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(54) APPARATUS FOR A PLANT FOR THE GAS MANAGEMENT

(57) Apparatus (3) for a plant (2) for the management of gases produced in a decentralized way, in particular renewable gases, said plant (2) comprising a first higher pressure network (4) and a second lower pressure network (5), said apparatus (3) is characterized by the fact that it:

- is configured to be connected upstream with said second lower pressure network (5) and downstream with said first higher pressure network (4),
- is configured to return the gas from and/or circulating in said second lower pressure network (5) to said first higher pressure network (4),
- comprises a compression unit (16) connected to a control unit (11), the latter being configured so that, on the basis of the measurements (19) of the gas pressure and/or flow rate made upstream of said compression unit (16), correspondingly controls the activation/deactivation of said compression unit (16) and/or the modulation of its flow rate,
- comprises a purification module (10) for removing from the gas from the second lower pressure network (5) the substances and/or compounds not accepted by the first higher pressure network (4).

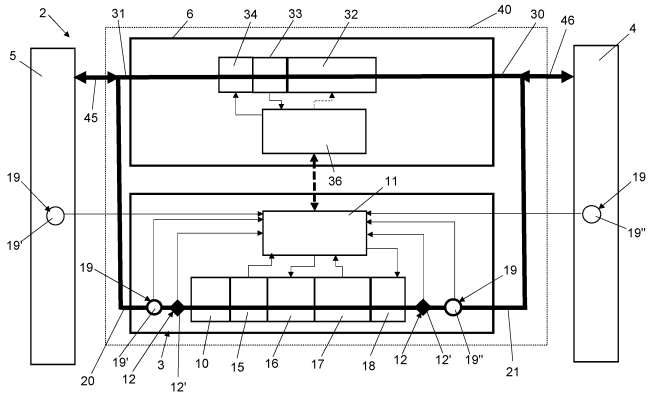

FIG. 2

EP 3 748 219 A1

Description

[0001] The present invention relates to an apparatus for a system for the management of gases produced in a decentralized way, in particular renewable gases.

[0002] Among the gases produced in a decentralized way are known, for example, biomethane, syngas, hydrogen, methanation of hydrogen.

[0003] As is known, for example, biomethane is a gas that mainly contains methane (CH_4) and that is produced from a renewable source. In particular, in fact, biomethane derives from biogas which is subjected to an upgrading or purification process (by removing carbon dioxide, dehydration, desulfurization, removing gaseous ammonia, dust or other impurities) until biomethane reaches substantially the quality similar to that of natural gas. In more detail, at the end of the purification or upgrading process, the biomethane thus obtained contains a quantity of methane ≥ about 95% and is chemically very similar to natural gas. The biomethane production plant can also include an appropriate compression and/or odorization of the biomethane obtained, which can thus be introduced into the gas transmission or distribution network to be used substantially in the same applications and destinations as for natural gas (for example for heating and cooking in domestic or industrial users).

[0004] Currently, the production plants of gas produced in a decentralized way, and in particular biomethane, are receiving considerable interest and this thanks also to the economic incentives provided in the sector, however their construction and diffusion arises mainly in the face of two contrasting problems:

- the high initial investment and the high operating costs, both in terms of operation and maintenance (O&M) and in terms of energy consumption, required by the systems to inject the gas, obtained from upgrading systems, into the transport network (high pressure), almost always receptive to the quantities of gas produced;
- the limited and inconstant receptivity of the distribution networks (low pressure), deriving in particular from the fact that in certain periods there could be a reduced consumption (and therefore demand) of the injected gas.

[0005] In essence, the aforementioned two problems can currently make the construction of gas production plants, produced in a decentralized way, injecting the gas thus produced into the transport and/or distribution networks, economically non viable.

[0006] DE102009038128 describes a method of injection of gas from a medium pressure distribution network to a higher pressure transport network. This method involves the use of a compressor controlled on the basis of pressure measurements made upstream of the compressor itself. The solution of DE102009038128 also provides a module to condition - for example by adding air or LPG - the biogas of the distribution network in order to adapt it to the greater calorific value of the natural gas circulating in the transport network.

[0007] FR3035598, DE102008058736, DE102013011289 and US2016/247167 describe a biogas injection plant from a storage unit, and/or in any case from the biogas production plant, to the distribution and/or transport network.

[0008] The object of the present invention is to propose an apparatus and a system for the management of gases produced in a decentralized way, in particular renewable gases, which allow to overcome the aforementioned drawbacks present in traditional solutions.

[0009] Another object of the invention is to propose an apparatus and a system which are highly efficient in terms of energy consumption.

[0010] Another object of the invention is to propose an apparatus and a system which allow to create a bidirectional flow of gas between a transport network (at higher pressure) and a distribution network (at lower pressure).

[0011] Another object of the invention is to propose an apparatus and a system which allow the surplus gas of the distribution network to flow towards the transport network, and this only when said distribution network or a portion thereof is no longer receptive (that is, when the users associated with said network or portion do not request it).

[0012] Another object of the invention is to propose an apparatus and a system which guarantee a continuity of absorption of gas produced in a decentralized way, in particular of renewable gases such as for example biomethane.

[0013] Another object of the invention is to propose an equipment and a system that allow to guarantee the introduction of gas, produced in a decentralized way, from the transport network to the distribution network when the requests (consumption) of gas by the associated users to the distribution network are greater than the quantities of gas, produced in a decentralized way, introduced into said network.

[0014] Another object of the invention is to propose an apparatus and a system which have high safety standards and which are environmentally friendly.

[0015] Another object of the invention is to propose an apparatus and a system which make the implementation of decentralized gas production plants economically convenient, thus favoring their diffusion.

[0016] Another object of the invention is to propose an apparatus and a system which are ameliorative and/or alternative with respect to the traditional ones.

[0017] Another object of the invention is to propose an apparatus and a plant with an alternative characterization, both in construction and functional terms, with respect to the traditional ones.

[0018] Another object of the invention is to propose an apparatus and a system which can be implemented in a simple, rapid and cost-effective way with respect to alternative solutions.

[0019] All these purposes, considered both individually and in any combination thereof, and others which will result from the following description are achieved, according to the invention, with the apparatus having the characteristics indicated in claim 1 and with the plant having the indicated characteristics in claim 11.

[0020] The present invention is further clarified hereinafter in a preferred embodiment thereof, given by way of non-limiting example only with reference to the attached drawings, in which:

Figure 1 shows a schematic view of the system of management according to the invention with associated the gas production plant and a plurality of users,

Figure 2 shows in schematic view the plant for the supply of gas produced in a decentralized way in a first embodiment, and

Figure 3 shows it in schematic view in a second embodiment,

Figure 4 shows it in schematic view a in a third embodiment,

Figure 5 shows it in schematic view in a fourth embodiment, and

Figure 6 shows it in schematic view in a fifth embodiment.

[0021] As can be seen from the figures, the plant according to the invention, indicated as a whole with the reference number 2, for the management of gases produced in a decentralized way - in particular renewable gases, such as biomethane, for example - comprises at least two devices, respectively at least one gas inlet apparatus 6 and at least one apparatus, according to the invention, for the re-introduction of gas 3, to be interposed between a first gas network 4 and a second gas network 5.

[0022] In plant 2 the gas present in the first network 4 is at a substantially higher pressure than that of the gas present in the second network 5. In the following, the first network 4 can also be defined as "higher pressure network" while the second network 5 can also be defined as "lower pressure network".

[0023] As shown in fig. 1, the second lower pressure network 5 can receive the gas produced in a decentralized way from a production plant P_1, P_2,... P_n. Furthermore, a plurality of users U_1, U_2,..., U_n are connected to the second network at lower pressure which require the gas circulating in said second network for their use. Suitably, the second network 5 is a network in which the gas already produced circulates, and is substantially ready for distribution. In particular, therefore, the second network 5 is substantially in direct fluidic connection with the production plant P_1, P_2, ... P_n, but does not include and/or does not correspond with said gas production plant. Conveniently, gas from the first network 4 circulates in the second network 5.

[0024] Conveniently, moreover, the gas present in the first network 4 has characteristics, in particular in terms of composition and preferably due to restrictions in use, which are different than those of the gas present in the second network 5.

[0025] Preferably, the gas circulating in the first network 4 is at a pressure of 5 - 70 bar. Preferably, the first network 4 is a transport network and/or a gas storage system. Conveniently, the first network 4 is a network that does not directly receive the gas produced by the gas production plant P_1, P_2, ... P_n and, therefore, is not in direct fluidic connection with said plant.

[0026] Preferably, the gas circulating in the second network 5 is at a pressure of substantially 1.5 - 8 bar. Preferably, the second network 5 is a gas distribution network to a series of users U_1, U_2,..., U_n connected/associated to it.

[0027] Suitably, the gas supply apparatus 3 is not intended to be interposed between the production plant P_1, P_2, ... P_n and a gas distribution or transport network, and this also applies to the gas inlet 6.

[0028] In particular, in the plant 2 the inlet apparatus 6 is configured to take/receive the gas from the first network at higher pressure 4 and inject it into the second network at lower pressure 5.

[0029] In essence, the inlet 6 is configured to allow the direct flow of gas from the first network 4 at higher pressure towards the second network 5 at lower pressure. In particular, the inlet apparatus 6 is connected at the inlet 30 and upstream with the first higher pressure network 4, while at the outlet 31 and downstream it is connected with the second lower pressure network 5.

[0030] Preferably, the inlet apparatus 6 is substantially of the traditional type. In particular, the inlet apparatus 6 may comprise at least:

- a module 32 for reducing the pressure of the gas which circulates/comes from the first network 4 at higher pressure and which, entering and passing through the inlet apparatus 6, is introduced into the second network 5 at lower pressure,
- a measuring module 33 for the gas which, passing through the inlet apparatus 6, passes from the first network 4 to the second network 5.

[0031] Suitably, the pressure reduction module 32 is configured to adapt the pressure of the gas present in the first network 4 to that provided in the second network 5 and, in particular, at a pressure suitable for the delivery of the gas to the users U_1, U_2, ..., U_n associated with said second network. Conveniently, the reduction module 32 can be positioned upstream and/or downstream with respect to the measuring module 33.

[0032] Conveniently, the gas inlet apparatus 6 also comprises an odorization module 34 configured to add an odorant to the gas which, by passing through the inlet device 6, passes from the first network 4 to the second network 5.

[0033] Conveniently, the measuring module 33 can be

positioned upstream and/or downstream with respect to the odorization module 34.

[0034] In the plant 2, the gas re-injection apparatus 3 according to the invention is configured to take/receive the gas that circulates in the second lower pressure network 5 (and which was previously introduced by the gas inlet apparatus 6 and/or by the system P_1, P_2, ... P_n gas production in a decentralized way) to return it - preferably under certain conditions - to the first higher pressure network 4. In essence, the gas re-injection apparatus 3 is configured to allow - preferably upon the occurrence of certain conditions - a gas flow that is inverse with respect to that allowed/defined by the inlet apparatus 6, that is, to allow a flow of gas from the second network 5 to the first network 4.

[0035] In particular, the gas re-injection apparatus 3 is connected upstream with the second lower pressure network 5, while downstream it is connected to the first higher pressure network 4.

[0036] Suitably, as represented for example in fig. 2, the inlet 20 of the gas re-injection apparatus 3 can be connected upstream to the second lower pressure network 5 by means of the same conduit 45 which connects the outlet 31 of the inlet apparatus 6 to said second network 5. Furthermore, the outlet 21 of the gas re-injection apparatus 3 can be connected downstream to the first network 4 at higher pressure by means of the same conduit 46 which connects the inlet 30 of the gas inlet apparatus 6 to said first network 4.

[0037] Conveniently, as represented for example in fig. 3, the inlet 20 of the gas re-injection apparatus 3 can be connected upstream directly to the second network 5 at lower pressure by means of a dedicated conduit 47, while the outlet 21 of said apparatus 3 can be connected downstream directly to the first network 4 by means of a further dedicated conduit 48.

[0038] Suitably, the flow which passes, through the inlet apparatus 6, from the first network 4 with higher pressure to the second network 5 with lower pressure is hereinafter also referred to as "direct flow"; the flow that passes through the gas re-injection apparatus 3 from the second lower pressure network 5 to the first higher pressure network 4 is also defined hereinafter as "reverse flow".

[0039] Suitably, the gas re-injection apparatus 3 is configured to receive the gas from the second lower pressure network 5 and to compress it (i.e. increase its pressure) and modify it in terms of composition so that it can be reintroduced and accepted in the first network 4 at higher pressure.

[0040] Advantageously, the inlet apparatus 6 and the gas re-injection apparatus 3 can be integrated within a single station or structure 40 (see fig. 2) or can be incorporated in two separate and distinct stations or structures respectively 41' and 41" (see fig. 3). Preferably, inside the plant 2, the inlet apparatus 6 can be installed in combination (i.e. be coupled and connected) to the inlet apparatus 3, or it could be installed independently of the latter.

[0041] The gas re-injection apparatus 3 comprises and/or is associated with a control unit 11 (for example a processor).

[0042] Conveniently, the inlet apparatus 6 can comprise its own and distinct control unit 36 which is connected and communicates directly with the control unit 11 of the gas re-injection apparatus 3 (see Figs. 2, 3 and 5). Suitably, as shown in fig. 4, the control unit 11 of the gas re-injection apparatus 3 and the control unit 36 of the inlet apparatus 6 can be connected to a central management unit 50 of the entire plant 2 and, therefore, communicate with each other through said central management unit. Suitably, as shown in fig. 6, the same control unit 11 can be shared between the inlet apparatus 6 and the re-inlet apparatus 3.

[0043] Advantageously, the control unit 36 of the inlet apparatus 6 is connected to the odorization module 34 so as to command the latter. Advantageously, the control unit 36 of the inlet apparatus 6 is connected to the measuring module 33 so as to receive the data detected by the latter.

[0044] Conveniently, the control unit 36 can also be connected to the reduction module 32 and, in particular, so as to control the latter.

[0045] The gas re-injection apparatus 3 comprises a compression unit 16 of the gas present/coming from the second network 5 at lower pressure and which, entering and passing through the reintroduction equipment 3, is brought back to the first network 4 at higher pressure. Suitably, the compression unit 16 is electrically or gas powered.

[0046] Conveniently, the control unit 11 is connected to the compression unit 16 to control its activation/deactivation (i.e. on/off regulation) and/or to modulate its flow rate. Preferably, the compression unit 16 comprises at least one compressor controlled to modulate its flow rate as a function of the gas pressure in the second lower pressure network 5 and the needs/requests of the first higher pressure network 4.

[0047] The gas re-injection apparatus 3 also comprises at least one pressure control device 12. Preferably, this at least one pressure control device 12 comprises at least one shut-off member configured to protect the higher pressure network 4 from overpressure, and/or the lower pressure network 5 from the sub-pressures.

[0048] Conveniently, a first pressure control device 12' is provided at the inlet 20 of the re-injection apparatus 3. Conveniently, a second pressure control device 12" is provided at the outlet 21 of the re-injection apparatus 3. Suitably, the control unit 11 can be connected to said first 12' and/or second 12" pressure control device to monitor their state or level of opening/closing.

[0049] The gas re-injection apparatus 3 comprises a gas purification module 10 which, suitably, is configured to adapt the gas present and coming from the second lower pressure network 5 to the gas quality specifications which, according to current legislation or sector, there are provided in the first higher pressure network 4. Pref-

erably, moreover, the gas purification module 10 is also configured to protect the appliances and instruments present inside the re-injection apparatus 3.

[0050] In particular, the purification module 10 is configured to remove from the gas - which comes from the second lower pressure network 5 and which enters the gas re-injection apparatus 3 - the substances and compounds that are not accepted by the first higher pressure network 4 or that could damage the appliances and/or the instruments of said re-injection apparatus 3. Suitably, the purification module 10 is configured not to cause any change in the calorific value or energy characteristics of the gas. Suitably, the purification module 10 is configured not to perform any addition and/or mixing of the gas - which comes from the second lower pressure network 5 and which enters the gas re-injection apparatus 3 - with further substances or compounds, such as for example air or LPG.

[0051] Advantageously, the purification module 10 comprises a unit configured to remove the odorant, both sulfur-based and sulfur-free, from the gas which is present in the lower pressure network 5 and which enters the re-injection apparatus 3. Preferably, this gas purification module 10 comprises an adsorption unit, for example activated carbon, for removing the odorant.

[0052] Conveniently, inside the re-injection apparatus 3, the purification module 10 is provided at the inlet 20 of said apparatus and, preferably, is positioned upstream of the remaining modules present in the latter, to thus remove from the gas substances and compounds which could damage the apparatus and/or instruments provided in said re-injection apparatus at the inlet. In particular, advantageously, the purification module 10 is provided, inside the re-injection apparatus 3, upstream of the compression unit 16, so as to remove from the gas entering the said compression unit the substances and compounds which could damage it.

[0053] Advantageously, the re-injection apparatus 3 also comprises an analysis module 15 configured to detect the quality and characteristics of the gas present and coming from the second network 5. Preferably, the analysis module 15 comprises at least one analysis apparatus, such as for example a gas chromatograph.

[0054] In particular, suitably, the analysis module 15 is configured to determine the energy content of the gas and its composition with respect to the specifications foreseen in the higher pressure network 4.

[0055] Conveniently, inside the gas re-injection apparatus 3 the analysis module 15 is positioned downstream with respect to the purification module 10 to thus analyse the characteristics of the gas coming out of the latter, and thus verify the effective and adequate removal of the odorant and/or other substances and compounds which are not accepted by the former higher pressure network 4.

[0056] Advantageously, inside the gas re-injection apparatus 3 the purification 10 and/or analysis 15 modules are positioned upstream with respect to the compression unit 16. Conveniently, in an embodiment (not shown), the analysis module 15 could also be positioned always inside the gas re-injection apparatus 3 and downstream with respect to the compression unit 16.

[0057] Suitably, the analysis module 15 can be a dedicated module provided for/in the gas re-injection apparatus 3 (cf. Fig. 2-4 and 6), that is, be configured only to analyze the reverse flow of gas that enters and passes through the re-injection apparatus 3.

[0058] Conveniently, as shown in fig. 5. the analysis module 15 can also be shared/shared between the re-injection apparatus 3 and the inlet apparatus 6. In particular, in this case, the operation of the analysis module 15 is as follows:

- when operating in connection with the inlet apparatus 6, it measures the composition of the gas and its energy content to calculate the volumes of the direct flow of gas at the reference conditions and/or measures the odorant rate to be applied using the odorization module 34 provided in the inlet apparatus 6,
- when operating in connection with the re-injection apparatus 3 it measures the gas composition and its energy content for the calculation of the volumes of the reverse flow of gas at the reference conditions and/or the measurement of the residual concentration of odorizing substances and/or other substances/compounds downstream of the purification module 10 of said re-injection apparatus 3.

[0059] Advantageously, in this case, the analysis module 15 also comprises a sorting group (pneumatic and/or electronic), not shown, which ensures that the analysis refers to the gas that passes through the inlet apparatus 6 or through the re-injection apparatus 3.

[0060] Advantageously, the re-injection apparatus 3 also comprises a measuring module 17. In particular, this measuring module 17 is configured to carry out the fiscal measurement of the quantity of gas that passes through the re-injection apparatus 3 from the first lower pressure network 4 than the second network 5 at higher pressure. Preferably, the measuring module 17 is suitable for carrying out a gas measurement for tax purposes and, in particular, it is configured to comply with the technical requirements defined by national or supranational (for example European) legislation in order to be used in commercial transactions.

[0061] Preferably, the measuring module 17 is also configured to perform the calculations under the reference conditions.

[0062] Advantageously, the measuring module 17 can be positioned, inside the re-injection apparatus 3, downstream with respect to the compression unit 16.

[0063] Conveniently, the measuring module 17 can be a dedicated module provided for/in the re-injection equipment 3 (see figs. 2-4 and 6), that is, be configured only to measure the flow of inverse gas that enters and passes through the re-injection apparatus 3. Alternatively, as

shown in fig. 5, the measuring module 17 can also be shared between the re-injection apparatus 3 and the inlet apparatus 6.

[0064] Advantageously, the analysis module 15 and the measuring module 17 can be integrated in a single system.

[0065] Conveniently, the analysis module 15 and/or the measuring module 17 of the re-injection apparatus 3 are connected to the control unit 11 to send to the latter the data representative of the detections and/or measurements carried out by said modules.

[0066] Advantageously, the plant 2 also comprises, inside or outside the re-injection apparatus 3, an interception module 18 to allow or interrupt the passage of gas which, leaving the apparatus 3, enters the first higher pressure network 4 Preferably, the interception module 18 comprises a valve assembly. Conveniently, the control unit 11 is connected to the interception module 18 to correspondingly control its opening/closing.

[0067] In particular, when the control unit 11 detects a condition in which the gas quality and the connection profiles are guaranteed and in which the first higher pressure network 4 is receptive, it activates the opening of the interception module 18, thus allowing the gas to pass/enter the first network 4 at higher pressure.

[0068] Advantageously, if provided inside the re-injection apparatus 3, the interception module 18 can be positioned downstream of the compression unit 16 and/or downstream of the possible measuring module 17. Preferably, the interception module 18 is provided at the outlet 31 of the re-injection apparatus 3.

[0069] Conveniently, as mentioned, in the plant 2, the interception module 18 could also be provided externally of the re-injection apparatus 3, preferably in an associated area and/or belonging to the first network 5 at higher pressure.

[0070] Conveniently, sensors 19 are provided inside the re-injection apparatus 3 and/or outside the latter, but always inside the plant 2, to detect and monitor the gas characteristics in terms of pressure. These sensors 19 are preferably connected to the control unit 11 to send to the latter a series of data representative of the detections and/or measurements carried out.

[0071] Preferably, these sensors 19 can be provided inside the first higher pressure network 4 and/or in the second lower pressure network 5, preferably at the delivery and/or redelivery points of fossil or non-fossil gas and/or at critical points (i.e. where the network pressure can reach minimum values). Preferably, these sensors 19 are connected remotely - via cable and/or wireless - with the control unit 11.

[0072] Advantageously, the detections made by these sensors 19 are sent to the control unit 11 which is configured to define, correspondingly, the setpoints of the reduction module 32 provided in the inlet apparatus 6.

[0073] Advantageously, said sensors 19 comprise pressure and/or flow sensors.

[0074] Preferably, at least one first sensor 19' is provided which is configured to detect the pressure and/or the gas flow rate in an area upstream of the compression unit 16. Conveniently, for this purpose, at least one first sensor 19' is provided which is positioned inside the re-injection apparatus 3 and/or a plurality of first sensors 19' are provided distributed in the second low pressure network 5 to detect the pressure - and in particular a rise in pressure - of the gas circulating/coming from said second low pressure network 5.

[0075] Advantageously, at least one second sensor 19" is provided configured to detect the pressure and/or flow of the gas in an area downstream of the compression unit 16 and, in particular, at the outlet 21 of the gas re-injection apparatus 6.

[0076] Conveniently, for this purpose, at least one second sensor 19" can be provided which is positioned inside the re-injection apparatus 3, preferably between the compression unit 16 and the interception module 18, and/or a plurality of second sensors 19" are provided distributed in the first high pressure network 4 to detect the pressure - and in particular an excessive increase in pressure - of the gas circulating in said first high pressure network 4.

[0077] Advantageously, therefore, the control unit 11 of the re-injection apparatus 3 is connected:

- with the analysis module 15 and/or with the measuring module 17 and/or with the sensors 19 to receive the detections made by them, and
- with the compression unit 16 and, preferably, also with the interception module 18, to command and/or correspondingly modulate their activation/deactivation on the basis of the readings received.

[0078] Advantageously, the control unit 11 of the re-injection apparatus 3 can also be connected to said at least one inlet apparatus 6 and, in particular, to a module (for example to the reduction module 32) or to an interception element provided and/or associated with said apparatus 6, to decrease and/or interrupt the flow of gas entering the second lower pressure network 5.

[0079] Preferably, as mentioned, for this purpose, the control unit 11 of the re-injection apparatus 3 can be connected directly, and therefore communicate directly, with the control unit 36 provided in the inlet apparatus 6 (see figs. 2 and 3). Conveniently, the control unit 11 of the re-injection apparatus 3 can be connected with a central management unit 50 of the entire plant 2 and then this central management unit will be connected and communicate with the control unit provided in the inlet apparatus 6 (see fig. 4).

[0080] Conveniently, the control unit 11 of the re-injection apparatus 3 is configured so that, if said at least one first sensor 19' detects an increase in the pressure of the gas circulating and/or coming into the second lower pressure network 5 above of a predefined pressure value (or range of values) P_x, it controls the activation of the compression unit 16 and/or correspondingly modulates its

flow rate and, preferably, also commands the opening of the interception module 18 (to thus allow the gas inlet into the higher pressure network 4) and, preferably, can also send a command to the inlet apparatus 6 to decrease and/or interrupt the flow of gas entering the second lower pressure network 5. Suitably, the flow of gas entering the second lower pressure network 5 could possibly be decreased or interrupted by acting manually and/or mechanically on the inlet apparatus.

[0081] Preferably, the control unit 11 can control the activation/deactivation of the compression unit 16 and, in particular, commands the activation of the compression unit 16 until the pressure upstream of said unit drops below a predefined pressure value (or range of values) P_z, lower than P_x and suitably settable.

[0082] Preferably, the control unit 11 modulates the flow rate of the compression unit 16 to keep the pressure detected upstream of the latter substantially constant by means of said at least one first sensor 19'.

[0083] Preferably, in order to avoid swinging, the control unit 11 is connected to the compression unit 16 by means of an inverter which modulates the flow rate of said compression unit according to the pressure detected upstream by said at least one first sensor 19'; in more detail, as said pressure decreases (in response to the request for gas by the users connected to the lower pressure network 5 or against the re-introduction of gas into the higher pressure network 4 through the re-injection apparatus 6), the control unit 11 controls the reduction of the flow rate of the compression unit 16.

[0084] Conveniently, it is understood that the aforesaid predefined pressure value (or range)/s P_x corresponds to a situation in which there is not sufficient demand of gas to receive all the gas introduced, and therefore there is not sufficient consumption of the latter by the users associated with the second lower pressure network 5, or a portion of this.

[0085] Conveniently, the control unit 11 of the re-injection apparatus 3 is also configured so that, if said at least one second sensor 19" detects an increase in the pressure of the gas circulating in the first network at higher pressure 4 above a predefined pressure value (or range of values) P_y, commands the deactivation of the compression unit 16 and/or correspondingly modulates its flow rate and, preferably, also commands the closure of the interception module 18 (to interrupt the inlet of the gas in the higher pressure network 4) and, preferably, it can also send a command to the inlet apparatus 6 to activate the passage of gas entering the second lower pressure network 5. Conveniently, it is understood that in this case the aforementioned predefined pressure value/s (or range of value/s) P_y corresponds to a situation in which there is an excessive compression of the gas in the first network at higher pressure 4.

[0086] Advantageously, the control unit 11 of the re-injection apparatus 3 is configured to optimize the gas recompression energy profiles, activating and controlling the compression unit 16 of the re-injection apparatus 3 only when necessary (i.e. when it has already been minimized or interrupted the flow of gas entering the second network 5 at a lower pressure), thus avoiding any waste of energy.

[0087] Preferably, the control unit 11 of the re-injection apparatus 3 is also configured to minimize the recirculations between the first higher pressure network 4 and the second lower pressure network 5 and this is obtained by acting on the inlet apparatus 6 in such a way to interrupt and/or decrease the flow of gas from said first network 4 to said second network 5.

[0088] Preferably, the control unit 11 of the re-injection apparatus 3 is also configured to guarantee the safety and continuity of gas supply to the network at a lower pressure 5 and, suitably, this can also be achieved thanks to the control device 12' and/or by monitoring the pressure upstream of the re-injection apparatus 3. In this way, therefore, it is ensured that said lower pressure network 5 never runs out of gas, thus allowing it to promptly satisfy the gas requests made by the users associated with said lower pressure network 5.

[0089] Preferably, the control unit 36 of the inlet apparatus 6 is also configured to guarantee the safety and continuity of gas supply to the lower pressure network 5 and, suitably, this can be obtained by acting on the reduction module 32 of the inlet apparatus 6 and/or monitoring the pressure downstream of said reduction module 32. In this way, therefore, it is ensured that said lower pressure network 5 never runs out of gas, thus allowing it to promptly meet gas requests carried out by the users associated with said lower pressure network 5.

[0090] Preferably, the control unit 11 is also configured to ensure that the gas of the reverse flow, that passing from the second lower pressure network 5 to the first higher pressure network 4, complies with the connection profiles required by said higher pressure network 4 in terms of quality, volumes and physical conditions (pressure and temperature) of the gas. In particular, for this purpose, the control unit 11 receives at the inlet the measurements that are carried out, on the gas that comes and passes through the re-injection apparatus 3, by the analysis module 15 and/or by the measuring module 17 and/or from the sensors 19, and correspondingly controls the interception module 18 and/or the compression unit 16; in more detail, if the measurements carried out are not in line with the profiles required by the first higher pressure network 4, the control unit 11 controls the closing of the interception module 18 and/or of the compression unit 16 thus avoiding the entry of gas into said first network 4.

[0091] Conveniently, a software configured and installed to manage the operation of the re-injection apparatus 3 and, in particular, is installed and executed inside the control unit 11 to command the activation/deactivation and/or to control the modulation of the compression unit 16 of said re-injection apparatus 3 - and preferably also of the interception module 18 - and thus allow the passage/block of the reverse flow of gas from the second

lower pressure network 5 towards the first higher pressure network 4.

[0092] Preferably, the software loaded and/or executed in the control unit 11 is configured to exclusively control re-injection apparatus 3 while the inlet apparatus 6 is controlled separately and/or manually as required.

[0093] Alternatively, the control unit 11 of the re-injection apparatus 3 can be connected directly (see figs. 2 and 3) and/or through a central management unit (see fig. 4) and/or can be shared (see fig. 6) with the inlet apparatus 6 and is configured to manage its operation so as to allow the passage/blocking (or reduction) of the direct flow of gas from the first higher pressure network 4 towards the second lower pressure network 5.

[0094] Advantageously, the software loaded and/or executed in the control unit 11 is configured to control the passage between:

- a first operating mode in which the inlet apparatus 6 is activated, while the re-injection apparatus 3 is deactivated, thus allowing only the direct flow of gas from the first higher pressure network 4 towards the second lower pressure network 5,
- a second operating mode in which the inlet apparatus 6 is deactivated and/or is activated in a suitably reduced manner, while the re-injection apparatus 3 is activated, thus minimizing the reverse flow of gas from the second lower pressure network 5 towards the first network at higher pressure 4.

[0095] The solution according to the invention is particularly advantageous in that:

- it is quick and easy to implement and install,
- is particularly safe,
- allows to reduce the costs for the start-up/construction of the gas supply system produced in a decentralized way, as well as the costs for its operational functioning, thus making the investment economically sustainable and thus encouraging the production of environmentally sustainable gas,
- saves electricity; in fact, the unit of the apparatus according to the invention is controlled so as to function only in case of actual need, thus avoiding making it work in a constant and continuous way,
- it is highly efficient as it allows the constant production of gas produced in a decentralized way without the need, in case of non-receptivity of the distribution network at lower pressure and associated with the users, to request the suspension of gas production or even to burn the precious gas produced in a decentralized way.

[0096] In particular, with respect to the solutions described in DE102009038128, FR3035598, DE102008058736, DE102013011289 and US2016/247167, the apparatus according to the present invention includes a purification module for removing substances and/or compounds from the gas coming from the second network at a lower pressure 5 not accepted by the first higher pressure network 4, and this is particularly appropriate since the gas present in the first network 4 has characteristics - in particular in terms of composition and preferably due to restrictions in use, and also for gas parameters that do not concern its energy content - which are different than those of the gas present in the second network 5.

Claims

1. Apparatus (3) for a plant (2) for the management of gases produced in a decentralized way, in particular renewable gases, said plant (2) comprising a first higher pressure network (4) and a second lower pressure network (5), said apparatus (3) is **characterized by** the fact that it:

   - is configured to be connected upstream with said second lower pressure network (5) and downstream with said first higher pressure network (4),
   - is configured to return the gas from and/or circulating in said second lower pressure network (5) to said first higher pressure network (4),
   - comprises a compression unit (16) connected to a control unit (11), the latter being configured so that, on the basis of the measurements (19) of the gas pressure and/or flow rate made upstream of said compression unit (16), correspondingly controls the activation/deactivation of said compression unit (16) and/or the modulation of its flow rate,
   - comprises a purification module (10) for removing from the gas from the second lower pressure network (5) the substances and/or compounds not accepted by the first higher pressure network (4).

2. Apparatus (3) according to claim 1, **characterized in that**:

   - it is connected upstream to the second network (5) at a lower pressure by means of at least one section of the same duct (45) which connects the outlet of an inlet apparatus (6) to said second network (5), and/or
   - it is connected downstream to the first network (4) at higher pressure by means of at least one portion of the same duct (46) which connects the inlet of an inlet apparatus (6) to said first network (4).

3. Apparatus (3) according to claim 1, **characterized in that** said purification module (10) is provided at the inlet (20) of said apparatus (3) and is positioned

upstream of the remaining modules in said apparatus, so as to remove from the gas inlet to said apparatus (3) the substances and compounds that could damage the appliances and/or instruments provided in said re-injection apparatus (3).

4. Apparatus (3) according to one or more of the preceding claims, **characterized in that** it comprises:

- an analysis module (15) positioned downstream of the purification module (10) and configured to detect the quality and characteristics of the gas before its introduction into the first network (4) at higher pressure,
- and by the fact that said analysis module (15) is connected with said control unit (11) to send the latter representative data of the detections carried out by said analysis module (15).

5. Apparatus (3) according to one or more of the preceding claims, **characterized in that** it comprises:

- a measuring module (17) configured to measure the amount of gas which, through the apparatus (3), passes from the second network at a lower pressure (5) to the first at a higher pressure network (4),
- and **in that** said measuring module (17) is connected with said control unit (11) to send to the latter data representative of the measurements carried out by said measuring module (17).

6. Apparatus (3) according to one or more of the preceding claims, **characterized in that** the control unit (11) is connected to the compression unit (16) by means of an inverter to modulate so, as a function of pressure and/or flow rate detected upstream of said compression unit (16), the flow rate of the gas leaving said compression unit.

7. Apparatus (3) according to one or more of the preceding claims, **characterized in that** it comprises at least one sensor (19, 19') configured to perform said measurements of pressure and/or flow of the gas upstream of said compression unit (16), said at least one sensor (19) being connected to said control unit (11) to send said pressure and/or flow rate readings to the inlet.

8. Apparatus (3) according to one or more of the preceding claims, **characterized in that** it comprises an interception module (18) to allow or interrupt the passage of gas that exiting the apparatus (3) enters the first network at a higher pressure (4), said control unit (11) being connected to said interception module (18) and being configured to correspondingly control the opening and closing of said interception module (18), thus allowing or interrupting the entry of gas into said first higher pressure network (4).

9. Apparatus (3) according to one or more of the preceding claims, **characterized in that** said control unit (11) is configured so that, on the basis of data representative of measurements and/or measurements made by said analysis module (15) and/or from said measuring module (17) and/or from said at least one sensor (19, 19') provided upstream of said compression unit (16), correspondingly controls the activation/deactivation of said compression unit (16) and/or said interception module (18).

10. Apparatus (3) according to one or more of the preceding claims, **characterized in that** it comprises:

- at least one first pressure control device (12, 12') which is positioned at the inlet of said apparatus (3), and/or
- at least one second pressure control device (12, 12") which is positioned at the outlet of said apparatus (3).

11. Plant (2) for the management of gases, produced in a decentralized way, between a first higher pressure network (4) and a second lower pressure network (5), **characterized in that** it comprises:

- at least one inlet apparatus (6) which is interposed between said first network (4) and said second network (5) and which is configured to draw/receive gas from the first higher pressure network (4) and introduce it into the second network at lower pressure (5),
- at least one re-injection apparatus (3) according to one or more of claims 1 to 10, which is interposed between said first network (4) and said second network (5) and which is configured to take/receive the gas that circulates in the second lower pressure network (5) to return it to the first higher pressure network (4).

12. Plant (2) according to the preceding claim, **characterized in that** said at least one inlet apparatus (6) and said at least one re-injection apparatus (3) are integrated within a single station or structure (40).

13. Plant (2) according to claims 11 or 12, **characterized in that** it comprises sensors (19, 19', 19") distributed in the first high-pressure network (4) and/or low pressure in the second network (5) to detect a pressure drop/rise of the gas circulating in said first high pressure network (4) and/or in said second low pressure network (5), said sensors (19, 19', 19") being connected with the control unit (11) of said re-injection apparatus (3) to correspondingly control:

- activating/deactivating and/or modulating the

flow rate of said compression unit (16) of said re-injection apparatus (3),
- the activation/deactivation and/or modulation of the opening of said interception module (18) of said re-injection apparatus (3).

14. Plant (2) according to one or more of claims 11-13, **characterized in that**:

- said at least one inlet apparatus (6) and said at least one inlet equipment (3) are connected together,
- the control unit (11) of the re-injection apparatus (3) is also configured to control the inlet apparatus (6) so as to allow/stop and/or regulate the flow of gas entering the second pressure network lower (5).

15. Plant (2) according to one or more of the preceding claims 11-14, **characterized in that** it comprises:

- an analysis module (15), configured to detect the quality and characteristics of the gas, and/or
- a measuring module (17), configured to measure the quantity of gas,
- and by the fact that said analysis module (15) and/or said measuring module (17) are shared by said at least one inlet apparatus (6) and from said at least one re-injection apparatus (3).

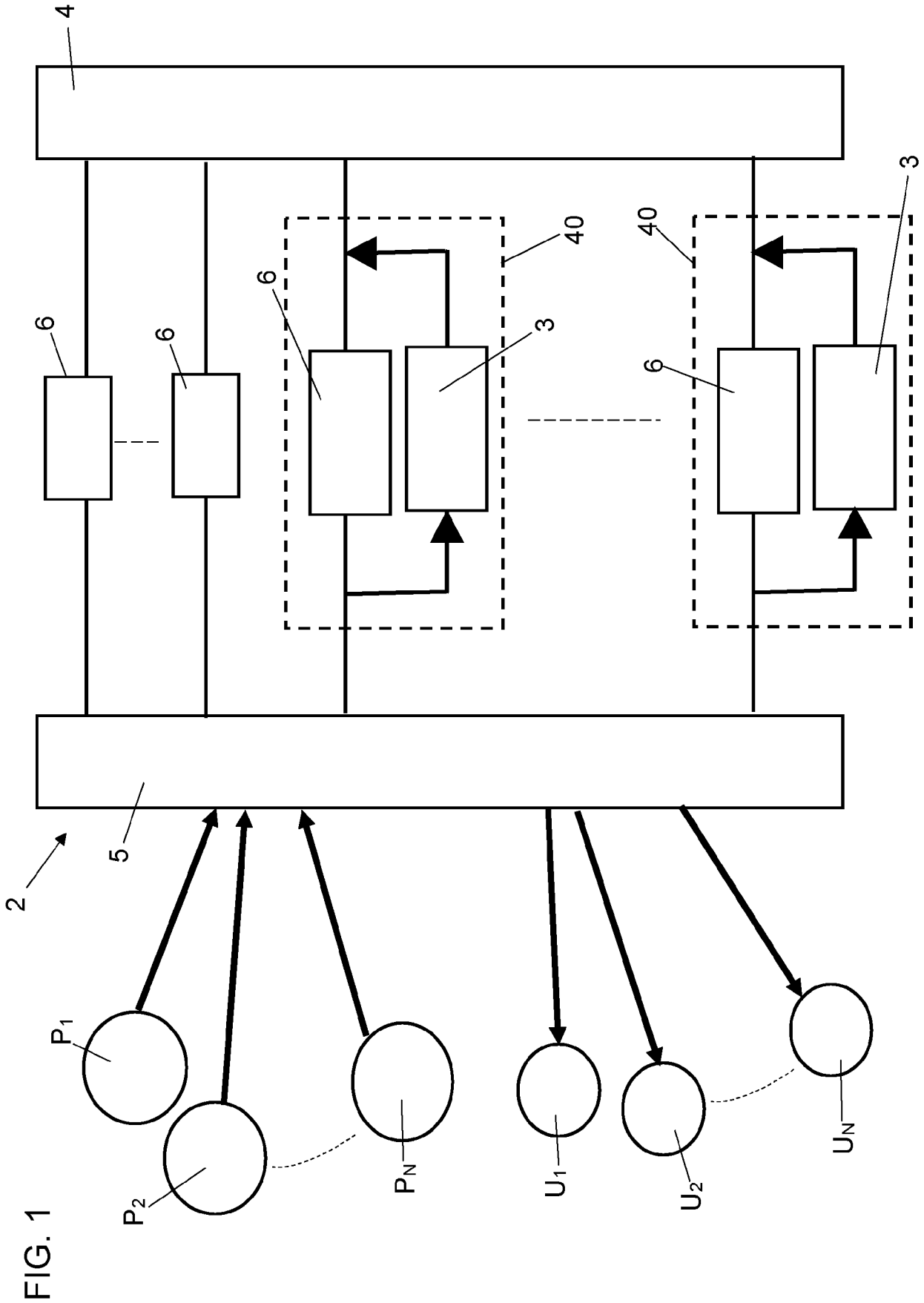

FIG. 1

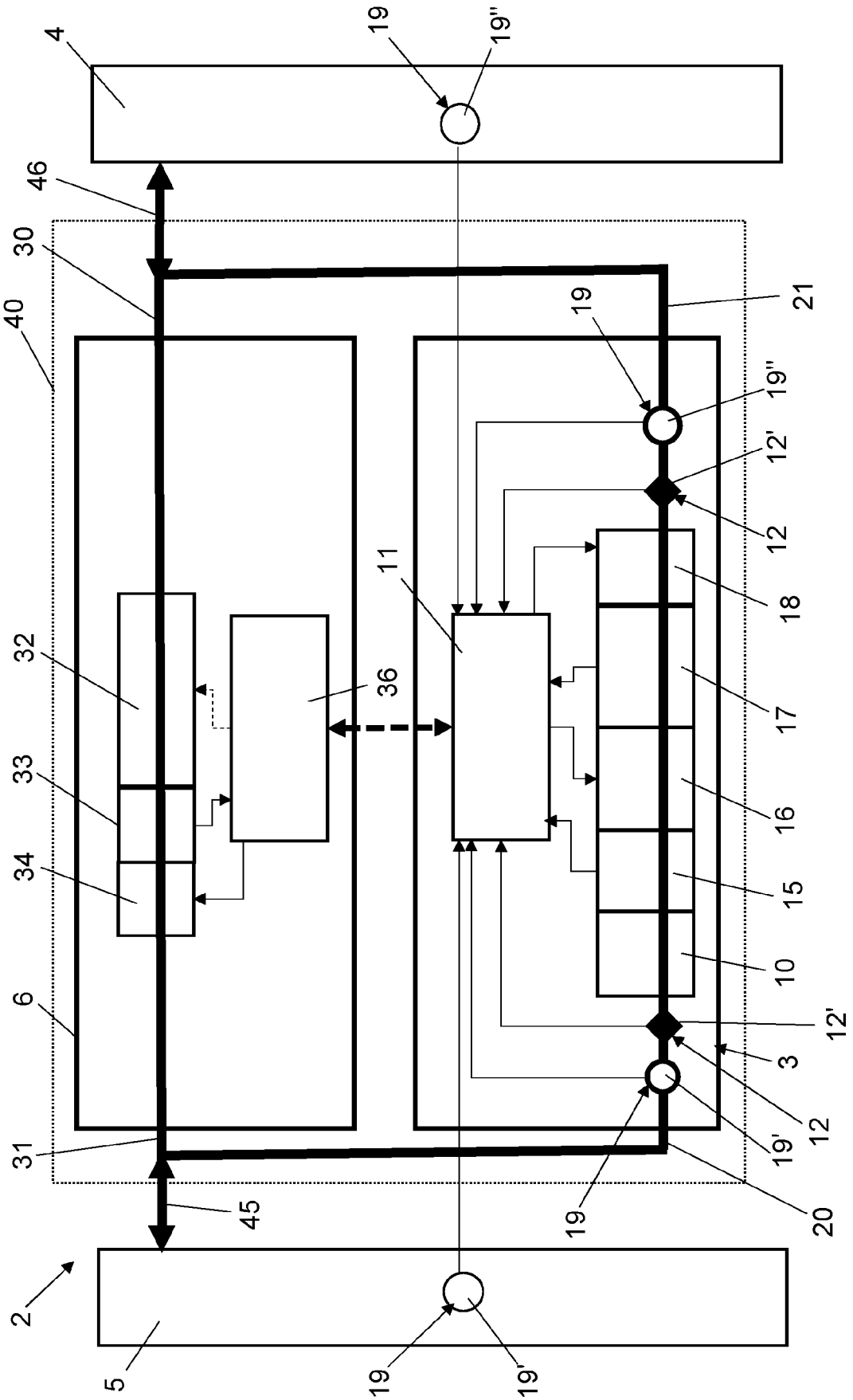
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FIG. 2

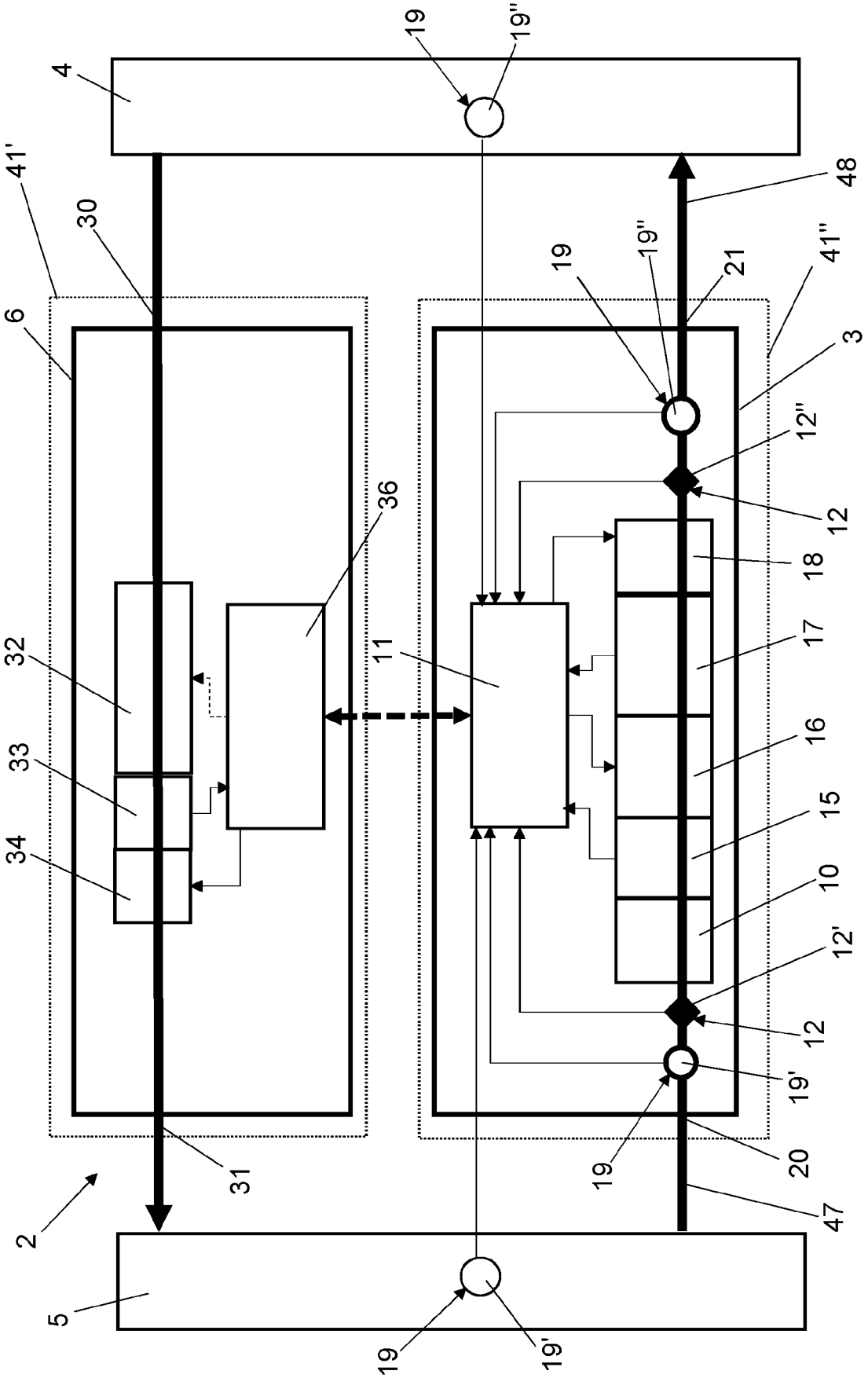
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FIG. 3

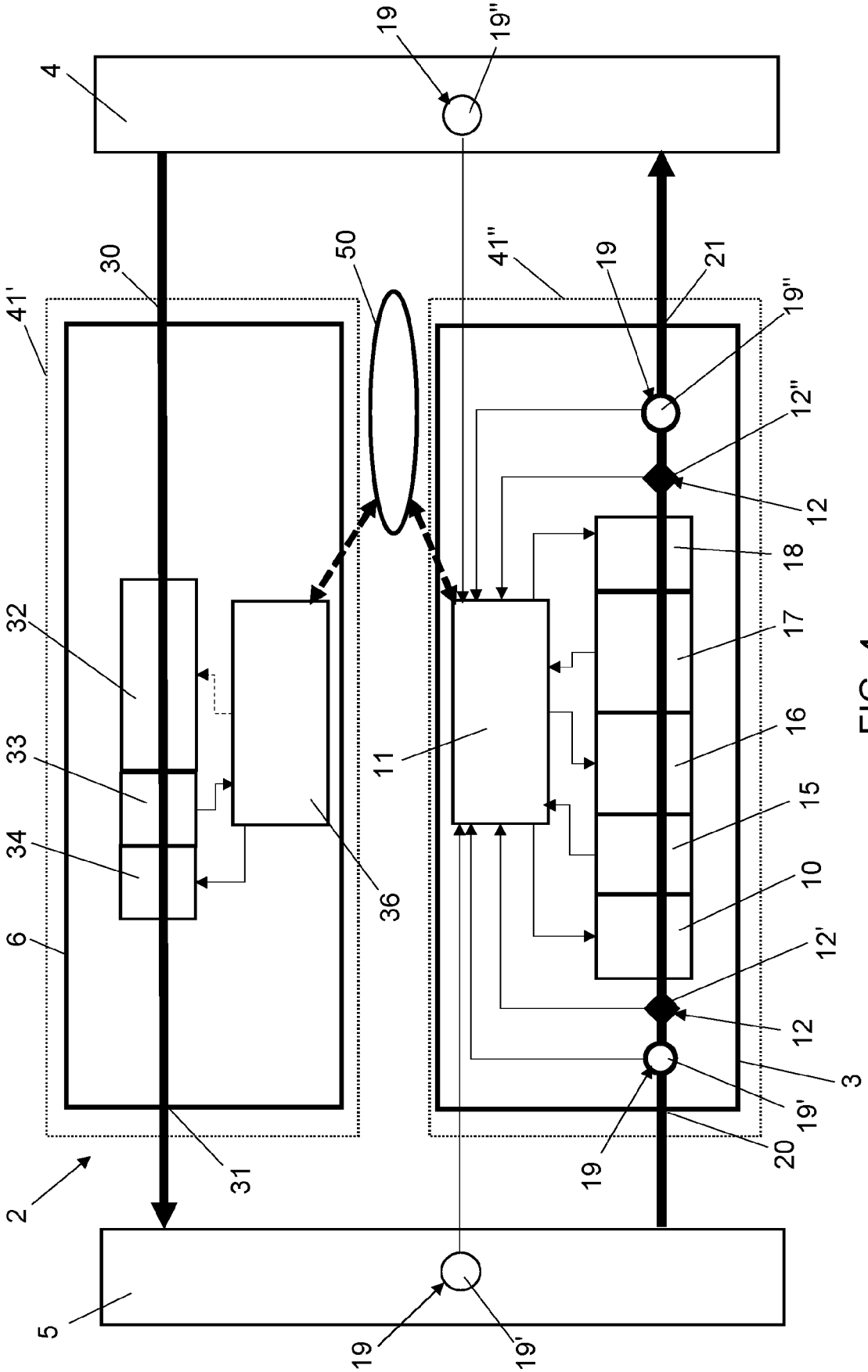
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FIG. 4

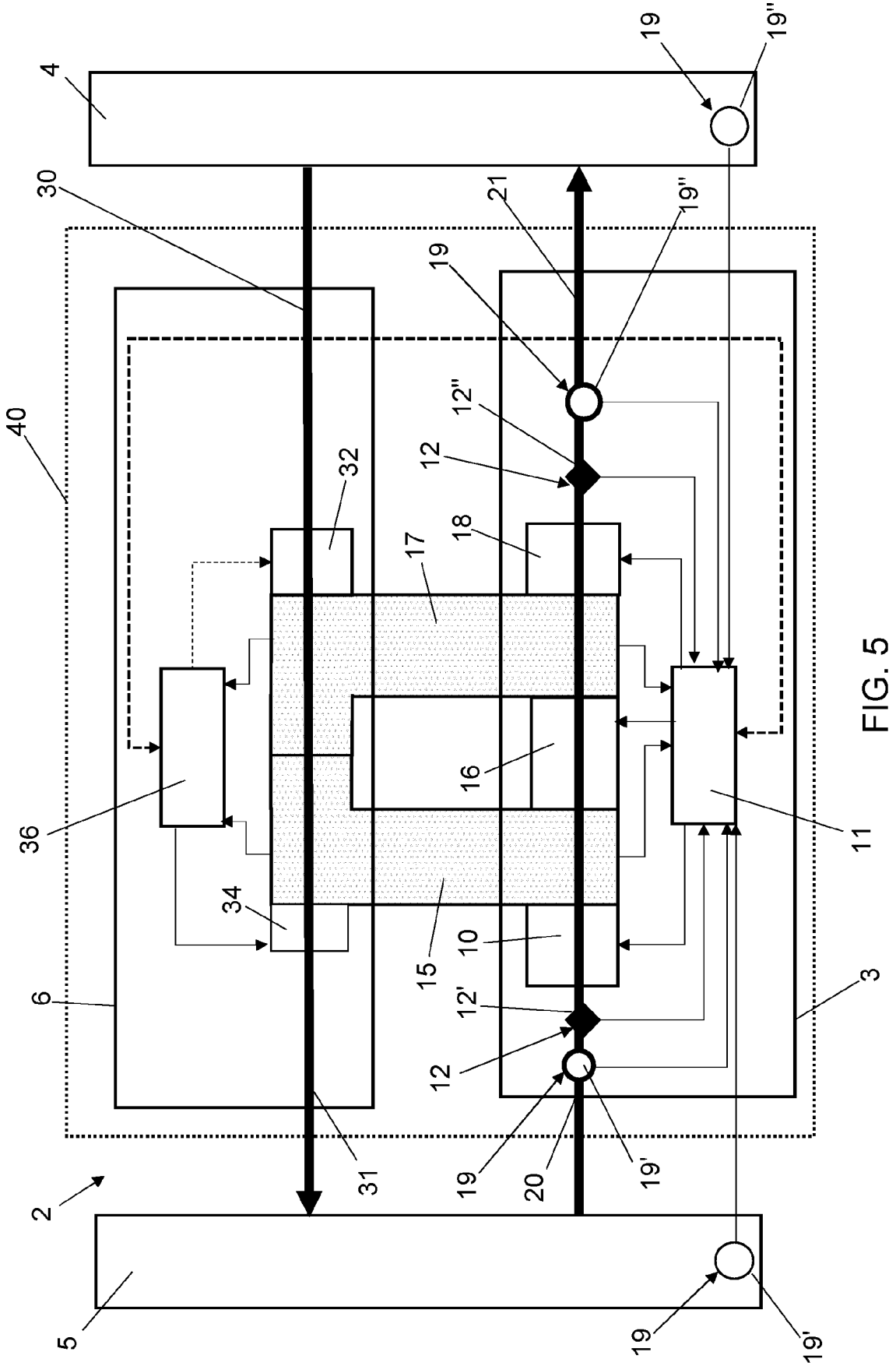
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FIG. 5

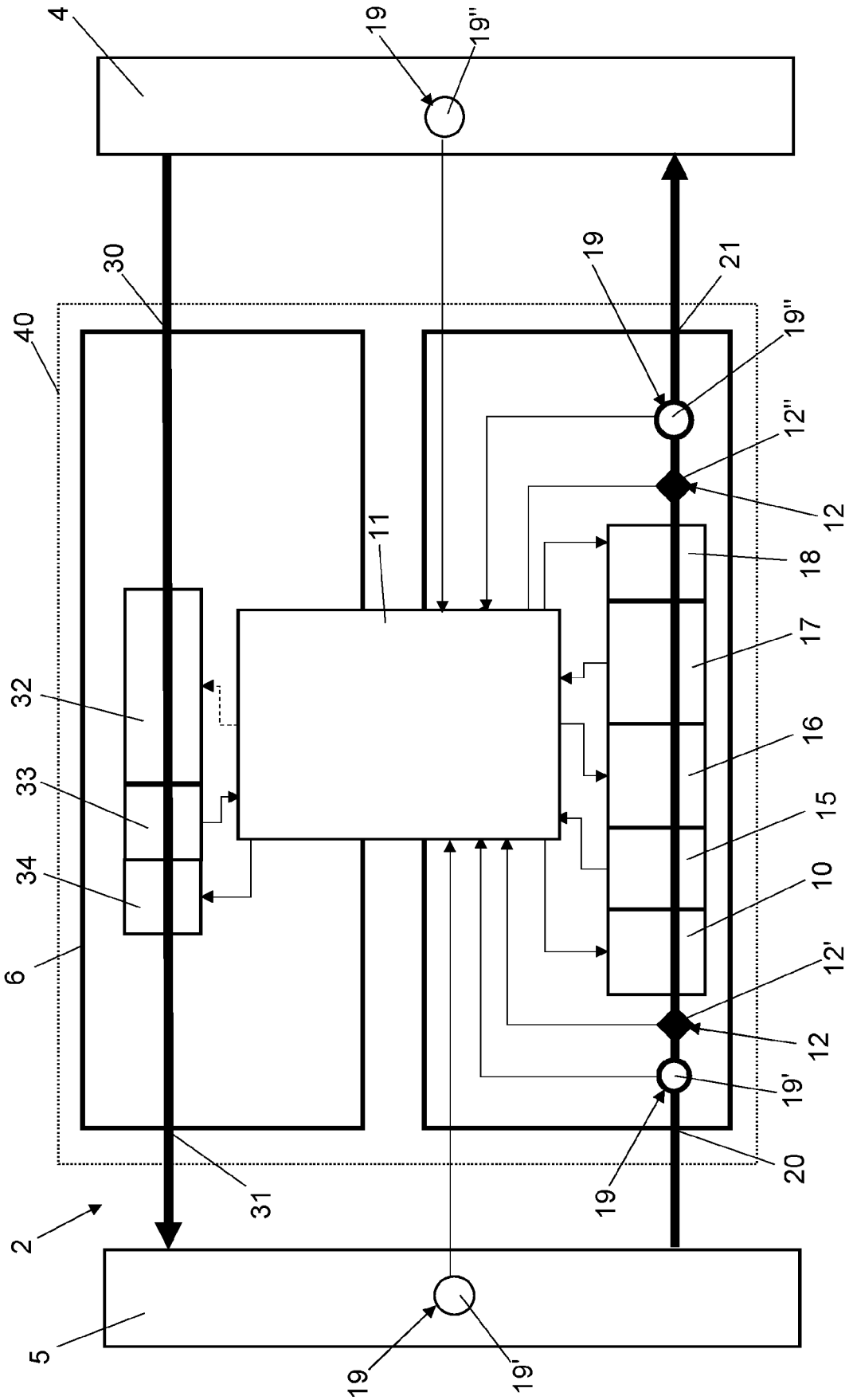
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FIG. 6

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EUROPEAN SEARCH REPORT

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	19 October 2020	Forsberg, Peter

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Application Number
EP 20 17 7982

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19-10-2020

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