1 562 744

PATENT SPECIFICATION

(11) 1 562 744

(21) Application No. 18137/77 (22) Filed 29 April 1977
(31) Convention Application No. 7605035
(32) Filed 3 May 1976 in
(33) Sweden (SE)
(44) Complete Specification published 12 March 1980
(51) INT CL³ H02G 1/10
(52) Index at acceptance
H2C 5
E1F 12X

(19)

(54) A TOOL FOR USE IN LAYING SUBMARINE CABLE

(71) We, TELEFONAKTIEBOLAGET L M ERICSSON, a Company organised under the laws of Sweden, of S-12625 Stockholm, Sweden, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a tool for use in laying a submarine cable, such as a power cable or a telecommunication cable.

According to this invention there is provided a tool for use in laying a submarine cable, comprising a drag unit for being dragged over the sea-bottom, the drag unit comprising a body which supports ploughing means for ploughing a trench in the sea-bottom, in which drag unit the underside of the body is mainly planar and has, at the back of the body, a central notch in the central part of which there is the ploughing means, shaped like a keel, the front part of which comprises two ploughs, namely an upper broad plough and a lower narrow plough behind the upper plough, and provides a stern frame, the front edge of which extends from the notch to the point of the upper plough and to the point of the lower plough, the body being provided with a pulling tube for use in pulling the drag unit over the sea-bottom and for guiding a submarine cable from a pulling vessel to the drag unit during a laying operation, the pulling tube communicating with a channel which passes through the body and terminates at an opening behind the lower plough, for guiding a submarine cable from the pulling tube through the body as the drag unit is pulled by the tube and down into a trench ploughed by the ploughing means.

The invention will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a side-view of a laying tool, a pulling vessel and a pulling tube;

Figure 2 shows a drag unit comprising the laying tool, seen from the side;

Figure 3 is a longitudinal section through the drag unit and part of the tube;

Figure 4 is a cross-section through the drag unit;

Figure 5 shows ploughing means which protrudes from the bottom of the drag unit;

Figure 6 is a sketch of a detail of the above-mentioned ploughing means;

Figure 7 shows the drag unit seen from above; and

Figure 8 shows the laying tool during refloating from or immersion to the sea-bottom.

The laying tool comprises a drag unit 22, this being provided with a pulling tube 26 joined to the unit 22 by means of a Cardan joint. The drag unit comprises a body 34 and ploughing means 27 shaped like a keel, the body being provided with a channel 43 which forms a guiding system together with the pulling tube 26. In use, cable 24 is fed from a vessel 23 and enters the drag unit 22 through the tube 26. In the drag unit 22, the pulling tube 26 passes to the channel 43, so designed that the cable 24 is forced in a direction towards the bottom of a trench 29 ploughed by the drag unit before the ploughing means 27 leaves it.

Such a trench 29 in the sea-bottom 32 is ploughed by the ploughing means 27 under the body 34. The laying system 22, 23, 24 and 26 is provided with a number of sensors and electronic equipment to allow continuous supervision of the operation of the system and of the depth of ploughing.

The body 34 of the drag unit 22 which is drawn in use along the sea-bottom, further has a central notch 42 at the back of the mainly planar underside. In the middle of this notch is the ploughing means 27, the side walls 28 of which are vertical and planar. Inside the ploughing means 27 is part of the channel 43 and its exit opening 44. It is possible to expose the channel 43 at its top so that cable can be placed inside the channel without pulling. The width of the ploughing means 27 is determined by the diameter of the cable that is intended to be layed. The ploughing means 27, at its front, provides an upper plough 48 and a lower plough 49, the upper plough being forward of the lower plough. This is necessary to

achieve that the opening 44 is disposed so that cable is forced down into the bottom of the trench ploughed by the ploughing means 27, even when the drag unit 22 is not quite working in a correct position. The ploughs 48 and 49 are somewhat broader than the behind lying parts comprising the walls 28 of the ploughing means 27 and the upper plough 48 is broader than the lower plough 49. This arrangement reduces friction and achieves that material 31 turned up in ploughing a trench is pushed aside in order to be placed on the bottom 32 alongside the trench 29 which has been ploughed. Thus, the material 31 will not be pressed into the walls of the ploughed trench. Such a process would lead to substantially larger friction and to a tendency to re-fill the trench. In front of the ploughs 48 and 49 there is a plate, a so-called stern frame 40, the task of which is, on the one hand, to split the bottom material and, on the other hand, to prevent objects fastening on the ploughs 48 and 49, and, finally, to force up the drag unit 22 entirely if it strikes bottom material of such a nature that, otherwise, the ploughing means 27 could fasten on such material or if the bottom material is too hard to plough through. The shape of the edge 41 of the stern frame 40 is such that, on the one hand, it is somewhat broader than the rest of the stern frame in order to reduce friction and, on the other hand, it has a surface which, in combination with the weight of the drag unit, causes the drag unit to be forced up when the bottom material is too hard, for example granite. In one example based on model tests, the edge 41 of the stern frame forms and angle 7 with the underside 36 of the body which is in the range from 20° to 45°; and the ploughs 48 and 49 provide lower and upper plough surfaces 50 and 51 respectively the edges of which forms angles 8 and 9 respectively which are within the ranges from 60° to 120° and 90° to 120° respectively. The shaping of the other parts of the drag unit depends on the ploughing depth 12, which depth is defined as the difference between the height 33 of the ploughing means 27 and the depth of the central notch 42.

The underside 36 of the body is, as mentioned, mainly planar except, of course, for the central notch 42 and a stem 35. The ploughing capacity also depends on the dimensions of the body 34. In the example, the radius of curvature of the stem in the area in which it curves to the planar part of the underside 36 exceeds the ploughing depth 12; the width of the imaginary line 15 where the curvature ends and the planar part of the underside 36 starts is at least 0.6 times the distance from this line to the perpendicular projection of the point 5 of the lower plough on to the underside (a distance which, in its turn, is in the range from 5 to 8 times the ploughing depth 12); and, furthermore, the perpendicular projection of the centre of gravity 16 on the underside is within the triangle defined by the said point of projection of the point 5 and the end points of the said imaginary line. It is our experience that, if these conditions are not fulfilled, the drag unit will, for example, have difficulties in starting ploughing, to plough unsatisfactorily in a "stem-down-position" and also to push a bank of loose material in front of itself. The stem 35 of the drag unit is, furthermore, angled, so as to avoid the risk that the drag unit is stopped by objects protruding from the sea-bottom.

In use, cable 24 runs through the pulling tube 26 into the channel 43 and out through the opening 44 in the ploughing means 27. The cable is forced down into the bottom of the ploughed trench 29, before the ploughing means leaves the cable behind the ploughs 48 and 49 providing, as mentioned, upper and lower ploughs of which the upper plough is in front. In the example, the opening 44 is shaped as is shown in Figure 6 in which

$$A=3\ D$$
$$B=1.5\ D$$

where D is the width of the ploughing means 27.

The radius of curvature R of the bottom 45 of the channel 43 in front of the lower edge 46 of the opening 44 is, in the example, at least 8 D, that part of the bottom surface of the channel which has this curvature, reaching, as a maximum, forward to the beginning 6 of the ploughing means. The distance C between the front edge 46 of the opening 44 and the perpendicular projection of the point 4 of the upper plough on to the bottom of the ploughed trench must not be too large and, in the example, is below $\sqrt{H\,(2R-H)}$, where H is the height 33 of the ploughing means. The flexibility of the cable being laid plays an important role concerning these conditions and, in the example, the width of the channel 43 increases towards the stem and is at least 1.4 D where it meets the pulling tube 26.

The joint 18 between the drag unit and the pulling tube 26, where the channel 43 meets the pulling tube, is shaped in a special way so as to make the drag unit operate in the intended manner in certain situations and to make it plough as correctly as possible and with regard to the mechanical properties of the cable being laid. The joint 18 is so-shaped that it is turnable vertically as well as horizontally and, furthermore, that its Cardan joint has the taps of one of the Cardan crosses resting in grooves which

can be opened. The height of the joint 18 above the underside of the drag unit is, in the example, less than the ploughing depth 12 and its position in the horizontal plane is within a distance of one ploughing depth in front of or behind the vertical plane through the said imaginary line where the curvature of the stem 35 ends.

The drag unit is also provided with flotation tanks 38 which are such that the tool floats without any cable but sinks with a cable inside. These tanks 38 are, furthermore, provided with valves 39 so adjusted that they allow automatic submergence, as long as the pressure in the tanks is lower than the pressure of the surrounding water. Each of the tanks is provided with an air valve 52 in order to facilitate a filling of the tanks with air. Furthermore, the distribution of weight is such that the centre of gravity 17 when the tool is deployed in a submarine position is above the centre of gravity 16 of the tool when not in this position by a distance which is at least 1/10 of the distance from the said imaginary line where the curvature of the stem 35 ends to the perpendicular projection on the underside 36 of the point 5 of the lower plough. In this way the immersion procedure is automated, the drag unit immerses steadily and no divers need to be near during the operation.

WHAT WE CLAIM IS:—

1. A tool for use in laying a submarine cable, comprising a drag unit for being dragged over the sea-bottom, the drag unit comprising a body which supports ploughing means for ploughing a trench in the sea-bottom, in which drag unit the underside of the body is mainly planar and has, at the back of the body, a central notch in the central part of which there is the ploughing means, shaped like a keel, the front part of which comprises two ploughs, namely an upper broad plough and a lower narrow plough behind the upper plough, and provides a stern frame, the front edge of which extends from the notch to the point of the upper plough and to the point of the lower plough, the body being provided with a pulling tube for use in pulling the drag unit over the sea-bottom and for guiding a submarine cable from a pulling vessel to the drag unit during a laying operation, the pulling tube communicating with a channel which passes through the body and terminates at an opening behind the lower plough, for guiding a submarine cable from the pulling tube through the body as the drag unit is pulled by the tube and down into a trench ploughed by the ploughing means.

2. A tool according to Claim 1, wherein the said edge forms an angle with the underside of the body which is in the range from 20° to 45°.

3. A tool according to Claim 1 or 2, wherein, at the front part of the ploughing means, the upper and lower ploughs each have an upper first plough surface and a lower second plough surface, the angle between the first and the second plough surfaces of the upper plough being in the range from 60° to 120° and the angle between the first and second plough surfaces of the lower plough being in the range from 90° to 150°.

4. A tool according to Claim 3, wherein the said stern frame reaches to the upper and lower plough surfaces of the two ploughs.

5. A tool according to any preceding claim, wherein, at the rear, the ploughing means has a planar underside extending from the lower plough, the remaining parts comprising vertical walls, the planar underside of the ploughing means not extending as far backwards as the vertical walls so that these walls are not interconnected at their bottoms at the very rear of the ploughing means.

6. A tool according to any preceding claim, wherein the underside of the body is planar, except for the said notch, until an imaginary line, perpendicular to a longitudinal axis of the body, from which line the underside provides a stem for the body, the distance from the perpendicular projection on to the underside of the body of the point of the lower plough to the said line being in the range from 5 to 8 times the ploughing depth.

7. A tool according to any preceding claim, wherein the pulling tube is fixed to the body near the front of the body by a Cardan joint which enables a movement of the tube relative to the body both vertically and horizontally.

8. A tool according to Claim 7, wherein the height of the Cardan joint above the underside of the body is less than the ploughing depth.

9. A tool according to Claims 6 and 7 or Claims 6, 7 and 8, wherein the Cardan joint is within a horizontal distance of a ploughing depth in front of or behind the vertical plane through the said imaginary line.

10. A tool according to Claim 3 or any of Claims 4 to 9 as dependent upon Claim 3, wherein the said ploughing surfaces have widths which exceed the rest of the ploughing means, the upper plough being broader than the lower plough.

11. A tool according to any preceding claim, wherein the said edge of the stern frame is broader than the rest of the stern frame.

12. A tool according to Claim 6 or any of

Claims 7 to 11 as dependent upon Claim 6, wherein the radius of curvature of the said stem exceeds the ploughing depth, namely the height of the ploughing means reduced by the depth of the said notch, in the area of the said imaginary line.

13. A tool according to any preceding claim, wherein the said body is provided with flotation tanks so that it can float without any cable but sinks if cable extends through it.

14. A tool according to Claim 13, wherein each of the tanks is provided with a valve for allowing automatic submergence as long as the pressure in the tanks is lower than the pressure of surrounding water.

15. A tool according to Claim 6 or any of Claims 7 to 14, as dependent upon Claim 6, wherein the perpendicular projection on the underside of the body of the centre of gravity of the drag unit is within the triangle determined by the perpendicular projection of the point of the lower plough on the said underside and the ends of the said imaginary line on the said underside.

16. A tool according to Claim 15, wherein the said imaginary line has a length which is 0.6 times the distance from the said projection of the point of the lower plough to the said imaginary line.

17. A tool according to Claim 15 or 16, wherein the centre of gravity of the drag unit when submerged is above the centre of gravity of the unit when not submerged by a distance which is at least 1/10 of the distance from the perpendicular projection on to the said underside of the point of the lower plough to the said imaginary line.

18. A tool according to any preceding claim, wherein the said channel is provided with a cover at its top which may be opened in order to allow cable to be inserted.

19. A tool according to any preceding claim, wherein the said opening opens on to the bottom of a trench ploughed by the ploughing means.

20. A tool according to Claim 19 and having the features of Claim 5, wherein the said vertical walls and the said underside of the ploughing means define the said opening.

21. A tool according to any preceding claim, wherein the width of the channel at its beginning is at least 1.4 times the width of the ploughing means.

22. A tool according to any preceding claim, wherein before the said opening, the bottom of the channel has a radius of curvature which is at least eight times the width of the ploughing means.

23. A tool according to Claim 22, wherein the distance between the front edge of the said opening and the perpendicular projection of the point of the upper plough on the bottom of a ploughed trench in use of the tool is less than $\sqrt{H(2R-H)}$ where H is the height of the ploughing means and R is the said radius of curvature of the bottom of the channel.

24. A tool for use in laying a submarine cable and comprising a drag unit, substantially as herein described with reference to the accompanying drawings.

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Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1980
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

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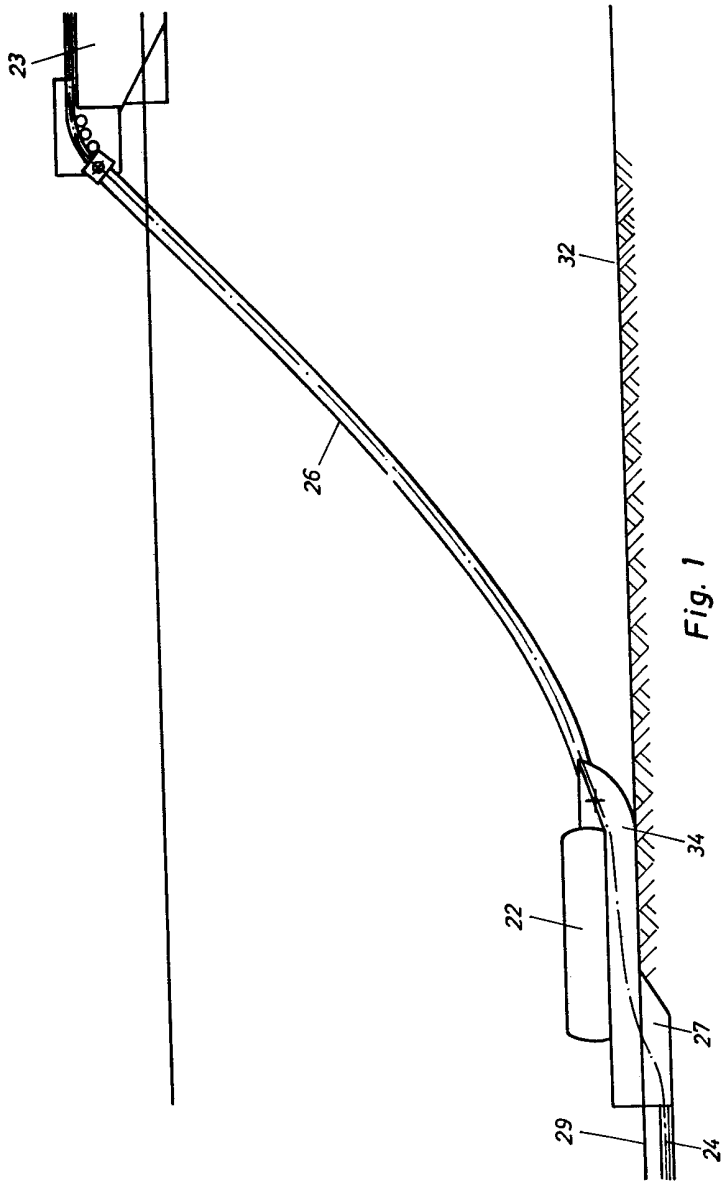

Fig. 1

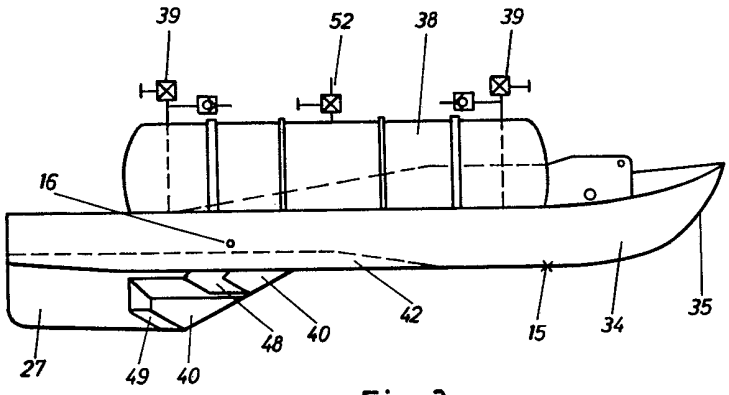

Fig. 2

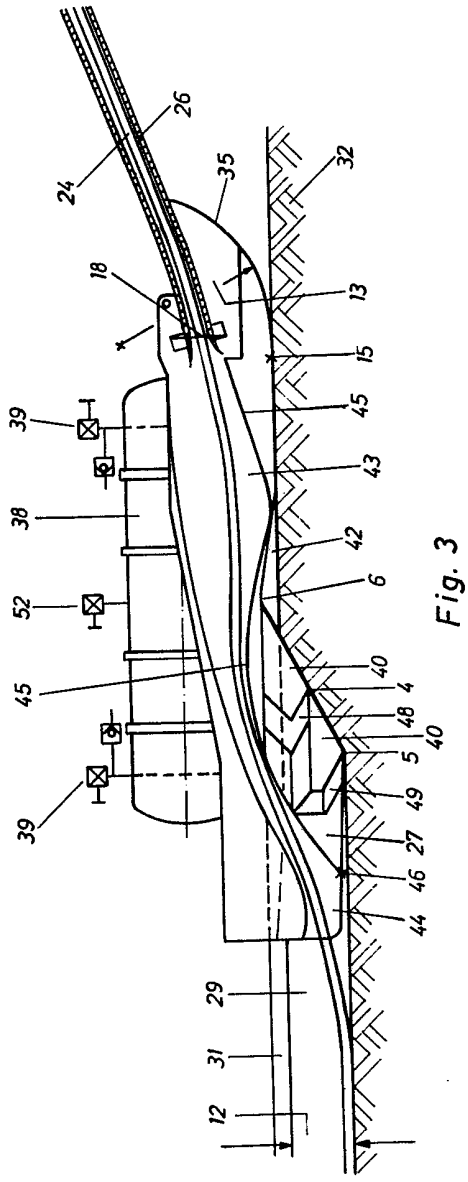
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Fig. 3

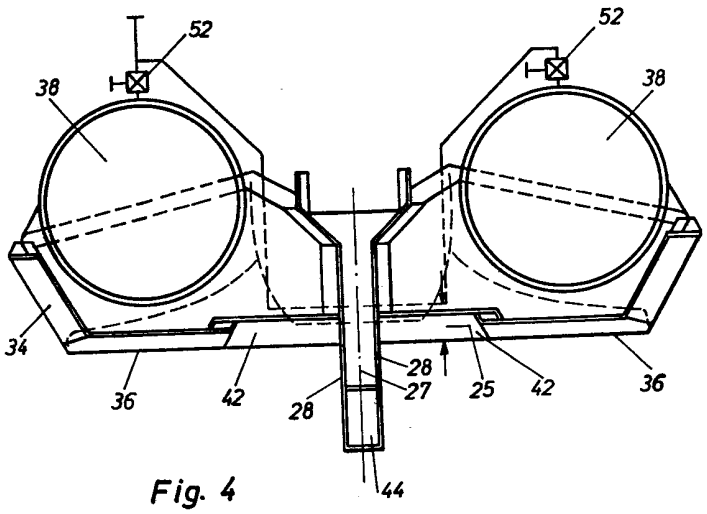


Fig. 4

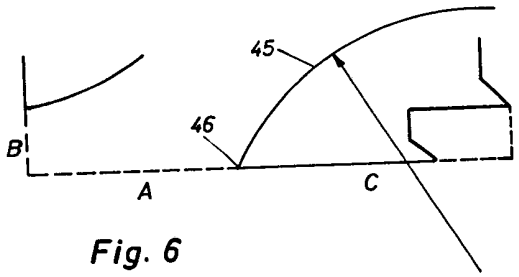
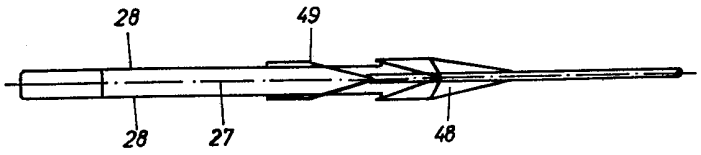
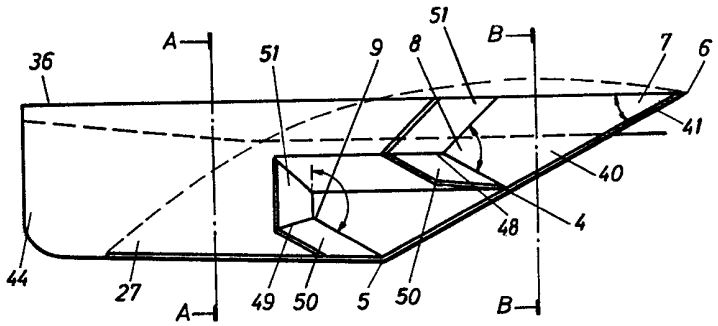


Fig. 6





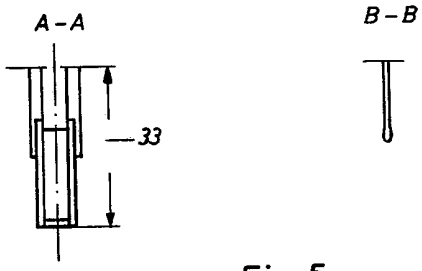


Fig. 5

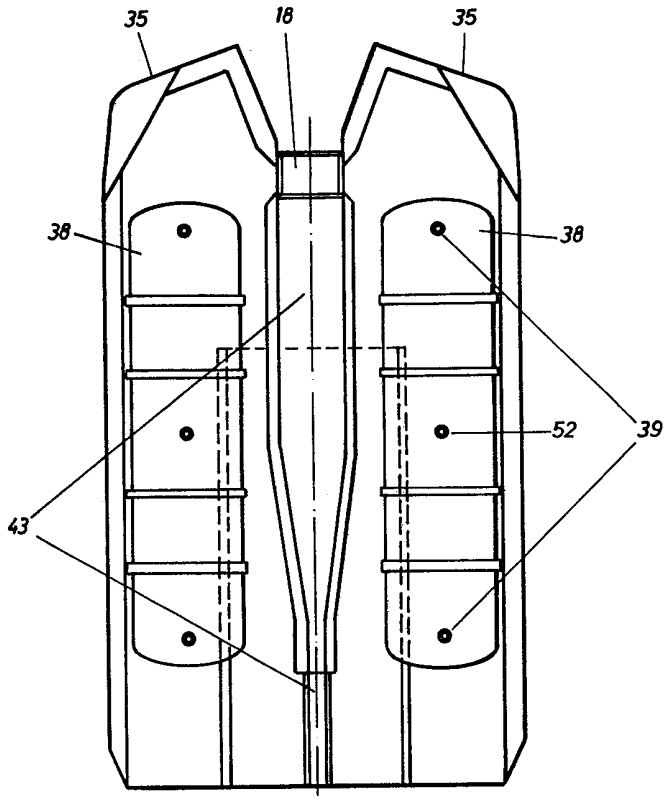


Fig. 7

1562744 COMPLETE SPECIFICATION
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Sheet 7

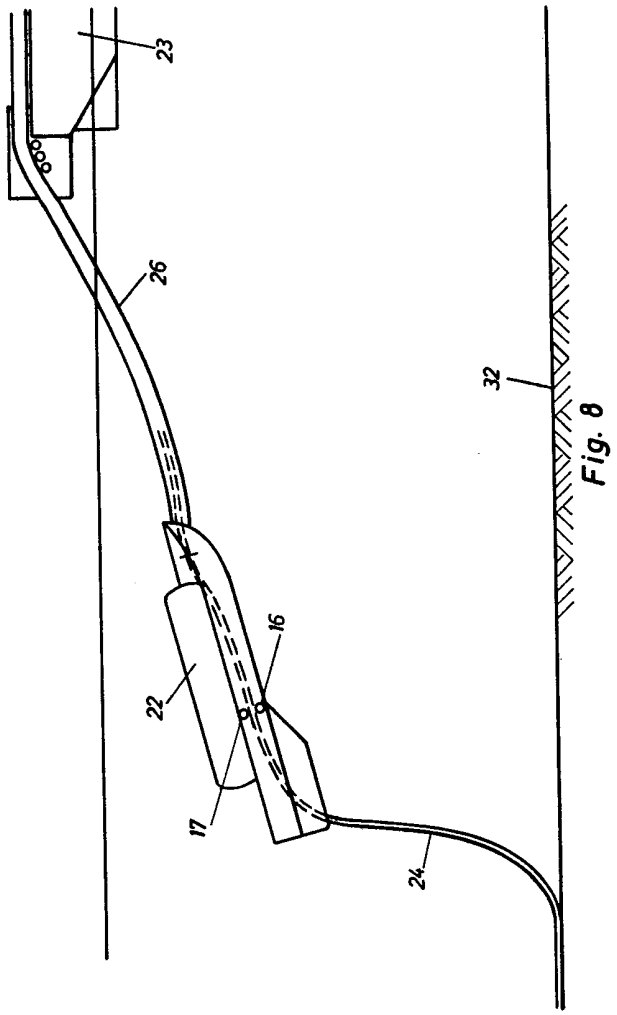

Fig. 8