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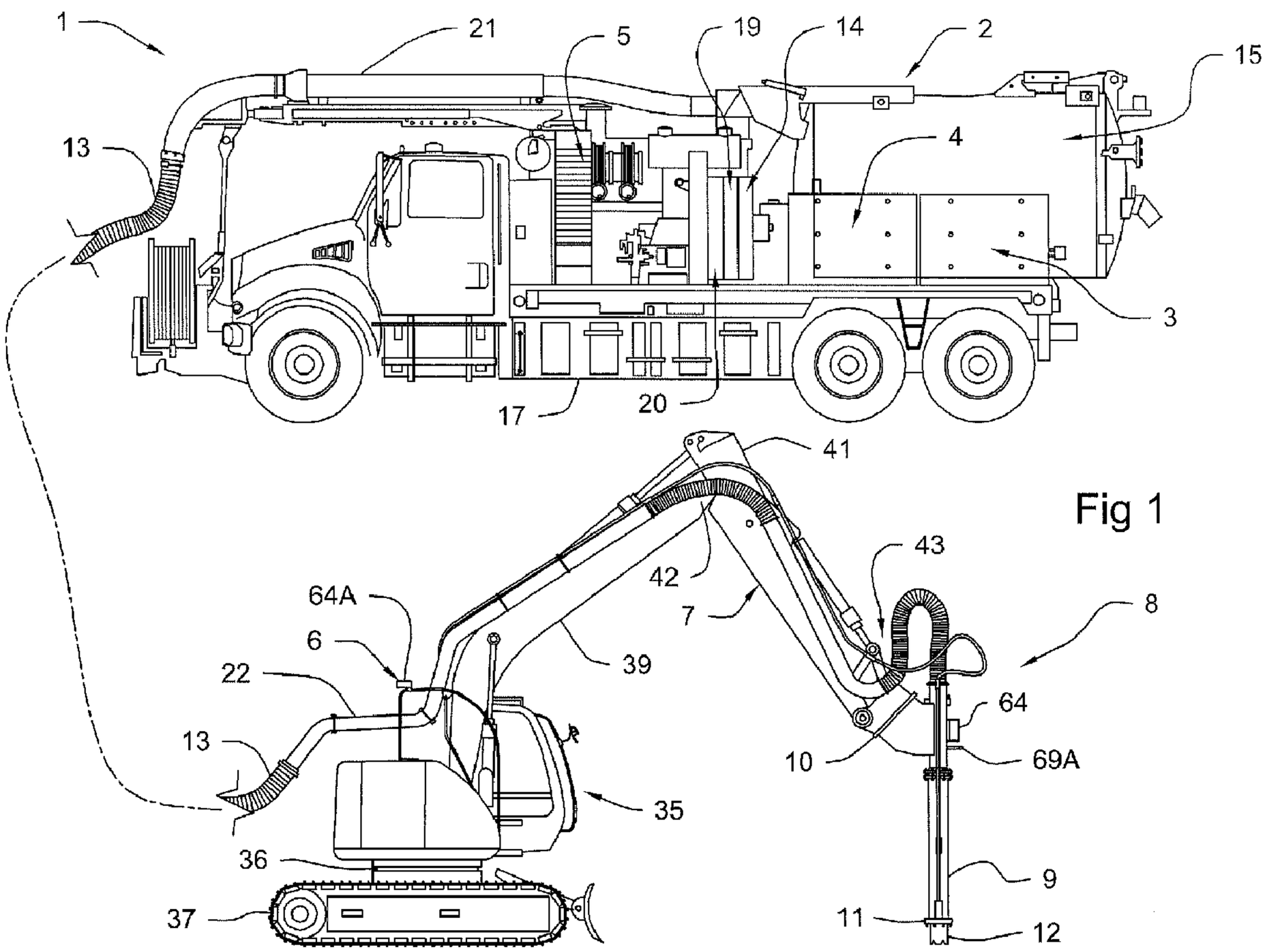

Fig 1

(57) Abrégé/Abstract:
An excavation system utilizes a vacuum truck having a vacuum system in combination with a small backhoe to which an excavator assembly is affixed to the backhoe extendable and articulating arm whereby manipulation of the excavator assembly can be

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(57) Abrégé(suite)/Abstract(continued):
controlled by an operator positioned in the backhoe operator cab. The vacuum assembly and the excavator assembly are operatively attached by an elongated, at least partially flexible vacuum hose operatively attached to the vacuum truck pump to permit material that is excavated to be transported from the excavator assembly to the vacuum assembly for storage or disposal.

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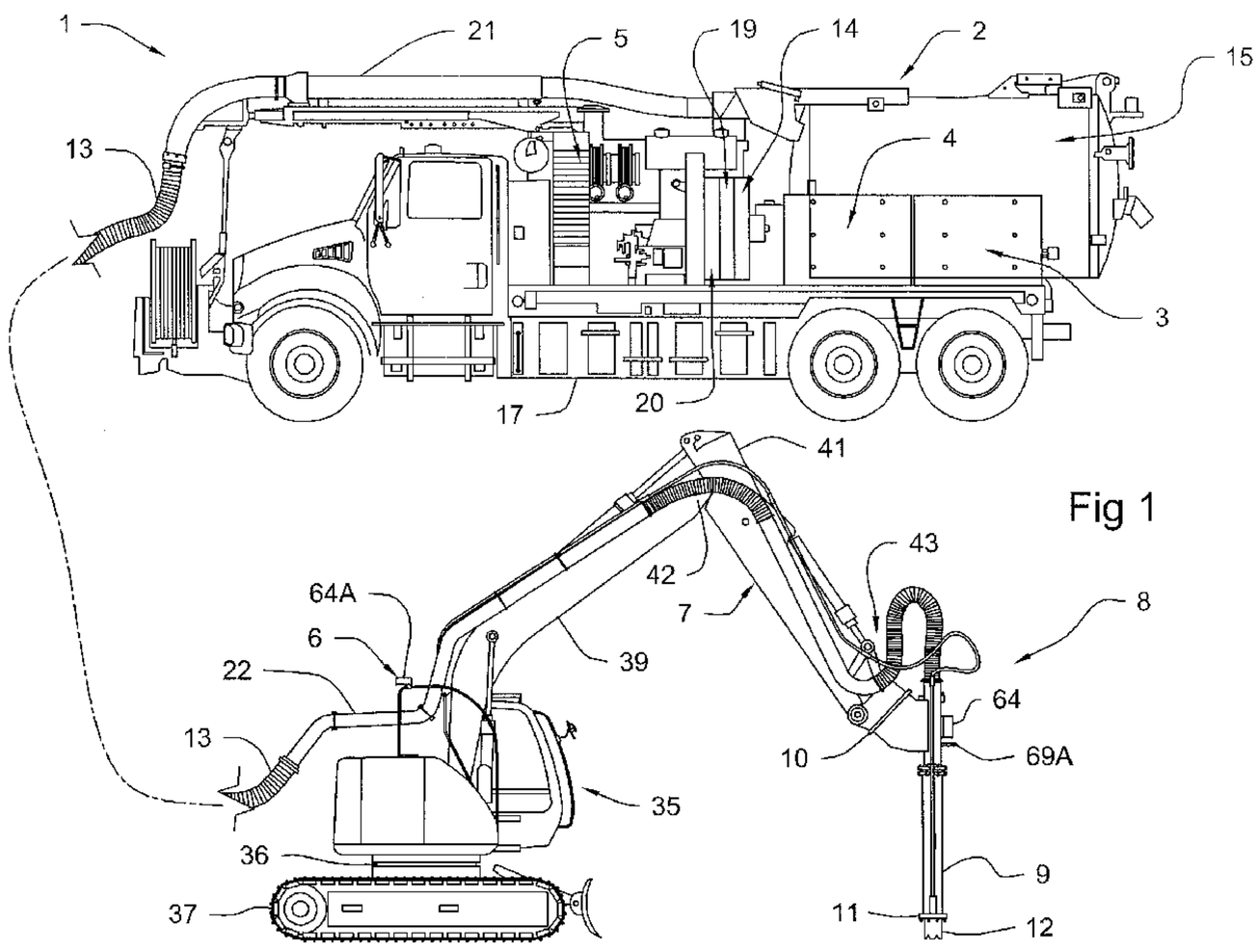

Fig 1

(57) Abstract: An excavation system utilizes a vacuum truck having a vacuum system in combination with a small backhoe to which an excavator assembly is affixed to the backhoe extendable and articulating arm whereby manipulation of the excavator assembly can be controlled by an operator positioned in the backhoe operator cab. The vacuum assembly and the excavator assembly are operatively attached by an elongated, at least partially flexible vacuum hose operatively attached to the vacuum truck pump to permit material that is excavated to be transported from the excavator assembly to the vacuum assembly for storage or disposal.

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AN EXCAVATION SYSTEM

SPECIFICATION

BACKGROUND OF THE INVENTION

Field of the Invention. This invention relates in general to excavators, and more particularly to soil excavators used for trenching at commercial and industrial sites.

Background of the Invention. There has been for some time various water jet/vacuum excavators used to expose underground utilities or piping, as well as for cutting precise trenches for installation of utility lines or piping.

In these prior art excavators, the excavation is achieved through use of a high pressure water jet (>1,200 psi) and the removal of the excavated soil through use of a vacuum system. One example of such excavators is described in U.S. Patent 6,484,422. However, these prior art devices are not capable of operating in all of the various field conditions where the excavation may be desired. In many instances these excavators do not have the mobility necessary to efficiently make the desired shaped trench, or the ability to maneuver in narrow spaces to get to the excavation site, or require too much down time to dispose of the collected excavated soil or are not constructed to efficiently excavate the site. Nor are this prior art devices constructed to deliver other equipment or material to the excavated site without extensive maneuvering or removal of field structures.

Yet another problem is the requirement for extensive equipment operator training. Still further, many of these prior art excavators required multiple personnel to operate the excavation equipment. In many cases the operating personnel have to be positioned in environmental or safety hazardous places that can cause harm or injury to the operating personnel.

Still further, many of these prior art excavators do not have the ability to perform other function that are commonly required in a trenching operation, such as breaking up concrete, picking up and removing obstacles to the excavation process, or cutting material for removal from the excavation site, etc. thus requiring additional equipment and lost down time.

In addition, it is difficult to determine the depth of the excavation during the excavating process, as well as it is difficult for the operator of the excavation equipment to confirm that soil is actually being excavated or determine if the excavated material may be clogging the vacuum hose that removes the material from the site.

Another problem with the use of these prior art excavation devices is damage caused by the trenching tubes striking the coated surfaces of pipes and/or utility lines that are buried underground at the excavation site. Also, a problem is the inability of these prior art excavation devices to be able to detect if explosive gases or environmentally harmful fumes have been released during the excavation operations.

Finally, these prior art excavators are primarily constructed to perform vertical surface trenching, and are not capable of efficiently performing horizontal trenching under pipes or other surface material, such as a concrete slab.

OBJECTS AND SUMMARY OF THE INVENTION

Therefore, one object of one embodiment of the invention is to provide an excavation system having greater mobility and maneuverability.

Another object of one embodiment of the invention is to provide an excavation system that is simple to operate without special training and which reduces the environmental and safety risks to the operating personnel.

Still another object of one embodiment of the invention is to provide an excavation system that has the ability to provide extensive trenching with minimal downtime to remove the collected soil and other excavated material.

A further object of one embodiment of the invention is to provide an excavation system that can perform more than an excavation function.

A further object of one embodiment of the invention is to provide an excavation system that can be operated by a single operator.

A further object of one embodiment of the invention is to provide an excavation system constructed to permit the operator to easily determine during the excavation process that material is being excavated from the site and that the material is not clogging the vacuum hose used to remove the material.

Another object of one embodiment of the invention is to provide a vacuum hose constructed to minimize clogging and provide better lift characteristics in removing the excavated material from the site to the system storage tank.

Another object of one embodiment of the invention is to provide an excavation tubing that reduces or eliminates damage to underground pipe coating and utilities buried at the excavation site.

A still further object of one embodiment of the invention is to provide a nozzle assembly that can utilize one or more fluid mediums to cut the material to be excavated, and which can more efficiently cut the material.

A still further object of one embodiment of the invention is to provide an excavation system that can efficiently perform horizontal trenching under objects or a solid surface.

A still further object of one embodiment of the invention is to provide an excavation

system that can provide warning of an unsafe or hazardous environment at the excavation site.

These and other objects and advantages of this invention shall become apparent from the ensuing descriptions of the invention.

Accordingly, this invention in one embodiment comprises an excavation system having a first vehicle on which is mounted a vacuum assembly. This first vehicle may be self-driven or may be constructed to be towed near the excavation site for use. A preferred first vehicle would be a conventional vacuum truck having a vacuum assembly. The vacuum assembly comprises one or more material storage tanks, a pump or similar device that can create vacuuming conditions within the vacuum hose having a discharge port operatively attachable to the material storage tank for receiving excavated material from the vacuum pump, and the elongated vacuum hose having an intake end and a discharge end, wherein the discharge end is operatively attachable to an intake port of the pump. The excavation system further includes a high pressure fluid delivery assembly (>1200 psi) mountable on the first vehicle. The high pressure fluid delivery assembly includes at least one fluid supply source, such as a tank, a high pressure pump having an output port and an input port operatively attached to the at least one fluid supply tank to receive fluid in the fluid supply tank, and an elongated high pressure fluid hose operatively attached at its input end to the pump output port to receive the fluid from the pressure pump.

In a preferred embodiment the fluid may be air, water or a combination of both. In another preferred embodiment the pressure pump is selected having the ability to pulsate the fluid through the fluid hose. If multiple fluids are utilized, then separate pressure pumps and separate fluid hoses may be used for each fluid.

In another preferred embodiment the vacuum hose includes a rigid section provided with elbows to increase the lift capability of the excavation system to transport the excavation material to the storage tank. In another preferred embodiment the vacuum hose includes a transparent section visible from within the backhoe cab to permit an operator to determine if excavated material is flowing through the vacuum hose.

The excavation system further including a power source mounted on the first vehicle operatively connected to the vacuum assembly to provide power to operate the vacuum assembly and to the high pressure fluid delivery assembly to provide power to operate the high pressure fluid delivery assembly.

The excavation system further includes a second maneuverable vehicle having an articulated, extendable arm, and an accessory mounting structure affixed at the extending end of the extendable arm. In a preferred embodiment the second vehicle would be a small backhoe to permit it to be maneuvered through narrow rows of piping of other site structures to get to the excavation site.

The excavation system also includes an excavator assembly comprising an elongated, hollow rigid excavator tube attachable to the accessory mounting structure, the rigid tube having a lower end with an intake port and an upper end with a discharge port, the discharge port operatively attachable at one end to the intake end of the vacuum hose to deliver excavated material to the vacuum hose.

In a preferred embodiment the intake port of the excavator tube is provided with a resilient coating, such as a soft rubber, to minimize any damage that might result should the intake port strike an underground pipe coating or utility line during the excavation process.

In another preferred embodiment the excavator assembly is affixed to the backhoe accessory mounting structure by a mounting adaptor structured to permit the excavator tube to be positioned for vertical trenching or to permit the excavator tube to be positioned for horizontal trenching. In a more preferred embodiment the mounting adaptor has a housing to contain a camera power source, such as a battery, and an exterior plate to which a camera can be mounted for viewing the excavation process. In another more preferred embodiment the mounting adaptor has a rigid discharge tube affixed to housing and is affixed at one end to the discharge port of the excavator tube and affixed at its other end to the intake port of the vacuum hose to permit excavated material to pass through the excavator tube, the discharge tube, the vacuum hose and into the storage tank.

The excavation system further comprises a fluid jetting assembly that includes a

nozzle assembly provided with one or more nozzles operatively affixed to the lower intake end of the rigid tube to direct the fluid outward from the intake end of the tube to the excavation site. In a preferred embodiment the nozzle assembly is constructed to permit the nozzles to rotate about the excavator tube, and more preferably to be adjustable in the direction that they direct the fluid.

In another preferred embodiment a vacuum gauge will be operatively connected to the vacuum hose to monitor the pressure within the vacuum hose and affixed to the second vehicle at a position that can be observed by the operator of the second vehicle for purposes of determining if the vacuum hose is becoming clogged by the excavated material.

The excavation system can further comprise a surveillance assembly having a camera mounted to the excavator tube or to the accessory mounting structure or to the extendable arm of the second vehicle. The camera is directed toward the excavation site and operatively connected to a monitor for receiving images transmitted by the camera and positioned in the second vehicle whereby the images may be viewed by the excavation system operator during operation of the excavation system. In a more preferred embodiment a second camera will be mounted to the second vehicle where it can be directed to record the rear of the second vehicle when the second vehicle is being backed up. The second camera is operatively connected to a monitor positioned in the cab of the backhoe to permit the operator to view the images from the second camera.

In another preferred embodiment a gas detector gauge having its sensor affixed to the excavator tube at a position to detect the presence of predetermined gases in the excavation trench. The gas detection gauge and any associated warning lights or horns are positioned on an instrument panel in the backhoe cab to be visible to or heard by the operator.

In still another preferred embodiment a trench depth measuring device is positioned to visually advise the operator of the depth of the excavation trench.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings illustrate a preferred embodiment of this invention. However, it is to be understood that this embodiment is not intended to be exhaustive, nor limiting of the invention. It is but one example of the construction of the improved excavation system of this invention.

Figure 1 is a side view of a preferred embodiment of the excavation system of this invention that includes the use of a conventional vacuum truck, a conventional small backhoe and the excavator assembly of this invention.

Figure 2 is a schematic illustration of the excavated material flow from the excavation site into the excavator tube and through the vacuum assembly hoses to the vacuum assembly vacuum pump and then to the storage tank.

Figure 3 is a schematic illustration of the high pressure fluid flow from the water storage tank through high pressure fluid delivery system hoses to the fluid jetting assembly of the excavator assembly.

Figure 4 is a three-quarter perspective view of the third elbow section and the fourth flexible section of the vacuum excavation assembly hoses positioned on the backhoe.

Figure 5 is a three-quarter perspective view of the mounting adapter used to attached the vacuum assembly to the backhoe accessory mounting structure.

Figure 6 is a three-quarter perspective view of the bracket used to attach the second section of the vacuum hose/piping to the backhoe arm.

Figure 7 is a front view of an instrument panel positioned in the backhoe cab to provide excavation information to the operator.

Figure 8 is a perspective view of the excavator assembly affixed to the backhoe accessory tool mount by mounting adaptor and further illustrating the depth indicator strip extending vertically along the outside surface of the excavator tube.

Figure 9 is a front view of a preferred embodiment of the excavator assembly.

Figure 10 is a bottom view of the excavator assembly viewed from Section arrows A -A of Figure 9.

Figure 11 is a side view of the excavator assembly taken along section arrows B – B of Figure 9.

Figure 12 is a top view of the excavator assembly viewed from section arrows C – C of Figure 9.

Figure 13 is a rear view of the excavator assembly taken along section arrows D – D of Figure 11.

PREFERRED EMBODIMENTS OF THE INVENTION

Without any intent to limit the scope of this invention, the preferred embodiments of the invention are described for an embodiment specifically adopted for use in industrial plant sites.

As indicated in **Figure 1** in one preferred embodiment of the invention the excavation system **1** comprises a first vehicle, such as a conventional vacuum truck **2**, having mounted thereon a vacuum assembly **3**, a high pressure fluid delivery assembly **4**, one or more power sources **5** used to operate the vacuum assembly **3** and the high pressure fluid delivery assembly **4**. The excavation system **1** also comprises a relatively small, maneuverable vehicle **6** having an extendible and articulating arm **7**, such as a small backhoe. The excavation system **1** still further comprises an excavator assembly **8** having a rigid excavator tube **9** attachable to the extendible and articulating arm **7** of the backhoe **6** via a mounting adaptor **10**. The excavator assembly **8** also includes a fluid jetting assembly **11** having nozzles **12** directed toward the excavation site.

As illustrated in the schematics of **Figs. 2** and **3**, to operatively connect the elements of excavation system **1** the vacuum assembly **3** further comprises appropriate hoses and/or piping **13A - 13D** to operatively connect the excavator tube **9** to pump **14** of vacuum assembly **3** to permit excavated material to be transported from the excavation site through hoses **13A – 13D** to a storage tank **15** of vacuum assembly **3**. There also appropriate hoses and/or piping **16A – 16B** and/or **16C – 16E** to operative connect a water reservoir, such as water tank **17** and/or an air source **18** to respective pumps **19** and **20** of the fluid jetting assembly **11** and then to the nozzles **12** of the high pressure fluid delivery assembly **4** for the purpose of directing fluid, such as air, water or a combination of both, to the fluid jetting assembly nozzles **12** to cut and otherwise break into smaller pieces the material to be excavated. In a preferred embodiment, it is desirable to be able to control the speed of pumps **14**, **19**, and **20** to permit the person operating the excavation system **1** to control the various aspects of the process. One way this could be done is to utilize known variable speed pumps.

A typical vacuum truck **2** will be equipped with a water tank **17** having a high

capacity water pump **19** that is operatively attached by piping **16A** to draw water from the water tank **17** and deliver it to high pressure hose **16B** that is coiled on a conventional reel mounted to truck **2**. The hose **16B** can then be uncoiled so that it extends to the excavation site. In a preferred embodiment of this invention fluid delivery pump **19** through a conventional directional flow control valve [not shown] or other similar known flow control apparatus operatively attached to the intake port of pump **19** can receive water from alternate water sources that may be available at the excavation site. This provides several advantages not found in the conventional vacuum truck. First, if such a water source (e.g., pond, river, lake, or man-made water delivery system) is available, then it is not necessary to haul water to the excavation site. Still further, there would not be a need to shut down the excavation process to drive the vacuum truck **2** back to a water source to refill the water tank **17**. In the typical vacuum truck **2** the end of hose **16B** will be attachable to a nozzle assembly that will be directed to the area to be excavated. The nozzle assembly will be either hand held or affixed to a rotatable and extendable boom structure **21**. Because the water is being delivered under high pressure it is dangerous for the person manhandling the nozzle and less efficient and effective in trenching at the excavation site. However, in this invention hose **16B** (and any number of extension hoses desired) is attached to rigid piping section **16C** that is attached to backhoe **6**. As becomes clear, this eliminates the need to use an operator to handle the nozzle assembly or the need to position the large vacuum truck **2** near the excavation site. Still further, this eliminates the need to maneuver the vacuum truck **2** in order to maintain the proper position of the nozzle assembly during the excavation process. Instead the necessary maneuvering can be done by the smaller and more nimble backhoe **6**.

In many instances the excavation material may be polluted and required to be delivered to a reclamation facility for treatment. When storage tank **15** becomes full it is necessary to shut down the excavation process while the vacuum truck **2** travels to the reclamation facility to unload the collected excavation material. To eliminate this problem and to provide for a more efficient process, it is preferred storage tank **15** be detachable from vacuum truck **2** for delivery to the reclamation facility by a third vehicle, and that a

second storage tank be available to continue to receive collected excavation material while the first tank is being emptied at the reclamation facility. In this embodiment the second tank would be constructed for attachment to the third vehicle or the vacuum truck so that it could later be delivered to the reclamation facility.

Figure 4 illustrates a preferred embodiment of the third section **13C** of vacuum hosing/piping **13**. In this preferred embodiment the third section **13C** will include rigid elbow shaped areas **22** whose design will provide for better vacuum lift forces to pick up and transport the collected excavation material through the various hose/piping sections **13A – 13D** to storage tank **15**. This construction will further minimize clogging of the various hose/piping sections **13A – 13D** by the collected excavation material. Section **13C** is attached to the frame of the backhoe arm **7** by brackets **23**, such as illustrated in **Figure 6**. Because different backhoes utilize different shaped arm **7**, bracket 23 is preferably constructed to fit the backhoe being used. However, in one embodiment bracket **23** is constructed having an elongated top metal strip **24** with three metal plates **25**, **26** and **27** extending perpendicularly down from top metal strip **24**. Plates **25** and **26** along with the section of strip **24** running between plates **25** and **26** form a first section **23A** that extends over and is attachable to the backhoe arm **7** by bolts (not shown) extending through bolt openings **33A** and **33B**, or by welding strip **24** to the backhoe arm **7**, or other known means to backhoe arm **7**. Plates **26** and **27** along with the section of strip **24** running between plates **36** and **27** form a second section **23B** shaped to receive a straight portion **28** of elbow section **13C**. The second section **23B** is provided with a plate **29** extending between plates **26** and **27** along a portion of one edge **30** of top strip **24** and having a cut-out section **31** to form a cradle in straight section **28** can be positioned. A U-shaped bolt **32** sized to fit over straight portion **28** and into bolt openings **33A** and **33B** in top strip **24** is used to secure elbow section **13C** to bracket **23**.

As seen in **Figs. 1, 4-6** and **8**, a conventional small backhoe **6** includes a cab **35** mounted atop a rotatable platform **36** operatively positioned over a pair of tracks **37** that are driven by a motor **38** to maneuver backhoe **6** into the desired location. Extending from platform **36** is extendable and articulated arm **7**. Arm **7** comprises a first arm section **39**

extending outward from the front **40** of the backhoe platform **36**. It further comprises a second arm section **41** pivotally attached at the extended end **42** of the first section **39** that extends further outward from the backhoe **6**. In addition arm **7** comprises a third hydraulic piston section **43** pivotally attached at the extended end **44** of the second arm section **41**. An accessory mounting structure **46** is pivotally fixed to the extended end **44** and to the piston rod end **45**. Various conventional accessory tools may be bolted to accessory mounting structure 46. One advantage of utilizing a small backhoe **6** as the second vehicle is the ability to attach multiple tools, such as hydraulic hammers to break up concrete, rakes and grapples to remove heavy objects from the excavation site, rock grinders, etc. to accessory mounting structure **46**. Typically, structure **46** comprises a metal plate **47** having a pair of separated parallel shoulder plates **48**. Each plate **48** has two bolt openings **49** and **50** that are aligned with the corresponding two bolt openings in the other plate **48** to permit two bolts **51A** and **51B** to be inserted through the aligned openings, respectively. One pair of aligned openings **49** or **50** are further aligned with openings in the extending end **44** of the second arm section **41** so that bolt **51A** can be inserted through the aligned openings. In similar fashion the third hydraulic piston section **43** has openings in its extending end **45** that can be aligned with openings **50** so that bolt **51B** can be inserted through the aligned openings. In this construction plate **47** can then be manipulated by the backhoe operator to be positioned in a variety of angles. In one preferred embodiment plate **47** has bolt openings on opposite perimeter sections to permit a wide variety of tools to be attached to plate **47**, including excavator assembly **8**.

To attach excavator assembly **8** a mounting adaptor **53**, such as illustrated in **Figs. 5, 8** and **11-13**, is used to attach excavator assembly **8** to accessory mounting structure **46**. Mounting adaptor **53** includes a housing **54** formed from a bottom plate **55** that can be welded to an extension tubing **65** of excavator tube **9**, two trapezoidal shaped side walls **56** and **57** extending vertically from bottom plate **55** and a roof **58** extending between side walls **56** and **57**. As illustrated in **Fig. 5**, positioned about two of the perimeter sections **59** and **60** of bottom plate **55** are a series of bolt openings **61** that can be aligned with bolt

openings **52** to permit housing **54** to be bolted to the accessory mounting structure **46**. Alternatively, as illustrated in **Figs. 11-13** bottom plate **55** has a center gap **55A** running the length of plate **55** (see Fig. 5) to permit contact with extension tubing **65** to allow bottom plate **55** to be welded to extension tubing **65**. In a preferred embodiment the incline angle **α** formed in the trapezoidal side walls **56** and **57** is selected to permit the excavator assembly **8** to be positioned perpendicularly to the surface of the excavation site for vertical trenching, or selected to permit the excavator assembly **8** to positioned horizontally to the surface for horizontal trenching under slabs or other surface objects. Inside housing **54** and affixed near the corner formed by bottom plate **55** and vertical side wall **56** is an open end pipe **62** sized to permit the high pressure water line to extend through pipe **62**. In the opposite corner formed by bottom plate **55** and vertical side wall **57** is battery housing **63** sized to permit a power source for a video camera **64** to be inserted within battery housing **63**. Extending outward from side wall **57** is camera support structure **69** on which camera **64** is mounted in a position to be directed toward the material intake opening of excavator tube **9**.

In another preferred embodiment a plexiglass or other transparent plate **69A** can be positioned in front of the camera **64** to prevent any material from striking the lens during the excavation process.

Mounting adaptor **53** further includes extension tubing **65** having a first end flange **66** shaped to receive and attached to the extending end **67** of flexible vacuum hose fourth section **13D**. At its opposite end tubing **65** has a second end flange **68** structured to affix to flange **70** of excavator tube **9**. In a preferred embodiment the flexible fourth section **13D** of vacuum hose/piping is sufficiently transparent to permit an operator in the backhoe cab **35** to see excavated material flowing through the fourth section **13D**. In another preferred embodiment a vacuum pressure gauge **72** having its pressure sensor **73** operatively located to measure the pressure within the vacuum hose/piping will be positioned within backhoe cab **35** to permit the operator to monitor the vacuum pressure within the vacuum hose and determine if the vacuum hose is becoming clogged by the collected excavation material. In still another preferred embodiment of this invention a monitor **74** operatively connected to

receive video from camera **64** is positioned within backhoe cab **35** to permit the operator to observe the excavation occurring. In a preferred embodiment a Plexiglas or other clear member **69A** is placed in front of the lens of camera **64** to protect it from flying debris or mud during the excavating process. As a safety measure to prevent the backhoe from hitting an object during the maneuvering of the backhoe **6**, it is preferred a second camera **64A** be mounted to backhoe **6** in a position to video the area behind the backhoe cab **35** and transmit those images a second monitor located within the backhoe cab **35** where the operator can see the transmitted images. If desired monitor **74** can be used to receive and display the images from both cameras. In still another preferred embodiment a gas detector **75** having its sensor **76** affixed to excavator tube **9** at a position to detect the presence of one or more predetermined gases in the excavation trench is utilized. A preferred position would be about 1-3 feet from the lower end **83** of excavator tube **9**. The gas detector gauge **77** or other audible horn or speaker **78** or visual warning light **79** are operatively mounted on instrument panel **80** located in backhoe cab **35** to permit the operator to see and/or hear the indication of the presence of the predetermined gases in the excavation trench. **Figure 7** illustrates such an instrument panel **80** that would include vacuum gauge **73**, monitor **74**, gas detection gauge **77**, horn **78**, warning light **79**, as well as information display devices, such as a trench depth monitor **81** if a conventional laser system is utilized. The instrument panel **80** can also be provided with as many of other indicator gauges **82** needed to display other information that may be desired by the operator.

Referring now to **Figs. 8-13**, lower end **83** of excavator tube **9** contains a series of notches **84** around its circumference that when lower end **83** is resting on the trench floor forms a series of openings **85** through which broken down material can pass when vacuumed into excavator tube **9**. In a preferred embodiment the lower end **83** is coated with a soft plastic or rubber compound to form a resilient surface **86** in order to minimize any damage to an underground pipe coating or surface, as well as minimize any damage to a utility line when struck by the lower end **83** during the excavation process. Excavator tube is provided with a flange **87** at its upper end to provide a connection with the lower flange **68** of discharge tubing **65**.

In a preferred embodiment the front surface **87** of excavator tube **9** is marked with depth indicators **88** that represent the depth of the excavated trench. More preferably each one foot of depth is painted a separate color from the adjacent markings to provide better visibility to the backhoe cab operator.

Fluid jetting assembly **11** is affixed to excavator tube **9** by one or more clamps **89**, preferably by welding fluid jetting assembly pipe **90** between first and second clamp pieces **91** and **92** forming clamp **89**. In a preferred embodiment a rest member **93** is affixed to each clamp **89** to provide protection to excavator tube **9** from being hit during transportation or during the excavation process. Rest member **93** also provides a means to support excavator tube **9** in an elevated position when it is not being used which can keep fluid jetting assembly **11** from being damaged. Pipe **90** is provided with a coupling **94** to connect to fluid delivery hoses **16**.

Fluid jetting assembly **11** further comprises a series of nozzles **12** operatively mounted on a circular tube **95** that is affixed to excavator tube **9** by brace members **96**. In turn fluid jetting assembly pipe **90** is operatively attached to circular tube **95** so that high pressure fluid from pipe **90** flows into tube **95** and out through nozzles **12** to strike the material to be excavated. In a preferred embodiment one or more of nozzles **12** can be adjusted to direct the high pressure fluid exiting the nozzles in a desired direction, such as inward toward the area beneath the notches **84** in order to obtain more efficient break up of the material to be excavated.

In operation the vacuum truck **2** and backhoe **6** are delivered to the site area. The vacuum truck **2** is positioned as close to the excavation area as practical. At that point backhoe **6** to which the excavator assembly **8** has been operatively attached is maneuvered to the excavation site. If needed the high pressure hoses **16** of fluid delivery assembly **4** is operatively connected to the water source and/or air source for delivery to the excavator assembly **8**. The backhoe operator manipulates the backhoe arm **7** through the hydraulic system of backhoe **6** to position the fluid jetting assembly **11** and its nozzles **12** to begin the excavating process. The vacuum hose pump **14** and the water and/or air pumps **19/20** are activated to begin the delivery of the fluids and the vacuuming of the

broken up material. The various information data is collected and displayed by the gauges, horn and warning lights **72, 77-79** and **81** attached to instrument panel **80**. Once the excavation has reached a desired depth as indicated by gauge **81** or by observation of the depth indicator markings **88** on evacuator tube **9**, the backhoe operator moves the backhoe as needed to continue the trenching.

There are of course many alternate constructions that are obvious from this description of the invention and the photographs of one embodiment of the invention. It is the intent of application that this invention also includes these obvious embodiments.

CLAIMS

What I claim is:

1. A vacuum excavation system for excavating material from a site, comprising:
   a. a first vehicle;
   b. a vacuum assembly mounted on the first vehicle, the vacuum assembly comprising:
      i. a material storage tank,
      ii. a vacuum pump having an intake port and a discharge port, the discharge port operatively attachable to the material storage tank to permit material discharged from the vacuum pump to be received in the material storage tank,
      iii. an elongated vacuum hose having an intake end and a discharge end, the discharge end operatively attachable to the intake port of the vacuum pump;
   c. a high pressure fluid delivery assembly comprising:
      i. a fluid pump having an input port operatively attachable to a fluid supply tank to receive fluid and a discharge port to discharge at high pressure fluid entering the input port,
      ii. piping operatively attached at its input end to the output port of the fluid pump to receive the high pressure fluid from the fluid pump;
   d. a power source operatively connected to the vacuum assembly to provide power to operate the vacuum pump and to the high pressure fluid delivery assembly to provide power to operate the fluid pump;
   e. a second vehicle, the second vehicle having an extendable, articulating arm with an accessory mounting structure mounted on the arm;
   f. an excavator assembly comprising:
      a. a mounting adaptor attachable to the accessory mounting structure wherein the arm can operatively position the excavator assembly at the site being excavated;

b. a rigid excavator tube attachable to the mounting adapter, the excavator tube having an intake port and a discharge port, the discharge port operatively attachable at one end to the intake end of the vacuum hose; and
c. a fluid jetting assembly affixed to the excavator tube having a nozzle assembly operatively attachable to the discharge end of the fluid piping to receive and redirect the fluid under pressure to the site to be excavated.

2. The vacuum excavation system according to claim 1 further comprising a gas detector having a sensor affixed to the excavator tube at a position to operatively receive gases emitted from the site.

3. The vacuum excavation system according to claim 1, wherein the power source comprises a first power source to operate the vacuum assembly and a second power source to operate the high pressure fluid delivery assembly.

4. The vacuum excavation system according to claim 3, wherein the second power source is a variable power source to permit modulation of the delivery rate of the fluid.

5. The vacuum excavation system according to claim 1, wherein the second vehicle is a backhoe having an operator cab containing controls for operating the extending, articulating arm, the vacuum assembly, and the high pressure fluid delivery assembly.

6. The vacuum excavation system according to claim 1, further comprising a surveillance assembly, the surveillance assembly comprising:
a. a video camera attached to the mounting adapter at a position to be directed to the excavation site,
b. a video transmitter operatively attached to the video camera to receive and transmit images from the video camera; and
c. a monitor located inside the operator cab, positioned to be visible to an operator in the operator cab, and operatively connected to the video transmitter to receive and display the transmitted images from the video camera.

7. The vacuum excavation system according to claim 6, wherein the surveillance

assembly further comprises:

a. a second video camera mounted to the backhoe at a position to be directed to the area located behind the backhoe;

b. a second video transmitter operatively attached to the second video camera to receive and transmit images from the second video camera; and

c. a second monitor located inside the operator cab, positioned to be visible to an operator in the operator cab, and operatively connected to the second video transmitter to receive and display the transmitted images from the second video camera.

8. The vacuum excavation system according to claim 7, wherein the monitor is electronically structured to receive transmitted images from multiple cameras and simultaneously display the transmitted images separately from each of the multiple cameras and wherein the second monitor is the monitor.

9. The vacuum excavation system according to claim 1, wherein the vacuum hose comprises:

a. a first connection section operatively and pivotally connected to the intake port of the vacuum pump;

b. a second flexible extension section operatively attached to the first section to permit the first vehicle to be positioned at a distance from the second vehicle;

c. a third rigid section operatively attached to the second flexible extension section and mounted to the backhoe; and

d. a fourth section having at least one flexible piece operatively attached to the third ridge section to permit the extension and articulation of the backhoe arm and attached at its opposite end to the excavator tube.

10. The vacuum excavation system according to claim 9 wherein the third rigid section is constructed forming elbows.

11. The excavation system according to claim 9 wherein the fourth section is at least in part constructed of material have sufficient transparency to permit an operator

to see excavated material passing through the fourth section.

12. The vacuum excavation system according to claim 9 wherein a vacuum gauge is mounted to the backhoe in a position for an operator of the backhoe to see, the vacuum gauge being operatively connected to the vacuum hose to measure the level of vacuum in the vacuum hose.

13. The vacuum excavation system according to claim 1 wherein the mounting adaptor comprises:

a. separated side plates, each plate having a first edge, an opposing edge and side edges between the first edge and the opposing edge, the first edge affixed vertically along the rigid tube, and the opposing edge being at an angle to the first edge;

b. an adaptor plate affixed to the opposing edges; and

c. a backhoe arm mounting member shaped and structured to be attachable to the accessory mounting structure.

14. The vacuum excavation system according to claim 13 wherein the angle being selected to permit the backhoe arm to position the rigid tube perpendicular to the site to be excavated.

15. The vacuum excavation system according to claim 14 wherein the angle is between about 40^{o} to about 50^{o}.

16. The vacuum excavation system according to claim 1 wherein the rigid tube having an upper end attachable to the vacuum hose and a lower end having at least two positioning members extending from the lower end a predetermined distance.

17. The vacuum excavation system according to claim 1 wherein the excavator tube has affixed along its vertical outer wall surface a visual ruler for use to indicate the depth of excavation.

18. The vacuum excavation system according to claim 1 wherein the excavator tube intake port comprises a resilient coating affixed to the intake port.

19. The vacuum excavation system according to claim 1 wherein the nozzle assembly is at least partially rotatable about the rigid excavator tube.

20. The vacuum excavation system according to claim 1 wherein the nozzle assembly comprises nozzles adjustably affixed to a support ring attached to the excavator tube.

21. A vacuum excavation system including a vacuum truck having a vacuum assembly having a vacuum hose, a high pressure fluid delivery assembly having fluid dispersing piping, and a power source operatively connected to the vacuum assembly and the high pressure fluid delivery assembly to create a vacuum in the vacuum hose and to deliver the fluid under high pressure through the piping, the improvement to which comprises:

a. a backhoe having a mobile support base, an extending, articulating arm pivotally attached at one end to the support base and an opposing end extendable from the support base with an accessory mounting member structure at the opposing end; and

b. an excavator assembly comprising:

i. a mounting adaptor attachable to the accessory mounting structure wherein the arm can operatively position the excavator assembly at the site being excavated, the mounting adaptor comprises separated side plates, each plate having a first edge, an opposing edge and side edges between the first edge and the opposing edge, the first edge affixed vertically along the rigid tube, and the opposing edge being at an angle to the first edge, wherein the angle being selected to permit the backhoe arm to position the rigid tube perpendicular to the site to be excavated;

ii. a hollow rigid excavator tube attachable to the mounting adapter, the excavator tube having a lower end with an intake port and an upper end with a discharge port, the upper end operatively attachable at one end to the intake end of the vacuum hose, the lower end having at least two positioning members extending from the lower end a predetermined distance; and

iii. a fluid jetting assembly affixed to the excavator tube having a nozzle assembly operatively attachable to the discharge end of the fluid piping to receive and redirect the fluid under pressure to the site to be excavated.

22. The vacuum excavation system according to claim 21, wherein the vacuum hose comprises:

a. a first connection section operatively and pivotally connected to the intake port of the vacuum pump;

b. a second flexible extension section operatively attached to the first connection section to permit the vacuum truck to be position at some distance from the backhoe;

c. a third rigid elbow section operatively attached to the second flexible extension section and mounted to the backhoe; and

d. a fourth section having at least one flexible piece operatively attached to the third elbow section to permit the extension and articulation of the backhoe arm.

23. The vacuum excavation system according to claim 21, further comprising a surveillance assembly, the surveillance assembly comprising:

a. a video camera attached to the mounting adapter at a position to be directed to the excavation site,

b. a video transmitter operatively attached to the video camera to receive and transmit images from the video camera; and

c. a monitor located inside the operator cab, positioned to be visible to an operator in the operator cab, and operatively connected to the video transmitter to receive and display the transmitted images from the video camera.

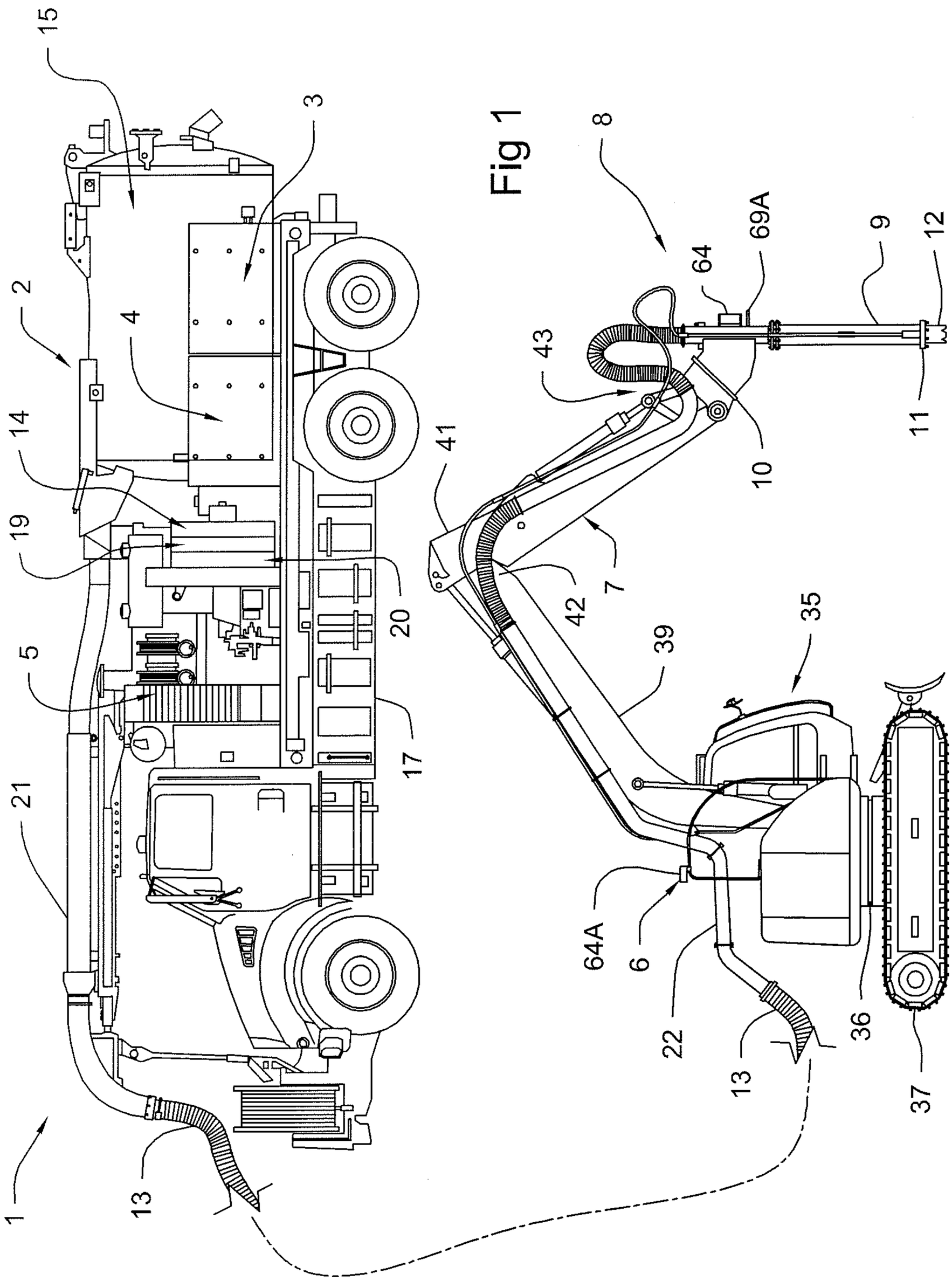
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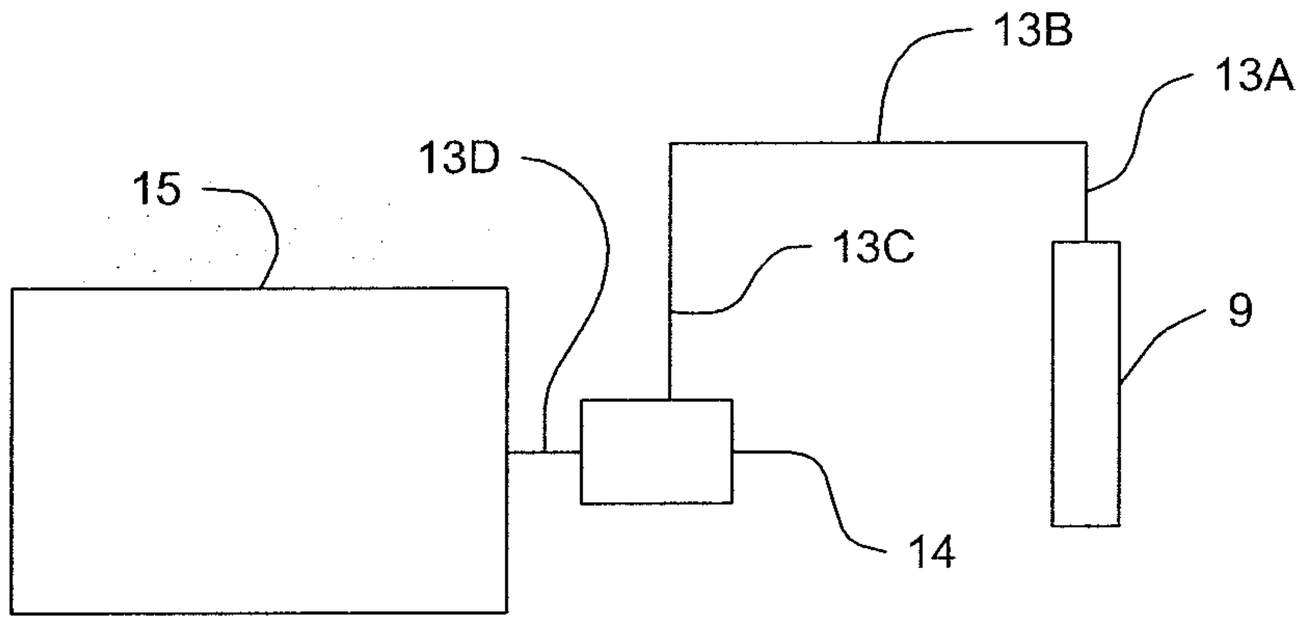
Fig 1

Fig 2



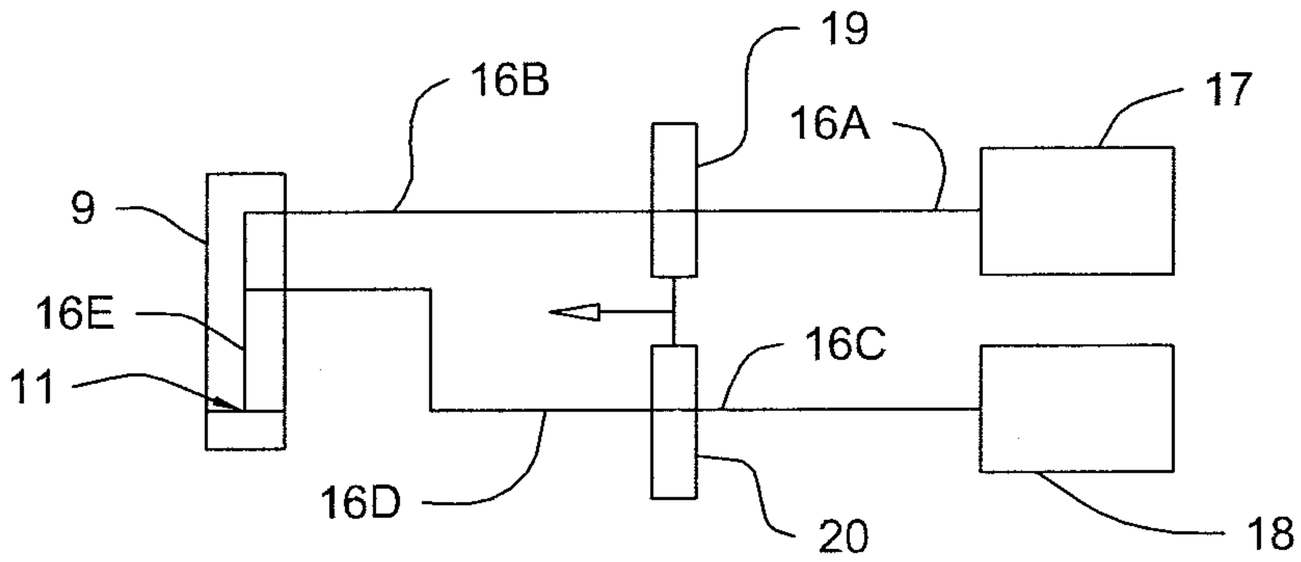


Fig 3

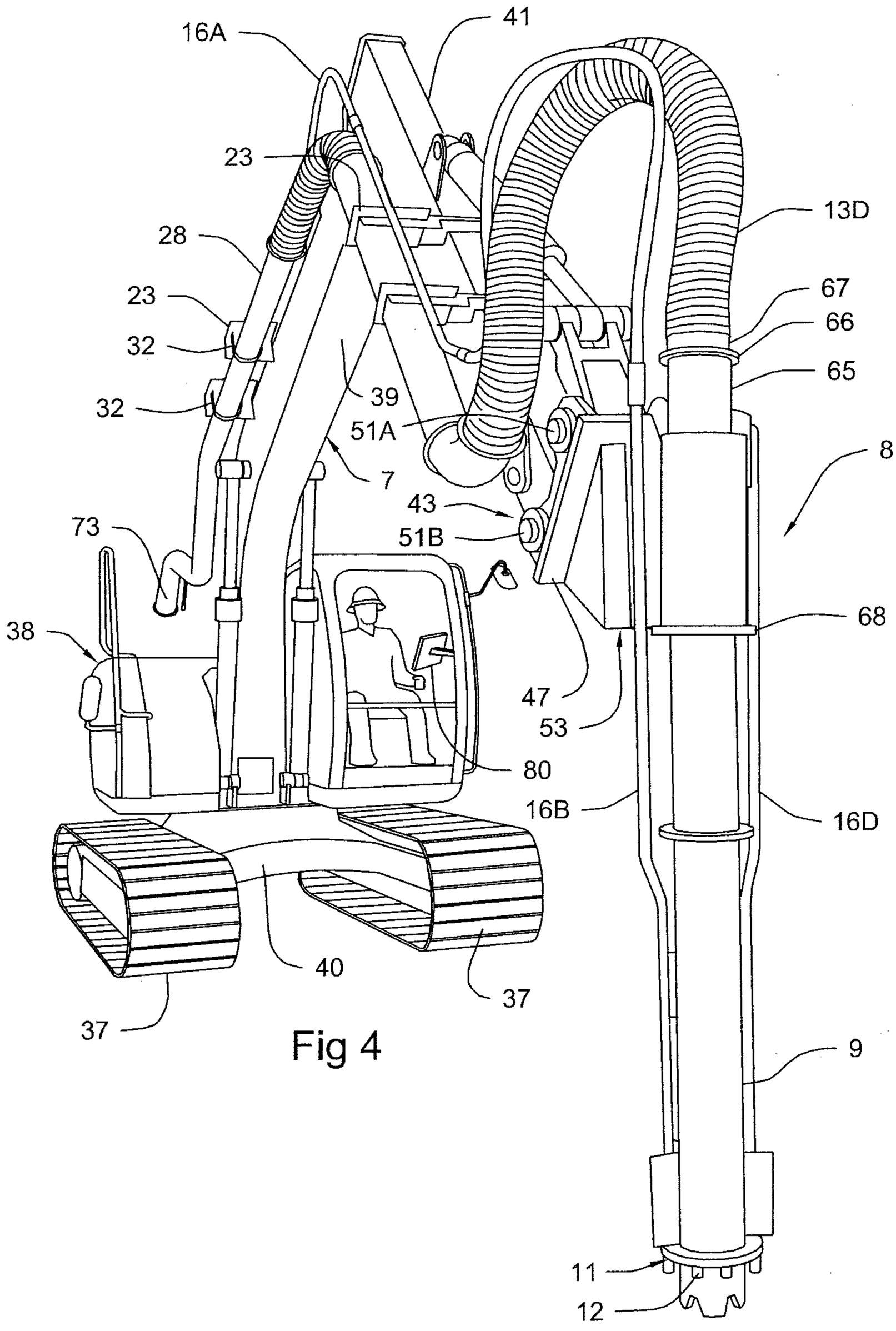

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Fig 4

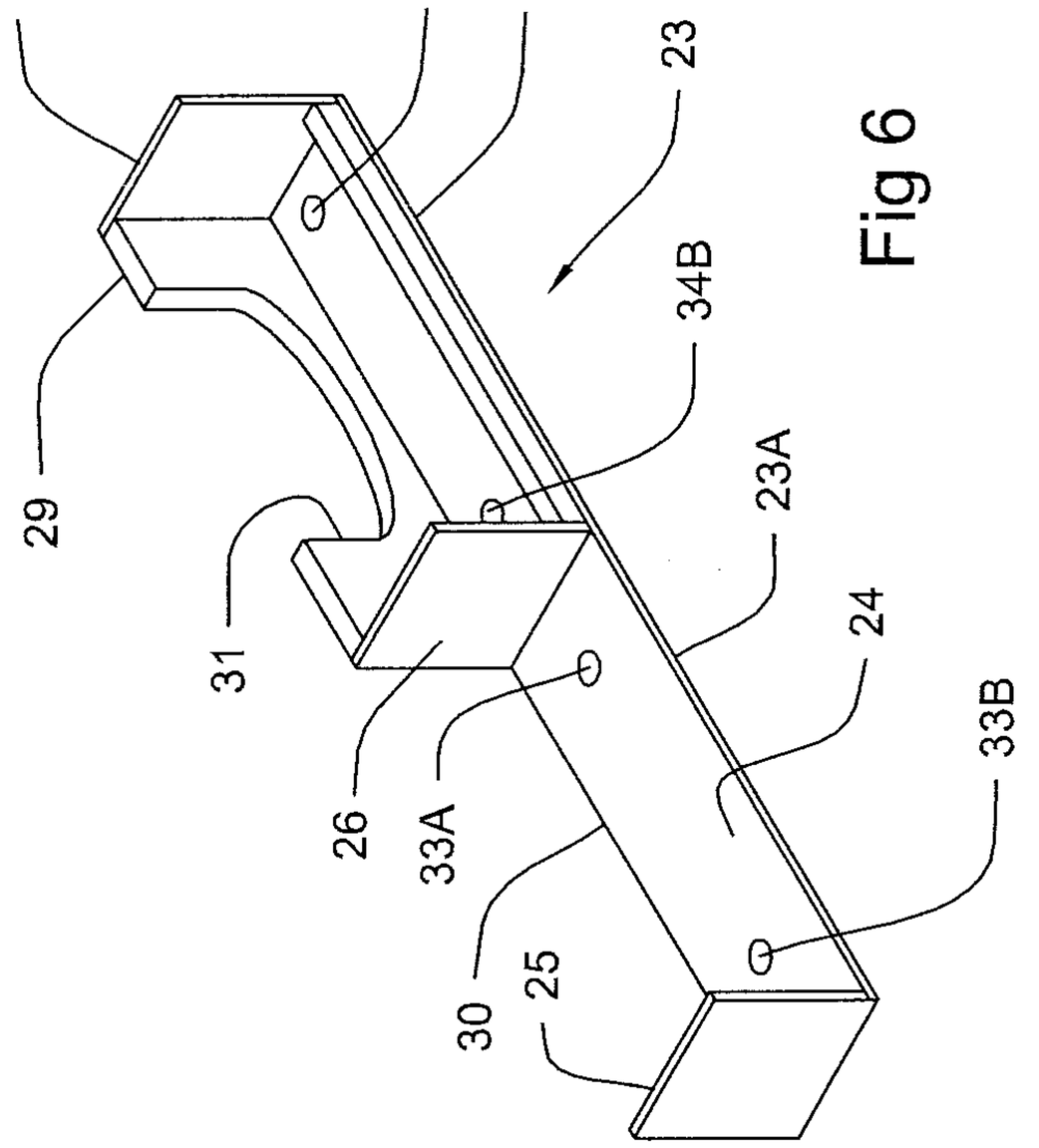
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Fig 6

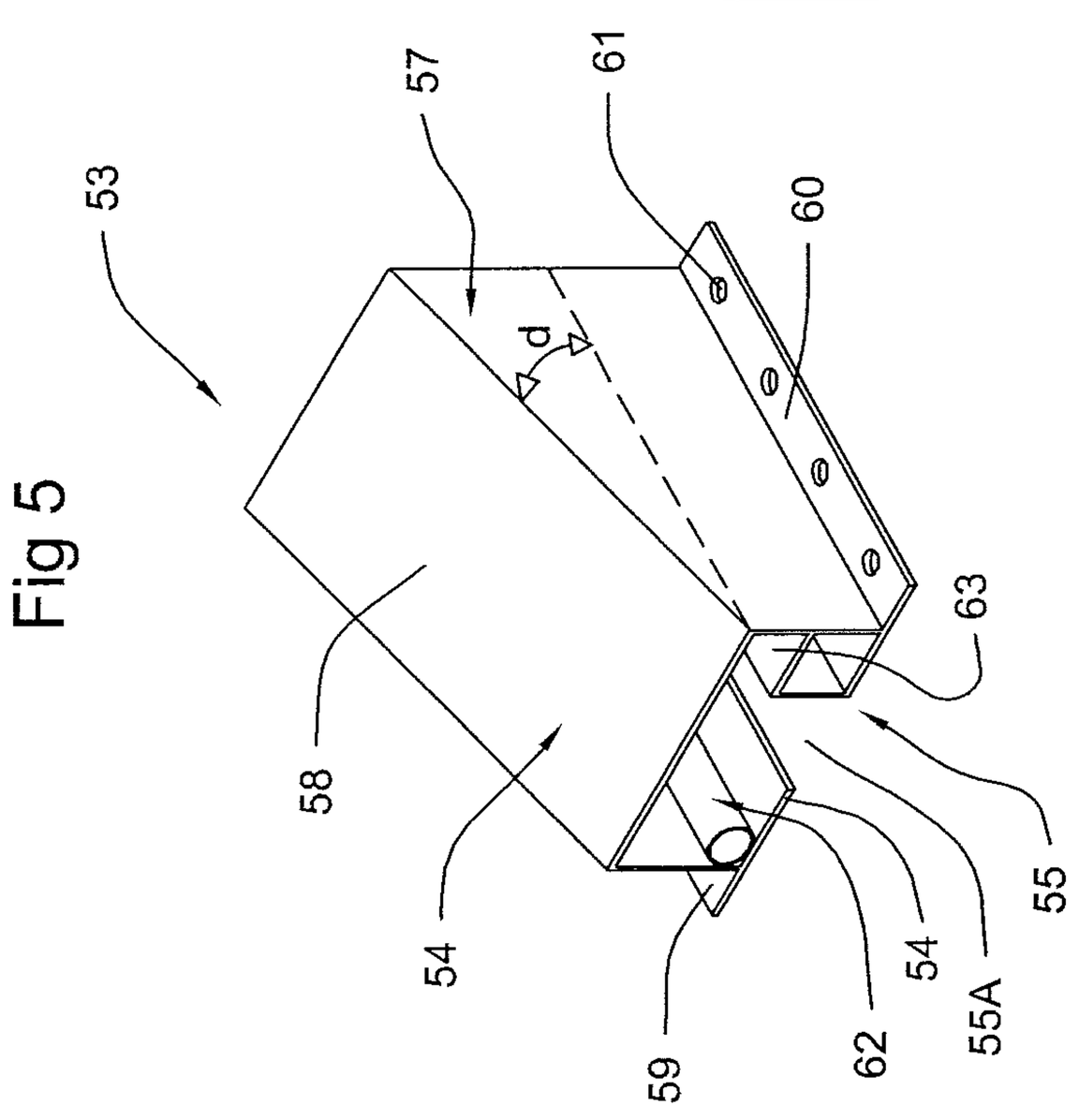
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Fig 5

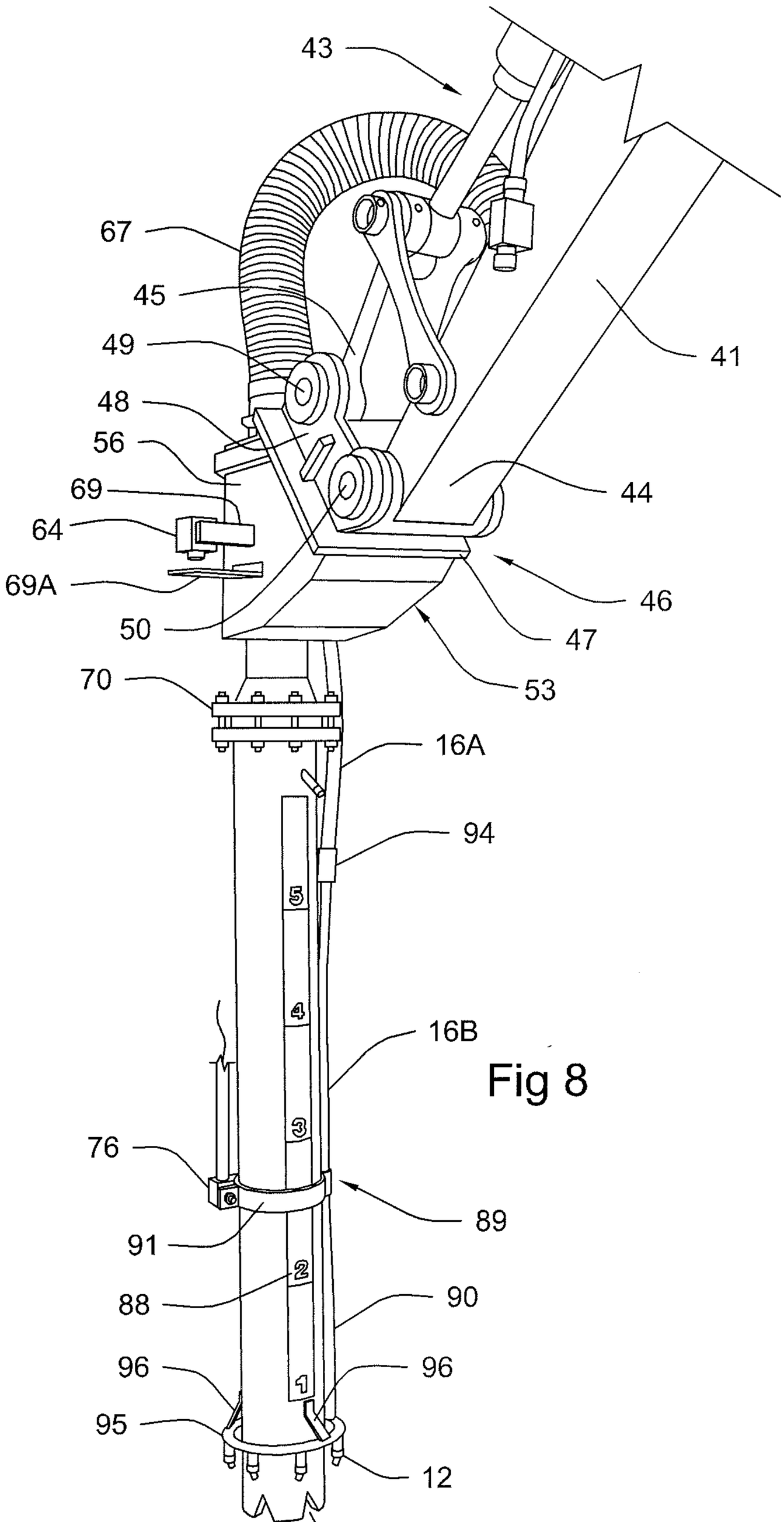
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Fig 8

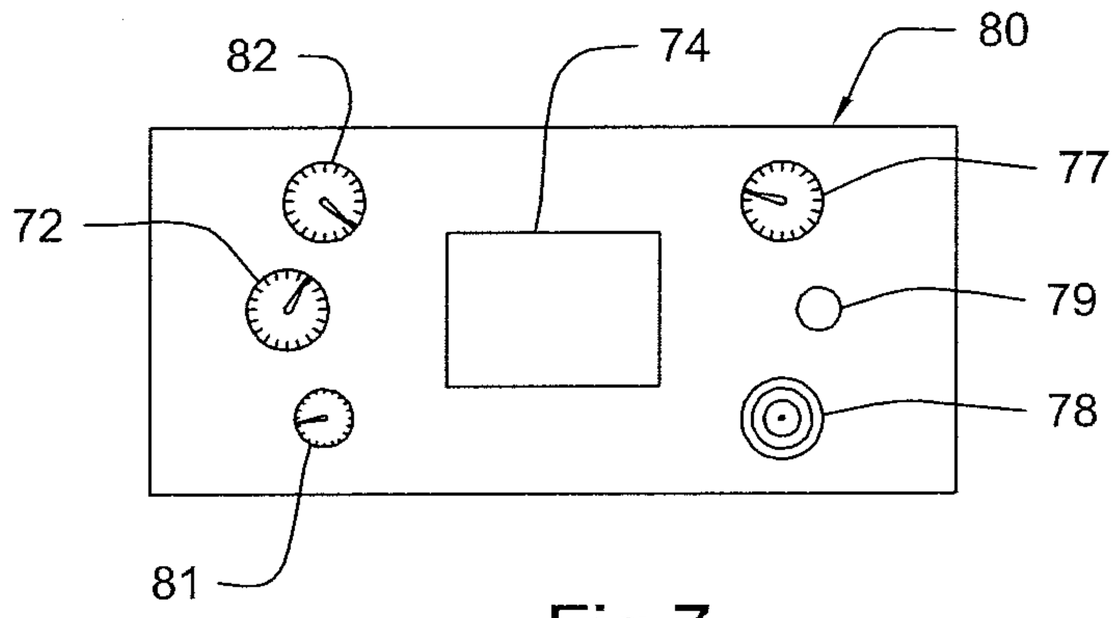

Fig 7

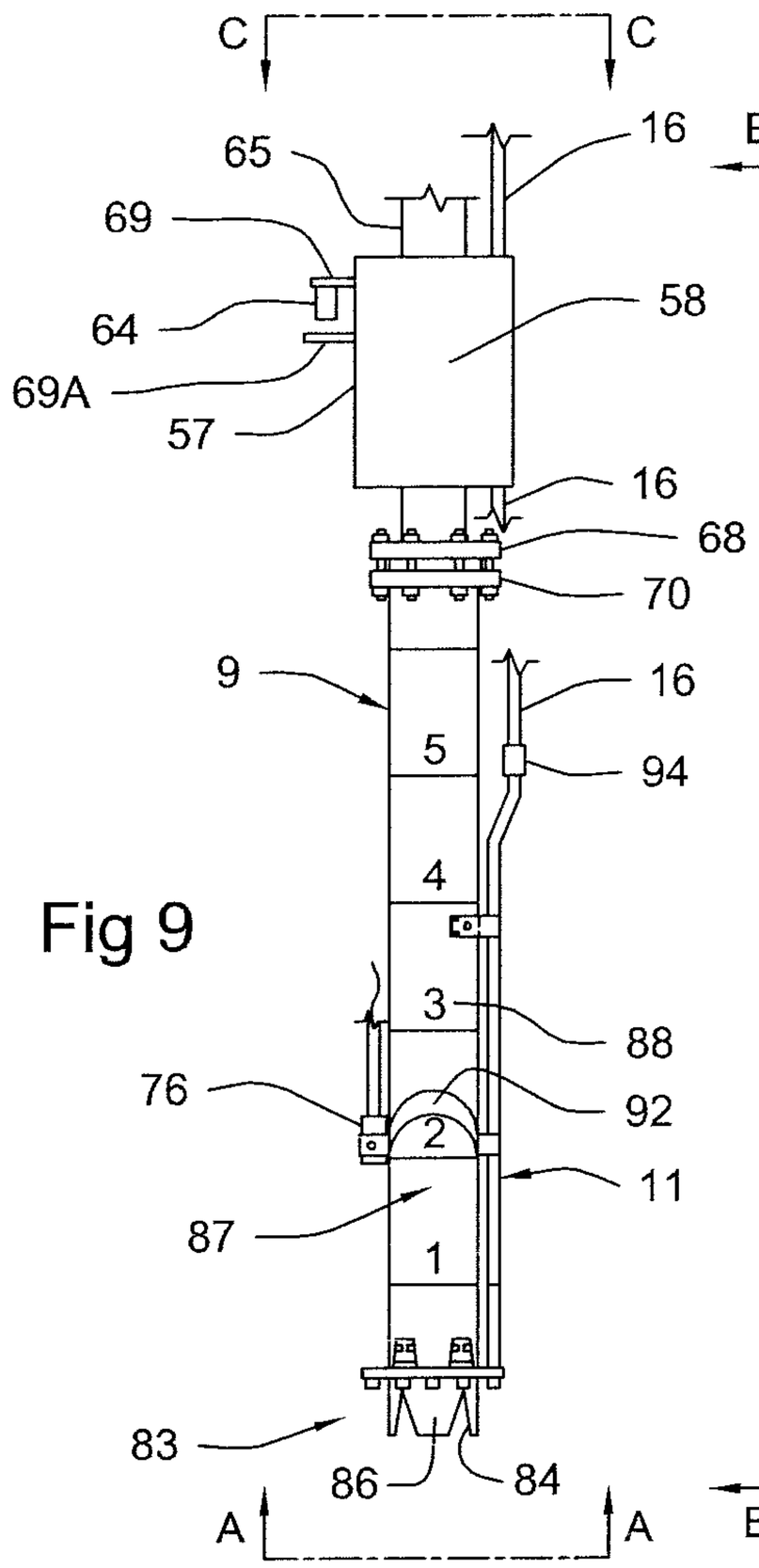

Fig 9

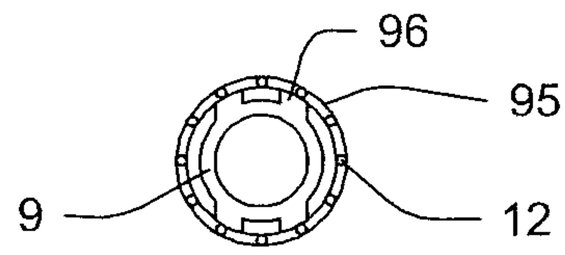

Fig 10

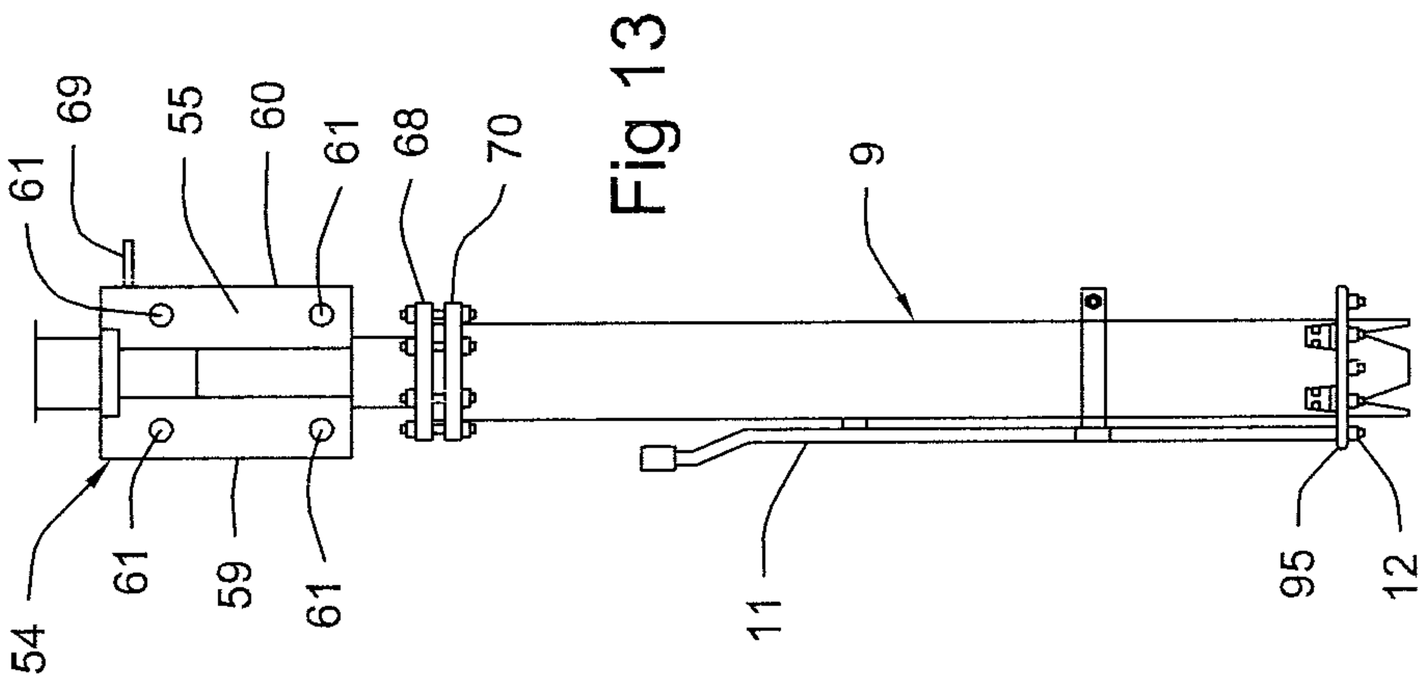

Fig 13

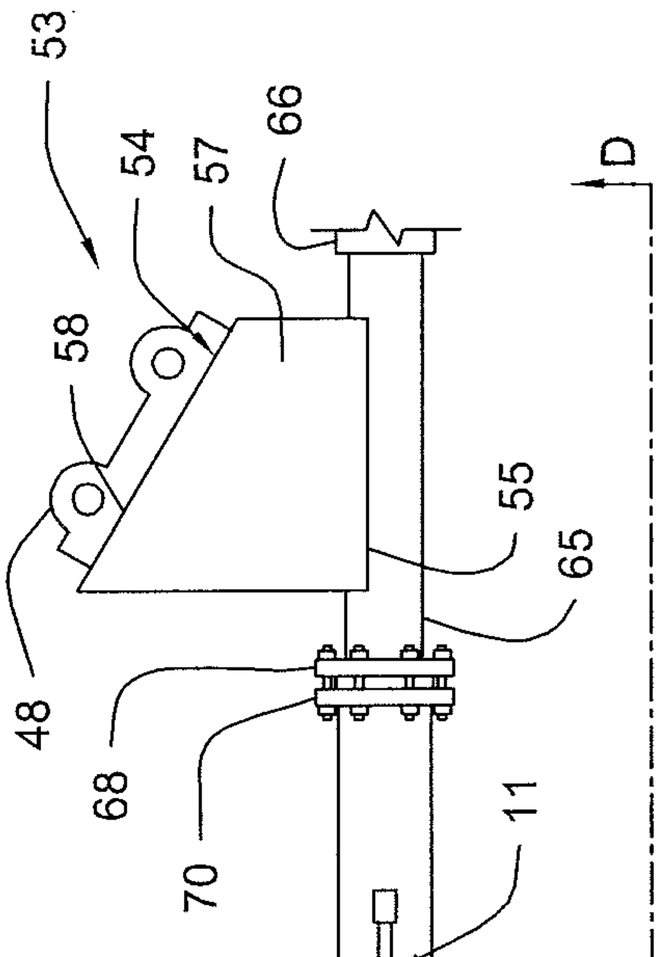

Fig 11

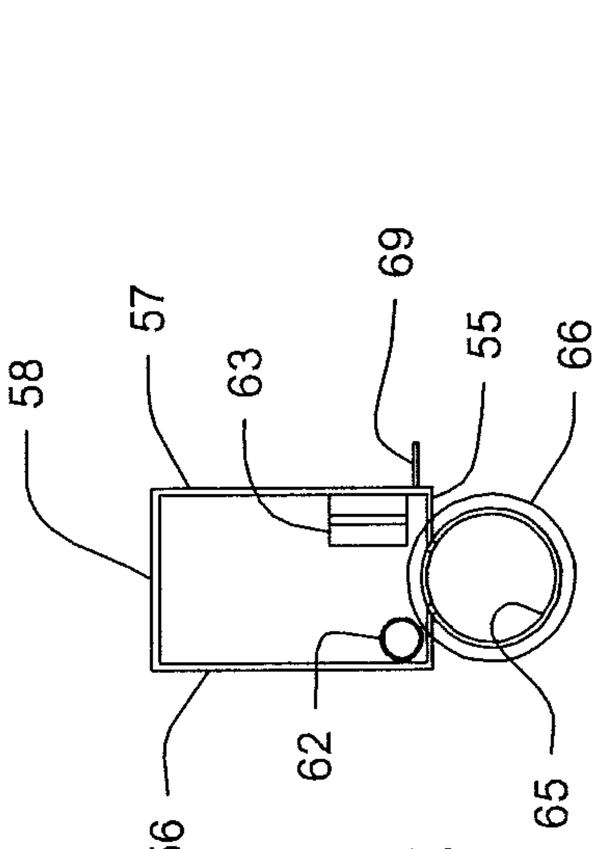

Fig 12

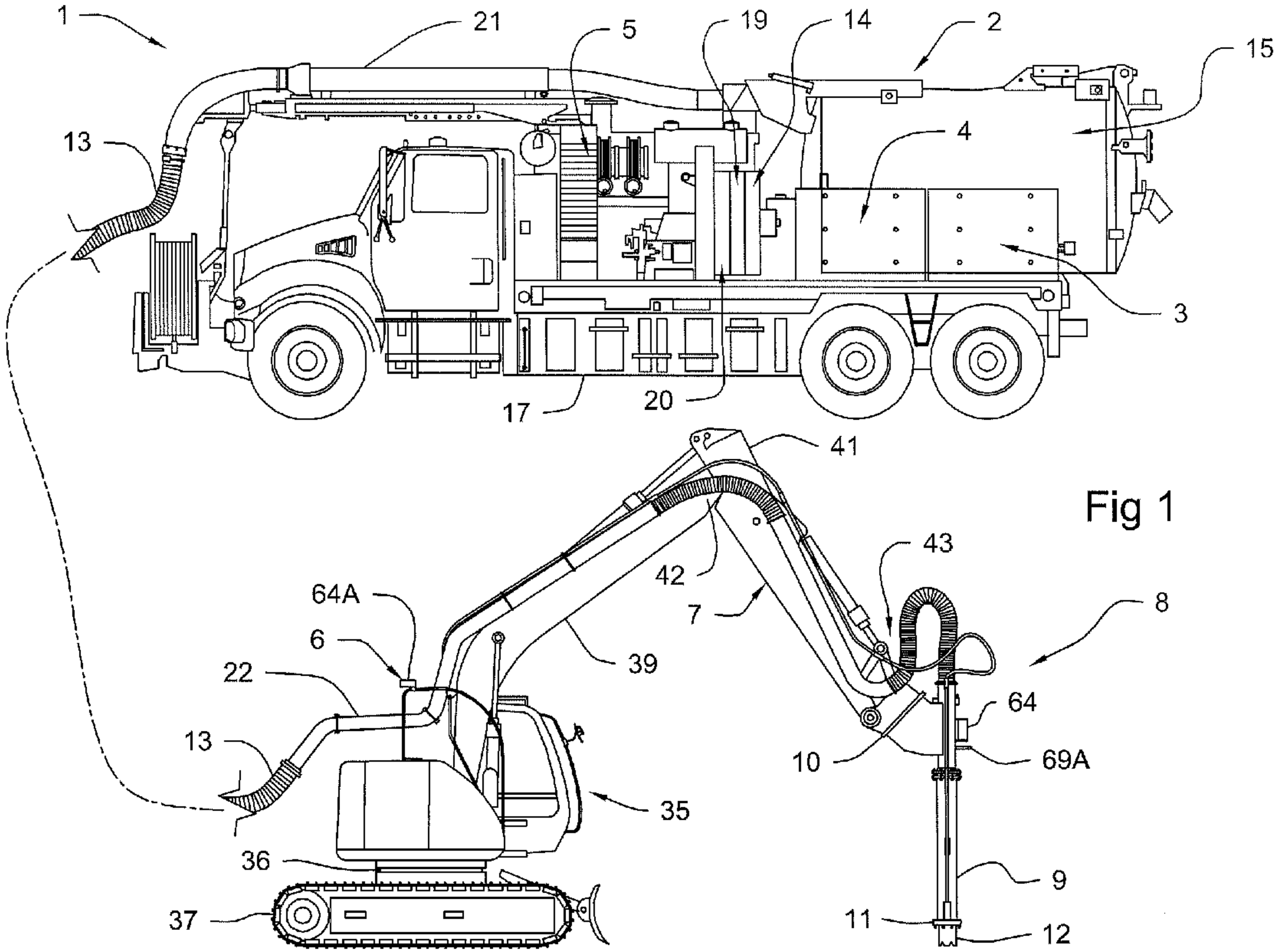
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Fig 1