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(54) **Apparatus for Cleaning an Interior of a Pipe**

(57) A pipe interior cleaning apparatus 2 comprises a main body 4 and a pair of support assemblies 6. A spray head 8 is rotatably mounted to body 4 and comprises a plurality of spray arms 10. A nozzle 12 is disposed at the end of each spray arm 10. The spray head 8, spray arms 10 and nozzle 12 are arranged to spray high pressure fluid, preferably water, from nozzle 12 onto the interior surface of a pipe to be cleaned. An electric motor 14 is coupled to spray head 8 to rotate the spray head 8.

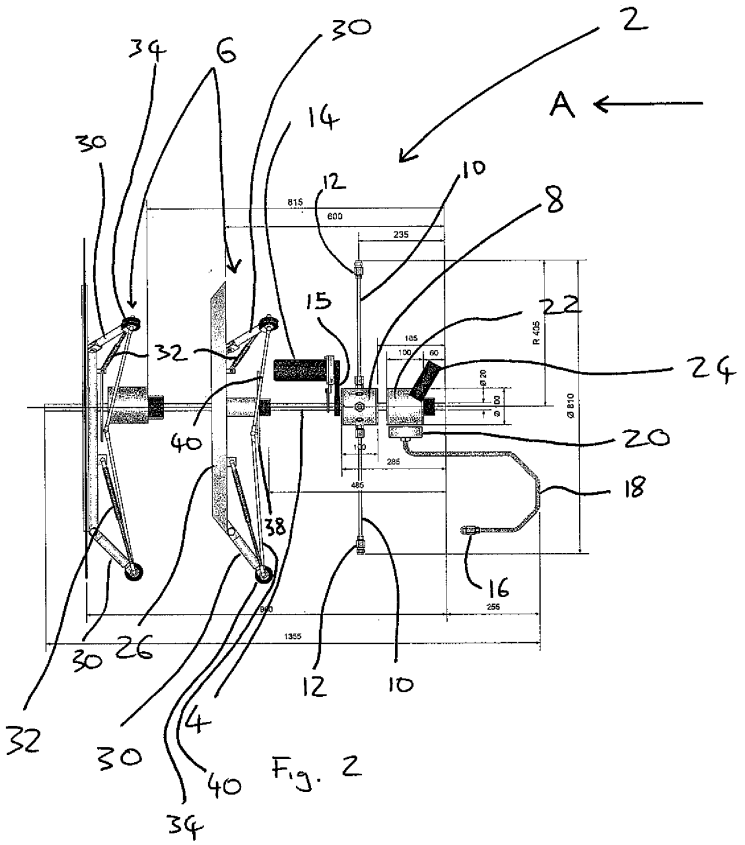

Fig. 2

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Description

[0001] The present invention relates to an apparatus for cleaning an interior of a pipe, and relates particularly, but not exclusively, to a pipe interior cleaning assembly. The invention also relates to a method of cleaning an interior of a pipe.

[0002] It is desirable to clean the interiors of water trunk main pipes in order to remove deposits from the interior surfaces of such pipes. In the past, water mains cleaning has been accomplished by the use of pigs. In order to clean a 500 metre section of water pipe with a pig, one pass of the pig requires approximately 330,000 litres of water to push the pig through the pipe and clean the interior surfaces of the pipe. Furthermore, several passes of the pig may be required which means that cleaning water pipes with pigs consumes very large volumes of water.

[0003] A preferred embodiment of the present invention seeks to overcome the above disadvantages of the prior art.

[0004] According to an aspect of the present invention, there is provided an apparatus for cleaning an interior of a pipe, the apparatus comprising:

a body and at least one nozzle, at least one said nozzle adapted to rotate relative to the body and spray fluid on to the interior of a pipe to clean the interior of the pipe; and

a support assembly arranged to engage the interior of the pipe to support the body relative to the interior of the pipe.

[0005] This provides the advantage that a high pressure water spray can be used to spray and clean the interior of a pipe. Such a system has been found to use a lot less water than known methods and is therefore less costly and more environmentally friendly. Rotating at least one nozzle relative to the body provides the advantage that even less water is used and also provides the advantage that spray is not directed to the same section of pipe wall for an extended period of time which reduces the likelihood of damage to the interior pipe wall.

[0006] Furthermore, this apparatus can operate regardless of rotational orientation, i.e. if the apparatus is turned upside down, it will continue to operate and has been shown to successfully clean lengths of pipe in excess of 500 metres in a single pass, whereas known pigging methods require multiple passes. It has been found that the apparatus can negotiate a 1D bend in a pipe. This means that for a pipe having diameter D, the apparatus can successfully negotiate a bend in the pipe having radius D.

[0007] In a preferred embodiment, at least one said nozzle is mounted at an end of a spray arm projecting from a spray head rotatably mounted to the body.

[0008] The spray arm may further comprise a flexible joint to enable the spray arm to bend.

[0009] This provides the advantage of reducing likelihood of damage to the apparatus. When the apparatus is advancing through a pipe, bends and deformations in the pipe could result in contact between the spray arm and the pipe wall. Consequently, the flexible joint enables the spray arm to bend when the spray arm comes into contact with the pipe wall.

[0010] In a preferred embodiment, said flexible joint comprises a portion of elastomeric tubing disposed between two substantially rigid portions of the spray arm.

[0011] Said elastomeric tubing may be reinforced with a high tensile steel wire helix.

[0012] This provides the advantage of reinforcing the flexible joint, and ensuring that the spray arm flexes back to a straight configuration when an obstacle has been cleared.

[0013] In a preferred embodiment, the apparatus further comprises a variable speed electric motor arranged to rotate the spray head relative to the body.

[0014] This provides the advantage that correct rotation speed of the spray head can be maintained. This also provides the advantage that rotation speed is not dictated by the water delivery flow rates to the apparatus. Consequently, the spray head is not allowed to run out of control which could result in poor cleaning and performance and excessive use of water. Furthermore, this provides the advantage that the spray head continues to rotate in the event that the spray head becomes partially submerged in any residual water in the pipe.

[0015] A variable speed electric motor provides the advantage of enabling the apparatus to be used to clean pipes of different diameters. Generally, in order to ensure that a pipe wall is sprayed with sufficient water, it is necessary that the spray head rotates slower for larger diameter pipes. Consequently, a variable speed motor enables the speed of rotation of the spray head to be selected according to the diameter of pipe to be cleaned.

[0016] In a preferred embodiment, the support assembly comprises a plurality of support legs moveably mounted to the body, each said support leg having an engaging member disposed at an end thereof to engage the interior of the pipe, wherein the support legs are adapted to extend and retract relative to the body to change the distance between the engaging members and the body to hold the body substantially at the centre of the pipe, the support assembly further comprising biasing means arranged to bias each said support leg outwardly from the body.

[0017] This provides the advantage of maintaining the body substantially at the centre of the pipe meaning that the distance between the nozzles and the wall of the pipe remains substantially constant. This improves cleaning effectiveness and also improves the consistency of the cleaning process.

[0018] Preferably, the apparatus further comprises an interlinking mechanism connected to each said support leg, wherein the interlinking mechanism causes each

said support leg to be deployed outwardly from the body to the same extent.

[0019] This provides the advantage of ensuring that the body and therefore the spray head and spray arms are centred in the pipe.

[0020] The interlinking mechanism may comprise:

a coupling member rotatably mounted on the body; and

a plurality of rods, each said rod pivotally mounted at a first end to a point on the coupling member remote from an axis of rotation of the spray head and pivotally mounted at a second end to a support leg, such that pivotal movement of one support leg results in rotational movement of the coupling member which causes movement of respective rods to pivot the other support legs.

[0021] This provides the advantage of a relatively compact interlinking mechanism that is not required to slide up and down the body.

[0022] The apparatus may further comprise at least one draft nozzle arranged to spray fluid substantially axially along the pipe.

[0023] This provides the advantage that fluid sprayed from the draft nozzle forces any fluid collecting in the bottom of the pipe away from the path of the rotating spray head in order to ensure maximum effectiveness of each spray nozzle.

[0024] At least one said draft nozzle may be arranged to spray fluid forwardly in a direction of movement of the apparatus.

[0025] Said draft nozzle may be rotatably mounted to the body and weighted to cause the draft nozzle to hang below the body.

[0026] This provides the advantage of ensuring that the draft nozzle sprays the base of the pipe.

[0027] In a preferred embodiment, the apparatus further comprises monitoring means to monitor the rotation of at least one said nozzle.

[0028] If the rotating spray head becomes stuck, then the high pressure fluid spray can cause damage to the interior of the pipe by directing spray onto the same region of pipe for a prolonged period. Consequently, monitoring means provides the advantage that a user will be made aware if the spray head becomes stuck and can then deactivate the apparatus.

[0029] According to another aspect of the present invention, there is provided a pipe interior cleaning assembly comprising:

a reeling drum for reeling an umbilical cleaning fluid line; and

an apparatus as defined above attachable to the umbilical cleaning fluid line.

[0030] According to a further aspect of the present invention, there is provided a method of cleaning the interior of a pipe, the method comprising:

pulling an umbilical cleaning fluid line through a length of pipe to be cleaned;

connecting an apparatus as defined above to the umbilical cleaning fluid line to supply cleaning fluid to the apparatus; and

moving the apparatus through the length of pipe to be cleaned to spray the interior wall of the pipe to clean the interior of the pipe.

[0031] A preferred embodiment of the invention will now be described, by way of example only and not in any limitative sense, with reference to the accompanying drawings, in which:

Figure 1 is a front view of an apparatus embodying the present invention for cleaning an interior of a pipe;

Figure 2 is a side view of the apparatus of Figure 1;

Figure 3 is a partially cut away perspective view of the rotary spray head and draft spray head of the apparatus of Figure 1;

Figure 4 is a partially cut away perspective view of a main seal housing ring of Figure 3;

Figure 5 is a side view of two spray nozzles of the apparatus of Figure 1 illustrating spray overlap from offset nozzles;

Figure 5a is a side view of a spray arm having a flexible joint;

Figure 6 is a schematic view of the first stage of a pipe cleaning process using the apparatus of Figure 1;

Figure 7 is a schematic view of the second stage of the pipe cleaning process;

Figure 8 is a schematic view of the third stage of the pipe cleaning process;

Figure 9 is a schematic view of the fourth stage of the pipe cleaning process;

Figure 10 is a schematic view of the fifth stage of the pipe cleaning process;

Figure 11 is a side view of a robotic carriage for pulling a winch bond through a pipeline;

Figure 12 is a top view of the robotic carriage of Figure 11; and

Figure 13 is a side view of a plunger assembly.

[0032] Referring to Figures 1 to 3, a pipe interior cleaning apparatus 2 comprises a main body 4 and a pair of support assemblies 6. Main body 4 is a length of steel tubing. Alternatively, in order to increase strength, a bore 44 can be drilled in a steel cylinder to form body 4. More or less than two support assemblies 6 can be used depending on the requirements of the pipe to be cleaned. A spray head 8 is rotatably mounted to body 4 and comprises a plurality of spray arms 10. A nozzle 12 is disposed at the end of each spray arm 10. The spray head 8, spray arms 10 and nozzle 12 are arranged to spray high pressure fluid, preferably water, from nozzle 12 onto the interior surface of a pipe to be cleaned.

[0033] Spray arms 10 are preferably formed from lengths of stainless steel pipe. Each spray arm may comprise a flexible joint 11 (Figure 5a) disposed along the length of the pipe. For example, a portion of flexible elastomeric tubing 11, such as black nitrile rubber tube may be used to join two lengths of steel tubing 10a and 10b to form an arm 10 having a flexible joint. This enables spray arms 10 to deform on contact with deformations and bends in a pipe wall and therefore prevents damage to the arms 10. The elastomeric tubing may be reinforced using a high tensile steel wire helix (not shown).

[0034] An electric motor 14 is coupled to spray head 8 to rotate the spray head 8. The electric motor 14 may be a variable speed electric motor which enables the speed of rotation of the spray head to be changed in order to clean pipes of different diameter. The electric motor 14 is powered by an onboard battery (not shown). Motor 14 is coupled to spray head 8 by a drive belt 15.

[0035] A draft spray head 22 is rotatably mounted to body 4 and connected to draft spray arm 18 and draft spray nozzle 16. Draft spray head 22 is freely rotatable on body 4 and is weighted by weight 20 to ensure that draft spray nozzle 16 is always positioned below the body 4. When the cleaning apparatus 2 is in operation and advancing along a pipe in the direction of arrow A, draft spray nozzle 16 sprays water axially along the pipe, and preferably forwardly of the cleaning apparatus 2, to remove water that has pooled at the base of the pipe to ensure that cleaning water sprayed by nozzles 12 can clean the base of the pipe.

[0036] Referring to Figure 3, draft spray head 22 may be formed from the same part as spray head 8. In Figure 3, spray head 8 comprises four spray arms 10. In order to convert spray head 8 into draft spray head 22, one of arms 10 is replaced with draft spray arm 18 and the other three arms 10 are removed. The apertures (not shown) to which arms are connected can then be closed with nuts (not shown) This enables a single part to be manufactured for both spray head 8 and draft spray head 22 to reduce manufacturing costs.

[0037] Monitoring means such as a CCTV camera 24 is arranged to transmit pictures of rotating spray head 8 and spray arms 10 to enable an operator to determine whether the spray head 8 is rotating. If the spray head 8 becomes stuck, nozzles 12 will continually spray high pressure water on the same points on the pipe interior. This can cause damage to the interior wall of the pipe such that if the CCTV camera 24 shows that the spray head 8 has become stuck, then the operator can shut down the cleaning apparatus 2. Monitoring means other than a CCTV camera can be used to monitor the rotation of spray head 8.

[0038] A support ring 26 forms an extension to body 4 and is connected to body 4 by a plurality of support ring arms 28. Support assembly 6 comprises a plurality of support arms 30 pivotably mounted to support ring 26. Biasing means, such as gas struts 32 are used bias support legs 30 outwardly of body 4. Engaging members such as nylon wheels 34 are arranged to engage the interior wall of a pipe to support the body centrally in the pipe. Since support legs 30 are biased outwardly by gas struts 32, then the support assembly 6 ensures that the body 4 is centred in the pipe. Spring struts can be used instead of gas struts. Spring struts have the advantage that they do not lose hydraulic pressure over time.

[0039] In order to improve the centring of body 4 in the pipe, an interlinking mechanism is provided. Interlinking mechanism comprises a coupling member such as a triangular plate 38 rotatably mounted on body 4. A ring may be used in place of the triangular plate. A plurality of rods 40 are pivotably mounted at a first end to triangular plate 38 and pivotably mounted at a second end to far ends of support arms 30. Consequently, when one of support arms 30 pivots relative to support ring 26, the respective rod 40 is pushed or pulled causing triangular plate 38 to rotate. This results in the remaining rods 40 being either pushed or pulled to move the remaining support arms 30 in the same manner as the first support arm.

[0040] Alternatively, a sliding ring mechanism can be used for an interlinking mechanism, similar to the mechanism used on an umbrella to interlink support arms 30 to ensure that the body member 4 and spray heads are centred in a pipe. A sliding ring (not shown) could be slidably mounted on body member 4 and biased to push rods 40 and therefore support arms 30 into outwardly extended positions. The biasing means may be adjustable in order to enable the apparatus to be calibrated for different pipe diameters.

[0041] Referring to Figures 3 and 4, the apparatus 2 is supplied with high pressure cleaning fluid, preferably water, via an umbilical (not shown) connected to central bore 44. Central bore may be formed by drilling a hole through a steel cylinder to provide a relatively strong body 4. This enables the apparatus to be pulled rearwardly through a pipe without the risk of deforming body 4. A seal housing ring 42 is disposed in both the spray head 8 and draft spray head 22 in order to seal the housing. This rotary sealing system enables delivery of water at

pressures up to 100 bar. Either lip seals or 0-rings can be used to seal the spray heads. The close proximity of spray arms 10, 18 and nozzles 12 and 16 to the central bore 44 ensures high pressure and therefore efficient cleaning.

[0042] Referring to Figures 1 and 5, it can be seen that four pairs of offset nozzles 12 are used. This configuration enables spray overlap which leads to more effective cleaning. For example, a nozzle separation of 10 degrees and nozzle distance of 50mm from the pipe wall results in an effective cleaning surface on pipe wall 46 of 75mm. The number of spray arms 10 and nozzles 12 can be changed depending on the requirements of the pipe to be cleaned. More or less arms can be used depending on the diameter of the pipe to be cleaned, and also the amount of cleaning required. For example, a pipe wall with a greater amount of deposit will require more cleaning, and therefore more spray arms can be used. The more arms that are used, the faster the apparatus can move along a pipe.

[0043] In operation, the apparatus of Figures 1 to 5 is fed with water from an umbilical connected to central bore 44 and the apparatus is pulled along the pipe by umbilical 44 via slow motion carriage (not shown) to ensure constant speed. Electric motor 30 rotates spray head 8 and therefore rotates spray arms 10 to spray the pipe wall 46 and remove deposits from pipe wall 46. Electric motor 14 ensures correct rotational speed of the cleaning head and also ensures that the rotational speed is not dictated by water pressure. Also, if the apparatus becomes partially submerged in residual water, for example in pipe depressions, then motor 14 ensures that the spray head continues to rotate. Support assembly 6 centre the body 4 and therefore spray assemblies in the centre of the pipe. Finally, draft nozzle 16 sprays water forwardly of the apparatus 2 to remove pooled water before cleaning.

[0044] Referring to Figures 6 to 10, the process of cleaning an interior of a pipe using the apparatus of Figures 1 to 5 will now be described.

[0045] Referring firstly to Figure 6, a reception pit 50 and launch pit 52 are excavated in the ground at the ends of a length of pipe 54 to be cleaned. A winch rope 56 is then pulled through the length of pipe 54 by a robotic carriage 58 (Figures 11 and 12). Robotic carriage 58 is powered by batteries 60.

[0046] Referring now to Figures 7 and 13, a foam swab assembly 62 comprising a foam portion 64, polyurethane seals 66, steel support plates 68 and towing eyes 70 is connected to winch rope 56 and pulled through the length of pipe to be cleaned. This helps to minimise the amount of standing water remaining in the pipe before cleaning.

[0047] Referring to Figure 8, a reeling drum 72 stores a umbilical assembly 74. Umbilical assembly 74 is connected to winch rope 56 and pulled through the pipe 54 from the reception pit 50 to the launch pit 52.

[0048] Referring to Figure 9, a water supply 76 is connected to umbilical 74 and the umbilical is then connected to the cleaning apparatus 2. A slow motion carriage 78 is connected to the umbilical and used to pull the cleaning apparatus 2 at a constant speed through the pipe 54. As the apparatus 2 advances through pipe 54, spray head and spray arms 10 rotate as shown by arrows B to spray the interior pipe wall and remove deposits from the pipe wall. It has been found that lengths of pipe in excess of 500 metres can be successfully cleaned with this system.

[0049] Finally, referring to Figure 10, once the cleaning apparatus 2 has been passed through the pipe 54, to ensure that no cleaning water remains in the pipe after the cleaning process a further plunger assembly comprising foam swab assembly 64 and clean foam swab assembly 80 is pulled through the pipe. Dirty water collected in the reception pit 50 is then pumped into a series of settlement tanks which are large enough to ensure sufficient dwell time to allow the pipe deposits to fall out of the suspension into the bottom of the tank allowing cleaning water to be removed and recycled.

[0050] It will be appreciated by persons skilled in the art that the above embodiment has been described by way of example only and not in any limitative sense, and that various alterations and modifications are possible without departure from the scope of the invention as defined by the appended claims. In particular, the cleaning assembly described can be used to clean pipes other than water pipes using cleaning fluids other than water.

Claims

1. An apparatus for cleaning an interior of a pipe, the apparatus comprising:

   a body and at least one nozzle, at least one said nozzle adapted to rotate relative to the body and spray fluid on to the interior of a pipe to clean the interior of the pipe; and
   a support assembly arranged to engage the interior of the pipe to support the body relative to the interior of the pipe.

2. An apparatus according to claim 1, wherein at least one said nozzle is mounted at an end of a spray arm projecting from a spray head rotatably mounted to the body.

3. An apparatus according to claim 2, wherein the spray arm further comprises a flexible joint to enable the spray arm to bend.

4. An apparatus according to claim 3, wherein said flexible joint comprises a portion of elastomeric tubing disposed between two substantially rigid portions of the spray arm.

5. An apparatus according to claim 4, wherein said elastomeric tubing is reinforced with a high tensile steel wire helix.

6. An apparatus according to any one of claims 2 to 5, further comprising a variable speed electric motor arranged to rotate the spray head relative to the body.

7. An apparatus according to any one of the preceding claims, wherein the support assembly comprises a plurality of support legs moveably mounted to the body, each said support leg having an engaging member disposed at an end thereof to engage the interior of the pipe, wherein the support legs are adapted to extend and retract relative to the body to change the distance between the engaging members and the body to hold the body substantially at the centre of the pipe, the support assembly further comprising biasing means arranged to bias each said support leg outwardly from the body.

8. An apparatus according to claim 7, further comprising an interlinking mechanism connected to each said support leg, wherein the interlinking mechanism causes each said support leg to be deployed outwardly from the body to the same extent.

9. An apparatus according to claim 8, wherein the interlinking mechanism comprises:

a coupling member rotatably mounted on the body; and
a plurality of rods, each said rod pivotally mounted at a first end to a point on the coupling member remote from an axis of rotation of the spray head and pivotally mounted at a second end to a support leg, such that pivotal movement of one support leg results in rotational movement of the coupling member which causes movement of respective rods to pivot the other support legs.

10. An apparatus according to any one of the preceding claims, further comprising at least one draft nozzle arranged to spray fluid substantially axially along the pipe.

11. An apparatus according to claim 10, wherein at least one said draft nozzle is adapted to spray fluid forwardly in a direction of movement of the apparatus.

12. An apparatus according to claim 10 or 11, wherein at least one said draft nozzle is rotatably mounted to the body and weighted to cause the draft nozzle to hang below the body.

13. An apparatus according to any one of the preceding claims, further comprising monitoring means to monitor the rotation of at least one said nozzle.

14. A pipe interior cleaning assembly comprising:

a reeling drum for reeling an umbilical cleaning fluid line; and
an apparatus according to any one of claims 1 to 13 attachable to the umbilical cleaning fluid line.

15. A method of cleaning an interior of a pipe, the method comprising;
pulling an umbilical cleaning fluid line through a length of pipe to be cleaned:

connecting an apparatus according to any one of claims 1 to 13 to the umbilical cleaning fluid line to supply cleaning fluid to the apparatus; and
moving the apparatus through the length of pipe to be cleaned to spray the interior wall of the pipe to clean the interior of the pipe.

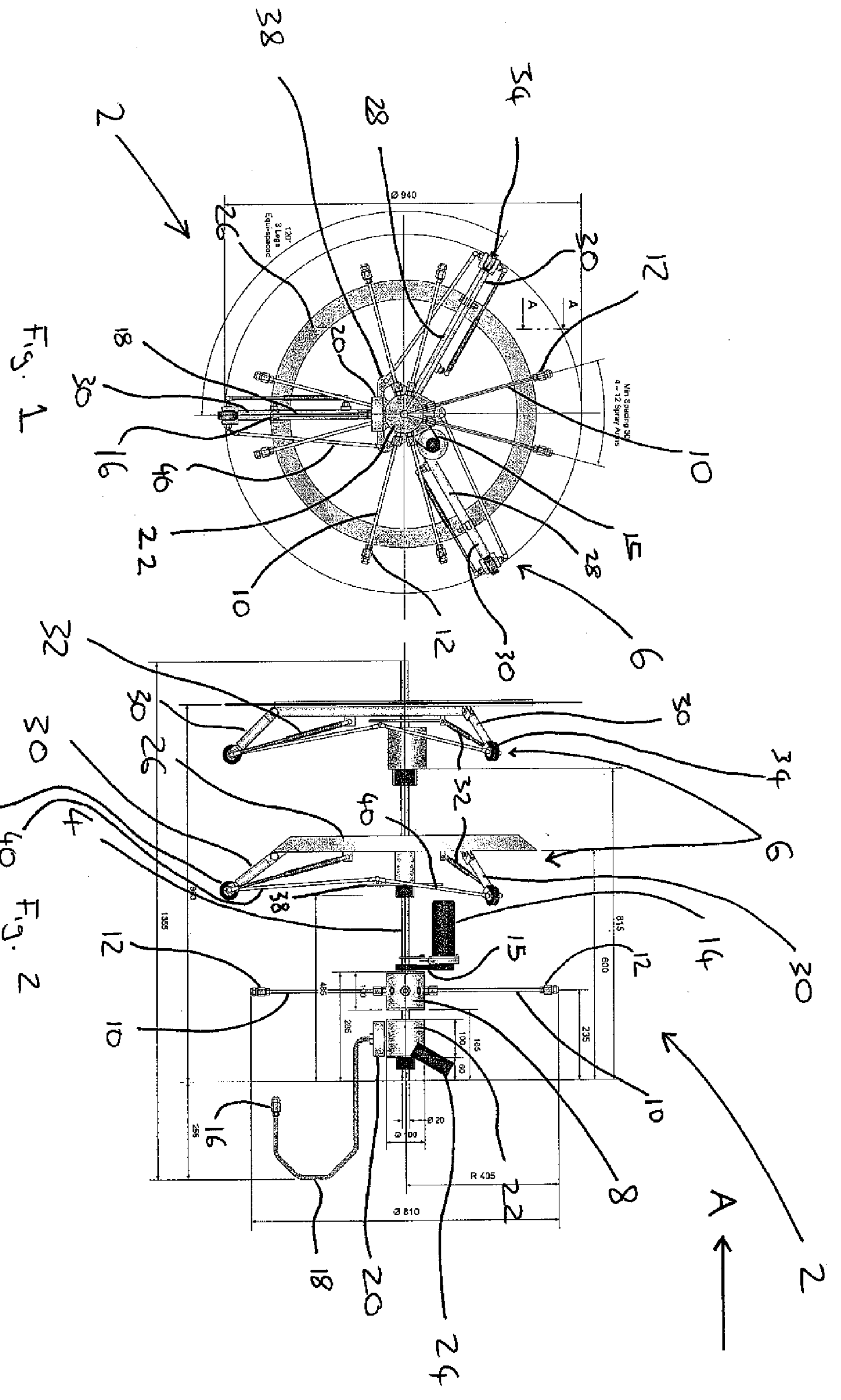
Fig. 1
Fig. 2

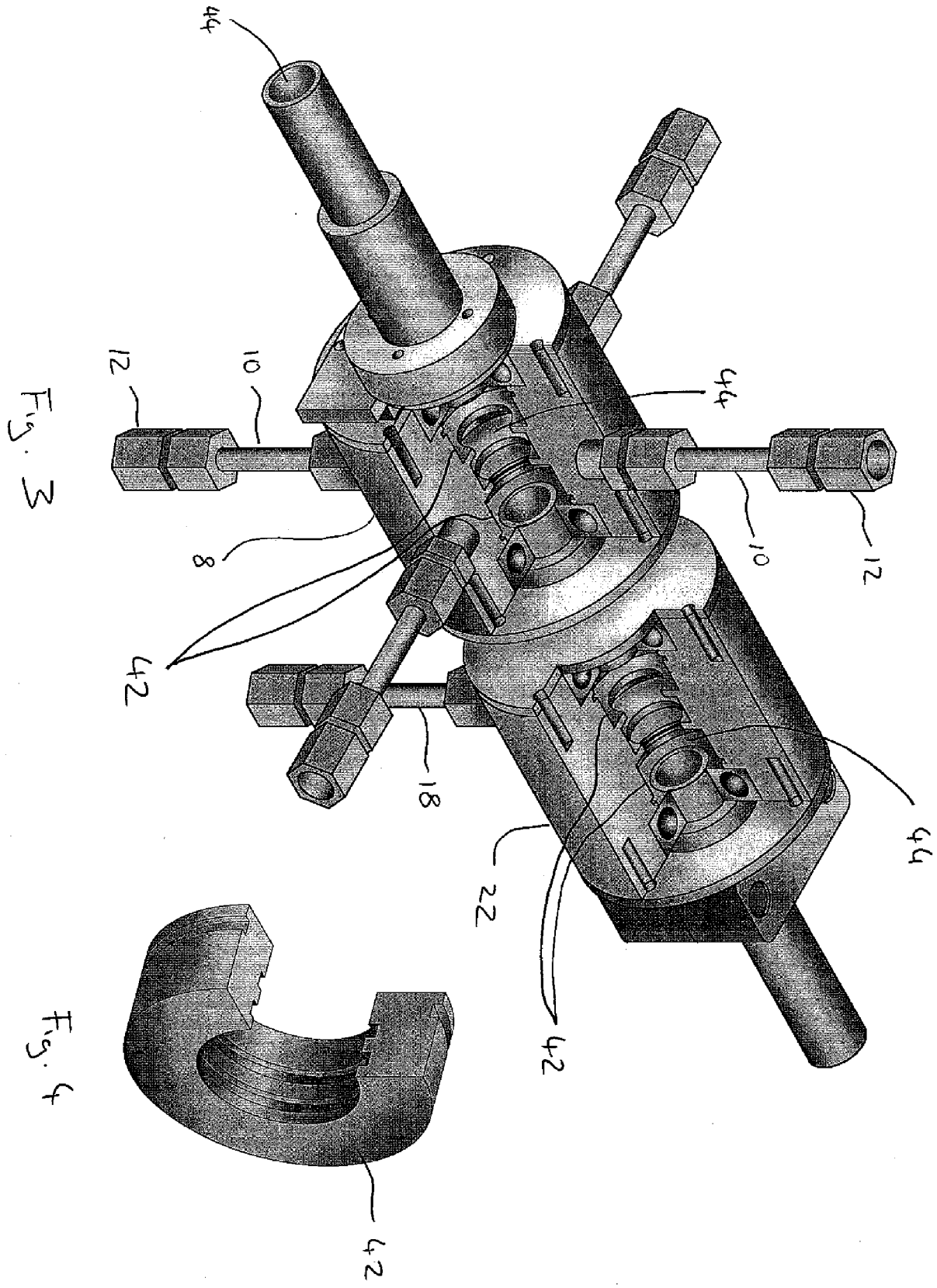

Fig. 3

Fig. 4

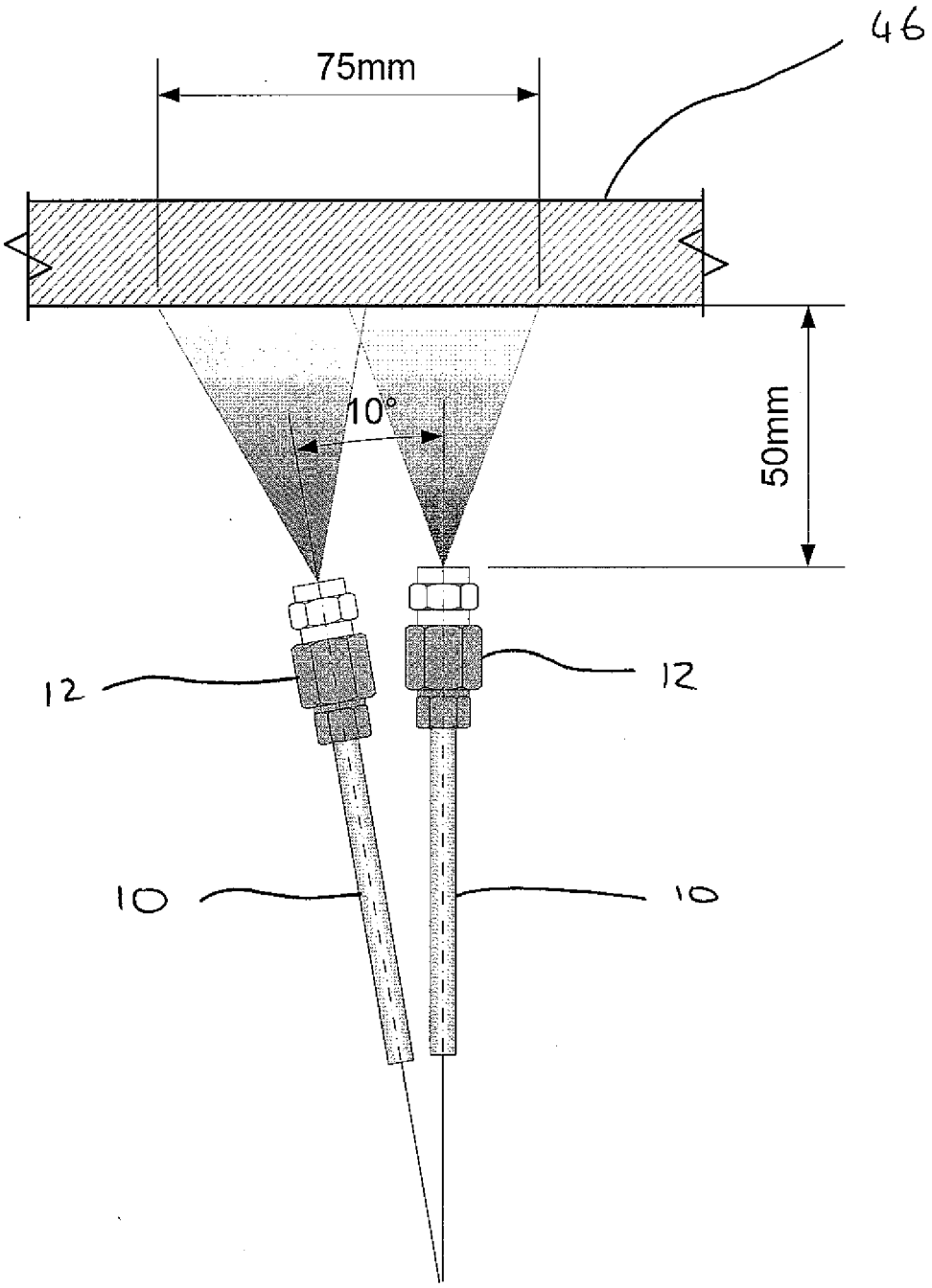

Fig. 5

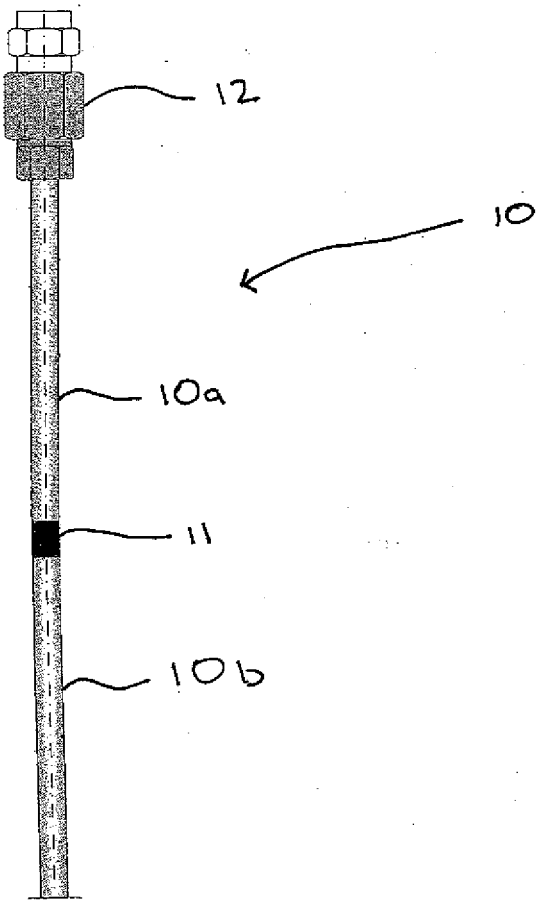

Fig. 5a

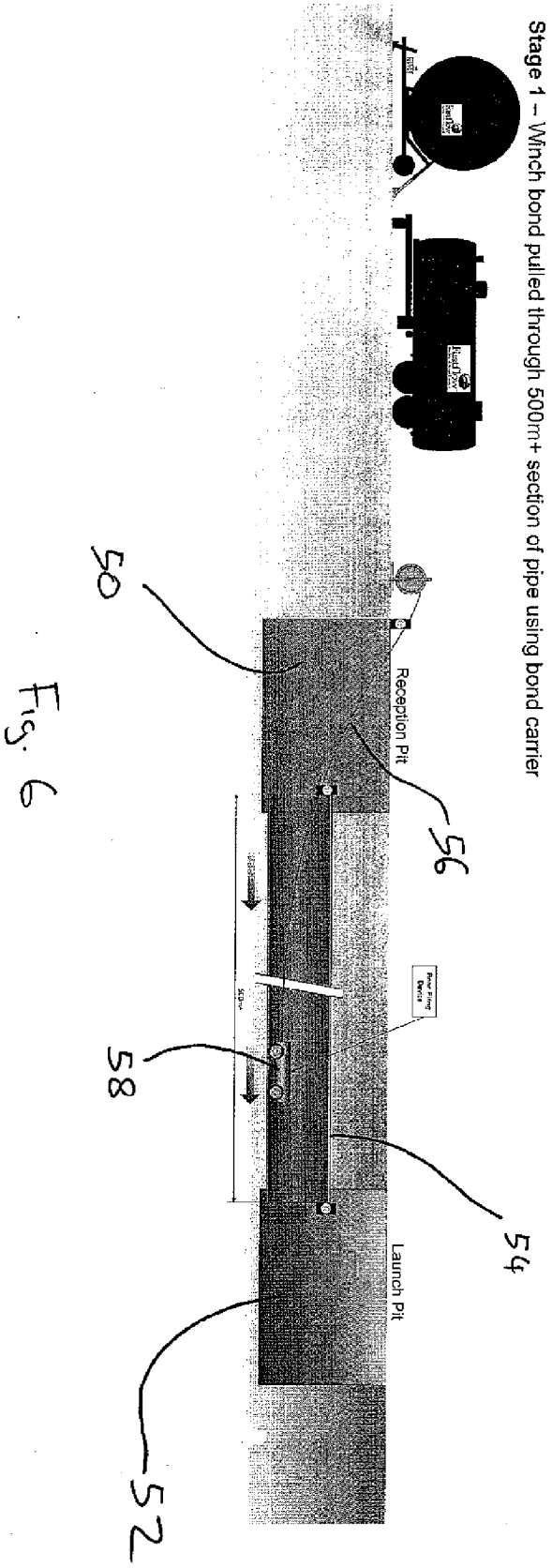
Stage 1 – Winch bond pulled through 500m+ section of pipe using bond carrier
Reception Pit
Launch Pit
50
52
54
56
58

Fig. 6

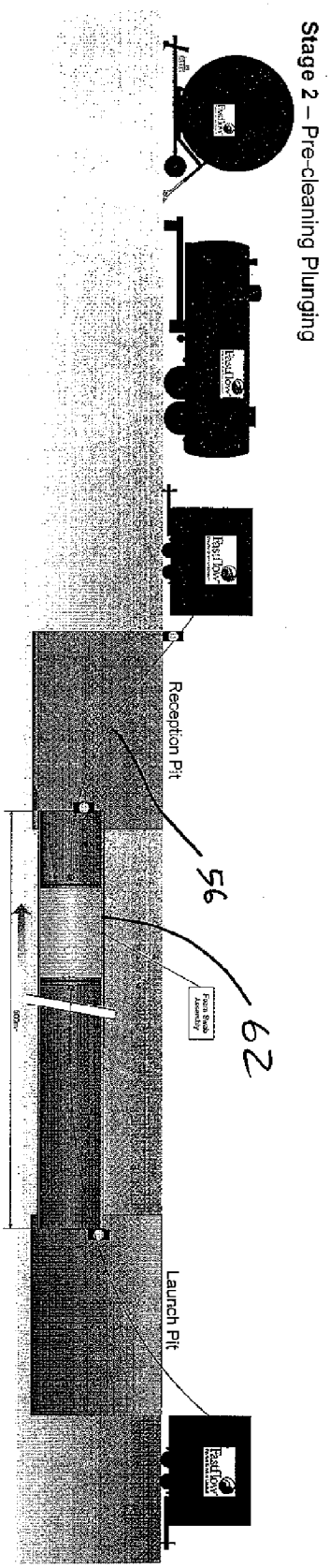
Stage 2 – Pre-cleaning Plunging
Reception Pit
56
62
Launch Pit

Fig. 7

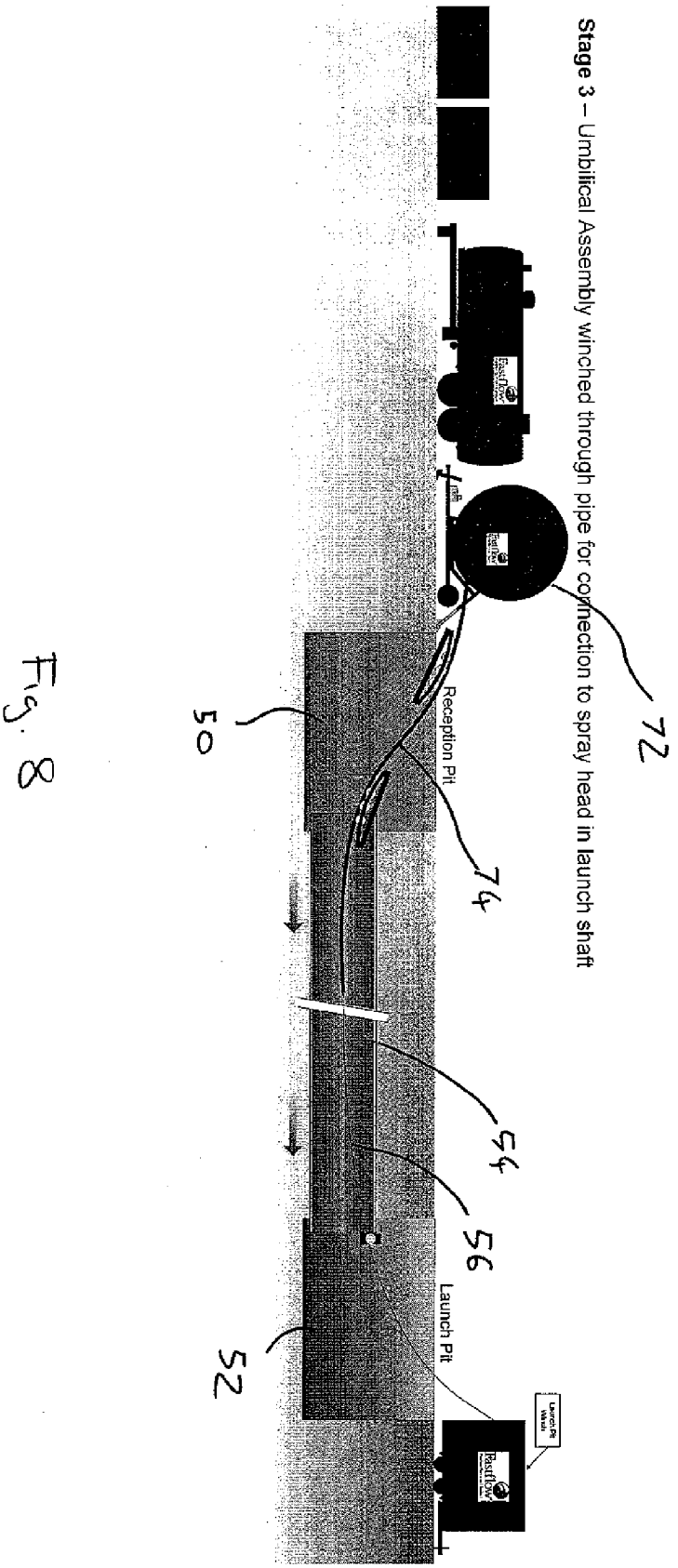
Stage 3 – Umbilical Assembly winched through pipe for connection to spray head in launch shaft
72
50
Reception Pit
74
54
56
52
Launch Pit

Fig. 8

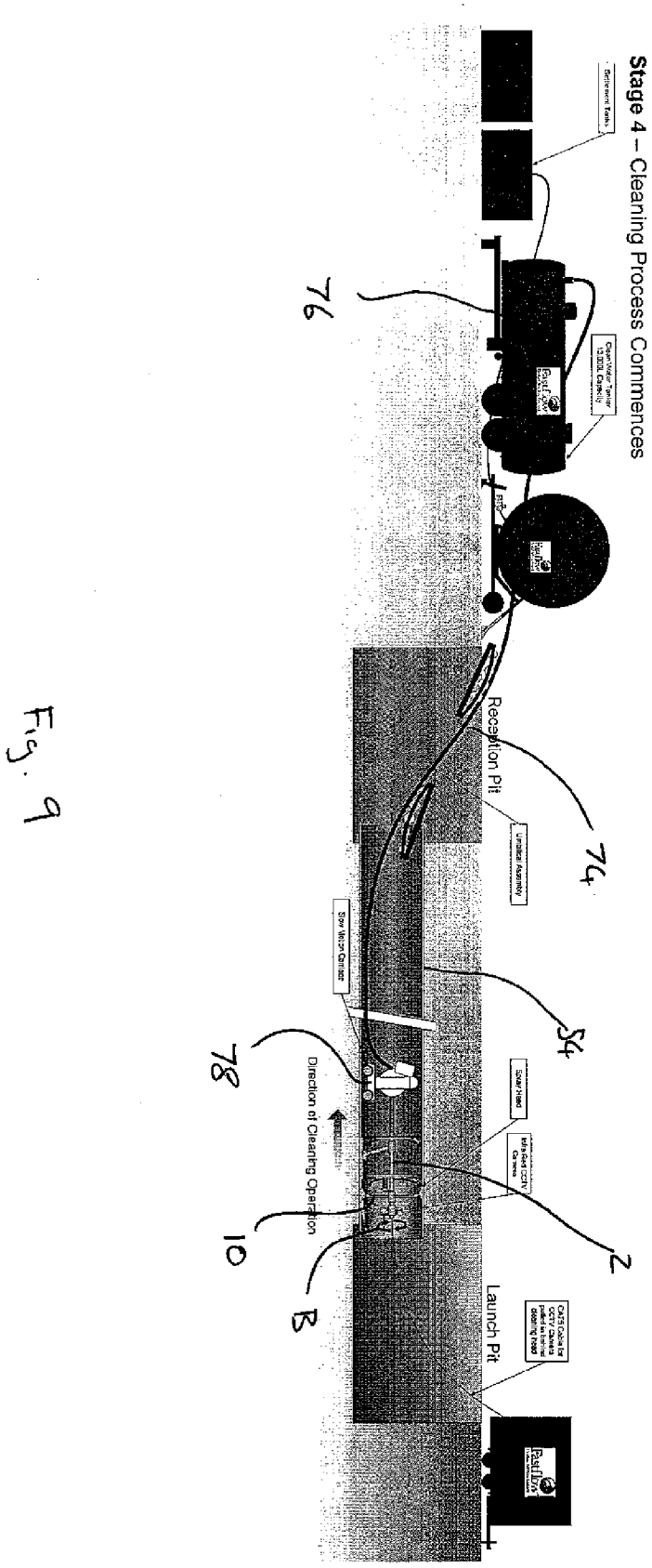
Stage 4 – Cleaning Process Commences
Reception Pit
Launch Pit
Direction of Cleaning Operation
76
74
54
78
10
8
2

Fig. 9

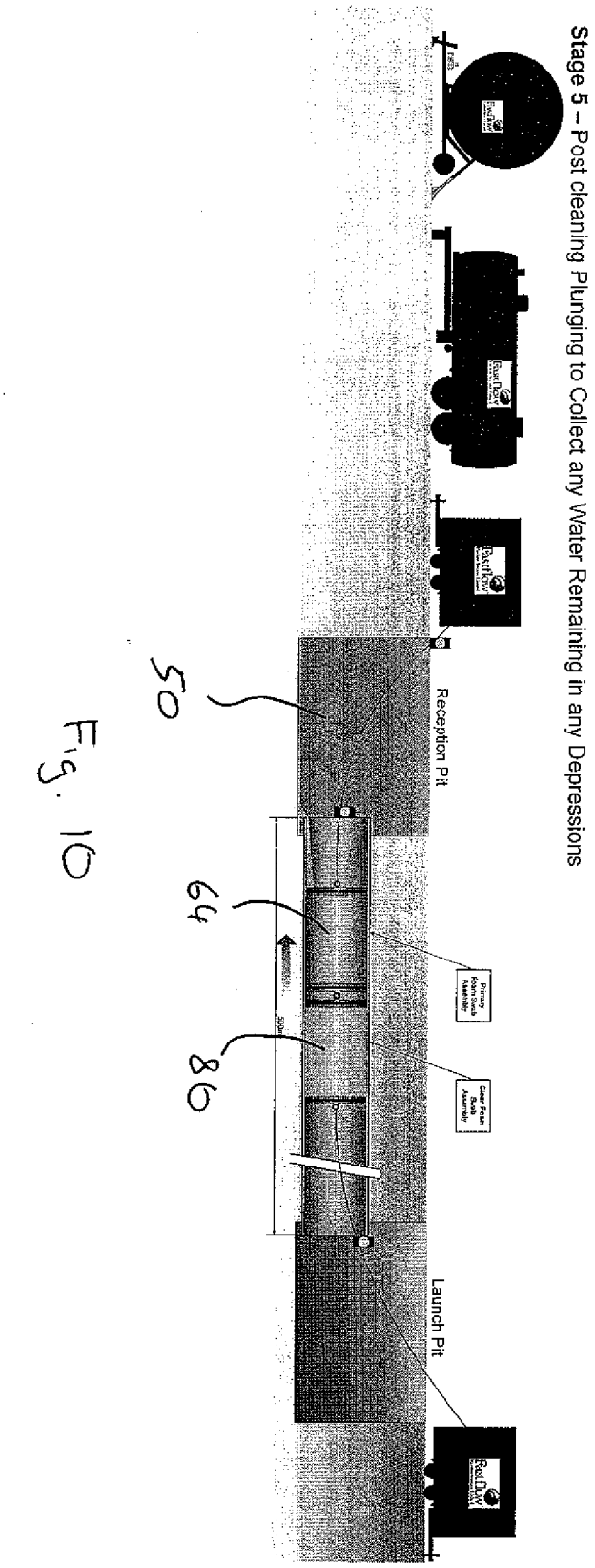
Stage 5 – Post cleaning Plunging to Collect any Water Remaining in any Depressions
Reception Pit
Launch Pit
50
64
80

Fig. 10

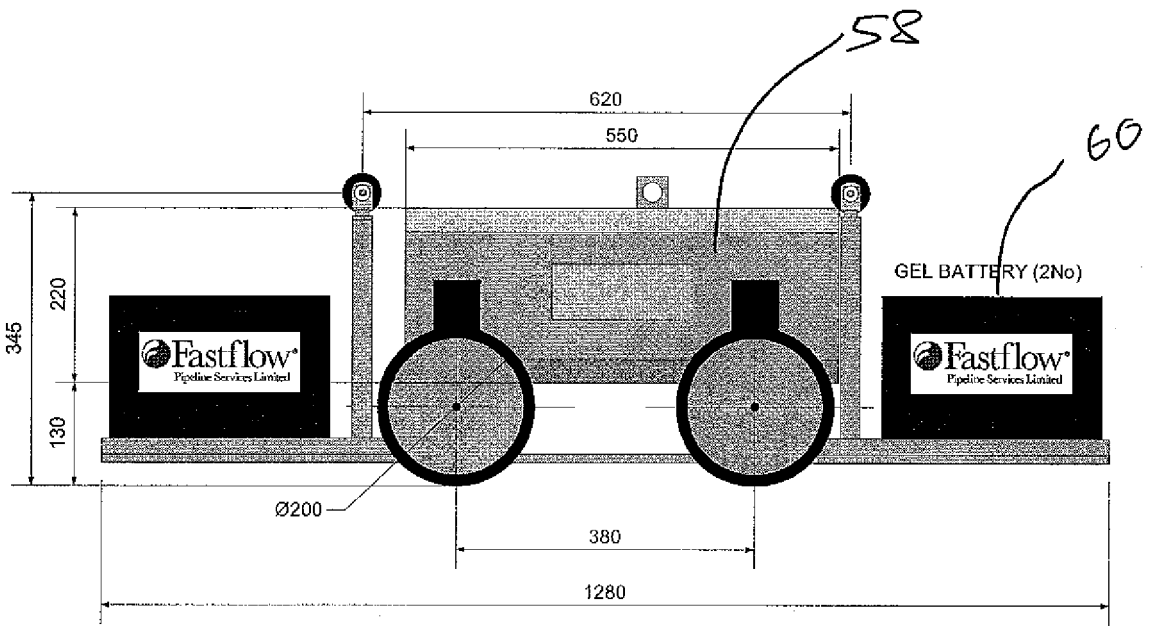
58
620
550
60
GEL BATTERY (2No)
345
220
130
Fastflow
Pipeline Services Limited
Fastflow
Pipeline Services Limited
Ø200
380
1280

Fig. 11

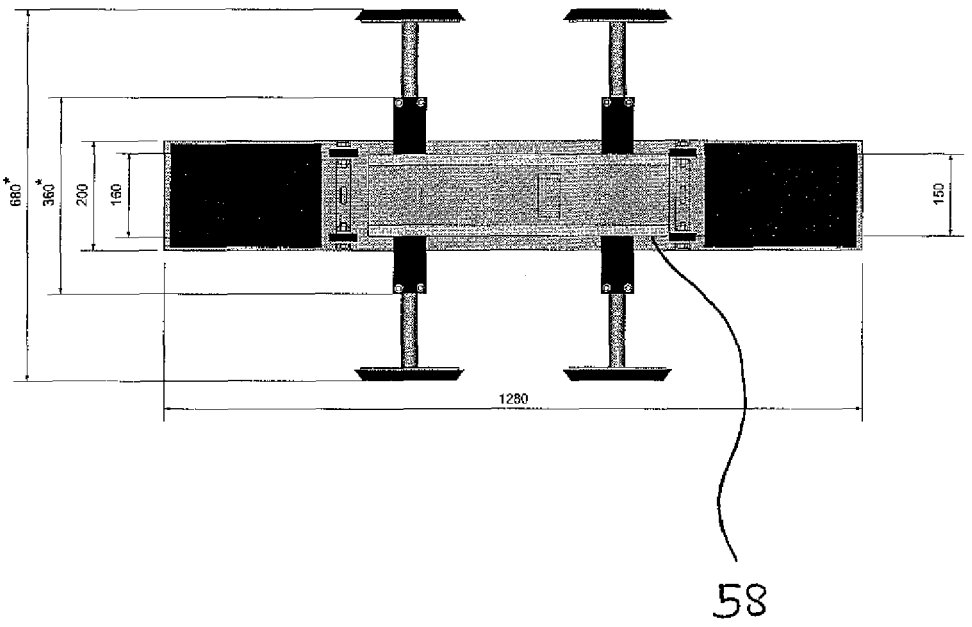

Fig. 12

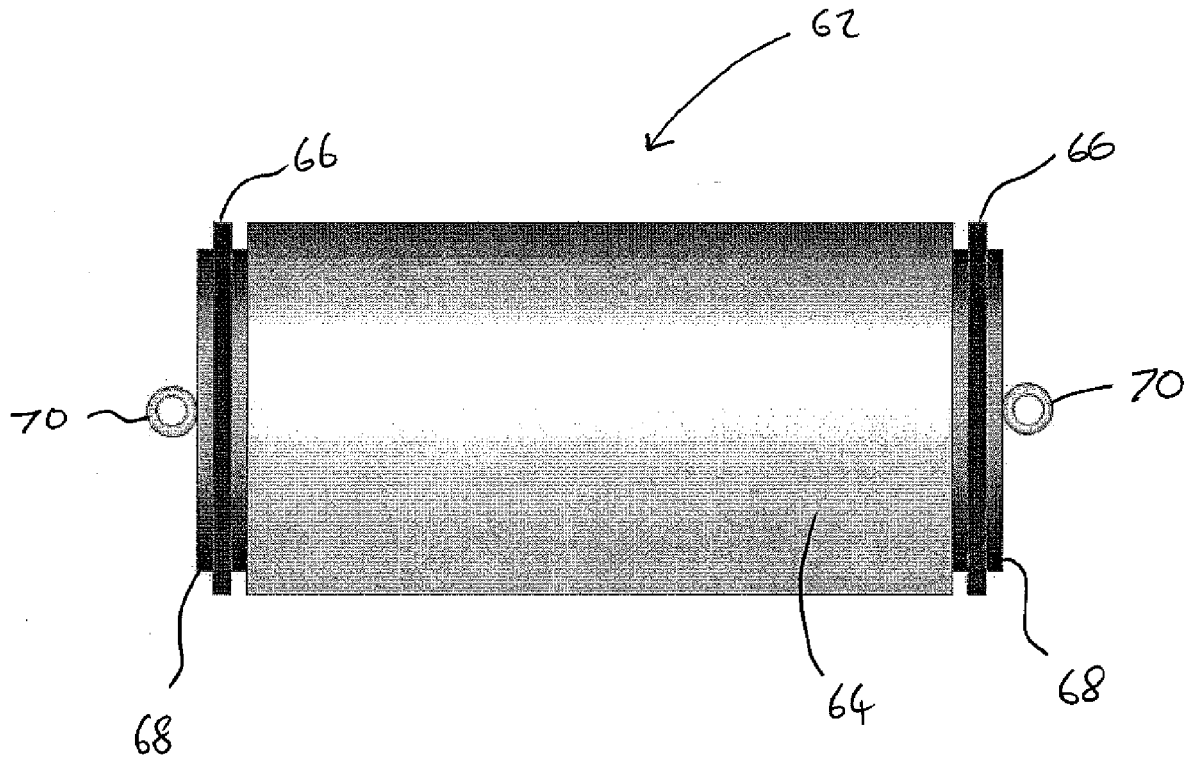

Fig. 13