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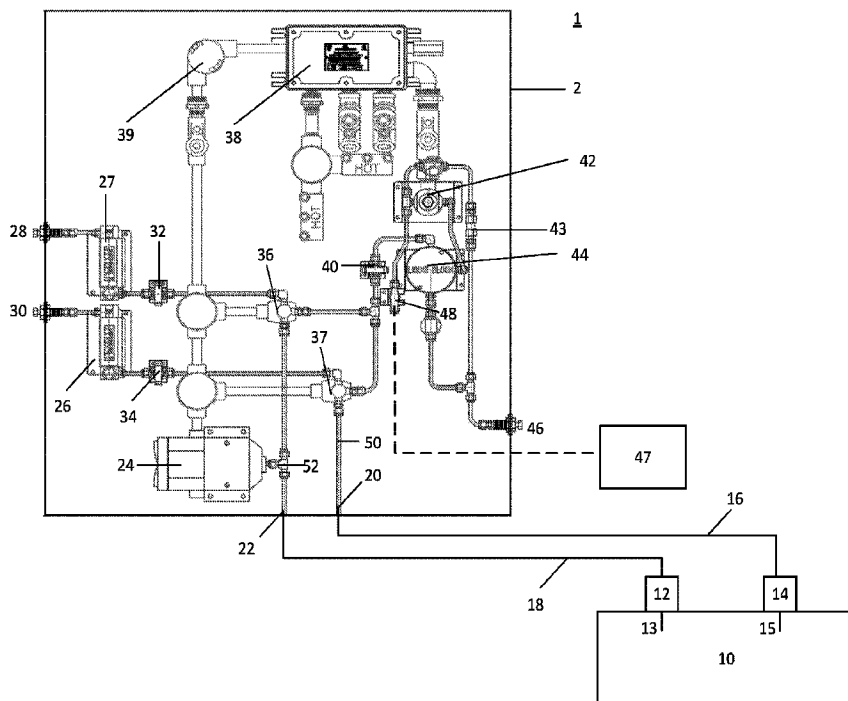
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(54) Title: MULTI-INPUT AUTO-SWITCHING GAS SAMPLE CONDITIONING SYSTEM



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A gas sample and conditioning device for sampling gas in storage or transport device and conditioning the gas while automatically switching between input lines based on a characteristic of the gas sample. Multiple input lines are provided within allows for flow between different input lines based on the characteristic of the gas sample.

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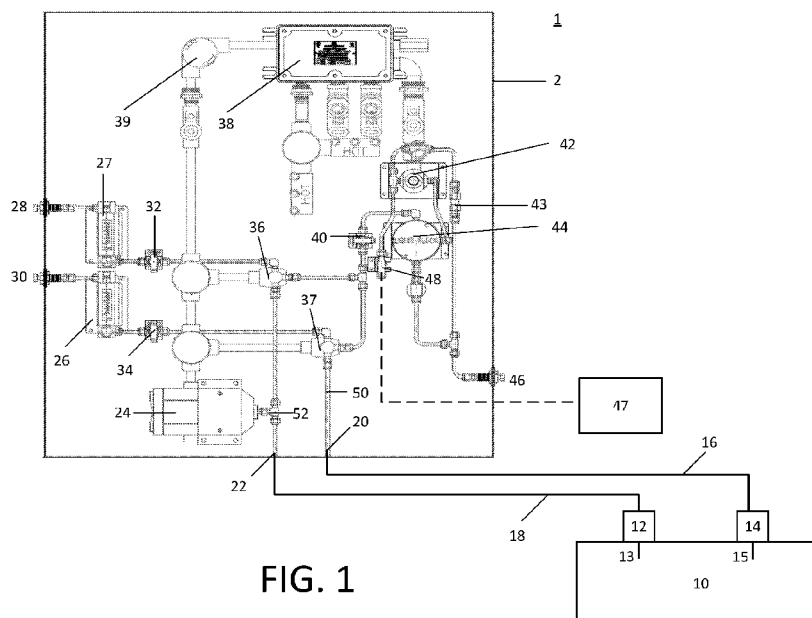


FIG. 1

(57) Abstract: A gas sample and conditioning device for sampling gas in storage or transport device and conditioning the gas while automatically switching between input lines based on a characteristic of the gas sample. Multiple input lines are provided within allows for flow between different input lines based on the characteristic of the gas sample.

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1 **MULTI-INPUT AUTO-SWITCHING GAS SAMPLE CONDITIONING SYSTEM**

2 This PCT international application claims priority from U.S. patent application
3 16/847,191 filed on April 13, 2020, which claims priority to U.S. patent application
4 62/834,144 filed April 15, 2019.

5 **TECHNICAL FIELD**

6 This invention relates generally to systems and methods for collecting, analyzing,
7 conditioning and maintaining samples of compositions in gaseous form. More particularly,
8 the invention relates to providing multiple input auto-switched gas sample lines in the event
9 of upstream interruptions in one or more of the gas sample lines or elsewhere in the system.

10 **BACKGROUND OF THE INVENTION**

11 Natural gas is a combustible gaseous mixture that can be essentially pure
12 methane or composed of several different hydrocarbon compounds obtained from sources
13 ranging from deep underground reservoirs formed by porous rock to renewable biogas
14 sources. The composition of natural gas extracted from different reservoirs varies
15 depending on the geographic location of the reservoir. In fact, it is not entirely uncommon
16 for the composition of gas extracted from a single given reservoir to vary to an extent.
17 Regardless of any variations, however, the primary component of natural gas is methane, a
18 colorless, odorless, gaseous saturated hydrocarbon. Methane usually makes up from 80%
19 to 95% of any natural gas sample and the balance is composed of varying amounts of
20 ethane, propane, butane, pentane and other hydrocarbon compounds.

1 Natural gas is used extensively in residential, commercial and industrial
2 applications. The utilization of Natural Gas for power generation is well known and growing
3 in importance and popularity to substitute for classical fossil fuels such as oil and coal as a
4 more ecologically benign alternative. It is the dominant energy used for home heating with
5 well over half of American homes using natural gas. The use of natural gas is also rapidly
6 increasing for electric power generation, cooling and as a transportation fuel.

7 Natural gas, like other forms of heat energy, is measured in British thermal units
8 or Btu. One Btu is equivalent to the heat needed to raise the temperature of one pound of
9 water by one-degree Fahrenheit at atmosphere pressure. A cubic foot of natural gas has
10 about 1,027 Btu. Natural gas is normally sold from the wellhead, i.e., the point at which the
11 gas is extracted from the earth, to purchasers in standard volume measurements of
12 thousands of cubic feet (Mcf). However, consumer bills are usually measured in heat
13 content or therms. One therm is a unit of heating equal to 100,000 Btu.

14 Accordingly, sampling and analysis of the natural gas along various points in the
15 pipeline network has become an increasingly important endeavor. More particularly,
16 because consumers are typically billed for natural gas in Btu's, it is important that the Btu
17 measurement of any particular gas volume be accurate. Further, because various suppliers
18 can, and do, supply gas, which comes from varying origins and geographic locations, to a
19 common pipeline, the measured Btu value within a given section of pipe can vary.

20 Gas samples can be extracted via a probe from a gas pipeline. Once the gas
21 sample is extracted, it can be provided through stainless steel tubing with a relatively small

1 diameter to an analyzer, such as, a chromatograph, for analysis. A chromatograph is a
2 device that utilizes a family of analytical chemistry techniques to separate mixtures into their
3 constituent components. Typically, the techniques utilized by a chromatograph include
4 separating the components of the mixture on the basis of differences in their affinity for a
5 stationary and a mobile phase to identify an accurate composition of the gas. As gas
6 chromatographs are extremely sensitive and expensive to fix, it is critical that the sampled
7 gas be conditioned to the correct temperature and pressure to avoid partial or full phase
8 change to a liquid phase before entering the gas chromatograph.

9 Problems can arise, however, when there is an interruption in the gas flow from
10 the gas pipeline upstream of the system or when gas samples at inadequate pressures are
11 passing through the steel tubing gas sample line. If there is inadequate pressure of the gas
12 sample, a constituent gas sample which is not representative of the natural gas in the
13 pipeline will be passed through the system for eventual analysis by the chromatograph. This
14 can result in inaccurate analysis which in turn leads to inaccurate Btu readings. Further, if
15 there is an interruption in flow, then the gas chromatograph will need to be quickly
16 deactivated to avoid being damaged. Reactivation of a chromatograph is time-consuming
17 and expensive.

18 According to one embodiment of the present invention, multiple gas sample input
19 lines can be implemented from one or more pipeline take-off probes thereby providing
20 multiple inputs of the gas sample to the system. This allows for one fully functioning gas
21 sample input line to provide natural gas to the system in the event that there is a problem,

1 such as pressure drops, upstream of the system in another sample input line. However,
2 while this helps alleviate issues relating to inaccurate sampling or gas chromatograph
3 shutdown due to inadequate pressure on the problematic gas sample input line, it can create
4 issues with respect to making adjustments to deactivate one sample input line while
5 activating another. These adjustments must be made manually and as the source of
6 adjustment (i.e. valve) for each line are often spaced at a large distance (i.e. 100 feet), it
7 greatly increases the labor and time required to update the settings of the lines. During this
8 delay time prior to deactivating the problematic sample input line, gas samples which are
9 not representative of the natural gas in the pipeline will be passed through the system
10 leading to faulty analysis by the gas chromatograph and inaccurate Btu readings. Further,
11 as control centers for monitoring gas flow and conditioning are often not near the pipeline
12 sample points and/or valves themselves, it can be time consuming for a technician to locate
13 and correct the pipeline flow. This results in lost production while system measurements
14 are halted until the system can be manually adjusted to accept natural gas from an
15 uninterrupted gas sample input line.

16 As for industrial applications, a typical facility that uses natural gas as a fuel source
17 will conventionally provide a natural gas feed (pipeline or storage tanks) for communicating
18 vaporized gas to a steam generator that powers electricity-generating turbines. For
19 example, liquid natural gas (LNG) can be extracted from a storage tank, vaporized and
20 passed through a feed line to a furnace for steam generation. Alternatively, the feedstock
21 in a feedline can originate with a renewable biogas facility which must maintain an adequate

1 pressure and flowrate for effective utilization. In the case of generation of electricity,
2 maintaining gas vapor at an appropriate pressure and flow rate to the steam generating
3 furnace prevents undesirable disruption to the generator necessary for turbine operation.
4 Such disruption can lead to shutting down the turbines until the problem is corrected.

5 To avoid such problems, vaporized gas conduit systems generally incorporate
6 sensors and alarms which are triggered when sub-optimal conditions arise. Conventionally,
7 upon detection of a gas flow/pressure anomaly, an alarm(s) will trigger in a control room to
8 alert staff of the problem at which time a system operator will promptly access the gas line
9 to verify the disruption and, if necessary, manipulate the appropriate valve either by
10 adjusting or turning off the pipeline feed. As discussed, while systems can include a back-
11 up vapor gas supply line to avoid the necessity of system shut down and a disruption of a
12 feedstock injection into a pipeline or generation of electricity, an operator, after shutting down
13 the first pipeline feed must access the second pipeline to open its valve(s) to maintain
14 positive gas flow to the analyzers and/or to provide for flow to the furnace. However, the
15 time required for the operator to access the first pipeline and, where the second pipeline is
16 implicated, the second pipeline, may require several minutes and traversing distances
17 required to move between remotely spaced facilities.

18 **SUMMARY OF THE INVENTION**

19 Illustrative, non-limiting embodiments of the present invention overcome the
20 aforementioned and other disadvantages associated with related art gas sampling and
21 conditioning systems. Also, the present invention is not required to overcome the

disadvantages described above and an illustrative non-limiting embodiment of the present invention may not overcome any of the problems described above.

It is an object of the present invention to provide a novel gas sampling and conditioning system, as well as a method thereof, that overcomes problems associated with conventional sampling and conditioning systems.

It is an object of the present invention to provide a novel gas sampling and conditioning system that can maintain incoming gas pressures in the event of interruptions upstream of a gas sample input line or elsewhere in the system.

Objects of the invention are satisfied by a structure and method for providing multiple gas inputs from the source. Further objects of the invention are satisfied by providing a system capable of monitoring the pipeline gas flow and pressure of both primary and back-up pipelines and providing automatic switching therebetween. Such a system reduces nuisances caused by active alarms and the labor associated with scrambling to rectify the problematic gas line feed.

Still further objects of the invention are satisfied by providing a structure and method for automatically adjusting the gas sample input line based on pressure readings. Further objects of the invention are satisfied by an automated multi-source switching adjunct and method for maintaining adequate pressure and flow rate of gas in a pipeline to maintain sample flow to a gas analyzer.

Other objects of the invention are satisfied by a structure and method that provide for purging gas line tubing of air to enhance gas line sample insertion efficiencies.

1 The present invention also satisfies additional objects by providing structures and methods
2 for maintaining adequate gas flow for analysis with reduced risk of operational disruptions
3 in case of sub-optimal flow conditions (i.e. rate and pressure).

4 To achieve these and other objects an embodiment in accordance with the
5 invention includes a system for maintaining the pressure of a sample of natural gas from
6 one or more gas transmission lines before directing the gas for conditioning and into a
7 chromatograph or other analyzer.

8 As used herein "gas" means any type of gaseous matter capable of pipe
9 transmission, including natural gas, biogas, organic gases, monomolecular gases, gas
10 mixtures, and equivalents.

11 As used herein "connected" includes physical, whether direct or indirect,
12 permanently affixed or adjustably mounted. Thus, unless specified, "connected" is intended
13 to embrace any operationally functional connection.

14 As used herein "substantially," "generally," and other words of degree are relative
15 modifiers intended to indicate permissible variation from the characteristic so modified. It is
16 not intended to be limited to the absolute value or characteristic which it modifies but rather
17 possessing more of the physical or functional characteristic than its opposite, and preferably,
18 approaching or approximating such a physical or functional characteristic.

19 In the following description, reference is made to the accompanying drawings
20 which are provided for illustration purposes as representative of specific exemplary
21 embodiments in which the invention may be practiced. The following illustrated

1 embodiments are described in sufficient detail to enable those skilled in the art to practice
2 the invention. It is to be understood that other embodiments may be utilized and that
3 structural changes based on presently known structural and/or functional equivalents may
4 be made without departing from the scope of the invention.

5 Given the following detailed description, it should become apparent to the person
6 having ordinary skill in the art that the invention herein provides a novel gas maintenance
7 system and a method thereof for providing significantly augmented efficiencies while
8 mitigating problems of the prior art.

9 In accordance with one exemplary embodiment, a gas sampling and conditioning
10 system is provided that includes a first probe device configured to extract a first gas sample
11 from a gas source to a first gas sample input line and a second probe device configured to
12 extract a second gas sample from the gas source to a second gas sample input line. Also
13 included is an enclosure connected to the first and second gas sample input lines and
14 configured to receive the first and second gas samples, the enclosure including a pressure
15 switch configured to generate data representative of a pressure of the first gas sample, a
16 microcontroller in communication with the pressure switch and configured to control flow of
17 the first and second gas samples from the first and second gas sample input lines based on
18 the data from the pressure switch, and gas conditioning equipment configured to receive
19 and condition the first or second gas sample from the respective gas sample input line based
20 on flow control by the microcontroller. The system further includes an analyzer device

1 configured to receive the conditioned first or second gas sample from said gas conditioning
2 equipment and determine constituent components therein.

3 In accordance with one exemplary embodiment, a multi-input auto-switching gas
4 sampling and conditioning device is provided that includes an enclosure connected to first
5 and second gas sample input lines and configured to receive corresponding first and second
6 gas samples from the respective gas sample input lines, the enclosure including a pressure
7 switch configured to generate data representative of a pressure of the first gas sample, a
8 microcontroller in communication with the pressure switch and configured to control flow of
9 the first and second gas samples from the first and second gas sample input lines based on
10 the data from the pressure switch, and gas conditioning equipment configured to receive
11 and condition the first or second gas sample from the respective gas sample input line based
12 on flow control by the microcontroller and transfer the conditioned first or second gas sample
13 to an analyzer device.

14 In accordance with one exemplary embodiment, a method of sampling and
15 conditioning a gas sample is provided that includes the steps of: extracting a gas sample
16 from a volume of gas to be conditioned, detecting a pressure of the gas sample and
17 controlling the flow of the gas sample based on the pressure, heating the gas sample to a
18 value within a predetermined temperature range, regulating the pressure of the vapor phase
19 gas of the gas sample to a value within a predetermined pressure range, and outputting
20 conditioned vapor phase gas within the predetermined temperature and pressure ranges to

- 1 an analyzer for determination of the constituent components of the conditioned vapor phase
- 2 gas.
- 3

BRIEF DESCRIPTION OF THE DRAWINGS

The aspects of the present invention will become more readily apparent by describing in detail illustrative, non-limiting embodiments thereof with reference to the accompanying drawings, in which:

FIG. 1 is diagrammatical partial cut-away front view of the interior of the multi-input auto-switching gas sampling and conditioning system connected to a remotely mounted enclosed gas probe on a pipeline according to one exemplary embodiment of the invention.

DETAILED DESCRIPTION

Exemplary, non-limiting, embodiments of the present invention are discussed in detail below. While specific configurations and dimensions are discussed to provide a clear understanding, it should be understood that the disclosed dimensions and configurations are provided for illustration purposes only. A person skilled in the relevant art will recognize that other dimensions and configurations may be used without departing from the spirit and scope of the invention.

FIG. 1 illustrates a system 1 in accordance with the present invention. As shown, the system 1 of FIG. 1 comprises an enclosure, such as a cabinet 2 having, for example, a generally rectangular configuration. The cabinet shown in this embodiment can be composed of polymeric resin, stainless steel, or any other appropriate material or combination of materials, e.g., aluminum panels etc., that provide a substantially strong housing. Further, a cabinet suitable for housing a system in accordance with the present invention is sufficiently commodious to allow for a thick insulative lining. For example, to

1 provide sufficient insulation, the insulating lining is approximately 1 inch thick or greater.
2 Cabinet 2 also includes microcontroller 38 and corresponding electrical connections 39 for
3 receiving and distributing electrical power in the system 1. The microcontroller 38 can
4 further control the operation of solenoid valves 36, 37 via correspondingly connecting
5 electrical connections 39. The cabinet 2 further includes gas conditioning equipment such
6 as a vaporizing heated pressure regulator 42 and liquid block 44. The heated pressure
7 regulator 42 is configured to maintain a desired constant gas pressure and temperature of
8 a gas sample and the liquid block 44 is configured to separate any liquid from the gas
9 sample. A corresponding relief/drain valve 46 is included to provide an output for expelling
10 any heated gases, particularly contaminated heated gases, from the heated pressure
11 regulator 42 and/or liquid from the liquid block 44. In accordance with an exemplary
12 implementation, the liquid block 44 can be a membrane-type device that separates the liquid
13 phase gases from vapor phase gases and provides the liquid phase portion for further
14 processing. The cabinet 2 also includes and an indicator mechanism (not illustrated), such
15 as a series of lights, wired to various connections within the junction box for indicating a
16 status of current operations.

17 The exemplary cabinet 2 illustrated in FIG. 1 further includes an inlet/outlet port
18 (not shown) for accommodating a power line to conduct electrical power, e.g., 110 volts
19 A.C., 220 volts A.C., 12 volts D.C., 24 volts D.C., or any other suitable voltage required by
20 components in or around cabinet 1 and specifically to electrical connections 39 and
21 microcontroller 38.

1 Heated pressure regulator 42 can be, for example, a vaporizing pressure regulator
2 that heats the gas both at its input and at its output. This is done to avoid adverse Joule-
3 Thomson effects which can result in all or part of the gas changing phase into a wet gas or
4 liquid as the gas pressure is changed, e.g., lowered to a pressure desirable by an analyzer
5 device 47 (i.e. gas chromatograph). Accordingly, the heated pressure regulator 42 heats
6 the gas before the pressure is changed and again after the pressure has been reduced to
7 maintain the gas in the gas phase. In this manner, the potential for liquid creation due to
8 hydrocarbon dew point dropout is greatly reduced. Heated pressure regulator 42 requires
9 electrical power to generate and control its heat and, thus, is electrically connected to the
10 electrical connections 39.

11 Gas pipes 50, such as 1/8 inch diameter stainless steel tubing, inside cabinet 2
12 can be for carrying gas samples from input ports 20, 22 and throughout the cabinet 2. Flow
13 rate metering valves 32, 34 are provided in the flow path of the gas along gas pipes 50 and
14 can be configured to control the flow rate of the gas based on specifications specific to the
15 application of the system 1 when implementing a speed loop with outlet ports 28, 30, as
16 described in U.S. Patent Nos. 8,056,399, 9,285,299 and 9,562,833. The flow rate metering
17 valves 32, 34 can be adjusted based on readings from corresponding rotometers 26, 27.
18 This can be done manually via manual inspection of the rotometers 26, 27 and/or
19 automatically by microcontroller 38 based on signals from rotometers 26, 27.

20 Exemplary operation of the system 1 described above will now be provided in
21 reference to FIG. 1. Further, additional reference as to aspects of the operation of the

1 system 1 is described in U.S. Patent No. 7,162,933, assigned to assignee of the present
2 invention, Mustang Sampling, LLC of Ravenswood, West Virginia.

3 Gas, for example natural gas, being transported or otherwise stored within a
4 device, e.g., pipe, 10, is sampled by sample probe devices 13, 15. For example, sample
5 probes 13, 15 can be membrane-type gas probes that permit vapor phase gas to permeate
6 through the membrane while preventing any liquid phase gases from passing through the
7 probe. Once the sample having substantially all vapor phase gas is collected, the sample
8 is directly input to optional intermediate enclosure devices 12, 14 where the sample is
9 heated. For example, the intermediate enclosure device can be a Pony® device
10 manufactured by Mustang Sampling, LLC. It should be noted that the intermediate
11 enclosure device is optional and according to alternative embodiments of the present
12 invention the intermediate enclosure device is eliminated.

13 A heated sample is output from the intermediate enclosure device and transported
14 via sample gas input lines 16, 18 to respective input ports 20, 22 of cabinet 2. Sample gas
15 input lines 16, 18 can include a stainless-steel tube through which the sample gas is
16 transported and a heat tracing cable in close proximity to the stainless tube for heating the
17 tube and, thus, the gas within the tube. Around the stainless tube and the heat tracing cable
18 an insulating material and a shielding material, e.g., rubber, plastic, etc., can be provided.
19 Accordingly, as described herein, to avoid interruption or inconsistent pressure on a gas
20 sample input line affecting the system, multiple gas sample input lines are provided in the
21 system 1. Although only two gas sample input lines 16, 18 are shown, additional gas sample

1 input lines could be implemented. In one exemplary implementation, however, at any given
2 time, the system 1 will be in operation with only one of the gas sample input lines 16, 18,
3 being used for analysis while the unused line(s) will direct samples out of the system via
4 corresponding outlet ports (i.e. outlet port 28, 30) to be redirected back into the pipeline 10.
5 For example, valves (i.e. solenoid valves) 36, 37 are provided downstream of gas inputs 20,
6 22 to control the flow of gas in the cabinet 2. In one example, both solenoid valves 36, 37
7 can be set to direct the flow of the gas sample to corresponding outlet ports, 28, 30,
8 respectively. This setting can be maintained until a predetermined pressure is detected at
9 juncture 52 by a pressure switch 24 at which point the pressure switch 24, or alternatively,
10 the microcontroller 38, based on signals from pressure switch 24, can control solenoid valve
11 36 to control the flow towards outlet port 28. Alternatively, in one example, the cabinet can
12 be pre-configured to have solenoid valve 36 control the flow towards outlet port 28 and
13 solenoid valve 37 control the flow toward outlet port 30 immediately upon sampling.

14 In this configuration, input gas samples are directed past pressure switch 24 and
15 through solenoid valve 36 to an adjustable metering valve 40 which controls the flow rate of
16 gas. This control can be performed manually or automatically by microcontroller 38 based
17 on signals at least from pressure switch 24 to ensure an acceptable flow rate to liquid block
18 44. The gas is then passed to the liquid block 44, where any liquid phase gas that is present
19 is separated from the vapor phase gas and is transported via stainless tubing to relief drain
20 46 for further processing and/or storage. The vapor phase gas is output from liquid block
21 44 and is provided to heated vaporizing pressure regulator 42. Heated vaporizing pressure

1 regulator 42 heats the inputted gas to within a certain temperature range, e.g., a temperature
2 range determined by the hydrocarbon dew point curve of the particular gas sample, and
3 reduces the pressure of the gas to a level that can be accommodated by the analyzer 47.
4 For example, in the case of natural gas, the inputted pressure could be approximately 2000
5 psig and the pressure regulator would reduce this pressure to about 10-20 psig, e.g., a
6 desirable pressure range for inputting gas to the analyzer 47 connected to cabinet 2 via
7 outlet 48. Due to the significant pressure reduction in the gas, if the temperature of the gas
8 were kept constant, the joule-Thomson effect dictates that hydrocarbon dew point dropout
9 would occur and at least a portion, if not all, of the sample gas would change into its liquid
10 phase. Accordingly, heated pressure regulator 42 is controlled by microcontroller 38 to heat
11 the reduced-pressure gas to avoid the Joule-Thomson effect and maintain the sample gas
12 in its vapor phase.

13 Pressure relief port 43 is optionally for relieving pressure in the event the pressure
14 at the output of heated pressure regulator 42 is above the desired range. For example, if
15 the desired range for the output of heated pressure regulator 42 is 10-20 psig and the output
16 of heated pressure regulator 42 is 100 psig as detected by an internal sensor, pressure relief
17 port 43 can open to permit sample vapor gas to escape outside cabinet 2 via port 46.

18 Having described the functionality and processing provided by the system 1 using pre-
19 configured gas sample input line 18, an example will now be provided with respect to use of
20 gas sample input line 16 due to a failure event(s) with respect to gas sample input line 18.
21 Failures can take the form of blockage in the gas sample input line 18, issues retrieving the

1 gas sample from pipeline 10, the malfunction of equipment such as the probes 13, 15, and/or
2 reduced pressure below an acceptable threshold for sampling and conditioning. In this
3 example, it is assumed that the flow of gas from gas sample input line 18 gets reduced in
4 pressure below an acceptable level for analysis. The drop in pressure on gas sample input
5 line 18 will be detected at junction 52 by the pressure switch 24. The pressure switch 24
6 can be configured to any pressure threshold (i.e. 100 psi in this example) such that any
7 sample detected at the junction 52 having a pressure less than 100 psi (i.e. interruption or
8 pressure fluctuations) will result in pressure switch 24 sending a signal to microcontroller 38
9 which will control solenoid valve 36 to shunt the flow away from the metering valve 40 and
10 toward the speed loop outlet port 28. At the same time as the microcontroller receives the
11 signal from pressure switch 24, or shortly thereafter, the microcontroller 38 controls solenoid
12 valve 37 to shunt the flow away from outlet port 30 and toward metering valve 40 for
13 conditioning and sample analysis. In other words, the system 1 will no longer intake gas
14 samples from input port 22 having upstream pressure issues and will instead intake samples
15 from input port 20. This could continue indefinitely or, in one example, pressure switch 24
16 can revert the intake of gas samples back to input port 22 when detecting pressures above
17 the predetermined pressure threshold (i.e. 100 psi) thereby indicating that there are no
18 longer any upstream issues with respect to gas sample input line 18.

19 Pressure switch 24 is connected to electronic connections and microcontroller 38
20 thereby providing the ability of the pressure switch 24 and/or microcontroller 38 to provide
21 control signals to de-energize or energize solenoid valves 36, 37 based on pressure

1 readings. One example of a pressure switch is a PSW-400 series (i.e. PSW-408) switch
2 manufactured by Omega Engineering, Inc. Such a switch can provide control based on
3 pressures ranging at least from 40 psi to 200 psi. However, other pressure switches could
4 be used to provide additional pressure range control functionality.

5 Accordingly, the multi-input auto switching functionality described herein provides
6 the advantageous features of automatically switching gas sample input lines when there is
7 an interruption or fluctuation in gas pressure coming from the pipeline 10 or other failure
8 event upstream of input port 22. This immediately prevents issues arising out of non-
9 constituent samples being provided to the analyzer 47, such as a gas chromatograph,
10 leading to inaccurate readings as well as potential shutdowns or damage to the gas
11 chromatograph. This in turn prevents downtime of the system 1 as reactivation of the gas
12 chromatograph is time consuming and can be very costly. The ability to automatically
13 control gas sample input lines also reduces labor costs and time as manual shutdown of
14 one gas sample input line and activation of another distantly located gas sample input line
15 is no longer required thereby reducing timeframes involving analysis of inaccurate non-
16 constituent gas samples. Further, for industrial applications, the system is able to maintain
17 gas vapor at appropriate pressure and flow rate to, for example, steam generating furnaces
18 thereby preventing undesirable disruption to the generator necessary for turbine operation.
19 This would also reduce nuisances caused by system alarms and associated labor.

20 Additional implementations and corresponding advantages are contemplated
21 herein. For example, signals from faulty instrumentation downstream of pressure switch 24

1 could result in flow changes. Thus, in one example, microcontroller 38 could control valve
2 36 to deactivate input from input port 22 when it receives signals indicative of a faulty valve
3 36. Conversely, microcontroller 38 could control valve 37 to deactivate input from input port
4 20 when it receives signals indicative of a faulty valve 37. Additional sensors, such as
5 pressure sensors, could be located along the flow of the gas sample from juncture 52 to
6 outlet port 28, or similarly, input port 20 to outlet port 30, which could provide signals to
7 microcontroller 38 indicative of failure events along those flow paths thereby resulting in
8 microcontroller 38 controlling valve 36 or 37, accordingly. Further, if a failure event is
9 detected at any point in the flow of a gas sample from the pipeline 10 to flow meter 40, such
10 as failure events on flow paths from both sample input line 16 and sample input line 18, the
11 microcontroller 38 could control respective controlling valve 36 or 37, accordingly, and/or
12 cause flow meter 40 to completely restrict the flow of the gas sample to prevent possible
13 damage to downstream conditioning equipment such as the heated pressure regulator 42
14 and liquid block 44.

15 Although several embodiments of the invention have been disclosed in the
16 foregoing specification, it is understood by those skilled in the art that many other
17 modifications and embodiments of the invention will come to mind to which the invention
18 pertains, having benefit of the teaching presented in the foregoing description and
19 associated drawings. It is therefore understood that the invention is not limited to the specific
20 embodiments disclosed herein, and that many modifications and other embodiments of the
21 invention are intended to be included within the scope of the invention. Moreover, although

1 specific terms are employed herein, they are used only in generic and descriptive sense,
2 and not for the purposes of limiting the description invention.

3 While various aspects of the present invention have been particularly shown and
4 described with reference to the exemplary, non-limiting, embodiments above, it will be
5 understood by those skilled in the art that various additional aspects and embodiments may
6 be contemplated without departing from the spirit and scope of the present invention.

7 It would be understood that a device or method incorporating any of the additional or
8 alternative details mentioned above would fall within the scope of the present invention as
9 determined based upon the appended claims.

10 Other aspects, objects and advantages of the present invention can be obtained
11 from a study of the drawings, the disclosure and the appended claims.

12 Exemplary implementations of the present description include:

13 A. A multi-input auto-switching gas sampling and conditioning system comprising:
14 a first probe device configured to extract a first gas sample from a gas source to a first gas
15 sample input line;
16 a second probe device configured to extract a second gas sample from the gas source to a
17 second gas sample input line;
18 an enclosure connected to the first and second gas sample input lines and configured to
19 receive the first and second gas samples, the enclosure including
20 a pressure switch configured to generate data representative of a pressure of the first
21 gas sample,

1 a microcontroller in communication with the pressure switch and configured to control
2 flow of the first and second gas samples from the first and second gas sample input
3 lines based on the data from the pressure switch, and
4 gas conditioning equipment configured to receive and condition the first or second
5 gas sample from the respective gas sample input line based on flow control by the
6 microcontroller; and
7 an analyzer device configured to receive the conditioned first or second gas sample from
8 said gas conditioning equipment and determine constituent components therein.

9 B. The system as recited in A, wherein said gas conditioning equipment includes a
10 pressure regulator configured to heat and regulate the pressure of the first or second gas
11 sample.

12 C. The system as recited in B, wherein said pressure regulator heats the first or
13 second gas sample and reduces the pressure of the first or second gas sample to maintain
14 a sample compatible with the analyzer device.

15 D. The system as recited in A, wherein said gas conditioning equipment includes:
16 a liquid block configured to receive the first or second gas sample and separate liquid phase
17 constituent components from vapor phase constituent components of the sample; and
18 a pressure regulator in communication with said liquid separator device for heating a vapor
19 phase gas sample received from said liquid separator device and regulating the pressure of
20 the vapor phase gas sample to a predetermined pressure value.

1 E. The system as recited in A or D, wherein the microcontroller controls flow of the
2 first and second gas sample as a function of data from the pressure switch indicative of the
3 pressure being below a predetermined threshold.

4 F. The system as recited in E, wherein the microcontroller controls flow of the first
5 and second gas sample by controlling first and second valves connected to the first gas
6 sample input line and second gas sample input line, respectively.

7 G. The system as recited in F, wherein, when the pressure switch detects that the
8 pressure of the first gas sample is less than the predetermined threshold, the microcontroller
9 causes the first valve to direct flow to a bypass outlet and causes the second valve to direct
10 flow of the second gas sample to the gas conditioning equipment.

11 H. A multi-input auto-switching gas sampling and conditioning device comprising:
12 an enclosure connected to first and second gas sample input lines and configured to receive
13 corresponding first and second gas samples from the respective gas sample input lines, the
14 enclosure including

15 a pressure switch configured to generate data representative of a pressure of the first
16 gas sample,

17 a microcontroller in communication with the pressure switch and configured to control
18 flow of the first and second gas samples from the first and second gas sample input
19 lines based on the data from the pressure switch, and

20 gas conditioning equipment configured to receive and condition the first or second
21 gas sample from the respective gas sample input line based on flow control by the

1 microcontroller and transfer the conditioned first or second gas sample to an analyzer
2 device.

3 I. The device as recited in H, wherein said gas conditioning equipment includes a
4 pressure regulator configured to heat and regulate the pressure of the first or second gas
5 sample.

6 J. The device as recited in I, wherein said pressure regulator heats the first or second
7 gas sample and reduces the pressure of the first or second gas sample to maintain a sample
8 compatible with the analyzer device.

9 K. The device as recited in H, wherein said gas conditioning equipment includes:
10 a liquid block configured to receive the first or second gas sample and separate liquid phase
11 constituent components from vapor phase constituent components of the sample; and
12 a pressure regulator in communication with said liquid separator device for heating a vapor
13 phase gas sample received from said liquid separator device and regulating the pressure of
14 the vapor phase gas sample to a predetermined pressure value.

15 L. The device as recited in H or K, wherein the microcontroller controls flow of the
16 first and second gas sample as a function of data from the pressure switch indicative of the
17 pressure being below a predetermined threshold.

18 M. The device as recited in L, wherein the microcontroller controls flow of the first
19 and second gas sample by controlling first and second valves connected to the first gas
20 sample input line and second gas sample input line, respectively.

1 N. The device as recited in M, when the pressure switch detects that the pressure
2 of the first gas sample is less than the predetermined threshold, the microcontroller causes
3 the first valve to direct flow to a bypass outlet and causes the second valve to direct flow of
4 the second gas sample to the gas conditioning equipment.

5 O. A method of sampling and conditioning a gas sample comprising:
6 extracting a gas sample from a volume of gas to be conditioned;
7 detecting a pressure of the gas sample and controlling the flow of the gas sample based on
8 the pressure;
9 heating the gas sample to a value within a predetermined temperature range;
10 regulating the pressure of the vapor phase gas of the gas sample to a value within a
11 predetermined pressure range; and
12 outputting conditioned vapor phase gas within the predetermined temperature and pressure
13 ranges to an analyzer for determination of the constituent components of the conditioned
14 vapor phase gas.

15 **INDUSTRIAL APPLICABILITY**

16 As for industrial applications, a typical facility that uses natural gas as a fuel source
17 will conventionally provide a natural gas feed (pipeline or storage tanks) for communicating
18 vaporized gas to a steam generator that powers electricity-generating turbines. For
19 example, liquid natural gas (LNG) can be extracted from a storage tank, vaporized and
20 passed through a feed line to a furnace for steam generation. Alternatively, the feedstock
21 in a feedline can originate with a renewable biogas facility which must maintain an adequate

1 pressure and flowrate for effective utilization. In the case of generation of electricity,
2 maintaining gas vapor at an appropriate pressure and flow rate to the steam generating
3 furnace prevents undesirable disruption to the generator necessary for turbine operation.
4 Such disruption can lead to shutting down the turbines until the problem is corrected which
5 leads to financial and infrastructural constraints.
6

WHAT IS CLAIMED IS:

1. A multi-input auto-switching gas sampling and conditioning system for hydrocarbon containing natural gas, comprising:
 - a first probe device configured to extract a first gas sample at a first pressure from a gas source to a first gas sample input line;
 - a second probe device configured to extract a second gas sample from the gas source to a second gas sample input line;
 - an enclosure connected to the first and second gas sample input lines and configured to receive the first and second gas samples, the enclosure including;
 - a pressure switch configured to detect the first pressure and generate data representative of said first pressure of the first gas sample;
 - a flow rate metering assembly connected to said first gas input line;
 - a first outlet port for redirecting flow of the first gas sample from said first gas sample input line;
 - a second outlet port for redirecting flow of the second gas sample from said second gas sample input line;
 - a microcontroller in communication with the flow rate metering assembly and pressure switch and configured to control flow of the first and second gas samples from the first and second gas sample input lines based on the data from the pressure switch wherein the microcontroller discontinues the flow of the first gas sample as a function of data from the pressure switch indicative of the first pressure being less than a predetermined threshold or the flow rate being below an acceptable minimum to prevent hydrocarbon dew point dropout and to direct the first gas sample to said first outlet port while automatically redirecting the second gas sample flow from the second outlet port;
 - and

gas conditioning equipment configured to receive and condition the first or second gas sample from the respective gas sample input line based on flow control by the microcontroller wherein said gas conditioning equipment includes a pressure regulator configured to heat and regulate the pressure of the first or second gas sample; and

an analyzer device configured to receive the conditioned first or second gas sample from said gas conditioning equipment and determine constituent components therein.

2. The system as recited in claim 1, wherein said pressure regulator heats the first or second gas sample and reduces the pressure of the first or second gas sample to maintain a sample compatible with the analyzer device.

3. The system as recited in claim 1 or 2, wherein said gas conditioning equipment includes:

a liquid block configured to receive the first or second gas sample and separate liquid phase constituent components from vapor phase constituent components of the sample.

4. The system as recited in claim 3, wherein the microcontroller controls flow of the first and second gas sample by controlling first and second valves connected to the first gas sample input line and second gas sample input line, respectively.

5. The system as recited in claim 4, wherein, when the pressure switch detects that the pressure of the first gas sample is less than 100 psi, the microcontroller causes the first valve to direct flow to a bypass outlet and causes the second valve to direct flow of the second gas sample to the gas conditioning equipment.

6. A multi-input auto-switching hydrocarbon containing natural gas sampling and conditioning device comprising:

an enclosure connected to first and second gas sample input lines and configured to receive corresponding first and second gas samples from the respective gas sample input lines, the enclosure including:

a pressure switch configured to generate data representative of a pressure of the first gas sample,

a microcontroller in communication with the pressure switch and configured to control flow of the first and second gas samples from the first and second gas sample input lines based on the data from the pressure switch as a function of data from the pressure switch indicative of the pressure being below a predetermined threshold,

a first outlet connected with the first gas sample input line and a second outlet connected to the second gas input line where the microcontroller switches said first gas sample to the first gas outlet upon receiving data from the pressure switch indicative of pressure below the predetermined threshold;

and gas conditioning equipment including a pressure regulator configured to heat and regulate the pressure of the first or second gas sample configured to receive and condition the first or second gas sample from the respective gas sample input line to prevent hydrocarbon dew point dropout based on flow control by the microcontroller and transfer the conditioned first or second gas sample to a downstream device.

7. The device as recited in claim 6, wherein said pressure regulator heats the first or second gas sample and reduces the pressure of the first or second gas sample to maintain a sample compatible with the downstream device.

8. The device as recited in claim 6 or 7, wherein said gas conditioning equipment includes:

a liquid block configured to receive the first or second gas sample and separate liquid phase constituent components from vapor phase constituent components of the sample.

9. The device as recited in claim 8 wherein the microcontroller controls flow of the first and second gas sample by controlling first and second valves connected to the first gas sample input line and second gas sample input line, respectively.

10. The device as recited in claim 9, where the microcontroller causes the first valve to direct flow to said first outlet and causes the second valve to direct flow of the second gas sample to the gas conditioning equipment.

11. A method of sampling and conditioning a hydrocarbon containing natural gas sample comprising:

- providing a first gas sample take-off from a gas sample source;
- providing a second separate sample take-off from a second gas sample source;
- extracting a gas sample from said first gas sample takeoff to be conditioned;
- detecting a pressure of the extracted gas sample to meet a predetermined minimum pressure threshold, detecting the flow rate of the extracted gas sample to meet a pre-established minimum;
- discontinuing the gas sample extraction from the first sample take-off upon detection of a pressure below the predetermined minimum pressure or a flow rate below the acceptable minimum and switching extraction to the second sample take-off to maintain the gas sample in its vapor phase;
- heating the gas sample to a value within a predetermined temperature range;
- regulating the pressure of the vapor phase gas of the gas sample to a value within a predetermined pressure range to prevent hydrocarbon dew point dropout;

and outputting conditioned vapor phase gas within the predetermined temperature and pressure ranges to an analyzer for determination of the constituent components of the conditioned vapor phase gas.

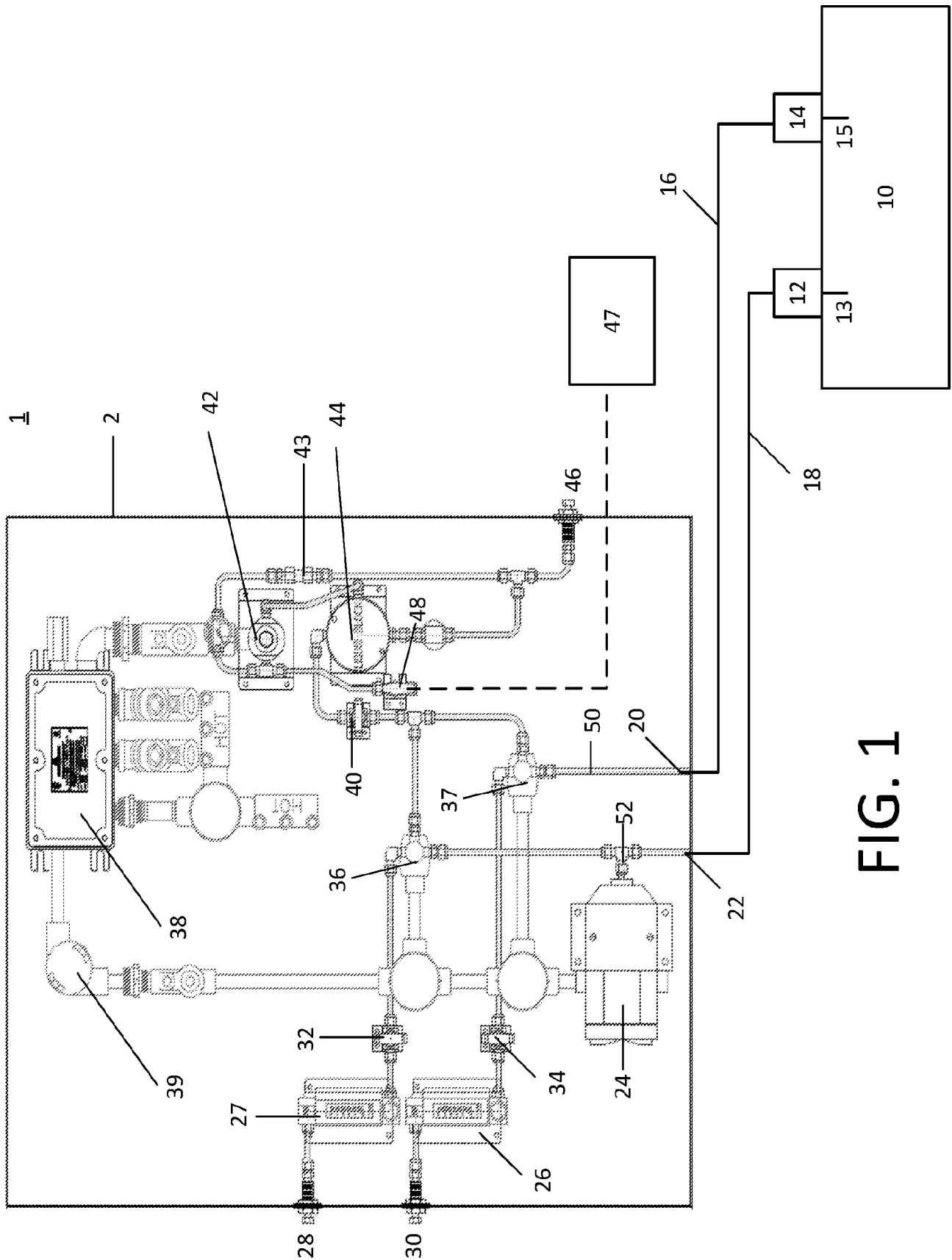


FIG. 1

