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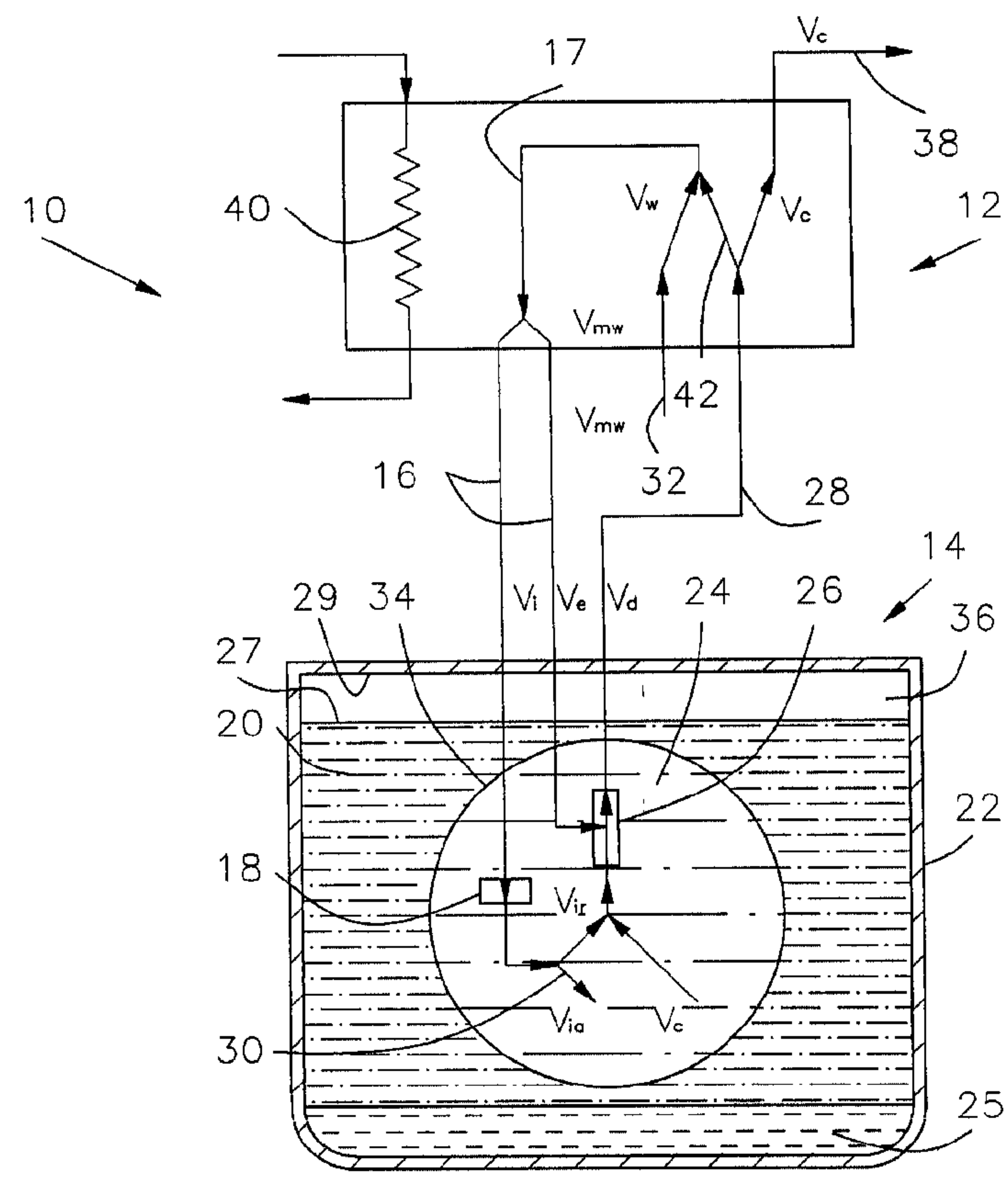


(57) Abrégé/Abstract:
A method and apparatus is disclosed to remove product from a containment structure. An extractor assembly includes integral injector and eductor assemblies axially spaced with respect to each other. The extractor assembly produces a mixing, emulsifying, or thermal cavity within the product below the top surface of the product whereby heat produced within the mixing, emulsifying, or thermal cavity must pass through the product before reaching the walls of the containment structure thereby utilizing the product as an insulator to maintain heat within the mixing, emulsifying, or thermal cavity.

## ABSTRACT OF THE DISCLOSURE

A method and apparatus is disclosed to remove product from a containment structure. An extractor assembly includes integral injector and eductor assemblies axially spaced with respect to each other. The extractor assembly produces a mixing, emulsifying, or thermal cavity within the product below the top surface of the product whereby heat produced within the mixing, emulsifying, or thermal cavity must pass through the product before reaching the walls of the containment structure thereby utilizing the product as an insulator to maintain heat within the mixing, emulsifying, or thermal cavity.

# APPARATUS AND METHOD FOR RECOVERING PRODUCT

## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

The present invention relates generally to apparatus and method for recovering products and, more particularly, to apparatus and method for forming a mixing, emulsifying, or thermal cavity within the product.

### 2. Description of the Background

In the past, various methods have been attempted for recovering products such as the extraction of heavy oil cargoes from sunken vessels. Such methods may also relate to recovery of products from other types of containments such as subterranean tanks, underwater tanks, floating tanks, and tanks located on the ground. Such tanks may be artificial or natural.

For instance, U.S. Patent No. 3,831,387 provides for removal of oil from a sunken vessel by means of a remotely controlled submersible pump-house or salvage capsule which performs the functions of gaining access to, and removal to the surface, of oil contained in the sunken vessel. The functions include means for securely but detachably fixing the capsule to the decking or hull of the vessel in proximity to the compartment from which the oil is to be

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salvaged, drill means for providing access to the compartment through one or more openings, extensible oil suction pipe means for inserting into the compartment from which the oil is to be salvaged, first pump means for removing oil from the ship compartment into a holding chamber, and a second pump means for removing oil from the holding chamber to the surface where it may be held in suitable storage such as balloons or salvage tankers. However, there is no description of a sufficiently efficient means for heating the product and reducing its viscosity.

U.S. Patent No. 4,287,903 to M. Cessou provides for an apparatus and method to displace product from a tank, such as that of an oil tanker, by forming and permanently maintaining at the upper part of the tank, above the product, an aqueous phase, filling progressively the tank as the product is removed through a drain pipe. Jets of hot water are introduced into this aqueous phase and a secondary injection is effected in the aqueous phase above the level of these jets. However, this system loses efficiency due to relatively high thermal losses resulting from direct exposure of the aqueous phase on top of the product to the high thermal conductivity of the tank, deck head, and hull. As well, the rate of emulsification or mixing of the product with water is not readily controllable because the hot water jets are introduced into the aqueous phase rather than the product.

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Other problems not necessarily addressed by the prior art also include the need for quick mobilization throughout the world, equipment design that is operable or adjustable with respect to adverse weather or sea conditions, a containment structure with sloping or irregular surfaces, and the need for backup safety features to prevent loss of product in the case of main equipment failure.

Thus, there has been a long felt need in the industry to provide a practical means for retrieving product in an efficient, workable manner. Those persons skilled in the art will appreciate the present invention which provides substantial solutions to these and other problems associated with product recovery apparatus and methods.

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SUMMARY OF THE INVENTION

In a preferred embodiment, the present invention provides an extractor apparatus for removing product from a containment structure that comprises an extractor housing with a product removal bore therein for removing the product. An extension assembly positions the preferably rigid extractor housing within the product of the containment structure. An injector assembly is secured to the extractor housing and has an injector to introduce feed fluid into the product. An eductor assembly is also secured to the extractor housing and has an eductor bore connecting to the product removal bore. A feed pump preferably supplies the injector assembly with feed fluid. The feed fluid, in one presently preferred embodiment of the invention, produces a pressure differential within the eductor assembly to induce product to flow into the eductor bore.

In a preferred embodiment, the present invention provides a method for removing product from a containment structure including forming a mixing, emulsifying, or thermal cavity with the product that contains a mixture of product and injected fluid. The mixing, emulsifying, or thermal cavity is positioned below the top surface of the product in the thermal containment structure. For this purpose, an injector assembly is introduced into the product through an opening in the containment structure. An eductor assembly is introduced into the product in proximity to the injector assembly. The mixing,

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emulsifying, or thermal cavity is formed within the product such that the mixing, emulsifying, or thermal cavity contains the injector assembly and the eductor assembly. The mixing, emulsifying, or thermal cavity contains a mixture of product and injected fluid therein and is, at least initially, substantially surrounded by unmixed product. The cavity can be formed by a variety of means including a combination of simultaneously injecting and removing product and injected fluids or gases. For example, by creating a thermal difference with heated fluids, a pressure change, a volume change, or by injecting one or a variety of fluids or gasses. These injected fluids or gasses can cause chemical reactions, thermal changes, viscosity changes, density changes, etc. in the cavity. If, for instance, the product is oil and injected fluid is water, then an emulsified mixture will be created in the cavity or region of interest which is maintained below the surface of the product.

The product, such as oil, surrounding the mixing, emulsifying, or thermal cavity insulates the mixing, emulsifying, or thermal cavity with respect to the containment walls and any seawater or other material outside the containment structure. An upper layer of substantially unmixed product is preferably maintained as long as possible throughout the extraction process to continue to keep thermal leakage to a minimum.

It is an object of the present invention to provide an improved apparatus and method for removing product from a

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containment structure.

It is a further object of the present invention to provide a method and apparatus that uses the insulating properties of the product to reduce thermal losses to the ambient environment.

It is yet another object of the present invention to provide full control over the size of the mixing, emulsifying, or thermal cavity created, as well as the ratio of it product/fluid contents.

A feature of a preferred embodiment of the present invention is an eductor introduced directly into the cargo or product in conjunction with a fluid injection device.

A further feature of a preferred embodiment of the present invention is an improved containment device to prevent leaking fluids around tank entry ports.

Yet another feature of a preferred embodiment of the present invention is a fail safe system which allows for termination of the removal operation and sealing of the tank in the event of loss of operational control.

Another feature is a pressure control system that maintains a pressure balance within the containment system or tank.

Another feature is an integral injector/eductor assembly.

An advantage of the present invention is a modular design that allows for rapid mobilization anywhere in the world.

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Another advantage of the present invention is a system designed to operate in adverse weather and current conditions and provides for intermittent operation where necessary due to extreme conditions.

Yet another advantage of the present invention is greater efficiency to thereby shorten operational times and reduce costs and environmental risks.

Another advantage of the present invention is that all product carrying hoses can be flushed with hot water prior to disconnection and all hoses have auto shut off capability triggered by disconnection.

These and other objects, features, and advantages of the present invention will become apparent from the drawings, the descriptions given herein, and the appended claims.

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## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates schematically a product extraction process in accord with the present invention;

FIG. 2 illustrates schematically a general overview of a system for extracting a product in accord with the present invention;

FIG. 3 is an elevational view, partially in section, of a cargo extraction module in position to tap into a product tank;

FIG. 4 is an elevational view, partially in section, of a cargo extraction module with cargo extractor assembly extended into a product tank;

FIG. 5 is an elevational view, partially in section, of a pressure control manifold through which the cargo extractor assembly of FIG. 4 extends;

FIG. 6 is an elevational view, in section, of a multi-ported cargo extractor assembly;

FIG. 6A is a cross-sectional view of the invention of FIG. 6 along the lines 6A-6A;

FIG. 6B is a elevational view, partially in section, of a manifold for the cargo extractor; and

FIG. 7 is an elevational view, partially in section, of a cargo extraction module in a mobilization / demobilization configuration.

While the present invention will be described in connection with presently preferred embodiments, it will be understood that it is not intended to limit the invention

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to those embodiments. On the contrary, it is intended to cover all alternatives, modifications, and equivalents included within the spirit of the invention and as defined in the appended claims.

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DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, and more particularly to FIG. 1, there is schematically shown a preferred embodiment of the product extraction process 10 of the present invention. While this invention is applicable to many product and containment systems, in this example the proposed product is heavy oil in the cargo tank of a sunken vessel. Product extraction process 10 can be divided into a surface process 12 and a remote process 14 as shown in FIG. 1 and, with components of an extraction system, in FIG. 2.

In the remote portion 14 of the process, hot fluid is pumped through lines 16 at an adjustable flow rate through an injector assembly 18 in the body of the oil 20 contained in cargo tank 22. A mixing, emulsifying, or thermal cavity 24 is created as a result of the combination of localized fluid injection, heat transfer, and eductor 26 suction. The injected fluid and cargo oil form a mixture of recovered injected fluid and cargo oil retrievable through line 28. The cavity, or region of interest, can be formed by a variety of means including a combination of simultaneously injecting and removing product and injected fluids or gases. For example, by creating a thermal difference with heated fluids, a pressure change, a volume change, or by injecting one or a variety of fluids or gasses. These injected fluids or gasses can cause chemical reactions, thermal changes, viscosity changes, density

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changes, etc. in the cavity. If, for instance, the product is oil and injected fluid is water, then an emulsified mixture will be created in the cavity or region of interest which is maintained below the surface of the product.

$V_{ir}$ is the rate of that portion of injected fluid which is recovered or drawn in through eductor 26. $V_c$ is rate cargo or oil 20 is extracted from tank 22 and which is separated into line 38 for storage or transportation. $V_{ia}$ is the rate at which injected fluid accumulates in tank 22 to replace the cargo oil 20 extracted. $V_e$ is the rate at which injection fluid flows into the eductor nozzle (see FIG. 6), as discussed hereinafter according to one of the preferred embodiments of the present invention, to induce the extraction flow into line 28 that contains the mixture of cargo oil 20 and injected fluid 17.

The fluid/oil mixture forms a mixing, emulsifying, or thermal cavity 24 within the body of oil 20 that is substantially centered around the injector/eductor assembly. Mixing, emulsifying, or thermal cavity 24 steadily enlarges because oil 20 is removed and water 30 from injector 18 is being added to the volume of the mixture. Over the course of the extraction process, mixing, emulsifying, or thermal cavity 24 enlarges to the point where all the oil 20 that can be extracted has entered the mixture and has been pumped to the surface.

Initially, mixing, emulsifying, or thermal cavity 24 is preferably entirely surrounded by product 20 although it may or may not be spherical in shape. As mixing, emulsifying, or thermal cavity 24 enlarges due to the removal of product 20 and replacement with injection fluid, mixing, emulsifying, or thermal cavity 24 will preferably first break through to aqueous layer 25, if present in tank 22, while still maintaining a layer of product 20 above mixing, emulsifying, or thermal cavity 24 but below a top surface 27 of product 20. Top surface 27 will be the top of the product body in which mixing, emulsifying, or thermal cavity 24 is formed and may or may not be separated from a top inner tank surface 29 by a layer of gas 36 or other fluid. Layer 36 of gas or other fluid, if present or injected, continues to prevent thermal leakage and product trappage (such as in between support members) in the very latter stages of the extraction process. After breaking through to aqueous layer 25, mixing, emulsifying, or thermal cavity 24 may be substantially dome shaped and steadily enlarges. Maintaining a layer of product above mixing, emulsifying, or thermal cavity 24 results in maximum thermal energy retention so as to provide the most efficient extraction of product.

The mixture of product and injected fluid enters the intake of the eductor 26 driven by the motivating flow rate $V_c$ and is pumped to the surface in line 28 where it enters surface process 12. It is important to maintain control over the balance of flow rates $V_{ia}$ and $V_c$ because an imbalance here could cause either an over-pressurization or an under-pressurization of cargo tank 22. This balance and the resulting tank pressure are controlled in this invention by control of flow rates $V_i$ and $V_e$, in lines 16 that may be separately controlled, and by the control of the pressure differential between the mixing, emulsifying, or thermal cavity 24 26 and the ambient sea 32 pressure and other pressure differentials discussed hereinafter. Such pressure differentials may be monitored on the surface or automatically controlled in remote portion 14 of the process.

In order to keep the extraction time to a minimum and thus increase efficiency thereby lowering costs and reducing environmental risks, it is important to maintain a high product (oil) / water ratio in the extracted mixture 28. In this invention, the ratio tends to stay relatively higher, as compared to other extraction processes, due to the designed use of the insulating properties of the product 20 around mixing, emulsifying, or thermal cavity walls 34. Furthermore, the product (oil) / water ratio is maintained at a higher value through control of the injector water temperature, the relative positioning of the injector/eductor assembly, and the design of the injectors including their array configuration (See FIG. 4,5 and 6). The size of mixing, emulsifying, or thermal cavity 24 and product (oil) / water mixture is controllable by, for instance, increasing or decreasing feed fluid flow rate and/or the temperature of the feed fluid.

The method of the present invention provides a high heat transfer to the product because all net heat delivered to the tank 22 must pass into product 20 as long as product

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20 surrounds mixing, emulsifying, or thermal cavity 24. The surrounding product 20 acts as an insulating layer which must be heated before any heat can reach the highly heat conductive sea water 32 so as to maintain mixing, emulsifying, or thermal cavity 26 at a relatively higher temperature.

Where desirable, in the latter stages of tank extraction, gaseous buffer 36 may be maintained/formed at the top of tank 22 to act as an insulator to maintain a higher temperature of liquids 20 in tank 22 or to promote freeing of product from entrapment areas e.g. tank ribs or deck stiffeners.

In surface process 12, which is described in more detail with respect to FIG. 2, the product (oil) is separated as lighter feed 38 where it is stored or transported to a storage facility. Water 42 from the product (oil) / water mixture 28 returns to be circulated along with additional sea water 32. The boiler 40 provides the heat energy for the injected water.

FIG. 2 provides a general description of a preferred embodiment of the apparatus or system. Cargo extractor assembly (extractor) 50 is inserted into product 52 in a containment device such as cargo tank 54 of a sunken vessel 56. Extractor 50 is supported by the cargo extractor module (module) 60, of which it is a part. Hose arrays 62, including jumper hose array 64, connect module 60 to the surface equipment. Hose arrays 62 and 64 are arranged as integral umbilicals by the use of hose spreaders 66, and associated flange connections 68. Hose arrays 62 and 64 are handled with subsea rigging system 70 on support vessel 72. This hose arrangement increases handling efficiency and eliminates damage associated with subsea hose motion thus enabling the system to operate in adverse current and weather conditions. Hose arrays 62 and 64 are also controlled using ballast block 74 to anchor hose arrays 62 and 64 to seabed 76 via clamp assembly 78 and cable 80 connecting to the support platform.

The main surface equipment consists of discharge handling system 82, hot water supply system 84, and surface control module 86. These systems are supported by boiler system 88, and sea water make-up system 90 via sea water intake 92. All of the surface equipment is mounted on a suitable support platform such as a vessel of opportunity 72.

To enhance mobilization, it is preferred that most of the surface equipment be of the type which can be bought and used with little or no modifications. Control module 86 may be dedicated to control of the operation according to the method of the present invention as discussed herein or may be a standard control module as used for other purposes. Use of standardized components for most elements of the system reduces costs and greatly increases mobilization speed by allowing purchase of most components on a local basis throughout the world.

FIG. 3, 4, and 7 provide views of module 60 during various stages of the operation. In FIG. 3, module 60 is

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in the hot tapping position. In the hot tapping position, module 60 is suspended preferably on four legs 96, that have hydraulically or mechanically adjusted feet 98 for leveling and/or raising module 60. Feet 98 may be affixed to the tank 100 if necessary as, for instance, may be required for operating with strong currents and/or adverse weather conditions. Leveling means 102 (see FIG. 7) and four feet 98 allow module 60 to operate on irregularly shaped, curved, or slanting surfaces.

Derrick 104 holds hot tapping machine 106 in position over valve 108. Valve 108 is connected to hot tap base 110 via a quick-connect flange connection. Hot tap base 110 is fastened and sealed to the deck 100. Hot tap machine 106 uses cutter 112 to cut a hole 114 (see FIG. 4 and 7) in deck 100 through the center of hot tap base 110. After completion of cargo extraction, cutter 112 is replaced with an annulus sealing head that places a seal 111 (see FIG. 7) in hot tap base 110 to effectively seal hole 114.

Variable ballast tanks 116, in conjunction with fixed buoyancy, are part of a variable buoyancy system which allows for overall weight and attitude adjustment to facilitate maneuvering of module 60. The buoyancy system may be controlled from the surface, by a diver, or via a remotely operated vehicle. During product extraction operations, module 60 is normally never allowed to be positively ballasted. Large diameter wheels 118 and assorted control apparatus allow a single diver or remotely operated vehicle to move module 60 to a new location while

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negotiating minor obstacles.

Hydraulic system 120 provides power for module 60 functions. Hydraulic system 120 may be supplied with hydraulic fluid from the surface, from a remotely operated vehicle, or generate its own pressure in the remote location. A multiplexed control system, or other control system, may be used to control module 60 remotely.

FIG. 4 discloses a view of module 60 with extractor 50 extended through hole 114 in tank top 100. For simplicity, the system is shown on a flat and horizontally positioned deck 100. However module 60 can be configured to meet the requirements of any particular project. Derrick 104 supports extractor 50 and is mounted on pivots 120 via arms 122 so that it may support extractor 50 in the preferred orientation position.

FIG. 5 shows, in greater detail than FIG. 4, a presently preferred embodiment of pressure control manifold 130. Extractor 50 passes through body 132 of pressure control manifold 130 (See FIG. 5 for detail of manifold 130). Pressure control manifold 130 connects to valve 108 which, in turn, connects to hot tap base 110. Pressure control manifold 130 contains reversed relief valves 134 that ensure that the tank pressure in the vicinity of the penetration 114 is pressure balanced and cannot fall outside the limits dictated by the setting of the relief valves 134. Relief valves 134 are preferably connected to hoses (not shown) that direct fluid to a desired location. Extractor 50 automatically provides a double seal for penetration 114 upon withdrawal from containment 100. The body of extractor 50 is sealed by seals 140 and, upon withdrawal of extractor 50, circumference plug end 136 engages seal 138 to thereby securely seal off penetration 114.

FIG. 6, 6A, and 6B provide a cross-sectional view of extractor 50. Extractor 50 preferably includes injector assembly 152 axially spaced from eductor assembly 159. Extractor 50 has a cylindrical body 150 with injectors, such as injector 153, and eductor intakes, such as intake 156 disposed along an end portion thereof. Injector assembly 152 preferably includes a plurality of injectors and may include upwardly directed injectors 153 and downwardly directed injectors 155. The eductor intakes 156 are connected by radial passageways 157, preferably more than two, communicating from the outside of the body 150 to central eductor bore 158 in the vicinity of eductor nozzle 154.

In a presently preferred embodiment, feed fluid flow through eductor nozzle 154 may be adjusted to produce a differential pressure between mixing, emulsifying, or thermal cavity 24 and central eductor bore 158, or along the length of radial passageways 157, to enhance draw of product/feed fluid mixture into intakes 156. Intakes 156 are a fixed and known distance above injector assembly 152. Discharge flow from the educator assembly 159 flows up through venturi 160 and passes into discharge bore 161.

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Feed fluid for the eductor assembly 159 and injector assembly 152 is preferably supplied through annular cavities 162 and 164 (see FIG. 6A) formed in housing 150 and axially disposed along extractor 50. Preferably at least two other annular cavities, 166 and 168, are available to provide communication to extractor discharge manifold 170 for mixing, emulsifying, or thermal cavity pressure, measurement, and relief flow. Thus, in a presently preferred embodiment, extractor 50 contains five substantially axially running passageways.

Opposingly oriented relief valves 172 of extractor discharge manifold 170 (FIG. 6B) limit direct pressure imbalance in the same way as do relief valves 134 in pressure control manifold 130. However, this relief valve system provides for pressure control at the core 23 of mixing, emulsifying, or thermal cavity 24 (see also FIG. 2), where the pressure changes first take place. Electronic sensors 174 (see FIG. 6) may be installed in the lower extremity of extractor 50 to provide for surface monitoring and additional control of pressure balance in the mixing, emulsifying, or thermal cavity 24. Eductor feed connector 176 (see FIG. 6B) , eductor discharge connector 178 and injector feed connector 180 are, in the presently preferred embodiment, disposed on an upper portion of extractor manifold body 182.

FIG. 7 shows module 60 in a mobilization / demobilization configuration. The entire derrick 104 with the extractor and hot tap machine 106 are folded and

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aligned over the top of module 60 (ballast tanks are not shown). The folding feature of the derrick facilitates ease of rigging during mobilization and may provide increased stability during deployment of module 60. By folding the derrick, module 60 provides a hydro-dynamically suitable configuration that allows a propulsion system to be incorporated therein.

In operation, the exact location of the intended penetration into the tank is determined. The deck is then cleaned in the general area of the intended penetration(s). Module 60 is then deployed from the deck of the surface vessel to the deck of the sunken vessel. The derrick 104 of module 60 is raised from the horizontal to the vertical position, if appropriate, after reaching the deck of the sunken vessel. Module 60 is aligned and leveled at the first penetration location. Hot tap base 110 is aligned prior to fastening. A check is preferably made for under deck gasses prior to attaching hot tap base 110. Hot tap base 110 is pressure tested prior to hot tapping the deck to allow insertion of extractor 50. The extraction process is then started up, including moving extractor 50 into the product through penetration 114. Once completed, the extraction process is stopped included retraction of extractor 50. Module 60 is then moved to the next extraction location as necessary.

Additional operational procedures may include such steps as placement of another hot tap base 110 on the deck close to the pre-determined location or alignment of module

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60 to the hot tap base of a previous penetration. The hot tap flange may be aligned using a flange alignment system. Hot tap valve 108 is connected to hot tap base 110. The seal 111 at a previous penetration, as discussed hereinbefore, may also be removed as desired. The hot tap assembly 106 is disconnected from hot tap valve 108. Pressure control manifold 130 is connected to hot tap valve 108 and that assembly is pressure tested. After completion of the operation, derrick 104 with extractor 50, hot tap machine 106, and module 60 are returned to the support platform.

All pressure regulators as well as bypass and relief valves are preferably designed into the overall system so that failure does not cause excessive tank pressure or allow product to leak into the environment. The hoses preferably have an auto shut off capability that is triggered upon disconnection. Furthermore, the product carrying hoses can be flushed with hot water before disconnection.

If operation parameters go out of limit due to weather conditions, machine failure, or the like, then valves in fluid lines 16 provide for automatic fluid dumping, extractor 50 is automatically retracted, the opening to the tank is sealed, and extractor 50 is insulated from product 2. Preferably extractor 50 is mounted with a passive retraction mechanism (not shown) that does not need power for retraction. For instance, the extension/retraction system could consist of a dual constant tension wire device

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that incorporates a passive retraction feature that activates if functions of module 60 fail. The containment system may be further secured with valve 108. The hoses are then flushed with water and extractor 50 is shut down prior to shutting down the entire pumping system.

The system allows for short and/or intermittent operation times. The hose arrays 62 and 64 can be laid down on the sea bed for a short term shut down. Preferably the hoses are first flushed with water as may be done in anticipation of adverse weather. A start-up heating system may be incorporated that is capable of bringing all fluids and equipment to operational temperature within a short time. Module 60 is preferably of modular construction to allow for air transport for emergency mobilizations.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof, and it will be appreciated by those skilled in the art, that various changes in the details of the illustrated construction or combinations of features of the various elements may be made without departing from the spirit of the invention.

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CLAIMS

**What is claimed is:**

1. A method for removing product from a containment structure, comprising the following steps:

forming a mixing, emulsifying, or thermal cavity within said product, said mixing, emulsifying, or thermal cavity containing a combination of product and injected fluid;

maintaining said mixing, emulsifying, or thermal cavity below a top surface of said product contained within said containment structure; and

removing said combination of product and injected fluid from said mixing, emulsifying, or thermal cavity.

2. The method of Claim 1, further comprising positioning said mixing, emulsifying, or thermal cavity such that all heat energy introduced into said mixing, emulsifying, or thermal cavity must pass through said product prior to contacting a wall of said containment structure.

3. The method of Claim 1, further comprising thermally insulating an upper portion of said mixing, emulsifying, or thermal cavity with respect to an upper containment structure inner wall surface by maintaining an upper product wall for a thermal insulator between said mixing, emulsifying, or thermal cavity and said top surface of said product within said containment structure.

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4. The method of Claim 1, further comprising controlling the size of said mixing, emulsifying, or thermal cavity by altering said injected fluid flow rate.

5. The method of Claim 1, wherein said step of forming further comprises introducing an injector assembly into said product through an opening in said containment structure and introducing an eductor assembly into said product in proximity to said injector assembly, said mixing, emulsifying, or thermal cavity being formed in surrounding relationship to said injector and said eductor.

6. The method of Claim 5, wherein the step of forming a mixing, emulsifying, or thermal cavity further comprises pumping feed fluid through said eductor to form a differential pressure such that a product/injector fluid mixture is drawn into said eductor.

7. The method of Claim 1, further comprising applying a pressure differential between said mixing, emulsifying, or thermal cavity and a pressure outside of said containment structure to a relief valve.

8. The method of Claim 1, further comprising sensing pressure within said mixing, emulsifying, or thermal cavity.

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9. A method for removing product from a containment structure, comprising the following steps:

introducing an injector assembly through an opening in said containment structure so it is positioned below a top surface of said product within said containment structure;

introducing an eductor assembly into said product in proximity to said injector assembly and below said top surface of said product within said containment structure;

pumping said heated feed fluid through said injector and removing a mixture of product and feed fluid through said eductor assembly so as to form a mixing, emulsifying, or thermal cavity within said product surrounding said injector assembly and said eductor assembly.

10. The method of Claim 9, further comprising insulating said mixing, emulsifying, or thermal cavity with respect to a wall of said containment structure by using said product surrounding said mixing, emulsifying, or thermal cavity.

11. The method of Claim 9, further comprising insulating said mixing, emulsifying, or thermal cavity with respect to an upper wall of said containment structure by using said product disposed between said mixing, emulsifying, or thermal cavity and said top surface of said product within said containment structure.

12. The method of Claim 9, further comprising providing said injector assembly and said eductor assembly within a

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substantially rigid housing such that said eductor assembly is axially spaced along said housing from said injector assembly.

13. The method of Claim 12, further comprising sealing said containment structure by withdrawing said substantially rigid housing out of said containment structure into a seal housing and into contact with a seal in said seal housing.

14. The method of Claim 9, further comprising forming a differential pressure between an internal portion said eductor assembly and said mixing, emulsifying, or thermal cavity to draw into said eductor a mixture of said product and feed fluid from said mixing, emulsifying, or thermal cavity.

15. The method of Claim 9, further comprising dispatching an underwater module containing said injector assembly and said eductor assembly from a support platform and supporting said underwater module on an outer surface of said containment structure.

16. The method of Claim 9, further comprising raising a derrick on an underwater module.

17. The method of Claim 9, further comprising providing a relief valve outside of said containment structure in

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direct communication with said mixing, emulsifying, or thermal cavity through a housing containing said injector assembly.

18. The method of Claim 9, further comprising maintaining a gaseous layer between said mixing, emulsifying, or thermal cavity and an upper portion of said containment structure.

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19. An extractor apparatus for removing product from a containment structure, comprising:

an extractor housing movable within said containment structure;

an injector assembly carried by said extractor housing so as to be movable therewith, said injector assembly having an injector to inject feed fluid into said product;

an eductor assembly carried by said extractor housing so as to be movable therewith, said eductor assembly having an eductor bore for receiving product from said containment structure; and

a feed pump to pump said feed fluid to said injector assembly.

20. The apparatus of Claim 19, wherein said extractor housing includes a first feed fluid bore therein to receive feed fluid from said feed pump for delivery to said injector assembly.

21. The apparatus of Claim 20, wherein said extractor housing includes a second feed fluid bore therein, said first and second feed fluid bores providing feed fluid to said injector assembly and said eductor assembly, respectively.

22. The apparatus of Claim 21, wherein said extractor housing includes a product removal bore therein for removing said product.

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23. The apparatus of Claim 21, further comprising:

a nozzle within said eductor assembly for receiving fluid from said second feed fluid bore so as to produce a differential pressure between said mixing, emulsifying, or thermal cavity and an inner portion of said eductor assembly.

24. The apparatus of Claim 20, wherein said injector assembly and said eductor assembly are secured so as to remain a fixed distance apart.

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25. An extractor apparatus for removing product from a containment structure, comprising:

a subsea module movable between a support platform and a remote containment structure;

an extractor housing carried by said subsea module, said extractor housing being movable within said containment structure;

an injector assembly secured to said extractor housing, said injector assembly having an injector to inject feed fluid into said product; and

an eductor assembly secured to said extractor housing for receiving product through an eductor bore, said eductor assembly being axially spaced along said extractor housing from said injector assembly.

26. The apparatus of Claim 25, wherein said extractor housing includes first and second fluid feed bores, said first fluid feed bore providing feed fluid to said injector assembly, said second fluid feed bore providing feed fluid to said eductor assembly.

27. The apparatus of Claim 25, further comprising a sealing assembly surrounding said extractor housing and securably mounted to said containment structure for sealing engagement with said extractor housing as it moves within said containment structure to thereby seal said containment structure.

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28. The apparatus of Claim 25, further comprising a pressure sensor disposed adjacent said injector assembly for transmitting a signal to said subsea module.

29. The apparatus of Claim 25, wherein said extractor housing includes a bore therethrough for communicating pressure adjacent said injector assembly and said eductor assembly to a relief valve external to said containment structure.

A

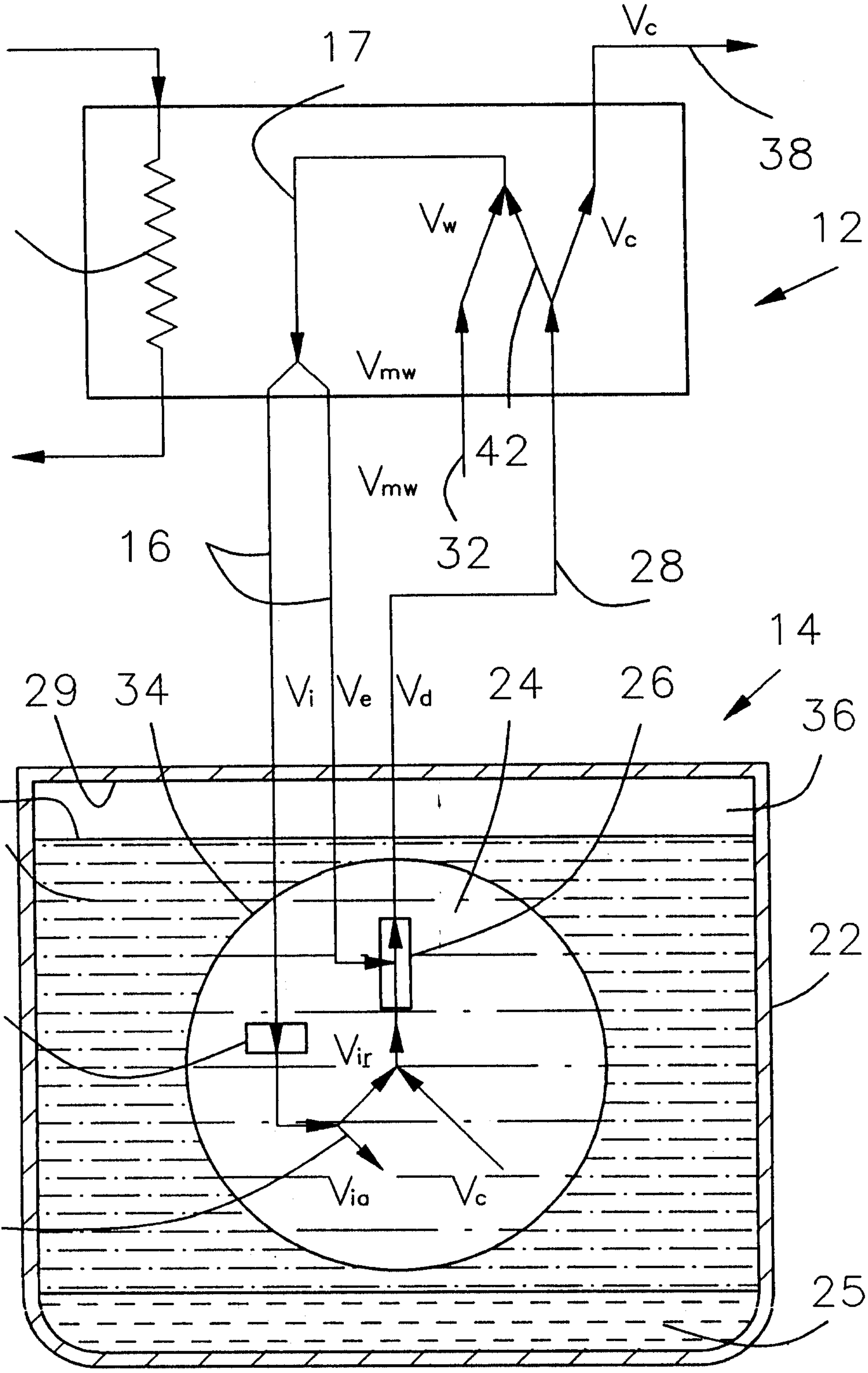
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FIG. 1

A

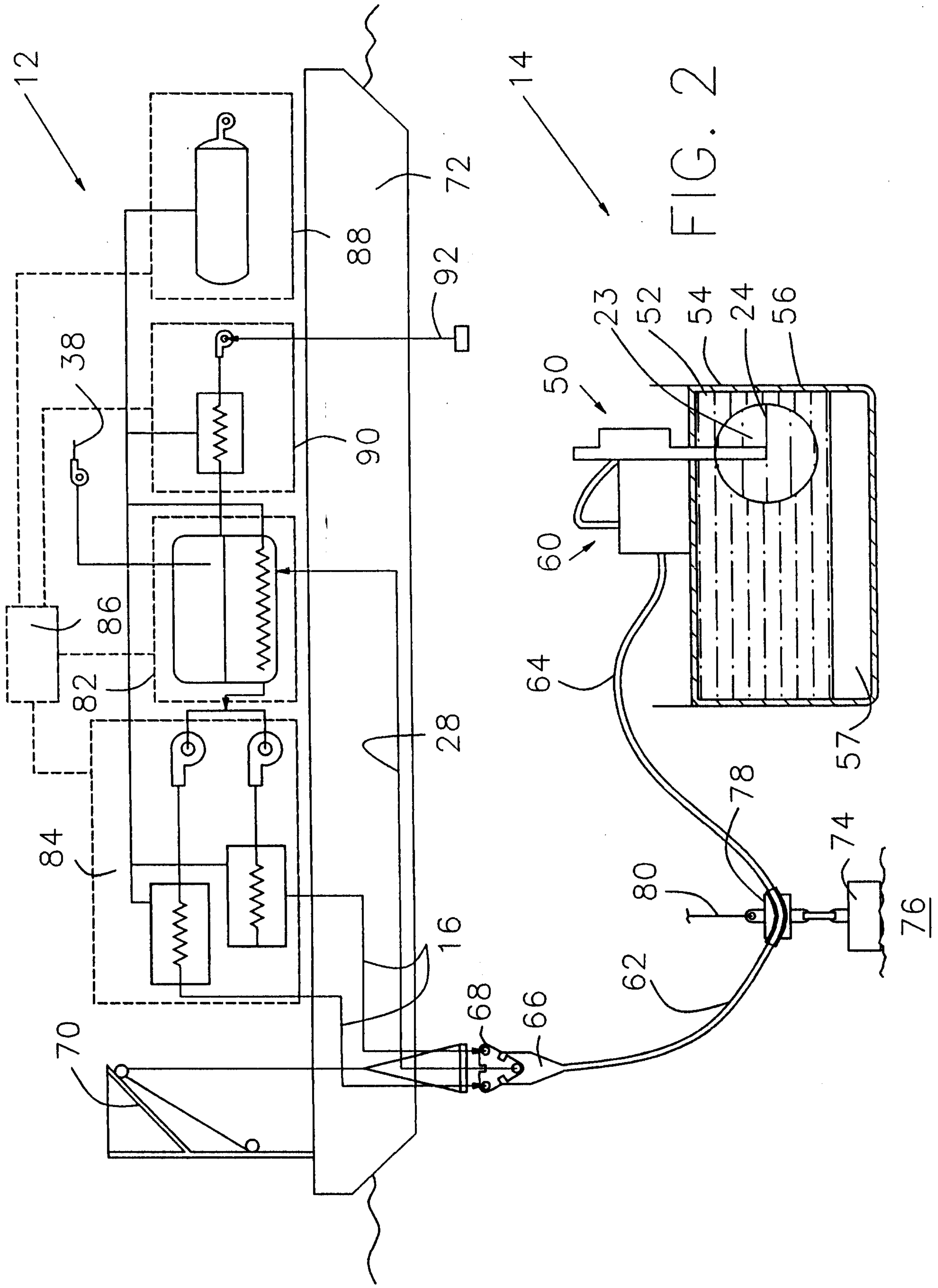
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FIG. 2

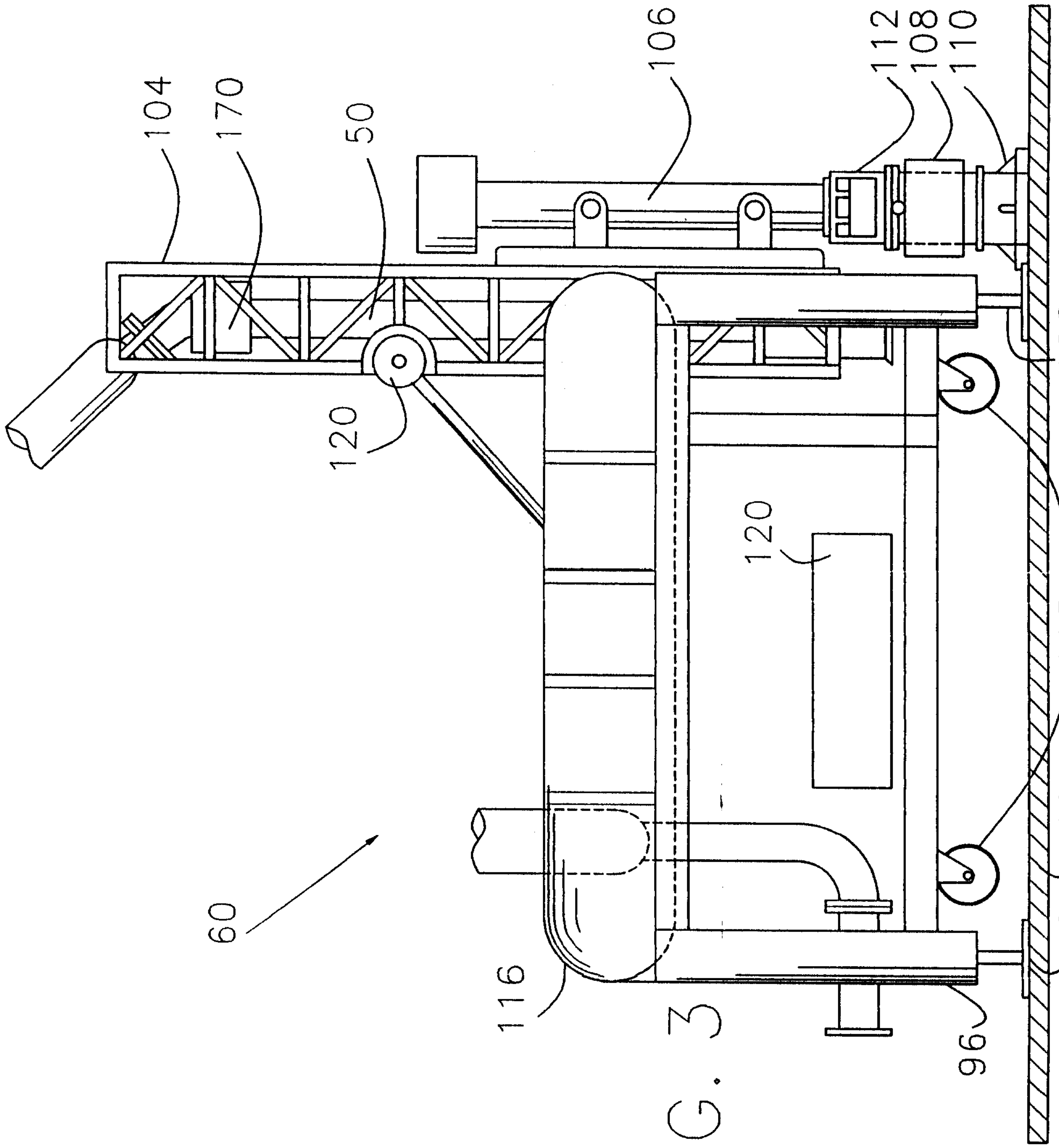


FIG. 3

A

Kirby, Eades, Gale, Baker

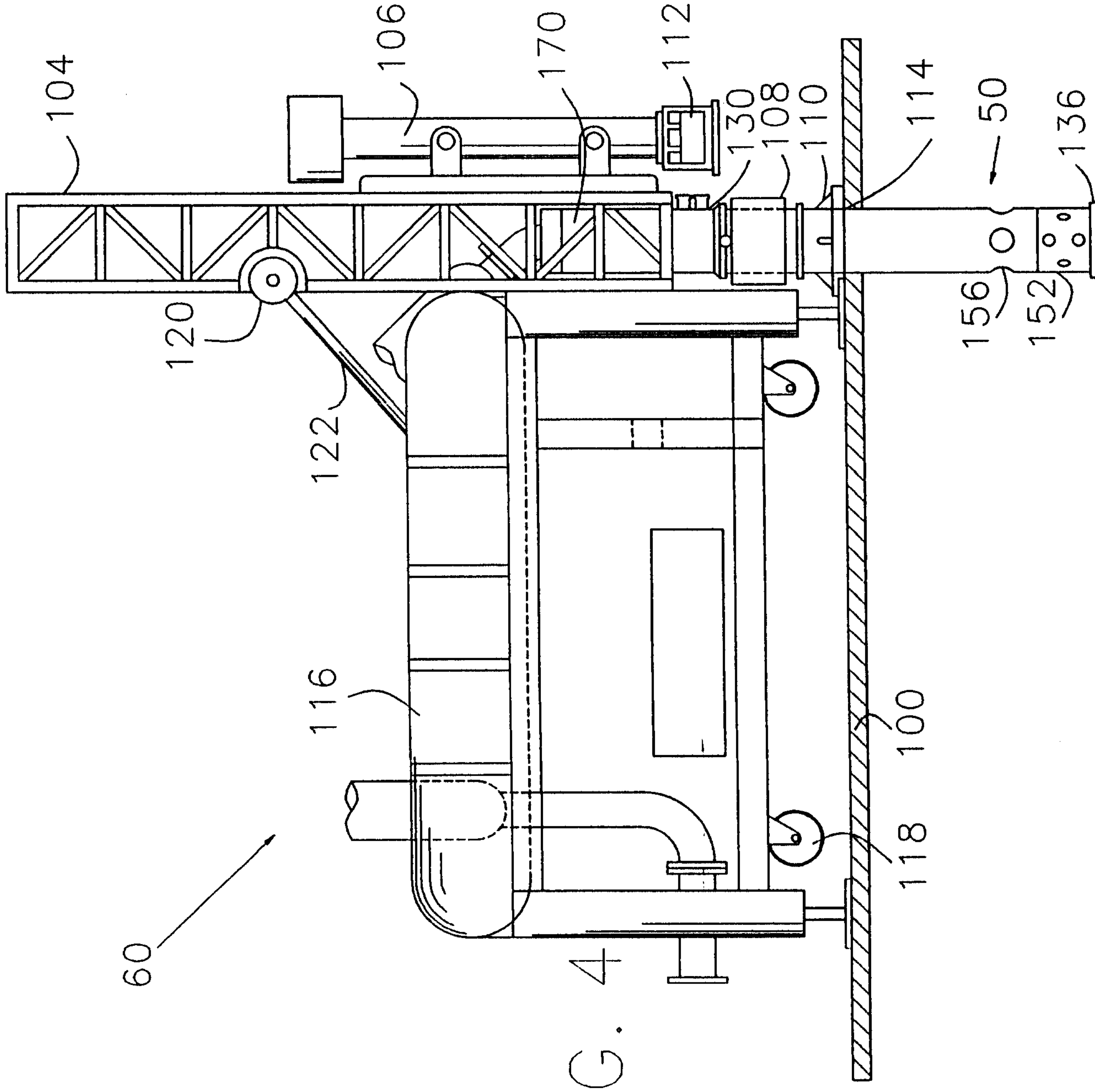


FIG. 4

Kirby, Eades, Gale, Baker

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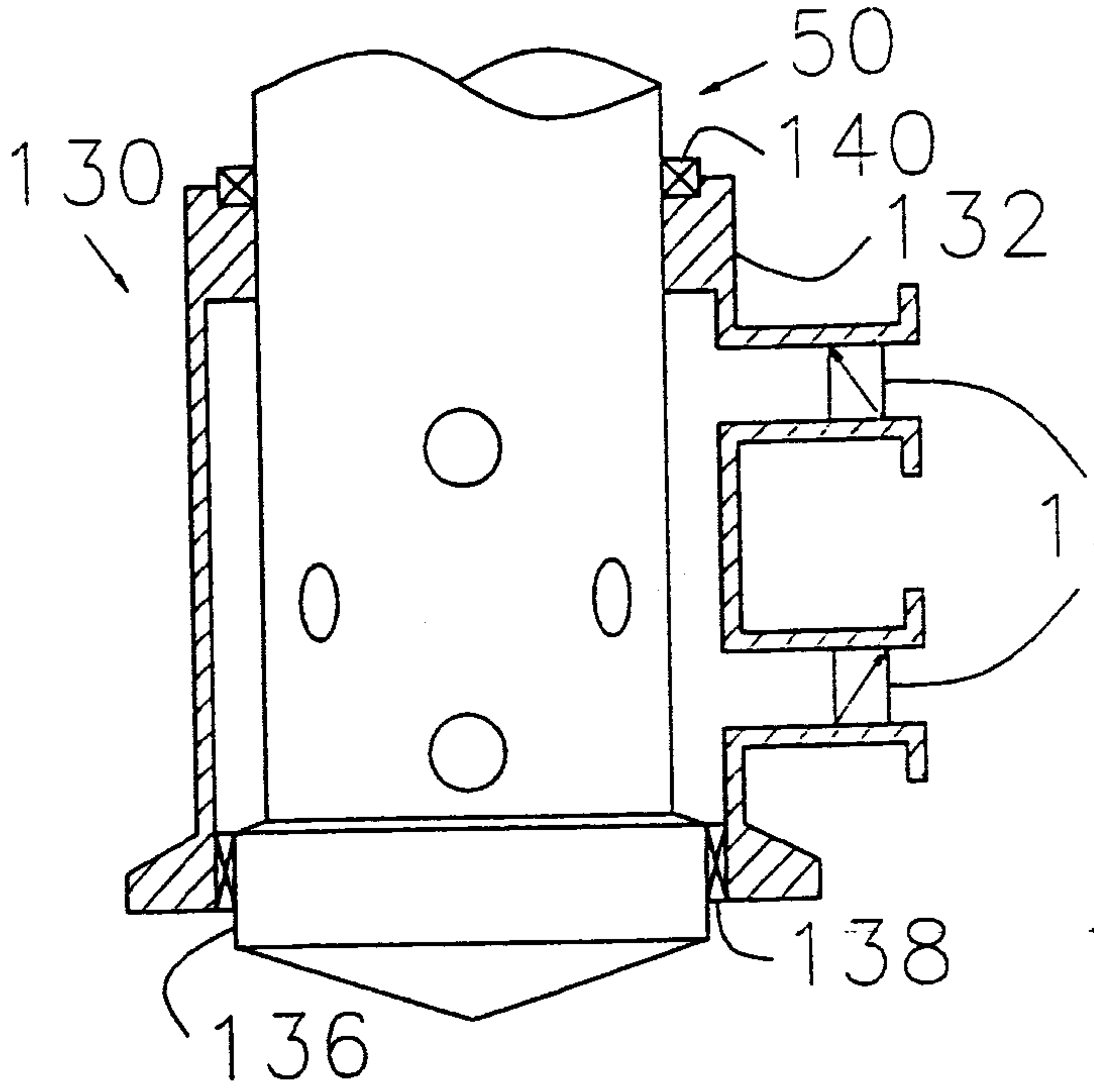


FIG. 5

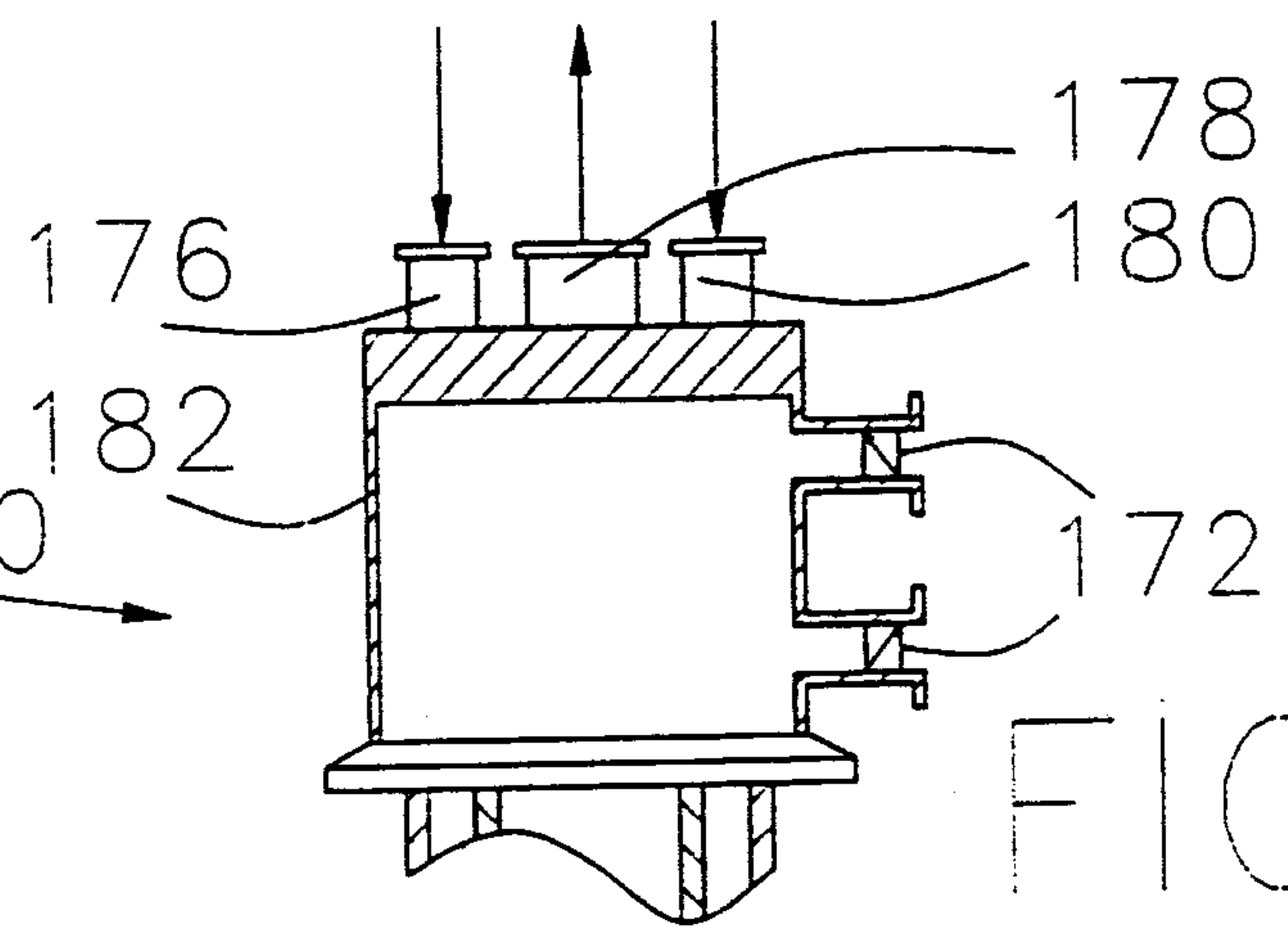


FIG. 6B

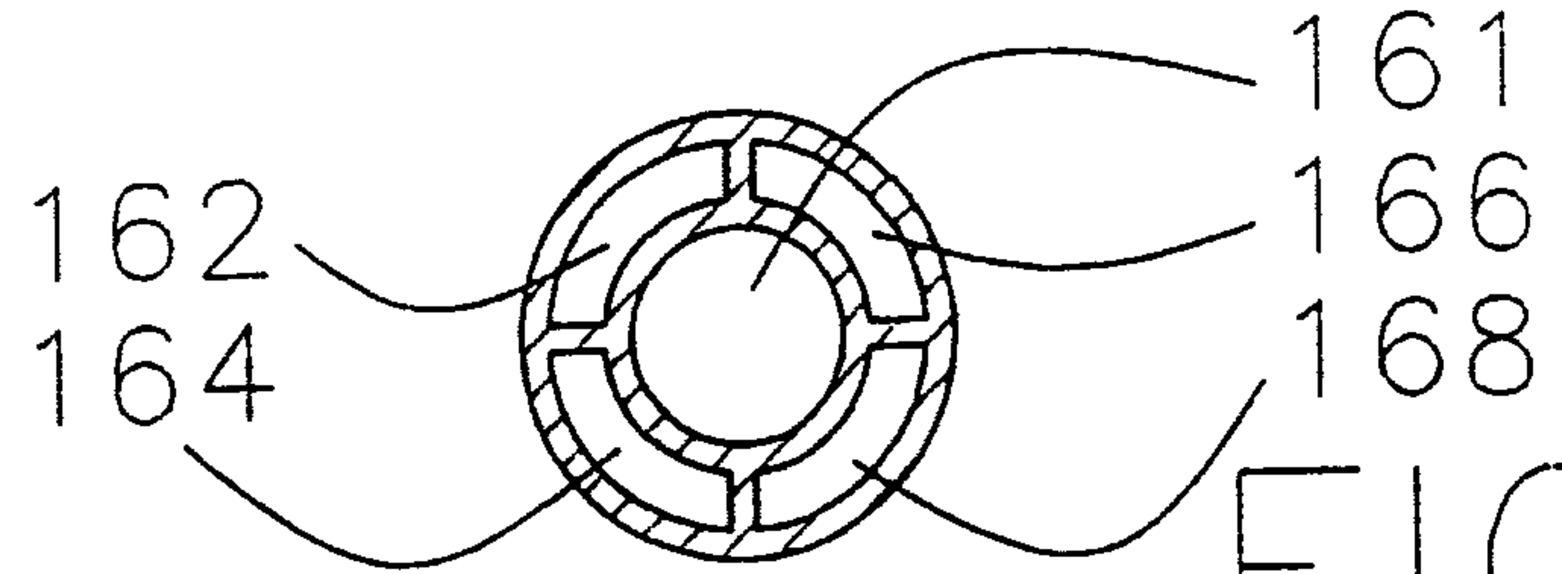


FIG. 6A

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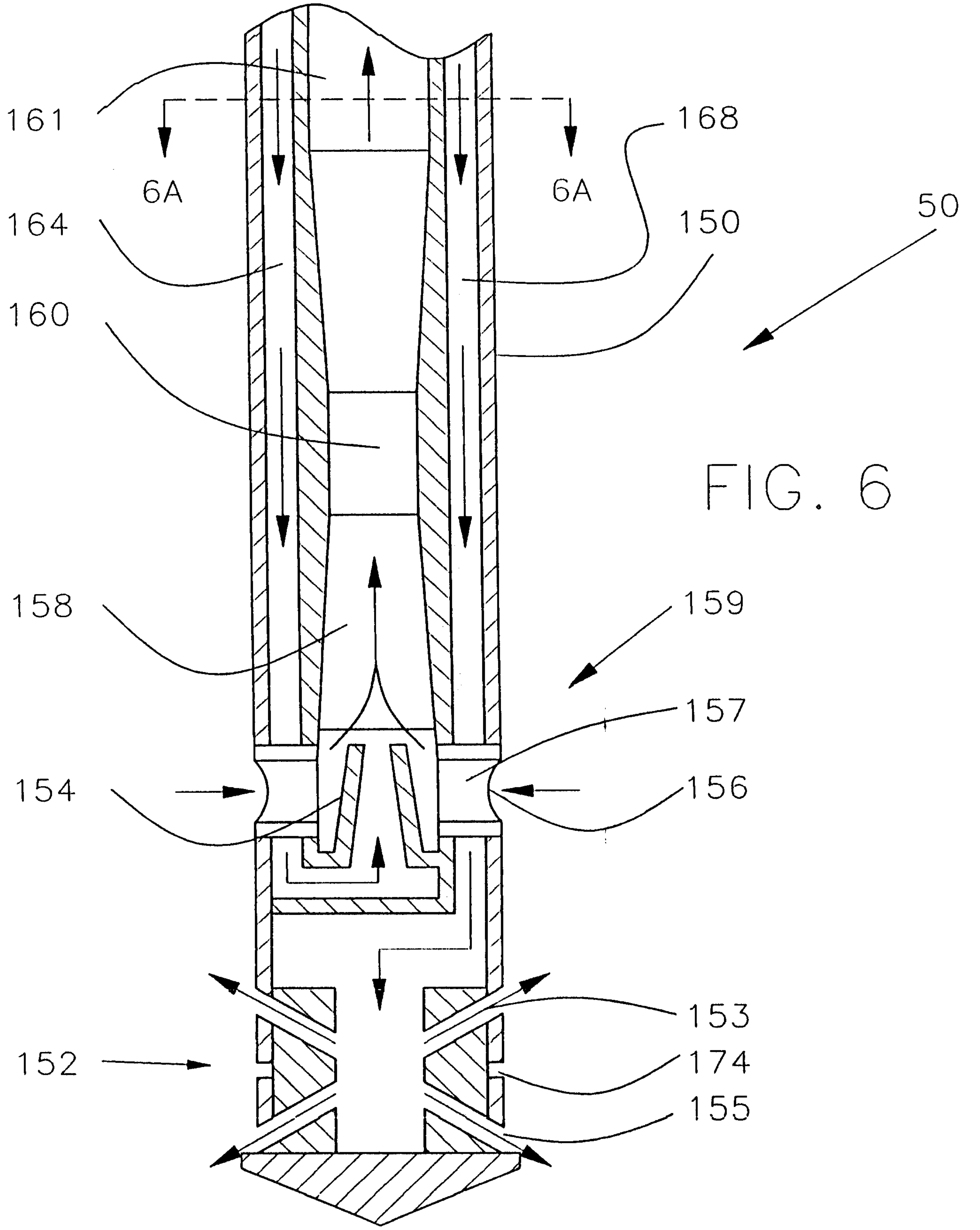



FIG. 6

A

Kirby, Eades, Gale, Baker

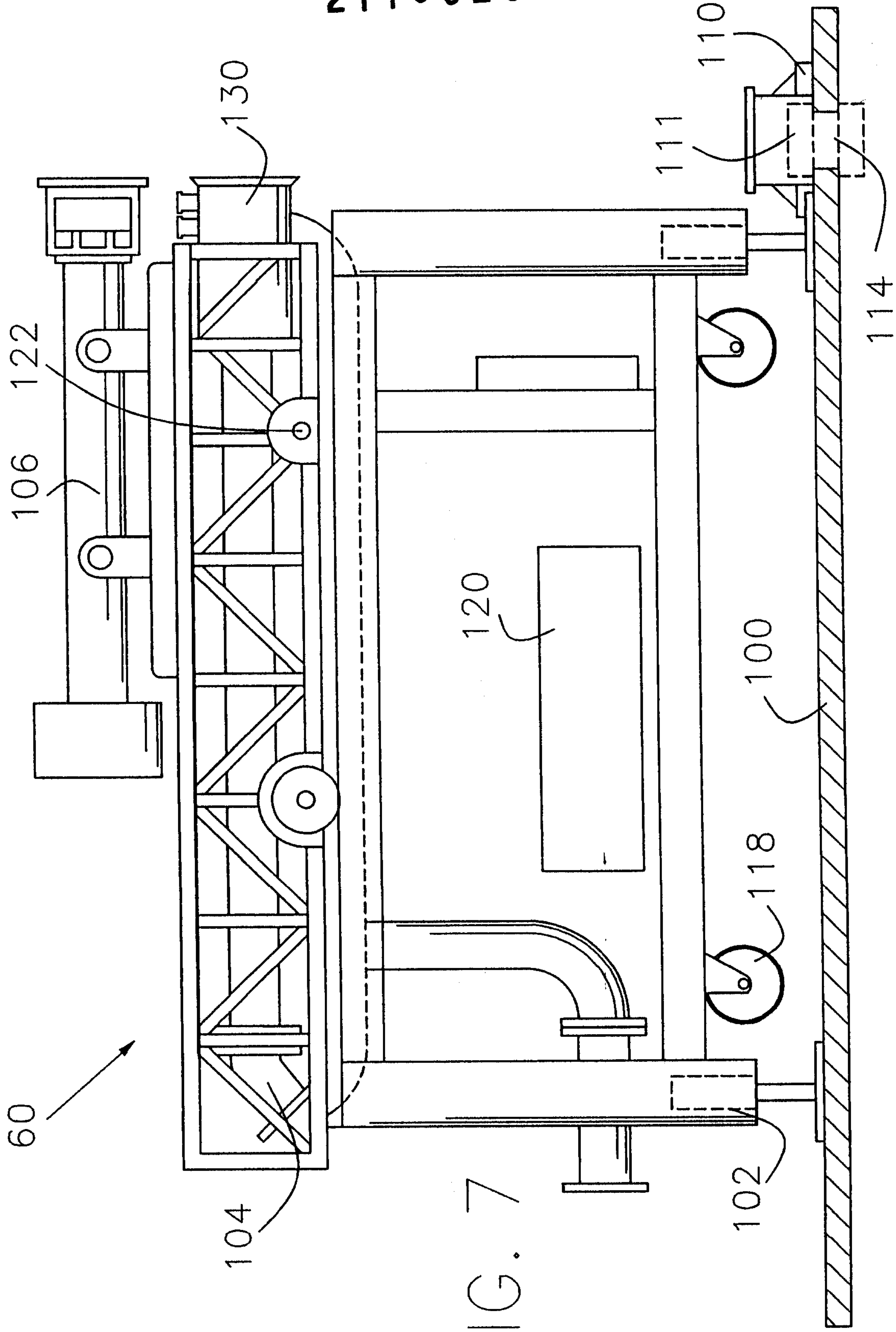
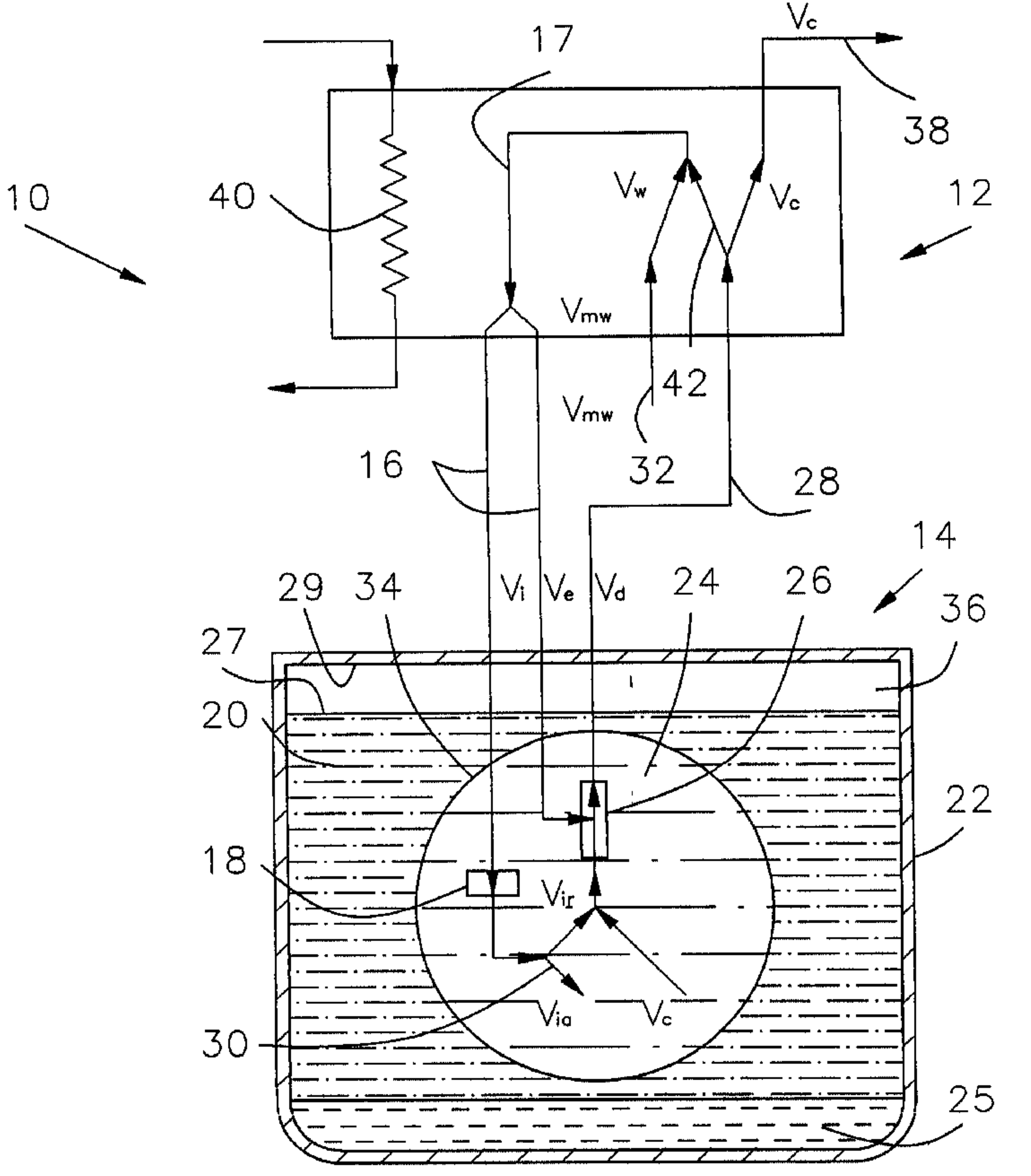



FIG. 7



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