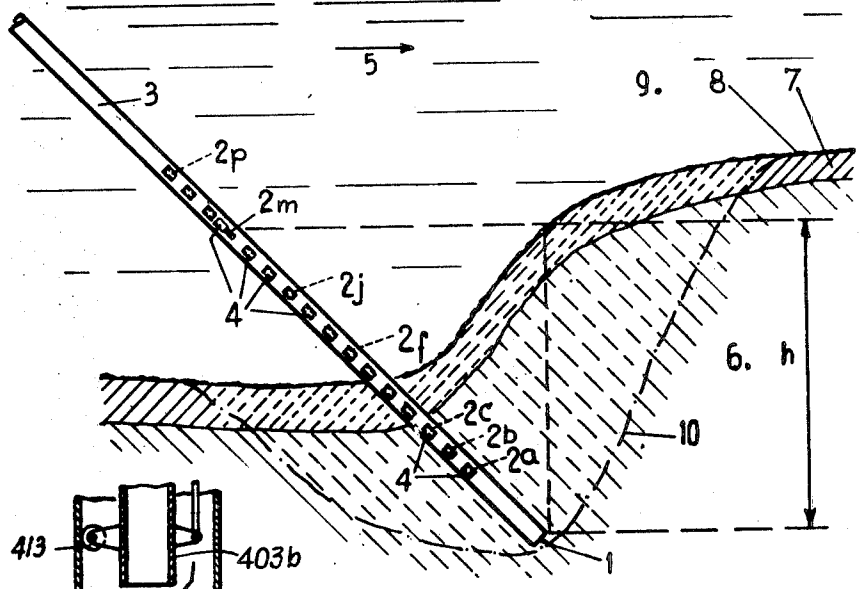
Oct. 12, 1971 JAN DE KONING 3,611,595

SUCTION DREDGER AND METHOD OF SUCTION DREDGING

Filed Aug. 8, 1969 2 Sheets-Sheet 1

FIG.1



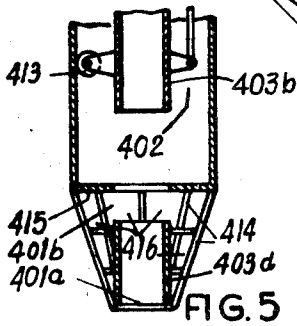


FIG. 5

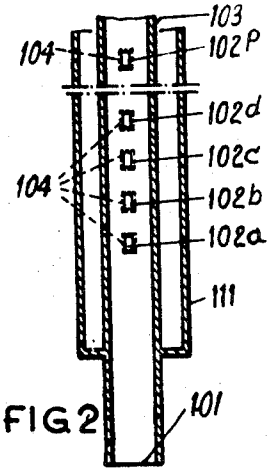


FIG 2

FIG.3

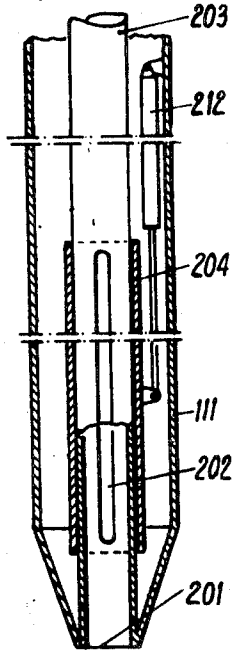


FIG.4

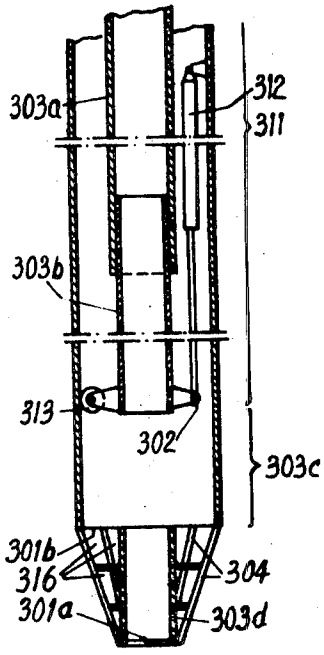


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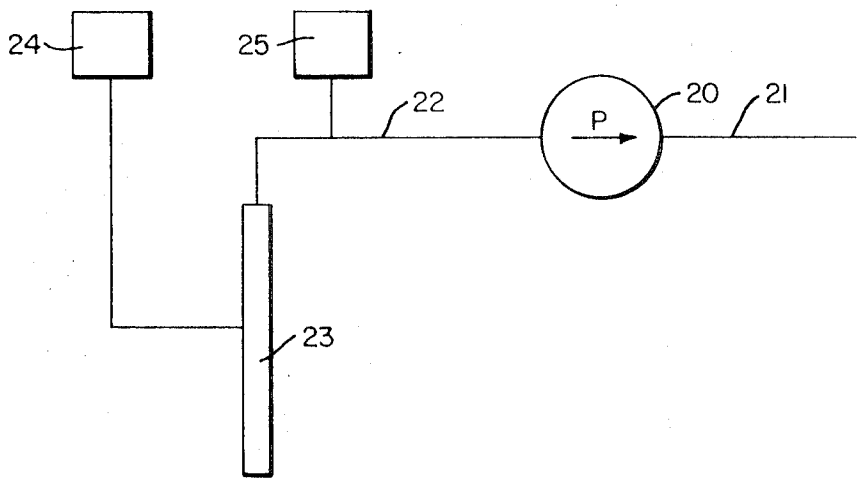
FIG. 6.



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SUCTION DREDGER AND METHOD OF SUCTION DREDGING

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Continuation-in-part of application Ser. No. 524,934, Feb. 3, 1966. This application Aug. 8, 1969, Ser. No. 866,050
Claims priority, application Netherlands, Feb. 4, 1965, 6501404
Int. Cl. E02f 3/92
U.S. Cl. 37—58 11 Claims

ABSTRACT OF THE DISCLOSURE

Method and apparatus for suction dredging particulate material such as sand. A suction pipe is inserted into a body of sand below the bottom of a body of water to withdraw a water-sand suspension having a desired concentration of sand in such suspension. At the lower end of the pipe, the sand is drawn in at very high concentration and at some level above this point water is separately introduced and the desired concentration is obtained by adjusting the level at which the water is introduced. The concentration of the resulting suspension is measured to enable the level of water introduction to be adjusted properly.

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of application Ser. No. 524,934, filed Feb. 3, 1966, now abandoned.

SUMMARY OF THE INVENTION

This invention relates to a suction dredger installation comprising a pump and a suction pipe which is connected to the pump and which has at least one first suction nozzle at the end and at least one second suction nozzle between the pump and the end. The invention also relates to a method of sucking up spoil by means of the said suction dredger installation, wherein the first suction nozzle draws spoil and the second suction nozzle draws mainly water into the suction pipe.

A suction dredger of this kind and a method of this kind are disclosed in German patent specification 815,625. This specification proposes so to construct the end of the suction pipe that the second suction nozzle can draw a considerable amount of water, more particularly if the first suction nozzle becomes clogged by large objects, i.e., large stones or rocks. In the known method, the first suction nozzle is held above the cavity while the attempt is made to obtain a constant spoil concentration in the drawn-up suspension. With the known method it is very difficult to obtain this constant concentration because the condition in front of the first suction nozzle are continuously subject to considerable variation.

The invention provides a method and a suction dredger installation of the type specified in the first paragraph, with considerable advantages over the prior art.

In the method according to the invention, the end of the suction pipe is inserted into the cavity and the distance between the two suction nozzles is adjusted to control the concentration of spoil in the drawn-in suspension in dependence upon the column of spoil and any other material floating thereon above the first suction nozzle. The spoil concentration in the sucked up suspension is thus accurately adjusted to the required value.

An important advantage of the method according to the invention is that it can be used to draw spoil from the cavity even beneath an impure top layer, for example a layer of clay. The impurities and large objects at the bottom of a dredging site cannot clog the suction nozzles with the method according to the invention. Preferably, the end of the suction pipe is inserted deeply into the cavity so as to reduce the risk of the impure top layer reaching the suction nozzle. Drawing spoil from a deep position beneath the cavity does not require more power than drawing spoil at the surface of the cavity.

The invention also provides a suction dredger installation adapted more particularly to performing the method according to the invention and which is characterized by adjustability of the distance between the two suction nozzles.

Finally, the invention provides a number of advantageous constructions of the suction pipe end, the distance between the two suction nozzles being adjustable, while the position of the first suction nozzle and the suction pipe with respect to the hard cavity can be maintained.

The invention will be explained hereinafter with reference to a method and a number of suction pipes for the suction dredger installation according to the invention.

BRIEF DESCRIPTION OF THE FIGURES OF DRAWINGS

FIG. 1 is a diagrammatic view of the surroundings of the end of a suction pipe during performance of the method according to the invention.

FIGS. 2, 3 and 4 each show an end of a suction pipe for a suction dredger installation according to the invention.

FIG. 5 is a detail corresponding with detail V of FIG. 4, of another modification of the end of the suction pipe for a suction dredger installation according to the invention.

FIG. 6 is a diagrammatic view illustrating the component parts of the suction dredger installation according to the present invention.

With reference to FIG. 6, certain relationships according to the present invention will be readily discernible therefrom. As shown, the suction dredger installation includes a suitable pump **20** having a discharge line **21** from which a fluid suspension of water and sand is obtained. It will be understood that the suction dredger installation may be mounted, for example, on a barge or the like with the barge receiving the material discharged.

The inlet side of the pump is connected to the conduit system indicated by the reference character **22** which leads to the suction pipe **23** which, at its lower end as will hereinafter be more particularly pointed out, is adapted to withdraw the spoil or sand into the conduit system. As is also pointed out hereinafter, a separate inlet for water is provided into the conduit system and the level at which the separately introduced water is comingled with the suspension of an inherently high sand concentration is controlled to produce the desired and much lower sand concentration reaching the discharge line **21**. The control for adjusting the point of water introduction is indicated by the reference character **24** and may take any suitable form compatible with the mechanism actually utilized for adjusting the water level intake.

Additionally, a sand concentration meter **25** is provided which measures the concentration of sand in the conduit system as effected by the comingling of the high sand concentration introduced into the lower end of the suction pipe and the separately introduced water. This meter may be of any suitable type, as for example to U.S. Pat. 2,661,550 or 2,768,529.

In any event, it is desired that the concentration of sand in the suspension be maintained in the range of about 10 to about 25%. Within this range, good pumping efficiency is obtained while at the same time effecting an efficient and essentially continuous withdrawal of sand or spoil from the bed of material being dredged.

In the method according to the invention, the suction dredger installation used has a suction pipe whose end differs from conventional constructions. Thus, the figures show only the free part of the suction pipe of the suction dredger installation which comprises a spoil pump between a pressure pipe and a suction pipe.

The suction pipe **3**, which is shown in the operative position in FIG. 1, comprises a first suction nozzle **1** and a second suction nozzle formed by opening one of the apertures **2***a*–**2***p*. These apertures are at different distances from suction nozzle **1** and normally each one is closed by a slide **4**. Each slide **4** can be remotely adjusted independently by suitable means, i.e., hydraulic means, between two positions in which the opening is respectively open and closed.

The suction pipe **3** is continuously moved in the direction of arrow **5** in the inclined position shown in FIG. 1. FIG. 1 also shows the following in the upward direction: a layer of sand **6**, a layer of clay **7**, impurities, i.e. wood, **8**, resting on the layer of clay, and water **9**. The soil enclosed by line **10** is brought into suspension by undermining while outside the line **10** the soil is consolidated.

According to the invention, aperture **2***m* is left open so that at that aperture the incoming water and the suspension drawn through the first aperture **1** are mixed with a very high sand concentration. The high-concentration suspension rises automatically to the level of the aperture **2***m* in the suction pipe because the end of the suction pipe forms a communicating vessel with the cavity in the consolidated soil indicated by line **10**. It will be immediately apparent that if aperture **2***j*, for example, were opened, the suspension would run out of the suction pipe into the water. The water would thus be prevented from entering through such aperture, so that the pump would draw only spoil with a very high concentration. This would result in stalling of the pump and sand clogging of the suction pipe, pump and/or pressure pipe.

On the other hand, if, for example, aperture **2***p* were opened, the water entering through that aperture would tend rather to be drawn in than the high-concentration suspension which would first be drawn in from aperture **2***m* to aperture **2***p* by the pump suction. The result would be a suspension having a too low sand concentration. In addition, the fact that a column of heavy suspension is drawn to an unnecessary height means a loss of pumping power.

By opening the correct aperture of the apertures **2***a*–**2***p* the sand concentration in the suspension can be controlled and the pumping power can be applied with maximum economy.

Sand is preferably drawn deeply from the cavity. This greatly reduces any chance of impurities or clay being drawn in. With the method according to the invention, in view of the frictional resistance in the bottom part of the suction pipe the fact that sand is drawn in from a low level does not require more energy than if it were drawn from the level of the impurities **8**. With the method according to the invention the dredged well is not first freed of clay and impurities; instead, the weight of clay and impurities is put to advantage for drawing in the sand. Neither the drawing of sand to the aperture **2***m* nor the conveying of water to the suction pipe **3** requires energy.

In order to prevent sand entering the second suction nozzle instead of water if the cavity suddenly falls in, a water pipe **111** is preferably disposed around the suction pipe **103**, the water pipe being closed at the bottom and open at the top, see FIG. 2. This water pipe always provides communication between the open second suction nozzle **102***a*–**102***p*, and the water above the dredging site. Otherwise, the construction and operation of the suction pipe of FIG. 2 in the same as that of the suction pipe of FIG. 1.

The pressure difference acting on the sand at the sand inlet and causing it to flow upwardly is determined by the weight of the column *h* of sand, clay and impurities above the first section nozzle **1**. This pressure difference is cancelled out by adjusting the second suction nozzle **2** to approximately the level of the top of the column *h*. Adjustment of the second suction nozzle to a higher or lower level respectively results in more water and more sand being pumped up. The concentration of sand in the suspension can be accurately controlled by continuous variation of the distance between the first and second suction nozzles.

FIG. 3 shows a suction pipe **203** with a continuously variable distance between the first suction nozzle **201** and the second suction nozzle **202**. In FIG. 3, the second suction nozzle **202** is formed by one or more slots in the suction pipe completely closed by means of slide **204** engaging around the suction pipe **203**. This slide is remotely adjustable by a hydraulic cylinder provided between the water pipe **211** and the slide **204**. The level of the second suction nozzle is determined by the level of the bottom end of the slide **204**.

The suction nozzle **303** shown in FIG. 4 is substantially the same as that shown in FIG. 3. For a proper understanding of the suction pipe **303** according to FIG. 4, it should be noted that the suction pipe **303** consists of four parts, i.e., a pipe part **303***a* rigidly connected to the pump, a part **303***b* axially slidable with respect to the fixed part **303***a*, a part **303***c* having a larger diameter and integral with the pipe **311** disposed around the suction pipe **303** and a pipe part **303***d* having a same diameter as pipe part **303***b* and being connected by means of a basket **304** to the end of the pipe part **303***c*. Thereby two first nozzles **301***a* and **301***b* are provided in the lower end of the pipe parts **303***d* and **303***c* respectively, while the water inlet is formed by an annular gap between the water pipe **311** and the bottom end of the slidable part **303***b*. The latter part is guided by three wheels **313**, which are distributed over the periphery, with respect to the water pipe **311** secured to the fixed part **303***a*. The part **303***b* is adjusted by means of three hydraulic cylinders **312** distributed over the periphery.

Preferably, adjustment of the distance between the first nozzle **301***b* and the water inlet is obtained automatically. The means for operating the slides, or valves, **4** and/or the slidable part **303***b* can be controlled by the concentration meter **25** incorporated in the suction pipe or pressure pipe.

While the end of the suction pipe **303** is introduced into the cavity the slidable part **303***b* is preferably pushed down until it abuts the portion **303***d*. A continuous pipe with just one aperture **301***a* is thus formed. The suction pipe can thus be used firstly as an injection lance and then as a suction pipe **303** with just a first suction nozzle **301***a* if the cavity is still hard or consolidated. In this way the suction pipe can be introduced into the cavity more easily at the beginning of the suction process. As soon as the cavity has been loosened by the first suction nozzle **301***a* and the concentration drawn up suddenly increases, the second suction nozzle **301***b* can be formed by pulling up the part **303***b*. In this way the first suction nozzle **301***a* is simultaneously opened, through which further the main volume of the drawn up suspension enters into the suction pipe.

The preferred embodiment of the suction pipe is shown in FIG. 5 and differs from the suction pipe **303** by the facts that a ring **415** having a central aperture in which the pipe part **403***b* just slidably fits, is arranged above the basket **414**, the pipe part **403***d* is shortened at its top and the pipe part **403***b* is lengthened at its lower end.

The suction pipe again is provided with two first nozzles, the one **401***a* of which is positioned in the lower end of the pipe part **403***d* and the other **401***b* of which is positioned like an annular gap between the upper end of the pipe part **403***d* and the ring **415**. This suction pipe can be

put in the cavity even more easy. During that operation first the slidable pipe part **403***b* is slided downwards until it abuts the pipe part **403***d* and the suction pipe is alternatively used as an injection lance and as a suction pipe having only one first nozzle **401***a* as long as the cavity in front of the nozzle is still consolidated. As soon as the cavity in front of this nozzle is loosened and the concentration of spoil drawn up is large, the pipe part **403***b* is lifted up to such a height, that its lower end remains below the ring **415**. The pipe part **403***b* is held in this position until the cavity surrounding the basket is loosened. When a too large spoil concentration threatens to be drawn up, the pipe **403***b* is lifted to clear the ring **415** and allow water to enter the lower end of pipe **403***b*.

During carrying out the method according to the invention by means of a suction dredger installation according to FIGS. 4 and 5, the water inlet is adjusted at such a height above the first nozzle **301***a* or **401***a* respectively that the pressure at the inside of the spoil inlets is not much lower than on the outside. This prevents any clogging of any of the spoil inlets or at least greatly reduces the chance of disturbing clogging. Since the end of the suction pipe is inserted into the cavity and moved along in good time, the spoil of the cavity is loosened by undermining and prepared as a readily dredged suspension having a high spoil concentration. The suction at the spoil inlet, which is principally the cause of clogging in conventional methods, can be small in the method of the invention, firstly because the suction nozzle is continuously kept in a suspension having a high spoil concentration instead of in front of a cavity which has to be worked loose, and secondly because a small part of the total flow of the suspension is fed through the spoil inlets. The water, which forms the greater part of the flow through the pump, does not enter the suction pipe via the suspension inlets. As soon as a large object covers a particular spoil inlet of the embodiments of FIGS. 4 and 5, turbulent flow occurs as a result of the spoil currents through the other spoil inlets and as a result of the movements of the suction pipe which take place periodically or continuously, and these turbulent currents have an opposite direction at the covered inlet; in other words, a pressure difference occurs over the covered inlet and is opposed to the small pressure difference normally prevailing over such inlet and even outweighs such pressure difference. Consequently nearly every object is detached from the inlet in question and drops behind the pipe.

For removing large objects possibly sticking in the spoil inlets, the pipe part **303***b* or **403***b* may be lifted periodically so that every time such lifting occurs the suction at the spoil inlets is decreased.

Lifting the pipe part **303***b* or **403***b* from the operational position will cause a reversal of spoil flow and thus removes said sticking objects from the spoil inlets.

If necessary, a cutter may be provided at the end of the suction pipe to loosen the hard cavity immediately in front of the first suction nozzle. The meshes of the basket **314** or **414** respectively are preferably constructed in the form of tubes which are connected to a water pump and which at the end adjacent the hard cavity are provided with exit apertures for water under pressure. If this basket strikes against the hard cavity the meshes make their own path therethrough and thus undermine the sand and clay above the basket.

What is claimed is:

1. A method of suction dredging sand which comprises the steps of:

inserting a suction pipe into a body of sand below the level of the bottom of a body of water so that a column of sand tends to form in said pipe due to the static head on the sand,

introducing water from a source above said bottom into said suction pipe,

commingling said water with said column of sand at a selected point along the length of said suction pipe,

subjecting said suction pipe to a source of suction to withdraw water and sand through said pipe,

and essentially adjusting the level of said selected point to a point adjacent that level to which said column will rise in the suction pipe due to the static head on the sand.

2. The method of suction dredging particulate material below the bottom of a body of water, which comprises the steps of:

forming a column of high concentration material by inserting a suction pipe into a body of the material below the level of the bottom of a body of water, said column extending upwardly from the lower end of said suction pipe,

subjecting the upper end of the suction pipe to a source of suction to withdraw the particulate material through the lower end of the pipe,

introducing water into said suction pipe at a selected point along the length of the suction pipe which is spaced above the lower end thereof and commingling water with the particulate material at said selected point,

and adjusting the location of said selected point with respect to the lower end of the pipe to maintain the concentration of particulate material in the particulate material-water mixture above said selected point within predetermined limits.

3. The method according to claim **2** wherein the concentration of particulate material in the mixture withdrawn is maintained within the range of about 10% to about 25%.

4. The method according to claim **2** including the steps of measuring the concentration of particulate material in the mixture being withdrawn through the pipe above said point at which the particulate material and water are commingled, and controlling the location of said point in response to the concentration measured.

5. A suction dredger installation comprising a pump and a suction pipe having an upper end connected to said pump and which has at least one first nozzle for spoil at its lower end and at least one second nozzle mainly for water between the pump and said lower end, and means for adjusting the level of said second nozzle independently of the levels of said upper end of the suction pipe and of said first nozzle to vary the distance between the two nozzles;

said suction pipe comprising inner and outer pipe sections, said outer section having an open lower end forming said first nozzle and said inner section having an open lower end forming said second nozzle with the surrounding wall of said outer section, said means being connected to said inner section to axially shift same within said outer section;

the lower end of said outer section being provided with an annular disc presenting an opening for receiving said inner section whereby such opening is closed; and

a sleeve carried at the lower end of said outer section beyond the opening of the latter, said sleeve being aligned with said inner section for engagement by the lower end thereof.

6. A suction dredger installation comprising, in combination:

a suction pump adapted efficiently to induct and discharge fluid suspensions of sand in water having selected values of sand concentration therein, and having an inlet for inducting such suspensions;

suction pipe means connected to said inlet and having an open lower end adapted to be inserted deeply into a body of sand below the level of the bottom of a body of water so that a first column of sand and water tends to form in said suction pipe means due to the static head on the sand, in which the concentration of sand in said first column is much greater than said selected values;

means for introducing water into said suction pipe means at a selected point along the length of said suction pipe means and for commingling water with said first column of sand and water to form a second column of water and sand above said first column which extends therefrom to said inlet; and

means for adjusting the level of said selected point with respect to said lower end of the suction pipe means to a point adjacent that level to which said first column will rise in the suction pipe means due to the static head on the sand whereby the concentration of sand in said second column is within said selected values.

7. The suction dredger installation according to claim **6** including means for measuring the concentration of sand in said second column, said means for adjusting being controlled by said means for measuring.

8. The suction dredger installation according to claim **6** wherein said suction pipe means comprises a first pipe directly connected to said inlet of the pump, an outer jacket surrounding said first pipe and having an opening above said first column for admitting water thereinto, and a second pipe slidably engaging said first pipe; and wherein said means for adjusting comprises an actuator for moving said second pipe relative to said first pipe.

9. The suction dredger installation according to claim **8** wherein said first pipe has a fixed lower end below which said jacket extends to present an open lower end thereat, and said second pipe is of a length to extend between said lower end of said first pipe and said lower end of the suction pipe means.

10. The suction dredger installation according to claim **9** including a nozzle fixed at and projecting from said lower end of said suction pipe means, said second pipe being aligned with said nozzle for engagement therewith so that said jacket may be isolated from said first pipe.

11. The suction dredger installation according to claim **6** wherein said suction pipe means comprises a first pipe directly conected to said inlet of the pump, and an outer jacket surrounding said first pipe and having an opening above said first column for admitting water thereinto, and wherein said means for introducing water comprises opening means along the length of said first pipe.

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U.S. Cl. X.R.

37—195; 302—15, 58; 137—4, 92