



(11)

EP 1 728 929 A2

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
06.12.2006 Bulletin 2006/49

(51) Int Cl.:
E02B 11/00 (2006.01)

(21) Application number: **06252882.3**

(22) Date of filing: **02.06.2006**

(84) Designated Contracting States:
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI
SK TR**
Designated Extension States:
AL BA HR MK YU

(72) Inventors:
• **Lusher, Mark David**
Colnbrook SL3 0DG (GB)
• **Kern, Roger John Graham**
Colnbrook SL3 0DG (GB)

(30) Priority: **03.06.2005 GB 0511324**

(71) Applicant: **The Waterflow Group plc**
Colnbrook, SL3 0DG (GB)

(74) Representative: **Campbell, Arlene**
Murgitroyd & Company
165-169 Scotland Street
Glasgow
G5 8PL (GB)

(54) Improvements in or relating to pipelines for drainage

(57) A method of repairing an underground drainage pipe, conduit or passageway (12, 142), by inserting a liner (40, 144) and then launching a pipeline pig (10, 110) through the pipe which simultaneously creates multiple holes (60) through the liner (40, 144) and the pipe wall

(24). The pipeline pig (10, 110) is also described having a number of cutting elements (54, 148) arranged substantially symmetrically about a central axis (52) which can be extended to drill or jet through the liner (40, 144) and wall (24). Existing conduits are thus made selectively permeable.

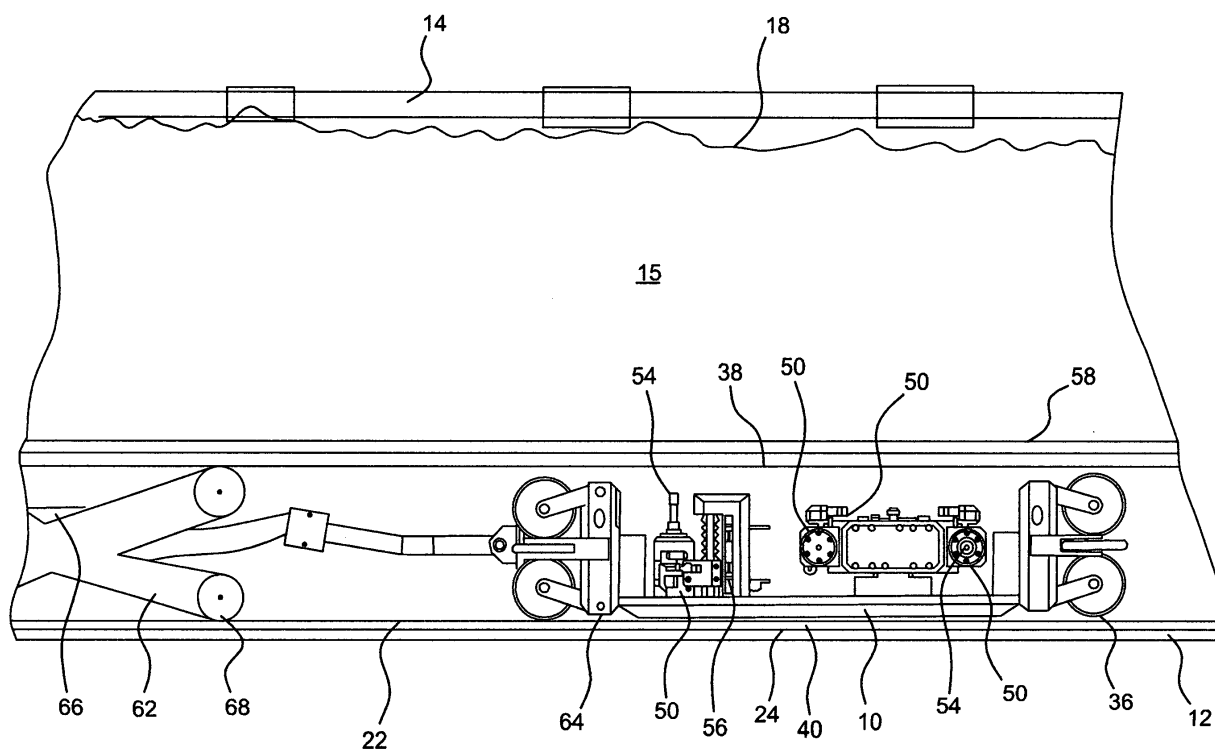


Fig. 1

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Description

[0001] The present invention relates to remedial work and/or replacement of conduits such as pipes, tubing or passageways located underground. More particularly, the present invention relates to a method for inserting a liner into an existing conduit and making the composite structure selectively permeable.

[0002] Drainage pipes are known in which sections of tubing are buried end to end underground. The tubing itself is non-permeable, being typically made of clay. Where one section of tubing overlaps the adjacent section, the joint is deliberately left open so that moisture and water can drain into the conduit through the joint. Alternatively the existing tube may have apertures in the form of holes or slots. Such arrangements are commonly used in railway drainage systems. Here the pipe sections are buried between parallel sets of tracks. The fill-in material above the pipe sections is specially selected to both provide sufficient support for the railway above while providing passageways to allow water to drain away from tracks and thereby prevent flooding. Catch pits are located at regular intervals e.g. 30 metres along the conduits to access the pipes and remove the silt and debris from the collected water.

[0003] Due to the age of many of these drainage systems they are now in need of repair and/or replacement. As silt and other fine debris is carried with the water towards the drainage pipe the joints, holes, slots and sections of the conduit, become clogged making them ineffective. Erosion or structural failure of the pipe also occurs and can cause the tubing to fracture and collapse.

[0004] Currently the pipe sections are checked periodically and are replaced when required. Replacement is a major job requiring access between the railway tracks; excavation of the existing pipe while supporting the walls of the excavated pit; removal and replacement of the pipe; and reconstructing the in-fill material. It will be appreciated that major disadvantages arise from this approach in terms of the time required, the cost, the risk to personnel and the infrastructure. Once the job is begun the railway line must remain closed until completion. The process does not lend itself to remedial or preventative work and is generally only undertaken when the railway line itself is under threat from subsidence, flooding or collapse.

[0005] A further example of the use of underground drainage pipes are those used in landfill sites. These are used to allow gas or leachate to pass into the pipe from ground surrounding the pipe or out of the pipe into ground surrounding the pipe. In some cases the pipe may be so configured by providing apertures in the wall of the pipe. Under certain circumstances the need can arise to improve upon the drainage capabilities of drainage pipes. Conventionally this can involve the excavation of the existing pipe, the provision of apertures in the existing pipe followed by the re-covering of the existing pipe. Alternatively, the existing pipe can be excavated and removed

and new pipe with the requisite apertures can be laid and covered. At any rate each approach is time consuming and expensive.

[0006] Pipeline pigs exist which are generally used for inspecting the inside of a conduit to determine the internal damage to the inner surface of a pipeline. These pigs are typically small vehicles which are propelled through a pipeline to complete a task. The simplest pigs are propelled by fluid pressure in the pipeline and include fins to wipe or scrape the inner surface of the pipeline to remove debris and other matter adhering thereto. More sophisticated pigs are remotely operated vehicles which are usually motorised to travel through a pipeline. These pigs can carry out a variety of tasks within a pipeline and are typically only limited in the requirement to have an umbilical line back to the point of launch. Such vehicles may be used to inspect the pipelines in drainage systems.

[0007] GB 2 252 807 describes a pipeline pig which includes a jetting cutter. The cutter is arranged so that as the pig progresses through a pipeline or other conduit, the cutter can be used to jet, cut and generally clear debris or other matter which has adhered to the inner walls of the pipeline. Where the pipeline has partially collapsed the cutter can be used to clear obstructions within the conduit. While the present applicants have considered that such a cutter could be used to form apertures through existing pipes to improve drainage, the formation of the multiple apertures required in an existing pipe has been found to weaken the pipe and cause collapsing thereof. A further disadvantage of this proposed technique is due to the force which can be applied to the cutting head. This force is created by either, or both, of the high pressure when the jet initially hits the pipe wall, and the pressure differential across the pipe wall accessed when breakthrough is achieved. The torque produced by either of these forces is sufficient to cause the pig to spin and knock the cutting element out of alignment.

[0008] A technique has been developed in which an underground passage can be lined in order to prevent leakage and erosion of the inner surfaces. The process is described, for example, in GB 1 340 068. Here a flexible laminate is inserted through a section of the passageway or pipe and is forced against the inner wall therein by fluid pressure. The laminate structure is then cured to form a liner contacting the inner wall of the passageway. The laminate structure is typically made of a relatively impermeable membrane, a fibrous sheet e.g. glass reinforced plastics, together with a resin. Once in place the liner is cured by, for example, UV illumination. While this technique can be used to line a conduit between the joints in a railway drainage system it will not assist drainage where the joints are already blocked with silt and/or other debris. Indeed, sealing the inner surface of the conduit precludes any drainage through apertures, fractures, cracks or in the permeability of the material of the pipe. Additionally, typically only short lengths of conduit are lined so that apertures or joints remain uncovered and the drainage capability of the conduit is not unduly re-

duced.

[0009] It is an object of the present invention to provide a method of repairing a drainage pipe without having to excavate the pipe.

[0010] It is a further object of the present invention to provide a method of repairing a drainage pipe which improves the permeability of the pipe.

[0011] According to a first aspect of the present invention there is provided a method of repairing an underground drainage pipe, comprising the steps:

- a) inserting a liner through at least a portion of the pipe, the liner being arranged to contact a wall of the pipe;
- b) launching a pipeline pig through the pipe, the pig including a plurality of cutting elements;
- c) locating at least one cutting element against an inner surface of the liner; and
- d) simultaneously creating a plurality of apertures through the liner and the wall to thereby provide a permeable pipe.

[0012] By first lining the pipe, the pipe can be made sufficiently strong to counteract the weakening effect of creating holes through it, if loading on the pipe is an issue. As the lining operation and the cutting can be achieved by accessing only the inside of the pipe, there is no requirement to excavate the entire pipe. By selectively making apertures through the liner and wall simultaneously, a selective number of drainage channels can be made through the pipe, so that a desired permeability can be achieved.

[0013] Preferably, the plurality of apertures are arranged substantially symmetrically around the inner surface. In this way, any force created from outside the pipe at breakthrough is balanced across the pig and prevents the pig from rotating and misaligning the cutting position. Additionally, by cutting a plurality of apertures at a time, this speeds up the process.

[0014] Preferably, the method includes the step of locking the pig in a selected position prior to step (c). By locking the pig in position, the pig is prevented from travelling along the pipeline during the cutting procedure under the influence from fluids within the pipe or the pressure outwith when breakthrough occurs. Locking also reduces the vibration of the pipeline pig during the cutting procedure.

[0015] Advantageously, the pig is initially moved through the pipe and steps (c) and (d) are undertaken as the pig is reversed back through the pipeline. The initial movement may provide a distance measurement from which the number of apertures required can be calculated. Additionally, the initial movement may be used to inspect the pipe. By cutting when the pig is reversed any debris from the cutting operation or which falls into the pipe through the newly created aperture is prevented from obstructing the forward passage of the pig.

[0016] Preferably the step of creating the plurality of

apertures is achieved by using cutting elements which are drill bits or cutters of a relatively hard material e.g. diamond or tungsten carbide. The step of creating the plurality of apertures may be achieved in two steps, the first by diamond cutting the liner and the second by fluid jetting the pipeline wall. The material of the liner has been found to cut more easily with a diamond cutter than a fluid jet. This is because the fluid jet tends to split the laminate structure of the liner and thus is less effective. By first providing a drilled hole, the fluid can be used to blast away the pipe wall behind. The quantity of damage to the pipe wall is immaterial as the liner provides sufficient strength to the composite structure. The combined cutting techniques may increase the speed of creation of the apertures.

[0017] According to a second aspect of the present invention there is provided a pipeline pig, the pig comprising traction means for moving the pig within a pipeline in a direction co-linear with a central axis of the pig; a plurality of cutting elements, the elements arranged substantially symmetrically about the central axis; and extension means for moving the cutting elements towards a wall of the pipeline.

[0018] The symmetrical arrangement of the cutting elements around the pig advantageously ensures that the pig is balanced so that any force created when the cutters engage the pipe wall or at breakthrough is uniform across the cutting elements and prevents the pig from spinning or displacing during the cutting process. Indeed by allowing external forces to act across the pig, the pig is self-centering during the aperture creation process. Additionally, by cutting a plurality of apertures at a time, this speeds up the process.

[0019] Preferably, the cutting elements are drill bits made of a relatively hard material. More preferably the cutting elements are diamond cutters which rotate to drill an aperture through the wall. Alternatively, the cutting elements may be formed from tungsten carbide. Such cutters can be made sufficiently small so that the pig can enter respectively small pipelines e.g. less than 9 inch diameter. They are also easily replaceable as required.

[0020] Advantageously, the cutting elements include fluid cutting means which ejects a jet of fluid. Preferably, each fluid cutting element is configured to eject under user control at least one jet of fluid such that the at least one jet of fluid impinges upon an inner surface of the conduit in which the pig is located, the jet of fluid being ejected with sufficient force to cut an aperture through the conduit.

[0021] As the pig may include water cooling means, the inclusion of a water cutting system is advantageous for use alone or in combination with the diamond cutting system.

[0022] Preferably, the pig further includes one or more cameras to view the wall of the pipeline. These cameras allow a user to inspect the pipeline while the pig traverses the pipeline. They also allow monitoring of the drilling process itself.

[0023] Embodiments of the present invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a schematic view of a pipeline pig, in use, according to the present invention;

Figure 2 is a schematic end view through the pipeline pig of Figure 1, in use, according to the present invention;

Figure 3 is a plan view of a pipeline pig according to an embodiment of the present invention; ,

Figure 4 is a plan view of a carriage section of a pipeline pig according to an embodiment of the present invention;

Figure 5 is a plan view of a pipeline pig according to an embodiment of the present invention;

Figure 6 an illustration of a control screen could be used in the method according to an embodiment of the invention;

Figures 7(a) and (b) are cross-sectional illustrations of a pipeline pig, in use, according to an embodiment of the present invention;

Figure 8 is a schematic illustration of a pipeline pig according to a further embodiment of the present invention.

Figure 9 is a plan view of the pipeline pig of Figure 8;

Figure 10 is a view of the pipeline pig of Figures 8 and 9, in use, looking down the bore of a pipe;

Figure 11 is a side view of the pipeline pig of Figures 8 to 9 in use; and

Figure 12 is a representation of an oscillating water cutting head according to an embodiment of the invention.

[0024] Reference is initially made to Figure 1 of the drawings which illustrates a pipeline pig, generally indicated by reference numeral 10, used within a drainage pipe 12 according to an embodiment of the present invention.

Figure 2 illustrates the pig 10 in cross-section within the pipe 12. The same reference numerals have been used to ease interpretation of the Figures. It should be noted that in the Figures the drainage pipe 12 is shown relatively close to the rails but this is for illustration purposes only. Additionally the pipe 12 in Figure 2 is enlarged to show relevant details of the pig 10 more clearly.

[0025] Drainage pipe 12 is shown as located under a set of railway lines 14a,b. A backfill material 15 is used between the pipe 12 and the lines 14 which should provide sufficient support between the rails 14a,b and the pipe 12, while providing drainage pathways to allow water to flow from the surface 18 to the pipe 12. Water, which drains to the pipe 12, will be directed towards the ends of the pipe 12 where it will enter the pipe 12 at the joint, as is known in the art. The joint is formed from the overlapping ends of adjacent pipes which are left unsealed to provide an access passage therebetween. As described hereinbefore, some pipes have holes or slots

formed in them also, to allow the water 20 to drain through without travelling top the joint. Water 20 and debris/slit will collect at the base 22 of pipe 12 against the inner surface 24 and will be removed via catch pits (not shown). Catch pits provide access to the inner surface 24 of the pipe 12 at regular intervals e.g. every 30 metres, along its length.

[0026] As is appreciated in the railway industry, silt and other debris can build up and block the pathways. In turn this can also restrict the passage of fluid into the pipe 12 through the narrowing or blockage of the access passages. Consequently water 20 will rise through the structure (illustrated in Figure 2) causing flooding of the tracks 14 and instability in the support provided by the in-fill material 15.

[0027] In order to increase the drainage capacity of the pipe 12 and hence provide remedial action to prevent the consequences described above, the present invention proposes a new and inventive technique.

[0028] Initially, a pig 10 is launched into the pipe 12 via access from the catch pit. Pig 10, to be described in greater detail with reference to the various embodiments shown in figures 3 to 5, is a remotely operated vehicle which is driven along the base 22 of the pipe 12. A user can steer the vehicle or pig 10 by monitoring images relayed from four cameras positioned on the pig 10. The images are displayed on a control screen 13, illustrated at Figure 6, at a remote surface location. The remote surface location is typically a van or other mobile control unit located near the catch pit. In addition to steering the vehicle 10, the cameras are used to inspect the inner surface 24 of the pipe 12. At the same time as the inspection is carried out, the distance travelled by the pig 10 is recorded via a gauge 36 mounted to the front of the pig 10. From this data a user can determine the extent of any damage to the pipe 12 prior to the remedial work being carried out. In cases where the pipe 12 has collapsed it may be decided that replacement of the whole or part of the pipe 12 is required instead of or in addition to using the present invention.

[0029] Where the pipe 12 is substantially intact, the pig 10 will have completed a check run through the pipe 12. The pig 10 is withdrawn by pulling or driving the device back to its starting point and removing it from the pipe 12.

[0030] The pipe 12 is then lined by a technique known to those skilled in the art and available from suppliers such as the Applicant of the present invention. In essence, a tubular laminate structure is drawn through the pipe 12. The flexible structure comprises a relatively impermeable membrane, a fibrous sheet e.g. glass reinforced plastics, together with a resin. The structure is inflated so that that it is forced outwards towards the inner surface 24 of the pipe 12. Fluid pressure, such as by a gas, may be used to inflate the tubular structure. The force is maintained until it is believed that the structure has fully contacted the inner surface 24, leaving no air gaps therebetween. A UV light is then shone at the inner surface 38 of the structure in order to cure the resin and

'set' the structure within the pipe 12. In this way a liner 40 of the structure is created against the inner surface 22 of the pipe 12. With the liner 40 in place, the pipe 12 is supported. The fibrous sheet within the liner provides a strengthened barrier in co-operation with the pipe 12. It will be appreciated by those skilled in the art that the liner can be inflated by other means such as using water and curing using an ambient cured resin or a heat cured resin whereby the water in the liner is heated.

[0031] The pig 10 is then launched through the pipe 12 to inspect the inner surface 38 of the liner. Once at the far end of the liner 40, as calculated from the distance gauge 36 or viewed via the cameras, the pig 10 is located at a first drilling point. A signal, transmitted down a pneumatic line 42 in the umbilical connection 44 from the pig 10, activates a locking system 46. The locking system 46 comprises a number of pads 48 on pneumatically driven arms which are driven radially outwards so that the pads 48 engage the inner surface 38. Typically six or more pads are used on a pig. Pressure is maintained on the pads 48 to prevent movement of the pig 10 longitudinally and rotationally within the pipe 12. All hydraulics and pneumatics are preferentially air driven systems.

[0032] Once locked in position, as viewed by the cameras, a second signal is sent via further lines 49 to the cutting heads 50. In this embodiment there are three cutting heads 50. As can be seen from the arrangement in Figure 2, the cutting heads 50 are arranged symmetrically around a central axis 52 of the pig 10. Each head 50 includes a diamond cutter 54 as is known in the art. While a diamond cutter is selected here, it will be appreciated that any hard cutting material may be suitable. Each cutter 54 is arranged on an extending arm 56, which is pneumatically or electrically driven to move the cutter 54 radially outwards to contact the inner surface 38. When correctly located, as verified by views given by at least one of the cameras 3, the three cutters 54 are activated together.

[0033] As the cutters 54 drill through the liner 40, they effectively maintain the stability of the pig due to a balance of forces at the central axis 52. Once the liner 40 is drilled through, the cutters continue through the wall of the pipe 12. On breakthrough, when the cutters reach the outer surface 58 of the pipe 12, they may experience a pressure or force when there is a pressure differential across the wall of the pipe 12 and liner 40. Each cutter 54a-c will experience this force at substantially the same time and as a result the combined forces will counteract each other and the pig 10 will remain stable and with the central axis 52 undisturbed in location. As the cutters 54 are located through the liner 54 and wall of the pipe 12, the pig 10 is prevented from rotating as each cutter 54 is effectively held in place, both by the surrounding liner 40 and the combined force from the other cutters 54. The force created on breakthrough can be detected via a gauge or the cameras to indicate to the user that drilling is complete.

[0034] The extending arms 56 are then retracted; the

locking system 46 is disengaged; and, the pig 10 is driven a short, but calculated distance to a new position. Here the procedure is repeated to drill a further set of holes 60 through the liner 40 and the pipe 12. The procedure can be repeated along the length of the pipe 12 until the desired number of holes 60 are completed or for a predetermined proportion of the pipe length.

[0035] Reference is now made to Figure 7 of the drawings which illustrates the cutting process. Figure 7(a) shows the pig 10 as it is towed by the robot tractor through the pipe 12. The cutters or drill bits 54 are retracted within the outer circumference of the pig 10 for their own protection and that of the liner 40. Any collisions between the pig 10 and the liner 40 are managed by the guide wheels 55 arranged around the pig 10. In position, Figure 7(b), the cutters 54 are extended out to and through the liner 40 to create the apertures or holes 60, uniformly around the liner 40.

[0036] Additionally, when the pig 10 is locked in a chosen position, with the arms 56 retracted, a carriage 63 on which the cutting heads 50 are mounted can be rotated.

In this way, sets of holes 60, can be created in a circumferential pattern around the inner surface 38 of the liner 40 and pipe 12. Thus a uniform pattern of holes 60 can be created along the length of the pipe 12.

[0037] When completed the pig 10 may be withdrawn the short distance out of the pipe 12 or may be re-launched through the pipe 12 to inspect the holes 60 drilled. The newly permeated pipe 12 can then be immediately operational.

[0038] Reference is now made to Figure 3 to 5, which illustrate pipeline pigs 10, according to embodiments of the present invention. Like parts to those of the pig of Figure 1 have been given the same reference numeral to aid clarity. Pig 10 comprises two sections, a traction or drive portion 62, and an operating portion 64. The drive portion 62 is as known in the art and comprises a wheeled buggy, robot tractor, or vehicle arranged to be driven through a pipeline or other conduit. The portion 62 is typically weighted so that it preferentially lies level within a pipe 12. The portion 62 is driven by a motor 66 connected to at least one set of the wheels 68. The motor 66 may be powered by battery and operated by wireless remote control from a location at the end of a pipe. Alternatively, the motor may be hydraulically or electrically driven through an umbilical cable 44 connection the pig 10 to a remote location outside the pipe 12.

[0039] Connected to the front of the drive portion 62 is the working portion 64. This portion 64, comprises a carriage 63 on which are mounted the cutting heads 50. The cutting heads 50 are arranged in a circular pattern, substantially in the same plane, which traverses the central axis 52. Any misalignment from this plane is purely due to the mechanical constraints and size limitations found on the pig 10.

[0040] Each cutting head 50 comprises an extending arm 56 which can be actuated to move a cutter element

54 on the head radially outwards. In this embodiment the cutter element 54 is a diamond drill bit as is known in the art, however other suitable cutting elements may be used. It is important that the cutting elements, when viewed from an end of the pig 10, are arranged equidistantly and symmetrically, all radiating outwards from the central axis 52. In the embodiments shown the cutting elements are positioned at 90 degree intervals around three sides of the central axis 52. It will be appreciated that any number of elements 54 can be used and that they can be either equally spaced around the full circumference or, as shown, they can be spaced substantially around the circumference. Such unequal distribution will primarily result from size limitations on the pig 10. The extending arms 56 are hydraulically operated and driven via a line 70 along the umbilical 44. Drive and control for the cutter elements 54 is also provided via the umbilical 44. In addition water cooling lines 72 run through the umbilical 44 which are used to cool and lubricate the drill bits.

[0041] Located adjacent to the cutting heads 50 are a set of cameras. Typically, Four cameras are used, though it will be appreciated that any number could be chosen. The cameras view the inner surface 38 in real-time, sending video images back along the umbilical 44 for display on the control screen 13. Illumination sources in the form of light bulbs can be incorporated with the cameras so that the inner surface 38 is illuminated for easier viewing. Alternatively, a fluorescent or reflective dye may be incorporated in the material of the liner 40 to aid visibility within the pipe 12.

[0042] Arranged near the front of the pig 10 is a locking system 46. The locking system 46 comprises a number of pads 48 on pneumatically driven arms 47 which are driven radially outwards so that the pads 48 engage the inner surface 38. Each of the circular pads 48 are spaced equidistantly from the adjacent pads 48 to provide a uniform distribution of pressure on contact with the inner surface 38. Pressure to operate the pads 48 and their control is provided through the flexible umbilical 44. If desired, a second locking system may be arranged at the rear end of the working portion 64. This will be operated in tandem with the first locking system 46 to improve stability of the pig 10 within a conduit.

[0043] Protruding from the front of the pig 10 is a distance gauge 36 in the form of a calibrated wheel or disc. Each revolution of the disc, or part thereof, is signalled to the user, through the flexible umbilical, so that the distance travelled by the pig 10 is recorded. In this way, length measurements can be made within the pipe 12 and coordinates provided for the location of the holes 60.

[0044] In a further embodiment of the pig 10, the carriage 63 is mounted between gimbals. The gimbals allow the carriage 63 to selectively rotate with respect to the central axis 52. Such rotation of the carriage 63 moves the cutting heads 50 by a set number of degrees. Once rotated, a further set of holes can be drilled adjacent to the original set. This increases the density of holes on a

single plane perpendicular to the central axis 52. In this arrangement the locking systems 46 may both be located on the carriage 63. However, it is preferable for one to be located on the carriage 63 and one on a non-rotating part of the portion 64. In this way, the portion 62 can be fixed relative to the carriage 63, to provide the necessary torque for rotation to occur. Additionally, once rotated, the carriage can be locked in position prior to drilling of the holes.

[0045] It can be seen from Figure 6, that the process can be fully controlled by a user at a remote location. From the control screen 13, a user can view the camera images; steer the pig 10 via control of the guide wheels 55; operate the cutters 54 by location and speed while monitoring the pressure and volume of air in the pneumatic lines; adjust flow rate of the water cooling system; and monitor electrical drive on the motors. Other features can be added dependent on the sensors which are mounted onto the pig 10.

[0046] Reference is now made to Figure 8 of the drawings which illustrates a pipeline pig 110 for cutting apertures in a conduit according to a further embodiment of the present invention. Pipeline pig 110 comprises a vehicle 112, which is configured to move within an underground pipe (which constitutes a conduit) and which in turn comprises of three or more water cutting heads 114a-e (which constitute cutting elements). Only one cutting head 114 is illustrated, but it will be appreciated that any number can be arranged symmetrically around the pig 110 to provide the required balance on use.

[0047] In addition, the pipeline pig 110 comprises a camera 116, which provides visual feedback to a remote user of the pipeline pig on the location and operation of the vehicle 112, and a pump 118, which delivers pressurised water via a high pressure hose 120 to the vehicle 112. The pump 118 is located remotely of the vehicle 112, for example above ground.

[0048] The pump 118 comprises a pressure regulator 122, which regulates the pressure of the water delivered to the vehicle 112 in dependence upon an output of a pressure measurement device 124 on the vehicle, which measures the pressure of the water at the water cutting heads 114.

The regulation of the pressure of the water is to a predetermined pressure (i.e. a set point pressure) set by a user of the pipeline pig. Alternatively, the pressure measurement device 124 may be provided on the pump 118 instead of or in addition to on the vehicle 112. The water may contain dispersed garnets and/or aggregates (not shown) to enhance the cutting effect of the water.

[0049] In one form, the pressure regulator may comprise a proportional valve (not shown), which regulates the pressure of the water in accordance with design principles that will be readily understood by the reader of ordinary skill.

[0050] In another form, the pressure regulator may comprise an on-off valve (not shown) that is operative to periodically engage with a flow of water, with the mark-

to-space ratio of engagement regulating the pressure of the water in accordance with design principles that will be readily understood by the reader of ordinary skill.

[0051] The pipeline pig 110 of Figure 8 also comprises adjustable arms 126 (which constitute extension means), which are operable to vary a spacing of each water cutting head 114 in relation to the vehicle 112. A motor 128 is provided in the vehicle 112 for providing motive force to move the vehicle.

[0052] Turning now to Figure 9 a plan view of the pipeline pig 110 of Figure 8 is provided. Thus, the reader is directed to the description given above with reference to Figure 8 for a description of the components of the pipeline pig 110 of Figure 9.

[0053] Figures 10 and 11 should now be considered together as they show the pipeline pig 110 of Figures 8 and 9 in use in the bore 140 of a drainage pipe 142. More specifically, Figure 10 is a view of the pipeline pig 110 looking down the bore 140 of the pipe 142 and Figure 11 is a side view of the pipeline pig 110.

[0054] The drainage pipe of Figures 10 and 11 is lined with a glass reinforced plastics liner 144. In accordance with typical practice the liner 144 has been inflated so that it abuts the inside surface of the pipe 142.

[0055] As shown in Figure 10 each water cutting head 114 comprises three nozzles 146a-c (references numerals provided on one only) from each of which a jet of water 148 is ejected. The nozzles 146 are formed at least in part of stainless steel as is each water cutting head 114 and a surface of each of the nozzles presented to the water is sapphire coated. Each nozzle 146 is screwed into the respective water cutting head 114. Each nozzle 146 is of predetermined characteristics (i.e. diameter, bore shape and length) to provide for a jet of water having requisite characteristics.

[0056] The other components of the pipeline pig shown in Figures 10 and 11 are as described above with reference to Figures 8 and 9.

[0057] Turning now to Figure 12 a representation of an oscillating water cutting head 114 according to an embodiment of the invention is shown. A cam 150 couples rotation of an oscillation motor 154 to a shaft 152, on which the water cutting head 114 is mounted. The shaft 152 is mounted on a part of the vehicle 158 by means of a flexible mount 156, which allows for back and forth movement of the shaft and hence the water cutting head. Pressurised water is provided to the water cutting head 114 by means of a pliable high pressure hose 160. The extent of oscillation of the water cutting head is determined by the dimension of the cam 150. The cam may be exchanged for a cam of different dimensions. Thus, the extent of oscillation of the water cutting head can be changed. The frequency of oscillation is determined by the gearing ratio of gears (not shown) coupling rotation of the oscillation motor 154 to the cam 150.

The gearing ratio is changeable by a user to change the frequency of oscillation of the water cutting head. Oscillation of the water cutting head 114 provides for the ejection

ed jet of water to describe a predetermined path over time. Thus, apertures of a predetermined shape and size may be cut.

[0058] In embodiments of the invention other than that shown in Figure 12 the water cutting head 114 may be non-oscillating.

[0059] Use of the pipeline pig 110 will now be described with reference in particular to Figures 10 and 11.

[0060] The vehicle 112 is driven under the motive force provided by the motor 128 into the bore 140 of a lined underground pipe 142, 144. The pipe 142 may have been lined because the pipe is worn or because the pipe would be strengthened by lining. Placement of a liner occludes apertures in the wall of the pipe or joints between pipe sections. Thus, the pipeline pig is to be used to provide apertures to restore the drainage capabilities of the pipe. The pipeline pig 110 may alternatively be used to provide apertures in unlined pipe 142 where existing apertures have become occluded over time or where the existing apertures have been found to provide insufficient drainage. While the vehicle 112 is moved within the bore 140 of the pipe 142 the pump 118 and other user control pipeline pig remains above ground for operation by a user. The water cutting heads 114 are raised towards the crown of the pipe 142 by means of the adjustable arms 126.

[0061] High pressure water containing garnets and/or aggregates is driven by the pump 118 down the high pressure hose 120 to the vehicle 112 where it is ejected as jets of water 148 from the nozzles 146. The jets of water 148 impinge upon the inner surface of the liner 144 and each is ejected with sufficient force to cut an aperture in the liner 144 and the pipe 142. It will be appreciated that five apertures will be simultaneously cut from the five heads 114a-e. The progress of the vehicle and aperture cutting operations are monitored by a user above ground by means of the camera 116. The pressure of the water and hence the force of the jets of water is measured by the pressure measurement device 124 and compared with a predetermined (set point) pressure set by the user. Maintenance of the water pressure at the predetermined pressure can be accomplished manually by the user or automatically by means of established and well known electrical control means in dependence upon the pressure measured by the pressure measurement device 124.

[0062] As can be appreciated from Figures 10 and 11 the vehicle 112 moves along the inside of the bore 140 of the pipe 142 under user control and as it so moves the jets of water 148 cut a series of apertures in the liner 144 and pipe 142.

[0063] In a further embodiment of the present invention, combined drill and fluid cutting elements are used. Here the drill bits first cut through the liner 144 and then the water jets are used to break away the pipe 142 behind. In this way an accurate pore or hole is formed in the liner, while lower pressure can effectively create the required aperture through the pipe wall.

[0064] The principal advantage of the present invention is that it provides a method of repairing a drainage pipe without requiring excavation of the pipe. By accessing the pipe only from the inside, the work can be done quickly and with minimal or no interruption to the site above the pipe. For railway applications this allows the work to be done in sections overnight without interrupting rail services.

[0065] A further advantage of the present invention is that it provides a method of repairing a drainage pipe which increases the drainage capability by improving the permeability of the pipe. By selecting the number and size of holes required any amount of additional drainage access to the pipe can be given.

[0066] A yet further advantage of the present invention is that it provides a method of repairing a drainage pipe which strengthens the existing pipe. The incorporation of a liner both strengthens the original pipe and provides an impermeable membrane from which a calculated increase in drainage capability can be incorporated.

[0067] A still further advantage of an embodiment of the present invention is that it provides a pipeline pig which can form multiple accurate holes through the liner and/or pipe. This is achieved by balancing a plurality of cutting heads around the pig.

[0068] Various modifications may be made to the invention herein described without departing from the scope thereof. For example any form of portable cutting elements may be used. They may also be controlled to cut an aperture to any desired shape or dimensions. Further gauges may be mounted on the pig to record rate of movement, drilling speeds and pressures so that the system may be optimised and fully automated.

Claims

1. A method of repairing an underground drainage pipe (12, 142), comprising the steps:

- (a) inserting a liner (40, 144) through at least a portion of the pipe (12, 142), the liner (40, 144) being arranged to contact a wall (24) of the pipe (12, 142);
- (b) launching a pipeline pig (10, 110) through the pipe (12, 142), the pig (10, 110) including a plurality of cutting elements (54, 148);
- (c) locating at least one cutting element (54, 148) against an inner surface (38) of the liner (40, 144); and
- (d) simultaneously creating a plurality of apertures (60) through the liner (40, 148) and the wall (24) to thereby provide a permeable pipe.

2. A method as claimed in claim 1 wherein the plurality of apertures (60) are arranged substantially symmetrically around the inner surface (38).

3. A method as claimed in claim 1 or claim 2 wherein the method includes the step of locking the pig (10, 110) in a selected position prior to step (c).

4. A method as claimed in any preceding claim wherein the pig is initially moved through the pipe and steps (c) and (d) are undertaken as the pig is reversed back through the pipeline.

5. A method as claimed in any preceding claim wherein the step of creating the plurality of apertures (60) is achieved in two steps, the first by drilling (54) the liner (40, 148) and the second by fluid jetting (148) the pipeline wall (24).

6. A pipeline pig (10, 110), the pig (10, 110) comprising traction means (62, 112) for moving the pig within a pipeline (12, 142) in a direction co-linear with a central axis (52) of the pig; a plurality of cutting elements (54, 148), the elements arranged substantially symmetrically about the central axis (52); and extension means (56, 126) for moving the cutting elements towards a wall (24) of the pipeline.

7. A pipeline pig (10, 110) as claimed in claim 7 wherein the cutting elements are drill bits (54) which rotate to drill an aperture through the wall.

8. A pipeline pig (10, 110) as claimed in claim 7 or claim 8 wherein the cutting elements includes fluid cutting means (148) which ejects a jet of fluid.

9. A pipeline pig (10, 110) as claimed in anyone of claims 6 to 8 wherein the pig includes locking means (46) for engaging the pig to the wall to lock it in position.

10. A pipeline pig as claimed in any one of claims 6 to 9 wherein the pig further includes one or more cameras to view the wall of the pipeline.

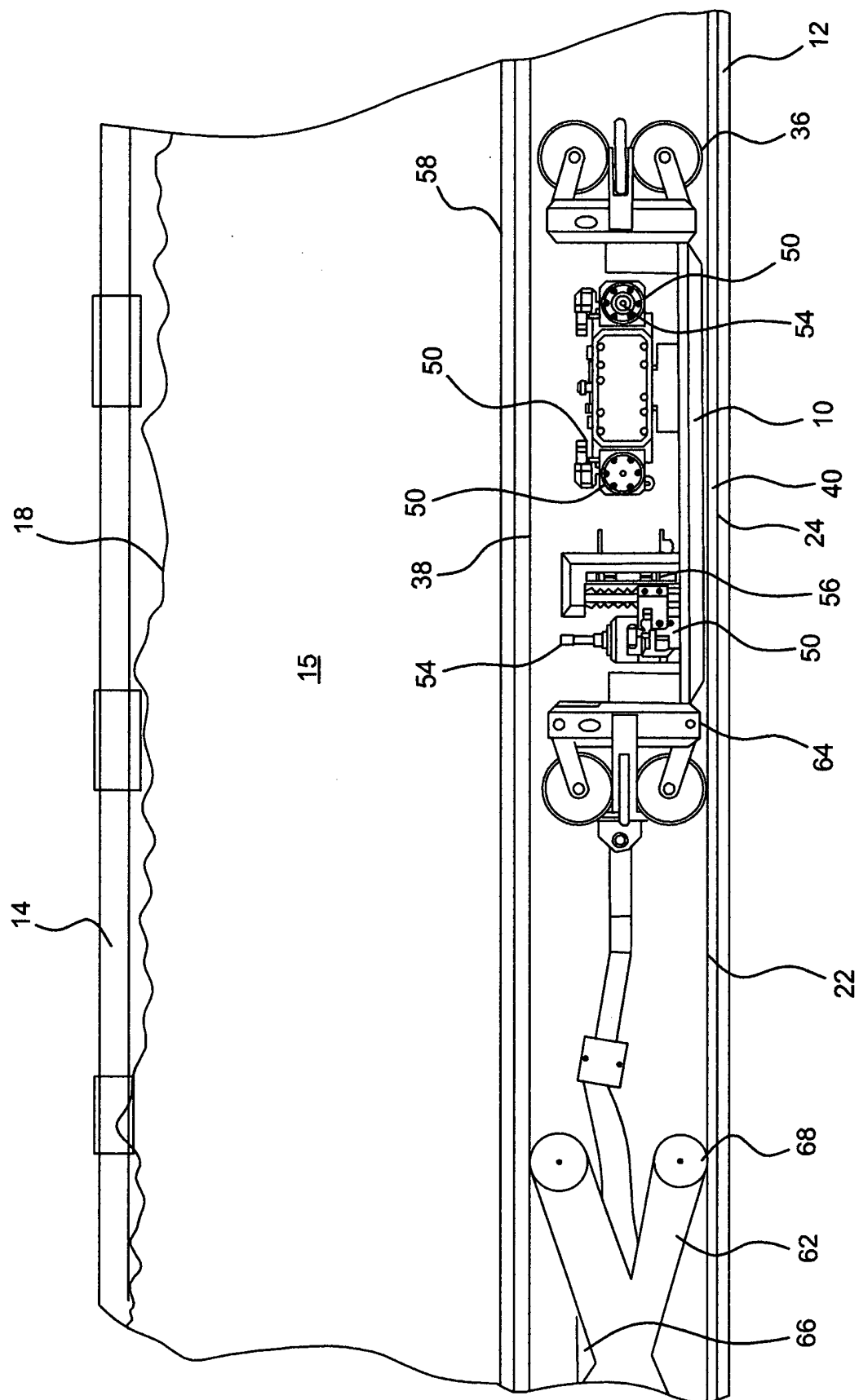


Fig. 1

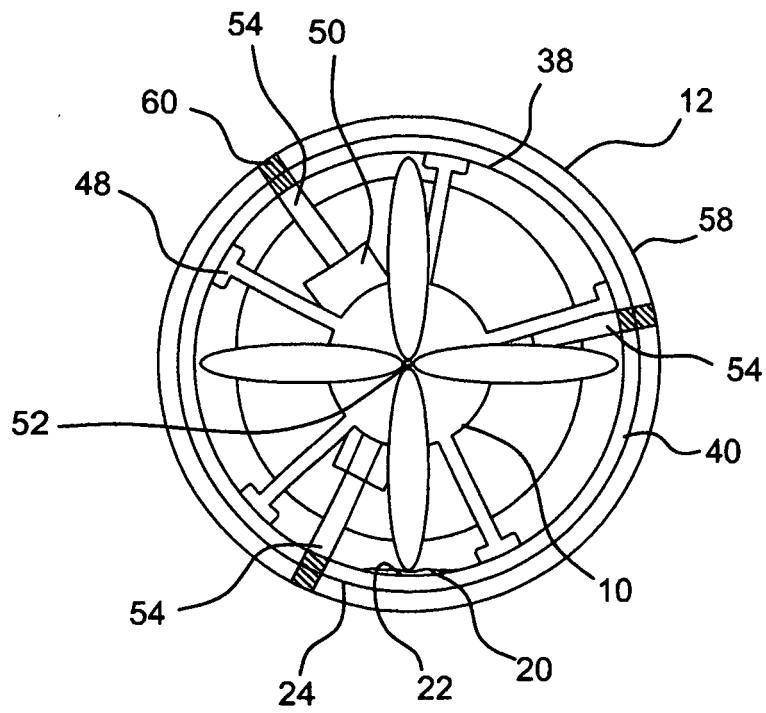
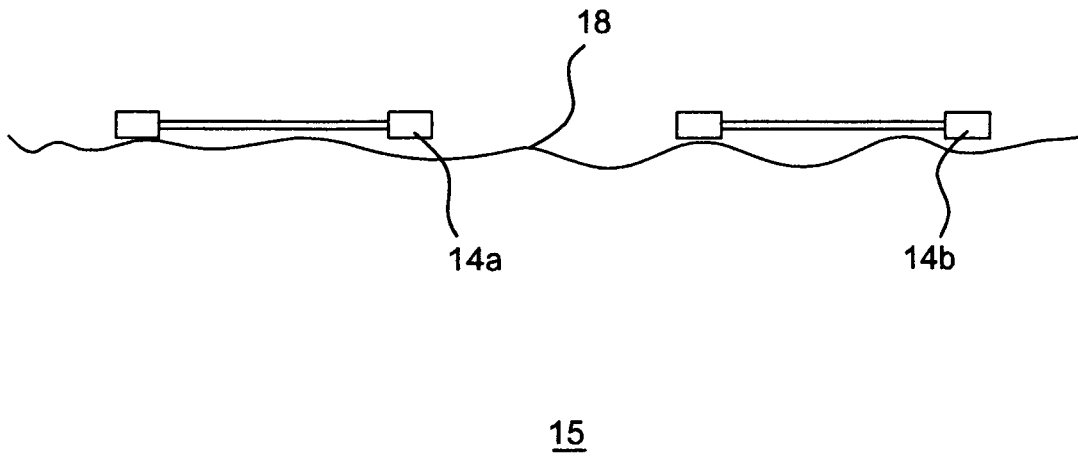


Fig. 2

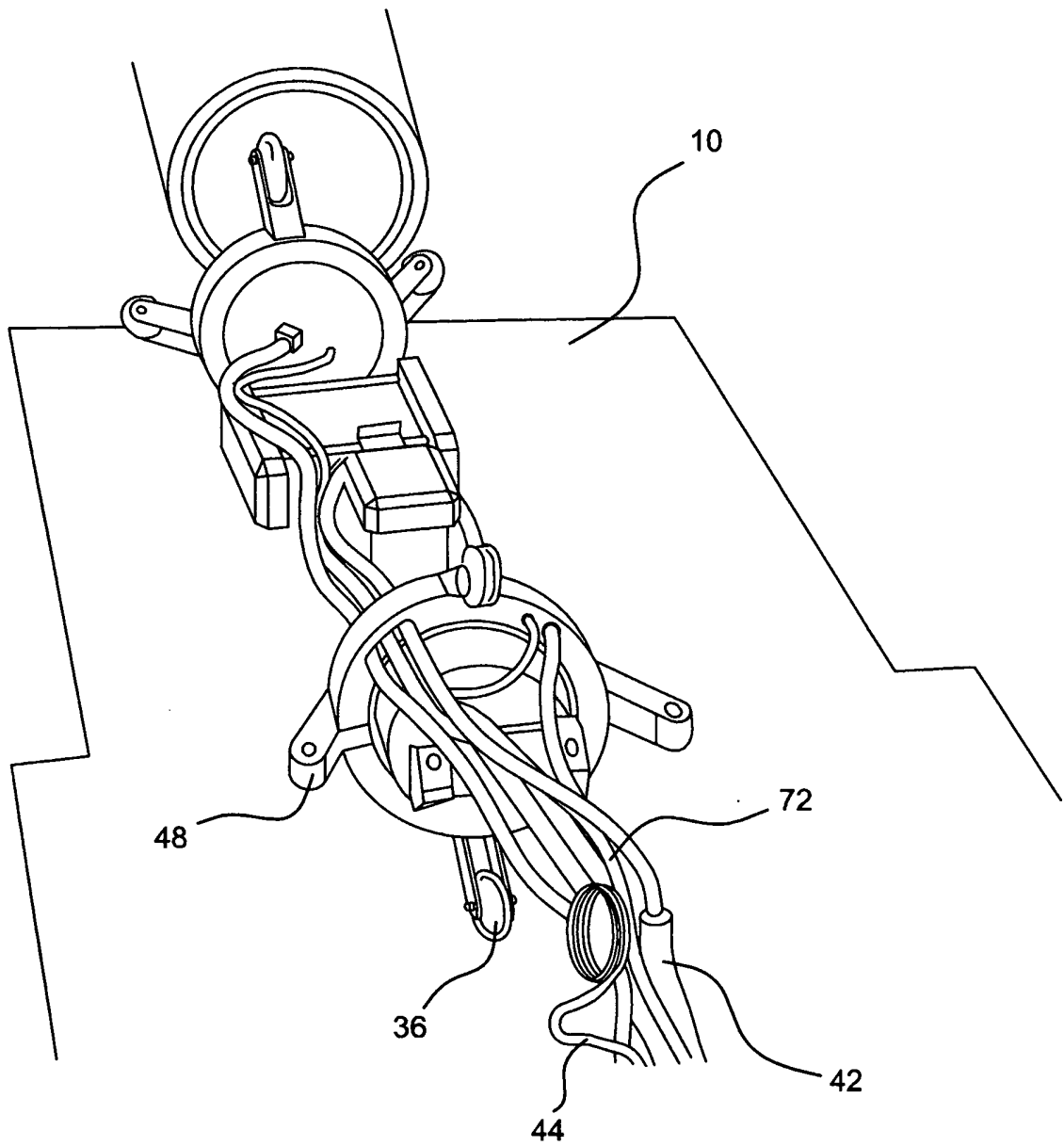


Fig. 3

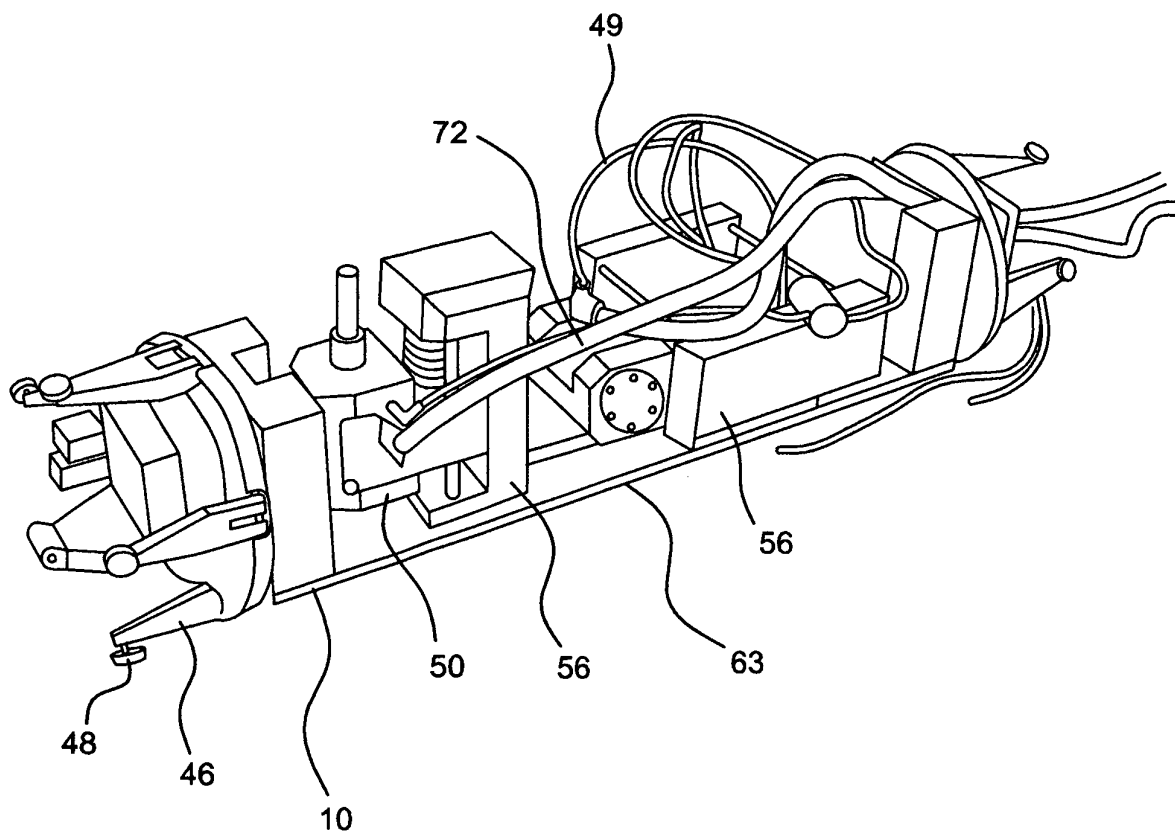


Fig. 4

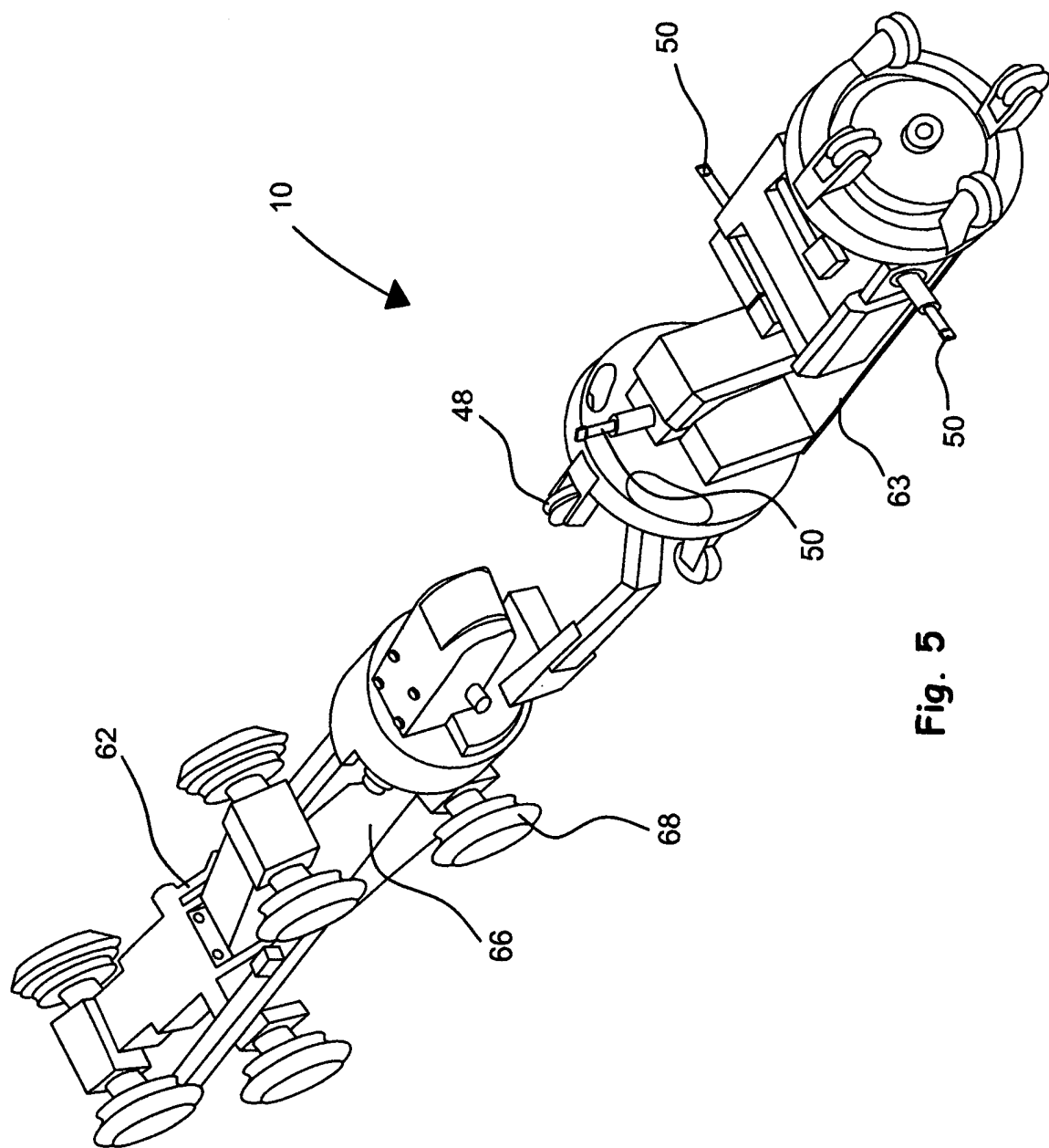


Fig. 5

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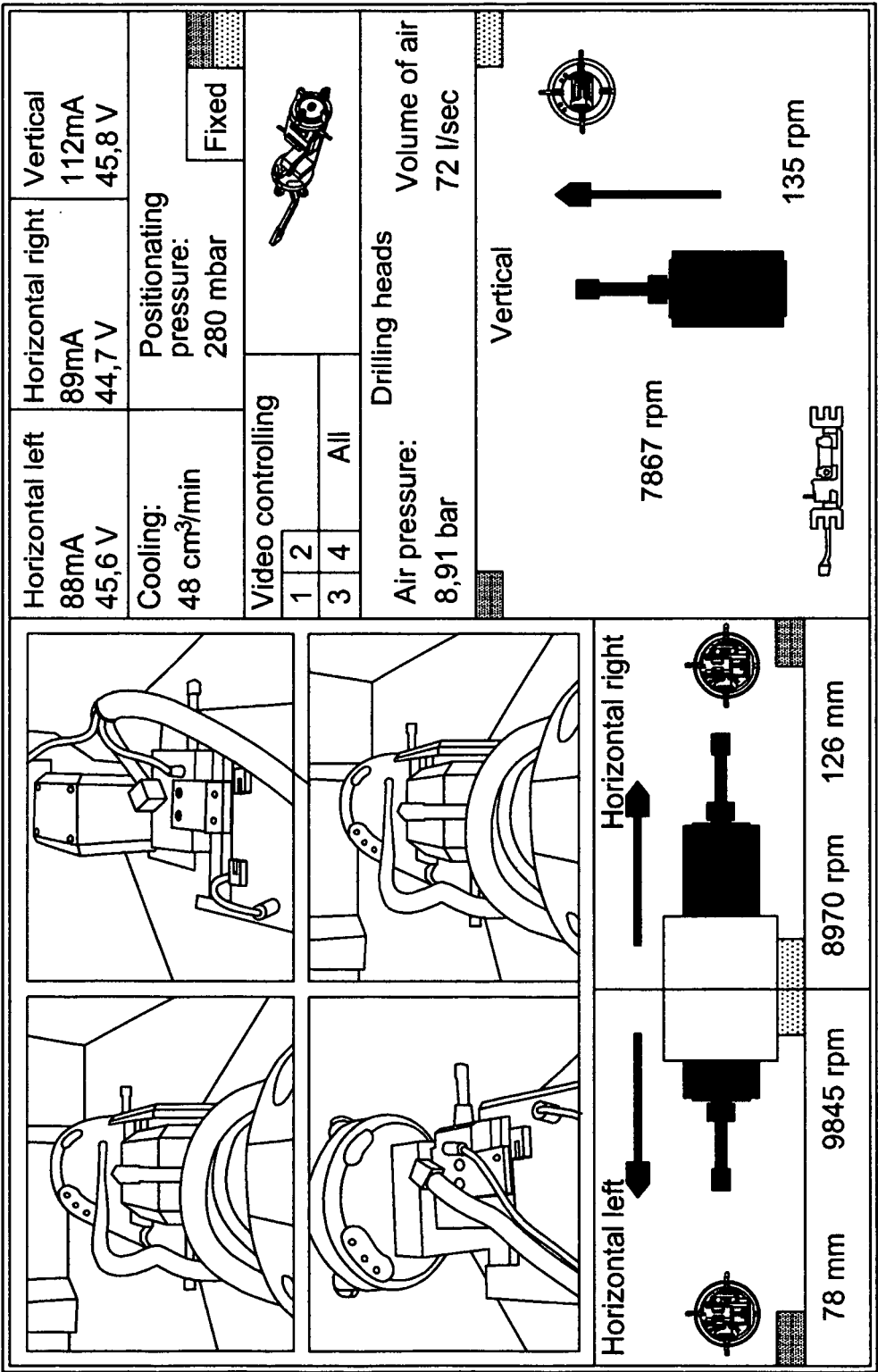


Fig. 6

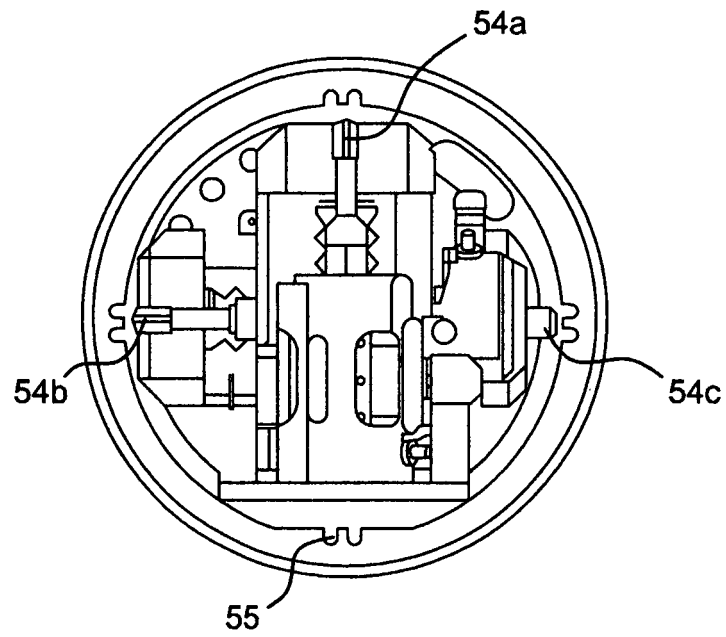


Fig. 7a

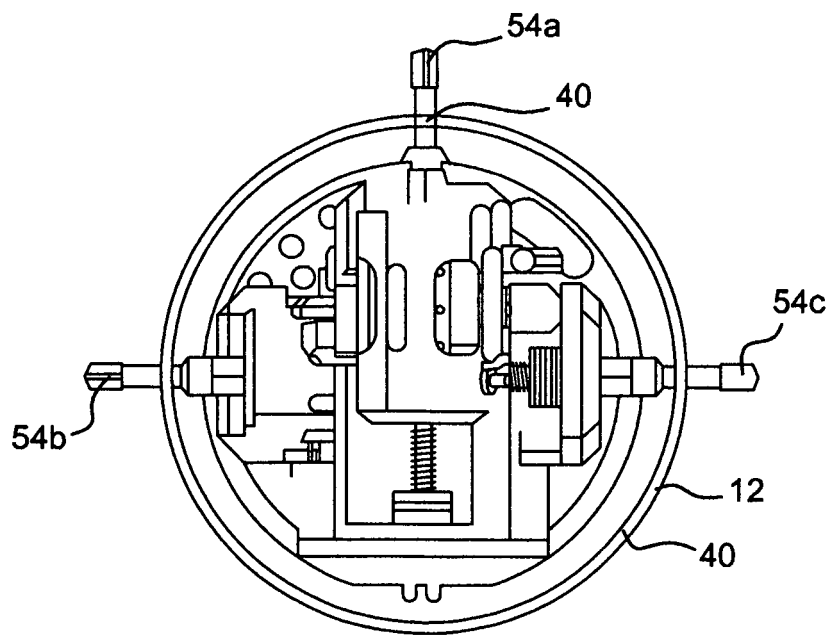


Fig. 7b

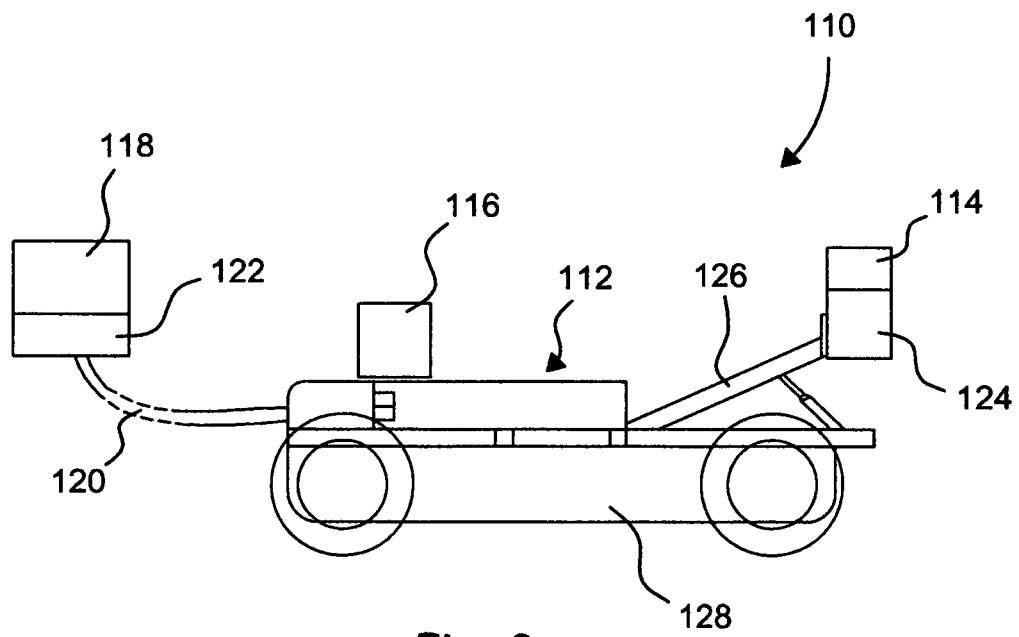


Fig. 8

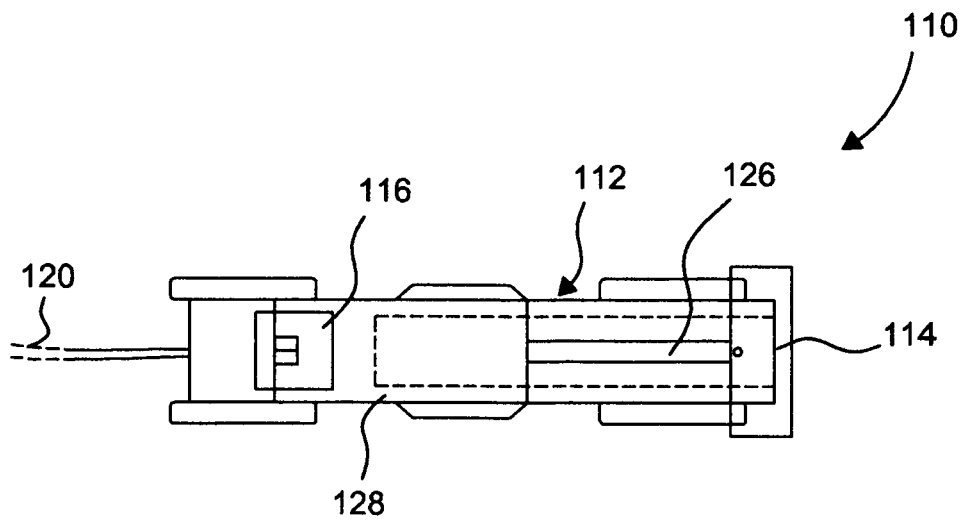


Fig. 9

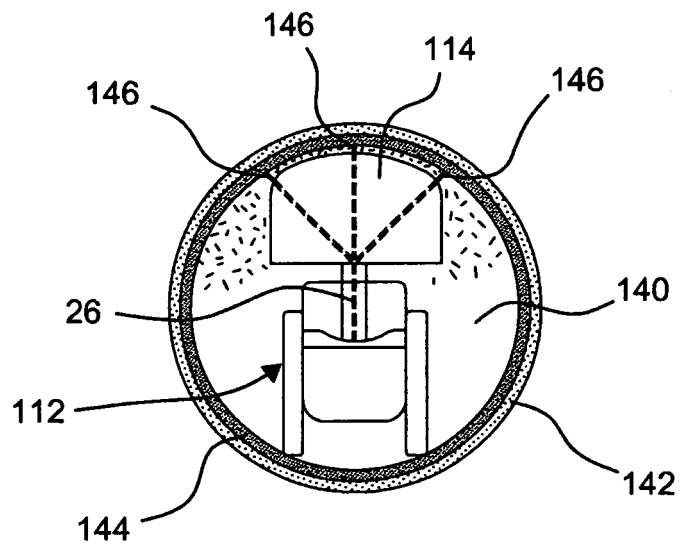


Fig. 10

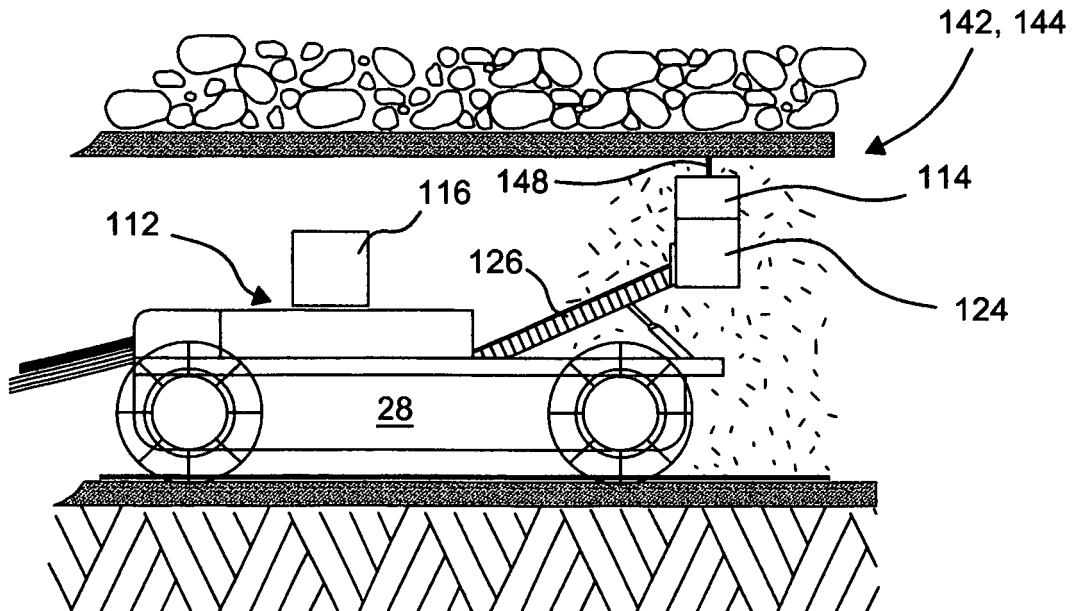


Fig. 11

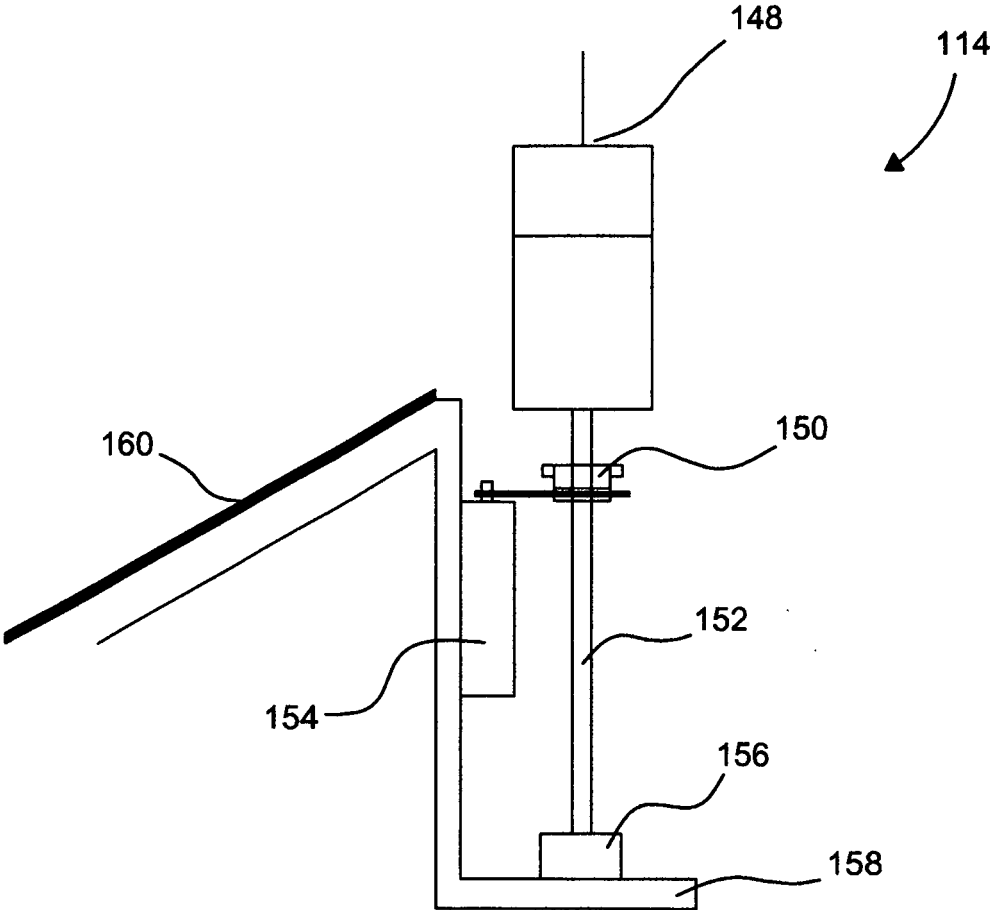


Fig. 12

REFERENCES CITED IN THE DESCRIPTION

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