is rotated moves along the trough toward the boat **10**. As the boats move together along their parallel courses the conveyor is drawn through the water so that the trough **23** travels laterally over the surface and sweeps the surface of the water at the same time drawing the oil longitudinally of the conveyor toward the boat **10** and into the reservoir **16** thereby removing oil from the surface of the water. By selecting a speed of operation of the rotation of the conveyor **12** and of movement of the boats relatively to the water it becomes possible to move substantially only oil toward the tube **14** and thereby lift oil with little, if any, water with it into the reservoir **16**. In the position of the boats in FIG. **1**, the water is assumed to be moving directly downwardly past the conveyor; the angular position or slope of the conveyor tends to direct the liquid toward the boat **10** and thus aids the movement of the liquid produced by rotation of the conveyor.

As shown in FIG. **4** the conveyor **12** comprises the core **17** which is a stranded cable comprising a plurality of individual strands **25** and a helical fin or screw **26** as shown in FIG. **3** the screw **26** is formed integrally with a central bead **27** which is locked within the strands **25** of the cable. A screw conveyor constructed in the manner illustrated is highly flexible and may be employed for many screw conveyor purposes and since it may be made in long lengths it is useful not only for sweeping purposes as illustrated in FIG. **1** but for pumping purposes wherein it is confined in a flexible tubing and employed to convey flowable substances including liquids and materials such as grain or silage. For the purpose of sweeping the surface of water as illustrated in FIG. **1**, the components of the conveyor are constructed of synthetic plastic materials such as nylon having specific gravity less than that of water so that the conveyor will float on the water.

FIG. **5** illustrates the cross section of the cable when constructed of plastic materials the fin or screw member **26** and its center bead **27** being formed integrally and being held securely in the center of a cable comprising six strands **25** each of which comprises a conventional seven strand cable built up from high tensile plastic filaments **28** and encased in a tight fitting plastic tube **30**. The figure is diagrammatic in that the cross sections of the strands **28** have been shown as circle rather than ellipses. The friction between the several plastic components is relatively low and on bending of the conveyor the components tends to move and accommodate the distortions while maintaining their relative positions and assuring secure holding of the helical blade in its required position.

In FIG. **6** another embodiment of the conveyor construction is illustrated, and comprises a blade **26*a*** having a central bead **27*a*** and securely bound in a cable comprising a plurality of steel wires **25*a***. The wires are formed in six cables each comprising the conventional seven strands of wire. For the purpose of minimizing friction in this construction each of the wires is preferably coated with a plastic material which reduces the friction between the wires and affords slight relative movements of the components of the conveyor while maintaining them in their required relative positions, thereby providing a more flexible conveyor construction. The construction of FIG. **6** provides increased tensile strength over that of the plastic cable of FIG. **5** and is particularly suited to the application to closed conveyors wherein the extended length of flexible conveyor is arranged within a tube for forcing flowing material through the tube.

Various other forms of conveyor may be constructed to provide the helical driving fin about a main tension carrying member. For example, as illustrated in FIG. **7**, a nylon rope **29** illustrated as comprising three rope strands **31** may be provided with a helical fin **32** which may, for example, be machined from a thick walled nylon tube and is arranged about the rope **31** in engagement with the rope along the inner edge of the helix. The helix is cemented or otherwise securely attached to the rope along its inner edge either continuously or at spaced intervals.

Another configuration of conveyor suitable for some applications is that indicated in FIG. **8** wherein a main rope **33** shown as of a seven stranded configuration is employed as the main core or tension carrying member. A second similar rope **34** is arranged in helical configuration along the length of the rope **33** and is cemented or otherwise attached to the rope **33** in a manner similar to the attachment of the fin **32** to the rope **29** of FIG. **7**, the circumferential outline of the helix being indicated by a dotted circle.

The type of rope selected for this conveyor depends upon its intended use; for floating conveyors the ropes are of nylon or other high tensile strength light

synthetic plastic. The cross section of the helically wrapped rope forming the conveyor is also selected in accordance with the intended use. Woven nylon ropes may be employed for the helix and for a relatively short pitch helix such ropes of rectangular cross section, as shown in FIG. 9, provide effective conveyor action. In FIG. 9, the central tension rope, indicated at 35, is a conventional nylon rope and is wrapped with helical rope 36 which is a woven or braided nylon rope of rectangular cross section.

Another form of rotor suitable for application in the system and method of the present invention is illustrated in FIGS. 10 and 11. This rotor includes a central tension carrying rope 40 of light synthetic plastic such as nylon and which is bound together tightly by a plurality of cables each comprising a cable wire coated with a synthetic plastic such as nylon and which is stretched in helical, configuration about the rope 40. Two of these cables, indicated at 41, are wrapped about the rope 40 in one direction and a third cable 42 is wrapped about the rope in the opposite direction. These cables enter the core of the rope 40 near the right end, as indicated, and pass through the center and out the end of the rope; a metal band 43 is provided about the end of the rope to clamp the end in its round configuration. The helical drive member of the rotor of FIG. 10 comprises a second rope 44 wrapped helically about the rope 40 and securely cemented or otherwise bonded thereto. Three additional ropes 45, 46 and 47 are arranged to complete the helix and to form a channel shaped pocket facing inwardly toward the rope 40 and defined by the rope 44 and the three ropes 45, 46 and 47. This pocket minimizes the outward movement of liquid radially away from the rope 40, the rope being rotated to move the liquid to the left as viewed in FIG. 10. The rope 45 is cemented or otherwise bonded to the rope 44 and the ropes 46 and 47 are secured to the ropes 45 and 46, respectively, the rope 47 having a slightly lesser radius of curvature than the other ropes provides the cup or channel shaped pocket about the outer periphery of the helix. The pocket formed by the ropes in the manner illustrated in FIG. 10 retains liquid within the helical pocket and is particularly useful when the rotor is employed as a free rotating element floating in the water.

The rotor of FIG. 10 may be employed in the same manner as the rotors previously described for the purpose of removing oil or similar liquids from the surface of a body of water. For some applications, it may be desirable to provide greater buoyancy than that available with the light plastic alone, and it also may be desirable to adjust the degree of buoyancy. For this purpose, gas chambers may be provided in the structure of the rotor.

As illustrated in FIGS. 10 and 11, each of the ropes 45, 46 and 47 is provided with a hollow tubular center indicated at 48, 49 and 50, respectively. The tubes forming the centers are constructed of a fluid tight material and the buoyancy of the rotor may be changed by changing the fluid content of these tubes. For example, gas such as air may be pumped into the tubes at selected pressures to provide buoyancy as desired, the opposite ends of the tubes being sealed by clamping or in any other suitable manner.

In order to supply the fluid to the tubes 48, 49 and 50, a rotating fluid transfer coupling is provided as illustrated in FIG. 12. This coupling comprises a rotatable member 52 to which the center rope 40 and the cables 41 and 42 are attached and a stationary outer coupling member 53 of cup shape configuration which surrounds the member 52 and is provided with a passage 54 connected with a supply pipe 55 through which air or other fluid at the desired pressure may be admitted. In the embodiment illustrated, the three tubes of the ropes 45, 46 and 47 are connected to a manifold 56 which enters a passage 57 in the rotor 52 and is in communication with the chamber 54. The members 52 and 53 are provided with flat faces in running engagement to form a suitable rotating seal and minimize leakage during relative movement of the two members. The cables 41 and 42 pass from the end of the rope 40 which is seated within a cylindrical recess 58 in the hub of the rotor 52, indicated at 60. The cables are then drawn through an axial passage 61 in the hub and are wrapped around the outer end of the hub and back over the outside thereof where they are clamped into position by a cap coupling 62 which is threaded on the hub 60 and clamps the cables against the end of the hub and between the hub and the cap. The cap may be locked in its clamped position by one or more set screws, one of which is shown at 63. The rotor is connected to the driving motor of the system, which may be the motor 15 of FIG. 2, by a suitable shaft coupling shown as comprising a plate 64 at the end of a drive shaft 65; the plate is attached to the coupling member 62 by suitable bolts 66.

The rotor 52 and stationary member 53 are held in operative relationship by retaining members, indicated generally at 67, suitable spring members (not shown) may be employed to maintain the relatively rotatable elements of the fitting in close sealing engagement for minimizing the leakage of fluid.

A further modification of the fluid conveyor for use in the present invention is illustrated in FIG. 13. In this conveyor a helical rope drive member, which has been illustrated as that of FIG. 8, is arranged within a flexible tube 68 of suitable lightweight synthetic plastic material which may be reinforced with glass fibers or other fibrous material. The tube has been illustrated as comprising a thin wall having a helical wire 70 wrapped about and bonded to it to provide the required stiffness of the tube wall while affording flexibility. The tube is provided with an upstanding inverted trough-like portion 71 providing an offset upstanding channel and the main tube has an internal diameter sufficiently large to afford free rotation of the rotor. The rotor comprises a central tension rope 72 and a helically formed rope 73 bonded to the central rope. Horizontal tubes of synthetic plastic material, indicated at 74 and 75, are cemented or otherwise secured to the sides of the tube 68 to provide the desired amount of buoyancy for holding the upper side of the assembly near the surface of the water and in an upright position where oil or other light fluid floating on the surface may be removed through a longitudinal opening. The longitudinal opening has been illustrated as constituting a multiplicity of rectangular openings 76 formed by individual openings between the turns of the wire 70. In the illustrated embodiment every other turn of the wire has been cut at

the openings so that each opening has a length twice that of the wire spacing. The tubular rotor assembly as illustrated in FIG. 13 may be made of extended length and be floated on water and is sufficiently flexible to follow swell or wave action. For the purpose of facilitating this following of the wave action, a plurality of drop weights are secured to the bottom of the tube 68 on lines 77.

The tubular conveyor assembly of FIG. 13 may be employed in a manner similar to the assemblies of the embodiments illustrated hereinabove for the purpose of sweeping an area of water to remove oil or other relatively light fluids floating thereon. The buoyancy of the tubular assembly may be adjusted in a manner similar to that employed with the rotor of FIGS. 10, 11 and 12 either by connecting the desired fluid supply to the buoyant member 74 and 75 or by employing in the tube 68 the rotor of FIG. 10.

The conveyor assembly of FIG. 12 may also be employed with a single boat 79 and a bridle hitch as illustrated in FIG. 14; in this application a length of the conveyor, indicated at 81 and is held by bridle lines 82 in a generally straight line. To facilitate the connection of the bridle lines, a boom 83 may be attached to the forward end of the boat 79. In addition, in order to stabilize the conveyor assembly, outriggers 85 are employed, each outrigger comprising a rigid arm and a float 86 which has been shown in generally triangular configuration, an enlarged view of the float being illustrated in FIG. 15. The bridle lines are connected to the floats at eyes 87 provided for this purpose and a vane 88 is provided on the bottom of each float and may be adjusted to provide varying degrees of bias of the float away from the boat 79.

The action of the assembly of FIG. 13 on water on which there is a swell is indicated in FIG. 16 where the drop lines 77 have been illustrated as carrying weights 88 at their bottom ends. The buoyancy of the assembly is adjusted so that the weights are carried while the inlet opening of the tubing 68 lie adjacent the surface of the body of water. The action of the weights together with the buoyancy of the conveyor assembly facilitates the action of the assembly in following the configuration of the waves, and assures more effective pick up of the lighter fluid floating on the surface which passes through the series of openings comprising the slot 76 along the side of the top ridge of the tube 68. In FIG. 16 the assembly has been illustrated as secured at one end to a floating vessel or boat 90 and as entering a motor drive and liquid pick up chamber 91 on the deck of the vessel.

Another manner in which the helical conveyor of this invention may be employed is illustrated in FIG. 17. In this figure, three vessels or boats 92, 93 and 94 have been illustrated in a generally equilateral triangle configuration with conveyor assemblies 95, 96 and 97 extending between respective pairs of the boats. The boats are anchored in position about an oil well or other source of relatively light fluid reaching the surface of the water and indicated at 98. This is thus a stationary installation and is provided in order to minimize the escape of oil or other light liquid flowing from the source 98 onto the water surrounding the area. The conveyor assembly of FIG. 13 is particularly well adapted to this installation wherein the conveyors 95, 96 and 97 are arranged with their slots 76 facing inwardly of the triangle. Tension cables as shown in FIG. 10 may be employed on the other embodiments having control tension ropes, for example, on the rope 72 of FIG. 13.

The invention as described heretofore may be employed by using power boats as indicated in FIG. 1 and may also be employed by anchoring the boats across a harbor or beach to effect a continuous removal of water or other liquid from the surface of the water in selected areas. When oil or other floating liquid is issuing from a stationary source such as an oil well or other leak under water, the area may be surrounded by a chain of conveyors embodying the invention as illustrated for example in FIG. 15 where boats are anchored at suitable distances to support the ends of adjacent conveyors. The buoyancy of the conveyors may be adjusted to conditions within a wide range by employing the constructions of FIGS. 10 and 12 and the construction of FIG. 12 may be used as a single wing sweep as illustrated in FIG. 13.

I claim:

1. An elongated rotor for flexible screw-type conveyors and the like comprising an elongated helical strip having a round bead extending along the central axis thereof and constituting a continuous core formed integrally therewith, and a plurality of stranded cables wound about said bead with the same pitch as said helical strip, said cables lying in engagement with one another and said bead and retaining said helical strip securely in its helical configuration.

2. The rotor of claim 1 wherein said cables and said strip are of synthetic plastic material having a specific gravity less than that of water.

3. An elongated rotor for flexible screw-type conveyors comprising a central tension carrying rope, a second rope extending about said tension rope in helical configuration, means for bonding said second rope to said tension rope, said second rope having a hollow tubular center member of flexible fluid-tight material, a terminal fitting, a member rotatable with respect thereto, and means for affording communication for fluid from said relatively rotatable member through said fitting to said center tubular member.

4. An elongated rotor for flexible screw-type conveyors comprising a central tension carrying multiple strand rope, a helical member bonded to said rope for rotation therewith, and means on said helical member spaced from and facing said rope and providing an axially facing open channel extending from said member about the periphery of said rope.

5. The rotor of claim 3 including at least two helical cables wound in opposite directions about said central rope for gripping said central tension carrying rope tightly when under tension and for facilitating the connection of a driving member to said central rope.

6. The rotor of claim 5 including a rigid fitting mounted about said central rope at the end thereof and having at least one passage for receiving said cables and means for connecting said cables securely to said fitting.

7. The rotor of claim 2 including tubes of synthetic plastic material each closely surrounding a respective one of said cables.

* * * * *