United States Patent [19]

Bruno

[11] **3,857,651**

[45] **Dec. 31, 1974**

[54] **PUMPING UNITS FOR CYCLONIC ELEVATOR**

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[22] Filed: **July 26, 1973**

[21] Appl. No.: **382,823**

Related U.S. Application Data

[63] Continuation of Ser. No. 155,750, June 23, 1971, abandoned.

[52] **U.S. Cl.** **417/171,** 417/163, 37/61, 302/15, 302/58

[51] **Int. Cl.** **F04f 5/42**

[58] **Field of Search** 37/61, 62; 417/194, 171, 417/197, 177, 163, 166, 196; 302/14, 15, 25, 29–31, 46, 47, 64

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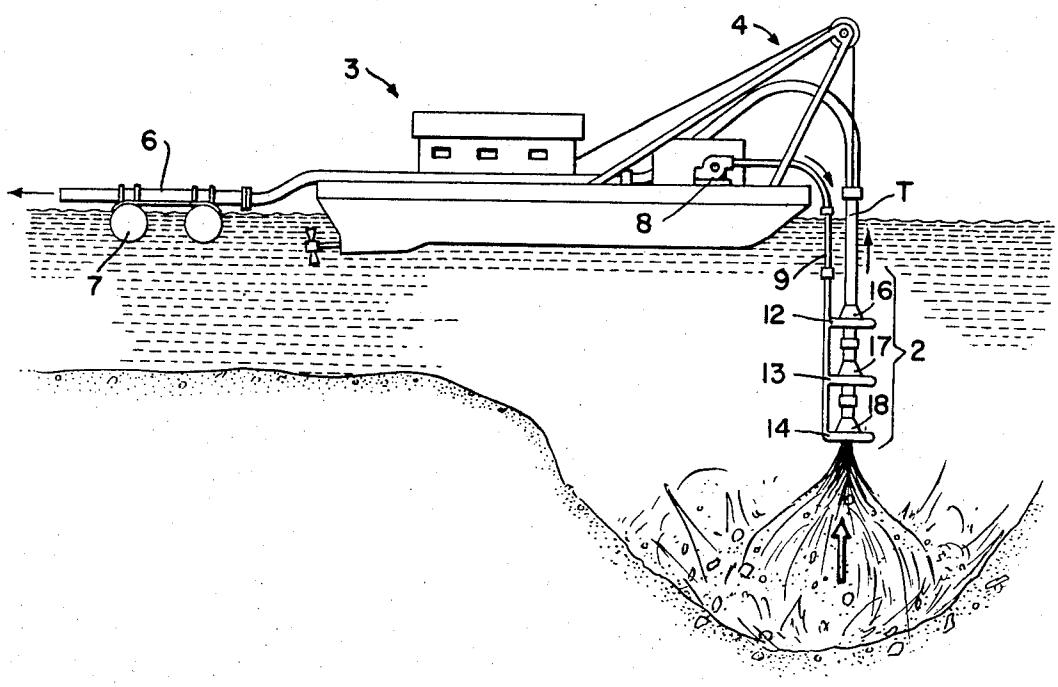
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Primary Examiner—Clifford D. Crowder

[57] **ABSTRACT**

Coaxial pumping units for cylindrical cyclonic elevator tubes in which a manifold circumscribing the latter for supplying fluid under pressure thereto has communication therewith via an annular transition ring provided with a plurality of circumferentially spaced jet orifices set at inwardly and circumferentially directed compound angles for ejecting vortically directed jets of fluid under pressure through the tubular elevator to effect transportation of comminuted and/or fluid material through such tubes.

5 Claims, 15 Drawing Figures



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SHEET 1 OF 4

FIG. 1.

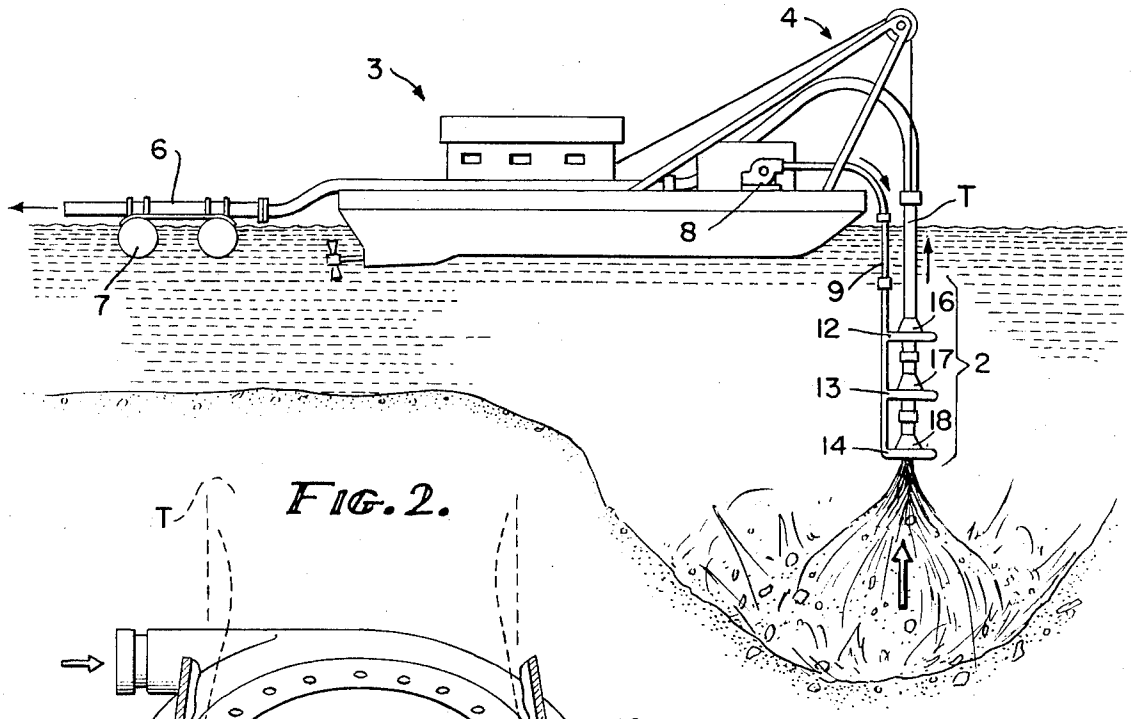
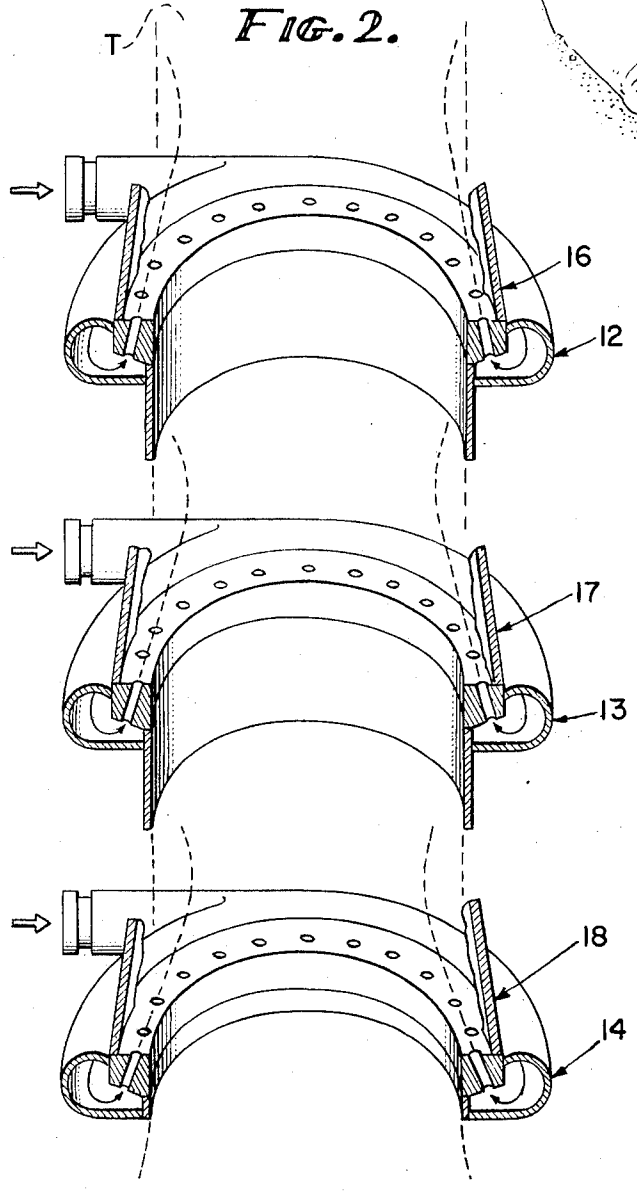


FIG. 2.



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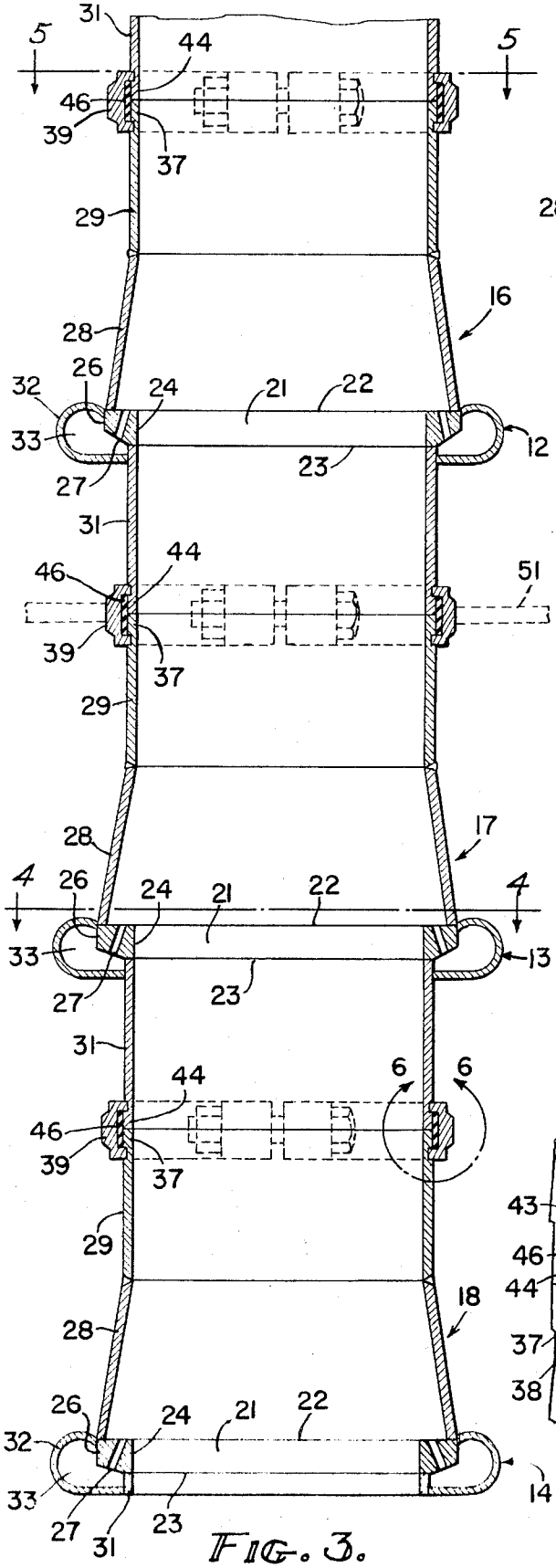


FIG. 3.

FIG. 4.

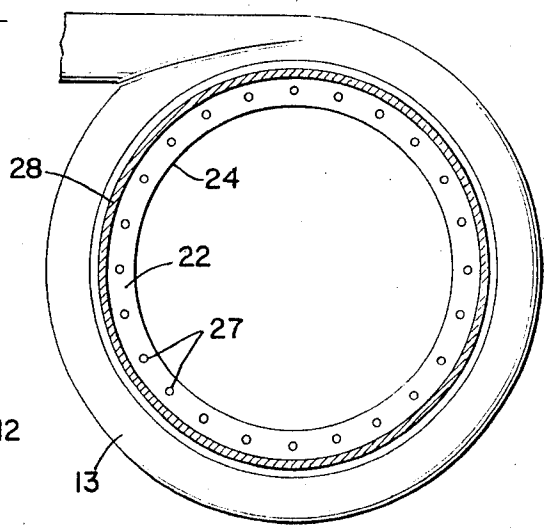
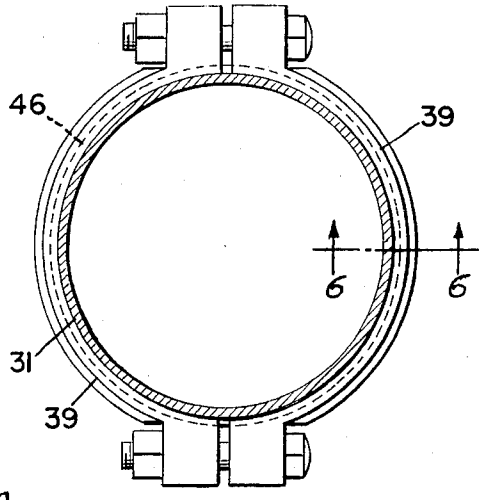


FIG. 5.



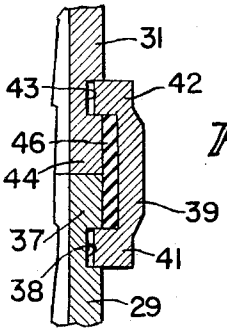


FIG. 6.

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FIG. 7.

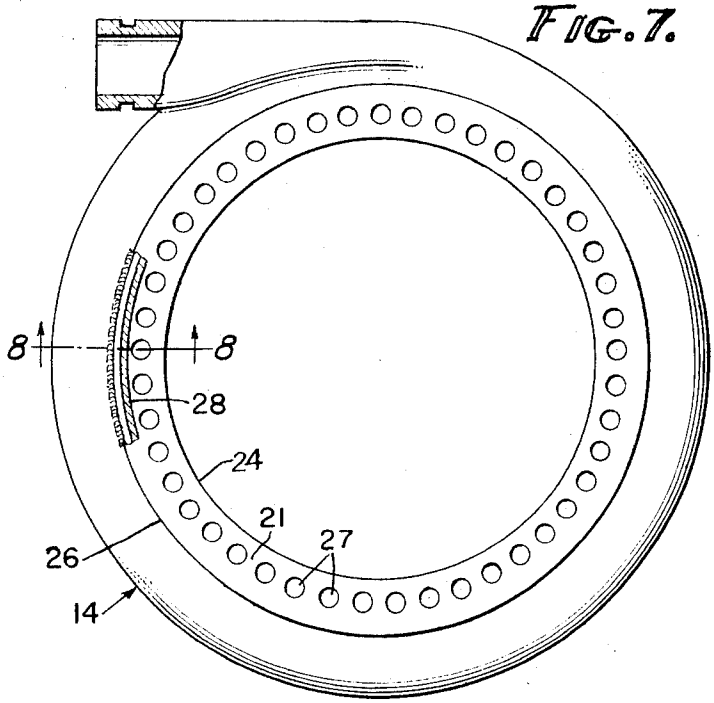


FIG. 10.

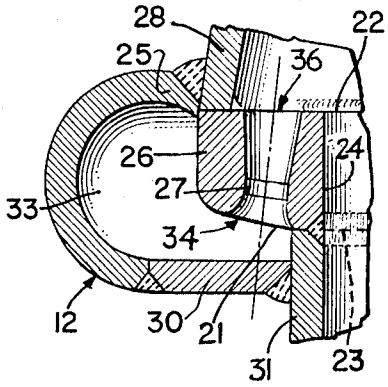


FIG. 9.

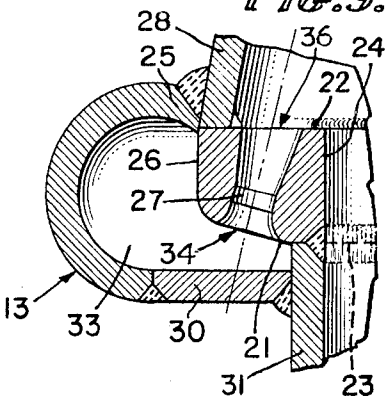


FIG. 11.

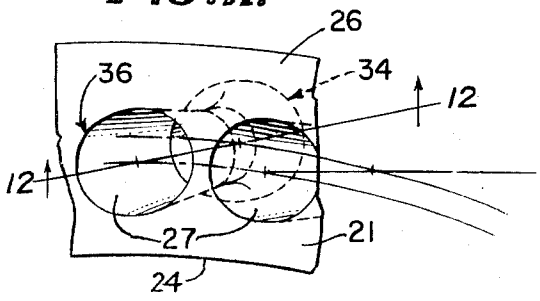


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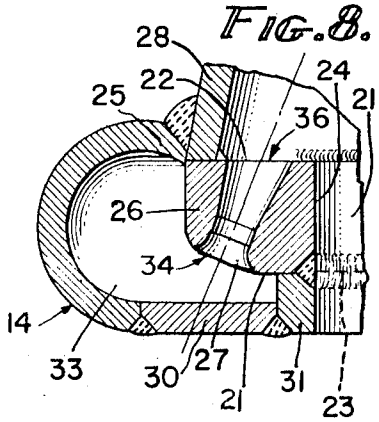


FIG. 12.

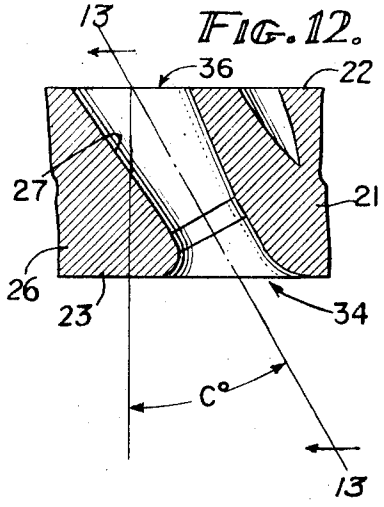
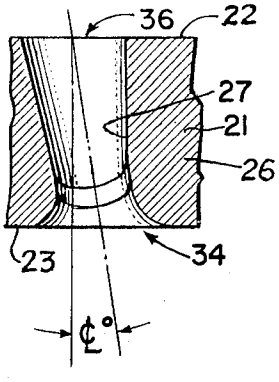


FIG. 13.



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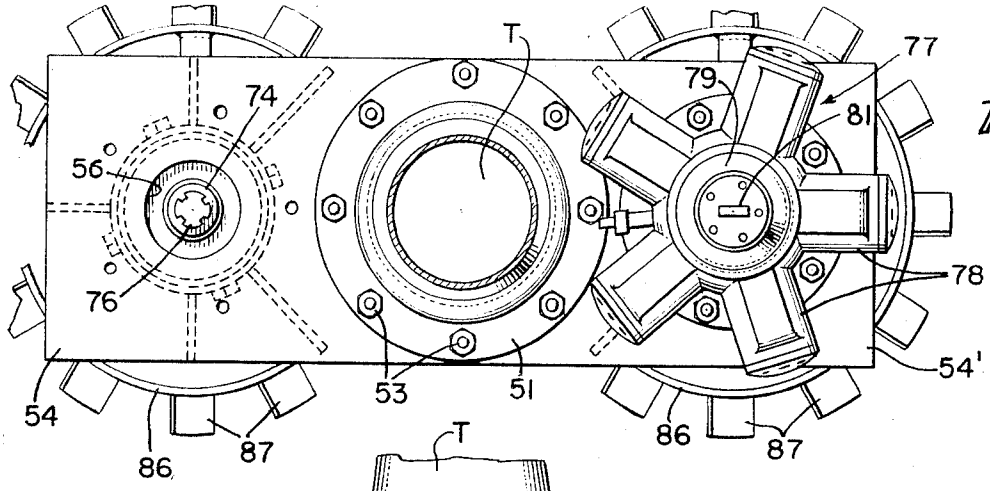


FIG. 15.

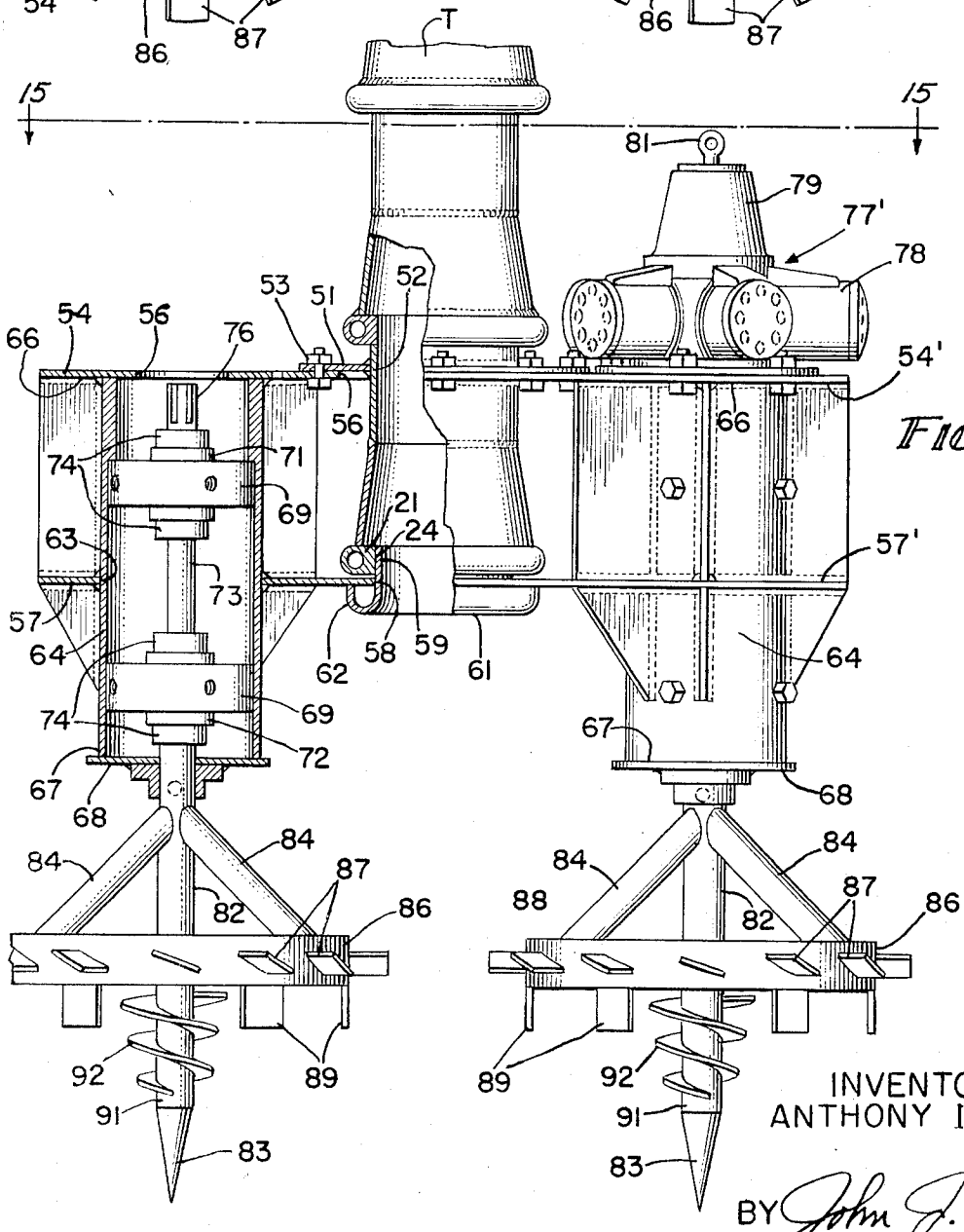


FIG. 14.

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PUMPING UNITS FOR CYCLONIC ELEVATOR

This is a continuation of application Ser. No. 155,750 filed June 23, 1971, now abandoned.

BACKGROUND OF INVENTION

In the transportation of dry comminuted or powdered materials from one place to another, for instance, cotton resulting from a ginning operation, wheat and rice hulls resulting from processes adapted to remove such hulls, and the transportation of powdered cement from kilns to storage areas, it is necessary to confine the material being transported so that it is not disseminated into the atmosphere, while simultaneously propelling the material to move along the conveyor. Heretofore, various types of mechanical conveying means have been utilized, but in most instances these mechanical conveying means have disadvantages which either precluded their use or rendered such use prohibitively expensive. For instance, most mechanical conveying means require elaborate support structures and driving mechanisms for moving the material from one point to another. In other instances, movement of the metal is ineffectively controlled, causing costly stopages which interrupt operations. Accordingly, it is one of the principle objects of this invention to provide a transportation means for wet or dry material that utilizes in general a tubular conveyor having smooth interior surfaces in conjunction with a fluid cushion interposed between the walls of the conveyor tube and the material being conveyed, while imparting to the material being conveyed a propulsive force causing it to move through the tubular conveyor.

In conveying apparatuses in which liquids are transported, such as water or oil, it has been the practice to impose a positive pressure on the inlet end of the conveyor with the pressure thus being transmitted to the body of material being moved. So far as is known, no attempt has heretofore been made to provide a layer of a different type fluid between the liquid being transported and the pipeline or tube within which it is contained. Accordingly, it is another object of the invention to provide for the transportation of a liquid medium through an elongated tubular conveyor by the method of providing a cushioning layer of a different fluid between the liquid being conveyed and the container through which it passes, while simultaneously causing said cushioning layer of fluid to impart to the liquid being conveyed a forward motion.

In the realm of underwater dredging, it has been customary practice to use "clam shell" or drag line and bucket type equipment which physically gouges the bottom of the ocean, lake or river, lifts the material thus confined within the "clam shell" or bucket up through the water and deposits the material in an appropriate barge or on shore. This method of underwater dredging loosens the mud and silt forming the bottom and causes wide dispersion of fine solids in suspension, thus causing a great deal of pollution of the surrounding body of water. Accordingly, it is a still further object of this invention to provide a dredging apparatus which effectively picks up loose material lying on the bottom of a body of water, loosens hard material so that it too may be lifted, and effectively prevents dispersion of solids in suspension beyond the immediate area being dredged.

Heretofore, mechanical means have had to be used to effect loosening of the hard material forming the bottom of a body of water. Suction type dredges have been used to lift loose material, but there has been no way other than through use of mechanical means to effect a loosening of hard materials so that these too could be lifted. It is one of the objects of the present invention to provide an apparatus and method which through the utilization of pneumatic and hydraulic means effects a loosening and lifting motion to the soil forming the bottom of a body of water.

Instances will of course be encountered when pneumatic and hydraulic means are insufficient to effect loosening of hard packed soil. Accordingly, in these instances, additional mechanical means may be necessary, working in conjunction with the pneumatic and hydraulic means, to initially break up the soil and cause it to be conveyed away.

BRIEF SUMMARY OF INVENTION

In terms of broad inclusion, the apparatus of the invention comprises a hollow conveyor tube provided at one end with a unitary pumping assembly adapted to discharge into the interior of the hollow conveyor tube in a predetermined pattern of a multiplicity of streams of a fluid under high pressure, the direction and force of discharge of said jets of high pressure fluid into the conveyor tube being controlled to simultaneously provide a cushion of such fluid between the material to be conveyed and the inner wall of the tubular conveyor, and impart to the material to be conveyed a forward motion. In one aspect of the invention, a plurality of separate pumping units are spaced axially along the conveyor tube for operation in series. The angle of inclination of discharge of the fluid medium into the interior of the conveyor is varied from a relatively sharp angle at the inception or first pump unit to a relatively shallow angle at the last pump unit. Additionally, the interior of the tubular conveyor in the area immediately adjacent the discharge of the fluid medium into the tubular conveyor is formed to provide Venturi action to increase the velocity of the fluids and entrained solid material moving through the tubular conveyor.

DESCRIPTION OF DRAWINGS

FIG. **1** is a perspective view illustrating the apparatus of the invention mounted on a barge. The dredging action of the inverted generally conical body of water immediately below the dredging apparatus is illustrated schematically.

FIG. **2** is a schematic view illustrating three successive pumping units and illustrating the angular relationship of discharge of a fluid medium into the interior of the tubular conveyor at successive stages along the conveyor from the three pumping units.

FIG. **3** is a vertical cross-sectional view through three of the assembled pumping heads.

FIG. **4** is a horizontal cross-sectional view taken in the plane indicated by the line **4—4** in FIG. **3.**

FIG. **5** is a horizontal cross-sectional view taken in the plane indicated by the line **5—5** in FIG. **3.**

FIG. **6** is an enlarged fragmentary vertical cross-sectional view taken in the plane indicated by the line **6—6** in FIG. **5.**

FIG. **7** is a plan view partly in horizontal section illustrating the pattern of fluid discharge bores in one of the pump assemblies.

FIG. 8 is an enlarged fragmentary vertical cross-sectional view taken through the 35th orifice in the first stage pumping unit, the view being taken in the plane indicated by the line 8—8 in FIG. 7.

FIG. 9 is an enlarged vertical cross-sectional view similar to FIG. 8, taken through the 35th orifice in the second-stage pumping unit.

FIG. 10 is an enlarged fragmentary cross-sectional view similar to FIGS. 8 and 9, illustrating a fragmentary section through the 35th orifice of the third stage pumping unit.

FIG. 11 is a full-size fragmentary plan view illustrating by way of example, the compound inclination of the axis of each of the fluid dispensing orifices of each pumping unit.

FIG. 12 is a vertical cross-sectional view taken in the plane indicated by the line 12—12 in FIG. 11, the plane of section being coincident with and including the axis of the orifice.

FIG. 13 is a vertical cross sectional view taken in the plane indicated by the line 13—13 in FIG. 12.

FIG. 14 is an elevational view illustrating a second embodiment of the invention which includes apparatus associated with the pumping heads operative to loosen and break up solid terrain in close proximity to the pumping heads.

FIG. 15 is a horizontal cross-sectional view taken in the plane indicated by the line 15—15 in FIG. 14.

DESCRIPTION OF PREFERRED EMBODIMENT

In terms of greater detail, the material moving and transporting apparatus of the invention will be described in connection with its use for underwater dredging purposes. It should be understood that use in such an underwater environment is being illustrated merely by way of example and not by way of limitation, it being believed that an underwater environment presents the most and greatest difficulties.

Referring to FIG. 1, the apparatus of the invention is designated generally by the numeral 2, and is shown mounted on an appropriate barge 3 equipped with a crane 4 operable to elevate or lower the apparatus into the water into spaced relation with the bottom under the body of water. The dredging assembly 2 is arranged coaxially of a hollow, cylindrical conveyor tube T which is connected to appropriate tubular extensions 6, supported on conventional buoys or floats 7. Air compressor means 8 are provided for pumping air under pressure to the dredging assembly.

As illustrated in FIG. 1, the compressor unit 8 is connected by an appropirate pipe or hose 9 to each of the manifolds 12, 13 and 14 associated with each of the pumping units 16, 17 and 18, respectively. For purposes of this description, the pumping units 18, 17 and 16 respectively, will sometimes be referred to as the first, second and third pumping or dredging stages.

Referring to FIG. 3, it will there be seen that each of the three stages of the dredging apparatus includes a transition ring 21 normal to the axis of the conveyor tube T and having a top surface 22, a lower surface 23, an inner periphery 24 and an outer periphery 26. The inner periphery 24 of the transition ring preferably has an inside diameter substantially equal to the inside diameter of the hollow conveyor tube to which the dredging units are detachably secured as will hereinafter be explained. Each of the transition rings is annular in configuration and is provided with a multiplicity of generally axially extending jet orifices in the form of bores 27, conveniently 45 in number so that the bores are spaced approximately 8.3° from one another around the transition ring.

Welded to the upper surface 22 of each transition ring adjacent its outer periphery is a generally conical section 28 which merges with a tubular cylindrical section 29 as shown. The inner diameter of the cylindrical section 29 is preferably equal to the inner diameter of the transition ring. Welded to the lower surface 23 of the transition ring is a downwardly extending tubular section 31, having a diameter substantially equal to the diameter of the cylindrical section 29, but projecting in the opposite direction therefrom. As shown, the inner peripheral surface 24 of the transition ring and the inner periphery of the cylindrical section 31 are flush, so that the transition from the cylindrical section 31 through the transition ring is a smooth one.

Sealingly interposed between the outer peripheries 26 of each of the transition rings and the outer peripheries of the associated cylindrical sections 31 attached thereto, preferably by welding, are the aforementioned manifolds 12, 13 and 14, respectively.

As depicted in FIGS. 8, 9 and 10, each manifold 14, 13 and 12, respectively, comprises an annular tube circumscribing the respective transition ring 21 of each pumping unit 18, 17 and 16, respectively. Such annular tube, 14, 13 or 12, as the case may be, is of C shape in cross section, i.e., radially of such annular tube, providing an upper crown 25 and a lower tail 30 spaced vertically a distance diametrically its C shape slightly greater than the vertical thickness, bottom to top, of the transition ring 21. The upper crown end 25 of the C shaped annular tube is secured, as by welding to the outer periphery of the flared open end of the conical section 28 and outer periphery 26 on the transition ring of the pumping unit and the lower tail end 30 of the C shaped annular tube extends horizontally toward and is secured by welding to the outer periphery of the downwardly extending tubular section 31 attached to the bottom of the transition ring 21 to thereby provide an annular chamber 33 circumscribing the bottom and outer periphery of the transition ring. The manifolds are appropriately detachably connected in parallel to the downwardly extending high-pressure supply pipe or hose 9 as illustrated in FIG. 1, thus connecting the chambers within the manifolds to the source of high-pressure fluid.

Relating bores 27 illustrated in FIG. 3 to the plan view of such bores illustrated in FIG. 7 and the enlarged fragmentary vertical cross-sectional view of a single bore 27 illustrated in FIG. 8, and referring also to the cross-sectional illustrations of these bores in FIGS. 11 through 13, it will be seen that each bore 27 is provided with an inlet end 34 and an outlet end 36. In general, the inlet ends 34 of all of the bores 27 formed in each transition ring 21 are spaced a predetermined equal distance from the central axis of the ring, while the outlet ends 36 of the bores vary in their spacing from the central axis of the ring. This variation in spacing of the outlet ends of the bores results in a different angularity of the axis of each of the bores with respect to the central axis of the ring that contains them. This difference in angularity of the different bores is illustrated in tabular form below in Table I.

In addition to being variably spaced from the central axis of the ring containing the bores, the outlet ends 36

of the bores are variably spaced circumferentially about the ring, thus causing a difference in angularity or inclination of the axes of the bores in a circumferential direction. It will thus be seen that each of the bores **27** is located in the transition ring so that collectively the inlet ends **34** of all of the bores lie on a common circle the center of which coincides with the central axis of the ring. The outlet ends **36** of the bores, however, vary in radial spacing from the central axis of the ring to form a spiral gradually diminishing pattern of outlet ends **36** in the direction of flow on the top surface **22** of the associated transition ring. The outlet ends **36** of the bores also vary in spacing along the spiral by virtue of the variable inclination of the axes of the bores as they progress circumferentially about the transition ring within which they are formed. It will thus be seen that the several bores in the transition ring each have their axes set to extend inwardly and circumferentially at compound angles. Moreover, that charging each manifold chamber **33** with a high-pressure fluid will immediately result in the discharge of forty-five separate high-pressure jets or streams inclined toward the central axis of the ring and also inclined circumferentially about the ring at such compound angles as to impart combined inwardly directed and a circumferentially directed vertical forces on any fluid, fluid-entrained solid material, or dry material that passes through the transition ring.

For the first stage unit **18,** illustrated in FIGS. **1** and **3,** the number of bores is preferably 45, proportioned to have a diameter of approximately 3/8 inch. The degree ¢° of inclination of the axis of each of the bores with respect to the central axis of the ring within which it is contained (FIG. **13**), together with the degree (C°) of inclination of the axis of each of the bores in a circumferential direction is indicated by the following tables in which the bores are listed as orifices by number from **1** to **45**:

TABLE I
FIRST STAGE

Orifice No.	¢°	C°
1	8	30
2	8	30
3	8	29
4	9	29
5	9	28
6	9	28
7	10	27
8	10	27
9	10	26
10	11	26
11	11	25
12	11	25
13	12	24
14	12	24
15	12	23
16	12	23
17	13	22
18	13	22
19	13	21
20	14	21
21	14	20
22	15	20
23	15	19
24	16	19
25	16	18
26	17	18
27	17	17
28	18	17
29	18	16
30	19	16
31	19	15
32	20	15
33	20	14
34	21	14
35	21	13
36	22	13
37	22	12
38	23	12
39	23	11
40	24	10
41	25	9
42	25	8
43	26	7
44	26	6
45	27	5

TABLE II
SECOND STAGE

Orifice No.	¢°	C°
1	9	20
2	9	20
3	9	20
4	9	19
5	9	19
6	10	19
7	10	18
8	10	18
9	10	18
10	10	17
11	10	17
12	10	17
13	10	16
14	10	16
15	10	16
16	10	15
17	10	15
18	10	15
19	10	14
20	10	14
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25	10	12
26	10	12
27	10	12
28	10	11
29	10	11
30	10	11
31	10	10
32	10	10
33	10	10
34	10	9
35	10	9
36	10	9
37	10	8
38	10	8
39	10	8
40	10	8
41	10	8
42	10	8
43	10	8
44	10	8
45	10	8

TABLE III
THIRD STAGE

Orifice No.	¢°	C°
1–9	9	14
10–18	8	13
19–26	7	12
27–35	6	11
36–45	5	10

From Table 1 above it will be seen that starting with orifice No. **1** the degree of inclination of the axis of this bore with respect to the central axis of the ring in which it is formed is 8°, whereas the degree of inclination of this bore in a circumferential direction is 30°. Thereafter, with respect to the first stage, each of the successive bores is inclined at a greater angle radially inward and at lesser angles of inclination circumferentially progressively in the direction of the diminishing spiral of outlets **36** about the transition ring **21** to the degrees indicated in Table I.

Referring to FIGS. **1** and **3,** and specifically to the second stage dredging unit **17,** with respect to the bores **27** in this second stage, orifice No. **35** of which is illustrated in FIG. **9,** it will be seen that while the same number of bores has been provided in the transition ring, the degree of inclination (¢°) of the separate bores with respect to the central axis of the ring containing the bores varies from 9° for orifice No. **1** to 10° for orifice No. **45.** It will thus be seen that there is a significant difference between the angularity of bores **27** in the second stage with bores **27** in the first stage, especially with respect to orifice Nos. **13** et seq. in the first stage dredging unit. Thus, in the first stage, the angularity of the bores starting with orifice No. **13** range from 12° for orifice or bore No. **13,** to a maximum of 27° for orifice No. **45.**

In like manners in the second stage, the preferred inclination (C°) of the axis of each of the bores in a circumferential direction ranges from 20° for orifice No. **1** to 8° for orifice No. **45.** This is in contrast with the pattern of inclination of the bores in the first stage in which the maximum inclination for orifice No. **1** was 30° and the minimum inclination 5°. From a functional point of view, it will thus be seen that in general the propulsive effect and rotative moment imposed on a stream of material, liquid or otherwise, by the pattern of first stage bores will be greater than the effect of the pattern of bores in the second stage, the second stage being effective and working on a body of liquid or other material that is already moving as a result of the propulsive effect of high pressure fluid jetted through the first stage bores. The inclination of each of the bores for the second stage is illustrated in Table 2 above.

Referring to the third dredging or pumping stage **16** of the apparatus, with specific reference to FIG. **10,** the inclination (¢°) of the axis of the bores **27** with respect to the central axis of ring **21** vary between a maximum of 9° and minimum of 5°. On the other hand, the circumferential inclination (C°) of the bores varies between a maximum of 14° and a minimum of 10°. Table **3** above sets forth the specific values of inclination for the respective bores.

Comparing FIGS. 8 through 10, it will be seen that maximum propulsive force and a maximum rotative moment on the fluid or material being transported is secured by action of the first stage 18. As the transported fluid or material gains momentum in an axial direction through the tubular conveyor, the high pressure fluid jetted from the circumferentially inclined bores also imparts a rotary moment that starts the material spiraling as it progresses axially through the conveyor tube T. By the time the material reaches the second stage, it has already begun to move in both an axially and circumferential direction. The second stage thus imparts an added boost to the charge of material passing through the conveyor, and passes the material on to the third stage in which the axial component of force exerted by the separate jets on the material passing therethrough is maximal and the rotative force is minimal. It will thus be seen that as many stages as is necessary may be arranged in series to propel the material over long distances, for instance up to several miles.

Referring to FIG. 3, it will be noted that the conical sections 28 next adjacent the respective transition rings 21, merge smoothly with the relatively smaller diameter cylindrical sections 29. The upper end portion 37 of each cylindrical section 29 is provided with a circumferential groove 38 (FIG. 6) adapted to receive a clamp ring 39 proportioned to provide a flange 41 and 42 locking respectively in grooves 38 and 43. The groove 43 is formed adjacent the end portion 44 of tubular section 31 projecting downwardly from the second stage 17. It will thus be seen that the first and second stages are clamped rigidly together so that their adjacent edges are in abutting relationship. To insure a fluid-tight connection between the cylindrical members 29 and 31, a deformable gasket material 46 is interposed between the outer surfaces of the end portions 29 and 44 and the clamp ring 39 so that when the clamp is tightly bound about the cylindrical members, the deformable gasket material seals the union between the cylindrical members. This construction is illustrated best in FIGS. 5 and 6. As shown, the relatively smaller diametered cylindrical sections 29 and 31 constitute venturi means disposed between the successive conical sections 28 of units 16, 17 and 18.

It will thus be seen that the clamp means illustrated in FIGS. 5 and 6 may be utilized to clamp as many stages together in series as may be needed for a particular application. Thus, under some circumstances, it may be sufficient to provide only a single or a first stage pumping or dredging unit. Under other circumstances, it may be necessary to utilize a plurality of pumping units. It should also be understood that the three different stages may be arranged in a different sequence from that illustrated. Thus, the unit 16 here designated as the third stage may be substituted for the first stage, etc.

In the use of the dredging apparatus, it will sometimes occur that the soil or material with which the dredging unit is used is so hard that the erosive force imposed on the material is not sufficient to loosen the material. Accordingly, as illustrated in FIGS. 14 and 15, the pumping and dredging apparatus of the invention is adapted to be used in conjunction with a mechanically driven excavating unit mounted on the lower end of the pumping and dredging unit, and adapted to engage such solid material and soil and effect loosening and scarifying thereof so that the pumping and dredging unit may act upon it.

As illustrated in FIG. 14, such mechanical scarifying apparatus comprises a support plate 51 having a central aperture, the inner periphery 52 of which is appropriately welded about the exterior of the lower most pumping unit between the first and second stages. The outer periphery of the support plate 51 is provided with appropriate apertures to receive cap screws 53. Detachably secured to the mounting plate 51 is a radially outwardly extending mounting plate 54 the inner end 56 of which is provided with a series of apertures to receive the cap screws 53 and is arcuate in form to conform to the configuration of the annular support plate 51. Preferably, to effect a balance, a second mounting plate 54' of similar construction is provided on the right hand side as viewed in FIG. 14 and is detachably secured to the support plate 51 in like manner. Both mounting plates 54 and 54' are provided with centrally disposed apertures 56 for purposes which will hereafter be explained. Each side of the mechanical scraifying apparatus is alike and therefore like reference numerals are applied to like parts thereof.

Axially spaced below the mounting plates 54 and 54', and in general alignment therewith extending radially outwardly in opposite directions from the central axis of the pumping unit is a second mounting plate 57 or 57' as the case may be. This plate is provided with a central aperture 58 adapted to fit around the outer periphery of tubular extension 59 of a bracket 61 having a generally J-shaped cross section including a return bend 62 adapted to be welded to the underside of the left and right mounting plates 57-57'. The tubular extension 59 of the J-shaped section is appropriately secured to the inner peripheral surface 24 of the lowermost transition ring 21. To provide detachability of the excavating apparatus from the pumping unit, the J-shaped bracket 61 may be secured by appropriate screws threaded into the associated transition ring of the pumping unit. Alternatively, where a permanent installation is desired, the apparatus may be welded directly to the pumping unit.

As illustrated in FIG. 14, each radially projecting portion of the second mounting plate 57 is provided with a generally centrally disposed aperture 63 spaced from the central axis 64 of the pumping unit. The apertures 63 are proportioned to snugly receive the outer periphery of a cylindrical mounting tube 64 the upper end 66 of which is appropriately welded to the underside of associated mounting plates 54 or 54', while the lower most end 67 of the mounting tube is closed by a closure plate 68 supported in a manner which will hereinafter be explained. Within the mounting tube, there are provided appropriate lugs 69 adapted to detachably support a bearing assembly 71 adjacent the upper end of the mounting tube, and a bearing assembly 72 adjacent the lower end of the mounting tube.

The bearing assemblies appropriately rotatably support a centrally disposed drive shaft 73 secured against axial displacement in the bearing assemblies by appropriate collars 74. The upper end of the drive shaft is splined at 76 for appropriate engagement to the drive shaft or drive pinion (not shown) of an appropriate drive unit designated generally by the numeral 77 in FIGS. 14 and 15 and preferably comprising a multiplicity of hydraulic motors 78 arranged circumferentially about the drive shaft and mounted on an appropriate

support frame **79.** A hoisting ring **81** is provided to facilitate placement of the motor assembly on the mounting plate **54,** and appropriate securing means (not shown) are provided to secure the motor assembly in position. Conventionally, such hydraulic motors are driven by appropriate hydraulic fluid channeled through conventional high pressure hoses or conduit (not shown) in the usual manner.

Below the closure plate **68,** the drive shaft **73** continues in a section **82** the lowermost end of which is conically pointed as at **83.** Intermediate the conical point **83** and the closure plate **68,** the drive shaft extension **82** is provided with radially extending spokes **84** welded at their inner (upper) ends to the drive shaft extension immediately below the closure plate **68.** The spokes are inclined downwardly, as illustrated best in FIG. **14,** the outer ends of the spokes being disposed within the inner periphery of the circular rim **86** having about its outer periphery and radially projecting therefrom a plurality of blades **87** each of which is provided with a leading edge **88** sharpened to effect cutting of any material with which it makes contact, and being inclined upwardly as illustrated in FIG. **14** so that upon rotation the blades **87** tend to drive loosened material upward in the direction of the pumping mechanism. Preferably, there are at least eight such blades provided around the outer periphery of the rim. Such blades are particularly useful for scarifying the vertical banks of a sea or river channel that might be encountered by the dredging apparatus.

To effectively loosen and scarify the soil immediately below the dredging apparatus, the rim **86** is provided with downwardly extending blades **89,** the downwardly projecting blades varying in height as indicated. There are preferably approximately **12** such downwardly extending blades.

It may occur that the nature of the terrain or soil into which the dredging apparatus must dig is of a nature to require a constant downward pressure on the part of the dredging apparatus over and above its own weight. To effectively provide such additional downwardly directed pressure, the lower end portion **91** of the drive shaft extension **82** is provided with spiral lands **92** as shown, proportioned to increase in diameter from the conical point **83** so that once the conical point has penetrated the soil, the lands **92** immediately begin to draw the drive shaft and associated structure downwardly into firm engagement with the soil.

It should be understood that while only two such excavating units have been shown associated with the pumping head, as many excavating units may be supported on the pumping assembly as is consistent with the clearances required for their operation. Thus, for a symetrical structure, two additional excavating units could be associated with the two shown to provide a total of four, the separate excavating units lying at 90° intervals around the central axis of the apparatus.

Having thus described the invention, what is claimed to be novel and sought to be protected by letters patent is as follows:

I claim:

1. Pumping units for a cylindrical cyclonic elevator tube in which fluid under pressure from a source thereof has communication therewith via a plurality of circumferentially spaced jet orifices set at inwardly directed angles gradually increasing from a minimum angle with respect to the central axis of the tube of not less than 5° and circumferentially directed compound angles of inclination correspondingly gradually decreasing in inclination from a maximum angle circumferentially for ejecting vortically directed jets of fluid under pressure upwardly through the cyclonic elevator to effect transportation of comminuted and/or fluid material through such tube; each said pumping unit comprising in combination:

a. a tubular section having an axial length substantially equal to its radius;

b. a frusto-conical section having its truncated end secured to the lower end of said tubular section and its flared sides extending therefrom a distance comparable to the length of said tubular section;

c. a transition ring having its outer periphery secured to the flared open end on said conical section and an inner periphery of a diameter comparable to said tubular section and having such circumferentially spaced jet orifices formed therebetween from the bottom to the upper surface thereof such that the inwardly directed angle of the minimum angle of such jet orifices converges with a projection of the inner surface of the flared side walls of said conical section, slightly above the truncated end of said conical section;

d. an intermediate tubular section having a diameter equal to that of said tubular section and secured opposite thereto to the bottom surface of said transition ring with its internal periphery flush with the inner periphery of said transition ring;

e. a manifold for each of said pumping units comprising an annular tube, of C-shaped cross section radially thereof and of a diameter vertically from its annular crown to its annular tail slightly greater than the vertical thickness, top to bottom, of said transition ring and having its annular crown secured to the outer periphery of the flared end of said conical section at its plane of connection to said transition ring and having its annular tail extending horizontally toward said intermediate tubular section and secured thereto for providing an annular chamber about the outer exposed periphery and bottom surface of said transition ring;

f. and means for communicating said annular chamber with the source of fluid under pressure.

2. The combination in accordance with claim **1** in which the plurality of spaced jet orifices formed in said transition ring of said pumping unit have their inlet ends on the manifold side of the transition ring arranged equidistant from center of the latter and their outlet ends on the opposite side of such ring, beginning with a first such jet orifices having its axis inclined at a minimum angle radially inward of such ring, arranged in groups progressively decreasing in distance radially of said transition ring in a spiral pattern toward the axis of the latter whereby said bores have their axes disposed in progressively decreasing angles toward center in such spiral pattern.

3. The combination in accordance with claim **1** in which the first named jet orifice in said transition ring has its outlet end offset relative to its inlet end at a greater distance circumferentially than such offset relation of the inlet to outlet of the other orifices of said plurality thereof and in which successive groups of orifices thereof have the offset relation of their inlet and outlet gradually diminishing in a circumferential direc-

tion progressively about the spiral pattern thereof on said transition ring.

4. The combination in accordance with claim **3** in which said pumping unit is modular and each includes means for detachably securing several such pumping units in tandem arrangement concentric to the elevator tube.

5. The combination in accordance with that of claim **3** including at least three stages of said pumping units arranged in tandem concentric to each other and to said cyclonic elevator tube comprising:

a. a first open ended entry stage having the circumferentially spaced orifices in its transition ring disposed at compound angles ranging from 8° to 27° radially and correspondingly 30° to 5° circumferentially;

b. a second, intermediate stage having the circumferentially spaced orifices in its transition ring disposed at compound angles ranging from 9° to 10° radially and correspondingly 20° to 8° circumferentially; and

c. an innermost stage having the circumferentially spaced orifices in its transition ring disposed at compound angles ranging from 9° to 5° radially and correspondingly 14° to 10° circumferentially.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,857,651 Dated December 31, 1974

Inventor(s) Anthony I. Bruno

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

On the cover sheet insert:

--[73] Assignee: Lake and Development Company of Tehama County, Santa Clara, Calif., part interest --.

Signed and Sealed this

Twenty-seventh Day of *December 1977*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

LUTRELLE F. PARKER
Acting Commissioner of Patents and Trademarks

[redacted]

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,857,651

DATED : December 31, 1974

INVENTOR(S) : Anthony I. Bruno

It is certified that error appears in the above—identified patent and that said Letters Patent is hereby corrected as shown below:

Certificate of Correction issued December 27, 1977, issued in error and is hereby rescinded.

THIS CERTIFICATE SUPERSEDES CERTIFICATE OF CORRECTION ISSUED December 27, 1977.

Signed and Sealed this

Fifth Day of *August 1980*

[SEAL]

Attest:

SIDNEY A. DIAMOND

Attesting Officer *Commissioner of Patents and Trademarks*