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CA 2735925 C 2017/01/17

(11)(21) **2 735 925**

(12) **BREVET CANADIEN**
CANADIAN PATENT

(13) **C**

(86) **Date de dépôt PCT/PCT Filing Date**: 2009/09/03
(87) **Date publication PCT/PCT Publication Date**: 2010/03/11
(45) **Date de délivrance/Issue Date**: 2017/01/17
(85) **Entrée phase nationale/National Entry**: 2011/03/03
(86) **N° demande PCT/PCT Application No.**: IB 2009/006734
(87) **N° publication PCT/PCT Publication No.**: 2010/026468
(30) **Priorité/Priority**: 2008/09/04 (ITMI2008A001586)

(51) **Cl.Int./Int.Cl.** *E02F 5/10* (2006.01), *E02F 5/12* (2006.01)

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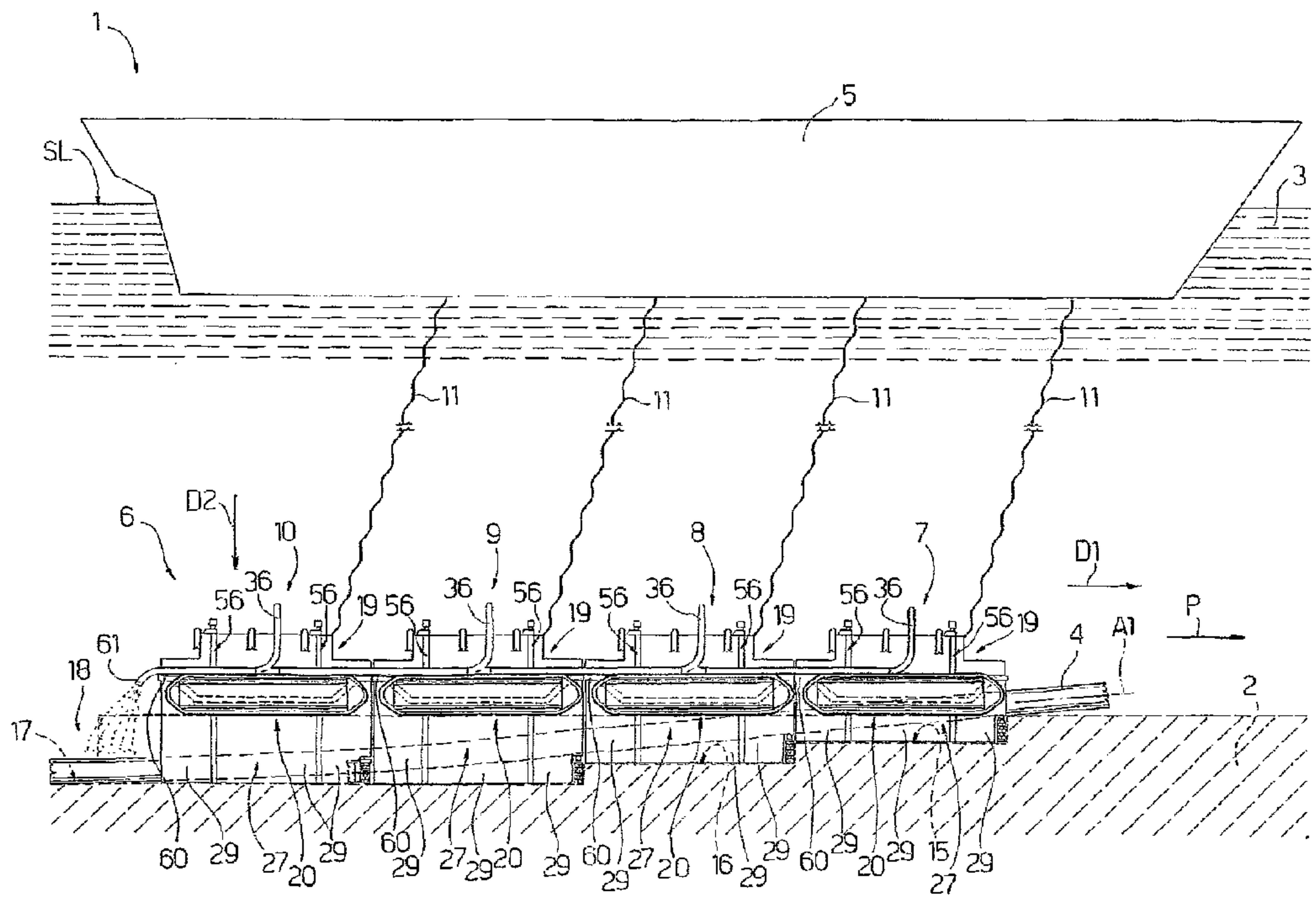
(54) **Titre** : PROCEDE ET SYSTEME D'ENFOUISSEMENT D'UN ELEMENT CONTINU DE FORME ALLONGEE DANS LE LIT D'UN BASSIN D'EAU

(54) **Title**: METHOD AND SYSTEM FOR LAYING UNDERGROUND A CONTINUOUS ELONGATED MEMBER IN A BED OF A BODY OF WATER



(57) **Abrégé/Abstract**:

A method of underground laying a continuous elongated member (4) in a bed (2) of a body of water (3), wherein the continuous elongated member (4) lies on the bed (2) of the body of water (3) along a given path (P); the method including the steps of: - fragmenting a soil mass (14) in the bed (2) along the given path (P) and under the continuous elongated member (4), so as to form in the bed (2) two scarp slopes (13) bounding the fragmented soil mass (14) by two soil masses (12) susceptible to slide; - advancing two supporting walls (27) along the given path (P) in an advancing direction (D1), along the respective two scarp slopes (13), and transferring the fragmented soil mass (14) between the two supporting walls (27), so as to promote sinking of the continuous elongated member (4) between the two supporting walls (27).

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 March 2010 (11.03.2010)

PCT

(10) International Publication Number
WO 2010/026468 A1

(51) International Patent Classification:
E02F 5/10 (2006.01) *E02F 5/12* (2006.01)

(21) International Application Number: PCT/IB2009/006734

(22) International Filing Date: 3 September 2009 (03.09.2009)

(25) Filing Language: Italian

(26) Publication Language: English

(30) Priority Data:
MI2008A001586 4 September 2008 (04.09.2008) IT

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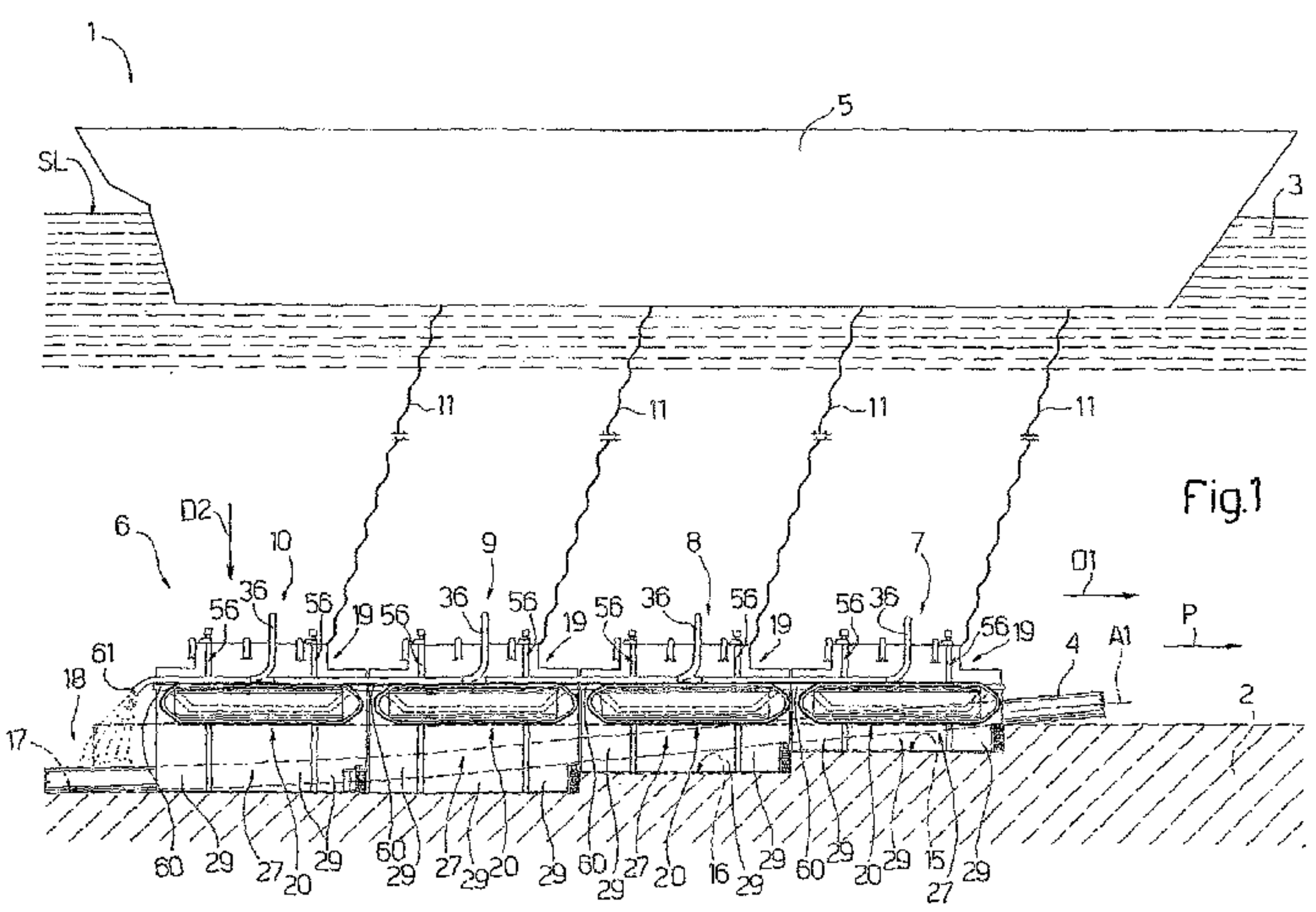
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) Title: METHOD AND SYSTEM FOR LAYING UNDERGROUND A CONTINOUS ELONGATED MEMBER IN A BED OF A BODY OF WATER.



(57) Abstract: A method of underground laying a continuous elongated member (4) in a bed (2) of a body of water (3), wherein the continuous elongated member (4) lies on the bed (2) of the body of water (3) along a given path (P); the method including the steps of : - fragmenting a soil mass (14) in the bed (2) along the given path (P) and under the continuous elongated member (4), so as to form in the bed (2) two scarp slopes (13) bounding the fragmented soil mass (14) by two soil masses (12) susceptible to slide; - advancing two supporting walls (27) along the given path (P) in an advancing direction (D1), along the respective two scarp slopes (13), and transferring the fragmented soil mass (14) between the two supporting walls (27), so as to promote sinking of the continuous elongated member (4) between the two supporting walls (27).

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METHOD AND SYSTEM FOR LAYING UNDERGROUND A Continuous ELONGATED MEMBER IN A BED OF A BODY OF WATER.

TECHNICAL FIELD

The present invention relates to a method of underground laying a continuous elongated member, such as an underwater pipeline, cable, umbilical, pipe and/or cable bundle, in the bed of a body of water.

BACKGROUND ART

In-bed laying an underwater pipeline normally comprises laying the pipeline along a given path on the bed of the body of water; fragmenting a soil mass along the path to a given depth; digging a trench or generally removing the fragmented soil mass; and possibly burying the pipeline.

More specifically, currently used known techniques comprise removing the fragmented soil mass to form a trench in the bed of the body of water; and laying the pipeline directly into the trench. The pipeline may later be covered over with the removed soil mass to fill in the trench and bury the pipeline.

Underwater pipelines carrying hydrocarbons are normally laid completely or partly underground for various reasons, some of which are discussed below. Underwater pipelines are normally laid underground close to shore approaches and in relatively shallow water, to protect them from damage by blunt objects, such as anchors or fishing nets, and are sometimes laid underground to protect them from natural agents, such as wave motion and currents, which may result in severe stress. That is, when a pipeline is laid on the bed of a body of water, it may span two supporting areas of the bed, i.e. a portion of the pipeline may be raised off the bed; in which case, the pipeline is particularly exposed to, and offers little resistance to the movements induced by, wave motion and currents. Underground laying may also be required for reasons of thermal instability, which result in deformation (upheaval/lateral buckling) of the pipeline, or to protect the pipeline from the mechanical action of ice, which, in particularly shallow water, may result in scouring of the bed.

To avoid damage, the pipeline often need simply be laid at the bottom of a suitably deep trench dug before laying (pre-trenching) or more often after laying the pipeline (post-trenching). At times, the protection afforded by the trench and eventual natural backfilling of the trench is not enough, and the pipeline must be buried using the fragmented soil mass removed from the trench, or any available soil mass alongside the trench.

The depth of the trench is normally such that the top line of the pipeline is roughly a metre below the surface of the bed, though severe environmental conditions may sometimes call for deeper trenches (of several metres). Trenching and backfilling are performed using digging equipment, and post-trenching (with the pipeline already laid on the bed) is the normal practice, to dig and backfill the trench in one go.

One method of in-bed laying underwater pipelines is described in Patent Application WO 2005/005736. This is a post-trenching method comprising the steps of fragmenting a soil mass in the bed to open the way; and drawing along the opening a huge plough, to form a trench, and vertical supporting walls connected to the plough and which respectively support two opposite soil masses bounded by two substantially vertical scarp slopes.

The above method has the drawback of being highly energy-intensive, due partly to the plough, and partly to friction between the supporting walls and the two soil masses. And energy consumption increases exponentially alongside an increase in trench depth.

Another method of in-bed laying underwater pipelines is described in Patent Application WO 2004/016366, which proposes fragmenting a soil mass in the bed, and removing the fragmented soil mass using a dredging unit on board a support vessel. That is, the fragmented soil mass is first sucked up from the bed along a dredging path up onto the support vessel, and then dumped back into the trench.

This method is also highly energy-intensive to draw the fragmented soil mass up onto the support vessel. Moreover, the scarp slopes are susceptible to slide; the method is unsuitable for in-depth laying underwater pipelines; and, in the event of slide, the pumps and conduits are called on to remove additional fragmented soil masses, thus further increasing energy consumption.

DISCLOSURE OF INVENTION

It is an object of the present invention to provide a method of underground laying an underwater pipeline in the bed of a body of water, designed to eliminate the drawbacks of the known art.

It is a further object of the present invention to provide a method enabling easy in-depth laying of underwater pipelines in the bed of a body of water.

According to the present invention, there is provided a method of underground laying a continuous elongated member in a bed of a body of water, wherein the continuous elongated member lies on the bed of the body of water along a given path; the method including the steps of:

- fragmenting a soil mass in the bed along the given path and under the continuous elongated member, so as to form in the bed two scarp slopes bounding the fragmented soil mass by two soil masses susceptible to slide;

- advancing two supporting walls, along the given path in an advancing direction, along the respective two scarp slopes; and

- transferring the fragmented soil mass between the two supporting walls, so as to promote sinking of the continuous elongated member between the two supporting walls.

The present invention provides for greatly reducing energy consumption by only removing the fragmented soil mass between the supporting walls preventing slide of the soil masses defined by the scarp slopes, thus enabling in-depth laying with the removal of only a small fragmented soil mass in relation to depth.

Another object of the present invention is to provide a system for underground laying a continuous elongated member in the bed of a body of water.

According to the present invention, there is provided a system for underground laying a continuous elongated member in a bed of a body of water, wherein the continuous elongated member extends on the bed along a given path: the system comprising an underwater vehicle comprising a work assembly which is set into the bed and comprises :

- a fragmenting unit for fragmenting a soil mass in the bed along the given path and under the continuous elongated member, so as to form in the bed two scarp slopes bounding the fragmented soil mass by two soil masses susceptible to slide;

- a sustaining unit comprising two supporting walls which are advanced, along the given path in an advancing direction, along the respective two scarp slopes; and

- means for transferring the fragmented soil mass between the two supporting walls, so as to promote sinking of the continuous elongated member between the two supporting walls.

BRIEF DESCRIPTION OF THE DRAWINGS

A number of non-limiting embodiments of the present invention will be described by way of example with reference to the accompanying drawings, in which:

Figure 1 shows a partly sectioned side view, with parts removed for clarity, of a system for underground laying an underwater pipeline in the bed of a body of water;

Figure 2 shows a cross section of the bed when digging a trench in which to lay the underwater pipeline;

Figure 3 shows an isometric view, with parts removed for clarity, of an underwater vehicle of the Figure 1 system;

Figure 4 shows a plan view, with parts removed for clarity, of the Figure 3 underwater vehicle;

Figure 5 shows a larger-scale front view, with parts removed for clarity, of the Figure 3 underwater vehicle;

Figure 6 shows an isometric view, with parts removed for clarity, of the Figure 3 underwater vehicle in another configuration;

Figure 7 shows a partly sectioned isometric view, with parts removed for clarity, of the Figure 3 underwater vehicle;

Figure 8 shows a side section, with parts removed for clarity, of the Figure 3 underwater vehicle;

Figure 9 shows a larger-scale isometric view, with parts removed for clarity, of a detail of the Figure 3 underwater vehicle;

Figure 10 shows a front section, with parts removed for clarity, of a detail of the Figure 3 underwater vehicle;

Figure 11 shows a larger-scale side view, with parts removed for clarity, of a detail of the Figure 3 vehicle;

Figure 12 shows a larger-scale section, with parts removed for clarity, of a detail of the Figure 11.

BEST MODE FOR CARRYING OUT THE INVENTION

UNDERWATER PIPELINE UNDERGROUND LAYING SYSTEM

Number 1 in Figure 1 indicates as a whole a system for underground laying underwater pipelines in a bed 2 of a body of water 3 of level SL.

In the following description, the term "body of water" is intended to mean any stretch of water, such as sea, ocean, lake, etc., and the term "bed" is intended to mean the concave layer of the earth's crust containing the mass of water in the body.

Underground laying system 1 provides for underground laying an underwater pipeline 4, which has an axis A1, extends along a given path P on bed 2, and has been laid beforehand by a known laying vessel not shown in the drawings. Underground laying system 1 comprises a support vessel 5; and a convoy 6 comprising a number of underwater vehicles 7, 8, 9, 10 advanced in an advancing direction D1 along path P.

Though the present description refers specifically to an underwater pipeline, underground laying system 1 provides for underground laying continuous elongated members of all types, such as cables, umbilicals, pipe and/or cable bundles, not shown in the drawings.

Underwater vehicles 7, 8, 9, 10 are guided along path P by support vessel 5. More specifically, support vessel 5 serves to guide vehicles 7, 8, 9, 10 along path P, and to supply vehicles 7, 8, 9, 10 with electric power, control signals, compressed air, hydraulic power, etc., so each underwater vehicle 7, 8, 9, 10 is connected to support vessel 5 by a cable bundle 11.

Each vehicle 7, 8, 9, 10 is designed to :

- fragment a respective soil layer of bed 2 to form two soil masses 12 bounded by respective opposite, substantially vertical scarp slopes 13, as shown clearly in Figure 2, and a fragmented soil mass 14 between the two scarp slopes 13;
- support soil masses 12 along scarp slopes 13 (Figure 2);
- transfer the fragmented soil mass 14 between the two opposite scarp slopes 13 (Figure 2);
- guide pipeline 4; and
- bury pipeline 4 with the removed fragmented soil mass 14.

Underwater vehicles 7, 8, 9, 10 are kept close together to seamlessly sink pipeline 4.

In the Figure 1 example, underwater vehicle 10 performs no fragmenting function.

The fragmented soil mass 14 is bounded at the bottom by bottom faces 15, 16, 17 increasing gradually in depth in the opposite direction to direction D1.

In other words, underwater vehicles 7, 8, 9, 10 dig a trench 18, on the bottom face 17 of which pipeline 4 is laid and covered with fragmented soil mass 14.

With reference to Figure 2, for the purpose of this description, the term "scarp slope" is intended to mean a surface connecting rock formations, sediment or terrains at different heights, and, in the example shown, scarp slopes 13 are substantially vertical.

Depending on the depth of trench 18 and the nature of soil mass 12, soil masses 12 bounded by respective scarp slopes 13 must be supported to prevent soil masses 12 from sliding.

For example, a soil mass of granular material, such as sand or gravel, tends to settle into a surface (natural slope) at a given angle, known as natural slope angle, to the horizontal.

If bed 2 is made solely of cohesive rock, on the other hand, there is practically no risk of soil masses 12 sliding at scarp slopes 13. Nevertheless, underground laying system 1 (Figure 1) is designed to cope with any type of problem, regardless of the geological structure of bed 2.

UNDERWATER VEHICLES

The following is a detailed description of underwater vehicle 9, with reference to Figures 3-10. Underwater vehicles 7, 8, 10 in Figure 1 are not described in detail, but are structurally similar to underwater vehicle 9, from which they differ solely as regards the size of certain component parts. Accordingly, the reference numbers used with reference to underwater vehicle 9 also apply to corresponding parts of underwater vehicles 7, 8, 10 in Figure 1.

In Figure 3, underwater vehicle 9 extends along an axis A2, and comprises a work assembly 19 which is set into bed 2; two drive assemblies 20 which rest on bed 2 and advance work assembly 19 in direction D1 (Figure 1); and two connecting assemblies 21, each for connecting a respective drive assembly 20 to work assembly 19, and for adjusting the relative positions of drive assemblies 20 and work assembly 19.

Work assembly 19 comprises a supporting frame 22; a sustaining unit 23; a fragmenting unit 24; a dredging unit 25; and an auxiliary dredging unit 26.

Supporting frame 22 substantially comprises a number of beams, each of which is inverted-U-shaped, as shown more clearly in Figure 7.

Sustaining unit 23 comprises two opposite supporting walls 27 fixed to frame 22 and parallel to axis A2. As shown more clearly in Figure 10, each supporting wall 27 comprises a base structure 28; a number of panels 29 connected elastically, preferably by rubber fasteners, to base structure 28; and a number of actuators 30 for inducing vibration in panels 29, preferably in a vertical direction D2 crosswise to axis A2 and parallel to supporting walls 27.

With reference to Figure 5, fragmenting init 24 comprises a number of vertical cutters 31 for fragmenting a soil mass cross section of a width substantially equal to the distance between opposite walls 27. Fragmenting unit 24 also comprises two arms 32, each of which supports half the number of cutters 31 and rotates, with respect to frame 22, about a vertical axis A3 (parallel to supporting walls 27) to set cutters 31 to a work position, in which arms 32 are perpendicular to supporting walls 27 and cutters 31 connect opposite supporting walls 27, and a rest position, in which arms 32 are parallel to supporting walls 27, so the pipeline can be placed between the two arms 32 and respective cutters 31.

Dredging unit 25 comprises two dredging devices 33. As shown more clearly in Figure 8, each dredging device 33 is fitted to underwater vehicle 9 and located at least partly between walls 27. In the example shown, each dredging device 33 comprises a suction conduit 34 having a suction port 35 located at the bottom of supporting wall 27 and, in use, under pipeline 4 (Figure 1); a delivery hose 36 for unloading the fragmented soil mass 14 downstream from convoy 6 (Figure 1); and a pump

37 between suction conduit 34 and hose 36.

With reference to Figure 7, auxiliary dredging unit 26 comprises two pumps 38 (only one shown in Figure 7) located on opposite sides of sustaining unit 23; and a number of conduits 39 extending between and directly over supporting walls 27. Each conduit 39 comprises two branches 40 respectively adjacent to the inner faces of opposite supporting walls 27; and a header 41 communicating with both branches 40 and having an outlet port 42. Each branch 40 comprises a suction port 43 located close to the bottom of respective supporting wall 27 and facing the opposite supporting wall 27.

Pumps 38 are connected to each branch 40 by a respective hose 44 which generates an upward jet in respective branch 40, so that each conduit 39 acts as an ejector pump between suction ports 43 and outlet port 42.

With reference to Figure 4, each drive assembly 20 comprises a supporting body 45; and a powered track 46 looped about supporting body 45 and movable about supporting body 45 by known means not shown in the drawings. Supporting body 45 is at least partly hollow, and comprises a control device 47 in turn comprising valves and a pump (not defined in detail), and a pipe 48 connected to the laying vessel to feed/expel air to/from body 45 and so alter the buoyancy of drive assembly 20 and underwater vehicle 9 as a whole. In other words, supporting body 45 is a variable-buoyancy body.

Each connecting assembly 21 comprises two articulated joints 49, each of which comprises a bracket 50 fitted to supporting body 45 to rotate about an axis A4; an arm 51 hinged to bracket 50; and an actuator 52, in particular a hydraulic cylinder, hinged to bracket 50 and arm 51 to form, with bracket 50 and arm 51, a variable-configuration triangle. Arm 51 is in turn hinged to a connecting member 53 fitted to work assembly 19 as shown in Figure 9.

With reference to Figure 9, connecting member 53 comprises a fork 54; and a dove-tail prismatic body 55 with a threaded central hole.

With reference to Figure 6, connecting assembly 21 also comprises four tracks 56 which, in the example shown, are grooves extending along supporting walls 27 in direction D2 (Figure 1). More specifically, each supporting wall 27 has two tracks 56; and two actuators 57, each located at a respective track 56 and connected to connecting member 53 to move connecting member 53 (Figure 9) with respect to supporting wall 27.

With reference to Figure 9, each track 56 has a seat having a dove-tailed cross section and engaged in sliding manner by prismatic body 55.

With reference to Figure 8, each actuator 57 is fitted to frame 22, and comprises an electric motor 58; and a threaded bar 59 housed in the seat of track 56 and engaging the threaded hole in prismatic body 55 so as to form, with prismatic body 55, a screw-nut screw mechanism.

With reference to Figure 6, each connecting assembly 21 comprises two tow bars 60 fitted to a respective pair of connecting members 53 and adjacent to a respective supporting wall 27. Each tow bar 60 of underwater vehicle 9 is connected to the respective tow bars of adjacent underwater vehicles 8 and 10, as shown in Figure 1.

With reference to Figure 1, hoses 36 of dredging devices 33 all extend downstream from the last underwater vehicle 10 in conveyor 6, and have outlet ports 61 located over pipeline 4, so the material removed by dredging devices 33 is fed back into trench 18 once pipeline 4 is sunk.

With reference to Figure 8, the work assembly also comprises a number of carriages 62 fitted to frame 22 and located between supporting walls 27 to push pipeline 4 downwards and so aid in sinking pipeline 4.

With reference to Figure 11, each panel 29 has an outer face 63; an inner face 64 (Figure 12); and vertical ribs 65 and horizontal ribs 66 for stiffening panel 29.

Panel 29 is equipped with a lubricating device 67 for forming a water film along outer face 63 of panel 29, and which comprises a number of nozzles 68 equally spaced along outer face 63; conduits 69 at vertical ribs 65 (Figure 12); and a pump (not shown) connected to conduits 69 by hoses 70 (Figure 12).

Nozzles 68 are housed in recesses 71 in panel 29, so as not to project from outer face 63.

With reference to Figure 12, each nozzle 68 is oriented to emit a jet at a 20° angle with respect to outer face 63 and in the opposite direction to advancing direction D1 (Figure 11).

With reference to Figure 11, the size of the jets and the number of nozzles are selected to cover the whole of outer face 63 with a film of water and so reduce friction between panel 29 and scarp slope 13 (Figure 2).

Operation of system 1 will be clear from the above description.

ADVANTAGES

In addition to the energy-saving advantages already mentioned, the fragmented soil mass is removed by dredging unit 25 and auxiliary dredging unit 26. In many applications, dredging unit 25 is unable to remove all the fragmented soil mass 14 on its own, so the rest of fragmented soil mass 14 is removed by auxiliary dredging unit 26.

Soil masses 12 are prevented from sliding at the fragmenting, removal, and sinking stages, by being confined by supporting walls 27; and friction between supporting walls 27 and soil masses 12 is greatly reduced by vibrating panels 29 contacting soil masses 12 along scarp slopes 13.

Underwater vehicles 7, 8, 9, 10 are highly versatile, and can adjust the position of work assembly 19 with respect to drive assemblies 20 and hence the depth of the work assembly in bed 2.

The distance between drive assemblies 20 and work assembly 19 can also be adjusted. For example, in sandy beds, it is best to keep drive assemblies 20 as far away as possible from work assembly 19, to prevent the weight of drive assemblies 20 from inducing slide of soil masses 12 and so further increasing friction between soil masses 12 and supporting walls 27.

Conversely, in rocky beds, where the above drawback does not apply, it is best to keep drive assemblies 20 as close as possible to work assembly 19, so as to provide greater forward thrust to fragmenting unit 24, which encounters considerable resistance in rocky terrain.

Because of the play between each track 56 and respective connecting member 53 and independent actuators 57, work assembly 19 can be tilted slightly with respect to drive assemblies 20.

Independent actuators 57 enable the two drive assemblies 20 to be set to two different heights with respect to work assembly 19, and therefore to operate at two different levels on either side of work assembly 19, while keeping work assembly 19 vertical.

Because cutters 31 can be set to a work position and a rest position, underwater vehicles 7, 8, 9, 10 can be withdrawn from the trench without interfering with pipeline 4 being sunk.

The above feature enables one or more underwater vehicles 7, 8, 9, 10 - for example, underwater vehicle 10 in Figure 1 - to be used solely for removal, support and sinking work.

Removal and setup of underwater vehicles 7, 8, 9, 10 are also made easier by the variable buoyancy of supporting bodies 45.

Clearly, changes may be made to the embodiment of the present invention as described herein without, however, departing from the scope of the accompanying Claims.

WE CLAIM:

1. A method of underground laying a continuous elongated member (4) in a bed (2) of a body of water (3), wherein the continuous elongated member (4) lies on the bed (2) of the body of water (3) along a given path (P); the method including the steps of:

- fragmenting a soil mass (14) in the bed (2) along the given path (P) and under the continuous elongated member (4), so as to form in the bed (2) two scarp slopes (13) bounding the fragmented soil mass (14) by two soil masses (12) susceptible to slide;

- advancing two supporting walls (27), along the given path (P) in an advancing direction (Dl), along the respective two scarp slopes (13); and transferring the fragmented soil mass (14) between the two supporting walls (27), so as to promote sinking of the continuous elongated member (4) between the two supporting walls (27).

2. A method according to claim 1, and including the step of vibrating at least a panel (29) of each supporting wall (27); the panel (29) contacting a respective soil mass (12) along the respective scarp slope (13).

3. A method according to claim 2, wherein the panel (29) of a respective supporting wall (27) is vibrated in a direction crosswise to the given path (P), in a substantially vertical direction (D2).

4. A method according to any one of claims 1 to 3, and comprising the step of lubricating with a water film the outer faces (63) of the supporting walls (27) contacting the" respective scarp slopes (13).

5. A method according to any one of claims 1 to 4, wherein the step of advancing said supporting walls (27) is performed by at least one underwater vehicle (7; 8; 9;

10) comprising drive assemblies (20) movable on the bed (2); and a work assembly (19) which is set into the bed (2) and includes said supporting walls (27) .

6. A method according to claim 5, and including the step of adjusting the relative position of the work assembly (19) and the drive assemblies (20) by means of two connecting assemblies (21), each located between the work assembly (19) and a respective drive assembly (20).

7. A method according to claim 6, and including the step of angling the work assembly (19) with respect to the drive assemblies (20) by means of the connecting assemblies (21).

8. A method according to claim 6 or 7, and including the step of adjusting the depth of the work assembly (19) in the bed (2) of the body of water (3) by means of the connecting assemblies (21).

9. A method according to any one of claims 6 to 8, and including the step of adjusting the distance between each drive assembly (20) and the work assembly (19) by means of the connecting assemblies (21).

10. A method according to any one of claims 5 to 9, and including the step of transferring the fragmented soil mass (14) by means of at least one dredging unit (25) comprising a suction port (35) located between the supporting walls (27), and an outlet port (61) located over the continuous elongated member (4).

11. A method according to claim 10, and including the step of supporting the dredging unit (25) by means of the underwater vehicle (7; 8; 9; 10).

12. A method according to any one of claims 1 to 11, wherein the step of fragmenting the soil mass is performed by a fragmenting unit (24) for defining a

given fragmented cross-section; the width of the fragmented cross -section being substantially equal to the distance between said supporting walls (27).

13. A method according to claim 12, and comprising the step of setting the fragmenting unit (24) in a work position and a rest position.

14. A method according to any one of claims 1 to 13, and comprising the step of pushing the continuous elongated member (4) downwards between the supporting walls (27).

15. A system for underground laying a continuous elongated member (4) in a bed (2) of a body of water (3), wherein the continuous elongated member (4) extends on the bed (2) along a given path (P): the system (1) comprising an underwater vehicle (7; 8; 9; 10) comprising a work assembly (19) which is set into the bed (2) and comprises:

- a fragmenting unit (24) for fragmenting a soil mass (14) in the bed (2) along the given path (P) and under the continuous elongated member (4), so as to form in the bed (2) two scarp slopes (13) bounding the fragmented soil mass (14) by two soil masses (12) susceptible to slide;

- a sustaining unit (23) comprising two opposite supporting walls (27) which are advanced, along the given path (P) in an advancing direction (Dl), along the respective two scarp slopes (13); and - means (25; 26; 25, 26) for transferring the fragmented soil mass (14) between the two supporting walls (27), so as to promote sinking of the continuous elongated member (4) between the two supporting walls(27).

16. A system according to claim 15, wherein each supporting wall (27) comprises at least a base structure (28), a vibrating panel (29) connected to the base structure (28), and means (30) for inducing vibration of the panel (29); each panel (29)

being positioned contacting a respective soil mass (12) along the respective scarp slope (13).

17. A system according to claim 16, wherein the supporting wall (27) comprises vibrating means (30) for inducing vibration of the panel (29) in a direction crosswise to the given path (P), in a substantially vertical direction (D2).

18. A system according to any one of claims 15 to 17, and comprising a lubricating device (67) for lubricating with a water film the outer faces (63) of the supporting walls (27) contacting the respective scarp slopes (13).

19. A system according to any one of claims 15 to 18, wherein the underwater vehicle (7; 8; 9; 10) comprises two drive assemblies movable on the bed (2) and connected to the work assembly (19).

20. A system according to claim 19, wherein each drive assembly (20) comprises a supporting body (45) of adjustable buoyancy.

21. A system according to claim 20, wherein each drive assembly (20) comprises a powered crawler (46) looped about the supporting body (45).

22. A system according to any one of claims 19 to 21, wherein the underwater vehicle (7; 8; 9; 10) comprises two connecting assemblies (21), each located between the work assembly (19) and a respective drive assembly (20) to adjust the relative position of the work assembly (19) and the drive assemblies (20).

23. A system according to claim 22, wherein each connecting assembly (21) comprises two tracks (56) supported by the sustaining unit (22), along the supporting walls (27); two connecting members (53), each fitted to a respective track (56); and two first actuators (58), each connected to a respective connecting

member (53) and to the sustaining unit (22) to move the connecting member (53) along the respective track (56) and with respect to the supporting wall (27).

24. A system according to claim 22 or 23, wherein each connecting assembly (21) comprises two articulated joints (49), each of which comprises a second actuator (52) for adjusting the distance between a respective drive assembly (20) and the work assembly (19).

25. A system according to any one of claims 15 to 24, wherein the means (25; 26; 25, 26) for transferring the fragmented soil mass (14) comprise a dredging unit (25) comprising at least a suction port (35) located between the supporting walls (27); and a first outlet port (61) located downstream from the suction port (35) and over the continuous elongated member (4).

26. A system according to claim 25, wherein the dredging unit (25) is supported entirely by the underwater vehicle (7; 8; 9; 10).

27. A system according to any one of claims 15 to 26, wherein the means (25; 26; 25, 26) for transferring the fragmented soil mass (14) comprise a auxiliary dredging unit (26) comprising at least an inlet port (42) for sucking up water; and at least a second outlet port (43) located at the bottom of the supporting walls (27) to inject water between the supporting walls (27).

28. A system according to any one of claims 15 to 27, wherein the fragmenting unit (24) defines a given fragmented cross section; the width of the fragmented cross section being substantially equal to the distance between said supporting walls (27).

29. A system according to claim 28, wherein the fragmenting unit (24) is movable between a work position, in which it bridges the two supporting walls (27), and a

rest position, in which the supporting walls (27) enclose the continuous elongated member (4).

30. A system according to any one of claims 15 to 29, wherein the work assembly comprises pushing means, comprising at least one carriage (62), located between the supporting walls (27); said pushing means being designed to push the continuous elongated member (4) downwards.

31. A method of underground laying a continuous elongated member in a bed of a body of water, wherein the continuous elongated member lies on the bed of the body of water along a given path, the method comprising:

fragmenting a soil mass in the bed along the given path and under the continuous elongated member, so as to form in the bed two scarp slopes bounding the fragmented soil mass by two soil masses susceptible to slide;

advancing a work assembly including two supporting walls that include tracks connected thereto, along the given path in an advancing direction, and along the respective two scarp slopes, by advancing one or more drive assemblies securing the work assembly; and

transferring the fragmented soil mass between the two supporting walls, so as to promote sinking of the continuous elongated member between the two supporting walls; and

adjusting a depth of the work assembly within the bed by moving the two supporting walls and tracks connected thereto along connecting members movably fitted within the tracks and connecting the two supporting walls to the one or more drive assemblies, while advancing the work assembly along the given path, by adjusting relative position between the work assembly and the one or more drive assemblies.

32. The method according to claim 31, further comprising vibrating at least a panel of each supporting wall; the panel contacting a respective soil mass along the respective scarp slope.

33. The method according to claim 32, wherein the panel of a respective supporting wall is vibrated in a direction crosswise to the given path in a substantially vertical direction.

34. The method according to claim 31, further comprising lubricating with a water film the outer faces of the supporting walls contacting the respective scarp slopes.

35. The method according to claim 31, wherein the step of advancing said two supporting walls is performed by at least one underwater vehicle comprising drive assemblies movable on the bed; and a work assembly which is set into the bed and includes said supporting walls.

36. The method according to claim 35, further comprising adjusting the relative position of the work assembly and the drive assemblies via two connecting assemblies, each located between the work assembly and a respective drive assembly.

37. The method according to claim 36, further comprising angling the work assembly with respect to the drive assemblies via the connecting assemblies.

38. The method according to claim 36, further comprising adjusting the distance between each drive assembly and the work assembly via the two connecting assemblies.

39. The method according to claim 35, further comprising transferring the fragmented soil mass via at least one dredging unit comprising a suction port

located between the two supporting walls, and an outlet port located over the continuous elongated member.

40. The method according to claim 39, further comprising supporting the dredging unit via the underwater vehicle.

41. The method according to claim 31, wherein adjusting the depth of the work assembly within the bed of the body of water comprises adjusting the depth of the work assembly via two connecting assemblies.

42. The method according to claim 31, wherein the step of fragmenting the soil mass is performed by a fragmenting unit for defining a given fragmented cross-section;

the width of the fragmented cross-section being substantially equal to the distance between said two supporting walls.

43. The method according to claim 42, further comprising setting the fragmenting unit in a work position and a rest position.

44. The method according to claim 31, further comprising pushing the continuous elongated member downwards between the two supporting walls.

45. A system for underground laying a continuous elongated member in a bed of a body of water, wherein the continuous elongated member extends on the bed along a given path, the system comprising:

an underwater vehicle comprising a work assembly which is set into the bed, the underwater vehicle including:

a fragmenting unit for fragmenting a soil mass in the bed along the given path and under the continuous elongated member, so as to form in the bed two scarp slopes bounding the fragmented soil mass by two soil masses susceptible to slide;

a sustaining unit comprising two opposite supporting walls which are advanced, along the given path in an advancing direction, along the respective two scarp slopes;

a dredging unit for transferring the fragmented soil mass between the two supporting walls, so as to promote sinking of the continuous elongated member between the two supporting walls;

one or more drive assemblies connected to the work assembly and configured to advance the work assembly within the bed of the body of water; and

one or more connecting assemblies securing the work assembly to the one or more drive assemblies, each connecting assembly of the one or more connecting assemblies including:

one or more tracks attached to the supporting walls;

one or more connecting members movably fitted into one or more respective tracks and connecting the work assembly to the one or more drive assemblies; and

one or more actuators connected to the one or more connecting members and configured to adjust the depth of the work assembly within the bed of the body of water by moving the one or more connecting members within the one or more tracks, while the drive assemblies advance the work assembly within the bed of the body of water.

46. The system according to claim 45, wherein each supporting wall comprises at least a base structure, a vibrating panel connected to the base structure, and means for inducing vibration of the panel; each panel being positioned contacting a respective soil mass along the respective scarp slope.

47. The system according to claim 46, wherein the actuators are configured for inducing vibration of the panel in a direction crosswise to the given path in a substantially vertical direction.

48. The system according to claim 45, further comprising a lubricating device for lubricating with a water film the outer faces of the supporting walls contacting the respective scarp slopes.

49. The system according to claim 45, wherein the one or more drive assemblies are movable on the bed of the body of water.

50. The system according to claim 49, wherein each drive assembly comprises a supporting body of adjustable buoyancy; and a crawler looped about the supporting body.

51. The system according to claim 45, wherein the dredging unit includes at least a suction port located between the supporting walls; and a first outlet port located downstream from the suction port and over the continuous elongated member.

52. The system according to claim 45, wherein the dredging unit is supported entirely by the underwater vehicle.

53. The system according to claim 45, further comprising an auxiliary dredging unit comprising at least an inlet port for sucking up water; and at least one outlet port located at the bottom of the supporting walls to inject water between the supporting walls.

54. The system according to claim 45, wherein the fragmenting unit defines a given fragmented cross section; the width of the fragmented cross section being substantially equal to the distance between said supporting walls.

55. The system according to claim 54, wherein the fragmenting unit is movable between a work position, in which it bridges the two supporting walls, and a rest position, in which the supporting walls enclose the continuous elongated member.

56. The system according to claim 45, wherein the work assembly comprises pushing means including at least one carriage, located between the supporting walls;

said pushing means being designed to push the continuous elongated member downwards.

57. A method of underground laying a continuous elongated member in a bed of a body of water, wherein the continuous elongated member lies on the bed of the body of water along a given path, the method comprising:

fragmenting a soil mass in the bed along the given path and under the continuous elongated member, so as to form in the bed two scarp slopes bounding the fragmented soil mass by two soil masses susceptible to slide;

advancing a work assembly including a first supporting wall and a second supporting wall, along the given path in an advancing direction, and along the respective two scarp slopes, by advancing one or more drive assemblies securing the work assembly;

transferring the fragmented soil mass between the two supporting walls, so as to promote sinking of the continuous elongated member between the two supporting walls;

adjusting a depth of the first supporting wall within the bed; and

adjusting a depth of the second supporting wall within the bed independent of the first supporting wall in a manner that the second supporting wall can be positioned at a different depth than the first supporting wall.

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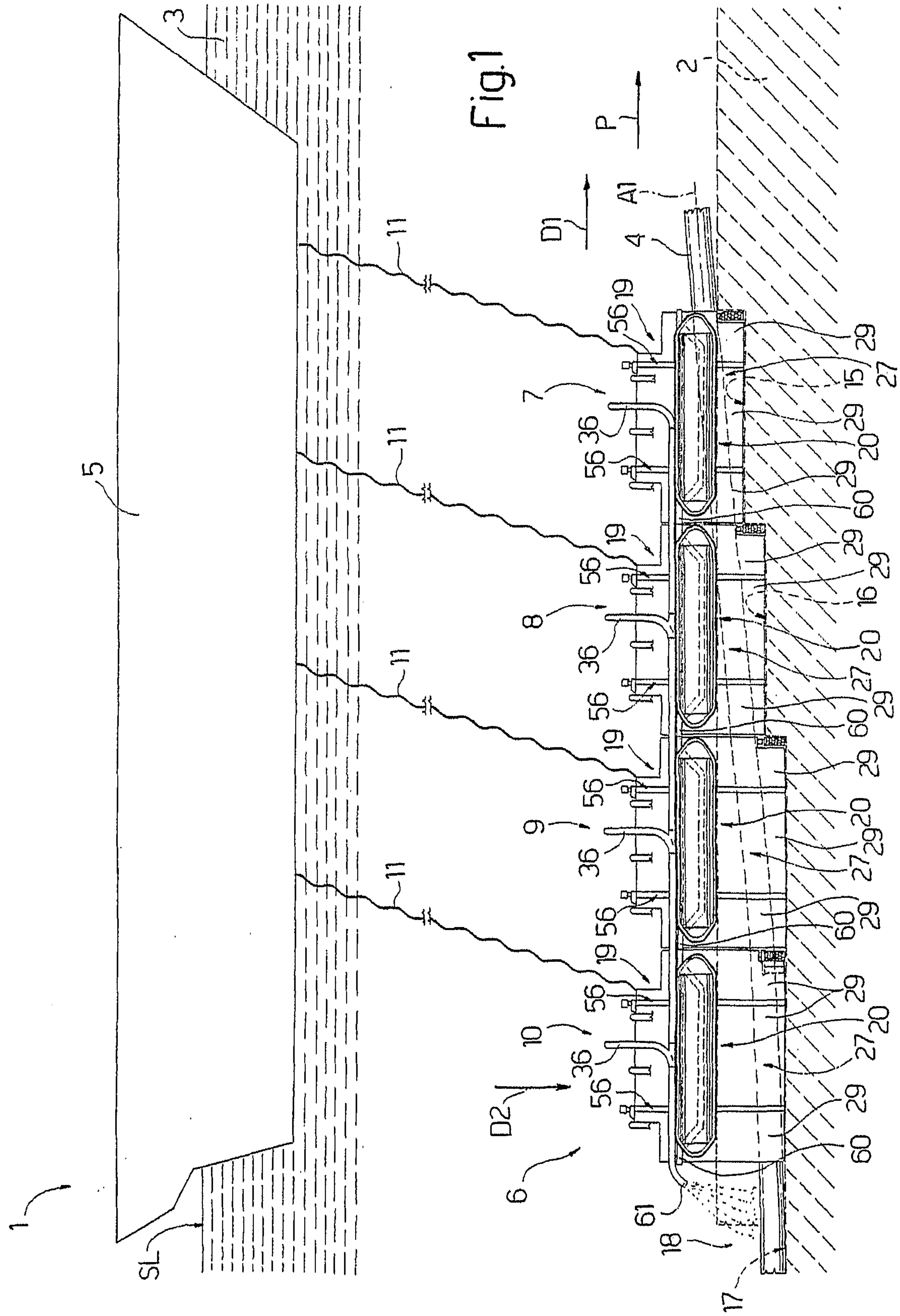

Fig.1

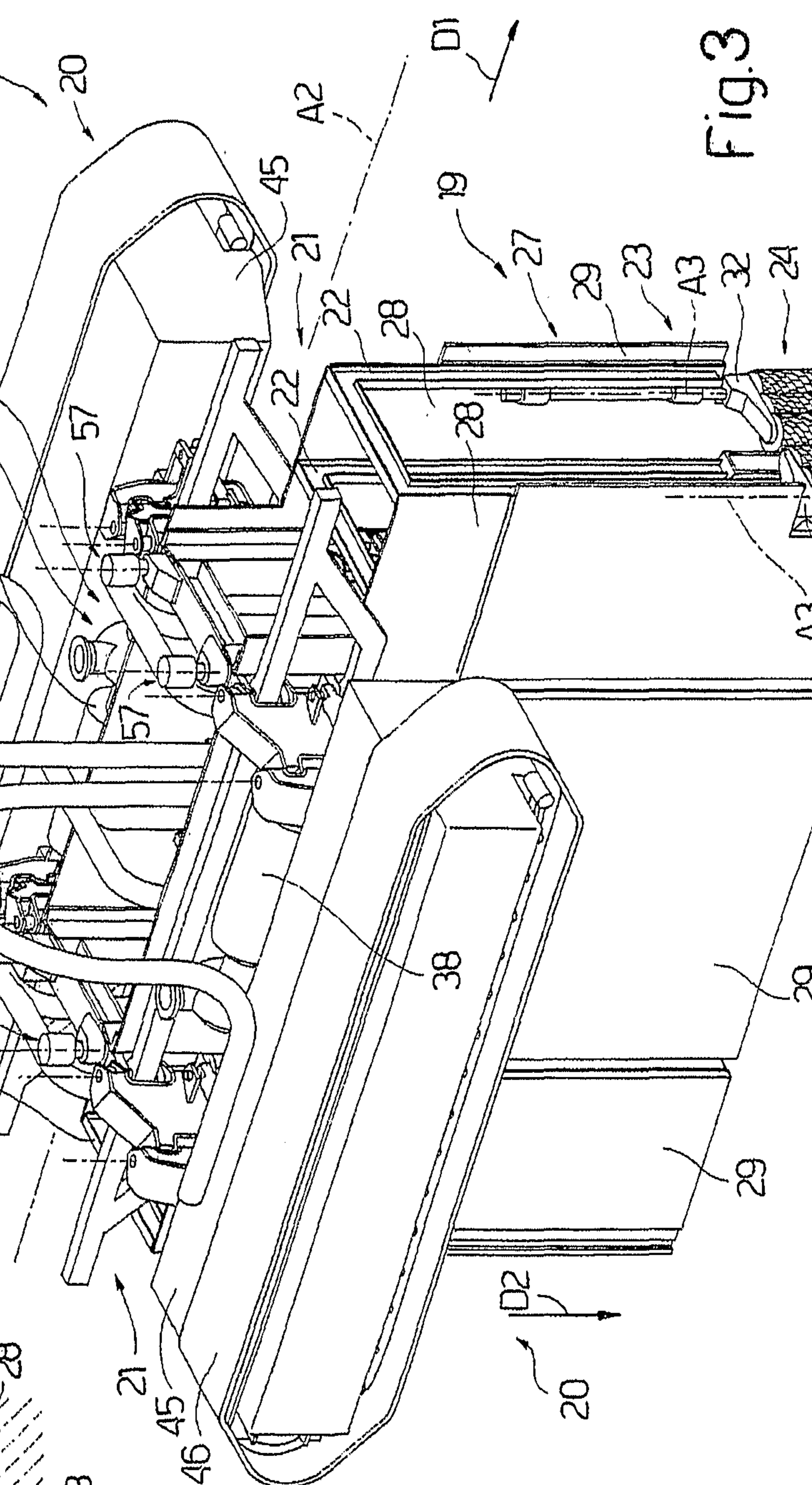

Fig.3

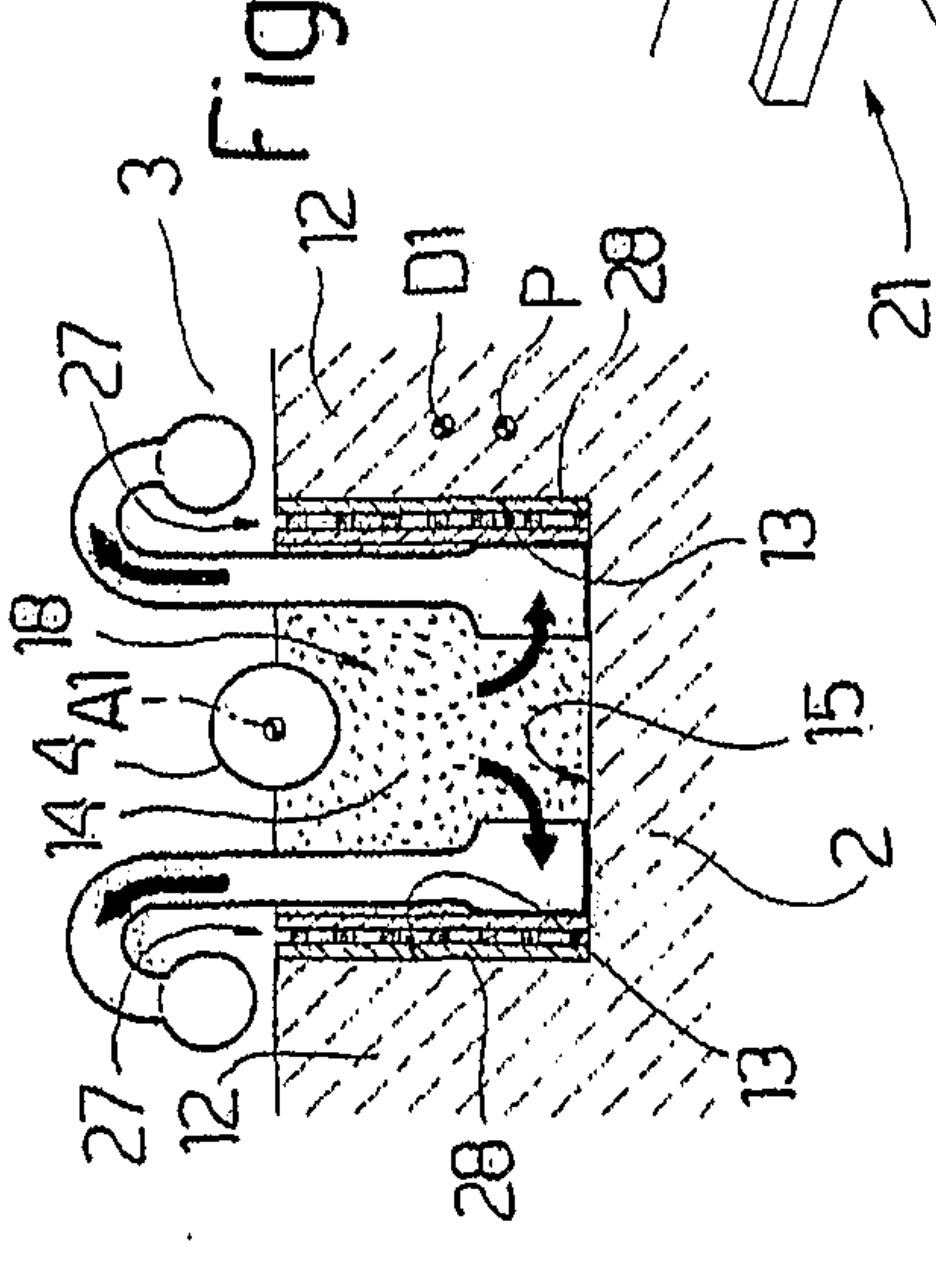

Fig.2

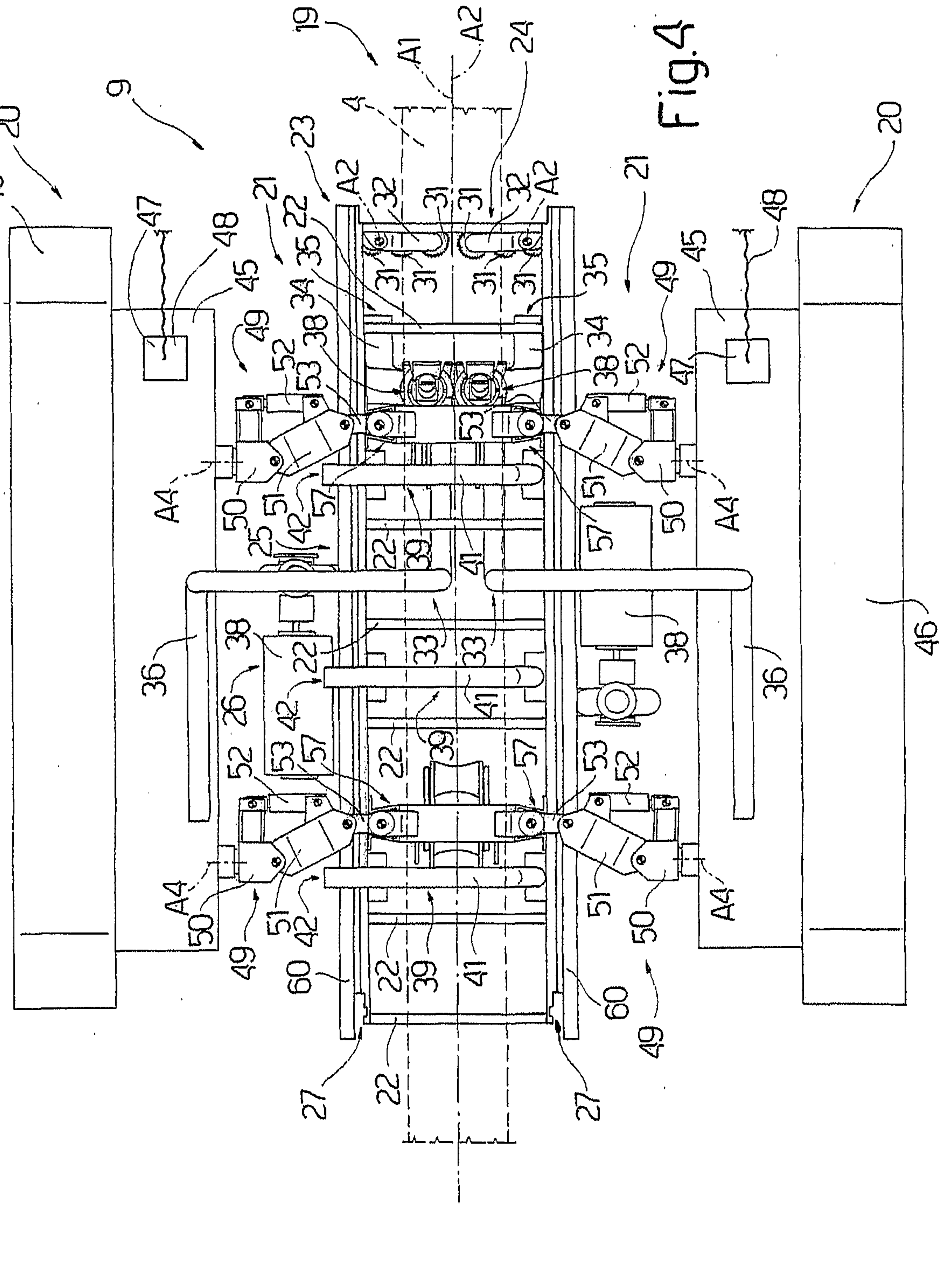

Fig.4

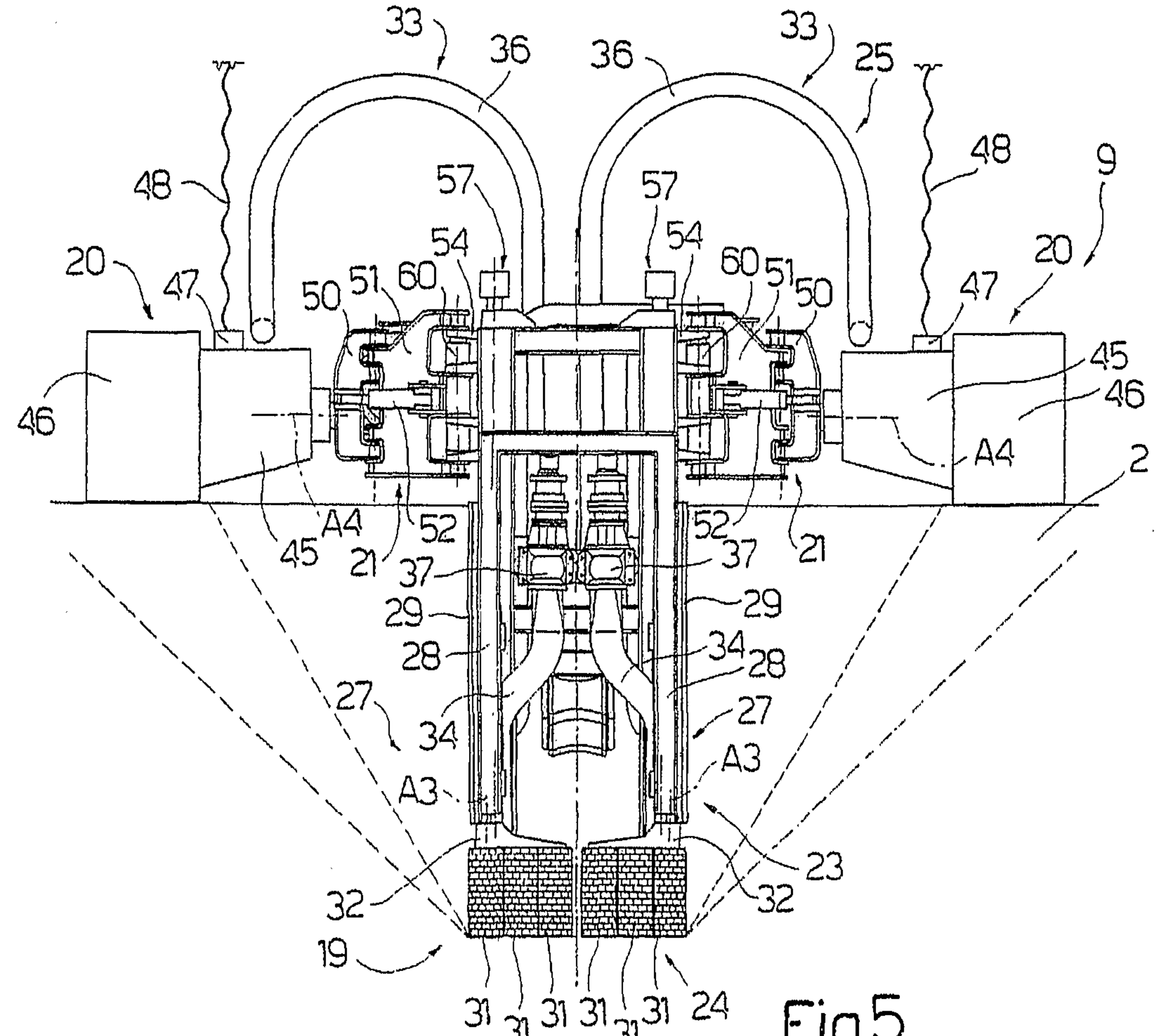
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Fig.5

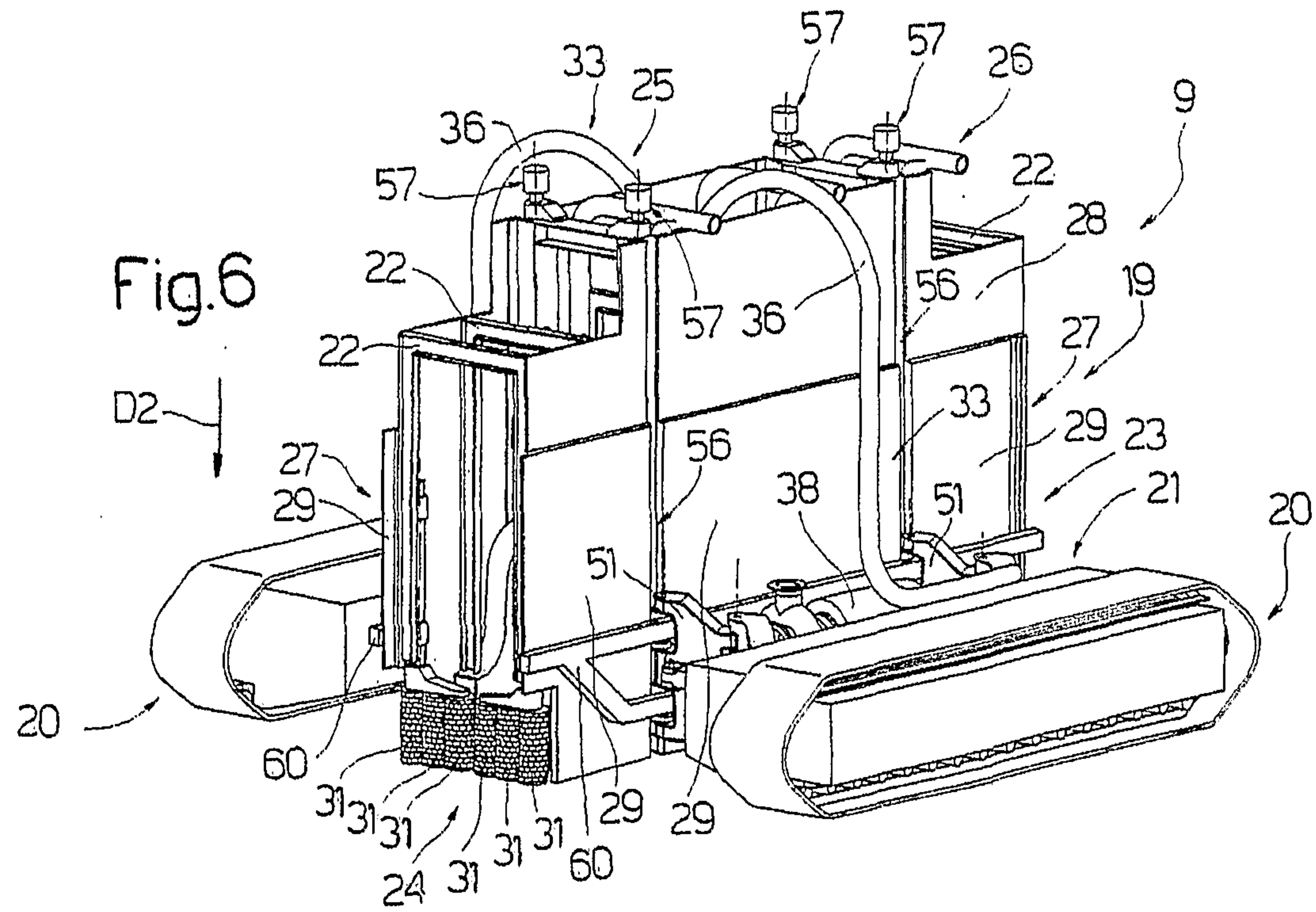
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Fig.6

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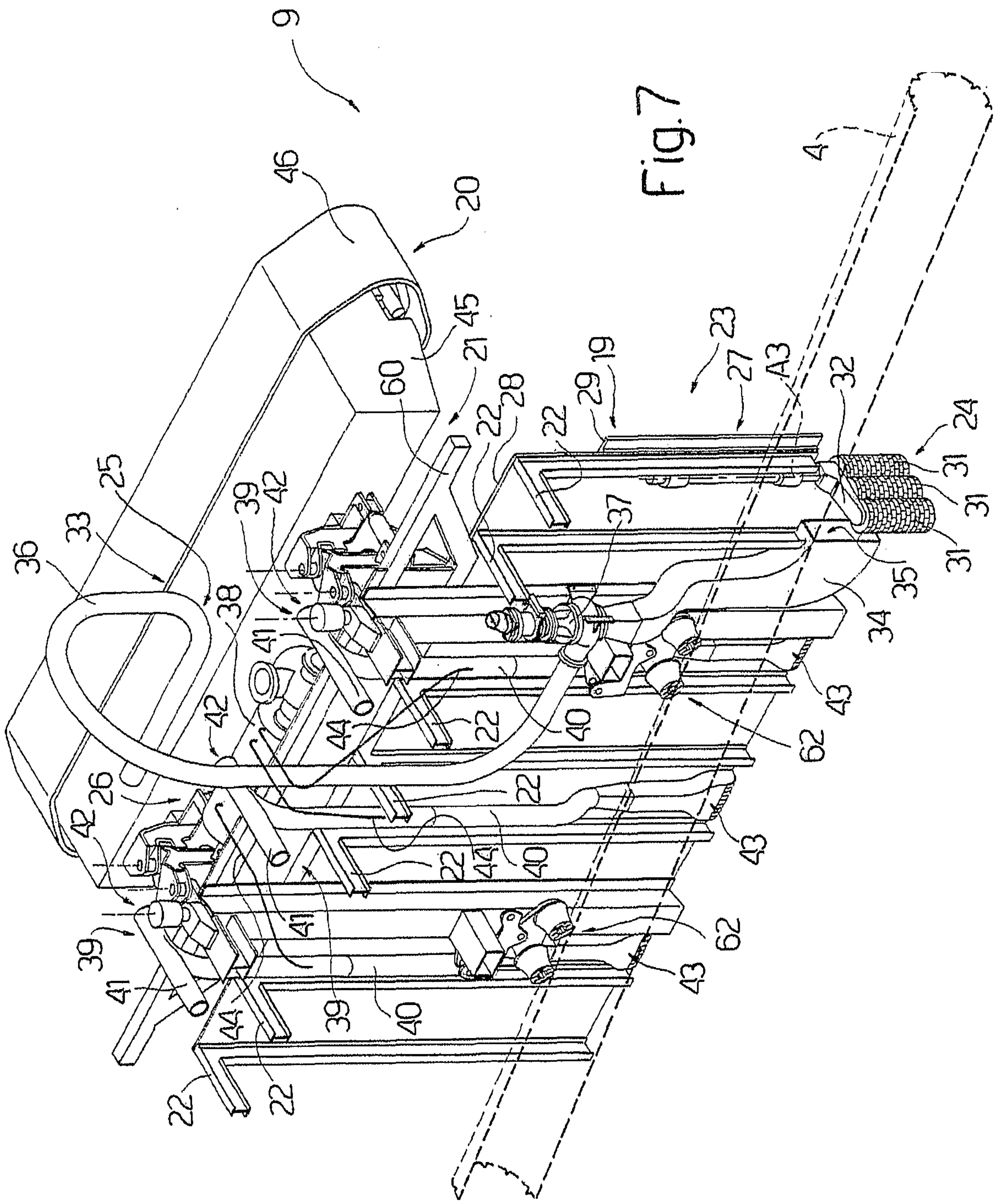
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Fig. 7

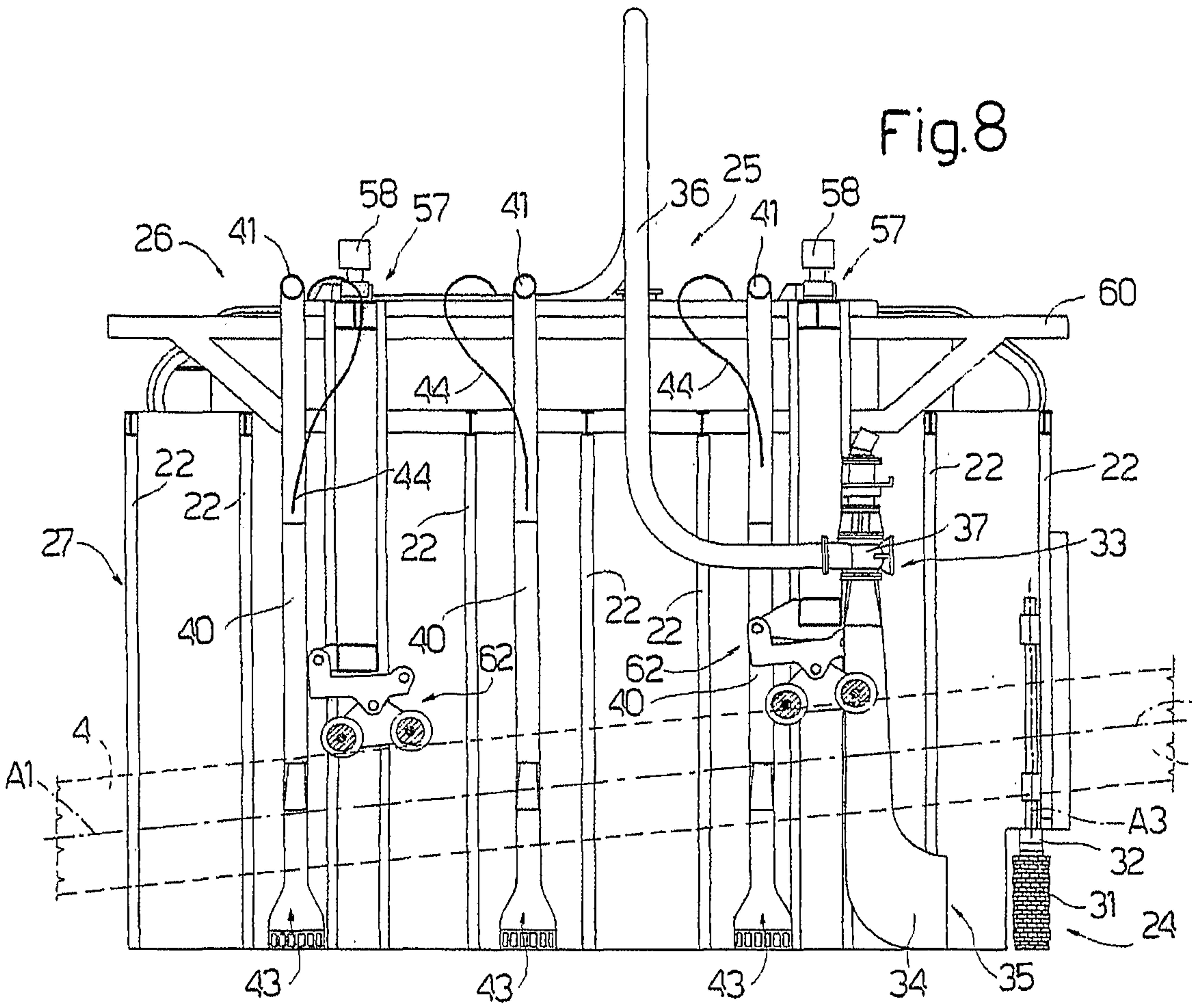


Fig.8

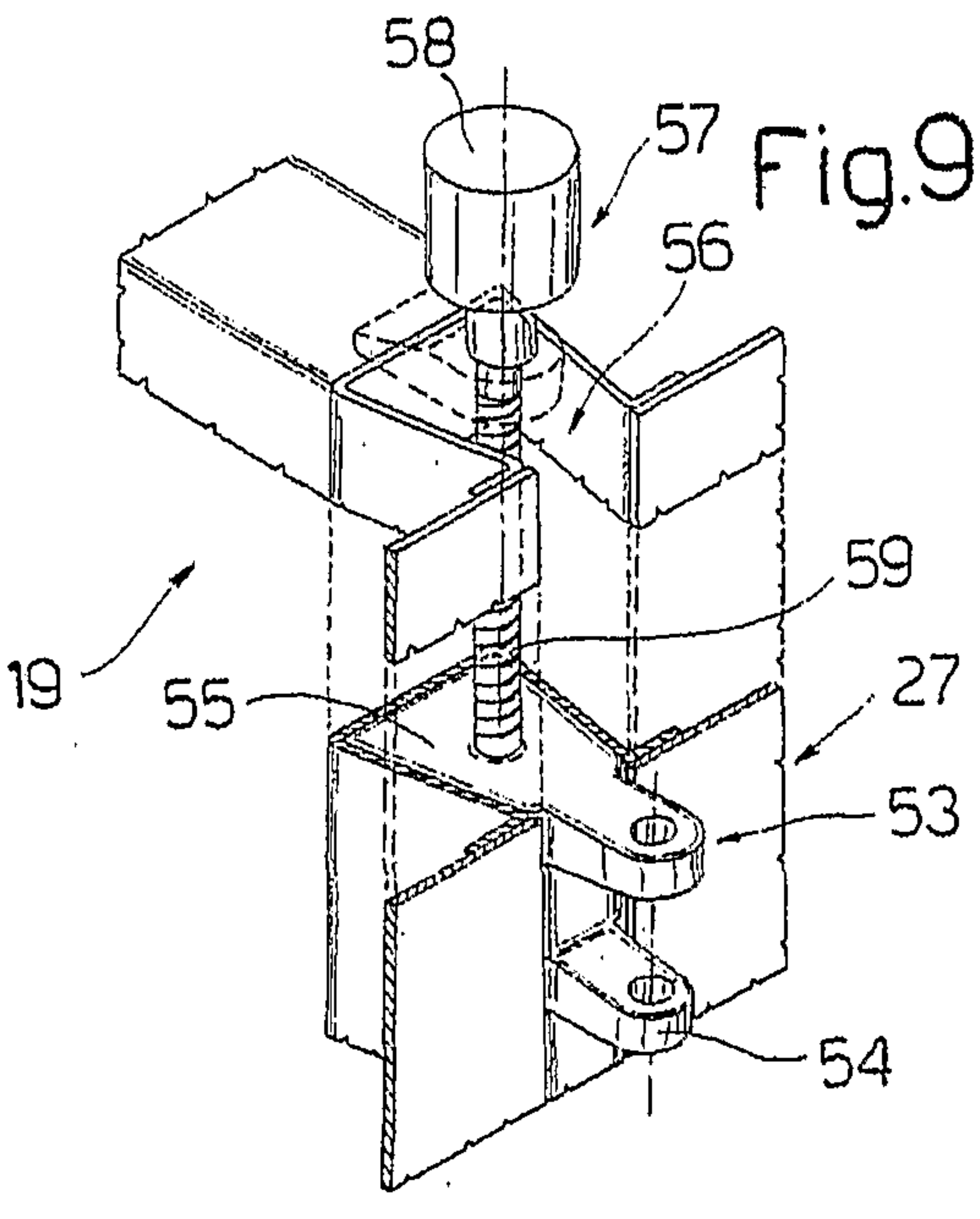


Fig.9

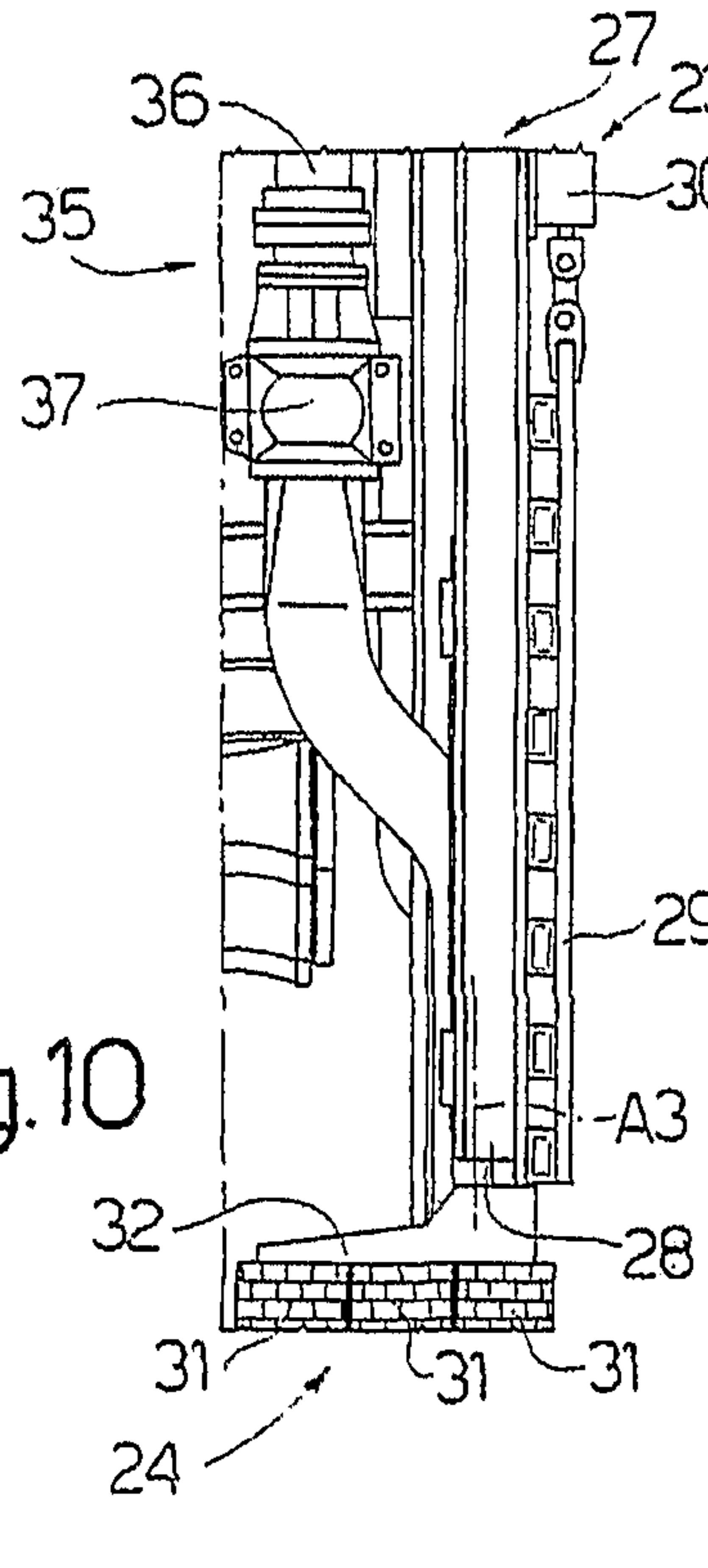


Fig.10

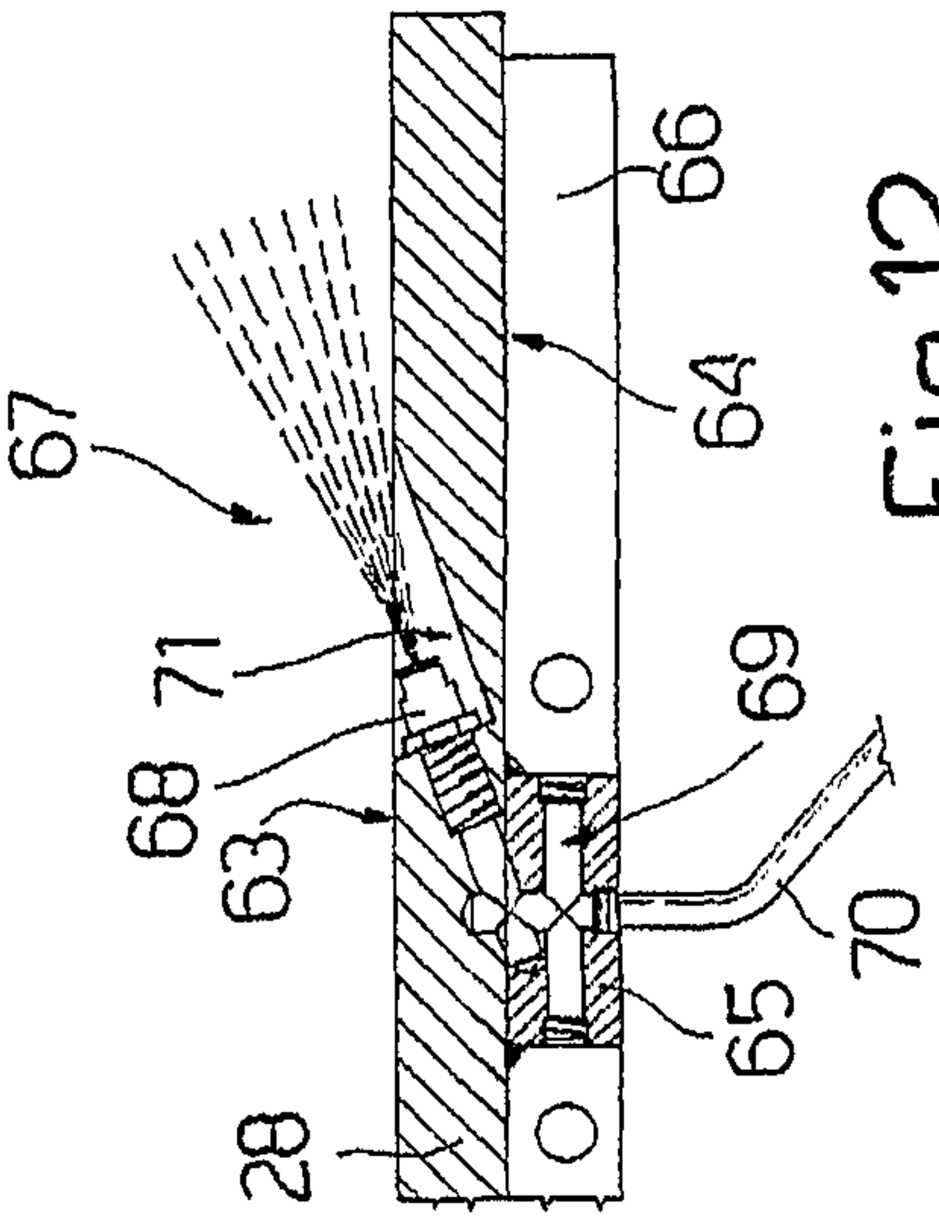


Fig.12

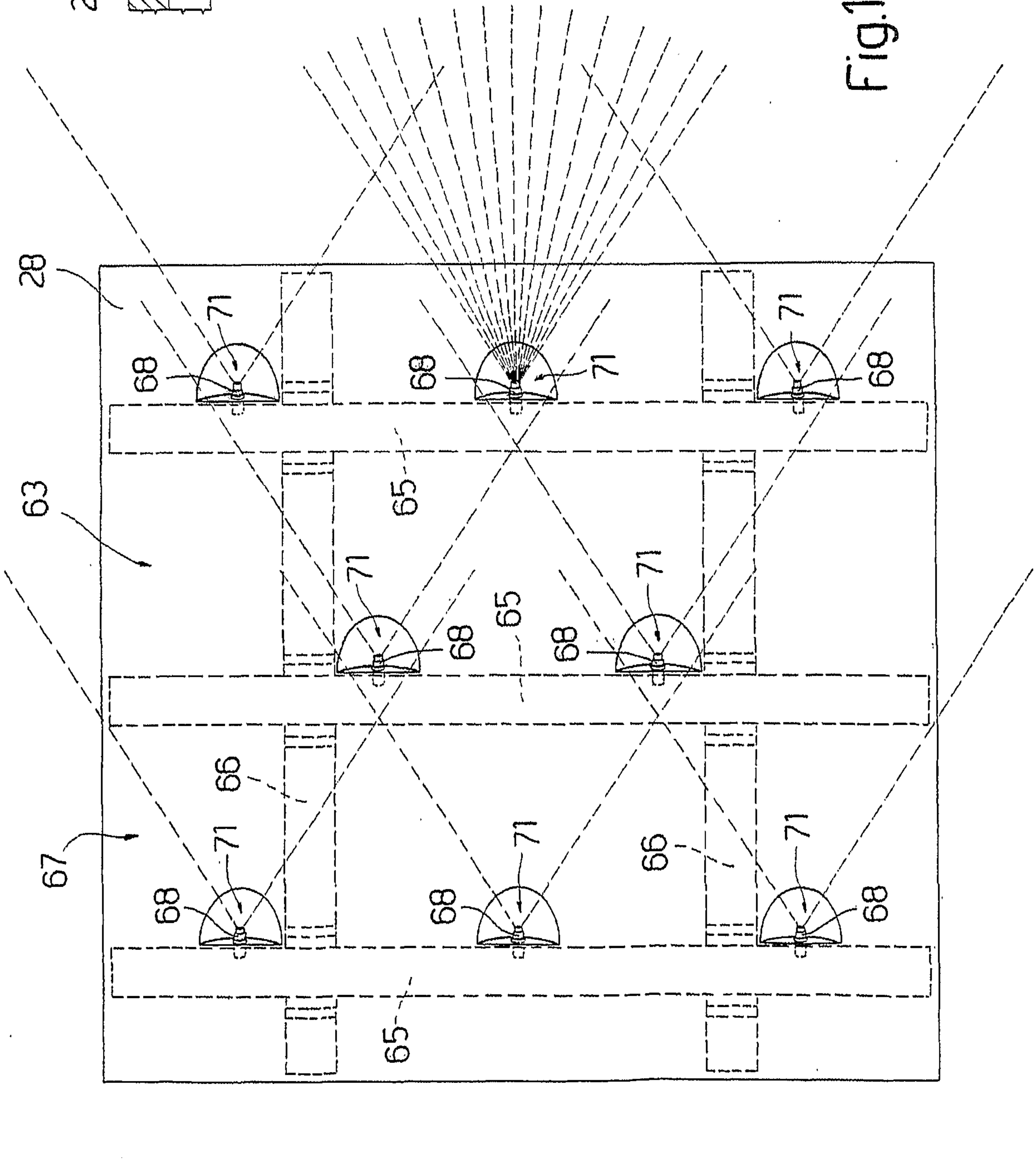
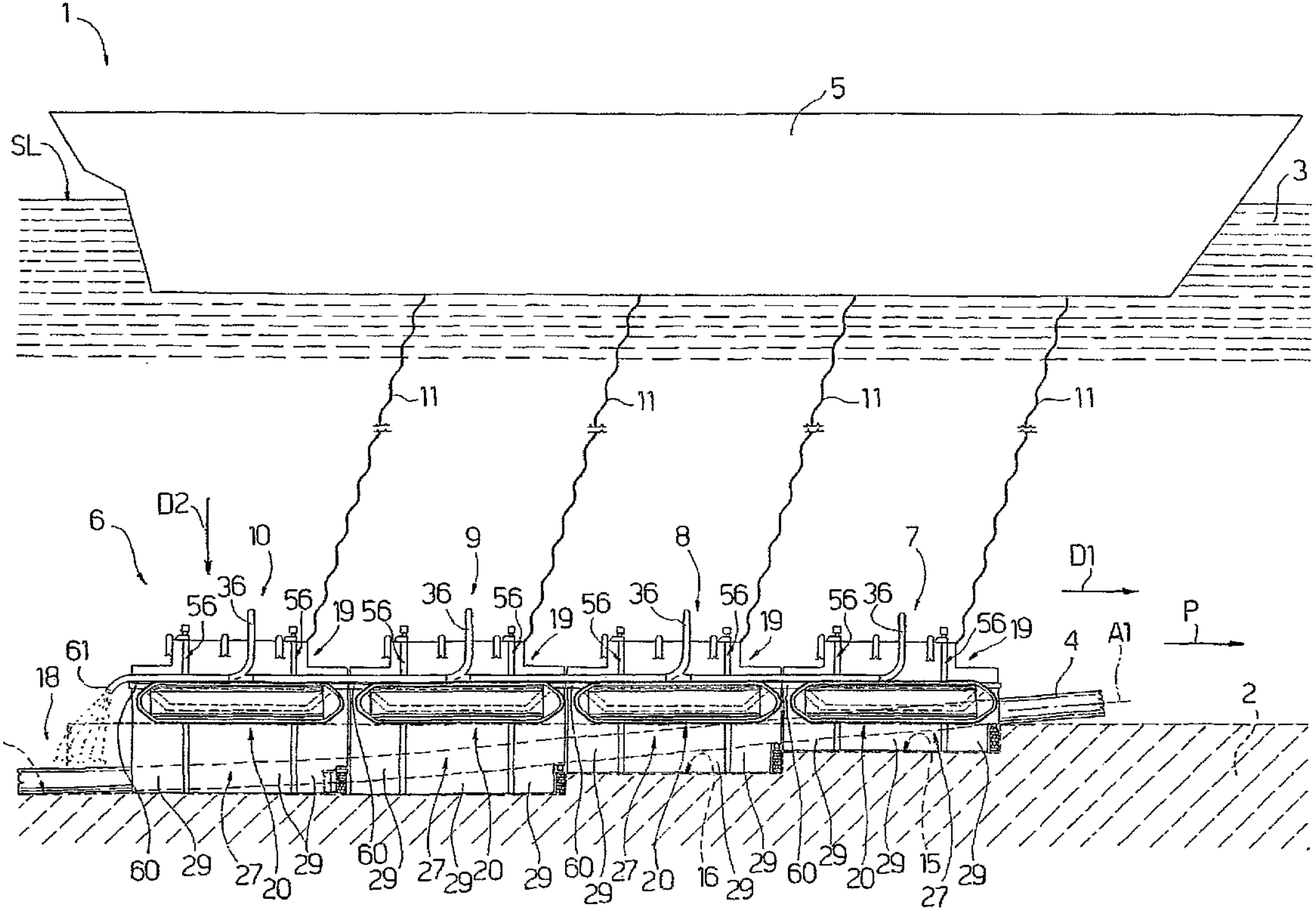


Fig.11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