Nov. 17, 1953 P. NOTARBARTOLO ET AL 2,659,211

MARINE EXCAVATOR

Filed July 28, 1948 3 Sheets-Sheet 1

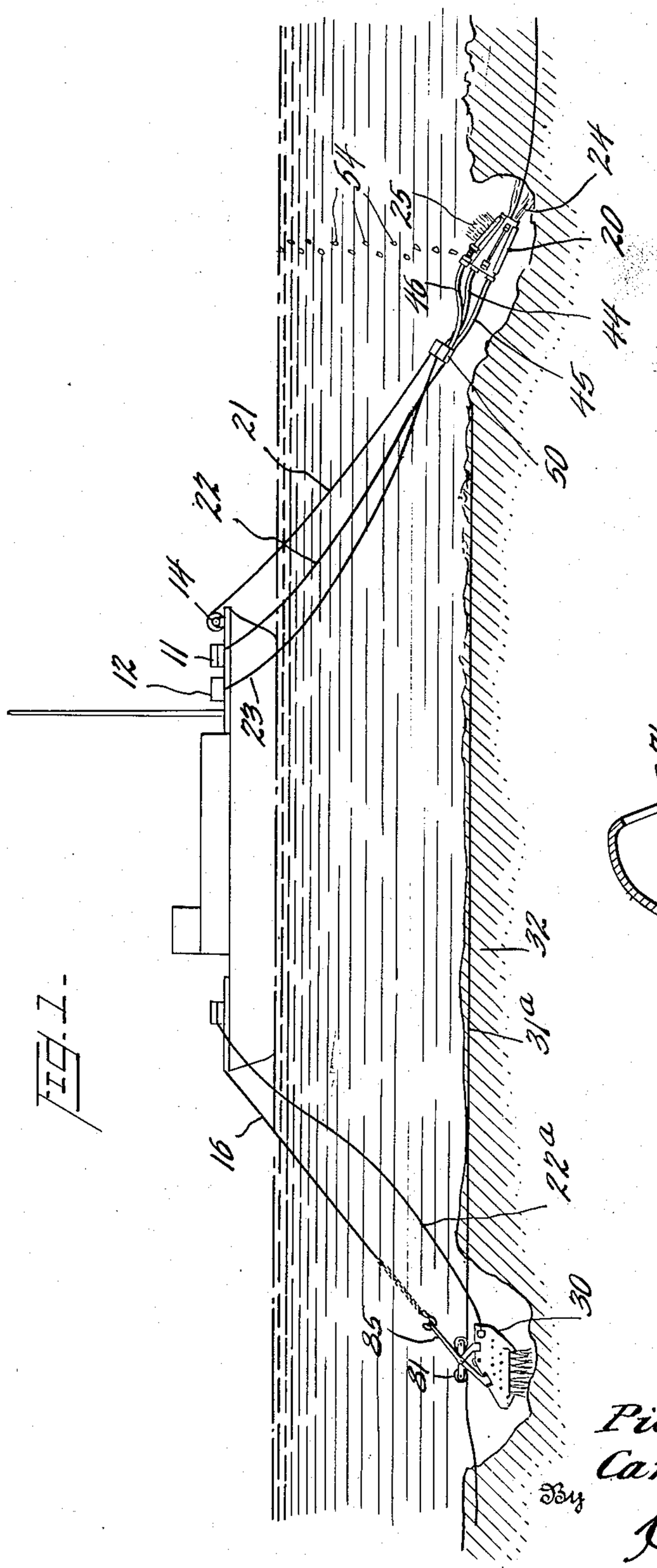

FIG. 1.

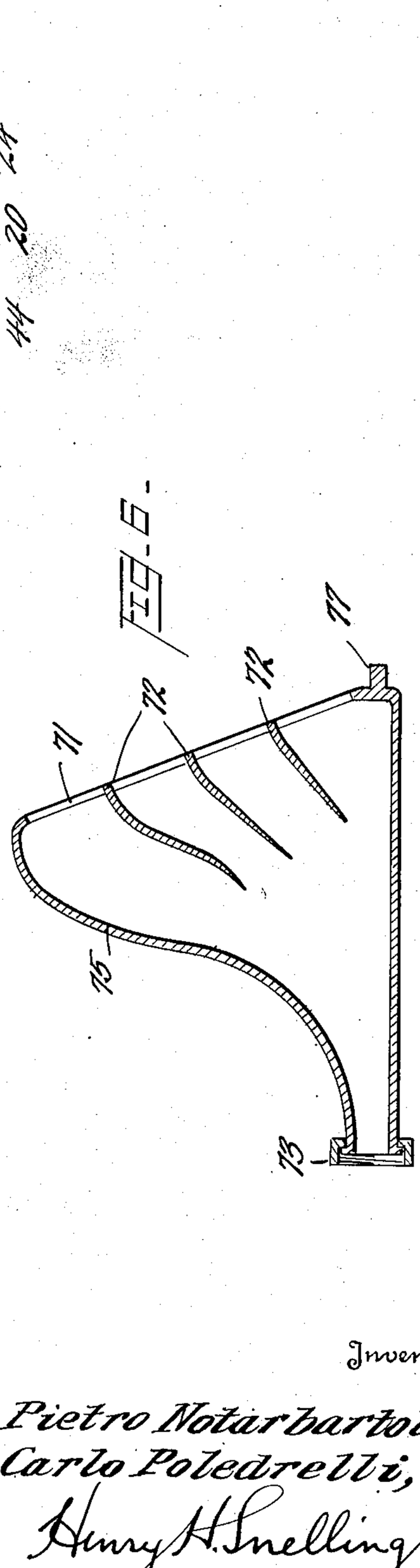

FIG. 6.

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3 Sheets-Sheet 2

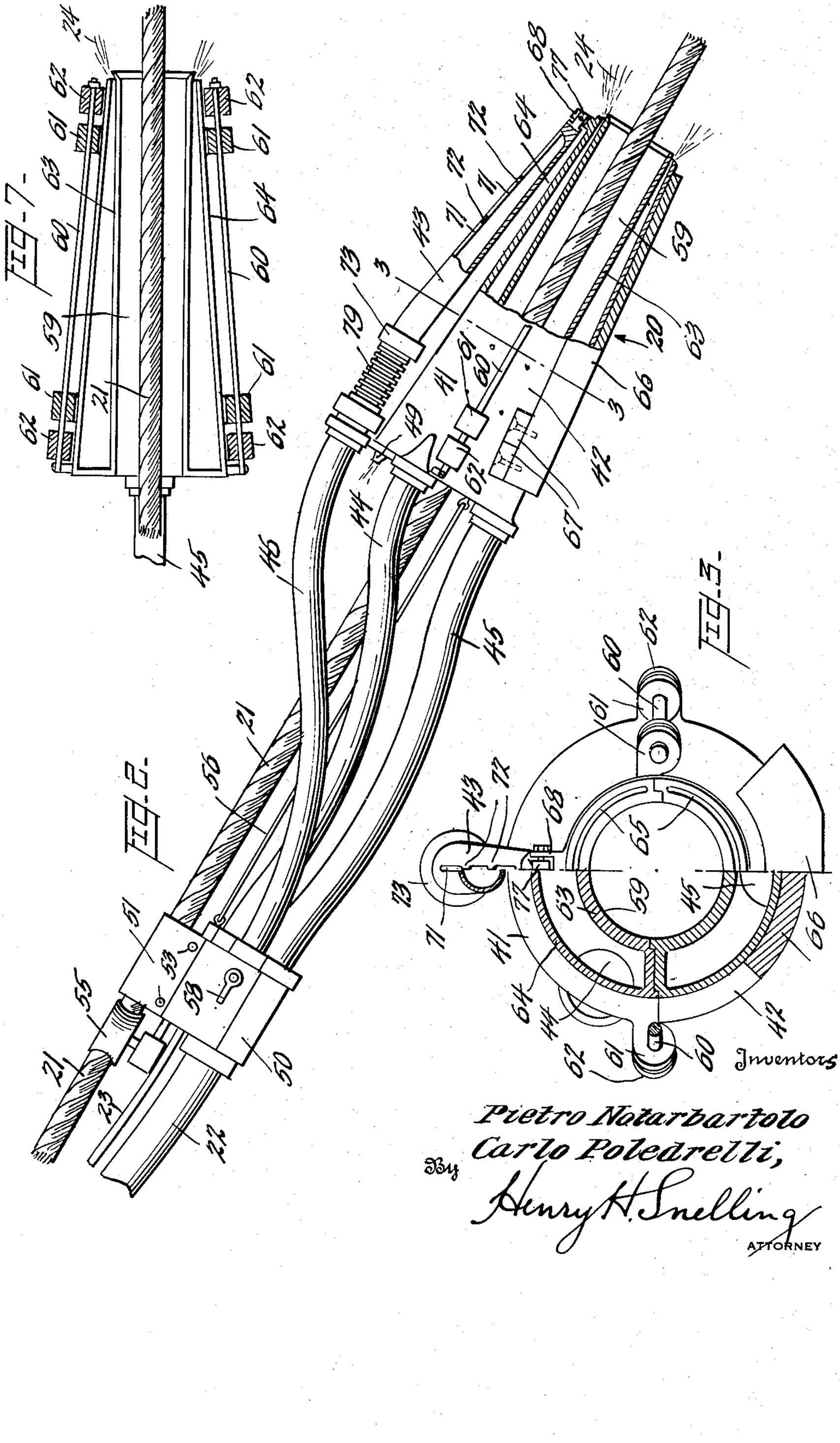

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FIG. 4.

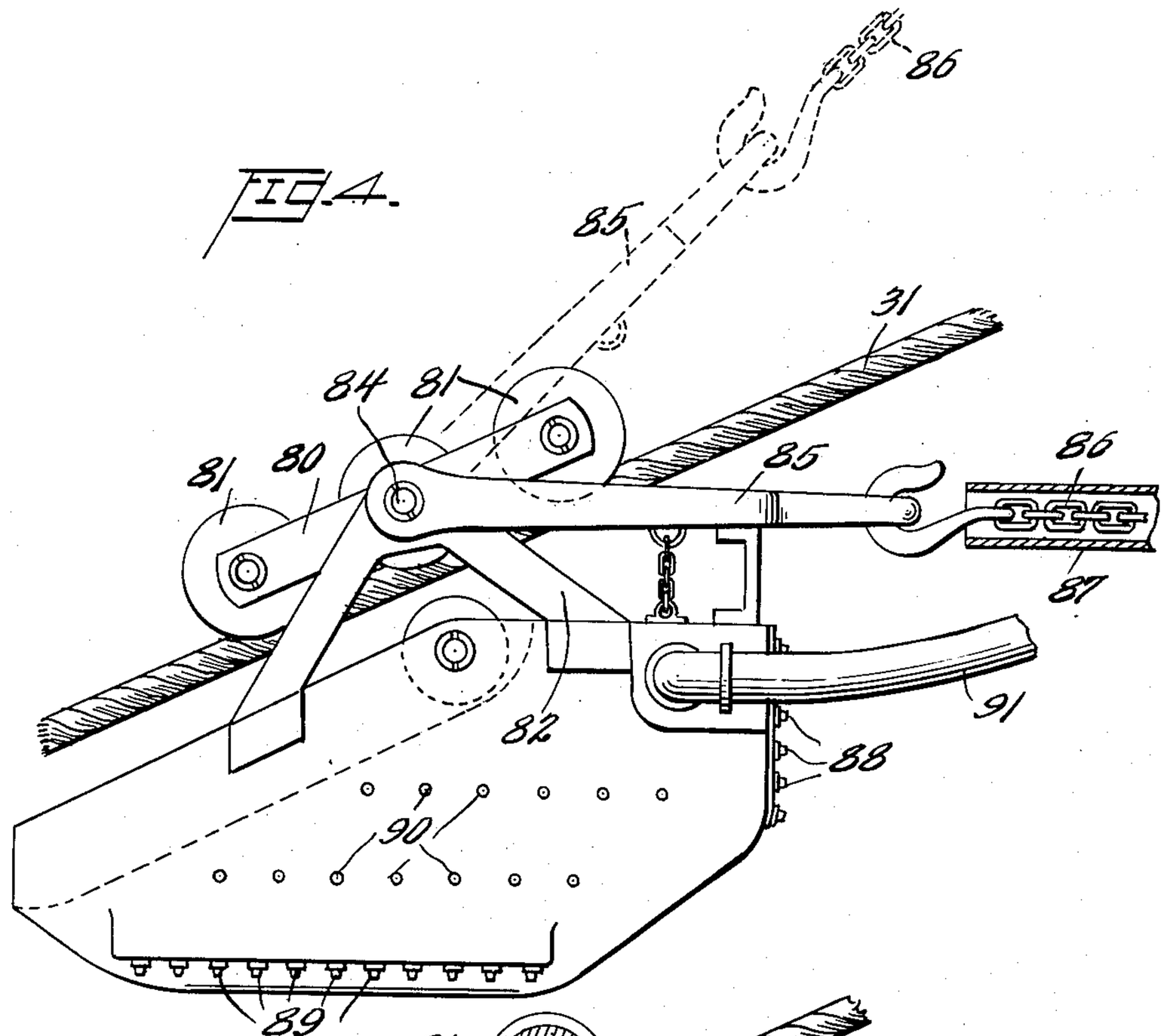
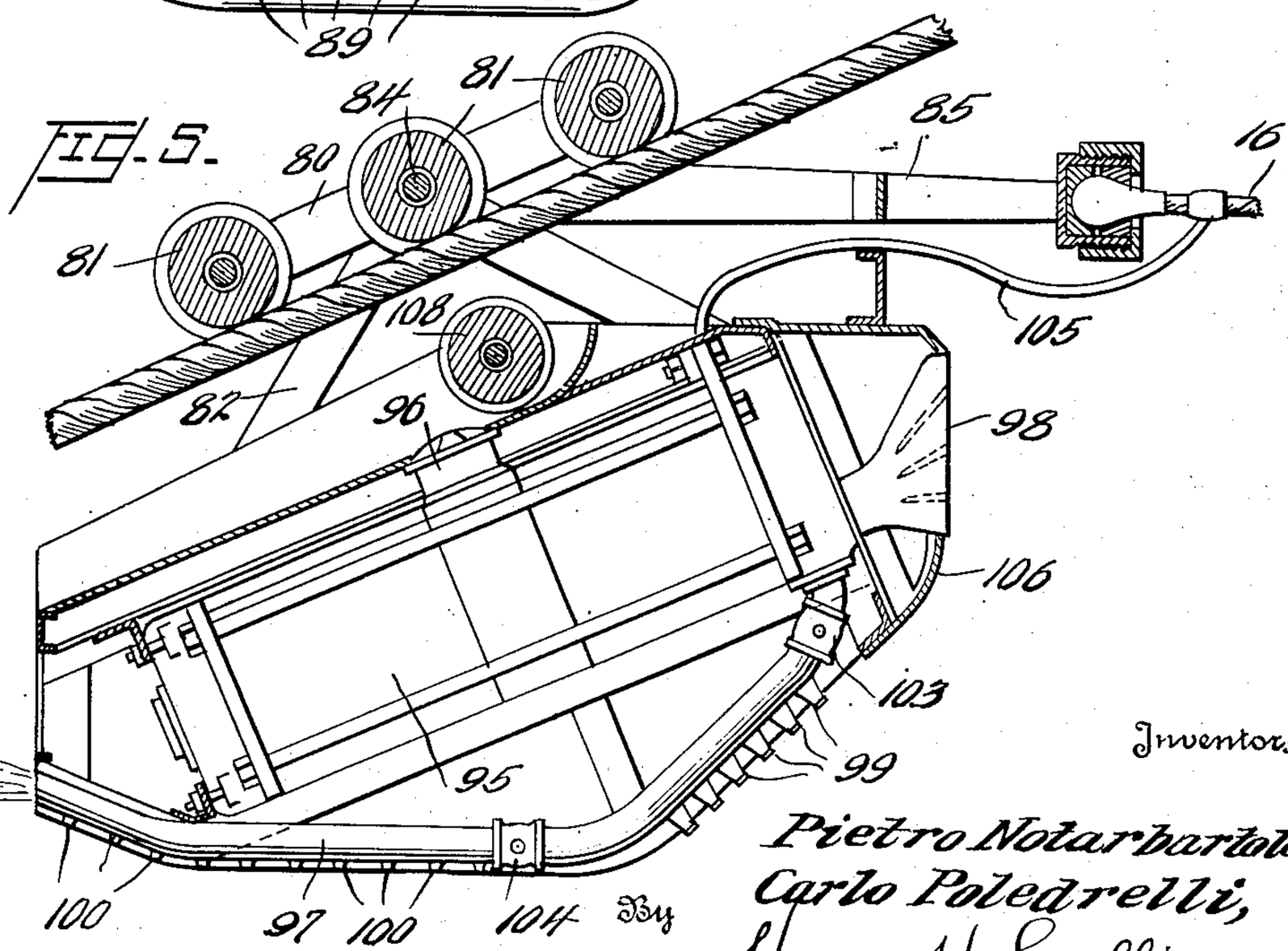


FIG. 5.



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MARINE EXCAVATOR

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Application July 28, 1948, Serial No. 41,164

16 Claims. (Cl. 61—72)

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This invention relates to a method and apparatus for either interring or disinterring submarine cables including reasonably flexible piping. The primary object of the present invention is to make it possible to bury a cable at a depth below the bottom greatly in excess of what has heretofore been believed possible and also to bury or to remove a cable where the water is quite deep.

An object of the invention is to provide a method of applying powerful water spouts from an excavator body having wide latitude of movement with respect to the cable ship or other naval craft from which the cable laying or cable removing operation is controlled.

A further object of the invention is to indicate the direction in which a cable being disinterred is directed in order that the cable ship or other vessel may follow this direction or path.

A further object of the invention is to provide an excavating device which may surround a cable being disinterred and which may move forwardly with respect to the cable either by its own weight or by means of auxiliary jets or by small motor-driven friction wheels resiliently engaging the cable; or by any combination of these means, the result being that the excavating device easily follows the direction of the cable to be disinterred. A preferred form simultaneously cuts an annular path around the cable, and in addition removes the material directly above the cable facilitating its recovery.

A still further object of the invention is to provide a method of burying or disinterring a cable by means which create a basin in the sea floor, rather than a mere trench, the basin moving progressively.

In the drawings:

Figure 1 is a diagrammatic view illustrating a vessel disinterring a cable at the front end and simultaneously interring a substitute cable.

Figure 2 is an elevation partly in central vertical section of a preferred form of excavator.

Figure 3 is a front elevation of the excavator, half in vertical mid-section.

Figure 4 is a slightly modified excavator shown as supported by a cable to be buried.

Figure 5 is a further modified form of excavator.

Figure 6 is one of a series of auxiliary ejectors.

Figure 7 is a horizontal section above the pivot rods of the preferred form of excavator.

Up to the present time it has frequently happened that a cable has become so deeply embedded that it is cheaper to lay a new cable than

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to disinter the old one. An exception naturally exists where some fault has to be repaired or the terminal has to be shifted slightly, and in these cases it is necessary to go to the heavy expense required under old practice. Another difficulty is that where the water depth is reasonably shallow, the draft of a suitably equipped cable ship is too great to permit navigation at that depth and this has required the use of smaller craft, the ability of which is seriously limited. Another point of difficulty has been that where a cable was buried deeper than say a foot, the pulling on the cable itself to free it frequently exceeded the limit of elasticity of the protective armor of the cable and it would break.

The present invention is based on the thought that a cable can be laid at almost any reasonable depth with much convenience and even for a distance of several miles from the shore, if we employ powerful streams of water applied from nozzles in an excavator that is not rigidly connected with the vessel and hence can precede the vessel and enter shallow waters below the draft of the mother ship.

The present device can readily lay a cable two feet beneath the bottom and this is generally considered a sufficient distance to insure against possible mishaps caused by tide or by mechanical actions. The water jet method here illustrated is capable of burying a cable two or three times that depth and can as readily remove a cable buried a fathom beneath the sea floor. It can operate at pressure up to fifty atmospheres.

Referring particularly to Figure 1 showing the general idea, a cable ship or other vessel **10** is equipped with a pump **11**, a compressor **12**, a cable winding device **14**, a towline **16**, and of course the usual devices (not shown) including dynamometer, sonic depth finder, profile recorder, cable length computer, etc. At the front end of the ship the excavator is numbered **20** and it surrounds a cable **21** which in this case is being disinterred and wound on spool **14** as it is recovered. An air pipe **23** leads from the compressor to furnish bubbles **54** to indicate on the surface of the water the direction of the cable and to operate a small compressed air motor driving a pair of wheels **55** engaging the cable **21** to move the excavator **20** forward on the cable. One or more water pipes **22**, either single or multiple, lead from the pump **11** to the excavator. The excavator **20** is shown as throwing a forward annular main stream **24** and an auxiliary stream **25**, the former surrounding the

buried cable 21 and the latter clearing away the material above the cable.

At the rear of the ship 10 an excavator 30 is being pulled by towline 16 and is burying a cable 31 which has previously been lightly laid on the sea floor or bottom 32. Naturally a cable can be buried as it is unwound. As in the previous case, the jets of water from the excavator clear a basin for the cable and the natural action of the sea buries the cable at the depth to which it is pulled down by the weight of the excavator 30 and its applied ballast. The depth at which the cable 31 will be buried will also depend upon the tautness of the towline 16 and its length.

In Figure 2 the excavator 20 is shown in its preferred form. It consists mainly of three major portions: a top portion 41 of the main body, a similar cooperating lower portion 42, and a readily removable secondary ejector 43. These three portions are supplied with water under pressure by pipes 44, 45 and 46 respectively, leading from an outlet box 50 which is supported by the cable 21 and has a loose clamping plate 51 secured by bolts 53 so that the outlet box may readily be removed from the cable. The outlet box 50 receives its water supply from main water pipe 22 and receives air thru a pipe 23 shown separate for convenience of illustration but actually located inside or attached to the main water pipe 22 in many cases. Thru the air pipe 23 compressed air is supplied to cause bubbles such as indicated at 54 to rise to the surface to show the direction in which the cable extends and the air also drives a small compressed air motor within the outlet box and driving the friction or traction wheels 55 on opposite sides of the cable. When the traction wheels 55 are used, the outlet box 50 is secured to the main portion of the excavator by a rigid rod such as 56 but where these wheels are omitted or are driven from the excavator body, as is generally the case, the rod is replaced by a simple wire which under tension pulls the outlet box along behind the excavator as it advances along the cable 21 by gravity, by auxiliary rear jets 49, or by the wheels yieldingly engaging the cable. Within the outlet box is a valve independently controlling the flow of water thru pipe 46. This valve is indicated by lever 58 which can manually be controlled by the diver who generally accompanies the expedition, or in our later models this valve is electrically controlled from the ship in any well known fashion.

As best seen in Figure 3 at the left, the upper section 41 and the lower section 42 are each complete in themselves, having a large clear cylindrical opening 59 and hinge on each other by either of two pivot rods 60, either or both of which can readily be removed from the lugs 61 and 62, one pair on the upper portion and the other pair on the lower portion. In this way the two portions are held together forming a hollow frusto-conical body. The inner wall 63 of each portion is cylindrical while the outer wall 64 is conical. While the water enters the top section thru pipe 44 and the bottom section thru pipe 45, it emerges as an annular jet or stream 24 as the water passes thru the arcuate slits 65 of practically 180° each. A ballast 66, preferably of lead, surrounds an angle of 60° of the bottom of the excavator and additional weights such as 67 may be applied, depending of course upon the depth at which the cable lies and the speed of travel of the excavator.

As the pull of the winding device 14 keeps the cable 21 from assuming a catenary form, the inclination of the cable is such as to cause the vertical component of the weight of the ballasted body to be sufficiently great as to counterbalance the reaction of the annular jet, hence the excavator will, in absence of either traction wheels or reverse jets, advance along the cable in accordance with the amount of ballast and the inclination of the cable modified by the speed of the mother ship. It will be noted that, differing from all previous devices, the advance of the excavator is generally quite independent of the advance of the ship. With the traction wheels 55 in use the excavator 20 may move into shallow water while the cable ship remains in deep water.

The auxiliary ejector or nozzle 43, fed thru pipe 46, fits in a pierced lug 68 rising from the upper portion 41 near the annular nozzle 65 and may consist of a mere conical pipe such as 43 having a vertical slot 71, preferably broken into a number of portions by small partitions or bridges 72. For sandy bottoms this type of secondary ejector is very satisfactory and four partitions divide the secondary nozzle into five long slots, these being directed upwardly and a bit forwardly. Where the bottom is muddy, the type of secondary ejector shown in Figure 6 is a bit more satisfactory. The flexible pipe 79 is threaded to receive a union 73 and the type of ejector shown in Figure 6 is merely flaring, being of the same width as the ejector 43 but rising as at 75 to a fan shape and having the same slots 71 divided by the partitions 72. The water blade in this case is directed generally forward and somewhat upwardly. A small boss 77 fits into the hole in lug 68 and may be secured in place by any ordinary fastening means. The pipe 79 permits angular adjustment of the secondary ejector whether a simple pipe like 43 or the fan shape shown in Figure 6, or any of the intermediate nozzles. It is the work of but minutes to substitute one secondary ejector for another, there being a number of them in a set.

In Figure 4 a somewhat modified ejector is illustrated, this form being particularly suited to laying a cable. The cable 31 as shown has already been laid upon the bottom and the excavator 30 is supported by this cable, in fact resting directly upon it, the support being by a carriage 80 in which are pivoted three or more wheels 81 of a shape to fit the cable 31. The excavator has a bracket 82 turning freely on the central pivot 84 and a shackle 85 of generally U-shape turns freely about the same pivot 84. The towline 16 preferably ends in a chain 86 to give added weight and we freely surround the chain at times with a steel pipe 87 to act as a further ballast. The forward nozzles are numbered 88 and the downwardly directed nozzles are numbered 89, preferably one row of nozzles 89 being on each side and there being but a single vertical row of nozzles 88. The smaller holes 90 are preferably directed a bit aft and aid materially in clearing the material while digging the trench. In this case the weight of the excavator 30 with or without added ballast pulls the cable 31 down to the desired depth. In this particular modification a water-pipe 91 leading on one side controls the front nozzles 88 and a similar pipe on the opposite side controls the nozzles 89 on each side as well as the flow thru the smaller holes 90. The velocity of flow is controlled by the speed of the pumps feeding the dual line 22*a* enclosing the pipes 91.

There are times when the depth at which it is desired that the cable shall be buried or the sea depth is so great that the interference of several pipes makes it advisable to substitute a self-contained unit. The modified form of excavator shown in Figure 5 receives electrical current thru the towline **16** connected to the shackle **85** pivoted to the carriage **80** as before. In this particular modification the water jets are all supplied by an electric pump **95** having an intake **96** and discharging thru a pipe **97**, successively to the front nozzle **98**, the auxiliary nozzles **99**, the bottom nozzles **100**, and the exit end of the pipe. In this modification the pump constantly discharges water which flows rearwardly as indicated at **101** which aids in moving the excavator forward. The amount of water delivered to the front nozzles **98**, or to the intermediate nozzles **99**, or to the bottom nozzle **100** is controlled by valves **103** and **104** electrically operated thru current wires within the armored cable **105**, leading from the towline **16** to the excavator body which in this case is quite heavily armored as indicated at **106** to give very considerable weight and also to withstand the great pressures to which this particular modification will be subjected.

Neither of the two valves are ever closed completely but the amount of closure determines the relative amount of water discharged thru the front nozzle or the other nozzles, there always being some discharge at **101**. As in the other modification, the idler wheel **108** merely prevents the carriage **80** from leaving the cable **31** on which it is supported. As perfectly obvious, this device will inter a pipe just as well as a cable where the pipe has the necessary amount of bending which can be rather slight when the towline **16** is of considerable length. The pump **95** is of variable speed type, draws in the sea water proximate the operation, and while heavily encased in armor may readily be drawn from the body when the armor is removed. This excavator either buries or disinters a cable, interring either a cable being payed out or a cable previously laid on the sea floor. The main nozzle **98** consequently may be directed slightly upward as shown or at a steep inclination to direct its stream across the cable.

What we claim is:

1. The method of recovering a buried submarine cable or pipe which consists in progressively discharging a substantially annular water jet roughly coaxial with the buried cable, raising the free end of the cable, and simultaneously discharging a water jet upwardly and forwardly with respect to the axis of the annular jet so as to remove the overhanging materials of the sea floor above the buried cable.

2. The method of laying a cable or pipe below the sea floor which consists in first paying out the cable to rest loosely upon the sea floor, then cutting a relatively deep basin in the sea floor directly below a portion of the payed out cable while pulling the said portion down into the basin and well below the level of the sea floor, and constantly extending the basin in the direction the cable is to extend, the natural action of the sea replacing the floor as the basin progresses.

3. The method of claim 2 in which the basin is cut by means of jets of water at high velocity, certain of said jets being directed vertically downward below the cable in the basin to insure the formation of a basin at least 50% deeper

below the sea floor than the desired depth of the cable, other jets located below the cable in the basin being directed forwardly whereby to form a constantly moving basin and prevent the formation of a tunnel.

4. The method of claim 2 in which the basin is cut by means of an annular water jet substantially coaxial of the payed out cable and surrounding the cable in the basin.

5. The method of claim 2 in which the cutting of the basin is by means of a series of jets of water at high pressure and at different angles with respect to horizontal and vertical and varying the velocity of the water thru the series of jets independently of each other, so as to dig the basin deeper or shallower as may be desired.

6. In a ship controlled submarine excavator, for burying or excavating a cable, a body supported at least in part by the cable, means for discharging a stream of high velocity water thru the body adjacent the cable to cut a basin, and means for moving the body forwardly along the cable independently of the movement of the ship.

7. The device of claim 6 in which the body is suspended from a carriage movable upon the cable.

8. The device of claim 6 in which the means include motor driven members which engage the cable to propel the body along the cable.

9. In a device for burying a cable beneath the sea floor, a ship, a cable extending from the ship to the floor, a carriage resting upon the cable, a body suspended from the carriage, a towline secured to the ship and pulling the carriage along the cable, a motor-driven pump within the body drawing water from the sea and discharging the water thru a system including a water conduit having an exit end at the rear of said body to aid in advancing the body, a forward nozzle at the front of said body for cutting a basin in the sea floor in advance of the body and below the cable, an auxiliary nozzle directed downwardly to deepen the basin, a valve between the two nozzles, and a second valve between the auxiliary nozzle and the exit end, said valves controlling the relative amounts of water discharged thru the two nozzles and thru the exit end whereby to make the basin deeper or shallower and thus determine the depth at which the cable will be buried as the natural action of the sea replaces the sea floor as the basin moves in the direction of the yet-unburied cable.

10. A device for disinterring a cable or pipe buried beneath a sea floor, comprising a shell having a forward annular nozzle surrounding the cable being freed, and means for conveying water under pressure to the shell and thru the nozzle, in which the shell is formed by two generally similar sections together forming a truncated cone, each section discharging thru an arc of approximately 180°, one section above the cable, and the means includes a pipe for each section whereby the discharge of water may be from the upper section alone, the lower section alone, or from both sections together.

11. A device for disinterring a cable or pipe buried beneath a sea floor, comprising a shell formed of two generally similar sections together forming a truncated cone, each section with a forward opening to form half of an annular nozzle, a high pressure water pipe for each of the two sections, an auxiliary nozzle and a third pipe leading to said auxiliary nozzle, said auxiliary nozzle throwing a jet or blade of water forwardly

and upwardly to remove overhanging material of the sea floor.

12. The device of claim 10 with means fixed with respect to the shell for moving the shell away from the freed portion of the pipe or cable and toward the still-buried portion.

13. The device of claim 12 in which the shell advancing means yieldingly engages the cable or pipe and is motor driven.

14. The device of claim 11 with rollers at a fixed distance from the shell yieldingly engaging the cable or pipe, and means to drive the rollers whereby the shell and the three pipes may be advanced along the cable or pipe independently of movement of a mother vessel taking in the cable or pipe as it is disinterred.

15. A submarine excavator comprising a body, a variable speed pump within the body, an intake for leading sea water to the pump, a conduit fed by the pump discharging to the sea in rear of the excavator, nozzles discharging forwardly and downwardly from the conduit through the lower portion of the body, a reversible nozzle at the forward end of the conduit, and means for altering the relative amounts of water discharged by the rear, front and intermediate nozzles to excavate a shallower or deeper basin beneath the sea floor.

16. An excavator for burying a submarine cable or for disinterring a buried cable, controlled from a mother vessel but operating independently thereof; comprising a body supported at least in part by the cable, means for moving the body on the cable independently of the movement of the mother vessel, a plurality of water jets extending from the body, one jet discharging above the centerline of the body and another jet discharging below such centerline, a pump for discharging water at high pressure through the jets, means for altering at will the relative amount of water passing through the jets to cut the sea floor at a greater or a less angle to form a basin of desired depth, and a third jet discharging water in rear of the body to aid in moving the body forward to advance it on the cable.

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