(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 325 561 A2

(12) # EUROPEAN PATENT APPLICATION

(43) Date of publication:
25.05.2011 Bulletin 2011/21

(51) Int Cl.:
F23N 5/00 *(2006.01)* ***F23G 7/08*** *(2006.01)*

(21) Application number: **10251981.6**

(22) Date of filing: **22.11.2010**

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

(30) Priority: **23.11.2009 GB 0920457**

(71) Applicant: **Hamworthy Combustion Engineering Limited**
Poole, Dorset BH17 0LA (GB)

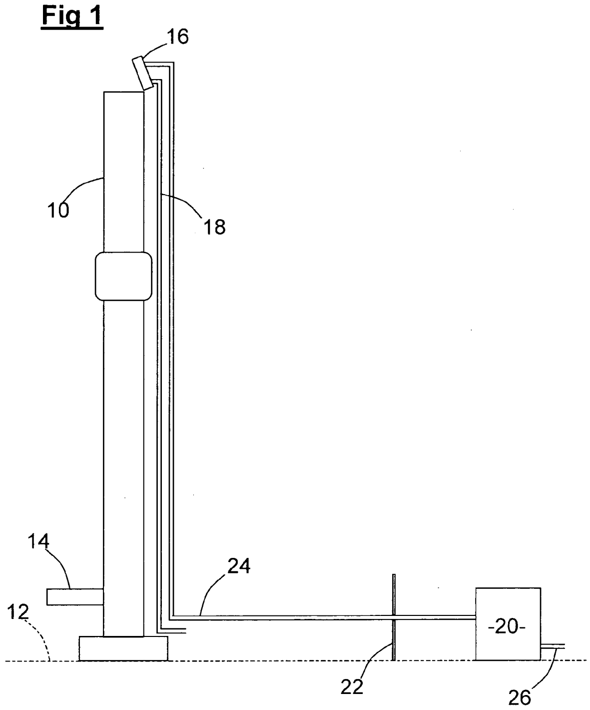
(72) Inventors:
- **Cioria, Giuseppe Eriberto**
  20040 Burago H. (MB) (IT)
- **Salani, Cesar Augusto**
  Campinas City
  Sao Paulo State (BR)
- **Webley, Nigel Peter**
  Ferndown BH22 8DS (GB)

(74) Representative: **Harkness, Katherine Joy et al**
Atkinson Wheller Ltd
St Brandon's House
27-29 Great George Street
Bristol BS1 5QT (GB)

(54) **Monitoring flare stack pilot burners**

(57) A flare stack comprises an upwardly extending gas discharge duct 10 and a pilot burner 16 operative at an burner location near the open top end of the duct 10 to ignite gas discharged by way of the duct. Atmospheric samples from the burner location are delivered to a monitoring station 20 remote from the duct 10 and at ground level 12. A sensor at the monitoring station 20 is responsive to a parameter of the sample indicative of combustion at the burner location such as increased CO_2 or NO_x or decreased O_2. An igniter is operatively associated with the sensor and arranged to light the pilot burner 16 automatically if the sensor does not detect said parameter in the sample.

Fig 1



Printed by Jouve, 75001 PARIS (FR)

Description

[0001] This invention relates to the monitoring of flare stack pilot burners to check that they are lit.

[0002] A flare stack (sometimes called a 'gas flare' or simply 'flare') is an upwardly directed duct, open at its top end, for disposing of unwanted gases released from petrochemical plants, oil and gas processing fields and other facilities, for instance to avoid over-pressure conditions. The released gases are both flammable and environmentally damaging, and to prevent their escape to the atmosphere they are burned before being discharged from the top of the flare stack. To this end a pilot burner is located, near the top of the stack, to ignite the released gases.

[0003] The pilot burner commonly comprises a plurality of burner elements, to provide backup in case of failure, and such arrangements have proved effective over many years - but only, of course, as long as the pilot burner is lit.

[0004] Pilot burners have very many different applications: boiler installations, for instance, both domestic and industrial, commonly use a pilot burner to ignite the boiler fuel. In most applications the pilot burner is not problematic. Thus in a boiler installation it is usually easy to monitor the status of the pilot burner, eg by visual inspection, and to relight it if necessary, eg by manual operation of an electronic igniter. Further, boiler installations are routinely arranged, typically by means of a thermocouple device responsive to the heat of the pilot burner, to shut off the supply of boiler fuel if the pilot burner goes out.

[0005] In a flare stack, the provision of a pilot burner presents a variety of problems as follows. First, the pilot burner is in a very exposed position, at the top of the flare stack, where it may be extinguished, for instance by a strong gust of wind or an updraught. Any local monitor such as a thermocouple is also exposed, and the effects of weather etc may cause it to degrade over time. Next, unlike boiler fuel, the gas delivered to a flare stack cannot be switched off to allow servicing unless the whole plant is shut down for a period; and economics means that this can be afforded only very infrequently, perhaps at three year intervals. Also, between scheduled services, all personnel are generally forbidden to enter an exclusion zone surrounding the flare stack, for safety reasons. Finally, the elevated location of the pilot light, which may be as much as 200m from the ground, makes it difficult to clean, repair or replace the pilot burner assembly and any local monitor even when access is permitted.

[0006] For these reasons arrangements for monitoring pilot burners in boilers and the like operating in a substantially stable environment in an accessible location are not applicable to the monitoring of flare stack pilot burners, which are exposed to a harsh and greatly varying environment in an inaccessible location.

[0007] This combination of problems can be tackled by monitoring the status of the pilot burner at a remote location conveniently sited, eg at ground level and outside an exclusion zone, where the monitoring system can be readily serviced as and when required, and relighting the pilot burner automatically whenever the monitoring system detects that it has gone out. (For completeness it may be noted that arrangements of this kind may include local pilot burner monitors such as thermocouples as well, to maximise overall reliability).

[0008] It is an object of the present invention to provide remote monitoring of a flare stack pilot burner.

[0009] Thus according to a first aspect of the invention there is provided a flare stack comprising a gas discharge duct, a pilot burner operative at a burner location to ignite gas discharged by way of the duct, sampling means operative to sample gases at the burner location and deliver a sample thereof to a monitoring location remote from the burner location, a sensor at the monitoring location responsive to a parameter of the sample indicative of combustion at the burner location and a signalling device operatively associated with the sensor and arranged to provide a signal automatically if the sensor does not detect said parameter in said sample.

[0010] The flare stack may include an igniter activated automatically in response to said signal to relight the pilot burner, although in many situations it may be enough for an operative to institute reignition action when said signal appears.

[0011] Preferably the monitored parameter is the proportion of a selected constituent of the sample and said signal is provided automatically if the sensor detects that said proportion differs from a predetermined reference value therefor.

[0012] The reference value may be an average from measurement of said proportion over time, said signal being provided automatically if the sensor detects a change from the average.

[0013] Alternatively the reference value may be a predicted value for said proportion. With this arrangement (a) the reference value may be the proportion of carbon monoxide in the sample and said signal provided automatically if the sensor detects that the proportion thereof in the sample is above the reference value or (b) the reference value may be the predicted proportion of oxygen in the sample and said signal provided automatically if the sensor detects that the proportion thereof in the sample is above the reference value or (c) the reference value may be the predicted proportion of carbon dioxide in the sample and said signal provided automatically if the sensor detects that the proportion thereof in the sample is below the reference value or (d) the reference value may be the predicted proportion of oxides of nitrogen in the sample and said signal provided activated automatically if the sensor detects that the proportion thereof in the sample is below the reference value.

[0014] The sensor may comprise an electrochemical cell or it may comprise other means such as a non-dispersive infrared (NDIR) sensor.

[0015] The sampling means preferably comprises a conduit extending from the burner location to the monitoring location. The sampling means may comprise an aspirator operative to draw the sample through the conduit from the burner location to the monitoring location and the aspirator may operate substantially continuously or periodically.

[0016] The igniter may comprise a flame front generator at the monitoring location operative when activated to propagate a flame through the conduit to the burner location. Alternatively the igniter may comprise a high energy electrical igniter at the burner location.

[0017] As a supplement to the remote sensor, the flare stack may also include a flame sensor such as a thermocouple at the burner location, the igniter being operatively associated with the flame sensor and arranged to ignite the pilot burner automatically if the flame sensor does not detect a flame, and for increased reliability the pilot burner may comprise a plurality of burner elements.

[0018] Preferably the gas discharge duct extends upwardly from ground level to an open end with the burner location adjacent the open end of the duct.

[0019] It is preferred that the monitoring location be remote from the duct, preferably at ground level for ease of monitoring and servicing, and the monitoring location may include a display operatively associated with the or each sensor and arranged to indicate the status of the pilot burner.

[0020] According to a second aspect of the invention there is provided a method of disposing of unwanted gas released from oil or gas production facilities, which method comprises providing a duct for discharge of the unwanted gas, providing a pilot burner at a burner location to ignite gas discharged by way of the duct, sampling gases at the burner location, delivering the sample to a monitoring location remote from the burner location, testing the sample at the monitoring location to detect a parameter indicative of combustion at the burner location and providing a signal automatically if said parameter is not detected in the sample.

[0021] The pilot burner may be reignited automatically when said parameter is not detected although in many situations it will be enough for an operative to institute reignition when said signal appears.

[0022] In this method of disposing of unwanted gases said parameter is preferably the proportion of carbon monoxide and/or oxygen and/or carbon dioxide and/or oxides of nitrogen in the sample, measured against a predetermined reference value for the parameter. The reference value may be either a time-averaged empirical value or a predicted value for the flare stack.

[0023] The invention will now be described by way of example only with reference to the accompanying drawings which are purely schematic and not to scale and in which -

Figure 1 shows in side elevation a flare stack embodying the invention;
Figure 2 shows a monitoring system of the flare stack of Figure 1;
Figure 3 shows a second monitoring system;
Figure 4 shows a third monitoring system; and
Figure 5 shows a fourth monitoring system.

[0024] The specific embodiments of the invention shown in the drawings are hereinafter described in relation to their use in an oil production facility but for the avoidance of doubt it should be noted that the invention is not so limited. The invention may be used in gas production facilities, in oil or gas processing facilities and in industrial premises quite unrelated to oil or gas production or processing such as steelworks.

[0025] Referring first to Figure 1, this shows a duct 10 extending upwardly from ground level 12 in an oil production facility. The nature of oil (and gas) production is such that from time to time unwanted gas — generally hydrocarbons - needs to be discharged, for instance to avoid excess pressure. The duct 10 therefore provides a discharge path for the unwanted gas, which is delivered to the duct 10 by way of a pipe 14.

[0026] The duct 10 is open at its upper end but the unwanted gas, which is mostly methane, cannot be released into the air because it is inflammable, toxic and environmentally damaging. Accordingly the unwanted gas is ignited so that it is burnt before being released. To this end a pilot burner 16 is positioned at a burner location near the top of the duct 10 to ignite gas discharged by way of the duct 10.

[0027] It is not necessary here to detail the form of the pilot burner 16. It comprises a plurality of burner elements fuelled by way of a gas line 18 and kept alight to ignite any unwanted gas discharged through the duct 10. In common fashion, a local thermocouple sensor is arranged to detect the flame from the burner element, so that if the flame should be extinguished for any reason it can be reignited automatically by a local high energy electrical igniter.

[0028] The very exposed location of the pilot burner 16 means not only that it may be extinguished but also presents serious problems in monitoring and maintaining the flame. Both the thermocouple sensor and the local electrical igniter are subject to severe and widely varying weather conditions which cause them to degrade and possibly become inoperative over the period of time - say three years - for which the flare stack is required to function without servicing or repair. But for all that period, unwanted gas may need to be discharged, at indeterminate moments - and it is therefore not acceptable for the pilot burner 16 to be out of action at any time. It will also be understood that the pilot burner 16 cannot be serviced or repaired during the period of operation because for safety reasons personnel cannot access it. (Apart from the difficulty and danger of carrying out repair work at the top of the duct 10, which may be 200m high, in practice the duct 10 is surrounded by an exclusion zone which personnel are not permitted to enter during the period of operation).

[0029] The invention provides a monitoring station 20 for monitoring the pilot burner 16 at a location remote therefrom and reigniting it whenever necessary. As can be seen from Figure 1, the location of the monitoring station 20 is at ground level and outside an exclusion zone indicated at fence 22, so the monitoring and associated systems at the monitoring station 20 can be readily inspected and serviced as required.

[0030] A conduit 24 extends from the burner location at the top of the duct 10 to the monitoring station 20. Gas samples from the burner location (ie just above the pilot burner 16) are delivered by way of the conduit 24 to the monitoring station 20 where they are tested for indications of combustion. If a sample shows no indication of combustion when tested at the monitoring station 20, a flame front generator (not detailed in Figure 1) fuelled from a gas supply 26 is automatically activated to reignite the pilot burner 16. This is conveniently done by way of the conduit 24, but it will be understood that a separate path may be provided and that some means other than a flame front generator may be activated to reignite the pilot burner 16.

[0031] The gas samples may be tested at the monitoring station 20 for various parameters indicative of combustion including the proportions of carbon monoxide (CO) and/or carbon dioxide (CO_2) and/or oxygen (O_2) and/or oxides of nitrogen (NO_x) in the samples, and test arrangements for these will now be described with reference to Figures 2 to 5.

[0032] Thus, referring next to Figure 2, this shows the monitoring station 20 to include a non-dispersive infrared (NDIR) sensor indicated at 30 for detecting the presence of carbon dioxide in a sample. An aspirator 32 draws sampled air through the conduit 24 as indicated by arrows A.

[0033] Whilst for ease of identification the aspirator 32 is illustrated with a fan in Figures 2 to 5, it is to be understood that a pump or other aspiration means may be provided, and it may alternatively be possible to blow the atmospheric samples through the conduit 24 from the burner location rather than drawing them through by aspiration at the monitoring location. Whatever kind of aspiration is used it should be dimensioned appropriately and otherwise configured and arranged to suit the form of the conduit 24 and the mode of operation. For instance, if samples are to be taken periodically, say once an hour, the aspirator 32 must have sufficient capacity to pass at least the volume of air in the conduit within a few minutes, suggesting a required throughput of some tens of litres per minute. However, if the sampling is continuous, a throughput of two or three litres per minute may be to be sufficient.

[0034] Aspirator capacity and other factors will affect the choice of continuous or periodic sampling at any particular site. Consider a conduit 24 of length L m and internal cross-sectional area A m. Then if the aspirator 32 is operated for 5 minutes every hour it must be able to pass at least the internal volume of the conduit 24 within 5 minutes, and so it must have a throughput of at least AU300 m^3/s. To secure the same response time of 1 hour with continuous sampling, the aspirator 32 must pass the internal volume of the conduit 24 within 1 hour, and so it must have a throughput of AU3600 m^3/s. It follows that, other things being equal, hourly sampling requires an aspirator some 12 times more powerful than continuous sampling. Overall, power consumption should be about the same but serviceability and noise levels are likely to be different. Another factor that may affect the choice between continuous and periodic sampling is the possibility with periodic sampling that carbon dioxide, being heavier than air, may pool at a low point of the conduit 24 and give rise to misleading tests at the monitoring station 20.

[0035] Returning now to Figure 2, the NDIR sensor 30, which is a spectroscopic device, comprises a sample chamber 34 extending transversely across the conduit 24 and having an infrared lamp 36 at one end, an infrared detector 38 at the other end and an optical filter 40 between the lamp 36 and the detector 38. The filter 40 absorbs all radiation from the lamp 36 except in the absorption band for CO at 4.67 μm. If CO is present in the chamber 34, the radiation reaching the detector 38 is attenuated, and the amount of attenuation is related to the concentration of carbon dioxide. (From Beer's Law, $I = 1_o e^{kP}$, where I is the intensity of light reaching the detector 36, I_o is the intensity measured with an empty sample chamber 32, P is the concentration of gas under test and k is a constant).

[0036] Thus the NDIR sensor 30 measures the proportion of CO in the atmospheric sample A drawn through the conduit 24 and passing through the chamber 34. And because the presence of CO in a proportion greater than in free air is an indicator of combustion, the sensor 30 detects whether the pilot burner 16, from which the atmospheric sample A is obtained, is alight. If the sensor 30 records a proportion of CO below a predetermined threshold it delivers a signal by way of a control line 42 to activate a flame front generator 44 which is supplied with gas at B and when activated causes a flame to be propagated up the conduit 24 - that is, in a direction opposite to the arrows A - to reignite the pilot burner 16. (Although not detailed in the drawings, the aspirator 32 may be switched off while the flame front generator 44 is activated). For monitoring purposes the output of the sensor 30 is also delivered, by way of a monitoring line 46, to a visual display unit (VDU) 48.

[0037] Since CO is present only in extremely small amounts in free air (usually not more than 100 parts per billion) any CO detected by the sensor 30 can be taken to be indicative of combustion.

[0038] As an alternative to the NDIR CO monitor 30 of Figure 2, the proportion of CO_2 in the sample A may be detected by an electrochemical cell 50 as shown in Figure 3. The sensor 50 is shown much enlarged in Figure 3a and comprises a substrate 52, a heating element 54, a dielectric sealing element 56, a metallic anode 58, a solid electrolyte 60 of CO_2—sensitive material and a metallic cathode 62. Electrochemical cells like the sensor 50 are well known and do not need detailed description here. Briefly, in the presence of CO_2 the CO_2—sensitivity of the electrolyte 60 causes an electromotive force (EMF) to be generated between the anode 58 and the cathode 62, and the change in EMF is related to the change in CO_2 concentration. Thus a drop in EMF as measured at 64 indicates a reduction in the proportion of CO_2 in the sample A which in turn indicates that the pilot burner 16 has been extinguished. Then the flame front generator 44 can be activated to reignite the pilot burner 16.

[0039] The heating element 54 maintains the electrolyte 60 at a temperature at which its CO_2-sensitivity is maximised. It functions satisfactorily in a range from 0.035% CO_2 (which is just below the average concentration of CO_2 in free air) to 5% CO_2 and thus provides an ample margin for measuring changes in CO_2 concentration around 1%. CO_2 threshold value for activation of the flame front generator 44 can be determined empirically for any given flare stack from actual measurement over time.

[0040] A solid-state device like the CO_2 sensor 50 may be cheaper than an NDIR sensor as shown in Figure 2. However, it may be prone to degradation over time, although this can be countered by periodically purging it, by a free air line (not shown) from the aspirator 32 or possibly by running the aspirator in reverse.

[0041] Figure 4 illustrates the use of an oxygen sensor 70. The sensor 70 comprises a tube 72 formed of yttria-stabilised zirconia (YSZ) and extending transversely across the conduit 24. The exterior of the YSZ tube 72, which is heated by a heater 74, is thus exposed to the sample flow A through the conduit 24. The interior of the YSZ tube 72 is exposed to a flow of free air C. A metallic reference electrode 76 is deposited on the inner surface of the YSZ tube 72 and a gas electrode 78 is deposited on its outer surface. A difference in partial pressure of oxygen between the inside and the outside of the YSZ tube 72 gives rise to an EMF which is measured at 64 and displayed for monitoring purposes at 48. As long as the pilot burner 16 is alight the proportion of oxygen in the sample A flowing through the conduit 24 is substantially less than that in the air C flowing through the YSZ tube 72 and the EMF stays substantially constant. If the pilot burner 16 is extinguished, there is a change in EMF and this provides a signal for automatic activation of the flame front generator 44.

[0042] Figure 5 illustrates the use of an electrochemical sensor 80 for detecting nitric oxide (NO) or nitrogen dioxide (NO_2 or nitrous oxide (N_2O), all of which are indicators of combustion and are commonly known collectively as NO_x. The sensor 80, which is shown greatly enlarged in Figure 5a, comprises a body 82 formed of solid YSZ electrolyte positioned in the wall of the conduit 24 adjoining the aspirator 32. The YSZ body 82 is formed with an inner passage 84 inside the conduit 24 and communicating with the aspirator 32 so that sample A passes therethrough. The body 80 is formed with an outer passage 86 outside the conduit 24 and open to the air surrounding the conduit 24. The inner passage 84 contains a measuring electrode 88 and pumping electrodes 90 and the outer passage 86 contains a reference electrode 92 and pumping electrodes 94. A heating element 96 is embedded in the body 82.

[0043] Devices like the sensor 80 are well known and do not need detailed description here. Briefly, an oxygen pumping action is set up by energising the pumping electrodes, so giving rise to an EMF related to the relative difference in partial pressure of oxygen between the sample A in the inner passage 84 and the free air in the outer passage 86. Beyond this, however, one of the pumping electrodes 90 in the inner passage 84 is coated with rhodium and this subjects NO_x in the inner passage 84 to a reducing action so that the EMF measured at 64 is related to the concentration of NO_x in the conduit 24 and can thus provide a signal for activating the flame front generator 44.

[0044] It should be understood from the foregoing that the essence of the invention is automatic provision of a signal at a remote location if a parameter of combustion is absent at the burner location.

[0045] Tests indicate that the most effective parameter for monitoring the status of the pilot burner 16 is the proportion of CO in the sample. However it should be understood both that other parameters may be sensed and that, if the presence of CO is to be tested, means other than an NDIR monitor may be used. Examples of sensors that might be used in the invention include the C series CO sensor available from Alphasense of Great Notley, UK, the TGS 4160 hybrid O_2 sensor unit available from Figaro Engineering Inc of Osaka, Japan and the Smart NO_x sensor available from Continental AG of Frankfurt, Germany. Notwithstanding these available sensors and the details of sensing systems outlined above, those skilled in the art should be well able to construct any of the sensing systems shown in Figures 2 to 5, or other systems able to detect products of combustion at a location remote from the burner location of a flare stack.

[0046] Variations on the embodiments of the invention particularly described hereinbefore will be apparent to those skilled in the art and in particular it is pointed out that, although the flare stack described provides for automatic reignition it may simply provide a signal to operatives for manual action.

Claims

1. A flare stack comprising a gas discharge duct (10) and a pilot burner (16) operative at a burner location to ignite gas discharged by way of the duct (10), **characterised in that** said flare stack comprises: sampling means operative to sample gases at the burner location and deliver a sample thereof to a monitoring location (20) remote from the burner location; a sensor (30/50/70/80) at the monitoring lo-

cation (20) responsive to a parameter of the sample indicative of combustion at the burner location; and a signalling device (38/64) operatively associated with the sensor (30/50/70/80) and arranged to provide a signal automatically if the sensor (30/50/70/80) does not detect said parameter in said sample.

2. A flare stack as claimed in Claim 1 **characterised in that** said flare stack includes an igniter (44) activated automatically in response to said signal to relight the pilot burner (16).

3. A flare stack as claimed in Claim 1 or Claim 2 **characterised in that** said parameter is the proportion of a selected constituent of the sample and said signal is provided automatically if the sensor (30/50/70/80) detects that said proportion differs from a predetermined reference value therefor.

4. A flare stack as claimed in Claim 3 **characterised in that** the reference value is an average from measurement of said proportion over time and said signal is provided automatically if the sensor (30/50/70/80) detects a change from the average.

5. A flare stack as claimed in Claim 3 **characterised in that** the reference value is a predicted value for said proportion.

6. A flare stack as claimed in Claim 5 **characterised in that** the reference value is the predicted proportion of oxygen and/or carbon monoxide and/or carbon dioxide and/or oxides of nitrogen in the sample.

7. A flare stack as claimed in any preceding claim **characterised in that** the sensor comprises an electrochemical cell (50/70/80) or a non-dispersive infrared (NDIR) sensor (30).

8. A flare stack as claimed in any preceding Claim **characterised in that** the sampling means comprises a conduit (24) extending from the burner location to the monitoring location (20) and an aspirator (32) operative to draw the sample through the conduit (24) from the burner location to the monitoring location (20).

9. A flare stack as claimed in Claim 8 **characterised in that** the aspirator (32) operates substantially continuously.

10. A flare stack as claimed in Claim 8 **characterised in that** the aspirator (32) operates periodically.

11. A flare stack as claimed in any of Claims 2 to 10 **characterised in that** said flare stack includes at the burner location a flame sensor (17) operatively associated with the pilot burner (16) and arranged to ignite the pilot burner (16) automatically if the flame sensor (17) does not detect a flame.

12. A flare stack as claimed in any preceding claim **characterised in that** said flare stack includes a display (48) at the monitoring location, which display (48) is operatively associated with the or each sensor (30/50/70/80) and arranged to indicate the status of the pilot burner (16).

13. A method of disposing of unwanted gas released from oil or gas production facilities, wherein the unwanted gas is discharged by way of a duct (10) and ignited by a pilot burner (16) at a burner location, **characterised in that** said method comprises: sampling gases at the burner location; delivering the sample to a monitoring location (20) remote from the burner location; testing the sample at the monitoring location (20) to detect a parameter indicative of combustion at the burner location; and providing a signal automatically if said parameter is not detected in the sample.

14. A method of disposing of unwanted gases as claimed in Claim 13 **characterised in that** said method comprises reigniting the pilot burner (16) automatically in response to said signal.

15. A method of disposing of unwanted gases as claimed in Claim 13 or Claim 14 **characterised in that** said parameter is the proportion of oxygen and/or carbon monoxide and/or carbon dioxide and/or oxides of nitrogen in the sample and the test measures such proportion against a predetermined reference value for the parameter.

16. A method of disposing of unwanted gases as claimed in Claim 15 **characterised in that** the reference value is a time-averaged empirical value for the sample.

17. A method of disposing of unwanted gases as claimed in Claim 15 **characterised in that** the reference value is a predicted value for the sample.

Fig 1

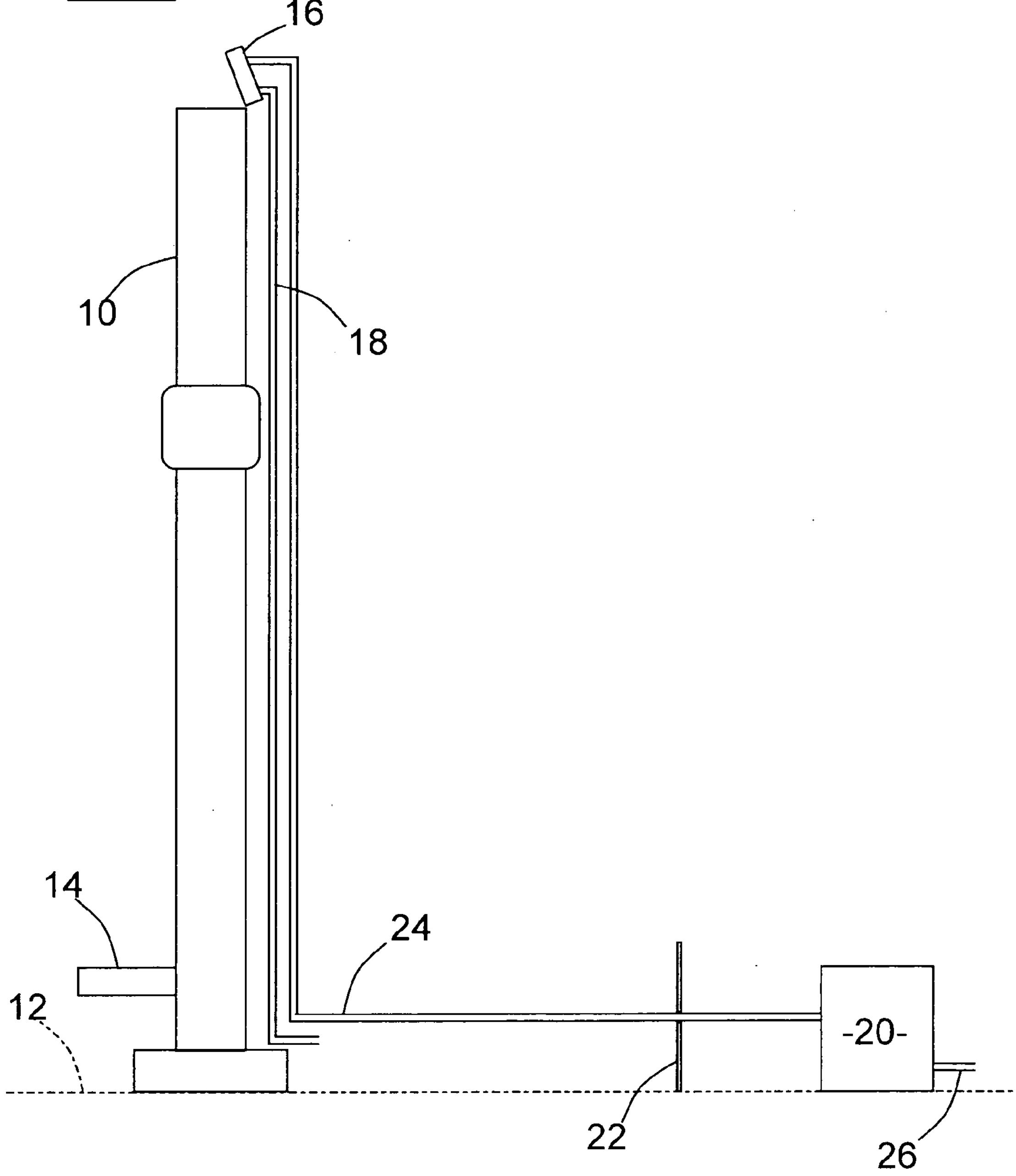


Fig 2

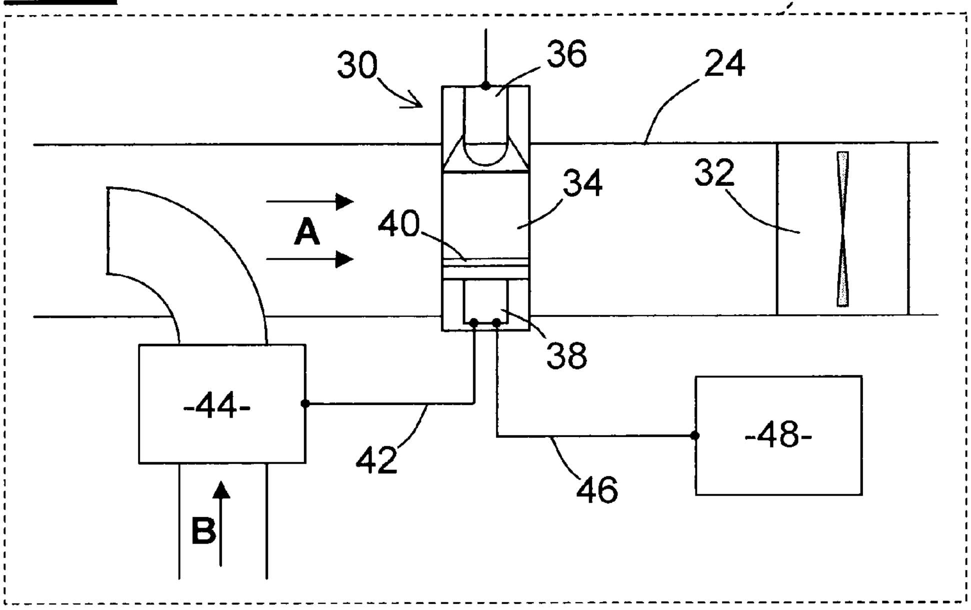


Fig 3a

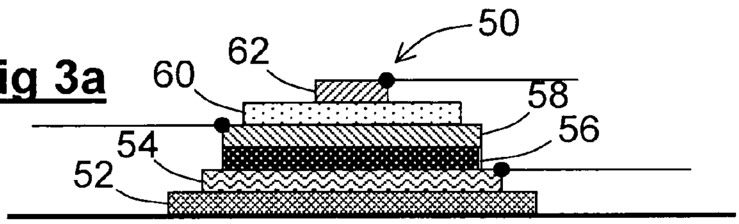


Fig 3

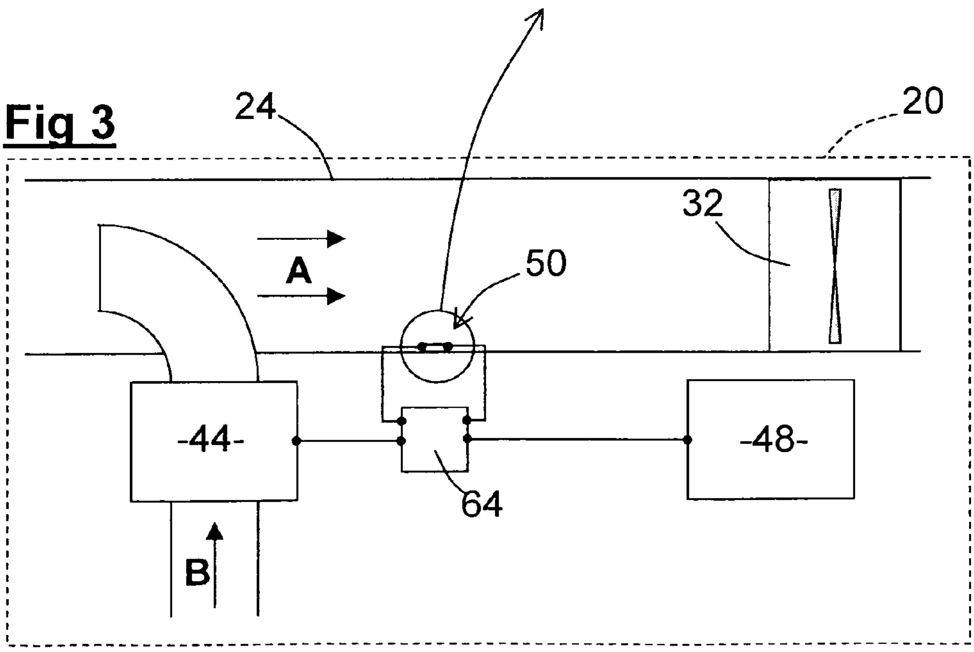


Fig 4

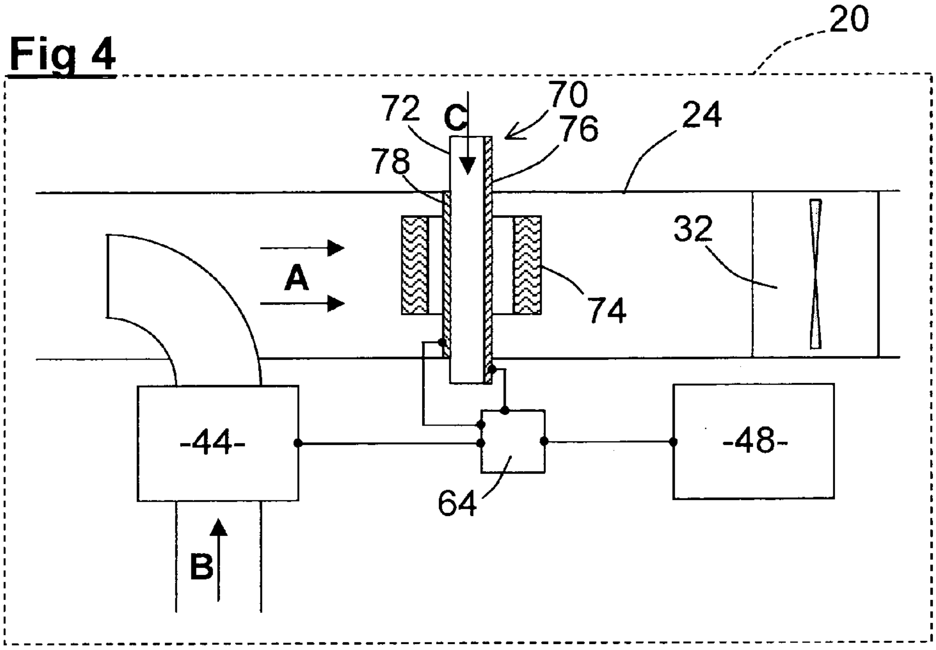


Fig 5a

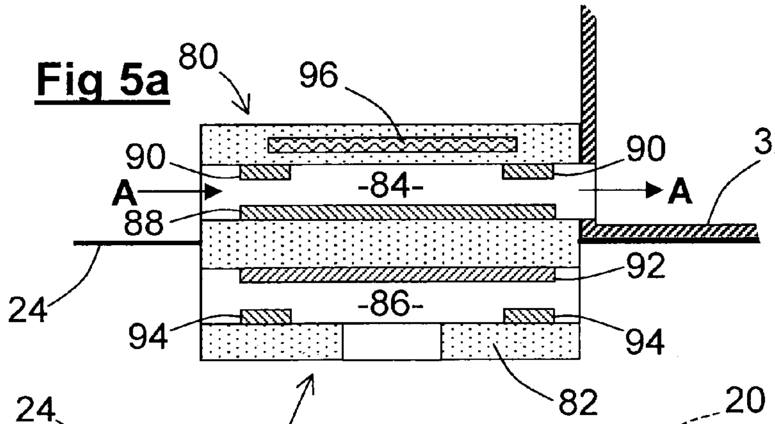


Fig 5