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(54) Trenching apparatus

(57) A trenching unit (12) used to cut trenches in the seabed for laying pipelines or cables.
The unit comprises: a jetting arm (3) with a plurality of sections, each section having at least one nozzle; means for supplying fluid to nozzles (8) in at least two sections; and means (4) for separately controlling the flow characteristics of the fluid supplied to each individual section of the jetting arm.

Two or more units of such apparatus can be used in tandem to extend the fluidisation period of a localised area of the seabed. This is particularly useful when pipes or cables are relatively stiff. The fluidisation period depends upon the distance between the units which is calculated as a function of the characteristics of the seabed and the capabilities of the individual units.
The distance between the units is determined by the length of an adjustable linkage.

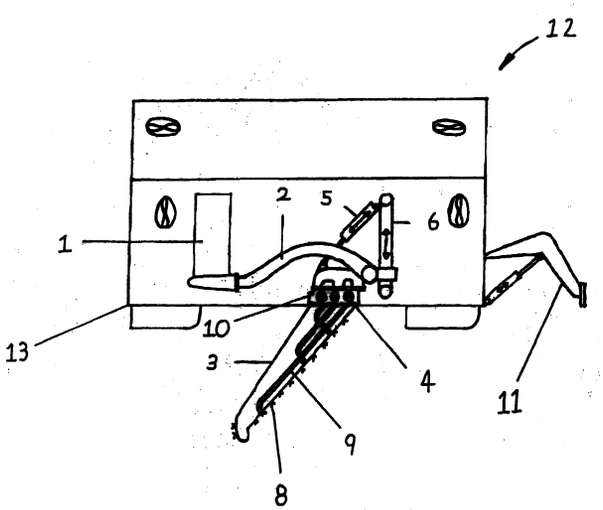

Figure 1

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Description

[0001] The present invention relates to apparatus and particularly to apparatus used for underwater trenching.

[0002] There is a need by oil and gas companies to lay underwater pipelines from offshore facilities to land sites, to make links between offshore facilities and to connect land based facilities separated by bodies of water, or waterways. These pipelines enable the transfer of large volumes of fluids such as crude oil and natural gas to be made, for example, from a rig to a refinery plant, or some intermediary storage facility. Similarly, electricity and telecommunications companies have to lay underwater cables to supply power to remote communities, for sales abroad, or to send electrical signals for telecommunications systems.

[0003] These pipelines, or cables, are typically laid by purpose built ships which are usually accompanied by one or more support vessels. The pipeline can be left exposed on the seabed. However this'is undesirable as it is more susceptible to damage from debris and inquisitive marine life. In shallow waters a more significant danger is interference with the pipeline by fishing operations; fishing nets, particularly drag nets, may become entangled with the pipeline and any attempt to forcibly remove the net may cause the pipeline to rupture. This could lead to serious environmental damage where the piped material is toxic, as well as disrupting the delivery of the material. In the case of power supply or telecommunications cables any damage could result in total loss of service.

[0004] With the large capital cost involved in laying pipelines companies are keen to protect their investments from harm. It is therefore common practice to create a trench in the seabed in which the cable can be laid. The trench is cut to the required dimensions to accept the pipeline with the depth being determined by a trade off between economic considerations and risk minimisation. That is, the cost of creating the trench against the probability of damage occurring to the pipeline, and hence, the associated costs of making repairs and the loss of goodwill by the customer. When correctly positioned within the trench, the pipeline can be covered by material removed from the seabed to afford further protection.

[0005] One particular group of trenching systems utilises water jets to fluidise a localised area of the seabed. A trenching unit is moved in the desired direction whilst fluidising the seabed in a localised area. This creates a channel, or trench, in the seabed wherein a pipeline can be laid. Some systems capture a significant proportion of the displaced material and direct it rearward to cover the pipeline when located in the trench. Other systems allow the displaced material to cover the pipeline through resettlement under the of action of gravity and tidal motion.

[0006] Water jets for such apparatus can be mounted on tubes, rotating discs and / or used in conjunction with mechanical cutters.

[0007] One such trenching system is described in US 4,516,880 and uses a pair of laterally spaced vertical cutting members positioned at each end of the machine. The cutting members comprise a series of water jets located at both ends of the cutting members. The cutting members oscillate in a vertical plane to cut a relatively broad trench. The fluidised material is removed from the trench through tubes and deposited away from the trenching operation.

[0008] The present invention aims to provide an improved trenching unit.

[0009] According to one aspect of the present invention there is provided a trenching unit comprising: a jetting arm with a plurality of sections, each section having at least one nozzle; means for supplying fluid to nozzles in at least two sections; and means for separately controlling the flow characteristics of the fluid supplied to each individual section of the jetting arm.

[0010] Preferably the current invention uses two jetting arms in parallel. Advantageously the distance between the jetting arms may be adjusted.

[0011] According to one embodiment of the invention the fluid flow characteristics comprise fluid pressure and / or fluid volume. The means for controlling the fluid flow characteristics comprises a discharge manifold having at least one individually operated valve for each section of the arm for which the fluid supply is to be controlled.

[0012] In a particular embodiment of the invention the jetting arm has three sections.

[0013] According to a specific embodiment of the invention the jetting arm is adjustably mounted to a housing which is movable over the medium to be trenched. The trenching unit preferably comprises means for adjusting the position and the orientation of the jetting arm relative to the housing. Means may be provided for setting and adjusting the angle which the arm subtends with the direction of motion of the unit. The angle of the arm may be fully adjustable in any or all of three dimensions but preferably at least the angle subtended in the vertical plane including the direction of motion is adjustable. When the angle at which the jetting arm is set relative to the unit housing is adjusted in a horizontal plane perpendicular to the direction of motion then it is possible to cut different profiled trenches. In another embodiment of the invention the jetting arm is arranged to move reciprocally in a direction perpendicular to the direction of motion.

[0014] The jetting arm may be fixed generally horizontally relative to the housing.

[0015] According to a preferred embodiment of the invention there is a communication means between a support vessel and the trenching unit for control signals to equipment onboard the trenching unit and the supply of power. The communication means may be an umbilical arrangement or a transmitter and receiver means.

[0016] Trenching units can be constructed according to the current invention to be more efficient, to exhibit

reduced operational costs and to provide a more flexible and controllable cutting apparatus, which can be more easily adapted to suit the material composition of the seabed.

[0017] According to another aspect of the invention an arrangement comprising at least two trenching units and a link connecting the two units in tandem, each unit comprising a jetting arm with at least one nozzle and means for supplying fluid to the or each nozzle.

[0018] In one embodiment the two trenching units are each according to the first aspect of the invention.

[0019] The link may be adjustable to set the distance between the units, either during the trenching operation to optimise the fluidisation period with respect to different seabed characteristics, or it may be fixed before trenching begins. In another embodiment the link is resilient.

[0020] It is to be understood that the present invention can be used in a variety of applications, primarily underwater environments, such as seas, oceans, lakes or rivers, but may also be adapted for use on land or in any environment in which trenches are required. The fluid used by the trenching unit is preferably water, and in underwater environments will usually be seawater. However applications can be envisaged where other fluids would be appropriate depending upon the material to be trenched.

[0021] In order that the invention may be clearly understood and readily carried into effect some preferred embodiments thereof will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 - is a schematic view of a trenching unit according to one aspect of the invention,

Figure 2 - is a schematic view of two trenching units linked together by an adjustable linkage, illustrating one embodiment of another aspect of the invention.

[0022] The trenching unit 12 of Figure 1 has two jetting arms 3 in parallel adjustably attached to a housing formed as a frame 13. The second jetting arm 3 is obscured in Figure 1 as it is set at the same angle relative to the base of frame 13 as the jetting arm 3 in view. Water pump 1 is connected to a discharge manifold 10 by a flexible hose 2. The discharge manifold 10 houses three valves 4, one connected to each of three individual sections of the jetting arm 3. Each valve 4 controls the water pressure and / or the volume of water supplied to its respective section of the jetting arm 3. It will be understood that the arm may comprise more than three sections thus more than three valves 4 may be used. The discharge manifold 10 may house as many valves 4 as is practicable and the water pressure to each of the individual sections of the jetting arm 3 may be controlled by more than one valve 4. Although the arm is described as having separate sections these need not be physically separated other than in connection with the fluid flow control.

[0023] The settings of the valves 4 may be altered during operation of the trenching unit 12, from a support vessel via an umbilical (not shown) which also provides electrical power and other control signals. This provides further means for optimising the cutting efficiency of the device. For example, particular characteristics of the seabed may require that the majority of the water be supplied to one section of the jetting arm 3 to maximise cutting effect in a highly localised area whilst other situations may require a more even supply of water to each section.

[0024] Each section of the jetting arm 3 has a plurality of nozzles 8 connected to respective valves 4 via separate respective water conduits 9. Water from nozzles 8 impacts the seabed in a localised area and fluidises the seabed sediment. Nozzles 8 are positioned along the length of the cutting arm. Preferably a majority of nozzles 8 are directed to face forwardly and a minority of nozzles 8 are directed rearward having regard to the direction of motion of the trenching unit.

[0025] The angle of the jetting arm 3 relative to the housing 13 may be altered by a hydraulic actuator 5. Likewise, the vertical position of the jetting arm 3, relative to the housing 13, can also be adjusted by a second hydraulic actuator 6. Angular and displacement settings can be set prior to submersion of the trenching unit 12 but can also be adjusted during trenching operations by signals from the support vessel via the umbilical (not shown). The angular and vertical position of the jetting arm 3 affects cutting efficiency and the profile of the trench. The jetting arm 3 can also be configured to move reciprocally in a direction perpendicular to the direction of motion. The distance between the arms 3 can be adjusted so as to alter the width of the trench. The jetting arms 3 may be arranged such that they are angularly adjustable and/or moveable independently of each other or the jetting arms 3 can be arranged such that adjustments are made synchronously to both jetting arms 3. So, for example, the jetting arms 3 may be raised in the vertical direction relative to frame 13 concurrently so that a shallower trench may be cut.

[0026] The jetting arm 3 can also be oriented to lie in a plane perpendicular to the direction of motion of the housing 13, with the majority of nozzles 8 directed forwardly, and may be set at some angle between the vertical position and the horizontal, to facilitate cutting trenches with a variety of profiles.

[0027] There is a device 11, located at one end of the trenching unit 12, for attachment to a pipeline or cable. The device 11 can be used as a directional guide or to provide propulsion for the unit 12 to move along the pipeline or cable. Means of moving trenching units along pipelines are well known in the art and a number of systems could easily be incorporated into the current invention. For example, US 4,516,880 teaches a trenching unit that moves along the pipeline by driving a number

of rollers which are kept in contact with the pipe through biassing means. The rollers may also be used to stabilise the machine in its upright position. Weight control may also be incorporated to maintain the unit 12 at a constant loading weight on a pipeline for example, as taught in US 4,516,880, which uses a flotation vessel adapted to have longitudinal tilt control, and fore and aft upper rollers, each having regulation devices for maintaining a selectively adjustable force between the flotation vessel and its attached frame and a pipeline. The weight control apparatus may be controlled from the surface.

[0028] The trenching unit may alternatively be propelled using the nozzles.

[0029] In figure 2, two trenching units 12 are shown in tandem coupled by an adjustable linkage 7. The distance between the units is determined by the length of the adjustable linkage 7. The adjustable linkage 7 is sufficiently resilient to maintain the distance between the units. The distance between the units can be set prior to submersion or during operations from a support vessel. This allows for an extended fluidisation of the seabed which is particularly useful in the situation when a pipeline is relatively stiff as it takes longer to lay the pipeline in the trench in the correct position. If the fluidisation period is not sufficiently long the pipeline may not be laid in the trench at the required depth making it more susceptible to damage. The optimum fluidisation period is controlled by the distance between the units and is calculated to take into account the material characteristics of the seabed sediment to be fluidised and the capabilities and settings of the individual trenching units.

[0030] In figure 2 each of the trenching units are identical to the trenching unit 12 shown in figure 1. However other trenching units, traditional forms or any new forms, could be linked in this way to provide an improved trenching apparatus.

Claims

1. A trenching unit comprising: a jetting arm with a plurality of sections, each section having at least one nozzle; means for supplying fluid to nozzles in at least two sections; and means for separately controlling the flow characteristics of the fluid supplied to each individual section of the jetting arm.

2. A trenching unit according to claim 1 comprising two jetting arms.

3. A trenching unit according to claim 2 comprising two jetting arms in parallel.

4. A trenching unit according to claim 2 or 3 wherein the distance between the two jetting arms is adjustable.

5. A trenching unit according to any one of the preceding claims wherein the fluid flow characteristics comprise fluid pressure and / or fluid volume.

6. A trenching unit according to any one of the preceding claims wherein the means for controlling the fluid flow characteristics comprises a discharge manifold having at least one individually operated valve for each section of the arm for which the fluid supply is to be controlled.

7. A trenching unit according to any one of the preceding claims wherein the jetting arm has three sections.

8. A trenching unit according to any one of the preceding claims wherein the jetting arm is adjustably mounted to a housing which is movable over the medium to be trenched.

9. A trenching unit according to claim 8 comprising means for adjusting the vertical position of the jetting arm, relative to the housing.

10. A trenching unit according to claim 9 wherein the means for adjusting the vertical position of the jetting arm comprises a hydraulic actuator.

11. A trenching unit according to any one of the preceding claims comprising means for adjusting the angle at which the jetting arm is set relative to the unit housing.

12. A trenching unit according to claim 11 wherein the means for adjusting the angle at which the jetting arm is set comprises a hydraulic actuator.

13. A trenching unit according to claim 10 or claim 12 comprising means for remotely controlling the or each hydraulic actuator.

14. A trenching unit according to any one of the preceding claims wherein the jetting arm is oriented horizontally relative to the unit housing.

15. A trenching unit according to any one of the preceding claims comprising means for adjusting the angle of the jetting arm within a horizontal plane perpendicular to the direction of motion, for cutting different profiled trenches.

16. A trenching unit according to any of the preceding claims wherein the jetting arm moves reciprocally in a direction perpendicular to the direction of motion.

17. A trenching unit according to any one of the preceding claims wherein the means for supplying fluid

comprises a water pump.

18. A trenching unit according to any one of the preceding claims comprising means for guiding the unit along a pipeline.

19. A trenching unit according to any one of the preceding claims comprising communication means for communicating with a support vessel.

20. An arrangement comprising at least two trenching units and a link connecting the two units in tandem, each unit comprising a jetting arm with at least one nozzle and means for supplying fluid to the or each nozzle.

21. An arrangement according to claim 20 wherein the link is adjustable to set the distance between the units.

22. An arrangement according to claim 20 or 21 comprising at least two trenching units according to any one of claims 1 to 19.

23. An arrangement according to claim 20, 21 or 22 wherein the adjustable linkage is resilient.

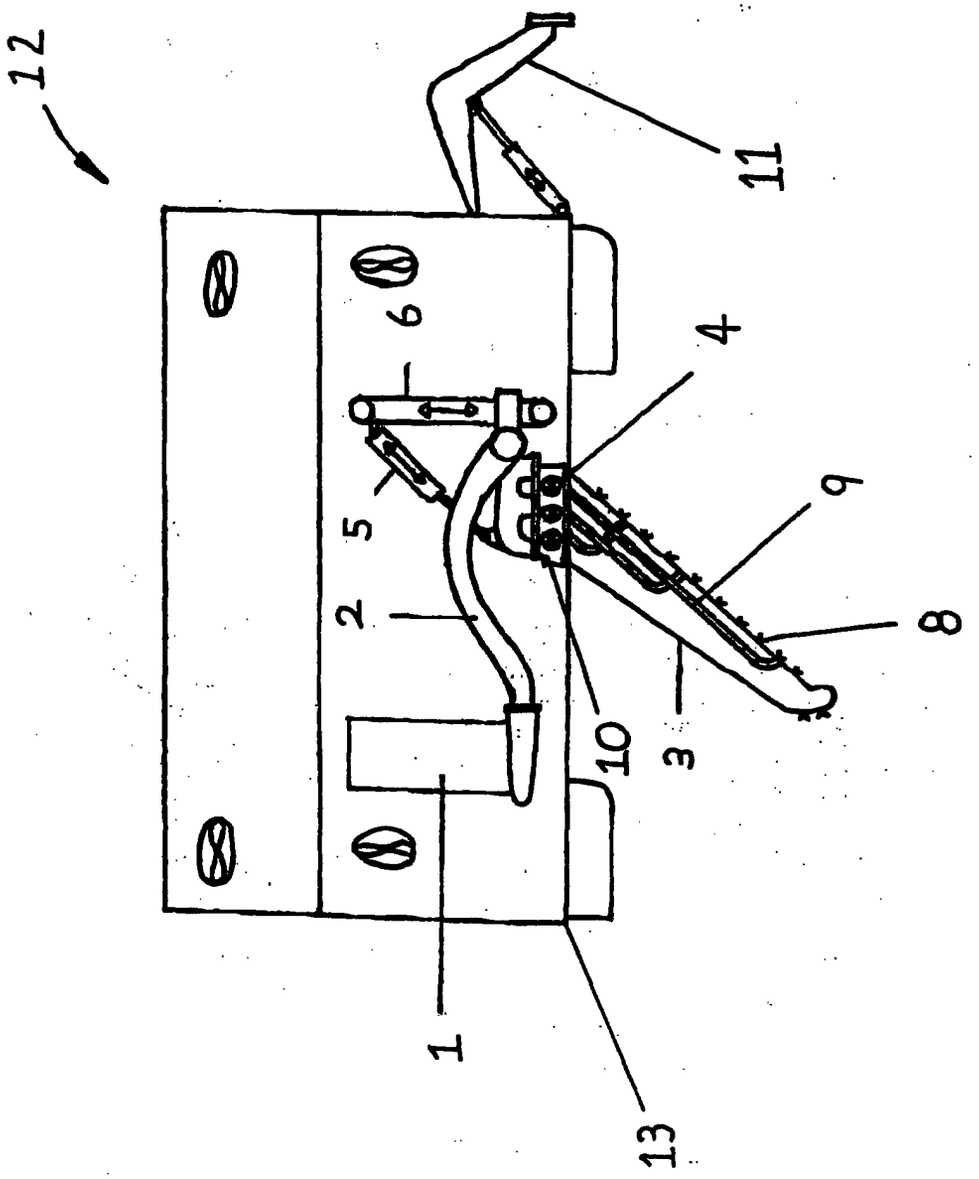

Figure 1

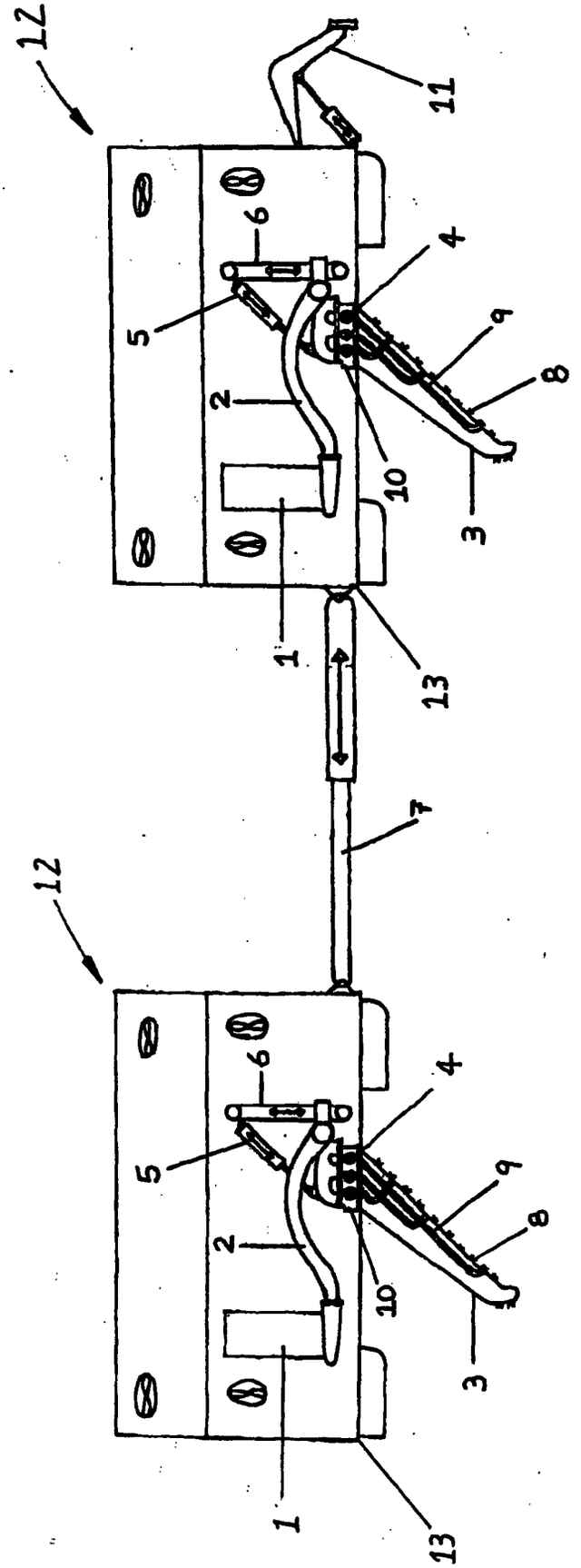

Figure 2