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(71) Applicants and

(72) Inventors: **MAPELLI, Angelo** [IT/IT]; Contrà Piave 14,
I-36100 Vicenza (IT). **JAMOLETTI, Francesco** [IT/IT];
Via Borgoratto, 5, I-24053 Brignano (IT).

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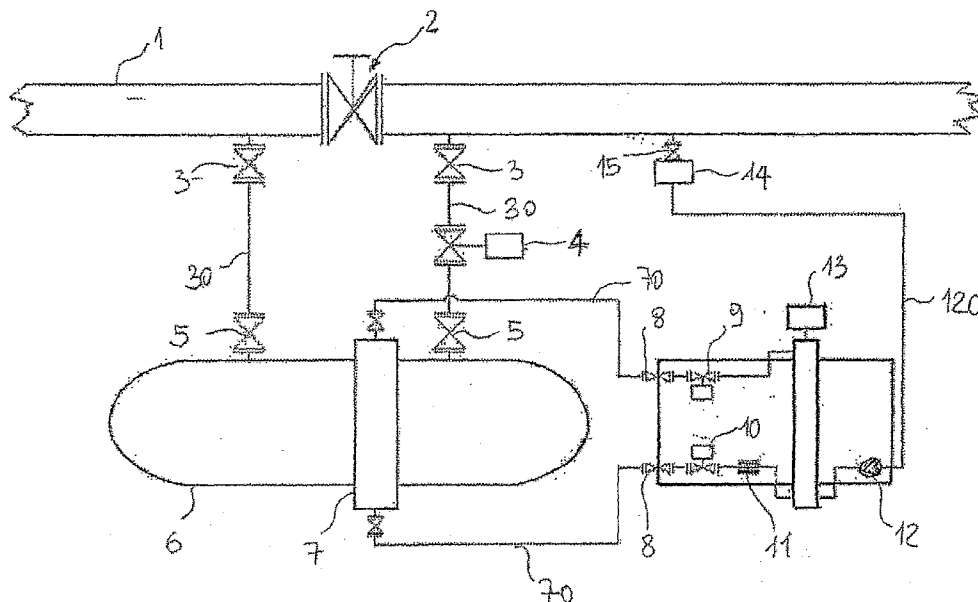
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(74) Agent: **BORSANO, Corrado**; Notarbartolo & Gervasi
S.P.A., Corso di Porta Vittoria, 9, I-20122 Milan (IT).

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ning of each regular issue of the PCT Gazette.

(54) Title: METHOD AND SYSTEM FOR ODORISING A GAS



(57) Abstract: A method and a system for odorising a gas fed into a main pipe (1) leading from a distributor station to a user by means of a device (14) for injecting a liquid odorant contained inside a lapping tank (6), pressurised at the same pressure value as the pipe (1). The system is characterised in that the delivery of the liquid odorant to said injection device (14) is unaffected by the pressure of the gas inside said main pipe (1) or by the pressure inside said pressurisable tank (6).

METHOD AND SYSTEM FOR ODORISING A GAS

FIELD OF THE INVENTION

The present invention relates to a method and a system for odorising a gas and, more
5 precisely, it concerns a method and a system for odorising a gas in the distribution network
of a natural gas production plant or the like.

STATE OF THE ART

Plants for distributing natural gas to users typically include provision for odorising the gas
(which is normally odourless) to facilitate the identification of any gas leaks into
10 environments occupied by people.

Several known systems have been used in the past to odorise natural gas or the like at gas
distribution plants for the above-mentioned purposes. These systems adopt an odorising
device that functions by means of the known lapping principle or, alternatively and/or
jointly, a device for mechanically dosing a given flow rate of a liquid odorant inside the
15 pipe that carries/distributes the gas to the users.

According to a first known lapping-type gas odorising system, in a decompression and
metering station, there is a pipe for drawing the gas from a distribution network, a
decompression and regulation system, a meter and a pipe for delivering the gas to one or
more users, arranged one after the other in succession. The gas pipe downstream from the
20 meter is fitted with a lapping system or device for odorising the gas.

This type of system is not very reliable, however, because the continual variations in the
flow rate conditions at every natural gas distribution plant make it impossible, using the
conventional lapping system, to assure the proper dosage of the concentration of odorant
without taking difficult and continuous manual action.

25 According to a second known type of system for odorising the gas at a distribution station,
a liquid odorant dosing device is installed on the delivery pipe and connected, by means of
a circuit, to a pressurisable balance tank containing a liquid odorant. The tank can be
pressurised by means of a circuit that carries a flow of gas in the pressurisable tank from
and to the intake pipe upstream from the regulating device. The object of this circuit for
30 delivering gas from/to the pressurisable balance tank containing the liquid odorant is to
generate a thrust pressure inside said tank to enable the dosage of the liquid through a

solenoid valve, depending on the variations in the flow rate demanded by the user downstream from the meter. Together with the solenoid valve, the pressure in the pressurisable balance tank thus adjusts the flow rate of the liquid odorant as a function of any changes in the pressure/flow rate in the intake pipe on the user side. Of course, pressure reducing means are provided to govern said operation of the pressurisable balance tank. In addition, the system is always accompanied by a conventional lapping-type odorising device that can be used as an alternative to the injection system during any stoppages of the latter.

Despite its straightforward design, this second type of odorising system has several drawbacks.

A first drawback lies in that the pressure adjustment for the liquid odorant in the pressurisable balance tank to deliver to the injector may be inaccurate, and any discrepancy gives rise to a correspondingly imprecise injection of liquid into the gas flow being distributed.

Another drawback lies in that a rather complex pneumatic management system is needed to fill the pressurisable balance tank, venting the overpressure upstream from the meter and filling the lapping tank by gravity. This operation cannot always be guaranteed because of the pressure drop due to the metering manifold. This drawback can make the device cut out.

Another drawback lies in that odorising system designed in this way can only function within certain previously-established ranges of pressure/flow-rate values, and only at natural gas distribution stations that provide for a decompression of the gas.

Another drawback concerns the minimum quantity that can be handled for each injection of liquid, which is far greater than the dosage actually needed per cubic meter of gas in transit.

Another drawback lies in the type of dosing unit used, which delivers the liquid by drop into a dispersion system to enable its proper vaporisation in the gas in transit.

SUMMARY OF THE INVENTION

The object of the present invention is to overcome the above-mentioned drawbacks, by means of a gas odorising system in a network for distributing gas to a user, that involves the use of an electric injector of liquid odorant into the gas delivery pipe, wherein the

injector is connected to an electric pump for delivering the liquid odorant coming from a tank containing said liquid, said system enabling a constant injection pressure and the dosage of each single injection according to need for each single cubic metre in transit, injecting a suitably vaporised liquid.

- 5 Another object of the present invention is to provide a gas odorising system in a network for distributing gas to a user that offers a considerable versatility, thanks to the opportunity to reprogram the injection system so that it can inject any type of commercially available odorant, always assuring the ideal concentration.

10 An additional object of the present invention is to provide a gas odorising system in a network for distributing gas to a user that is simple to construct, fully controllable and easily manageable, easy to service and calibrate, highly reliable and safe in use, and that is suitable for interfacing with a remote unit for computer-assisted management, e.g. using a PLC, PC or the like.

15 The present invention thus concerns a gas odorising system in a network for distributing gas to a user according to the attached claims.

Moreover, the present invention includes a method for managing and monitoring the gas odorising system in a network for distributing gas to a user according to the attached claims.

BRIEF DESCRIPTION OF THE DRAWINGS

20 A detailed description of the system for odorising a gas in a network for distributing gas to a user is provided below, according to a preferred embodiment of the intervention and given here as a non-limiting example with reference to the attached figures, wherein:

- figure 1 is a schematic view of the circuit for the delivery and management of the gas odorising system according to the present invention;
- 25 - figure 2 is a partial cross-sectional view of the injector device of the present invention; and
- figure 3 is a partial cross-sectional view of the injector device in figure 2.

DETAILED DESCRIPTION OF THE INVENTION

30 Figure 1 shows the gas odorising system of the present invention. According to this system, there is a main pipe 1 for delivering the gas coming from a distribution station to a user. This main pipe has a pressure differential valve 2 normally provided in this type of

system for delivering gas to a user. Upstream and downstream from the differential valve 2 there are respective on/off valves 3 for the purpose of drawing off a given flow rate of gas upstream from the differential valve and subsequently returning it to the main pipe 1 downstream from the differential valve.

5 As shown in the figure, each on/off valve 3 is connected to a respective pipe 30 that is connected in turn to a tank 6, containing a liquid odorant of the known type, such as mercaptan or the like (better illustrated later on).

Moreover, each pipe 30 has respective on/off valves 5, one of the two of which is always micrometrically precise and used to adjust the flow rate, and both of which are installed so
10 as to be able to isolate the tank from the main pipe 1. In addition, there is typically another solenoid valve 4 on the pipe 30 delivering the gas into the main pipe 1. The purpose of the solenoid valve 4 is to enable the lapping device to be disabled during the operation of the dosing system and vice versa.

There is a level sensor 7 of the known type installed in the tank 6 to provide an indication
15 of the level of the liquid odorant inside.

Moreover, the level sensor 7 is connected to two pipes 70, each of which is complete with a respective on/off valve 8 and solenoid valve 9 and 10, respectively.

The pipe 70 coming under the influence of the solenoid valve 10 is connected to a device
20 11 for filtering the liquid phase of the liquid odorant. This filtering device 11 also has a settling tank 13, the purpose of which is well known.

According to the present invention, there is also an electric circulator device 12 connected to the filter 11 so as to draw off a predetermined flow rate of liquid odorant coming from the filter 11 and carry it through a pipe 120 that is connected to an injector 14 pneumatically connected to the main pipe 1 (better illustrated later on). There is also an
25 on/off valve 15 downstream from the injection device 14 and upstream from the main pipe 1 for the purpose of isolating the injection system if necessary.

Figures 2 and 3 show the injection device 14 of the present invention.

According to the present invention, the injection device 14 consists of an injector 16 contained inside a casing 17. The casing 17 substantially consists of two parts. A first part
30 18 consists of a cylindrical body with a threaded coupling surface 19 and a matching surface 20, while the second part consists of a substantially hollow complementary

cylindrical body 21 with a complementary threaded coupling surface 19 and a complementary matching surface 20, each of which is designed to co-operate with the corresponding surfaces on the first part. In addition, the matching surface 20 on the second part 21 contains an O-ring type gasket 22.

- 5 Inside the casing thus created, the injector 16 is locked in a suitable seat formed by the two parts 18 and 21, and prevented from performing any horizontal or vertical movement once the casing 17 has been closed.

In operation, the injector 16 is first connected electrically by fixing the power supply wire to the connector on the injector (e.g. by means of a Faston connection). Then, once the
10 injector 16 is locked inside its seat, all the remaining space inside the casing 17 is filled with a silicone resin 23 whose thermal and mechanical characteristics depend on the intended type of usage (e.g. a silicone resin such as HIGH TEMPERATURE BOSTIK 2464, suitable for working temperatures continually at 260°C).

Moreover, to prevent the connection between the two threaded parts 19 from working
15 loose, a locking pin 24 is inserted on the outside edge of the casing 17. A suitable clamp 25 is also provided for earthing the casing.

As will appear evident to a person skilled in the pertinent art, according to a first aspect of the present invention, the above-described injection device 14 forms an integral part of the
20 odorising system of the present invention, designed to deliver a liquid (mercaptan or the like) under controlled conditions into the pipe 1 carrying natural gas, methane gas or coal gas under pressure.

The injected liquid is kept at a pressure that can vary, according to need, from 0.5 to 1 bar higher than the pressure in the main pipe 1 thanks to the motor-driven pump 12 installed upstream from the injection device 14.

- 25 The presence of a liquid under pressure in the device 14 is guaranteed by a level sensor that cuts off the system in the event of a shortage of liquid odorant in the tank 6, switching off the power supply to the injection device 14 and pump 12, as well as cutting off the flow of liquid odorant by means of the normally-closed solenoid valves provided.

According to another aspect of the present invention, the casing 17 is installed directly on
30 the on/off valve 15 and this is connected to the main pipe 1. In this way, the dismantling of the injector can be done only after cutting off the gas by closing the on/off valve 15.

According to another aspect of the present invention, in the event of a malfunction of the injection device 14, it can be replaced after cutting off the gas flow by closing the on/off valve 15.

5 According to another aspect of the present invention, the injection device 14 is tested, calibrated, assembled with the corresponding protective casing 17 and sealed at the factory before it is dispatched, and consequently needs no further adjustment in the field.

Another aspect of the odorising system of the present invention lies in that it can advantageously be managed by an electronic management system. More precisely, because the injection device 14 is managed by an electric injector 16 powered by an electric circulator 12, the delivery of the liquid odorant from the tank 6 to the main pipe 1 can be
10 managed from a remote unit, such as a PLC unit, a PC or the like.

In fact, once the data coming from each of the single devices in the odorising system of present invention have been recorded and processed, e.g. the values of the instantaneous flow rate coming from the physical metering system adopted at the station, the level of the
15 liquid in the tank 6, the level of the settling tank 13, the position of the solenoid valves, the functioning of the electric circulator 12 and of the injection device 14, all these devices can be continuously managed in real time, enabling an effective adjustment of the system to suit any operating conditions in the main pipe 1.

In addition to processing the data, the remote management and monitoring unit can also
20 transmit these data to a display installed on a control panel (not shown in the figures) and the operator monitoring and managing the system can interact with the system by means of said panel. This means that both the electronic control and management unit, complete with the functional programming options, and the corresponding control panel can be installed in a safe area of the operator's choice.

25 All the system function, such as the level in the tank 6, the level in the settling tank 13, the position of the solenoid valves and the functioning of the electric circulator 12 and injection device 14, can be displayed and controlled "online" on the display on the control panel. According to the present invention, moreover, the data recorded by the control unit can be a continuously-refreshed data set, enabling an instantaneous and ongoing
30 assessment of the dosages relating to the flow rate of the gas in transit.

More particularly, according to another aspect of the present invention, the electronic

control of the system can include a precise monitoring of the quantity of odorant to inject through the injection device 14, as explained below.

In the apparatus of the known type, the dosage of the odorant relies on a calculation of the quantity to inject or deliver based on pulses emitted by a meter that monitors the volumes
5 for fiscal purposes. The pulses are proportional to the volume of gas flowing in the main pipe.

Each pulse is multiplied by a correction factor mainly to take into account the absolute pressure and the temperature of the gas in transit.

The volume meter does not emit single pulses; instead, it groups them together (usually 3-4
10 at a time) so that, after correction, they relate to an equivalent of the passage of approximately 15-20 cubic metres of gas. If, after acquiring this value, the dosing apparatus were to immediately inject the quantity of odorant corresponding to the pulses received, there would be major oscillations in the amount of odorant delivered into the piping, because the quantity needed for 15-20 cubic metres of gas would all be injected
15 into 1 cubic metre of gas; then no more liquid would be added until the next set of pulses is received.

In some cases, when the meters used are large in size, the value of one pulse relates to an equivalent of 10 cubic metres of gas, further increasing the above-described problem.

This problem is overcome by the electronic system for dosing the quantity of odorant to
20 inject, according to the present invention, in that it provides for the following steps:

- acquiring the pulses emitted by the meter, received as input;
- assessing the quantity of odorant required;
- comparing said quantity with the single quantity of each injection that the system considers optimal in order to obtain the number of injections needed;
- 25 - waiting for the next pulse input;
- measuring the time elapsing since the previous pulse input;
- diluting the odorant to inject between said number of injections and distributing the odorant over the time interval elapsing between one pulse input and the next.

The system thus injects the odorant needed in an ongoing, more frequent process,
30 guaranteeing an even concentration of the odorant in the gas in transit, avoiding the risk of

its overdosage (especially during periods of low gas consumption) alternating with periods of a shortage of odorant.

The system can also electronically and automatically control the opening time of the injection device 14 on the basis of the flow rate of the gas in transit, obtaining said single
5 optimal quantity of odorant for each injection.

In fact, the system is complete with a control logic that uses the gas consumption recorded on the previous days in order to establish the opening time for the injection device 14 on each day.

This control logic disregards official holidays and the days prior to them, since they are
10 days on which consumption can vary considerably: for instance, the settings for Mondays are based on the consumption on the previous Friday.

For official holidays or Saturdays and Sundays, the values of the previous week-end can be considered.

After checking the daily volume, the control logic applies the best opening times to the
15 injection device so as to dose and deliver the odorant evenly and effectively in every cubic metre of gas in transit.

The odourising system according to the present invention offers numerous advantages.

The first advantage lies in that only a very straightforward reprogramming action is needed to enable the injection of any type of odorant commercially available, thus assuring its
20 optimal concentration in the gas.

Another advantage lies in that the system's design is extremely rational. The use of the electric injection device 14, powered by an electric circulator 12, can always guarantee the injection of the required quantity of liquid whatever the gas delivery conditions in the main pipe 1. For instance, a relationship can be established between the number of injections and
25 the cubic metres of gas in transit. By keeping the delivery pressure of the injection device 14 constant thanks to the presence of the electric circulator 12, the quantity of liquid injected can be guaranteed to within a margin of error of $\pm 2.5\%$.

Another advantage lies in that the electronic level measuring device 13 can verify the quantity of odorant injected instant by instant, serving a dual purpose in that it also checks
30 the level of the odorant contained in the main tank 6. The electronic management of these measuring devices is entrusted to the control unit, which can send alarm messages and

remotely control the entire process: every time the tank monitored by the level sensor 7 becomes empty, a check is performed on the dosage and the self calibration of the system is activated.

5 An additional advantage lies in that, being extremely rational, the system is likewise very straightforward to maintain. In fact, the only devices that need checking are the filter 7 upstream from the injection device 14 and the injection device 14 itself. The electric circulator 12 is of the mechanical type, with no diaphragm, so it does not need any maintenance. In practice, maintenance on the filter 7 upstream from the injection device 14 can be done as and when necessary. This is an unlikely event because the quantity of
10 liquid to inject is distributed among numerous cycles and consequently at a very low instantaneous flow rate, which virtually eliminates the risk of impurities being entrained towards the filter 7 (which is typically made of stainless steel with a mesh size of 60 μ). The injection device 14 is the only part of the system liable to wear, but its structural design derives from fatigue tests well in excess of the real requirements - in terms of the
15 working environment, the working temperatures and the number of cycles - for its use in the system of the present invention. For instance, at a station constantly delivering 5000 standard cubic meters per hour, 24 hours a day, the injection device 14 has a working life of 15 years.

Another advantage lies in that all the functional devices in the system are designed to be
20 installed and then tested remotely using a remote supervisor system. All the information obtained during the operation of the system can be saved for as long as necessary. The system's reliability is guaranteed by tried and tested, prime quality electronic management apparatus, electromechanical safety systems and a remote management of the system. For instance, a maximum limit of injections can be established beyond which the system will
25 cut out to avoid erroneous concentrations in the event of a malfunction of the meter from which the PLC receives the adjusted volume data.

Another advantageous feature of the system of the present invention lies in that, thanks to the remote and interfaced management via a control unit, such as a PLC or the like, the system can be used for a daily data logging of the number of injections performed and the
30 quantity of odorant delivered, and for particular needs it is very easy to obtain any type of printout of these data according to any schedule required. For example, a remote terminal

can be used to check on screen the number of injections made per hour and the quantity of odorant injected per hour, as well as the daily averages. A screen with a web page format enables the entire system to be monitored as if the user were at the station.

5 Another advantageous feature of the system lies in that it affords a considerable operating safety by comparison with the conventional systems. In fact, any malfunctions are detected while the system is in operation using extremely straightforward, but highly reliable devices. In the event of any possible anomaly, the system is disabled and the lapping-type odorising means are switched on automatically. All these operations can be handled either automatically by the PLC or manually by the operator. The presence of liquid in the main
10 tank is monitored by a specific sensor and, if the level drops to below the minimum setting, the system is disabled. Based on the customer's needs, a series of printouts can be scheduled at different deadlines. All alarms are indicated on screen and relayed to a remote station.

CLAIMS

1. A system for odorising a gas fed into a main pipe (1) and carried from a delivery station to a user, comprising means (2) for regulating the delivery pressure in said main pipe (1), a pressurised tank (6) containing a liquid odorant and on-off/regulating means (3,30,4,5) for said tank (6),

characterised in that it also comprises a device (14) for injecting said liquid odorant coming from said tank (6) into said main pipe (1), and means (12) for transferring said liquid odorant from said tank (6) to said injection device (14), arranged so that the delivery of the liquid odorant to said injection device (14) is independent from the value of pressure of the gas in said main pipe (1) or the value of pressure inside said pressurised tank (6).

2. A system for odorising a gas fed into a main pipe (1) according to the previous claim, wherein said means for pressurising said tank of liquid odorant (6) comprise:

- at least one circuit (30) for supplying the gas from/to the main pipe (1) and from/to said tank (6); and
- on/off valves (3,4,5) on said circuit for transferring the gas from/to the main pipe and from/to said tank (6).

3. A system for odorising a gas fed into a main pipe (1) according to the previous claim, wherein at least one valve (4) of said on/off valves (3,4,5) is a solenoid valve or controlled by a solenoid valve.

4. A system for odorising a gas fed into a main pipe (1) according to claim 2 or 3, wherein said gas transfer circuit (30) is positioned upstream from said means (2) for regulating the pressure in said main pipe (1).

5. A system for odorising a gas fed into a main pipe (1) according to any of the previous claims, wherein said means (12) for feeding said injection device (14) comprise an electric circulator (12) connected by a circuit to said tank of liquid odorant (6) and operated electrically by a remote control unit.

6. A system for odorising a gas fed into a main pipe (1) according to any of the previous claims, wherein said tank (6) contains a mechanical and/or electronic sensor (7) for indicating the level of the liquid odorant.

7. A system for odorising a gas fed into a main pipe (1) according to the previous claim, also comprising a filtering device (11) connected to said level sensor (7) by means of two

pipes (70), each of which is fitted with respective on/off valves (8, 9, 10).

8. A system for odorising a gas fed into a main pipe (1) according to the previous claim, wherein at least one valve (9, 10) of said on/off valves is a solenoid valve.

5 9. A system for odorising a gas fed into a main pipe (1) according to claim 7 or 8, wherein said filtering device (11) comprises a settling tank (13).

10. A system for odorising a gas fed into a main pipe (1) according to any of the previous claims, wherein said means for feeding said injection device (14) comprise an electric circulator device (12) pneumatically connected to said filter (11) and to said injection device (14).

10 11. A system for odorising a gas fed into a main pipe (1) according to any of the previous claims, wherein said injection device (14) is connected directly to said main pipe (1) downstream from said pressure regulating means (2) and is complete with an on/off valve (15).

15 12. A system for odorising a gas fed into a main pipe (1) according to any of the previous claims, wherein said injection device (14) comprises an electric injector (16) contained inside a casing (17).

13. A system for odorising a gas fed into a main pipe (1) according to the previous claim, wherein said casing (17) comprises:

- 20 - a first part (18) consisting of a cylindrical body with a threaded coupling surface (19) and a matching surface (20);
- a second part (21) consisting of a substantially hollow, complementary cylindrical body, which also has a complementary threaded coupling surface (19) and a complementary matching surface (20), each of which is suitable for co-operating with the respective surfaces on said first part (18).

25 14. A system for odorising a gas fed into a main pipe (1) according to the previous claim, wherein said casing (17) also comprises an "O-ring" gasket (22) fitted inside said matching surface (20) on said second part (21).

30 15. A system for odorising a gas fed into a main pipe (1) according to claim 12 or 13 or 14, wherein said casing (17) has recesses for containing and retaining said injector (16), said injector (16) being locked in position by the closure of said first part (18) on said second part (21).

16. A system for odorising a gas fed into a main pipe (1) according to any of the claims from 12 to 15, wherein said casing (17) also comprises an internal volume (23) between said injector (16) and said parts (18,21) that is filled with a silicone resin of predetermined thermal and mechanical characteristics depending on the type of operation required.

5 17. A system for odorising a gas fed into a main pipe (1) according to the previous claim, wherein said casing (17) also comprises a locking pin (24) placed on the outer edge of the casing (17).

18. A system for odorising a gas fed into a main pipe (1) according to any of the previous claims from 12 to 17, wherein said casing (17) also comprises a clamp (25) for earthing the
10 casing.

19. A system for odorising a gas fed into a main pipe (1) according to claim 1, comprising a system for electronically managing the quantity of said odorant to inject through said injector (14), comprising means for:

- acquiring the pulses emitted by the meter, received as input;
- 15 - assessing the quantity of odorant required;
- comparing said quantity with the single quantity of each injection that the system considers optimal in order to obtain the number of injections needed;
- waiting for the next pulse input;
- measuring the time elapsing since the previous pulse input;
- 20 - diluting the odorant to inject between said number of injections and distributing the odorant over the time interval elapsing between one pulse input and the next.

20. A system for odorising a gas fed into a main pipe (1) according to claim 19, wherein said electronic management system comprises means for controlling the opening time of said injection device (14) according to the flow rate of the gas in transit, thus obtaining
25 said single optimal quantity of each injection.

21. A method for odorising a gas carried in a main pipe coming from a distributor station and leading to a user, comprising the following steps:

- recording the pressure in said main pipe (1) as a function of the gas flow rates to said user with the aid of pressure regulating means (2) on said main pipe (1);
- 30 - pressurising a pressurisable tank (6) containing a liquid odorant by means of a pneumatic communication between said main pipe (1) and said tank (6), and means

(3,30,4,5) for pressurising said tank (6); and

- delivering the liquid odorant to an injection device (14) provided on said main pipe (1) downstream from said pressure regulating means (2) in a manner that is unaffected by the pressure of the gas inside said main pipe (1) or the pressure inside said pressurisable tank (6).

5

22. A method for odorising a gas according to claim 21, comprising the following steps:

- acquiring the pulses emitted by the meter, received as input;
- assessing the quantity of odorant required;
- comparing said quantity with the single quantity of each injection that the system considers optimal in order to obtain the number of injections needed;
- waiting for the next pulse input;
- measuring the time elapsing since the previous pulse input;
- diluting the odorant to inject between said number of injections and distributing the in the time elapsing between one pulse input and the next.

10

15 23. A method for odorising a gas according to claim 22, comprising a stage for controlling the opening time of said injection device (14) on the basis of the flow rate of the gas in transit, obtaining said single optimal quantity of each injection.

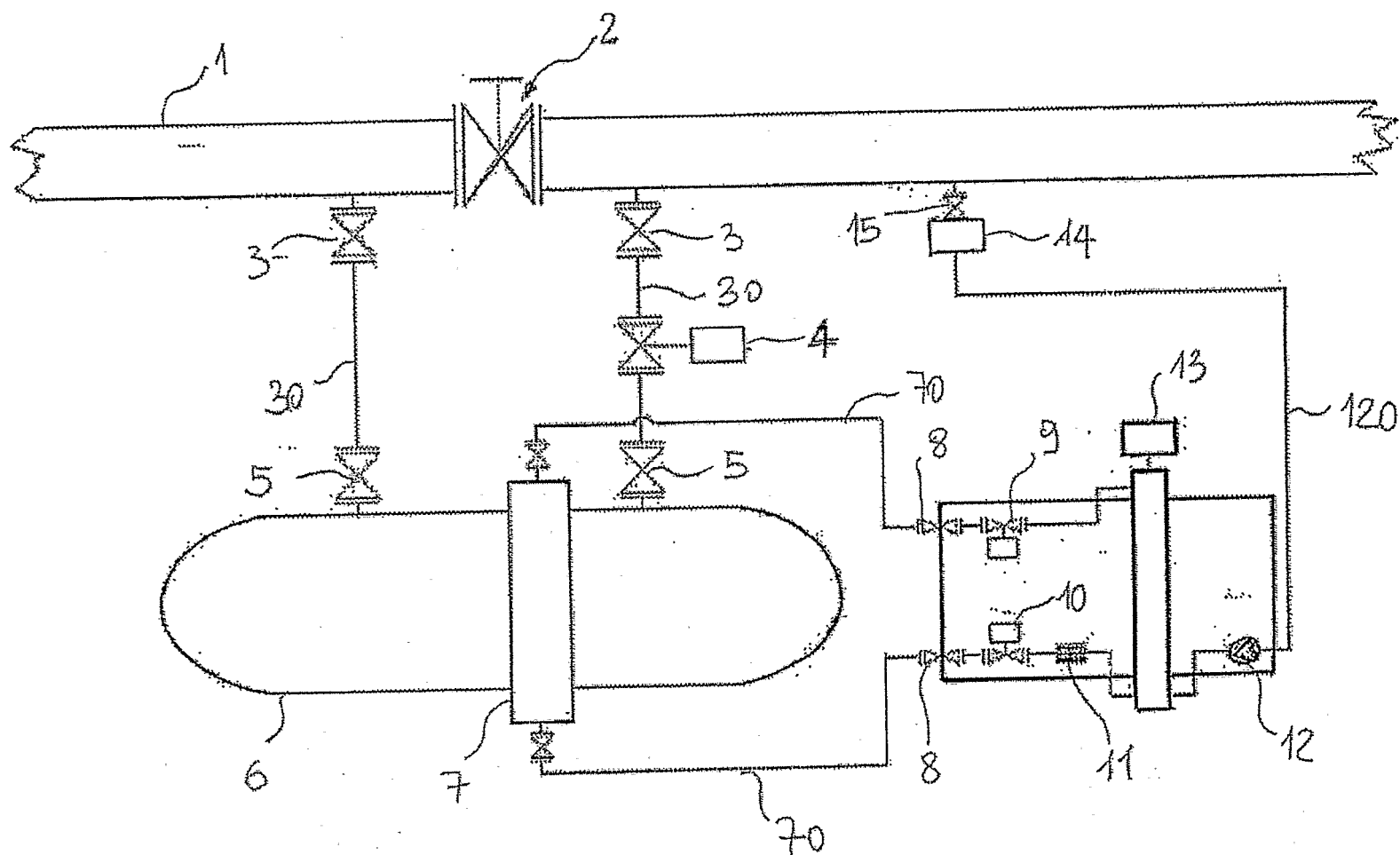


Fig. 1

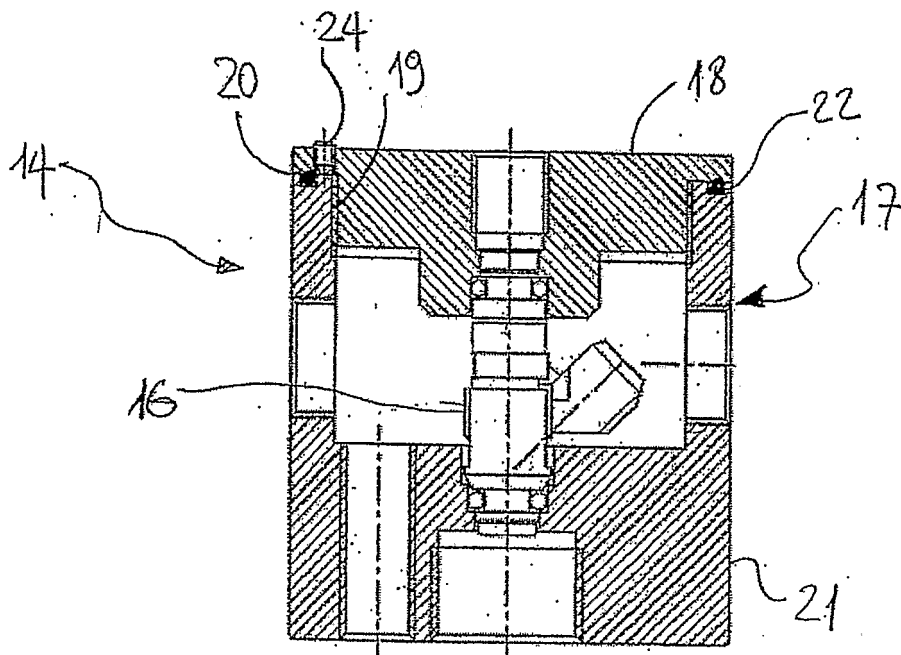


Fig. 2

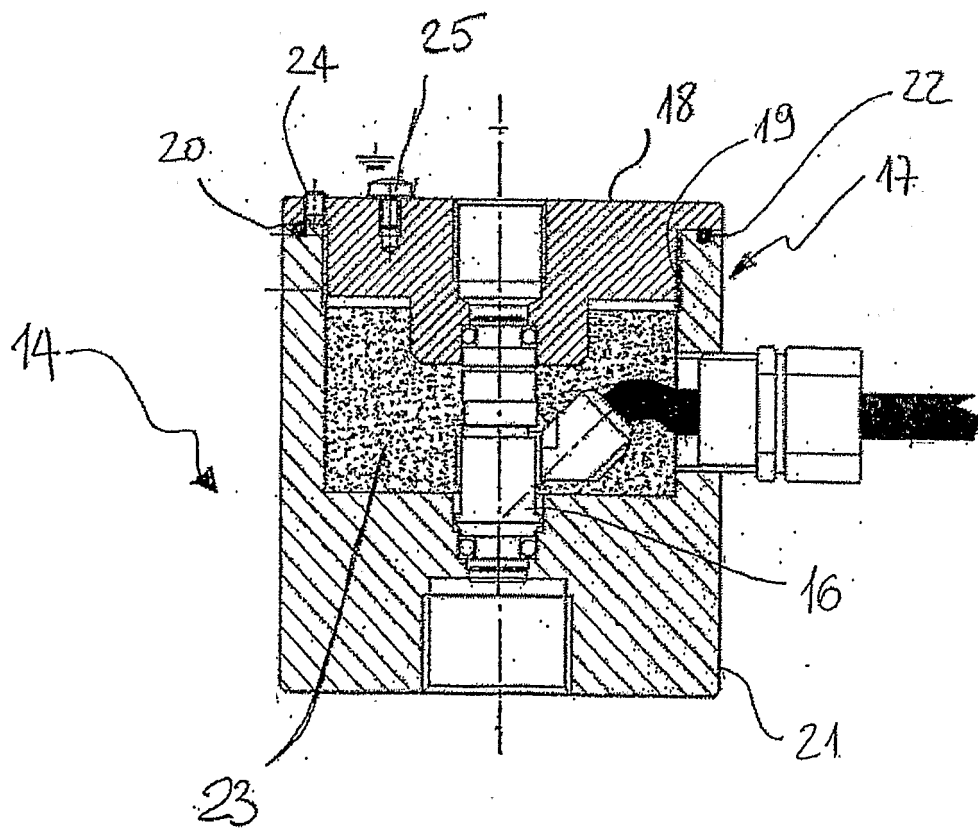


Fig. 3