(19) DANMARK

(10) **DK/EP 3254101 T3**

Patent- og Varemærkestyrelsen

(12) Oversættelse af europæisk patentskrift

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(51) Int.Cl.: ***G 01 N 33/28 (2006.01)*** ***G 01 N 33/30 (2006.01)***

(45) Oversættelsen bekendtgjort den: **2024-06-17**

(80) Dato for Den Europæiske Patentmyndigheds bekendtgørelse om meddelelse af patentet: **2024-04-03**

(86) Europæisk ansøgning nr.: **16706980.6**

(86) Europæisk indleveringsdag: **2016-02-05**

(87) Den europæiske ansøgnings publiceringsdag: **2017-12-13**

(86) International ansøgning nr.: **EP2016052451**

(87) Internationalt publikationsnr.: **WO2016124721**

(30) Prioritet: **2015-02-06 FR 1550956**

(84) Designerede stater: **AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**

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(54) Benævnelse: **INSTALLATION OG METODE TIL OVERVÅGNING AF VARIATIONEN I SMØREMIDDELS BASISKE EGENSKABER**

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FACILITY AND METHOD FOR MONITORING THE VARIATION IN THE BASICITY OF A LUBRICANT

The present invention relates to an installation for monitoring the variation of the basicity of a lubricant circulating through a piece of equipment, such as a ship's engine. The invention further relates to a method for monitoring the variation of the basicity of a lubricant.

In the field of internal combustion engines used on commercial ships, it is known that it is suitable to monitor the condition of an engine by analyzing a lubricant circulating in the engine. Such an analysis serves to detect wear or corrosion phenomena that tend to occur in an engine. In the past, engine operation was relatively stabilized and it was sufficient to check the quality of a lubricant on an ad hoc basis, during stopovers, to anticipate the maintenance operations to be carried out. Nowadays, engines are increasingly sophisticated and sensitive to wear or corrosion phenomena, so analyses have to be carried out at sea, in particular in order to monitor the Base Number (BN) of engine oil. The above requires training crew and taking elaborate equipment on-board, the operation of which is relatively difficult to master, even by a trained sailor. Furthermore, the above increases the workload of the crew.

Within such a framework, it is known from the article "*A low cost mid-infrared sensor for on-line contamination monitoring of lubricating oils in marine engines*" by Ben Mohammadi et al. (Optical Sensing and Detection Conference - Brussels - 12-15/4/2010) how to provide a system for analyzing the TBN (Total Base Number) that corresponds to the total base number, using a sensor wherein a sample of the lubricant to be studied, is placed. The material used is elaborate and complex to handle. If such equipment were to be carried on-board a ship, the implementation thereof would require regular taking from the engine of the ship, a quantity of oil intended to form a measurement sample. The above would be both time-consuming and complex.

WO-A-03/073075 discloses a method for analyzing the basicity of a lubricant wherein a measurement, made on a sample of a lubricant to be tested, is compared with measurements made on samples of reference lubricant. Again, such approach is intended for laboratory operation and requires a skilled workforce.

WO-A-2010/046591 envisions the use of an on-board system in which the oil leaving an engine is directed to a functional component associated with a measuring system used for determining the base number thereof. In practice, the flow-rate of oil leaving the engine is low and the flow at the engine outlet consists of droplets which trickle inside a conduit to the point that it is not certain that the functional component is supplied with a sufficient oil flow-rate for the measurements the component makes, to be correct.

US-A-2007/0084271 teaches how to determine the base number of the lubricant by means of a signal generator coupled with a current sensor. Given the equipment used, such an approach is complex to implement, and sensitive to disturbances.

Such problems arise not only in the two-stroke or four-stroke propulsion engines of ships but also in other secondary motors also on-board ships, e.g. for accessories such as hoists. Such problems also arise for gearboxes of equipment on-board ships or fixed installations such as a tidal turbine or a wind turbine. In general, monitoring the basicity of a lubricant is important for all lubricated equipment and known techniques are not conducive to automation.

It is also known from AU-A-2005201261 how to mount a multi-sensor system between an oil circulation line and a recovery pan, the system comprising, among others, a cooling tank arranged downstream of a main valve and a calibration valve, and upstream of an X-ray fluorescence sensor comprising a tube wherein the oil to be analyzed flows. Such equipment is complex and delicate to operate.

It is such drawbacks that the invention intends more particularly to overcome by proposing a new installation for monitoring the variation of the basicity of a lubricant circulating in a piece of equipment which is suitable for working in a simple and autonomous way, which frees the crew on-board a ship from repetitive and elaborate tasks.

For this purpose, the invention relates to an installation for monitoring the variation of the basicity of a lubricant circulating in a piece of equipment, the installation comprising at least a circulation conduit for the lubricant, the conduit being coupled, upstream, to the equipment in question, and downstream, to a lubricant recovery pan as well as a sensor for determining the base number of the lubricant. The installation comprises a first controlled valve for interrupting the circulation of the lubricant in the conduit and a buffer tank for the accumulation of lubricant. The installation comprises a first bypass line connected upstream on the one hand to said first valve and on the other hand to said buffer tank, a second controlled valve for interrupting the circulation of the lubricant in the first bypass line, a second lubricant discharge line, from the buffer tank to the recovery tank, said second line being arranged downstream of the first bypass line and a third controlled valve for interrupting the circulation of the lubricant in said second discharge line. Furthermore, the sensor is arranged on the second discharge line and serves to determine the base number of the lubricant leaving the buffer tank.

By means of the invention, the buffer tank is used to accumulate a sufficient quantity of lubricant serving to correctly supply the base number sensor.

The lubricant of the present invention comprises at least one lubricating base oil. In general, lubricating base oils can be mineral, synthetic or vegetable oils and mixtures thereof. The mineral or synthetic oils generally used in the application belong to one of the groups I to V according to the classes defined in the API classification (or the equivalents thereof according to the ATIEL classification) hereinbelow. The API classification is defined in American Petroleum Institute 1509 “Engine Oil Licensing and Certification System” 17th edition, September 2012. The ATIEL classification is defined in “the ATIEL Code of Practice”, issue 18, November 2012.

	Concentration of saturates	Concentration of sulfur	Viscosity index
Group I Mineral oils	< 90 %	> 0.03 %	80 ≤ VI < 120
Group II Hydrocracked oils	≥ 90 %	≤ 0.03 %	80 ≤ VI < 120
Group III Hydrocracked or hydroisomerized oils	≥ 90 %	≤ 0.03 %	≥ 120
Group IV	PAO (Poly alpha olefins)		
Group V	Esters and other bases not included in group I to IV bases		

Group I mineral oils can be obtained by distillation of chosen naphthenic or paraffinic crude oils, then purification of the distillates obtained, by methods such as solvent extraction, solvent or catalytic dewaxing, hydrotreatment or hydrogenation. Group II and III oils are obtained by more demanding purification processes, e.g. a combination treatments chosen from hydrotreatment, hydrocracking, hydrogenation and catalytic dewaxing. Examples of Group IV and V synthetic base oils include polyisobutenes, alkylbenzenes and poly-alphas olefins such as polybutenes or esters.

In lubricants, the lubricating base oils can be used alone or in a mixture. For example, a mineral oil can be combined with a synthetic oil.

Cylinder oils for marine two-stroke engines are generally characterized by a viscosity grade SAE-40 to SAE-60, generally SAE-50 equivalent to a kinematic viscosity at 100°C comprised between 16.3 and 21.9 mm^2/s, measured as per the standard ASTM D445. Grade SAE-40 oils have a kinematic viscosity at 100°C comprised between 12.5 and 16.3 cSt according to the standard ASTM D445. Grade SAE-50 oils have a kinematic viscosity at 100°C comprised between 16.3 and 21.9 cSt according to the standard ASTM D445. Grade SAE-60 oils have a kinematic viscosity at 100°C comprised between 21.9 and 26.1 cSt according to the standard ASTM D445. The lubricants used with the invention preferentially have a kinematic viscosity measured according to the standard ASTM D445 at 100°C, ranging from 12.5 to 26,1 cSt, preferentially from 16.3 to 21.9 cSt. In order to obtain such a viscosity, the lubricants can additionally comprise one or a plurality of additives. Typically, a conventional formulation for marine engines, preferentially two-stroke engines, has an SAE-40 to SAE-60 grade, preferentially SAE-50 (according to SAE J300 classification) and comprises at least 40% by weight of lubricating mineral, synthetic base oils or mixtures thereof, suitable for use in a marine engine. For example, a lubricating base oil of Group I, according to the API classification, can be used for the formulation of a cylinder lubricant. Group I base oils have a Viscosity Index (VI) ranging from 80 to 120; the concentration of sulfur thereof is greater than 0.03 % and the concentration of saturated hydrocarbon compounds is less than 90%.

The lubricant can further comprise an additive selected from overbased detergents or neutral detergents. Detergents are typically anionic compounds including a long lipophilic hydrocarbon chain and a hydrophilic head, the associated cation being typically a metal cation of an alkali or alkaline earth metal. The detergents are preferentially chosen from alkali metal or alkaline earth metal salts (in particular, preferentially, calcium, magnesium, sodium or barium) of carboxylic acids, sulfonates, salicylates and naphthenates, as well as the phenate salts. The metal salts can contain the metal in an approximately stoichiometric amount compared to the anionic moiety(ies) of the detergent. In such case, one refers to non-overbased or “neutral” detergents, although same also bring a certain basicity. Such "neutral" detergents typically have a BN, measured as per ASTM D2896, of less than 150 mg KOH/g, or less than 100 mg KOH/g, or yet less than 80 mg KOH/g of detergent. Such so-called neutral detergents could contribute in part to the BN of the lubricants. Neutral detergents such as carboxylates, sulfonates, salicylates, phenates, naphthenates of alkali metals and alkaline earth metals, e.g. calcium, sodium, magnesium or barium type, are used. When the metal is in excess (in a quantity greater than the stoichiometric quantity compared to the anionic moiety(ies) of the detergent), the detergents are said to be overbased. The BN thereof is high, greater than 150 mg KOH/g of detergent, typically ranging from 200 to 700 mg KOH/g of detergent, preferentially from 250 to 450 mg KOH/g of detergent. The excess metal that provides the overbased character to the detergent is in the form of metal salts insoluble in oil, e.g. carbonate, hydroxide, oxalate, acetate, glutamate, preferentially carbonate. In the same overbased detergent, the metals of the insoluble salts can be either the same as the metals of oil-soluble detergents or different. The metals are preferentially chosen from calcium, magnesium, sodium or barium. Thereby, the overbased detergents are in the form of micelles composed of insoluble metal salts held in suspension in the lubricant by the detergents in the form of oil-soluble metal salts. The micelles can contain one or a plurality of types of insoluble metal salts, stabilized by one or a plurality of types of detergent. Overbased detergents with a single type of soluble metal salt detergent will generally be named after the nature of the hydrophobic chain of the latter detergent. Thereby, the overbased detergents will be referred to as phenate, salicylate, sulfonate or naphthenate type depending on whether the detergent is a phenate, a salicylate, a sulfonate or a naphthenate, respectively. Overbased detergents will be referred to as mixed type if the micelles comprise a plurality of types of detergents, different from each other by the nature of the hydrophobic chain thereof. The overbased detergent and the neutral detergent can be chosen from carboxylates, sulfonates, salicylates, naphthenates, phenates, and combination detergents combining two or more of such types of detergents. The overbased detergent and the neutral detergent are in particular compounds chosen from calcium, magnesium, sodium or barium, preferentially calcium or magnesium. The overbased detergent can be overbased by insoluble metal salts chosen from the group of alkali metal and alkaline earth metal carbonates, preferentially calcium carbonate. The lubricant can comprise at least one overbased detergent and at least one neutral detergent such as defined hereinabove.

As mentioned hereinabove, in one embodiment of the invention, the lubricant can have a BN, determined as per standard ASTM D-2896, of at most 50, preferentially at most 40, advantageously at most 30 milligrams of potassium hydroxide per gram of lubricant, in particular ranging from 10 to 30, preferentially from 15 to 30, advantageously from 15 to 25 milligrams of potassium hydroxide per gram of lubricant. In such embodiment of the invention, the lubricant could not comprise detergents containing alkali metals or alkaline-earth metals overbased by metal carbonate salts.

In another embodiment of the invention, the lubricant has a BN, determined as per the standard ASTM D-2896, of at least 50, preferentially at least 60, more preferentially at most 70, advantageously from 70 to 100.

The lubricant can also comprise at least one additional additive selected from dispersants, anti-wear additives or any other functional additive. Dispersants are well known additives used in the formulation of the lubricant, in particular for application in the marine field. The primary role thereof is to maintain in suspension the particles initially present or appearing in the lubricant during the use thereof in the engine. Dispersants prevent the agglomeration of particles by acting on steric hindrance. Dispersants can also have a synergistic effect on neutralization. The dispersants used as lubricant additives typically contain a polar group, associated with a relatively long hydrocarbon chain, generally containing from 50 to 400 carbon atoms. The polar group typically contains at least one nitrogen, oxygen or phosphorus element. Compounds derived from succinic acid are dispersants particularly used as lubricating additives. Succinimides, obtained by condensation of succinic anhydrides and amines, succinic esters obtained by condensation of succinic anhydrides and alcohols or polyols, are more particularly used. Such compounds can then be treated with various compounds, in particular sulfur, oxygen, formaldehyde, carboxylic acids and compounds containing boron or zinc for producing e.g. borated succinimides or zinc-blocked succinimides. Mannich bases, obtained by polycondensation of phenols substituted by alkyl moieties, of formaldehyde and of primary or secondary amines, are also compounds used as dispersants in lubricants. In one embodiment of the invention, the concentration of dispersant can be greater than or equal to 0.1%, preferentially from 0.5 to 2%, advantageously from 1 to 1.5% by weight with respect to the total weight of the lubricant. Anti-wear additives protect surfaces under friction by forming a protective film adsorbed on the surfaces. The most widely used is zinc di-thiophosphate or DTPZn. Various phosphorus, sulfur, nitrogen, chlorine and boron compounds are also found in said category. There is a wide variety of anti-wear additives, but the most widely used category is phosphor-sulfur additives such as metal alkylthiophosphates, more particularly zinc alkylthiophosphates, and more specifically zinc dialkyldithiophosphates or DTPZn. The preferred compounds have the formula $Zn((SP(S)(OR_1)(OR_2))_2$, where R_1 and R_2 are alkyl moieties, preferentially having from 1 to 18 carbon atoms. DTPZn is typically present in concentrations on the order of 0.1 to 2% by weight with respect to the total weight of the lubricant. Amine phosphates, polysulfides, in particular sulfur olefins, are also commonly used anti-wear additives. Anti-wear and extreme pressure additives such nitrogen and sulfur additives are also usually found in lubricants for marine engines, such as e.g. metal dithiocarbamates, more particularly molybdenum dithiocarbamate. Glycerol esters are also anti-wear additives. Examples include e.g. of mono-, di- and trioleates, monopalmitates and monomyristates. In one embodiment, the concentration of anti-wear additives ranges from 0.01 to 6%, preferentially from 0.1 to

4% by weight with respect to the total weight of the lubricant.

The other functional additives can be chosen amongst thickening agents, anti-foam additives for inhibiting the effects of the detergents, which can be e.g. polar polymers such as polymethylsiloxanes, polyacrylates, antioxidant and/or rust-inhibiting additives, e.g. organo-metallic detergents or thiadiazoles. Same are known to a person skilled in the art. The additives are generally present in a concentration from 0.1 to 5% by weight with respect to the total weight of the lubricant.

According to advantageous but non-mandatory aspects, an installation according to the invention can incorporate one or a plurality of the following features, taken in any technically permissible combination:

- The installation comprises means for gas pressurization of the inner volume of the buffer tank.

- The means of gas pressurization comprise a source of compressed air and a set of valves or a pneumatic manifold for putting into selective communication the internal volume of the buffer tank with the source of compressed air or the ambient atmosphere.

- The installation comprises means of detection of the lubricant level in the buffer tank.

- The means of detection of the lubricant level in the tank comprise a gas pressure sensor in the inner volume of the buffer tank.

- Furthermore, the installation comprises a sensor for determining the specific gravity, the viscosity, the moisture content and the temperature also arranged on the second discharge line and as well as a sensor for determining the concentration of iron dissolved in the lubricant in the buffer tank.

Moreover, the invention relates to an automated method for following the variation of the basicity of lubricant circulating in a piece of equipment, by means of an installation such as mentioned hereinabove. The method comprises the steps of:

a) closing the first valve
b) opening the second valve and closing the third valve in order to feed the buffer tank from a quantity of lubricant accumulated in the conduit, upstream from the first valve
c) opening the third valve for circulating the lubricant present in the buffer tank through the second discharge line, in contact with the sensor for determining the base number of the lubricant
d) using an output signal from said sensor for determining the base number of

the lubricant.

Advantageously, such a method can incorporate one or a plurality of the following features, taken individually or according to any technically permissible combination:

- When the installation comprises means for gas pressurization of the contents of the buffer tank, a step is provided for e) after step b) and prior to step c) and consists of pressurizing the buffer tank with gas, with a pressure comprised between 6 and 12 bar, preferably between 7 and 10 bar and preferentially again equal to 7 bar.

- Step c) is interrupted, while a residual amount of lubricant remains in the buffer tank

- The method includes a step f) after step d), consisting of unclogging a filter integrated into the first bypass line by having the lubricant circulate from the buffer tank to the conduit.

The invention further relates to a method for monitoring the operation of a piece of equipment on-board a ship, said method comprising the determination, on-board the ship, of the base number of a lubricant of the equipment in question, by using an automated method such as mentioned hereinabove.

The invention will be better understood and other advantages thereof will become more clearly apparent in the light of the following description of two embodiments of an installation according to the principle thereof given only as an example and with reference to the enclosed drawings wherein:

- Figure 1 is a schematic representation of the principle of an installation according to the invention, as carried on-board a ship,

- Figure 2 is a schematic representation on a smaller scale of the fluidic part of the installation shown in figure 1, in a first operation configuration,

- Figures 3 to 5 are views similar to figure 2 when the installation is in a second, third and fourth operation configuration,

- Figure 6 is a view similar to Figure 1 for an installation according to a second embodiment of the invention,

- Figures 7 to 11 and 13 to 18 are views similar to figure 2 for the installation shown in figure 6, in different operation configurations,

- Figure 12 is a view on a larger scale of the detail XII in Figure 11, and

- Figure 19 is a view similar to Figure 1 for an installation according to a third embodiment of the invention.

In Figures 2 to 5 and 7 to 18, the lubricant present or circulating in a part of the installation is represented grayed out.

The installation 2 shown in Figures 1 to 5 is on-board a ship shown in Figure 1 by means of the engine M thereof which includes a plurality of cylinders, e.g. twelve or fourteen cylinders. A conduit 4 connects the engine M to a recovery pan 6 for the lubricant. In practice, the engine oil flows by gravity into the conduit 4 with a pressure P4 comprises between 1.1 and 6 bar absolute. The oil flow-rate in the conduit 4 may be low, to the point that the oil streams on the inner wall of the conduit.

The conduit 4 extends vertically, from top to bottom, from the engine M towards the recovery pan 6. In such embodiment, the oil flowing in the conduit 4 comes from at least one cylinder of the engine M.

A tap-off 8 is provided on the conduit 4 and equipped with a manually controlled valve 10, which makes it possible to take a quantity of oil coming out of the engine M in order to carry out physicochemical analyses, following an approach known per se.

The installation 2 comprises a shut-off valve 20 mounted on the conduit 4 and which serves to selectively interrupt the flow of oil in the conduit 4, towards the recovery pan 6. The shut-off valve 20 is controlled by an electronic unit 22 by means of an electrical signal S20.

As can be seen only in Figure 1, the installation 2 comprises a housing 24, represented by the line thereof as a dashed line and inside which are arranged the constituent elements of the installation 2, with the exception of the part of the shut-off valve 20 which is integrated into the conduit 4.

The installation 2 further comprises a buffer tank 26 which is arranged in the housing 24 and which is connected to the conduit 4 by means of a first bypass line 28.

282 denotes the mouth of the line 28. The mouth is arranged upstream of the valve 20 on the conduit 4. The first bypass line 28 is equipped, going from the mouth 282 thereof to the outlet 284 thereof in the buffer tank 26, with a filter 30, a shut-off valve 32 and a tap-off 34. The filter 30 serves to prevent too large size impurities from flowing in the first bypass line 28. The shut-off valve 32 serves, selectively, to open or close the first bypass line 28. The valve 32 is controlled by the electronic unit 22 by means of an electrical signal S32. The tap-off 34 is connected, through a controlled valve 36, to a source 12 of pressurized air which is not part of the installation 2 but belongs to the standard equipment of a ship.

In practice, the source 12 of pressurized air could be a compressor on-board the ship and which supplies a compressed air network which also serves other equipment than the installation 2. In a variant, the source 12 can be a pump dedicated to the installation 2.

The installation 2 further comprises a tap-off 38 connected to the tank 26, on which is mounted a shut-off valve 40 and which serves to bring the internal volume V26 of the tank 26 into communication with the ambient atmosphere.

In one embodiment, the tap-offs 34 and 38 are independent. In a variant, the tap-offs can be replaced by a single tap-off, connected to the first line 28 or directly to the tank 26, on which the valves 36 and 40 are mounted in parallel, being connected to the source 12 of air under pressure and to the ambient atmosphere, respectively. In such case, it is possible to combine the valves 36 and 40 in the form of a single three-way valve. The valves 36 and 40 are controlled by the electronic unit 22 by means of respective electrical signals S36 and S40.

The installation 2 further comprises a second line 42 for discharging the lubricant, from the internal volume V26 of the tank 26 towards the recovery pan 6. The second discharge line 42 is thus arranged downstream of the first bypass line 28 and of the tank 26, along the flow path of the lubricant. In the example, the second line 42 extends from the tank 26 towards the conduit 4. The mouth 422 thereof is located in the lower part of the tank 26, while the outlet 424 thereof is arranged on the conduit 4, downstream of the shut-off valve 20, as shown in the figures, which reduces the time of an analysis cycle because the shut-off valve 20 can be closed in order to create an oil column in the conduit 4, while measurement steps take place. In a variant, the outlet 424 of the second line 42 is arranged upstream of the shut-off valve 20, making it possible to simultaneously carry out steps of draining and unclogging the filter 30 and, if appropriate, to reduce the cost of the installation 2.

The second line 42 is equipped with a shut-off valve 44 which is controlled by the electronic unit 22 by means of an electrical signal S44.

Two sensors 46 and 48 are arranged on the line 42, upstream of the valve 44.

The sensor 46 serves to measure the density D, the viscosity V, the humidity H and the temperature T of a liquid present in or flowing through the second line 42. The sensor can be of the type marketed by the AVENISENSE company under the name Cactus. In a variant, the sensor 46 can be of another type or serve to measure only one or certain of the parameters mentioned hereinabove.

The sensor 48 is a sensor for the base number (BN), sometimes called alkalinity index. It can be a sensor operating with infrared technology, in the mid-infrared, or any other sensor suitable for the determination of the BN of a lubricant.

The installation 2 further comprises a first level sensor 54 and second level sensor 56 which serve, respectively, to detect when the quantity of oil in the tank 26 reaches a first level N1 or a second level N2. The electrical output signals S54 and S56 of the sensors 54 and 56 are delivered to the unit 22.

In a variant, the sensors 54 and 56 can be replaced by a single sensor, such as a pressure sensor, which serves to detect when the oil reaches each of the two levels N1 and N2 in the tank 26.

Figures 2 to 5 schematically illustrate the successive steps of an automated method implemented by means of the installation 2 shown in Figure 1. The method is automated in the sense that same can be implemented, partially or preferentially totally, without human intervention, under the control of the unit 22. The same applies to the method explained hereinafter with regard to the second embodiment of the invention.

By default, and outside the sampling phases, the oil coming out of the engine flows into the conduit 4, in the direction of arrow F1 in Figure 1, from the engine M to the recovery pan 6, without being retained by the valve 20 which is in the open or ON configuration, while the other valves are closed.

When it is suitable to determine the base number of the oil coming out of the engine M, the unit 22 switches the valve 20 to the closed position, so that a retention is generated in the conduit 4, where a quantity of oil, i.e. lubricant, accumulates, as represented by the grayed out part L in Figure 2.

In the configuration shown in Figure 2, the conduit 4 serves as a decanting column and impurities I accumulate in the vicinity of the valve 20, inside the conduit 4 and in the lower part of the quantity of lubricant L.

In the first step represented by the configuration shown in Figure 2, the valves 32 and 40 are open, while the valves 36 and 44 are closed.

When the level of lubricant L in the conduit or column 4 reaches the mouth 282, oil begins to flow through the first bypass line 28, more particularly through the filter 30 and the valve 32, into the internal volume V26 of the tank 26 into which the oil flows by gravity. Indeed, the outlet 284 of the first line 28 is located in the upper portion of the tank 26 and the oil can flow along the wall of the tank 26. Since the valve 44 is closed, the oil progressively fills the part of the second discharge line 42 located upstream of the valve 44, including the internal volumes of the sensors 46 and 48, then the internal volume V26, forcing out the air towards the atmosphere, through the valve 40. Such step corresponds to the configuration shown in Figure 3.

When the sensor 56 detects that the level N2 of the oil inside the tank 26 is reached, the control unit 22 switches the installation 2 to a new step shown in Figure 4 wherein the valve 20 switches to the open configuration, which makes it possible to drain the decanting column by directing the remainder of the quantity L of lubricant present upstream of the valve 20 as well as the impurities I towards the recovery pan 6. The flow in the direction of the arrow F1 thus continues as far as the recovery pan 6. Moreover, the valves 32 and 40 are closed and valve 36 is open, which makes it possible to place the part of volume V26 which is not occupied by the lubricant, i.e. the part of the volume V26 located above the level N2, under an air pressure P1 equal to the pressure of the air source 12, which, in the example, is equal to 7 bar absolute.

The above having been done, the unit 22 moves the installation 2 to a next step, represented by the configuration shown in Figure 5, wherein the valve 44 is open, the other valves keeping the state thereof of the configuration shown in Figure 4. In such case, the effect of the pressure P1 of the air in the upper portion of the volume V26 is to push the oil into the second discharge line 42, through the sensors 46 and 48, which enables the sensors to supply to the unit 22 the signals S46 and S48, respectively, representative of the parameters the signals detected.

Where appropriate, the signals S46 and S48 can be processed in the unit 22 in order to determine the values of the monitored parameters, in particular by comparison with known values for reference lubricants.

The signals S46 and S48 or signals extrapolated from said signals, may be sent outside the installation 2 in the form of a conjugate signal S2 which can be used by a central control unit of the engine M.

In practice, the passage section of the sensor 48 for the base number is approximately 3 mm by 0.1 mm and it is suitable to be able to feed the passage section with a sufficient flow-rate, for a length of time sufficient for performing the measurement of the base number. The construction of the installation with the tank 26 serves to generate a reserve forming a "buffer" of oil, in the form of the quantity of oil L1 contained in the tank 26 in the configuration shown in Figure 4. Part of the oil reserve L1 can be discharged, either continuously or sequentially, into the second discharge line 42 so that the sensor 48 has a sufficient quantity of oil to be analyzed.

Starting from the configuration shown in Figure 5, it is possible, in a subsequent step, to continue emptying the tank 26 and the entire second discharge line 42 by keeping the valve 44 open and continuing to inject compressed air through the valve 36.

In a variant, it is possible to stop draining the tank 26 when the oil level reaches the level N1, so as to keep a quantity L2 of oil permanently in the second discharge line 42, more particularly in the sensors 46 and 48 the active parts of which in contact with the oil are not at risk to dry out. If such second approach is selected, a certain amount of oil should be used during a next measurement, in order to clean the second discharge line 42 beforehand and not disturb the next measurement.

In the second and third embodiments of the invention shown in Figures 6 et seq., elements similar to the elements of the first embodiment bear the same references. Hereinafter will be described mainly what distinguishes such embodiments from the preceding embodiment.

In the embodiment shown in Figures 6 to 18, the first and second lines 28 and 42 meet at a T-shaped branch 29. Thereby, the outlet 284 of the first bypass line 28 coincides with the mouth 422 of the second discharge line 42. The section of line located between the tank 26 and the branch 29 is common to the first and second lines 28 and 42. Such line segment opens out into the lower part of the tank 26, so that the oil which flows from the conduit 4 to the tank 26 reaches directly into the lower part of the tank.

Three levels N1, N2 and N3 are defined in the tank 26, the levels N1 and N2 being comparable to the levels of the first embodiment.

In the second embodiment, no level sensors identical to level sensors 54 and 56 are used, but a pressure sensor 58 is used, the output signal S58 of which is supplied to the electronic control unit 22. Moreover, a level sensor 60 is mounted in the conduit 4 upstream of the valve 20, i.e. above the latter.

Furthermore, the tap-offs 34 and 38 and the valves 36 and 40 of the first embodiment are replaced by a single tap-off 38′ to which the pressure sensor 58 is connected, as well as a three-way, three-port distributor 62, which is coupled both to the pressurized air source 12 and to the ambient atmosphere. The distributor 62 is controlled by the unit 22 by means of a dedicated electrical signal S62.

The installation 2 further comprises a third sensor 50 mounted in the upper portion of the tank 26 and arranged to aim at an interface I26 defined between a quantity of lubricant present in the tank 26 and the air present above said quantity. The 50 sensor is a sensor using Laser Induced Breakdown Spectroscopy (LIBS) technology.

More precisely, as can be seen in Figure 12, the sensor 50 comprises a control unit 50A, a transmitter 50B of a laser beam directed towards the interface I26, as represented by the arrows F2, and a receiver 50C apt to receive a beam emitted in return, from the interface I26 and represented by the arrows F2R. The laser beam F2 emitted by the emitter 50B excites the quantity L1 of lubricant and, during the de-excitation, an emission of a spectrum characteristic of the quantity L1 occurs, in the form of the beam F2R emitted in return. The components 50B and 50C of the sensor 50 are integrated into an upper wall 262 of the tank 26 and connected to the unit 50A by two wire connections 50D and 50E.

Such technology enables the sensor 50 to determine the concentration of dissolved iron in the oil contained in the tank 26, more particularly the concentration of ions Fe^{2+} and Fe^{3+}. In this way it is possible to determine the level of corrosion of the parts of the engine in contact with the oil and, consequently, to initiate preventive or corrective maintenance actions when need be.

In a variant, another type of sensor 50, also serving to determine the concentration of dissolved iron in the oil contained in the tank 26, can be used. In such case, the sensor may be integrated into the second line 42, in particular arranged downstream of the sensor 48 for the base number.

The 2 installation works as follows:

By default, the valve 20 is open and the valves 32 and 44 are closed, whereas the distributor 62 is in the configuration shown in Figure 6 where the distributor isolates the internal volume V26 of the tank 26 from the source 12 of compressed air and from the ambient atmosphere.

When it is suitable to determine the base number of the oil coming out of the engine M, the unit 22 activates the valve 20 by means of the signal S20 during a first step, in order to bring same into the closed configuration shown in Figure 7. In said configuration, oil is present in the first bypass line 28, between the filter 30 and the valve 32, because of an operation of unclogging the filter 30, carried out previously and which is explained hereinafter.

In such configuration, the valves 32 and 44 and the distributor 62 are closed.

The level sensor 60 is positioned so that, when the column of oil retained in the conduit 4 upstream of the valve 20 attains the level N0 detected by the sensor, as shown in Figure 8, a predetermined quantity of lubricant L′ is present above the mouth 282. For example, the predetermined quantity can be equal to 100 ml. When the level sensor 60 detects that the level N0 is attained in the conduit 4, the internal volume V26 of the tank 26 is brought to atmospheric pressure by actuating the distributor 62 in order to bring the distributor into the configuration shown in Figure 8.

Starting from said configuration, the unit 22 controls the valve 32 and the distributor 62 in a following step in order to transfer the quantity L′ of oil from the conduit 4 to the tank 26, as represented by the configuration shown in Figure 9. In said configuration, the valve 32 is open, while the distributor 62 is closed. The transfer of oil from the conduit 4 to the buffer tank 26 is thus accompanied by an increase in the air pressure inside the tank 26. The compression ratio of the air trapped in the tank can be related, after calibration, to the initial volume of air in the tank 26 and to the volume of oil transferred.

For example, for adiabatic compression and an initial volume of air in the tank 26 equal to 160 ml, the pressure in the tank 26 reaches 1.7 bar absolute for 50 ml of oil transferred.

Similarly, considering a tank 26 initially containing 250 ml of air, it is possible to transfer 80 ml, i.e. the quantity L1 shown in Figure 10, into the tank 26 before reaching an air pressure P1 equal to 1.7 bar absolute in the upper portion of the latter. The above is the example considered hereinafter.

In such case, the oil level N2 is reached in the tank 26 during the step represented by the installation 2 in the configuration shown in Figure 10.

The unit 22 then automatically controls the valves and the distributor to reach the configuration of Figure 11 where the tank 26 is pressurized through the distributor 62 which connects the volume V26 to the compressed air source 12, so that the pressure P1' of air inside the tank 26 becomes equal to 7 bar. In order for the above to take place, the valve 32 has previously been switched by the unit 22 to the closed configuration, in order to prevent oil from returning from the tank 26 to the conduit 4. Moreover, in said step, the valve 20 is switched by the unit 22 to the open configuration, so that the flow of oil from the engine M towards the recovery pan 6 can again take place in the direction of the arrow F1. Also during said step, the sensor 50 is used for determining the concentration of dissolved iron, in particular of ions Fe^{2+} and Fe^{3+}, in the quantity L1 of oil contained in the tank 26.

To this end, the sensor 50 aims at the oil/air interface I26 which is located at level N2 in the tank 26. The output signal S50 of the sensor 50, or a signal extrapolated from said signal, is integrated into the output signal S2 of the installation 2.

From such configuration, the unit 22 controls the spool valve 62 and the valve 44 by means of the signals S62 and S44, so as to close the distributor 62 and open the valve 44 respectively and thereby reach the configuration shown in Figure 13 where the oil contained in the tank 26 is progressively driven out of the latter because of the pressure P1 prevailing in the upper portion of the internal volume V26.

The oil thus flows through the sensors 46 and 48 which are apt to detect the parameters for which the sensor is intended and to supply corresponding signals, S46 and S48, to the unit 22, as in the first embodiment.

The discharge of the oil contained in the tank 26 through the second discharge line 42 can take place in a plurality of cycles, by successive expansion of the volume of air trapped in the tank and successive connections to the air source 12. For a 250 ml tank initially containing 80 ml of oil, it is possible e.g. to perform three successive expansions, between 7 bar and 6.2 bar, preceded by three connections to the air source 12. In this way it is possible to deliver a total volume of 50 ml into the second discharge line 42 and to reach the configuration shown in Figure 14 where a residual quantity L2, of 30 ml of lubricant, remains in the tank 26 while being subjected to a pressure P2 equal to 6.2 bar.

The three successive expansions take place by successively filling the tank 26 with air at 7 bar beforehand, by means of an appropriate command of the distributor 62.

The three expansions serve to circulate 50 ml of lubricant through the sensors 46 and 48 during three successive steps, which allows the sensors to generate three sets of signals S46 and S48 or a set of combined signals, intended for and supplied to the unit 22, then transmitted and/or processed as in the first embodiment.

Starting from the configuration shown in Figure 14, the unit 22 moves the installation 2 into the configuration shown in Figure 15 where the internal volume V26 of the tank 26 is again pressurized to the pressure P1' of 7 bar, by appropriate control of the distributor 62, whereas the valve 44 is closed.

Once such operation has been carried out, the unit 22 controls the valve 32 to open and the distributor 62 to close, which has the effect of forcing out the oil present in the lower part of the tank 26 through the first bypass line 28, into the conduit 4, in the direction of unclogging of the filter 30. Such step is represented by the configuration shown in Figure 16. The fact of lowering the pressure in the tank 26 from 7 to 6.2 bar makes it possible to circulate a quantity of about 20 ml from the tank 26 to the conduit 4. At the end of such step, a quantity L3 equal to 10 ml of lubricant remains in the tank 26, at a pressure P2 of 6.2 bar.

Once such operation of unclogging the filter has been carried out, the unit 22 moves the installation 2 in the configuration shown in Figure 17 where the valve 32 is closed again, whereas the valve 44 is open and the distributor 62 is placed in a configuration for feeding the volume V26 with pressurized air. The above has the effect of discharging the residual quantity of oil present in the second discharge line 42 and in the sensors 46 and 48 until the configuration of Figure 18 is obtained, where the second discharge line 42 and the sensors 46 and 48 are empty of oil and filled with air. The above corresponds to the configuration shown in Figure 7 and mentioned hereinabove.

It should be noted in Figures 17 and 18 that the part of the first bypass line 28 located between the valve 32 and the outlet 284 is emptied by the air coming from the tank 26. The above should be connected to the fact that, in practice, the valve 32 is arranged immediately upstream from the branch 29.

In the third embodiment of the invention shown in Figure 19, a plurality of conduits 4 are used, each of the conduits being provided to collect oil from a single cylinder of the engine M.

Each conduit 4 is equipped with a valve 20 controlled by the electronic unit 22 and which makes it possible to interrupt the flow F1 of lubricant in the conduit 4 in question. A first bypass line 28 is connected both to each conduit 4, upstream of the valve 20 thereof and to the inlet of the buffer tank 26 which is the same as in the first embodiment. The installation 2 thus comprises as many first bypass lines 28 as conduits 4. Starting from the mouth 282 thereof, each first bypass line 28 is equipped with a filter 30 and a shut-off valve 32. The first four lines 28 meet downstream of the respective shut-off valves 32 thereof and the tap-off 34 is common to the first four bypass lines 28, as well as the outlet 284 thereof into the buffer tank 26.

A tap-off 8 is provided on each conduit 4 and is equipped with a manually controlled valve 10, according to an approach parallel to the approach mentioned hereinabove with regard to the first embodiment. In a variant, only one or certain conduits 4 are equipped with such a tap-off 8.

The second discharge line 42 is common to all the cylinders of the engine and downstream of the tank 26, receives the oil coming from all the first bypass lines 28. The outlet 424 of the second discharge line is arranged on one of the conduits 4, downstream of the shut-off valve 20 thereof.

The third embodiment serves to optimize the bulk of the conduits 4 and the pathway thereof within the engine compartment of a ship. The installation saves space compared with the first embodiment.

By successively implementing the method explained above with regard to the first embodiment, for each of the conduits 4, the installation of the third embodiment makes it possible to know, by means of the sensor 48, identical to the sensor of the first embodiment, the basicity of the fuel at the outlet of each of the cylinders of the engine M to which a conduit 4 is connected.

In the example shown in Figure 19, four conduits 4 are provided, each dedicated to a cylinder of the engine M. In a variant, the number of conduits 4 is different, while remaining greater than or equal to 2, in order to adapt the installation 2 depending on the configuration of the engine M and to the space available for housing the conduits 4.

Whatever the embodiment, installation 2 serves for an efficient measurement of the base number or BN of an oil coming out of the engine M by means of a method that can be automated and that does not require any particular knowledge on the part of a user, since the signal S2 can be directly readable, either by man or by a machine.

In practice, the maximum pressure P1′ prevailing in the internal volume V26 of the tank 26, which depends on the pressure of the source 12, is not limited to 7 bar. Same is comprised between 6 and 12 bar, preferentially between 7 and 10 bar, depending on the pressure of the compressed air network available on the ship. The value of 7 bar is preferred because same gives good experimental results and corresponds to a commonly available pressure level. It is important that the pressure P1 is higher than the pressure P4 of the oil in the conduit 4, which is between 1.1 and 6 bar as mentioned hereinabove. Indeed, it is the difference between the pressures P1 and P4 that ensures the flow of the oil through the second discharge conduit 42.

Whatever the embodiment, the installation 2, which is essentially included in the housing 24, is easy to install on-board a ship and does not require the valve 20 to be installed in the conduit 4, the connection of the lines 28 and 42 to said conduit and the feeding thereof with current and air under pressure. The installation 2 can thus be easily installed on a new ship or used to retrofit a ship in service.

The invention is described hereinabove in the case of the use thereof for a ship propulsion engine. However, the invention is applicable to other equipment, e.g. an auxiliary engine or an engine for a ship accessory, as well as a gearbox, in particular a gearbox for a turbine or for a wind turbine.

In the foregoing, the words "oil" and "lubricant" are used indistinctly because an engine oil is a lubricant. However, the invention is applicable to other lubricants such as transmission and gear oils, compressor oils, hydraulic oils, turbine oils or centrifuge oils.

The features of the embodiments and variants envisaged hereinabove can be combined to generate new embodiments of the invention.

INSTALLATION OG METODE TIL OVERVÅGNING AF VARIATIONEN I SMØREMIDDELS BASISKE EGENSKABER

PATENTKRAV

1.- Installation (2) til overvågning af udviklingen af basiciteten (BN) af et smøremiddel, der cirkulerer i udstyr (M), denne installation omfatter:

- mindst et rør (4) til cirkulation (F1) af smøremidlet, hvor dette rør er forbundet, opstrøms, til udstyret, og nedstrøms, til en genvindingstank (6)
- mindst en sensor (48) til bestemmelse af smøremidlets basicitetsindeks (BN)
- en akkumuleringstank til smøremiddel (26)
- en første bypass-ledning (28), der på den ene side er forbundet med røret og på den anden side med tanken
- en anden ledning (42) til udledning af smøremidlet fra tanken til genindvindingstanken, idet denne anden ledning er placeret nedstrøms for den første bypass-ledning (28),
- en første ventil (20) til kontrolleret afbrydelse af cirkulationen (F1) af smøremidlet i røret (4),
- en anden ventil (32) til kontrolleret afbrydelse af smøremiddelstrømmen i den første bypass-ledning, hvor den mindst ene sensor (48) er anbragt på den anden udledningsledning (42),

idet installationen er kendetegnet ved, at:

- tanken (26) er en buffertank (26) til opsamling af smøremidlet
- en tredje ventil (44) til kontrolleret afbrydelse af smøremiddelcirkulationen er inkluderet i den anden udløbsledning
- sensoren (48) gør det muligt at bestemme basicitetsindekset for det smøremiddel, der forlader buffertanken (26),
- den første bypass-ledning (28) er forbundet med røret opstrøms for den første ventil.

2.- Installation ifølge krav 1, kendetegnet ved, at den omfatter midler (12, 22, 36, 40; 12, 22, 62) til at sætte det indre volumen (V26) af buffertanken (26) under tryk med gas.

3.- Installation ifølge krav 2, kendetegnet ved, at gastrykmidlerne omfatter en trykluftkilde (12) og et sæt ventiler (36, 40) eller en pneumatisk fordeler (62) til selektivt at placere det indre volumen (V26) af buffertanken (26) i forbindelse med trykluftkilden eller den omgivende atmosfære.

4.- Installation i henhold til et af de foregående krav, kendetegnet ved, at den omfatter midler (54, 56; 60) til detektering af smøremiddelniveauet i buffertanken (26).

5.- Installation i henhold til krav 2 og 4, kendetegnet ved, at midlerne til detektering af smøremiddelniveauet i tanken omfatter en sensor (58) for gastrykket i buffertankens (26) indre volumen (V26).

6.- Installation i henhold til et af de foregående krav, kendetegnet ved, at den yderligere omfatter,

- en sensor (46) til densitet (D), viskositet (V), fugtighed (H) og temperatur (T), som også er placeret på den anden udledningsledning (42)
- en sensor (50) for indholdet af opløst jern i smøremidlet i buffertanken.

7.- Automatiseret fremgangsmåde til overvågning af ændringer i basiciteten af et smøremiddel, der cirkulerer i udstyr (M), ved hjælp af en installation (2) i henhold til et af de foregående krav, kendetegnet ved, at den omfatter mindst følgende trin:

a) lukning af den første ventil (20),
b) åbning af den anden ventil (32) og lukning af den tredje ventil (44) for at tilføre buffertanken fra en mængde (L; L') smøremiddel, der er akkumuleret i røret (4), opstrøms for den første ventil,
c) åbning af den tredje ventil (44) for at cirkulere smøremidlet i bufferbeholderen gennem den anden udledningsledning (42) i kontakt med sensoren (48) til bestemmelse af smøremidlets basicitetsindeks,
d) brug af et udgangssignal (S48) fra denne sensor til at bestemme smøremidlets alkalinitetsindeks.

8.- Fremgangsmåde ifølge krav 7, kendetegnet ved, at den implementeres med en installation (2) ifølge et af kravene 2 eller 3, og ved, at den omfatter et trin e) efter trin b) og før trin c), og som består i:

e) at sætte det indre volumen (V26) af buffertanken (26) under tryk med gas ved et tryk (P1) på mellem 6 og 12 bar, fortrinsvis mellem 7 og 10 bar, og endnu mere fortrinsvis lig med 7 bar.

9.- Fremgangsmåde ifølge et af kravene 7 eller 8, kendetegnet ved, at trin c) afbrydes, mens en restmængde (L2) smøremiddel forbliver i buffertanken (26).

10.- Fremgangsmåde ifølge krav 9, kendetegnet ved, at den omfatter et trin f) efter trin d), som består i:

f) at rense et filter (30), der er indbygget i den første bypass-ledning (28), ved at cirkulere smøremiddel fra buffertanken (26) til røret (4).

11.- Metode til overvågning af driften af udstyr (M) om bord på et skib, kendetegnet ved, at den omfatter bestemmelse, om bord på skibet, af basicitetsindekset (BN) for et smøremiddel i udstyret ved at implementere en metode i henhold til et af kravene 7 til 10.

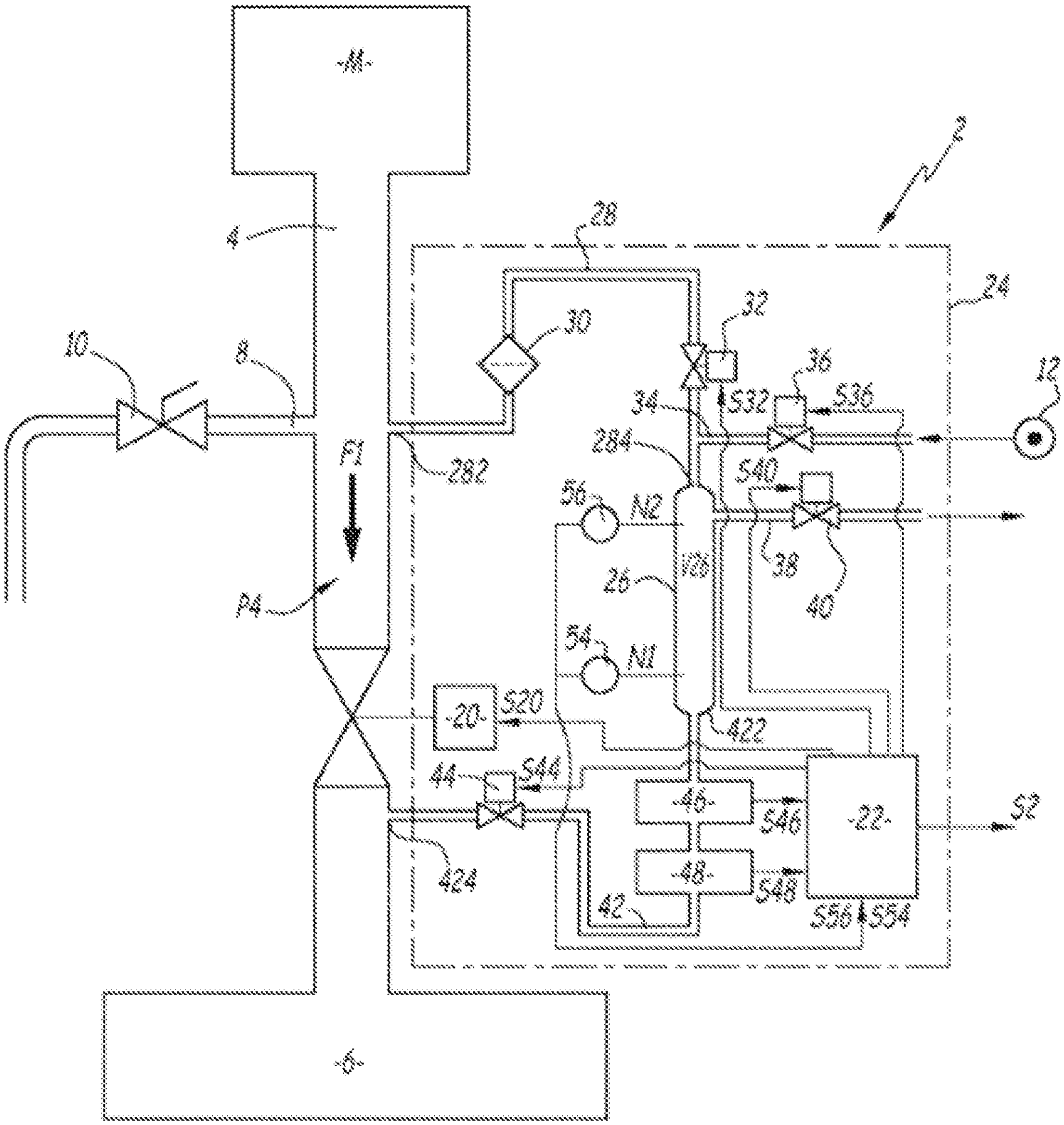

-M-
2
28
4
30
32
24
10
8
36
12
34
S32
S36
F1
284
282
S40
56
N2
38
40
V26
P4
26
54
N1
-20-
S20
422
44
S44
-46-
-22-
S2
S46
424
-48-
S48
42
S56
S54
-6-

Fig.1

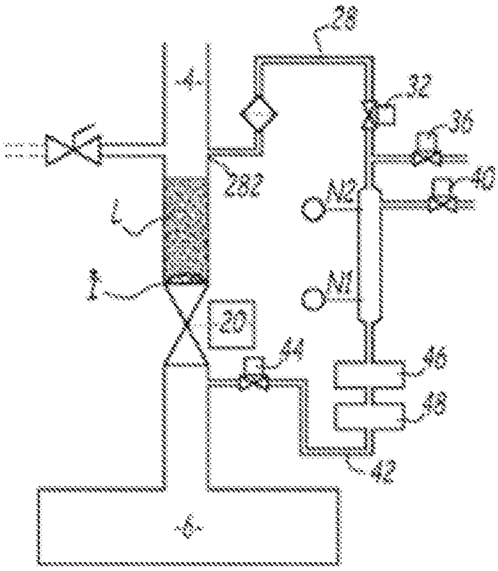


Fig.2

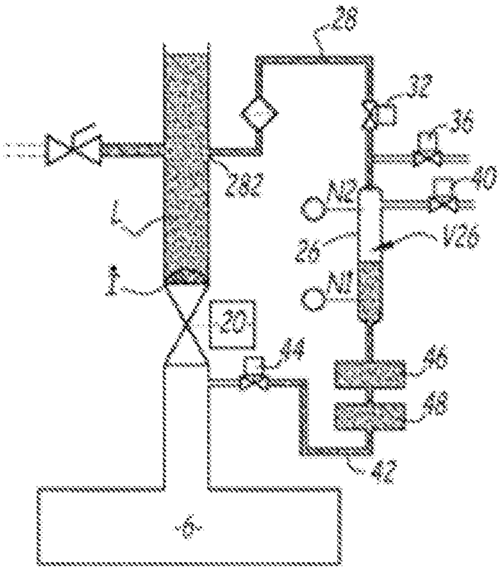


Fig.3

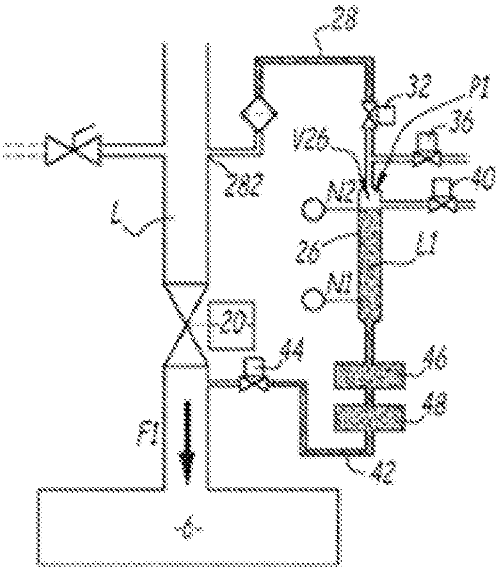


Fig.4

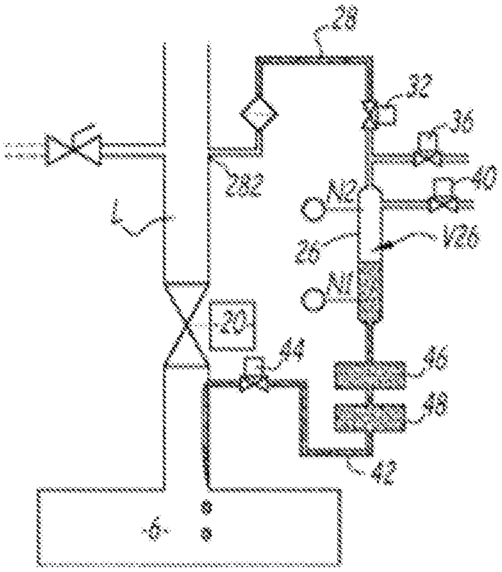
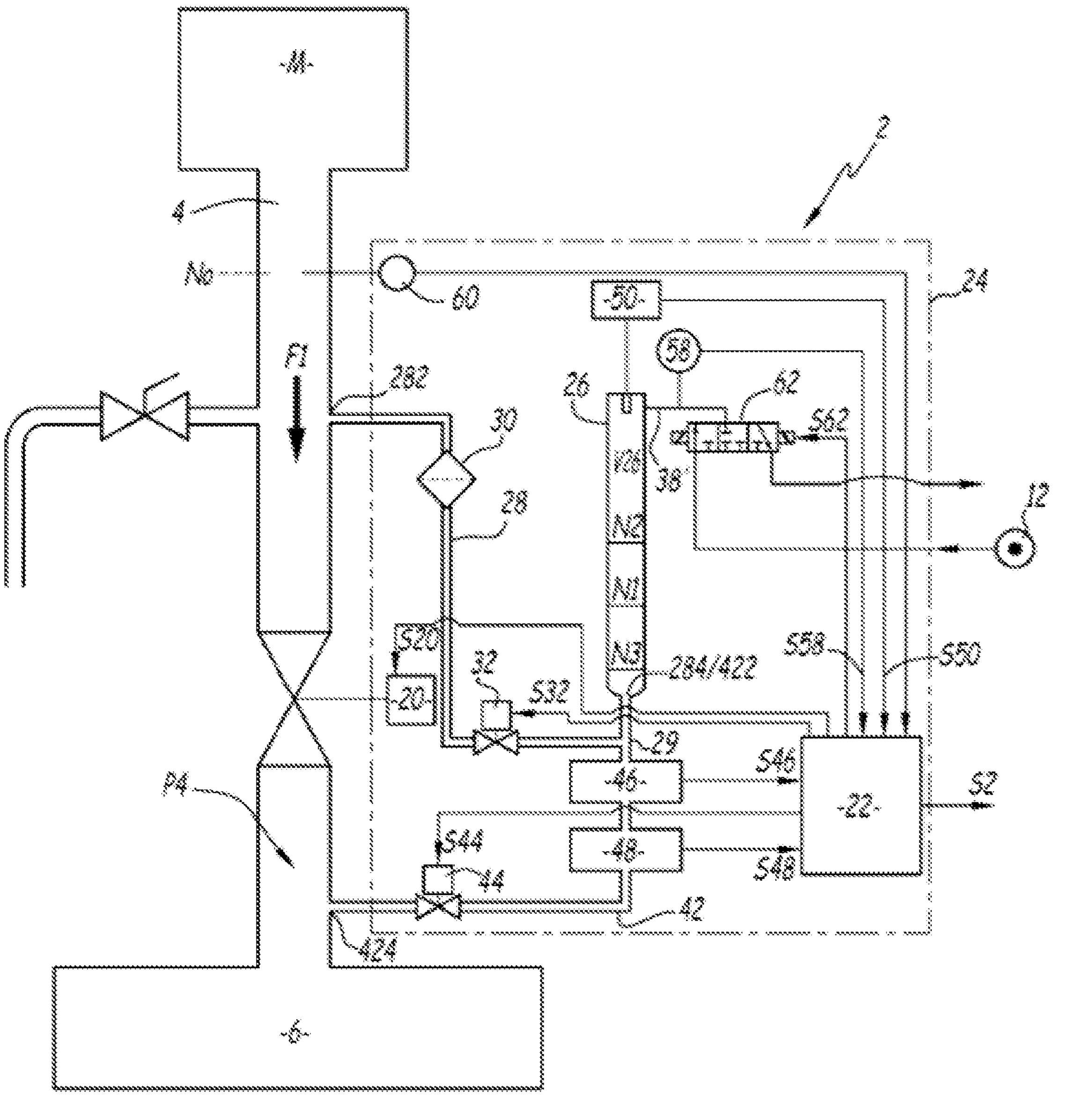


Fig.5



-M-
4
No
60
2
24
-50-
58
F1
282
30
26
62
S62
V26
38
28
12
N2
N1
S20
N3
284/422
S58
S50
32
S532
-20-
29
S46
-46-
-22-
S2
P4
S44
-48-
S48
44
42
424
-6-

Fig.6

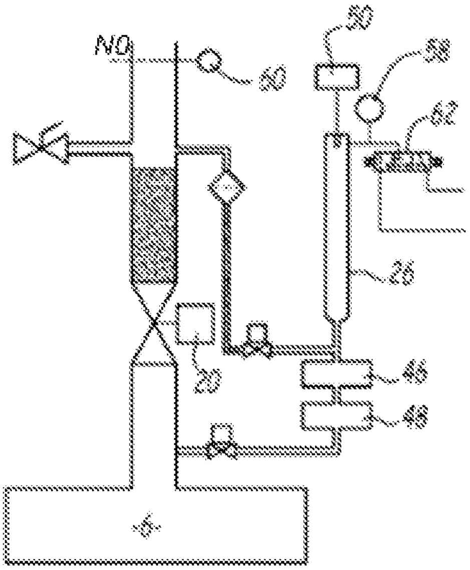


Fig.7

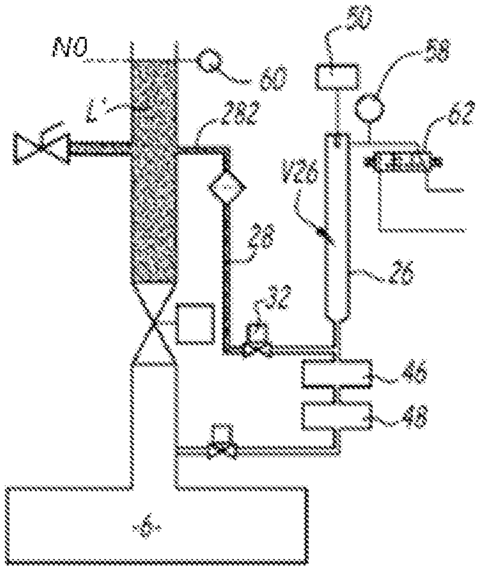


Fig.8

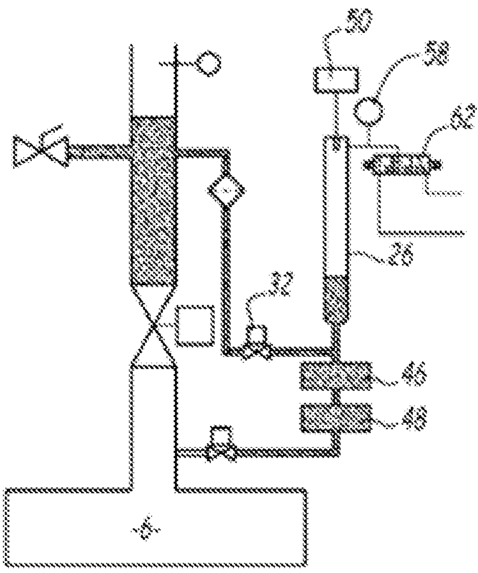


Fig.9

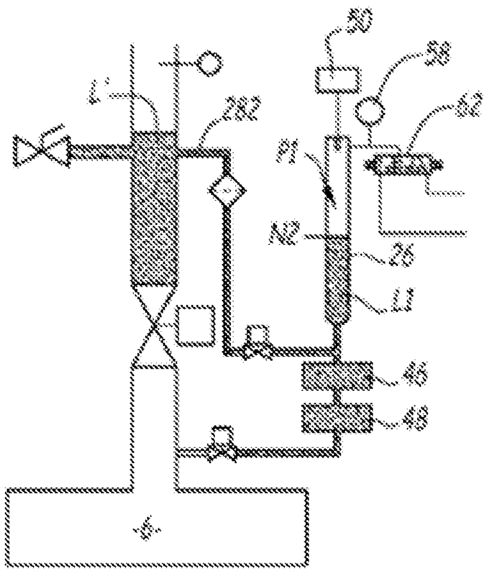


Fig.10

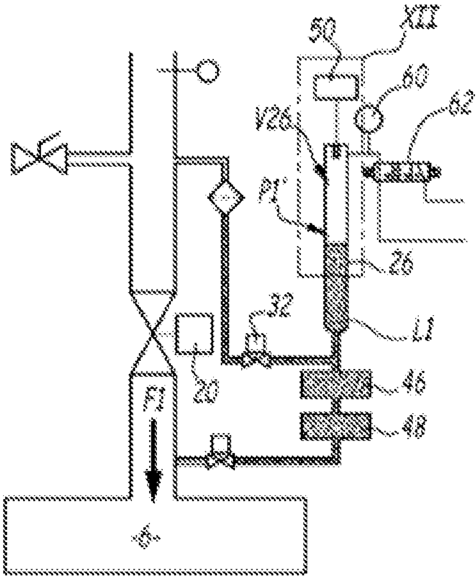


Fig.11

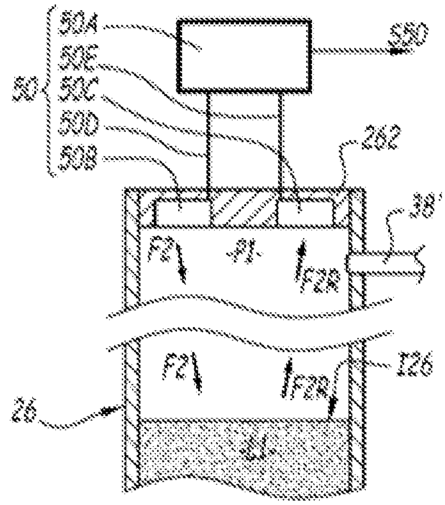


Fig.12

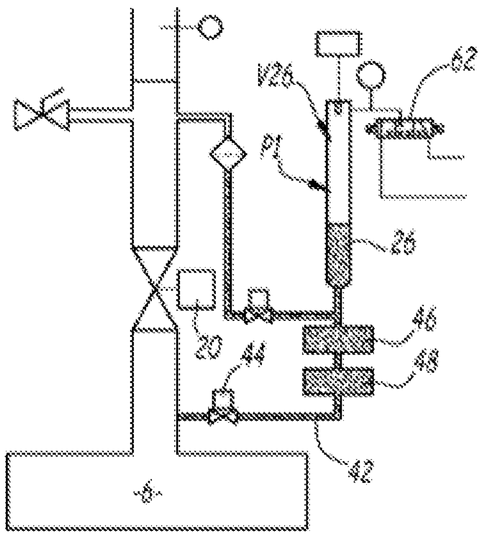


Fig.13

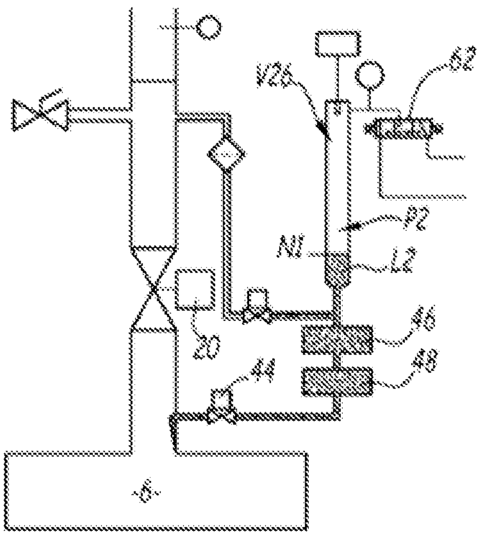


Fig.14

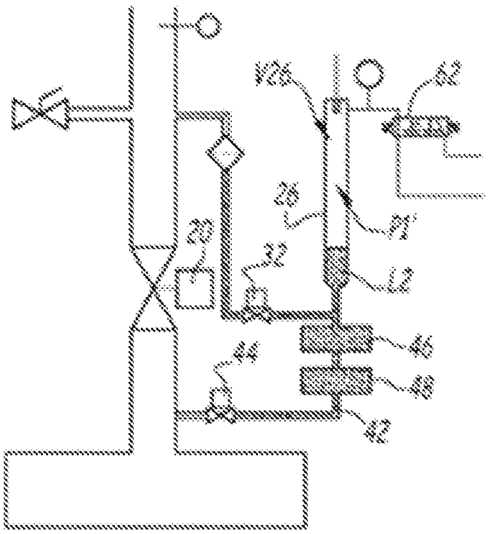


Fig.15

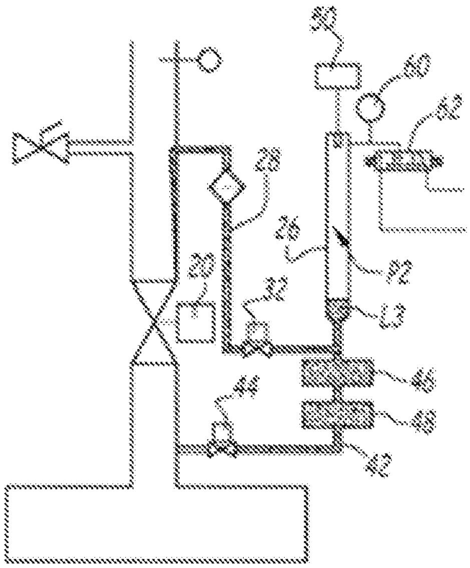


Fig.16

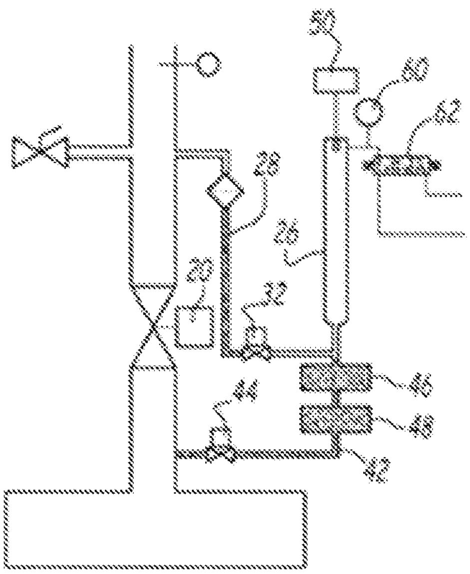


Fig.17

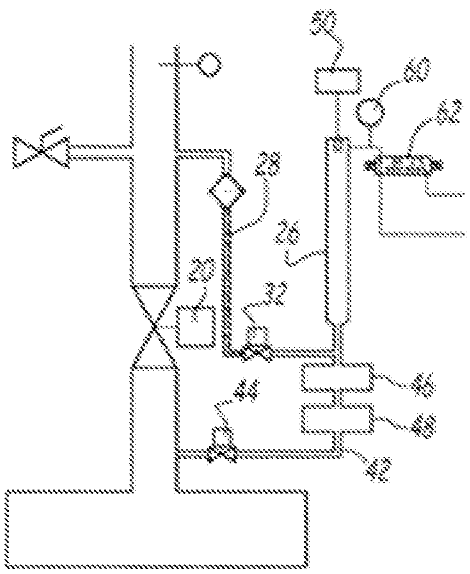


Fig.18

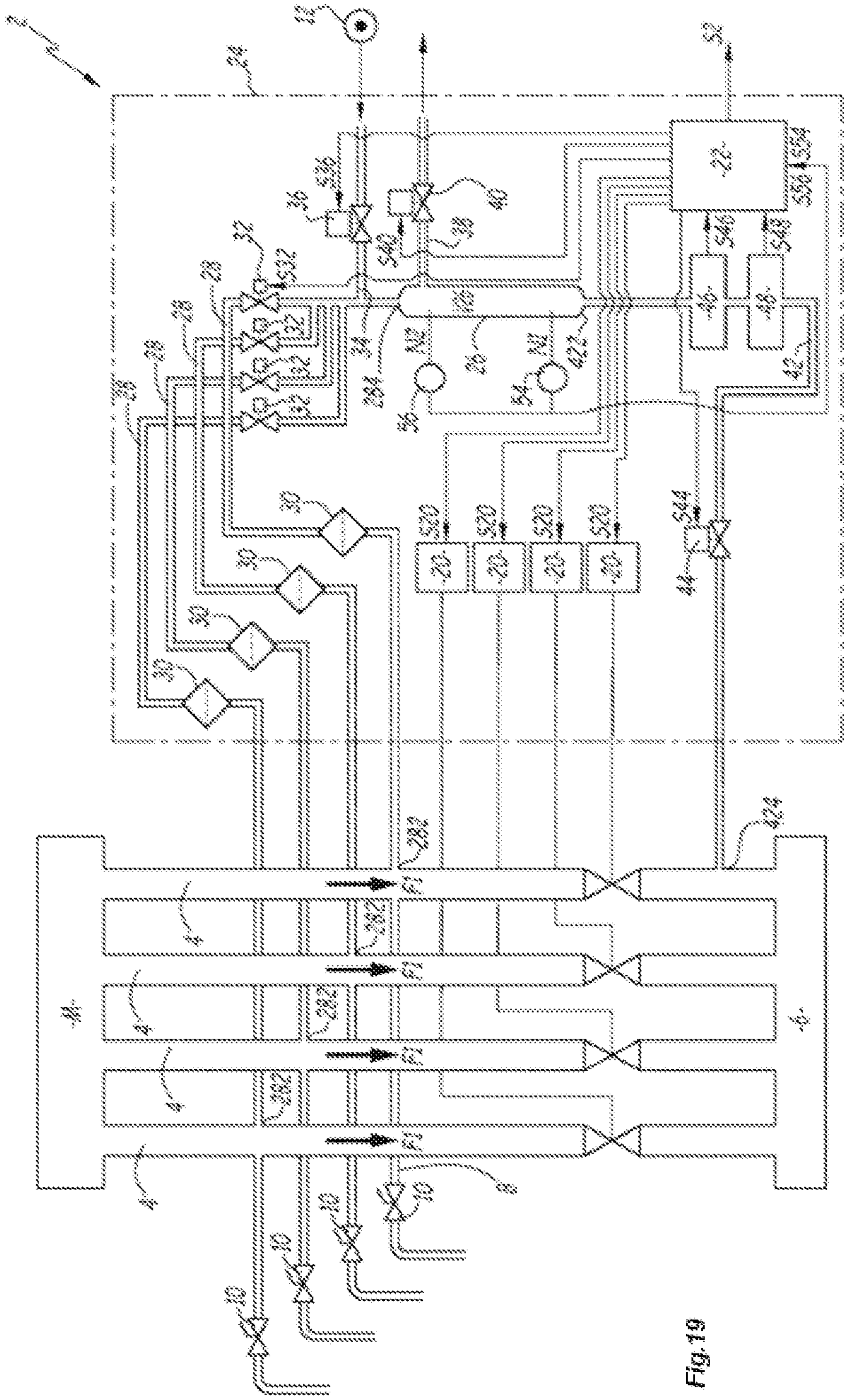


Fig.19