

UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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ENERCOP SAND SOLUTIONS INC.  
Petitioner,

v.

SPECIALIZED DESANDERS INC.,  
Patent Owner

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Patent No. 8,945,256

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**DECLARATION OF DAVID SIMPSON, P.E.**

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## LIST OF EXHIBITS CONSIDERED

Exhibit No.	Description
1001	U.S. Patent No. 8,945,256 B2 to Hemstock (the “256 Patent”)
1003	Prosecution File History, U.S. Patent Application (U.S.13/372,291) (’256 Patent)
1004	U.S. Patent No. 6,983,852 to Hemstock et al. (“Hemstock”)
1005	Sedimentation of Noncolloidal Particles at Low Reynolds Numbers, Robert H. Davis and Andreas Acrivos, Annual Review of Fluid Mechanics, Vol. 17, 1985, published by Annual Reviews Inc., pages 91-118 (“Davis”)
1007	U.S. Patent No. 1,458,234 to Miller (“Miller”)
1008	Engineering Data Book, Gas Processors Suppliers Association, Revised Tenth Edition 1994 (the “Data Book”) (Sections 7 and 17)
1013	Canadian Patent 2,433,741

I, David Simpson, declare as follows:

1. My name is David A. Simpson. I am over the age of 18 years and am fully competent to make this declaration. I make the following statements based on personal knowledge and, if called to testify to them, could and would do so.

2. I have agreed to serve as an expert witness in this matter on behalf of Enercorp Sand Solutions Inc. (“Petitioner”) to, among other things, provide this Declaration as an expert in wellsite equipment and phase separation and render an opinion regarding the technological background and validity of the claims of U.S. Patent No. 8,945,256 (the “’256 patent”) (Ex. 1001).

#### **I. BACKGROUND AND QUALIFICATIONS**

3. I am a registered Professional Engineer in the States of Colorado (#37104) and New Mexico (#16189). I am the founder, owner, and Principal Engineer of MuleShoe Engineering, an engineering consulting firm based in Farmington, New Mexico that has provided consulting services to the oil and gas industry since 2003.

4. I have a Bachelor of Science Degree in Industrial Management from the University of Arkansas, Fayetteville (1980) and a Master of Science Degree in Mechanical Engineering from the University of Colorado, Denver (1993), with an emphasis in Fluid Mechanics and Thermodynamics.

5. I have 38 years of experience working in the Oil & Gas industry, including working with separation equipment and vessels, including desanders.

6. I have served in a consulting role with three different pressure vessel manufacturers and am the patent holder of U.S. Patent 8,597,402 B2, entitled “Device For Capturing Gas and Solids from a Produced Water Stream,” disclosing an invention that is specifically designed for removing solids from a combined raw gas/liquid/solid stream. Further, I am the author of “Pneumatic Controllers in Upstream Oil & Gas,” published in October 2014 in Oil & Gas Field Facilities Journal (peer reviewed section) that is being used as the design basis for the development of API Pneumatic Standard 4590 that is currently in the development stage.

7. A copy of my resume is attached to this Declaration as Attachment A. My resume also includes a list of my publications in the last ten years and a list of the matters in which I have testified as an expert witness at trial, arbitration, and/or by deposition in the last four years.

8. My compensation for the study of materials and preparation of this case is \$225/hr. My compensation is not in any way affected by the outcome of this case.

## **II. BASES FOR OPINIONS**

9. The opinions set forth in this declaration are my own. My opinions are based on my review of materials provided in this matter and cited throughout this

Declaration and as itemized in the “Exhibits Considered” preceding this declaration, as well as my educational background, my experience working in the oil and gas industry, and my experience consulting and providing expert testimony in cases involving similar and/or related technology. I have also considered certain additional materials which are referenced herein.

10. My analysis of the materials relating to this matter is ongoing and I will continue to review any new material that is provided to me. This Declaration represents certain opinions that I have formed to date and the bases for those opinions. I reserve the right to revise, supplement, and/or amend my opinions based on new information presented to me and on my continuing analysis of the materials cited throughout this Declaration and those identified in the “Exhibits Considered.”

### **III. LEGAL STANDARDS**

11. I am not an attorney. For purposes of this declaration, I have been informed about certain aspects of the law that are relevant to my analysis and opinions, as set forth below.

#### **A. Claim Construction**

12. In an *inter partes* review, it is my understanding the claims are to be given their broadest reasonable construction in light of the specification and prosecution history as it would be interpreted by one of ordinary skill in the art at the time of the claimed invention.



13. Under the broadest reasonable interpretation standard, it is my understanding that the words of the claims must be given their ordinary and customary meaning as understood by those of ordinary skill in the art at the time of the invention.

14. It is my understanding that the ordinary and customary meaning of a term may be evidenced by a variety of sources, including the words of the claims themselves, the specification, the prosecution history, and extrinsic evidence concerning relevant scientific principles, the meaning of technical terms, and the state of the art.

15. I understand that a patent holder is his own lexicographer and is entitled to provide alternate definitions of words in common usage, but if the patent holder uses a term that is in common usage without providing an alternate definition, then that term should generally be understood as having its common meaning.

16. I also understand that some claims are independent, and that those independent claims are complete by themselves. Other claims refer to these independent claims and are “dependent” on those independent claims. The dependent claims include all of the limitations of the claims on which they depend.

#### **B. Prior Art**

17. Among other things, I understand prior art could include printed publications in or outside the United States by the applicant before the claimed

invention was discovered, patents or printed publications more than one year before the date of the application, and patent applications filed or patents granted on an application filed in the United States before the invention was discovered.

18. I have been instructed to assume for purposes of my analysis that February 3, 2012 is the relevant date for determining what is “prior art.” In other words, I should consider as “prior art” any patents or publications publicly available prior to February 3, 2012 or a patent application filed in the United States before the invention was discovered. I further understand that for purposes of this proceeding before the United States Patent Trial and Appeal Board, only patents and other documents that qualify as a “printed publication” may be relied on as prior art.

### **C. Anticipation**

19. It is my understanding that anticipation is a question of fact that is determined from the perspective of one of ordinary skill in the art at the time of the claimed invention. I also understand that the standard for anticipation in an inter partes review proceeding is by a preponderance of the evidence.

20. It is my understanding that a claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference.

21. I understand that if the prior art reference does not expressly set forth a particular claim element, the prior art may still anticipate if that element is “inherent”

in its disclosure. To establish inherency, it is my understanding that evidence must make clear that the missing descriptive matter is necessarily present in the thing described in the reference. It is my understanding that inherency may not be established by probabilities or possibilities. In other words, it is my understanding that the mere fact that a certain thing may result from a given set of circumstances is not sufficient to establish inherency.

22. I understand that under the principles of inherency, if a prior art device, in its normal and usual operation, would necessarily perform a claimed method, then the method will be considered to be anticipated by the prior art device. I also understand that when the prior art device is the same as a device described in the specification for carrying out the claimed method, it can be assumed the device will inherently perform the claimed process.

#### **D. Obviousness**

23. It is my understanding that obviousness is a question of law with underlying factual inquiries that are determined from the perspective of one of ordinary skill in the art at the time of the claimed invention. I also understand that the standard for obviousness in an inter partes review proceeding is by a preponderance of the evidence.

24. It is my understanding that a claimed invention is obvious if the differences between the claimed invention and the prior art are such that the claimed

invention as a whole would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art to which the claimed invention pertains. I understand that a person of ordinary skill in the art is presumed to have knowledge of all relevant prior art.

25. It is my understanding that obviousness requires consideration of the following underlying factual inquiries:

- determining the scope and content of the prior art;
- ascertaining the differences between the claimed invention and the prior art;
- resolving the level of ordinary skill in the art; and
- evaluating objective evidence or “secondary considerations” of non-obviousness, such as commercial success, long-felt but unresolved needs, failure of others, industry praise, and unexpected results.

26. It is my understanding that a reference must be analogous art to the claimed invention in order to be properly considered for use in an obviousness inquiry. It is my understanding that a reference is analogous art to the claimed invention if:

- the reference is from the same field of endeavor as the claimed invention (even if it addresses a different problem); or

- the reference is reasonably pertinent to the problem faced by the inventor (even if it is not in the same field of endeavor as the claimed invention).

27. It is my understanding that whether a reference is reasonably pertinent turns on how the problem faced by the inventor is reflected, either explicitly or implicitly, in the specification.

28. It is my understanding that the following are exemplary rationales that may support a conclusion of obviousness:

- Combining prior art elements according to known methods to yield predictable results;
- Simple substitution of one known element for another to obtain predictable results;
- Use of known techniques to improve a similar method or product in the same way;
- Applying a known technique to a known method or product ready for improvement to yield predictable results;
- Obvious to try – choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success;
- Known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design

incentives or other market forces if the variations are predictable to one of ordinary skill in the art; and

- Some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.

29. Regarding “objective evidence” or “secondary considerations,” I understand that for such evidence to be relevant to the obviousness of a claim, there must be a causal relationship (called a “nexus”) between the claim and the evidence.

#### **IV. SUMMARY OF OPINIONS**

30. For reasons described in more detail in this Declaration, my opinions are summarized as follows:

31. Claims 1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 13, and 16 (the “Base Claims”) of the ’256 patent are obvious in view of the combination of U.S. Patent No. 6,983,852 to Hemstock (Ex. 1004) (hereafter, “Hemstock”) and the article “Sedimentation of Noncolloidal Particles at Low Reynolds Numbers,” by Robert H. Davis and Andreas Acrivos, published in the Annual Review of Fluid Mechanics in 1985 (Ex. 1005) (hereafter, “Davis”). I understand this combination is referred to as “Ground 1” and will so reference it in this declaration.

32. The Base Claims are obvious in view of Hemstock and the Engineering Data Book, Revised Tenth Edition, published by the Gas Processors Suppliers Association (GPSA) in 1994 (relevant excerpts of which are include in Exhibit 1008) (hereafter, the “Data Book”). I understand this combination is referred to as “Ground 2” and will so reference it in this declaration. Claims 8 and 12 of the ’256 Patent (the “Inclination Angle Claims”) are also obvious in view of Ground 2.

33. The Inclination Angle Claims are obvious in view of the combination of Hemstock, Davis, and U.S. Patent No. 1,458,234 to Miller (Ex. 1007) (hereafter, “Miller”). I understand this combination is referred to as “Ground 3” and will so reference it in this declaration.

34. Claims 14 and 15 of the ’256 Patent (the “Eccentric End Claims”) are also obvious in view of Ground 3.

35. The Eccentric End Claims are also obvious in view of Hemstock, the Data Book, and Miller. I understand this combination is referred to as “Ground 4” and will so reference it in this declaration.

## **V. LEVEL OF ORDINARY SKILL IN THE ART**

36. I have been asked to provide my opinions regarding the knowledge and understanding of a person of ordinary skill in the art as of the earliest effective filing date of the ’256 patent. I understand that date is February 13, 2012, which I will hereafter refer to as the “effective filing date.”

37. I understand that the factors considered in determining the ordinary level of skill in the art include: (i) the levels of education and experience of persons working in the field; (ii) the types of problems encountered in the field; and (iii) the sophistication of the technology.

38. I understand that a person of ordinary skill in the art is not a specific real individual, but rather a hypothetical individual having the qualities reflected by the factors above. This hypothetical person has knowledge of all prior art in the relevant field as if it were arranged on a workshop wall and takes from each reference what it would teach to a person having the skills of a person of ordinary skill in the art.

39. I also understand that a person of ordinary skill in the art is also a person of ordinary creativity, not an automaton. Therefore, a person of ordinary skill in the art has and applies common sense to modify or combine references in the prior art, and can also find any teaching, suggestion, or motivation, whether to modify or combine, whether explicit or implicit.

40. As of the effective filing date, it is my opinion that a person of ordinary skill in the art as to the '256 patent would have at least a bachelor's degree in petroleum, chemical, or mechanical engineering, or equivalent experience and education. Alternatively, a person of ordinary skill in the art could have a bachelor's degree in some other engineering or scientific discipline, and at least three years of



experience working with separators designed for raw well fluids, as might be acquired working with such equipment in oil and gas production, gas processing, petroleum refining, chemical processing, or similar fields. This is the general educational background or experience level of active workers involved in designing separation systems similar to those described in the '256 Patent, Hemstock, Miller, and the relevant portions of the Data Book. The technology in this field is not subject to rapid innovation, and I would not consider it extremely sophisticated.

41. The analysis set forth herein is based on the timeframe of the alleged invention being prior to the effective filing date. As of that date, I qualified for the level of ordinary skill required by the above definition, and am in a position to provide an opinion on the understanding of a person of ordinary skill in the art as of that date. When I address the understanding of a person of ordinary skill in the art, I am referring to such a person's understanding as of the effective filing date.

42. I understand that a person of ordinary skill in the art can collaborate with one or more other persons of ordinary skill in the art for one or more aspects with which the other person may have superior expertise, experience, and/or knowledge.

## **VI. TECHNOLOGICAL BACKGROUND**

43. The '256 Patent is concerned with the control and separation of solids from oil and gas well production streams. Such streams often contain gases, liquids

(hydrocarbon and/or water) and solids. Water and sand must be removed in order to process the more valuable hydrocarbons for distribution and use. The patent thus relates to a specific application of the broader technological field of phase separation and related equipment.

#### **A. General Principles**

44. Various industries require the phase separation of multiphase (solid, liquid, and/or gas phases) streams to varying degrees. Such phase separation may be performed by various methods and types of equipment, all of which may generally be referred to as “separation equipment” or “separators.” Separators have various different characteristics, but the term has no rigid definition. An apparatus used to separate sand from a production stream is commonly referred to as a “sand separator” and often, a “desander.”

45. There are various types of separators. These devices work in three primary ways: changes in momentum, acceleration (either through inducing angular velocity or through gravity settling), and coalescing. Separators work because different fluid components have different densities and therefore react to the same acceleration with different responses. Thus, denser liquids and solids will tend to settle out of a gas, and solids will tend to settle out of a liquid, when the forces acting on the liquid or solid particle (e.g., for gravity settling, the force of gravity) are greater than the drag force of the fluid flowing around it. The drag force is a function

of the particle's terminal velocity in a particular fluid, which is dependent on the size of the particle and the relative density of the host fluid and the included fluid or solid.

46. Although there are no rigid definitions with regard to terminology, separators are often distinguished by reference to the phases or species separated. A “single phase” separator is generally understood as one having a single outlet that does not require manual intervention (i.e., the unit may separate multiple species, but at the outlet any species that is not retained in the vessel will be recombined). A “two phase” separator will separate the phases of a multiple phase inlet stream into two separate streams, while a “three phase” separator will separate an inlet stream into three separate phase streams. In short, some numerical value in front of the word “phase” refers to the number of unique outlet paths from the vessel that function without manual intervention, not the number of species of fluids combined in the vessel inlet stream. Obviously, a separator may have other outlets that may be opened manually, on batch basis and outside of normal steady-state operation, but the presence of such outlets does not change whether a particular separator is considered a single, two, or three phase separator.

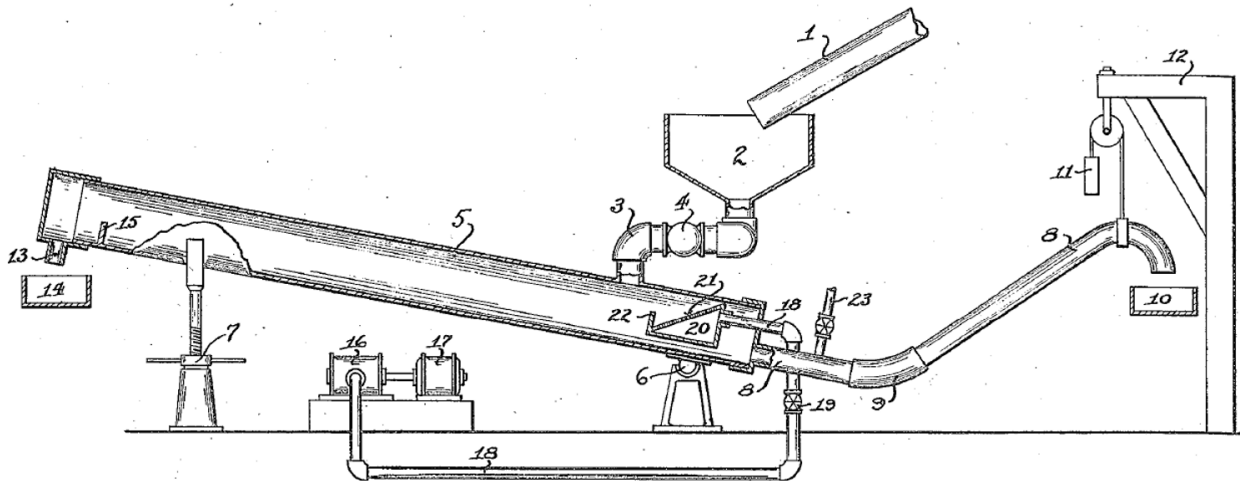
47. The sizing of separation equipment is largely based on empirical methods. Three main factors are considered in separator sizing: 1) vapor capacity, 2) liquid capacity, and 3) operability. The required vapor capacity (assuming the separator is intended to have a gaseous component in the inlet stream) will determine

the cross-sectional area necessary to reduce the velocity of the gas enough to permit liquid droplets and solid particles to disengage from the gas stream and fall towards the bottom of the vessel at the design flow rate. Liquid capacity is generally determined by the flow restrictions in the appropriate outlet flow line(s). Operability issues include the separator's ability to deal with the accumulation of solids if present, unsteady flow/liquid slugs, changes in ambient conditions, etc. Finally, the optimal design will usually result in a footprint or aspect ratio that satisfies these requirements in a vessel of reasonable cost.

## **B. Separators in the Oil and Gas Industry**

48. In the oil and gas industry, separation of solids, liquid, and gases arises in multiple contexts. Here I will discuss three which are relevant to the prior art and the '256 Patent.

49. With regard to drilling operations, solids must be separated and removed from the mud used in drilling operations. Drilling mud is a fluid pumped down through the drill bit, which circulates into the bottom of the hole and carries drill cuttings and other particulates away from the bit and back to the surface. Thus, many apparatuses and methods have been devised to perform this function. Miller shows that as long ago as 1923, it was known to use an inclined settling vessel to separate drill cuttings and other vessels from the drilling mud, as shown in the figure below:



50. In Miller, the drilling mud undergoing separation enters the drilling vessel 5 from hopper 2, and compressed air is bubbled through the mud to induce particulate settling. *Id.* at 2:51-61, 2:88-3:24.<sup>1</sup> Miller's vessel is inclined from the vertical, and is supported by jack 7 which allows the angle of the vessel to be adjusted based on operating conditions. *Id.* at 2:51-61. Heavier particulates migrate toward the lower end of the vessel due to the force of gravity, while cleaned mud exits at outlet 13. *Id.* at 3:14-21. The concentrated heavier particles pass out from the lower end of the vessel through pipe 8. *Id.* at 3:21-25. Pipe 8 is a smaller diameter than vessel 5 and is situated eccentrically toward the bottom of the vessel, so that solids migrating to the bottom might easily exit. *Id.* at 1.

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<sup>1</sup> References to Miller will cite the page number (of the exhibit) to the line number, e.g., [page]2:[line]100.

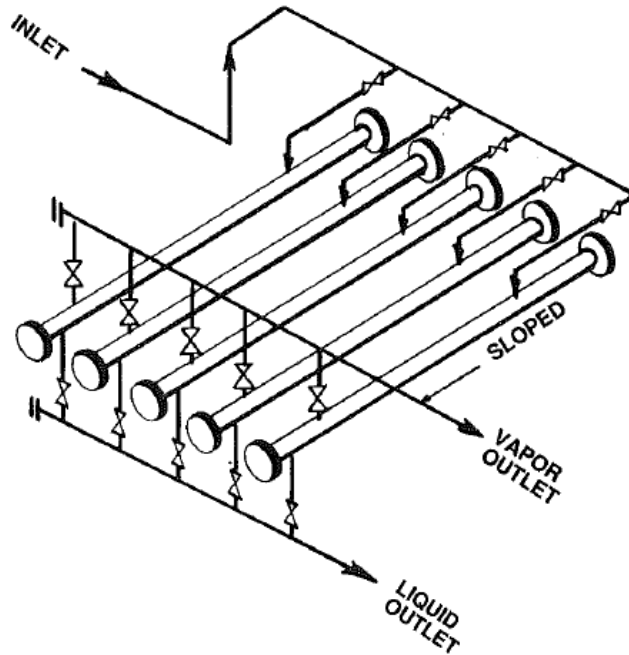
51. Miller's device applies a particular type of separation: sedimentation. As discussed in Davis, sedimentation is a process whereby particles fall under the action of gravity through a fluid in which they are suspended. Sedimentation is commonly used in the chemical and petroleum industries. By inclining his vessel, Miller takes advantage of a now well-known phenomenon, by which sedimentation is enhanced in inclined channels.

52. A second context in which separation issues arise in the oil and gas industry is the removal of liquids from fluid streams containing at least two species or phases. In two phase flow (e.g., gas and liquid which may or may not be the same chemical compound), several different types of flow or "flow regimes" are possible. The "slug flow" regime is frequently encountered when a gas phase and a liquid phase (which could include a third phase of solid particulates entrained in either the gas or the liquid) are present in a flowing pipe or stream. The liquid phase forms intermittent "slugs" of almost all liquid, interspersed between gas phase flow. These slugs represent significantly increased fluid momentum that can damage piping and equipment and their arrival can overwhelm the ability of equipment to remove the liquid/solid mixture from the vessel. It is generally desirable to remove this liquid from the stream.

53. To address this issue, devices called "slug catchers" are used to manage the issues raised by slug arrival. These vessels are generally operated as single-phase

separators, in that they have only a single open outlet during normal operation. These vessels usually have a liquid and/or solids outlet, the valve on this outlet is normally shut and is operated only manually at the discretion of the operator. Slug catchers are a type of separator, to which all the normal principles of separator design apply. The design parameter that frequently takes precedence for slug catchers is expected slug size. This precedence often leads to separation equipment with multiple barrels, which are generally called “finger slug catchers” or “harp slug catchers.” Each barrel in a finger slug catcher will be sloped such that the fluid outlet will have an entry point that is physically lower than the entry nozzle which creates a “liquid disengagement” section above a “belly reservoir” which has its height determined by the entry point of the fluid outlet. This configuration is described well in the figures of the ’256 patent and has been a staple of pipeline operations for decades prior to the effective filing date.

54. As shown in Figure 17-1 from the Data Book (reproduced below) and consistent with my experience, slug catchers are generally inclined to some degree, usually less than ten degrees, although this is dependent on the design conditions:



55. As mentioned, while Figure 17-1 shows both a vapor outlet and a liquid outlet, in normal usage the liquid outlet is blocked by a manual valve that is only operated occasionally. One of the reasons for this is that, if the liquid outlet were not normally closed, there is a significant possibility that the slug catcher would be “blown dry,” and gas would exit the liquid outlet. This can create a hazardous situation, in addition to directing gas away from its designed outlet and downstream gathering system. Thus, normally, the outlet flow through the vapor outlet will have both liquids and vapors. In common usage, it is normal for harp-type slug catchers such as this one to accumulate solids that must be flushed out the liquid outlet. In many operations, when a slug is anticipated (e.g., when the pipeline is undergoing a pigging operation) the operator will stand by the manual liquid drain and rapidly



open it to flush solids from the fingers of the slug catcher along with the slug of liquid. Frequently there are also additional fittings and pipe connections (not shown in Figure 17-1) to facilitate adding liquid to aid in the solids removal from the slopped barrel between anticipated slugging events.

56. A third application for settlers in the oil and gas industry is separating solids from production streams, which may involve the same issues as the prior application requiring the separation of liquids from two phase gas/liquid stream. The ability of fluids to carry a solid is a function of solid particle size, fluid density, and dominant-species velocity. A common approach to dealing with a stream that contains gas, liquid, and solids is to first separate the gas from the heavy species by significantly increasing the cross-sectional flow area, thereby dropping the velocity of the stream. At the lower velocity, the heavy species will tend to fall out of the flow stream. Vessels designed for significant solids will tend to have a larger liquid/solid reservoir and a larger liquid-handling capacity than one designed for streams that do not anticipate significant solids. These vessels will also tend to have some method to remove accumulated solids from the vessel, usually involving a shut-down and opening the vessel or fittings to flush the vessel.

57. The specific context to which the '256 Patent is addressed is the final context above—the goal is to separate solids from the fluids produced from the well. Production wells often produce solids of various types and sources (collectively,

referred to as “sand”) with the produced oil or gas. The presence of sand in production streams creates problems for downstream processing equipment and piping, including mechanical erosion, sand blockage, and the costs of removal. Thus, there has long been a recognized need for the removal of such sand, regardless of its source.

58. Various types of separation equipment have been used to accomplish such removal, including filters, cyclones, and standard vapor/liquid separators, which rely primarily on gravity settling and impingement. The vessel described in the '256 Patent is a type of single-phase separator in that it only has one normal outlet flow path.

## **VII. CLAIM CONSTRUCTION**

59. I have reviewed the '256 Patent's specification, claims, and prosecution history. In my opinions provided herein, I have given the claims of the '256 Patent their ordinary and customary meaning as understood by those of ordinary skill in the art at the time of the invention, based on the words of the claims, the specification, the prosecution history, and my understanding of the relevant scientific principles, the meaning of technical terms, and the state of the art.

60. One term appearing in the specification, as well as independent Claims 1 and 9 (and thus all the claims) is “freeboard portion.” This term is not used routinely in the art. The specification, however, clearly uses “freeboard portion” to

refer to the substantially gas-filled portion of the desanding vessel above the gas/liquid interface. *See* '256 Patent, Abstract (“a freeboard portion formed adjacent an upper portion of the vessel above a gas/liquid interface”); 2:13-17 (“an upper freeboard portion ... for encouraging water and particulates to fall out of the freeboard portion”); 4:13-18 (“Particulates S and liquids L ... are periodically cleaned out ... to ensure that the maximum accumulated depth does not encroach on the freeboard portion 13”). Thus, a person of ordinary skill in the art would understand that “freeboard portion” as used in the claims to refer to the substantially gas-filled portion of the desanding vessel above the gas/liquid interface.

61. Another term, “replaceable,” appears in claims 4 and 5. The term is used in the specification with regard to Figures 4 and 5, where it is explained that:

While the inlet 24 can be integrated with the vessel 22, one can also provide an inlet 24 or discharge 29 that is replaceable for ease of maintenance. Options include accepting eventual wear and shutdown of the desander 20 for replacement of an integrated inlet 24; modifying the material or configuration of the inlet 24 to prolong service life, or using replaceable discharge of nozzle for minimizing turnaround time.

'256 Patent, 6:9-18.

62. In the oil and gas industry, “replaceable” in this context generally refers to the capacity to be removed without requiring welded modifications to the pressure vessel. Thus, if a nozzle on a vessel is replaceable, it may be removed without

requiring any welding on the vessel itself. This is entirely consistent with the way in which “replaceable” is used in the specification of the ’256 Patent.

63. Thus, in my opinion, a person of ordinary skill in the art, in view of this disclosure and consistent with the standard usage in the field, would understand “replaceable” to refer to the capacity to be removed without requiring welded modifications to the pressure vessel.

64. In my opinion, other than as I have explained above, pursuant to the broadest reasonable interpretation, the claim terms of the ’256 Patent do not have any special meanings beyond their ordinary meaning. Therefore, for purposes of my analysis, I have given them their broadest reasonable interpretation as understood by one of ordinary skill in the art, consistent with the disclosure of the ’256 patent.

## **VIII. DETAILED OPINIONS OF UNPATENTABILITY**

### **A. The Scope And Content Of The Prior Art**

#### **1. The Prior Art References**

65. Before I explain the particular combinations underlying the asserted grounds, I will briefly discuss the general details of each prior art reference.

##### **a. Hemstock**

66. Hemstock is a U.S. Patent that issued on January 10, 2006. I understand that one of its named inventors, Christopher Hemstock, is also the named inventor of the ’256 Patent. Hemstock describes a desanding apparatus virtually identical to that disclosed in the ’256 Patent, except that it is not tilted or inclined. It appears to

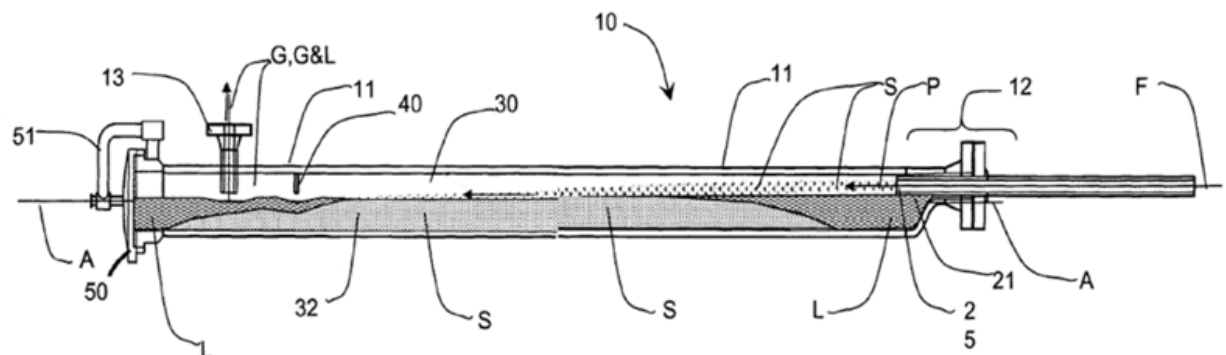
be the same apparatus disclosed in Canadian patent 2,433,741 (Ex. 1013), discussed in the background section of the '256 Patent specification. *Compare* Hemstock with Ex. 1013. Thus, the primary difference between Hemstock and the '256 Patent is the inclined angle of the desander in the '256 Patent.

67. Hemstock's invention relates to the problem of sand and other particulates in production streams:

The present invention relates to a system and apparatus for the removal of particulates such as sand from fluid streams produced from a well while minimizing abrasion of the involved equipment. . . . Production from wells in the oil and gas industry often contain particulates such as sand. ... As the particulates are produced, problems occur due to abrasion, and plugging of production equipment.

Hemstock, 1:13-32.

68. A modified version of Hemstock's Figure 3, which combines the right and left segments together, is include below:



*Fig. 3 (modified)*

With reference to Figure 3, Hemstock teaches that its desander 10:

comprises a substantially horizontal, cylindrical pressure vessel 11 having a first fluid inlet end 12 adapted for connection to a fluid stream F such as from wellhead piping 9 and a fluid outlet 13 . . . . The fluid stream F typically comprises a variety of phases including gas G, some liquid L and entrained particulates such as sand S.

*Id.*, 3:32-42. Hemstock's fluid outlet 13 discharges gas and liquids during normal operation. *Id.*, 1:34-42, 3:35-42, Fig. 3. Sand accumulates and is removed on a batch basis via cleanout 50. *Id.*, 3:35-42, 5:2-6, 5:44-47. Hemstock's vessel is a single-phase separator as discussed above in that there is only one fluid exit path during normal operations.

**b. Davis**

69. Davis is a paper entitled "Sedimentation of Noncolloidal Particles at Low Reynolds Numbers" from the Annual Review of Fluid Mechanics, published in 1985. Davis was written by Robert H. Davis, of the Department of Chemical Engineering of the University of Colorado, Boulder, and by Andreas Acrivos, Department of Chemical Engineering, Stanford University, Stanford, California. Davis at 3. I understand it to be a printed publication and prior art to the Challenged Claims based on its publication date.

70. Davis explains that sedimentation is a process "wherein particles fall under the action of gravity through a fluid in which they are suspended," and which

“is commonly used in the chemical and petroleum industries as a way of separating particles from fluid.” Davis at 3. This is an accurate statement.

71. Davis explains that because sedimentation is often very slow, “there exists a need for constructing simple devices that could accomplish this solid-liquid separation more rapidly.” *Id.* at 17. This includes settling vessels which include or comprise an inclined, narrow tube or channel. *Id.* Davis explains that “[t]he enhancement in the sedimentation rate [in an inclined channel] can be viewed as resulting from the fact that whereas particles can only settle on the bottom in a channel with vertical walls, such particles can also settle onto the upward-facing wall in a tilted channel.” *Id.* “These particles then form a thin sediment layer that rapidly slides down toward the bottom of the vessel under the action of gravity. Thus, one can interpret the increase in the settling rate as due to an increase in the surface area available for settling.” *Id.* at 18. Davis further explains that this effect had already been known for many years at the time. *Id.*

**c. Miller**

72. Miller is a U.S. Patent that issued on June 12, 1923. Miller states that the described invention “relates to the separating art, and ... is especially adapted for the separation of solid matter from liquids, and is particularly intended for the separation of sand, minerals and other heavy particles and cuttings from mud-laden water, slimes and other liquids, especially from the mud-laden water used in drilling

wells.” Miller, 2:9-20. Thus, Miller’s apparatus is designed to remove entrained solids from a liquid.

73. Miller’s separation vessel is inclined and mounted on a jack, which allows the angle of the vessel to be varied “to suit.” *Id.* at 2:51-61. Drilling mud containing solid particulates is fed into the vessel from supply pipe 1, where it is separated using the action of both gravity and the bubbling of compressed air through the mud. *Id.* at 2:51-61, 2:88-3:24, 3:14-21. Solids migrate toward the lower end of the vessel and out via outlet pipe 8, which is attached off-center towards the bottom of the vessel. *Id.* at 1 (Figure); 3:14-25.

**d. The Data Book**

74. The Data Book is the Revised Tenth Edition of the Engineering Data Book, a publication of the Gas Processors Suppliers Association, published in 1994. I understand it to be a printed publication and prior art to the Challenged Claims based on this publication date.

75. The Data Book is a very well-known publication to those of skill in the art, and is usually referred to by engineers and others in the industry as “the GPSA Data Book.” It is available for purchase from the GPSA by the public, and in my experience, various editions may be found in almost every engineering department of every company having anything to do with gas production or processing. The GPSA’s current website ([gpsamidstreamsuppliers.org/gpsa-databook](http://gpsamidstreamsuppliers.org/gpsa-databook)) states that the



Data Book has become “the worldwide authoritative resource for technical and design information pertaining to the gas processing industry and its approved practices and procedures. The book has also found wide acceptance among the petroleum refining, gas transmission and petrochemical industries.”

76. Section 7 of the Data Book is a chapter entitled “Separators and Filters.”

The chapter begins by discussing the separation of gases, liquids, and solids:

Three principles used to achieve physical separation of **gas and liquids or solids** are momentum, gravity settling, and coalescing. Any separator may employ one or more of these principles, but the fluid phases must be ‘immiscible’ and have different densities for separation to occur.

Data Book at 7-1 (emphasis added). The Data Book explains that separation vessels usually have four major sections:

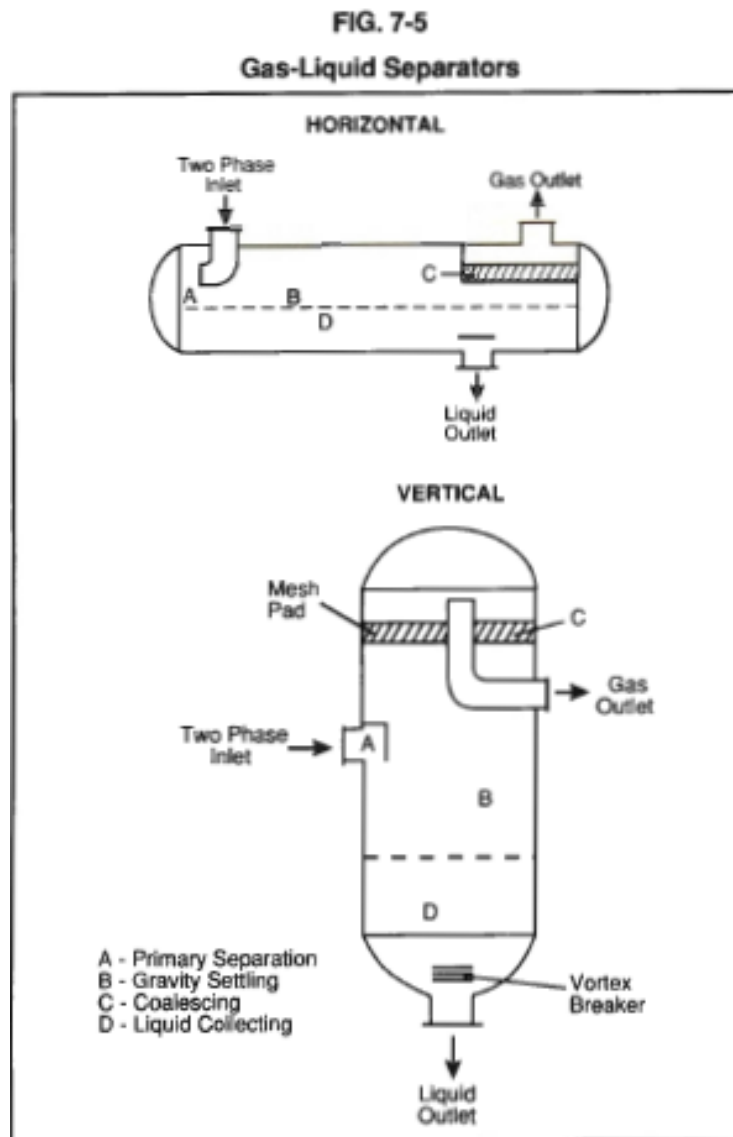
Regardless of shape, separation vessels usually contain four major sections plus the necessary controls. These sections are shown for horizontal and vertical vessels in Fig. 7-5. The primary separation section, A, is used to separate the main portion of free liquid in the inlet stream. It contains the inlet nozzle which may be tangential, or a diverter baffle to take advantage of the inertial effects of centrifugal force or an abrupt change of direction to separate the major portion of the liquid from the gas stream.

The secondary or gravity section, B, is designed to utilize the force of gravity to enhance separation of entrained droplets. It consists of

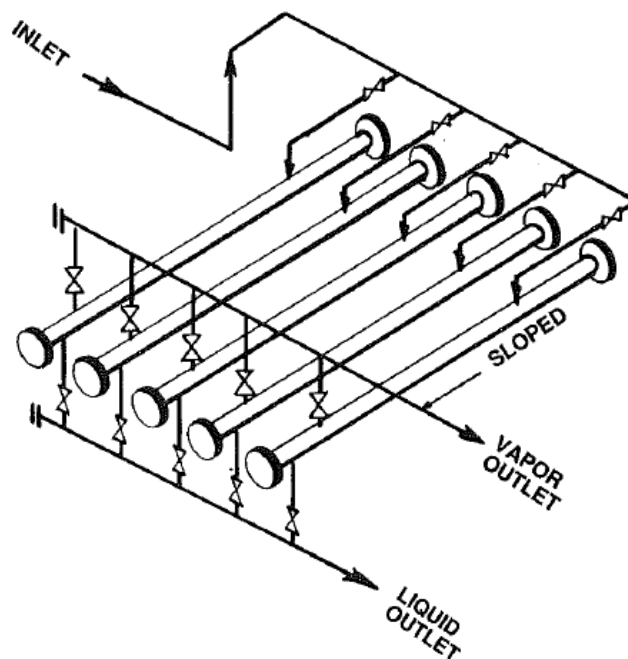
a portion of the vessel through which the gas moves at a relatively low velocity with little turbulence . . .

The sump or liquid collection section, D, acts as receiver for all liquid removed from the gas . . . .

*Id.* at 7-5. Figure 7-5 shows:



77. Section 17 of the Data Book (Volume II) is entitled “Fluid Flow and Piping.” This chapter includes a discussion of multi-phase flow, including the problem of liquid slugging (large liquid volumes occurring at irregular intervals) and the design of “slug catchers.” *Id.* at 36, 41. The text explains that slug catchers are used to absorb fluctuating liquid inlet flow rates, and may be “either a vessel or constructed of pipe.” *Id.* at 41. Pipes, including those manifolded together, are often used to avoid the expense of thick walled vessels. *Id.* In such designs the pipes are generally inclined one to ten degrees, depending on the designer. *Id.* An example of such a device is included in Figure 17-21, referenced below:



## 2. Analogous Art

78. Regarding whether the asserted prior art is analogous to the claimed invention, it is my opinion that all of the asserted references are from the same field

of endeavor as the claimed invention, and further they are all reasonably pertinent to the problem faced by the inventor.

79. The '256 Patent states that it “relates to a system and apparatus for the removal of particulates, such as sand, from fluid streams produced from a well ....” '256 Patent, 1:5-7. The specification goes on to explain the problems that such particulates can cause to production equipment, as well as prior art systems such as a “P-Tank” and a filter bags. *Id.*, 1:13-2:6. The invention is described as an improvement on a similar vessel, and both the prior art device and the invention described in the specification rely on a fundamental separation principle, gravity settling, for both liquid and solids from a gas stream (i.e., using the vessel’s higher cross-sectional area to lower the fluid velocity such that the drag force on the liquid and solid particles will cause them to drop out of the gas stream). *Id.*, 2:7-21, 2:33-44; Data Book at 3. Based on this disclosure, I would understand the specification’s field of endeavor to be phase separation and related equipment, with a focus on such systems for use with hydrocarbon production streams.

80. The particular problem faced by the inventor is at least two-fold. First, the original problem, which is the same as in the prior art patent (Hemstock), is simply how to remove particulates from a well production stream. *See* '256 Patent, 1:5-8. The '256 Patent also describes additional problems, in view of the prior art vessel described in Hemstock, which are (1) improving the ease with which the

vessel can be cleaned, and (2) further improving separation efficiency. *Id.*, 2:22-26. Thus, I would understand the particular problem to be solved as any one of these three problems.

81. In my opinion, all of the references relied on in the asserted grounds are (1) from the same field of endeavor as the '256 Patent and (2) are reasonably pertinent to at least one of the problems faced by the inventor.

82. Hemstock's stated field of invention is exactly the same as the '256 Patent's, and of course the '256 Patent is admittedly merely an improvement on that invention. *See* Hemstock at 1:13-16, '256 Patent, 2:7-29 (discussing the applicant's "elongated horizontal design" and referencing Canadian patents identical to or substantially the same as Hemstock); Ex. 1003 at 77 (stating that the claimed invention is an improvement over Hemstock). As just discussed, one of the particular problems faced by the inventor of the '256 Patent is the exact same problem addressed in Hemstock: the removal of particulates such as sand from a well production stream. Thus, Hemstock is both from the same field of endeavor as the '256 Patent and reasonably pertinent to the problem faced by the inventor.

83. Davis relates to the separation of solids from liquids via enhanced sedimentation. Davis at 17. Davis is thus from the same field of endeavor—phase separation, particular related to solids. Davis itself explains that sedimentation is commonly used in the chemical and petroleum industries. Davis at 3. Davis also

teaches a method—the use of inclined channels—which can greatly reduce settling times for solids settling out of a liquid. *Id.* at 17. Thus, Davis teaches a more efficient way to separate solids from liquids than a horizontal vessel, and is thus reasonably pertinent to the additional problem of further improving separation efficiency that was faced by the inventor. Thus, in my opinion Davis is both from the same field of endeavor as the claimed invention, and reasonably relates to the particular problem faced by the inventor.

84. Miller is directed to the field of solid/liquid separation. Miller, 2:5-8. Miller further states that it is an object of the invention to effect the solid/liquid separation “in a simple and efficient manner.” *Id.*, 2:35-37. Thus, in my opinion Miller is from the same field of endeavor—phase separation and related equipment—including the separation of solids. Miller does not disclose the use of its device on a production stream, but in my opinion this does not remove it from the field of endeavor. Further, it is reasonably pertinent to the problem of improving the ease with which a desanding vessel can be cleaned, as it discloses the construction of a device which allows for continuous removal or cleanout of separated solids. Miller, 3:21-34. Miller is also reasonably pertinent to the problem of improving separation efficiency in a desanding device that separates solids and liquids, as Miller states that the intention of its device is to effect such a separation in a simple and efficient manner.

85. The Data Book contains basic instructions regarding the design of separation vessels or separators, and specifically addresses the separation of gases, liquids, and solids, including streams containing hydrocarbons such as well production streams. Data Book at 3-17, 41-42. Thus, in my opinion, it is from the same field of endeavor as the '256 Patent. It is also reasonably pertinent to one of the problems faced by the inventor, improving separation efficiency. The Data Book teaches various ways to improve separation efficiency. *Id.* at 5-12, 41. It also discloses devices, such as slug catchers, which are specifically designed to handle the same type of multiphase flow anticipated by the inventor. *Id.* at 41; *see also* Hemstock, 2:7-9; '256 Patent, 1:62-64 (“Usually, multiphase flow in the oil and gas operations [sic] is unstable. Large slugs of fluid followed by a gas mist are common.”). Thus, in my opinion the Data Book is both from the same field of endeavor and reasonably pertinent to the problem faced by the inventor of the '256 Patent.

#### **B. Differences Between The Prior Art And The Asserted Invention**

86. In discussing the differences between the asserted grounds and the claims, I will first discuss why, in my opinion, the combinations of the asserted grounds possess every element of the claims against which they are asserted. Then, I will explain the reasons I believe that the combinations of the asserted grounds support the conclusion that the challenged claims are obvious.

## **1. The References Comprising each Asserted Ground**

87. I understand that Petitioner proposes four different grounds of unpatentability. Ground 1, the combination of Hemstock and Davis, is asserted against Claims 1-7, 9-11, and 16. Ground 2, the combination of Hemstock and the Data Book, is asserted against Claims 1-13 and 16. Ground 3, the combination of Hemstock, Davis, and Miller, is asserted against Claims 8, 12, 14, and 15. Ground 4, the combination of Hemstock, the Data Book, and Miller, is asserted against Claims 14 and 15.

## **2. Comparison between the References and the Challenged Claims**

88. In this section I will compare the teachings of the prior art references of the asserted grounds and the limitations of the Challenged Claims.

### **a. Claim 1**

#### **1.0 A desanding system for receiving a gas stream containing entrained liquid and particulates comprising:**

89. Hemstock teaches a single-phase desander for intercepting a fluid stream from a wellhead, which contains liquid, gas, and solids. Hemstock, 2:25-30. Hemstock states that the solids are entrained. *Id.*, 3:37-39. Hemstock also explains that such multiphase flow in oil and gas operations is unstable, and can contain both entrained liquids in a gas mist (if the flow is primarily gas phase) or gas flow punctuated by large slugs of liquid. *Id.*, 2:7-9. Hemstock also explains that liquid in the vessel is typically “re-entrained for discharge with fluids exiting the outlet 13.”



*Id.*, 4:55-57 (emphasis added). From this disclosure it is clear that the liquids were entrained in Hemstock's inlet fluid stream. Hemstock's desander thus receives a fluid stream from a wellhead, containing gas, entrained liquid and particulates.

90. The Data Book discloses separator vessels for receiving gas streams containing entrained liquids and solids ("particulates"). Data Book at 3, 5-7.

**1.1 a vessel elongated along a longitudinal axis and having a fluid inlet adjacent a first end of the vessel and a fluid outlet spaced along the longitudinal axis from the fluid inlet towards a second end of the vessel,**

91. Hemstock discloses a horizontal pressure vessel elongated along its central longitudinal axis, as shown in Figures 1b and 3, which has a first fluid inlet end 12 adapted for connection to a fluid stream from the wellhead, and a fluid outlet 13 spaced along the longitudinal axis towards the second end of the vessel. Hemstock, Fig. 1b, Fig 3, 3:32-37.

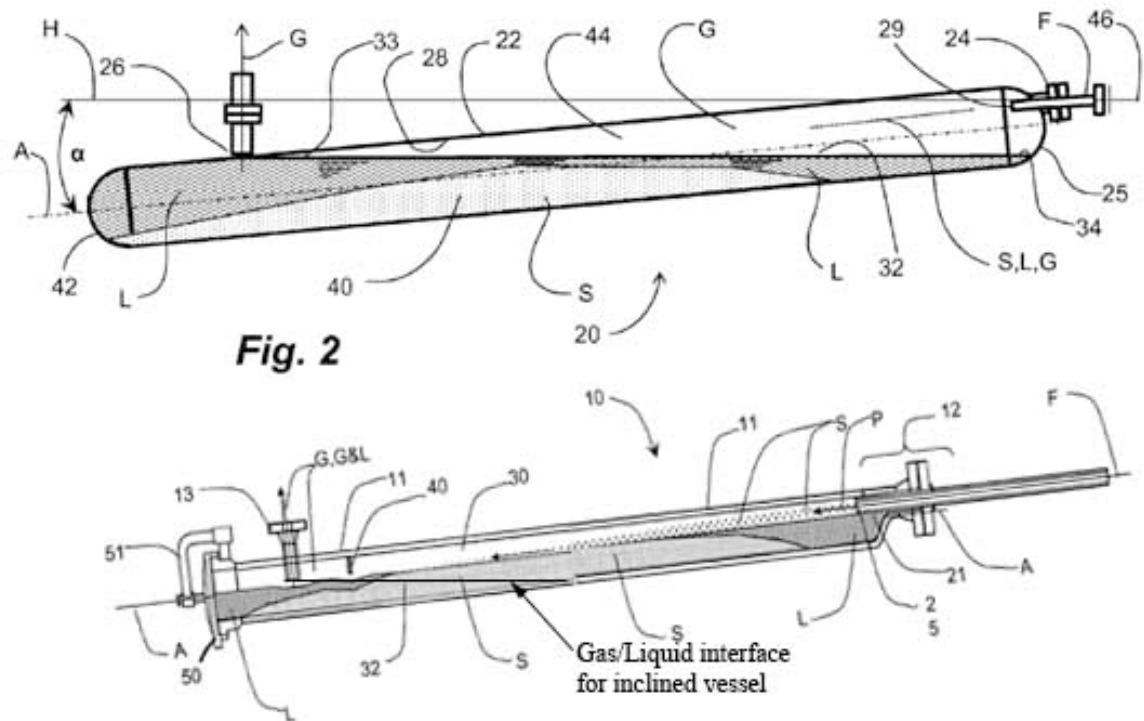
92. Miller discloses an elongated vessel 5 having a fluid inlet from hopper outlet 3 near the lower end of the vessel, and an outlet for cleaned mud 13 spaced along the longitudinal axis from the inlet towards the second end of the vessel. Miller, 1, 2:51-75. However, outlet 13 is not the same outlet used for solid removal.

93. The Data Book discloses multiple horizontal separators, vessels elongated along a longitudinal axis, having a fluid inlet at a first end and a fluid outlet spaced along the longitudinal axis toward the second end. Data Book at 7, 41.

**1.2 said vessel being inclined from a horizontal at a non-zero inclination angle at all times during operation such that the fluid outlet is lower than the fluid inlet,**

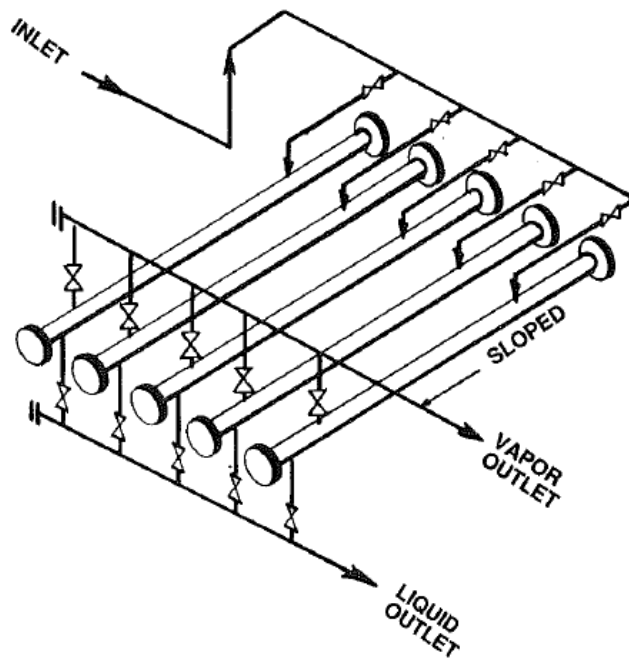
94. Hemstock teaches a horizontal, non-inclined vessel, which has a freeboard both above and immediately below the fluid outlet. Hemstock, Fig. 3, 4:15-21 (discussing the substantially gas-phase volume of freeboard portion 30 in Figure 3 and illustrating that it exists both below and above the fluid outlet 13.) Hemstock's vessel is substantially the same as the vessel disclosed in the '256 Patent. I understand, based on how the vessel must function and based on Figures 3, 4a, and 4c in Hemstock that the exit point for the fluids from the vessel (the entry into the fluid outlet) is physically located at a lower elevation than the inlet nozzle. While in the '256 Patent this is accomplished with a flush-mounted exit nozzle in an inclined vessel, in Hemstock this is achieved by extending the end of outlet nozzle 13 some distance below the top of the vessel. Hemstock, 5:27-36, Fig. 4c. A person of ordinary skill in the art, familiar with flow characteristics, would expect that the weir in Figure 4b has a significantly reduced chance of providing proper freeboard. Thus, while Hemstock does not teach an inclined vessel, it does teach the establishment of a freeboard by placing the fluid outlet physically lower than the fluid inlet. However, even if it did not, if Hemstock were inclined the fluid outlet would necessarily be lower than the fluid inlet. This can be seen by comparing figures from the two patents, which I have done below. The bottom figure is a

modified version of Figure 3 from Hemstock, showing the entire vessel, inclined at approximately the same angle as the vessel depicted in Figure 2 of the '256 Patent. I have also included an annotation showing where the gas/liquid interface would necessarily occur in Figure 3 if it were inclined:



95. Davis teaches that sedimentation is commonly used in the chemical and petroleum industries as a way to separate particles from fluid. Davis at 3. Davis explains that because sedimentation is often very slow, “there exists a need for constructing simple devices that could accomplish this solid-liquid separation more rapidly.” *Id.* at 17. Davis explains that a simple device that can accomplish solid-liquid separation more rapidly is a settling vessel comprising an inclined, narrow tube or channel. *Id.* at 17.

96. The Data Book discloses that a slug catcher may be a pressure vessel or merely constructed of pipe, and that such devices are “generally inclined from one to ten degrees” and that “[d]ifferent pipe inclinations ... are favored by different designers.” Data Book at 41. Figure 17-21, reproduced below, shows an example of a “multiple pipe (harp) slug catcher” that is sloped, having separate vapor (gas) and liquid outlets. *Id.* Due to the incline from inlet to outlet, the vapor and liquid outlets are necessarily lower than the fluid inlet.



**1.3 the fluid inlet discharging the gas stream into the vessel at an inlet velocity,**

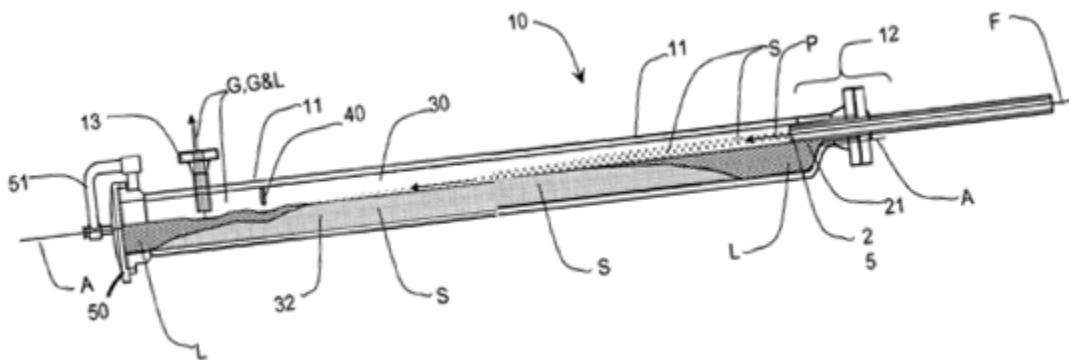
97. Hemstock discloses a vessel with a “fluid inlet adjacent a first end of the vessel and adapted for receiving the fluid stream, the fluid inlet discharging the fluid stream at an inlet velocity.” Hemstock, 2:40-46.

98. The Data Book discloses a number of vessels having fluid inlets which discharge a fluid stream into the vessel, as shown in Figures 7-5 and 17-21. Data Book at 5, 41.

99. This element specifies that the fluid inlet discharges the gas stream at an inlet velocity. The inlet velocity is simply the velocity of the fluid as it exits the inlet port or nozzle, and is a function of the volumetric flow rate and the cross-sectional area of the port or nozzle. Any fluid inlet stream discharged into any vessel, pipe, or other space necessarily has an inlet velocity.

#### **1.4 the gas stream travelling down the inclined vessel to the fluid outlet**

100. Hemstock teaches that the inlet stream travels from a first end of the vessel at the fluid inlet 12 to the other end, where the fluid outlet 13 is spaced horizontally from the inlet. Hemstock, 2:40-50, 3:32-37, Fig. 3. If Hemstock were inclined, the gas in the inlet stream would travel from the inlet, down the inclined vessel, to the fluid outlet, as shown here:



101. The Data Book teaches that the inlet stream into the harp slug catcher travels down the inclined or sloped vessel to the vapor outlet. Data Book at 41. As

previously discussed, I would expect the liquid outlet to be shut in via a manual block valve during normal operation.

**1.5 the vessel having: a gas/liquid interface formed at the fluid outlet having a belly storage portion formed therebelow and a freeboard portion formed adjacent an upper portion of the vessel above the interface,**

102. Hemstock discloses that its vessel comprises an upper freeboard portion and a lower belly portion, where the “freeboard portion” is maintained using a depending flow barrier adjacent the vessel’s outlet.” Hemstock, Abstract, 4:44-47. The upper freeboard portion 30, which is substantially gas phase, and the belly portion 32 formed below the freeboard portion, which stores liquids and sand, necessarily form together a gas/liquid interface where they meet. *Id.*, 4:15-21, 4:37-43, Fig.3. Freeboard portion 30 is formed adjacent an upper portion of the vessel above the interface as shown in Figures 1b and 3.

103. The Data Book discloses a sloped harp slug catcher having both vapor and liquid outlets. Data Book at 41. The Data Book explains that such devices must have sufficient volume for liquid level fluctuation. Thus, when a liquid slug occurs, the slug catcher separates the liquid and vapor phases due to gravity settling, providing a surge volume for the of the liquid slug.

104. A person of ordinary skill in the art would have understood that slug catchers such as the inclined harp slug catcher in the Data Book function as a single phase separator, just like Hemstock’s device, because the liquid outlet valves are

manual valves that are closed during normal operation. Thus, a person of ordinary skill in the art would have understood based on the Data Book's disclosures that such a device necessarily has a gas/liquid interface which extends horizontally from the fluid outlet in the same manner as disclosed. A person of ordinary skill in the art would also understand that the device in Figure 17-21 has three modes of operation: (1) steady state; (2) liquid starved; and (3) liquid flooded. In the steady-state mode the liquid level will be exactly at the gas/liquid outlet and any additional liquid that enters will exit with the gas. In the liquid-starved condition, more liquid is exiting the vessel through evaporation than is entering and the liquid level falls below the outlet nozzle. A system operating in either mode 1 or mode 2 would perform equally well with or without the slug catcher installed. Mode 3 occurs when a large-volume slug of liquid enters the fingers or harp strings. In this mode, the gas/liquid interface rises to well above the outlet nozzle and requires new gas to chaotically flow through the liquid volume to get to the outlet. This accumulation (as long as the slug size is smaller than the design slug size) converts a short duration liquid event into a long duration froth event that is much easier for the downstream production equipment to process. It is common for system-operators to anticipate maintenance events with a high probability of creating a slug (e.g., running a pipeline pig) and to stand by the manual drain valves to drain the liquid to the tank to keep it from ever reaching the downstream production equipment. Operators frequently observe significant

accumulations of solids in the liquid exiting the slug catcher during a manual drain. Occasionally the drain lines plug with solids and the drain lines do not flow. This is often corrected by backflushing the drain lines with water or gas to allow accumulated liquids to flush out the interfering solids. Solids management is a regular part of the operation of harp-type slug catchers. The operation of a harp-style slug catcher in the steady-state mode is identical to the operation of the '256 device.

**1.6 the freeboard portion having a freeboard cross-sectional area which diminishes along the inclined vessel from the fluid inlet to the fluid outlet; and**

105. Hemstock teaches that flow barrier 40 “depends downwardly from the top of the vessel 11,” and is preferably spaced apart from the inlet 11. Hemstock, 5:9-15. Figure 3 shows that cross-sectional area of freeboard portion 30 is reduced at the point where flow barrier 40 is installed, as compared to the cross sectional area of the freeboard portion between flow barrier 40 and inlet 12. *Id.*, Fig. 3. Thus, the cross-sectional area of Hemstock’s freeboard portion is smaller at the location of flow barrier 40 than it is closer to the fluid inlet. If Hemstock were inclined, the cross-sectional area of the freeboard portion would necessarily diminish along the vessel from the inlet to the outlet, as the liquid interface must remain level.

106. Davis shows that, in an inclined channel having a phase interface (in Davis, liquid and solid), the cross-sectional area of the lightest phase will decrease



in the downward direction, due to the accumulation of the heavier phase. Davis at 17 (showing in Figure 4 that the cross sectional area of region A of particle-free fluid above a suspension decreases from the top of the channel to the bottom). This is because the phase interface must remain level.

107. The Data Book discloses, as discussed for Claim 1.5, an inclined slug catcher device which necessarily has a gas/liquid interface forming both a freeboard and a belly storage portion. The cross-sectional area of the device's freeboard portion must necessarily diminish along the inclined device from the fluid inlet to the fluid outlet, as the gas/liquid interface must remain level, causing there to be a larger cross-sectional area in the freeboard portion (which is higher) than the lower end.

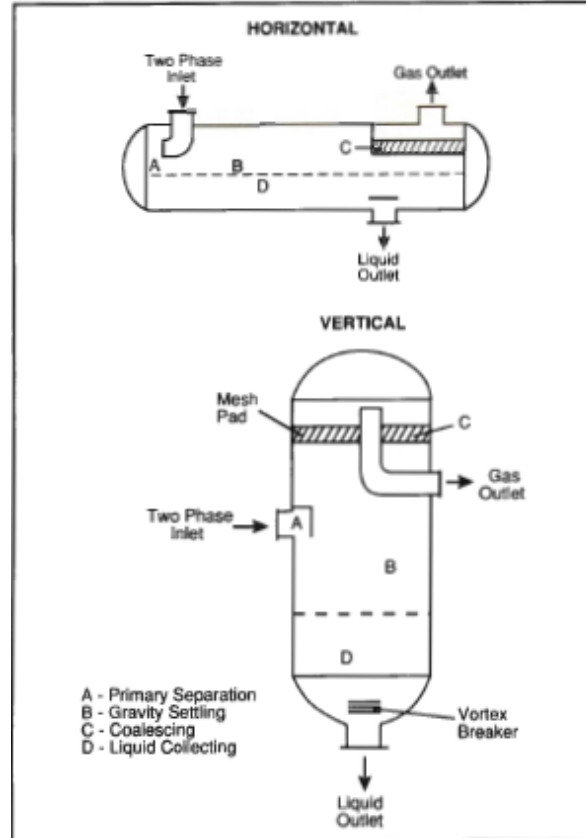
**1.7 the freeboard portion at the fluid inlet causing the gas stream to have a freeboard velocity adjacent the fluid inlet which is less than the velocity of the fluid in the inlet, wherein the freeboard velocity is such that the entrained liquids and particulates fall out of the gas stream and collect in the belly storage portion, and**

108. Hemstock teaches that the fluid stream F enters through inlet 12, and is received by a larger cross-sectional area and substantially gas-phase volume of freeboard portion 30, and “[a]ccordingly, the velocity of the fluid stream F slows to a point below the entrainment or elutriation velocity of at least a portion of the particulates S in the fluid stream.” *Id.*, 4:18-24. Further, Hemstock explains that liquids L from the fluid stream, along with particulates S, also collect in the vessel's

belly portion 32. *Id.*, 4:37-43. These liquids accumulate there because they “dropout” of the fluid stream. *Id.*, 4:59-63. This indicates that liquids entrained in Hemstock’s fluid stream F settle out of the fluid stream due to the velocity in freeboard portion 30 dropping low enough to allow gravity to overcome the drag force on the entrained liquid particles exerted by the gas flowing around it. Thus, both the liquid droplets and solid particles fall out of the fluid stream into the belly storage portion, which begins at the gas/liquid interface as discussed with regard to Claim 1.5. Hemstock, 4:37-43.

109. The Data Book discloses that standard horizontal separator design includes a “gravity” section (corresponding to the freeboard portion) which consists of a “portion of the vessel through which the gas moves at a relatively low velocity,” which enhances separation of entrained droplets. Data Book at 5, 7 (Fig. 7-5). This is shown as section “B” in Figure 7-5 below:

FIG. 7-5  
Gas-Liquid Separators



110. Separated droplets (which one of ordinary skill in the art would understand would also include entrained solid particulates, if present) gather in the sump section “D” (corresponding to the belly storage portion) which “acts as a receiver for all liquid removed from the gas.” *Id.*

**1.8 wherein a desanded gas/liquid stream flows out of the freeboard portion and out the fluid outlet, being free of a substantial portion of the particulates, and**

111. Hemstock teaches that “[t]ypically, liquid L out of the fluid stream F accumulates in the belly portion 32 to a steady state level and then is re-entrained

for discharge with fluids exiting the outlet 13.” Hemstock, 4:55-59. Further, this fluid stream is “substantially free of particulates.” *Id.*, 2:59-61.

112. The Data Book explains that for a standard horizontal separator (which would include a slug catcher) the lighter phase (gas) stream flow out of the gravity section and out the fluid outlet, free of a substantial portion of entrained droplets). Data Book at 5, 7, 41. As discussed, a person of ordinary skill in the art in reviewing the Data Book would understand this reference to droplets to apply equally to any solid particulates, which would behave in the same manner as droplets of similar size and characteristics with respect to the principles of gravity separators.

**1.9 particulates accumulate in the belly portion for flowing downvessel towards said second end.**

113. Hemstock explains that belly portion 32 receives and temporarily stores both liquids L and sand S which separate from the fluid stream F. Hemstock, 4:15-19, Fig. 3. The particulates have a fall trajectory from the fluid inlet such that they accumulate prior to the flow barrier. *Id.*, 2:50-61. Thus, the particulates entrained in fluid stream F at inlet 12 flow towards outlet 13, falling into the belly portion 32 for accumulation.

114. The Data Book discloses inclined slug catchers. Data Book at 41. Although the Data Book’s discussion of slug catchers does not reference solids, a person of ordinary skill in the art would understand that particulates in the inlet stream are not uncommon, and any such particles (assuming the slug catcher was

adequately sized to separate them) would necessarily accumulate with any liquid (assuming the liquid outlet valve was closed and only opened on a periodic basis). See the discussion at Claim 1.5, above.

**b. Claim 9**

115. I understand that Claim 9 teaches a method, rather than an apparatus or device. Although the asserted references do not all explicitly teach methods related to the specific claim limitations, in my opinion the steps required by Claim 9 would be the necessary and natural result of the normal use and operation of the asserted references, in combination. Thus, below I have referenced where, with regard to each method step, the references teach a limitation which would, in its normal use and operation, naturally result in the performance of the claimed method limitation.

**9.0 A method for desanding a fluid stream emanating from a wellhead, the fluid stream containing gas, entrained liquid and particulates, the method comprising:**

116. If Hemstock's system were used as detailed in its specification, the normal use and operation of Hemstock's system would necessarily and naturally result in receiving a fluid stream from a wellhead containing gas, entrained liquid, and particulates.

**9.1 providing an elongated vessel having a longitudinal axis, a fluid inlet adjacent a first end of the vessel and a fluid outlet spaced along the longitudinal axis from the fluid inlet;**

117. See the discussion of Claim 1.1, above.

118. Normal use and operation of Hemstock's desander would necessarily and naturally result in the performance of this step.

**9.2 inclining the vessel at angle from horizontal at a non-zero inclination angle so that the fluid outlet is lower than the fluid inlet for forming a freeboard above the fluid outlet;**

119. See the discussion of Claim 1.2 and 1.5 above, and Claim 10, below.

120. Although Hemstock's desander is not inclined, the combination of the weir and/or the extended nozzle create a freeboard section. If it were inclined (as suggested by the asserted grounds), the inclined desander would necessarily and naturally result in the performance of this step.

**9.3 discharging the fluid stream from the fluid inlet, into the inclined vessel and substantially parallel to the longitudinal axis for**

121. See the discussion of Claims 1.3 above and 3, below.

122. The normal use and operation of Hemstock's desander would necessarily and naturally result in the performance of this step.

**9.4 establishing a liquid interface in a belly portion of the vessel, the belly portion being formed below the fluid outlet, and**

123. See the discussion of Claims 1.5, above, and Claim 10, below.

124. The normal use and operation of Hemstock's desander would necessarily and naturally result in the performance of this step.

**9.5 directing the liquid and particulates along a trajectory in the freeboard portion of the vessel to intercept a substantial portion of the particulates at the liquid interface for storage in the belly portion; and**

125. See the discussion of Claim 1.7, above.

126. The normal use and operation of Hemstock's desander would necessarily and naturally result in the performance of this step.

**9.6 recovering a desanded gas stream at the fluid outlet which is substantially free of particulates.**

127. See the discussion of Claim 1.8, above.

128. The normal use and operation of Hemstock's desander would necessarily and naturally result in the performance of this step.

**c. Dependent Claims**

**2. The desanding system of claim 1 wherein fluid inlet has a discharge end, the discharge end oriented for discharging the gas stream into the freeboard portion.**

129. Hemstock discloses that fluid inlet 12 has a discharge end, which is the protruding discharge portion 25 of nozzle 21, which extends into upper freeboard portion 30. Hemstock, 3:43-4:14, Figs. 2a, 2b, 3.

130. The Data Book teaches that the fluid inlet of a standard horizontal separator has a discharge end oriented for discharging the gas stream into the freeboard or gravity phase portion. Data Book at 5, 7 and Fig. 7-5.

**3. The desanding system of claim 1 wherein discharge end of the fluid inlet directs the gas stream into the freeboard portion and parallel to the longitudinal axis.**

131. Hemstock: Nozzle 21 (including its discharge portion 25) directs the incoming fluid stream (containing gas, liquid, and solid particulates) into the freeboard portion along the nozzle's axis in a path (P) substantially parallel to the vessel's longitudinal axis (A). *Id.*, 4:5-14, Figs. 2a, 2b, 3.

132. The Data Book discloses that the discharge end of the fluid inlet into the horizontal separator shown in Figure 7-5 directs the inlet stream into the freeboard portion (gravity portion B) and parallel to the vessel's longitudinal axis. Data Book at 7.

**4. The desanding system of claim 1 wherein the fluid inlet further comprises a replaceable nozzle having a discharge end oriented for discharging the gas stream into the freeboard portion.**

133. Hemstock discloses that fluid inlet 12 has a nozzle 21, with discharge end 25, having a threaded inlet 23 for connection with coupling 24 on wellhead piping 9. Hemstock, 3:48-60, Figs. 1, 2a, 2b. Thus, the vessel is positioned over the nozzle. *Id.*, Figs. 2a, 2b. The nozzle inlet 23 is "typically formed of heavy-wall piping to extend its operational life .... Further, the nozzle's discharge 25 protrudes into the vessel 11 sufficiently to extend beyond the inlet 12 and into the freeboard portion 30, thereby aiding in minimizing localized wear on the *less easily replaced* inlet 12, or eccentric fitting 31, of vessel 11." *Id.*, 4:5-14 (emphasis added).



134. Based on Hemstock's description of the nozzle that it is a separate element from the vessel and does not require any welded modifications to the vessel to be removed, a person of ordinary skill in the art would understand that the nozzle is replaceable as claimed.

**5. The desanding system of claim 4 wherein the replaceable nozzle is connected to the fluid inlet at a flange.**

135. Hemstock: Replaceable nozzle 21 is connected to fluid inlet 12 at flange 20. Hemstock, 3:48-60, Figs. 2a, 2b.

**6. The desanding system of claim 1 wherein the gas stream emanates from a wellhead and the fluid inlet further comprises: a discharge end for directing the gas stream into the freeboard portion and parallel to the longitudinal axis; a receiving end for receiving the gas stream and orthogonal to the wellhead.**

136. Hemstock's fluid stream emanates from a wellhead via piping 9. Hemstock, 3:32-39, Fig. 1a. As discussed for claims 2, and 3, the fluid inlet 12 includes nozzle 21 with discharge end 25 which directs the gas stream into the freeboard portion and parallel to the longitudinal axis. The fluid inlet 12 also has a receiving end, nozzle inlet 23, for receiving the inlet stream from the well. *Id.*, 3:55-60. Nozzle inlet 23 is "adapted for threaded connection to an existing coupling 24 from the wellhead piping 9." *Id.*

137. As stated in the '256 Patent, connective piping between a wellhead and downstream equipment is "typically in rectilinear or orthogonal arrangements." '256 Patent, 5:6-8. That is, it is either straight or at a 90° angle (perpendicular). These,

and other less common piping angles, have long been known. For example, Figure 17-21 in the Data Book shows an inclined slug catcher “orthogonal” to its inlet piping. Davis at 41. Thus, a person of ordinary skill in the art would understand from Hemstock’s discussion of the piping connections between inlet 23 and coupling 24 that the inlet piping could inherently be modified to include any required angle or turn to orient the desanding vessel and inlet nozzle as necessary with relation to the wellhead or inlet piping. This would merely be dependent on existing piping configurations and space limitations at the wellsite. Thus, a person of ordinary skill in the art would have understood based on Hemstock’s disclosure that its receiving end could be oriented either “rectilinear” (straight) or “orthogonal” to the wellhead or the wellhead piping, whichever would be necessary based on considerations at the wellsite.

**7. The desanding system of claim 1 further comprising:**

**a conduit for conducting a fluid stream containing entrained particulates from a wellhead, the conduit having a desander end; and**

**wherein the fluid inlet further comprises a discharge end for directing the fluid stream into the freeboard portion and oriented parallel to the longitudinal axis, and a receiving end for receiving the gas stream and oriented orthogonal to the desander end.**

138. Hemstock discloses a conduit, wellhead piping 9, which carries fluid stream F, containing entrained particulates, from the wellhead and connects to inlet end 12 of desander 10. Hemstock, 3:32-39.

139. The claim limitations related to the fluid inlet discharge and receiving end are discussed with respect to claims 2, 3, and 6 above.

**8. The desanding system of claim 1 wherein the inclination angle is variable for varying fluid stream conditions.**

140. Miller discloses an elongated solid/liquid separator vessel mounted at an angle to the horizontal, supported by means of a jack, “by means of which the angle of said vessel may be varied and adjusted to suit.” Miller, 2:6-8, 2:51-59. Miller does not explicitly state a preferred angle of inclination. The angle disclosed in Miller’s figure appears to be approximately 10°-15° from the horizontal, and is definitely less than 20°.

141. The Data Book teaches that slug catchers are generally inclined from “one to ten degrees” and that “[d]ifferent pipe inclinations ... are favored by different designers.” Data Book at 41.

142. A person of ordinary skill in the art would understand from these disclosures that the inclination angle to be used for a given fluid stream must be determined based on experience or experimentation with regard to the particular characteristics of the fluid stream in question, such as velocity, viscosity, and the amount of particulates entrained in the stream.

**10. The desanding system of claim 1 wherein said gas/liquid interface is formed during operation, the gas/liquid interface extending horizontally from about the fluid outlet.**

143. Hemstock's gas liquid interface is at the meeting of the upper freeboard portion 30 and the lower belly portion 32, as discussed with regard to Claim 1.5. The "freeboard portion is maintained using a depending flow barrier adjacent the vessel's outlet." Hemstock, Abstract, 4:44-47. Hemstock discloses that the flow barrier 40c can be formed by outlet 13. *Id.*, 5:16-20, Fig. 4c. The flow barrier maintains the freeboard portion (gas) above the lower edge and forms the belly storage portion (liquid, solid) below the lower edge. *Id.*, 2:50-55, 4:44-47. A person of ordinary skill in the art would understand from these disclosures, as shown in Figures 4a-4c, that the gas/liquid interface is formed around the location of the flow barrier. Thus, as shown in Figure 4c, Hemstock discloses that the gas/liquid interface (30/32) extends horizontally from near, or about, the location of fluid outlet 13 and barrier 40c.

144. For the Data Book, see the discussion of Claim 1.5, above.

**11. The desanding system of claim 1 wherein said the cross-section area of the freeboard portion is at its greatest adjacent the fluid inlet.**

145. Hemstock teaches, as discussed with regard to Claim 1.6, that freeboard portion 30's cross sectional area is reduced at the point where flow barrier 40 is installed, as compared to the cross sectional area of the freeboard portion between flow barrier 40 and inlet 12. Hemstock, 5:9-15, Fig. 3. Thus, the cross-sectional area

of Hemstock's freeboard portion is at its minimum at the location of the flow barrier. Further, due to the accumulation of liquid and solids, which are deposited from the inlet stream into the belly portion, as shown in Figure 3, the cross-sectional area of Hemstock's freeboard portion would be at its greatest adjacent the fluid inlet. Also as discussed with regard to Claim 1.6, if Hemstock were inclined, the cross-sectional area of the freeboard portion would diminish from the inlet down to the outlet. Thus, the cross-sectional area of the freeboard portion would be at its greatest adjacent the fluid inlet.

**12. The desanding system of claim 1 wherein said inclination angle is between about 2 degrees and about 20 degrees.**

146. With regard to Miller and the Data Book, my testimony regarding Claim 8 above applies equally here.

**13. The desanding system of claim 1 further comprising: an access closure at said second end for removal of accumulated particulates.**

147. Hemstock discloses a quick release pressure-vessel compatible cleanout 50 for access to vessel 11 for cleanout of the accumulated particles. Hemstock, 5:44-46, Fig. 3. The cleanout is performed manually on a batch basis. *Id.*, 5:46-58.

**14. The desanding system of claim 1 wherein said vessel has a smaller diameter downstream of the fluid outlet than the diameter of other portion of the vessel.**

148. Miller discloses, for a solid/liquid settling vessel, the use of an eccentrically located, smaller diameter outlet pipe 8. Miller, 1, 2:51-64, 3:21-24. 15. The desanding system of claim 14 wherein second end of the vessel is an eccentric end. A POSITA would understand from this disclosure that the smaller diameter pipe could be included as part of the pressure vessel itself, as such pressure vessels have long been well-known in the art. For more details in this regard, please refer to the discussion of Ground 3 below, with regard to the motivation to modify Hemstock and Davis based on the suggestions in Miller.

149. See the discussion of Claim 14, above.

**16. The method of claim 9 further comprising: accumulating particulates in said belly portion; and periodically removing accumulated particulates.**

150. See the discussion of Claim 13, above.

**3. The Asserted Grounds Possess Every Element of the Challenged Claims**

**a. Grounds 1 and 2: Hemstock and either Davis or the Data Book**

151. The first two asserted grounds are the combination of Hemstock and Davis (Ground 1) or Hemstock and the Data Book (Ground 2). Either of these combinations has every single element of the Base Claims (1-7, 9-11, 13, and 16), arranged in the same way as they are claimed.

152. For Claims 1 and 9, inclining Hemstock would not have changed Hemstock's fulfillment of elements 1.0, 1.1, 9.0, or 9.1. It would lower the fluid outlet below or further below the inlet than the original design (1.2, 9.2) and cause the fluid stream to travel down the inclined vessel to the outlet (1.4). It also would necessarily cause the gas/liquid interface to form (or more precisely, remain) at the fluid outlet (1.5, 9.2, 9.4), as discussed with regard to claim element 1.5. Inclining the separator would necessarily cause the gas-liquid interface, which must remain horizontal, to be at an angle to the separator's longitudinal axis, which would cause the cross-sectional area of the freeboard portion (gas phase) to diminish along the vessel from the fluid inlet to the fluid outlet, as illustrated in Figs. 3A and 3B of the '256 Patent (1.6). '256 Patent Figs. 3A, 3B. Inclining the desander would have further lowered velocity in the freeboard portion by decreasing the liquid level in the freeboard portion nearest the inlet nozzle (1.7). This obviously improves separation efficiency. The incline would cause the trajectory of liquid droplets and solid particulates, entering the vessel through the horizontal fluid inlet nozzle, to intersect with the gas/liquid interface (similar to the '256 Patent's Figure 7), where a substantial portion of the particulates would be intercepted (9.5). This would have been expected to improve Hemstock's already existing ability to flow a substantially desanded gas/liquid stream out of fluid outlet 13 (1.8, 9.6) because the multiphase raw well fluid could have a section of the freeboard where there was no coherent

gas/liquid interface (as shown in Figure 4 of the '256 Patent) and the stream could travel in this section without developing a high-energy-loss no-flow boundary between the inlet stream and the liquid surface. In other words, the no-flow boundary between the fluid and the pipe wall is much lower energy loss than the no-flow boundary between the fluid and a gas/liquid interface, since the gas is unable to perform work on the vessel wall as it would against a gas/liquid interface. This work results in a larger energy transfer from the gas than simple fluid friction. Finally, inclining the desander would not have taken away the desander's ability to accumulate particulates in the belly portion (1.8, 9.6), and would naturally have resulted in the particulates accumulating closer to the cleanout end of the vessel due to the force of gravity, which would in fact be expected to make cleanout quicker and easier.

153. Inclining Hemstock's vessel would not have changed Hemstock's fulfillment of the limitations of dependent claims 2, 3, 4, 5, 6, 7, 11, 13, or 16. For claim 10, as just discussed with respect to elements 1.5, 9.2, and 9.4, inclining the vessel would necessarily cause the gas/liquid interface to form (or more precisely, remain) at the fluid outlet.

154. Thus, and as shown in the preceding section, Hemstock possesses every element of these claims, except those related to the inclination of the vessel (required by elements 1.2, 1.4, and 9.2 and referenced by elements 1.6 and 9.3). However, if



Hemstock were inclined, as suggested by Davis or the Data Book, it would possess each of these elements as well.

155. With regard to claim 9, a person of ordinary skill in the art would understand that the normal use and operation of the combination—which is Hemstock’s vessel, but inclined or sloped as suggested by Davis and the Data Book—would necessarily and naturally result in the performance of every step of the claimed method. This is because Hemstock already performed every step of Claim 9 except those related to it being an inclined vessel.

156. In summary, inclining Hemstock as discussed with regard to Grounds 1 and 2 herein would not impact Hemstock’s fulfillment of any of the claim limitations it already disclosed, and would fulfill all of the claim limitations of the Base Claims that it did not already disclose.

**b. Grounds 2 and 3: Hemstock and the Data Book (Ground 2) and Hemstock, Davis, and Miller (Ground 3)**

157. The third asserted ground is the combination of Hemstock, Davis and Miller. Grounds 2 and 3, in addition to possessing every element of the Base Claims, also possess every element of Claims 8 and 12, the Inclination Angle Claims, which relate to the degree of inclination of the vessel.

158. The Data Book discloses separation vessels where the angle of inclination is between 1° and 10°. This range includes angles between 2° and 20°. Further, the Data Book discloses that the angle chosen is a design choice, and thus

variable. Thus, the combination of Hemstock and the Data Book also possesses every element of Claims 8 and 12.

159. As discussed, Miller discloses a vessel where the angle of inclination could be varied continuously using a jack. Further, it implicitly discloses, based on its Figure, the use of an angle between 2° and 20° (specifically, between 10° and 15°). Therefore, the combination of Hemstock, Davis, and Miller possesses every element of Claims 8 and 12.

**c. Grounds 3 and 4: Hemstock, Davis and Miller (Ground 3) and Hemstock, the Data Book, and Miller (Ground 4)**

160. Ground 4 is the combination of Hemstock, the Data Book, and Miller. Grounds 3 and 4 (in addition to possessing every element of the Base Claims and the Inclination Angle Claims) also possess every element of Claims 14 and 15, the Eccentric End Claims, which relate to the inclusion of a smaller diameter, eccentrically placed end on one end of the vessel.

161. Miller discloses a vessel having a smaller diameter pipe, located eccentrically, at the lower end of the vessel where heavy particulates accumulate and are removed from the vessel. Although Miller discloses a vessel with a smaller diameter pipe, a person of ordinary skill in the art would recognize that there is no difference between such a configuration and the use of a vessel having a smaller diameter section. The two structures are equivalent. Therefore, the combination of

Miller with either Hemstock and Davis or Hemstock and the Data Book possesses every element of Claims 14 and 15.

**4. Rationales Supporting a Conclusion that the Challenged Claims are Obvious in View of the Asserted Grounds**

162. In this section I will explain the different rationales which support the conclusion that the challenged claims are obvious in view of the asserted grounds.

**a. Grounds 1 and 2: Hemstock and either Davis or the Data Book Render the Base Claims Obvious**

163. The first two grounds are the combination of Hemstock and either Davis (Ground 1) or the Data Book (Ground 2). The differences between the Base Claims (1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 13, and 16) and either combination is such that the subject matter of each of these claims would have been obvious to a person of ordinary skill in the art.

164. As discussed above, either of these combinations possesses every single element of the Base Claims.

165. Hemstock discloses a horizontal desanding vessel and system which receives a multiphase (gas, liquid, and solid) fluid stream, and which substantially removes the particulates from the stream by lowering the fluid velocity in the vessel to the point where the particulates fall out and accumulate in the vessel, along with liquid in the inlet stream. Hemstock, 2:25-61. This is the exact same desanding vessel and system claimed in the '256 Patent, with the exception being that the '256

Patent requires inclining the vessel from the horizontal in claim elements 1.2 and 9.2. Thus, Hemstock itself discloses every element of the Base Claims except for the inclination of the vessel required by elements 1.2 and 9.2.

**i. Motivation to Modify Hemstock based on the Teachings of Davis.**

166. Davis teaches that the sedimentation process is often very slow and that there exists a need for constructing devices that could accomplish solid-liquid separation more rapidly. Davis at 17. Davis further teaches that there existed settling vessels composed either of a narrow tube or channel inclined from the vertical which can significantly reduce settling times. *Id.*

167. A person of ordinary skill in the art would have been motivated to modify the teachings of Hemstock by inclining the desander, as taught or suggested by Davis's teaching that an inclined tube or channel would achieve more rapid separation between the solid and liquid phases.

168. A person of ordinary skill in the art, using the invention taught in Hemstock, faced with the problem of achieving more efficient separation efficiency, would have desired more rapid sand settling in the liquid in order to prevent, to the maximum extent possible, re-entrainment of the solid particulates with the liquid stream leaving via outlet 13. This is because, as discussed in Hemstock, the retention of particulates in the outlet stream "contaminates both surface equipment and the

produced fluids and impairs the normal operation of the oil and gas gathering systems and process facilities.” Hemstock, 1:47-50.

169. Furthermore, a person of ordinary skill in the art would have been motivated to incline Hemstock’s settler simply to decrease solid settling times, for the same reason as just discussed.

**ii. Motivation to Modify Hemstock based on the Teachings of the Data Book.**

170. According to the Data Book, sloped slug catchers were well-known and useful for absorbing fluctuating liquid slugs that sometimes occur in two phase (gas and liquid) flow in process and transmission piping. Data Book at 41. The Data Book explains that such devices are generally inclined from one to ten degrees, based on design choices. *Id.*

171. Based on the Data Book’s teaching that an inclined device is desirable for absorbing the fluctuating liquid inlet flow rates through liquid level fluctuation, a person of ordinary skill in the art would have been motivated to modify Hemstock by inclining the desander. This is because such a person would have wanted to maximize the desander’s ability to handle liquid slugs, as Hemstock itself explains that the expected multiphase flow from the wellhead was unstable and that “[l]arge slugs of fluid followed by a gas mist” were common. Hemstock, 2:8-9.

172. A person of ordinary skill in the art would have further recognized that gas/liquid interface in the inclined slug catcher taught in the Data Book would

necessarily be at an angle to the longitudinal axis of the slug catcher, due to the inclination. Because the slug catcher is inclined, liquid will necessarily gravitate or pool towards the separator's lower discharge end. This means that the liquid level in the separator's upper end (where fluid from the well enters the vessel) will necessarily be lower than it would be in the upper end of an equivalent horizontal slug catcher. Thus, compared to a non-inclined horizontal separator, the inclined device will necessarily have a larger cross-sectional area in its gravity section (or as used in Hemstock and the '256 Patent, the freeboard portion) at the end of the vessel where the mixed phase fluid enters, because the liquid level would occupy a smaller portion of the vessel's cross-sectional area there than for a horizontal separator. A person of ordinary skill in the art would also have appreciated that due to the higher cross-sectional area, the fluid velocity in the gravity section of the vessel would be lower than a horizontal separator having the same diameter, result in improved liquid/vapor separation efficiency. Improving the disengagement efficiency of the separator would have been a second, independent reason to incline Hemstock's vessel.

173. Finally, a person of ordinary skill in the art would have understood that slug catchers such as the inclined harp slug catcher in the Data Book function as a single phase separator, just like Hemstock's device, because the liquid outlet valves are manual valves that are closed during normal operation. *See* discussion at Claim

1.5, above. Because Hemstock's desander functions in the same way, accumulating solids in the vessel but re-entraining liquid in the fluid outlet, a person of ordinary skill in the art would naturally have understood that the Data Book's inclined design would be effective and useful for Hemstock's single phase desanding vessel.

**iii. Reasonable Expectation of Success in Inclining Hemstock's Desander**

174. A person of ordinary skill in the art would have had a reasonable expectation of success in modifying Hemstock by inclining the vessel. Inclined vessels and inclined elements in otherwise horizontal vessels were well-known to improve settling of solids from liquids, and in improving settling of liquids from gas. This can be seen in Miller's sand separator, and the Data Book's slug catcher. With these teachings as a background, a person of ordinary skill in the art would have expected that inclining Hemstock's vessel would improve solid-liquid settling time and promoted more efficient separation, based on the teachings of Davis. A person of ordinary skill in the art would also have expected that inclining Hemstock's vessel would improve the vessel's ability to handle slug flow and more efficiently separate entrained liquids from the gas phase, based on the teachings of the Data Book.

175. A person of ordinary skill in the art would not have expected that inclining Hemstock's vessel to have any negative impacts on its operation. This is because the changes resulting from inclining a single-phase vessel were well understood. These include the change in the angle of the gas-liquid interface to the

vessel's axis. However, a person of ordinary skill in the art would have understood how to design such a vessel to ensure it was adequately sized and capable of achieving the desired separation, based of course on the expected mass flow rates of the stream constituents and the operating conditions.

176. Inclining the vessel was certainly within the knowledge and ability of a person of ordinary skill in the art. This modification would merely have required providing a higher support on one end, as well as possibly modifying the angle of the connection to the inlet and/or outlet piping. Such changes were within the skill of a person of ordinary skill in the art, as they would require nothing more than the use of well-known angled pipe fittings. At its most complex, this would simply require pipe fitters and welders to make connecting fittings having the correct angle elbow, or bend pipe to fit up to the vessel and/or the inlet and outlet piping, a process very well known in wellsite-piping.

#### **iv. Grounds 1 and 2: Conclusion**

177. Based on the foregoing, a person of ordinary skill in the art would have reasonably expected that inclining Hemstock's desander based on either Davis or the Data Book's suggestions would improve separation efficiency by improving liquid/solid settling times and vapor/liquid disengagement, improve the ability to handle two phase slug flow, and would not have been expected to impede or harm the system's functionality. Accordingly, a person of ordinary skill in the art would



have found the subject matter of all of the Base Claims obvious in view of Hemstock as modified by either the suggestion in Davis or the Data Book.

**b. Grounds 2 and 3: Hemstock and either the Data Book or Davis, and Miller Render the Inclination Angle Claims Obvious**

178. Ground 3 is the combination of Hemstock and Davis with Miller. The differences between the Inclination Angle Claims (Claims 8 and 12) and either Grounds 2 or 3 are such that the subject matter of each of these claims would have been obvious to a person of ordinary skill in the art.

179. As discussed for Grounds 1 and 2, the combinations of Hemstock and Davis or Hemstock and the Data Book possess every element of Claim 1 from which these claims depend. Claims 8 and 12 respectively require that the desander's inclination angle be variable for varying fluid stream conditions, and that the inclination angle be between about 2°-20°.

**i. Motivation to Modify Hemstock based on the teachings of the Data Book.**

180. The Data Book discloses that angles of between one to ten degrees were used in slug catchers and that this angle was a design choice. Data Book at 41.

181. In addition to the motivation to modify Hemstock based on the the teachings of the Data Book discussed with respect to the Base Claims, a person of ordinary skill in the art would have been motivated to further make the inclination angle variable to suit varying stream conditions. The Data Book itself explains that

the inclination angle is a design choice. Data Book at 41 (“Different pipe inclinations and different manifolding arrangements are favored by different designers.”). A person of ordinary skill in the art would have been motivated to make the angle variable because it was well known that different fluid streams have different properties, and therefore that different angles might be more or less suited to maximize gas/liquid separation efficiency for a particular stream. A person of ordinary skill in the art would also have been motivated to select an angle between about 2° and 20°, as the Data Book explicitly suggests angles (between 1° and 10°).

**ii. Motivation to modify Hemstock based on the teachings of Davis and Miller**

182. A person of ordinary skill in the art would have been motivated to modify the teachings of Hemstock to incline the desander based on the teachings of Davis, as discussed for Ground 1. One of ordinary skill in the art would have further been motivated to make the inclination angle variable so as to suit varying stream conditions, as suggested by Miller.

183. Miller teaches that it was known to vary and adjust the inclination angle of a solid/liquid separator “to suit.” Miller, 2:51-59.

184. A person of ordinary skill in the art would have been motivated to modify the teachings of Hemstock to incline the desander based on the teachings of Davis, as discussed for Ground 1, and to further make the inclination angle variable so as to suit varying stream conditions, as suggested by Miller. This is because a

person of ordinary skill in the art would have understood, based on the teaching in Miller (that the angle may be varied and adjusted “to suit”) that the appropriate angle would need to be determined based on the composition of the inlet stream. Thus, one of ordinary skill in the art would have been motivated to make the angle variable, because it was well known that different fluid streams have different properties and therefore different angles might be more or less suited to maximize solid/liquid separation efficiency for a particular stream.

185. A person of ordinary skill in the art would also have been motivated to select an angle between 2° and 20° based on Miller’s disclosure. Miller does not explicitly state an angle, but a person of ordinary skill in the art reviewing Miller would have determined that it discloses an angle of approximately 10°-15°, which is between 2° and 20°. A person of ordinary skill in the art would also have been motivated to use an angle between 2° and 20°, as such angles are disclosed in Miller.

**iii. Reasonable Expectation of Success in Making the Inclination Angle Variable and Between About 2-20 Degrees**

186. A person of ordinary skill in the art would have had a reasonable expectation of success in making the inclination angle variable and further in selecting an angle between 2° and 20° degrees. This is, first, because it was an obvious matter for a mechanic to make the angle of inclination variable by use of a device such as Miller’s jack, or by using replaceable base supports of varying

heights. Doing so would have necessitated changes to the angle of pipe fittings for the inlet and outlet nozzles and any other connective piping, but this would have required only the mechanical skills of a pipe fitter.

187. There was also a reasonable expectation of success in making such modifications because each of Miller and the Data Book suggest that different angles might be necessary dependent on stream conditions and show that different inclination angles have been successful in similar applications.

188. Thus, a person of ordinary skill in the art would have reasonably expected that making the inclination angle of Hemstock's desander variable and between about 2 and 20 degrees would be successful in improving the separation efficiency between gas, liquid, and solid particulates, dependent on the particular characteristics or conditions of the inlet stream. Accordingly, a person of ordinary skill in the art would have found the subject matter of claims 8 and 12 obvious in view of Hemstock and the Data Book (Ground 2) and Hemstock, Davis, and Miller (Ground 3).

**c. Grounds 3 and 4: : Hemstock, Miller, and either Davis or the Data Book Render the Eccentric End Claims Obvious**

189. Ground 4 is the combination of Hemstock and the Data Book with Miller. The differences between the Eccentric End Claims (Claims 14 and 15) and either Ground 3 or Ground 4 are such that the subject matter of each of these claims would have been obvious to a person of ordinary skill in the art.

190. As discussed for Grounds 1 and 2, the combinations of Hemstock and Davis or Hemstock and the Data Book possess every element of Claim 1 from which these claims depend. Claims 14 and 15 require that the vessel have a smaller diameter downstream of the fluid outlet (Claim 14) and that that smaller diameter end be an eccentric end (Claim 15).

**i. Motivation to Modify Hemstock and Davis or Hemstock and the Data Book as suggested by Miller**

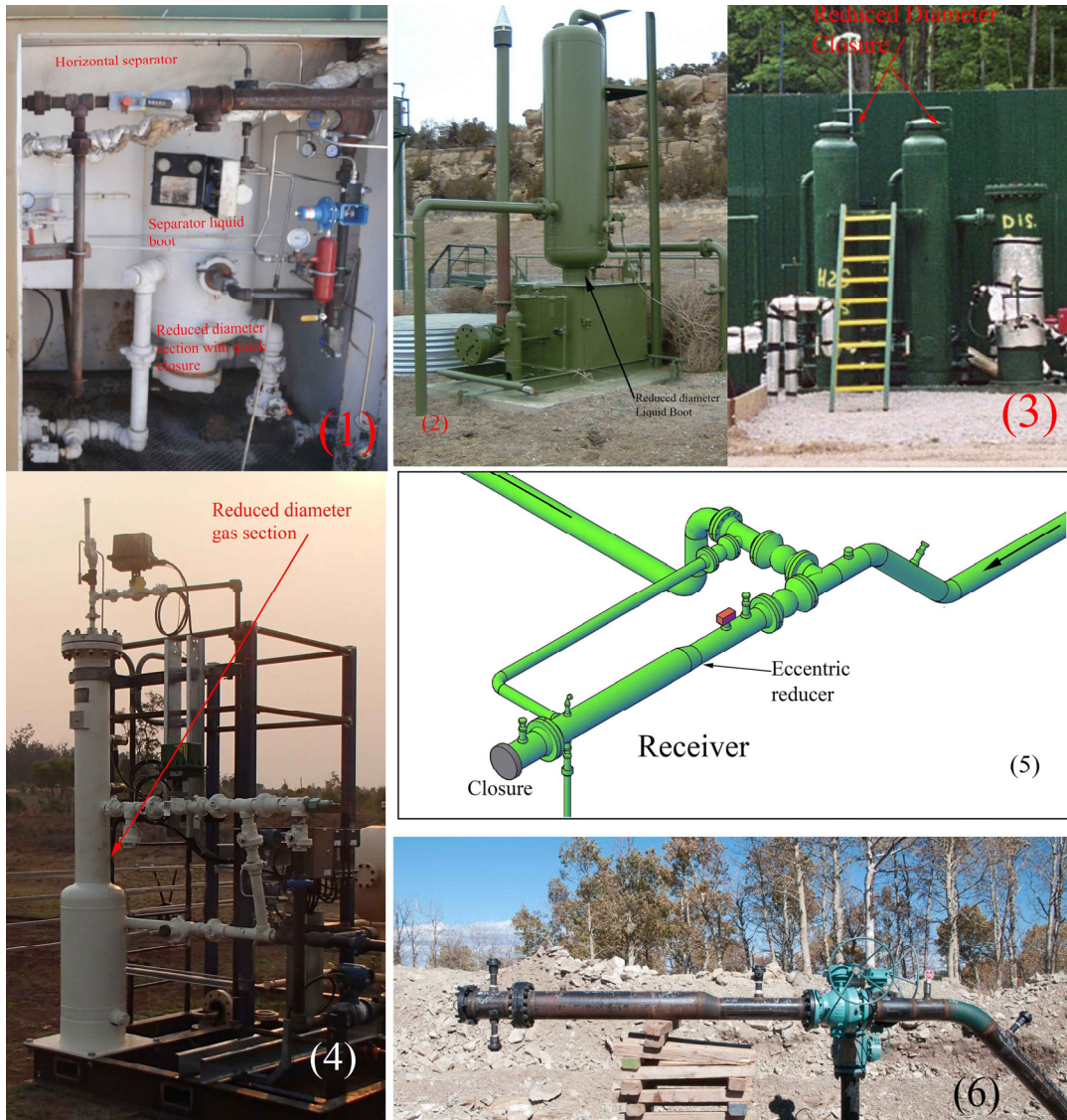
191. Miller suggests that a solid/liquid settling vessel use an eccentrically located, smaller diameter end on the lower end where solids will be removed from the vessel. Miller explicitly discloses using an outlet pipe rather than a different diameter vessel. Miller, 1, 2:51-64, 3:21-24. One of ordinary skill in the art would understand that Miller, in detailing a smaller diameter pipe, also suggested a smaller diameter portion of the vessel itself, as similar pressure vessels were well-known in the art long before the priority date of the '256 Patent.

192. There are many reasons for reducing the diameter of vessels, and it is a common practice. These reasons all fall into one of two categories: (1) the design of the vessel and the expected fluid dynamics require different diameters in different sections; or (2) a smaller diameter section would be less expensive for the required functionality. Smaller diameter cylindrical elements tend to use less material and are marginally less expensive. Smaller diameter fittings represent noticeable cost savings. Smaller diameter quick-release closures are significantly less expensive.

Smaller diameter piping can accomplish a given pressure rating with thinner walls than larger diameter piping requires for the same pressure—resulting in a noticeable cost saving. It is very common for vessels with quick-release closures to reduce their diameter to the minimum diameter that satisfies design requirements.

193. As mentioned above, the use of a smaller-diameter end on a pressure vessel was a common practice long before the effective filing date. Below is a collection of annotated photographs from my archives. These photographs are:

- (1): A combined two-phase production separator and desander with a reduced diameter quick closer [taken in 2011, La Plata County, CO]
- (2) A two-phase production unit with a reduced-diameter liquid section [photograph taken in 2004, San Juan County, NM];
- (3) Filter vessels with reduced size closure [photograph taken in 2010, Antrim County, MI]
- (4) Vessel designed to take gas and solids from a predominantly liquid stream [photograph taken in 2009, Queensland, Australia],
- (5) Engineering drawing of pig receiver [generated in 2011]; and
- (6) Pig receiver under construction [photograph taken in 2011, Garfield County, CO].



194. This group of photographs show that there is absolutely nothing the least bit unusual or unique about changing the diameter of a pressure vessel, and that the method of accomplishing the diameter change can be done with fittings (either eccentric or concentric) or by modifying a pressure vessel fabricated head. Modifications to the pressure-head can be done in any orientation required by the process. There are common welding templates for creating a concentric connection

(i.e., the centerline of the smaller pipe is an extension of the centerline of the larger cylinder), eccentric connection (i.e., the inside surface of one portion of the smaller pipe is flush with the inside of the larger pipe and the centerlines are parallel), offset connection (i.e., the centerline of the smaller pipe is parallel with the centerline of the larger pipe, but the smaller pipe is neither concentric nor eccentric but is in some intermediate location), or angled (i.e., the centerline of the smaller pipe is not parallel with the centerline of the larger pipe).

195. The assembly shown in photographs (5) and (6) is called a “pig receiver” which is a device intended as a single-phase separator with a large solids component. These units are designated as “pipeline accessories” in most U.S. states and international jurisdictions, and “pressure vessels” in other jurisdictions—exactly the same designation as the device in the ’256 patent. ASME B31.8 (Section 831.35(d), Special Components Fabricated by Welding) formalizes the distinction by saying [emphasis added]: “Prefabricated units, *other than regularly manufactured butt welding fittings, that employ plate and longitudinal seams as contrasted with pipe that has been produced and tested under one of the specifications listed in this Code*, shall be designed, constructed and tested under the requirements of the BPV Code.” B31.8 clearly draws the line at longitudinal welds as opposed to pipe (including ERW and other piping fabricated by the manufacturer from plate to an included specification) and butt weld fittings. In either case, the



device has an eccentric reducer for process purposes (i.e., there needs to be room in the barrel for both solids and the mechanical “pig” that pushed the solids out of the pipeline into the receiver) and the extra cost of the larger quick-release closure is justified by the process.

196. Thus, a person of ordinary skill in the art using Hemstock’s desander (whether modified by inclining it as discussed with regard to Grounds 1 or 2, or not) would have understood that such a smaller diameter for the end containing the quick release pressure-vessel compatible cleanout 50 (Hemstock, 5:43-58) was common for such quick-opening fittings, because such closures on pressure vessels are increasingly expensive as the closure size increases, and it is common to try to reduce this cost by reducing the vessel size at the closure.

197. Further, the desander’s freeboard portion must be sized based on the mass flow rate of gas, liquid, and solids to achieve a velocity resulting in adequate separation. This is variable depending on the properties of the inlet stream. It is common for pressure vessels to be fabricated from flat plate, rolled into a cylinder in the fabrication shop and longitudinally welded. This operation allows the inside diameter of the pressure vessel to be optimized for process conditions. It is common for these cylinders to be a different diameter and wall thickness than standard pipe fittings. Fabricated cylindrical closures come in a wide variety of configurations. On the other hand, quick-closures are manufactured to rigid pipeline diameters and

wall thicknesses and it is simply not possible to acquire, for example, a 27-inch quick closure. In the case of a 27-inch outside diameter vessel needing a quick closure it is common practice to put a 27-inch head on the cylinder and cut a 16-inch or 20-inch hole in the head to let in a length of standard 16-inch or 20 inch pipe with a quick closure. Thus, a person of ordinary skill in the art would have understood that having a standardized and smaller cleanout would allow for fabrication and material costs to be optimized (and thus lowered).

198. A person of ordinary skill in the art would further have been motivated to make this smaller diameter end an eccentric end, situated on the lower end of the inclined vessel, as taught in Miller, because this, being the lowest part of the vessel, is naturally where solids will tend to accumulate. Using a non-eccentric end, such as a concentric end, would create a dead space at the lowest point in the desander vessel, from which it would be difficult to remove accumulated solids.

**ii. Reasonable Expectation of Success in Modifying Hemstock's Inclined Desander based on Miller's suggestion.**

199. It would have been obvious to a person of ordinary skill in the art to incline Hesmtock's desander based on the teachings of Davis, as discussed for Ground 1, or the Data Book, as discussed for Ground 2, and to further include a smaller diameter eccentric end as suggested by Miller. Such a modification was well within the knowledge and skill of a person of ordinary skill in the art, and would

merely require sizing the smaller diameter end sufficiently to ensure that cleanout could be performed efficiently and safely.

200. As discussed, a person of ordinary skill in the art would have had a reasonable expectation of success in making such a modification because similar vessels were well known in the art. This modification would not have been expected to impact the functionality of the desander, because downstream of the fluid outlet, liquids and solids have disengaged from the gas phase, and the belly area has a very low velocity, making the vessel diameter at this point inconsequential.

201. Thus, a person of ordinary skill in the art would have reasonably expected that making the cleanout end of Hemstock's desander a smaller diameter, eccentric end would be successful in standardizing the design of cleanout components while lowering fabrication and material costs.

202. Accordingly, a person of ordinary skill in the art would have found the subject matter of all claims of the '256 Patent obvious in view of Hemstock, Davis, and Miller (Ground 3) and Hemstock, the Data Book, and Miller (Ground 4).

### **C. Objective Indicia of Non-Obviousness**

203. I have not been informed of any objective evidence or "secondary considerations" of non-obviousness at this time. Should I be informed of any such evidence I will review it and account for it in my analysis of all of the factors relevant to the obviousness analysis.

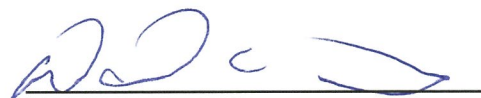
204. However, the claimed invention of the '256 Patent, based on the evidence I have reviewed to date, appears to be no more than an inclined version of Hemstock's prior art vessel. This modification, which is suggested in multiple different contexts in the prior art, does not appear to be inventive or novel.

## **IX. CONCLUSION**

205. I reserve the right to revise or supplement my opinions after I have had the opportunity to review any new testimony, or other additional documents or information that may be brought to my attention, or in response to any critiques of my testimony.

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Executed on this 15 day of Sep, 2018



David A. Simpson, P.E

# Attachment A

## **David A Simpson, P.E.**

5505 Lee LN  
Farmington, NM 87402  
(505) 326-2115  
www,muleshoe-eng.com

**Performance Objective:** Utilize a depth and breadth of engineering and operational experience to contribute to the profitability of Oil & Gas production operations in low-pressure operations.

### **Areas of Expertise:**

- Gas well deliquification and Artificial Lift Technologies
- Low-pressure operations
- CBM development and operations
- Gas compression using reciprocating, rotary-screw, and thermo-compressors
- Project management
- Pipeline modeling, design, construction, and operations
- Gas measurement
- Corrosion management
- Produced-water gathering and disposal
- Gas line purging principles and practice
- Litigation support

### **Education:**

BS Industrial Management, University of Arkansas, Fayetteville, 1980  
MS Mechanical Engineering, University of Colorado, Denver, 1993

### **Career Brief:**

2003-current – MuleShoe Engineering, **Principal Engineer** providing engineering consulting services to the Oil & Gas industry and to various manufacturers of Oil & Gas products. Focus on low-pressure operations, deliquification/artificial lift, Coalbed Methane, Compression, and facility design. Worked on new field CBM development in the San Juan Basin, USA; Surat Basin, Queensland, Australia; Narrabri basin, New South

Wales, Australia; Kalahari Desert, Botswana; and Iguana Field, Columbia. Provided technical support to three pressure vessel manufactures and four manufacturers of downhole and wellhead equipment.

- 1993-2003 – BP America Production Company, **Facilities Engineer** for CBM wells and gathering facilities in the San Juan Basin of Northern New Mexico. Identify opportunities to increase revenue, design projects to implement opportunities, manage construction, and oversee operations. Projects have included nine gathering-system expansions, four major compression facilities, de-bottlenecking 85 high-rate wells for very-low-pressure operations, and installation of 50,000 horsepower of rotary-screw compression on well sites. The projects have added over \$1,300 million (NPV<sub>13</sub>) for a gross expenditure of \$41 million. Ongoing operations include innovations in the design of pigging equipment, using pipeline modeling to define pigging schedules, gas-well deliquification projects, corrosion and scale interventions, and extensive use of a Geographical Information System to reconfigure gathering-system valves to correct operational problems. Engineering Technical Authority (Well Site Equipment, Compression, Gathering Systems).
- 1991-1993 – Amoco Production Company (now doing business as BP America Production Company), **Team Leader and Consulting Engineer** for San Juan Basin Outside Operated Team. Restructured the portfolio of outside-operated properties from an \$18 million annual profit into a \$200 million annual profit by applying effective property management, good partner relations, and appropriate engineering interventions. Supervised a staff of 5 and acted as consulting engineer in the areas of reservoir engineering, reserves estimating, production engineering, and facilities engineering.
- 1980-1991 – Amoco, **Production Systems Analyst** in General Office and field settings. Project manager and system designer on 35 major software-development projects ranging from the *Worldwide Reserves Inventory System* (that defines the way hydrocarbon reserves are calculated, stored, and reported and has been in use for over 20 years) to the *Automated Maintenance Scheduling System* that formalized maintenance processes in 15 plant and field locations and required acting as a maintenance consultant for the operations. Project-management responsibilities included supervising up to 45 employees on software projects that ranged upwards of \$5 million expenditure. Field support included a system that proved to the State of New Mexico that their Proration Order should be eliminated and it was.

1971-1977—U.S. Navy, **Nuclear Mechanical Operator** (Pay grade E-5), USS Truxton CGN35. Acted as a plant operator, engine room supervisor, and maintenance supervisor.

**Professional Affiliations:**

- Registered Professional Engineer (Mechanical), Colorado (37104), New Mexico (16189)
- National Council of Examiners for Engineering and Surveying Council Record Holder (22978)
- Society of Petroleum Engineers – Four Corners Petroleum Section Chairman 2005-2006
- American Society of Mechanical Engineers
- National Association of Corrosion Engineers
- National Society of Professional Engineers

**Standing Committees Participation:**

- Eng-Tips.com *Round Table* board, Member, current
- Program Chair, SPE ATW “Managing the Performance of Low Pressure Gas Wells and Associated Facilities” 2008
- Member of the Board of Directors, Global Energy, LTD, Calgary, AB, 2009-2010

**Publications:**

- “Impact of Entrained Water on Natural Gas Measurement”, Master’s Theses, University of Colorado at Denver, April, 1993
- “Field Experience with Meter Provers”, with Ron Beaty, Gas Research Institute “Seminar on Meter Station Design”, San Antonio, TX, January 24-25, 1996
- “Vented Gas from Wellsite Control Equipment, SPE 61030”, with James Jensen, SPE International Conference on Health, Safety, and the Environment in Oil and Gas Exploration and Production, Stavanger, Norway, June 26-28, 2000
- “Coal Bed Methane Production, SPE 80900”, with James F. Lea and James C. Cox, SPE “Production and Operations Symposium”, Oklahoma City, OK, March 23-25, 2003
- “Producing Coalbed Methane at High Rates at Low Pressures, SPE 85409”, with Mike Kutas, SPE Annual Technical Conference and Exhibition, Denver, CO, October 5-8, 2003
- “Low-pressure gas well deliquification requires different approaches”, *Oil & Gas Journal*, February 27, 2006



#### Attachment A

- *Gas Well Deliquification, 2<sup>nd</sup> Edition*, James F. Lea, et al, Gulf Professional Publishing, 2008, contributing author, Chapter 14 “Coal Bed Methane”
- “Device capitalized on flow stream strengths in pumping gas wells”, *Oil & Gas Journal*, November 5, 2012
- “Facilities Selection Impacts Reservoir Performance, SPE-169837-MS”, May, 2014, presented at SPE Hydrocarbon Economics and Evaluation Symposium, Houston, TX, May 19-20, 2014
- “One Engineer’s Perspective on Global Warming”, August, 2014, published at [www.ENGINEERING.com](http://www.ENGINEERING.com)
- “Pneumatic testing of Pipelines as an Alternative to Hydrostatic Testing”, July, 2014, published at [www.ENGINEERING.com](http://www.ENGINEERING.com)
- “New Processes are Needlessly Reducing the Recovery from Onshore Gas Fields”, Sept, 2014, published at [www.ENGINEERING.com](http://www.ENGINEERING.com)
- “Pneumatic Controllers in Upstream Oil & Gas”, Oct, 2014, published in *Oil & Gas Field Facilities Journal (peer reviewed section)*
- “Are US gasoline pump prices actually high?”, Nov, 2014, published at [www.ENGINEERING.com](http://www.ENGINEERING.com)
- “Orkney Islands use Renewables to Generate 103% of Power Needs”, Feb, 2016, published at [www.ENGINEERING.com](http://www.ENGINEERING.com)
- “Does Petroleum Have to Come from Squashed Dinosaurs?”, June, 2016, published at [www.ENGINEERING.com](http://www.ENGINEERING.com)
- [Practical Onshore Gas Field Engineering](#), David A Simpson, P.E., published by Elsevier, July 14, 2017, ISBN: 0128130229

#### **Patents:**

- *Downhole system and methods for deliquification of a wellbore*, US Patent 8,302,695
- *Device for capturing gas from a produced water stream*, US Patent 8,439,999 and Australian Patent 2013-202601
- *Device for capturing gas and solids from a produced water stream*, US Patent 8,597,402

#### **Training Courses:**

- “Practical Onshore Gas Field Operations”, 3-day course for Oil & Gas professionals and managers without direct field responsibility. Course is presented as in-house training and covers upstream processes from reservoir topics, drilling, deliquification, surface equipment, compression, produced water disposal, through plant concepts.

- “Practical Onshore Gas Field Engineering”, 5-day course for Oil & Gas engineers with direct field responsibility. Course is presented as in-house training and covers upstream processes from reservoir topics, drilling, deliquification, surface equipment, compression, produced water disposal, through plant concepts. This course includes extensive exercises and pre-course/post-course testing.

### **Litigation History**

M & G Drilling Company, Inc. v. Enterprise Field Services LLC, 2006, First Judicial District, County of Santa Fe, State of New Mexico.

- **Participation:** Expert report only

May v. Tuboscope Pipeline Services, Inc., DHP Midstream, L.P., et al. Case No. CV-2007-917 C, 2008, Roswell, New Mexico.

- **Participation:** Expert report only

SG Interests I, LTD, SG Interests VII, LTD, and Margan Investments, LLC v. Gunnison Energy Corporation, Arbitrated in City and County of Denver CO, 2013.

- **Participation:** Both deposed and testified at arbitration.

Epic Lift Systems, LLC v. Integrated Production Services, Inc., 2015, Petitions for Inter-Partes Review before the *Patent Trial and Appeal Board* for three patents

- **Participation:** Prepared expert witness declarations for all three actions, was deposed for two of the actions.

Sandtinel v. Undisclosed, 2018, Petition for Inter-Partes Review before the *Patent Trial and Appeal Board* for the patents:

- Patent No.: Undisclosed
- **Participation:** Prepared expert witness declarations for submittal. Actions withdrawn prior to filing.