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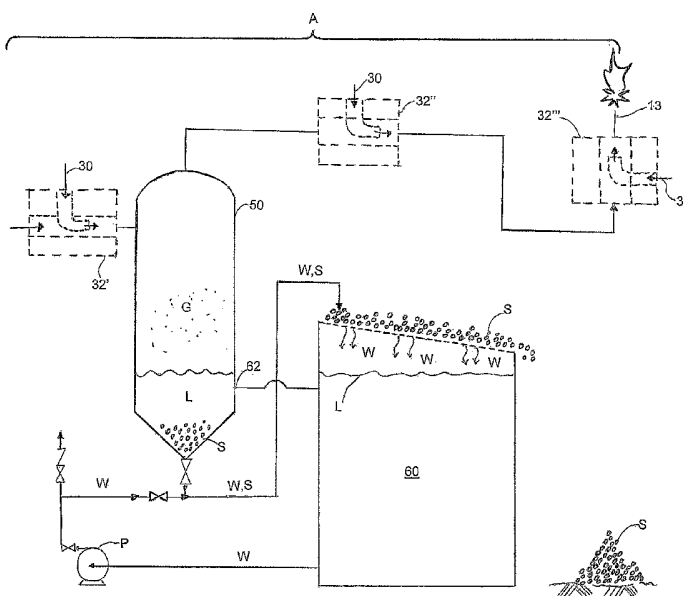
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(54) Title: CONTINUOUS POSITIVE FLOW BACKFLASH PREVENTION SYSTEM



(57) Abstract: A method and system for the prevention of backflash from an ignition source in a flare stack to a separator or wellbore particularly during drilling and production. A continuous positive flow of air or exhaust gas is provided into the flow of gases from the wellbore or the separator to ensure that the velocity of the flow is always higher than the velocity at which the flame can propagate backwards into either the separator or the wellbore. This method and system is particularly applicable to balanced, underbalanced and air drilling operations where the flow of gas from the wellbore is intermittent and unpredictable and can stop and start during connection and disconnection of the air used as the drilling fluid.

1 **"CONTINUOUS POSITIVE FLOW BACKFLASH PREVENTION SYSTEM"**

2

3

FIELD OF THE INVENTION

4

5 Embodiments of the invention relate to systems for preventing
6 backflash from a flame source and, more particularly, to the prevention of
7 backflash from a flame used to burn at least a portion of combustible gases from
8 a wellbore, either directly or following separation in a separator.

8

9

BACKGROUND OF THE INVENTION

10

11 In the drilling of oil and gas wells and in oil and gas production
12 facilities, flare stacks and/or blooie lines are used, through which combustible
13 gases, offgassed from the wellbore, are released and burned. The release of gas
14 through the flare stack or blooie line is typically intermittent and has non-
15 predictable rates, including low velocity flow, creating the potential for backflash,
16 which is the advancing of the flame front back through the flow to the source of
17 the gas.

17

18 During the drilling of oil and gas wells, using a variety of drilling
19 fluids including, but not limited to air, mist, foam, aerated and liquid mud
20 systems, the release of combustible gases is most likely to occur while drilling at
21 balanced or underbalanced phases of well control. Air drilling operations,
22 whether straight air, mist or foam, are particularly at risk for backflash and,
23 particularly so, when stopping and starting the flow of air to the wellbore while
24 making drillpipe connections. After connection and following commencement of
the flow of air in the drillpipe, it takes some time before the air completes the

1 circuit downhole and back to surface, thus leaving a lower gas velocity below
2 the flare igniter and therefore creating the potential for backflash.

3 Generally, backflash is most likely to occur where there is a
4 combination of three factors, namely; a low to zero velocity flow of a combustible
5 air and hydrocarbon gas mixture through the flare stack or blooie line; the
6 combustible gas mixture is contained in a finite structure within the flare stack
7 and/or blooie line or other structure; and there is a means for igniting the
8 combustible gas mixture. One such typical example exists in a flare stack line
9 extending from a separator vessel or a blooie line extending from the wellhead in
10 underbalanced or balanced drilling wherein a combustible gas mixture flows from
11 the wellbore flow tee, diverter or rotating diverter head or the separator to the
12 flare stack and/or blooie line having an outlet to the atmosphere, the flare stack
13 and/or blooie line being equipped with a continuous ignition source.

14 As described in "Flammability and Flashback Prevention (a work in
15 progress)" by Dan Banks, P.E posted on the worldwide web at
16 www.banksengineering.com/about_flame_arrestors_and_detona.htm , flame
17 progresses at a defined rate through a combustible mixture. If the flow velocity of
18 the gas mixture through the flare stack and/or blooie line falls below a minimum
19 gas velocity, the minimum gas velocity being a velocity greater than a flame
20 propagation velocity, the flame is capable of moving upstream from the point of
21 ignition to the source of the gas and igniting the gas therein. For example, in the
22 case of a methane/air mixture, the velocity in the pipe must exceed 1.5 ft/sec to
23 prevent flame propagation upstream to the ignition source. If the gas source of
24 the combustible mixture is at the separator, the separator is at risk of explosion;
25 or if the flame front of the backflash travels down into the wellbore, a downhole

1 fire and possibly an explosion is likely, which could result in the loss of the entire
2 well section.

3 Typically, conventional underbalanced separators utilize
4 backpressure valves during balanced and underbalanced drilling operations to
5 attempt to prevent backflash however, in some circumstances the backflash can
6 still occur through the backpressure valve. Further, pressure maintained in the
7 separator as a result of the backpressure valve retards entrained gas from
8 evolving from the drilling fluids in the separator. As drilling fluids are passed to a
9 shale shaker, entrained gas which did not evolve in the separator can evolve at
10 the shaker, creating a fire potential or the potential for the release of
11 carcinogenic and toxic gases. The backpressure valve may also result in the
12 exertion of a higher bottom hole pressure on the formation which can interfere
13 underbalanced drilling. In the case of blooie line systems, it is typical that no
14 backflash systems are employed. In either case, it is known in the industry that
15 backflashes to separator vessels and into wellbores have occurred, resulting in
16 compromise to the structural integrity of mud/gas separators and causing
17 underground fires. In Canada, backflashes have been experienced by a number
18 of companies, particularly while air hammer drilling and/or foam drilling.

19 As reported by Susan Eaton in New Technology Magazine, March
20 2002 "Conquering Foothills Challenges - the air force", air drilling can be
21 dangerous, risky and costly, and underground fires are a real danger. As
22 suggested, successes have been realized using a combination of air and
23 nitrogen or nitrogen alone to replace combustible mixtures with air, however
24 providing a source of compressed nitrogen suitable for use in the volumes

1 required for air drilling is costly and requires additional specialized equipment at
2 surface.

3 Flame arrestors are known in the industry. Known flame arrestors
4 typically either quench flame by reducing the velocity of the flame, stop flame
5 propagation, pass the gas mixture through a water chamber or heat sink to
6 dissipate heat and reduce potential for ignition, block the fuel gas path with a
7 thermal fuse plug causing the backflash to die out, or block the flow of fuel gas
8 using a quick-acting non-return valve. Flame arrestors have been known to plug
9 up and/or freeze as a result of cuttings and/or wet gas.

10 Venturi-type arrestors are used to create a restriction in the
11 delivery of the gas mixture and therefore increase the velocity of the gas to be
12 greater than the flame velocity. In cases where gas flow decreases or stops,
13 venturi-type arrestors are no longer effective. Typically, flow through the gas
14 delivery system is monitored and makeup gas is added only when the flow of the
15 gas drops below a critical level.

16 Inline flame arrestors are also known. Arrestors of this type are
17 typically heat-sink type arrestors filled with metal, ceramic or fluid and act to
18 absorb heat from a flashback to quench the temperature below ignition
19 temperatures. Fluid-type arrestors are prone to freezing when used in low
20 ambient temperatures and therefore are not functional in many drilling
21 applications.

22 In cases where a large influx of fluids or gas, called a "kick", is
23 encountered or predicted while drilling, the operator typically shuts the blowout
24 preventer (BOP), weights up the drilling fluid and commences drilling again using
25 a heavier drilling fluid to increase the hydrostatic head in the wellbore which is

1 capable of suppressing or minimizing the fluid influx. Cessation of drilling and
2 weighting up the drilling fluid results in lost drilling time and decreased rates of
3 penetration (ROP).

4 Clearly what is needed is a simple, reliable backflash flame
5 arresting system that can be employed in a number of flaring applications and,
6 more particularly, to flaring operations where the flow of combustible gas to the
7 flare may be intermittent and unpredictable, such as in air drilling. Further, it is
8 desirable that the system permit continued drilling despite the intermittent influx
9 of combustible hydrocarbons so as to maintain high ROP's.

10

11 SUMMARY OF THE INVENTION

12 A method and system for prevention of backflash from an ignition
13 source to a source of combustible gas utilizes a flow of addition fluid, typically air
14 or exhaust gas, introduced into the flow of combustible gas to the ignition source
15 in at least a minimum flame propagation velocity to ensure a continuous positive
16 flow to the ignition source regardless the intermittent and unpredictable nature of
17 the flow of combustible gas. Embodiments of the invention are particularly useful
18 when drilling wellbores in balanced and underbalanced conditions and more
19 particularly, using air/foam/aeration drilling.

20 In a broad aspect of the invention, a method for prevention of
21 flashback from an ignition source towards a wellbore during drilling of the
22 wellbore comprises injecting a drilling fluid into a wellbore; producing the drilling
23 fluid from the wellbore for removing cuttings from the wellbore, the produced
24 drilling fluid containing combustible gas; flowing the combustible gas to the
25 ignition source for burning of said combustible gas; and continuously providing

1 an addition fluid at a velocity of at least a minimal flame propagation velocity into
2 the flowing combustible gas downstream of the wellbore and upstream of the
3 ignition source for avoiding flashback from the ignition source.

4 In a further broad aspect of the invention, a system for the
5 prevention of flashback from an ignition source connected to a wellbore
6 producing unpredictable and intermittent flows of combustible hydrocarbons
7 during drilling of the wellbore, comprises a source of addition fluid connected to
8 the flow of combustible hydrocarbons between the wellbore and the ignition
9 source; a venturi for accelerating the flow of the addition fluid into the flow of
10 combustible gas for inducing flow of combustible gas to the ignition source;
11 wherein the addition fluid is continuously provided to the flow of combustible
12 hydrocarbons in a velocity in excess of a minimal flame propagation velocity to
13 prevent backflash from the ignition source to the wellbore.

14 The addition fluid is typically air or exhaust gas and in an
15 embodiment of the invention, is provided into the flow between the wellbore and
16 the ignition source using a venturi, which acts to accelerate the flow of the
17 addition fluid causing the combined flow to be accelerated and ensures the
18 combustible gases flows towards the ignition source. The venturi inlet can be
19 positioned anywhere between the wellbore and the ignition source, typically a
20 flare stack or blooie line.

21 In an embodiment of the invention, the venturi is positioned
22 between a separator and the flare stack, the separator acting to provide
23 containment of the off-gas produced with the drilling fluids and cuttings from the
24 wellbore and to direct the gas evolved from the drilling fluids to the flare stack.
25 The use of the separator in combination with the positive flow achieved by the

1 addition fluid, enables drilling to proceed regardless whether "kicks" of
2 combustible gas come from the wellbore, eliminating the need to shut the BOP's
3 and weight up or otherwise change the drilling fluids and reducing the fear of
4 backflash, while at the same time providing containment of gases within the
5 separator for evolution therein and release to the flare stack without fear of
6 gases remaining entrained and releasing at the shale shaker. The ability to drill
7 without altering the hydrostatic head in the wellbore permits balanced and
8 underbalanced drilling to continue and further results in being able to maintain
9 higher ROP's.

10 In the case where there is a potential for the release of sour gas
11 from the wellbore, a vacuum degasser is introduced after the separator and
12 discharges gas to the flare stack and liquid to the shale shaker. Liquids exiting
13 the separator are passed to the vacuum degasser to ensure that any gas
14 remaining in the liquid is evolved from the liquid, the evolved gas being flowed to
15 the flare stack and the liquids and solids directed to the shale shaker.

16 Often drillers overlook the advantages of air drilling due to the time
17 and costs associated with rig up and rig out of conventional air equipment
18 implementation. A further advantage of the system of the present invention is
19 that the system can be installed at the start of well drilling and can be used for all
20 drilling fluid programs which might be employed, including conventional
21 overbalanced, balanced, underbalanced and air drilling and transitions
22 therebetween. Further, implementation of the system of the present invention
23 minimizes drilling interruptions with changes of drilling fluids.

24

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic of a typical mud drilling operation, being an air, mist, foam aerated mud or liquid mud drilling operation, illustrating a conventional wellsite configuration from a wellhead through to a flare or alternatively to a blowline, a dotted line indicates recycling of drilling mud to the wellbore in the case of a mud drilling operation;

Figure 2 is a schematic of an embodiment of a flare for use in an embodiment of the invention in a wellsite configuration according to Fig. 1;

Figure 3 is a schematic illustrating an embodiment of the invention being a system for backflash prevention used in a drilling application and incorporating a flare according to Fig. 2, the particular embodiment illustrated being an air drilling operation using air, mist or foam as a drilling fluid, the system however being applicable to all mud drilling systems;

Figure 4 is a schematic illustrating alternate venturi positioning and recirculating of fluid from a shale shaker tank past a solids outlet at a bottom of a separator for moving solids from the separator to the shale shaker; and

Figure 5 is a schematic illustrating an embodiment of the invention having a vacuum degasser and being particularly applicable for drilling operations wherein the off-gas from the wellbore may contain at least a portion being sour gas.

1 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

2 With reference to Fig. 1, a conventional drilling system comprises a
3 drilling rig 10, a wellhead 11, wellbore 12 and a flare 13. Drilling fluids 14 are
4 injected into the wellbore 12 to aid in extraction of cuttings 15 with the drilling
5 fluids 14 from the wellbore 12. Suitable drilling fluids 14 include air, mist, foam or
6 aerated mud or non-compressible liquid drilling fluids. The cuttings 15 are
7 separated 16 from the drilling fluids 14 at surface 17. In the case where aerated
8 mud or non-compressible mud is, the drilling fluid 14 is typically recirculated to
9 the wellbore 12, following separation 16 of the cuttings 15. In air, mist or foam
10 drilling, air is used to extract cuttings from the wellbore 12, in place of drilling
11 mud. The cuttings 15 may be lifted as dust or mist should there be an influx of
12 water into the wellbore 12. Further, agents may be added to the wellbore 12
13 during drilling to create a foam to aid in lifting the cuttings 15. Drilling fluids 14
14 returning to surface 17 often include wellbore gases G including combustible
15 hydrocarbons or off-gas which is burned at the flare 13 or alternatively, directly
16 from a blowie line 18, which is typically used to discharge returned drilling fluids
17 14 to a flare pit 19. The rate of production of off-gases is highly unpredictable
18 and typically intermittent.

19 Having reference to Fig. 2, an embodiment of a flare 13 safely
20 used in flaring wellbore off-gas comprises a flare stack 20 having an inlet 21 for
21 receiving a flow of wellbore gas G. An ignition source 22 is positioned within an
22 upper end 23 of the flare stack 20 or adjacent an outlet 24. The ignition source
23 22 is typically continuous, providing a flame 25 for combusting the combustible
24 wellbore off-gases, and discharging products of said combustion through the
25 outlet 24 to atmosphere.

1 In one embodiment of the invention, a continuous source of
2 addition fluid 30, typically air or exhaust gas, is introduced to the flow of off-
3 gases G from the wellhead 11 at a constant velocity equal to or in excess of a
4 minimum flame propagation velocity. The minimum flame propagation velocity is
5 that velocity at which the flame is prevented from traveling upstream through the
6 flow of gases. As shown in Fig. 1 and 3, the addition fluid 30 may be added at
7 any point A in the flow stream downstream of the wellhead 11, and upstream of
8 the ignition source 22.

9 Further, in an embodiment shown in Figs. 2-4, the addition fluid 30
10 is introduced through an addition fluid inlet 31, such as a venturi 32. The venturi
11 32 may comprise an arrangement wherein the addition gas inlet 31 is located co-
12 axially in the flow stream. The addition fluid 30 is discharged at a velocity higher
13 than the velocity of the wellbore off-gas G and thereby accelerates the wellbore
14 off-gas. Wellbore off-gas is drawn around the addition fluid inlet 31 and into the
15 flow of addition fluid 30 for directing the combined fluid or mixture F to the
16 ignition source 22.

17 In one embodiment, shown in Fig. 2, the addition fluid 30 is
18 introduced into flare stack 20 upstream from the ignition source 22. An air
19 blower, helical screw or reciprocating compressor 40 or the like, may be used to
20 supply the addition fluid 30 flow to the addition inlet 31. In the case of a
21 methane/air mixture, the minimum flame propagation velocity is approximately
22 1.5 ft/s and therefore, the addition fluid 30 must be provided at 1.5 ft/s or greater
23 so that, should there be no flow from the wellbore 12, the minimum critical
24 velocity is met and the flame 25 will remain at the ignition source 22 and not
25 propagate upstream towards the wellbore 12 or separator 16. In addition to

1 providing a continuous positive flow of gases from the wellbore 12 to the flare 13
2 and preventing a backwards propagation of the flame 25 to the wellbore 12, the
3 venturi 32 creates a suction which can act to draw the produced wellbore off-
4 gases G away from the wellhead 11 and any associated equipment and
5 processes, further increasing the safety of personnel working on site. This may
6 be particularly advantageous in the case of produced sour gas, which if
7 accidentally vented, may present increased hazards to the environment and to
8 personnel on site.

9 The system, while particularly applicable where drilling is planned
10 to be operated under balanced and underbalanced conditions, is also applicable
11 to overbalanced drilling which may become balanced or underbalanced either by
12 choice during drilling or as a result of problems encountered in the well.

13 Having reference to Figs. 3-5, the flare stack 20 and continuous
14 positive air/gas flow system of the present invention is incorporated into an
15 overall system for prevention of backflash in a drilling operation and, more
16 particularly, in an air drilling operation having a three-phase separator 50 for
17 separating gases from liquids and cuttings produced from the wellbore 12. The
18 separator 50 is typically positioned between the wellhead 11 and the flare stack
19 20 and, in conventional air drilling operations, is at risk for structural damage as
20 a result of explosions caused by backflash from the flare 20. As shown in Fig. 4,
21 locating an addition fluid 30 and venturi 32 at some point A, 32', 32'', 32''' and
22 more preferably as an embodiment 32'', 32''' between the separator 50 and flare
23 stack ignition source 22 acts both to ensure that backflash to the separator 50
24 does not occur and further, due to the induction of wellbore off-gases G, acts to
25 minimize separator pressure to further effect gas liberation from liquids therein.

1 More particularly, and in a preferred embodiment of the invention,
2 the separator 50 for use in the present system is configured as a vertical
3 separator, adapted for use in mud drilling systems and aerated mud systems, as
4 well as air, mist and foam drilling systems. The separator 50 comprises a
5 tubular, closed body 51 having an inlet 52 formed in a sidewall 53 of the
6 separator 50 adjacent a top end 54 of the separator 50 for receiving a stream of
7 fluids M comprising gases G, liquids L and cuttings 15 from the wellbore 12. A
8 solids outlet 55 is formed at a bottom 56 for directing solids S, particularly
9 cuttings 15, out of the separator 50 and a gas outlet 57 is formed at the top 54 of
10 the separator 50 for discharging wellbore off-gases G.

11 Preferably, the bottom 56 is conical and angled at 33° or greater to
12 ensure that solids S, which are gravity separated from liquids L and gases G
13 therein, do not become trapped in the separator's bottom 56 and are instead
14 directed for discharge from the solids outlet 55.

15 Gases G, released from the liquids L and solids S, are contained
16 within a headspace 58 above the liquids L in the separator 50 and are directed
17 from the gas outlet 57 to the flare stack 20.

18 As shown in Fig. 3 and, in greater detail, in Fig. 4, largely
19 dewatered solids S, separated from the returned drilling fluids 14 and discharged
20 from the solids outlet 55 at the bottom 56 of the separator 50 are directed to a
21 shale shaker 60 where the solids S can be readily sampled. A level of liquid L in
22 the separator is hydraulically kept constant with a liquid level L in the shale
23 shaker tank 60 resulting in a stagnant sump and causing the solids S to drop
24 from the bottom 56 of the separator 50. Due to the significant volume of liquid L
25 relative to the solids S in the conical portion of the separator 50, the residence

1 time within the separator 50 is relatively long, maximizing any gas G evolution
2 therefrom and into the head space 58. Further, the liquid L forms a liquid barrier
3 preventing gas from venting to the shale shaker tank 60.

4 Preferably, as shown in Fig. 4, to aid in the discharge of solids S
5 from the solids outlet 55, screened fluids W are pumped P, from the shale
6 shaker tank 60 or alternately from a mud tank or spare tank 61, past the solids
7 outlet 55 where the fluids W combine with the solids S to carry the solids S onto
8 the shale shaker 60. The fluids W are largely solids free and are continuously re-
9 circulated by the pump P. As there is little remaining solid S in the fluid W
10 following screening on the shale shaker 60, it is not required that the pump P be
11 a solids pump.

12 A large portion of the liquids L separated in the separator 50 are
13 routed to the shale shaker 60 from a liquid outlet 62 positioned in the sidewall 53
14 of the separator 50.

15 Advantageously, the vertical separator 50 has a smaller footprint
16 than conventional horizontal separators used in underbalanced drilling and thus
17 requires less space at the wellsite. Depending upon the intended use
18 requirements and reservoir conditions, the separator 50 may or may not be
19 pressure rated. Further, the system reduces the number of personnel required to
20 operate the site.

21 As shown in an embodiment in Fig. 5, and for more complete
22 degassing especially for use where the off-gases G produced from the wellbore
23 12 may contain at least some H₂S or sour gases, a vacuum degasser 70 is
24 connected to the system at the liquid outlet 62 for increased removal of off-gases
25 G from the drilling fluids 14. Liquid L transported via the liquid outlet 62 to the

1 vacuum degasser 70 are largely solids-free to avoid plugging of the vacuum
2 degasser 70. Gas G entrained within the liquid L is removed by the vacuum
3 degasser 70 by differential gas liberation in accordance with conventional
4 technology. The separated gas G is then routed to the flare stack 20 for flaring.

5 The addition fluid 30 is introduced downstream of the vacuum
6 degasser 70 and adds further to the safety of the system ensuring that a
7 continuous ignition source 22, provided for flaring of hazardous sour gas, can be
8 maintained without fear of backflash, regardless the intermittent or unpredictable
9 production of said hazardous off-gas G.

10

**THE EMBODIMENTS OF THE INVENTION IN WHICH AN
EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS
FOLLOWS:**

1. A method for prevention of flashback from an ignition source
towards a wellbore during drilling of the wellbore comprising:

injecting a drilling fluid into a wellbore;
producing the drilling fluid from the wellbore for removing cuttings
from the wellbore, the produced drilling fluid containing combustible gas;

flowing the combustible gas to the ignition source for burning of
said combustible gas; and

continuously providing an addition fluid at a velocity of at least a
minimal flame propagation velocity into the flowing combustible gas downstream
of the wellbore and upstream of the ignition source for avoiding flashback from
the ignition source.

2. The method as described in claim 1 wherein the
continuously providing the addition fluid step further comprises

accelerating the flow of combustible gas with the addition fluid for
inducing flow of combustible gas to the ignition source.

3. The method as described in claim 2 wherein the
accelerating step comprises introducing the addition fluid through a venturi.

4. The method as described in claim 1 wherein the source of
the combustible gas is an off-gas from the wellbore, the off-gas being produced
at intermittent and unpredictable velocity.

1 5. The method as described in claim 4 wherein the minimum
2 flame propagation velocity is dependant upon a composition of the off-gas.

3
4 6. The method as described in claim 4 wherein the off-gas is a
5 mixture of methane and air and the minimum flame propagation velocity is about
6 1.5 feet per second.

7
8 7. The method as described in claim 1 wherein the providing of
9 the addition gas step comprises adding the addition fluid between a wellhead
10 fluidly connected to the wellbore and the ignition source.

11
12 8. The method as described in claim 1 further comprising:
13 separating the combustible gas from the drilling fluid; and then
14 flowing the combustible gas to the ignition source.

15
16 9. The method as described in claim 9 wherein
17 the separating of the combustible gas from the drilling fluid is in a
18 separator; and
19 the providing of the addition fluid step comprises adding the
20 addition fluid between the separator and the ignition source.

21
22 10. The method as described in claim 1 wherein the ignition
23 source is a flare.

1 11. The method as described in claim 1 wherein the addition
2 fluid is air.

3

4 12. The method as described in claim 1 wherein the addition
5 fluid is exhaust gas.

6

7 13. The method as described in claim 1 wherein the drilling is or
8 has become balanced drilling.

9

10 14. The method as described in claim 1 wherein the drilling is or
11 has become underbalanced drilling.

12

13 15. The method as described in claim 1 wherein the drilling is
14 selected from the group consisting of air drilling, mist drilling, foam drilling, non-
15 compressible fluid drilling, aerated mud drilling or mud drilling.

16

1 16. A system for the prevention of flashback from an ignition
2 source connected to a wellbore producing unpredictable and intermittent flows of
3 combustible hydrocarbons during drilling of the wellbore, the system comprising:
4 a source of addition fluid connected to the flow of combustible
5 hydrocarbons between the wellbore and the ignition source;
6 a venturi for accelerating the flow of combustible gas with the
7 addition fluid for inducing flow of combustible gas to the ignition source; and
8 wherein the addition fluid is continuously provided to the flow of
9 combustible hydrocarbons in a velocity in excess of a minimal flame propagation
10 velocity to prevent backflash from the ignition source to the wellbore.

11

12 17. The system as described in claim 16 wherein the addition
13 fluid is provided continuously during drilling of the wellbore using a drilling fluid,
14 injected into and produced from the wellbore for removing cuttings therefrom.

15

16 18. The system as described in claim 17 wherein the drilling is
17 or has become underbalanced.

18

19 19. The system as described in claim 17 wherein the drilling is
20 or has become balanced.

21

22 20. The system as described in claim 12 wherein the drilling is
23 selected from the group consisting of air drilling, mist drilling, foam drilling, non-
24 compressible fluid drilling, aerated mud drilling or mud drilling.

25

1 21. The system as described in claim 17 further comprising:
2 a separator positioned downstream from the wellbore and
3 upstream from the addition fluid for separating the combustible hydrocarbons
4 from the drilling fluid and produced cuttings; and
5 a gas outlet for flowing the combustible hydrocarbons from the
6 separator to the ignition source.

7
8 22. The system as described in claim 16 wherein the addition
9 fluid is air.

10
11 23. The system as described in claim 16 wherein the addition
12 fluid is exhaust gas.

1 24. The system as described in claim 21 wherein the separator
2 is a vertical separator comprising:

3 an enclosed tubular body having an inlet for accepting the
4 produced drilling fluid comprising liquids, combustible hydrocarbons and
5 cuttings from the wellbore, the tubular body providing a headspace for
6 evolving gases therefrom;

7 a conical bottom permitting gravity separation of the cuttings from
8 the liquids and gases, the conical bottom having a solids outlet for
9 directing solids to a shale shaker;

10 a gas outlet at a top end for directing the evolved gases to the
11 ignition source; and

12 a liquid outlet formed in a sidewall of the tubular body for removing
13 a portion of the liquids therefrom,

14 wherein the addition gas is provided to the flow of gas downstream
15 from the separator's gas outlet and upstream from the ignition source for
16 preventing backflash from the ignition source to the separator.

17

18 25. The system as described in claim 24 wherein the conical
19 bottom is angled at about 33 degrees or greater.

20

1 26. The system as described in claim 21 further comprising:
2 a vacuum degasser connected to the liquid outlet for receiving and
3 further degassing liquids removed from the separator, the removed gas being
4 directed from the vacuum degasser to the ignition source,
5 wherein the addition gas is provided to the flow of gas downstream
6 from the vacuum degasser and upstream from the ignition source for preventing
7 backflash from the ignition source.

8

9

1 **THE EMBODIMENTS OF THE INVENTION IN WHICH AN**
2 **EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS**
3 **FOLLOWS:**

4
5 1. A method for prevention of flashback from an ignition source
6 towards a wellbore during drilling of the wellbore comprising:

7 injecting a drilling fluid into a wellbore;

8 producing the drilling fluid from the wellbore for removing cuttings
9 from the wellbore, the produced drilling fluid containing combustible gas;

10 flowing the combustible gas to the ignition source for burning of
11 said combustible gas; and

12 continuously providing an addition fluid at a velocity of at least a
13 minimal flame propagation velocity into the flowing combustible gas downstream
14 of the wellbore and upstream of the ignition source for avoiding flashback from
15 the ignition source.

16

17 2. The method as described in claim 1 wherein the
18 continuously providing the addition fluid step further comprises

19 accelerating the flow of combustible gas with the addition fluid for
20 inducing flow of combustible gas to the ignition source.

21

22 3. The method as described in claim 2 wherein the
23 accelerating step comprises introducing the addition fluid through a venturi.

24

25 4. The method as described in claim 1 wherein the source of
26 the combustible gas is an off-gas from the wellbore, the off-gas being produced
27 at intermittent and unpredictable velocity.

1 5. The method as described in claim 4 wherein the minimum
2 flame propagation velocity is dependant upon a composition of the off-gas.

3

4 6. The method as described in claim 4 wherein the off-gas is a
5 mixture of methane and air and the minimum flame propagation velocity is about
6 1.5 feet per second.

7

8 7. The method as described in claim 1 wherein the providing of
9 the addition gas step comprises adding the addition fluid between a wellhead
10 fluidly connected to the wellbore and the ignition source.

11

12 8. The method as described in claim 1 further comprising:
13 separating the combustible gas from the drilling fluid; and then
14 flowing the combustible gas to the ignition source.

15

16 9. The method as described in claim 9 wherein
17 the separating of the combustible gas from the drilling fluid is in a
18 separator; and

19 the providing of the addition fluid step comprises adding the
20 addition fluid between the separator and the ignition source.

21

22 10. The method as described in claim 1 wherein the ignition
23 source is a flare.

24

1 11. The method as described in claim 1 wherein the addition
2 fluid is air.

3

4 12. The method as described in claim 1 wherein the addition
5 fluid is exhaust gas.

6

7 13. The method as described in claim 1 wherein the drilling is or
8 has become balanced drilling.

9

10 14. The method as described in claim 1 wherein the drilling is or
11 has become underbalanced drilling.

12

13 15. The method as described in claim 1 wherein the drilling is
14 selected from the group consisting of air drilling, mist drilling, foam drilling, non-
15 compressible fluid drilling, aerated mud drilling and mud drilling.

1 16. A system for the prevention of flashback from an ignition
2 source connected to a wellbore producing unpredictable and intermittent flows of
3 combustible hydrocarbons during drilling of the wellbore, the system comprising:
4 a source of addition fluid connected to the flow of combustible
5 hydrocarbons between the wellbore and the ignition source;
6 a venturi for accelerating the flow of combustible gas with the
7 addition fluid for inducing flow of combustible gas to the ignition source; and
8 wherein the addition fluid is continuously provided to the flow of
9 combustible hydrocarbons in a velocity in excess of a minimal flame propagation
10 velocity to prevent backflash from the ignition source to the wellbore.

11

12 17. The system as described in claim 16 wherein the addition
13 fluid is provided continuously during drilling of the wellbore using a drilling fluid,
14 injected into and produced from the wellbore for removing cuttings therefrom.

15

16 18. The system as described in claim 17 wherein the drilling is
17 or has become underbalanced.

18

19 19. The system as described in claim 17 wherein the drilling is
20 or has become balanced.

21

22 20. The system as described in claim 17 wherein the drilling is
23 selected from the group consisting of air drilling, mist drilling, foam drilling, non-
24 compressible fluid drilling, aerated mud drilling and mud drilling.

25

1 21. The system as described in claim 17 further comprising:
2 a separator positioned downstream from the wellbore and
3 upstream from the addition fluid for separating the combustible hydrocarbons
4 from the drilling fluid and produced cuttings; and
5 a gas outlet for flowing the combustible hydrocarbons from the
6 separator to the ignition source.

7

8 22. The system as described in claim 16 wherein the addition
9 fluid is air.

10

11 23. The system as described in claim 16 wherein the addition
12 fluid is exhaust gas.

1 24. The system as described in claim 21 wherein the separator
2 is a vertical separator comprising:

3 an enclosed tubular body having an inlet for accepting the
4 produced drilling fluid comprising liquids, combustible hydrocarbons and
5 cuttings from the wellbore, the tubular body providing a headspace for
6 evolving gases therefrom;

7 a conical bottom permitting gravity separation of the cuttings from
8 the liquids and gases, the conical bottom having a solids outlet for
9 directing solids to a shale shaker;

10 a gas outlet at a top end for directing the evolved gases to the
11 ignition source; and

12 a liquid outlet formed in a sidewall of the tubular body for removing
13 a portion of the liquids therefrom,

14 wherein the addition gas is provided to the flow of gas downstream
15 from the separator's gas outlet and upstream from the ignition source for
16 preventing backflash from the ignition source to the separator.

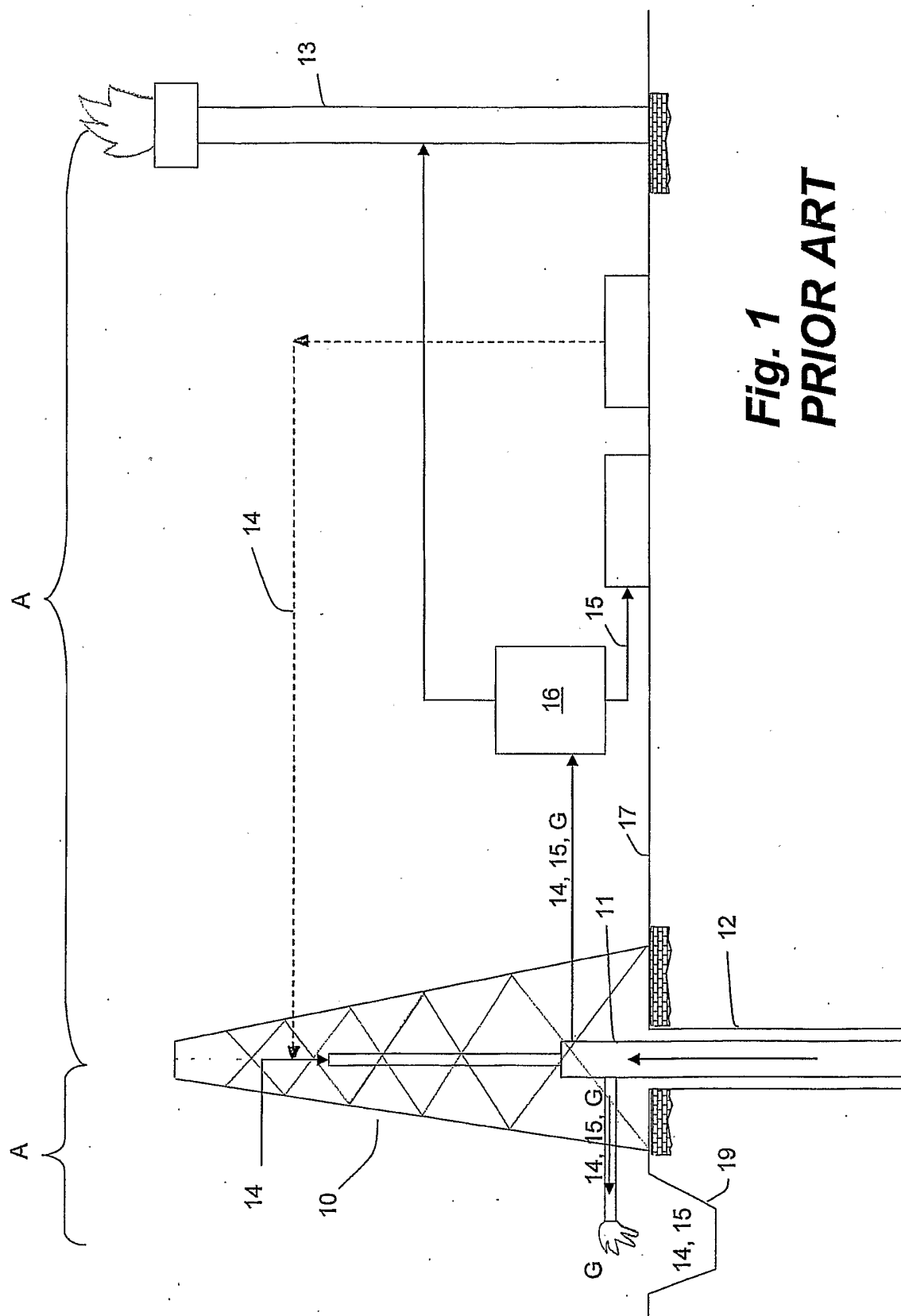
17

18 25. The system as described in claim 24 wherein the conical
19 bottom is angled at about 33 degrees or greater.

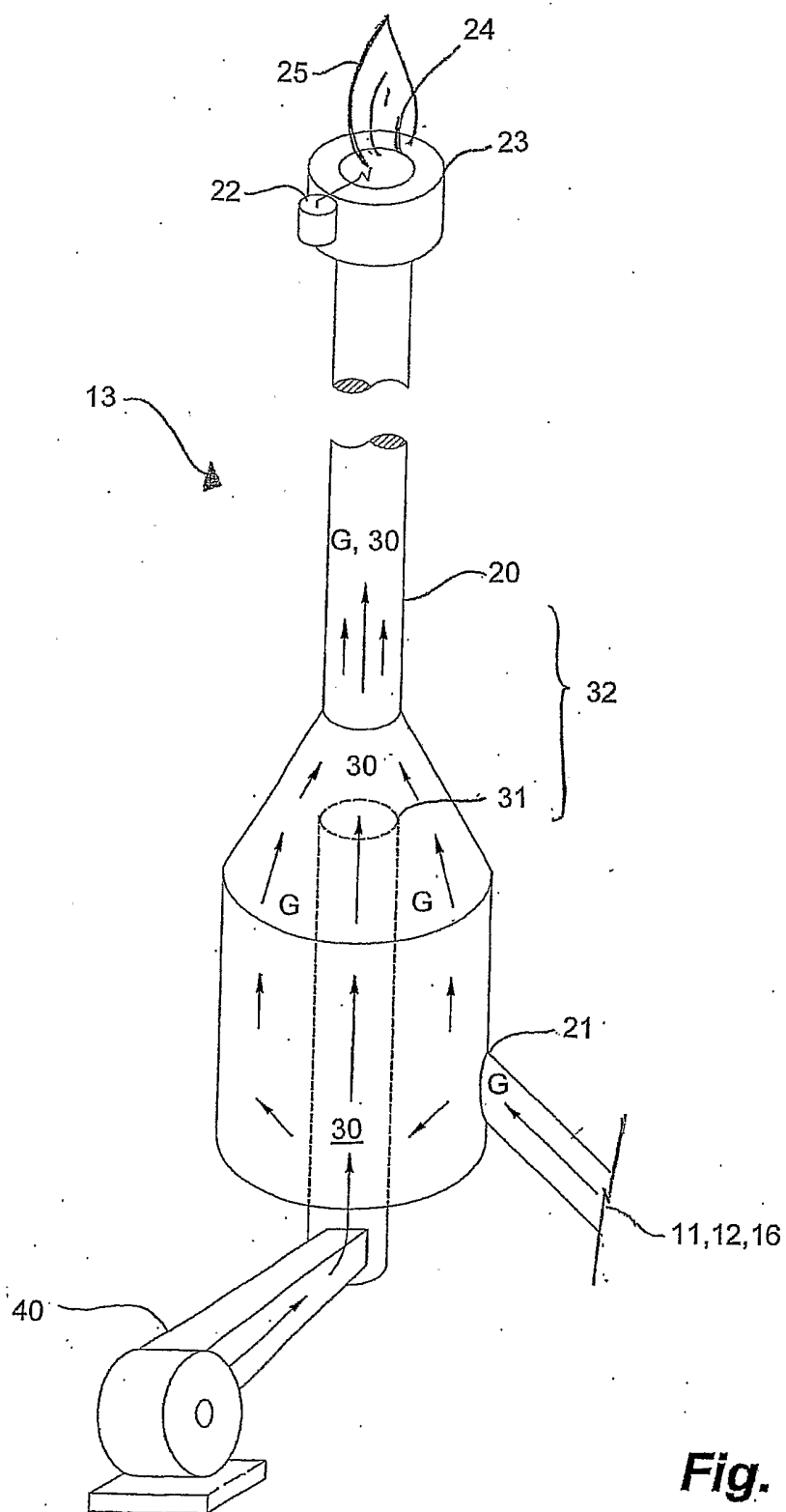
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1 26. The system as described in claim 21 further comprising:
2 a vacuum degasser connected to the liquid outlet for receiving and
3 further degassing liquids removed from the separator, the removed gas being
4 directed from the vacuum degasser to the ignition source,
5 wherein the addition gas is provided to the flow of gas downstream
6 from the vacuum degasser and upstream from the ignition source for preventing
7 backflash from the ignition source.
8

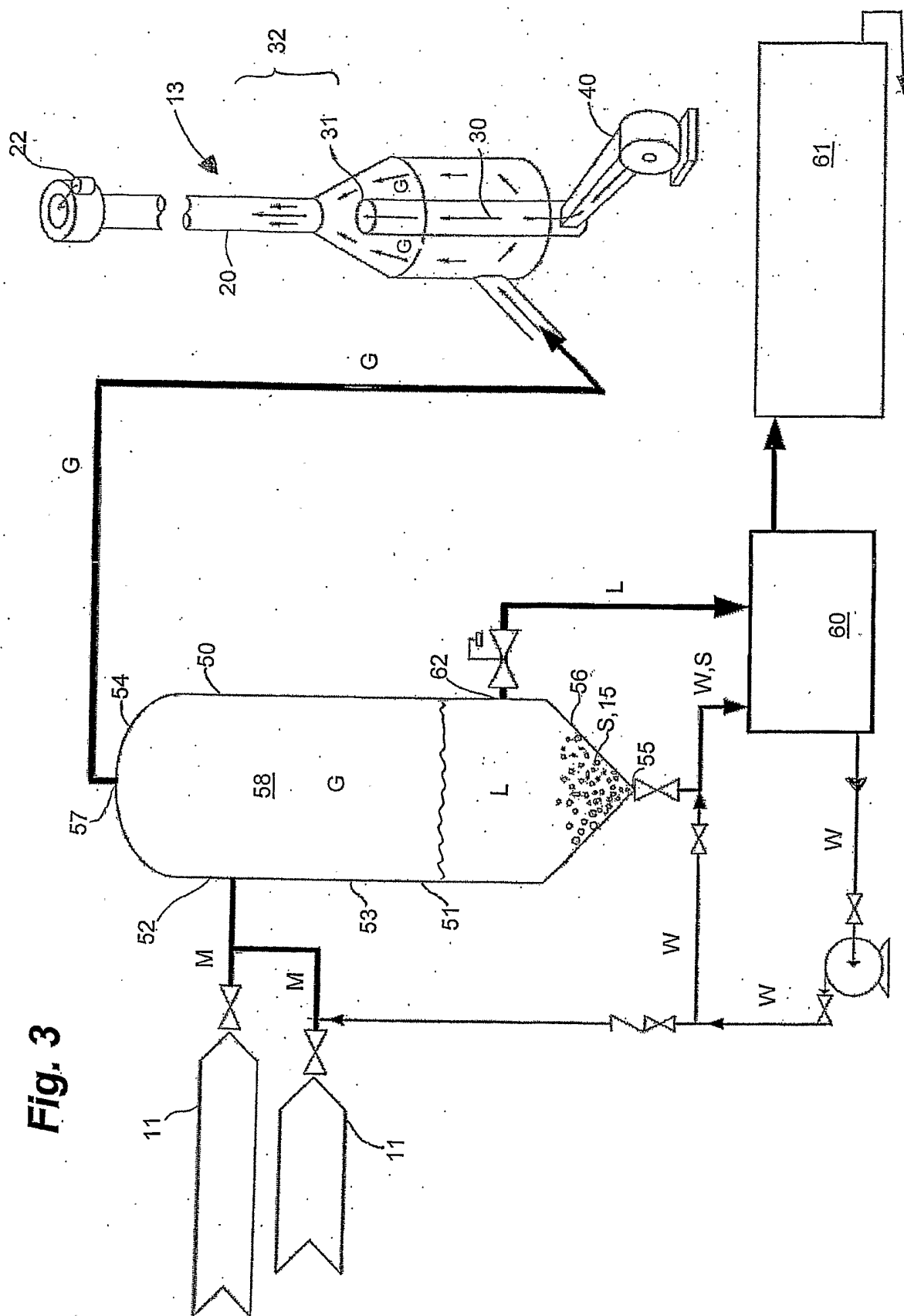
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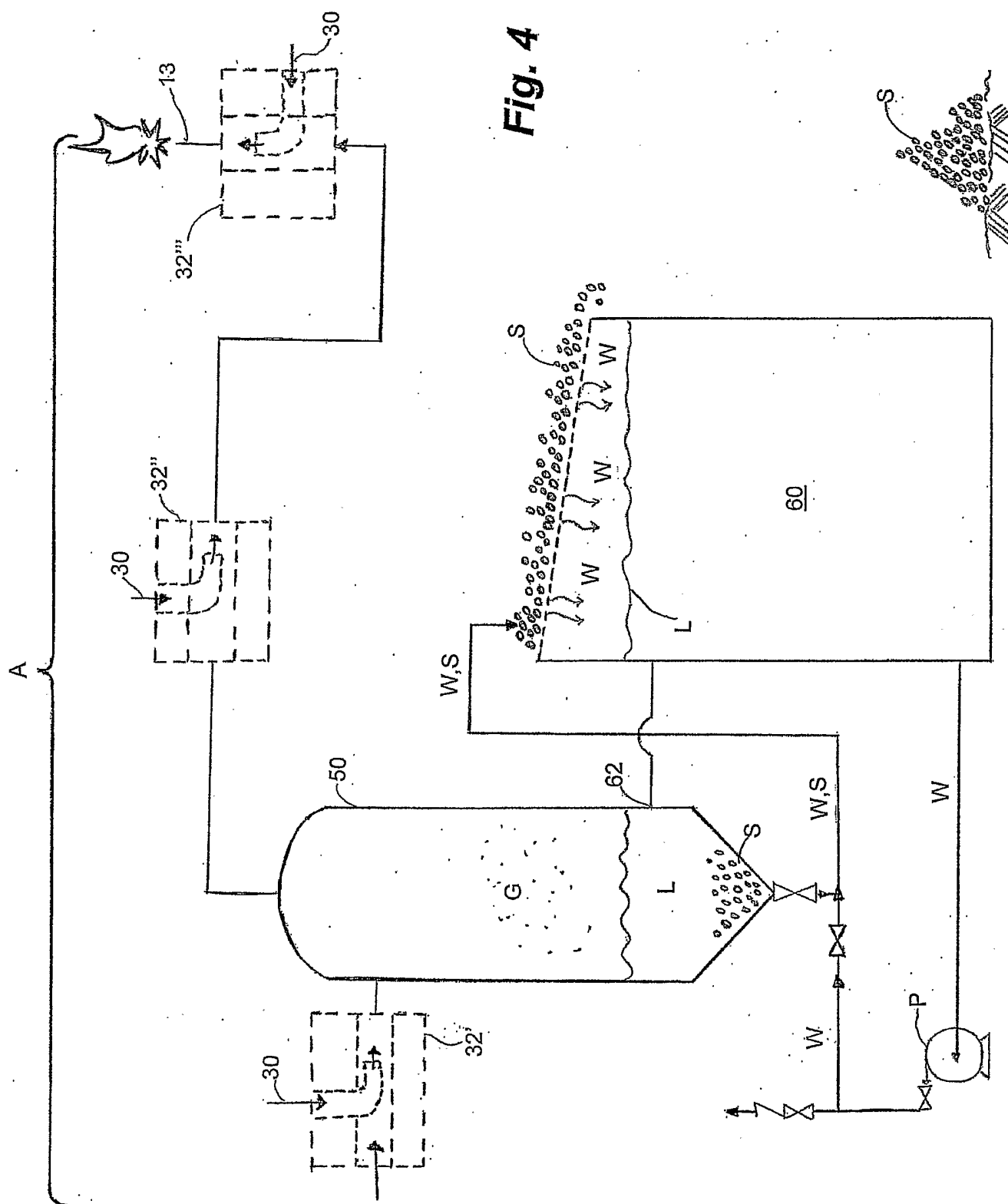
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**Fig. 2**

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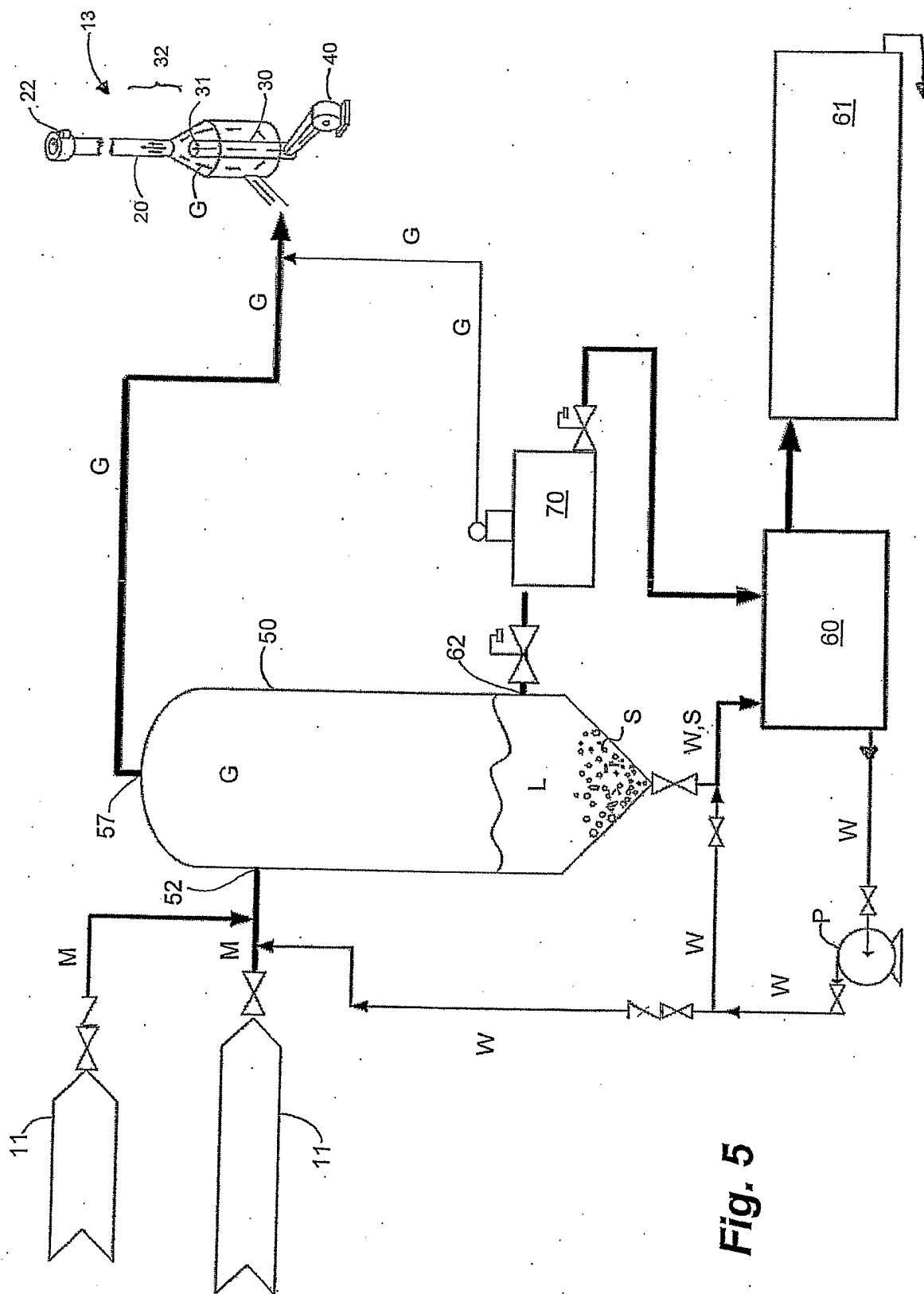


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2005/000763

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7): E21B 35/00, E21B 41/00, E21B 21/01

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(7): E21B 35/00, E21B 41/00, E21B 21/01, F23D 14/82, A62C 4/02

USPC: 166/90, 422/220, 431/346

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)

USPTO, Espacenet, CPD, Internet; keywords: backflash, flashback, burnback, backburn, prevent/ed/ing/er, well, wellbore, borehole, flame, arrestor/er, interrupter/ing/ion, backfire (singly or in combination, with or without class, as appropriate).

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 3,463,227 (SMITH, A.L.) 26 August 1969 (26-08-1969)	1 - 26
A	US 4,865,820 (DUNSTER et al.) 12 September 1989 (12-09-1989)	1 - 26
A	US 4,909,730 (ROUSSAKIS et al.) 20 March 1990 (20-03-1990)	1 - 26

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier application or patent but published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

21 July 2005 (21-07-2005)

Date of mailing of the international search report

16 August 2005 (16-08-2005)

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/CA2005/000763

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
US3463227	26-08-1969	none	
US4865820	12-09-1989	AR243404 A1 AT81490T T AU604956 B2 AU2098888 A BR8804104 A CA1314129 C CN1014494B B DE3875305D D1 DE3875305T T2 DK174008B B1 EP0303439 A2 ES2035301T T3 GR3006155T T3 IN171676 A1 JP1159037 A KR9609153 B1 MX165662 B NO173127B B NZ225814 A SU1711659 A3 ZA8805993 A	31-08-1993 15-10-1992 03-01-1991 16-02-1989 02-05-1989 09-03-1993 30-10-1991 19-11-1992 25-02-1993 08-04-2002 15-02-1989 16-04-1993 21-06-1993 05-12-1992 22-06-1989 16-07-1996 27-11-1992 26-07-1993 27-03-1990 07-02-1992 25-04-1990
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